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MARCH 1989, VOLUME 6, NO. 3

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Editorial

WHY DIDN'T I THINK OF THAT?

An editor always wants the latest issue of the magazine to be the best, and I believe that this issue lives up to those expectations. However, for reasons to be explained, I am not as happy as I could be.

On page 36 is a story on an attention getting add-on circuit for your car's third (middle) brake light. With that circuit in place, the light will flash a series of three dots (Morse code for "S") whenever the brake is used. The accessory can be used with either an existing light or in a new installation. I saw a similar commercial unit for sale and decided it would be cheaper and better to build my own. Before I could get around to it, though, the article's author, Chadwick Pryson, beat me to it! I was unhappy with myself.

On page 33 is the article on "Ding-A-Ling," an executive mind blower that can relax and entertain you during those high-tension periods that arise during the work day. It's a great little gadget that can be manipulated to sound like 4-tone temple bells, and more. Great idea, but I had it *first*! Well, mine wasn't exactly like the one the author, Walter Schopp, came up with. I had a two-tone circuit in mind, but Walter beat me to it anyway! Darn it!

The pay off occurred with the "Fox Hole Radio" story on page 71. I actually built a nearly identical radio for some Cub Scouts and lectured to them about how experimenters built radios in the old days. Keenan Whitley submitted his article a few weeks later. All I had to do was shoot some pictures and put my lecture down on paper in an article format, but I was beat out again. What's going on?

Well, that won't happen again. I've cleaned the bench top and loaded the 35-mm camera with Plus-X film. Next time I get an idea, I'm going to act on it immediately.

Now why didn't I think of that sooner?

Julian Martin

Julian S. Martin, KA2GUN
Editor

Letters

SPACE INVADERS

Popular Electronics is great! I built Larry Lisle's "BC Antenna Coupler" (October, 1988). Although it was difficult and time-consuming, I found it extremely useful when, tweaking the old knob on the 365-pF variable capacitor, I inadvertently picked up some pre-invasion communications from the Antares Blitz Starfleet. Of course I notified the State Department immediately. Subsequent broadcast leaks have been rare, but there have been enough to confirm that "Boy! Are we gonna be in trouble in some 3,475,000 years!"

Anyway, thanks for a terrific magazine. Lately I've particularly enjoyed Marc Ellis' restoration of the Zenith Model 75232. He seems like a nice man; do you think he'd give me the set when he's finished?

B.G.
Fontana, CA

He is a nice guy, but I doubt he's that nice. Besides, with those Antarians on the way, you won't have that much time to enjoy it!

SCR TESTER

The "SCR Tester" that ran in the December 1988 issue of **Popular Electronics** will, indeed, sort truly "dead" SCR's from the living. With DPDT toggle switches added in both the anode circuit and the gate circuits, it would do the same for Triacs.

However, while the published tester checked for a shorted or open gate, an SCR can fail in other ways. For use with normal voltages, the device must be able to withstand 1.414 × RMS line voltage in both polarities. If it does not, it will fire whenever the peak voltage rises enough to trigger it. In that mode, the load is partially powered on both half-cycles of the line voltage.

In addition, the required gate current can rise above design specifications (hard triggering). The published tester may or may not trigger a device with that problem, depending on the condition of the battery used to power the tester. So, if the trigger circuit in the appliance is over-designed, the SCR may work in the appliance and yet be rejected by that tester.

Finally, if high-efficiency LED's and some small-signal diodes are tested as described in the article, I can almost guarantee that they will test bad—the current limiting shown will exceed the allowable current and destroy the more sensitive devices. Incidentally, some VOM's will do the same thing if you use the ×1 resistance range!

R.T.
Richardson, TX

PARTS PAUCITY

I'm having trouble locating the 500-pF, 10K-WVDC doorknob capacitors for the "Solid-State Tesla Coil"(**Popular Electronics**, October, 1988). I've called every TV shop for a hundred miles, and no one has any. I would like to know where I could get them and where I could find out more about Nikola Tesla (my local library has very little on him).

My friends and I enjoy your magazine. We only have one complaint: Almost every project we build has at least one part that we cannot locate. There is just one electronics-parts store in our area, and they cannot fill all our needs. I also have a box full of parts catalogs, but there are still some things that I cannot find. If you could list some sources for parts at the end of each article it would be most helpful.

S.S.
Chesnee, SC

What you say may be true, but I wonder what those repair shops use when they need to service the high-voltage power supplies in their customer's sets. They may not want to be bothered, but why not give it another try. If all else fails, you can always salvage the capacitors from a discarded TV set.

By now you may have spotted it, but we ran an interesting article on a little known facet of Tesla's life in the December, 1988 issue. The author of that story, Marc J. Seifer, may be able to steer you to some sources for additional information; why not drop him a line in care of this magazine?

We try as best we can to anticipate hard-to-locate parts and we do give sources for anything we feel may cause some problems. Even so, it's rare to find everything you need from one supplier, and you have to be prepared to do a good deal of hunting in some cases. See the following letter for another reader's view on the problem, and how he gets around it.

OLD-TIME PERSISTENCE

Reading your "Letters" column, I get the feeling that the experimenter of today doesn't have the *stuff* we old-timers have. They try a local electronics store, or write to one mail-order company, and when they can't get what they want they throw their arms up in despair and write to you.

I have always kept a few dozen catalogs around here. Most catalogs are free—you just have to write and ask. Sams' catalog of schematic diagrams is free; ECG (Sylvania's line of industry-standard replacement semiconductors) and others publish cross-references for solid-state components. There are all kinds of parts and information out there!

As far as minimum orders go, many companies that I deal with have no minimums. Included among them is Circuit Specialists Inc. (P.O. Box 3047, Scottsdale, AZ 85271), which offers free catalogs, good prices, and fast delivery. Another company without a minimum-order requirement is Electronic Parts Supply (741 East 14th St., Oakland, CA 94606); they sell the Japanese parts I use to repair CB radios for one-third to one-half the price of American counterparts.

OK, guys, go to it—start writing and asking!

F.J.S.
El Cerrito, CA

OUT OF SEQUENCE

In Holiday Light Sequencer *(***Popular Electronics***, December 1988) a reference was made on page 31 to a Fig. 6. That reference should be deleted and replaced with the following text:*

For the Holiday Light Sequencer to produce the aforementioned sequences, the lights from each of the strings must also be arranged in sequence. For instance, to create a one-of-four sequence, the lights from four light sets, designated A, B, C, and D, are arranged as follows: set A, light 1; set B, light 1; set C, light 1; set D, light 1; set A, light 2; set B, light 2; and so on. The lamps can be kept in their proper positions by wrapping wire ties or electrical tape around the light strings.

Editor

WAYWARD WOOFERS

In regard to the woofers specified for the "Towers of Power" article (October, 1988), at just about the time that the article was published I learned that Precision had filed for a Chapter 11 (bankruptcy) the previous summer. Because of that, the drivers specified in the article are no longer available, although some dealers may have a few of the units still in stock.

One advantage of the double-chamber reflex is that the enclosure, with its double-band tuning, is not as driver specific as a classic reflex. Peerless of Denmark, the precursor of Precision in this country, is still in business. They have made some changes in their drivers but Maurice Thaler, of Madisound Speaker Components, says that the Peerless model 1556 is "very close" in specifications to the Precision model TX 205F called for by the project. The address for Madisound is: Madisound Speaker Components, 8608 University Green, Box 4283, Madison, WI 53711; Tel. 608/831-3433.

If you do use the Peerless woofer you may need to make a minor change in the crossover network: The filter, consisting of C4, R1, and L3 may not be needed. One way to test for that is to wire a switch across the filter. Closing it would short out the filter, eliminating it from the circuit; opening the switch would restore normal operation.

Mr. Thaler also stated that Madisound's experience with capacitors is contrary to mine and that electrolytics run on the high side in value. I have tested a good number since receiving that information and have found it to be a mixed bag. Hence, it would be a good idea for readers to check the values of the electrolytics before using them in the circuit.

David B. Weems

HAVES AND NEEDS

I have a dinosaur (early 1960's?) Model 5015, 0- to 50-volt, 0- to 1.5-amp power supply from Power Designs, Inc. of New York. Can anyone help me find a schematic, or at least a cross-reference for Clevite transistors? (I can't find them in Sams.) The power supply is roaring at 30 to 80 volts, and I want to stop it before it ravages all post-dinosaur soft bodies. Although high in voltage, it remains regulated.

Bill Graham
7537 Tamarind Avenue
Fontana, CA 92336

SEARCHING FOR SCHEMATICS

I've been reading in **Popular Electronics** that many people out there want help finding schematics for equipment. Well, I can give them some tips and ideas.

The first thing to do is go to the public library and ask for the Howard W. Sams Annual Index—a book filled with radio, TV, VCR, and even some computer-service data publications. Look up the manufacturer's name and the model number to get a cross-reference of the Sams number, then ask the librarian if they have that schematic. You can't check them out, but you can make copies of them. If the library doesn't have the schematics you need, you can purchase them from Howard W. Sams & Company.

Although they don't have schematics for test equipment, and their selection of computer schematics is somewhat limited, Sams will do their best to direct you to another source if you want something that they don't have.

Another way to get schematics is to contact the manufacturers. Most that I've done business with were very helpful. (Of course, there were a few that wouldn't lift a finger to help me.)

S.P.
Hayward, CA

That's excellent advice, and often following your suggestions will turn up that hard-to-find schematic. Of course, there's a whole bunch of obscure or out-of-production equipment from obscure or out-of-business manufacturers (especially off-shore ones) out there. When you're up against one of those, that's the time to turn to a valuable resource: your fellow **Popular Electronics** *readers via our monthly "Haves and Needs" department here in "Letters."* ■

Electronics Library

To obtain additional information on the books and publications covered in this section from the publisher, please circle the item's code number on the Free Information Card

ILLUSTRATED OS/2

by J. Emmett Beam

Because the OS/2 program is sophisticated, and its commands are cryptic, it can seem intimidating. This comprehensive guide shows readers how to tap the power of OS/2 with a minimum of confusion. Beginners can learn to use OS/2 both as a software-to-machine interface and as a handy "housekeeping" tool for file maintenance, and the book is a convenient reference for intermediate and advanced OS/2 users.

The book is organized into individual lessons, or "modules." Each is easy to read, full of practical examples and hands-on exercises, and includes descriptions, applications, and illustrations showing how OS/2 is used to solve everyday problems.

The book describes how to take advantage of multitasking, interprocess communications, and the operating system's increased speed and memory to gain productivity. The book includes in-depth information on Assembler-, Linker-, and Codeview-debugger utilities for programmers; practical tips on using Presentation and Session Manager interfaces; and techniques for running MS/PC-DOS within the OS/2 environment.

Illustrated OS/2 is available for $19.95 from Wordware Publishing, Inc., 1506 Capital Avenue, Plano, TX 75074; Tel. 1-800-231-7467.

CIRCLE 88 ON FREE INFORMATION CARD

VCR CONNECTIONS GUIDE
TV Accessory Hookup Made Easy

by Louis E. Frenzel, Jr.

Lou Frenzel has a well-deserved reputation for demystifying complex subjects, and this perplexing topic hits close to home: how to connect VCR's and other television accessories for maximum performance. Frenzel, with the help of the Howard W. Sams engineering staff, helps you meet that challenge successfully.

Watching TV used to be a simple thing. But with the array of signal sources and accessories available today, it sometimes seems as if you need a degree in engineering to get everything working properly. This book details—in plain English, with clear illustrations—how to hook up VCR's, cable converters, video games, stereos, satellite receivers, and other increasingly popular add-on devices.

The book explains the theory of interconnection, and presents helpful maintenance and troubleshooting tips. Information on such video devices as camcorders, video processors, stereo decoders, switchers, and remote controls is included. All the most common combinations of televisions, VCR's, and accessories are covered to help you get the most from the equipment you now own, and to adapt your video system when adding new components.

VCR Connections Guide: TV Accessory Hookup Made Easy is available for $8.95 from Howard W. Sams & Company, 4300 West 62nd St., Indianapolis, IN 46268; Tel. 800-428-SAMS.

CIRCLE 95 ON FREE INFORMATION CARD

MASTER HANDBOOK OF 1001 PRACTICAL ELECTRONIC CIRCUITS
Solid-State Edition

Edited by Kendall Webster Sessions

This book is written for anyone who's experienced the frustration of spending hours searching for a specific circuit—or has gone through the trouble of designing and building their own circuit, only to discover that it already exists, in de-bugged form. The circuits in this source book represent a full range of professional, home, and hobby applications.

The basic concept is to make it quick and easy for the reader to find the circuit he needs, to get the parts for it, to build it, and to customize it. Most of the book is devoted to illustrations—the text that accompanies each drawing is short and concise. Each circuit has been breadboarded, tested, and simplified, and each includes all the information the reader will need to make it work for his particular application. Every component on each circuit diagram is carefully labeled. The book is categorized and indexed for easy access to specific circuits, and a parts index is included.

The up-to-date semiconductor circuits presented include alarms, sensors, triggering circuits, audio amplifiers, automotive circuits, filters, power supplies, voltage multipliers, timers, test equipment, diode circuits, transmitters, transceivers, receivers, converters, control circuits, RF power amps, RF generators, and more.

Master Handbook of 1001 Practical Electronic Circuits: Solid-State Edition is available for $19.95 from Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

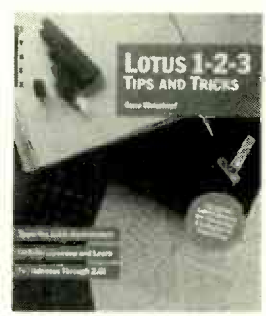
CIRCLE 98 ON FREE INFORMATION CARD

LOTUS 1-2-3 TIPS AND TRICKS

by Gene Weisskopf

Designed for all levels of Lotus 1-2-3 users, this book offers dozens of specific shortcuts, pointers, and cautions for the most efficient use of that program. The "tips" it offers are bits of sound advice on productive work habits to ensure success. "Tricks," on the other hand, are hidden shortcuts or combinations of Lotus features that produce unexpected results. "Cautions" are just that: warnings about specific topics or general bad habits that are potentially damaging.

The book covers those features that should be mastered by all Lotus users. It



is a basic, step-by-step guide as well as a compilation of handy techniques. Readers learn how to use macros to increase the system's power; to plan and create clean worksheets that are easy to work with; to quickly gain access to DOS; to find hidden errors that are disrupting calculations; to use impressive graphs to present data; and to increase the clarity, speed, and accuracy of all operations. It describes how to use the often-neglected @ functions for working with text and dates, and how to use the @d function to get more value from the database.

Also included are details on two popular

Lotus add-in programs: "Learn" (for recording macros) and "Speedup" (for making the system work faster). Techniques for troubleshooting the printing process help readers take control of their printouts. For those who are considering upgrading to 1-2-3 Release 3, the author takes a look at the new features it offers.

Lotus 1-2-3 Tips and Tricks is available for $21.95 from Sybex, Inc., 2021 Challenger Drive #100, Alameda, CA 94501.

CIRCLE 87 ON FREE INFORMATION CARD

REMOTE CONTROL HANDBOOK

by Owen Bishop

Reader response to *Remote Control Projects* (No. BP73) prompted the creation of this new book on the subject. Aimed at electronics enthusiasts as well as technicians with serious applications for remote-control technology, the book contains updated and improved versions of some of the previous circuits—primarily, the simplest ones to build and use—as well as many circuits that have never been published before.

Many of the new circuits reflect recent technological changes in the field. Those include circuits for interfacing microcomputers to remote-control systems, for using AC house wiring as a transmission link, and for using fiber optics in remote-control circuits. Other projects offerred in the handbook include voltage-to-frequency conversion, frequency-to-voltage conversion, and stepper motors.

All of the circuits are presented as simple modules that the reader can combine to create increasingly complex remote-control projects. Virtually all the circuit modules detailed in the book are compatible with one another, permitting them to be linked in a wide array of configurations to suit individual requirements.

The 219-page book also contains several useful appendixes. In them, beginners will find an introduction to electronic theory, project building, and computer interfacing; readers of all levels of experience will appreciate the pin-outs of all semiconductors and IC's used in the circuits, the listings of parts suppliers, and the discussion of various types of power supplies used for remote control applications.

Remote Control Handbook (No. BP240) is available for $8.95 (including shipping) from Electronics Technology Today, P.O. Box 240, Massapequa, NY 11762.

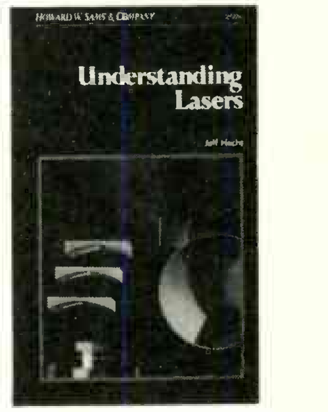
CIRCLE 97 ON FREE INFORMATION CARD

UNDERSTANDING LASERS

by Jeff Hecht

Non-technical types in particular tend to think of lasers in terms of flashy sci-fi devices and special effects in films. In reality, lasers have become commonplace in many fields—invisibly enhancing our everyday lives in CD-players, telephones, supermarket checkout lanes, and doctors' offices.

This book explores those real-life laser applications for students, hobbyists, or anyone with an interest in lasers. Arranged similarly to a textbook, the concise text



is accompanied by illustrations, and each chapter concludes with a summary and a self-quiz. A broad overview of lasers is followed by a review of the fundamental concepts of physics, quantum mechanics, and optics needed to understand laser technology. The book explains how lasers work, and describes the accessories—including lenses, prisms, and "active" optics that bend laser light—that help them work more effectively.

Subsequent chapters provide detailed coverage of the three laser families: gas, solid-state, and semiconductor. Free-electron and X-ray lasers are discussed, and applications of lasers in medicine, industry, and communications are presented.

Understanding Lasers is available for $17.95 from Howard W. Sams & Company, 4300 West 62nd St., Indianapolis, IN 46268; Tel. 800-428-SAMS.

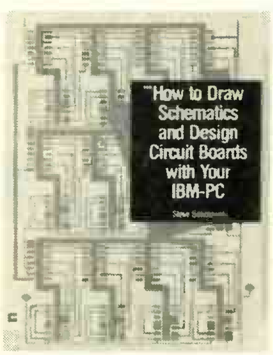
CIRCLE 95 ON FREE INFORMATION CARD

HOW TO DRAW SCHEMATICS AND DESIGN CIRCUIT BOARDS WITH YOUR IBM-PC

by Steve Sokolowski

With Computer-Aided Engineering (CAE), the most complex printed-circuit boards and schematics can be automatically designed by computers that have been fed the proper data. Unfortunately, CAE software is too expensive for most hobbyists and home technicians.

This book bridges the gap between what's available to corporate engineers and to hobbyists, by presenting two elaborate programs that generate professional printed-circuit board artwork and complete schematics. No expensive engineering-graph



ics card is necessary. Anyone with an IBM-PC or compatible, a color monitor, 128K of memory, a disk drive, and a graphics printer can create engineering graphics with this book.

The "PC Board Designer" program allows readers to generate printed-circuit board artwork on an inexpensive graphics printer, to a scale of 1:1. The "Schematic Designer Program" has 30 pre-programmed electronic symbols for highly professional results.

Written for the novice electronics and computer hobbyist, technical jargon is avoided. Readers are taken, step-by-step, from loading MS-DOS and graphic utilities, right through to etching and soldering their own boards. Drawing commands for both CAE programs are described clearly and, for illustrative purposes, the book details how to use the programs to draw a 12-volt power supply and the circuit board to be used with it. All the information needed to convert the PCB layout into a finished board is provided.

How to Draw Schematics and Design Circuit Boards with Your IBM-PC is available for $13.95 from Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

CIRCLE 98 ON FREE INFORMATION CARD

MICROCOMPUTER TROUBLESHOOTING & REPAIR

by John G. Stephenson and Bob Cahill

Just like any other electronic device, computers sometimes break down. Yet even experienced do-it-yourselfers are often leery of tinkering with the high-tech innards of a microcomputer. This book removes the mystery surrounding computers by supplying the reader with all the information necessary to understand how they work and how to keep them working properly.

The book is intended for readers with some basic knowledge of electronics and the ability to use simple hand tools and a VOM—whether they have an interest in entering the computer-repair field, or just want to get the best performance out of their own PC's. It thoroughly explains basic troubleshooting principles and how to apply them to make any necessary repairs. Because of the tremendous variety of computers and peripherals on the market, the book focuses on broad concepts rather than specific details. Once those concepts are grasped, they can be applied to many different types of computer equipment.

Rules of safety are presented up front, followed by a "service profile" that describes common computer problems and their causes. The book explains how to decide when to tackle a problem and when to have an expert do the repair. It describes the steps that computer users can take before problems occur, and how to localize and diagnose troubles that do occur—including professional tips and tricks to help pinpoint problems quickly. Techniques for testing resistors, diodes, transistors and circuits containing IC's are also included.

Most of the book is devoted to discussing the troubleshooting and repair of each separate part of the computer system—floppy- and hard-disk drives, CPU's, printers, modems, serial interfaces, monitors, displays, and power supplies. Illustrations and complete, step-by-step troubleshooting charts are included. Finally, appendixes provide resistor color codes, manufacturer's logos and IC-numbering systems, a handy troubleshooting chart of symptoms and possible causes, dealer and manufacturer addresses, and *COMPUTERFACTS* index.

Microcomputer Troubleshooting and Repair is available for $21.95 at bookstores, computer stores, electronics distributors, or direct from Howard W. Sams & Company, 4300 West 62nd St., Indianapolis, IN 46268; Tel. 800-428-SAMS.

CIRCLE 95 ON FREE INFORMATION CARD

PROGRAMMER'S GUIDE TO OS/2

by Michael J. Young

For those who are familiar with the C language and the basics of MS-DOS, this book is a comprehensive introduction to the principles and techniques of software development using OS/2. Programmers looking for specific techniques, or simply seeking a deeper understanding of the OS/2 environment will appreciate the clear explanations of basic concepts and systems architecture, with an emphasis on the differences between MS-DOS and OS/2.

The book takes a step-by-step approach to programming, using many concrete examples of the material presented. Readers can discover how to write an MS-DOS program for the OS/2 compatibility box, to create software that works under both operating systems, to program specifically for OS/

2's protected mode, to create a complete multitasking OS/2 application, and to use OS/2's interprocess communication facilities to synchronize concurrent tasks.

The 625-page guide contains complete reference documentation on the OS/2 application program interface, including clear summaries of the OS/2 kernel functions and special functions for the screen, keyboard,

(Continued on page 12)

Electronics Library
(Continued from page 8)

and mouse. There is in-depth coverage of such specialized topics as dynamic-link libraries, creating OS/2 monitors to implement background utility software, and an introduction to the Presentation Manager windowed operating environment. The appendices provide quick reference to OS/2 service calls, I/O control functions, and error codes; sample programs are compatible with Microsoft C version 5.1 and the Microsoft OS/2 Programmer's Toolkit.

Programmer's Guide to OS/2 is available for $24.95 from Sybex, Inc., 2021 Challenger Drive #100, Alameda, CA 94501.

CIRCLE 87 ON FREE INFORMATION CARD

DELTON T. HORN'S ALL-TIME FAVORITE ELECTRONIC PROJECTS

by Delton T. Horn

The variety of projects in this book will appeal to both beginners and experienced electronic hobbyists. The main emphasis is on practicality. Each of the 16 projects presented include step-by-step instructions and easy-to-follow drawings, diagrams, and schematics.

The book is divided into two sections—projects for the home and projects for the shop. The former section includes an intercom, digital clock, AM/FM radio, various amplifiers, a car theft alarm, and electric-motor speed controller. Some of the "shop" projects are a digital-to-analog converter, logic probe, digital frequency meter, DC voltmeter, multiple-output power supply, and constant-current or constant-voltage source.

Delton T. Horn's All-Time Favorite Electronic Projects is available for $7.95 from Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

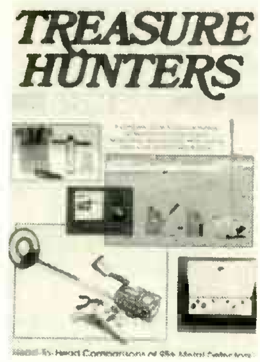
CIRCLE 98 ON FREE INFORMATION CARD

TREASURE HUNTERS BUYERS GUIDE

edited by R. Anderson

More than a million Americans own metal detectors, and at least 50 new treasure-hunting products were introduced in 1988 alone. To help treasure hunters to keep abreast of the latest technologies, and to introduce newcomers to the variety of metal detectors and accessories that are available, the publishers of *Western & Eastern Treasures* magazine have put together this book.

It features more than 90 metal detectors, for use on land or underwater, and ranging in price from $20 to $2000. Also included are over 100 treasure locators, scoops, trowels, and accessories. Each listing includes a clear description of the unit's



capabilities and features, a photograph, and pricing information. The detectors are also compared side-by-side in charts covering over 50 categories, to help readers determine the right detector for their individual needs. A glossary offers explanations of how detectors work, along with definitions of terms.

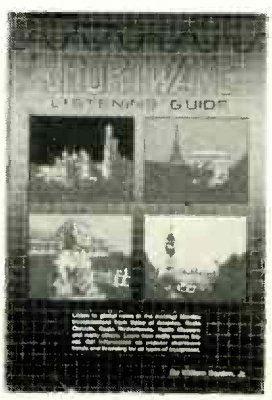
Treasure Hunters Buyers Guide is available for $7.95 through local metal-detector dealers, bookstores, or directly from People's Publishing Company, P.O. Box 1095, Arcata, CA 95521.

CIRCLE 86 ON FREE INFORMATION CARD

SHORTWAVE LISTENING GUIDE

by William Barden, Jr.

If you've been considering getting into shortwave radio listening as a hobby, this book will help you get started. In simple language, it describes the radio-frequency bands and the types of equipment needed to use those bands. It explains all the basics of radio, including how radio waves travel and Morse code, and discusses the various types of radio broadcasts and transmissions. A list of radio bands is provided, along with de



scriptions of the stations and operations on those bands.

The book also discusses radio equipment, such as portable shortwave receivers, CB gear, scanners, and amateur radio equipment—and offers tips on what features to look for when buying equipment. Radio facsimile, portable phones, and satellite reception are also explained. A glossary of radio terminology helps newcomers understand radio-communications jargon.

Shortwave Listening Guide is available for $2.95 from local Radio Shack stores.

CIRCLE 85 ON FREE INFORMATION CARD

INTRODUCTION TO ELECTRONICS DESIGN

by F.H. Mitchell, Jr. and F.H. Mitchell, Sr.

This book takes an "adaptive systems approach" that aims to teach electronics-design students to work in an environment of ever-changing technologies and increasingly sophisticated computer networks. All the skills it teaches are oriented toward complex future settings.

The text moves from basic building-block concepts to complex integrated circuits and systems. The importance of manufacturing and economic restraints to the design process is emphasized, to give readers a broad understanding of real-life design settings and interactions between different performance settings. The ABET definition of design is followed; the text is oriented toward meeting ABET accreditation requirements.

Semiconductors are covered in detail, including fundamental concepts, modeling of materials and devices, performance parameters, and the effects of performance on circuit operation. Readers are provided with insight into today's semiconductor devices while learning the background information needed to understand tomorrow's devices.

Material throughout the book emphasizes the importance of computer-aided design. SPICE is introduced as a design aid, and worked-out applications are included. Modeling and model-building are described as key elements of computer-aided design. Readers are encouraged to view computer simulation as a basic aspect of the electronics-design process.

Introduction to Electronics Design is available for $55.00 from Prentice-Hall, Englewood Cliffs, NJ 07632.

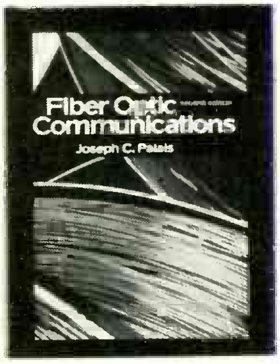
CIRCLE 99 ON FREE INFORMATION CARD

FIBER OPTIC COMMUNICATION Second Edition

by Joseph C. Palais

This introductory book requires no background in fiber optics or optic communications, and uses only the simplest algebraic and trigonometric concepts when describing fiber-optic characteristics. Fundamental concepts of optics, communications, and electronics appear in the text as needed for clarity.

To identify the basic components of fiber-optic systems, block diagrams of entire systems are presented at the beginning of the book; those are referenced throughout the



text. The basics of optics and wave travel are reviewed, and the technology of combining optic components onto a single substrate is introduced. The main devices in a fiber-optic system—the fiber, light source, light detector, couplers, and distribution networks—are presented. Modulation formats, the effects of noise on message quality, and system design are covered. Examples of operational systems are presented in the final chapter, where the design information developed throughout the book is applied to realistic problems.

Fiber Optic Communication: Second Edition is available for $35.00 from Prentice Hall, Englewood Cliffs, NJ 07632.

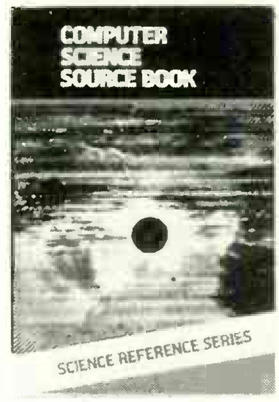
CIRCLE 99 ON FREE INFORMATION CARD

THE COMPUTER SCIENCE SOURCE BOOK

edited by Sybil P. Parker

This book, part of McGraw-Hill's new "Science Reference Series," is an in-depth treatment of computer science and data processing. It comprises a group of articles written by authorities in their areas of expertise and specialization, and the material presented is arranged in sections according to subject matter.

Various types of computers—analog, digital, microcomputers, and supercomputers—are examined. Complete explanations are given for architecture and circuitry, the theory and mathematics of computation, computer communications and networks, programming, and software. The section on artificial intelligence includes articles on expert systems, computer vision, speech



recognition, voice response, and natural-language programming. Under the heading called "Systems Applications" there are authoritative pieces on such topics as computer security; computer-aided engineering, design, and manufacturing; computer-integrated manufacturing; word and image processing; cryptography; data-processing systems and management; and data-base management systems.

Computer Science Source Book is available, in hardcover, for $35.00 from McGraw-Hill Book Company, 11 West 19th St., New York, NY 10011; 1-800-2-MCGRAW. ■

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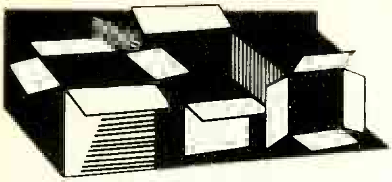
CIRCLE 13 ON FREE INFORMATION CARD



New Products

To obtain additional information on new products covered in this section from the manufacturer, please circle the item's code number on the Free Information Card

AUDIO COMPONENT KITS

Heath Company's line of kit and assembled high-end audio equipment includes a compact-disc player, cassette deck, 100-watt power amplifier, AM/FM stereo tuner, preamplifier, and two speaker systems. All of the equipment in the line was designed for Heath by *Harmon Kardon* and incorporates many of the latest advancements in audio technology.

The power amplifier, preamp, and tuner are available either assembled or in kit form; the other components in the line are sold only fully assembled. Each kit includes a detailed instruction manual that makes construction easy for the intermediate hobbyist. (Heath's construction manuals have long been the standard against which others are judged.)

The CD player, *Model ADW-2530*, includes a "discrete analog output section" that decreases intermodulation distortion. It uses a 3-beam laser optical head for precise tracking and laser positioning, and includes a sample-and-hold processor to

reduce switching noise. Model ADW-2530 also features a 10-function wireless remote control and a 36-track programmable memory.

The *ACW-2540* cassette deck features *Dolby HX Professional*, a headroom-extension system that retains dynamic audio signals during recording. Among the deck's other features are a 7-segment LED peak-metering system, a frequency response of 20 Hz to 20 kHz (±3 dB), record mute, MPX filter, metal-tape capability, and a solenoid transport.

The power amplifier, *Kit AA-2500*, features more headroom to handle digital recordings, and wide bandwidth and low negative feedback. It offers four dual-polarity power supplies that eliminate channel-to-channel interference and assure proper balance of current between high- and low-level stages.

Kit AJ-2520, the stereo tuner, provides a digitally synthesized, quartz-locked tuning system that virtually eliminates drifting and mistuning. It has an all-metal chassis to maintain audio-signal purity, 16-station FM or AM memory, muting, 3-segment LED signal-strength meter, and manual up/down tuning.

The preamp, *Kit AP-2510*, is a full-featured, low-noise unit with several inputs. One speaker system, *Model ASW-1230*, was designed by JBL; it is a 3-way floor system with ported enclosure. The second speaker system, *Model ASW-1082*, is an 8-inch, 2-way bookshelf system with a ported enclosure and 60-Hz to 20-kHz frequency response.

Heath's entire audio line is featured in their current catalog. For complete pricing information, or to request a free catalog, contact the Heath Company, Hilltop Road, St. Joseph, MI 49085; Tel. 1-800-44-HEATH.

CIRCLE 70 ON FREE INFORMATION CARD

DISK-PROTECTION DEVICE

Arrick Computer Products' Write-Guard is an easily installed piece of hardware that allows the computer user to write protect their hard- or floppy-disk drives, making it impossible to write, change, or erase any data on that disk.

Write-Guard is designed as protection from computer viruses and operator error. Activated with the flick of a switch, it monitors the disk controller and intercepts any write commands. When it detects an unauthorized write command, it warns the user

with audio and visual signals, and notifies DOS that the command was unsuccessful. A reset button turns off the light and buzzer, and the device itself can simply be switched off when it is not needed.

As virus protection, Arrick recommends using Write-Guard when turning on the computer, when trying new software, and when using a modem to access computer bulletin boards. As operator-error protection, the device can be used during back-ups, when using new programs, and when doing such file-maintenance tasks as copying and erasing.

The unit's circuit board, designed around the 32-pin connector that is found on most hard- and floppy-disk drives, connects to the disk drive where the cable plugs in; the control box can be affixed to the side of the computer with the included Velcro. Each unit protects one disk drive; two or more can be used on systems with multiple drives.

Write-Guard costs $59.95. For further information, contact Arrick Computer Products, 2107 West Euless Blvd., Euless, TX 76040.

CIRCLE 71 ON FREE INFORMATION CARD

UNIVERSAL REMOTE CONTROLLER

Onkyo's third-generation "Unifier" (*Model RC-AV20*) offers simplified operation, smaller size, and reduced price in a universal programmable remote-control unit. One RC-AV20 can replace the separate infrared remotes that come with VCR's, TV's, audio components, and cable boxes from

many manufacturers, which tend to accumulate in droves with today's multi-component home-entertainment systems.

The latest Unifier has a keypad that is arranged for easy control of up to 10 components. Each of the 51 programmable keys is controlled by a master audio/video switch for dual-mode operation. The unit can "learn" up to 102 different command codes, with color symbols at each key to simplify identification—and to make programming and operation straightforward for even the novice user.

The RC-AV20 Unifier has a suggested retail price of $99.95. For additional information, contact Onkyo, 200 Williams Drive, Ramsey, NJ 07446.

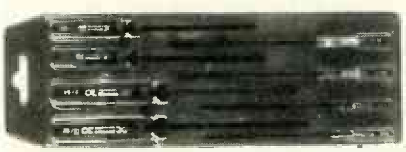
CIRCLE 72 ON FREE INFORMATION CARD

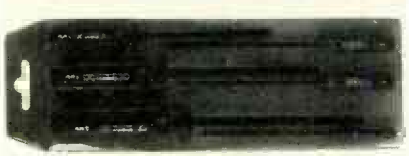
HEX DRIVER ASSORTMENT

The *Balldriver* hex-driver assortments from *Bondhus Corporation* include several small-dimension tools, in inches or millimeters, that are commonly required for maintenance, repair, and assembly work.

Model BSX 8S contains eight precision-sized fastening tools. Individual tools sizes (0.05-, 1/16-, 5/64-, 3/32-, 7/64-, 1/8-, 9/64-, and 5/32-inch) are marked on the handles for easy identification. The metric set, *Model BSX 6mm*, contains 1.5-, 2-, 2.5-, 3-, 4-, and 5-mm hex drivers.

Balldriver hex tools come packaged in





a sturdy vinyl pouch with a snap-lock flap that permits quick access, yet keeps tools securely in place. The tools allow hex-socket head fasteners to be tightened or loosened at angles up to 25°, and provide fast insertion and removal with positive, full-depth engagement of fasteners.

Balldriver hex-tool kits, Model BSX 8S and Model BSX 6mm, cost $11.53 and $9.65, respectively. For more information, contact Bondhus Corporation, 1400 East Broadway, Monticello, NY 55362.

CIRCLE 73 ON FREE INFORMATION CARD

COMPACT-DISC PLAYER

The *B226-S* compact-disc player is part of *Revox's* new *200-S* line of high-end audio components. The B226-S features European system 16-bit quadruple oversampling, a new generation transport with precision-tooled aluminum die-cast plate, two digital audio-signal outputs, and a digital-to-

analog converter of the type used in professional players.

The unit's controls, designed for convenience and ease of use, are logically arranged acccrding to primary and secondary functions. The electro-luminescent display shows track number, and time remaining and time elapsed for both track and disc. When the display is programmed for track mode, an additional proportional bargraph shows relative position within the track. The display also indicates the program number; the number of selections remaining on the disc; programming steps; and the status of pause, autostop, and loop functions.

The CD-player can be random-access programmed with up to 19 selections for playback in any desired sequence. It offers fast scanning in forward and reverse, skipping and repeat of selections, and pre-programming of later selections during playback. Specific sections of a musical selection can be played at will, with fast access and search time for the desired starting point.

The model B226-S compact-disc player has a suggested retail price of $1,895.00. For additional information, contact Studer Revox America, Inc., Revox Division, 1425 Elm Hill Pike, Nashville, TN 37210.

CIRCLE 74 ON FREE INFORMATION CARD

DIGITAL PEDOMETER

Home Company's 562 Digital Pedometer is a simple, but handy device for walkers and runners. It accurately registers the distance—in miles and tenths of miles—that has been walked or run. It will count up to 100 miles, and can be reset back to zero at the push of a button.

The lightweight and compact device is

unobtrusive. It can be comfortably worn on the exerciser's belt or waistband.

The Digital Pedometer 562 costs $14.95. For more information, contact Home Company, 4967 Brittany Drive, Dept. PR-1, Stone Mountain, GA 30083.

CIRCLE 75 ON FREE INFORMATION CARD

DUAL-DISPLAY MULTIMETER

The *Fluke 45* multimeter features a multi-function dual display, that allows more measurements to be taken from a single connection and a single instrument setup. The 5-digit unit includes a built-in RS-232 interface for PC-instrument applications.

Up to 81 different measurement combinations can be viewed using the bright, vacuum-fluorescent primary and secondary displays. That is particularly useful in applications requiring two different measurements of the same signal. In power-supply testing, for example, measurement for VDC output can be viewed on the primary display while the VAC ripple is shown on the secondary display.

The Fluke 45 has a compare function for easy in-tolerance testing that shows a hi/lo/pass evaluation on components. Along with diode test and continuity functions, it

has a frequency-counter function to 1 MHz and an assortment of dB-calculation functions. With the standard RS-232 interface, measurement data can be easily filed, manipulated, printed, or transmitted by modem.

Other features include true AC plus DC RMS capability, MIN MAX, relative reference, "Touch Hold", and autoranging. Closed-case calibration is possible over either the RS-232 or the optional IEEE-488 interface. Basic one-year accuracy specifications are .03% VDC and .5% VAC (2% at 60 Hz), .05% DC amps and 1% AC amps (.4% at 60 Hz) for current measurements, and .05% ohms for resistance measurements.

The Fluke 45 is available in early 1989, at a suggested list price of $595.00. For more information, contact John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, WA 98206; 800-443-5853, ext. 33.

CIRCLE 76 ON FREE INFORMATION CARD

OZONE-SAFE REFRIGERANT

Chemtronics' E-Series Freez-It is a circuit refrigerant with superior thermal properties that chill faster using less refrigerant. With an environmentally sound formula that contains no ozone-depleting chlorofluorocarbons (CFC's), it is designed to be an ozone-safe substitute for Chemtronic's conventional, popular *Freez-it* circuit refrigerant.

A second-generation EPA-exempt fluorocarbon, E-Series Freez-It provides high purity, low toxicity, and inertness similar to the conventional type. Properly applied, the advanced product is safe for all components and evaporates quickly, leaving no residue. It can be used for low-temperature testing of thermal intermittent compo

nents and systems with instant freezing of small areas to as low as −96°F (−71°C). It is also useful for heat-sink protection of components during soldering and testing, and freezing of adhesives to facilitate removal.

E-Series Freez-It, in convenient 12-ounce aerosol cans with wide push-button valves, has a suggested list price of $4.60. For more information, contact Chemtronics Inc., Customer Service, 681 Old Willets Path, Hauppauge, NY 11788; Tel. 800-645-5244 (in NY, 516-582-3322).

CIRCLE 77 ON FREE INFORMATION CARD

SATELLITE RECEIVING SYSTEM

R.L. Drake's Model ESR2450 is their top-of-the-line integrated receiver decoder (IRD) with built-in power supply, VideoCipher II decoder, on-screen graphics, UHF remote control, and full-stereo sound with DNR noise reduction.

The unit features a built-in actuator control system with power supply, that moves the antenna to any of 36 pre-stored satellite positions with the push of a button. Those 36 positions can be stored in the ESR2450's non-volatile memory, making satellite access a simple procedure for

either C- or Ku-bands. In addition, there are 30 Priority View program memories that offer immediate recall of favorite channel settings.

The UHF remote control allows dish owners to hook up more than one TV and to operate the satellite-TV system from anywhere in the house. (The unit will also work via infrared signals.) Large, on-screen graphics are easy to read, and display such information as channel, satellite, polarity, and signal strength. That information is displayed whenever a function is changed, and can be recalled to the screen with a touch of a button on the remote control.

The ESR2450 features full stereo sound with noise reduction. It receives analog stereo sound in both the discrete and matrix modes, and digital stereo sound when decoding scrambled subscription programming. Other features include parental lockout, selectable audio-bandwidth filters, and automatic TV-antenna switching. Special color-coded controls simplify setup and help the user enter program information.

The microprocessor-controlled unit uses a 950- to 1450-MHz block input frequency, and features input switching to eliminate the need for external relays. It can accommodate one C-band and one Ku-band LNB or two C-band LNB's, and is compatible with all Drake LNB's and its BDC24 downconverter.

The ESR2450 integrated receiver decoder, including a one-year limited warranty, has a suggested retail price of $1489.00. For further information, contact R.L. Drake Company, P.O. Box 112, Miamisburg, OH 45342.

CIRCLE 78 ON FREE INFORMATION CARD

DC/AC INVERTER

The *Pocket Power Inverter* from *Atlantic Solar Products* is a compact 12-volt DC to 115-volt AC power supply. Measuring only 1.2- × 3.5- × 4.5-inches, and weighing just 14 ounces, it is completely portable and can be stowed in a tool box or glove compartment.

The unit is easy to use. By simply plugging it into a car cigarette lighter you have an AC-power supply and an AC source to recharge battery-powered devices. The Pocket Power Inverter can be used to power

audio and video equipment, data communications equipment such as fax and answering machines, electronic test equipment, and small appliances.

It features automatic shutdown, in the event of overloading and excessive discharging of the battery, and an audible low-battery-voltage alarm. The unit has an input operating range from 10- to 15-volts DC with a voltage out of 115 amps, and 200-watt surge capability.

The Pocket Power Inverter has a suggested price of $149.95. For more information, contact Atlantic Solar Products, Inc., 9351-J Philadelphia Road, Baltimore, MD 21237.

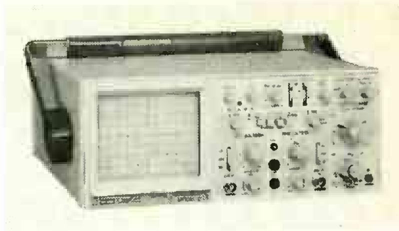
CIRCLE 79 ON FREE INFORMATION CARD

DUAL-TRACE OSCILLOSCOPE

B&K-Precision's Model 2125 is a 20-MHz dual-trace oscilloscope with delayed sweep and a built-in calibration source. The high-sensitivity unit (1-mV-per-division) features a built-in component tester for capacitors, inductors, diodes, transistors, and zener diodes.

The scope's delayed sweep covers from 0.1 microsecond-per-division to 50 milliseconds-per-division in 18 steps, permitting waveform expansion for close review of short-duration pulses and high-frequency waveforms. A 10 × sweep magnifier is also featured; hold-off is continuously variable for main sweep up to 10 times normal.

Other features include alt, chop, or add



modes of dual-trace operation; and selectable auto or normal triggered-sweep operation with input coupling for AC, TVH, TVV, and line operation. X-Y operation and a Z-axis input are offered for phase comparison, special applications, or interconnection to external component testers. Signals are displayed on a bright CRT with P31 phosphor. Trace rotation is accessible by a front-panel control.

Designed for bench or field-service use, the Model 2125 comes with a rugged metal case with soft handle. Also included with the unit are two 10:1 probes, instruction manual, schematic diagram, and parts list.

The Model 2125 dual-trace oscilloscope costs $620.00. For additional information, contact B&K-Precision, Division of Maxtec International Corp., 6470 West Cortland St., Chicago, IL 60635. ■

CIRCLE 80 ON FREE INFORMATION CARD

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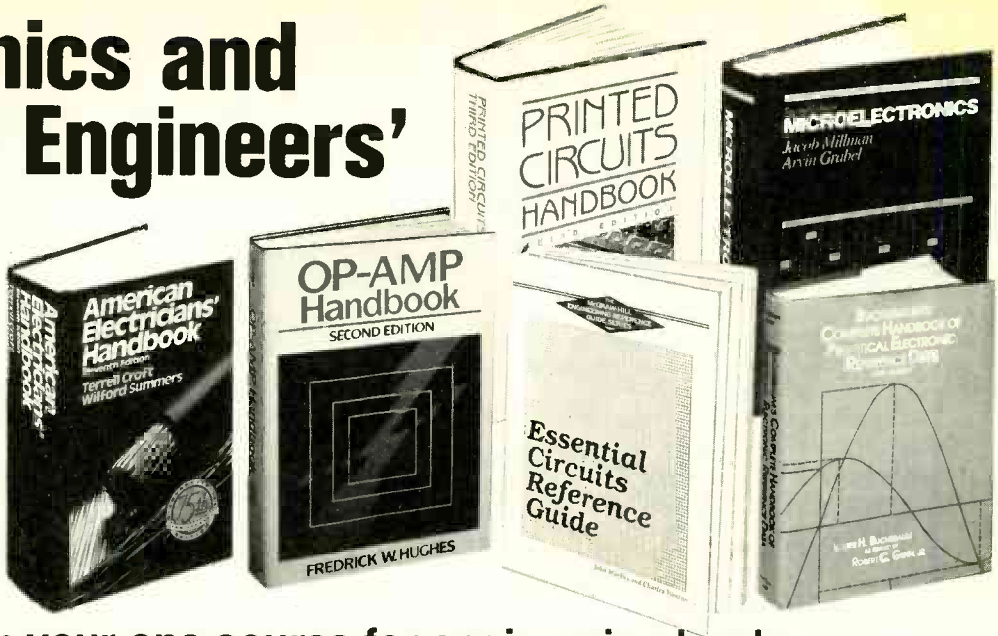

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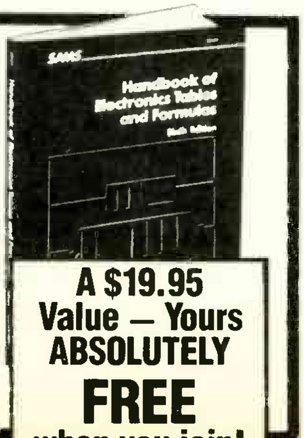

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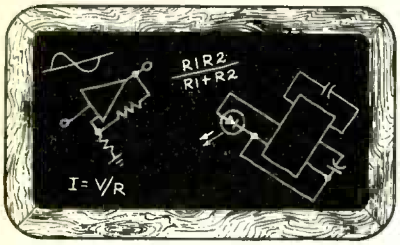

Think Tank

By Byron G. Wels

AND THE MAIL COMES IN...

Hey! Did you hear about the technician that kept a spool of solder in the refrigerator for making cold-solder joints?

But seriously, now....That's a joke, but it makes an interesting point. Those of us who are serious about our hobby come in varying levels of knowledge. Some of us are at the engineering level, others are raw beginners. That makes the selection of projects a difficult problem. For example, I consider myself to be a fairly-advanced experimenter, having been deeply involved in the hobby for well over thirty or more years.

So, I must resist the temptation to use only those projects that I consider challenging. I have to keep in mind the youngster that's just breaking in. Make things too difficult for him, and you'll lose his interest—and eventually him—forever. On the other hand, make things too simple, and the advanced hobbyist is gone. So we try to provide a good mix of circuits that, hopefully, contain something for everyone.

I remember when I worked as electronics editor for *Popular Mechanics*. In those days, the electric drill was not as commonplace as it is today, and when we took photos of a project, we were required to show a hand-operated drill (the eggbeater type) so the guy who didn't have an electric drill would not be put off!

Soldering still seems to be a bit of a problem for some of our readers. We all know that it's an integral part of the hobby, and if soldering gets in your way, we urge that you get into it as quickly as possible. But there's something about seeing metal melt and then reharden, that worries some of our new readers. Spend a bit of time practicing, and before long, you won't think twice about it.

Then you can stick a spool of solder in the refrigerator for making those cold-solder joints!

Lights-On Reminder. Sometimes, darkness sneaks up on you while you're driving. You're on the road, it gets dark slowly, and your eyes become accustomed to the lack of light. As a result, you're driving in deep twilight with your headlamps off. It's not until you see somebody coming toward you with their own lights on, or you recognize that the street lights have come on. Or some clown races past you and yells "headlights, stupid!"

All of that may result in a near (or real) accident.

This unit (see Fig. 1) sounds an audible alarm when the ambient light level falls below a certain point. One input of U1 is fed from a voltage divider (consisting of potentiometer R1) connected across the supply lines. If the light-dependent resistor is in pretty-bright light, it shows a low resistance, and low voltage is fed to the non-inverting input of U1. Integrated circuit U1's output goes low, and the output tone is silenced.

If the photocell is given a weaker light level, the voltage to the non-inverting input of U1 rises higher than that to its inverting input, and U1's output goes high. That triggers the alarm. Use R1 to set the light level at which you want the speaker to sound off.

Naturally, you'll have to mount the photocell where outside light can get at it. The left side of the windshield isn't a bad place.

Okay Byron, there's my effort. I sure hope it gets me a free copy of the Fips book! —*Earl Trent, Oklahoma City, OK.*

It sure does Earl! Look for it in the mail, it went out today. The only thing I might add by way of improvement, is an SPST switch to cut the whole thing off. Remember to wire this to the cool side of your ignition switch, too. You don't want the alarm coming on when the car is parked in the garage!

Practice Amp. Have you got a youngster at home that's working with a "group?" Well it seems to *me* that some of those "groups" are nothing more or less than four kids who devote every waking moment to seeing how much noise they can make at the same time. One of them plays drums. It takes a van and two helpers to carry his assortment of drums into the house. Another plays bass, two others play guitars, and they all "sing" into mikes at the same time.

The amplifiers are something else. Those things are six feet tall, with speakers the same size. Window rattlers, you say?—I call them window *smashers!* The funniest part is that each time they finish a "song," they all say "that was *great!*"

My wife and I decided that group practice was bad enough, but our son would crank his amplifier and mike up to full volume to practice his part. We

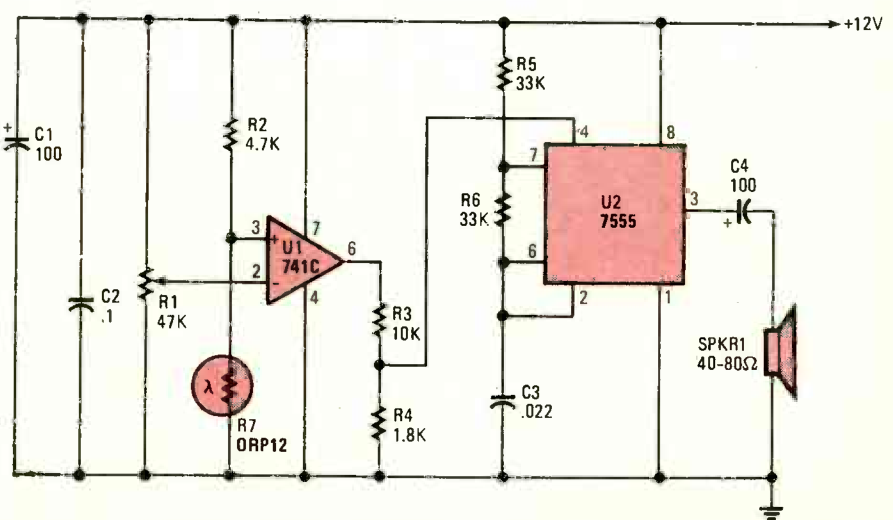

Fig. 1. The Lights-On Reminder sounds an audible alarm when the ambient light level falls below a certain point.

agreed that was a bit too much, and he could practice without the amplifier. (I mean how much can you take of "Whoa-whoa, baby!")

That's what brought me to design the *Practice Amp*. With an output of under two watts, it was sufficient for him to hear. And with his door closed, we could still hear the TV set in the living room.

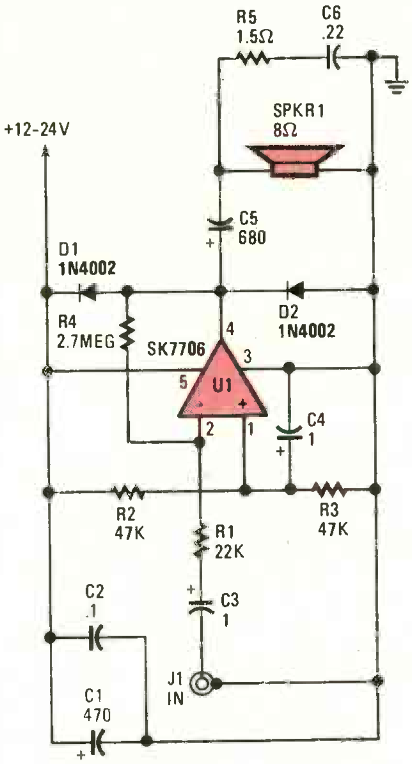

Fig. 2. The Practice Amp has a power output of under two watts.

Check Fig. 2. The first thing that will hit you is that there's no volume or tone control. No need for them, as they are built into the guitar. The circuit is nothing more than an SK7706 op-amp, configured as an inverting high-power class B output stage, whose non-inverting input is biased by R2 and R3. The inverting circuit is biased by R4. Resistors R1 and R4 form a negative-feedback network that sets the voltage gain and input impedance at a value equal to the resistance of R1.

Diodes D1 and D2 are used for protection and C4 is used to filter out hum. That lets you use a 12-volt plug-in type power supply; just be sure that the power supply that you use can deliver at least 250 mA. Make sure you use a fairly-large heatsink for the IC.

Well, there it is! I hope that earns me a copy of the Fips book. I've been hearing a lot about it recently and am dying to get my hands on one!—*Frank Settin, Alberqueque, NM.*

Sure does Frank. I sent it out just today! Incidentally, if you need more volume, you can increase the value of R4, but that may have an adverse effect on the signal-to-noise ratio. But, give it a try, anyway.

Signal Injector. I can remember when I was a kid. A radio-man once told my dad to keep the trolley wires bright, and keep dust off the transformer. So one Saturday each month, dad would take the back off our old radio and polish the bus connections with a small piece of steel wool. Then he'd polish the set's transformer. After that session, dad would turn on the radio, sit back, and say "sounds better, huh?"

Now that I'm into electronics myself, I realize that the guy was giving dad a job to do that would do no harm, and let him feel he was helping the radio!

The circuit (see Fig. 3) that I'm contributing is about the handiest thing I've found as an aid to tracing radio circuits. It's simple, inexpensive, and can be built in one evening.

To use it, you start at the speaker, if no tone is heard, you move back to the amplifier input, and listen for the tone. If no tone is heard, you continue back-tracking from the output to the input—covering all stages in between—and the stage where you lose the signal is the stage that is not operating.

The unit is a simple oscillator built around an LF351 JFET-input op-amp. Resistors R1 and R2 bias the non-inverting input while R3 biases the inverting input from the output. That provides 100% negative feedback, but the decoupling caused by C2 gives reduced feedback and high voltage gain when dealing with audio frequencies. The fundamental operating frequency is about 800 Hz.

Potentiometer R4 is the output-level control. The construction, as I said, is simple. There's nothing critical here, and it works very well. —*Barney Creighton, Los Angeles, CA.*

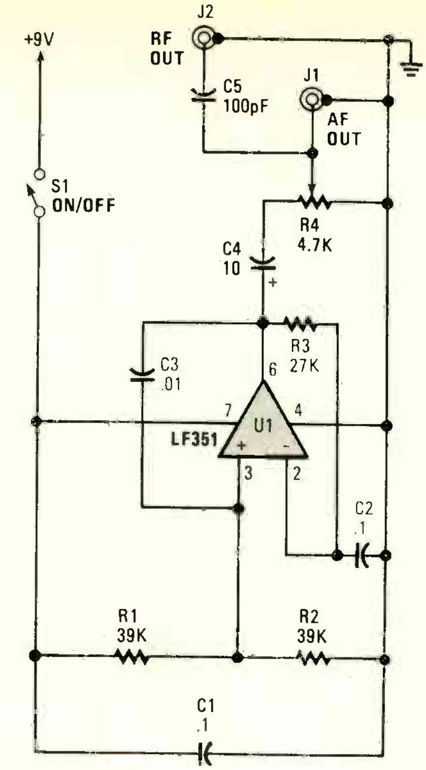

Fig. 3. The Signal Injector is comprised of a simple oscillator circuit (built around an LF351 JFET-input op-amp), with 100% negative feedback.

Barney you neglected to mention that capacitor C3 provides positive feedback for the circuit, and because of the powerful oscillation at a square-wave output, it also helps contain the necessary high-frequency harmonics! This is the kind of thing our readers want to see. I'm sending out your copy of the Fips book today. Hope you enjoy it!

Coin Flipper. Byron, I'm sure you've had rainy days, cranky kids, and nothing on TV for them to watch. They started to get cranky, and I heard complaints like "At least dad has his workshop in the basement. We've got nothing to do!" Well I didn't remember anything in my marriage vows about having to entertain the kids, but I got to work and built this *Coin Flipper*, which seems to keep them occupied, even when there *is* something to watch on TV!

See Figure 4. The Coin Flipper is basically a 555 astable circuit that drives two LED's, LED1 and LED2. LED2 is switched on when the output of U1 is high, and LED1 is activated when its output is low. When U1 oscillates, LED1

THINK TANK

and LED2 switch on alternately as the output of U1 switches from state to state. Resistor R1's value is high in comparison to R2, so the waveform at the output is a squarewave with a mark/space ratio of nearly one-to-one. You can't see that, because the oscillating frequency is too high to observe.

Naturally, U1 can oscillate only when S1 is closed. That's because the charge and discharge paths of C2 would be interrupted. When you release S1, you break the circuit and U1 latches whatever the output state happens to be at the time.

Build the unit into a little black box with the on/off switch, the momentary contact switch and the two LED's on the cover. Mark one LED "heads" and the other "tails" and you can settle back to read a copy of the Fips book without being disturbed. The only problem is that I don't have a copy!—*Bruce Haley, Sioux Falls, SD.*

Oh yes you do, Bruce. Or at least you will have by the time this appears in print! Why? Because you did exactly what this column is really all about. You've taken an existing, standard type of circuit, given it a twist and a shake, and come up with something entirely new. I'm sure at least one of our readers will re-adapt your circuit to a completely new aplication, too.

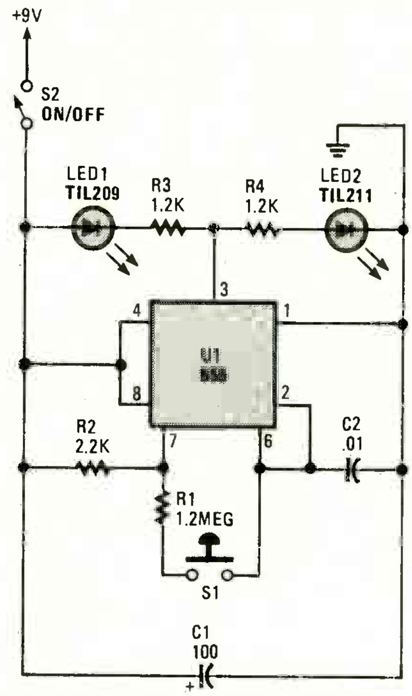

Fig. 4. The Coin Flipper is basically a 555 astable circuit that is used to drive LED1 and LED2.

Switch-Off Timer. By, my wife has to have music while she falls asleep, and turns the transistor radio on next to the bed. Well, if you stop to consider that the radio plays all night long, and she only listens to it for five minutes or so until nighty-night time, a lot of nine-volt batteries are being wasted. I came up with this circuit that adds a sort-of sleep alarm. She turns on the radio, goes to sleep, and ten minutes later, the radio shuts off.

See Fig. 5. The circuit is built around a 4001 quad 2-input NOR gate. Only two of the gates are used in the circuit. The inputs of the other two gates are tied to the ground bus (to prevent spurious operation) and the unused outputs are ignored. The two functioning gates are

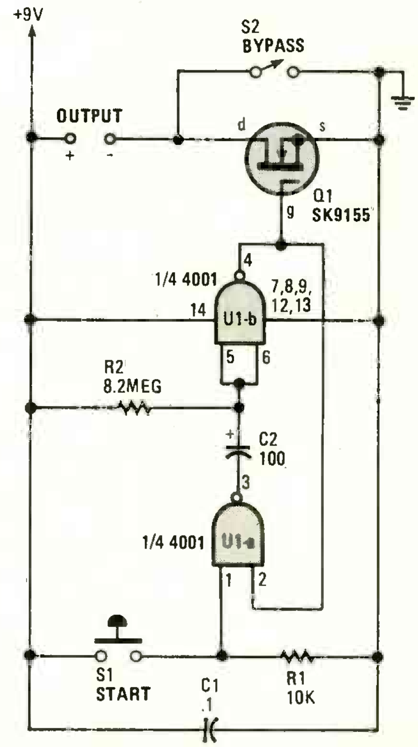

Fig. 5. This simple timer circuit is designed to shut down any device that is connected to it after a pre-set interval.

connected as a monostable multivibrator whose output pulse-width is about 600 seconds, as set by C2 and R2.

Normally, the output of the multivibrator is low, and the N-channel VMOS transistor, Q1, is cut off. That provides no negative supply to the output, and the radio is switched off. If S1 is momentarily pressed, a trigger is applied to U1-a causing power to be applied to the receiver. After the output pulse ends, the multivibrator returns to its low state, switching off the radio.

Switch S2 enables the timer to be bypassed so you can use the receiver normally. No on/off switch is needed because in standby, no significant current is consumed.

Capacitor C2 must have a low leakage current and the high value needed almost calls for a tantalum unit. Just watch your polarity! —*Maxwell Crain, Los Alamos, NM.*

Good job Max! Readers, be sure about the polarity of the added battery clip. It will actually have to be wired in reverse in order to have the correct polarity, and then it's just a matter of connecting your clip (backwards) to the receiver's clip. We're rewarding your effort with a copy of the Fips book! Thanks for sharing!

Telephone Bill Reducer. When you're on the phone with somebody, it's easy to lose track of time. You get into a conversation, and it isn't until you get the bill that you realize how long-winded you were. The unit described here (see Fig. 6) doesn't automatically hang up after a time, it simply emits audible clicks on a timed basis. That makes you aware that the taximeter is running, and you'd be amazed at how it helps curtail unimportant phone conversations!

As the schematic diagram shows, the circuit is nothing more than a 7555 oscillator/timer configured for astable operation. I used a 7555 because it reduces current consumption. Diode D1 serves as a steering diode that provides a brief charge time, which triggers U1 into the discharge mode and almost at once provides a "click" in the loudspeaker. When you make a call, and the party picks up the phone, press the on-off switch. You should hear an immediate click, to indicate that the unit is working. The clicks should repeat at regular intervals, depending on the setting of the rotary switch.

Capacitor C1 starts to discharge through whichever of the seven timing resistors has been switched into the circuit. No great degree of accuracy is needed, as this is not designed to be a charge calculator, but a relative indicator. Capacitor C1 has to be a high-quality unit, and a tantalum unit is ide-

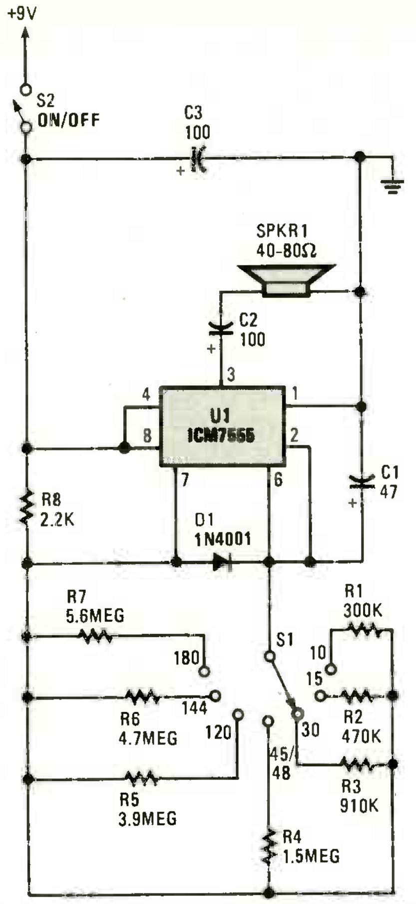

Fig. 6. The Telephone Bill Reducer is built around a 7555 CMOS oscillator/timer.

al. Okay, that's my story. Have you a story to tell me? —*George Appleton, Ames, IA.*

Got a good story to tell you George! Check the mail for your copy of the Fips Book! Readers, check your local telephone directory for toll charges, or call your telephone business office for the information. Then you can calibrate the rotary switch with some meaningful information.

One-Second Timer. If you're as much into photography as you are into electronics, this makes for a very-useful project. Turn the thing on, and the LED flashes at one-second intervals. I find it extremely handy for timing those "B" or "T" shots with the camera. And in the darkroom, it makes a super enlarger timer. I built mine into a small black box, so it's simple enough to carry along in the gadget bag, and there's always room for it in the darkroom.

See Fig. 7. The circuit uses an LF351 op-amp, biased by R1, R2, and R3, to behave like a form of Schmitt trigger. The output takes the low state when the input goes about ⅔ of a volt positive, and high if the voltage drops below ⅓ volt. That causes the output to go high at first. Capacitor C2 charges quickly to ⅔ volt by way of R4.

When the output drops low, C2 discharges through R4, sending the output high again, thereby producing continuous oscillation. Adjust R4 to provide a frequency of 1 Hz by calibrating the unit against a watch of known accuracy. Couple the output of U1 to an LED by way of a DC-blocking capacitor and current limiting resistor (R5) and the LED will be briefly pulsed on as the output goes positive.

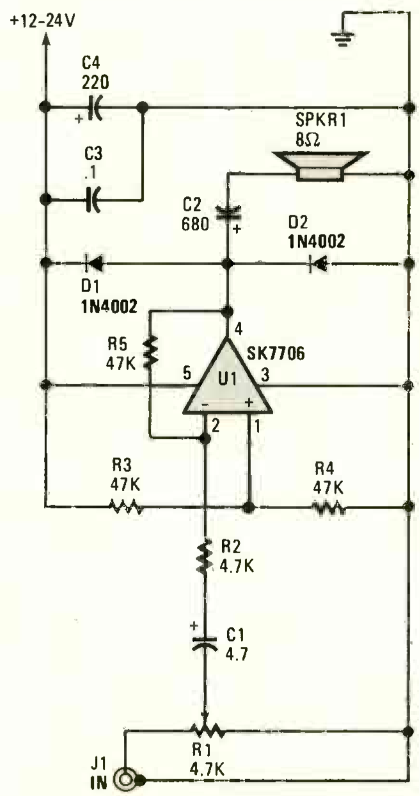

Fig. 7. One-Second Timer is built around an LF351 op-amp that biased (by R1, R2, and R3) to behave like a Schmitt trigger.

Diode D2 is there to make sure there is a charge and discharge path for C3 so that the output is properly coupled to LED1. The unit draws less than 2 mA. —*Sean O'Leary, Atlanta, GA.*

Okay Sean. I liked the idea of that diode D2 in the circuit. It shows great care and thoughtfulness on your part. When you're your own engineer, you've got to learn to cover all the bases. Chalk up one Fips book!

Cassette/Radio Booster. If you've ever wondered why even the most-expensive cassette or radios have such a pip-squeak sound, don't blame the unit. There's just so much that you can do with a speaker that would have been better-designed as an earphone. It seems you just can't have it both ways. Want a miniature, easily portable unit? Sure you do. But see how "miniature" you can make a 12-inch woofer!

The circuit shown in Fig. 8 uses the values of R2 and R5 to provide a voltage gain of 20 dB (10 times) and an input impedance of 4.7K. The input impedance is slightly shunted by R1. The layout isn't critical, and the circuit should really make a big difference.— *Manny Larsen, Madison, WI.*

If you require a lower input impedance, simply substitute a 15-ohm, 2-watt resistor across the amplifier input. You might have to operate the circuit with R1 at full volume, but you can compensate by dropping the volume level at the signal source.

We're rushing a copy of the Fips book out to you and hope you like reading it.

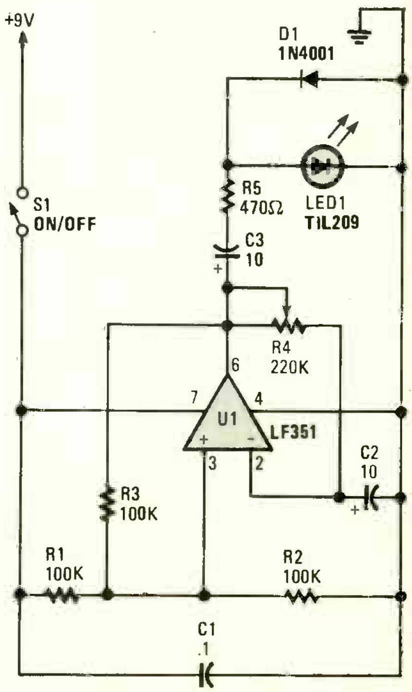

Fig. 8. The Cassette/Radio Booster provides a voltage gain of 20 dB (10 times) and has an input impedance of 4.7K.

Well, that's all the space they've given me for this month. Just barely enough left to tell you to send your circuits to *Think Tank*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735 ■

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MARCH 1989

EXECUTIVE'S DING-A-LING

By WALTER W. SCHOPP

Every busy executive needs this four-tone bell cube that allows him to compose music on his desk while making those monumental decisions.

Here is the ideal present for the executive who has everything. It is easy and inexpensive to build, and fun to play with. The *Executive Ding-A-Ling* (as it's been dubbed) will help a not-so-busy executive with a boring desk job through the day by keeping him occupied for hours. The gadget can provide a very tranquil experience. It's also very entertaining for children, but that may not be a tranquil experience for the parents.

The Executive Ding-A-Ling is a 3-½-inch cube that, when tilted in one direction, produces a bell tone. Tilt it in another direction and a different bell tone is produced. Tipping it in four different directions produces four different bell tones. Slowly roll the tipping axes in a circular motion and you'll hear church bells.

Tilt it in a prescribed pattern and you can play a simple tune. Roll it fast or shake it and you'll get a discord of bell sounds. Now what else could someone with a boring desk job need to help them get through the day?

How it Works. The schematic diagram for the Executive Ding-A-Ling is shown in Fig. 1. The circuit consists of four independent, adjustable tone generators (each of which is built around a 4007 dual complementary pair plus inverter) that are tuned to the four desired notes.

The notes are produced and diminished to make them sound like a bell. That is accomplished by applying the tone to an FET amplifier (within the 4007s), and slowly turning it off via a resistor/capacitor time constant. The time constant components for U1 are C5 and R7. Those components are duplicated in the other three tone generators, U2, U3, and U4. (All the generators are identical.)

The tones are created when the box is tilted, causing one of four normally-open, miniature mercury switches (which are mounted in four different directions) to close. The closing of a mercury switch applies a positive voltage to pin 3 of the IC to which it is connected.

The output of the activated generator (pin 4 of U1 to U4) is fed through a coupling capacitor to R5, and from

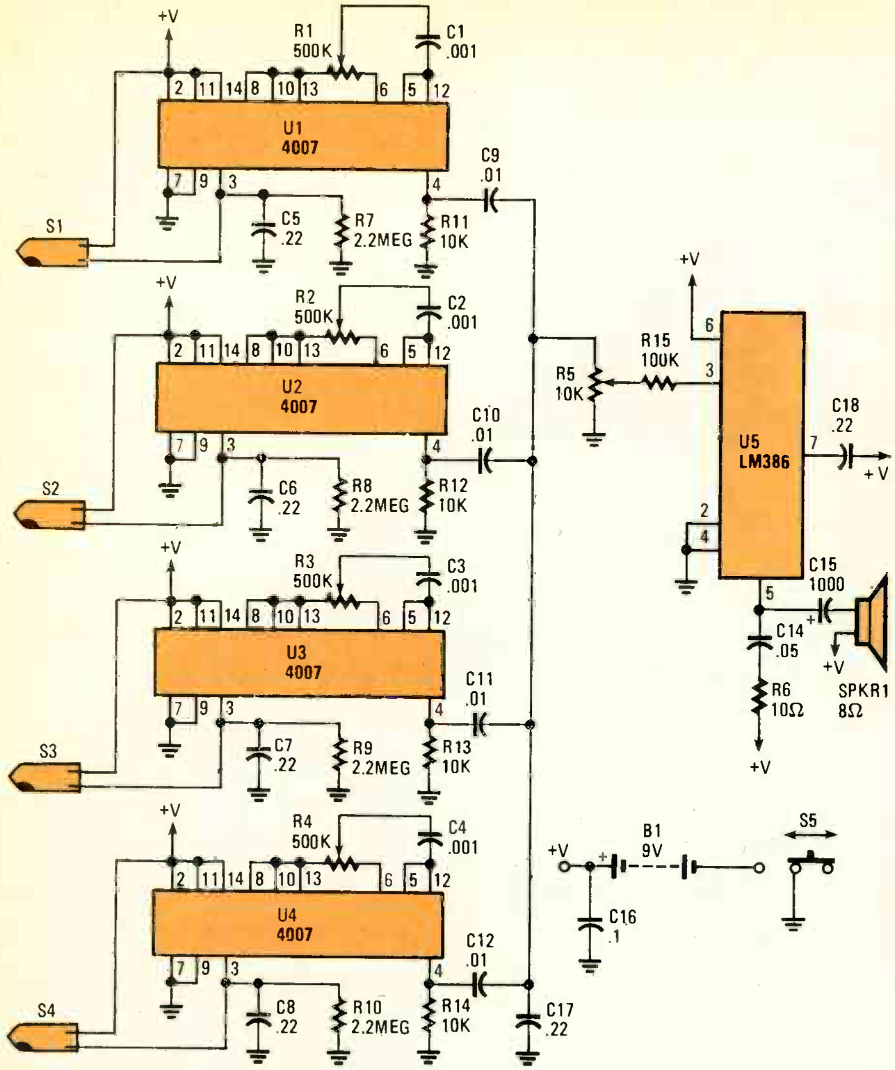
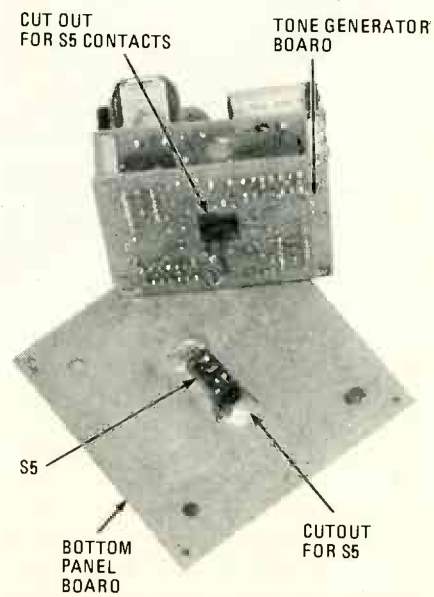


Fig. 1. The Executive Ding-A-Ling consists of four independent, adjustable tone generators (each built around a 4007 dual complementary pair plus inverter) that are tuned to the four desired musical notes.

the wiper of R5 to the input of U5 (an LM386 low-power audio amplifier). Amplifier U5, configured to provide a gain of about 20, then applies the amplified signal across SPKR1.

Construction. In order to get the complete project into a small package, the author built the Executive Ding-A-Ling on three different circuit boards; the tone generator board, the battery/amplifier board, and the speaker board. The finished boards were then stacked, using stand-offs to separate the boards.

Templates for the tone generator and battery/amplifier boards are shown in Figs. 2 and 3. Assemble the tone generator board, guided by the parts-placement diagram shown in Fig. 4. It is important to note that the miniature mercury switches must be mounted about ⅛ inch above the board's surface.



The bottom panel of the enclosure is made from a piece of printed-circuit material. A square hole is cut in its center to allow access to the control lever of S5 when the project is completed.

PARTS LIST FOR THE EXECUTIVE DING-A-LING

SEMICONDUCTORS

U1–U4—CD4007 dual complementary pair plus inverter, integrated circuit
U5—LM386 low-power audio amplifier, integrated circuit

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1–R4—500K ultraminiature PC-mount trimmer potentiometer (Circuit Specialist Cat. #32AA505)
R5—10K ultraminiature PC-mount trimmer potentiometer (Circuit Specialist Cat. #32AA401)
R6—10-ohms
R7–R10—2.2-megohm
R11–R14—10,000-ohm
R15—100,000-ohms

CAPACITORS

C1–C4—.001-µF ceramic disc
C5–C8, C17, C18—0.22-µF Tantalum
C9–C12—.01-µF, ceramic disc
C13—not used
C14—.05-µF, ceramic disc
C15—1000-µF, 16-WVDC radial-lead electrolytic
C16—0.1-µF, polyester

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor radio battery
S1–S4—Miniature mercury switch
S5—Miniature SPST switch
SPKR1—8-ohm speaker
Printed-circuit or perfboard materials, enclosure (see text), IC sockets (optional), battery snap connector, stand-offs, rubber feet, etc.

Note: The ultraminiature PC-mount trimmer potentiometers specified are available from Circuit Specialists, PO Box 3047, Scottsdale, AZ 85257; Tel. 800/528-1417.

A set of four miniature mercury switches, part #3004, is available for $10.00 (including shipping and handling) from Electronic Enterprises, 3305 Pestana Way, Livermore, CA 94550.

After soldering, the switches are tilted downward on an angle so that their tops touch the board surface. That keeps the mercury in the tip of the switch, so that its contacts are open when the board is level. Make sure the cases of the switches do not touch any other component. Once they are located, a drop of epoxy under the tip of each switch will hold it in place.

Miniature mercury switches are difficult to locate in electronic parts supply houses, but can be obtained from the supplier given in the Parts List. Upon completion, put the tone generator board to the side and assemble the

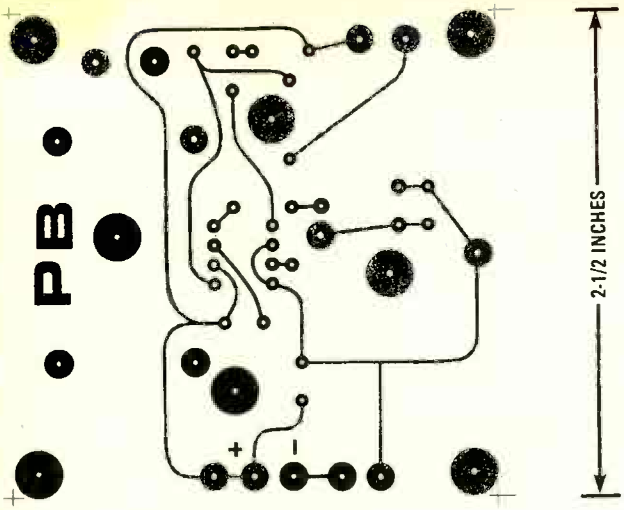


Fig. 2. Here is the printed-circuit pattern for the tone-generator board.

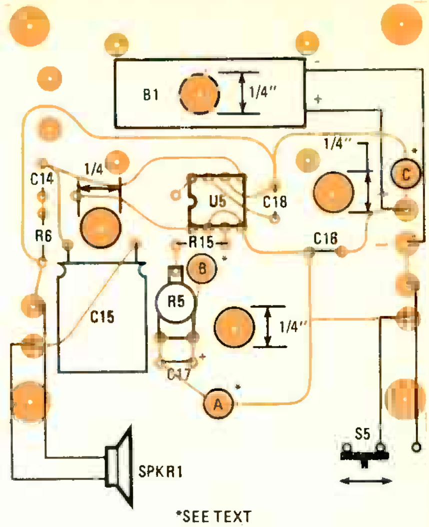


Fig. 5. Assemble the battery/amplifier board, using this layout diagram as a guide. Note the location of the battery, which is mounted on the board (located between four 1/4-inch donut pads as shown), and is held in place by a home-brew (wire) retaining system.

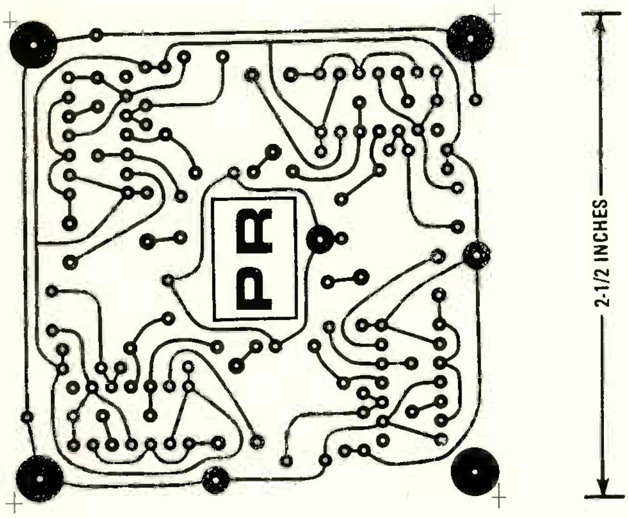


Fig. 3. Here is the printed-circuit pattern for the battery/amplifier board.

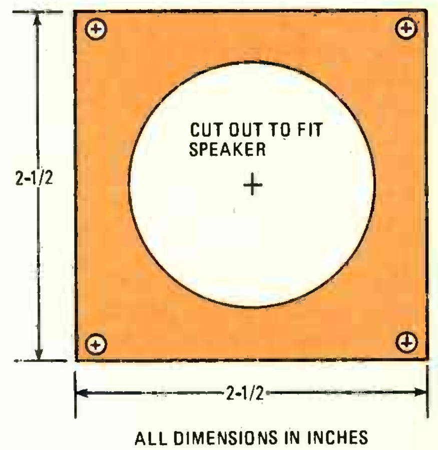


Fig. 6. Here is the layout for the speaker board—an unetched piece of printed-circuit material, with a hole cut in the center to cradle the speaker. Use epoxy or RTV cement to hold the speaker in place.

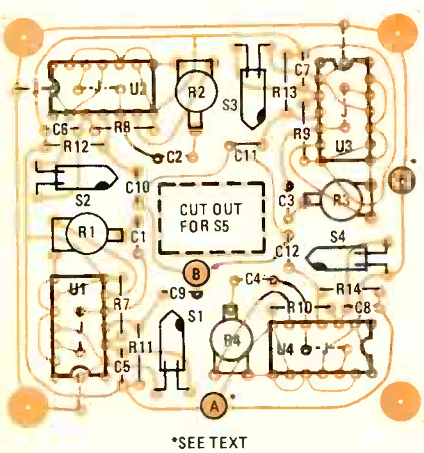


Fig. 4. Assemble the tone generator board, guided by this parts-placement diagram. It is important to note that the miniature mercury switches must be mounted about 1/8 inch above the board's surface.

battery/amplifier board, using Fig. 5 as a guide.

Note the location of the battery, B1, on the printed-circuit board. The battery is mounted on the board (located between four donut pads as shown), and held in place by a home-brew retaining system. The battery holder is nothing more than two short lengths of No. 14 wire wrapped around the battery and soldered to the board.

A small loop of solid No. 14 wire was also placed at the bottom end of the battery to keep it from sliding out the back end. When the holder is completed, the battery should be easy to replace by sliding it out of the formed wire loops. Next place and solder the circuit components on the board. When complete, lay the board on the side, and start to prepare the speaker board.

The speaker board is an unetched piece of printed-circuit material, with a hole cut in the center to cradle the speaker. The layout for the speaker board is shown in Fig. 6. The size of the hole is dependent on the size of the speaker. After placing the speaker in its cutout cradle, it is epoxied in place.

Next cut a piece of printed-circuit material to the dimensions shown in Fig. 7. That board will serve as the bottom panel of the enclosure. Note that a square hole is cut in the center of the board. That hole is to allow the control lever of S5 to be accessible when the project is completed.

Once the board has been prepared, place the slide switch on the copper side of the board with its control lever protruding through the hole provided, and solder it in place.

Connecting the Boards. In preparation for the final assembly, solder two 3-inch leads to the terminals of speaker SPKR1, and sideline it for a while. Solder a battery snap connector to the component side of battery/amplifier board. Next, solder cut-off pieces of

(Continued on page 102)

FLASHING BRAKE LIGHT

Everyone seems to have a third brake light on their car. Distinguish your's from the rest with this simple circuit that flashes the light for increased safety.

BY CHADWICK PRYSON

After considering the onslaught of after-market "add-on" devices available today, especially third brake lights, I chose to cut my odds of falling victim to a rear-end collision by making *The Flashing Brake Light*. It can be used with any existing 3rd brake light or in a new installation. If you've ever been in a traffic situation where you wished the guy (or gal) behind you would pay more attention to the laws of physics and stay further behind, then you'll be able to appreciate what this dandy circuit can do for you.

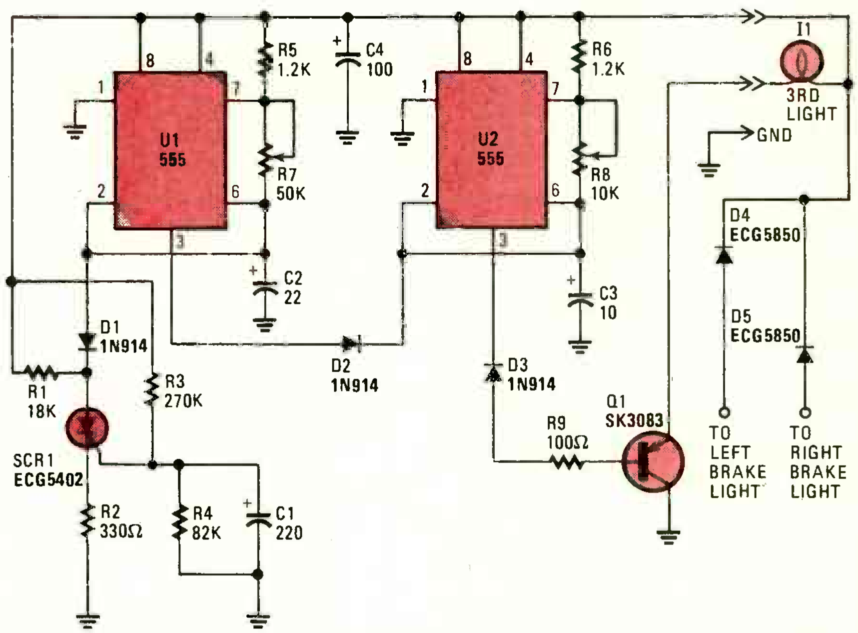


Fig. 1. The flasher consists of two timers with specially configured trigger connections. Integrated circuit U1 controls when and how long the flashing should take place. Integrated circuit U2 oscillates to control the flashing itself.

Putting On the Brakes. With the project installed, when you first brake, The Flashing Brake Light turns on the third brake light in the conventional fashion. After approximately one second, a series of short pulses strobe the light. The number of pulses ranges from about two or three to six or seven, depending on the circuit settings and when the brake pedal was last applied. The light resumes normal operation after the pulses cease. The initial delay makes the light less annoying in a bumper-to-bumper situation.

About the Circuit. If you take a glance at the schematic diagram for the project shown in Fig. 1, you will see a dual timer circuit using two 555 timers, both set up to operate in the astable mode. When power is first applied, three things happen: the light-driving transistor, Q1, is switched on due to a low output from U2, pin 3; timer U1 begins it's timing cycle, with the output (pin 3) going high, inhibiting U2's trigger (pin 2) via D2; and charge current begins to move through R3 and R4 to C1.

When U1's output goes low, the inhibiting bias on U2 pin 2 is removed, so U2 begins to oscillate, flashing the third light via Q1, at a rate determined by R8, R6, and C3. That oscillation continues until the gate-threshold voltage of SCR1 is reached, causing it to fire and pull U1's trigger (pin 2) low. With its trigger low, U1's output is forced high, disabling U2's triggering. With triggering inhibited, U2's output switches to a low state, which makes Q1 conduct, turning on I1 until the brakes are released. Of course, removing power from the circuit resets SCR1, but the RC network consisting of R4 and C1 will not discharge immediately and will trigger SCR1 earlier. So, frequent brake use means fewer flashes.

Bear in mind that the collector/emitter voltage drop across Q1, along with

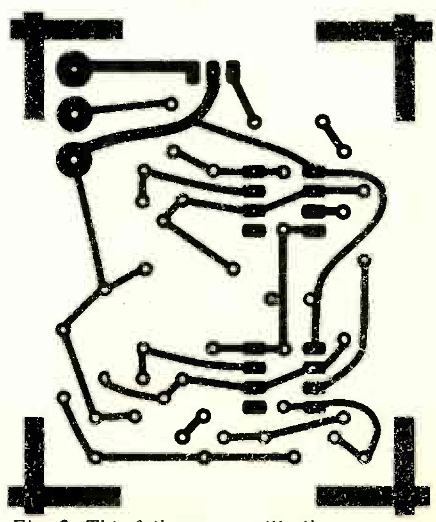


Fig. 2. This foil pattern will allow you to make a printed-circuit board of your own on which to mount the components.

the loss across the series-fed diodes, reduces the maximum available light output. If the electrical system is functioning properly (at 13 to 14 volts for most vehicles), those losses will be negligible.

Building it. Construction is straightforward. You can use either a perfboard or PC board to mount the parts. If you create a PC board using the foil pattern shown in Fig. 2, be sure to connect the jumpers that run underneath the ICs before installing the ICs themselves (see Fig. 3).

Since Q1 draws more than two amps

PARTS LIST FOR THE FLASHING BRAKE LIGHT

SEMICONDUCTORS
U1, U2—555 timer integrated circuit
SCR1—ECG5402 silicon controled rectifier
Q1—SK3083 PNP switching transistor
D1, D2, D3—1N914 rectifying diode
D4, D5—6-amp, 50-PIV, rectifying diode (ECG5850 or equivalent)

CAPACITORS
(All capacitors are 16-WVDC electrolytic units.)
C1—220-µF
C2—22-µF
C3—10-µF
C4—100-µF

RESISTORS
(All fixed resistors are ¼-watt, 5% units.)
R1—18,000-ohm
R2—330-ohm
R3—270,000-ohm
R4—82,000-ohm
R5, R6—1200-ohm
R7—50,000-ohm, trimmer potentiometer
R8—10,000-ohm, trimmer potentiometer
R9—100-ohm

ADDITIONAL PARTS AND MATERIALS
I1—12-volt, 2-amp, third brake light
Printed-circuit board or perfboard materials, metal cabinet, wire, etc.

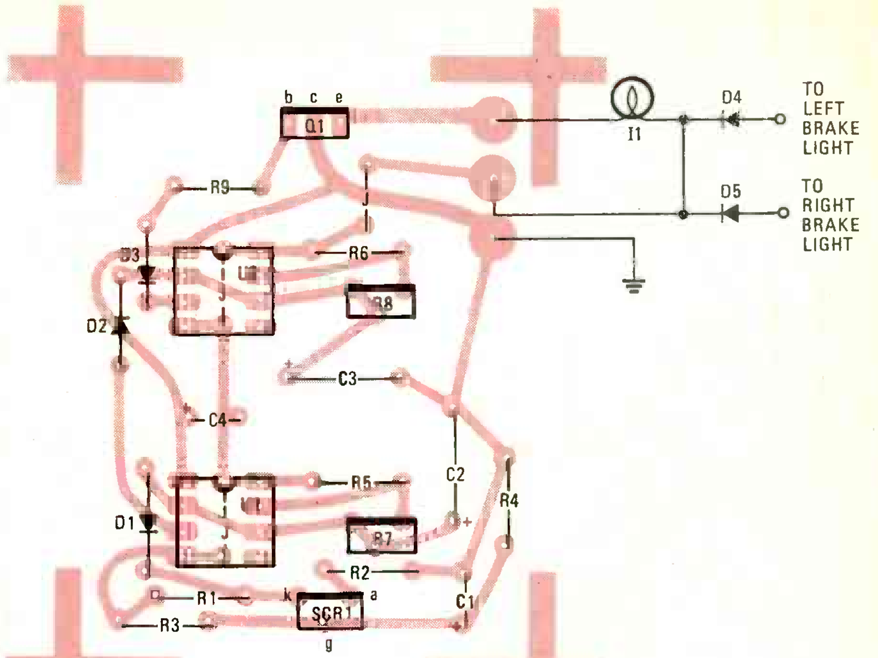
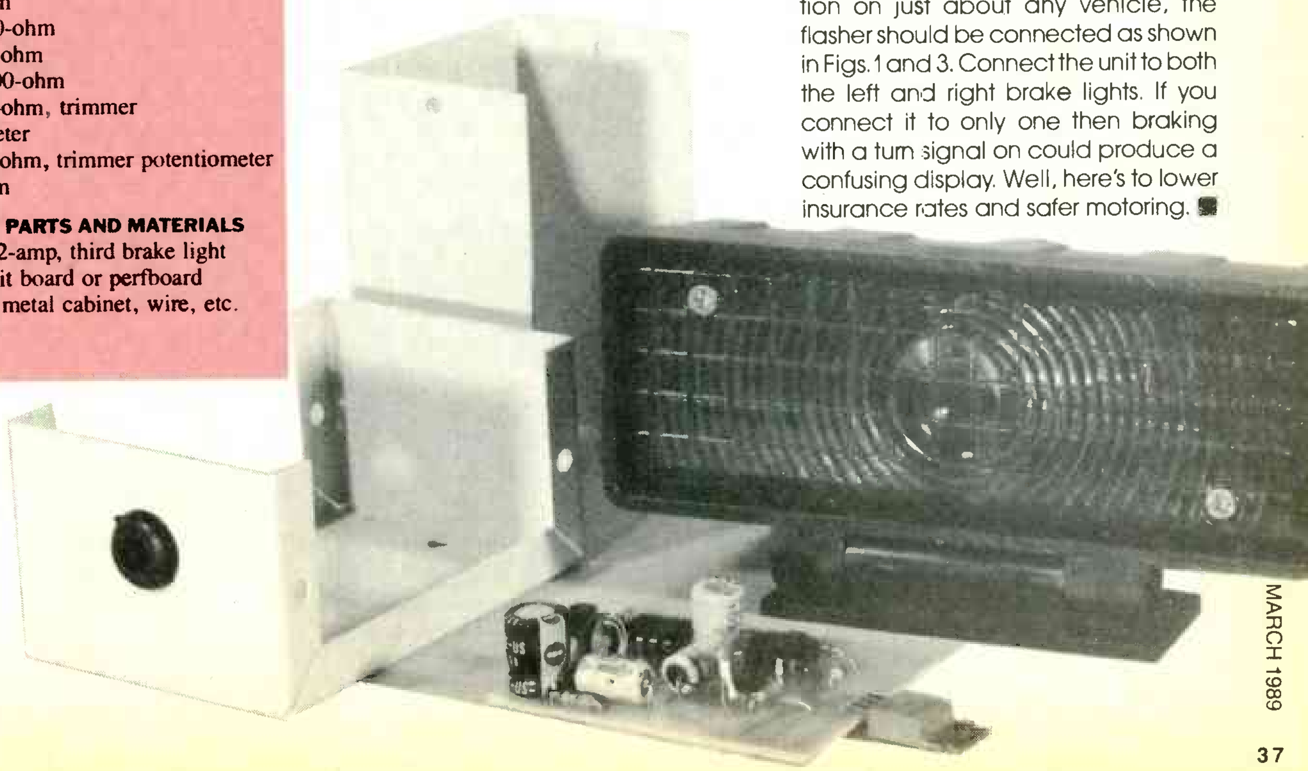


Fig. 3. You should use this parts-placement diagram as a guide for stuffing the parts on the PC board.

(the actual value depending on the lamp model), a metal box that will double as a heat sink should be used as the enclosure. No mounting kit is necessary to attach Q1 to the box since they are both at ground potential. A small piece of mylar film was used to insulate the PC-board from the enclosure in the prototype and some kind of insulation is recommended.

In incandescent bulbs, there is a time lag between the introduction of current and peak brightness. The lag is quite noticeable in an automotive bulb, so the duration of a squarewave driving such a bulb should be set long enough to permit full illumination. For that reason, and because lamps and automobile electrical systems vary, some adjustment of R7 and R8 will be necessary to arrive at the most effective pulse timing.

Hooking Up. To insure proper operation on just about any vehicle, the flasher should be connected as shown in Figs. 1 and 3. Connect the unit to both the left and right brake lights. If you connect it to only one then braking with a turn signal on could produce a confusing display. Well, here's to lower insurance rates and safer motoring. ■



Popular HANDS-ON REPORT Electronics

SENTRY SENH0648 STEREO HEADPHONES

CIRCLE 56 ON FREE INFORMATION CARD

Here's a pair of budget headphones that deliver top-shelf sound!

When a product appears on the marketplace with performance that exceeds that of similar higher-priced units, you have to wonder if its due to a breakthrough in technology or just marketing. Consumers are not too concerned with marketing chit chat, so if a product has a popular price, they view the purchase as "acquiring a product that gives much more for the dollar than expected." That is the case with *Sentry's* new *Model SENH0648 Digital Stereo Headphones Set.*

The First Test. The idea for this review came about one Saturday morning when a replacement of an existing headset was required for my mini-stereo system. Jogging had whipped my old braided and shielded cord into a frayed static generator. Each stride made—and broke—connections, making listening to FM music unbearable. The Sentry SENH0648 was purchased for $16.95 and put to good use during the following dawn's jog. Needless to say, the headset's performance was superior to its predecessor. However, the full extent of the headset's performance was not appreciated until the following evening.

I was given a choice of watching an idiotic TV game-show my wife enjoys, or listening to some music. I snapped on the headset and tuned in my favorite FM music-station to enjoy some relaxing contemporary music.

The ear pieces had a hefty feel yet the overall headset was practically weightless and fit comfortably. The expansion headband and rotating earpieces provided a comfortable fit. It was then that I realized that the sound from the headset was also *comfortable*. After the first hour of continuous listening, earlobe fatigue did not set in, as it usually does with inexpensive headsets. I searched for the plastic packaging the unit came in and found it. The manufacturer's ratings for the Sentry SENH0648 were listed as 20–20,000 Hz, with a sensitivity of −100 dB ±3 dB. Not bad specs, and the listening test agrees!

The headband on the Sentry SENH0648 was deliberately convoluted so that you could see the front and back of the earpieces at the same time. Notice the venting resonant ports on the outside surface and the foam cushion on the inside surface. The mini-plug on the headphone's 6-foot, extremely pliable cord is connected to the phone-plug adaptor supplied with the headphones. The left and right earpieces are identified "R" and "L."

The Acid Test. I disconnected the Sentry headphone set from the mini-stereo and plugged it into my quality hi-fi/stereo system. That was easy to do because Sentry supplied a solid, metal-jacketed phone-plug adapter for that purpose. Great sound came from the foam-cushioned ear pads!

I played a few Gilbert and Sullivan CD selections from *The Mikardo* and *The Pirates of Penzance*, which embrace the full dynamic range of music styles anyone would expect to reproduce on a headset: solos, choral groups, and orchestrations. "By Jove, this headset has it!"

The frequency response appeared to range from 20 to 20,000 Hz, and was as flat as the packaging claimed. The recorded passages were crisp and clean throughout the audible frequency range, with the bottom end warming to the mellow timbre of a timpani. The separation between voices and musical instruments was exceptional and without audio mid-range peaking. I attribute that virtue to the manufacturer's use of 40-mm ferrite drivers with an internal impedance of 32 ohms.

The Sentry Model SENH0648 Digital Stereo Headphone Set is inexpensive compared to units similar in appearance and sound that sell for $60 to $80 in audio outlets. Look for it; it's a peg-board item that will move fast. If you need help finding it, write to Sentry Industries, Inc., 252-C Lake Avenue, Yonkers, NY 10701 or circle No. 56 on the Free Information Card. ■

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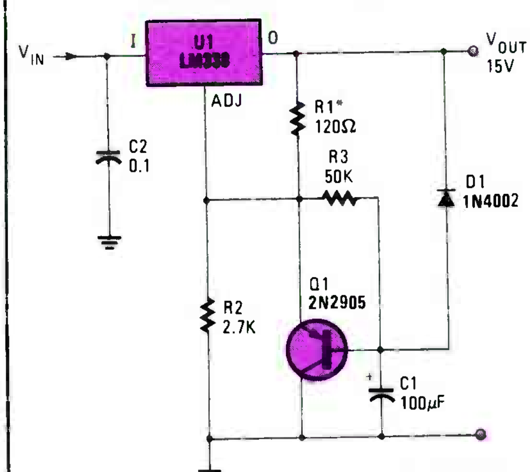
Popular Electronics

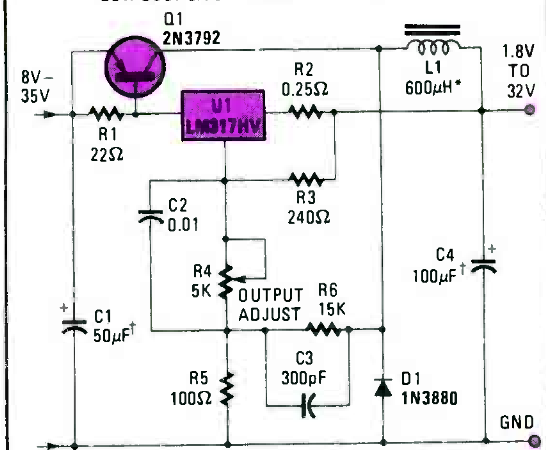
100 Popular Electronics FactCard — Regulator Applications

SLOW TURN-ON 15V REGULATOR



*R1 = 240Ω FOR LM138 AND LM238

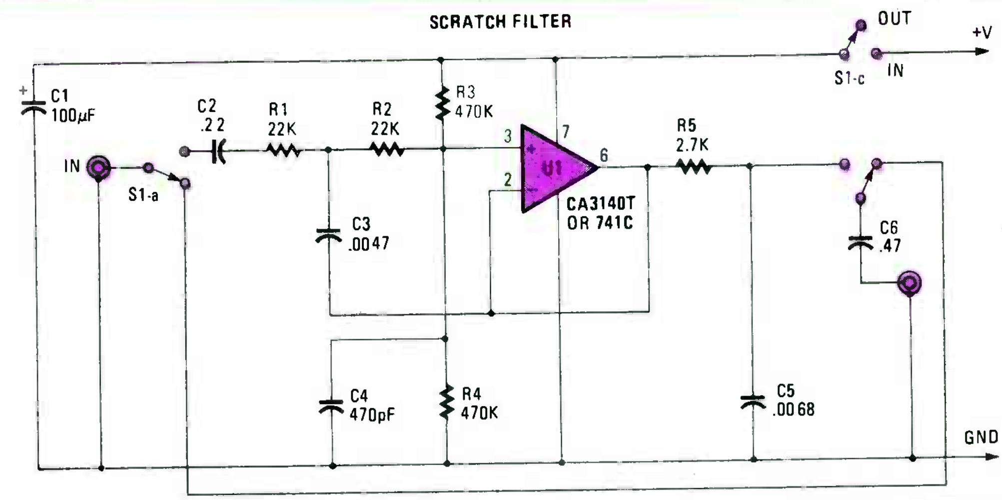
LOW COST 3A SWITCHING REGULATOR



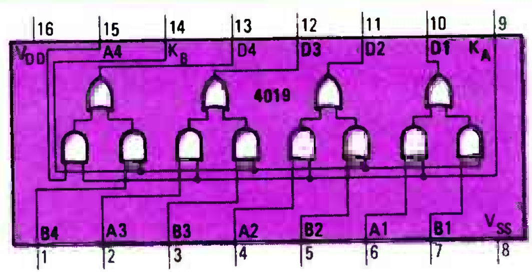
†SOLID TANTALUM
*CORE—ARNOLD A-254168-2 60 TURNS

101 Popular Electronics FactCard — Op-Amp Applications

SCRATCH FILTER



102 Popular Electronics FactCard — 4019: Quad AND-OR Select Gate



APPLICATIONS

- AND-OR select gating
- Shift-right/shift-left registers
- True/complement selection
- AND/OR/EXCLUSIVE-OR selection

ABSOLUTE MAXIMUM RATINGS

V_{DD} Supply Voltage	−0.5 to +18V
V_{IN} Input Voltage	−0.5 to V_{DD} +0.5V
T_S Storage Temperature Range	−65°C to +150°C
P_D Package Dissipation	500 mW
T_L Lead Temperature (Soldering, 10 seconds)	260°C

RECOMMENDED OPERATING CONDITIONS

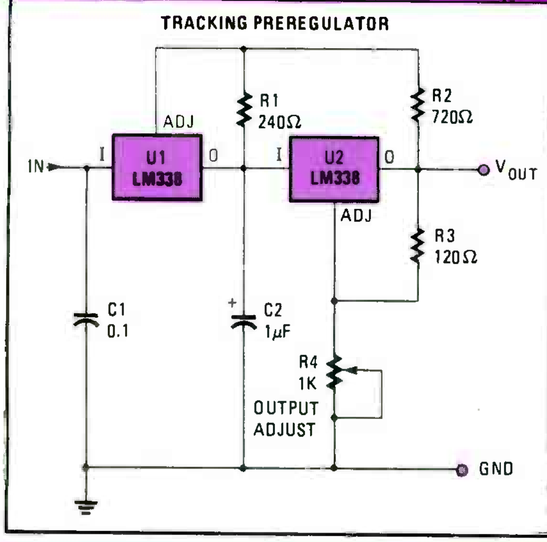
V_{DD} Supply Voltage	3 to 15V
V_{IN} Input Voltage	0 to V_{DD}V
T_A Operating Temperature Range	
CD4019BM	−55°C to +125°C
CD4019BC	−40°C to +85°C

FEATURES

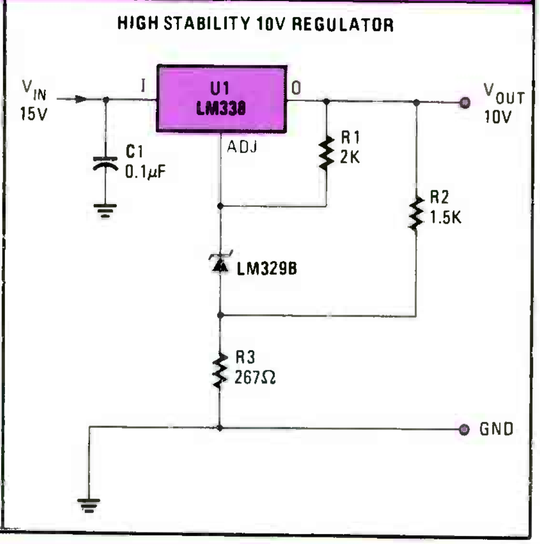
Wide supply voltage range	3V to 15V
High noise immunity	0.45 V_{DD} (typ.)
Low power TTL compatibility	fan out of 2 driving 74L or 1 driving 74LS

100 Popular Electronics FactCard — Regulator Applications

TRACKING PREREGULATOR



HIGH STABILITY 10V REGULATOR



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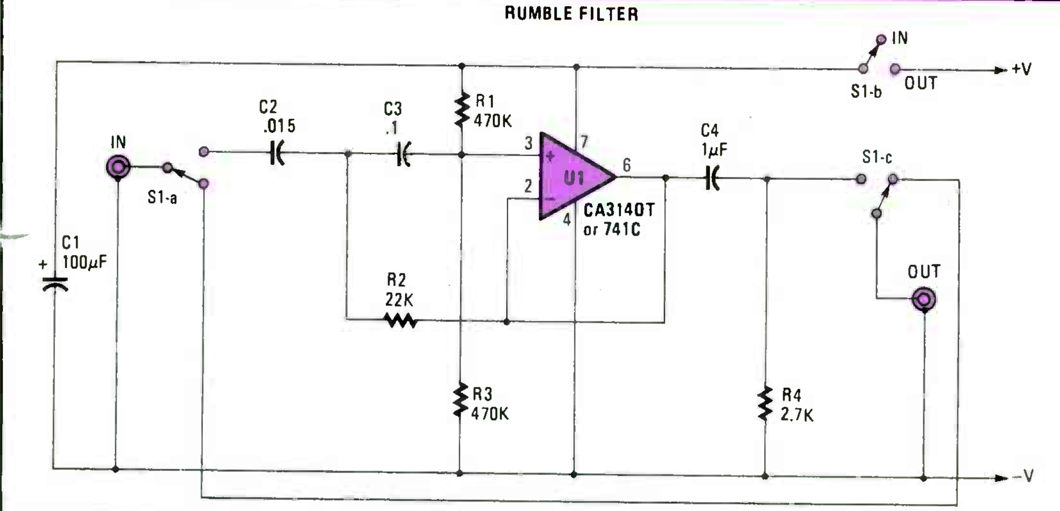
RUMBLE FILTER



102 Popular Electronics FactCard — 4019: Quad AND-OR Select Gate

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Quiescent	—	0,5	5	0.02	μA
Device	—	0,10	10	0.02	
Current,	—	0,15	15	0.02	
I_{DD} Max	—	0,20	20	0.04	
Output Low	0.4	0,5	5	1	mA
(Sink)	0.5	0,10	10	2.6	
Current	1.5	0,15	15	6.8	
I_{OL} Min.	4.6	0,5	5	−1	
Output High	2.5	0,5	5	−3.2	
(Source)	9.5	0,10	10	−2.6	
Current	13.5	0,15	15	−6.8	
I_{OH} Min.					

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Output Voltage	—	0,5	5	0	V
Low-Level	—	0,10	10	0	
V_{OL} Max.	—	0,15	15	0	
Output Voltage	—	0,5	5	5	
High-Level,	—	0,10	10	10	
V_{OH} Min.	—	0,15	15	15	
Input Low	0.5,4.5	—	5	—	V
Voltage,	1,9	—	10	—	
V_{IL} Max.	1.5,13.5	—	15	—	
Input High	0.5,4.5	—	5	—	
Voltage	1,9	—	10	—	
V_{IH} Min.	1.5,13.5	—	15	—	
Input Current I_{IN} Max.	—	0,18	18	$\pm 10^{-5}$	μA

BY JAN AXELSON AND JIM HUGHES

DIAL-UP RESISTANCE BOX FOR YOUR WORKBENCH

This easy-to-use resistance substitution box will simplify your electronics experimenting.

Whether you are an electronics prototyper or experimenter, you are bound to have had the unpleasant experience of having to wade through what seems like tons of resistors to find the one value that will make a circuit operate as it was designed to. And even if you haven't been faced with such a problem, you are probably aware of how time consuming and frustrating that sort of task can be.

For such a tedious task, many hobbyists and professionals (particularly those involved with product development) use a resistor substitution box. Such a device provides a convenient way to temporarily plug a resistance into a circuit, and test its operation without having to solder and unsolder components.

Our version of that circuit aid, the *Easy-Dial R-Box*, provides a wide range of resistances—adjustable in one-ohm steps—ready to plug into your circuits. Selecting a value is simple with the Easy-Dial R-Box: Six thumbwheel switches let you choose any value from 0 to 999,999 ohms. And, as an added benefit, the resistance value selected can be read directly from the thumbwheel's dial setting.

When might you use the R-Box? Perhaps you'd like to know what resistor value will give the exact output frequency you need in a 555 timer circuit. Or maybe, you are testing the effects of different feedback resistors in an op-amp circuit, or just finding the precise dropping-resistor value to use with an LED. Whatever the application, if it involves experimenting with resistors, chances are the R-Box can help.

About the Circuit. Figure 1 is the complete schematic diagram of the R-Box. The circuit contains six decimal thumbwheel switches connected in series. Each is a single-pole, 10-position switch. As you rotate the thumbwheel, the switch's COMMON terminal (C) connects in sequence to terminals 0 through 9, and numbers (printed on each wheel) rotate into a display window to let you know which position has been selected.

Inside the R-Box, nine equal-value resistors are connected between adjacent terminals on each switch. The result is that the resistance between each COMMON and 0 terminal is proportional to the number displayed on the thumbwheel.

The thumbwheel and all the resistors of the R-Box fit easily into an enclosure measuring 4 × 3 × 2 inches.

For example, if you set S1 to position 9, there are nine 1-ohm resistors in series between S1's COMMON and 0 terminals. Each time you rotate the thumbwheel back one position, a resistor "drops out" of the series, until at position 0 the resistance is 0 ohms (not including the natural resistance of the interconnecting wires and switches).

All six switches are wired in much the same manner. However, each successive group of resistors has a resistance value that is ten times that of those that precede. That is, for example, the resistors connected to switch S2 have a value that is ten times that of those connected to S1. Likewise, the resistors connected to S3 are ten times those that are connected to S2. In a similar manner, the total resistance available from each switch is ten times that of its predecessor.

The six switches are then connected in series, with the endpoints connecting to jacks J1 and J2 on the front of the R-Box. The total resistance of the R-Box—from J1 to J2—equals the sum of the six values selected by the thumbwheels. When the switches are snapped together, the resistance equals the six-digit number displayed.

R-Box Construction. Building the R-Box isn't difficult, but it does require a few hours of your time to insert and

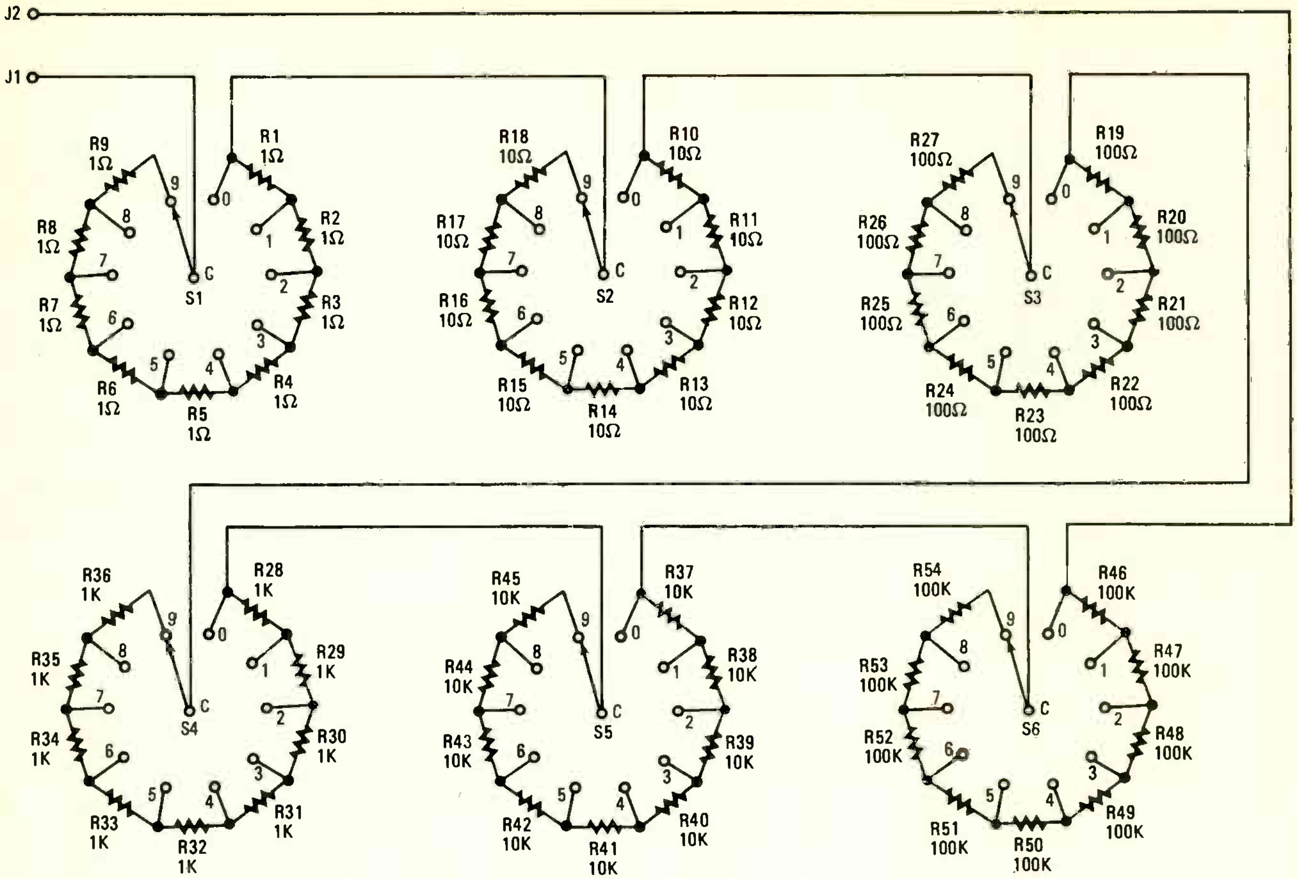


Fig. 1. The R-Box contains six decimal thumbwheel switches wired in series. The resistance between J1 and J2 can be adjusted in 1-ohm steps from 0-ohm to 999,999-ohm.

solder the 54 resistors used in the project. Half-watt resistors are preferred over quarter-watt units for greater power-handling capacity.

The series-connected switched-resistor strings are terminated in banana jacks, and housed in a suitable enclosure. (See photos for a look inside of the completed R-Box.) The front-panel mounted thumbwheel switches specified for the project snap together and are sandwiched between a pair of end plates, forming one easily installed unit.

The first step in the assembly of this project is to measure and cut a hole in the enclosure for the switches. A convenient way to accomplish that is to drill a ⅜-inch starter hole anywhere inside the planned opening, then use a nibbling tool (available from Radio Shack and elsewhere) to cut the rectangular opening required.

After making the opening, test it for proper size by inserting the switches and making any adjustments needed. Also drill two holes for J1 and J2.

When the enclosure is prepared, separate the six switches, cut seven 4-inch lengths of hookup wire, and strip ¼ inch of insulation from the ends of each. Connections to the switch terminals are made at the small printed circuit boards that are part of each switch. The circuit trace to each terminal includes two holes, making it easy to mount the resistors.

Begin with S1. Feed the end of one of the prepared lengths of wires through a hole (the one closest to the outside edge of the board) at terminal 0, and solder the wire to the circuit trace. Leave the other end of the wire free for now.

Feed the legs of R1 through holes at terminals 0 and 1 on S1. (Use Figure 1 as a wiring guide.) Solder the leads in place and clip off any excess wire. Then insert and solder R2–R9. Wire the other five switches in the same way, using the appropriate resistor values for each.

When all six switches are prepared, you're ready to link them together. Solder the free end of the wire at terminal 0 of S1 to the COMMON terminal of S2. In the same way, connect S2 to S3, S3 to S4, and so on, using the wires soldered to terminal 0 on each.

Solder the final length of prepared wire to COMMON on S1. The other end of that wire, and the remaining unconnected wire (at terminal 0 on S6), will each be soldered to a jack after the switches are installed.

PARTS LIST FOR THE EASY-DIAL R-BOX

(All resistors are ½-watt, 5% units, unless otherwise noted.)

R1–R9—1-ohm
R10–R18—10-ohm
R19–R27—100-ohm
R28–R36—1000-ohm
R37–R45—10,000-ohm
R46–R54—100,000-ohm
J1, J2—Insulated banana jack (or binding posts)
S1–S6—Decimal thumbwheel switches (Jameco #MX85)
Printed-circuit or perfboard materials, enclosure (Jameco #B2741 or equivalent), thumbwheel-switch endplates (Jameco MXEP1), wire, solder, hardware, etc.

Note: All parts available from Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002; Tel. 415/592-8097.

Checkout. This is a good time to check out the R-Box for proper operation. Clip your ohmmeter to the COMMON terminal of S1 and terminal 0 of S6. Then dial in and measure the resistance at the established setting. Be sure to test

(Continued on page 103)

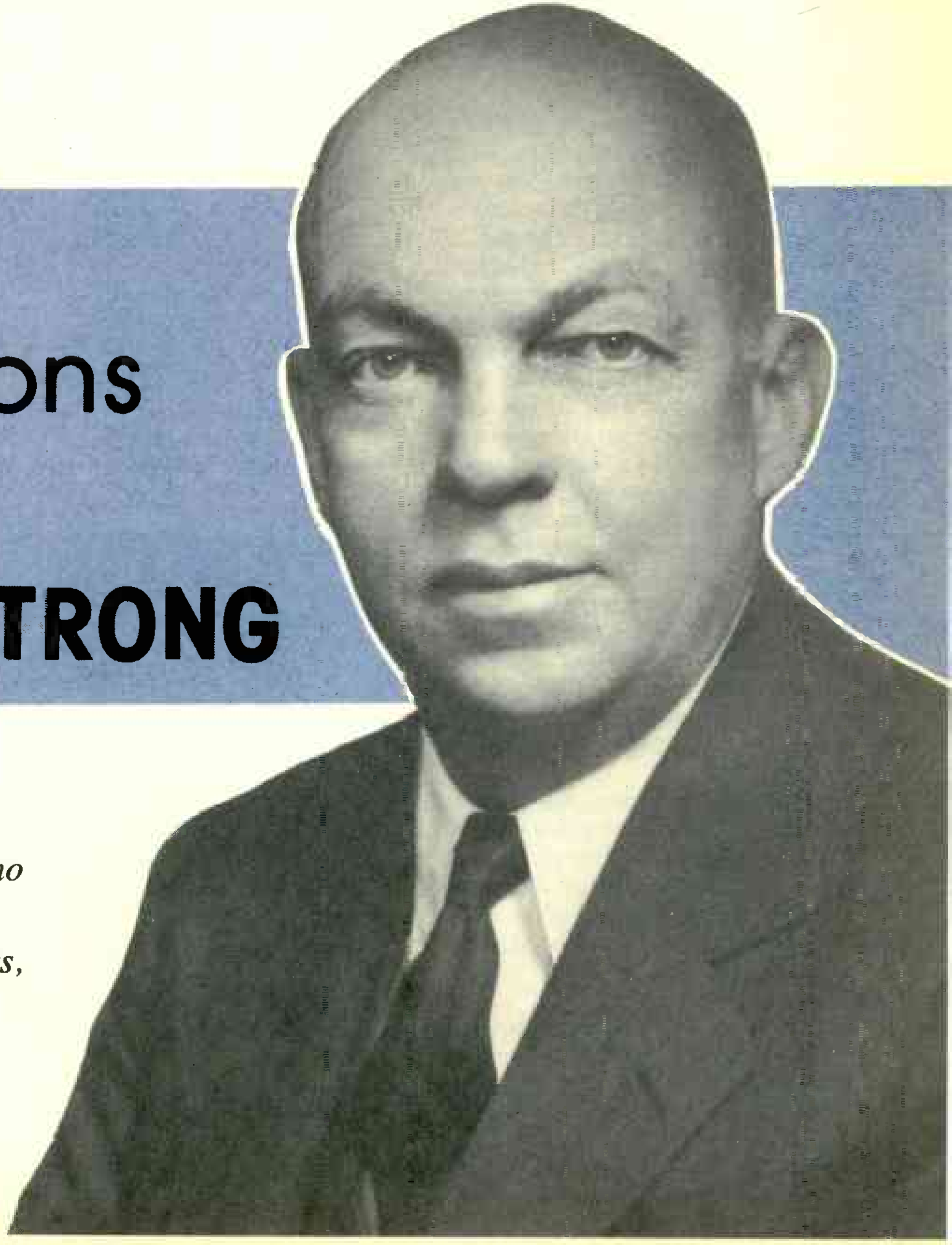
Hard to believe as it may be, one man alone invented the regenerative, superheterodyne, and superregenerative receivers, as well as the first tube-type transmitter and FM-radio broadcasting. And yet, most men of history change our world on a grand scale, making their mark in the world more than once. But unlike many of those men, Howard E. Armstrong's historic life ended in tragedy.

He was born in New York City on December 18, 1890, into a comfortable middle-income family. The family moved to Yonkers, New York, and it was there that Armstrong did much of his early radio experimenting in the attic. (The house has since been declared a historical landmark.) He decided to become an inventor and began to experiment with radio at age 14 when he read about Marconi's wireless bridging the Atlantic.

Much was happening in radio at that time. By 1906, Dunwoody and Pickard had invented the crystal detector; thus, the crystal set was born. The following year, de Forest invented the triode vacuum tube, which he called the *audion*. Up until that time, none of the radio receivers had any amplification; they merely detected the radio signal coming from the antenna and sent it to the headphones for listening. The audion did provide a small amount of amplification, but it was not really much of an improvement over the basic crystal set. Receiver voltage gains of 1,000 or more were, as yet, unheard of. With only weak and insensitive receivers to work with, one needed very powerful and expensive transmitters to communicate over long distances.

Obviously, if one could greatly improve the sensitivity of receivers, it would allow broadcasters to save a lot of money by permitting them to use lower powered transmitters. So Armstrong searched for ways to improve reception. During those early years, he built kites seven-feet tall to hoist his antenna wire, and he even

The Inventions of E.H. ARMSTRONG



Learn about a man of vision who invented three of the most sensitive types of radio receivers, the vacuum-tube oscillator, and FM radio.

BY COURTNEY HALL

built a wooden antenna tower in his yard that was 125-feet high. Armstrong graduated from Yonkers High School in 1909, and enrolled in Columbia University in New York City to study electrical engineering.

The Regenerative Receiver. In due time, Armstrong's never-give-up attitude bore fruit. During the first semester of his senior year at Columbia, in the fall of 1912, he invented the regenerative detector using the triode audion vacuum tube (see Fig. 1). By feeding back some of the detector's output signal to the detector's input to boost the input, the regenerative detector could be made to amplify the feeble voltage from the antenna by factors of several thousand. The amount of feedback had to be controllable, though, and the feedback control was often called the "regeneration control."

If the feedback was increased far enough, the detector would begin to oscillate, thus generating a signal of its own. That meant that for voice or music reception, the feedback needed to be very carefully adjusted to just below the point where oscillation began for greatest sensitivity. For detecting continuous wave (CW) signals in Morse Code, however, the receiver was outstanding. Not only did the detector produce impressive amplification, its tuning became very selective as feedback was increased toward the critical point of oscillation, and it could reject unwanted signals much better than other detectors of that time. On the downside, the tuning and feedback controls interact, so both had to be adjusted to maintain sensitivity when tuning across a frequency range. Also, feedback adjustment was critical when searching for very weak signals.

Since the regenerative detector was also a vacuum-tube oscillator when the feedback was increased far enough, then the inventor of the regenerative detector must of necessity also be the inventor of the vacuum-tube oscillator.

The Superheterodyne Receiver. After graduation, Armstrong stayed on at Columbia until the United States became involved in World War I. He was then appointed a Captain in the Army Signal Corps in 1917, and after brief military training, he embarked for Paris, France. There, he upgraded the army's radio-communication equipment and worked on the development of a sensitive receiver for high frequencies to intercept German radio signals. Armstrong used an oscillator and a mixer, as shown in Fig. 2, to convert the high RF frequencies to a lower frequency, called the intermediate frequency (IF), so that vacuum tubes available to the Allies could amplify the signal with ease before it was fed to the detector.

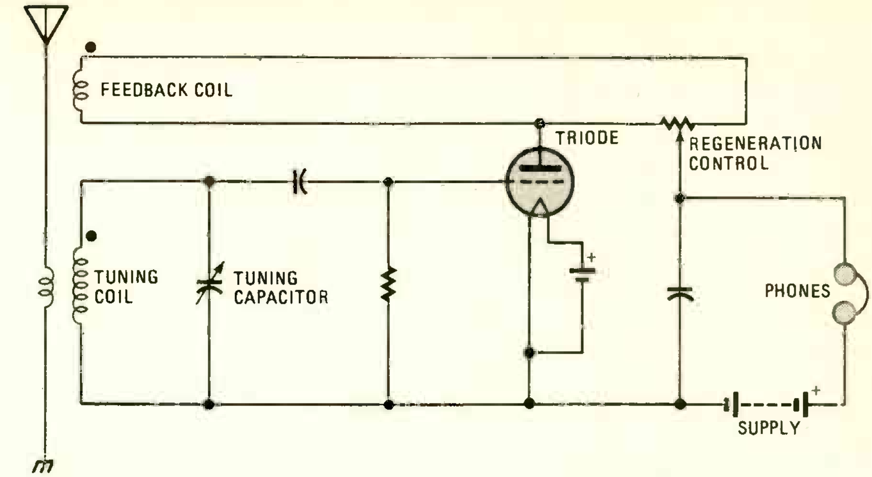


Fig. 1. Invented by Armstrong in 1912, the regenerative receiver coupled some of the plate current back to the tuning coil, which increased the amplification and selectivity far beyond anything available in other receivers of that time. When the regeneration control was increased far enough, the circuit became the first vacuum-tube RF oscillator.

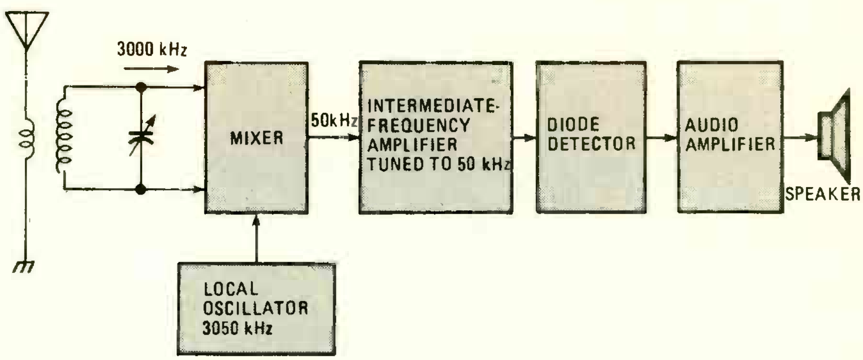


Fig. 2. Armstrong invented this receiver in 1918 to intercept German high-frequency radio communications. The mixer output frequency is the difference between the signal frequency from the antenna (3000 kHz) and the local oscillator frequency (3050 kHz). The 50-kHz signal is then amplified and sent to the detector for demodulation.


The high power broadcast antennas that dot our landscape may not ever have been hoisted if it weren't for Armstrong.

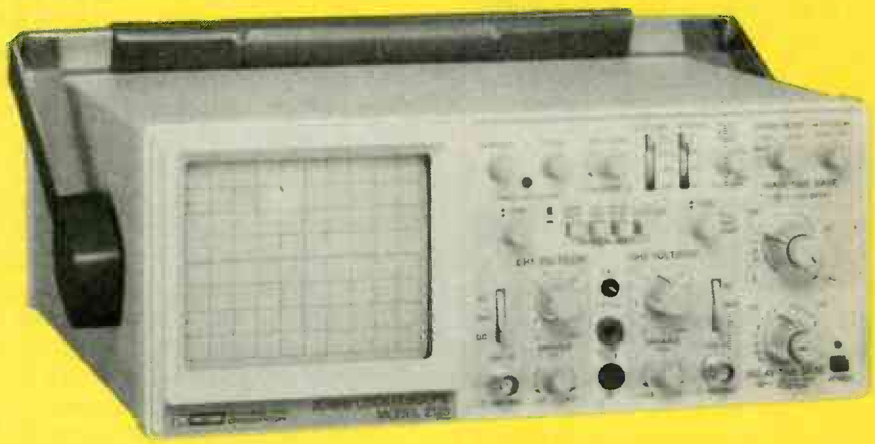
He got the receiving system working in 1918 and named it the *superheterodyne receiver.* Since the amplification and selectivity of the superheterodyne are determined to a great extent by the IF amplifier, the receiver has about the same gain and bandwidth, regardless of what frequency the mixer and local oscillator are tuned to. Unlike the regenerative receiver, there is no critical feedback control to adjust. In February 1919, Armstrong was promoted to the rank of major, and in September he went home to Yonkers.

Armstrong became a wealthy man

(Continued on page 105)

Choosing and Using an OSCILLOSCOPE

BY JOSEPH J. CARR



Get all the facts on the most useful device to hobbyists since fingers

When we last left you, we were in the midst of our discussion of the vertical oscilloscope controls. We will continue that now, look at the rest of the controls, and then show you how to get the most from your oscilloscope.

Ground—The ground jack is connected to the chassis ground at the input of the vertical amplifiers. It can be used to provide a universal (star) ground in order to eliminate (or prevent) ground-loop errors.

5× Mag—The 5× MAGNIFICATION control increases the sensitivity by five times, which means that all of the volts/div and millivolts/div calibrations must be divided by five. For example, when the VOLTS/DIV knob is in the 50-mV/div position and the 5× MAG button is pressed, a 5× MAG light turns on to warn the operator, and the sensitivity increases five-fold (i.e. to 10 mV/div in the example case). That feature is especially useful when dealing with low-level signals that are ordinarily below the threshold of the normal settings. It also effectively doubles the number of available sensitivity factors.

Channel-2 Polarity—The POLARITY control inverts the channel-2 vertical signal when pressed. If not used, the polarity of the channel-2 signal is not inverted. The control allows us to have a pseudo-differential input on a single-ended oscilloscope (see the ADD control following).

Vertical Mode—This control forms a sub-group that includes the following:

Ch1, Ch2—Selects the single-channel mode. When CH1 is pressed, the oscilloscope operates as a single-channel model and displays only the channel-1 signal. When CH2 is pressed, only the channel-2 signal is examined.

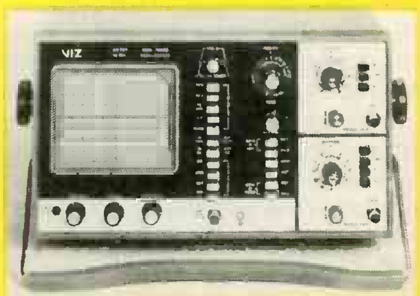
Alt, Chop—These are dual-channel modes. There is only one electron beam being used by both channels, and it must be shared by them. In the ALT mode, the channel-1 trace is drawn during one sweep and then the channel-2 trace is drawn during the next. In other words, the oscilloscope alternates between displaying the two the signals. In the CHOP mode, the electron beam is switched back and forth rapidly between channel-1 and channel-2 and draws both graphs during each sweep. The input signal must have a frequency much lower than the chopping frequency.

Add—With this selection two input signals are combined into one, with the resultant amplitude being the algebraic sum of the two channels (CH1 + CH2). If the CH2 POLARITY control is pressed, then the inputs become pseudo-differential and the summation is CH1 – CH2.

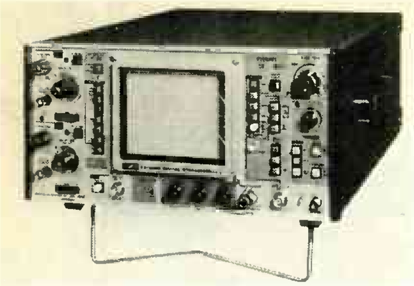
X-Y—With this selected the internal time base is disconnected and the instrument becomes a vectorscope. That means that channel-1 becomes a horizontal ("X") input, while channel-2 is the vertical ("Y") input. In this mode, the oscilloscope can be used for modulation measurements, color-TV Lissajous patterns, and so forth.

Horizontal Group. The horizontal control group determines the horizontal deflection and sweep characteristics. The controls consist of SWEEP TIME, SWEEP VERNIER, HORIZONTAL POSITION, 10× MAG, and SWEEP MODE. They are as follows:

Sweep Time—This is the main horizontal timing control, and is used to set the amount of time a horizontal division will represent. The calibration of the control is in units of time/division (Sec/div, mS/div, or μS/div). The period



Special oscilloscopes, like this Viz, have the capability of triggering on either the horizontal or vertical TV-sync pulses.



Storage oscilloscopes like this Iwatsu, allow you to capture a waveform(s) in memory for later viewing.

of a signal can be determined if you know this control's setting and the number of divisions occupied by one cycle of the signal. For example, if exactly one cycle of a sinewave occupies 6.2 divisions of the horizontal graticule when the switch setting is 2 mS/div, then the period of the signal is:

$$6.2 \text{ Div} \times 2 \text{ mS/div} = 12.4 \text{ mS}$$

Because frequency is the reciprocal of the period, we can calculate the frequency as:

$$f = 1/T = 1/.0124 \text{ sec} = 80.65 \text{ Hz.}$$

The control is not continuously variable, so it has an finite number of settings.

Sweep Vernier—This is a continuously variable time control that allows the user to interpolate between the rigid sweep-time settings. The sweep-time settings are accurate only when the vernier is in the "CAL'D" position. The control knob is ganged to the SWEEP-TIME control, and its knob is concentric to and mounted on the SWEEP-TIME control.

Horizontal Position—The HORIZONTAL (or "FINE") POSITION control moves the trace left and right on the CRT screen. Like the equivalent VERTICAL control, the HORIZONTAL POSITION control is used to place key features right over graticule points for purposes of precise measurement.

10× MAG—The 10× MAG (magnification) control speeds up the sweep ten times. For example, if the TIME-SWEEP control is set to 10 mS/div, then the 10× MAG control would force it to become 1 mS/div.

Sweep Mode—The SWEEP-MODE control selects automatic (AUTO), normal (NORM), and single sweep (SINGLE) modes. In the AUTO mode, the sweep will periodically retrigger even if no signal is present in the vertical amplifier. The NORM mode requires the presence of a vertical signal before the CRT will begin sweeping; the screen is blank otherwise. In the SINGLE mode, the CRT beam will sweep only once. The SINGLE mode can operate in one of two ways. If there is a periodic signal present, pressing the button in the AUTO mode will force one sweep to take place. If the NORM mode is selected, then the SINGLE button will reset the circuit, which will sweep only after another valid input signal is received.

Trigger Group. The triggered-sweep oscilloscope is considerably more useful than the old untriggered forms. A triggered-sweep unit will not allow the CRT beam to sweep across the screen unless it is told to do so. For internal triggering, a specific signal must be present in the vertical amplifier to initiate a sweep. It must have the right slope, and amplitude as set by the user. In external triggering, a trigger signal that is separate from the vertical signal starts a sweep. Some models also allow delayed triggering. That is, the sweep will not actually begin until some pre-set time after a triggering signal is received. The trigger group is shown along with the horizontal controls in one of the photos. The controls include: TRIGGER LEVEL, SLOPE, SOURCE, COUPLING, EXTERNAL TRIGGER INPUT, and a HORIZONTAL-DISPLAY SELECTOR. In addition, some models also have a vernier TIME DELAY control. Keep in mind that the SWEEP MODE control, which we discussed under the horizontal-controls section, is also part of the trigger group, as is the CH1-CH2-NORM switch shown along with the vertical-controls group.

Trigger Level—The TRIGGER-LEVEL control determines the minimum amplitude of a vertical signal required to trigger the horizontal sweep. The range of the control runs from negative, through zero, to positive voltage values.

Slope—The SLOPE control determines whether the trigger occurs on a negative-going or a positive-going edge of the input waveform.

Source—The SOURCE control selects the source of the signal applied to the triggering circuits. The selections are INT, LINE, EXT, and EXT/10. The internal selection, INT, means that trigger is derived from the input signal selected by the CH1/CH2/NORM switch in the vertical section. For example, with the SOURCE control in INT and the other switch in the CH1 position, the signal in the channel-1 vertical amplifier will cause triggering. The LINE selection means that the 60-Hz AC line will cause triggering, a feature useful in some measurements. The EXT means that the signal applied to the external-trigger input (EXT TRIG INPUT) will trigger the sweep circuits. Again, some useful measurements are possible with this feature. The EXT/10 is the same as EXT, but a 10:1 attenuator is in the signal path.

Coupling—The COUPLING control allows us to tailor the triggering used, and has selections of: AC, HF REJ, TV and DC. The AC and DC selections are self-explanatory, and are similar to the same markings on the VERTICAL SELECTOR switch. The HF REJ uses a low-pass filter at the input of the trigger circuit that rejects high frequencies. For example, that will permit triggering on the modulation of a modulated RF carrier while ignoring the unmodulated RF signal. Some oscilloscopes also have a LF REJ, which is similar except that the filter is a high-pass filter. The TV selection allows us to synchronize the sweeps to the horizontal/vertical frequencies used in televisions. Some models have separate TV VER and TV HOR selections.

External Trigger Input—An input connector that provides the trigger circuit with an external signal for special-purpose syncing and triggering. Some oscilloscopes also have a TRIG GATE feature that uses that connector as an output jack. That feature produces a short-duration pulse for synchronizing external circuits, other scopes, or a camera to the sweep system.

Time Delay—The time delay control allows us to program a short delay between the triggering event selected with the LEVEL and SLOPE controls, and the beginning of the sweep. Using that control we can view small segments of the waveform, while using the main signal as the trigger event.

Horizontal Display—The HORIZ DISPLAY is a switch bank that allows certain sub-modes. Not all oscilloscopes have this feature, even though it is very useful. In one mode, the oscilloscopes operates as any triggered-sweep oscilloscope would. But in the A INTEN mode, a segment of the waveform is intensified (see photo). The position of the intensified segment is a function of the TIME DELAY control, while the length of the intensified portion is a function of the DELAY TIME control that is concentric with the TIME/DIV control. We can use the mode to designate a small segment of the waveform for a closer look. When the "B" switch is pressed, only that portion of the waveform is displayed. When the ALT button is pressed, the main waveform and the time-delayed "close-up" portion are displayed together. A screw adjust A-B SEPARATION control allows us to either separate or superimpose the waveforms.

Now that we've become acquainted with the cathode-ray oscilloscope and its controls, let's look at the problems of getting a signal into the oscilloscope. Probes may not make for the most appealing subject matter in the world, but they are very important.

Why Probe Further? So what's the big deal? All one needs to do is attach a piece of wire to the vertical-input connector, right? No, not right. The art and science of using oscilloscope probes is more than that.

Figure 4 shows the most basic form of input probe for oscilloscopes. Here we see a length of shielded cable, usually coaxial cable, with a BNC (banana plugs or PL-259 on older instruments) on one end and a pair of alligator clips on the other end. That method works well for signals with frequencies from DC up to a certain point, and for many of you that probe set is all that is required. But there is a problem that must be recognized. The cable has capacitance on the order

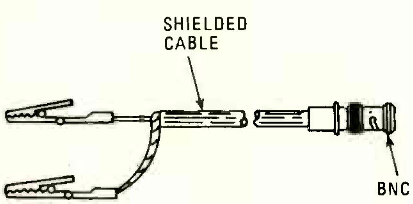


Fig. 4. This is the most basic form of oscilloscope probe. That probe works well for signals with frequencies below RF. In the RF region the cable capacitance starts to cause roll off.

of 20-pF per foot. The input impedance of a typical oscilloscope is a 1 megohm resistance shunted with a 20-pF capacitance. If the cable is 3-feet long, then it has a capacitance of 60-pF, that when added to the natural input capacitance results in 80-pF shunting 1 megohm. The RC network thus created has a low-pass filter characteristic that rolls off -6 dB/octave above a frequency of:

$$f=1/2RC$$
$$f=1/(2)(3.14)(10^6 \text{ ohms})(8 \times 10^{-11} \text{ farads})$$
$$f=1/.0005=1990 \text{ Hz}$$

The probe would load down any high frequency circuit that it is used to measure, so it is not the best choice. And the fundamental frequency need not be anywhere near the cutoff frequency for there to be problems. Non-sinusoidal signals are made up of a collection of sinewaves consisting of a fundamental plus harmonics. Thus, a 100-Hz fast-risetime squarewave is made of a 100-Hz sinewave plus even harmonics up to infinity. The low-pass filter effects of the probe will roll off the higher harmonics and round off the shoulders of the squarewave.

The answer to the frequency-response problem is to use a low-capacitance probe, two examples of which are shown in Fig. 5. The probe in Fig. 5A is the standard 10:1 ratio probe. The output signal of this probe is one-tenth the input signal. If the resistors used are precision types, then the scale factor on the oscilloscope vertical attenuator is multiplied by ten. For example, when the vertical attenuator is set to 0.5 volts/cm, the actual scale factor is 5 volts/cm. In Fig. 5B we see the same sort of idea, but with a ratio of 100:1.

In many types of low-capacitance

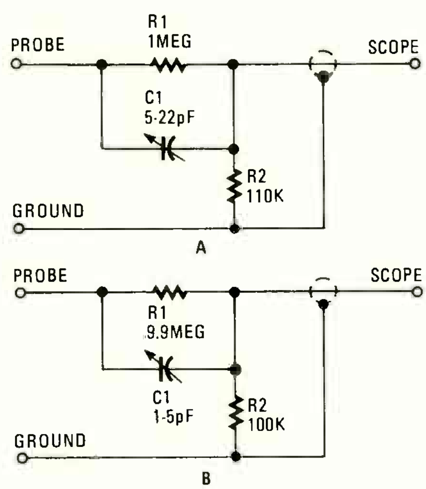


Fig. 5. The probe in A is a 10:1 ratio probe. Its output one tenth the input. In B we see the same sort of idea, but with an input/output ratio of 100:1.

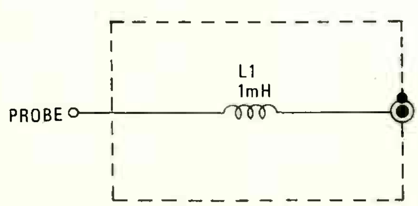


Fig. 6. Here we show a probe used for transmitter measurements in broadcasting. The 1-mH choke suppresses the RF that gets to the probe from the surroundings.

probes, the capacitor is selected to flatten the frequency response. In most cases, a fast-risetime 1000-Hz squarewave is applied to the input of the probe when it is connected to the oscilloscope. The probe capacitance is then adjusted to show as square a squarewave as possible.

Probe Grounds. Oscilloscope probes are equipped with a ground lead, which is connected through the cable shield to the chassis of the oscilloscope. The AC-line cord is also connected to the chassis. As a result, many people are tempted to use the AC power-line ground as the signal return. That is always a bad practice and is sometimes dangerous. At the very least it will distort the waveform, and is especially likely to roll-off the high frequency characteristics. In other cases, the long ground represented by the AC power-line connection will cause ringing of the waveform. That shows up as overshoot on squarewaves. Note: *You should always use the ground lead on the scope probe as the local signal ground.*

Another problem with the ground lead is in AC/DC equipment. An AC/DC (or transformerless) radio or TV set uses the neutral of the AC power line as ground or common in the DC power supply. As long as the plug is inserted correctly, and the building's electrical system is correctly wired, that is safe. But, and that is a big "but", if one of the wires is crossed, or the plug is inserted backwards, then there lurks a deadly monster on the bench. If you come between the now hot chassis and true ground, such as when you try to attach the oscilloscope/probe ground to the equipment chassis, then you may be electrocuted. At the very least you will experience a big bang and a bright flash as the house fuse blows and the scope probe melts. The only safe way to *scope-out* AC/DC equipment is to use an isolation transformer between it and the AC power mains. In fact, it is good practice to use an isolation transformer on all benches at all times (I do).

Isolation. Another problem is the matter of isolation from external fields. The classical problem is taking a look at a waveform in the presence of interfering electromagnetic fields. The classical solution to the problem is insertion of an RF choke in series with the scope probe. Figure 6 shows a probe that can be used for radio-transmitter measurements in broadcasting. The 1-mH RF choke suppresses the RF that gets to the probe when it is in the presence of an radio field.

A problem that exists with the probe is the possibility of self-resonance. All RF chokes, indeed all inductors, have a certain amount of capacitance between windings and a stray capacitance to ground. The capacitances interact with the inductance of the coil to create a tank circuit, and that spells trouble in some cases.

Demodulating Probes. Amplitude-modulated RF signals are encountered frequently in electronics, ranging from hobby, to service work, to engineering laboratories. If you want to observe a modulating signal to the exclusion of its RF signal, or if you have only a low frequency oscilloscope that will not even see the RF carrier that the modulation is riding, then the *demodulator probes* shown in Fig. 7 can help. In all three versions of demodulating probes, there is a signal diode present that is used as an RF detector. Although silicon diodes (1N914, 1N4148, etc) are usable, they have a higher junction potential than germanium diodes (1N34, 1N60 etc), and so cannot "see" as weak a signal.

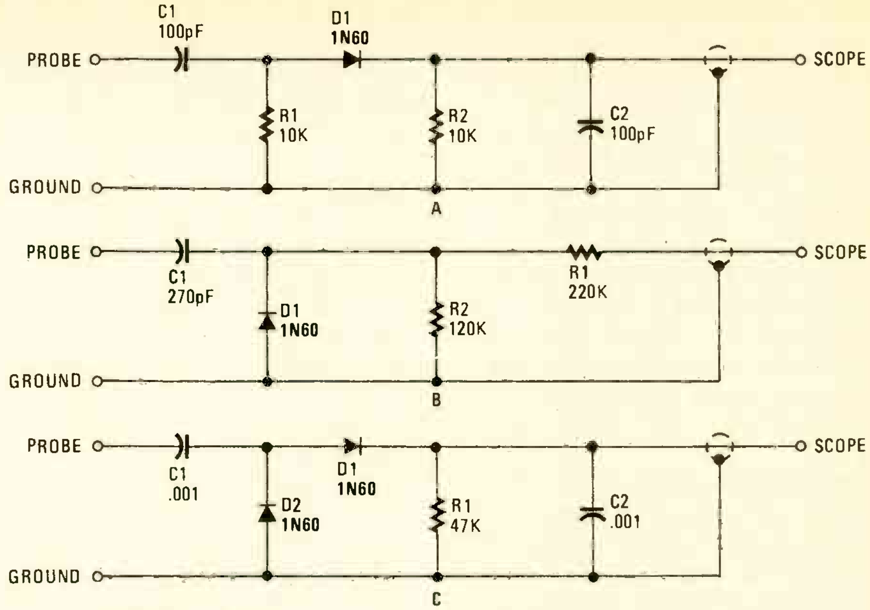


Fig. 7. The demodulator probe shown in A uses a series detector. The capacitor values shown are typical but not right for all applications. A shunt detector version of the probe is shown in A voltage-doubler version is shown in C.

The demodulator probe shown in Fig. 7A uses a series detector. Capacitor C1 must be tailored to the application, although the 100-pF unit shown here is a nominal value useful in many situations. The capacitance must be small enough to not load the circuit under measurement. Capacitor C2 is usually .001 to .01-μF, but it may be either higher or lower in some cases. The issue is whether or not the capacitor shunting R2 deteriorates the frequency response relative to the modulation. A shunt detector version of the probe is shown in Fig. 7B; it functions in a similar manner to A. The last demodulator probe is the voltage-doubler version shown in Fig. 7C. The probe has a higher output signal than the others, and so is useful for smaller signal levels or less sensitive oscilloscopes. However, there is some distortion of the waveform in some cases.

RF Work. The number of RF applications for oscilloscopes has expanded in recent years with the availability of relatively low cost oscilloscopes that have bandwidths in the 20-MHz to 100-MHz range. In the recent past, such an oscilloscope would have been prohibitively expensive. Fifteen years ago, one shop owner I worked for went pale and gulped at the price of a 15-MHz oscilloscope that he needed to qualify for a warranty-station contract; that scope costs less than $800 today. And, while not exactly cheap, the prices of current 50-MHz oscilloscopes are within the reach of many hobbyists or small service shops.

(Continued on page 98)

**TABLE 1—
OSCILLOSCOPE MANUFACTURERS**

Here are some of the companies that manufacture hobbyist-grade oscilloscopes like the ones mentioned in this article. For more information, contact the company directly, or circle the appropriate number on the Free Information Card.

B+K
6470 West Cortland St.
Chicago, IL 60635
(CIRCLE 29 ON FREE INFORMATION CARD)

OK Industries
4 Executive Plaza
Yonkers, NY 10701
(CIRCLE 30 ON FREE INFORMATION CARD)

Hameg, Inc.
88-90 Harbor Rd.
Port Washington, NY 11050
(CIRCLE 64 ON FREE INFORMATION CARD)

Heath Co.
Benton Harbor, MI 49022
(CIRCLE 65 ON FREE INFORMATION CARD)

Hewlett-Packard Co.
1501 Page Mill Rd.
Palo Alto, CA 94304
(CIRCLE 66 ON FREE INFORMATION CARD)

Hitachi
175 Crossways Park West
Woodbury, NY 11797
(CIRCLE 67 ON FREE INFORMATION CARD)

Iwatsu Instruments, Inc.
430 Commerce Blvd.
Carlstadt, NJ 07072
(CIRCLE 68 ON FREE INFORMATION CARD)

JDR Instruments
110 Knowles Dr.
Los Gatos, CA 95030
(CIRCLE 69 ON FREE INFORMATION CARD)

Kikusui
19601 Mariner Ave.
Torrance, CA 90503
(CIRCLE 80 ON FREE INFORMATION CARD)

Leader Instruments, Inc.
380 Oser Ave.
Hauppauge, NY 11788
(CIRCLE 81 ON FREE INFORMATION CARD)

Philips/Fluke
PO Box C9090, M/S 250C
Everett, WA 98206
(CIRCLE 82 ON FREE INFORMATION CARD)

Sencore
3200 Sencore Dr.
Sioux Falls, SD 57107
(CIRCLE 83 ON FREE INFORMATION CARD)

Tektronix, Inc.
Beaverton, OR 97077
(CIRCLE 84 ON FREE INFORMATION CARD)

Viz Test Equipment
175 Commerce Dr.
Fort Washington, PA 19034
(CIRCLE 89 ON FREE INFORMATION CARD)

GIZMO®

A CHRONICLE OF CONSUMER ELECTRONICS

MARCH 1989

VOLUME 2
NUMBER 3

Digital Midget

CIRCLE 31 ON FREE INFORMATION CARD

AIWA STEREO RADIO CASSETTE RECORDER (HS-J800A). Manufactured by: Aiwa America, Inc., 35 Oxford Dr., Moonachie, NJ 07094. Price: $240.

At least some of our interest in this top-of-the-line stereo radio cassette recorder was inspired by a recent ad campaign for *Aiwa's* personal-stereo products: "Aiwa can't outspend the competition," the print ad asked, "so can we outsmart them?"

The layout went on to claim a tripling of the company's "research and development effort," pointing to the *HS-J800A* and its companion models (*HS-J380, HS-J280*) as the "world's first digital cassette headphone stereo systems." Personal-stereo design has been a pace setter in consumer electronics and Aiwa's assertion of technological advance represents a head-on challenge in a product category practically defined by high performance.

Utilitarian in appearance, the HS-J800A incorporates a built-in clock, an AM/FM tuner with LCD digital display, and five station presets for each broadcast band. The unit's tape recorder features auto reverse, Dolby-B noise reduction, and metal/normal tape-selection and recording capacity. The HS-J800A comes equipped with a battery recharger/AC adapter, a rechargeable battery, headphones, and a separate microphone, along with the usual fabric case.

In terms of digital features, Aiwa calls its integrated-circuit tuner pack "breakthrough technology that enables miniaturized electronic systems to employ digital features using as little as 2 volts."

The time/station LCD is easy to read and provides tape direction and pre-set selection information. To the right of the display, there's a tiny power-indicator light and a radio-station HOLD switch that overrides the tuner controls (two silver buttons below the display). The FM/AM-select switch and the two buttons used for setting time and preset-station selections complete the HS-J800A's front-panel controls. The tape player/recorder's auto-reverse feature is engaged in two ways. There's a fixed REVERSE MODE control and an instant DIRECTION switch.

Battery life is listed in the directions as two hours of listening and an hour-and-a-half of recording for the rechargeable pack (following a one-hour charging), and four hours of either listening or recording, with two "AAA" alkaline batteries. In our use of the unit, that was fairly close to the mark. Power loss was signaled by intermittent transmission, which has the virtue of making the malfunction source clear.

Compact and sleek, the HS-J800A weighs about 8.5 ounces. That gives the unit a bit more heft than competition personal stereos, but the added ounces are accounted for by the unit's recording capacity. Or, perhaps, its sturdiness gives it extra bulk. During **GIZMO's** use of the system we managed to drop it twice without damaging the unit.

An enjoyable and comfortable unit to use on-the-go, the only significant drawbacks in its design seemed to be in its incidental features. The fabric case, for example, rendered too many controls inaccessible. We soon stopped using it. Slipping the HS-J800A into a coat pocket would often engage the tape-pause control. With the case in place, that meant fishing the system out, sliding the fabric cover off and flipping the pause, before trying to reverse the process without again engaging the pause.

Even without the case, the unit's five side-mounted controls were vulnerable. Without some effort, putting the HS-J800A into a pocket might move the volume thumb wheel, switch the unit from tape to radio (or vice versa), engage the pause, or disturb the unit's metal/normal tape setting or Dolby switch.

One **GIZMO** tester was disappointed by the supplied headphones, preferring the in-the-ear bud variety to the Aiwa's over-the-ear design. The style, he pointed out, allows surrounding noise to infiltrate the personal-stereo listening experience, which is probably the point. Along with the usual brochure on safe use of headphones, that design is aimed at keeping the user/wearer from walking directly into traffic while sonically separated from the environment. He also pointed out that at high volumes the HS-J800A's sound reproduction becomes distorted.

Still, it was a disappointment that the headphones didn't do a better job of filtering out urban noise at its everyday extremes. Surely there should be some happy compromise between being at the mercy of surrounding noise and headphone-induced audio oblivion. In the

(Continued on page 8)

TURN PAGE FOR CONTENTS

THIS MONTH IN GIZMO

Gizmo is published by Gernsback Publications Inc., 500-B Bi-County Blvd., Farmingdale, NY 11735. Senior Writer: George Arthur. Contributing Writers: Loren Begay, Chris Clements, Rick Hammer, Tony Haynes, Erik Lacitis, Rick Marx, John Noonan.

CIRCLE 32 ON FREE INFORMATION CARD

VHF To Go

CASIO PORTABLE VIDEOCASSETTE RECORDER/TV (VF-3000). Manufactured by: Casio, Inc., 570 Mt. Pleasant Ave., P.O. Box 7000, Dover, NJ 07801. Price: $1,399.

Here's an electronic device that should appeal to parents with that proverbial discretionary income. In the past decade, the VCR has become America's babysitter. Tired after a hard day at work? Need to relax but the kids are driving you crazy? You know what to do. Head down to the neighborhood video-rental store.

Now, *Casio* has come up with a product that further extends the VCR's babysitting range. The *VF-3000* is a portable 3.3-inch LCD TV built into a mini VHS VCR unit. The whole thing weighs only 4.9 pounds and measures 8- × 6- × 3-inches. (Of course, when you attach the battery pack to this VCR/TV combo, it adds another 1.75 inches to its width.)

The VF-3000 is convenient enough to take to football, basketball, or other sporting events—a popular use for LCD mini-TV sets. But we wonder why anyone would want to take the VF-3000 to a stadium and record with its VCR? Why not just use a home unit, which should get better reception? We did consider the VF-3000's potential business uses; say, taking it on a trip to show a sales video. Unfortunately, we don't feel that's practical since with that 3.3-inch screen, any get-together would have to be a pretty small huddle.

No, what intrigued us—this is what happens when baby-boomers who are now parents review electronics—were the unit's possibilities for mollifying children. It could certainly make for less hassles on those long car trips. Just bring along some videos and let the kids zone out in the backseat.

We were quite happy with this TV/VCR unit's performance. The liquid-crystal screen (with a stated pixel count of 93,720) delivers a high-resolution image. The six-section rod antenna proved efficient enough to clearly bring in VHF and UHF channels. The manual says reception may be poor in automobiles or other vehicles. But, obviously, that doesn't affect use of the VCR. To preserve tape quality, the manual says that the unit should be operated on a level surface and not on your lap—an instruction that we ignored when testing our sample.

We tested the recording quality of the VF-3000 under what we thought would be typical conditions: taping a broadcast signal using antenna reception. As you might expect, it wasn't as sharp as what would be recorded by a standard-size VCR hooked up to cable. But, on the other hand, the image that was displayed was eminently watchable. The unit tapes and plays back only at standard-VHS speed and takes 10 minutes to rewind a 160-minute tape; it appears that there's only so much in the way of features than can be packed into a lunch-box size VCR.

The VF-3000 comes equipped with a somewhat bulky battery pack. A 2½-hour charge is good for two hours of VCR viewing, or three hours of recording with the TV off. An "E" message flashes on the screen if the battery pack runs low during recording. If recording continues, power will turn off automatically to prevent excessive battery discharge. To prevent unscheduled shutdowns, we recommend using the AC adapter supplied with the unit whenever possible.

The VF-3000 is exactly as advertised, a charming, miniaturized version of a full-size home deck. A gizmologist who used the unit said there was something about it that made him think of a paperback book. We thought that was an apt analogy, although one that was not altogether appropriate. You see, in publishing the paperback version is not only smaller, but less expensive than the original edition. ■

Sound Advice

ACOUSTIC RESEARCH LOUDSPEAKERS (TSW 105). Manufactured by: Teledyne Acoustic Research, 330 Turnpike St., Canton, MA 02021. Price (per pair): $275.

ACOUSTIC RESEARCH POWERED LOUDSPEAKERS (TSW 115P). Manufactured by: Teledyne Acoustic Research. Price (per pair): $400.

CIRCLE 33 ON FREE INFORMATION CARD

Loudspeaker performance seems to be one of those topics, like brain surgery and wine appreciation, designed to intimidate non-experts and remind them of what they don't know. Certainly the esoteric heights of speaker terminology aren't bogus. Sound reproduction and amplification is a science, with a history and an accumulation of data stretching back to the beginnings of recording.

But the topic's obscurity is in many ways unfortunate. In purchasing speaker systems, consumers often end up at the mercy of glib sales personal or buying with their eyes (and ears) closed, hoping for the best based on not much more than word-of-mouth or the amount printed on the price tag. In terms of the technology of these *Acoustic Research* speaker systems, our knowledge is pretty much limited to the information supplied by AR in technical bulletins and white papers. The *TSW 105* is described as a "bookshelf acoustic suspension 2-way system with magnetically shielded drive units in a vertical array."

We can confirm that these are bookshelf speakers. Seventeen-and-a-half inches tall, they fit easily (on their side) into our office shelves. AR's instructions for installation and use anticipates that users might need to put these vertically arrayed speakers on their side and, in refreshingly non-technical language, generally explain the whys and wherefores of speaker placement.

Interestingly, after years of listening to beat-up and outmoded speakers, it took our ears several weeks to realize the improvement represented by the TSW 105. The difference was dramatic, but at first hard to discern. We were so used to filling in the "missing part" of music heard over our old speakers that only gradually did we become aware of the 105's significantly more detailed audio performance.

Our first sense of improved performance came when listening to a record once hailed as a milestone in sophisticated stereo production, the two-decades-old "Sgt. Pepper's Lonely Hearts Club Band" Beatles album. Here was a record our ears knew "by heart"; but listening to it for the first time through the 105 speakers we were suddenly discerning sounds we'd previously only thought we'd heard.

We suspect that at least part of the reason for our slow audio uptake is the character of these speakers. They seem to belong to an earlier era of high-fidelity design. Think chamber-music quartets instead of heavy-metal rock, quiet appreciation instead of the sonic overkill of stadium rock and roll. These are refined speakers, and in their performance there's a delicacy of reproduction and balance that seems downright genteel.

For **GIZMO's** test of the jazzier *TSW 115P's*, we turned the speakers over to a professional audio technician and a home studio musician. These amplified, powered loudspeakers are described in an AR white paper as having "all the same features and compact external dimensions as the TSW 105" with the addition of an internal power amplifier and the company's "electronic bass extension" technology. Among uses mentioned are connection to stereo television, hi-fi VCR's, personal-stereo cassette players, and CD players

Perhaps perversely, **GIZMO's** testers used them only in a home-studio setting, connected with a four-track mixer/recorder cassette deck. Both were impressed with the speakers' performance over a two-week period. Describing the source signal as raw and fluid, both technician and musician thought that the TSW 115P delivered accurate, undistorted sound, which made the speaker exceptionally suited to home-studio monitor use.

The implication is that by doing a superior job with raw sound, the speakers could be expected to excel in amplifying the expertly produced and processed output of the music industry. However, both testers saw the absence of any tone-style control on the right "master" speaker of the pair as something of a shortcoming. Although the listener can control volume, there's no way to shade or modify the bass or treble. Fine, they thought, if the TSW 115P is hooked up to a source with those controls. But in the case of various stereo televisions, VCR's, and some portable-CD units, the absence of those adjustments on both source and speaker could present a problem. The addition of a low-pass filter control would be one approach to remedying that limitation.

Our testers were also less than enthusiastic about the speaker system's cable, which is permanently connected to the "slave" speaker. Unless the user felt confident about splicing into the AR cable, he or she would have to use the supplied connection at the supplied length. And it wasn't clear that positive/negative strands are even indicated. A curious design decision, undertaken perhaps to assure that users don't misconnect the pair, leading in the case of powered speakers such as these to something possibly more serious than phase cancellation.

Finally, they wondered why volume and power controls were at the back of the TSW 115P instead of on the front. If used at home, or permanently mounted, that placement makes it necessary to pull the speakers off their shelf perch to turn them on or adjust the volume. Not a practical arrangement, to say the least!

In general, speaker performance was more than satisfactory in our opinion. On the more subjective side, our testers thought the AR units lacked a certain power or bass-line presence, again reflecting their refinement and gentility of design. As speakers in a small listening space, however, the TSW 115P would more than do the job. ■

Living with the Birds

"Country" makes you think of squawking birds, chirping crickets, and a more relaxed lifestyle, right? Leave the city and you enter a media void bounded on one side by frog-filled ponds and on the other by dense, pine-scented woods.

These days, however, country living has taken on a different character, and a part of the reason is the large-scale advent of satellite television. Although the first satellites were installed by rural pioneers who simply wanted to get TV—any TV—in areas beyond antenna range and cable operations, today's satellite user is a high-tech entertainment and information fiend. In many cases, the rural dish user is more in touch than his city cousin. For example, in New York state, somebody two-hundred miles out of the city can watch 110 channels. In Brooklyn, until the end of last year when cable service finally became available in some areas, viewers were limited to six or seven broadcast channels and a handful of local UHF signals. The country boy can get French TV from Quebec, continuous Wall Street reports, "adult" entertainment, and religious programming from every denomination short of Hare Krishna.

As owners of a country cabin, we found the biggest lure for many city friends was the opportunity to watch shows they couldn't receive at home. They'd come up for the weekend only to sink into the couch, get a quick lesson on the remote controls, and barely move for the barbecue.

Home-satellite technology seems to change by the moment, and the cost is keeping pace. The basics of the system include the dish antenna itself, a television, a tuner, and a descrambler. With installation, that is about a $4,500 investment. With a Chapparal dish and Zenith Advanced System 3 monitor, we use the Ma/Com T-6 Tuner and the VideoCipher II descrambler. But the business of satellite television changes about as fast as the technology: Chaparral has stopped manufacturing dishes. Noted companies like Luxor, Sperry, and Interstat have also left the dish business.

As manufacturers of satellite equipment seem to come and go by the month, it's best to consult a reliable dealer for the equipment. As novices, we relied on dealer recommendations for our purchasing choices.

The Ma/Com T-6 and VideoCipher II that we use are also out of production. When they were introduced, a new era of satellite TV was beginning. It was the dawn of signal scrambling—the coding of signals by cable companies. With scrambling, the satellite viewer must put out a hefty initial outlay and then pay subscription fees. It doesn't seem fair, but that's a matter for Congress.

As home equipment, the Ma/Com T-6 Tuner and the VideoCipher II proved to be superb machines. At their release, they were the state of the art. Developed for Home Box Office by Ma/Com, both units use solid-state semiconductors. Technology fans dubbed their IC circuits "the black centipede"—a black chip with silver legs, suggesting the body of an insect. While there are competing systems, the internal crystal-based synthesizers used to control channel selection are considered superior to any other switching technology by many satellite mavens.

The T-6 Tuner and the VideoCipher II—each about the size and shape of a standard VCR—can be used with other equipment from other manufacturers, but they were most effective when used in tandem. While Ma/Com has been absorbed by General Instrument Corporation (6262 Lusk Blvd., Mira Mesa Business Park, San Diego, CA 92121), the equipment's two-year warranties are still being honored. And satellite servicemen claim that the machines rarely require repair.

Novice satellite purchasers will discover that state of the art hardware today is represented by the "IRD" (Integrated Receiver/Descrambler). The IRD merges the functions of both tuner and VideoCipher descrambler in one compact package. General Instrument continues as a leader in the manufacture of IRD's; their model 2750R is pictured.

To take the satellite plunge successfully, a trained, knowledgeable installer is both a blessing and a necessity. There are complicated measurements and calculations to be charted; concrete to be poured; cable to be laid; and equipment to be hauled, installed, and tuned. Some residences, if heavily wooded or situated in lowlands, may be completely unable to receive satellite signals. Before the equipment is purchased, it's essential to get a knowledgeable appraisal of the reception possible and available. Very few sites will receive every satellite. Located atop a hill, we were able to get most everything but an NBC affiliate-station feed. One nearby neighbor, unable to receive any satellite signals, had a fifty-foot tower built on his property, extending above the tree line—at a cost of $20,000. That kind of expense, although unusual, is not unknown in home-satellite installation.

A further caution: some towns and suburban planning authorities may have ordinances forbidding satellite-dish installation, or regulating them as unsightly additions to the skyline. Consult with your local town hall or planning-commission office before investing.

Once the zoning rules are clear, preliminary calculations and purchases are made, the concrete foundations are poured, and the outdoor dish is installed on the grounds. The cable is then laid underground into the house and connected to the primary television set. When the cable connections are made to the back of the tuner, the satellites are tuned for the best possible reception. The tuning will be done via the tuner or IRD unit, which tunes the dish's "feedhorn," the device that collects microwave signals that are reflected from the surface of an antenna; the feedhorn is mounted at the focal point in all prime parabolic antennas. A minor adjustment can mean the difference between getting a Los Angeles Dodgers' game and going without.

The tuning operation is a tricky one and, once again, one that the installer should provide when setting up the system. The consumer is paying too high a ticket not to get the most from a dish. But with the cost comes clarity and near-perfect reception, with a variety of channels and programming sources. Those are the unrivalled pluses of home-satellite viewing.

Once up and running, there's still one more step. To watch cable networks like

HBO or Cinemax, or view special packages like WWOR in New York, Chicago's WGN, or WXYZ in Detroit, contact a subscription packager, a company like Superstar Connection/United Video, Primetime 25, or Home Dish Only. In many instances, a satellite-equipment dealer will also broker the package, calling the cable companies or packagers directly for an uplink. Others can be purchased with information displayed on the TV screen. Expect to pay about $250 a year for a package of 15 channels, services like Showtime, CNN, TBS, MTV, Nickelodeon, and other popular cable networks, including the so-called "superstations." After ordering, make sure you get what you pay for; slip-ups have been a notorious satellite subscriber problem. But once your number is locked in, all you'll have to worry about is footing the monthly bill.

Now you're ready for serious satellite TV. The first trick is to learn to use the remote-control system. If you have a TV with a remote, a VCR with a remote, plus the remote for the IRD, you'll find yourself with a stack of confusion. Keep the controllers away from the small fry, leave the TV and VCR on channel 3, and concentrate on the IRD or tuner remote. First tune in the satellite, or "bird," using a listings directory like the weekly one-hundred-plus page *OnSat*. That programming documentation will make tuning much easier and less confusing, especially for the novice. Published by Triple D Publishing (P.O. Box 2347 Shelby, NC 28151), *OnSat* costs $50 per year.

New from *OnSat* and Triple D is an "on-line" directory called the Superguide, downloaded into a reception unit on a weekly basis. The receiver, plus a small remote (both being revamped and redesigned as this is being written) sells for $389. The on-line listing service, depending on which combination of listings, breakouts, and schedules is selected, costs from $40 a year on up. The Superguide can actually provide print-outs of program listings straight from the TV screen when hooked up to a computer printer.

Settling into a "bird" (with an arcane moniker like Galaxy3, Westar 5, or F-Satcom 1), the user merely punches the up or down arrow on the controller until the desired channel comes into view. At first the tendency is to channel-hop, in search of the best program—like a party-goer on New Year's Eve, always with someplace better to be.

Tuner features often include a lock device, which restricts selected channels. An audio tuner allows the satellite owner to listen to radio stations broadcasting via satellite, providing a great alternative to the limited commercial-radio listening options in isolated areas.

Compatibility was one of the great features of our tuner/VideoCipher units. All standard-TV equipment we used interfaced without adapters or boards. Programs recorded via the Ma/Com tuner play back with crystal clarity even on a basic, budget VCR. Home recordings are often genuinely better in quality than cassettes rented from video shops.

One note: the system should remain powered at all times. After only a few minutes down, the memories will require reprogramming. One of our summer neighbors turns his system off over the winter and hires a service person to come in every Memorial Day and get it up and re-programmed, at a price.

Other maintenance concerns depend on the quality of the original installation or service. Properly placed and installed, the dish itself is fairly indestructible, weathering even the toughest northeastern winters in our case. There's no need to wander outside in boots and parka to try and pull in the Seahawks' season finale. It's recommended that dish owners get the feedhorn realigned on an annual basis, to assure that it's at the proper angle for the best possible reception. We've been lucky to have an expert technician to field our questions;

(Continued on page 8)

Fax Acting

VSI FAXSWITCH II (1002). Distributed by: Executive Communications Systems, 2622 Quaker Ridge Pl., Ontario, CA 91761. Price: $295.

With the high tide of facsimile-machine usage fast approaching, we're waiting for the day when fax installations outstrip available telephone lines. It will be headline news as everything comes skidding to a halt as fax communication backs up around the globe. If this science-fiction vision were ever to come to pass, the *Vada Systems, Inc. Faxswitch II* would promise at least temporary relief.

The device, a black box outfitted with DIP switches and three telephone jacks, allows the fax user to devote a single line to both voice and fax transmission, voice and modem, or some other combination and keep an answering machine connected as well. A fairly versatile fax accessory, it seems to us that the Faxswitch II is both a little more and a little less than it might be.

Its three line jacks are labeled FAX, C.O., and PH. SYS. To those are connected, respectively, the facsimile machine or modem, the telephone or answering machine to which the phone is connected, and the telephone line.

CIRCLE 35 ON FREE INFORMATION CARD

The Faxswitch II's DIP switches are located in the device's bottom surface and set two important operating codes or signals. One sequence of set switches decides between the telephone keypad's asterisk (*) and pound (#) signs as a signal in the phone/fax-line's operations. According to the Faxswitch II directions, for answering-machine use, the recorded outgoing message should instruct the caller to press the selected keypad symbol if the call is a manual facsimile call. If the call is an ordinary voice transmission, message recording proceeds in the usual way. If, with the answering machine connected to the unit (and turned on) and the phone unattended, an auto-dial fax call is received, "the Faxswitch II will decode the incoming tones and switch the call to the fax machine automatically."

The second signal set by the DIP

(Continued on page 8)

CIRCLE 36 ON FREE INFORMATION CARD

One from the Heart

HEARTWATCHMAN WIRELESS HEART RATE MONITOR (8888). Manufactured by: Computer Instruments Corporation, 100 Madison Ave., Hempstead, L.I., NY 11550. Price: $179.

There are joggers, there are runners, and then there are fitness full-timers—the kind of people who subscribe to fitness magazines, follow developments in shoe technology, and feel more at home on the running path than in their own residence. The relative sophistication (and cost) of the *Heartwatchman* will probably most impress those who are deeply involved in the running and exercise lifestyle. Ironically, the new or casual runner might benefit as much as the maven, if not more, from this heart-rate monitor.

The Heartwatchman is a simple, effective heart monitor that acts like an electronic coach for runners. It gauges the runner's heart rate and tells him "heart rate below target" if the exerciser is goofing off. The Heartwatchman monitors the runner's performance while freeing his hands and eyes for concentrating on running.

The Heartwatchman utilizes two elements common to most heart-rate monitors we've seen: an electrode unit that straps across the chest and a display unit to transmit heart-rate information to the wearer. But this wireless heart-rate monitor does away with the cord connecting the two elements and feeds information to the user via an earphone and a synthesized voice.

The wireless electrode-equipped transmitter straps to the chest with an included elastic belt and is surprising comfortable in use. Doing away with the connector wire eliminates hassles, and the user can forget that he is wearing the unit. The transmitter itself fits snugly under the breast bone and uses a dime-sized lithium battery to power its transmissions to the receiver on the belt.

The receiver is slightly larger than an audio cassette and features a standard-sized LCD that shows ECG-style heart-rate and time-elapsed period timer readouts. If the receiver is connected to the earphone, however, there's no need to read the monitor at all. The unit informs the user of heart rate at specific intervals in a clear, although synthesized, female voice. The receiver can also be connected to a personal-stereo system, and will automatically interrupt the music to give the heart-rate reading. The period timer also cuts in with a reminder that a specific programmed exercise time has elapsed.

The Heartwatchman can be programmed to keep the runner within a specified target range of heart-rate. Working much like a personal trainer, the unit curtly informs the user: "Heart-rate below target." That feature is useful in preparing for a marathon, or for any serious training regimen. For the casual user, however, the vocal interruption advising target-range status is a bit too intrusive. One slight quibble we had with the Heartwatchman is that there's no way to turn that function on and off. One has to "deprogram" the unit if one simply wants heart-rate information and not target-range status. Clearly, Heartwatchman is designed for people in serious training, for whom such information is vital.

The sleek, black-plastic encased unit is made in Japan and powered by a pair of AA batteries, in addition to the transmitter's lithium cell. (The batteries allow the Heartwatchman to remember a programmed heart-rate target range.) There are accessories, including a small, external speaker and an AC adapter, that allow the exerciser to use the Heartwatchman with an exercise bike or other gym equipment.

The serious runner—well-tuned to body response and perhaps able to estimate heart-rate at any given time during an exercise period—might be interested in the Heartwatchman for its technical wizardry. But he might actually need the unit less than the beginning runner. That is because the unit can function as an electronic trainer, cajoling, prodding, insisting that the exercise pay off with suitable aerobic benefits. The Heartwatchman, a boon for the gadget fan and the exercise enthusiast, might also benefit the everyday man-in-the-street. It can encourage healthy exercise at any level of dedication, especially if the user enjoys gizmos both technologically complex and user simple. ■

Sounding Them Out

RODAR-J ULTRASONIC PEST REPELLER. Manufactured by: The Monadnock Co., P.O. Box 189, Dedham, MA 02026. Price: $79.95.

CIRCLE 37 ON FREE INFORMATION CARD

The household rodent, eternal adversary of humankind, rears its ugly gray head in the most unpleasant places. Until recently, pesky little creatures were considered an unfortunate fact of life. Something to plague every homeowner or apartment dweller; something we humans just had to live with. Rats and mice, who've proven that they can survive a nuclear blast, were enemies that required constant vigilance. But, are they still?

In the world of rodent repellents, there's now far more than peanut-butter-coated traps, sticky goo, or dangerous poisons. Today, there's a way for the animal-lover to dispose of a rodent problem without disposing of the rodents themselves. Sound too good to be true? Meet the *Rodar-J* from the *Monadnock Company*, a marriage between the Pied Piper and contemporary audio and electronic technology.

The Rodar-J is just a 4- × 5-inch box with a flashing-green light at the lower-left front of the unit. But it has the power to help any home or office stay free of small, furry visitors. The manufacturer says that it can repel small nuisances, from fleas to bats.

Our quest for an effective rodent repellent became urgent when we began our first autumn of country living. The pitter-patter of mice at all hours was the curse of the cabin. Their faces poked out of cracks and from behind refrigerators. We gave up on conventional warfare: nothing is more disgusting than throwing out dead mice that have been garroted by traps or poisoned by toxic chemicals. Not to mention the agony of setting the old-fashioned traps, prone (as comedy has noted for decades) to spring back on fingers unwittingly maneuvered. There had to be a better way.

The advertisement we saw promised, "No rats, mice, bats, squirrels, roaches, fleas, or other pests." The price was hefty, about ten times what any conventional method would cost—about the same amount as a good exterminator's fee. But if it really worked, it could save far more in the long-run. When a squirrel unceremoniously croaked, his body splayed on our kitchen island, the purchase decision was made.

The Rodar-J is lightweight and unimposing, rather resembling a small loudspeaker. It plugs into any standard 110-120-volt outlet in an area where pests have been seen, such as the kitchen, basement, or attic. The only indication that the unit is powered is the red flashing-LED light. Dogs and cats were unbothered by its ultrasonic vibrations that range, according to the instructions, from 23 kHz to 56 kHz.

The Rodar-J operates on less than five watts, covering an interior area up to 2,000 square feet, and will not interfere with other electronic devices such as TV's, radios, or kitchen appliances. The Monadnock Company recommends that the unit point into the area to be protected, wall-mounted or in a corner three to seven feet off the floor and aimed down. A keyhole in the back panel makes mounting easy.

The ultrasonic vibrations "bounce around the room, reflecting and deflecting throughout the area." The manufacturer makes no claims that the product will kill pests, only repel them. We imagine blaring disco music, for example, crashing in from all directions at the hapless creatures, sending them fleeing in distress.

At first the visible results of the Rodar-J may be slow to show themselves; families of mice will not instantly pack their bags and beat it. The information accompanying the device cautions, "do not try for spectacular demonstrations of ultrasound." Placing the ultrasound near a trapped mouse will yield no instant visible results. The urge for food and warmth are too basic for the creatures to immediately desert their habitat. In the initial weeks, rats and mice may still need to be lured from their nests by conventional traps and bait located at the perimeters of the area covered by the Rodar-J.

But, gradually, we did notice a serious drop in new rodent activity. As the Rodar-J does its ultrasonic job, and the influx of new creatures ceases, the rodent problem becomes manageable. Soon, additional measures such as sticky traps and "Hav-a-Heart" traps can help bring an end to unwanted four-legged householders.

We've lived with the Rodar-J in a rural setting for three years. The mouse problem isn't completely solved, and occasionally we find droppings, but not at all the kind of mess we would find before installing the device. The unit requires no maintenance and is left on all the time. We were so satisfied with its performance—solid if not magical—that we've purchased a supplemental Rodar-J to cover the living room. Particularly in rural areas, and in some urban settings also, total rodent eradication is an elusive goal. But the Rodar-J makes protection from mice, rats, fleas, and roaches a little easier, and a lot less personal. ■

Coming Next Month

- Nintendo Power Set
- Jamo Flat Art Speakers
- Mitsubishi Auto-Changer Double-Cassette Deck
- And Much More!

DIGITAL MIDGET

(Continued from page 1)

meantime, we're sure many buyers of the unit will supply their own headphones. On the plus side, the headset is comfortable to wear and, triple-jointed, folds into a neat oblong for storage.

As a tape recorder, the HS-J800A was most impressive. Its simple microphone could pick up conversation from an adjoining room with fidelity that was good enough to understand the words. Even in the midst of lots of incidental noise, the recorder offered excellent fidelity within the microphone's effective range, which we judged to be a little less than three feet (no figure is given in the directions' specifications table). Of course, the HS-J800A's dependence on headphones renders it a little awkward for checking sound levels and operation during recording.

As for the radio's breakthrough digital-tuner pack, we can only say that the HS-J800A performed well enough in the midst of urban ether interference. While not miraculous, at least compared to other personal-stereo radios, there did seem to be some slight improvement in the system's ability to hold onto a station signal. A small digital step for radio-listening humanity, we guess, but a giant one for personal-stereo miniaturization. ■

FAX ACTING

(Continued from page 5)

switches is the number of rings needed to activate both answering machine and fax machine. And here's where things can get slightly tricky. According to the instructions, "the number of rings selected should be one more than the number of rings necessary to activate your Fax or answering machine." If the user doesn't know that, installation of the Faxswitch II will be something of an exercise in frustration.

That was certainly **GIZMO's** experience. We attempted to hook up the device with a Cobra Print Phone and a Code-a-Phone answering machine. We weren't able to get the Code-a-Phone to operate. Returning to the instructions, we found, in a note under an installation diagram, that with some answering machines, "a dual modular adapter might be required."

Finally, minus the answering machine, we got the Faxswitch II to do its switching with the fax—but not consistently. Sometimes it transferred the right call to the right instrument (fax or phone) and sometimes it didn't. We were pretty sure the problem originated with us and not with the device. Given a little longer to test and use this product, the kinks could probably have been smoothed out. ■

LIVING WITH BIRDS

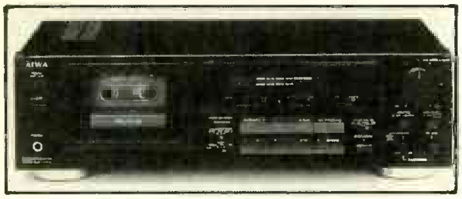
(Continued from page 5)

there are also users' forums and technical groups that provide supplemental information. Dedicated users often end up following congressional and regulatory activities in regard to satellite use, as well as studying trade journals for equipment advances and updates. Like the home computer, the satellite is one high-tech appliance that repays big dividends for careful study and attention.

All in all, we were delighted with our VideoCipher II and Ma/Com T-6 Tuner. So was someone else—ten months after installation, we were robbed by high-tech crooks who expertly cut the cable, removed the actuator from the dish and slipped off with the T-6 tuner, VideoCipher II, and our stereo VCR. They snubbed the TV. Despite the special authorization code formatted into the original equipment, and registered with the FBI, the machines have not been recovered. Presumably when the thief orders Showtime he will be caught.

In any case, tuner/descrambler technology is well into transition and the IRD unit is, according to the satellite gurus, the way to go. We'll have to try them, next. In the meantime, the dish assembly is a constant reminder of what we lost. ■

Gizmo/Bytes



Three-Head Cassette Deck

Three-Head Cassette Deck

Bias can be an ugly thing, especially in tape recording. The new *Three-Head Cassette Deck (AD-F780)* from *Aiwa* (35 Oxford Dr., Moonachie, NJ 07074) incorporates what's described as a unique bias shield that minimizes bias interference and reduces intermodulation distortion. The deck also features Super DX recording and playback heads, and Dolby-HX-professional, -B, and -C noise reduction. Other features include manual-recording calibration, IC-logic control, fluorescent display, and electronic tape counter, as well as memory rewind and repeat, switchable MPX filter, auto-tape and record-mute selectors, and record/play timer standby. Price: $450.

CIRCLE 38 ON FREE INFORMATION CARD

Loudspeaker Systems

Loudspeaker Systems

"Long-term listenability" is the audio watchword for the new *Monitor Series Loudspeaker Systems* from *Precise Acoustic Laboratories* (200 Williams Dr., Ramsey, NJ 07446). The first product line from the recently formed company, the five-model Monitor Series includes the *Monitor 10*, a three-way, tuned-port, floor-standing unit with a 10-inch woofer housed in an enclosure separate from a 6½-inch midrange and a 1-inch soft-dome tweeter. The cabinet dampens most vibration with absorbing material and grooves placed around each drive. The cabinet stands 44-inches high and is finished in a natural-oak veneer. Price: $1,500.

CIRCLE 39 ON FREE INFORMATION CARD

Gizmo/Bytes

Multi-Feature Telephone

The multiplicity of long-distance services makes simplicity of operation an important feature of any multi-feature telephone. The *Masterphone (MP100)* from *Dictograph Corp.* (3725 Walden Ave., Lancaster, NY 14086) delivers 30 major features in an easy-to-operate package. Instrument features include one-step connection to long-distance systems, "backspace erase" to correct mistakes in dialing, single-touch computer access (via the MP100's "transient memory system"), automatic disconnect, and automatic line selection. Multi-status display indicates which lines are in use, on hold, or busy. The phone also features a 100-phone-number memory capacity and a re-dial function that allows re-dial every five minutes or continuously. Price: $149.95.

CIRCLE 40 ON FREE INFORMATION CARD

Multi-Feature Telephone

Computer Desk

Keep computer hardware and tangled cords out of sight but right at hand with the *Computer Desk (CT2222)* from *Bush Industries* (P.O. Box 460, Jamestown, NY 14702). The monitor shelf's height is adjustable and the desk features two box drawers for stationery and office supplies, a large supply cabinet for disks and accessories, and a full-length overhead shelf. This light-oak desk is protected from wear and tear by a laminate finish and features a "clean contemporary look." Also pictured are a matching printer stand and corner unit, available separately. Price: $199.95.

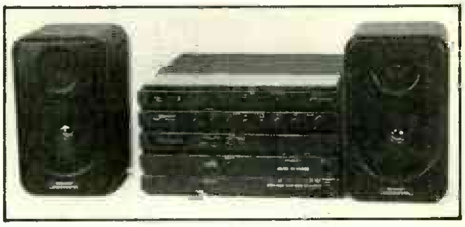
CIRCLE 41 ON FREE INFORMATION CARD

Computer Desk

Compact Music System

The trend, or at least a trend, in music systems currently is toward the clean, the direct, and the simple: elegance without any sacrifice of audio quality. The *Stereo Music System (CMS-NC50CD)* from *Sharp Electronics Corp.* (Sharp Plaza, Mahwah, NJ 07430) provides an entirely "user-friendly" system utilizing the concept of "ergonomic" design. The most frequently used controls are larger than other switches and adjustment buttons, and the AM/FM stereo-synthesized tuner features digital readouts and a 14-station preset function. The system also features automatic level-control recording, oil-damped soft eject, and two-way speakers. Price: $499.95.

CIRCLE 42 ON FREE INFORMATION CARD

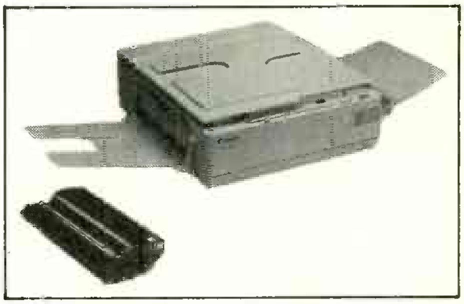


Compact Music System

Personal Copier

Canon (One Canon Plaza, Lake Success, NY 11402) has updated its line of personal copiers (see **GIZMO**, November, 1988). The new *PC-5 II Personal Copier* features replaceable cartridges that contain everything that might run out or wear out, including the drum, developer and enough toner to make over a thousand copies in any of five colors. The PC-5 II has a warm-up time of 18 seconds, with a first duplication taking 14 seconds; after that the unit reaches a speed of 6 copies per minute. The user can select a multiple-copy run of 1 to 9 and the system includes a 50-sheet paper feeder that handles sizes ranging from business card to letter-size sheets. The Canon Personal Copier weighs in at 26 pounds. Price: $895.

CIRCLE 43 ON FREE INFORMATION CARD

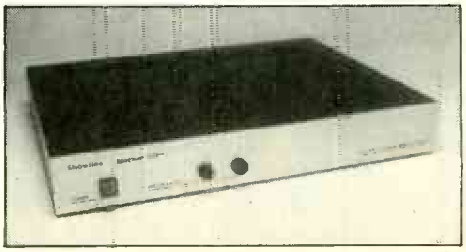


Personal Copier

Video Synchronizer

Sophisticated, broadcast-style video effects are within the grasp of the dedicated home-video enthusiast with the new *Spectrum Dual A/B Roll Frame Synchronizer (1000)* from *Showline Video* (120 Beacon St., Boston, MA 02116). The digital synchronizer pulls together any two video sources, connects to any VCR, and features independent freeze frame from either or both sources. The unit features S-Video (Y/C) inputs for compatibility with the new high-resolution VCR's, and external-sync input. Price: $2,995.

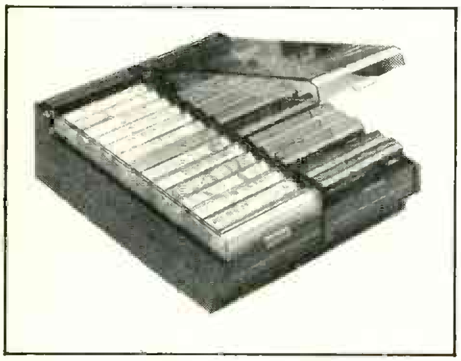
CIRCLE 44 ON FREE INFORMATION CARD



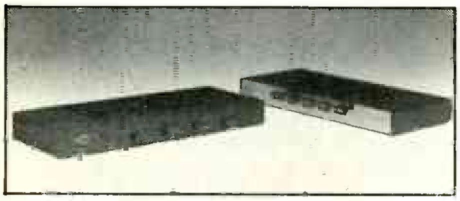
Video Synchronizer

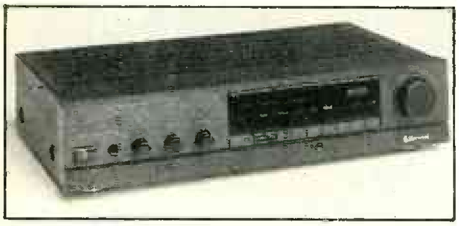
Gizmo/Bytes


Electronic Keyboard


Modular Storage Files

Radar Detector


Stereo Switcher


Integrated Amp


Dual-Line Telephone System

Electronic Keyboard

Sales figures tell the story of the increasing popularity of electronic keyboards. Six years ago, some 282,000 were sold; by 1987, according to the American Music Conference, a research organization, nearly 4.8 million were taken home by consumers. The *Tone Bank Keyboard (MT-540)* manufactured by *Casio* (570 Mt. Pleasant Ave., Dover, NJ 07801) gives the user 49 mid-size keys on a ten-note polyphonic keyboard with dual stereo-speaker effects. The 12-bit PCM-instrument sound generator and a "tone bank" of 20 PCM-instrument sounds equals some 210 sound combinations. An additional eight environmental sound effects are also part of the MT-540's audio arsenal. The electronic musician can select from 20 rhythms using 46 PCM-sound sources, a Casio chord system that harmonizes 16 sounds, and real-time memory. MIDI in/out orchestrates the Tone Bank with other keyboards as well as with personal computers. Price: $269.50.

CIRCLE 45 ON FREE INFORMATION CARD

Modular Storage Files

Get it together and take it with you. End the clutter of audio cassettes at home or on the road with the *Amalfi Smartfile Storage Unit (Audio 28)* from *Certron Corp.* (1651 S. State College Blvd., Anaheim, CA 92806). The sturdy black plastic box with see-through hinged lids holds 28 tape cassettes or 28 Sega game cartridges. Price: $14.95.

CIRCLE 46 ON FREE INFORMATION CARD

Radar Detector

It's a jungle out there on the interstate, rife with speed traps and home to thousands of radar detectors, among the most controversial electronics items to come down the consumer pike in recent years. A new compact *Cordless Radar Detector (RD-XL)* from *Maxon* (10828 N.W. AirWorld Dr., Kansas City, MO 64153) utilizes dual-conversion "MiniMizer" circuitry to detect an X- or K-band signal, verifies it as traffic surveillance, and alerts the driver in just one-tenth of a second. Maxon's "SmarTrac Anti-Falsing Alarm" is designed to prevent false alarms caused by other radar detectors. The RD-XL features a dark/mute switch, city/highway-mode selection, mounting hardware, and a soft-vinyl carrying pouch. Power is from six AA batteries. Price: $249.95.

CIRCLE 50 ON FREE INFORMATION CARD

Stereo Switcher

Get on top of your wall of sound with the *Speaker Switcher (SDS-4)* from *Sonance* (32992 Calle Perfecto, San Juan Capistrano, CA 92675). The unit is designed for connecting pairs of 8-ohm speakers to a single amp and operating any loudspeaker connected to it. With a power rating of 200 watts, the Speaker Switcher automatically adjusts impedance so that the amp never faces a load of more than 4 ohms. Price: $180.

CIRCLE 51 ON FREE INFORMATION CARD

Integrated Amp

More audio bang for the consumer buck is how *Sherwood* (13845 Artesia Blvd., Cerritos, CA 90701) characterizes its new *Integrated Amplifier (AI-1110)*. The unit offers 50-watts per channel, from 20-Hz to 20-kHz frequency response; headphone, tuner, CD, video, and DAT/auxiliary selector switches; and tape-input capabilities. Sherwood's direct switch is said to minimize phase delay and improve transient response. The amp has a surround-sound system at an impedance of 8 ohms and special fuse protection. Price: $169.95.

CIRCLE 52 ON FREE INFORMATION CARD

Dual-Line Telephone System

Decades ago, multi-line systems were confined to large office and factory installations, but today both home and small-business users increasingly seek multi-line flexibility. Enter the new *Advanced Two-Line Telephone System (GTE 4250)* marketed by *GTE* (One Standard Forum, Stamford, CT 06904). Even though no additional wiring or central control unit is necessary, GTE says it's possible to link up to six of these instruments together. Compatible with either loop or star wiring, a call-security feature ensures privacy. The GTE 4250 offers 40-number memory, electronic hold with visual indicators, three-way conferencing, and a re-dial that automatically tries again up to 15 times. Price: $179.95.

CIRCLE 53 ON FREE INFORMATION CARD

Nintendo Power

More than two million consumers are said to play various Nintendo home-video games and the game maker has taken the unusual step of establishing a bi-monthly magazine aimed at Nintendo fans. *Nintendo Power* is published by *Nintendo of America, Inc.* (4820-150 Ave. N.E., Redmond, WA 98052) and the four-color, hundred-page magazine reviews new games, runs contests, compares games, and previews new ones. It also is a forum through which the players can communicate both with the company and each other. Price (per year): $15.

CIRCLE 54 ON FREE INFORMATION CARD

Opus Phone

Tell it to Opus, the misunderstood, sensitive, flightless waterfowl star of the comic strip, "Bloom County." The *Opus Telephone* from *Tyco Industries* (855 Valley Rd., Clifton, NJ 07013) has a head that turns when the receiver is removed from the tele-fowl. The instrument features a pulse/tone switch, a last-number dialed recall, a mute button, and a limited warranty. The user can talk directly to Opus, but will the telephone answer back on its own? Price: $49.95.

CIRCLE 34 ON FREE INFORMATION CARD

Opus Phone

TV Monitor/Receiver

Many high-quality TV monitor/receivers do not give the viewer a complete picture. The culprit is the usual round-cornered screen. The Super-VHS compatible *TV Monitor/Receiver (YM-300)* from *Yamaha Electronics Corp. USA* (6660 Orangethorpe Ave., Buena Park, CA 90620) features a 30-inch square screen to deliver the total view. The YM-300, besides its square-cornered screen, includes a professional-performance comb filter that improves horizontal resolution to 560 lines and assures image sharpness regardless of video source. The unit's flexible tuner permits presets to be divided into two groups; it also includes a "memory skip" feature that marks only active channels and a lock-out capability so that access to selected channels can be controlled with a code. The YM-300 sound system includes a mode that simulates a stereo output from the front-mounted speakers. Price: $1,999.

CIRCLE 55 ON FREE INFORMATION CARD

Remote-Control Speaker System

Remote-Control Loudspeaker System

The idea here seems to be to tune the speakers to the listening ear instead of the other way around, but at this price the consumer had better be serious about his listening and ears. The *Pentaamplified Loudspeaker System (550)* from *Altec Lansing* (Milford, PA 18337), is rated at 1,400 watts, and features remote control that allows the system's 10 amplifiers to be adjusted up or down 6 dB in 2-dB increments. In the speakers, the midrange drivers and the tweeters are diamond coated. Woven carbon is used in the 10-inch subwoofer, 8-inch bass and 6½-inch mid-bass speaker cones. Upper-bass, lower-midrange, and upper-midrange drivers, and tweeter are housed in a separate, swiveling cabinet, allowing the subwoofers to remain stationary, for still further sensitive adjustment to listening environment and preferences. Price (per pair): $12,000.

CIRCLE 57 ON FREE INFORMATION CARD

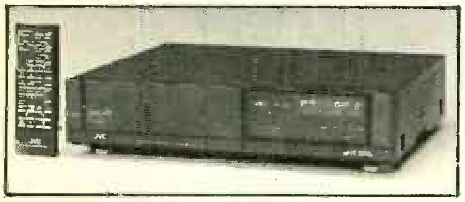
Clock-Radio/Telephone

The *Bedroom Phone Clock Radio (RP 1000)* from *Cobra Electronics* (6500 W. Cortland St., Chicago, IL 60635) helps the user find it in the dark and saves space bedside. The unit cradles a phone in a clock radio with a lighted keypad for in-the-dark calling. There's also last-number re-dial and a ringer-volume control. The AM/FM radio mutes when the telephone is used and features a snooze button, a 60-minute sleep timer, and an alarm with buzz tone or radio. The Bedroom Phone Clock Radio features a back-up battery, and its dial is part of the handset. Price: $59.95.

CIRCLE 58 ON FREE INFORMATION CARD

Clock-Radio Telephone

Gizmo/Bytes



Super-VHS VCR

Microchip Parrot

Wall Outlet Ionizer

Cassette Carrying Case

Super-VHS VCR

Without sacrificing the use of previous technology, video consumers can command the sophisticated capabilities of Super-VHS recording and playback at a resolution of more than 400 lines. The *HR-S5000U Super-VHS VCR* from *JVC Co. of America* (41 Slater Dr., Elmwood Park, NJ 07407) can record and play back in the standard-VHS mode and can use pre-Super-VHS software with picture quality ensured by HQ image-improvement circuitry. Features include a wide-bandwidth tuner, a tape-stabilizing head drum, and the four-video-head system used in two previous JVC models. The unit remote control, in conjunction with an on-screen programming menu, presets channels, sets the timer and clock, and is a unified controller for TV/VCR use. The HR-S5000U's real-time tape counter makes it possible to get to any point in the cassette via a "go-to" control for quick access. Hi-fi VHS-stereo sound has a dynamic range of 90 dB. The VCR can be used to edit, assemble, and audio dub. It also offers noiseless still picture, frame advance, and slow-motion playback. Price: $1,299.

CIRCLE 59 ON FREE INFORMATION CARD

Microchip Parrot

Besides having an enormously larger and more clearly articulated vocabulary than that of its living and breathing counterparts, the *Byte Bird* talking parrot from *The Sharper Image* (650 Davis St., San Francisco, CA 94111) doesn't require as much in the way of clean-up. No more scattered bird seeds. Along with repeating anything said to it, Byte Bird flaps his wings, moves his head and body, and makes parrot sounds (as long as his concealed switch is engaged). Sewn of soft plush, this bird weights 1½-pounds, is made in Korea, and comes with a one-year warranty. Sharper Image calls this the "parrot of the future." Price: $103.

CIRCLE 60 ON FREE INFORMATION CARD

Video Transfer Telescreen

Film-to-tape transfer equipment for home use is yet another sign that we're well into the video era. The German photographic and video equipment firm *Hama* (11916 Valerio St., N. Hollywood, CA 91605) has introduced a new *Video Transfer Telescreen (3012)* which the company says does double duty. The unit displays slides and movies to permit recording them with any video camera onto cassette and can also be used for "table-top viewing of movies or slides." The Telescreen's metal-coated front-surface mirror and its high-resolution glass screen make for high-quality transfers, and there's no need for complete darkness when viewing or copying slides and films. The screen area is approximately 64 square inches. Hama also offers a separate titling kit (*3015*) for adding titles or special effects in conjunction with Telescreen transfer. Price: $74.95.

CIRCLE 61 ON FREE INFORMATION CARD

Wall-Outlet Ionizer

The mail-order firm that offers the *Pollenex Ionizer* promises that once it's in use, "you breathe fresh, clean air in your home or office once again, as if you were standing on a green hillside after a spring rain." That seems a mighty tall order for such a compact device. From *Haverhills* (131 Townsend St., San Francisco, CA 94107) the Pollenex plugs into any standard 120 VAC outlet and can ionize the air in a space of up to 1440 cubic feet. The unit produces millions of negative ions that "act like magnets to sweep the air clean of smoke, dust, cooking odors, pollen, and other airborne pollutants." An occasional cleaning with soap and water keeps the Ionizer humming away. Price: $29.95

CIRCLE 62 ON FREE INFORMATION CARD

Cassette Carry Case

Yet another piece of equipment for toting around audio cassettes, this one is dubbed the *Denim Voyager (36130)* by its manufacturer, *Lebo* (60 West St., Bloomfield, NJ 07003) and is described as a "rugged denim bookbag smaller than a briefcase." Inside, a cassette tray features individual compartments for 48 unboxed or 30 boxed audio cassettes, or a combination of both. The tray can be removed and the Voyager can do double duty as an all-purpose case or commuter bag. The Denim Voyager features reinforced stitching for durability and comes complete with a matching handle and a clip-on shoulder strap. A second compartment can be used for a cassette player, headphones, and other items. Price: $26.

CIRCLE 63 ON FREE INFORMATION CARD

The BRIGHTEST and the BEST in CONSUMER ELECTRONICS

BY BYRON G. WELS,
Associate Editor

Who says there's nothing new in consumer electronics? Here are some products that were innovative enough to attract the eyes of even the most jaded reviewer!

You've probably heard the old saying: "Invent a better mousetrap and the world will beat a pathway to your door." And that's really what it's all about, isn't it? During the last Summer Consumer Electronics Show (called "Innovation") in Chicago, numerous new products were presented to a judging committee for design award honors. They were divided into one hardware and two software groups.

In this article we're going to take a brief look at some of the winners. Note the word "some;" there were 157 winners in all, and all were worthy in their

own way. But, since we're publishing an article rather than a book, we had to make some rather arbitrary decisions about which to include; also note that none of the software winners are presented here.

Serving as Chairman of the Judging Committee was Leonard Feldman, a highly respected technical writer and editor.

It was explained that each submitted product was first evaluated by a judge with expertise in the field the product was representative of. After that, the products were examined by the entire panel so that all of the entries received a fair trial.

We spoke to Mr. Feldman. He said, "When you are faced with over 500 entries and have to narrow the field down to perhaps 50 or so winners, it's important to define the criteria by which innovative products should be judged. All our judges agreed that engineering innovations, good styling and ergonomics, recognizable user benefits, and originality should be important in our selection process.

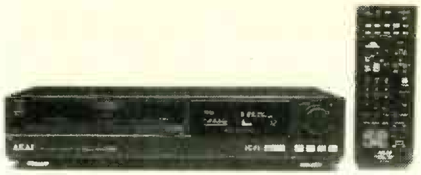
"Using those criteria, it was surprising how unanimous most of our choices were. There is no shortage of engineering and design innovation in the consumer-electronics field. Each new technological breakthrough brings a host of new products that deserve the kind of recognition represented by these awards."

Innovation. Innovation was a good name for this awards show, for most of the products submitted were indeed innovative. They leave you with a feeling of "Why didn't I think of that!" Here are some of the winners:

Akai Division, Mitsubishi Electric Sales America. VS-A77U-B VHS Hi-Fi VCR: This unit has quick start with built-in instant A/V true Dolby Surround-Sound decoding, selectable rear-channel delay line, and a 10-watt-per-channel power amplifier.

Asahi Research Corp. PC-50 Piggyback Video Light: A completely integrated light system for camcorders, the light head and battery pack become one unit. A safety "Tempox" precision glass with frosted finish provides even light distribution.

Atari Corp. Atari XE Video Game System: It plays a wide range of games and can even function as a personal



Model VS-A77U-B VCR: This is a quick-start, hi-fi VCR with Dolby Surround-Sound decoding (a first) and offers movie lovers theater-like sound at home. It features a 10 watt/channel stereo amplifier, and the four-head unit has a 167-channel, frequency-synthesized cable-ready MTS tuner, 8-event/1-year on-screen programming, and Quick-Index picture search. The deck comes complete with universal remote for up to 45 TV/audio functions.

PC-50 Piggyback Video Light: While many of today's camcorders can capture an image with very little ambient light, the resulting quality of that image with enhanced light can be magnificent. The results are pictures with snap and breathtaking color fidelity, and that is brought to you by the Asahi Piggyback. That integrated lighting system automatically adjusts for light intensity according to distance and brightness.

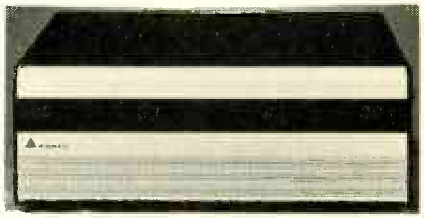
computer. It contains a full 64-kilobyte RAM for advanced gaming, word processing, and other home-computer applications.

Audio Access. PX-240 Compact Disc: Imagine the ability to store and play 240 discs, in a remarkably compact (17 × 1.7 × 6-½-inch) player. Extensive software includes automated playback by playlist, or randomly by type and tempo of music. It will even remotely control other devices around the house.

Azden Corp. WMS-4011 Wireless Microphone System: Designed for improved sound from camcorders, the pass-around hand-held microphone has a built-in transmitter and a clip-on receiver.

Blaupunkt. PSA 108 Parametric Sound Amplifier: This item cures the resonant acoustic distortions in over 83 different models of cars by tuning out, or "equalizing," the car's unwanted resonances.

CBM America Corp. Citizen Portable Fax Machine: The first Group-3 modular and portable combination Fax and copier, its ideal for use on-the-go or in a home office. It's lightweight and includes fine or normal resolution, halftones, auto contrast, and automatic/answer mode.



PX-240 Compact Disc: "How many times have you thought 'I wish we had music here...in the living room... kitchen...bedroom...outdoors by the pool?' This CD system can give you this, and more. You can send commands to your hi-fi and video system by touching a keypad on a wall or by pressing a button on a handheld control. One touch lets you listen to preset FM stations or scan, looking for something new. Touch again and you can hear compact discs, have music from your cassette deck, or complete control of your video system!"

WMS-4011 Wireless Mic System: "As the camera manufacturers developed newer and smaller camcorders with more sophisticated electronics and less shielding, wireless mics started picking up noises from the cameras. Hence we [Azden] developed a second generation of wireless mics, the Series II, with all-new circuitry to overcome these noises. The cosmetics also changed as we were able to reduce the size of both the receivers and transmitters by 40%, and we changed the mounting system so that the receiver could mount horizontally on the camera making it less cumbersome."

Cobra Electronics Group/Dynascan Corp. Cobra PP-1 10 "Print Phone" Portable Fax/Copier: This compact, personal Fax has the reliability and advanced technology of high-resolution contact-image sensors. The fully-portable unit doubles as a quality, full-page desktop copier.

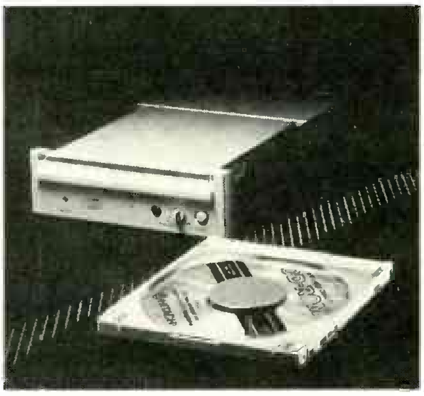
PP-110 Portable Fax/Copier: This unit is a portable Fax machine that doubles as a desk-top copier. It sends and receives a full page of copy in less than a minute over standard telephone lines. The PP-110 uses "clear print circuitry" with solid-state contact-image sensors for high-resolution Fax/copy use.

Duracell U.S.A. DL123A XL Lithium Battery: This is the first high-rate, three-volt, user-rechargeable lithium-battery line. They are designed to power "auto-everything" cameras. Light weight, outstanding shelf life, and excellent all-weather performance come standard. They will allow designers to down-size cameras and other devices.

DL123A XL Lithium Battery: The DL123A XL Lithium Battery uses prior research expertise, innovative engineering design, and state-of-the-art production technology. It realizes maximum performance together with safety, reliability, and long storage life for consumer applications. Unique features include the type, quality, and composition of the battery's active ingredients. Novel internal-design features and thermal-control materials permit the efficient utilization of the battery's active ingredients.

Fox Marketing, Inc. 080 Wireless Remote Radar Detector: It's the World's first two-piece remote radar detector that requires no wiring between the sensor module and the in-vehicle alert unit.

Hitachi Sales Corp. of America. CDR-3500 CD-ROM drive: The built-in half-height CD-ROM Drive holds up to 550 megabytes on one disk. Some of its features are high data reliability and audio capability; it has a disk cartridge for easy disk handling, and can be installed vertically.



CDR-3500 CD-ROM: The CDR-3500 is the smallest CD-ROM in Hitachi's lineup. It features 552 Megabytes of on-line memory that can be placed into a small computer. Miniaturized optoelectronic technology and attention to detail allowed Hitachi to design the unit for either vertical or horizontal use. It's now available in the half-height size.

Hitachi Sales Corp. of America. VY-55A Video Printer: Now you can get a hard copy from a TV screen in 80 seconds. The model is front loading for both paper and ink film, with 456 x 527-dot picture elements. It accepts NTSC, YG, and RGB input, and is adjustable by tint, contrast, brightness, and color controls. It even has a built-in mirror effect for iron-on prints.

Panasonic Co. KX-TV10 Integrated Video Phone: The next generation in telecommunications, this integrated video telephone enables users to see still images of the person they're speaking with. It offers a 4-inch monitor and a full-feature telephone with speakerphone and speed dialing.

Parsec of Delaware Ltd. The FM Dish: The dish (shown on page 61) is an FM antenna that includes a 3-stage tuning system. It delivers 40dB of gain and increases FM selectivity by up to 5dB. It can be Omni- or unidirectional.

Signamail: "It's a rainy afternoon. You put on a raincoat and run outside to get the mail. When you get there, the mailbox is empty. Did the mailman come? Did you receive any mail? A transmitter unit fits inside any standard mailbox. Signamail sends an electronic signal to your home receiver once mail has arrived. You stay dry and save valuable time."

Phoenix Gold. TRC-1 Digital Time-Base Generator and Field Synchronizer: Now any VHS or Beta VCR can be locked to any video camera without costly modifications. Combined with a special-effects generator, you can have a studio at home with this device. It does professional wipes, dissolves, and glitch-free switching.

Signamail Systems. Signamail: If you've got a curbside mailbox, and you're waiting for an important piece of mail, a rainy day or a cold winter's morning can result in several uncomfortable trips only to find the box empty. Signamail solves that problem. When the mail is delivered, Signamail lights a small LED inside the house to let you know the mail has arrived. If you do get mail, you're *still* going to have that uncomfortable trip to the mailbox, but at least it won't be in vain.

Sony Corporation of America. CDX-A20 Car CD Changer: This second-generation car compact-disc changer offers the utmost in versatility, and can be operated by a variety of controls, including a choice of two remote commanders or two AM/FM/Cassette removable DIN units. The CDX-A20 also incorporates Sony's advanced digital-audio technology.

We'd sincerely like to congratulate the winning firms and their design-engineering staffs with a "well done!" ■

HEADPHONE AMP FOR CD PLAYERS

BY JOHN CLARKE AND LEO SIMPSON

Many CD players do not have a headphone jack, even though there are many who would prefer to listen to their favorite discs via headphones. By the same token, there is something faintly ridiculous about feeding the CD's audio output to a stereo amplifier (which might have a power capability of 100-watts per channel) just to provide a few milliwatts of power to drive a set of headphones.

While several of the smaller CD players have the internal circuitry necessary to provide headphone drive, the headphone jack and volume control have been omitted. For most of us, the idea of any modification to a CD player (no matter how slight) would be totally absurd. However, the *CD Player Headphone Amplifier**—an external headphone amplifier, built around a pair of NE5534 low-noise op-amps—presented in this article is a much more attractive alternative.

The circuit (housed in a plastic enclosure and powered by a 9- or 12-volt AC power pack) is just about as simple as you can get without degrading the signal quality from the CD player. Mounted on the top of its enclosure is an on/off switch, a volume control, and a stereo headphone jack, with a 4-way RCA jack panel mounted to its side.

The 4-way RCA jack panel allows you to connect the CD Headphone Amplifier to your CD player for listening via headphones, while allowing the CD output signal be fed to an existing stereo system.

Even if your CD player already has a headphone jack, you may want to build the CD Player Headphone Amplifier. Some CD players don't include a headphone volume-control, which would allow you to boost or decrease the output signal level to provide a comfortable listening level. Either way, the CD Player Headphone Amplifier could be a big improvement.

How It Works. Refer to Fig. 1. The circuit is built around two Signetics NE5534 low-noise bipolar op-amps (one for each channel), which provide the necessary boost to drive the headphones. Unaided, most op-amps would be unable to handle the job. But the NE5534, with its unusually low noise characteristic, can drive 600-ohm loads at full output. That means that the NE5534 is capable of delivering more output current than most op-amps, which makes it an excellent op-amp for this application.

Since both halves of the circuit are exactly the same, we'll explain the circuit's operation in terms of the right channel. Keep in mind, however, that the left channel operates in exactly the same manner.

Op-amp U1 is configured as a non-inverting amplifier, providing a gain of about 3.7 as set by R3 and R4 (the 22,000-ohm and 82-ohm feedback resistors).

The input signal is fed through the

*This story first appeared in *Silicon Chip, Australia* (April, 1988); reprinted with permission wiper of R1 (a dual-ganged potentiometer) and coupled through C1 (a 0.1-µF capacitor) to the non-inverting input of U1. Capacitor C2 (a 22-pF compensation capacitor connected across pins 5 and 8 of U1) helps to keep the op-amp stable at the selected level of gain.

The boosted output signal of U1 is

Does your CD player lack a headphone jack? Here's a simple way to add one and make listening to compact discs easier than ever before!

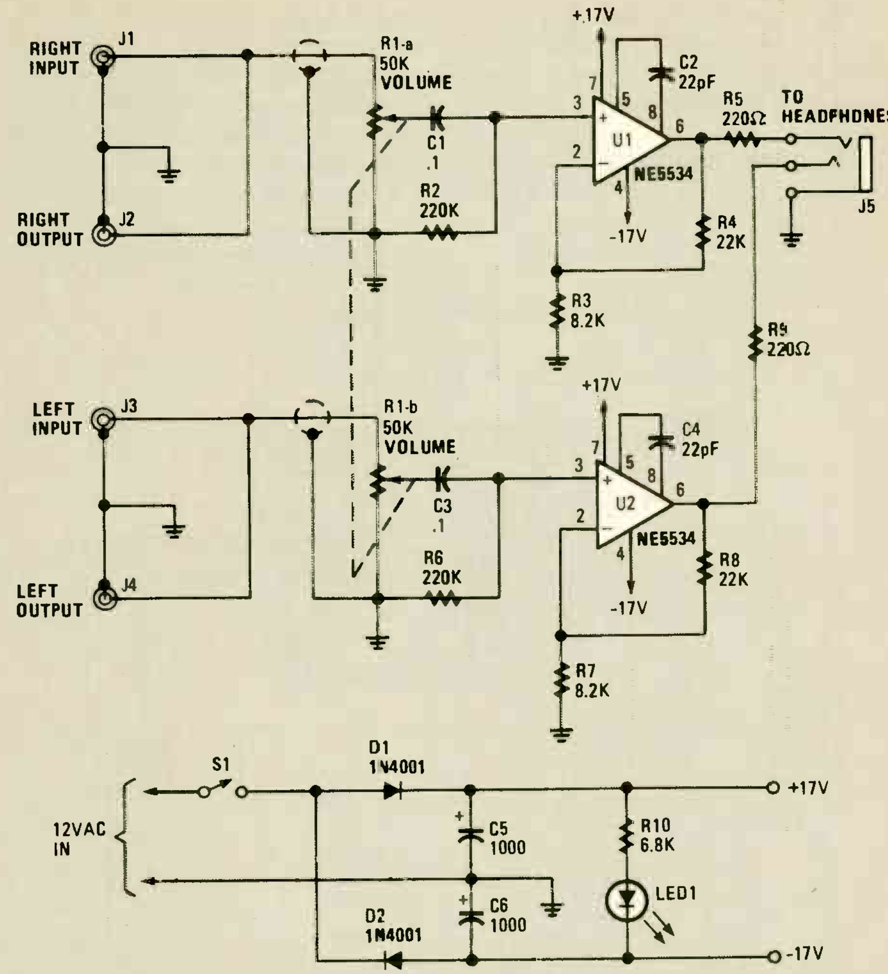


Fig. 1. The circuit—which is built around a pair of 5534 low-noise op-amps, allowing a very simple power supply to be used—gives excellent sound reproduction.

then fed to the headphones via a 220-ohm resistor (R5). That resistor limits the output current to a value that's safe for both the headphones and the op-amps. The circuit can drive just about any headphone to ear-shattering volume, whether the headphones have a low impedance (8 to 32 ohms) or a high impedance (600 to 2000 ohms).

The power for the CD Headphone Amplifier is provided by a 9- to 12-volt AC, wall-mounted power pack, feeding both a positive and negative half-wave rectifier circuit. The rectifier circuit—made up of D1 and D2—outputs ± 17 volts of unfiltered DC. The resulting DC output is filtered by C5 and C6 (two 1000-µF electrolytic capacitors), and then used to power the circuit.

Normally, such an op-amp circuit would require three-terminal regulators to provide balanced supply rails of ± 15 volts. But the 5534 op-amp is rated for operation up to ± 22 volts, which means that we can dispense with 3-terminal regulators. The op-amps also have excellent power-supply rejection, which means that any variations in the unregulated 17-volt supplies are ignored. That results in extremely quiet and hum-free amplifiers.

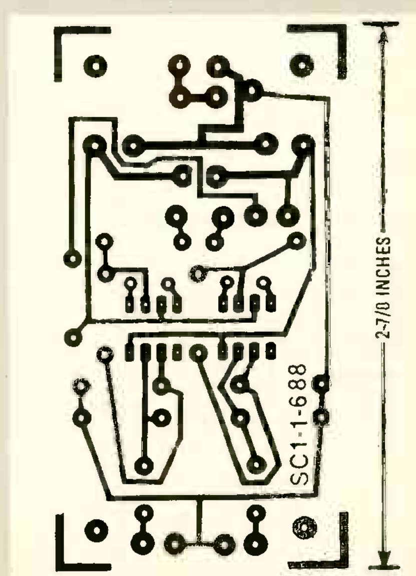


Fig. 2. Actual-size template for the CD Player Headphone Amplifier's printed-circuit board.

A light-emitting diode (LED1) connected in series with R11 (a 6800-ohm resistor) across the ± 17-volt lines serves as a power indicator.

Construction. The Headphone Amplifier was built on a printed-circuit board (PCB), measuring 2⅞ × 1½ inches and housed in an enclosure measuring 5¼ × 2¾ × 2 inches. A full-scale template of the CD Player Headphone Amplifier's printed-circuit board is shown in Fig. 2.

Once you've etched and drilled the board, and gathered all of the parts for the CD Player Headphone Amplifier, begin assembling the circuit using Fig. 3 as a guide. When assembling the circuit, take care that the polarized components are not inadvertently misoriented. For instance, installing just one of the rectifier diodes (D1 or D2) incorrectly would result in an inoperative circuit.

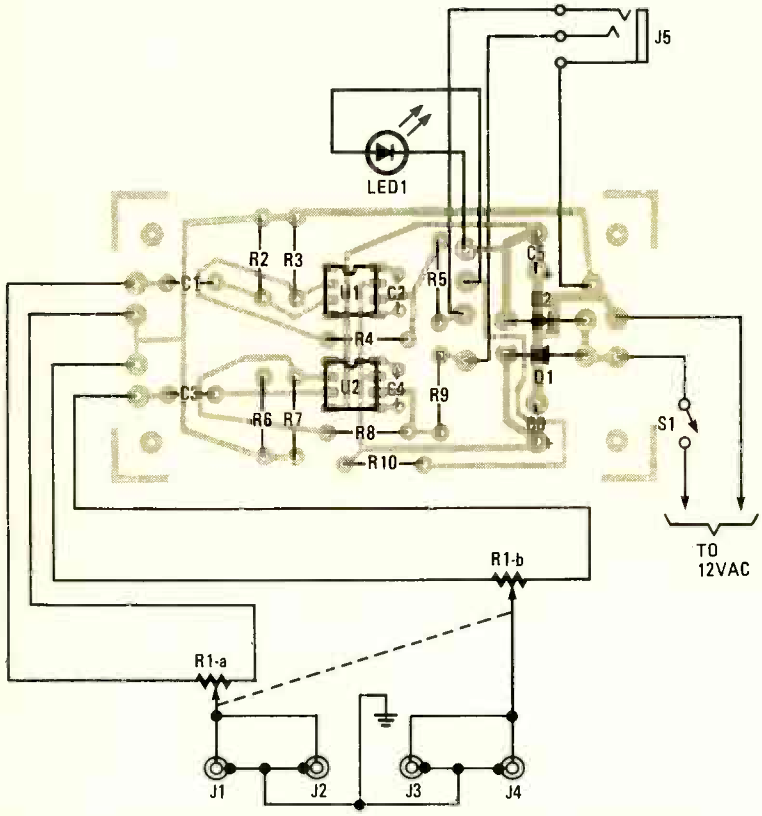


Fig. 3. Here is the parts layout for the CD Headphone Amplifier's printed-circuit board. Use shielded cable to connect J1–J4 though R1 to the circuit board.

PARTS LIST FOR THE CD-PLAYER HEADPHONE AMPLIFIER

U1, U2—NE5534 op-amp, integrated circuit
D1, D2—1N4002 1-amp, 100-PIV rectifier diode
LED1—Jumbo red light-emitting diode
R1—50,000-ohm dual-ganged potentiometer
R2, R6—220,000-ohm, ¼-watt, 5% resistor
R3, R7—8200-ohm, ¼-watt, 5% resistor
R4, R8—22,000-ohm, ¼-watt, 5% resistor
R5, R9—220-ohm, ¼-watt, 5% resistor
R10—6800-ohm, ¼-watt, 5% resistor
C1, C3—0.1-µF, metallized-polyester capacitor
C2, C4—22-pF, ceramic-disc capacitor
C5, C6—1000-µF, 25-WVDC, radial-lead electrolytic capacitor
J1–J4—4-way RCA panel jack
J5—Stereo headphone jack
S1—Single-pole, single-throw (SPST) switch

Printed-circuit or perfboard materials, enclosure, IC socket, 12-volt plug-in AC power supply, knob, coax cable, hookup wire, solder, hardware, etc.

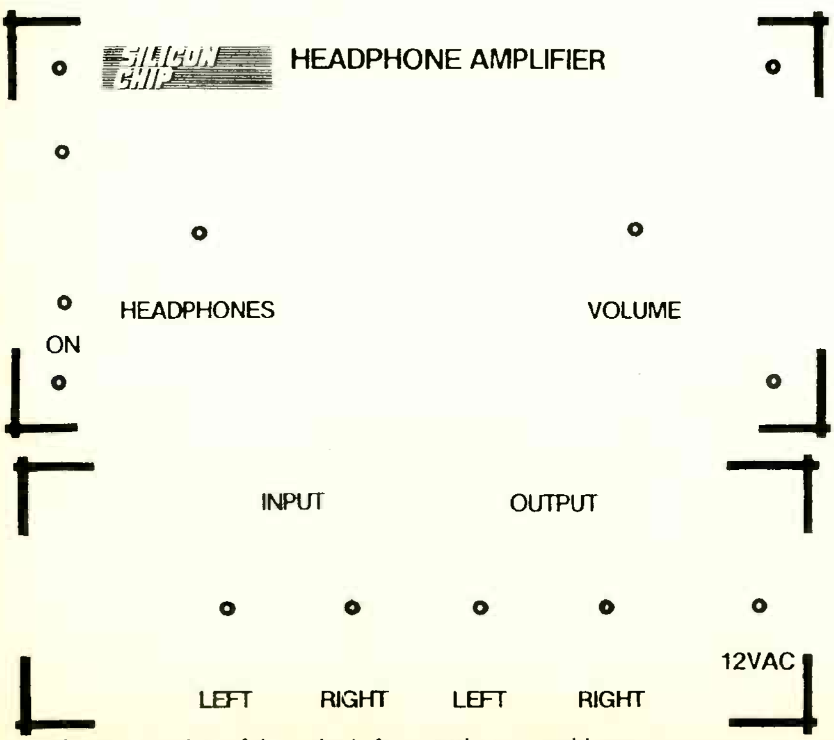


Fig. 4. This is a template of the author's front- and rear-panel layouts.

Once the circuit board is complete and you are reasonably sure that you've made no assembly errors, put the board to the side for a while and begin preparing the project's enclosure.

If the CD Player Headphone Amplifier circuit is to be used solely to drive a pair of headphones (and will not be feeding the output signal to a stereo system), only two RCA jacks are needed. However, if the circuit is to feed a stereo system, four RCA jacks will be needed. The four-jack version obviously provides greater flexibility.

Prepare the enclosure by drilling holes in the top of the enclosure for the volume control (R1), the headphone jack (J5), and the power switch (S1). On the side of the enclosure, drill the appropriate number of holes to accommodate the RCA jacks (J1 to J4 or J1

(Continued on page 108)

THE 555 CALCULATOR PROGRAM

This short computer program allows you to spend more time building 555-timer circuits and less time performing timer calculations.

BY JAMES TARCHINSKI

LISTING 1—TC-555.BAS

```
1000 CLEAR : WIDTH 80 : SCREEN 0,0,0,0 : KEY OFF : CLS : COLOR 11
1010 PRINT "***********************************************************"
1020 PRINT "*                                                         *"
1030 PRINT "*                555 TIMER CALCULATION PROGRAM            *"
1040 PRINT "*                                                         *"
1050 PRINT "*              (c) 1988 by James E. Tarchinski            *"
1060 PRINT "*                                                         *"
1070 PRINT "***********************************************************"
1080 LF$=CHR$(10)+CHR$(10)
1090 COLOR 11 : PRINT LF$+"Would you like to:" : COLOR 10
1100 PRINT
1110 PRINT "  1. Calculate circuit data from the component values"
1120 PRINT "  2. Calculate component values from circuit data"
1130 PRINT "  3. Exit the program"
1140 PRINT
1150 P$="Your choice: ": GOSUB 1560
1160 IF V<1 OR V>3 THEN BEEP : GOTO 1090
1170 IF V=3 THEN END
1180 IF V=2 THEN 1370
1190 '
1200 '================== CALCULATE CIRCUIT DATA ====================
1210 '
1220 PRINT LF$+"Enter the following components.": PRINT
1230 P$="R1 (ohms): " : GOSUB 1560 : R1=V
1240   IF R1<1000 THEN PRINT "(NOTE: R1 should be greater than 1000 ohms)"
1250 '
1260 P$="R2 (ohms): " : GOSUB 1560 : R2=V
1270 P$="C1 (uF):   " : GOSUB 1560 : C1=V/1000000!
1280   IF R1*R2*C1=0 THEN PRINT "ERROR: Illegal value(s)." : GOTO 1090
1290 '
1300 TH=.693*C1*(R1+R2) : PRINT LF$+"High time = ";TH;" seconds."
1310 TL=.693*C1*R2 : PRINT "Low time = ";TL;" seconds."
1320 DC=100*(TH/(TH+TL)) : PRINT "Duty cycle = ";DC;"%."
1330 PERIOD=TH+TL : PRINT "Period = ";PERIOD;" seconds."
1340 F = 1/PERIOD : PRINT "Frequency = ";F;" Hz."
1350 GOTO 1090
1360 '
1370 '================ CALCULATE COMPONENT VALUES ==================
1380 '
1390 PRINT LF$+"Enter the following parameters.": PRINT
1400 P$="Frequency (Hz): ": GOSUB 1560 : F=V
1410 IF F<>0 THEN 1450
1420   P$="Period (seconds): ": GOSUB 1560 : T=V
1430   IF T=0 THEN 1090 ELSE F=1/T
1440 '
1450 P$="Duty cycle (in %): ": GOSUB 1560 : DC=V/100
1460   IF DC<=.5 THEN PRINT "ERROR: Duty cycle must be > 50%.": GOTO 1450
1470   IF DC>=1 THEN PRINT "ERROR: Duty cycle can not be > 100%.": GOTO 1450
1480 '
1490 P$="Value of R2 (ohms): ": GOSUB 1560 : R2=V
1500   IF R2<1000 THEN PRINT "(NOTE: R2 should be greater than 1000 ohms)"
1510 '
1520 R1=R2*(2*DC-1)/(1-DC) : PRINT LF$+"R1 = ";R1;" ohms."
1530 C1=1440000!/(F*(R1+2*R2)) : PRINT "C1 = ";C1;" uF."
1540 GOTO 1090
1550 '
1560 '==================== INPUT SUBROUTINE ======================
1570 '
1580 COLOR 11 : PRINT P$; : COLOR 7
1590 INPUT "",IN$ : COLOR 10
1600 V=ABS(VAL(IN$))
1610 RETURN
```

There are two basic types of calculations that can be performed for any electronic circuit, regardless of the number of inputs or outputs it has: analytic and design. If the inputs to a given circuit are known, analytical calculations can be done to determine the corresponding outputs. On the other hand, design calculations are used to determine the circuit necessary to yield a desired output based on a specific input.

One reason for the popularity of the 555 timer/oscillator over other integrated timers is the simplicity of its design and analysis equations. Although the complexity of the equations may not warrant the use of a computer program to perform the number crunching, the frequency with which they are performed does.

TC-555.BAS is a BASIC-language program for the IBM PC and PC compatible computers designed to perform both types of calculations for oscillating 555-timer circuits. A printout of the program is given in Listing 1.

Before we look at how to use the TC–555.BAS program, lets examine the circuit theory that the program is based upon.

Circuit Theory. Figure 1 is a schematic diagram of the 555-timer's standard *astable* (oscillating) configuration. In that mode of operation, three external components must be used with the 555: R1, R2, and C1. Those component values are inputs to the timer-circuit program. By altering the values of those components, the waveform on pin 3—the output pin of the 555—can be adjusted.

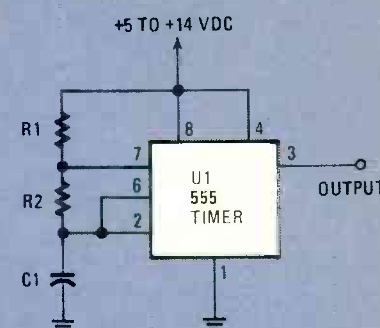


Fig. 1. Here's a 555 timer set up in its standard oscillating configuration. The timing is fairly independent of the supply voltage which is shown as a range.

A graph of the output of an astable 555 is given in Fig. 2. Note the two output variables: TH, the length of time pin 3 is high, and TL, the length of time it's low. Other important output parameters, such as the circuit's frequency and duty cycle, can be easily derived once TH and TL are known.

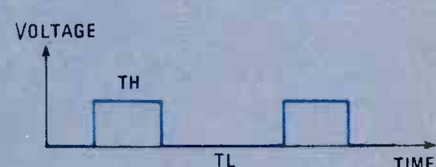


Fig. 2. The output waveform found on pin 3 of an oscillating 555 timer consists of high and low alterations.

Two equations yield the circuit's outputs (TH and TL) given the circuit's inputs (R1, R2, and C1). The equations are:

$$TH = 0.693(R1 + R2)C1$$
$$TL = 0.693(R2)C1$$

Once TH and TL are known, the circuit's period, frequency, and percent duty cycle can be derived by applying the equations:

$$PERIOD = TH + TL$$
$$F = 1/PERIOD$$
$$D = 100 \times TH/(TH + TL)$$

Where PERIOD, F, and D are the period, frequency, and duty cycle, respectively.

Those five equations allow you to calculate the circuit's output from its component values, but what about a set of design equations to give you component values given the desired output? Notice that the circuit has three input variables but only two output variables. It would therefore be impossible to derive specific values of R1, R2, and C1 knowing only TH and TL. Because of that TC–555.BAS requires you to assume a value for for R2. It can then calculate the values for R1 and C1 necessary to obtain a desired output. The computer requires that you enter three pieces of information: (1) either the period or frequency of the circuit, (2) the required duty cycle, and (3) a value for R2.

The following design equations and the equation for F, are used by the program to determine the values of R1 and C2, once the three pieces of information are entered:

$$R1 = R2(2D - 1)/(1-D)$$
$$C1 \text{ (in } \mu F) = 1440000/(F(R1 + 2R2))$$

Program Operation. After you enter TC–555.BAS into your computer, immediately save it to disk to protect against a Murphy's Law catastrophe. (If you think Murphy really has it in for you, you might want to save a backup copy of the program as well.) Next you'll want to test the program by feeding it values for known circuits. Two examples are given below for that purpose, and to demonstrate how to use TC–555.BAS.

In the first example, the output characteristics of a circuit are derived from these inputs:

R1 = 10,000 ohms
R2 = 1,000 ohms
C1 = 47 µF

The session should look like this:

```
***************************************************************
*                                                             *
*              555 TIMER CALCULATION PROGRAM                  *
*                                                             *
*           (c) 1988 by James E. Tarchinski                   *
*                                                             *
***************************************************************


Would you like to:

        1. Calculate circuit data from the component values
        2. Calculate component values from circuit data
        3. Exit the program

        Your choice:?
```

The user of the program will be greeted with this opening screen that announces itself and prompts for the desired operation including program termination.

Would you like to:

1. Calculate circuit data from the component values
2. Calculate component values from circuit data
3. Exit the program

Your choice: 1

Enter the following components:

R1 (ohms): 10000
R2 (ohms): 1000
C1 (uF): 47

High time = .35281 seconds
Low time = .032571 seconds
Duty cycle = 92.66666%
Period = .390852 seconds
Frequency = 2.558513 Hz

In the second example, we seek the values of R1 and C1 needed given:

PERIOD = 1.5 seconds
D = 60%
R1 = 10,000 ohms

The corresponding session should look like this:

Would you like to:

1. Calculate circuit data from the component values
2. Calculate component values from circuit data
3. Exit the program

Your choice: 2

Enter the following parameters

Frequency (Hz):
Period (seconds): 1.5
Duty cycle (in %): 600
Value of R2 (ohms): 10000

R1 = 5000.002 ohms
C1 = 86.39999 µF

Notice in the listing of the second example that nothing is entered in response to the "Frequency (Hz):" prompt. If anything were entered, the computer would use the frequency to determine the circuit's period, and it would not prompt you to enter the period. Only one of the two values are needed, not both.

Program Description. The first task that any computer program should perform is variable and system initialization. That is just what lines 1000–1080 of TC–555.BAS accomplish. Variable storage is initialized, the screen is set to 80-column mode, the function keys are turned off, and the screen is cleared all in the first line of code. After a short program header is generated, line 1080 then defines the string variable LF$. LF$, which stands for Line Feed, is used throughout the program to print blank lines on the screen.

After initialization, the program proceeds to print the menu, which gives the user the option of calculating the output characteristics from the component values, calculating the component values from the output characteristics, or exiting the program. Line 1150 allows a selection to be made, then lines 1160–1180 check the validity of the input and take the appropriate course of action.

The next section of code, 1200–1360, calculates the circuit data from the entered component values. After the output characteristics are displayed by lines 1300–1340, line 1350 then returns to line 1090, and the menu is again displayed. A similar format is found in another section of the program (lines 1370–1550), where component values are calculated from a circuit's output.

One subroutine is used to receive all the data for the program. The subroutine begins at line 1560 and returns the value entered by the user in the variable "V." Note that an ABS instruction is used in case a negative value is accidentally entered. ■

EXPERIMENTER'S

METAL DETECTOR

Use this student's model to learn how metal detectors work, then use it to find some burried treasure!

By Stan Czarnik

People just getting started in electronics often have trouble finding projects simple enough for them to understand and complete in a short space of time. The *Metal Detector* described in this article is neither hard to build, nor difficult to understand. Putting this circuit together will help you become familiar with the operation of transistors and the action of inductor-capacitor circuits.

But best of all, you can have the whole thing up and running in a couple of hours.

How It Works. The Metal Detector circuit—as shown by the schematic diagram in Fig. 1—consists of a simple common-emitter oscillator; the output frequency of the oscillator falls within the AM broadcast band.

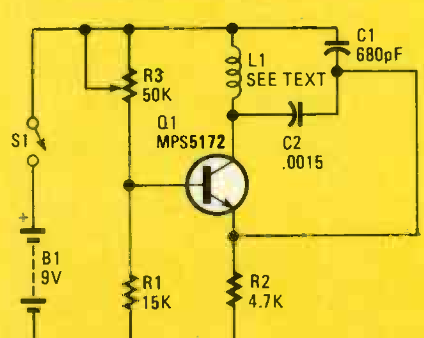


Fig. 1. The metal detector system is based on a simple transistor oscillator. This is one construction project that will not consume a lot of time.

When switch S1 is closed, electrical energy is fed through potentiometer R3 to the base of Q1, forward-biasing it. That causes Q1 to turn on, permitting a current to flow through a parallel-resonant LC tank circuit consisting of L1 and C1. Transistor Q1 is also used to control the current in the tank circuit.

Capacitors C1 and C2 charge and then discharge, as current flows through inductor L1, creating an electromagnetic field around the coil. When current flow ceases, the magnetic field collapses and the energy is converted back into electricity. That permits the capacitors to charge and the cycle repeats itself. The center tap between C1 and C2 provides positive feedback to the emitter of Q1.

Now, how can this circuit be used to

detect metals? The key is the magnetic field around the inductor. When ever a conductor such as iron, copper, silver, gold, etc., is brought near the inductor, it is inductively coupled to the inductor via the magnetic field. That causes the resonant frequency of the tank circuit, and therefore the oscillator frequency to change. Since the oscillator frequency falls within the AM broadcast band, those changes can be heard by monitoring the oscillator on a conventional AM radio.

Construction. The components needed to build the Metal Detector are fairly common, and you may already have them in your junkbox. The circuit layout and method of construction is not critical. The author chose to build the circuit on printed-circuit board. If you decide to use a printed-circuit board too, a suitable template for the board is shown in Fig. 2. If you wish, a kit of parts, including a silk-screened printed-circuit board from the source given in the Parts List.

Note from the photos that the author did not choose to place his circuit in an enclosure, but instead, opted to mount the circuit board on a block of wood. If you follow the author's lead, it will be necessary to drill two or three holes in the board to allow for mounting. Do the drilling before installing any components. Be very careful when doing the drilling. While the exact location of the holes is not crucial, it is imperative that you do not sever any of the copper traces.

Mount and solder the components as indicated on both the face of the circuit board and in the parts-placement diagram (Fig. 3), with one exception. Instead of attaching the inductor directly to the board, solder a couple of short pieces of hook-up wire to the inductor position. Those are to be connected to a pair of binding posts. The binding posts make it possible to experiment with different types and values of inductors.

Once you've mounted and soldered all the parts, you'll be ready to fasten the circuit board to the wood block. But first check your work for construction errors—poor solder joints, solder bridges, etc.

Place a ¼-inch spacer on each of the screws between the board and the wood block; they keep the board a safe distance from the wood block. Do not screw the circuit card directly to the block; you might break it.

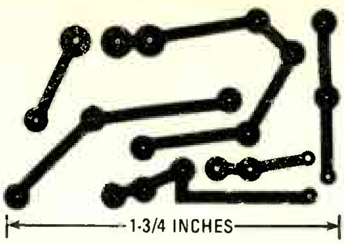


Fig. 2. This full-scale printed-circuit foil pattern may be used to produce your own printed-circuit board.

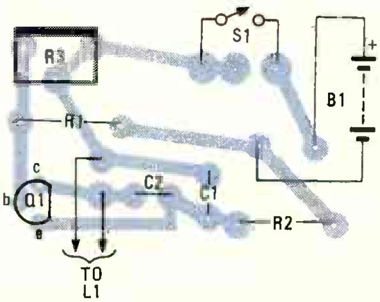
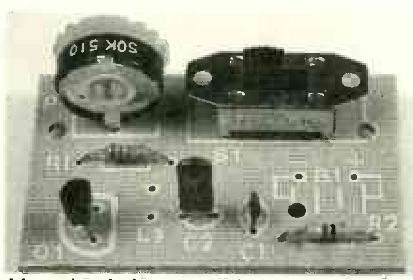


Fig. 3. If you've elected to etch your own printed-circuit board from the foil pattern provided, follow this layout.



Mounting holes are drilled in the board before any components were installed. Be careful when drilling the holes, so as not to sever the copper traces.

PARTS LIST FOR THE METAL DETECTOR

Q1—MPS5172 general-purpose NPN silicon transistor
R1—15,000-ohm, ¼-watt, 5% resistor
R2—4700-ohm, ¼-watt, 5% resistor
R3—50,000-ohm potentiometer
C1—680-pF, ceramic-disc capacitor
C2—0.0015-µF, polyester capacitor
B1—9-volt transistor-radio battery
L1—See text
S1—Single-pole, single-throw slide or toggle switch
Printed-circuit or perfboard materials, AM radio, wood or plastic block, 9-volt battery snap and holder, binding posts, soldering lugs, aluminum spacers, hook-up wire, solder, tape, hardware, etc.

Note: A complete kit of parts for the Metal Detector is available for $6.95, plus $2.50 S/H, from Consolidated Electronics, 705 Watervliet Ave., Dayton, OH 45420-2599; Tel. 513/252-5662. Note: All orders subject to a $10.00 minimum.

The author's prototype was mounted on a wood block of about 4½-inches long, 2¾-inches wide, and ¾-inch thick. Position the circuit board, binding posts, and a 9-volt battery holder wherever you wish.

The Coil. It will be necessary to wind your own coils. If you've purchased the kit, then you already have the wire with which to wind your coils. But that wire may be a bit difficult to work with. About 45 or 50 feet of 26-gauge enamel-coated magnet wire is a good alternative. You will also need a circular form on which to wind the coil.

The form should be about 4 or 5 inches in diameter; the open end of a large plastic cup works fine. A form of that size will take 30 to 35 turns of wire. The leads coming off the coil should be at least several inches long. Don't forget to scrape the insulation from the ends of the wire before connecting the coil to the oscillator. Hold the coil together with some tape.

Operation. Obtain a small AM radio. Place the radio close to oscillator. The trick to getting the Metal Detector to operate properly lies in tuning the oscillator to an unused radio frequency. A few minutes of trial and error experimentation may be necessary.

Start by turning on the radio and cranking up the volume. Find a spot on the radio dial that is clear of radio stations. Try looking between 900 and 1200 kHz. If you live in or near a large city (like I do), finding such a spot can be a bit difficult. You may have to settle for a frequency with a low-level signal, but the metal detector should still function; the signal coming from the oscillator will overpower the weaker signal coming from the radio station.

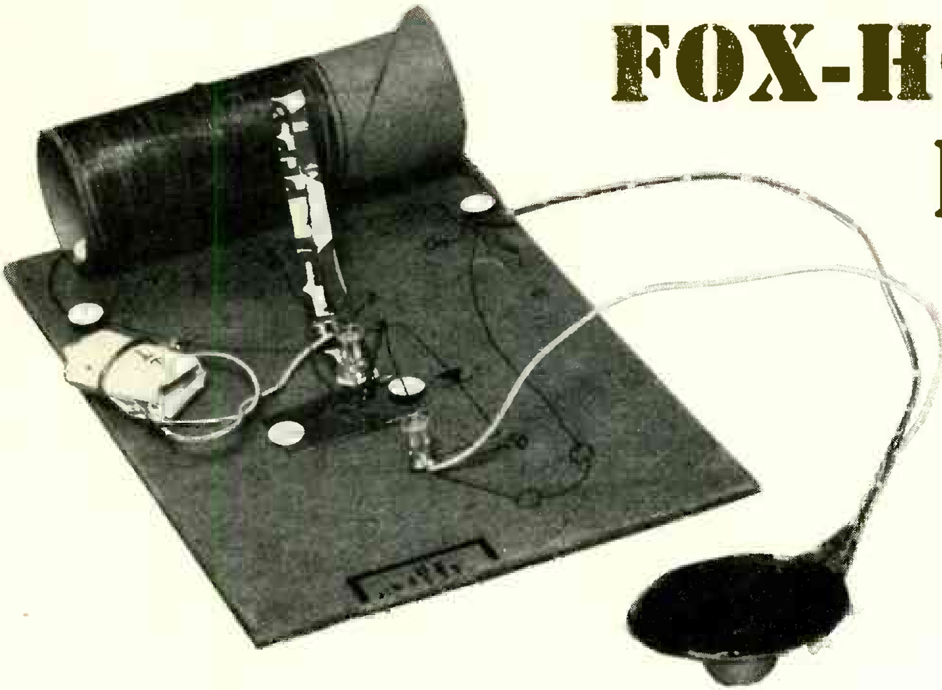
Using a fresh battery in the detector is very important. Also, you may need to operate the radio at full volume, so make sure that the noise will not disturb anyone.

Switch on the oscillator and rotate the potentiometer slowly. That changes the frequency generated by the oscillator slightly. Keep turning until you hear the oscillator output; you'll know it when you hear it (I got something between a whistle and a squeal).

Pass a piece of metal over the coil and listen closely to the sounds coming from the radio. The shift in frequency will follow the movements of the metal object.

(Continued on page 103)

BUILD AN AUTHENTIC FOX-HOLE RADIO



Put your ingenuity to the test by building this fox-hole radio using the same materials and techniques as your grandfather.

BY KEENAN WHITLEY

The *Fox-Hole Radio* was probably the most popular electronic project from the end of World War I to the beginning of World War II. I can't tell you the actual number of Fox-Hole Radios (originally called *trench* radios—the term *fox hole* came about during World War II), but ever since the returning doughboys brought the concept to America, tens of thousands must have been built every year thereafter for some time.

It was easy to build, and the emerging radio broadcasting industry was transmitting radio programs that everyone wanted to hear. If you had one in your home during the early twenties, you were bound to be quite popular, as evidenced by many visiting friends on Saturday night.

Now you can build one as I did—a component at a time. There's no challenge in running down to the local electronic-parts store to buy what you'll need. In the 1920's there were few if any electronic-parts stores in the cities and towns of North America. Do what great granddad did—scrounge and scrape up materials around your home, and don't spend a penny.

Putting it Together. When I sat down to build a primitive radio, I was handicapped by not having a variable capacitor or high-impedance headphones, so I had to design a radio that did not use them (See Fig. 1). You will have limitations when building your radio too. Think out practical solutions other than buying the materials. The fun in the project is to use what you can scrounge from your parts box or a junk heap.

I wound scavenged wire onto an emptied toilet-tissue roll to make my tuning coil. In place of the roll you could use a wood dowel of the same size. The enamelled wire came from an old television set's power transformer. Look for one that's not dipped in tar or other sticky stuff. If you use wire from a transformer, you'll have to take the transformer core apart to get at it. That's because the coil was wound first and then the metal laminated core was placed around it, so you'll have to undo what the manufacturer did in reverse order. Be careful not to kink the wire as you remove it from the form.

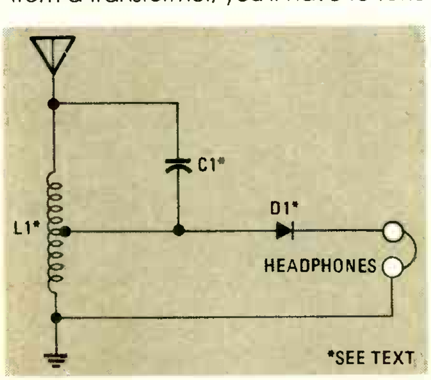
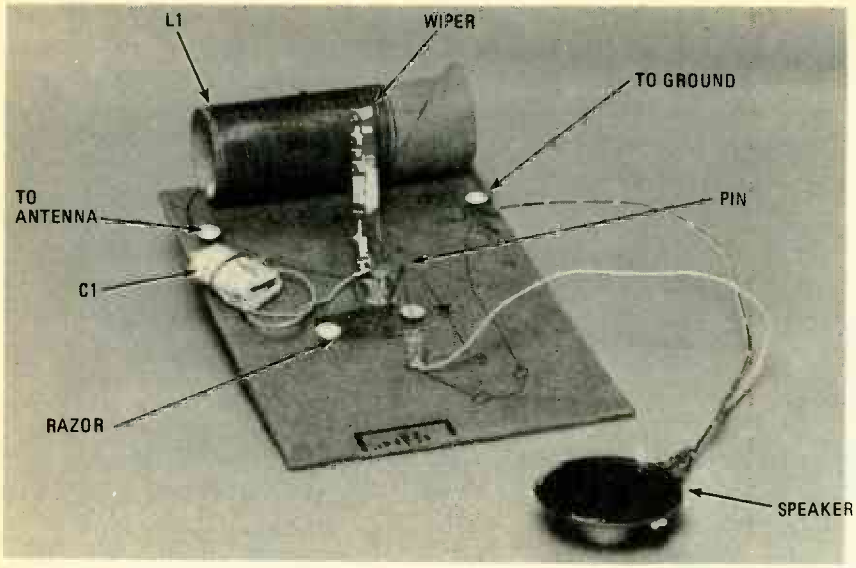


Fig. 1. The diode in this schematic is just used to represent the detector stage, don't take the symbol literally.

Make as many turns of enamelled wire as you like for your first model; that's what I did. It is best to wind from end to end leaving about a ¾-in. space at each end. Wind the turns close together. The enamel on the wire prevents the turns from shorting to each other. If you have some clear lacquer, either brush or dip the lacquer onto the form to lock the coiled wire in place and give strength to the paper form. Do not use metallic staples (or brads for a wood dowel) to secure the wire's ends. Instead, puncture or drill small-diameter holes at each end and lace one wire lead through each.

Use a piece of No. 400 sandpaper, fine emery cloth, a knife blade, fingernail file, or whatever to remove the enamel insulation from the solid copper wire in an area about one-inch wide down the entire length of the coil. Do it gently. Do not sand through the copper wire or inadvertently move one coil's bare surface onto another causing a shorted turn. Blow the dust away; the dust contains copper parti-



The positioning of the parts on the board you use is not critical. Notice how the capacitor is bundled instead of being rolled up to demonstrate how forgiving the circuit is.

cles that may cause a shorted turn in your tuning coil.

Secure the tuning coil to the breadboard chassis. My original prototype was tacked directly to my workbench, but if you work on a kitchen table, think twice—everyone must use the kitchen. The project photographed for this magazine was assembled on a Masonite hardboard with thumb tacks and pushpins to mount most of the parts.

The Tap. Now rummage through the kitchen trash bin to find a metal can. Beer cans and soda cans are easiest to cut. Coffee and food cans are second best. Cut a strip about 1-½-inches wide and about six-inches long. I cut up a soda can with a heavy butcher knife (I forgot where I left my old pair of scissors, which would work as well). Tin snips are best if you have them. Maybe you can find a metal strap that only needs the ends trimmed.

Handle the metal strip carefully or the strip may not be the only thing cut! Use pliers to fold the long edges of the strip and crimp them down to form harmless edges. Two electricians' pliers make it easy and safe to do, but you may wish to place the strip in a vice and bend it instead. Punch a hole in one end with a nail and fold the other end back as you did the sides. (When these radios were first made, no one owned an electric drill.) Now sand or scrape the paint off both ends. Attach the strip to the board with a nail through the hole so it can pivot. The other end of the strip must touch the sanded area of the coil at all points along the coil's length as it will be used as a wiper. If you use a pine board, a round-head wood screw can secure the strip and permit it to rotate. If you use a screw, it should be snug enough so that the strip does not move after being positioned if the radio is jostled. However, the strip should be loose enough so that the strip turns freely. I used pushpins for my unit, and that worked very well.

Making a Fixed-Value Capacitor. Now on to the kitchen. You'll need to cut two strips of aluminum foil about 1-inch wide and 6-inches long. That will be the capacitor. Or you can use the foil-lined paper from a pack of cigarettes. Make three slightly larger strips of paper and sandwich the foil between them in this order: paper, foil, paper, foil, paper. You should end up with a five-layer thick strip. Attach leads to each of the foil layers, and roll or fold strip to a convenient size. Secure it with Scotch tape, a rubber band, or tape. Attach one lead to one lead of the coil, and the other lead to the pivot for the tap.

From the other end of the coil, run a wire to ground. To make an earth ground, I drove an old curtain rod 18-inches deep into a flower bed. I know that there are better electrical grounds in the house, but the doughboys of WWI lived in wet trenches and used bayonets. I neither live in a trench nor own a bayonet so I compromised.

PARTS LIST FOR THE FOX-HOLE RADIO

- C1—Two pieces of aluminum foil separated by paper.
- L1—Many turns of enameled wire wound on a tissue roll or dowel (see text).
- Antenna—length of wire over ten feet long, insulated or not, with glass, ceramic, or plastic insulators.
- Coil tap—Any piece of metal around ½ inch wide and 6 inches long (see text for more information).
- D1—Razor-blade detector, or any diode or rectifier of low-level radio signals.
- Headphones—1000-ohm headphones or any 16-ohm or higher transducer with matching transformer.
- Main Board—A piece of ¾-in. pine shelving, hardboard, thick cardboard, etc.

The Detector. If this is your first try at a crystal-type receiver, I suggest that you dispense with authenticity for a while and use a small-signal diode of any type. Many RF detectors as well as the legendary razor blade (which we'll cover shortly) will work. If the antenna is long enough, you can even use a 3A3 high-voltage rectifier tube from an old TV set.

If using a diode to start with, don't worry about its polarity—the headphones can't tell the difference. Then, after the Fox-Hole Radio is operational, you can replace the diode with a razor-blade detector.

Start making the razor-blade detector by tacking or nailing a quench-blued razor blade onto to the project board and run a wire from it to the coil's wiper. A quench-blued razor should be used because the oxide layer on it helps to rectify the radio signal. Tack down some strong solid wire near the blade and wrap the free end around a straight pin. Position the pin's tip so that it makes light contact with the flat surface of the blade.

No matter which detector you use, attach one end to the pivot on the tap and the other end to one side of the headphones. The other side of the headphones should be connected to ground.

Headphones. You will probably not come across high-impedance headphones in your junkbox. There is no need for them in this semiconductor age with its inherent low-impedance output. You may find some odd-ball miniature speakers with impedances

(Continued on page 96)

E-Z MATH

DeMORGAN'S THEOREM

BY LOUIS E. FRENZEL, JR.

With two powerful yet simple rules, you can design and analyze circuits of NAND and NOR gates

In the previous two articles, I introduced you to Boolean algebra and showed you how to analyze and design digital-logic circuits. You learned about truth tables and basic Boolean rules for minimizing complex logical expressions. There is one additional theorem that you need to learn. It is known as DeMorgan's theorem, and I devote this article to it.

DeMorgan's theorem is important as it gives us a set of rules and procedures for working with NAND and NOR circuits. Since the majority of integrated-circuit gates are of the NAND or NOR variety, you can't design too many circuits without DeMorgan's theorem. Knowing the theorem will also help you to understand that any logic gate (AND, OR, NAND, NOR) can be used to perform virtually any logic function, as you will see.

Explaining DeMorgan's Theorem. There are two basic forms of DeMorgan's theorem. Those are:

$$\overline{A+B}=\overline{A}\,\overline{B}$$
$$\overline{AB}=\overline{A}+\overline{B}$$

Take a minute and look at those two equations and try to determine what they mean. DeMorgan's theorem is telling you that an OR expression can be rewritten as an AND expression and vice versa. More specifically, the term on the left-hand side of the first equation is the familiar NOR expression, while the term on the left in the second equation is the familiar NAND equation. DeMorgan's theorem tells us that the NOR term in the first equation is equal to the complemented A and B terms ANDed together. In the second equation, DeMorgan's tells us that the NAND expression is equal to terms A and B inverted and then ORed.

You can prove to yourself that the AND and OR expressions are equal to one another by using truth tables. For example, let's take the second equation and prove that both sides are equal with a truth table (see Table 1). With two input signals—A and B—there are four possible input combinations. We then proceed to produce the other terms in the equation needed, including $\overline{A}$, $\overline{B}$, $\overline{A+B}$ and $\overline{A}\,\overline{B}$. As you can see, the fourth and seventh columns, $\overline{A+B}$ and $\overline{A}\,\overline{B}$, are equal. Study the truth table carefully to be sure that you understand how it was used.

Exercise 1. To ensure that you understand the process, use a truth table to prove the equality of the terms in the first DeMorgan equation. Once you have done that, check the answers against those at the end of the article.

Like other Boolean rules, DeMorgan's theorem will help you to reduce logical expressions to their minimal form. It will also allow you to change AND expressions into OR expressions, or OR expressions into AND expressions. The biggest value of DeMorgan's theorem is in working on Boolean expressions that have a NOT bar over the complete expression. A typical example is:

$$X=\overline{A+\overline{B}+C+(\overline{\overline{A}C})}$$

None of the Boolean rules shown earlier will permit you to make any changes in the expression as it stands; the NOT bars stop you cold. But when you use DeMorgan's theorem, you can easily manipulate the terms and change the expression into other forms.

We will show you how to apply DeMorgan's theorem to an expression like that in just a minute. But first, let's take a look at how we can change equations from one form to another using the two basic DeMorgan expressions.

Assume that you start with the left-hand term of the first DeMorgan equation above. What procedure can you use to convert it to the term on the right? The procedure is relatively simple, consisting of the following steps:

a. Change the OR sign to an AND sign or vice versa.

b. Complement each variable in the expression individually.

TABLE 1—DeMORGANS THEOREM

A	B	(A+B)	$\overline{A+B}$	$\overline{A}$	$\overline{B}$	$\overline{A}\,\overline{B}$
0	0	0	1	1	1	1
0	1	1	0	1	0	0
1	0	1	0	0	1	0
1	1	1	0	0	0	0

c. Complement the expression.

The procedure actually works for both forms of DeMorgan's theorem. Let's apply it to the first DeMorgan's expression so that you can see how the procedure works.

We start with the left-hand side of the equation:

$$\overline{A+B}$$

First we change the OR to an AND. The expression becomes:

$$\overline{AB}$$

Second, we complement each variable individually. That results in:

$$\overline{\overline{A}\,\overline{B}}$$

Third, we complement the entire expression. That gives:

$$\overline{\overline{\overline{A}\,\overline{B}}}$$

The two NOT bars over the expression cancel one another. Remember the law of the double negative? The final expression is:

$$\overline{A}\,\overline{B}$$

As you can see:

$$\overline{A+B}=\overline{A}\,\overline{B}$$

Exercise 2. Now try the procedure yourself on the second DeMorgan's equation. Check your answer to see if you did the problem correctly.

While there are only two variables in both forms of DeMorgan's theorem, keep in mind that the basic concepts apply to logic expressions with three or more as well. Note how the three-term OR expression following can be converted into an equivalent NAND expression using the procedure described earlier:

$$F=\overline{A+\overline{B}+\overline{C}}$$

Change ORS to ANDS:

$$F=\overline{A\overline{B}\,\overline{C}}$$

Complement each variable:

$$F=\overline{\overline{A}\,\overline{\overline{B}}\,\overline{\overline{C}}}=\overline{\overline{A}BC}$$

Complement the complete expression:

$$F=\overline{\overline{\overline{A}BC}}=\overline{A}BC$$

A four-term AND expression can be converted into an equivalent four-term OR expression by using the same procedure. The example below illustrates the procedure:

$$V=\overline{\overline{W}X\overline{Y}Z}$$

Change ANDS to ORS:

$$V=\overline{\overline{W}+X+\overline{Y}+Z}$$

Complement each variable:

$$V=\overline{\overline{\overline{W}}+\overline{X}+\overline{\overline{Y}}+\overline{Z}}=\overline{W+\overline{X}+Y+\overline{Z}}$$

Complement the complete expression:

$$V=\overline{\overline{W+\overline{X}+Y+\overline{Z}}}=W+\overline{X}+Y+\overline{Z}$$

Minimizing Equations with DeMorgan's. Now let's apply DeMorgan's theorem to some typical Boolean expressions. Basically we will use DeMorgan's theorem as a primary rule, but, as you will discover, it will continue to be necessary to use the other Boolean rules to effect the greatest reduction. The Boolean rules are summarized for your convenience in the boxed text entitled "Boolean Laws."

Using DeMorgan's theorem, let's change each of the expressions following into their alternate form. Just use the three-step procedure given earlier:

$$A+\overline{B}$$

Change OR to AND:

$$A\overline{B}$$

Complement each term:

$$\overline{A}\,\overline{\overline{B}}=\overline{A}B$$

Complement the complete expression:

$$\overline{\overline{A}B}$$

Here's another example:

$$\overline{AB+\overline{B}C}$$

Change OR to AND:

$$\overline{(AB)(\overline{B}C)}$$

Complement each term:

$$\overline{\overline{(AB)}\,\overline{(\overline{B}C)}}$$

Complement the complete expression:

$$\overline{\overline{\overline{(AB)}\,\overline{(\overline{B}C)}}}=\overline{(AB)}\,\overline{(\overline{B}C)}$$

But wait; that's not all; you can take that one step further and change each term using DeMorgan's:

$$\overline{(AB)}\,\overline{(\overline{B}C)}$$

The term in the left-hand parentheses becomes $\overline{A}+\overline{B}$ by DeMorgan's. The term in the right-hand parentheses becomes:

$$B+\overline{C}$$

Therefore, the equivalent expression is:

$$(\overline{A}+\overline{B})(B+\overline{C})$$

We can go even further by multiplying the terms out by the law of distribution:

$$\overline{A}B+\overline{A}\,\overline{C}+\overline{B}B+\overline{B}\,\overline{C}$$

The $\overline{B}B$ term is zero because of the law of complements so it drops out leaving:

$$\overline{A}B+\overline{A}\,\overline{C}+\overline{B}\,\overline{C}$$

Continuing with our examples, consider the term:

$$XY\overline{Z}$$

Change AND to OR:

$$X+Y+\overline{Z}$$

Complement each term:

$$\overline{X}+\overline{Y}+\overline{\overline{Z}}=\overline{X}+\overline{Y}+Z$$

Complement the entire expression:

$$\overline{\overline{X}+\overline{Y}+Z}$$

Now look at a more complex expression:

$$\overline{(A\overline{B})(D\overline{E}F)}$$

Change AND to OR:

$$\overline{(A\overline{B})+(D\overline{E}F)}$$

Complement each term:

$$\overline{\overline{(A\overline{B})}+\overline{(D\overline{E}F)}}$$

Complement the complete expression:

$$\overline{\overline{\overline{A\overline{B}}+(D\overline{E}F)}}=\overline{A\overline{B}}+(D\overline{E}F)$$

We can take that further by expanding

each term; The complete expression is:

$$\overline{A} + B + \overline{\overline{D} + E + \overline{F}}$$

Of course, we could have left it in its previous form. One isn't necessarily any better than the other.

Let's try one more complex expression. Follow it through step-by-step to be sure you see how each step was obtained:

$$X = \overline{\overline{A}B + CD} + A\overline{C} + B \text{ (DeMorgan's)}$$

$$X = (\overline{\overline{A}B})(\overline{CD}) + A\overline{C} + B \text{ (DeMorgan's)}$$

$$X = (\overline{A} + B)(\overline{C} + \overline{D}) + A\overline{C} + B \text{ (distribution)}$$

$$X = \overline{A}\,\overline{C} + \overline{A}\,\overline{D} + B\overline{C} + B\overline{D} + A\overline{C} + B \text{ (commutation, distribution)}$$

The AC term is moved to the third position so that all of the terms containing a B can be grouped together:

$$X = \overline{A}\,\overline{C} + \overline{A}\,\overline{D} + A\overline{C} + B(\overline{C} + \overline{D} + 1)$$

By the law of union:

$$X = \overline{A}\,\overline{C} + A\overline{C} + \overline{A}\,\overline{D} + B$$

The $\overline{A}\,\overline{D}$ and $A\overline{C}$ terms are reversed.

And by the commutation and distribution laws:

$$X = \overline{C}(\overline{A} + A) + \overline{A}\,\overline{D} + B$$

Using the law of complements:

$$X = \overline{C}(1) + \overline{A}\,\overline{D} + B$$

From the law of intersection:

$$X = \overline{C} + \overline{A}\,\overline{D} + B$$

There is one key thing you should notice about the original expression. There is not one thing you can do to it until you apply DeMorgan's first. None of the other Boolean rules are applicable or useful until DeMorgan's breaks up the expression, thus allowing considerable manipulation and minimization.

One very important detail is that the following equations are not true:

$$\overline{AB} = \overline{A}\,\overline{B}$$

$$\overline{A+B} = \overline{A} + \overline{B}$$

A NOT bar over the complete expression does **not** mean the same thing as individual NOT bars over each variable. Don't forget that when working with Boolean equations. The complement is not communitive.

Exercise 3. Okay, time for you to try one yourself. Reduce the following expression to its minimum form using DeMorgan's and any other Boolean rules:

$$\overline{(\overline{A} + C)} + \overline{ABC} + \overline{A}\,\overline{B}\,\overline{C}$$

Applying DeMorgans to Gates. Earlier I said that DeMorgan's theorem is applicable to the use of NAND and NOR gates. If you look at the two basic forms of DeMorgan's theorem, you will see that the left-hand expressions do indeed represent a NAND gate and a NOR gate, respectively. What DeMorgan's is telling us then is that a NAND gate can be used to perform OR operations, and a NOR gate can be used to perform AND operations. That means you can use one type of gate exclusively to simulate any of the three basic logic functions: NOT, AND, or OR.

For starters, it is pretty easy to see how any NAND or NOR gate can be used to perform the NOT function. That can be accomplished by simply connecting all of the input lines on a NAND or NOR gate together, forming a single input. That effectively converts the circuit into an inverter. Examples are shown in Fig. 1.

Of course, inverter circuits are also available in integrated-circuit form, and should be used where signal complements are needed. But don't forget that a NAND or NOR can perform the NOT function if an individual inverter is not available but one of those other gates is.

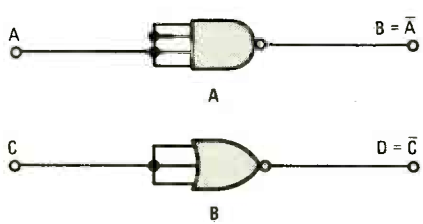


Fig. 1. Both NAND (A) and NOR (B) gates can function as inverters, if necessary, by tieing their inputs together.

Now let's examine each of the DeMorgan's theorems in more detail. Take the basic expression:

$$\overline{AB} = \overline{A} + \overline{B}$$

We can draw the logic circuit corresponding to the left-hand term as shown in Fig. 2A. It is simply an AND gate followed by an inverter. That, of course, is the NAND function. The special symbol for the NAND gate is shown in Fig. 2B as a memory refresher. The circle on the output indicates inversion. Figure 2C shows an alternate symbol used to represent the NAND. The box represents the logic circuit, whereas the half arrowhead or triangle on the output indicates inversion. The ampersand designates the AND function.

Now let's draw the circuit corresponding to the right-hand term of the DeMorgan's expression. It is:

$$\overline{A} + \overline{B}$$

The circuit representing that expression is shown in Fig. 3A. Input signals, A and B, are inverted to obtain $\overline{A}$ and $\overline{B}$, and are then applied to an OR gate. The result is the correct output expression.

You can also draw the circuit using the symbol shown in Fig. 3B. It is the OR symbol with circles at the input representing the inverters. The circuit is known as a negated OR or negative NOR gate. We call it that simply because it performs the NOR function assuming the inputs and output are complements.

Positive and Negative Logic. The terms positive and negative logic refer to how we assign voltage levels to the binary variables 0 and 1. With positive logic, binary 1 is always assigned the most-positive of the two levels while binary 0 is assigned the most-negative level. Some examples of positive logic are:

binary 0 = 0 volts or ground
binary 1 = +5 volts

binary 0 = −6 V
binary 1 = 0 volts

binary 0 = −12 volts
binary 1 = +12 volts

Negative logic is the opposite. Binary 1 is assigned the most-negative level while binary 0 is assigned the most-positive level. Some examples of negative logic are:

binary 0 = +5 volts
binary 1 = 0 volts

binary 0 = 0 volts
binary 1 = −6 volts

binary 0 = +5 volts
binary 1 = −5 volts

Usually, only one assignment scheme is used for a given circuit. But many circuits use mixed assignments of positive

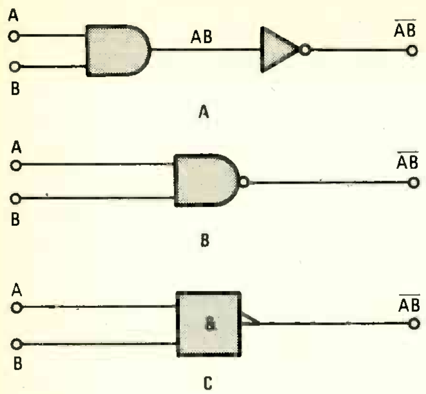


Fig. 2. An AND *and* NOT *gate combined (A) is really a* NAND *gate (B), which has a special symbol shown in C.*

and negative logic.

The important thing to notice here is that the circuit in Fig. 2 performs the positive NAND function while the circuit in Fig. 3 performs the negative OR function. But according to DeMorgan's theorem, the two are the same. The circuit itself doesn't change, as it still performs the same electrical operation. What is different is how you assign and interpret the logic levels in the circuit. You can see that by examining Table 2. There we have presented the truth table in terms of two binary voltage levels: 0 volts (ground), and +5 volts. That is the circuit's electrical truth table. Now assuming positive logic-level assignments, you can see that the NAND function is performed. Refer to the converted truth table in Table 3.

Now assume negative logic-level assignments for the inputs and output. That leads to the truth table shown in Table 4. Here you can see that if either one, or both, of the inputs is binary 1, the output is binary 0. That, of course, is the classical truth table for a NOR gate.

Thanks to DeMorgan's theorem, our one gate can perform both NAND and NOR functions. To perform the NOR function, you must use complementary

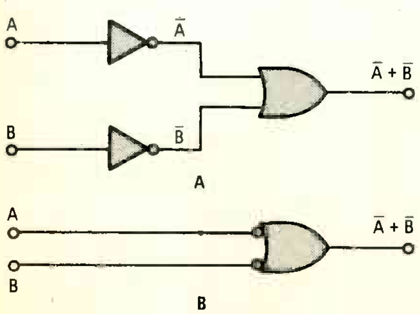


Fig. 3. An OR *gate with inverted inputs (A) is called a negated* NOR *and is drawn with circles at the inputs (B).*

TABLE 2—ELECTRICAL TRUTH TABLE

A (volts)	B (volts)	$\overline{AB}$ (volts)
0	0	5
0	5	5
5	0	5
5	5	0

TABLE 3—POSITIVE-LOGIC NAND

A	B	$\overline{AB}$
0	0	1
0	1	1
1	0	1
1	1	0

TABLE 4—NEGATIVE-LOGIC NOR

A	B	$\overline{A}+\overline{B}$
1	1	0
1	0	0
0	1	0
0	0	1

inputs and output, but in most applications, that is not a problem.

Now let's look at the other form of DeMorgan's theorem:

$$\overline{A+B} = \overline{A}\,\overline{B}$$

Drawing the symbol for the left-hand term, we get the circuit shown in Fig. 4A. An OR gate is followed by an inverter to produce the desired output. Of course, that is the NOR function, and its special symbol is presented in Fig. 4B to refresh your memory. The alternate symbol for a NOR is shown in Fig. 4C. The greater-than/equal-to 1 symbol indicates the OR function. That, of course, is a positive-logic NOR circuit as the truth table shows.

Now let's draw the circuit for the right-hand side of the equation. It says that the input terms, A and B, must be inverted before being applied to an

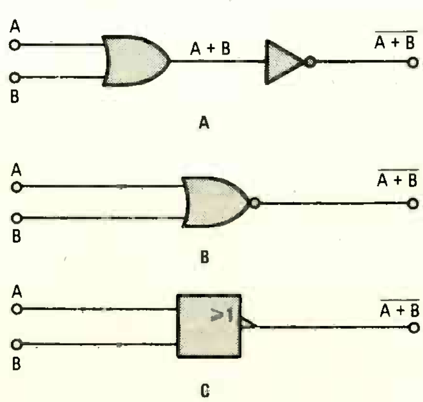


Fig. 4. An OR *with a* NOT *gate output (A) forms a* NOR *gate (B), which has a special symbol as shown in C.*

AND gate as shown in Fig. 5A. The alternate symbol for that is shown in Fig. 5B. The circles at the input replace the inverters. The circuit is a negative NAND gate. It performs the NAND function, but only with negative logic-level assignments. Again you can see that by looking at the truth table in Table 5.

Using positive logic-level assignments, we get the truth table shown in Table 6. That, of course, is the truth table for a positive NOR gate. But using negative logic-level assignments, we get the truth table shown in Table 7. Changing the inputs and output to negative logic causes the circuit to perform the NAND function. The output is binary 0 only when both inputs are binary 1. So, you can see that a positive OR can perform the NAND function if you change the logic-level assignments.

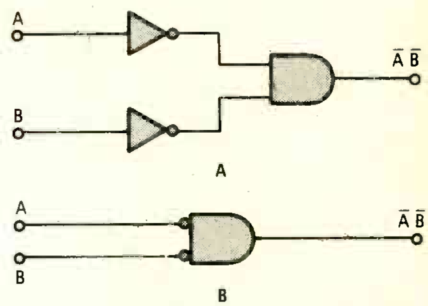


Fig. 5. An AND *gate with inverted inputs (A) is called a negated* AND *and is drawn with circles at the inputs (B).*

Applying NAND and NOR Gates. If you know DeMorgan's theorem, you will have greater flexibility in applying both NAND and NOR gates when you design. Knowing DeMorgan's also helps you understand and interpret logic diagrams whether they use NAND or NOR gates. In general, you can implement any logic function with either NAND or NOR gates, although most practical circuits usually use both. To give you a few examples of how to apply what you learned in the previous sections, let's take some examples.

Gating. Gating is a common logic function. It allows one logic signal to control the passage of another. When the control signal is in one binary state, it blocks the input signal. With the control in the other state, it allows the input signal to pass. An AND gate is normally used for that purpose. Figure 6 shows that application. When the control input is binary 0, naturally the AND-gate

TABLE 5—ELECTRICAL TRUTH TABLE

A	B	$\overline{A+B}$
0	0	5
0	5	0
5	0	0
5	5	0

TABLE 6—POSITIVE-LOGIC NOR

A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

TABLE 7—NEGATIVE-LOGIC NAND

A	B	$\overline{AB}$
1	1	0
1	0	1
0	1	1
0	0	1

output will be binary 0 and the pulse condition of the upper input will be ignored. On the other hand, when the control input is binary 1, the AND gate is enabled and the state at the other input passes through to the output.

If a NAND gate is available, it too can be used in that fashion. The operation of the circuit will be the same as that described above. However, because the NAND gate inverts, the output signal will be an inverted version of the input pulse train. In many applications, it doesn't matter whether the signal or its

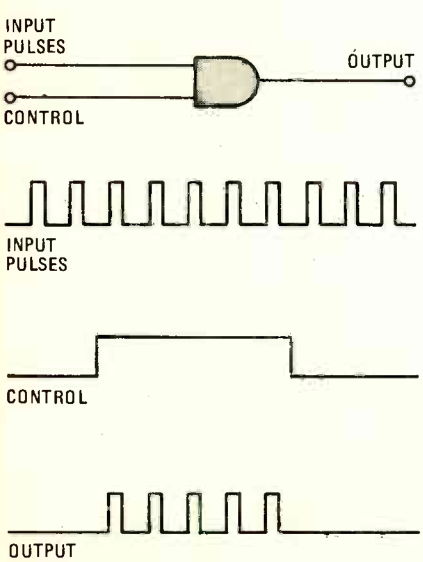


Fig. 6. Any AND gate can be used to control the flow of input pulses. One input is used to accept input pulses, and the other a control signal. If the control goes high, the input signal appears at the output as shown.

complement is available. If the output must be exactly the same as the input, then of course an inverter can be connected to the NAND-gate output, effectively forming an AND gate.

You can also use a NOR gate to perform that function. You can use it as a negative NAND, as is illustrated in Fig. 7. The input- and control-signal levels must be reversed. A binary 1 at the control input blocks the gate, preventing the pulse train from appearing at the output. A binary 0 enables the gate, allowing the pulse train to pass through. Like the positive NAND gate, the circuit will also invert the input. If the output must have the same phase as the input, an inverter can be connected to the output to correct for that condition.

As you can see, the most-intuitive way to simulate a basic gate is to use a NAND gate. It is normal for most of us to think in terms of positive logic, but keep in mind that negative logic is just as good, so a different kind of circuit can be used. The only requirement is that the complements of the input signals be available at the inputs. Usually that is no problem, as both the normal and complement values of a logic signal are often both available from a signal source. If the complement is not available, it can be easily generated with an inverter or a gate set up as one.

Decoding. Another common application is decoding. A decoder is a circuit that signals when a specific binary code or bit pattern is presented to it. A common decoder application is decoding the output of a binary counter or shift register, and they are normally made of *flip-flop* circuits.

When a flip-flop's T (toggle) input receives a signal, its output switches state. If it is a 1 when the toggle signal is received, it becomes a 0 and vice versa. When the T goes low again nothing happens and the output of the flip-flop stays the same until another high is received. That means the toggle input must go high-low-high-low just to cause the flip-flop to go high-low. That means the T input changes twice as often as the output. If we cascade stages of flip-flops together—connecting the output of one to the toggle of the next—each will change state half as often as the one proceeding it.

Now for the binary part: When a flip-flop is *set*, it is said to be storing a binary 1 and its non-inverted output will be binary 1. If the flip-flop is *reset*, it is said

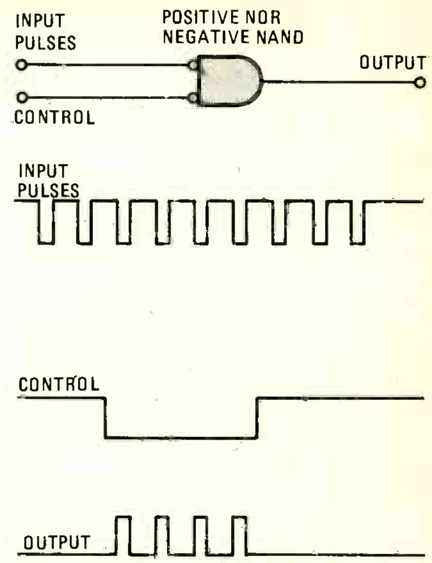


Fig. 7. A negative NAND gate can be used to control the flow of pulses. One input receives the input pulses, and the other a control signal. When the control goes low, the inverted input signal appears at the output as shown.

to be storing a binary 0 and, therefore, its non-inverted output will be binary 0. So each non-inverted output can be used to represent a bit in a binary number. Then each time the first flip-flop receives an input signal the number will be incremented by one. That is exactly what happens in a binary counter.

Figure 8 shows a 4-bit binary counter consisting of four flip-flops, connected to two decoding gates (the AND and NAND shown). The input signal for the circuit is received by the top-most flip-flop, whose non-inverted output is sent to the second gate, which sends its output to the third, and so on. Each time an input pulse is applied to A, the binary value stored will be incremented. The counter has 16 states, 0000 through 1111. That is the binary equivalent of the decimal numbers 0 through 15.

By noting the non-inverted outputs of each flip-flop in the counter, we determine the binary number corresponding to it. For example, if the second and fourth flip-flops in the chain are set (1) while the first and third are reset (0), the number stored in the counter is 1010. The first flip-flop contains the least significant bit (LSB) while the last flip-flop is the most significant bit (MSB). Therefore, the binary number contained in the counter would be written 1010.

If the counter is initially at 0000 and

six input pulses then occur, the flip-flop states will become 0110. Looking at the outputs, you can tell that six input pulses occurred because 0110 is the binary equivalent of the decimal number 6.

Now suppose you want to create a circuit that will detect when six input pulses occur. We can use a flip-flop counter to count the pulses, and a decoder to monitor the flip-flop outputs and signal when a decimal 6 (0110 in binary) is present in the counter.

The decoder is nothing more than an AND gate connected to the appropriate output (normal or inverted) of each flip-flop. Since there are four flip-flops to monitor, a four-input AND gate is required. In order for the AND-gate output to be binary 1, you know that all of the inputs have to be binary 1 simultaneously. So each AND input must be connected to the flip-flop outputs (either inverted or non-inverted) that will yield a 1 when a 6 is stored in the counter. In other words, if a flip-flop will contain a 0 for the desired digit then its *inverted* output should be sent to the AND gate, but if it holds a 1 then its non-inverted output should be sent to the gate. Therefore, we must connect the correct flip-flop outputs to the AND-gate inputs in order to detect the desired bit pattern.

Assuming we want to detect the code 0110, then the connections must be as shown in Fig. 8. The A flip-flop is reset, therefore, its non-inverted output is 0, so we must connect the inverted output of the A flip-flop to the AND gate input. The same is true for the D flip-flop. On the other hand, if flip-flops B and C are set, their normal outputs will be binary 1. Therefore, we can connect them to the AND-gate inputs. Now, whenever the number 0110 appears in the counter, the AND-gate output will become binary 1 signaling that six input pulses have occurred. For all other states, the AND gate output will be 0.

Naturally, you can also use a NAND gate for decoding purposes. The input connections would be exactly the same as those shown for the AND gate in Fig. 8. The only difference is that when the number 0110 is detected, the NAND-gate output will go to binary 0. At all other times, the output will be binary 1. In most applications, it doesn't matter whether the output is 0 or 1. If the output must be a binary 1, then of course, the output of the NAND gate can always be inverted.

A NOR gate can also perform the

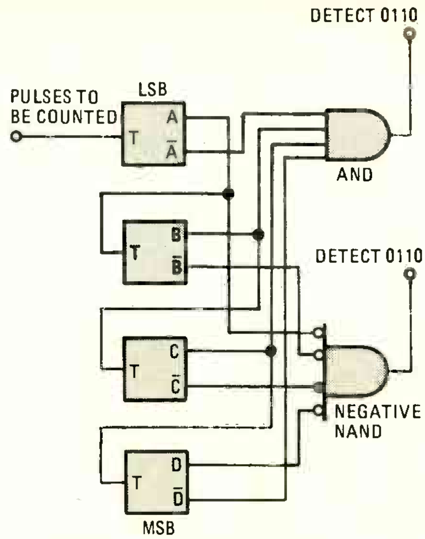


Fig. 8. Here two simple detectors determine when the number six is held by a counter made of flip-flops.

NAND function and, therefore, it too can be used as a decoder gate. That is illustrated in Fig. 8. There we are using the negative NAND symbol for the positive NOR gate. To see how the circuit works note the use of the four inversion circles at the input to the AND symbol. The connections to that gate must be the opposite to those applied to the AND and positive NAND gates. To detect the input 0110, the A and D flip-flops will be reset. Therefore, their normal outputs will be binary 0. Those binary 0 states will be applied to the inverter circles at the symbol input and will be inverted before being applied to the AND symbol which requires all binary 1 inputs before outputting a 1. Flip-flops B and C will be set during that time. The complement outputs must be connected to the input inversion circles where they are inverted and applied to the AND gate.

Overall, the operation of the negative NAND decoder gate is the same. When the number 0110 appears in the counter, the output of the gate will go to binary 1, signaling the occurrence of six input pulses. Again the only difference is that the states of the inputs had to be reversed in order to get the circuit to function as a gate.

One last thing about the application. Normally you wish to design a circuit with the least number of parts. If only NAND or NOR gates were available, the positive-NOR/negative-NAND implementation would use the fewest number of circuits assuming that a binary-1 output is needed when the desired state is decoded. If a positive NAND is used, an inverter at the output of the NAND gate would be required. That one additional circuit makes the NOR implementation more desirable. Now you can see that your choice of NAND or NOR circuits is important as it will indeed help reduce the number of overall circuits required. In large designs, that can be a significant number.

OR Applications. Now let's take a look at how OR functions can be simulated with both NANDS and NORS gates. Suppose we wish to implement a simple burglar-alarm circuit. Assume that a room that has two windows and a door is to be protected with the alarm. Reed-switch sensors are set up on the door and windows to sense whether the windows or door are open or closed.

The basic circuit to perform that function is shown in Fig. 9. The reed switches are connected to resistors and a DC supply that generates binary voltage levels. A magnet is placed

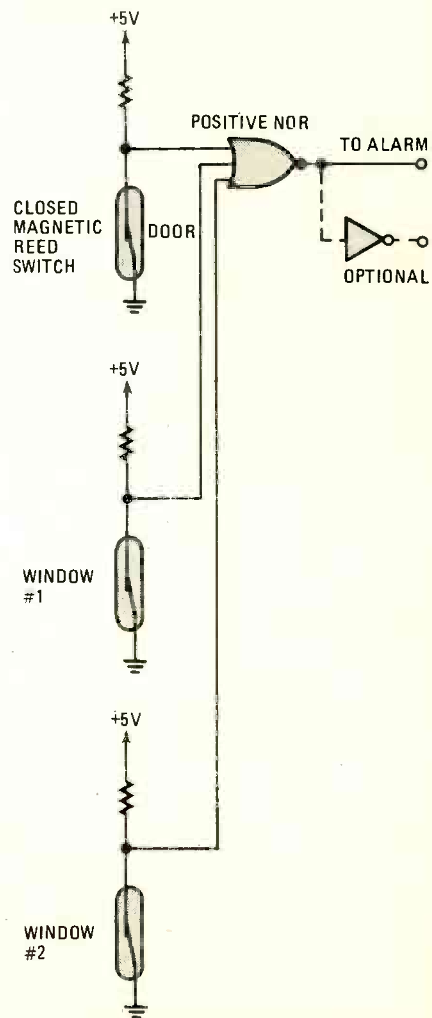


Fig. 9. Three switches are monitored by a NOR gate to tell if a window or door has been opened to trigger an alarm.

adjacent to each reed switch causing it to be closed. That is the normal state when all windows and doors are closed. However, if a window or door should open, a magnet will move away from a switch and the switch will open. While the switches are closed, a binary 0 or ground output is produced. If the switch is open, the output will be a logic-level signal of +5 volts.

Since we want to detect when any one or more input signals is +5 volts, then we need an OR circuit. Let's use a NOR gate for that purpose. Now, if any door or window is opened, a binary 1 will be generated. That will cause the NOR-gate output to go to zero. That zero signal can then be used to operate an indicator light, buzzer, bell, or other warning device. If a binary-1 output signal is needed to trigger the alarm indicator, then an inverter can be placed at the output.

The function can also be performed with a positive NAND gate is used as a negative NOR. To do that, however, we must reverse the input logic levels. In other words, when the windows and doors are closed, we must produce a binary 1 or +5 volt output signal. And when the door or windows are opened, we must produce a binary 0 signal. That can be done with the circuit shown in Fig. 10. Keep in mind that no more components are required, we have just wired them differently to produce inverted logic. When the magnet is adjacent to the reed switch, the reed switch is still closed. However, in the revised circuit, a closed reed switch applies the +5 volts across the resistor, thereby producing a binary-1 output to the logic circuit. When the magnet moves away from the reed switch as a door or window is opened, the reed switch opens. That removes the +5 volts from the resistor. There is zero volts across the resistor, therefore, the logic output is a binary 0.

The circuit performs the same function using the NAND gate as a negative NOR. When all of the doors and windows are closed, all outputs are binary 1 and, therefore, the output of the circuit will be binary 0. If any door or window is opened, the related input will produce a binary 0 output, causing the circuit to produce a binary 1 output, sounding the alarm.

Again, whether to use a NAND or NOR gate depends upon the output level required to switch the alarm on. If a binary 0 is required, the positive NOR implementation is simplest. If a binary-1 output is required, the positive NAND-negative NOR implementation would be best as it uses a minimum of hardware.

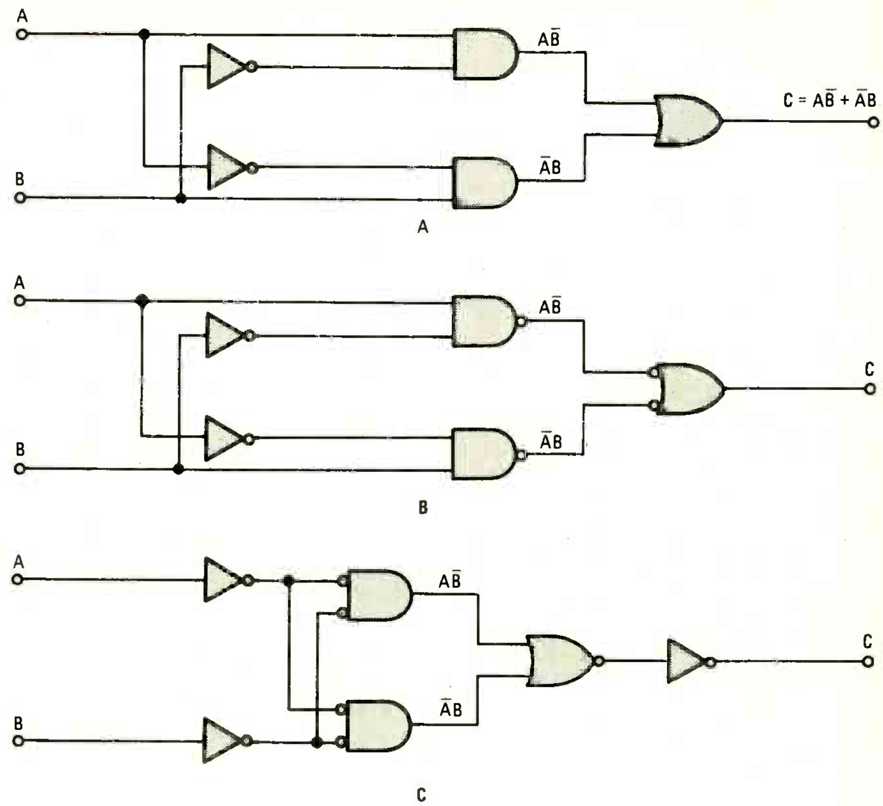


Fig. 11. An XOR can be simulated by combining ANDS, NOTS, and ORS (A); NANDS, NOTS, and negative NORS (B); or negative NANDS, NORS, and NOTS (C).

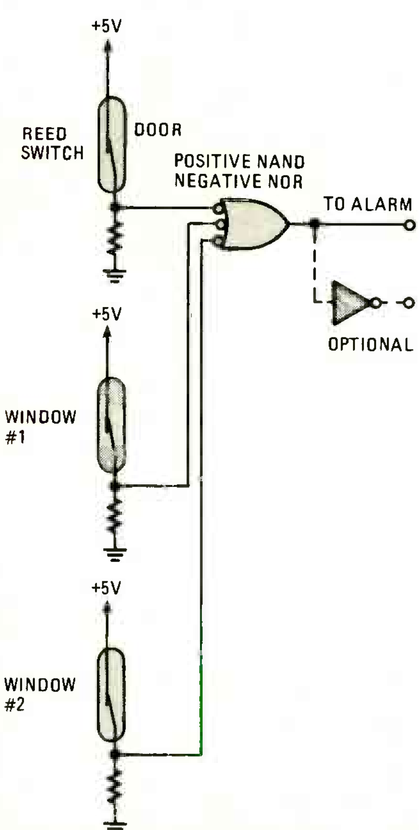


Fig. 10. Reed switches are monitored by a negative NOR gate to tell if a window or door has been opened.

XOR Circuits. An exclusive-OR (or XOR) gate is a circuit that produces a binary-1 output when the two inputs are different (complementary). The circuit produces a binary 0 output if the inputs are the same. That is expressed in the truth table shown in Table 8. That unique logic function is widely used in digital circuits. It is used in comparators, parity generators, binary arithmetic circuits, and many others. Most integrated-circuit manufacturers produce prepackaged XOR circuits, so it is usually not necessary to create them with gates. On occasion, however, you may have to. It is also academically interesting to examine the way that an XOR gate can be simulated by other gates.

If you remember the procedure for generating a logic circuit from a truth table, you can easily arrive at the circuit for an XOR. Referring to Table 8, write the Boolean expression by creating a sum-of-products from the input variables that generate a binary-1 output. The output is 1 when input state A is

(Continued on page 104)

Circuit Circus

By Charles D. Rakes

THE ELECTRONIC ART OF DETECTION

In response to a reader's request, our Circus starts this month off with an electronic solution to the problem of tracing hidden or mislaid wire cables. There's nothing more frustrating than to be called in on a job where alarms, intercoms, telephones, and other pieces of equipment are interconnected with cables that run in all directions through walls, under floors, in the ceiling, and numerous other inaccessible places. If that has happened to you, or if you want to avoid an unpleasant experience in the future, the next few tracer circuits might just save your sanity.

Bug Tracer. The first circuit (see Fig. 1) can be used to ferret out a single bug and trace its connecting wire back to its origin in a matter of minutes. The Bug Tracer is made up of a simple RF-injector circuit (consisting of Q1 and Q2) and a pocket-size, AM broadcast receiver. The two-transistor RF injector circuit supplies a constant RF signal to one end of a cable. Then the AM receiver is used as a detector, allowing you to trace the wire to its source.

Transistor Q1, along with RES1 (a piezoelectric ceramic resonator), make up a simple RF oscillator that operates either at or near the AM-radio 455-kHz IF frequency. That means that the second or third harmonic signal can easily be picked up by the receiver. Transistor Q2 is connected in an emitter-follower circuit to protect the oscillator from output loading. That helps to stabilize the output frequency and signal level.

The injector circuit can be built on a 1- × 2-inch piece of perfboard and housed in a plastic cabinet allowing ample room for the switch and battery. A short lead with an alligator clip connected to the injector's output offers a handy way to attach it to the cable or wire that's to be traced.

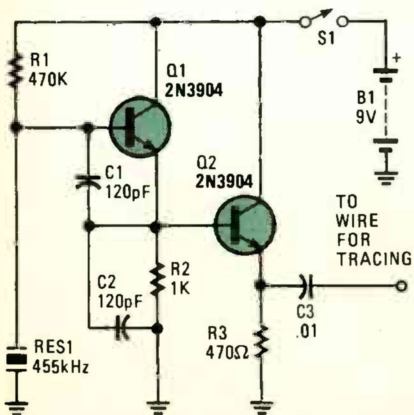


Fig. 1. The Bug Tracer circuit can be used to ferret out eavesdropping devices and trace the connecting wires back to the source, by detecting RF emissions.

PARTS LIST FOR THE BUG TRACER

- Q1, Q2—2N3904 general-purpose NPN transistor
- R1—470,000-ohm, ¼-watt, 5% resistor
- R2—1000-ohm, ¼-watt, 5% resistor
- R3—470-ohm, ¼-watt, 5% resistor
- C1, C2—120-pF, 100-WVDC, ceramic-disc capacitor
- C3—.01-µF, 100-WVDC, ceramic-disc capacitor
- RES1—455-kHz ceramic resonator (Panasonic or similar)
- B1—9-volt transistor-radio battery
- S1—SPST toggle or slide switch
- Printed-circuit or perfboard materials, enclosure, IC sockets, battery and battery holder, wire, solder, hardware, etc.

Using the Bug Tracer is simple. Locate one end of the cable or wire you want to trace and connect the Tracer's output to it. Determine the location of the ferrite tuning coil in the AM radio. Position the receiver so that the ferrite coil is perpendicular to the cable and tune for the strongest signal originating from the cable. As long as that relationship is maintained, the signal received from the cable will be at its strongest. Keep that position and move the receiver along over the hidden cable until you reach the source.

Since Murphy often lurks nearby don't be surprised if a few red herrings show up. One instance that might cause a slight problem is when the cable splits, within a hidden junction box, into two or more new directions. Instead of chopping into the wall, floor, or ceiling, trace out each run and see if the total wiring scheme makes sense.

If the cable happens to be shielded, the injector will probably need to be connected to the shield to function. In the tracing game when the first effort doesn't pan out, it's usually a good indication that the next attempt will at least place you one step closer to success.

Closed-Loop Tracer. The second tracer—consisting of both a transmitter and receiver—is designed to follow a closed-loop wire or cable system, making its operation slightly different from the previous circuit. Instead of sending out an RF signal that rides the cable like it was a long-wire antenna, the *Closed-Loop Tracer* follows an induced voltage path that's created by feeding a low current, audio-frequency signal through the cable.

The cable-under-test functions like a single-turn primary of a transformer and the two receiver coils are the step-up secondary windings. When the pick-up coils come within close proximity to the current-carrying cable, a small voltage is generated (induced)

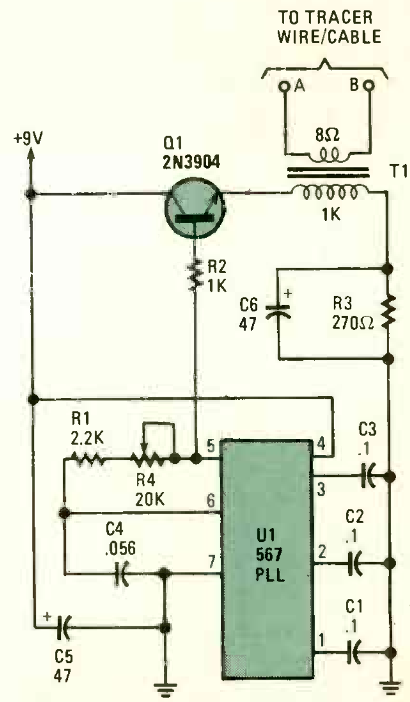


Fig. 2. The Closed-Loop Tracer is designed to follow an induced voltage path that's created by feeding a low current, audio-frequency signal through the cable.

in each coil, and that induced voltage is then processed by the receiver's circuitry.

The schematic diagram for the signal-generator or transmitter portion of the Closed-Loop Tracer is shown in Fig. 2. The circuit is built around a 567 phase-locked loop (PLL) configured as a variable-frequency, audio-generator circuit, which is designed to produce a squarewave output at pin 5. Potentiometer R4 allows the oscillator to be easily tuned to the receiver's frequency. Transistor Q1 isolates the oscillator from the load and matches the impedance of the primary of T1. Resistor R3 limits current flow through Q1. The low-impedance secondary of T1 supplies the cable drive signal.

PARTS LIST FOR THE CLOSED-LOOP TRACER

- U1—567 phase-locked loop (PLL), integrated circuit
- Q1—2N3904 general-purpose NPN transistor
- R1—2200-ohm, ¼-watt, 5% resistor
- R2—1000-ohm, ¼-watt, 5% resistor
- R3—270-ohm, ¼-watt, 5% resistor
- R4—20,000-ohm potentiometer
- C1–C3—0.1-µF, 100-WVDC, ceramic-disc capacitor
- C4—0.056-µF, 100-WVDC, mylar capacitor
- C5, C6—47-µF, 16-WVDC, electrolytic capacitor
- T1—Audio-output transformer (1K to 8-ohms)
- Printed-circuit or perfboard materials, enclosure, IC sockets, battery and battery holder, wire, solder, hardware, etc.

Tracer Receiver. The *Tracer Receiver*, see Fig. 3, is a stereo audio amplifier/detector circuit operating near 1 kHz. Inductors L1 and L2 (hand-wound coils, consisting of 200 turns of #26 wire wound on 2-inch ferrite cores) are tuned to the operating frequency of the amplifier/detector. The received-signal strength of each individual receiver is indicated by an LED. The audio output of the Receiver is fed to a stereo headphone.

That dual-receiver scheme helps in locating and tracking the hidden wire or cable by giving a directional output that indicates the cable's path.

A quick run down of the receiver's operation goes like this. Since both receiver circuits are exactly alike, we'll discuss the circuit's operation, focusing on the upper half of the circuit. The 1-kHz signal is picked up by L1 and coupled to the input of op-amp U1-a, which provides a gain of about 100.

The output of op-amp U1-a is fed through volume-control potentiometer R7 to the input of U1-b, which magnifies the already amplified signal 100 times more. That puts the maximum gain of the receiver at about 10,000. The output of U1-b follows two paths: In the first path, the signal is coupled through C9 and R13 to J1 and is used to drive one half of a stereo headphone.

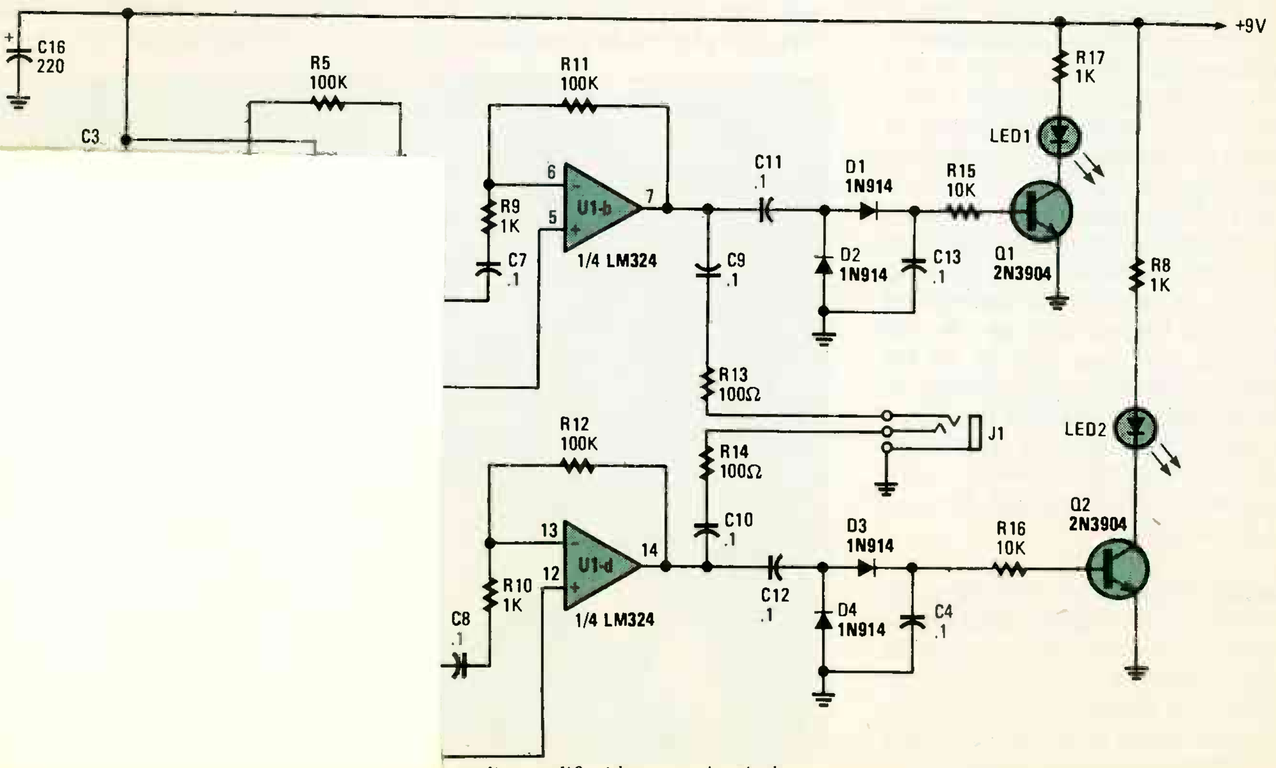
In the other path, the signal is fed through a voltage doubling/detector circuit (consisting of D1, D2, C11, and C13) that converts the amplified 1-kHz signal to a DC voltage that's used to drive Q1. When Q1 is turned on, LED1 lights, indicating a received signal.

The transmitter circuit can be built on perfboard and housed in a metal or plastic cabinet. If the unit is to be used often and/or for long periods of time, it would be better to use 6 "AA" cells for the power source rather than a common 9-volt transistor-radio battery.

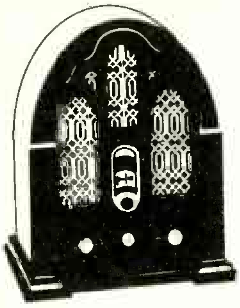
Receiver Construction. Start the receiver construction by winding the two input coils, L1 and L2. Each is wound on a 2-inch length of quarter-inch ferrite-rod material. If quarter-inch rod material can't be located, any similar size antenna-rod material will do for the coil's core.

Neatly scramble wind each coil on the rod equally distributing it over the

(Continued on page 97)



› audio amplifier/detector circuit that
ıd-wound coils, L1 and L2, that are tuned



Antique Radio

A SALUTE TO THE OLD

By Marc Ellis

A week or so ago, my copy of the December issue came in the mail. Like any regular reader would do, I immediately checked it over to see what further progress had been made in transforming **Hands-on Electronics** into "Popular Electronics. And one of the first things I noticed was the staff editorial "Popular Electronics is in our Blood".

While stressing the many links to the old publication that exist among its current staff and contributors, the editorial was quick to point out that we are *not* the old **Popular Electronics**. Rather, we are the *new* **Popular Electronics**, a magazine dedicated to developing a fresh look and approach—one designed with the interests of contemporary electronics hobbyists in mind.

I certainly agree with that. In fact, I'd say that—even before the transition to **Popular Electronics** was in the wind—this magazine was tops in content, graphic design, and quality of writing. I've always been proud to be associated with it.

But I felt that *someone* should take a fond look back at the original publication—if only to remind readers of the tradition of excellence behind the name and the new look we are now adopting. And since, after all, I'm the antique-radio columnist, maybe it's appropriate for me to take a crack at the job! Accordingly, I've temporarily put aside the column that I had planned to write this month so that I could do just that.

Popular Electronics and Me. My connection with **Popular Electronics** began in the early 1960's. I was then living in New York City and working to establish a career in scientific and technical writing. Temporarily at liberty after termination of an uneasy relationship with one of the local advertising agencies, I interviewed for an editorial position at **Popular Electronics**.

After several days had passed, I'd still heard nothing about the outcome of the interview. So, without much hope (and wondering where my next car payment was going to come from) I called the Ziff-Davis offices to see if a decision had been made. "Oh, yes," said the personnel lady, in an offhand tone that startled me with its casualness "we'd like to have you join our staff." Thus began one of the more enjoyable job experiences of my working career.

I ran into trouble almost immediately, however. Having been unemployed for a couple of months, I'd developed the habit of sleeping until well past ten in the morning. That sleeping habit made it very difficult for me to get up early enough in the morning to present myself at the offices at the appointed starting time on work days.

In response to my embarrassed explanations, Managing Editor, Julian S. Martin (better known to you as Editor of this publication) offered to call me up around seven every morning when he got up. Accustomed to the up-tight atmosphere of an advertising agency, where distance between management and subordinates was rigidly maintained, that offer from a boss I hardly knew really shocked me. Nevertheless, I took Julian up on it, and he faithfully called me every morning for the couple of weeks required to get back on track. After that everything was fine.

I was with the magazine for only a little over a year when, being young, mobile, and eager for new experiences, I left to join the staff of another (non-electronic) magazine. Parting was very amicable, however, and we stayed in touch. One thing led to another, and a couple of years ago I began to write this column.

Compared to the veterans of 20 years or more mentioned in the staff editorial, I'm perhaps not the best qualified to reminisce. But, checking some of the issues from my early-1960's era against earlier and later ones, I'd say that the **Popular Electronics** that I worked for was probably fairly typical of the magazine during its heyday. In

*Your author in a relaxed moment at the old **Popular Electonics** offices. I can't recall much about the miniature solid-state project I'm holding, but I do remember that it was built into an old tuna can and the inside was sticky.*

Our thanks to Mr. J. Sienkiewicz for his contribution to this month's column.

*Editorial Assistant Maria Schiff and I pose for a photo to enhance one of the 1961 issues of **Popular Electronics**. The home-brew, battery-operated project looks like a do-it-yourself home electrocution device, but I'm pretty sure it was a lie detector.*

any case, if any of the "vets" want to refine, or add to, my story, that would be fine!

The Construction Projects. Looking over the old issues, I see that the "bread-and-butter" construction projects of the early-to-mid 1960's weren't too different from the ones we see now. Devotees of ham and test gear, hi-fi and SWL equipment, auto and household electronics, and...you name it...all found plenty of work for their soldering irons. Quite a lot of the gear still used vacuum tubes, but transistorized projects were very much in evidence, and were edging out the tubes—little by little—with every passing month.

For me, the transistorized projects took quite a bit of getting used to. I'd been an active electronics hobbyist and radio amateur as a kid, but had been able to find very little time for such activities after starting college. Except for reading an occasional magazine, I'd been away from electronics for over ten years. So I obviously had a lot of catching up to do before I could be much help in editing construction projects for the magazine.

And it wasn't just the technical side of hobby electronics that had undergone some changes. The substitution of transistors for tubes as active circuit elements also seemed to have had an effect on the kinds of projects that were being built.

Bleeps, Buzzes, and Flickers. During my earlier days as a hobbyist, most people undertaking to build electronic circuits had fairly serious purposes in mind. Tubes and associated parts, including the required power-supply components, tended to be on the expensive side. My friends and I had been interested in items like receivers, transmitters, code oscillators, audio amplifiers, and test equipment, And it wasn't unusual to cannibalize a successfully-completed project to obtain parts for completing the "brainstorm" of the moment.

*Emily the Robot was the lead story for the March, 1962 issue of **Popular Electronics**.*

But transistor circuits were a different story. General-purpose transistors were cheap and plentiful, sometimes available in experimenter assortments at prices like ten for a buck. Power requirements were minimal, and even multi-transistor circuits could be operated for hours on a set of inexpensive flashlight batteries. The associated circuit components—low-voltage capacitors and low-wattage resistors—were also dirt cheap.

It's not surprising, then, that the construction articles of that period included a large variety of just-for-fun projects whose main outcome seemed to be to produce flickering lights and/or bleeping, buzzing, or burping sounds. Those who were readers during that era will remember the whistle switches, electronic door chimes, electronic metronomes, fish callers, lie detectors, and simulated musical instruments. And even if a project title indicated a serious purpose, the project itself often proved to be a tongue-in-cheek gizmo not always intended to do a definitive job of accomplishing its function.

I think my own favorite of the "just for fun" projects was *Emily...The Robot With a One-Track Mind*, by Bernard Dickman (March, 1962 issue). Emily (short for Electro-Mechanical Inebriated Ladybug) had only one purpose in life, and that was to follow a trail of white tape that you could lay out along any desired course. Built on an ordinary aluminum electronic chassis, she had a single front wheel and two rear wheels individually driven by separate geared-down electric motors.

The motors were controlled by a downward-pointing photocell acting through a transistor and a relay. The circuit was arranged so that Emily's left-hand motor would turn (moving the robot to the right) until the photocell sensed the light reflected back by the white tape. Then power would be transferred to the right-hand motor, which moved Emily to the left, until the photocell became dark—at which time, the robot moved to the right again, etc.

Since both motors were never powered at the same time, Emily followed a weaving, inebriated-looking

(Continued on page 95)

Computer Bits

By Jeff Holtzman

FLOPPY-DISK DRIVES

Last month I started talking about buying your first PC. My conclusion was that the motherboard should be built around an 80286 CPU with a clock speed of at least 10 MHz. Now let's talk about floppy disks.

In the IBM-compatible world, disks comes in two sizes (5.25 and 3.5 inches), each of which have two capacities. The 5.25-inch disks come with capacities of 360K and 1.2MB; the 3.5-inch disks with 720K and 1.4MB. Although disks in each size resemble each other externally, internally they're quite different, and those differences sometimes make it impossible, or at least difficult, to use one capacity disk in another capacity drive.

For compatibility with early versions of DOS, 360K disks can also be formatted to hold 320K, 180K, and 160K bytes of storage, but these days there is seldom a practical reason for doing so.

The 360K format is by far the most common. All IBM-compatible machines have built-in support for it, and most software is distributed in it, although many newer packages come with both 360K and 720K disks.

The advantage of the 3.5-inch formats is that they hold two to four times as much information as the older ones. They're also more rugged and easier to transport. However, not all machines can deal with the newer formats without resorting to special hardware, special software drivers, or both.

What hardware and software is required to use the new formats?

Hardware Requirements. To be able to install a disk drive on a PC compatible, three elements are necessary: a disk controller, a disk drive, and software to allow the CPU to read and write data.

You can connect low-density drives (360K and 720K) to a standard XT controller, but high-density drives require a controller with a faster data-transfer rate (DTR). All AT controllers have the faster DTR, but most XT controllers don't. There are exceptions; JDR's model MCT-FDC-1.2 ($69.95) and Jameco's JE1043 ($54.95) allow you to install any format through 1.4MB in an XT. Those controllers handle only two internal drives, but Jameco also sells a four-drive controller, the JE1049 for $59.95. Only two of the four can be mounted internally, however.

Another possibility is the CompatiCard from MicroSolutions (132 W. Lincoln Highway, DeKalb, IL 60115, 815-756-3411). Although the card costs $175, it can handle four drives of all types, and all four may be mounted internally. (Most controllers that allow more than two drives require that the third and fourth drives be mounted externally.)

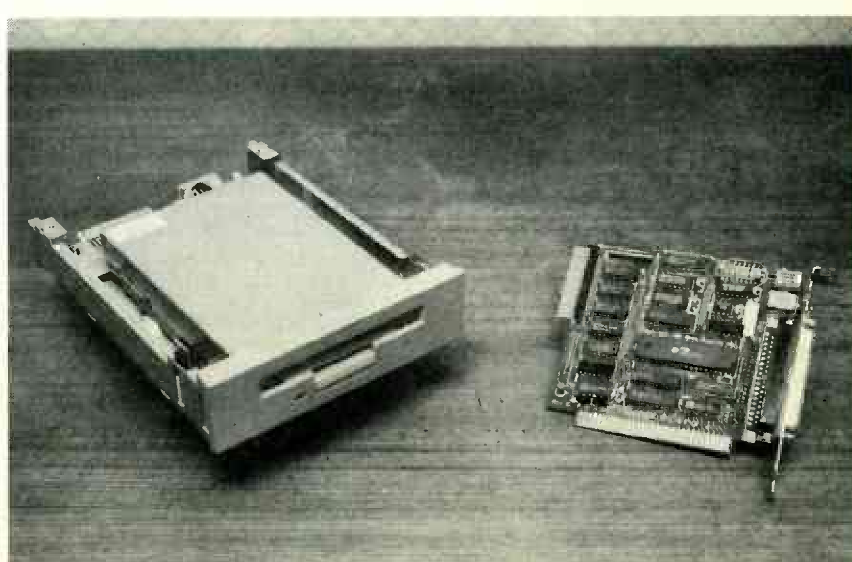
The CompatiCard may also be used in conjunction with an existing floppy-disk controller. Normally, you cannot install two standard disk controllers in one machine, because their I/O ports would conflict. The ability to install two controllers could be useful, for example, if you already have a combined hard/floppy disk controller, and want to add a high-density drive to your system.

As for disk drives, you can't read or write to a high-density disk in a low-density drive, in either size. However, you can, albeit less successfully, read and write to low-density disks in high-density drives. Most 1.4MB drives have no trouble reading and writing to 720K disks. The problem is in trying to write to a 360K disk in a 1.2MB drive.

The reason is that the 1.2MB drive has a narrower read/write head than a 360K drive, so the tracks it writes are narrower than those created by the low-density device. If either (or both) the 1.2MB and the 360K drives happen to be out of alignment, the 360K drive might pick up "noise" in the gap between adjacent tracks. Depending on the degree of misalignment, the noise might overcome the real signal, making that track unreadable.

One solution to the problem is a program called CPYAT2PC, which allows a 1.2MB drive to write to 360K disks more reliably than DOS can do by itself. The program works by moving the read/write head in smaller increments and writing each track twice. The effects of misalignment are thereby reduced.

At $79, plus $4 shipping and handling, the program isn't cheap, but if you're out of drive bays or disk-controller ports, it's a lifesaver. (Microbridge Computers International, 655 Sky Way, Suite 125, San Carlos, CA 94070; Tel. 800/523-8777, 415/593-8777, 212/343-1858.) CPYAT2PC works well,



Add a 3.5-inch drive to your 8088-based machine with the CompatiCard. It allows four internal drives, and may function as a secondary disk controller.

but for daily use and most reliable operation, you'd want a separate 360K drive.

Software Requirements. In addition to disk drives and a proper disk controller, you also need proper software. The BIOS ROM (or EPROM) on the motherboard contains the basic routines for controlling one or more disk drives. The problem is that older machines don't have built-in support for newer disk formats. The solution is to supplement the BIOS with a driver that you load from disk into memory via your CONFIG.SYS file.

The BIOS in most XT-level machines support only the 5.25-inch 360K format. However, DOS 3.3 contains a driver (called DRIVER.SYS) that allows you to connect any drive up through the 1.4MB type, assuming you have the proper floppy-disk controller. DOS 3.2 contains an earlier version of DRIVER.SYS that supports 1.2MB and 720K drives. Also, equivalent software usually comes with advanced floppy-disk controllers, and sometimes with high-density drives. If all else fails, JDR sells one separately.

However, because the driver is loaded after the boot process has begun, you can't boot from a drive without built-in (BIOS) support. On XT's, that generally means you must keep a 360K drive as the boot (A) drive.

AT owners have more flexibility. All AT's have built-in support for 360K and 1.2MB drives; some have support for 720K drives; and most of those manufactured in the last year and a half also support the 1.44MB format.

You use a setup program supplied by the manufacturer to specify the number and types of floppy drives you have. Some machines have the setup routine in ROM; with others, you must load it from disk.

What to Buy. If you're in the market for an 80286 (or 80386) motherboard, find out which types of drives it supports. Built-in BIOS support is more reliable than loading a driver into RAM; in addition, with BIOS support, you can save 10K or so of RAM that a separate driver would use.

Unless you're starved for slots, don't buy a combined hard/floppy disk controller. You may pay a little more for separate controllers, but you'll have greater flexibility when you want to upgrade your system.

If you're assembling your system from scratch, you'll have to decide which disk formats are most important to you. The 360K format is so widely used that you'll want a drive with that format. If you want a second drive, a 1.4MB drive is your best bet because it can read and write both 1.4MB and 720K disks, and generally costs only about $20 more than either the 1.2MB or the 720K drives. (At the present time, 1.4MB diskettes are much more expensive than the 720K variety; but prices will drop as the format becomes more popular.)

If you're building your system around an 80286 or 80386 motherboard, any AT controller should handle both types of disks. But if you're going the 8088 route, make sure you get a controller that can handle high-density disks.

Product of the Month. Last month I discussed Microsoft Works, a low-cost "integrated" software package that provides word processing, spreadsheet, database, and telecommunications.

PFS: First Choice (Software Publishing, Corp., P.O. Box 7210, 1901 Landings Drive, Mountain View, CA 94039-7210, 415-962-8910) is a similar program that provides the same basic quartet of applications. And after studying both, I've come to the definite conclusion that I can't say one is definitely superior to the other. The two programs are so similar that their reference manuals even use the same example in explaining how to search a file using wildcards!

In general, First Choice provides more power, but Works provides a better user interface, better on-line help, and better integration of the separate modules.

Here are some points of comparison: The First Choice spreadsheet provides about 72 functions, which is 20% more than Works. Those 72 functions include a number of BASIC-like string-handling routines.

Both programs can read and write Lotus 1-2-3 files and plain ASCII text files. However, by sending in the First Choice registration card, Software Publishing will send you a program that allows you to load and save documents in a number of different word-processing formats.

First Choice allows you to add several of your own programs to its main menu; Works has no comparable feature, but it does let you exit to DOS and return with everything intact.

Both programs come with a spelling checker, and First Choice comes with a thesaurus, but you have to send in a card to get a thesaurus from Microsoft. The word processing functions themselves in both are adequate, but can't compete with WordStar, WordPerfect, and other top-of-the-line products.

First Choice allows you to embed ruler lines in your document that allow you to change tab settings and margins at will. Works has only one master ruler line, but blocks of text can be formatted as desired, and Works also makes it very easy for you to format tables nicely.

Both programs support mice and macros; First Choice has a pop-up calculator. On the other hand, Works allows you to "split the screen" and view several parts of the same document or spreadsheet simultaneously.

With First Choice, you can't keep several applications open simultaneously; the program closes one when you load another, and the waiting that results is distracting. Works allows you to have a maximum of eight applications open simultaneously. In each, you can call up a menu that lists which are open and switch to the desired one.

Works has a smoother user interface. In addition, its on-line help is better detailed, and you can even run an on-line tutorial at any time. Further, Works' printed documentation is also superior.

Both programs have their weaknesses. Neither includes a program for creating graphics—either a draw/paint or a CAD program would be a welcome addition.

The communications modules in both programs are also weak. For example, both support only text and XMODEM file-transfer protocols, and both support only ANSI and VT52 terminal emulations. And neither allows you to upload or download files while working in one of the other modules. However, one point in First Choice's favor is that, during an on-line session, information comes into the First Choice editor, so you can edit it just like a regular text file.

Both programs come on both 5.25- and 3.5-inch disks, so installing them on a laptop or desktop PC is equally easy. Both cost about the same.

My choice? Although First Choice provides somewhat more power, I'd go with Works, because overall that program is easier to use. And that's what's most important for someone just starting out. ■

DX Listening

PANNING THE SHORTWAVE SPECTRUM

By Don Jensen

Alvaro de Mendana, a Spanish explorer outbound from Peru in search of the Great South Land—today's Australia—stumbled across the Solomon Islands in 1568. His two ships weighed anchor at a sandy-beached, palm-fringed isle he called Guadalcanal, after the little Spanish village where he'd been born.

In its swift-running streams, the Spaniards found gold. Not much, mind you, but enough gold dust to start rumors that the chain of Pacific islands would turn out to be as rich as King Solomon's mines!

To DX'ers today, the Solomon Islands still offer "gold"—in the form of two elusive and exotic shortwave stations—to listeners who "pan" the shortwave frequencies.

For several hundred years, little happened to stir those Melanesian islands off New Guinea. Missionaries came and so did the slavers, until, in 1893, the British stepped in to make the Solomons a protectorate. Another half century passed until the Japanese invasion and the bloody battle that followed in 1942.

The six-month battle for the Solomons, and particularly, Guadalcanal, took 20,000 Japanese and 3,600 American lives. Even today the scars of that battle remain in that tropical paradise, rusting tanks and sunken hulks off shore.

Independence came in 1978 to the six main islands and hundreds of smaller atolls that make up the Solomons nation. The northern island of Bougainville, though geographically part of the Solomons, politically is part of Papua, New Guinea.

On Guadalcanal, the capital, Honiara did not even exist four decades ago when the Marine Raiders stormed ashore. Today, it is the only urban area on the island, with office buildings, local businesses, branches of Japanese and Australian companies, a few tourist hotels, and even a couple of first-rate restaurants. Amid the tropical flora on the ridges overlooking the town, are rows of homes.

Here also is the shortwave outlet of the Solomon Islands Broadcasting Corp., which is the island nation's statutory authority for communications.

During the current favorable shortwave-listening season, the 10-kilowatt SIBC stations can be heard on two frequencies: 5,020 and 9,545 kHz. Programming is mostly in English, though some Pidgin will be heard.

Particularly interesting is the local newscast at 0730 UTC, which includes the times of high and low tide. The station can be heard during the early morning hours until its sign off, shortly after 1130 UTC.

At Kieta on Bougainville, the National Broadcasting of Papua New Guinea, operates its own shortwave outlet, *Maus Bilong Sunkamap* (Mouth Belong Sun-come-up, or Voice of the Sunrise).

Though *Radio North Solomon* also operates a 10-kilowatt shortwave station, it is considerably more difficult to log in North America on its 90-meter frequency, 3,325 kHz. Nearly impossible is a second listed frequency, 6,020 kHz.

The station airs programs in Pidgin and some English. For listeners in the eastern half of the U.S. and Canada, the best time to listen is probably between about 1200 and 1300 UTC. For west coast listeners, reception is more likely a bit later, up until the station signs off just before 1400 UTC.

Both SIBC and Radio North Solomon offer attractive listening targets for SWL's during the current winter DX-listening season!

Feedback. Letters with your comments and questions about shortwave listening, and your loggings of stations heard, are always welcome. Send them to *DX Listening*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

This month, we heard from R.L. Shook of North Chicago, IL, with a very basic question: "Can you please define the frequency range of shortwave?" he asks.

Yes, but in several different ways, R.L. There is a technical answer and a more traditional one. Shortwave isn't really a technical term, though because it is a useful "handle," we all use it. Shortwave is a word that dates back

Hearing Mexico on a crystal set he built in junior high school is what first got DX'er Kirk Allen interested in the listening hobby back in 1969. Later he was briefly a novice radio operator, but he became an active SW-DX fan in 1982. An avid fisherman, Kirk, of Newkirk, OK, also likes "fishing" on the shortwave bands for Latin American and Indonesian low-power stations. Kirk doesn't take the easy path!

to the early days of radio experimentation, when folks were communicating mostly on wavelengths that were considerably longer.

In time, though, radio pioneers discovered that when it came to long-distance radio, it was possible to get more bang for the buck, that is, reliable communications with relatively modest transmitter power, on the shorter wavelengths—*i.e.*, shortwaves.

As the technical definitions evolved, those frequencies between 3,000 and 30,000 kilohertz (equivalent to 3–30 megahertz) were designated as the high frequencies (HF). For the literally-minded radio fan, that defines shortwave.

In the same definition set, the ranges 10–30 kHz are the very low frequencies (VLF); 30–300 kHz are the low frequencies (LF), and 300–3000 kHz are the medium frequencies (MF). Above the HF/shortwave range is scanner territory, the very high frequencies (VHF) and ultra high frequencies (UHF), and so on up the spectrum.

But from the earliest days of broadcasting, listeners have tended to consider all programming above the top end of the regular AM radio dial (1600 kHz) to be shortwave. Despite that, as you begin to tune upward in frequency from the last medium-wave AM broadcaster, the first programming you're apt to come across will be in the 2.3-MHz area. Though they are often hard to hear, there is a decent handful of broadcasting stations, mostly in Brazil and Central America, operating in that 120-meter band.

So, while a bit broader than the 3- to 30-MHz HF definition of shortwave, our practical standard for this column will stretch technical niceties a bit to include broadcasting stations operating as far down as 2.3 MHz.

Reader Shook goes on to note that he is temporarily using a receiver capable of tuning between 2 and 30 MHz. Shook adds that apart from that set, he "has yet to see a receiver in today's market that can even begin to compare with that range."

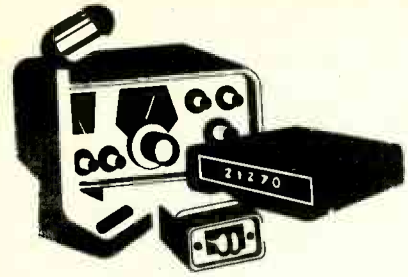
He says he's looking for a set that can cover 5 to 20 MHz. While it is true that some of the inexpensive portable receivers shortchange the low end of the shortwave range, any set worth considering for serious SW listening should include at least 30 to 300 MHz. And I think you should shop around some more, R.L., since most communications receivers these days do.

Down the dial. Here are what other listeners are hearing these days. You may be able to log these stations too. As always, all frequencies are given in kilohertz (kHz), and time is given in Universal Coordinated Time (UTC).

Germany—6,085. After West Germany's international SW station, *Deutsche Welle* signs off that frequency at 0545 UTC, you may hear German-language home service from *Bayerischer Rundfunk* with German pops. The frequency is blocked again at 0600 UTC when the *Voice of America* signs on the adjacent 6,080-kHz channel.

South Africa—7,140. *Capital Radio* is a commercial shortwave station, broadcasting from one of the South African "homeland" areas, Transkei. On this one you'll hear popular music, commercials, and even traffic reports.

Venezuela—4,830. *Radio Tachira*, broadcasting from San Cristobal, offers one of the better signals from northern South America. It can be heard during late-evening hours at around 0100 UTC with Spanish programs of lively Latin music. ■



Ham Radio

By Joseph J. Carr, K4IPV

CURING COMPUTER/RECEIVER INTERFERENCE

In the October 1988 edition of this column we discussed a number of computer and computer-interface products that are of interest to amateur-radio operators (some of them work on SW receivers as well). Many of those products have an unfortunate side effect that is difficult to overcome: electromagnetic interference (EMI).

We mentioned that problem briefly last October, but I feel that an additional discussion is in order. The problem is that digital devices, such as computers, and radio receivers, are mutually incompatible devices! The shortwave receiver is a highly sensitive detector of electromagnetic waves.

If it wasn't a highly sensitive EM detector, then you wouldn't hear much more than the AM broadcast band blowtorch down the street; a crystal set is not very sensitive to interference, but it doesn't pick up many desired signals either! The receiver must be extremely sensitive to hear rare DX, and that's a basic fact.

So What's the Beef? Another basic fact is that digital devices operate using squarewaves or near-squarewaves. Those signals are extremely rich in harmonic energy. In fact, textbooks tell us that a symmetrical squarewave is composed of a fundamental sinewave (F) plus an infinite number of even-numbered harmonics (2F, 4F, 6F, 8F, etc.).

While most of those have amplitudes that are too small to be detected by even the most sensitive receiver, it is not unlikely for a fast risetime squarewave (common to digital circuits) to have many dozen, or even over 100 harmonics strong enough to be picked up by a standard communications receiver (with a sensitivity of 1 microvolt). Thus, the squarewave used in your personal computer is incompatible with your favorite communications receiver.

We used to use that fact in the days before digital-VFO dials to calibrate our receivers (a 100-kHz non-sinusoidal wave from a crystal oscillator provided harmonics throughout the HF spectrum), but from a computer the "birdies" up and down the band are a pain in the neck.

What to Do? After the October column appeared, I received a letter from Dr. William E. Tompkins (KB5FYK) of Texas who had worked out a solution. The good doctor is both an amateur-radio operator and a long-time SWL. He uses the G&G/Microlog SWL Morse-code decoder with his station receiver, both for amateur work and to log coastal marine and beacon stations.

Doctor Tompkins encountered a lot of QRM "hash" from his Commodore-64/SWL combination around 40/41-meters. I suspect that the actual frequency will prove to be related to the clock frequency of the C-64. The point is, however, that Doctor Tompkins provides a solution to many users of the SWL/C-64 or C-128.

In addition, although he did not claim such, I suspect that his circuit will also work nicely for other digital projects that interface between a receiver and a personal computer. Let's call the circuit in Fig. 1 the *Tompkins Fiber-Optic Computer Interface Unit* (or TFOCIU for short).

Figure 1 shows the schematic diagram of the TFOCIU. The transmitting end of the circuit consists of an LM386 low-voltage audio amplifier (U1) feeding a 2N2222 general-purpose silicon NPN transistor, which is used to drive a light-emitting diode (LED2).

The LM386 contains all of the circuitry needed for the preamplifier and power-amplifier stages of a receiver audio section. That IC is a high-gain circuit, so if you build the interface unit, be sure to keep the input and output leads separated, and mount the V+ decoupling capacitor (C1) as close as possible to the LM386.

Audio from the speaker jack of your receiver is converted to an infrared-light signal by LED2. A 5-meter length of 1-mm diameter fiber-optic cable connects the LED transmitter to the receiver.

The receiver consists of an IR pho-

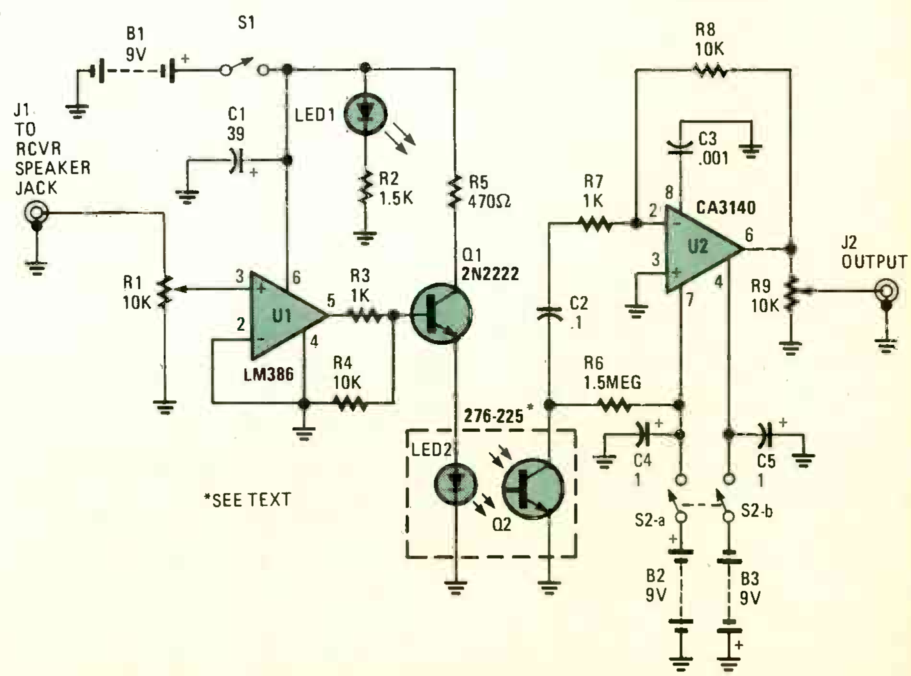


Fig. 1. The transmitting end of the TFOCIU circuit consists of an LM386 low-voltage audio amplifier (U1) feeding a 2N2222 general-purpose silicon NPN transistor, which is used to drive a light-emitting diode (LED2).

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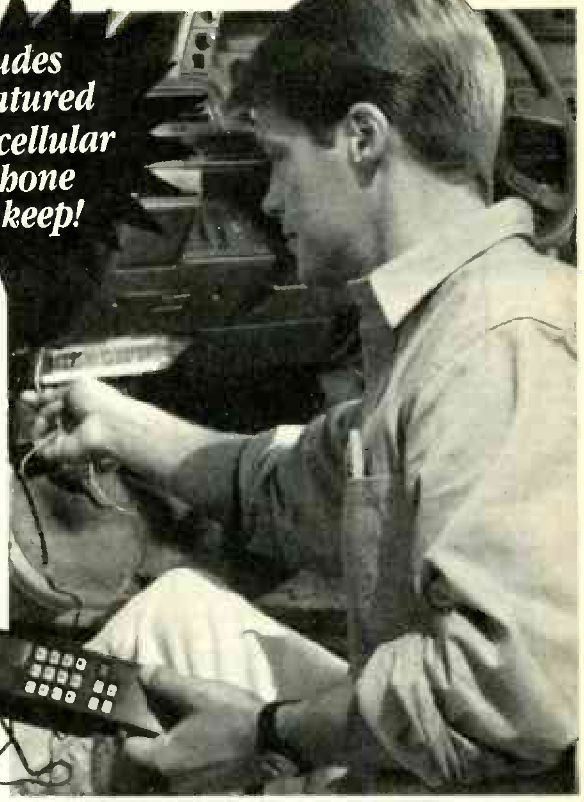

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Accredited by the National Home Study Council 9-039 todetector transistor (Q2) feeding a CA3140 BIMOS op-amp (U2). The modulated light that's fed through the fiber-optic cable is converted back to an audio signal by photodetector (Q2). The audio output of Q2 is fed to op-amp U2, were the signal is boosted ten fold, before being applied to the audio input of the SW receiver (or whatever digital device is used).

For a fiber-optic transmission path, the LED and phototransistor should be a matched pair, such as Radio Shack's fiber-optic emitter/detector set (part number 276-225), but any matched set should suffice. If the LED is replaced with a high-intensity IR LED (such as Radio Shack's 276-143), then it is not strictly necessary that the fiber-optic cable be provided. The circuit will work at least acceptably through the air (just don't come between the LED and the phototransistor, or transmission will stop).

Both transmitting and receiving ends of the circuit (U1 and U2, respectively) should be put in their own shielded enclosures. The circuits are small enough that they can be built into aluminum boxes that are only a little bigger than the batteries required to power the circuit. Use only those types of boxes that have an overlapping lip of aluminum all around the seam between the two half shells. Although "joint" boxes are cheaper, they are next to useless for suppressing EMI and they are mechanically weak. Pay a little more money and get the right box for the project.

According to Dr. Tompkins letter, the fiber-optic interface completely eliminated the interference that he'd experienced from the C-64/SWL combination. I suspect that there are at least two reasons for that. First, the conducted and radiated interference that is normal with a wire cable is not present on a fiber-optic cable. Second, the long fiber-optic run allows the receiver and computer to be physically separated.

Because the digital device and its interconnecting cable(s) can be considered an antenna, we know that the field falls off according to the inverse-square law, so doubling the distance cuts the EMI crud by a quarter.

The TFOCIU provides not only noise-free SWL and ham receiver operation, but also provides a means by which you can exercise your urge to experiment with neat things. If you are like many of us, then it will occur to you that the TFOCIU circuit has many uses besides its advertised application.

For example, how about fiber-optic communications over short distances? I'm seriously considering running a fiber-optic cable through a wall into another basement room next to my writing office in order to link my IBM-PC computer to the C-128 in the other room. The RS-232 cable picks up RF from my ham shack (which is in still another adjacent basement room), and causes all kinds of crud to be sent between the computers. I suspect that I can use both computers at the same time (if my arms are long enough) with an RFI-free, fiber-optic interface unit.

If you hear KB5FYK on the air then tell him, "well done, doctor Bill!" ■

PARTS LIST FOR THE TOMPKINS FIBER-OPTIC COMPUTER-INTERFACE UNIT

SEMICONDUCTORS

U1—LM386 low-power audio-amplifier, integrated circuit
U2—CA3140 BIMOS op-amp, integrated circuit
Q1—2N2222 general-purpose NPN silicon transistor
LED1—Jumbo red light-emitting diode
LED2/Q2—Radio Shack fiberoptic emitter/detector pair (RS 276-225)

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)

R1, R9—10,000-ohm potentiometer
R2—1500-ohm
R3, R7—1000-ohm
R4, R8—10,000-ohm
R5—470-ohm
R6—1.5-megohm

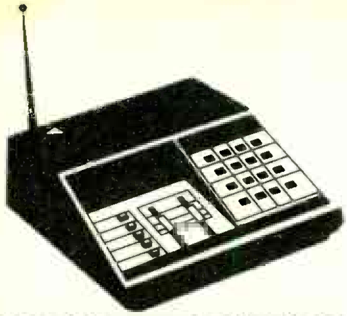
CAPACITORS

(All electrolytic capacitors are 16-WVDC units unless otherwise noted.)

C1—39-µF, electrolytic
C2—0.1-µF, ceramic disc
C3—0.001-µF, ceramic disc
C4, C5—1-µF, electrolytic

ADDITIONAL PARTS AND MATERIALS

B1–B3—9-volt transistor-radio battery
J1, J2—See text
S1—Single-pole, single-throw toggle switch
S2—Single-pole, double-throw toggle switch
Printed-circuit or perfboard materials, fiber-optic cable (Radio Shack 276-228 or equivalent), chassis box, IC sockets, connectors, 9-volt battery holders, wire, solder, hardware, etc.



Scanner Scene

By Marc Saxon

SPEAKING OF MODIFICATIONS

When I offered to send out copies of the cellular-frequency restoration for the Radio Shack PRO-2004 scanner, I was deluged with requests. One who requested the information was Al Hart of New York, NY who wrote back to say "it worked like a champ." Al then asked if there were any other modifications that we might know of for the Radio Shack (Realistic) PRO-2004 scanner.

There are any number of other simple modifications for that scanner circulating around, the most worthwhile being a way of changing the set from a 300-channel scanner to one that receives 400 channels in 10 memory banks of 40 channels each.

If you want to add an extra 100 channels to your PRO-2004 with a do-it-yourself modification that takes only a couple of minutes, send me a request accompanied by self-addressed, stamped return envelope (SASE) and I'll be happy to pass the information along to you. (Note: Any request not accompanied by an SASE will not be honored.)

Scanner Market. Many people in scanning are excited about units that are capable of picking up the 80-MHz band. Well, the *Uniden Bearcat 9500XLT* is a 100-channel scanner that covers from 29 to 54 MHz, 118 to 174 MHz, and 406 to 956 MHz (except 824 to 849 MHz and 869 to 895 MHz, the cellular phone bands).

The 100 scanning channels are divided into five banks of 20 each. Especially interesting features of the Bearcat 950XLT include an optional CTCSS PL (selective calling) decoder board and something called *Service Scan.* The decoder board allows you to scan any of the standard tones in any combination within the 100 memory channels of the 950XLT. The decoder board—which is sensitive to the 38 standard CTCSS tones between 67.0 and 2500.3 Hz—prohibits the squelch from opening unless a valid tone frequency is received.

Service Scan consists of a series of front-panel pushbuttons that permit automatic search of factory pre-programmed police, fire, emergency services, aircraft, and marine frequencies. Scanning at a rate of 15 channels-per-second, the unit operates on 13.8-volts DC or, with the aid of its AC adaptor, on house current.

Of course, the 950XLT has all of the standard scanner features: Priority channel, scan delay, lockouts, keyboard lock, search/scan, and instant weather-channel access. The most often asked question about the unit relates to whether the deleted cellular 800-MHz band channels can be restored. Apparently, some enthusiasts have been able to accomplish that (although details of that modification are not presently available). However recent rumors have it that units currently rolling off the production lines have a design change that effectively kills any chance of simply snipping out a diode to restore those frequencies.

The 950XLT sells in the $250 price

The Uniden Bearcat 950XLT has 100-channels divided into five banks of twenty each and features an optional CTCSS PL (selective calling) decoder board and something called "Service Scan," in addition to all of the usual scanner features.

range. For more information, either check with your nearest Uniden dealer or write to the Uniden Corporation of America, 6345 Casteleway Court Indianapolis, IN 46250.

In the Mail. Mick Slater, somewhere in Indiana, asks us to remind readers that there's a world of knowledge to be gained by simply listening to the 46-MHz cordless telephone frequencies. With his exterior antenna, he easily hears conversations within a five-block radius of his station. He says that within only a few weeks of listening to those frequencies, you'll know more about the private lives of your neighbors than you ever imagined.

We wholeheartedly concur, Mick! The private telephone conversations that waft out over the airwaves on those and various other bands are sometimes astounding, often funny, and always interesting. And there are many scanner enthusiasts who now specialize in that type of monitoring, ignoring police, fire, and other communications.

Speaking of cordless telephones, Ed Berringer of Texas would like to know the frequency used by the *Astroking 55*—a long-range cordless telephone used by one of his neighbors. Ed reports that the unit has a range of as much as 30 miles, and with an available booster, the range can be extended for 60-mile operation.

Even though Ed lives down the block, he can't pick it up on his scanner, and its owner told him that that's because the Astroking 55 operates on a special frequency. The Astroking 55 is one of several high-powered private mobile or cordless-telephone systems made overseas (supposedly for use overseas) although many of the units have found their way into the American marketplace (even though they are illegal in the USA).

The base/mobile system sells in this country on the underground market for about $2,000. The mobile set puts out 10 watts on a frequency in the 137-MHz band, while the base-station unit runs 15 watts on a frequency in the 72-MHz band. Forty-watt power boosters are available for the mobile unit, and 80-watts for the base unit.

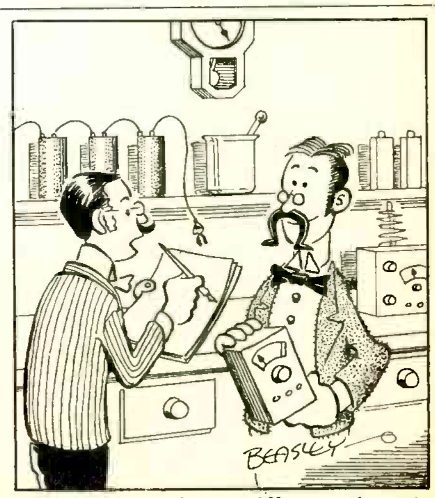
If your scanner can receive the 72- and 137-MHz bands, you'll be able to hear that system. If the FCC catches your neighbor using the Astroking 55, he'll be somewhat unhappy. For all of the money he put into that system, he might just as well have gotten a cellular phone and done things legally!

From Las Vegas, we got a note from someone identified only as *R.K.P.* who asks us to run the frequencies used by the United States Department of Labor. The most often noted USDL operating frequency seems to be 406.20 MHz, although the agency appears to also use 162.025, 162.225, 162.6125, 164.70, 166.20, 408.025, 409.025, 411.35, 412.45, and 415.45 MHz. You might want to check out all of those frequencies in your area to see which (if any) are active. The USDL is an interesting agency to monitor, and is often involved in organized-crime investigations and surveillance.

Joe Dubec in Algiers, LA wrote to say that he's heard activity on 158.445 MHz—a frequency he detected while experimenting with his unit's search/scan mode. Joe wants to know if we can tell him what type of stations use that channel, since it's not listed in any of the reference sources.

Joe says, "it seems to be a maritime operation." That frequency is used by companies involved in cleaning up oil spills from harbors, rivers, and other waterways in all areas of the nation. Similar communications take place on 36.25, 40.71, 150.98, 161.58, and 454.00 MHz. Any person situated in a coastal area, or near a major river, should keep those frequencies punched up in their scanners at all times.

If you have a question, comment, favorite frequency discovery, or other news, we'd like to hear from you. Write to *Scanner Scene*, **Popular Electronics**, 500-B, Bi-County Blvd., Farmingdale, NY 11735. ■



"All right Mr. Ohm, we'll name the unit of resistance after you—now, what shall we use for the symbol?"

ANTIQUE RADIO
(Continued from page 85)

course along the line. But she never got lost! And I'm sure that no reader had more fun with Emily than we editorial types as the robot was put through her paces on a labyrinthine path laid out through the office corridors.

Well, parts are still cheap and plentiful, but we don't see quite as many goofy projects today as we did back during the 1960's. Maybe it's because the transistor is no longer a new toy. Or is it because we live in a more serious, less optimistic era?

The Columns. Then, as now, **Popular Electronics** ran excellent columns on ham radio and shortwave listening. They were conducted by as engaging a pair of columnists as ever set pen to paper. Herb Brier, who ran *Across the Ham Bands*, was well known for his commitment to helping young newcomers get started in the hobby. His column packed a lot of information into a very small space.

Hank Bennett, of *Short Wave Report*, helped carry the U.S. mail during his normal working hours. But when he put on his writing hat, Hank's love and enthusiasm for the shortwave-listening hobby were infectious indeed. My copy of Hank's *The Complete Short Wave Listener's Handbook* (Tab Books, 1974) is one of the most well-worn books in my radio library. It has been revised and reprinted more than once over the years, and I believe it's still in print.

Dick Strippel's *On the Citizen's Band* and Lou Garner's *Transistor Topics* have no modern counterparts, but they were interesting and lively columns as well. Like the Brier and Bennett columns, Dick's contributions opened with some general operating news

Remember drugstore tube testers? Cartoonist Dave Harbaugh levels a well-deserved pot shot (July, 1961 issue).

(written in his own special chatty style) and closed with a compilation of material on reader activities.

Lou Garner certainly had his hands full covering the exploding semiconductor field. His columns were loaded with application hints, product photos, and technical information on new devices. And like the other columns, Lou's column incorporated many contributions from the readers—mostly in the form of circuit designs that used semiconductor devices.

Other Regular Features. Much as I'm enjoying the job, I'll never be able to talk about all of the contributors to the old **Popular Electronics** within the alloted space. But there are a few folks who demand mention. John Frye, for example, who wrote the monthly *Carl and Jerry* stories. Carl and Jerry were fictional characters who were close friends, clever electronic experimenters, and undergraduates at the mythical Parvoo University.

John's action-packed stories exploited all of those characteristics as, month after month, the boys used their electronic know-how to get themselves into—and out of—a variety of scrapes. The stories were filled with details, both electronic and collegiate.

Almost every issue also contained an electronic quiz by Robert Balin. Usually requiring the reader to match a schematic, or other type of drawing with a short description. Those clever quizzes would trip up people who thought they knew their electronics.

Finally, I'd like to recall the regularly-appearing feature *Hobnobbing With Harbaugh*. Dave had a devilish eye for the humor in things electronic that brightened up any issue containing a page of his distinctive cartoons. He poked fun at readers, advertisers, and hallowed electronic institutions alike—for the enjoyment of all.

Coming Attractions. Next month's column will feature reader Larry Lovell's mystery device. We asked for help from the readers at large in identifying that odd gizmo (November, 1988 issue), and it has been definitively pegged as a wireless remote-control for a Philco broadcast set. We'll have the in-depth story on it next time. Until then, I'd like to hear from *you*! Send your comments and questions to *Antique Radio*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

FOX-HOLE RADIO
(Continued from page 72)

from 15 to 70 ohms, but they are scarce. The cheap earplugs and 2-inch diameter speakers are usually only 10 ohms or so. Your best bet is to connect an audio-output transformer to the circuit. The high-impedance side should be connected across the detector and ground, and the low-impedance winding goes to the earplug or miniature loudspeaker. After the unit is operational, you could add an op-amp circuit to boost the audio output and provide the necessary impedance matching. If you have an antique 1000-ohm headset (forget about the transformer and op-amp), use it.

The Sky Hook. For an antenna system, use any wire over 10-feet long. Place it as high as you can and secure it to whatever you attach it to with an insulating material. My antenna wire came from a discarded TV yoke. It comes apart easily. The wire was run out my back door and tied to a convenient tree. Connect one end of the antenna to the ungrounded side of the coil.

Listen to the headphones carefully. If you hear nothing, try moving the wiper along the coil. The moving tap may cause some static which is normal, however, when you remove your hand from the tap, the tap should be snug and no noise should be heard in the headphones. If you hear sharp static, check all your connections. If all goes well, you will be able to hear the strongest AM station in your area. Moving the tap across the coil will tune in other signals, but they may be drowned out by the more powerful signals, which usually come from the nearest stations.

The radio lacks selectivity and is not very sensitive, but in the 1910's through 1920's, similar radio circuits brought radio to the public. Its main utility today lies in the fact that it is totally signal-powered. No AC or batteries are needed.

The Fox-Hole Radio will reward the experimenter with a low-cost, practical introduction to AM radio reception. It's a tinkerer's dream since there are many ways to improve the circuit. For instance, an audio transistor will work as a detector and can be made to amplify the signal. Or you could replace the fixed capacitor with a variable one and leave the movable tap fixed at the high end of the coil. ■

CIRCUIT CIRCUS

(Continued from page 83)

length of the core. Leave about 8-inch leads at each end, and tape the completed winding. Cut a T-shaped coil holder, to match the drawing in Fig. 4, from ⅛-inch plywood, plastic, or fiber board and cement each coil in place.

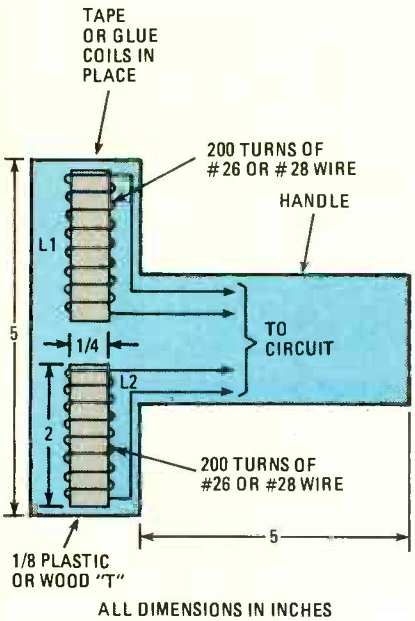


Fig. 4. Coils L1 and L2 are each wound on a 2-inch length of quarter-inch ferrite-rod material.

Keep the layout neat and the interconnecting leads as short as possible. For a compact and handy instrument, mount the receiver atop the handle of the "T" coil holder. Mount LED1 on the same side of the cabinet as L1, and LED2 on the same side as L2.

To use the Tracer, connect its transmitter to ends of the cable or wire and use the receiver to ferret out the cable's path. If a separate wire or common-ground circuit is available to complete the transmitter's current path, use the hookup shown in Fig. 5A.

Actually, it's not always possible to have a return lead or common ground to use to complete the current path. In that situation, an external wire can be used, as shown in Fig. 5B.

Also, in some instances, I have found it possible to use two wires in the same cable for the current path by feeding the transmitter into the wires at one end and connecting the same two wires together at the opposite end of the cable. That method will only work part of the time due to the self canceling effect of the transmitter's field on the two parallel-running conductors.

PARTS LIST FOR THE TRACER RECEIVER

U1—LM324 quad JFET-input op-amp, integrated circuit
Q1, Q2—2N3904 general-purpose NPN transistor
D1–D4—1N914 general-purpose silicon diode
LED1, LED2—Jumbo light-emitting diode (any color)
R1, R2, R8, R9, R10, R17—1000-ohm, ¼-watt, 5% resistor
R3, R4—2200-ohm, ¼-watt, 5% resistor
R5, R6, R11, R12—100,000-ohm, ¼-watt, 5% resistor
R7—Dual 10,000-ohm, audio-taper potentiometer
R13, R14—100-ohm, ¼-watt, 5% resistor
R15, R16—10,000-ohm, ¼-watt, 5% resistor
C1, C2—0.27-µF, 100-WVDC, mylar or similar capacitor
C3–C14—0.1-µF, 100-WVDC, ceramic-disc capacitor
C15—47-µF, 16-WVDC, electrolytic capacitor
C16—220-µF, 16-WVDC, electrolytic capacitor
L1, L2—200 turns of #26 wire on 2-inch ferrite core (see text)
J1—Stereo phono jack
Printed-circuit or perfboard materials, enclosure, IC socket, wood material (see text), battery and battery holder, wire, solder, hardware, etc.

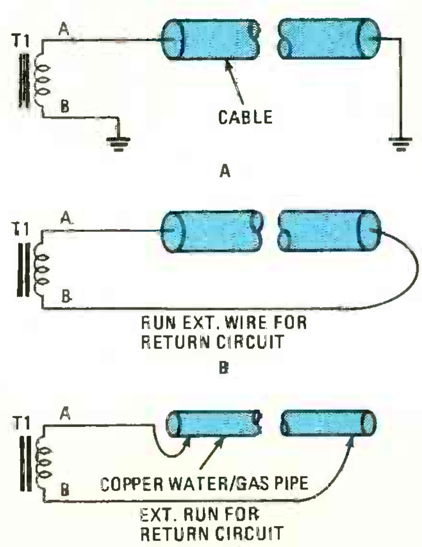


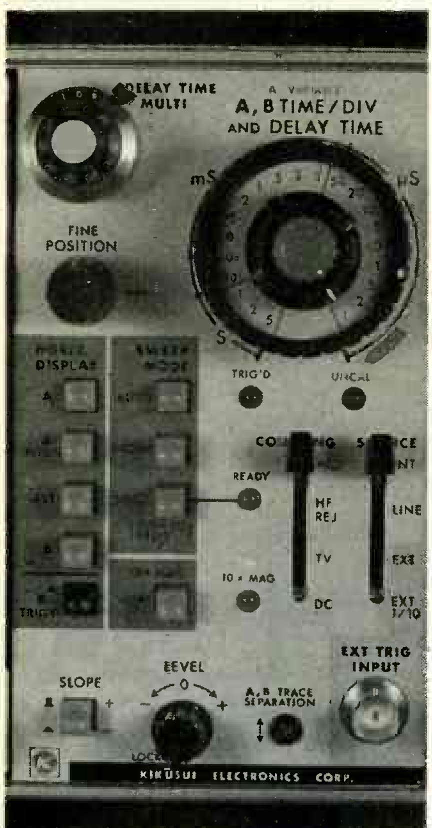
Fig. 5. How the Closed-Loop Tracer is used depends on what you have to work with.

Another use for the Tracer can be found in Fig. 5C. If you want to trace the path of a copper or metal pipe, connect the transmitter's output to one end and run a separate wire lead to the opposite end. ■

OSCILLOSCOPES

(Continued from page 48)

In some RF measurements there is a need to mount an adapter as close as possible to the oscilloscope. In one photo, you can see an adapter that the author uses to make time-domain reflectometry tests on coaxial cable and other transmission lines. Notice that a BNC "tee" connects the adapter through a male-male connector directly to the input on the oscilloscope.



The horizontal-control group (with some trigger controls) is shown here. They are grouped for ease of use.

The reason that is done is to place the box as close as possible to the input of the oscilloscope.

In some cases it is necessary to connect several RF boxes together with an oscilloscope. For example, a signal source and a marker generator may be connected together to present "blips" on a CRO that identify specific frequencies. One cannot simply connect the devices in parallel because, in RF circuits, it is necessary to keep the system impedance (denoted R_O) constant. In most RF circuits R_O is 50-ohms, although in TV systems it is often 75-ohms and sometimes that impedance is 300-ohms.

Figure 8A shows a linear combiner

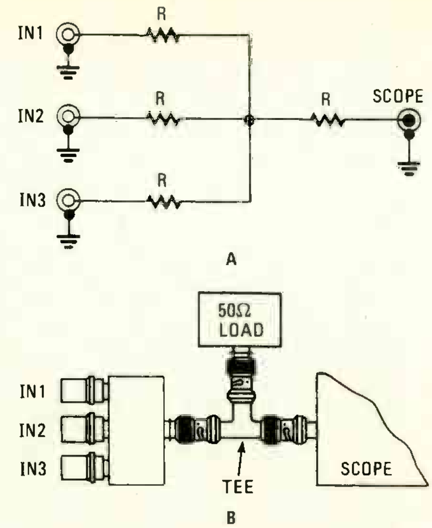


Fig. 8. A shows a linear combiner that allows us to connect 3 devices to an oscilloscope. In B we see the combiner coupled to a 50-ohm dummy load via a tee-connector for 50-ohm system use.

that allows us to connect 3 devices together. Each resistor inside a combiner of N devices is selected to be 1/Nth of the system impedance. So, in the case shown, with a 50-ohm system the resistors would be 16.67 ohms each; so in a two-port system, use 25-ohm resistors. A basic requirement of the coupling system is that it must be terminated in the system impedance. In Fig. 8B we see the combiner coupled to a 50-ohm dummy load via a tee-connector to the oscilloscope input. It is also possible to use a barrel

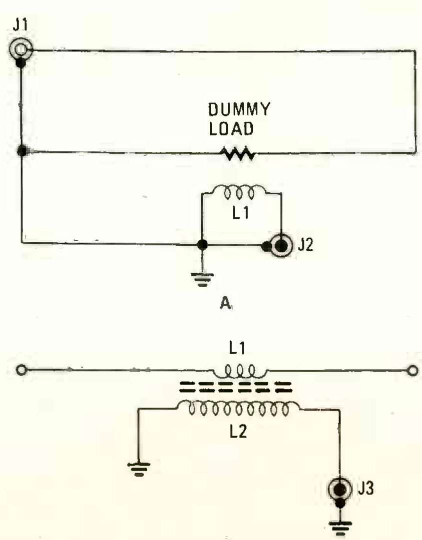


Fig. 9. In A we show a method for using a dummy load to couple an oscilloscope. The dummy load would be used in place of an antenna. Figure B shows a coupler used for displaying a current waveform. In general, a ferrite toroid is used for the current transformer.

attenuator between the output of the combiner and the input of the oscilloscope, although that is not the best practice.

Figure 9 shows two other methods for obtaining an RF signal for the oscilloscope input. In Fig. 9A we see a method for using a dummy load for coupling to an oscilloscope. The dummy load is a high-power, noninductive resistor with a value equal to the system impedance (most often that impedance is 50-ohms). For those not familiar with the dummy load, one would be used in place of an antenna for purposes of testing, troubleshooting, and tuning-up a transmitter. The pick-up sensor used to obtain the oscilloscope input, L1, is a 2 or 3 turn, 1- to 2-inch diameter loop of solid wire inside the dummy-load housing.

Figure 9B shows a method for displaying a current waveform. L1 is a

When making RF measurements, adapters should be mounted as close as possible to an oscilloscope. Note how that is accomplished with a "tee" connector.

small coil that is connected in series with the line in which the current is flowing. Coil L2 is the secondary, and is used as a voltage output to the oscilloscope. In general, a ferrite toroid is used for that type of current transformer.

Of course the applications of oscilloscopes is so numerous that no one article could ever describe all the connection techniques used. Here we have tried to present the broadest selection, to give you a taste of the instrument's wide range of applications. That is a testament to the oscilloscope's usefulness and explains why they are the single-most popular electronic instrument for almost any application, and one that's a must for almost every experimenter's workbench. You have now learned how an oscilloscope works, how to operate an oscilloscope, and how to connect signals to it. So go to it and enjoy. ■

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APEC9

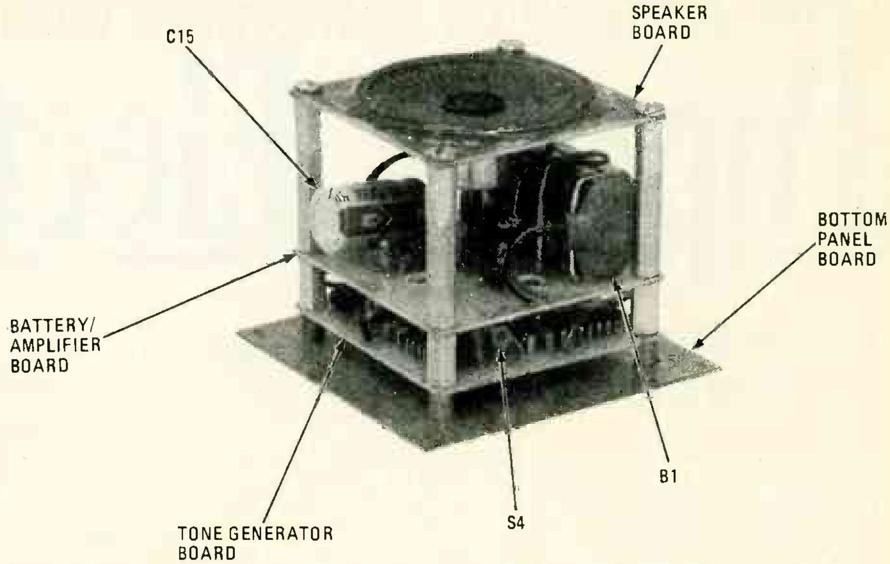
EXECUTIVE DING-A-LING

(Continued from page 35)

component leads to the copper side of the battery/amplifier board at points A, B, and C, making sure that the leads are at least ¾-inch or longer. Afterward, temporarily put the battery/amplifier board aside. Solder two leads to S5 (located on the bottom-panel board).

Install 1½-inch screw-on spacers to the speaker board, using 1¾- to 2-inch screws. That should leave about ¼ to ½-inch of the screw protruding through the ends of the spacers. Connect the leads from the speaker to the appropriate pads on the battery/amplifier board. Do not mount the battery/amplifier board on the 1½-inch spacers yet. If you do, it will be necessary to undo the installation when you are ready to adjust the tone generators.

Thread the wires from S5 (on the bottom-panel board) through the square hole in the tone-generator board, and solder them to the appropriate pads on the battery/amplifier board. Then, line up the component leads from the battery/amplifier board with the corresponding pads on the tone-generator board, and solder in place.



This is what the completed assembly should look like once the boards are stacked.

Finally, mount the bottom-panel board, separated by ¼-inch spacers, to the tone-generator board, using ½-inch screws. Those screws should be long enough to go through the ¼-inch spacers, both boards, and into the ½-inch spacers.

Next, connect the battery without putting it into its holder. That allows you to adjust R2, which is located under the battery. Apply power to the circuit, and set the assembly down so the unit is right-side up and level. Each tone generator can be adjusted for proper triggering and tone by shorting the two leads of any one mercury switch and adjusting the corresponding potentiometer through the ¼-inch hole in the battery/amplifier board.

After the tones are adjusted and the volume is set, the speaker board is mounted on top of the four 1½-inch stand-offs, and the battery placed in the holder to complete the assembly. (The completed assembly is shown in the photos.)

A simple enclosure for the Executive Ding-A-Ling can be built from wood or plastic. A grille of sorts, or holes through which to vent the audio, must be drilled through the top of the box. As a grille, the author used a small piece of perforated metal (grille metal), which was affixed to the inside of the enclosure with epoxy.

When the electronic assembly is installed in the enclosure, the bottom-panel board becomes the bottom cover. The bottom, which at this point supports the electronic assembly, is held in place with four small screws. The overall size of the bottom plate can be modified to fit the enclosure you may choose, or build.

Now that you've completed the project, you are ready to sit back at your desk during a busy day and play with your Executive Ding-A-Ling. Just don't let the boss catch you or you might have to make one for him. ■

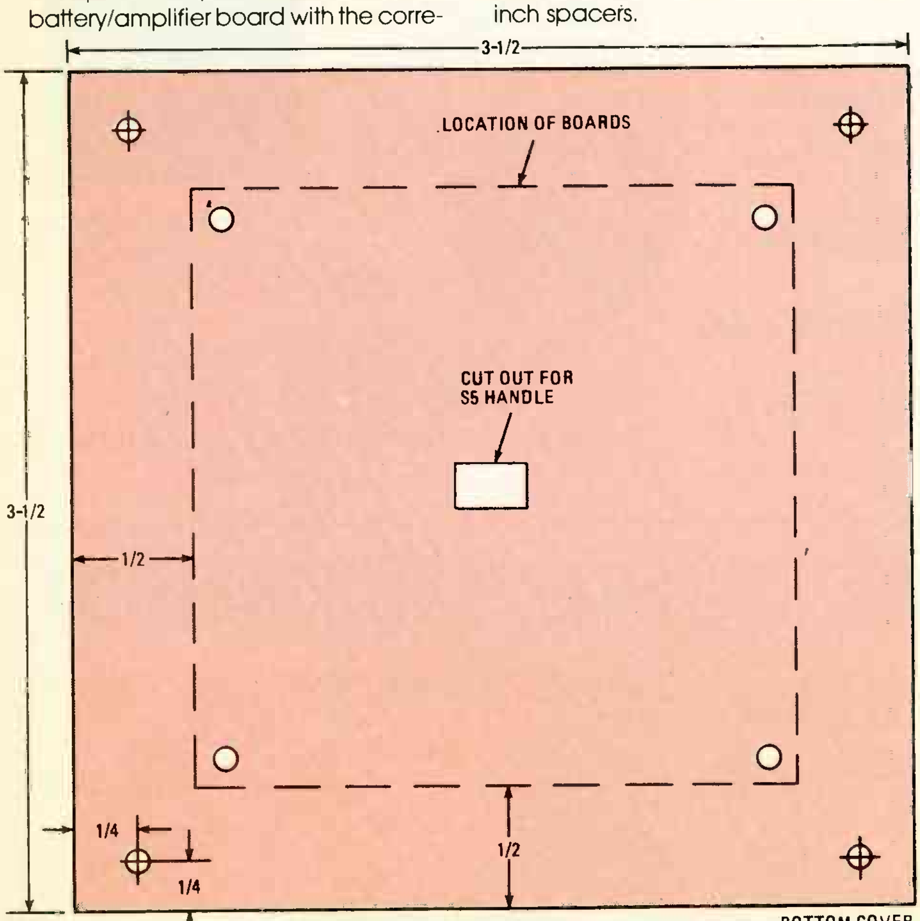


Fig. 7. A piece of printed-circuit material is cut to the dimensions shown, and serves as the bottom panel of the enclosure. Note the square hole cut in the center of the board. That hole allows the control lever of S5 to be accessed when the project is completed.

THE EASY-DIAL R-BOX

(Continued from page 42)

all ten positions of each switch of your dial-up resistance box.

If 5-percent-tolerance resistors are used, the measured accuracy should be within 5 percent of the total readout. (Meter accuracy and resolution can also affect the reading. And the switches, wiring, jacks, etc., of the R-Box will add a small resistance—less than one ohm—to each reading. For greater accuracy, 1-percent tolerance resistors may be substituted for the 5-percent units specified.)

To make sure the thumbwheels are linked together properly, test sets of adjacent switches, such as in the sequence 000022, 000220, 002200, 022000, 220000.

If all or most of the settings give incorrect readings, the switches are probably wired in the wrong order. If just a few readings are incorrect, check the wiring and switch operation at that part of the circuit. When all looks okay, the switches are ready to be inserted into the enclosure.

The resistors mounted on the switches may cause the assembly to be a little taller than the opening, making installation from the front difficult. If so, tilt and slide the switches in one at a time from the inside of the enclosure, then snap them together. Be sure S1 is the rightmost switch as you face the display. That is, the least-significant digit (thumbwheel with the smallest value resistors) should be at the far-right.

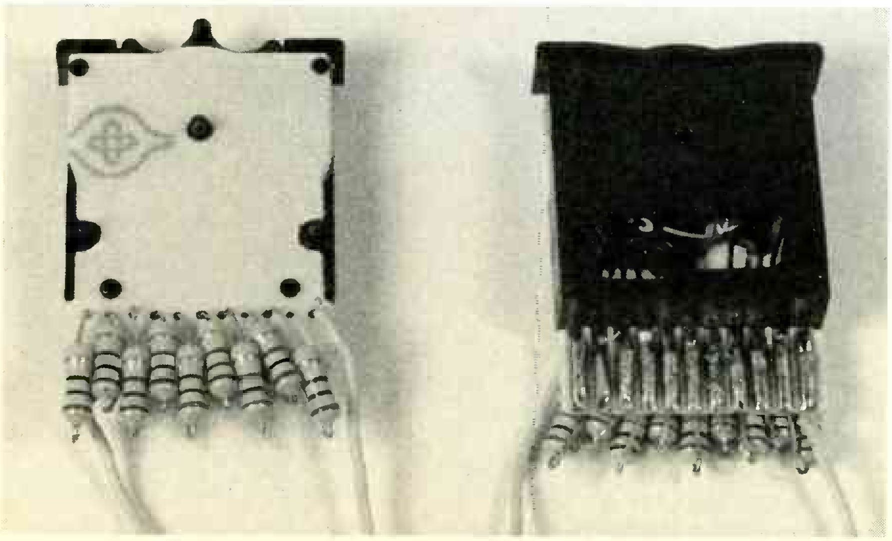
When all are inserted and joined together, slide the thumbwheels part way out the front of the opening, snap on the end plates, and push the set of switches into place. Brackets on the endplates will snap open and hold the switches in place. You might also add a few rubber feet, stacked underneath and on top of the switches, to give additional support.

Finally, install the banana jacks (J1 and J2) and solder one of the remaining two free wires to each. Mount and attach the cover, and you're in business.

R-Box Tips. To use the R-Box, plug your test leads into J1 and J2. Dial in the resistance you want and clip the test leads to your circuit in place of a resistor. About the only caution to keep in mind when using the R-Box is not to exceed the wattage rating of the resistors. For instance, a 20-ohm resistor with 3 volts across it consumes close to half a watt. Decreasing the resistance or increasing the voltage in such a situation may be more than the ½-watt resistors can handle!

In particular, take care when selecting low value resistors and remember that a setting of 000000 is nearly a dead short (a resistance of 1 ohm or less). Dial in the resistance that you want before connecting the R-Box in a powered circuit. (Or use a fixed resistor in series with the R-Box to limit the current.)

The Easy-Dial R-Box is a timesaver. With it, you'll do much less rounding up (and putting back) assortments of resistors for hit-and-miss trial operations. And the easy-to-read display window makes selecting values a snap. Build yourself one today! ■



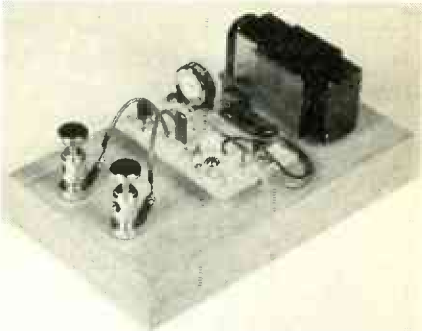
Each thumbwheel switch contains a small printed-circuit board that provides connections to each switch terminal. The resistors for the R-Box mount directly on those boards.

METAL DETECTOR

(Continued from page 70)

Problems. The metal detector system is simple. If you have assembled the circuit correctly and installed a fresh battery, the unit should work perfectly the first time you try it. If it doesn't, check the ends of the wires coming from the coil. Those ends should be clean, bright, and free of insulation. Poor electrical connections can be very troublesome.

If the system still does not operate to your satisfaction, the problem may be the radio. If the radio is not operating as it should, the performance of the metal detector may suffer. Also, make sure that the radio is located physically close to the oscillator. A good place seems to be right next to the detector's binding posts and the lead wires of the inductor.



The circuit board, binding posts, and battery holder have all been fastened to a block of wood. The baseboard adds to the project's appearance.

There is another way of accomplishing the same thing. Connect one end of a two or three-foot length of flexible hook-up wire to either of the binding posts. Wrap the other end around the radio. The wire amounts to a simple antenna, which allows you to position the radio some distance away from the oscillator.

An Electronic Pendulum. The circuit you've built is not quite as powerful as those used for any really serious outdoor treasure-hunting. But, you can use it to detect large metallic objects. And there are other applications for the circuit.

For instance, you can use the circuit as a novel electronic pendulum. Suspend a fairly heavy metal weight from a string directly over the coil. Put the pendulum into motion and the detector will respond to the speed and position of the weight. ■

E-Z MATH

(Continued from page 81)

TABLE 8—
EXCLUSIVE OR

A	B	C
0	0	0
0	1	1
1	0	1
1	1	0

1 and B is 0. We write that as $A\overline{B}$. The output is also binary 1 where A is 0 and B is 1. That, of course, is written as $\overline{A}B$. The sum of products is then:

$$C = A\overline{B} + \overline{A}B$$

With the Boolean expression, you can now draw the logic circuit. Assuming that only the A and B signals are available, and using only ANDS, ORS, and inverters, the circuit will appear as shown in Fig. 11A. Take a minute and examine the circuit and verify that for yourself.

Now let's see how we can use NANDS or NORS to simulate the XOR circuit. Begin by using NAND gates. The resulting circuit is shown in Fig. 11B. Two NAND gates are used to replace the AND gates of Fig. 11A. Another NAND gate is used as a negative NOR for the output OR circuit. The two inverters are still required at the input to produce both the normal and complement input signals. Note in Fig. 11B that there are two circular inverters, one after the other at each of the NAND-gate outputs or NOR-gate inputs. This is equivalent to having two inverters cascaded. Two inverters cascaded, of course, represents double negation or double complementing which is the same as using no inverters at all. One inverter produces an inversion but the second one corrects it. The result is that the output is exactly the same as the input.

You can also use positive NOR gates to simulate the XOR as shown in Fig. 11C. The AND functions required at the input are implemented by using the negative NANDS. The only correction required is reversing the logic levels on the inputs. The NAND-gate outputs are ORed together in the NOR gate. But since that is a NOR gate instead of an OR, we must connect an inverter to the output to obtain the correct polarity logic signal. The NOR version, of course, performs the same logical function.

Looking at the NAND and NOR circuit implementations in Figs. 11B and 11C, you can see that the NAND version is the most economical since the NAND version does not require an inverter at the output and using one less circuit minimizes the design.

That's all for this month. Why not test your knowledge by trying your hand at the three exercise problems? The answers to those are given above. Good luck and see you next month. ■

Boolean Laws

1. Laws of Intersection:

$A(1) = A$
$A(0) = 0$

2. Laws of Union:

$A + 1 = 1$
$A + 0 = A$

3. Laws of Tautology:

$AA = A$
$A + A = A$

4. Laws of Complements

$A\overline{A} = 0$
$A + \overline{A} = 1$

5. Laws of the Double Negative:

$\overline{\overline{A}} = A$

6. Laws of Commutation:

$AB = BA$
$A + B = B + A$

7. Laws of Distribution:

$A(B + C) = AB + AC$
$(A + B)(A + C) = A + BC$

8. Laws of Association:

$A(BC) = (AB)C = ABC$
$A + (B + C) = (A + B) + C$
$= A + B + C$

9. Laws of Absorption:

$A(A + B) = A$

$A(\overline{A} + B) = AB$

$AB + \overline{B} = A + \overline{B}$

$A\overline{B} + B = A + B$

Answers to Exercise Problems.

1. See Table 9.

2. $\overline{AB}$

Change AND to OR:

$\overline{A + B}$

Complement each term individually:

$\overline{\overline{A} + \overline{B}}$

Complement the entire expression:

$\overline{\overline{\overline{A} + \overline{B}}} = \overline{A} + \overline{B}$

3. $Y = \overline{\overline{A} + C} + \overline{ABC} + \overline{A}\,\overline{B}\,\overline{C}$

Expand the second and third terms with DeMorgan's:

$Y = A\overline{C} + \overline{A} + \overline{B} + \overline{C} + \overline{A}\,\overline{B}\,\overline{C}$

Rearrange that equation by law of commutation:

$Y = \overline{A} + \overline{B} + A\overline{C} + \overline{C} + \overline{A}\,\overline{B}\,\overline{C}$

Use laws of distribution:

$Y = \overline{A} + \overline{B} + \overline{C}(A + 1) + \overline{A}\,\overline{B}\,\overline{C}$

Reduce by law of complements:

$Y = \overline{A} + \overline{B} + \overline{C} + \overline{A}\,\overline{B}\,\overline{C}$

Factor out C by law of distribution:

$Y = \overline{A} + \overline{B} + \overline{C}(1 + AB)$

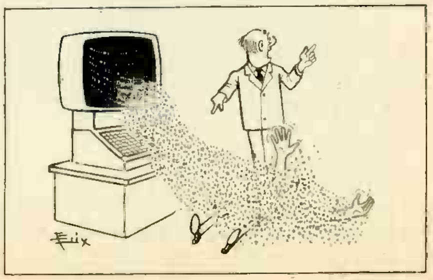
Reduce that equation by law of complements, which yields:

$Y = \overline{A} + \overline{B} + \overline{C}$

As a result.

TABLE 9—PROBLEM 1 ANSWER

A	B	AB	$\overline{AB}$	$\overline{A}$	$\overline{B}$	$(\overline{A} + \overline{B})$
0	0	0	1	1	1	1
0	1	0	1	1	0	1
1	0	0	1	0	1	1
1	1	1	0	0	0	0



E.H. ARMSTRONG

(Continued from page 44)

from the sale of his patents, and used his money to search for a means to eliminate static from radio reception. At the same time, however, he spent much energy and money in patent litigation; de Forest claimed to have invented the regenerative receiver before Armstrong. De Forest eventually won in the courts in spite of evidence from his own statements that showed he did not even understand how his own audion worked. The scientific community sided with Armstrong, however; the Institute of Radio Engineers awarded him a gold medal for inventing the regenerative receiver, and the Franklin Institute in Philadelphia also gave him credit for the invention.

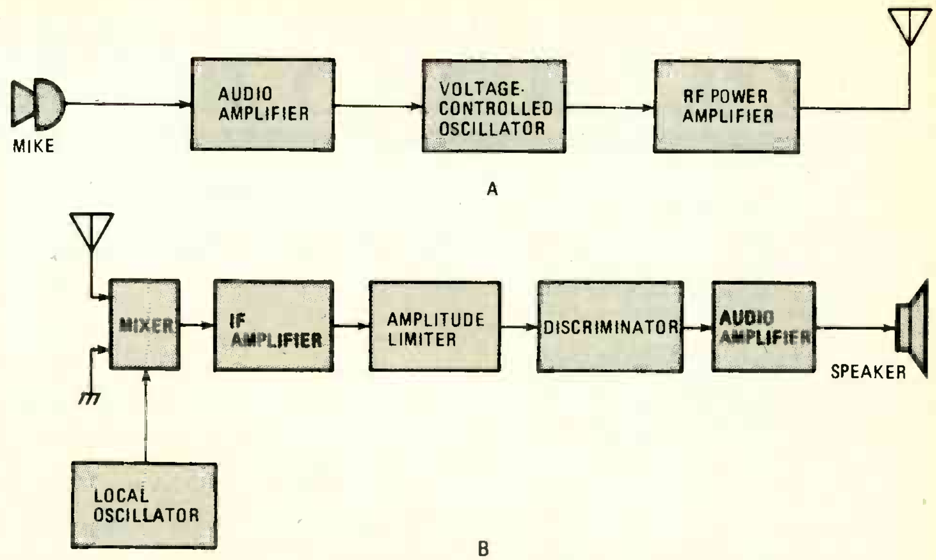


Fig. 4. Patented by Armstrong in 1933, FM did away with static interference, bringing high fidelity to radio reception. The frequency of the transmitter (A) is modulated by the audio from the microphone. The receiver (B) is similar to Armstrong's earlier superheterodyne except that in place of the detector, there is a limiter to eliminate any amplitude variations, and there is a discriminator to demodulate the signal.

The Superregenerative Receiver. While working on a regenerative receiver circuit in 1921, Armstrong discovered the phenomenon of superregeneration. It produced a fantastic amount of amplification from a simple detector circuit. The superregenerative detector is simply a regenerative detector whose feedback is adjusted so that the circuit oscillates, and some means is provided for the oscillations to be turned on and off at 20 to 200 kHz. That off-on frequency is called the quench frequency.

There are two main types of quenched detectors: the separately quenched and the self-quenched detector. In a separately quenched detector (see Fig. 3), a separate quench oscillator supplies the driving voltage to turn the detector on and off. In a self-quenched detector, the grid resistor and capacitor are selected so that the detector quenches its own oscillations. In either, the quench frequency must be high enough so the ear cannot hear it, or else it could interfere with the detector's normal audio output. Although the superregenerative detector was a very simple, inexpensive circuit with great sensitivity, it did not have the selectivity of the regenerative detector or the superheterodyne. Because of that, it was used primarily for police and aircraft communications in the uncrowded VHF frequency region. Armstrong filed for a patent on the superregenerative receiver in 1921 and sold it to RCA in June 1922 for a very substantial sum.

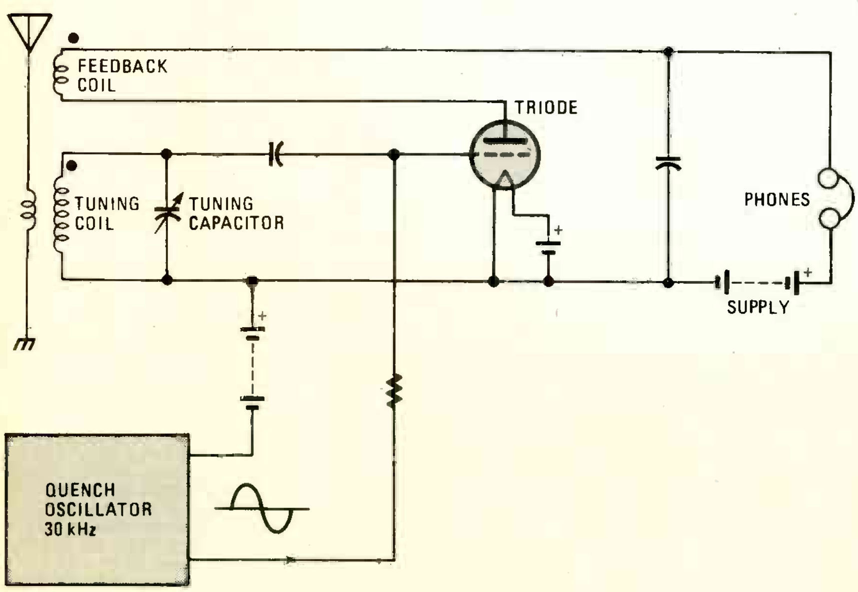


Fig. 3. In 1921, Armstrong invented this receiver that has astounding gain but poor selectivity. Composed of a regenerative detector and a quench oscillator, it proved to be quite valuable in early VHF work. The quench oscillator turns the regenerative detector on and off 300,000 times per second; when the detector is on, it oscillates.

Frequency Modulation. Since static was known to be a form of amplitude-modulated interference, Armstrong pursued the development of a frequency-modulated communications system that could reject all amplitude-modulated signals. He worked very hard on FM from 1928 to 1933. He had to design and build both transmitter and receiver (see Fig. 4) as well as suitable test equipment, and some of his breadboard circuits contained over 100 vacuum tubes. On December 16, 1933, he was issued four patents for his frequency-modulation system.

The radio industry was at first reluctant to embrace FM, but when it did start using FM for radio, TV sound, and emergency-vehicle communications, many manufacturers ignored Armstrong's patents. He filed suit for patent infringement in 1948, and the legal battle that ensued dragged on until it had drained Armstrong's spirit and fortune. The tragic death of Edwin Howard Armstrong occurred sometime during the evening of January 31, 1954 when he took his own life. ■

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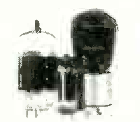

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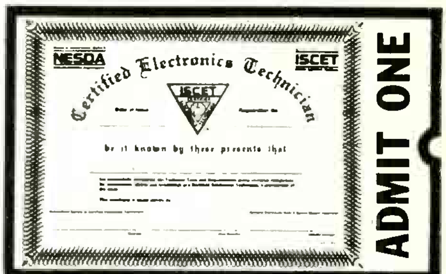

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CD HEADPHONE

(Continued from page 66)

and J3, whichever applies), and a hole for the power cord. The front-panel and side-panel layouts of the CD Player Headphone Amplifier's enclosure are shown in Fig. 4.

Select a stereo jack suitable for mating with the plug on your headphones. If your headphones have ⅛-inch plugs, you may be tempted to use a ⅛-inch stereo jack. But he warned, however, that most ⅛-inch jacks do not stand up well to prolonged use and are difficult to solder. It is suggested that you install a ¼-inch jack and then use a ⅛-inch to ¼-inch adapter plug.

Mount the headphone jack (J5), switch S1, and potentiometer R1 to the front panel of the enclosure, and the signal input/output jacks (J1 to J4) to the side panel. When making the connections between J1 through J4 to R1 and from R1 to the printed-circuit board, coaxial cable should be used. The shields of the cables—as indicated in Fig. 1—connect from jacks J1 to J4 to the ground end of potentiometer R1 to the circuit board.

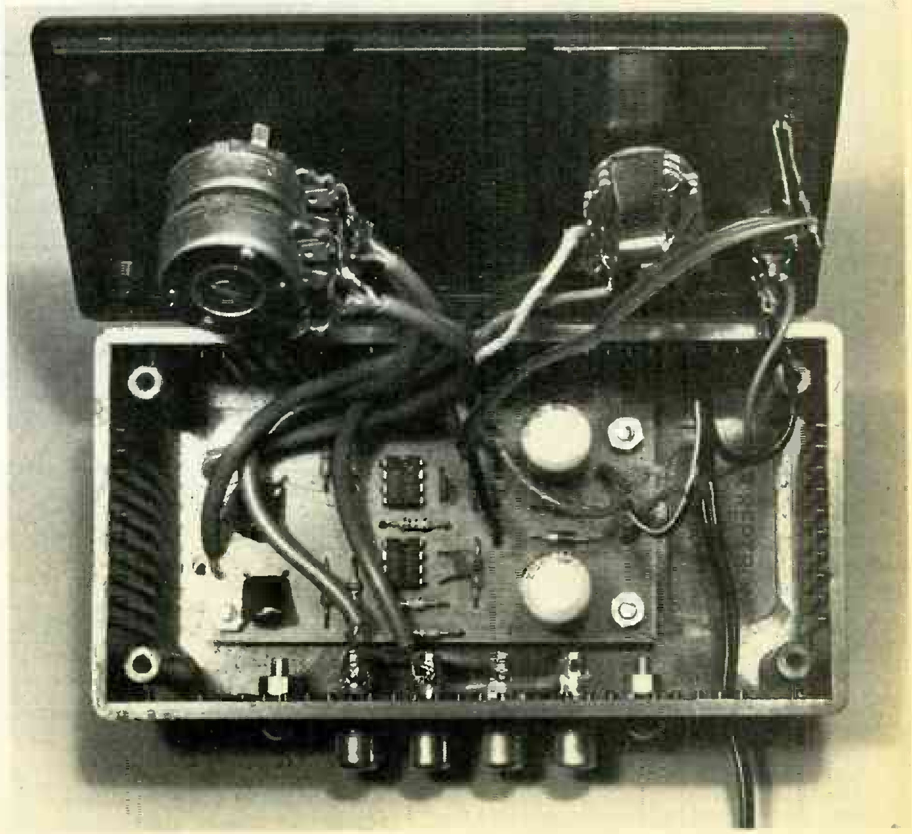
Then, after threading the power cord though the hole provided, one

The finished project may be compact, but it can drive most stereo headphones to ear-splitting volume.

lead of the cord is connected to S1, and from there to the appropriate point on the circuit board. The other lead goes directly to the board.

It is recommended that the AC power supply be permanently wired to the CD Player Headphone Amplifier: Power-supply jack inputs can cause problems. When this phase of the assembly is complete, check your work for errors. If everything checks out okay, apply power to the circuit and plug in your phones.

There should be no sound from the phones, even with the volume control turned full-on. If that's true, turn down the volume, connect your CD player, and sit back to enjoy the music. ■



This view shows the shielded cable and other wiring connections to the printed-circuit board.

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The members of the Electronic Industries Association Consumer Electronics Group (EIA/CEG) through the Product Services Committee, has marketed the illustrated parts kit for vocational schools, educators and technicians. This is the same material used in the Digital and Microprocessor Course during EIA's summer workshop programs. These workshops are organized by the Consumer Electronics Group and co-sponsored by national service organizations and state departments of vocational education.

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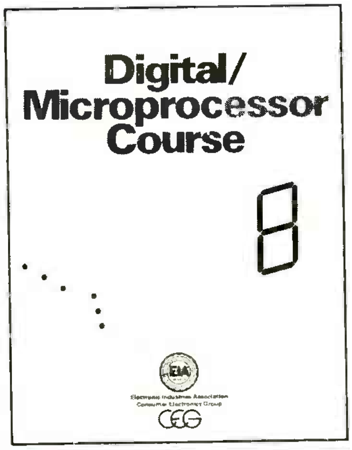

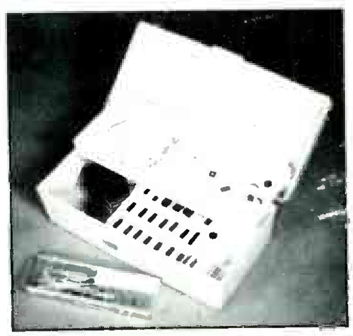

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