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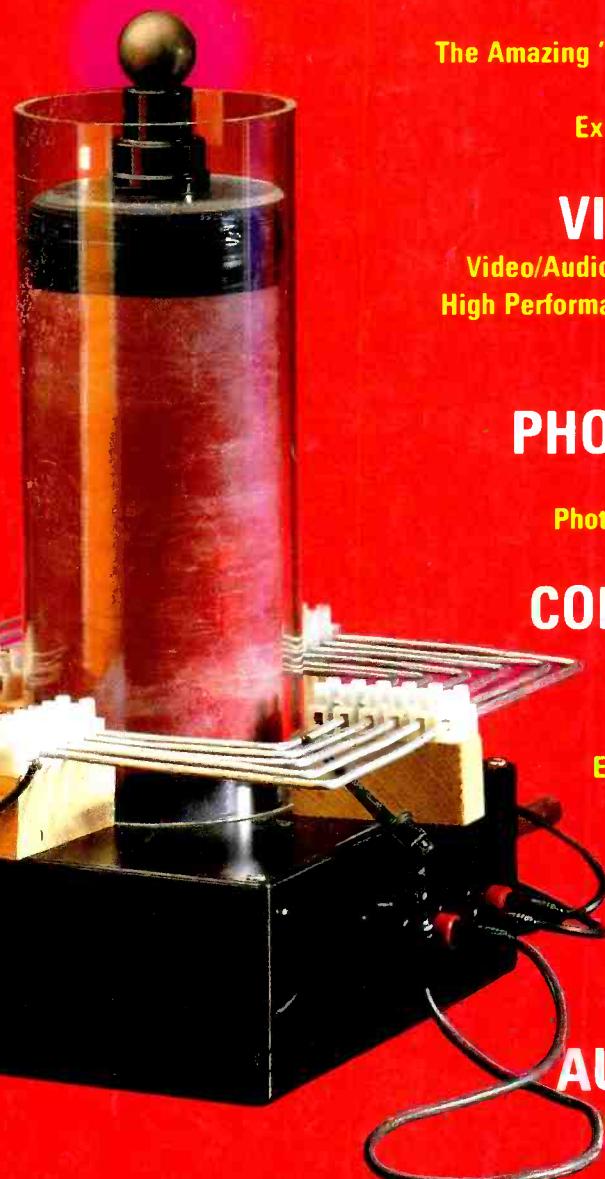
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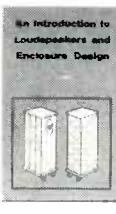
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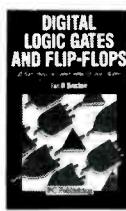
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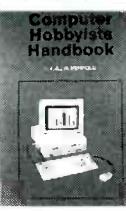


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As a service to readers, **1990 Popular Electronics Electronics Hobbyists Handbook** publishes available plans or information relating to newsworthy products, techniques and scientific and technological developments. Because of possible variances in the quality and condition of materials and workmanship used by readers, we disclaim any responsibility for the safe and proper functioning of reader-built projects based upon or from plans or information published in this magazine.

Since some of the equipment and circuitry described in **1990 Popu-**

lar Electronics Electronics Hobbyists Handbook may relate to or be covered by the U.S. patents, we disclaim any liability for the infringement of such patents by making, using, or selling of any such equipment or circuitry, and suggest that anyone interested in such projects consult a patent attorney.

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Farmingdale, NY 11735
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Fax: 1-516-293-3115

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Advertising Sales offices listed on page 164.

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Editorial

THE BEST OF THE BEST

Welcome to the second edition of the **Electronics Hobbyists' Handbook**—164 action-packed pages featuring the best of the best from the past year of **Popular Electronics**.

And what a year it has been. Putting together a magazine like this one is never easy. But selecting among the many interesting projects and articles of the past year was nearly impossible this time around.

In the end, though, we let you, our readers, make the choices. We looked at the many stories and topics that your cards and letters told us you liked or wanted the most, and brought them to you again in this retrospective.

For instance, Tesla coils and other high-voltage projects have always been among our most popular stories, but the Square Tesla Coil set a record in terms of reader interest.

Projects such as The "Antigravity" Generator, The Executive's Ding-A-Ling, and The Hot Socket delighted readers who like the lighter side of our hobby. Those of a more serious bent went wild over some of the accurate and useful pieces of test gear we featured such as the Logic Probe/Logic Pulser pair, the Dial-Up Resistance Box, and the 10-MHz Frequency Counter.

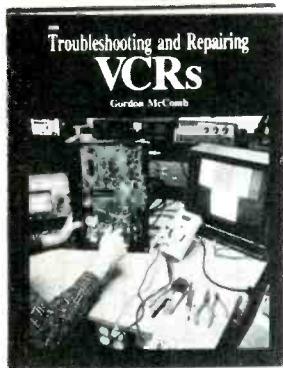
One of the most difficult parts of building projects is finding components and suppliers—or at least it used to be. The comprehensive listings in The Parts Connection and Supplying the Electronics Workshop showed our readers where to find 99% of all parts you are ever likely to need, including esoteric items, chemicals, and surplus components.

But, alas, we couldn't include everything in these pages. Leaf through this magazine; if you like what you see, why not join us every month in **Popular Electronics**. It's the only way you'll never miss out on a single exciting story. We look forward to seeing you there!

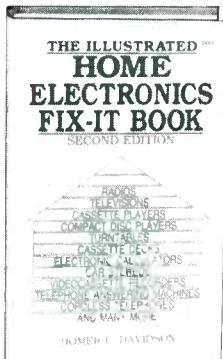
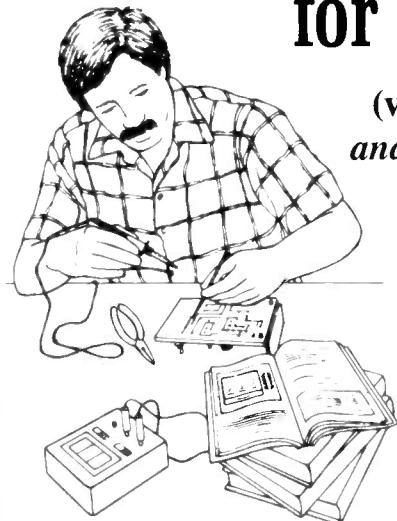
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Managing Editor

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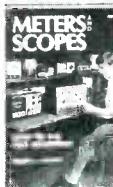
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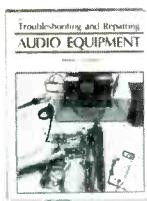
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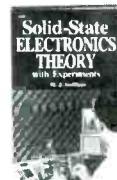
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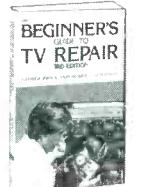
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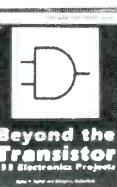
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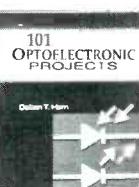
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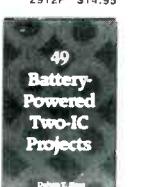
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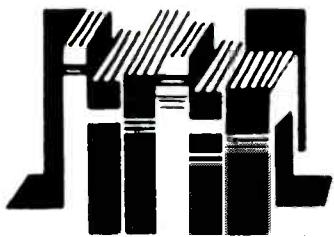
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by Mark Crane

This guide to Microsoft's word processor for Windows is comprehensive and easy to read. Organized by function, with thorough explanations of each application, the book can help Word users of all levels of experience. Handy tips and techniques make learning to use Word easier and more enjoyable. The book covers all the basics, including how to design, edit, format, and print documents, as well as advanced techniques for using the features that take Word into the realm of desktop publishing. Practical examples and plenty of illustrations round out the text.

Word for Windows Companion is available for \$26.95 from The Cobb Group, P.O. Box 24480, Louisville, KY 40224.

CIRCLE 51 ON FREE INFORMATION CARD

VCR KEY ITEMS CROSS REFERENCE: from Manufacturers' Model Numbers to TCE Stock Numbers

from Thomson Consumer Electronics

This 120-page guide provides the servicer with a quick reference source of key wear items such as belts, motors, pressure rollers, and headwheels for nine popular VCR brands—RCA, GE, Hitachi, Philco, Qua-



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sar, Sylvania, Magnavox, Panasonic, and Philips. More than 900 models are listed in the book, which contains references to 90% of a servicer's parts needs for those brands. The Thomson stock number is included, as well as a reference number that corresponds to the number shown on the service-data parts list and on the exploded-view diagram of the VCR model listed.

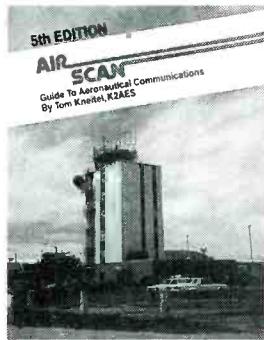
The VCR Key Items Cross Reference is available from Thomson Consumer Electronics, Inc., Service Dealer Parts and Components Merchandising, 2000 Clements Bridge Road, Deptford, NJ 08096-2088.

CIRCLE 52 ON FREE INFORMATION CARD

AIR SCAN: Guide to Aeronautical Communications: 5th Edition

by Tom Kneitel, K2AES

The latest edition of this comprehensive guide has been expanded by almost 40 percent. The guide to aeronautical communications covers HF (2–30 MHz); VHF (118–137 MHz); 137–174 MHz, 406–512 MHz, and even 800-MHz bands. Civil, military, commercial, and federal communications in the United States, Canada, Mexico, the Caribbean, the Pacific Territories, Greenland, and Iceland are covered. A small sampling of the communications areas discussed includes Air National Guard, Police and Forest-Fire Air operations, control



towers, air ambulance frequencies, air-to-ground telephone calls, hurricane hunters, airline "company" frequencies, flight instruction, weather information, and NORAD. The listings are conveniently arranged according to state and city, with a VHF log that shows the most important and interesting nationally used aeronautical channels. The expanded Canadian listings include all civil and military landing areas and seaplane-base two-way communications facilities. There is also a special section that provides detailed information on getting the most out of monitoring aeronautical communications.

Air Scan: Guide to Aeronautical Communications, 5th Edition costs \$14.95. It

can be ordered directly from CRB Research Books, Inc., P.O. Box 56, Commack, NY 11725; please add \$2.00 shipping and handling for mail orders. (NY residents must also include \$1.12 sales tax.)

CIRCLE 53 ON FREE INFORMATION CARD

3D COMPUTER GRAPHICS: A User's Guide for Artists and Designers: 2nd Edition

by Andrew S. Glassner

This book strives to provide its readers with ready access to computer graphics, an increasingly popular and powerful business tool. For industrial design students, slide and film producers, artists and designers in print and television media, illustrators, and video animators, it offers a thorough explanation of the principles and hardware used to create 3-dimensional computer graphics. Readers who are unfamiliar with programming and mathematics, and have only limited computer backgrounds, will benefit from the author's straightforward, non-technical approach.

The second edition has been completely updated and redesigned. It covers the latest hardware and color systems, rendering and advanced modeling techniques, and computer-assisted animation and production procedures. The new edition also features full-color, high-resolution graphics produced by the latest technology, with detailed guidelines for creating images of equal quality. Each chapter ends with a summary of key terms and concepts to simplify the learning process.

3D Computer Graphics: A User's Guide for Artists and Designers, 2nd Edition is available for \$26.95 from Design Press, Division of Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-822-8138.

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from W.W. Grainger, Inc.

The 4th edition of Grainger's catalog includes more than 2,000 items, organized by application and product categories to make comparison and selection easier. Instruments for precision measuring, HVAC, environmental testing, electrical, electronics, and automotive applications are featured. Some of the leading manufacturers represented include Fluke, Tektronix, Alnor, Dickson, Amprobe, OTC, and Simpson.

The Test & Measurement Instruments Catalog (No. 104T) is available from W.W. Grainger, Inc., 333 Knightsbridge Parkway, North Suburban, IL 60251.

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AUTOMATIC CONTROL SYSTEMS AND COMPONENTS

by James R. Carstens

This book is intended as a self-taught "refresher course" for engineers who work with automatic controls, and as a text for students in engineering and engineering technology. A background in basic physics will aid in understanding the concepts it presents, and some math is involved in its discussions. The book opens with an intensive review of electronic theory, particularly as it applies to the area of controls. The Laplace transformation, a math concept that simplifies much of the more difficult theory, is also introduced in the book's opening



chapters. Considerable material is presented on electrical components, especially transducers. The following chapters present design problems and their solutions, following trains of thought that a typical engineer might use when approaching a problem. In-depth coverage is given to designing control systems, various process control systems, system communications, and computers and automatic control systems. Appendices contain some simple, but interesting, software problems that prove some of the concepts discussed in the text.

Automatic Control Systems and Components is available in hardcover for \$57.40 from Prentice-Hall, Inc., Englewood Cliffs, NJ 07632.

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UNDERSTANDING TELECOMMUNICATIONS

by Ronald R. Thomas

Exciting technological advances, dramatic growth, changing government regulations, the abundance of commercially available electronic equipment—the rise of the "information society"—are all factors that make it hard to keep up with the field of telecommunications. This timely guide provides a non-technical introduction to the field of telecommunications. The single-source reference uses plain English and takes a prac-

tical, rather than theoretical, approach. It offers a comprehensive overview, with background information and insights into computer communications, electricity and electronics, long-distance communications, telecommunications careers, telephone systems, radio and television broadcasting, and more.

Understanding Telecommunications is available for \$17.60 from TAB Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

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THE BOOK OF FAX: Second Edition

by Daniel Fishman
and Elliot King

The fax machine was the uncontended consumer-electronics success of the 1980's, and as we enter the 90's, it's firmly entrenched as a basic communications device in both homes and offices. In the year and a half since the first edition of this book appeared, many advances have been made in facsimile technology, although the basics remain the same. Retaining its original, highly informative, and easy-to-read format, the second edition helps those considering the purchase of fax equipment to evaluate their needs, determine which fax features meet those needs, determine whether to lease or buy—in other words, to make the most economical choice. Convenient check-lists make comparisons and decision-making easier. For readers who already own fax machines, the book offers insights on managing fax in the office, preventing fax "junk mail," and using features such as polling and broadcasting. Besides an up-to-the-minute list of fax resources—vendors, directories, associations, and publications—the book's fifty new pages delve into new topics such as advances in PC/Fax, the growth of cellular fax, and desktop and plain-paper fax. Now that fax has become generally accepted as a basic tool, the "creative phase" can begin, according to the authors, who have devoted a new chapter to innovative fax uses.

The Book of Fax: Second Edition is available for \$9.95 from Ventana Press, P.O. Box 2468, Chapel Hill, NC 27515.

CIRCLE 58 ON FREE INFORMATION CARD

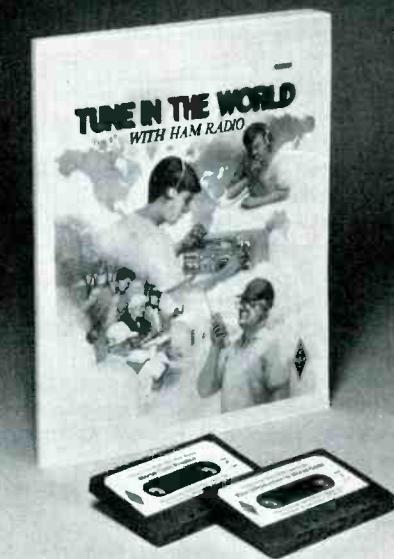
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finding out for sure, and of doing something about it. The 20-page booklet contains a variety of privacy-assurance devices, ranging from "bug" detectors to a complete "countermeasures" system that contains the tools needed to detect hidden microphones, phone taps, video cameras, and tape recorders, as well as RF subcarriers, carrier current transmitters, RF transmitters from 3 MHz to 1.5 GHz, and visible and infrared light. A selection of books about electronic surveillance and how to avoid it is also included.

Privacy Assurance Devices, Catalog No. 901 is free upon request from Capri Electronics Corp., 1238 Highway 160-B, P.O. Box 589, Bayfield, CO 81122; Tel. 303-884-9084.

CIRCLE 59 ON FREE INFORMATION CARD

MACINTOSH SHAREWARE CATALOG

from Educorp

More than 10,000 programs of public-domain/shareware software for Macintosh computers—including more than 50 new disks—are listed in this 350-page ninth edition of the *Software Encyclopedia*. The disks, which are guaranteed to be virus-free, cost between \$3.99 and \$6.99, plus shipping and handling. Each listing includes detailed illustrations and full descriptions of the included programs. Also available is a CD-ROM disk that contains all 10,000 programs in the catalog. It costs \$199.00. Other computer products, such as blank floppy disks, are featured as well.

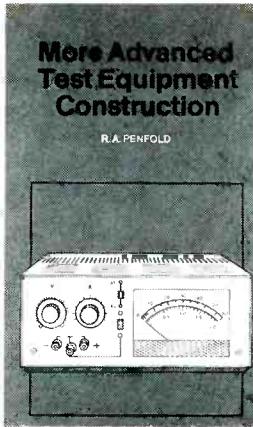
Software Encyclopedia: 9th Edition is free from Educorp, 531 Stevens Avenue, Suite B, Solana Beach, CA 92075; Tel. 800-843-9497.

CIRCLE 60 ON FREE INFORMATION CARD

MORE ADVANCED TEST EQUIPMENT CONSTRUCTION

by R.A. Penfold

Written as a follow-up to *Test Equipment Construction*, this book goes beyond the basic gear to describe more advanced projects for readers who have some practical experience in electronics construction. Along with the rewards of building test equipment from scratch, the completed projects provide a useful range of test instruments for servicing and development. Some of the designs presented include a digital voltmeter; a bench power supply; digital capacitance, resistance, and current meters; a digital heatsink thermometer; a pulse gen-



erator; an AF digital frequency meter; a dynamic transistor tester; and a crystal calibrator. Full circuit diagrams accompany the building instructions. Detailed notes on any necessary set-up steps are also provided, along with information on how to put the finished projects to efficient use.

More Advanced Test Equipment Construction (order No. BP249) is available for \$8.95 (including shipping and handling) from Electronics Technology Today, Inc., P.O. Box 240, Massapequa Park, NY 11762-0240.

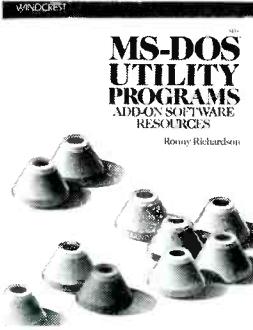
CIRCLE 61 ON FREE INFORMATION CARD

MS-DOS UTILITY PROGRAMS: Add-on Software Resources

by Ronny Richardson

Designed to help readers avoid wasting money on unnecessary programs, this book combines the most useful features of a product catalog and magazine reviews. It aims to enable readers to carefully weigh their utility options and determine just what they need to optimize their systems.

The book describes the capabilities and operation of virtually every DOS utility available in today's market. Included are descriptions of programs for data protection and security, hard-disk management, backup, file recovery, DOS expansion, data transfer, and computer-performance evaluation. It also examines memory-resident



aids, anti-viral programs, and some DOS alternatives. Each entry includes evaluations of performance, ease of installation and use, and even of the manual's legibility, along with pertinent addresses, phone numbers, and pricing information.

MS-DOS Utility Programs: Add-on Software Resources is available for \$24.95 from Windcrest, Division of TAB Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

CIRCLE 62 ON FREE INFORMATION CARD

COMPUTERS AND ENGINEERING MANAGEMENT

by Thomas F. Wheeler

Explaining precisely how computers can be effectively used to help with the full scope of an engineering manager's job, this book focuses on practical ways to achieve computer-efficient management. Written for engineers as well as for managers, the book examines everything from underlying concepts of computers to the role of computers in improving productivity. Topics range from configuring computers to fit an organization's specific needs to the process of combining different elements into an integrated system.

Filled with helpful guidelines and practical advice, the book includes case histories that clarify the process of designing, planning, and implementing an integrated computer-engineering system. It explains how the design process can benefit from computer technology and how to evaluate and choose a system. Alternative database systems are described, as are management applications. The book also discusses how to make computers more accessible to end users, procedures for connecting to networks, and techniques for designing applications and putting them to use in both mechanical and electronic engineering.

Computers and Engineering Management is available for \$46.50 from McGraw-Hill Book Company, 11 West 19th Street, New York, NY 10011; Tel. 1-800-2-MCGRAW.

CIRCLE 63 ON FREE INFORMATION CARD

COMPUTER CATALOG

from JDR Microdevices

A complete resource for computer enthusiasts and electronic hobbyists, this 100-page catalog from JDR is filled with parts and accessories for computers, including mini-386 and 80386SX motherboards, high-density hard drives and controllers, laptop s, computer cases, and software. A notable addition to the 1990 catalog is "Derick's

"High Tech Corner," a series of columns written by JDR's chief engineer, Derick Moore. He covers a wide range of computer topics, with a focus on helping customers to understand the rapidly changing technology.

The 1990 JDR catalog is free upon request from JDR Microdevices, 2233 Brigham Lane, San Jose, CA 95124; Tel. 408-559-0250.

CIRCLE 64 ON FREE INFORMATION CARD

clude tables of integrals, Gauss' method of successive elimination, generalized operating paths, and derivations pertaining to beat periods and time periods in the linear mixing of two sinusoids.

Besides its emphasis on practical applications over theory, the book makes extensive use of the mathematics that facilitate understanding of the communications principles presented. Readers are expected to have at least a rudimentary understanding of basic electronic devices and their

circuits, and the ability to follow calculations of the coefficients for a trigonometric Fourier series and to recognize (but not necessarily to solve) a differential equation. Clear mathematical derivations along with many worked examples are provided.

Radio Concepts: Analog is available in hardcover for \$59.95 from John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158. ■

CIRCLE 66 ON FREE INFORMATION CARD

1990 CATALOG

from Jameco Electronics

A convenient source book for computer and electronics enthusiasts, this 82-page catalog lists more than 5,000 items. Product lines include everything from integrated circuits to computer peripherals and kits. Several new products have been added to the 1990 catalog, in the categories of test instruments, anti-static equipment, tools, 80386 computer kits, and more. Handy RAM cross-reference and IC pin-out charts are also included.

The 1990 Catalog is free upon request from Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002; Tel. 415-592-8097.

CIRCLE 65 ON FREE INFORMATION CARD

RADIO CONCEPTS: ANALOG

by Ralph S. Carson

By covering the fundamental concepts underlying analog radio communications, this book fills a gap in practical information left by many standard textbooks—it includes the analysis, design, and operation of electronic circuits. Some of the topics covered in depth are linear and nonlinear mixing; noise, including noise spectra, thermal noise, and other noise sources; amplitude-modulation process; special functions and filters; the superheterodyne radio receiver; and spurious responses. Appendices in-

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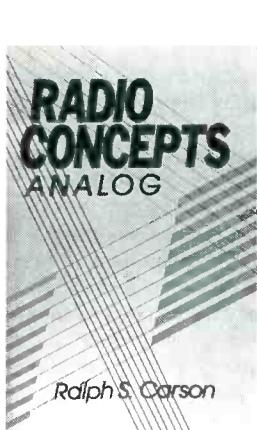
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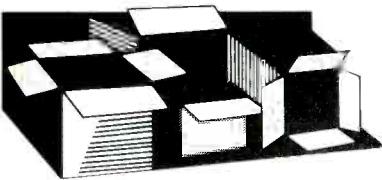
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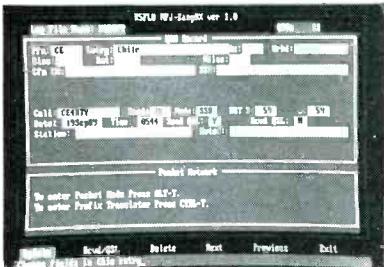
New Products

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

DX SOFTWARE

If you're a DX'er who has a computer, you can use *MFJ's Easy DX* program to get organized and to help you get your DXCC award. The IBM-compatible software instantly organizes all your DXCC activity, and includes a packet terminal program and a PacketCluster interface so that you'll get the latest DX information.

You can enter any call and learn at a glance if you need that country on the band, the mode, or both; and if you've worked it before. The program even gives you a list of contacts with the country, including bands, modes, and QSL's received, so that you can get the station to QSY the band you need him on. When you enter a call or prefix it tells you the country, azimuth to



the major city and the sunrise and sunset times at that QTH. Contest logs from popular CT-logging programs can be imported, making it easy to bring your contest QSO's into your DXCC log.

A built-in packet-radio program allows Easy-DX to monitor the PacketCluster DX-spotting network, and send "DX" in Morse code if a country you need on the band, mode, or both is reported on the network. You need only be within earshot of the speaker—not necessarily at your computer. There are two packet screens. The receive-only screen can be displayed along with Easy-DX, so that any packet channel can be monitored during logging. The second screen is for the send-and-receive packet terminal program.

The MFJ Easy-DX program, which comes

on two 5 1/4-inch floppy disks and requires a 100% IBM-compatible system with at least 512K of RAM (a hard disk is recommended), costs \$39.95. For additional information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, MS 39762; Tel. 601-323-5869.

CIRCLE 71 ON FREE INFORMATION CARD

SCPC RECEIVER

Using a form of broadcasting known as Single Channel Per Carrier (SCPC), many radio programs—including some of the National Public Radio stations, Mutual Radio Networks, sports networks, news, and syndicated shows—are distributed via satellite to selected affiliate stations across the country. The narrowband SCPC signals can't be tuned with a regular satellite receiver, and professional SCPC receivers are priced out of the range of most consumers.

Now, *Heil Sound's* SC ONE! SCPC receiver provides the home consumer with broadcast-quality SCPC reception. The stand-alone receiver tunes 900 to 1500 MHz block down-converter lines. A low-loss, high-



frequency (2-GHz) splitter is provided so that regular home TVRO systems can be split and operated simultaneously with the SC ONE!, allowing the user to view programs while tuning SCPC signals.

The receiver's controls are straightforward and easy to use. A volume-control/on-off switch, a ten-turn master-tuning switch, and a single-turn fine-tuning switch are located on its front panel. A line-level audio output is available on the back panel. High-quality audio is produced through a front-panel speaker.

The SC ONE!, complete with all cables, splitters, connectors, and a program-guide chart, costs \$450.00. For further information, contact Heil Sound, Ltd., 2 Heil Drive, Harissa, IL 62257; Tel. 618-295-3000.

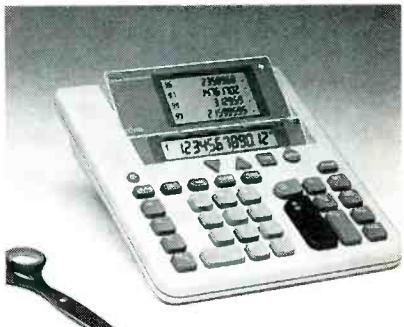
CIRCLE 72 ON FREE INFORMATION CARD

PAPER-FREE PRINTER CALCULATOR

For those who like to see the figures that they're adding up, but don't require a written record of their calculations, Texas Instruments has introduced the TI-5128 Paper-Free Printer calculator. It has a large 4-line, 12-digit LCD with decimal, commas,

line item, and audit-trail symbols. The LCD stores up to 99 lines of numbers and scrolls forward or backward so that the user can review previous entries or calculations. Individual entries can be changed right on the display, and the total is automatically recalculated—eliminating the need to re-enter an entire calculation due to one small error, and providing a means to compare different results.

The full-size keyboard features well-spaced contoured keys, including a programmable tax key that calculates and adds sales tax with one keystroke. The TI-5128 has an independent add register as well as a full four-function memory (add to, subtract from, subtotal, and total). Other features include a selectable decimal, a gross-



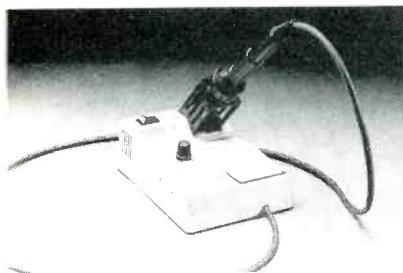
profit-margin key for calculating sales prices and profits, and a right-shift key for easy entry corrections. The calculator is powered by three AA batteries (included); an AC adapter is available separately.

The TI-5128 Paper-Free Printer calculator and optional AC-9175/9480 AC adapter have suggested retail prices of \$95.00 and \$6.95, respectively. Both will be available in the third quarter of 1990. For additional information, contact Texas Instruments, Consumer Relations, P.O. Box 53, Lubbock, TX 79408; Tel. 806-747-1882.

CIRCLE 73 ON FREE INFORMATION CARD

SOLDERING STATION

Designed for durability, quick recovery, and low cost, OK Industries' SA-570 Series soldering station provides high-power and consistent performance. It has an operating range of 600° – 800°F, offering high power for various applications, including use on boards with exceptional thermal demands. A powerful 70-watt heating element with precise RTD temperature control allows excellent stability and repeatability as well as quick recovery on "heavy" joints. The directly grounded tip meets MIL-STD-2000 resistance and voltage requirements. The SA-570 station has a low-profile, small-footprint housing, and requires minimum



bench space. The lightweight handpiece is comfortable and safe to use. The soldering station uses high-mass soldering tips that are available in a wide range of profiles.

The SA-570 Series soldering station has a suggested list price of \$89.60. For additional information, contact OK Industries, Inc., 4 Executive Plaza, Yonkers, NY 10701; Tel. 1-800-523-0067.

CIRCLE 74 ON FREE INFORMATION CARD

DIGITAL STEREO HEADPHONES

Sentry Industries' Digital 880 CD stereo headphones incorporate highly efficient speaker elements to deflect distortion, and special input wiring to avoid signal loss. For comfortable listening, the headset has a tangle-free cord and soft-leather earpads and headband. The Digital 880 has power-



ful, 40-mm samarium-cobalt speakers, a 20–20,000-Hz frequency response rating, and a 105-dB sensitivity rating. Phono jacks and a one-year warranty are included.

The Digital 880 stereo headphone has a suggested retail price of \$49.95. For further information, contact Sentry Industries, Inc., 252-C Lake Avenue, Yonkers, NY 10701; Tel. 914-968-0180.

CIRCLE 75 ON FREE INFORMATION CARD

GRAPHIC EQUALIZER

Designed to meet the needs of dedicated audiophiles at a reasonable cost, ADC's top-of-the-line Soundshaper 310 graphic

equalizer has an omnidirectional pickup microphone, a pink-noise test signal, and a real-time analyzer display. The unit can be used to fine tune any stereo system, and to enhance television and VCR sound. It adjusts the stereo system for room acous-



tics, eliminates harsh or dull sound, and makes cassettes for use in the car that are customized to overcome road and engine noise.

In addition to ten bands per channel with 15-dB boost or cut sliders, the 310 features a real-time analyzer whose sensitivity control allows the listener to analyze the music spectrum by keeping the display centered regardless of how loud or soft the signal is. By simply pressing the pink-noise button and plugging in the microphone, the user can watch the fluorescent real-time

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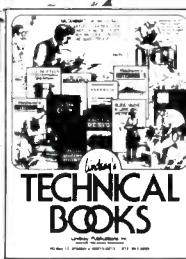
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frequency display analyze the system as it is being fine tuned. The ± 15 -dB sliders boost and cut every octave. A defeat/bypass button is provided for comparison.

The Soundshaper 310—which has two tape-monitor record/play loops with two-way dubbing—makes easy work of custom cassette recording. A switchable, precision, 18-dB/octave infrasonic filter provides cleaner bass and a signal-to-noise ratio lower than that of a CD player (100 dB below one volt, A-weighted).

The Soundshaper 310 10-band graphic equalizer has a suggested retail price of \$199.95. For additional information, contact ADC, 707 East Evelyn Avenue, Sunnyvale, CA 94086.

CIRCLE 76 ON FREE INFORMATION CARD

LOUDSPEAKER LINE

The updated line of Celestion *DL* Loudspeakers offers improved specifications and more attractive styling. The *DL* 4, *DL* 6, *DL* 8, and *DL* 12 loudspeakers each feature a one-inch, two-piece titanium dome tweeter for exceptional high-frequency performance. The *DL* 4 (pictured) is equipped with a $6\frac{1}{2}$ -inch treated-paper bass driver, while the *DL* 6 and *DL* 8 each use an 8-inch polyolefine low-frequency unit. The *DL* 12 features dual 8-inch polyolefine bass drivers. The *DL* series has a higher grade simulated-walnut vinyl on the outer panels, and the baffle is enhanced with a new finish and improved graphics.

In the larger cabinets (DL 8 and DL 12), "Figure Eight" brace construction was used. The panel-stiffening technique, adapted from the aerospace industry, works by pin-



ning all four sides of the 18-mm particle boards to make them stiffer. The DL 12 cabinet also uses "Transfer Bass Loading" construction, in which the lower bass-driver output is directed to a separate enclosure in the rear half of the cabinet and the mid-bass is loaded into the front half. The separately sealed halves help to alleviate power-sharing difficulties normally encountered in that type of system.

The DL 4, DL 6, DL 8, and DL 12 loudspeakers have suggested retail prices of \$339.00, \$439.00, \$569.00, and \$849.00, per pair, respectively. For more information, contact Celestion Industries, Inc., 89 Doug Brown Way, Holliston, MA 01746; Tel. 518-429-6706.

CIRCLE 77 ON FREE INFORMATION CARD

PHOTO/CONTACT TACHOMETER

The multifunction TACH-1 from A.S. Sperry is a digital photo/contact tachometer that combines 0.05% basic accuracy with the capability of RPM and surface-speed measurements. Its memory-call button automatically displays last value, maximum value, and minimum value.

The TACH-1 has a 5-99,999-RPM photo range, a 0.5-19,999-RPM contact range, and surface speeds of 0.05 to



1,999.9 meters per minute and 0.2 to 6,560 feet per minute. It comes packed complete with a carrying case, four AA batteries, reflective tape, two RPM cone adapters, an RPM funnel adaptor, a surface-speed test wheel, and a one-year warranty.

The TACH-1 digital photo/contact tachometer has a suggested list price of \$224.95. For more information, contact A.W. Sperry Instruments, Inc., 245 Marcus Blvd., Hauppauge, NY 11788.

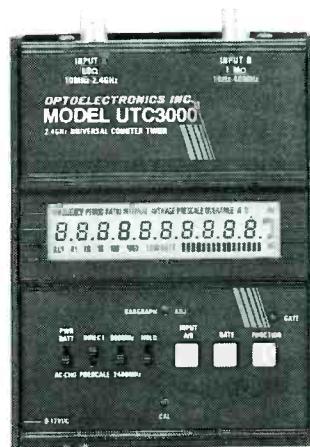
CIRCLE 78 ON FREE INFORMATION CARD

HAND-HELD UNIVERSAL TIMER/COUNTER

A 10-digit, hand-held, universal timer counter from Optoelectronics, model UTC3000, incorporates high-speed ASIC and custom LCD technology. It has direct-

count frequency capability (1 Hz resolution in one second) to over 150 MHz, and switched prescalers to maximize resolution from frequencies to over 2.4 GHz. The counters have multiple preamplifiers to permit efficient antenna pickup measurements. A 16-segment bargraph indicates input-signal level to ensure reliable counting and to aid in RF security sweeps.

Pushbuttons control gate selection (between 4 gate times), function, and input selection. Hold, prescale, and direct count switches are also conveniently located. Calibration and bargraph adjustments are ac-



cessible from the front panel. In addition to the frequency and bargraph displays, the 120-segment LCD has annunciators for function, gate time, number of cycles averaged, units, and low battery. The UTC3000 also has universal timer/counter features such as period, period average, time interval, time-interval average, and ratio.

The UTC3000 universal timer counter costs \$375.00. For additional information, contact Optoelectronics Inc., 5821 NE 14th Avenue, Ft. Lauderdale, FL 33334; Tel. 305-771-2050.

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CAR-STEREO UNITS

Featuring a unique theft-deterrent design, Profile's DN-928 (pictured) and DN-924 car-stereo units cannot be used when the detachable control section is removed. The control section easily slips on or off its base by moving one lever, and is small and light enough to fit in a pocket. That design makes it much more convenient than conventional pull-out units that are heavy and cumbersome to carry around.

Both units feature an electronically tuned radio with PLL synthesizer as well as auto-memory prescan, station presets that allow selection of up to 18 FM and 12 AM stations, electronic station seek, and a local/DX switch. A large three-color LCD is com-



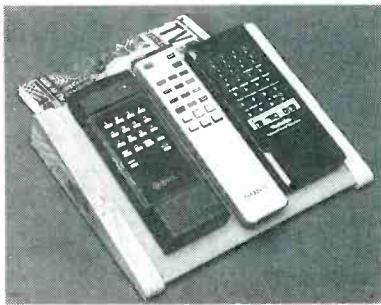
plemented by the addition of two-color, selective night-light illumination. The DN-924 has an auto-stop tape deck and 4.5-watts-per-channel power output. The 25-watts-per-channel DN-928 features an auto-reverse tape deck. Both units have CD-input capability and 60-dB signal-to-noise ratios.

The DN-924 and DN-928 car stereo units have suggested retail prices of \$199.00 and \$299.00, respectively. For further information, contact Profile Consumer Electronics, 11155 Knott Avenue, Suite I, Cypress, CA 90630.

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REMOTE-CONTROL ORGANIZER

Providing an attractive and practical way to keep track of as many as three remote-control units, *Brave Innovations' Remote Mate* is a single "master control center." The unit features oak sides with a natural stain finish, a "Velvet Loop" top, and a com-



partment to hold program guides. When placed on a coffee table or couch, the Remote Mate, sloped at a 15° angle, aims the remotes' signals straight to the TV or stereo.

The velcro-like material that covers the top of the unit is available in four colors—navy, black, walnut, and suede. Each remote unit gets two "Velcoins" attached to its back; those secure the remotes to the top of the Remote Mate, yet allow the remotes to be easily removed whenever it is necessary.

The Remote Mate organizer has a suggested list price of \$19.95. For more information, contact Brave Innovations, Inc., 195 West Main Street, Avon, CT 06001; Tel. 203-673-8878.

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550-MHz FREQUENCY COUNTER

An affordable, general-purpose instrument, *B&K-Precision's* model 1804 high-frequency counter features measurement to 550 MHz, an 8-digit LED, a low-pass filter, 1.0-second and 0.1-second gates, and an overflow indicator. It has a direct range of 5 Hz – 1 MHz, and a prescale range of 10 MHz – 550 MHz. Resolution is 10 Hz on prescale and 1 Hz for direct mode using the 1.0-second gate, and 100 Hz prescale and 10 Hz direct using the 0.1-second gate. The model 1804 provides ± time-base ac-



curacy ± 1 count and a time-base accuracy ± 2 counts, with the 1.0- and 0.1-second gates, respectively.

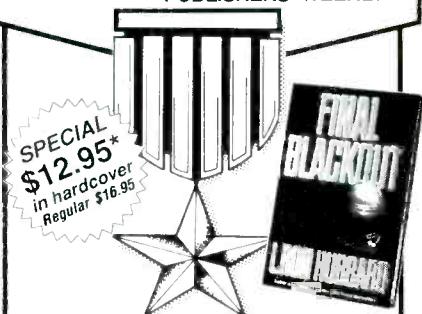
Input impedance for the direct range is 1 megohm, shunted by less than 40 pF. For the prescale range, impedance is 50 ohms to match communications applications. Sinewave sensitivity for the direct range is 30 mV rms at 5 Hz – 30 MHz, 50 mV rms at 30 – 80 MHz; and 100 mV rms at 80 – 100 MHz. The prescale range has 50-mV-rms sensitivity at 10 – 550 MHz. The input filter is a switch-selectable, 100-kHz, low-pass filter.

The model 1804 high-frequency counter, including an AC power adapter, costs \$295.00. For more information, contact B&K-Precision, Maxtec International Corporation, 6470 West Cortland Avenue, Chicago, IL 60635; Tel. 312-880-9087. ■

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BY VINCENT VOLLONO

Nikola Tesla, considered by some to be the greatest inventor of the electrical age, is today best remembered for his fascinating power-transmission experiments, using his famous Tesla Coil. In his original experiment, he was able to transmit electrical energy without wires to light incandescent lamps located over 25 miles away.

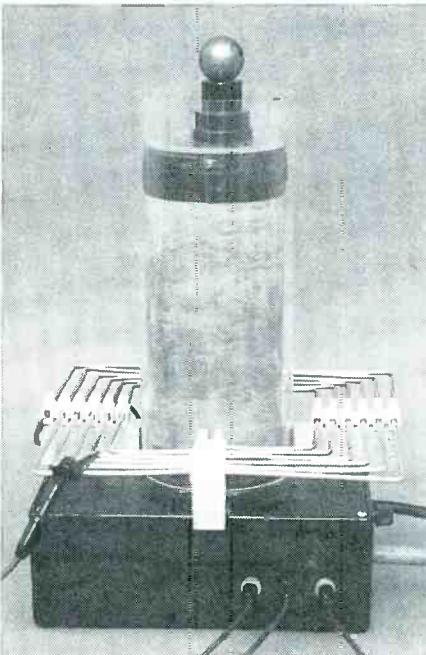
Today, most similar circuits—like the *Tesla Coil* described in this article—are used for educational and experimental purposes. Unlike many of the modern versions, our circuit feeds AC to a power transformer capable of outputting about 3-kV AC at 20 millamps. The output of the transformer is sent to a primary coil, and is magnetically coupled to a secondary coil with a top capacitance. And if the primary coil is properly tuned, a spectacular high-frequency, high-voltage output is produced at the secondary coil.

Circuit Description. Figure 1 shows the schematic diagram of the Tesla Coil circuit. The circuit consists of little more than a few coils, a step-up power transformer, and a capacitor. Power from an AC wall socket is fed to transformer T1 (a small neon-sign transformer) which steps the voltage up to about 3000-volts AC.

The stepped-up output of T1 is fed through L1 and L2 across C1, causing it to charge until enough power is stored in the unit to produce an arc across the spark gap. The spark gap—which momentarily connects C1 and L3 in parallel—determines the amount of current transferred between C1 and L3.

The arcing across the spark gap sends a series of high voltage pulses through L3, giving a sort of oscillating

THE SQUARE SQUARE SQUARE SQUARE SQUARE SQUARE TESLA COIL



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effect. The energy fed through L3 is transferred to L4 via the magnetic coupling between the two coils. (Because of the turns ratio that exists between L3 and L4, an even higher voltage is produced across L4.) Coil L4 steps up the

voltage, which collects on the top-capacitance sphere where it causes an avalanche breakdown of the surrounding air, giving off a luminous discharge.

In order to get maximum output from the Tesla Coil, certain conditions must be met. First of all, the primary and secondary resonant frequencies must be made equal by tuning the primary coil, L3. That's accomplished by tapping L3 at points along the coil with a clip lead.

In addition, the setting of the spark gap greatly effects the output of the Tesla Coil. Our Tesla Coil is designed to use either a stationary spark gap or an optional rotary spark gap; both of which must be adjusted for maximum output. (We'll discuss the rotary spark gap a little later.)

If L3 and L4 are coupled too close, coil efficiency is reduced; over-coupling prevents the circuit from resonating at maximum efficiency. That also causes a breakdown between L3 and L4, which can produce arcing between the two coils. By increasing the coupling between L3 and L4, the amount of energy increases in L4 until a "critical coupling" is reached.

In addition, the Q of the coils is very important (the Q of a coil is equal to its inductive reactance divided by its resistance). The lower the Q, the higher the efficiency of the coil. The primary coil was made from a few turns of aluminum grounding wire (so its resistance is very low). The secondary has many more turns of fine magnet wire, which by its very nature exhibits a higher resistance than does the wire used in the primary coil (L3).

Rotary Spark Gap. The rotary spark

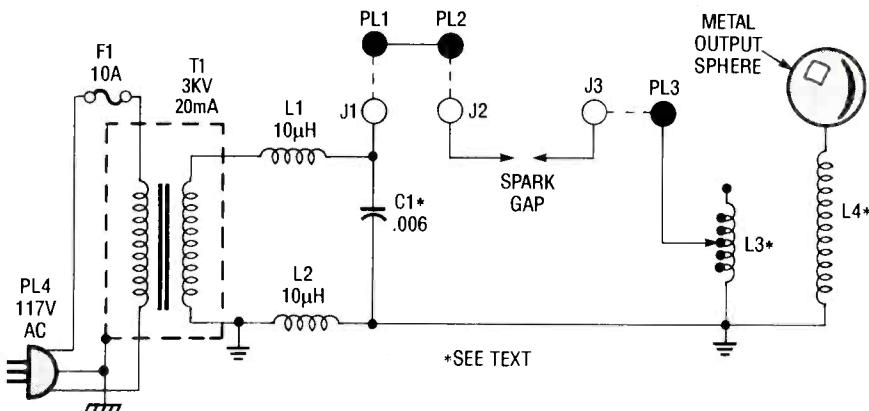


Fig. 1. The Tesla Coil circuit consists of little more than a few coils, a step-up power transformer, and a capacitor.

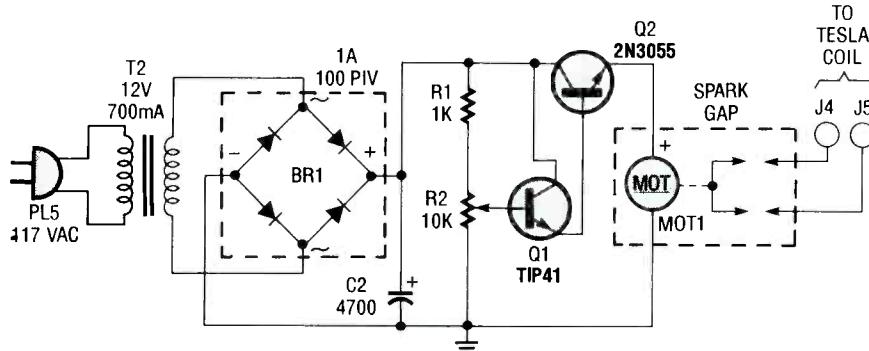


Fig. 2. Here's the schematic diagram for the optional rotary spark gap. The circuit is made up of a 12-volt power transformer, a bridge rectifier, a 4700- μ F capacitor, and a 12-volt DC motor.

gap is a simple add-on circuit for the Tesla Coil, consisting of a variable DC power supply and a small, 5000 rpm, DC motor. The circuit allows you to vary the output of the Tesla Coil by adjusting the rotating speed of the motor. A rotary gap is far more efficient than the stationary gap because the stationary gap could cut out, requiring that the gap be readjusted.

Figure 2 shows the schematic diagram of the rotary spark gap, which is assembled as a separate unit. The circuit is made up of a 12-volt power transformer, a bridge rectifier, a 4700- μ F capacitor, and a 12-volt DC motor. Power is delivered to the circuit via a 117-volt AC line cord, and fed to transformer T2 (a 12-volt, 700-mA unit), which provides a 12-volt AC output. The output of the transformer is fed to BR1 (a 1-amp, 100-PIV full-wave bridge rectifier), which converts the AC input to provide 12-volts DC for the operation of the motor.

The output of the rectifier is fed to the base of transistor Q1, which along with Q2 forms a Darlington pair. The output of Q1, which controls the bias presented to the base of Q2, is controlled by potentiometer R2. Potentiometer R2 is used to adjust the base bias on Q1, thereby varying the current through Q2,

which in turn varies the rotating speed of the motor.

The rotary spark gap has a stationary post (two screws) mounted on a small square of perfboard, which face a rotor (another perfboard square on which four screws are mounted and electrically connected together with bus wire). The stationary posts and the rotor posts are positioned as close as possible. The movement of the rotor makes and breaks the gap giving maximum impulse power, and will not cut out if the stationary and rotor posts are set properly.

The rotary spark gap is connected to the Tesla Coil through separate wires and banana jacks (J4 and J5). When the circuit is powered up, the current that normally travels through the stationary spark gap on the Tesla Coil is rerouted through the rotary gap via J4 and returned to the Tesla Coil via J5. To make the connections plug PL1 into J1, PL2 into J4, and PL3—which in Fig. 1 is used to connect the output of the stationary spark gap to L3—into J5.

Construction. The author's prototype of the Tesla Coil was built into a large plastic enclosure; because of the high voltages involved, it is imperative that

you avoid metal enclosures. Because the circuit consists of very few parts, its components can easily be hard-wired together within the housing, using Fig 1 as a guide. There is nothing particularly critical about the layout of the circuit. Just be sure to maintain adequate spacing between the individual com-

PARTS LIST FOR THE TESLA COIL

- L1, L2—10- μ H, AC-line filter choke
- L3—6 turns, #10 aluminum grounding wire, see text
- L4—348 turns, #24 magnet wire, see text
- T1—3-kV, 20-mA, neon-sign transformer
- C1—.006- μ F, 5000-WVDC ceramic capacitor (see text)
- F1—10-amp fuse
- J1-J3—Banana jack
- PL1-PL3—Banana plug
- PL4—3-conductor AC power plug with line cord
- Metal output sphere, plastic or wooden enclosure, "L" brackets wire, solder, wood, hardware, etc.

PARTS LIST FOR THE ROTARY SPARK GAP

- Q1—TIP41 NPN silicon power transistor
- Q2—2N3055 NPN silicon power transistor
- BR1—1-amp, 100-PIV, full-wave bridge rectifier
- MOT1—12-volt, 5000-rpm, DC motor
- T2—12-volt, 700-mA, step-down power transformer
- R1—1000-ohm, 1/4-watt, 5% resistor
- R2—10,000-ohm potentiometer
- J4, J5—Banana jack
- PL5—2-conductor AC power plug with line cord
- Perfboard materials, plastic or wooden enclosure, wood, wire, solder, hardware, etc.

Note: A 3-kV, 20-mA, neon-sign transformer (T1) is available as part number 720-391 from N. Glantz & Son, 18-218 57th St., Brooklyn NY 11220, Tel. 800-522-5120. The 12-volt DC motor for the optional rotary spark gap (MOT1) is available from H&R Corp., 401 E. Erie Ave, Philadelphia, PA 19134, Tel. 800-848-8001. Contact those companies directly for pricing, shipping and handling charges, etc.

Plans for making your own high-voltage capacitors, such as the one required for C1, are available for \$3.50 postpaid from Alegro Electronic Systems, 3 Mine Mountain Road, Cornwall Bridge, CT 06754; ask for item number UHVC400.

ponents.

Start by drilling holes in the enclosure to pass wires through and for the panel-mounted components. In the author's prototype, three sides of the enclosure were outfitted with appropriate sized holes. A $1\frac{1}{8}$ -inch hole was drill in one side of the enclosure, through which a ground wire connects to L3.

On another side of the enclosure, holes were drilled to accommodate a dowel rod (which is part of the stationary spark gap), a fuse holder, and the power cord. On the third side, three holes were drilled for banana jacks. It will also be necessary to drill holes in the bottom of the enclosure suitable for T1's mounting hardware.

Begin assembly by mounting the power transformer on the bottom of the enclosure. Next connect a $10-\mu\text{HAC}$ filter choke in series with each of T1's secondary leads, and then connect the free ends of each coil across C1 (see Fig. 1).

Note: In the author's prototype, C1 is really two $.012-\mu\text{F}$ 2500-volt AC capacitors that were wired in series to create C1 (giving the capacitor an effective rating of $.006 \mu\text{F}$ at 5-kV AC). If you use the same scheme, keep the connecting leads between the capacitors as short as possible. After connecting the capacitors together, cover the gap between the two units with non-conductive tape, and connect the jerry-rigged unit in the circuit as shown.

Stationary Spark Gap. The stationary gap can be made from two $\frac{3}{16}$ -inch carriage bolts (see Fig. 3). One bolt is stationary and the other one is adjustable so that it can be used to vary the spark gap. A $\frac{1}{2}$ -inch wooden dowel is attached to the bolt that is to be adjustable, allowing adjustments to the gap to be made from outside the project's enclosure.

The wooden dowel is very important; one does not want to adjust the gap by touching metal (or any other conductive device), since the gap is adjusted with the Tesla Coil in operation.

The bolts that form the spark gap are supported by two "L" brackets mounted to spacers so that they face each other (see Fig. 3). The stationary post of the spark gap is connected to J3, and the movable bolt is connected to J2.

Primary Coil. The original primary coil (L3) was made from 6 turns of #16 aluminum grounding wire in a pancake style winding. However, to give the unit

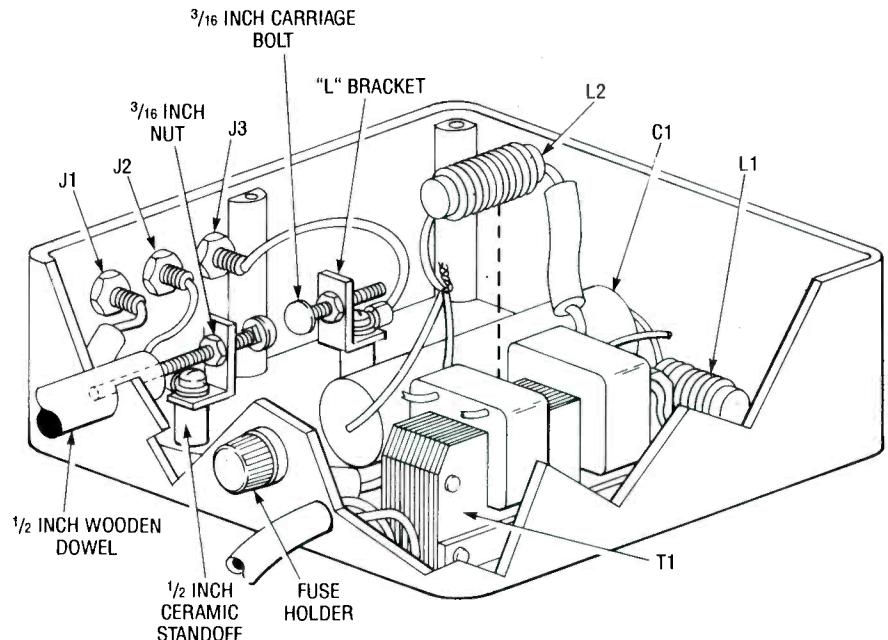


Fig. 3. The stationary spark gap is made from two $\frac{3}{16}$ -inch carriage bolts supported by "L" brackets mounted to spacers so that they face each other. One bolt is made stationary, while the other is made adjustable so as to vary the spark gap.

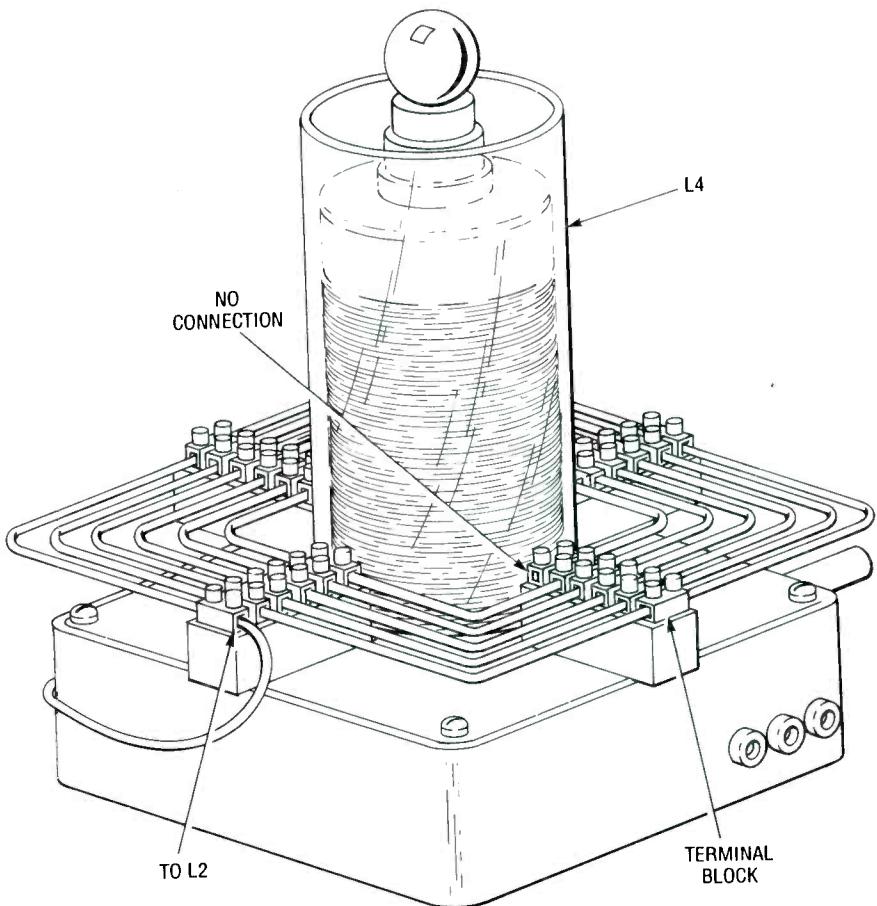


Fig. 4. The inner winding of L3 should have an area of about 6-inches square. When making the coil be careful that you do not form wire loops, instead of the continuous coil illustrated here.

a somewhat unusual look, the original (more-or-less round) primary coil was replaced with a square version made from heavier #10 aluminum grounding wire. The Coil was formed on four 6-

position, twin-turnscrew type barrier blocks, which were mounted on four blocks of wood.

The wood blocks (with barrier blocks attached) were mounted to the top of

the enclosure near the edges, and bus wire was then connected to the barrier blocks to form the coil. Note: The wires do not have to be fed through the barrier strips because of the twin-tunscrew arrangement. The wire can be cut to the proper size and screwed into the terminal strip to form the primary coil.

The inner dimensions of L3 should be about 6-inches square. When making the coil be careful that you do not form wire loops, instead of the continuous coil illustrated in Fig. 4. When you are finished with the coil, there should be one unoccupied screw terminal at the center and another at the outer rim of the coil. The unoccupied terminal at the outer rim of L3 is connected to ground via a wire that's brought out through a hole in the enclosure. The unoccupied terminal at the center of the coil is left floating.

The Secondary Coil. To fabricate the secondary coil (L4), the author wound about 348 turns of #24 magnet wire onto an 8½-inch length of 3½-inch diameter PVC tubing. That works out to be about 48 turns per inch, covering 7¼ inches on the PVC tubing.

The coil was wound by hand using a simple jig—which consists of little more than a stand for the wire and another for the coil form. When winding the secondary coil, try to keep the winding as even as possible without overlapping any turns.

After the coil has been wound, apply clear varnish or polystyrene (Q-DOPE) to hold the coil windings in place, and to help insulate the coil. Next drill a small hole in the center of the Tesla Coil enclosure lid, and thread the lower lead of L4 through the hole and connect it to the ground end of L3 (as shown in Fig. 1) and mount L4 in the center of L3 (see Fig. 4). The secondary coil is then secured in place with glue.

As an added measure of protection, you can also place clear plexiglass 4-inch OD (outside diameter) tubing over the secondary coil as a second layer of insulation. You might also seal the insulating tube and place mineral oil in it, thereby further increasing the tubing's insulating properties, but that's not necessary for this type of Tesla Coil.

The Output Sphere. The output sphere—a 1¼-inch steel ball on top of a plastic spacer—also serves as the top capacitance. An important point here is that the surface area represents the capacitance not the inner area of the

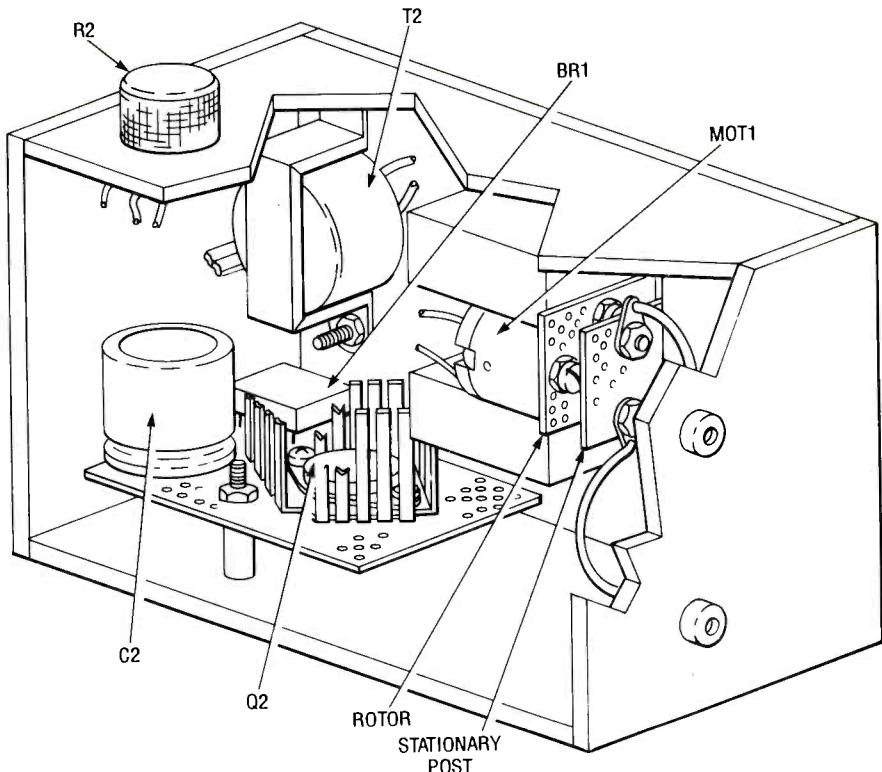


Fig. 5. The rotor of the rotary spark gap is made from a small perfboard square containing four #6 screws that are connected through bare bus wire. The stationary post consist of another perfboard square (of equal size), containing two #6 screws that are not tied together electrically.

ball. It matters not if you use a solid ball or a hollow ball; they will both work equally well as long as their surface areas are equal.

The size of the sphere effects the secondary's resonant frequency, so if you use a larger sphere, it will be necessary to retune the primary coil for maximum output. A bigger sphere collects more energy, causing it to give off a higher output. So experimenting with the top capacitance is highly recommended.

The Rotary Gap. The rotary spark gap is not necessary to the operation of the Tesla Coil. So, if you do not wish to build the optional rotary gap, skip this section.

The rotor of the rotary spark gap is made from a small perfboard square on which four #6 screws are mounted and electrically connected through bare bus wire. The stationary post consist of another perfboard square (of equal size), containing two #6 screws that are not tied together electrically. The screws of the stationary post are instead taken out to J4 and J5. Perfboard is specified because the holes in perfboard make it easy to align the screws on the rotor with those on the stationary post.

The first step in building the rotary

gap is to build and mount the motor support. In the author's prototype (see Fig. 5), the motor mount was made from small blocks of wood assembled in a "U" shape. A wooden mount is also used to secure the stationary post in place.

The distance between the rotor screws and the stationary post screws must be as small as possible without touching in order for the unit to function properly. After mounting the motor mount in the enclosure, place the motor in the mount and secure it in position with epoxy.

Next assemble the motor controller circuitry on a piece of perfboard, using Fig. 2 as a guide. Note that T2, R2, J4, and J5 aren't mounted to the perfboard, but instead are mounted to the rotary-gap enclosure. Once the controller board is assembled check your work for wiring errors. If all checks out, solder wires to the appropriate points on the board for connection to the off-board components. Set the board to the side for now; it will be installed in a moment.

Mount the off-board components on some convenient spot on the enclosure. Mount R2 so that you'll have easy access to its wiper. Jacks J4 and J5 can be mounted in any desirable location.

(Continued on page 140)

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BY JOHN CLARKE AND
LEO SIMPSON



This simple adapter circuit fits in your FM tuner and lets you tap into hidden FM transmissions

Although new to some countries, subcarrier transmissions on FM broadcasts have been made for years. They are referred to as Subsidiary Communications Authorized transmissions or SCA. They are based on a 67-kHz subcarrier that is placed on a station's main FM carrier. It's even possible to have multiple subcarriers, some carrying digital data and others carrying audio.

So you can receive such broadcasts, we present the SCA Adapter* that can be hooked into most FM tuners with a minimum of fuss. Low in cost, it uses just a few readily available integrated circuits.

Before we describe the Adapter circuit, let's briefly talk about FM-subcarrier transmissions. They have no effect on standard FM mono and stereo radios. Also, they are fully compatible with

all existing FM radios, whether stereo or mono. In fact, unknown to the great mass of FM listeners, such transmissions have been going on for some time.

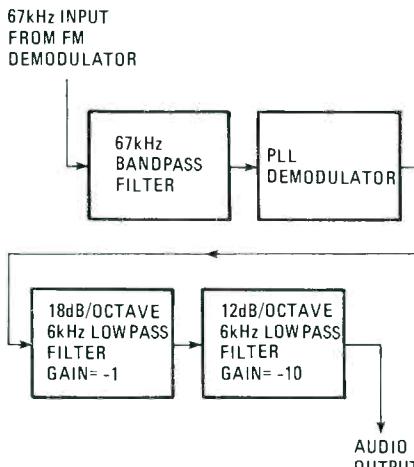


Fig. 1. This block diagram shows the four circuit functions of the SCA Adapter. The corresponding functions are also marked on the circuit diagram in Fig. 2.

But while all FM radios are presently unaffected, they are capable of picking up the subcarrier transmissions. With the addition of an adapter such as the one we'll describe here, they will be able to detect the hidden audio signals.

The SCA Adapter prototype was built on a compact printed-circuit board accommodating three low-cost op-amps, a phase-locked loop IC, a 3-terminal regulator, and a handful of resistors and capacitors.

How it Works. Figure 1 shows a block diagram of our circuit. The 67-kHz signal present at the output of the FM detector (in the radio to be modified) is first fed to a 67-kHz bandpass filter, and then to a phase-locked loop (denoted PLL), which recovers the audio on the 67-kHz subcarrier.

The audio output of the PLL is then passed through a low-pass filter, which attenuates frequencies above 6 kHz at the rate of 18 dB/octave. Another 12-

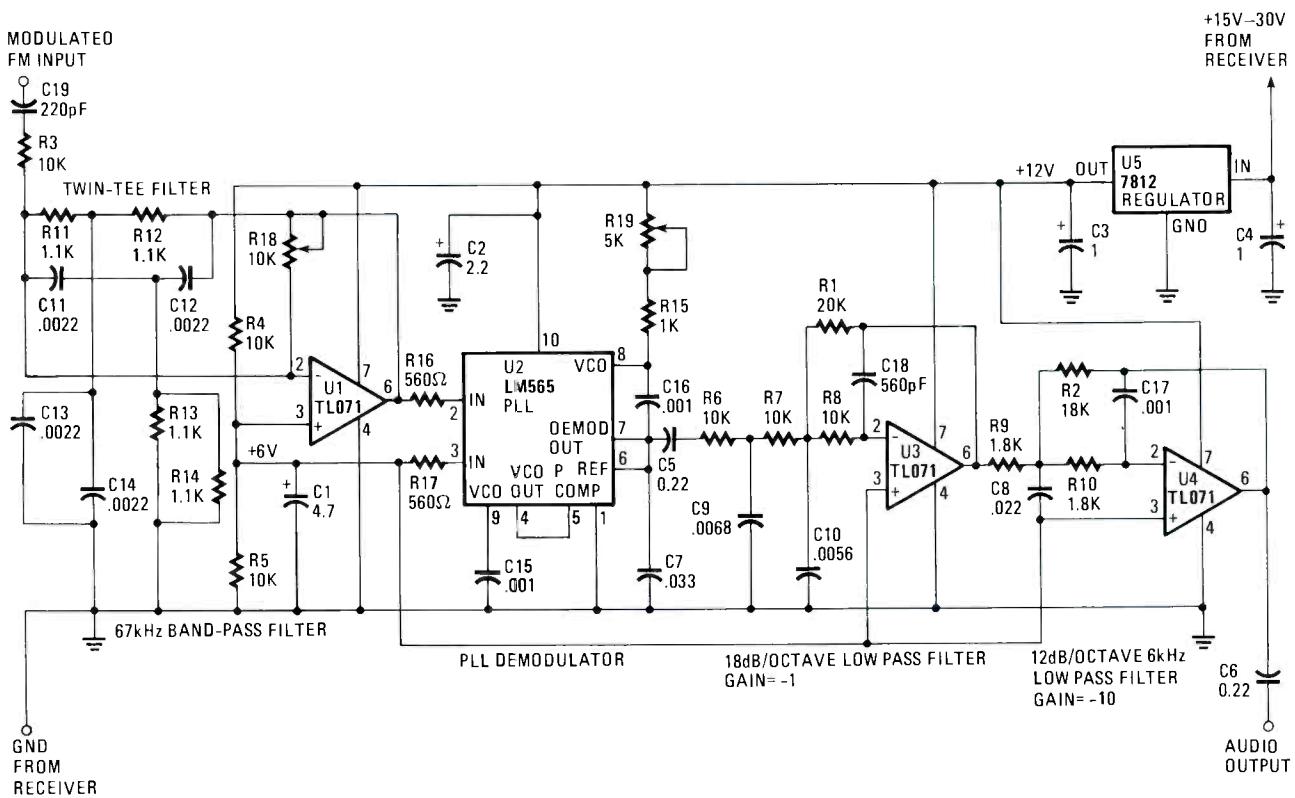


Fig. 2. The circuit for the SCA Adapter is basically a PLL with input and output filter stages.

dB/octave low-pass filter stage completes the conditioning of the signal before it is passed to an external audio amplifier.

Figure 2 shows the complete circuit. Op-amp U1 and its associated components comprise the 67-kHz bandpass filter. A twin-T network, comprised of four 1100-ohm resistors and four 0.0022- μ F capacitors, is connected in the feedback network of the op-amp.

That gives some gain at 67 kHz and heavy attenuation for frequencies above and below that frequency.

An additional passive filter at the input to the twin-T network (containing a 220-pF capacitor and a 10,000-ohm resistor) provides some additional roll-off for frequencies below 67 kHz.

In practice, the bandpass-filter action covers a frequency range of about 10 kHz above and below the 67-

kHz center frequency. Resistor R18 sets the gain of the bandpass-filter stage.

Integrated-circuit U2 is a National LM565 phase-locked loop that demodulates the 67-kHz frequency-modulated (FM) signal from U1. The LM565 PLL consists of a voltage-controlled oscillator (VCO) set to 67 kHz, and a comparator that compares the incoming frequency-modulated 67-kHz signal at pin 2 with the VCO signal fed into pin 5.

The output of the comparator represents the phase difference between the incoming signal and the VCO signal, and is therefore the audio modulated by the subcarrier. Treble de-emphasis of 150 μ s is provided by a .033- μ F capacitor (at pin 7).

The free-running VCO frequency is determined by the .001- μ F capacitor at pin 9, and the resistance between the positive rail and pin 8 (100 ohms in series with R19). Variable-resistor R19 adjusts the oscillator frequency (also known as the "center frequency") so that the incoming signal is within the lock range of the PLL.

To minimize noise in the demodulated output, it is important to reduce the lock range of the PLL to a minimum. That is achieved by shorting pins 6 and 7 together. To a lesser extent, the lock range—and therefore the noise output—becomes smaller for lower input

PARTS LIST FOR THE SCA ADAPTER

SEMICONDUCTORS

U1, U3, U4—TL071 FET op-amp, integrated circuit

U2—LM565 phase-locked loop, integrated circuit

U5—7812 3-terminal 12-volt regulator, integrated circuit

CAPACITORS

C1—4.7- μ F, 16-WVDC, electrolytic

C2—2.2- μ F, 16-WVDC, electrolytic

C3—1- μ F, 16-WVDC, electrolytic

C4—1- μ F, 35WVDC, electrolytic

C5, C6—0.22- μ F, metallized polyester

C7—.033- μ F, metallized polyester

C8—.022- μ F, metallized polyester

C9—.0068- μ F, metallized polyester

C10—.0056- μ F, metallized polyester

C11—C14—.0022- μ F, metallized polyester

C15—C17—.001- μ F, metallized polyester

C18—550-pF polystyrene
C19—220-pF ceramic

RESISTORS

(All resistors are $\frac{1}{4}$ -watt, 5% precision units unless otherwise noted.)

R1—20,000-ohm, 2% precision

R2—18,000-ohm

R3—R8—10,000-ohm

R9, R10—1800-ohm

R11—R14—1100-ohm, 2% precision

R15—1000-ohm

R16, R17—560-ohm

R18—10,000-ohm, miniature vertical trimmer potentiometer

R19—5,000-ohm, miniature vertical trimmer potentiometer

ADDITIONAL PARTS AND MATERIALS

Printed-circuit board, hookup wire, audio leads, solder, etc.

signals, so we keep the input signal as low as possible without affecting the PLL's operation.

Following U2 is the 18-dB/octave filter containing U3, which has a gain of one for the desired signal frequencies. The filter is followed by the final stage, U4, which has a gain of 10.

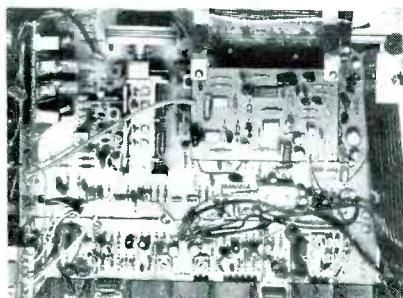
The adapter is ideally powered from the tuner or receiver it is built into, so we had to make its input-voltage requirements non-critical. The solution is to use a 12-volt, 3-terminal regulator that enables the circuit to be powered from any +15- to +30-volt supply.

The three op-amp IC's and the PLL are all biased to half the supply voltage by a voltage divider consisting of two 10,000-ohm resistors, which is decoupled by a 4.7- μ F capacitor. The center of the voltage divider is connected to pin 3 of each op-amp and the PLL.

PCB Assembly. The printed-circuit board for the project (see Fig. 3) measures just $3\frac{5}{8} \times 2\frac{1}{4}$ -inch and will help ease assembly if made. Point-to-point assembly can be used but will be a bit difficult to perform accurately.

No special points need to be watched when installing the parts on the board except that component polarities must be correct (see Fig. 4). Note also that U1 has a different orientation to U2, U3, and U4.

When assembly and soldering are finished, check your work carefully and then connect a DC supply of between 15 and 30 volts. Now check the voltage at the output of the 3-terminal regulator, at pin 7 of the TL071 op-amps, and at pin 10 of the PLL. In each case, the reading should be close to 12-volts. The voltage at pins 3 and 6 of each op-amp, and pin 3 of the PLL, should be close to 6-volts DC.



The photo shows the SCA Adapter installed in an older AM/FM stereo receiver, the Harman Kardon HK5701. Two brackets were used to suspend the Adapter above the tuner board.

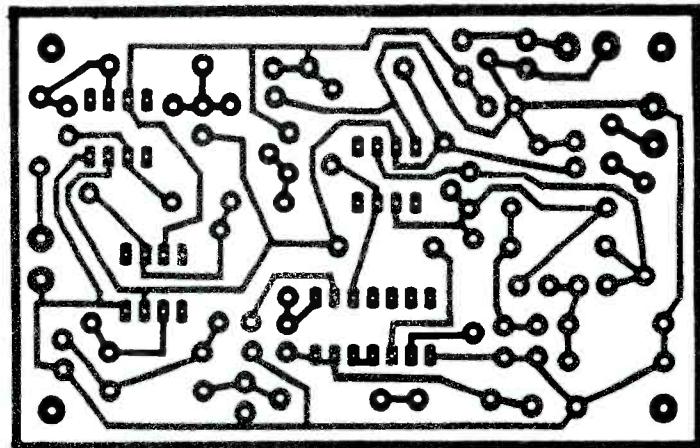


Fig. 3. Full-size PC artwork for the SCA Adapter. Its use is recommended.

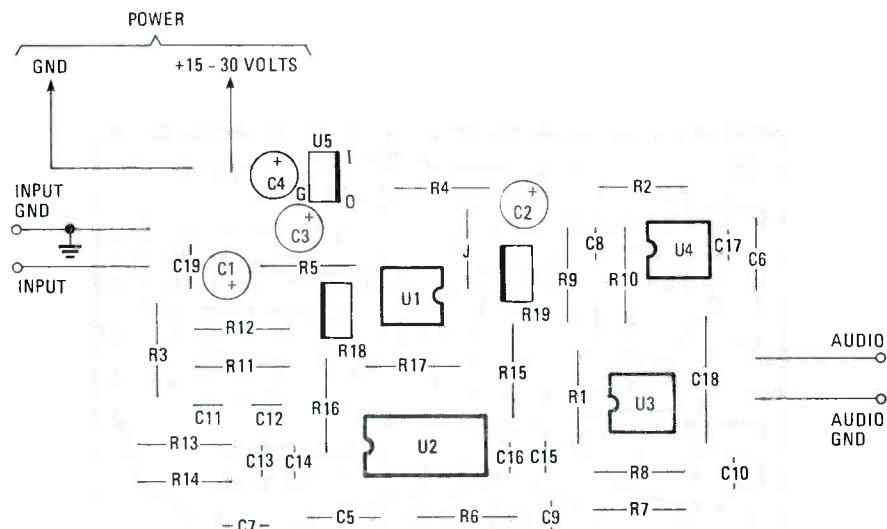


Fig. 4. Take care when assembling the board; U1 is oriented differently from U3 and U4.

If everything is okay, you are ready to install the Adapter in your FM tuner or stereo receiver.

Finding the Signal. Here comes the tricky part. Ideally, you need access to the circuit diagram of your tuner or receiver. Next, you need to identify a positive DC-supply rail of between +15 and +30 volts. Then, you need to find the output of the FM demodulator of your receiver or tuner.

In a stereo tuner, that comes before the multiplex decoder and treble de-emphasis networks. In a mono tuner, you must identify the demodulator output before de-emphasis. After de-emphasis, the 67-kHz signal will be nonexistent.

Most medium-priced tuners use two IC's to do most FM-signal processing. They are the IF amp and detector IC, followed by a multiplex (MPX) decoder IC. The most convenient point to

pick off the 67-kHz signal is at the input to the MPX decoder.

Setting Up. Having found the signal and made the necessary connections from the Adapter to your tuner, the set-up procedure is relatively simple. First, make sure that R18 is set so that its wiper is turned toward the LM565. That will provide maximum signal. Now adjust R19 so that there is an audio signal. Find the extreme settings of R19 where the audio signal drops out, then set R19 between the two extremes.

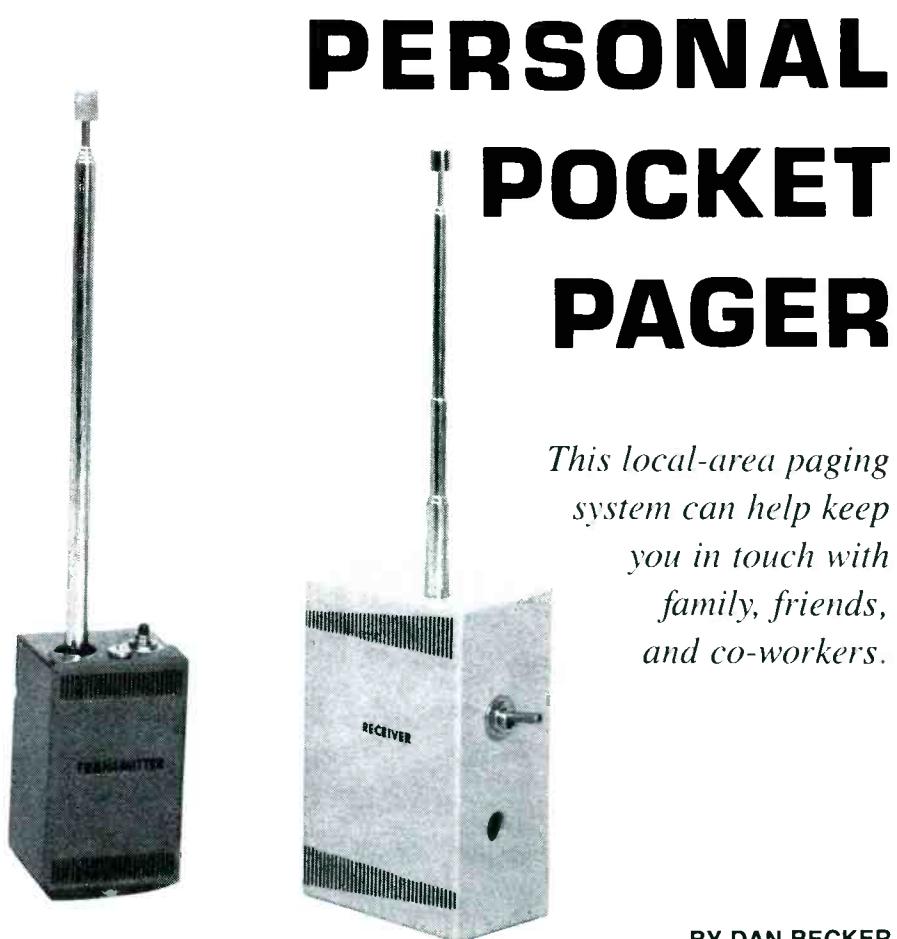
Resistor R18 is used to minimize noise from the audio signal when the FM-signal level is poor. Adjust the trimmer until the sound becomes distorted and then back off the adjustment until the distortion is no longer audible. If you have a strong FM signal, adjustment of R18 will have no effect on the noise level, and so it should be left at its maximum-resistance setting. ■

While working outdoors or in your garage, often it would be helpful for those indoors to have a convenient way to alert you if you are needed. Or perhaps your children are playing outdoors and you would like an easy way to call them in. This article describes a wireless transmitter/receiver combination—called the *Personal Pocket Pager*—that allows you to page (beep) someone from a distance of up to about 100 feet.

When activated, the transmitter sends out an amplitude modulated (AM) 49,890-MHz RF carrier. The receiver detects, amplifies, and decodes the RF signal, which, in turn, activates a piezo beeper (buzzer). The receiver is small enough to carry in a pocket or sit on your workbench. The transmitter is also small and fits easily into a pocket for quick access.

The Transmitter. Figure 1 shows a schematic diagram of the transmitter circuit. A 7555 CMOS oscillator/timer, U1, generates a 490-Hz squarewave. Resistors R1–R3, and capacitor C3 determine the squarewave's frequency. Capacitor C2 and L3 prevent RF currents from reaching the trigger input, pin 2 of U1; at the same time, 490-Hz signals pass unattenuated. The 490-Hz output of U1 at pin 3 is used to drive a crystal-oscillator circuit built around Q1, which generates the 49,890-MHz RF-carrier signal.

Capacitor C5 bypasses RF current to ground, placing transistor Q1 in a common-base configuration. Resistors R4–R6 set Q1's quiescent DC emitter current to about 7 milliamperes (mA). Inductor L1 is used to tune capacitors



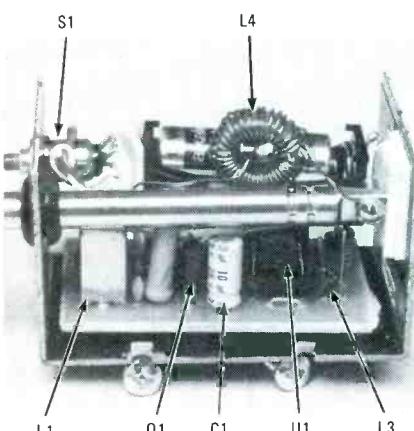
This local-area paging system can help keep you in touch with family, friends, and co-workers.

BY DAN BECKER

C6, C7, and Q1's collector-base capacitance to a resonant frequency of 49,890 MHz. RF transformer T1 matches the low impedance of the whip antenna to the 780-ohm load resistance required by the oscillator. The antenna-loading coil, L2, tunes out the capacitive reactance exhibited by the electrically short whip antenna changing the antenna into a resistive load. Capacitors C1, C4, and C8 filter the V+ (power supply) bus.

With switch S1 closed, the square-wave signal from U1 periodically grounds the pin 3 end of resistor R6. With R6 grounded, Q1 is supplied a DC current that, in turn, allows Q1 to generate an RF carrier. In that way, U1 switches Q1 on and off at a frequency of 490 Hz to generate an amplitude-modulated RF envelope.

The RF Receiver. Figure 2 shows the schematic diagram of the RF receiver. Transistor Q1 and its components comprise a super-regenerative receiver. Resistors R1–R4 bias Q1 for a quiescent-emitter current of about 1 mA.



Shown here is the Pocket Pager's completely assembled transmitter, which should give you some idea of its actual size. Because of tight spacing, the resistors have been vertically mounted.

The primary and secondary currents of T1 are 180-degrees out of phase, providing positive feedback. Capacitor C6 tunes T1 to resonance at 49,890 MHz. Capacitor C6 and transformer T1 make the circuit into a Hartley RF oscillator. Capacitor C4 is non-critical, but it does improve performance by providing an RF current path around transistor Q1 for the discharge from the T1/C6 tank circuit.

Capacitor C1 couples the antenna to the primary of T1. From there, the received signals are used to drive the base of Q1 through T1's secondary and capacitor C2 (which affects Q1's DC bias rate). Because of that, the circuit oscillates at two frequencies simultaneously: 49,890 MHz, and 450 kHz. During each 49,890-MHz cycle, before RF oscillation begins, Q1 acts like a high gain RF amplifier, greatly magnifying the antenna's signal.

Once amplified, the signal causes an increase in the average DC emitter current of Q1; and that, in turn, increases the voltage drop across resistor R4. So, amplitude variations in the

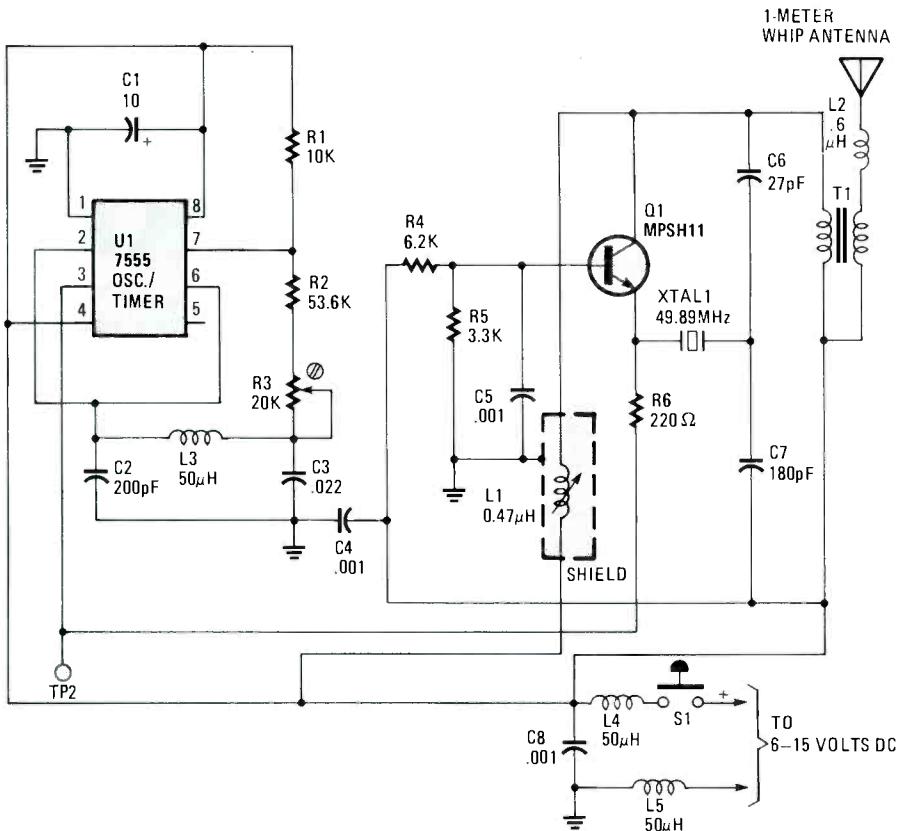


Fig. 1. The transmitter is built around a 7555 CMOS oscillator/timer. U1—whose frequency is dependent upon the values of resistors R1-R3 and capacitor C3—and is designed to generate a 490-Hz squarewave output.

antenna's signal result in voltage variations across R4. Capacitor C7 couples the demodulated RF signal that appears at R4 to op-amp U1.

Op-amp U1-a provides 10 dB of gain to the 490-Hz signal from R4. Op-amp U1-b further amplifies and shapes the 490-Hz signal into squarewave pulses. To do that, resistors R5 and R6 set the voltage gain of U1-a to 40 dB (100 times). Resistors R7-R9, R12, and R13 fix the quiescent DC-output voltage at pins 1 and 7 to 2.5-volts. Resistor R10 allows a test probe to sample the 490-Hz tone at pin 1. A ferrite bead (connected in series with R10 and located at TP1) and C9 block any RF current that may be present. Another ferrite bead (connected across the opposite end of C9) keeps RF current from reaching any test probes connected to circuit ground. Capacitor C10 couples the 490-Hz signal, from pin 7 of U1-b, to pin 3 of U2 (an LM567 PLL tone decoder). Resistor R16 divides pin 7's output voltage, decreasing the transmitter's range, but increasing the receiver's immunity to interference from other transmitters using the 49-MHz band.

Integrated-circuit U2 contains circuits that can be set to detect a specif-

ic signal frequency when applied to its input at pin 3. Resistors R17 and R18, and capacitor C14 set the detection frequency to 490 Hz. Capacitors C11 and C12 fix the circuit's bandwidth to

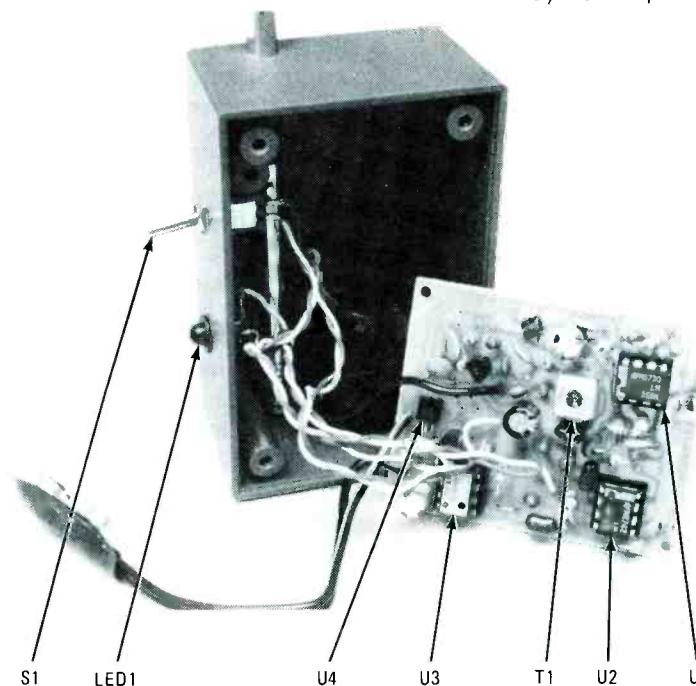
less than 100 Hz. Pull-up resistor R19 keeps output pin 8 high until a signal is decoded, at which time pin 8 goes low. Upon going low, pin 8 grounds the cathode of LED1 through current-limiting resistor R20, causing it to light.

Capacitor C15 couples a high-to-low trigger pulse from U2 to U3 (a 7555 oscillator timer). After triggering, pin 3 of U3 goes high, turning transistor Q2 on. When Q2 conducts, the negative lead of the piezo buzzer (BZ1) is grounded, causing BZ1 to sound. Resistor R22 and capacitor C16 fix the time interval during which BZ1 sounds to about one second.

Pushbutton S1 allows you to transmit a signal by connecting power to the circuit. A low power voltage regulator, U4, provides a constant 5-volts source, which is used to operate the circuit. Capacitors C3, C8, C13, C17, and C18, and RF choke L3 bypass RF and the 490-Hz signals to ground, filtering the V+ bus.

Construction. Because both units include RF circuitry, printed-circuit boards are recommended. Full-sized templates of the printed-circuit boards for Personal Pocket Pager's transmitter and receiver (respectively) are shown in Figs. 3 and 4. You can etch your own, or you can purchase etched and drilled boards from the source given in the Parts List.

You may want to power the receiver



Here is what the receiver's printed-circuit board looks like with all the components installed. The receiver is somewhat larger than its counterpart, the transmitter. If used as a stationary unit, it can be powered from a wall-mounted power supply, or a home-brew power supply circuit.

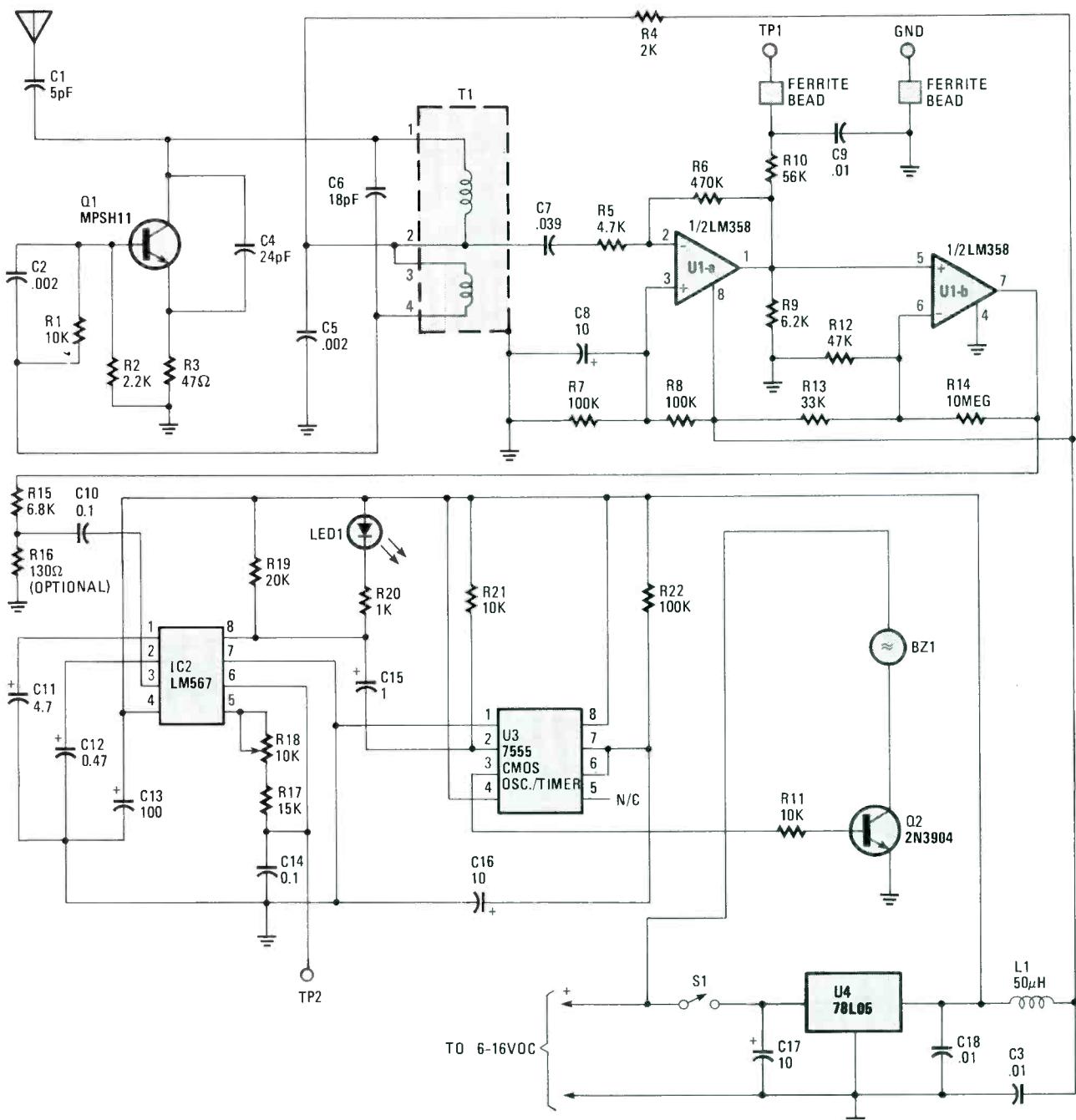


Fig. 2. The RF receiver is built around an LM358 dual op-amp (U1), an LM567 PLL tone decoder (U2), and a 555 oscillator (U3).

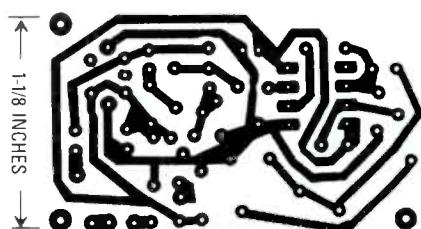


Fig. 3. Shown here is a full-sized template of the transmitter's printed-circuit board.

from an AC-to-DC wall transformer. If so, the receiver will fit into an enclosure about 2½ by 3 inches. Alternatively, make the receiver portable by select-

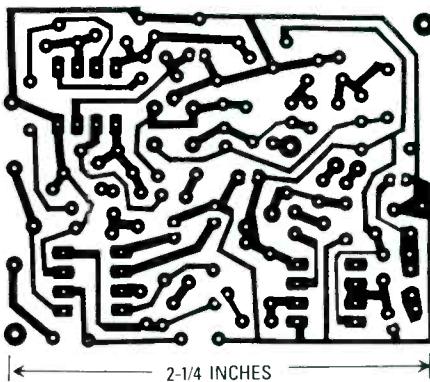


Fig. 4. Here is a full-sized template of the receiver's printed-circuit board.

ing an enclosure that is large enough to hold a battery—almost any rechargeable battery, in the 6- to 12-volt range, works fine. Before assembling, use the receiver's printed-circuit board as a template to mark mounting holes in the enclosure. Drill the holes, using a 3/32-inch bit, for the mounting hardware. In addition, drill a hole for the antenna, a 1/8-inch hole for the wire from the wall transformer (if applicable), and mounting holes for the piezo buzzer, on-off switch S1, and LED1.

For the transmitter, select an enclosure with enough room for the printed-circuit board, a whip antenna, and a 9-volt battery. Before assem-

biling the circuit board, use it as a template to mark the enclosure for mounting holes. Drill the mounting holes with a $\frac{3}{32}$ -inch bit. Finally, drill appropriately sized mounting holes for pushbutton-switch S1, and a hole for the whip antenna.

Following Figs. 5 and 6, assemble the transmitter and the receiver (respectively) printed-circuit boards. Observe the proper polarity of the electrolytic capacitors, the IC's, and the diodes.

Mount the capacitors and resistors. The capacitors are mounted flush against the board to minimize lead lengths; that's especially important in the RF and tone decoder circuits. Note that all resistors are vertically mounted.

Don't forget the test points. Figure 7 shows the construction of the test point terminals. Test point TP1 on the transmitter board (see Fig. 5 for its location,

PARTS LIST FOR THE RF TRANSMITTER

SEMICONDUCTORS

U1—7555, CMOS oscillator/timer integrated circuit
U2—MPSH11, ECG229, TCG229, or SK3246/229, NPN RF transistor

RESISTORS

(All resistors are $\frac{1}{4}$ -watt, 5%, unless otherwise noted.)

R1—10,000-ohm
R2—53,600-ohm, 1%
R3—20,000-ohm, trimmer potentiometer
R4—6200-ohm
R5—3300-ohm
R6—220-ohm

CAPACITORS

(All capacitors must be rated at for least 16 VDC.)

C1—10- μ F, electrolytic
C2—200- μ F, ceramic disc
C3—0.022- μ F, metalized film
C4, C5, C8—0.001- μ F, ceramic disc
C6—27-pF, ceramic disc
C7—180-pF, ceramic disc

INDUCTORS

L1—0.47- μ H, RF inductor, TOKOI 7KSM series
L2—0.6- μ H, antenna loading coil
L3-L5—50- μ H, miniature RF choke
T1—RF transformer (see below)

ADDITIONAL PARTS AND COMPONENTS

S1—Single-pole single-throw, momentary contact pushbutton switch
XTAL1—49,890-MHz series resonant crystal
Printed-circuit board, antenna (one-meter whip or, a one-meter length of #22 hookup wire), enclosure, 8-pin DIP socket, wire, solder, etc.

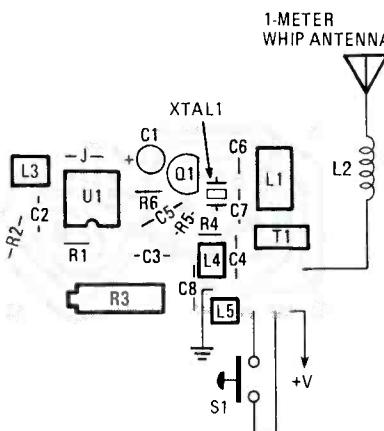
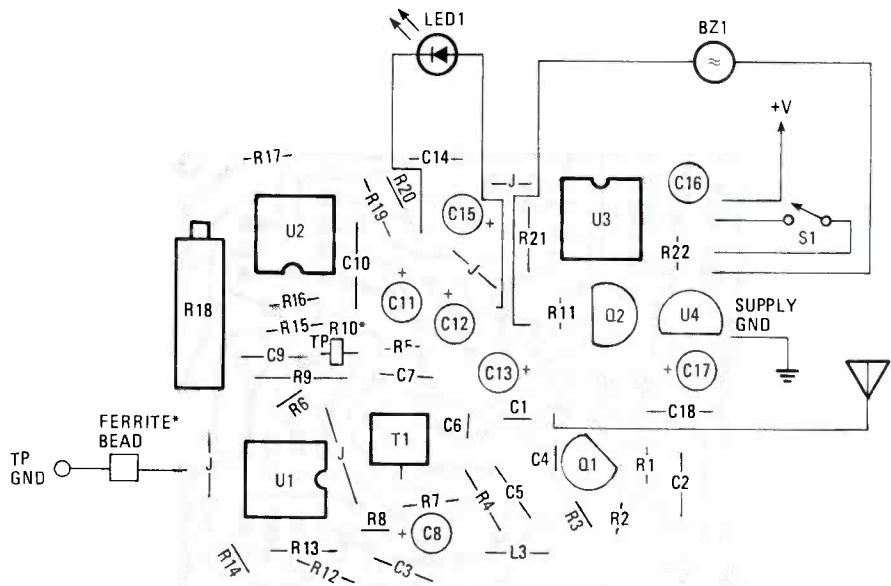


Fig. 5. Following this layout diagram, assemble the transmitter, being mindful that the resistors are vertically mounted on the board due to tight spacing.

On the transmitter circuit, solder one lead of the antenna loading coil, L2, to the printed-circuit board, and attach the other lead to the base of the whip antenna.

Tuning. The following alignment procedure uses a frequency counter and an amplifier/speaker with an auxiliary- or microphone-input jack. All test points are referenced to the circuit-board ground.

Temporarily, remove U2 (receiver) from its socket. Apply power to the transmitter and receiver circuits. Adjust trimmer potentiometer R18 for 490 Hz while measuring the frequency at TP2 (receiver). Similarly, adjust R3 for 490 Hz while measuring the frequency at TP1



*SEE TEXT

Fig. 6. Assemble the receiver printed-circuit board, using this layout diagram as a guide. Note the locations of the two ferrite beads, and be sure not to leave them out.

and Fig. 7A for construction details) is made by bending a $\frac{1}{4}$ inch, 180-degree loop in one lead of resistor R6. Install and solder the resistor onto the printed-circuit board so that the loop is accessible with a test probe.

Similarly make two test points on receiver's printed-circuit board (see Fig. 6 for their locations). Test point TP1 (see Fig. 7B) is made by inserting a ferrite bead over one lead of resistor R10. Make a ring in the lead so that the bead stays in place, and then solder the lead to the board. Install a second ferrite bead over a $\frac{1}{2}$ -inch length of hookup wire to form TP2. Bend the end of the lead into a ring to secure the ferrite bead in place, and connect the other end (with the ferrite bead installed) on the printed-circuit board.

(transmitter). Remove the frequency counter and attach an audio amplifier/speaker to TP1 (receiver).

Using a small screwdriver, adjust the core of T1 (receiver), and the core of L1 (transmitter) until the top of each core is even with the top of its housing. A rushing noise, and possibly the 490-Hz tone, should be heard. Alternately, adjust L1 and T1 for the strongest reception of the 490-Hz tone. Next, place the transmitter at the fringe of its range and tune T1 (receiver) for the best reception. Disconnect all test equipment and power, and reinsert U2.

A second harmonic of the transmitter's signal may be detected on an FM receiver tuned to about 100 MHz. If so, minimize that signal by carefully adjusting L1.

PARTS LIST FOR THE RF RECEIVER/ALERT BEEPER

SEMICONDUCTORS

U1—LM358 dual op-amp integrated circuit
 U2—LM567 tone decoder, integrated circuit
 U3—7555 CMOS oscillator/timer integrated circuit
 U4—78L05 low power +5-volt regulator, integrated circuit
 Q1—MPSH11, ECG229, TCG229, or SK3246/229, NPN RF silicon transistor
 Q2—2N3904 general-purpose NPN silicon transistor
 LED1—Light-emitting diode (any color)

RESISTORS

(All resistors are $\frac{1}{4}$ -watt, 5%, units unless otherwise noted.)
 R1, R11, R21—10,000-ohm
 R2—2200-ohm
 R3—47-ohm

R4—2000-ohm
 R5—4700-ohm
 R6—470,000-ohm
 R7, R8, R22—100,000-ohm
 R9—6200-ohm
 R10—56,000-ohm
 R12—47,000-ohm
 R13—33,000-ohm
 R14—10-megohm
 R15—6800-ohm
 R16—130-ohm
 R17—15,000-ohm
 R18—10,000 ohm, 20-turn, trimmer potentiometer
 R19—20,000-ohm
 R20—1000-ohm

CAPACITORS

C1—5-pF, ceramic disc
 C2, C5—0.002- μ F, ceramic disc
 C3, C9, C18—0.01- μ F, ceramic disc

C4—24-pF, ceramic disc
 C6—18-pF, ceramic disc
 C7—0.039- μ F, metallized film
 C8, C16, C17—10- μ F, electrolytic
 C10, C14—0.1- μ F, metallized film
 C11—4.7- μ F, electrolytic
 C12—0.47- μ F, electrolytic
 C13—100- μ F, electrolytic
 C15—1.0- μ F, electrolytic

ADDITIONAL PARTS AND COMPONENTS

L1—50- μ H, RF choke
 T1—RF transformer
 S1—Single-pole, single-throw toggle switch
 Printed-circuit board (see below) or perfboard, VHF ferrite beads, antenna (two feet of #22 hookup wire), 8-pin DIP sockets, plastic enclosure, piezo buzzer, hookup wire, solder, hardware, etc.

ORDERING INFORMATION

one DIP socket, and the printed-circuit board, \$29.95. Antenna, switch, and enclosure not included.

RECEIVER COMPONENTS

TS3310, transformer T1, \$7.95; complete receiver kit RFR23 (including all semiconductors, resistors, capacitors, ferrite beads, L1, T1, antenna wite, DIP sockets and the printed-circuit board) is

available for \$39.95. Enclosure and battery not included.

Add \$4.50 for shipping and handling (a one time charge covering all items ordered). NC residents must add sales tax. For technical information write to Time Space Scientific at the above address, and include a self addressed stamped envelope.

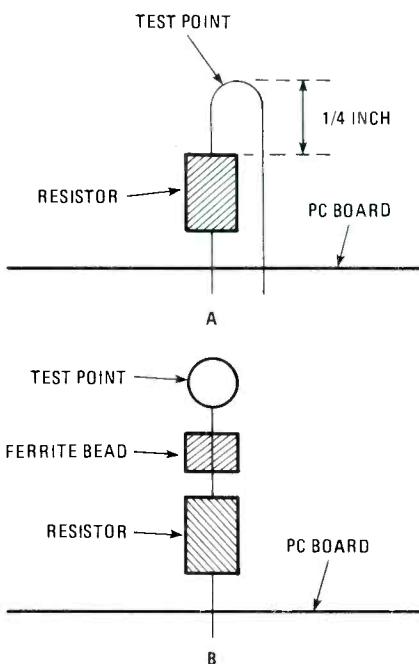


Fig. 7. Shown here are construction details of the test point terminals.

FCC Rules. The Personal Pocket Pager is designed to comply with part 15 of the FCC rules and regulations. It can be built without having to obtain special permission from the Federal Com-

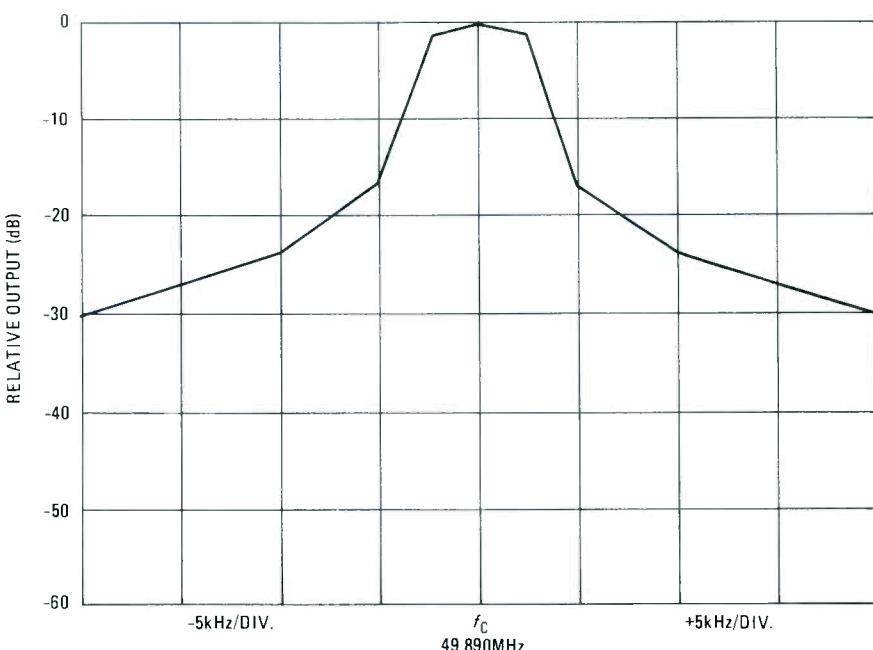


Fig. 8. This diagram illustrates the RF of the transmitter, as seen on a spectrum analyzer. As Required by FCC regulations, Part 15, the bandwidth is less than ± 10 kHz.

munications Commission. However, it is recommended that you read part 15, sections 15.133, 15.118 and 15.119 of the Federal rules and regulations which are available at most libraries.

Figure 8 shows the signal of the RF transmitter, as seen on a spectrum analyzer. As required by FCC regulations, Part 15, the bandwidth is less than ± 10 kHz. ■

Most people who enter the fascinating hobby of antique-radio collecting begin by acquiring the radio sets themselves. But it isn't possible to continue that activity very long without also becoming a collector of related items. For example, those who are interested in repairing their radios and keeping them running (and most of us fall into that category) must also collect tubes, parts, and servicing information. And what radio collector can resist picking up old magazines and catalogues containing all the related promotional material?

For some, the radio-related collectibles become as important as the sets themselves—or perhaps more so. Others tend to pick up only what they need for practical purposes and, perhaps, to add a little color to the radio room. If you're new to the hobby, you probably don't yet know where you stand, but this article will give an orientation that will help you make up your mind and add more spice and good fortune to your house-sale and flea-market forays by giving you more items to look for!

Collecting Radio Tubes. No matter how little you might care about radio-related collectibles, you won't be able to avoid an involvement with radio

Understanding Tube Designations.

At first, tubes were identified by a serial-type numbering system. In an early form of the system, the type number was prefixed by two letters, indicating base style and a digit associated with the manufacturer. Thus an early type 80 having a common base style might be labeled UX280, UX380, UX480, etc., depending on who manufactured it. A little later, the initial designators were dropped and only the serial type

*There's a lot more to
radio collecting
than just collect-
ing radios!*

*Here's a guide
to the different
types of radio-
related collect-
ibles, and what
makes each of
them so fascinating.*

BUYER'S GUIDE TO

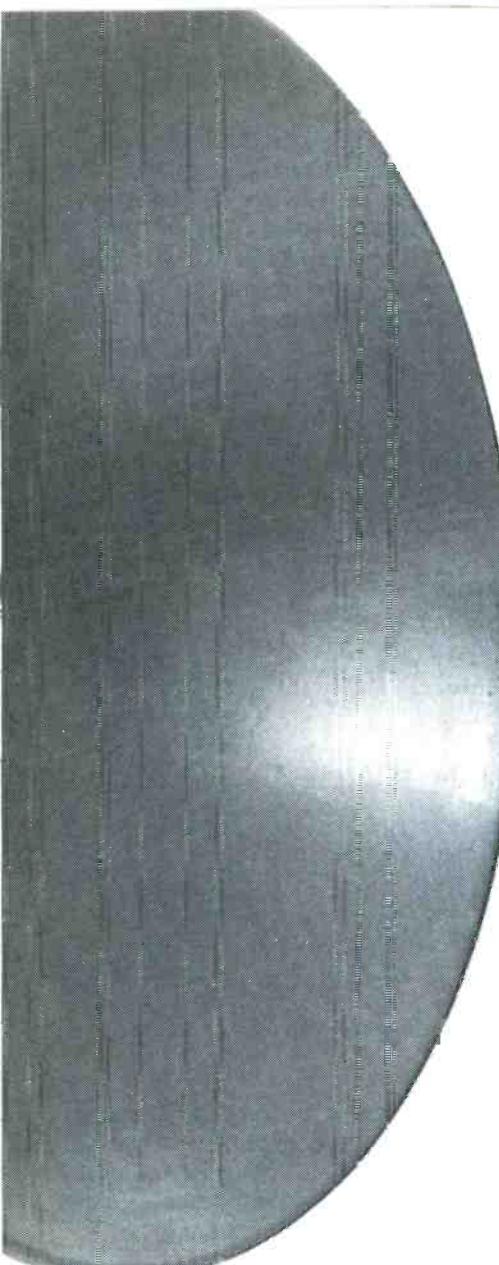
BY MARC ELLIS

tubes. The evolution of radio receivers was very much tied to the evolution of new tube types. Once you gain an understanding of the latter, you'll be in a much better position to understand—and date—the radios you already own, and those you'll find in the future.

Tubes also make extremely interesting collectibles in their own right. While tubes dating from the earliest days of radio (such as the DeForest audion) are rare, and seldom seen outside of museums, those dating from the beginnings of radio broadcasting (early 1920's) are easier to find because they were mass produced.

number was used (for example, the above tube would be labeled simply "80").

In the 1930's, as tube types multiplied, the serial-numbering system became inadequate and a more sophisticated one was devised. As first introduced, type numbers in the new system contained three designators: a number identifying the filament voltage, followed by a letter related to the tube function (amplifier or rectifier), followed by a number indicating the number of active elements in the tube. For amplifier tubes, the letter was chosen from the early part of the al-



phabet; for rectifiers, from the latter part of the alphabet.

For example, the 6C6 has a 6-volt filament; is an amplifier; and contains 6 active elements (a filament, a cathode, three grids and a plate). On the other hand, a 5Z3 has a 5-volt filament; is a rectifier; and contains three active elements (a filament and two plates). The 6D6 and 5Y3 (an amplifier and a rectifier, respectively) perform functions similar to the tubes just discussed, but have different operating characteristics. That is reflected by the differences in identifying letters.

Physical Changes in Radio Tubes.

The evolution of physical/tube characteristics is also of interest to the collector. The glass envelopes of the earliest tubes were like those of contemporary light bulbs; pear shaped with a pointed seal at the top. Later, following trends in light-bulb design, the seal was moved to the bottom of the tube so that it could be hidden in (and protected by) the base.

Still later, in the 1930's, pear-shaped envelopes gave way to the "double-dome" or "ST" style. And a little later in the same decade, more compact tube designs made it possible to release new types (and some older ones) in the "bantam" or "GT" style. That envelope was much shorter than previous ones, straight sided, and had a rounded top. Some manufacturers released the same types in metal-enclosed glass envelopes, having rough-

but could also bayonet-lock into the older sockets.

Tube cartons can be as interesting to collectors as the tubes they contained. From the plain generic-looking styles of the early 1920's to the colorfully lithographed ones of later years, they can make a very interesting display.

A detailed discussion of radio-tube history is beyond the scope of this article. But for more information on tubes from the early years of broadcasting through the early 1930's, check your back issues of **Hands-on Electronics**. You'll find the *Ellis On Antique Radio* columns of February, March, and April 1987, as well as May, 1988, to be very helpful.

John Rider's Mighty Manuals. As mentioned a little earlier, your preoccupation with printed radio literature will begin almost immediately after acquiring your first few sets. Because once you start working on the radios, you'll want to acquire schematics and other servicing information.

There are individuals and organizations who will look up information and photocopy it for you for a nominal fee. But if you have the space and the inclination, you can build your own personal library of original service data.

In my opinion, the best way to do that is to begin acquiring volumes of John Rider's *Perpetual Trouble Shooter's Manual*. Rider began publishing the manual some time in the late 1920's or early 1930's, and added

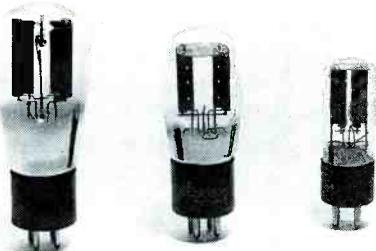
RADIO COLLECTIBLES

ly the same outer dimensions as the "GT" style.

Tube bases also changed over the years. Brass gave way to bakelite as a base material, and the original short-pin, bayonet-lock style was changed to the longer-pin type that engaged with friction contacts in the tube socket. Some transition-period tube bases had the longer, friction-contact pins,

a new volume to it approximately every year (with some breaks during World War II).

Each new book provided schematics and service information for virtually every radio released since publication of the prior one. The complete set contains 23 hefty tomes covering radios from the early 1920's through the early 1950's.



These three versions of the familiar type-80 tube show the evolution of bulb styles. At far left is an original pear-shaped bulb; in the center is an "ST" (double-dome) style; and at the right is a "GT" (straight-sided) bulb.

Rider volumes still turn up regularly at antique-radio swap meets and hamfest flea markets, and they're easy to spot. Look for a distinctive dark-blue binder with a quaint cover illustration of an antenna strung between two towers. A separate Rider series, similarly bound, covered television sets—but they are plainly marked as such, and you can avoid them (unless, of course, you are into early TV's).

The Rider manuals of most practical interest to collectors are probably volumes 1 through 13. (The latter bears a 1942 copyright, and covers the last of the pre-war radios). However, if you look at the Rider set as a collectible in its own right, you'll obviously want to acquire as many of the volumes as possible.

Price and Availability. The earliest volumes in the set (1 thru 4 or so) don't seem to turn up very often, and are expensive. The volumes towards the end of the series are also hard to come by. I suspect that the manuals declined in popularity towards the end of the run, and not as many were printed. Asking prices for the more common volumes seem to be from six to fifteen dollars each, depending on the mood of the owner.

Rider also published an abridged version of volumes one though five, complete in one book that is bound uniformly with the rest of the set. It was probably intended for repairmen who got into the business some years after the series was instituted and didn't have as much need for the earliest data. The abridged version is much more common than the individual volumes, and would be a good alternative for those who can't find the latter. I've seen it priced at about \$40.00.

Though I didn't realize what I was buying at the time, I was lucky enough

to purchase the complete volumes 1-3 bound in one book. It was originally offered by RCA as part of a tube deal, and the binder is the same physical size and type as that used in the standard Rider manuals. However, the cover is red instead of blue and shows a vacuum tube instead of the traditional antenna and towers. I've never seen another one like it.

Finding Your Way Through Rider's.

Without an index, locating sets in Rider's is something of a pain in the

softbound pamphlet form. The indexes don't seem to turn up as often as the manuals, but some have been made available in reprint form by *Antique Electronic Supply* (688 W. First St., Tempe, AZ). Current prices are \$17.95 for the index to Volumes 1-15 (205 pages, spiral bound) and \$7.95 for the index to volumes 16-22 (48 pages, spiral bound).

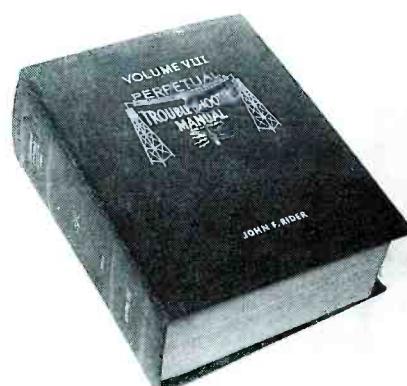
An interesting alternative to the Rider indexes is offered by *The P.R. Mallory Radio Service Encyclopaedia*—a radio-receiver index



Colorfully lithographed radio-tube cartons can be as interesting as the tubes they once contained.

neck. You're pretty much reduced to guestimating the year that your set was manufactured, then looking it up, trial and error fashion, in the volumes that most closely correspond. Since the books tend to be big, heavy and clumsy, doing so can be an unpleasant task.

Every few years, Rider published an index for the books that had been released up to that time; they were in



Rider's "Perpetual Troubleshooter's Manual" series is not only the most exhaustive reference source available to collectors today, but is also a collectible item in its own right.

compiled for the purpose of recommending the correct Mallory controls, capacitors, or vibrator for every model. But each entry also includes the correct Rider's reference!

My Sixth Edition was copyrighted 1948 and, I suspect, is based on the Rider index to Volumes 1-15, which appeared in 1947. If you can find one of them, you may be able to get it for very little money since its value is not generally known (mine cost two bucks!). Some time after purchasing it, I bought a serviceman's assortment of Mallory controls in a metal storage cabinet. The cabinet had a compartment obviously intended to accept the manual—which must have been included with the deal.

The Supreme Series. Another source of schematics and service information was the "Most-Often Needed" series offered by Supreme Publications. Like Rider, Supreme released a new compilation each year. But while Rider published huge binders covering virtually every set ever produced, Supreme published relatively slim soft-cover books containing an



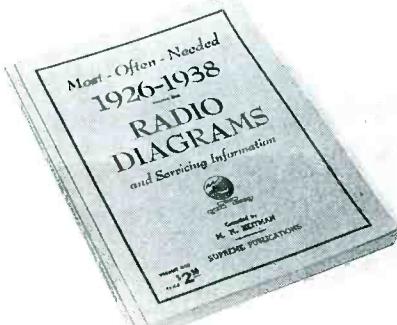
P.R. Mallory Radio Service Encyclopaedia (Sixth Edition) stores behind compartment containing assortment of Mallory controls. The manual contains an index to Rider's through about volume 15.

edited assortment of material on the most popular models.

To my mind, the Supreme manuals are more valuable as practical references than as collectibles. The first volume, which bears a 1941 copyright date, covers 1926 to 1938 sets. From then on, they came out every year with a gap during World War II. The manuals were published at least into the late 1960's.

The 1926-1938 volume was reprinted by Supreme more than once over the years, and copies turn up quite often at hamfests and antique-radio meets. It's a good starter book for the beginning antique-radio collector, providing information on the more common sets. But keep in mind that its approximately half-inch thickness covers a time span that would be represented by three feet or more of Rider volumes.

It's worth noting that most of the Supreme manuals are available, in re-



The first "Supreme" manual covers common sets from 1926 to 1938, and has been reprinted many times over the years. It is a great "starter" reference book for beginning collectors.

print form, from ARS Enterprises, P.O. Box 997, Mercer Island, WA 98040. When last I looked, the 1926-1938 volume—and the subsequent individual-year volumes through 1959—were priced at \$17.00 each. Later volumes were \$5.00, and a master index was available at \$8.00. Write them for current information.

Generic Servicing Books.

Although we've covered collections of service information for specific sets, there are some generic books on servicing that are not only useful, but collectibles in their own right. And since they were very popular volumes when originally published, there are still a number around to be discovered today.

For example, watch for the radio books published by McGraw-Hill during the 1920's, 1930's, and 1940's. They have easy-to-spot, drab-green bindings with gold-lettered titles on the spines. The volumes by Moyer and Wostrel (including *Practical Radio* and *Radio Construction and Repair*)

Radio Physics Course, published by Radio Technical Publishing Co., has a more theoretical slant and will help you understand the "why" of vintage radio circuitry. My copy, a second edition revised in 1933, was printed in 1937.

No discussion of vintage servicing books would be complete without mentioning the many contributions by John F. Rider of *Perpetual Trouble Shooter's Manual* fame. Most of those are relatively short books focused on specific aspects of servicing, and were published by Rider himself. Look for such titles as *Servicing Superheterodynes*, *Practical Testing Systems*, *The Oscillator at Work*, and various titles in the *An Hour a Day With Rider* series.

Other Printed Materials. Vintage trade and hobby periodicals contain articles and advertising that will help you to understand the equipment that you're collecting and the context in which it was used. A list of the well-known and little-known titles in that



Vintage trade and hobby periodicals help you better understand your early equipment and the context in which it was used.

ing) are interesting relics of the 1920's.

For insights into radios of a later period, keep an eye open for *Principles and Practice of Radio Servicing* by Hicks. Editions of that book were published in 1939 and 1943.

Two classics of the 1930's, both by Alfred A. Ghirardi, should be on every collector's shelf. *Modern Radio Servicing*, published by Murray Hill Books, is packed with practical information on troubleshooting 1930's-era sets. The edition on my own shelf bears a 1935 copyright, but there may have been subsequent revisions and expansions.

area would be endless, but watch for publications such as *Radio News* and Gernsback's own *Radio Craft* and *Short Wave Craft*. Also interesting are private or "house" publications produced for dealers and servicemen by the manufacturers of radios and radio components.

Be sure not to neglect non-electronics magazines, either. The ones targeted for middle-class or carriage-trade readers contain elaborate display advertising for expensive consumer goods such as radios, automobiles and cameras. Old issues of



These interesting parts from the early 1920's include Rauland audio transformer (far left); a Dubilier RF transformer (far right); a CLE-RA-TONE tube socket with original box (top center); and a vernier dial (bottom center).

The National Geographic are still fairly easy to find, and are a very rich source of such advertising. I've found a lot of fascinating information on the sets in my collection in old issues of that publication.

Anything like a complete discussion of collectible printed materials relating to antique radio would be impossible in an article of this scope. The volume of books, periodicals, catalogues, instruction manuals, promotion pieces, and other types of advertising—aimed at both the general public and the electronics professional—is huge.

My advice is keep your eyes open at the book stores and swap meets. If a piece interests you and you can afford it, make the purchase. I continue to enjoy all of the printed items I've picked up over the years.

Parts: Collectible and Otherwise.

Most of the collectibles covered so far have a definite dual purpose. They're not only interesting in themselves, but also useful—or even necessary—for radio maintenance and repair. Oddly enough, that isn't always the case with radio parts. The collectible ones tend not to be the ones most needed for practical radio service, while the ones needed to keep the radios running tend not to be collectibles. Admittedly, I've made something of a forced distinction here, and there'll be plenty of exceptions, but let me explain what I mean.

I associate collectible parts and accessories with the radios of the 1920's period. During that era, many people built their own sets from plans published in books and magazines. The parts, much larger in size than the comparable electronic components of today, were individually packaged, advertised, and sold.

There were many competing manufacturers, and they vied with each other in the extravagance of their performance claims and the colorfulness of their advertising and packaging. The parts themselves, crafted of bakelite, glass, silk- or cotton-covered wire, and polished or brightly painted metal, were definitely made to be looked at. Among the parts of interest to collectors are knobs, dials, tuning capacitors, audio- and radio-frequency transformers, tube sockets, rheostats, resistors, plugs, and jacks.

part failure. Therefore, parts that have been acquired as collectibles can generally stay on the display shelf.

The Changes of the 1930's. I've always thought that the marketing of radio parts in the 1920's had a lot in common with the marketing of certain kinds of auto parts today; particularly the ones intended to improve performance or convenience and simple enough to be installed by the "back-yard mechanic" set. But by the 1930's, radio receivers had become much more complex. Most sets were factory built, rather than home made—and the average radio listener was less apt to be in the market for parts to improve performance.

As you might expect, then, radio parts became more functional in physical design. They were being made to do their jobs, and not especially to be looked at. But with increased circuit complexity and higher component operating voltages, parts failures were, and are, much more common in the more-modern sets.

It's certainly true that proper resistors, capacitors, transformers, speakers, and other components suitable for use in repairing vintage radios are becoming harder and harder to come by. So most radio collectors acquire them as they can. But parts for repairing 1930's-and-later sets could hardly be called collectibles. They're usually not displayed, but stored in drawers and cabinets until needed.

★ POWER

WHEN it comes to making a loudspeaker deliver the goods, there's nothing like a pair of AmerTran. Built to operate by the pair, they secure from two stages all you could possibly hope for in audio amplification. Look for a pair of AmerTran in the set you buy—use them in the sets you build. Learn just what the famous AmerTran "kick" means—and then get a loudspeaker to take it.

AmerTran is made in two sizes, one quality—
A F. 6—rate \$1.50 and A F. 8—rate \$3.50.
Buy them by the pair!

AMERICAN TRANSFORMER COMPANY
101 SUMMIT STREET, NEWARK, N. J.
"Transformer leaders for over ten years."

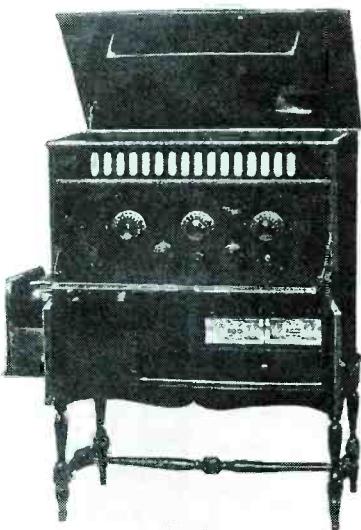
Price includes A F. 6 & 8.
Not for battery service, switch
any other source available.

AMERTRAN

1920's-era radio-parts advertising sometimes resembles today's advertising for high-performance auto parts.

People bought parts not only to build new sets, but to improve the performance or convenience of existing sets. Parts in the latter category included not only straightforward components such as vernier-dial drives and "high-fidelity" audio transformers, but also a colorful assortment of more fringe apparatus, such as antenna substitutes, variable grid leaks, self-adjusting filament rheostats, and multiple-headphone adapters.

The radio sets of that era were so simple, and the parts so basic and generally well-made, that breakdowns due to component failure were relatively uncommon. It's true that restorers of 1920's radios sometimes have to deal with such problems as burned-out audio transformers and grid-leaks whose resistance has escalated over the years. But most performance difficulties can be traced to poor contacts caused by dirt and corrosion, not a



Special radio furniture was designed to provide storage for the early battery set, its power sources and the other accessories required for its operation. Such furniture can be used to display the most prized items in your collection.



RHAMSTINE★

"B" RECTIFIER

Better than "B" Batteries

Only \$25

A Advantages

Battery eliminators and chargers were heavily marketed prior to the introduction of AC-powered sets. There are many still around to be discovered today.

Batteries, Chargers, and Eliminators. Vintage accessories can add yet another colorful and fascinating dimension to your collection of radio items. This is another category so rich in collecting potential that even a partial list of possibilities would be difficult to compile. But, just as in the case of parts, your most interesting "finds" are apt to date from the 1920's.

One important group of accessories is associated with the batteries used to power most radios of that period. First of all, there are the batteries themselves although—because of the corrosive chemicals they contained—not many of them survive today. The lead-acid storage "A" batteries used to light the filaments were generally 6-volt automobile types. However, I've seen special versions designed for radio use; some had beautiful teakwood outer cases incorporating handles for easy carrying.

The "B" and "C" batteries that provided plate and grid-bias power were generally of the non-rechargeable dry-battery type. Today, they are probably harder to find than the filament batteries because they were thrown away when exhausted. Those that were kept were generally quickly rendered unsightly after the chemicals inside ate their way through the outer casing. Yet, for some unaccountable reason, some of those dry batteries have survived (though quite dead, of course) in good cosmetic condition. Most have colorful, lithographed wrappers, and certainly look interesting when displayed along with examples of the radios they once powered.

Battery chargers and eliminators also make interesting collectibles. Both of those types of units plugged into normal, commercial, AC-power lines. The former—scaled-down versions of the commercial types then in use—made it possible for radio enthusiasts to replenish their "A" batteries at home—thereby, avoiding the discomfort and the danger of lugging them to the neighborhood gas station. The latter actually took the place of "A" and/or "B" and "C" batteries.

A word to the wise: avoid the temptation of trying to operate one of your prized battery sets from a vintage battery eliminator. The regulation of the old units was generally far from ideal even when new. Today, after many years of aging, the values of the carbon resistors and controls used to establish the correct voltages may be nowhere near original specification. The result could be dangerously high voltages that might well pop tube filaments and/or burn out AF-transformer windings.

Modern battery eliminators, using semiconductor regulators, are available from several sources. They provide stable, well-filtered DC power that is not only safer for your set, but will make it perform better.

Before leaving the subject of battery-radio accessories, I'd like to touch on a couple of other collectible categories that you might find of interest. With battery condition so crucial to proper set operation, most radio owners equipped themselves with some kind of a battery tester. The typical tester was a "watchcase" style

meter housed in a highly chromed, round case a few inches in diameter. Some models tested for voltage; some for current; and some for both. They came in a variety of brands and styles, and an assortment of them makes a fine addition to any collection of sets from that period.

Finally, you might like to look for special radio furniture. Back in the 1920's, a typical radio installation consisted of the radio unit itself, plus a separate speaker, an array of batteries, possibly a charger, and/or eliminator. The natural setting for that novel, and very important, collection of apparatus was the family living room. But some housewives understandably felt it to be an eyesore. The answer, for many families, was a cabinet that would house all that stuff much like the hi-fi system organizers on the market today.

The typical unit contained compartments for storing (and concealing) radio, batteries, speaker, charger, etc. Many took the form of a drop-leaf desk, with the drop leaf serving as the radio operating table when open. If you can find one of those, and have the space to show it off properly, it can be a focal point for your collection—providing display space for some of your most prized pieces.

Reproducing Equipment. This could easily be one of the largest and most important categories in your collection of radio accessories. But why do I consider such things as headsets and speakers to be accessories? Because, back in the 1920's, such items were generally not packaged with the radio, but sold separately, much as hi-fi components are today. If the radio manufacturer offered them for sale, they might be purchased along with the set, or they might not. There were many makers competing for the set-buyer's dollar, and the buyer might well be tempted by a better price, a style more to his or her liking, or claims of improved performance.

The earliest speakers in common use with broadcast sets were of the horn type. The sound-reproducing unit within the base of most horns was essentially an overgrown earphone. The sounds were produced by vibrations induced in a metal diaphragm by the action of a pair of electromagnets. The horn then acted as an acoustical amplifier, very much in the manner of a megaphone.

(Continued on page 160)

How would you like to tune in the BBC, Radio Moscow, South America, and trouble spots around the world while driving to work, or even while vacationing? The HPS Converter connected to your car's radio can make it possible!

The HPS (High-Performance Shortwave) Converter is a simple project that can be assembled in just a few hours. You can make your car a traveling shortwave-listening post.

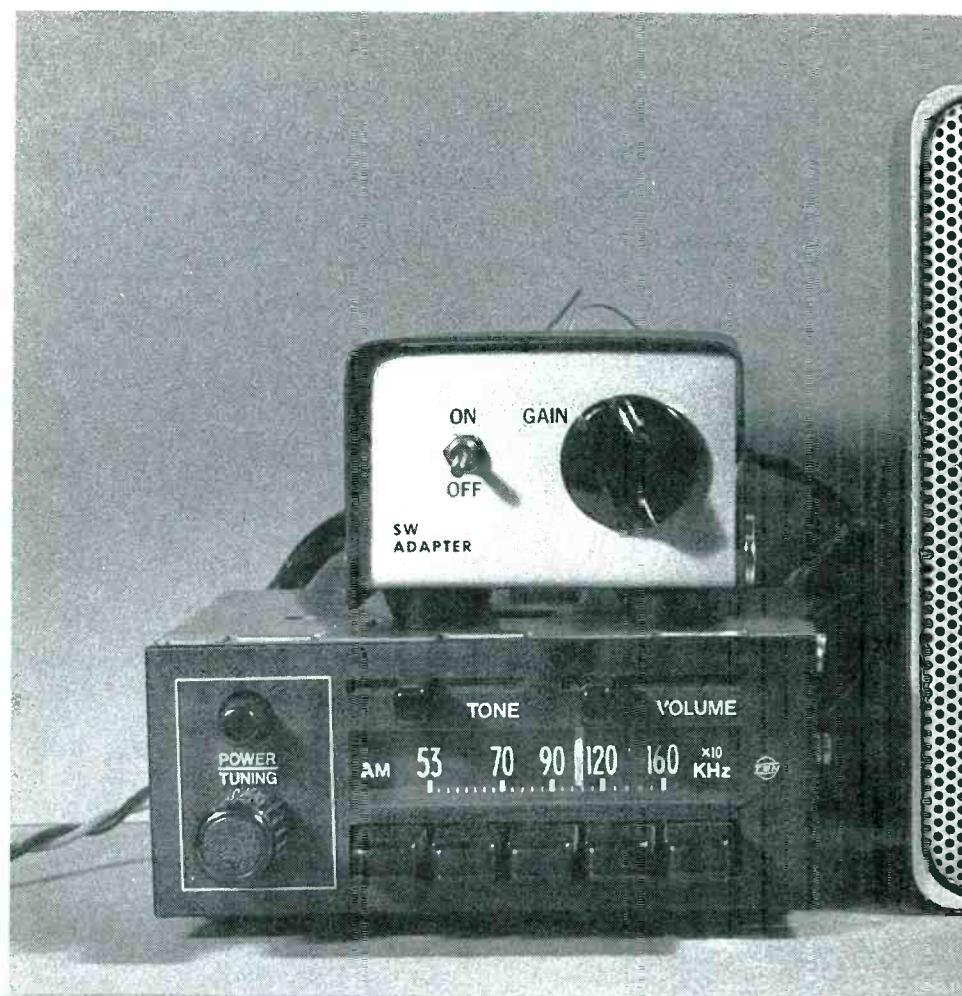
Several one-transistor shortwave-converter circuits have been published recently and they will all work, but the HPS Converter out-performs all of them. The converter circuit uses the Signetics NE602 frequency-converter integrated-circuit chip. One evening, with just a 3-foot antenna, I logged over 30 stations between 9.5 and 10 MHz, and about ten of them—including the BBC from England, as well as stations from France, and Austria—were loud and clear like listening to local broadcast stations. Signal selectivity is much better than with most shortwave radios priced under \$150, and tuning is easy because a single, popular shortwave band stretches across the whole dial.

Why a Car Radio? Car radios are among the best AM receivers made. They have to endure vibration and give decent reception with a puny antenna. Think about it: a 33-inch whip is only $\frac{1}{360}$ th of a wave at 1000 kHz, so the length for a $\frac{1}{4}$ -wave antenna at that frequency would be 90 times longer.

Not only that, but car radios are well shielded to keep out electrical noise coming from the engine. Their metallic cases make them ideal to use with converters. You can be sure the car radio won't hear anything but the tuned station entering through the antenna jack; local AM stations won't intrude on your shortwave listening.

In fact, you must use a car radio. Other kinds of receivers with antenna jacks don't work well with the converter, because they usually use the external antenna to supplement, rather than replace, the built-in loop. As a result, there's no way to keep AM broadcast signals from blanketing the dial.

Best of all, AM car radios are cheap, because people get rid of them when they upgrade to FM stereo. I bought one at a swap meet for one dollar. If you can't find a deal like that, go to a



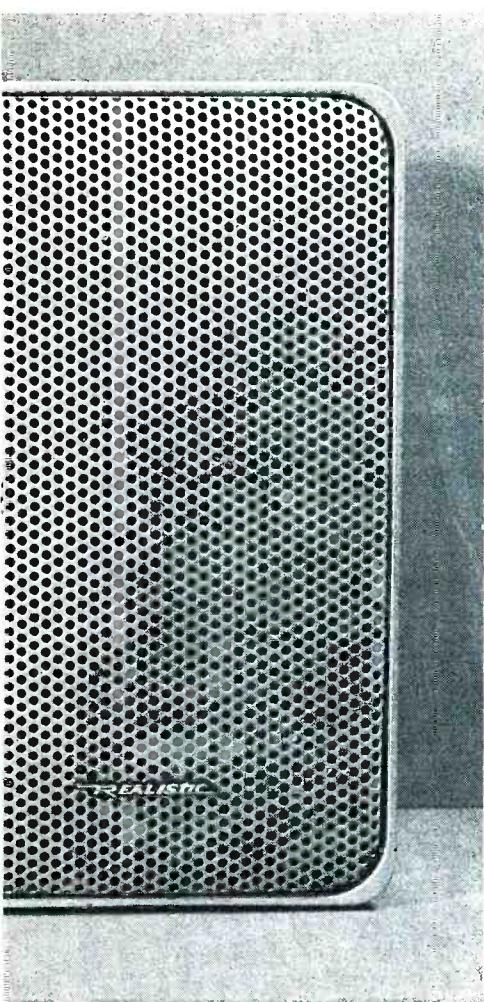
High-Performance Shortwave Converter

junkyard or a car-stereo dealer and offer up to \$5 for a working AM radio. Any AM/FM set will work equally well, of course, on the AM band.

Frequency Conversion. Figure 1 shows the schematic diagram of the HPS Converter circuit. The NE602 chip, U1, contains oscillator and mixer stages. The mixer combines the oscillator signal with the input RF (Radio-Frequency) signal to produce signals whose frequencies are the sum and difference of the input frequencies. For example, an 8.5-MHz oscillator and a 10-MHz incoming signal will give output signals at 18.5 MHz ($10 + 8.5$) and 1.5 MHz ($10 - 8.5$). Re-

call that 1.5 MHz is 1500 kHz and an ordinary AM radio will tune to it. The other output, 18.5 MHz, is so far out of the broadcast band that it won't have any effect on the AM radio. Both the original signal at 10 MHz and the oscillator signal at 8.5 MHz are seen at the output, but the radio will tune them out.

The choice of crystal depends on what shortwave band you want to hear. The most active band at night is 5.9–6.5 MHz. To hear that band on an AM radio, you can use a typical 5-MHz microprocessor crystal in the oscillator. The 9.5–10-MHz band is less crowded and includes the time-signal station WWV. For that band, you'll need a crystal of



A car radio and our high-performance shortwave converter can put your shortwave-listening hobby on the road.

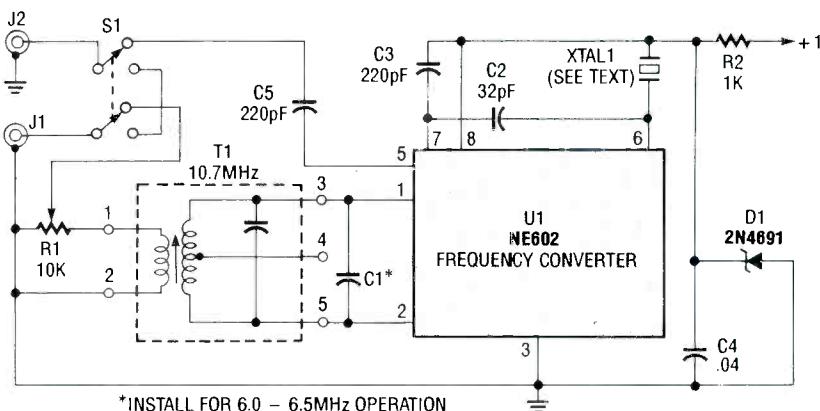


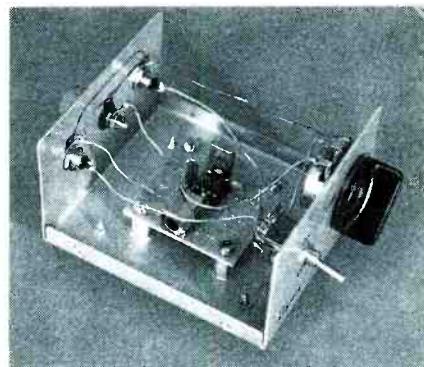
Fig. 1. The NE002 integrated-circuit chip amplifies the output signal by ten times. Interconnecting leads should be kept short and layout should appear neat for satisfactory operation.

around 8.5 to 8.9 MHz. There is no standard microprocessor crystal in that range, but you can use an amateur-radio crystal, have a crystal custom-made, or use a CB crystal.

Why a CB crystal? CB crystals oscillate at around 27 MHz in their third-overtone mode. In this circuit, however, they'll oscillate on their fundamental frequency, which is only a third as high. For example, a channel-5 receiving crystal is rated at 26.560 MHz and oscillates at 8.853 MHz in this circuit—ideal for the 9.5–10-MHz band. Any CB crystal, receiving or transmitting, will get you at least part of that band, though with some high-channel CB crystals you'll lose stations below about 9.6 MHz.

The Filter Circuit. Transformer T1 rejects signals that are outside the band you are interested in. If T1 weren't there, you'd hear signals below the crystal frequency as well as above it. That is called imaging. Here's an example: A 7.5-MHz signal is picked up by the antenna and mixes with the 8.5-MHz oscillator frequency. The difference between those two signals is 1 MHz—right in the center of your AM dial. Thus, transformer T1 should pass signals from 9 to 11 MHz and attenuate all others.

The transformer, T1, used in the circuit is a 10.7-MHz IF transformer salvaged from an FM radio. They are fairly easy to obtain new from parts stores and mail-order houses. Most 10.7-MHz IF transformers will tune across the 9.5- to 10-MHz band without modification; all you need to do is turn its tuning slug. To get the 6.0- to 6.5-MHz shortwave band, you'll have to add a 150-pF capacitor (C1 in the diagram).



As you can see the converter can be placed in a very small cabinet if you wish to conserve space. As long as the enclosure is metal that will not cause any reception problems.

The GAIN control, potentiometer R1, prevents overloading from extremely strong signals. It's wired backward, compared to the usual configuration for a GAIN control, so that T1 will always see the same resistive load. If your antenna will always be short—under 6 feet—you can omit R1 and connect the antenna directly to T1, terminal 1.

Construction. The HPS converter was



The rear panel of the converter housing reveals the two jacks for connecting the antenna and receiver. The center jack goes to the 12-volt DC supply. The power-supply ground is the cable shield.

built on perfboard and placed in a small metal enclosure. If you wish to construct yours on a printed-circuit board, a foil pattern is presented for you in Fig. 2. A parts-placement diagram for the foil pattern is given in Fig. 3 to help you stuff the board properly.

The metal enclosure blocks out signals from nearby AM stations and shielded cable between the converter and the radio is recommended for further isolation. Keep in mind that the shielded cable should be kept as short as possible.

As an important option, a DPDT antenna ON/OFF switch, S1, was included to take the converter out of the circuit for

PARTS LIST FOR THE HPS CONVERTER

CAPACITORS

- C1—150-pF, ceramic-disc (see text)
- C2—32-pF, ceramic-disc
- C3, C5—220-pF, ceramic-disc
- C4—0.04- or 0.05- μ F, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

- U1—NE602N frequency-converter, integrated circuit
- D1—6.2-volt, 0.4- or 1-watt Zener diode
- R1—10,000-ohm panel-mount potentiometer
- R2—1,000-ohm, $\frac{1}{4}$ -watt, 5% resistor
- J1, J2—RCA phono jack
- S1—DPDT, toggle switch, panel mount
- T1—10.7-MHz IF transformer (green color coded)
- XTAL1—8.5-MHz crystal or CB channel-5 receiving crystal (see text)
- XTAL2—5.0-MHz microprocessor crystal for 6-MHz band

AM car radio, 8-ohm speaker, 12-volt, 200-mA (or better) wall-plug power supply (see text), metal enclosure, shielded cable, wire, perfboard, knob, solder, hardware, etc.

The following are available from Small Parts Center, 6818 Meese Drive, Lansing, MI 48911: T1, \$0.80; U1 \$2; XTAL1, \$1.60; XTAL2, \$5.50; an etched and drilled circuit board, \$4.00 postpaid; a complete kit of parts less crystal and enclosure, \$10.50 postpaid. Send a check or money order only. Add \$2.50 per order to cover shipping and handling if ordering only the non-postpaid items. Michigan residents add appropriate sales tax.

XTAL2, costing \$1.62 as part number X051, is available from Digi-Key Corporation, P.O. Box 677, Thief River Falls, MN 56701-0677; Tel. 800-344-4539. They accept Visa and MasterCard. Add \$3 per order for shipping and handling. Minnesota residents add appropriate sales tax.

JAN Crystals, 2341 Crystal Drive, Fort Myers, FL 33906; Tel. 800-237-3063, will custom-make a crystal for any frequency for less than \$10. Specify a load capacitance of 32 pF, a tolerance of .005%, in an HC-18/U package.

regular AM listening. The wiring for the optional switch must be totally contained within the metal case.

Figure 4 shows the complete inter-unit hookup. The converter needs only a +12-volt power supply such as a car battery if you wish to install it in a vehicle. You can use dry cells or a suitable DC power supply if the unit will not be

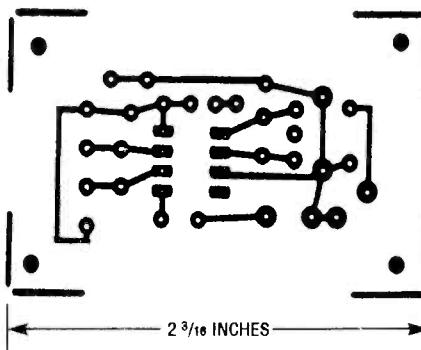


Fig. 2. This foil trace pattern is presented for you to use for your printed-circuit board if you choose to make your own from scratch.

installed your car.

The unit requires less than 200 mA of current at 12 volts, but for home installation, you must of course take the radio's power requirements into account. You'll of course need an 8-ohm speaker if your radio doesn't have a built-in one. A small bookshelf loudspeaker will sound really good, however common 4- or 5-inch replacement speakers will work equally well in a homemade cabinet.

Regardless of the type of installation, a wise move would be to connect the power lead from the converter to the 12-volt supply bus inside the AM radio so that the radio's ON/OFF switch will control

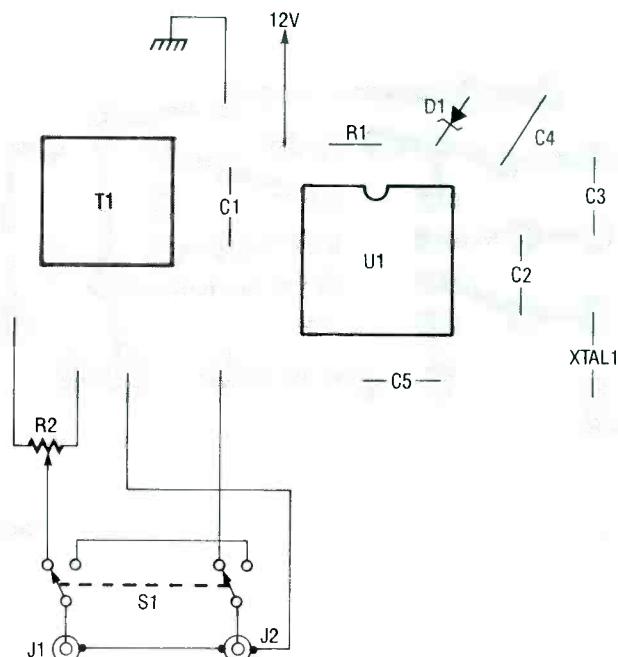


Fig. 3. Use this parts-placement diagram to stuff your own circuit board. You need only orient the diode, transformer, and integrated circuit properly to get the converter to work.

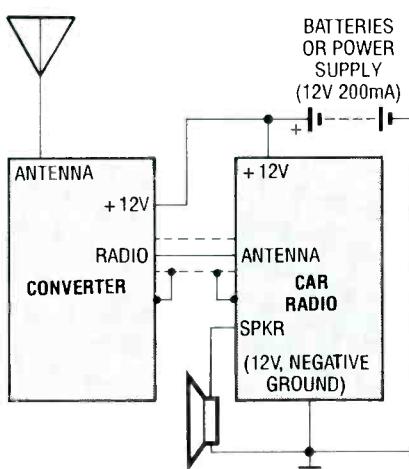


Fig. 4. The complete setup is illustrated in this diagram. The converter is grounded through the cable shield. You could add a ground wire if you wish.

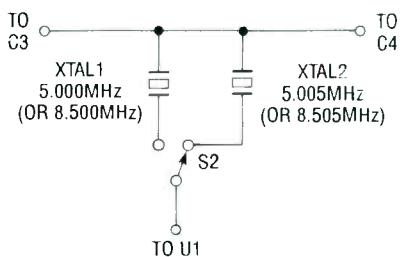


Fig. 5. A SPST crystal-selector switch can choose between crystals to enable a digital receiver to tune in 5-kHz steps. Lead length is critical, so keep it short.

the converter also. The ground for the power supply (or battery) travels through the grounded shield on the cable that connects the converter and the AM radio, so it requires no wire of its own.

(Continued on page 159)

BUILD AN ELECTRONIC DARKROOM TIMER

Build this simple circuit and let it watch the clock for you!

BY DOUGLAS E. PCPE

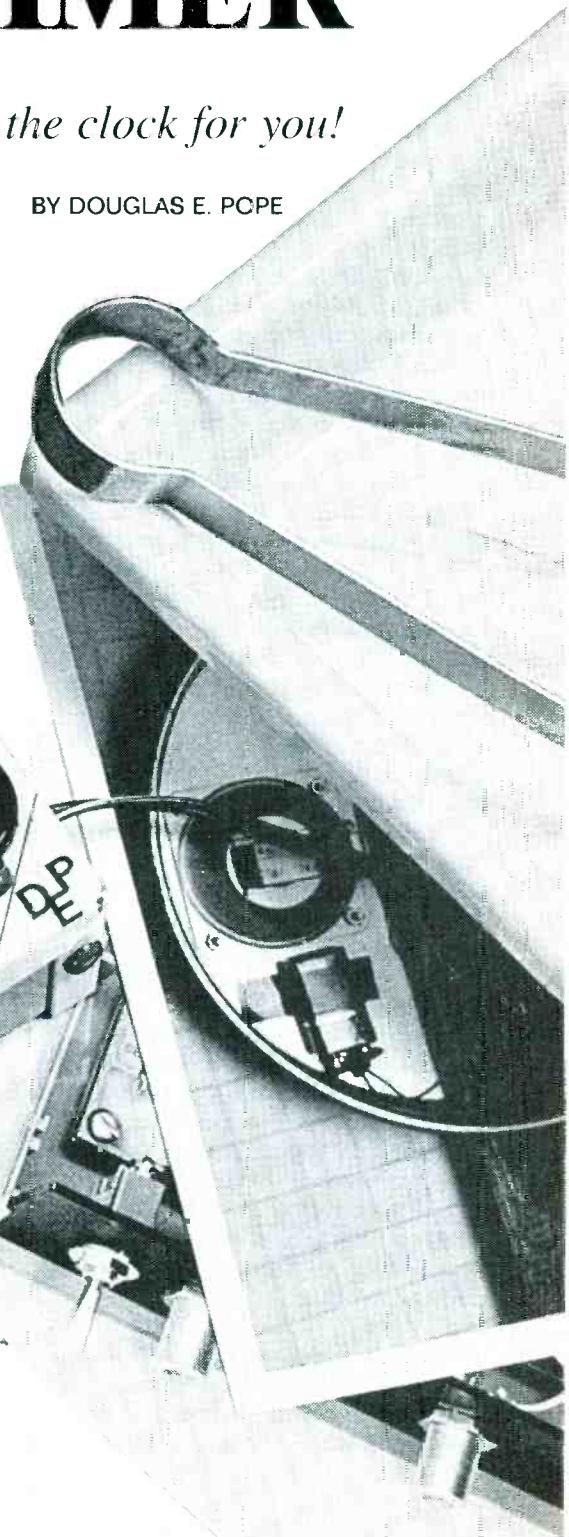
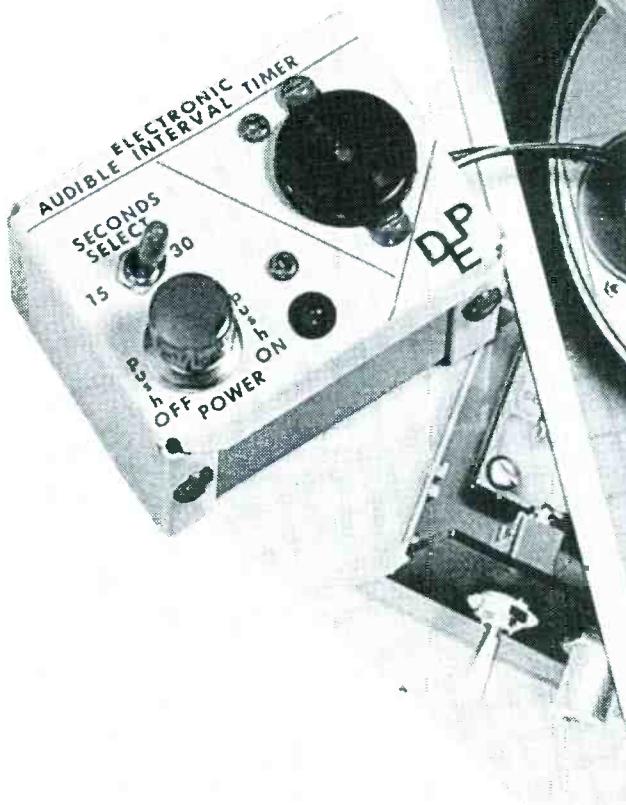
Being a professional photographer, I spend many hours behind the camera and in the darkroom. My time in the darkroom is what sparked the idea for this project. When developing film, the developing tank must be inverted or the film agitated at set intervals; normally 30-second intervals for black-and-white film, and 15-second intervals for color.

Usually, a darkroom timer or stopwatch is used to time the total length of each step in the process; some steps may be as long as 15 minutes or more. Sitting and staring at a timer display to note those intervals can be rather boring. That's where the *Electronic Darkroom Timer*, described in this article, comes into play.

The Electronic Darkroom Timer has a buzzer that beeps at preset intervals, so you are free to do other darkroom chores without the fear of missing an agitation interval. And it's equally well suited for timing the tray processing of black-and-white prints. With the particular paper and chemistry that I use, the print stays in the developer for 1½ minutes, in the stop bath for 30 seconds, in the fixer for 2 minutes, and in the water wash for 3 minutes.

With the darkroom timer set for 30 second intervals, you can simply count the beeps; i.e., 3 beeps in the

developer tray, one beep in the stop bath tray, 4 beeps in the fixer tray, and 6 beeps for the water wash. Believe me, it's much better than having to watch the second hand of a wall clock, or setting a darkroom timer for each step of the process, or counting "one Mississippi, two Mississippi," etc.



About the Circuit. Figure 1 shows the schematic diagram of the Electronic Darkroom Timer. The circuit is built around a 555 oscillator/timer, a pair of general-purpose transistors, a buzzer, and an LED. The 555 (U1) is configured as an astable multivibrator (free-running oscillator). The frequency of the oscillator is determined by the values of resistors R1–R3 and capacitors C1–C4.

Switch S1 is used to divide the capacitor network to vary the time interval between beeps; when S1 is closed, the circuit beeps at intervals of 30 seconds, and with S1 closed, it beeps at 15-second intervals. (Those intervals can be altered by substituting different values for those components.)

When power is applied to the circuit (by closing switch S2), the output of U1 at pin 3 is initially high. That high is applied to the base of transistor Q1 (an MPS2907 general-purpose PNP unit), keeping it turned off. That high is also applied to the anode of LED1 (which is used as a power on indicator) through resistor R7, turning it on. (See the timing diagram shown in Fig. 2).

While that's going on, timing capacitors C1–C5 begin to charge through timing resistors R1–R3. And a DC voltage is applied to BZ1's driver input through R5 and to its feedback terminal (through R4), which is also connected to Q2's base terminal. The V+ voltage applied to Q2's base causes it to turn on, tying BZ1's common terminal high.

When the timing capacitors are sufficiently charged, a trigger pulse is applied to pin 2 (the trigger input) of U2, causing U1's output to momentarily go low. That low causes LED1 to go out and transistor Q1 to turn on. That, in turn, grounds the common lead of buzzer BZ1, causing BZ1 to sound. Afterward, the output of U1 returns to the high state, turning off Q1 and turning on LED1, until another time interval has elapsed, and the process is repeated.

The circuit is powered by a 9-volt AC adapter, which plugs into a standard 117-volt household outlet. But because the circuit draws only about 10 to 15 millamps, a 9-volt alkaline transistor-radio battery might also be used to power the circuit. All parts can be easily obtained from local electronics-parts suppliers, or can be mail ordered from most parts houses.

Putting It Together. There is nothing critical about the construction of the circuit, and component substitutions are permissible. For instance, Q2 (which

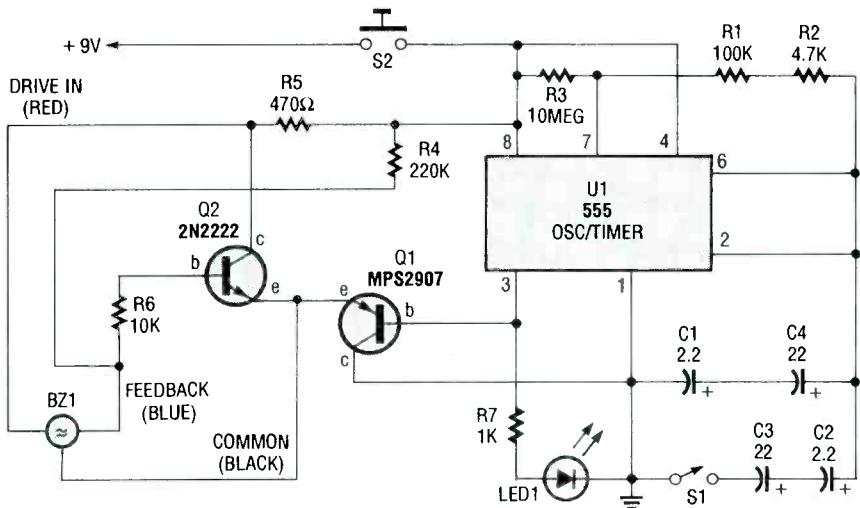


Fig. 1. The Electronic Darkroom Timer is built around a 555 oscillator/timer, a pair of general-purpose transistors, an LED, and a buzzer.

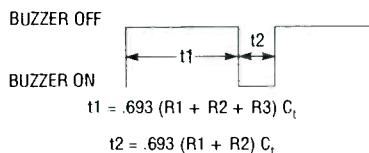


Fig. 2. Here is the output waveform of the 555 oscillator/timer (U1).

is specified as a 2N2222) can be replaced by a 2N3904; Q1 (an MPS2907 PNP unit) can be replaced by a 2N3906. In addition, the values of the timing capacitors (C1–C4) can be increased or decreased to alter the preset time intervals.

The author's prototype of the Electronic Darkroom Timer was built on a printed-circuit board measuring about 2-inches square. A template for the board is shown in Fig. 3. Once you've etched the board, check to make sure that there are no copper bridges where they should not be. If you find

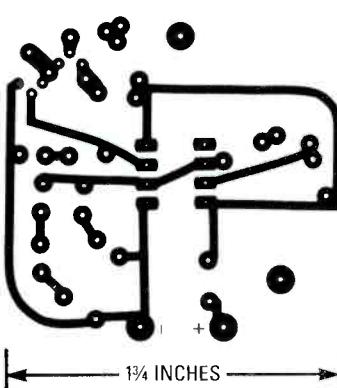


Fig. 3. The author assembled his prototype of the Electronic Darkroom Timer on a printed-circuit board, the template for which is shown here.

PARTS LIST FOR THE ELECTRONIC DARKROOM TIMER

SEMICONDUCTORS

U1—555 oscillator/timer, integrated circuit (Radio Shack 276-1723)

Q1—MPS2907 general-purpose PNP silicon transistor (or similar)

Q2—2N2222 general-purpose NPN silicon transistor (or similar)

LED1—Jumbo light-emitting diode

RESISTORS

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

R1—100,000-ohm

R2—4700-ohm

R3—10-megohm

R4—220,000-ohm

R5—470-ohm

R6—10,000-ohm

R7—1000-ohm

CAPACITORS

C1, C2—2.2- μ F, 16-WVDC, tantalum

C3, C4—22- μ F, 16-WVDC, tantalum

ADDITIONAL PARTS AND MATERIALS

BZ1—Miniature Piezo Buzzer (Radio Shack 273-064 or equivalent)

S1—SPST toggle switch

S2—SPST push-on/push-off pushbutton or toggle switch

Printed circuit or perfboard materials, enclosure, IC sockets, 9-volt DC, 300-mA plug-in adapter or 9-volt alkaline battery (optional, see text), wire, solder, hardware, etc.

any, they can be cut with an X-acto knife or a razor blade.

When you are satisfied that the board has been properly etched, install the components on the board using Fig. 4 as a guide. As always, start by installing an IC socket in the position provided for

(Continued on page 159)

Most electronic construction projects come to life as the result of a three-part plan: First the schematic and plans are obtained—either created by yourself or taken from a magazine or book; next the parts are gathered; and finally the project is constructed and tested.

Judging from the mail received here at *Popular Electronics*, step two, the gathering of the parts, is a real stumbling block for some. So that is what we are going to deal with here—the how, what, and where of collecting the parts for your projects.

A project always seems to start out better if you have some of the parts on hand. Your stock of parts will never be complete (not as long as they keep creating new devices), but it is very desirable to build up a selection of the generic "building-block" components: resistors, capacitors, inductors, etc. When that's been done, it is only necessary to get any specialized parts needed. A good stock of parts will also allow you to substitute and modify with ease during the testing stage, allowing you to get maximum performance from your circuit.

To start out, let's talk about a few generic items and the different types that are available. The information presented will help you to make intelligent decisions in purchasing the components and in choosing substitutions if a specified component can not be found.

Fixed Resistors. Resistors are found in just about every electronic circuit. They are used to impede current flow and to change voltage levels. When they do either, they dissipate some electrical energy as heat. The heat a resistor is capable of giving off is an important characteristic because overheating a resistor will eventually cause it

to change its resistance value. Heat dissipation is measured in watts. To give you a feeling for what a watt is, low wattage resistors—like a 1/4, or 1/2 watt—should run cool to the touch. However, that is a dangerous test to perform on high wattage resistors, so to find out how much power a resistor must dissipate, you can use this formula:

$$\text{Power (in watts)} = \frac{\text{Voltage}}{\text{Resistance}}$$

provided you know the resistance, R, in

ohms, and you measure the voltage across it, V, in volts:

Resistors made to dissipate large amounts of heat are called power resistors. The most common ones are constructed of wire wrapped on a ceramic form and then coated with a sealer. Because they are made with wire, most power resistors have some inductance and should not be used in circuits involving high frequencies.

For the most part, your projects will use the small 1/4- and 1/2-watt resistors. The three most popular types are carbon composition, carbon film, and metal film.

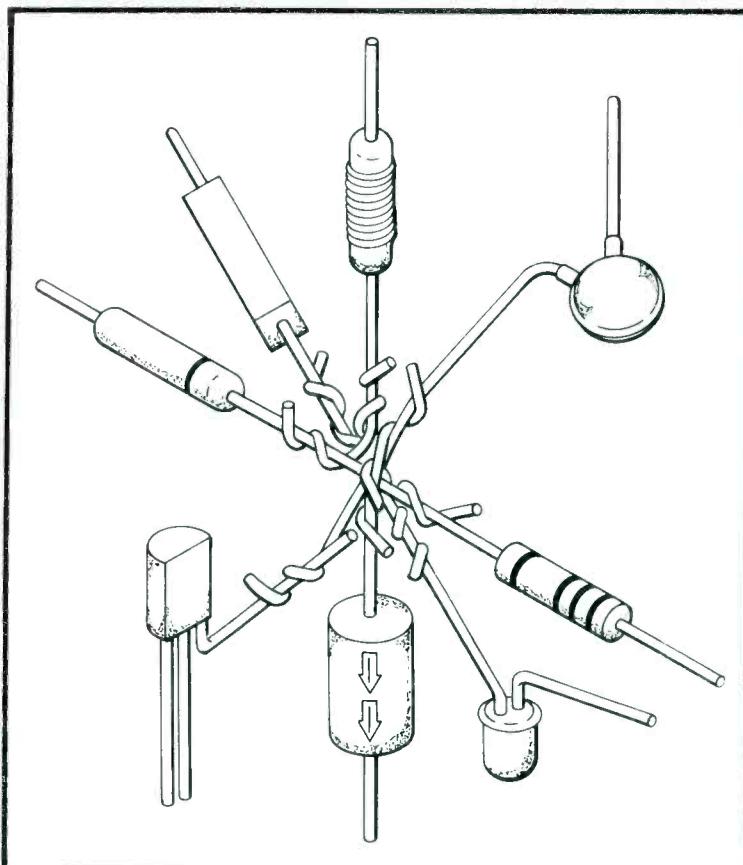
The carbon-composition type is an old workhorse made by mixing carbon with a binder, fusing them together, and encasing them. That type of construction is susceptible to moisture absorption, which can cause the resistance value to change as much as 20%. Also, carbon-composition resistors can add electrical noise to a circuit. So that type of resistor would not be a good choice when building a low-noise audio preamp. Carbon-composition resistors do, however, have excellent surge- and transient-handling capabilities. They most commonly have either 10% or 20% tolerance.

The newer resistor types are manufactured by depositing a film on a core of glass or aluminum oxide. The film can be carbon (to

create a carbon-film resistor) or metal (for a metal-film resistor). That construction technique produces more-stable resistors, and for that reason film resistors are the recommended type to use. Carbon-film resistors are gradually replacing carbon-composition resistors because they are generally less expensive to manufacture.

Carbon-film resistors are generally available with 5% tolerance, however, metal-film resistors are premium-grade

THE PARTS



CONNECTION

BY JACK CUNKELMAN

Make your next project your best project with helpful advice on parts selection and mail-order sources.

resistors with even greater tolerance. Metal-film resistors are very stable, work well in high-frequency applications, and are electrically very quiet. The tolerance in a metal-film resistor's value is typically 1%.

Figure 1 illustrates the bands used to identify the resistance values of low-wattage resistors. Both a normal (A) and a high-precision resistor (B) are shown. The numerical values corresponding to the various colors you can find on a resistor are given in Table 1.

The position of a band on a resistor determines what information it will tell you. For instance, the last band (the right-most band in the drawings) on a resistor indicates its tolerance. The first two bands on a normal resistor represent the first two digits in the resistor's value. For a precision resistor, the first three bands represent the first three digits. The band just to the left of the tolerance band for both types is the multiplier. It indicates the number of zeroes that follow the first digits.

Unlike low-wattage resistors, power resistors have their values printed on their body.

Variable resistors. Variable resistors or potentiometers provide a way of adjusting their resistance value—a moving contact brush that touches the resistive element. Moving the contact varies the resistance value.

The resistive elements are made of various materials—carbon, cermet, and conductive plastic being the most popular. They typically have power-dis-

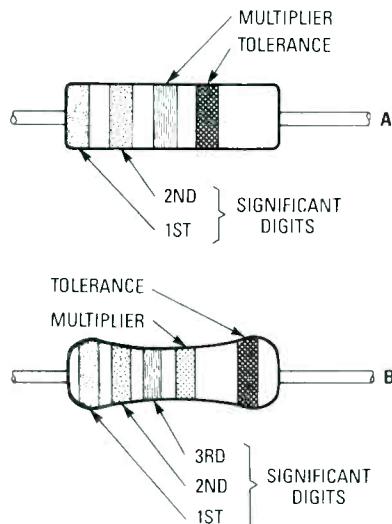


Fig. 1. Here we show the arrangement of bands on both a regular (A) and a high-precision (B) resistor body. Notice the precision resistor has more digits to specify its value more accurately.

TABLE 1—THE RESISTOR COLOR CODE

COLOR	SIGNIFICANT FIGURE VALUES	MULTIPLIER	TOLERANCE
BLACK	0	1	—
BROWN	1	10	1%
RED	2	100	2%
ORANGE	3	1000	3%
YELLOW	4	10000	4%
GREEN	5	100000	—
BLUE	6	1000000	—
VIOLET	7	—	—
GREY	8	—	—
WHITE	9	—	—
SILVER	—	0.01	10%
GOLD	—	0.1	5%

sipation ratings of one or two watts.

Units capable of controlling large amounts of power are usually called rheostats and use resistive wire as the resistive element.

Small trimmer potentiometers are available to provide adjustable resistance values for fine-tuning circuit operation. They have a rotational life of only a few thousand cycles since they are meant to be adjusted by the builder or servicer of a piece of equipment and not by the everyday user. They are available in single- and multiple-turn styles. Multiple-turn potentiometers obviously have more resolution than single-turn types.

Linear- and Audio-Taper Potentiometers.

The taper a potentiometer has depends on the relationship between potentiometer rotation and potentiometer resistance. Most potentiometers have what is called a linear taper. That means its resistance will change in proportion to how much you move its wiper. To determine the taper of a potentiometer, connect an ohmmeter between the wiper arm and one end of the potentiometer. Rotate the potentiometer to the middle of its rotation range. If the ohmmeter reads close to $\frac{1}{2}$ of the potentiometer's total resistance, you have a linear-taper potentiometer—50% rotation, 50% resistance.

If you are using the potentiometer to control audio levels, a linear taper is not ideal. The ear perceives loudness or gain in a nonlinear fashion, so using a linear potentiometer in such applications will result in a person only using a small portion of the potentiometer's rotation range. What is needed is a semi-log or audio-taper potentiometer. At 50% rotation, the resistance from one end of the potentiometer to the wiper is just 15% of its total resistance.

While an audio-taper potentiometer

is best for audio use, if you are stuck with a linear-taper potentiometer there is a simple fix. Connect the signal source to one side of the potentiometer, and a resistor that's $\frac{1}{10}$ of the potentiometer's value across the wiper and the remaining terminal. That will approximate an audio taper.

Capacitors. Because there are so many types of capacitors available, the process of selecting a capacitor is a little more complicated than selecting a resistor. There seems to be a natural dividing line between capacitor types at around $1 \mu F$. For example, capacitors above $1 \mu F$ are of the tantalum- and aluminum-electrolyte types, and capacitors below that value are made from mylar, ceramic, paper, and several plastic materials. Table 2 lists types of capacitors, their main characteristics, and the best use for each.

The first two types of capacitors in the table, aluminum electrolytic and tantalum, are "polarized." They must be placed in the circuit observing the polarity markings on the body of the capacitor, just as you would for a battery. The higher potential in the circuit must be connected to the positive terminal of the capacitor. To do otherwise will result in the failure of the capacitor. It is also not wise to use a polarized capacitor in a circuit that does not apply a polarizing voltage across the capacitor; they can not withstand any reverse current. And, finally, the voltage rating of the capacitor should be the sum of the DC polarizing voltage plus the peak value of the AC signal being coupled.

There are many capacitor-case styles. Figure 2 shows some of the more common ones for polarized capacitors. The capacitance value is usually written plainly on the case along with the polarity markings for the capacitor. Figure 3 shows some of the case

TABLE 2—CAPACITOR CHARACTERISTICS

TYPE	TYPICAL VALUE RANGE	TYPICAL TOLERANCE	APPLICATIONS & CHARACTERISTICS
Aluminum Electrolytic	0.68—200,000 μ F	−10%—+75%	Power-supply filtering, bypass, coupling. Used where large values are needed.
Tantalum Electrolytic	.001—1000 μ F	5—20%	Bypass, coupling, decoupling. Very stable, long life
Ceramic	1pF—2.2 μ F	5—30%	Transient decoupling, bypass. Value changes with frequency and temperature.
Mica	1pF—1 μ F	1—30%	Timing, Oscillator, and AF circuits. Very stable.
Polypropylene	1pF—10 μ F	2—10%	Blocking, bypass, coupling, and timing circuits. Filter, noise suppression. Good for audio through UHF
Polyester (Mylar)	.001—10 μ F	5—20%	Blocking, filtering, transient suppression. Good for audio. Small size with medium stability.
Paper	.001—10 μ F	10—20%	General purpose. Large size, low cost, medium stability, and poor moisture characteristics.
Polystyrene	51pF—0.15 μ F	1—5%	Timing and tuned circuits. Small capacitance change with temperature. Excellent stability. Good in audio circuits.

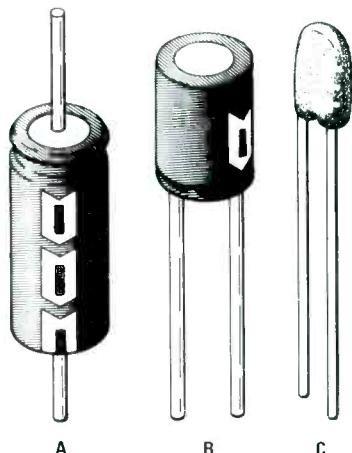


Fig. 2. Polarized capacitors have their polarity clearly marked. Shown are the axial-lead (A), radial-lead, and tantalum (C) types.

styles for non-polarized capacitors (usually below 1 μ F). Their value is either written plainly on their body or given using a three-digit code. The first and second digits are significant numbers and the third digit is a multiplier. The value you get by deciphering the number is in picofarads (denoted pF). There are some capacitors whose values are color-coded on their bodies just like resistors. In fact, you can use the same color code as used for resistors to determine their value.

Trimmer and variable capacitors are also available, at values in the pF

range. They come in single- and multiple-turn types, just like trimmer potentiometers. The dielectric material used in a trimmer capacitor determines how well it works at high frequencies. Most commonly available trimmers will all work well at frequencies below 30 MHz.

Inductors. When an inductor is used in a circuit, the goal is to make the circuit more or less sensitive to a particular frequency or group of frequencies. A circuit will have either a choke or a coil to achieve the desired effect.

The terms inductor, choke, and coil seem to be used interchangeably at times and to some degree their uses do overlap. Typically though, a coil is used to resonate or peak at a certain frequency, while a choke is used to affect a group of frequencies. Specifications for inductors shown in catalogs lists the

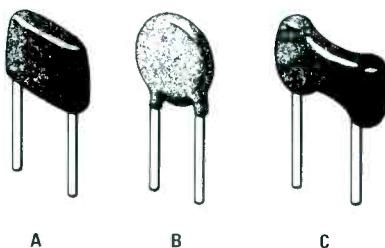


Fig. 3. Non-polarized capacitors come in many different types. Shown are the more popular ones: an epoxy-dipped (A), a disc (B), and a metal-film (C) capacitor.

"Q," "test frequency," and "current" for a particular coil. The Q is called the factor of merit of a coil, and is an indication of how sharp the response of the coil is when resonating at the listed test frequency. Since all inductors are wound with wire, the current rating is the amount of current the wire can safely carry.

The type of core in the coil has a great effect on the frequency response of the coil. Iron cores are used at low frequencies (up to 100 kHz). Coils used with frequencies up to 30 MHz are usually space-wound (air core) or wound on cores made of ferrite. Coils used above 30 MHz are usually wound on nonferrous materials such as brass or copper.

An adjustable coil is wound on a ceramic form, which makes it act like an air-wound coil. A threaded slug or core, made from iron, ferrite, or brass (depending on the frequency range of the unit) is screwed into the coil form to adjust its inductance.

A small, hollow section, of ferrite material can be slipped over a single wire to form a very effective radio-frequency choke. That is useful on microphone preamps used near strong radio-frequency fields to keep high-frequency currents from flowing in the wire between the microphone and the preamp input.

Coil characteristics are so precarious, it is probably wise to use the exact coil specified in a particular project. If the coil is to be handmade, follow the article's instructions on how to wind the coil, being careful to use the same core materials and form factor—the ratio of the diameter to length for the coil—specified. The form factor greatly affects a coil's other specifications.

An inductor is a relatively complex device because it has a great many independently variable characteristics. To complicate matters further, value markings on inductors are almost nonexistent. However, some newer construction techniques that coat the inductor with epoxy or plastic do permit the placement of marking bands to indicate the inductor's value. The color bands can be deciphered using the same color-code system as resistors. The value obtained will be in henries.

Semiconductor Substitutions.

Before we discuss the major semiconductor components, give heed to these words on semiconductor substitution: Unlike the components discussed

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Minimum order: none, \$0.95 handling on orders under \$30
Shipping methods: UPS, us mail
Shipping charges: \$2.50
Notes: New and surplus parts; Quantities usually limited; They've got a little of everything
CIRCLE 24 ON FREE INFORMATION CARD

Circuit Specialists

PO Box 3047
Scottsdale, AZ 85257
Catalog: 85 pages, free
Telephone orders: 800/528-1417
Inquiries/help: 602/966-0764
Hours: 9:00 am to 5:00 pm MST, Mon.-Fri.
Payment: check, M.O., Master Card, Visa, C.O.D.
Minimum order: \$15 for charged orders only
Shipping method: 1st-class mail, Parcel Post, UPS
Shipping charges: \$2.00, more for heavy items
Foreign orders: yes
Notes: Stocks most of the popular parts of interest to the hobbyist and serious tinkerer
CIRCLE 25 ON FREE INFORMATION CARD

Cornell Electronics Co.

4217 University Ave.
San Diego, CA 92105
Catalog: 12 pages, free
Telephone orders: 619/281-9792
Inquiries/help: 619/281-9792
Payment: check, M.O., Master Card, Visa, C.O.D.
Minimum order: none
Shipping charges: orders under \$100: \$2.50 plus 10% of the order; orders over \$100: \$2.50 plus \$7.50
Foreign orders: yes; Canada and Mexico
Notes: Sells TV and radio tubes
CIRCLE 26 ON FREE INFORMATION CARD

Digi-Key

PO Box 677

tion is risky with such devices and should be done with a great deal of thought and care.

If you really can't find a specified

Thief River Falls, MN 56701

Catalog: 115 pages, free
Telephone orders: 800/344-4539
Inquiries/help: 218/681-6674
Hours: 8:30 am to 5:00 pm CST
Payment: check, M.O., Master Card, Visa, C.O.D.
Minimum order: none, service charge on orders below \$25
Shipping methods: UPS, Parcel Post, air freight
Shipping charges: none on prepaid orders
Foreign orders: yes; Mexico and Canada
Notes: A good source of capacitors, resistors, IC's, and transistors
CIRCLE 27 ON FREE INFORMATION CARD

Eddie Electronics

2700 Hempstead Turnpike
Levittown, NY 11756
Catalog: 147 pages, free
Telephone orders: 800/645-4722
Inquiries/help: 516/735-3330
Hours: 9:00 am to 5:30 pm EST, Mon.-Sat.
Payment: check, M.O., Master Card, Visa
Minimum order: charge: \$50; other: \$25
Shipping methods: UPS, Parcel Post
Shipping charges: from chart: \$4.50 (for up to \$100) to \$15 (for up to \$1000)
Foreign orders: some, must inquire
Notes: Sells components, test equipment, video items, and surplus parts
CIRCLE 28 ON FREE INFORMATION CARD

Edmund Scientific Co.

101 East Gloucester Pike
Barrington, NJ 08007
Catalog: 151 pages, free
Telephone orders: 609/573-6250 or 609/547-3488
Inquiries/help: 609/573-6260 (orders); 609/573-6253 (technical)
Hours: 9:00 am to 5:00 pm EST, Mon.-Fri.
Payment: check, M.O., Master Card, Visa, Diners Club, American Express, Carte Blanche
Minimum order: none
Shipping methods: UPS, Parcel Post
Shipping charges: from chart, \$3.95 to \$18.95
Notes: Has optics, lasers, astronomy, microscopes, lab equipment, general state-of-the-art scientific stuff
CIRCLE 29 ON FREE INFORMATION CARD

Fordham

260 Motor Parkway
Hauppauge, NY 11788
Catalog: 163 pages, free
Telephone orders: 800/645-9518, NY 800/832-1446
Inquiries/help: 800/344-6325
Hours: 8:00 am to 6:00 pm EST, Mon.-Fri.; 9:00 am to 3:00 pm Sat.
Payment: check, M.O., Master Card, Visa, American Express, C.O.D.
Minimum order: \$25
Shipping method: UPS, Parcel Post
Shipping charges: flat rate based on total

part, the best place to get substitution information is out of the SK- and the ECG-series replacement guides. For more information about the SK-series

ELECTRONICS PARTS DISTRIBUTORS

order, plus \$1 insurance fee

Notes: Sells test equipment, components, and TV and video items.

CIRCLE 30 ON FREE INFORMATION CARD

Halted Specialties

3500 Ryder Street

Santa Clara, CA 95051

Catalog: 40 pages, \$1.00 (free with order or in stores) Telephone orders: 800/442-5833; CA 408/732-1573, BBS 408/732-2814

Inquiries/help: 800/442-5833; CA 408/732-1573, BBS 408/732-2814

Hours: 8 am to 7 pm PST Mon.-Fri., 9 am to 5 pm PST Sat.

Payment: Check, postal money order, Visa, Master Card, American Express, C.O.D.

Minimum order: \$10, orders under \$20 subject to \$2 fee

Shipping method: UPS unless otherwise requested

Shipping charges: Exact UPS charges; items shipped by other methods are charged the carrier's prevailing rate plus a \$5 surcharge.

Notes: Retail stores in Santa Clara, Santa Rosa (6819 Redwood Dr., Cotati, CA 94931), and Sacramento (5549 Hemlock St., Sacramento, CA 95841); SELs components, surplus gear, computer items, lasers, optoelectronics, test equipment, and more

CIRCLE 31 ON FREE INFORMATION CARD

Hosfelt Electronics Inc.

2700 Sunset Blvd

Stubenville, OH 43952

Catalog: 64 pages, free

Telephone orders: 800/524-6464, OH 614/264-6464

Inquiries/help: 614/264-6464

Hours: 9:00 am to 5:00 pm EST, Mon.-Fri.

Payment: check, M.O., Master Card, Visa, American Express, C.O.D.

Minimum order: none

Shipping methods: UPS

Shipping charges: orders from \$1 to \$100: \$3.50; \$101 to \$250: \$4.50; \$250 and up for free

Foreign orders: no

Notes: Sells surplus and new components

CIRCLE 32 ON FREE INFORMATION CARD

Jameco Electronics

1355 Shoreway Road

Belmont, CA 94002

Catalog: 74 pages, free

Telephone orders: 415/592-8097

Inquiries/help: 415/592-8121

Hours: 7:00 am to 5:00 pm PST, Mon.-Fri.

Payment: check, M.O., Master Card, Visa, C.O.D.

Minimum order: \$20

Shipping methods: UPS, 1st-class mail

Shipping charges: by UPS: 5% of total order, \$2 minimum (\$1.50 extra for insurance)

Foreign orders: yes

Notes: Stocks new components, IC's, tools, computer equipment, and some surplus

parts

CIRCLE 33 ON FREE INFORMATION CARD

JDR Microdevices

110 Knowles Dr.

Los Gatos, CA 95030

Catalog: 31 pages, free

Telephone orders: 800/538-5000

Inquiries/help: 800/538-5000

Hours: 7:00 am to 5:00 pm PST, Mon.-Fri.; 10:00 am to 3:00 pm Sat.

Payment: check, M.O., Master Card, Visa, C.O.D.

Minimum order: \$10

Shipping methods: UPS

Shipping charges: \$2.50 for the first lb., and additional over that

Foreign orders: yes

Notes: Stocks new IC's, components, computer boards and computer equipment

CIRCLE 34 ON FREE INFORMATION CARD

MCM Electronics

858 East Congress Park Dr.

Centerville, OH 45459

Catalog: 155 pages, free

Telephone orders: 800/543-4330, OH 800/762-4315

Inquiries/help: 800/543-4330, OH 800/762-4315

Hours: 7:00 am to 8:00 pm EST, Mon.-Fri.; 9:00 am to 5:00 pm Sat.

Payment: M.O., Master Card, Visa, C.O.D.

Minimum order: \$1 service charge for orders under \$10, \$25 minimum for charge, \$15 minimum C.O.D.

Shipping methods: UPS

Shipping charges: see UPS rate table

Foreign orders: yes; 800/824-9491

Notes: Japanese transistors, IC's, components, VCR and TV parts, speakers, and computer parts

CIRCLE 35 ON FREE INFORMATION CARD

Mouser Electronics

2401 Hwy. 287 North

Mansfield, TX 76063

Catalog: 183 pages, free; call 800/992-9943

Telephone orders: 800/346-6873

Inquiries/help: 817/483-4422

Hours: 7:00 am to 5:30 pm CST

Payment: check, M.O., Master Card, Visa, American express, Diners Club, Discover, Carte Blanche, C.O.D.

Minimum order: none, \$5 service charge for orders under \$20

Shipping methods: UPS, Parcel Post

Shipping charges: 10% of order for check or M.O.

Foreign orders: yes

Notes: Stocks most components needed by a hobbyist

CIRCLE 36 ON FREE INFORMATION CARD

Newark Electronics

4801 North Ravenswood Ave.

Chicago, IL 60640

Catalog: free

Telephone orders: 312/784-5100

Payment: Master Card, Visa, C.O.D.

Minimum order: \$25

Shipping methods: UPS, US postal express mail, air freight, truck

Shipping charges: actual amount added to charge card

Foreign orders: yes

Notes: Numerous regional offices, order from local office if possible (addresses and phone numbers in catalog); full-line industrial distributor

CIRCLE 37 ON FREE INFORMATION CARD

Parts Express International, Inc.

340 East First St.

Dayton, OH 45402

Catalog: 83 pages, free

Telephone orders: 800/338-0531

Inquiries/help: 800/338-0531

Hours: 8:30 am to 6:00 pm, Mon.-Fri.

Payment: check, M.O., Master Card, Visa, Discover, C.O.D.

Minimum order: none, \$1 service charge orders less than \$10

Shipping methods: UPS

Shipping charges: \$2 flat rate up to 5 lbs on prepaid orders, actual cost on credit card orders

Notes: Japanese parts, semiconductors, TV, VCR parts

CIRCLE 38 ON FREE INFORMATION CARD

Sintec Company

28 8th St.

PO Box 410

Frenchtown, NJ 08825

Catalog: 67 pages, \$2.00

Telephone orders: 800/526-5960, NJ 201/996-4093

Inquiries/help: 201/996-4093

Hours: 8:15 am to 5:00 pm EST, Mon.-Fri.

Payment: check, M.O., Master Card, Visa, C.O.D.

Minimum order: \$10

Shipping methods: first-class mail, UPS

Shipping charges: up to \$100, costs \$3; \$100 to \$250, costs \$4; above \$250, costs \$5

Foreign orders: yes

Notes: New electronic components

CIRCLE 39 ON FREE INFORMATION CARD

Solid State Sales

P.O. Box 74D

Somerville, MA 02143

Catalog: 17 pages, \$0.25

Telephone orders: 800/343-5230

Inquiries/help: 617-547-7053

Hours: 8:00 am to 4:45 pm EST Mon.-Fri., 10:00 am to 2:30 pm EST Sat.

Payment: check, money order, Master Card, Visa, C.O.D.

Minimum order: C.O.D. or charge \$20, check or money order \$5

Shipping method: UPS or parcel post

Shipping charges: 10% for orders under \$25, 5% for orders between \$25 and \$50, 3% for orders over \$50.

Notes: Sells new components

CIRCLE 40 ON FREE INFORMATION CARD

replacement guide write to:

Sales Promotion Services

Thompson Consumer Electronics

Distribution and Special Products

2000 Clements Bridge Road

Depford, NJ 08096-2088

or for information on the Phillips ECG

guide write to:

Phillips ECG, Inc.

Distributor & Special Markets Div.

1025 Westminster Dr.

Williamsport, PA 17701

Tel. 800/225-8326.

Parts are not available from the given addresses, must be purchased through their distributors. When purchasing a replacement guide ask for a list of distributors.

A replacement guide listing Radio Shack parts is also available at Radio Shack Stores. Your local Radio Shack store will also order SK-series parts for you and have them shipped to the store.

Another tool that'll help you understand device specifications and packaging is a data book. Start collecting data books from various manufacturers for your reference library. Note that some of the parts suppliers mentioned later have data books available for sale.

Diodes. The two categories of diodes—germanium and silicon—are probably the least difficult to substitute for. However, the two types can not be interchanged because the junctions of each behave differently. Other considerations of substitution are the voltage and current rating of the diode. Use a diode with a rating at or above what the designer of the circuit specifies. If the diode in question is used in a switching power supply or in a high-frequency switching or detection application, it is probably wise to use the exact diode specified, again because of how diode junctions behave. My stock includes a pile of 1- and 3-amp 400-volt diodes and I find that they supply most of my needs for general-purpose diodes.

Transistors and Integrated Circuits.

Transistors are the next easiest part to substitute for. A friend of mine has used this simple rule: There are only two kinds of transistors: NPN and PNP; and he has applied it with much success. In reality, however, most projects work the best with the transistors specified.

A generic replacement for almost any transistor made, can be chosen from the replacement guides mentioned earlier. However, the cost of a substitute is usually higher.

Finally, when dealing with integrated circuits, substitutions are best left to the experts. The specified IC is probably the only one that will work either because of physical pin-out specifications or electrical specifications. There are generic substitutions available from the same companies mentioned above, but the selection of substitutes is more limited than for transistors and diodes.

TABLE 3—PACKAGING CODES

PACKAGE	MOTOROLA	NATIONAL	RCA/GE	SIGNETICS	TEXAS INSTRUMENTS
8-pin dip plastic	P	N-8	E	N	P
14 pins or more, plastic	P	N	E	N	N
Dip ceramic	L	D or J	D	F or I	J
TO5-TO101 Metal can	G	H	S or T	H	L
TO220 Tab	T	T	—	U	KC
TO3 Steel	—	K	—	—	—
TO3 Aluminum	K	KC	—	—	K

However, there is some hope because of "second sourcing," as the industry calls it. Second sourcing means a given IC is made by more than one company. That came about because the number of manufacturers of equipment using the more popular IC's created a sufficient market demand to support many chip manufacturers.

Identifying substitutions for parts is a problem because each manufacturer calls a given chip something different, but it is possible to figure out the chip part number. A typical IC part number can be broken down as follows:

XX-YYYY-Z

Where XX is the device family, YYYY is the device number, and Z is the package type.

Take the ever-popular 741 op-amp for instance. The device number, 741, appears in the part number of each supplier, but each puts their own prefix and suffix in the number to describe the part. For example:

National—LM741N
Silicon General—SG741M
Raytheon—RC741NB
Signetics—μA741N
Motorola—MC1741CP1

Table 3 is a cross reference of package suffixes for some of the more popular manufacturers. The plastic DIP (dual in-line package) enclosure is by far the most popular and least expensive type available to the experimenter. The same device in a ceramic package, for instance, will usually cost more because it has a wider operating-temperature range—the range is usually 0 to 70°C for plastic-packaged devices.

Where Are the Parts? One could not start to discuss the acquisition of parts without mentioning Radio Shack first.

They, through their mass-merchandising abilities, have made it easy and convenient to purchase a large number of the parts needed for projects. In fact, many parts lists in magazine projects specify many Radio Shack parts, so use them for convenience. I have never been disappointed by their quality, but remember you are paying a bit extra for the convenience of it all.

The local telephone book may provide you with the names of other local parts distributors. In my yellow pages they are listed under "Electronic Parts and Supplies." The larger distributors are usually located only in larger metropolitan areas.

By far the most convenient way to do your shopping is by mail. It is, in my estimation, the best way to get the latest technology for the best prices (for that matter, the best prices on the everyday stuff also).

However, there seems to be some natural divisions in the kinds of parts distributors, each having their own advantages and disadvantages. First there are the full-line parts distributors; They may be your only choice if your project requires a newly introduced IC. If they carry a manufacturer's line, chances are they can get you any IC from that manufacturer. Just remember they are accustomed to dealing with industrial accounts, so they may not get excited over your order, but be persistent.

Also, as with most distributors, be aware of any minimum-order amount. It is not negotiable, so you'll have to abide by their rules. Add some other needed items to an order to help you get up to the minimum. I keep a running "want list" on a clipboard for that very reason and use the listed items to "fill-in" any order that does not meet the *(Continued on page 158)*

HOLIDAY LIGHT SEQUENCER

Illuminate your Yuletide celebration with this light-controller circuit

BY DANIEL P. RAY

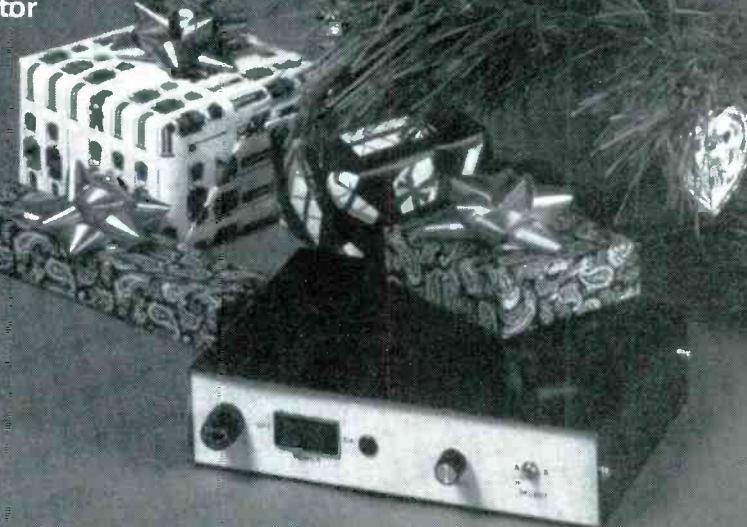
If you are looking for that special decoration to adorn your humble home this holiday season, then look no farther! With this easy-to-build project—the *Holiday Light Sequencer*—you can transform your standard Christmas lights into an exciting display that will rival even the most expensive commercial systems!

The Holiday Light Sequencer is so-named because it interfaces a digital sequencing circuit with four 117-volt AC (household-current) sockets. The Sequencer consists of a variable-frequency pulse generator and four D-type flip-flops. The circuit produces several different selectable sequences that are fed to the four AC sockets via optoisolator/couplers (with triac-driver outputs) and power triacs.

To see how the circuit operates, refer to the schematic diagram of the Holiday Light Sequencer circuit shown in Fig. 1. Integrated circuit U1 (a 555 oscillator/timer) is wired as a conventional pulse generator. The frequency of the pulse generator is controlled by potentiometer R11. Resistor R2 puts a reasonable limit on the highest speed attainable.

The output of the pulse generator is fed to the common clock input of U2, a 74C175 quad D-type flip-flop. Each flip-flop is configured so that its Q output is coupled to the D input of the subsequent flip-flop (as shown in Fig. 2).

(Continued on next page)



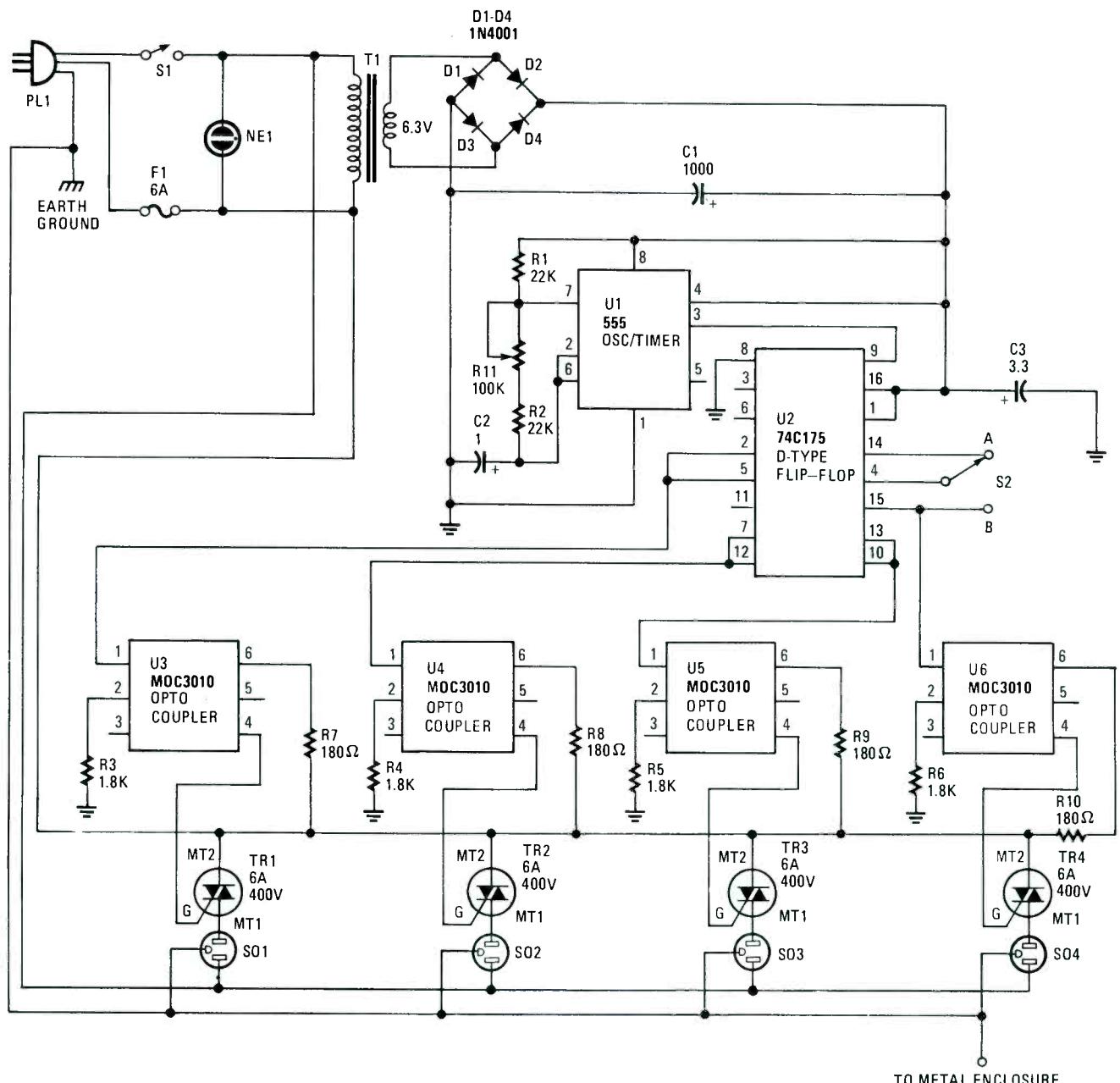


Fig. 1—The Holiday Light Sequencer circuit consists of a 555 oscillator/timer (configured as a pulse generator), feeding a 74C175 quad D-type flip-flop. The four flip-flops, in turn, drive four MOC3010 optoisolator/couplers, which are used to trigger four triacs to provide power to the four strings of lamps.

Information on the D input of each flip-flop is transferred to the Q (and \bar{Q}) outputs on the leading edge of each clock pulse. Switch S_2 allows you to invert the information on the D input of the first flip-flop at any time during the cycle. That allows you to create a number of different sequences, which are determined by the state of the Q output at the time of the switching.

Some of the possible sequences are:

- 1 through 4 on, 1 through 4 off;
- 1 of 4 on sequence;
- 1 of 4 off sequence;
- 2 of 4 on sequence;
- 1 and 3 on to 2 and 4 off;

and others where the sequence of events is difficult to determine.

However, if S_2 is switched to position B while all outputs are high or all are low, which seldom occurs, the sequence stops and the outputs remain either all on or all off. If that happens, you only need to switch back to position A for at least one pulse duration, and then back to position B again.

Likewise, S_2 should be in position A (pin 4 connected to pin 14) each time the power is turned on. That's because the data on pin 4 must be a logic 1 in order to start a sequence; otherwise all outputs remain at logic 0 regardless of the clock pulses.

Interface. Each output of the sequencing circuit is connected to an MOC3010 optoisolator/coupler (U3–U6), which contains an infrared-emitting diode with an infrared-sensitive diac (triac driver or trigger) in close proximity. (See Fig 3.) The diac is used as a trigger for the triac, which carries the 117-volts AC.

Each time the infrared-emitting diode receives a logic 1, it turns on, causing the diac to conduct. With the optoisolator/coupler's internal diac conducting, the triac turns on, and power is supplied to whatever load is plugged into the corresponding AC socket. So the sequencing circuit and

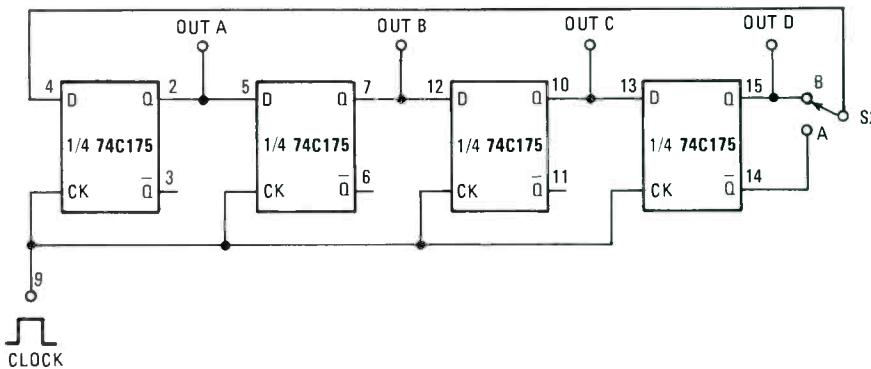


Fig. 2—Shown here is a functional diagram illustrating the actual configuration of the four flip-flops in the Holiday Light Sequencer circuit.

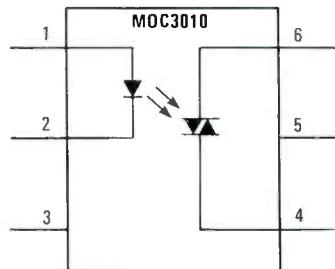


Fig. 3—This block diagram shows the inner workings of the MOC3010 optoisolator/coupler. Its output element is a diac or triac driver.

the 117-volt AC outputs are "optically coupled" and are effectively isolated from each other.

Power for the sequencing circuit is provided by a 6.3-volt miniature transformer. The output of the transformer is rectified by a four-diode bridge circuit, the output of which is filtered by C1 (a 1000- μ F electrolytic capacitor). Capacitor C3 is added at the supply pin of U2 to suppress transients.

Construction. First of all, you absolutely must break off the links between the terminals on the duplex sockets (S01-S04), so that each socket can be controlled individually. That is very important! Do it before anything else so you can't forget later. Next, mark the locations of all the components that are to be mounted to the front and rear panels of the enclosure.

Drill and cut holes in the metal enclosure for the panel-mounted components. The holes for the sockets are a little hard to make. However, you can use a wall plate (socket cover) as a template to mark the holes, and then drill with the largest size bit available (without going oversize). The socket holes can then be shaped and/or enlarged as needed with a small file or grinding wheel.

The author's prototype was built on printed-circuit board, the foil pattern for which is shown in Fig. 4. Once the board is etched and drilled, begin installing the board-mounted compo-

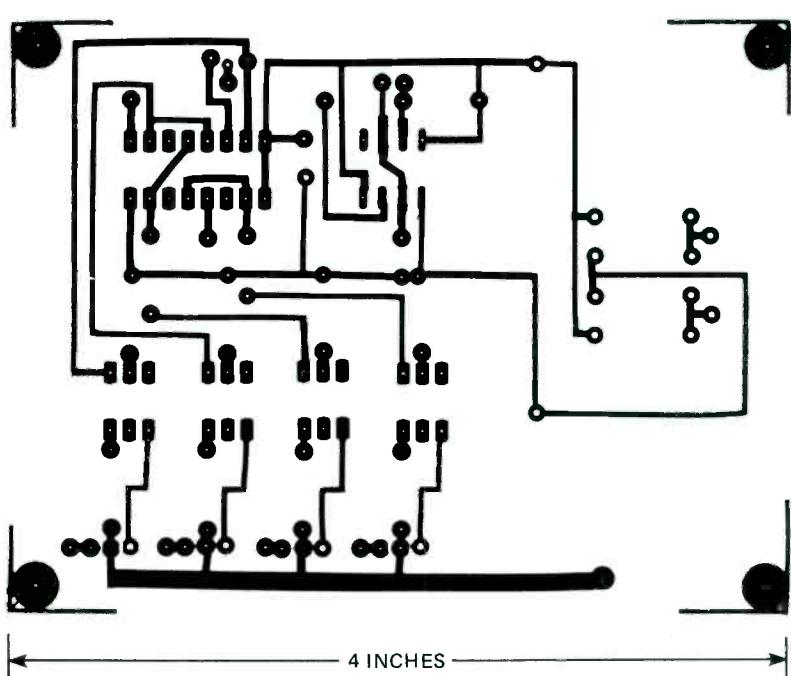


Fig. 4—Shown here is a full-size foil pattern for the Holiday Light Sequencer's printed-circuit board.

nents, using Fig. 5 as a guide. Note from the diagram that R2 is not mounted on the PC board, but is soldered directly to potentiometer R11. Use #18 insulated wire (or heavier) for all 117-volt AC connections. Use a copper or aluminum heat sink for the four triacs if you plan on using high-wattage lamps. Mount the circuit board on insulating spacers, making sure that none of the connections on the foil side touch the metal case. Make sure that the AC ground is connected to the appropriate terminal on all the sockets and to the metal enclosure. Secure the power cord with a suitable connector or strain relief.

The Lights. 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.

The plugs should be marked with the letters A, B, C, and D so that they can be plugged into the corresponding sockets on the Holiday Light Sequencer. If your lights are the "flashing" type, locate the flasher bulb and replace it with an ordinary one.

Warning. Always keep in mind that household current (117-volts AC) can be lethal! Never turn on the power un-

less the circuit is completely enclosed. Never try to make repairs or modifications to the circuit without first unplugging the unit. The AC fuse must not be omitted from the circuit. The fuse assures that the project won't be damaged in the event of a wiring error.

The Holiday Light Sequencer is intended for indoor use only. Do not use it outdoors, unless you can completely shield it from all forms of precipitation.

Troubleshooting. After checking your wiring several times, put the cover on, plug in the Holiday Light Sequencer, and plug the four sets of lights into the corresponding sockets. (You should check all the lights beforehand by plugging them into a household wall socket).

With R11 set at mid-position and S2 to position A, flip on the power switch, S1. If nothing happens after several seconds, you should set S2 to the other position. If the lights now start to se-

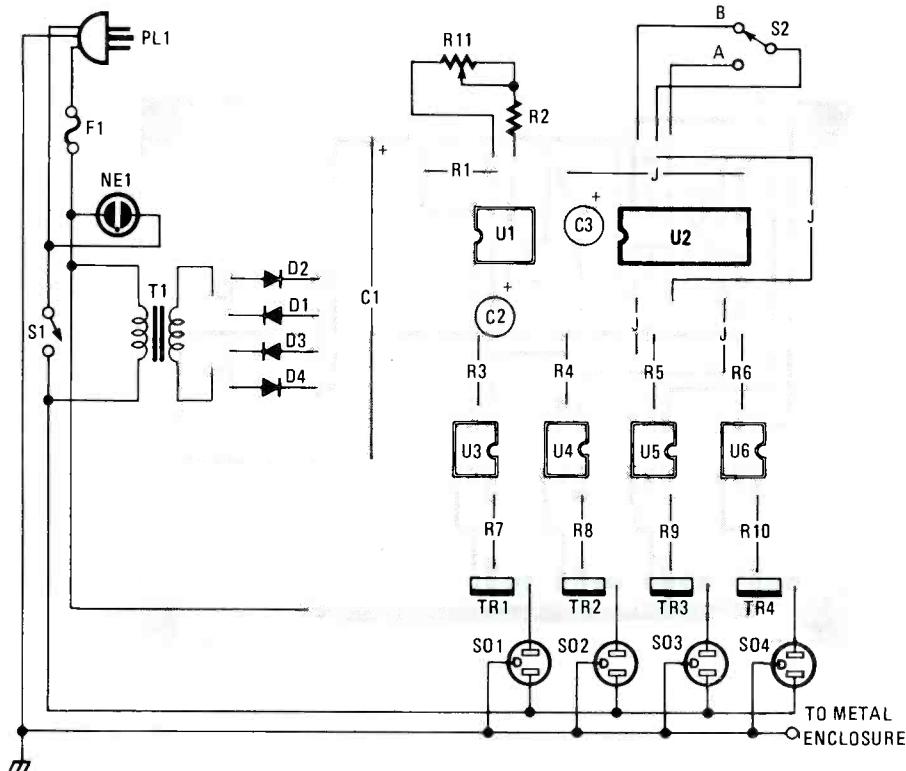
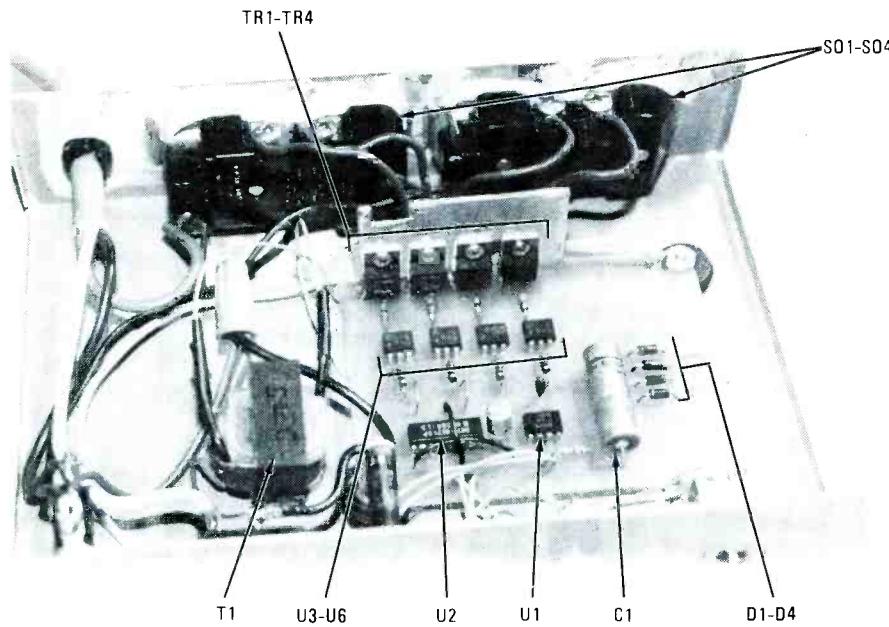


Fig. 5—Shown here is the parts-placement diagram for the Holiday Light Sequencer. When installing the parts, pay strict attention to the orientation of the components. Also it is a good idea to use sockets for the six ICs.



Here is the finished project prior to being sealed into its enclosure. Note that S01-S04 consist of two duplex sockets, which come with a shorting bar between the two individual sockets. It is necessary to sever the shorting bar between the sockets to allow the strings of lamps to be controlled individually.

quence, then either the wires to S2 should be reversed (with the unit unplugged of course), or that setting can be marked as position A.

If nothing happens with S2 in either position, check the fuse. If it is blown, then unplug the unit and look for a short in the 117-volt AC wiring. Solder

bridges are another possible problem. For instance, solder bridges on the triacs may cause the corresponding socket(s) to stay on constantly.

Improper orientation of the IC(s), missing jumper wires, or poor solder connections can also cause problems. But, if the schematic diagram of

PARTS LIST FOR THE HOLIDAY LIGHT SEQUENCER

SEMICONDUCTORS

U1—555 oscillator/timer, integrated circuit
U2—74C175 or 40175B quad D-type flip-flop, integrated circuit

U3-U6—MOC3010 optoisolator/coupler (Radio Shack 276-134 or similar), integrated circuit
TR1-TR4—6-amp, 400-volt triac (Radio Shack 276-1000 or similar)

D1-D4—IN4001 (or similar) 1-amp, 50-PIV, silicon rectifier diode

RESISTORS

(All resistors are $\frac{1}{4}$ -watt, 5% units, unless otherwise noted.)

R1, R2—22,000-ohm

R3—R6—1800-ohm

R7—R10—180-ohm

R11—100,000-ohm potentiometer

CAPACITORS

C1—1000- μ F, 16-WVDC (or better) electrolytic

C2—1- μ F, 16-WVDC (or better), Tantalum or radial-lead electrolytic
C3—3.3- μ F, 16-WVDC (or better), Tantalum or radial-lead electrolytic

ADDITIONAL PARTS AND MATERIALS

T1—117-volt primary, 6.3-volt secondary, miniature power transformer

F1—6-amp fuse 3AG

S1—Single-pole, single-throw, rocker switch

S2—Single-pole, double-throw, miniature toggle or slide switch

NE1—117-volt snap-in neon lamp

PL1—117-volt AC molded 3-conductor plug with power cord

S01-S04—117-volt AC sockets

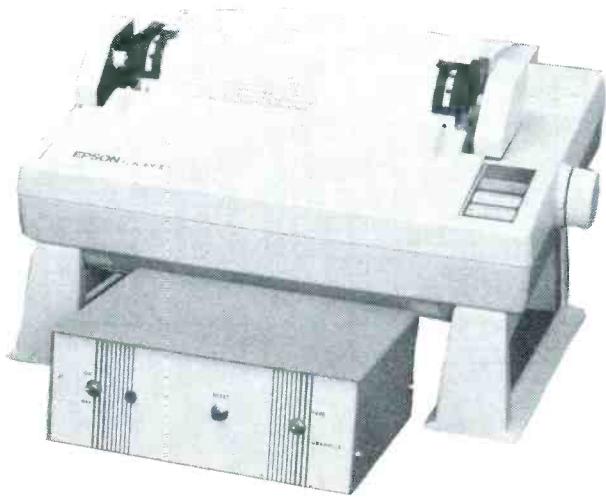
Printed circuit or perfboard materials, metal enclosure (Radio Shack 270-272 or similar), IC sockets, fuse holder, hookup wire, solder, hardware, etc.

the circuit is followed very closely, there should be no problem in getting the Holiday Light Sequencer to work.

Operation. While the sequencer is working properly with S2 in position A, try switching to position B at various times during the cycle to create an amazing variety of sequences. Several other sequences are obtainable by plugging set B into the C socket and vice versa. Adjust potentiometer R11 for the desired rate and just sit back and enjoy the show!

And when the Yuletide season is over, don't pack the Holiday Light Sequencer away with the rest of the decorations. Try plugging in a 150-watt floodlamp (to any socket) for wild strobe-type lighting effects! Or maybe you can do something with your patio lanterns.

BUILD YOUR OWN



PRINTER SPOOLER/BUFFER

Free up your computer and avoid switching cables between machines with this combination print buffer and automatic T-switch

BY JOHN EMERSON

I got my start in computing several years ago, with a home-brew 8085-based computer running the CP/M operating system. When fairly sophisticated CAD packages started showing up for MS-DOS, I purchased an XT clone. However, with a large investment in CP/M software, I wasn't ready to relegate my old 8085 system to the dust heap. And therein began my dilemma—two computers and only one printer.

It seemed that no matter which computer I was using, the printer was hooked up to the other. And although my printer is extremely fast, outputting 400 lines per minute, waiting for the printout of a long listing was tiresome. I had spooler programs, but they use memory, disk space, and bus cycles. The spooler programs also assumed a much slower printer, which caused the print speed to be cut to less than 100 lines per minute. The *Print Buffer/Spooler*(PSB) described in this article—which combines the functions of an automatic T-switch and a 64K spooler—solved both my problems.

System Overview. The PSB circuit (see Fig. 1) has a relatively low parts count, and handshakes with Centronics-compatible parallel printers and ports. It is built around an 8031 microcontroller, which is supported by readily available parts. The PSB has two major modes of operation: graphics and text. In the graphics mode, what goes in, comes out. A form-feed character is inserted after each computer releases the buffer. Characters cannot be swapped, inserted, or deleted because most control codes are also valid pin-patterns for dot-matrix printers in the graphics mode.

The main difference between the graphics and text modes lies in the way that form feeds are handled. The text mode eats them. That is, the input routine inserts a form-feed between computers (as in the graphics mode), but the output routine keeps track of the last character printed. If the last character printed was a form-feed, the PSB deletes any additional, consecutive form-feeds. In other words, there's always one form-feed between

computers, but there's never more than one form feed.

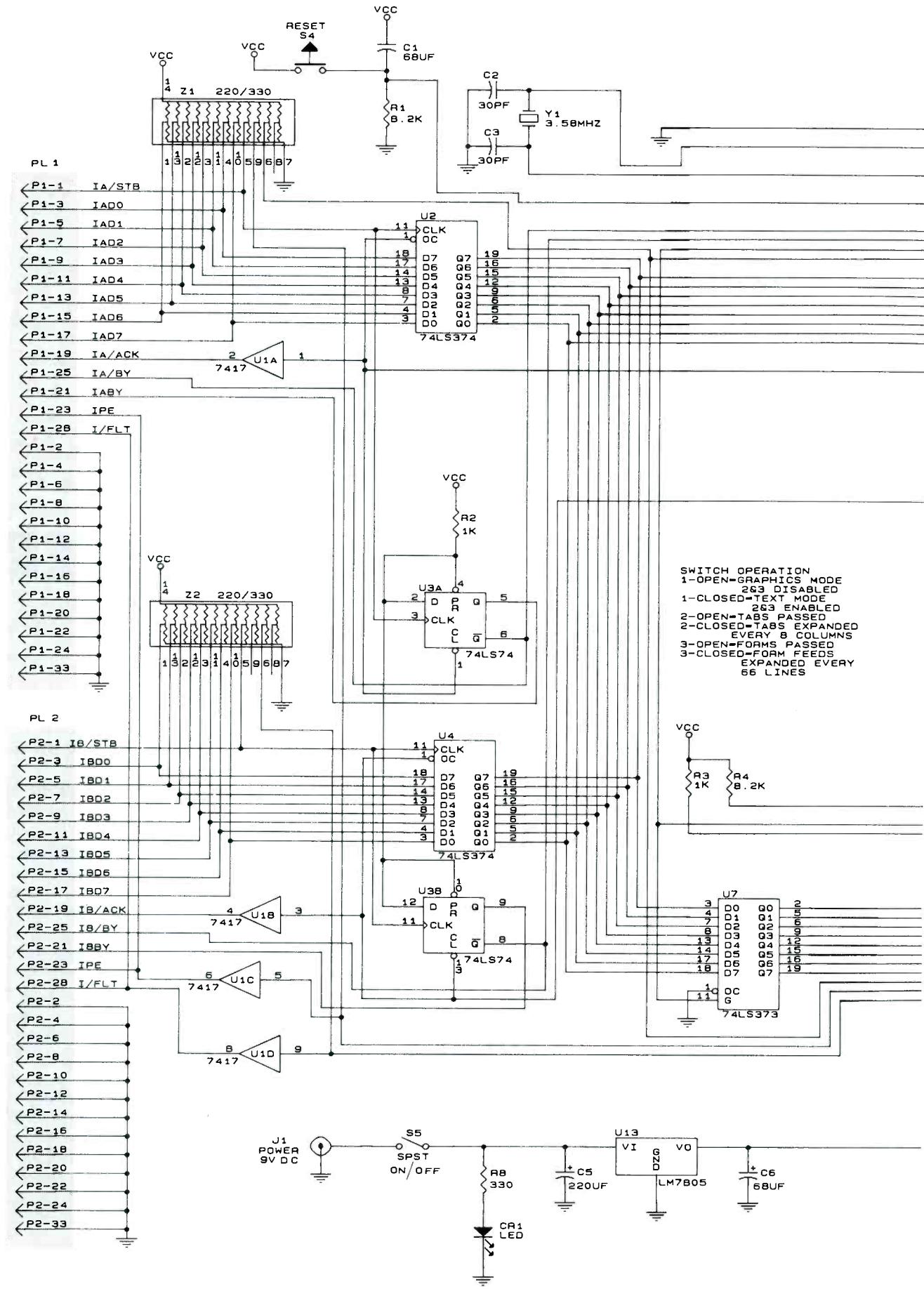
In the text mode, additional switches allow the unit to expand tabs and form feeds, although they are fixed at 8-spaces per tab and 66-lines per page. While my printer is very fast, it doesn't understand a tab code. I've also had even dumber printers that didn't understand form feeds. The PSB can compensate for those shortcomings.

In the graphics mode, those switches are disabled because the circuit can't tell the difference between a tab or form-feed and the graphics bit-patterns 09H and 0CH.

The 8031 Microcontroller. Like the popular Z80, the 8031 has built-in clock-generation circuits, eliminating the cost of external clock hardware and allowing it to operate directly from a crystal. And as we all know, any reduction in parts count, reduces the final cost.

Unlike the Z80, the 8031 uses a modified Harvard architecture, with separate address spaces for programs and

FROM COMPUTER 1



TO SHARED PRINTER

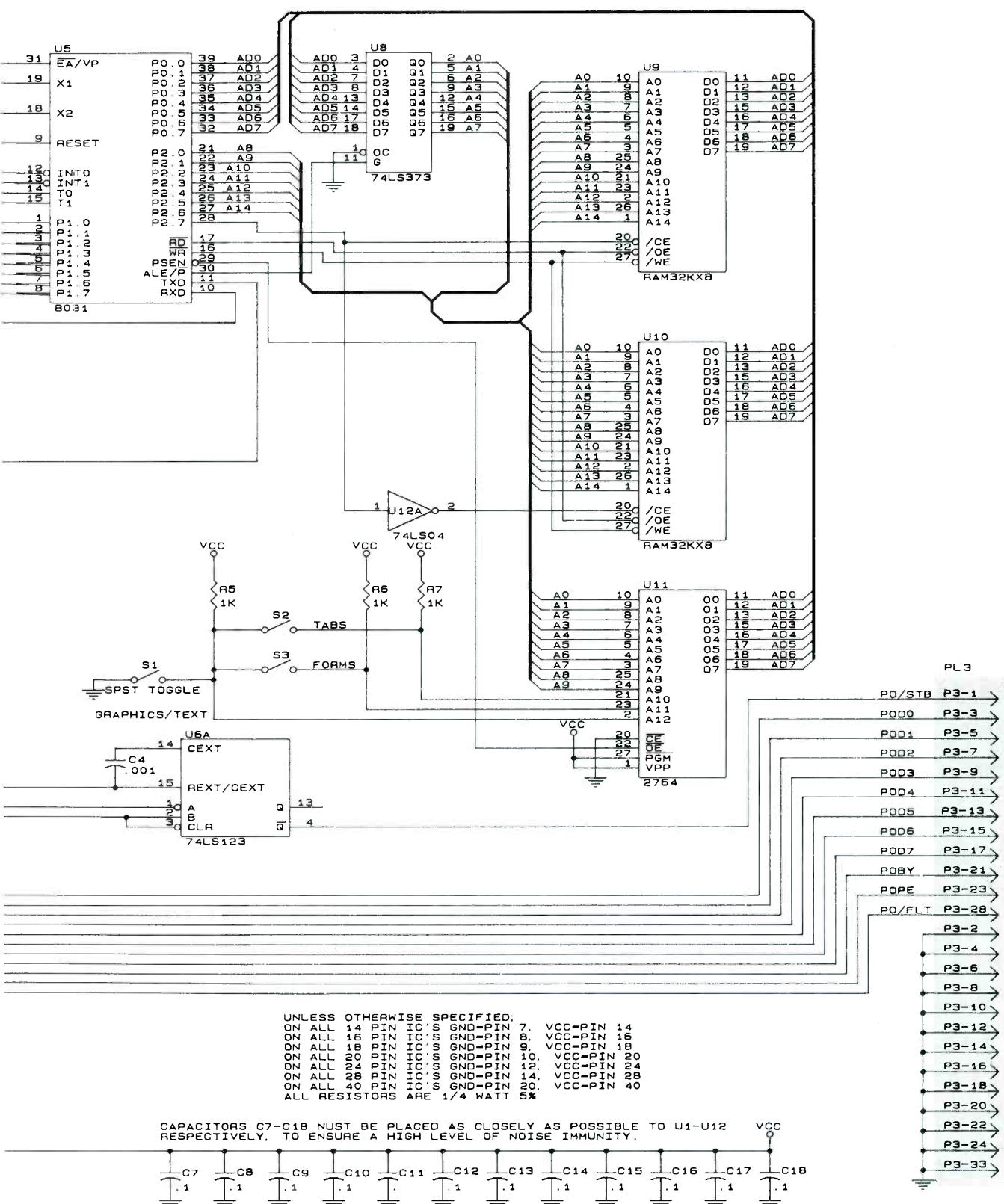


Fig. 1—The Print Spooler/Buffer—built around an 8031 microcontroller, which is supported by readily available parts—has a low parts count, and handshakes with Centronics-compatible parallel printers and ports.

data. A true Harvard architecture has separate address and data buses, allowing that type of computer to read or write data for the current instruction while it simultaneously reads the next instruction, making it a very fast computer.

The 8031 has common address and data busses, but separate read lines for program (/PSEN) and data (/RD). That doesn't increase speed over a common address space, but it does effectively double the amount of memory that the 8031 can address. It can address up to 64K of program and up to 64K of data, for a maximum of 128K, compared to the Z80's 64K total (without external bank-switching hardware). That permits the use of a full 64K buffer, plus 8K of program, without the bank-switching hardware that the Z80 would have needed.

The 8031 has two on-board, 16-bit timer/counter circuits, allowing one computer to time-out when it is done with the buffer, something that could be done entirely in software (with a speed penalty) in a Z80 system. That scheme avoids some additional programming or external counter hardware.

The 8031 has a good interrupt structure, allowing the timer and two computer-interface ports to be interrupt driven without incurring a hardware penalty. With the Z80, some sort of decoding hardware would be required to handle three sources. The 8031 has 128 bytes of onboard RAM, 32 of which are organized into four banks of work-

ing registers. Because 32K static RAMs are fairly expensive, I wrote the software to test for the presence of external RAM, and generate a small (104-byte) buffer in that internal memory.

Although not used in the printer-sharer circuit, the 8031 has a full duplex, interrupt-driven serial port (UART) onboard. It is available in versions with onboard ROM (8051) and even EPROM (8751). If external memory is not required, the data, address, and handshake pins may be configured as up to four 8-bit parallel ports. For control functions, each I/O port bit can be addressed individually.

The 8031 instruction set includes the ability to set or clear individual bits in the accumulator, several registers, and the I/O ports, and to test those same bits and perform a jump on bit set or cleared. Arithmetic functions include multiply and divide instructions, each of which is executed in just four cycles. The rest of the instructions are executed in one or two cycles.

Circuit Analysis. Assume that computer A places a byte of data on the IAD0-IAD7 terminals of PL1, then pulses PL1's IA/STB terminals low. On the rising (trailing) edge of the pulse, the data from PL1's IAD0-IAD7 terminals is clocked into U2. The same rising edge clocks U3-a. Flip-flop U3-a's Q output goes high, sending an active-high busy signal (IA/BY) back to computer A—which is interpreted by the computer to mean "Don't send me any more, I'm processing."

Flip-flop U3-a's Q output goes low, giving computer A an active-low busy signal (IA/BY) and sending an interrupt to U5 (the 8031 microprocessor). An interrupt (or interrupt service routine) tells the processor to stop its current task, save its place, and do something else for a while. On completion of the interrupt service routine, the processor returns to the original task.

During the interrupt service routine, pin 10 of U5 is brought low. That signal enables the three-state outputs of U2 to send the buffered byte to U5 pins 1 to 8 (P1.0-P1.7). The interrupt routine then reads the data through P1.0-P1.7 (U5 pins 1-8) and brings pin 10 high again. The high-to-low transition clears U3-a, removing the busy signals being returned to the computer. The low-to-high transition returns U2 to its three-state mode. The output of U5 at pin 10 is buffered by U3-a and returned to the computer as an acknowledge signal (IA/ACK).

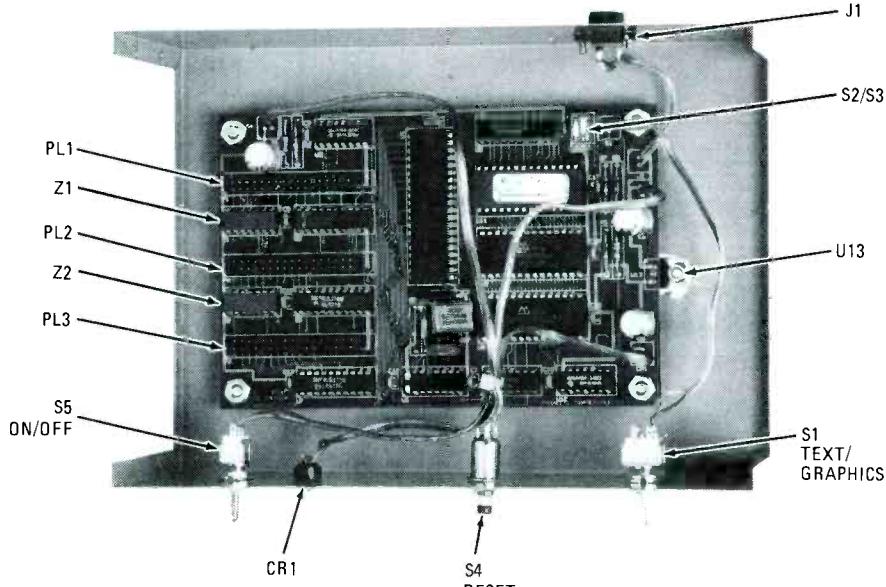
The interrupt-service routine, having accepted the first byte from computer A, places that byte into the 64K buffer. That disables responses to computer B's interrupt lead and sets one of the internal timer/counters for 15 seconds. Once the timer/counter starts running, it returns to the main program.

The sequence is repeated for each character sent by computer A. With each character, the timer is reset to count out 15 seconds. As long as computer A delays no more than 15 seconds between characters, the counter never reaches zero, and computer B's interrupt remains disabled.

Assume computer A has the buffer, and that less than 15 seconds have elapsed since it sent the last character. Computer B sends one character. When its IB/STB signal sets U3-b, that flip-flop sends busy and not-busy signals back. Meanwhile, the character is latched into U4. Since U5 is prevented from acknowledging computer B's interrupt, the character is not read into the buffer. Computer B gets a continuous busy signal, and cannot send any more characters.

Meanwhile, U5 continues to accept characters from computer A at over 2000 characters-per-second (cps), assuming that computer A can send that fast. Fifteen seconds after computer A has sent its last character, the timer (no longer being reset) arrives at zero, and generates its own interrupt.

At that point, the timer-interrupt service routine stops the timer and inserts



Shown here is a top-side view of the Print Buffer/Spooler's fully-populated printed-circuit board prior to the sealing of its metal enclosure.

a form-feed character into the buffer after the last character received from computer A. It then enables the interrupt signals from both computers. Computer A's interrupt is already enabled, but computer B has been waiting for that signal.

On return from the timer interrupt, the processor recognizes the pending computer-B interrupt, originating at the Q output of U3-b, present at U5 pin 13. The computer-B interrupt service routine accepts the character from U4, placing it into the buffer immediately after the timer's form-feed. That clears U3-b (removing the busy for computer B), disables the computer-A interrupt, sets the timer (again for 15 seconds), and then returns to the main loop.

As long as computer B continues to send characters at intervals of less than 15 seconds, the interrupt for computer A remains disabled. The circuit can accept characters from computer B, while continuing to print computer A's file from the buffer. Should the buffer become full (temporarily stopping the timer), the active computer interrupt is disabled until the main loop has taken one character from the buffer and sent it on to the printer. The interrupt is then re-enabled.

The main-loop software takes characters from the buffer and sends them to the printer. Because it uses the same I/O bus for sending that the interrupts use for receiving, it must temporarily disable the active computer's interrupt for the duration of the transfer, then remember which computer was active, and re-enable its interrupt when the job is complete.

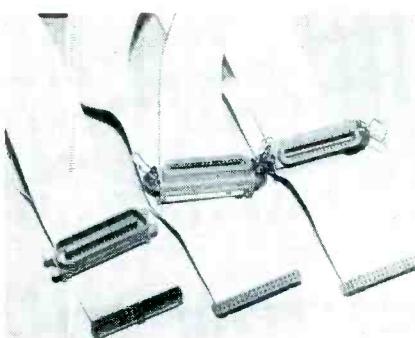
The main loop polls T1 (U5 pin 15), an input connected to the printer's busy signal. If the printer is busy processing the last character sent, U5 sits in a tight loop, testing and re-testing pin 15. When the busy signal is cleared, the loop is expanded to test for a character in the buffer.

If the printer is not busy and there is at least one character in the buffer, the processor disables the active computer interrupt, takes the next character from the buffer, places it on U5's P1.0-P1.7 terminals, and uses the port as an output. The processor then brings its pin 14 high, allowing data to be fed to U7. When pin 14 of U5 is brought low again, the data is latched into U7, and U6-a (which is set to produce the 1.5- μ s pulse that the printer expects) is triggered.

Once the data has been latched

into U7, the processor clears the P1.0-P1.7 terminals and returns the port to the input mode. It then re-enables the active computer's interrupt and goes back to polling the printer's busy signal.

In text mode, however, the previous character is saved in one of the registers. The current character is tested, to see if it is a form feed. If it is not, the character is sent normally. If it is a form feed, the character is then compared to the previous character. If that was also a form feed, it returns to the main loop without sending the character. The result is that multiple, consecutive form-feeds are disallowed.

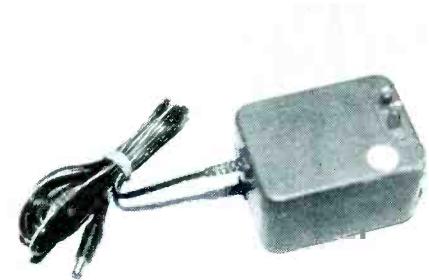


Three ribbon cables are needed to connect the PSB between your two computers and the printer. One end of each cable is terminated in a 34-pin header connector. The other ends of the cables terminate in connectors selected to mate with the computer or printer ports to which they are to be attached.

The disallowance of consecutive form feeds is a very useful feature. For example, consider that my text editor inserts a form feed at the end of each file, my 8080 assembler inserts a form feed at the beginning of each file, and the sharer program inserts a form feed between files. If a text file were printed, followed by a program listing, I could end up with three consecutive form-feeds between the two documents—a waste of paper—if that feature were missing.

The tab-expansion feature uses a register and software to count characters (modulo 8). Non-printing characters, such as a line-feed or bell, do not count. A carriage return resets the counter. When a tab character is encountered, the program branches to a loop, printing space characters and bumping the counter until it rolls over, and then returns to the main loop.

Similarly, the form-feed expansion counts line-feeds (modulo 66). When a form feed is encountered, it prints line



A wall-mounted power supply capable of providing between 8 and 24-volts DC at 1 amp can be used to power the Print Buffer/Spooler. The author chose a 9-volt unit as his power source.

feeds and bumps the counter, returning to the main loop when the form-feed counter rolls over. Note that that routine is placed after the multiple form-feed test.

Switches are used to set the upper addresses of the program memory. That approach may seem a bit strange, but there is a good reason. In designing the basic unit, all available signal pins on the 8031 (U5) were used. I had no way to add features by testing a switch and doing a conditional branch because I had no place left to attach the switches. Instead, I wrote five different versions of the program.

Each version has its logical origin at address 0000H, even though they are physically loaded into ROM at address 0 (text mode, expand forms and tabs), 400H (text mode, expand only forms), 800H (text mode, expand only tabs), 0C00H (basic text mode, no expansions), and 1C00H (graphics mode). The switches then select which of the five physical addresses are presented to the processor as address zero.

Because the five programs are not identical, changing any mode switch while operating could easily send the 8031 (U5) branching off to never-never land. The switches should only be changed with the power off.

In hardware, the paper empty (POPE) and fault (PO/FLT) signals from the printer are buffered by U1-c and U1-d, and sent directly to both computers. The 8031 doesn't need to know the type of error; it simply sees a busy signal from the printer and can't send.

Construction. The authors prototype of the circuit was fabricated on a double-sided printed-circuit board, the foil patterns for that board are shown in Fig. 2. You can, if you wish, wire-wrap the Print/Buffer Spooler, but bear in

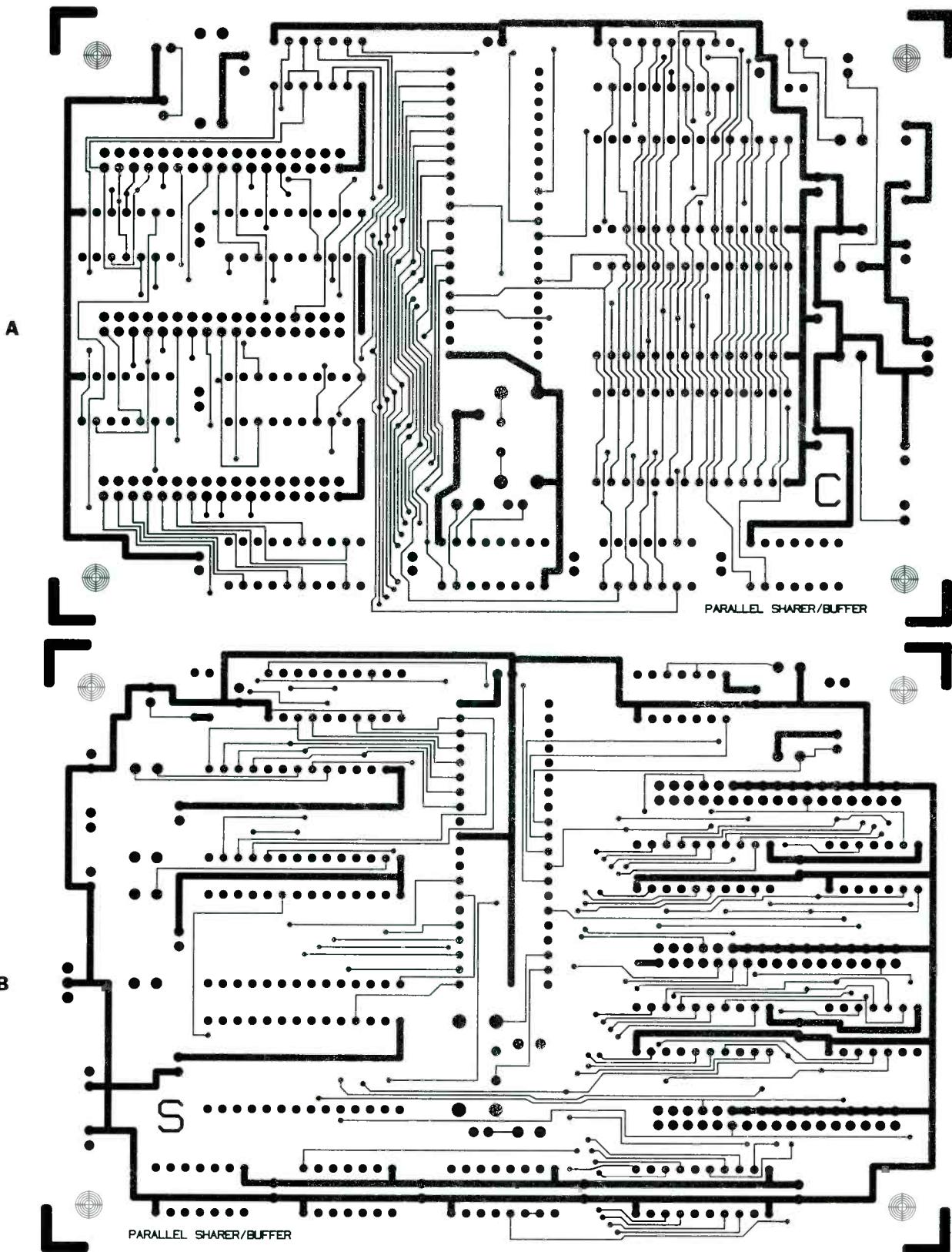


Fig. 2—The full-scale foil pattern for the double-sided printed-circuit board. The component side is shown in A; the solder side is shown in B.

mind that there are some fairly-high frequencies running through the circuit. So, if you go the wire-wrap route, it's important that lead lengths be kept as short as possible, especially in the paths running from U5 pins 18 and 19 to

Y1, Y1 to C2 and C3, and C2 and C3 to ground. In the area of U6, the paths from U6 to C4 and R3, and from R3 to V_{cc} , should also be kept fairly short.

Note that the 32K static RAMs are CMOS devices and as such, anti-static

precautions are an absolute necessity. The RAMs are not necessary to the sharing operation. The program tests for their presence and sets itself up according to the amount of RAM found. The circuit can be built and will work without them. They can be added later, as your budget permits.

PARTS LIST FOR THE PRINT SPOOLER/BUFFER

SEMICONDUCTORS

U1—7417 hex buffer/driver, integrated circuit
 U2, U4—74LS374 octal D-type flip-flop, integrated circuit
 U3—74LS74 dual D-type flip-flop, integrated circuit
 U5—8031 microprocessor (CPU w/128 X 8 RAM I/O), integrated circuit
 U6—74LS123 dual monostable multivibrator, integrated circuit
 U7, U8—74LS373 octal D-type transparent latch, integrated circuit
 U9, U10—43256-15L RAM, integrated circuit
 U11—2764 8 X 8 EPROM, integrated circuit
 U12—74LS04 hex inverter, integrated circuit
 U13—7805 5-volt, 1-amp regulator, integrated circuit
 CR1—T1-3/4 or similar light-emitting diode

RESISTORS

(All resistors are $\frac{1}{4}$ -watt, 5% units, unless otherwise noted.)

R1, R4—8200-ohm
 R2, R3, R5-R7—1000-ohm
 R8—330-ohm
 Z1, Z2—220/330-ohm terminating network (14 pin DIP)

CAPACITORS

C1, C6—68- μ F, 16-WVDC, electrolytic (vertical mount)
 C2, C3—30-pF ceramic disc or mica

C4—0.001- μ F, ceramic disc
 C5—220- μ F, 35-WVDC, electrolytic (vertical mount)
 C7-C18—0.1- μ F, ceramic disc

ADDITIONAL PARTS AND MATERIALS

J1—Selected to match power-supply connector (see text)
 PL1-PL3—34-pin header (Digi-Key R230-ND)
 S1, S5—Single-pole, single-throw toggle switch
 S2, S3—2-place DIP switch (Digi-Key CT2062)
 S4—Single-pole, single-throw normally-open, pushbutton switch
 Y1—3.58-MHz color-burst crystal
 Printed circuit or perfboard materials,
 34-pin header connectors (Digi-Key R8305-ND mates with PL1-PL3), 34-conductor ribbon cable, 8- to 24-volt wall-mounted DC power supply, enclosure, IC sockets, wire, solder, hardware, etc.

Note: All resistors, capacitors, switches and connectors, and most ICs are available from Digi-Key Corporation, PO box 677, Thief River Falls, MN 56701-9988. The 8031 and 43256-15L 32K X 8 static RAMs are available from Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002. The terminating networks Z1 and Z2 are available from Ohm Electronics, Inc., 746 Vermont St., PO Box 368, Palatine, IL 60067; Tel. 312/359-5500.

The following items are available from the author: pre-programmed EPROM, \$8.95 (containing the algorithms for all five modes of operation); double-sided glass-epoxy printed-circuit board, UL FR-4 rated (with solder mask and silk-screened component-placement legend) \$15.95; source code (MS-DOS 3.2 format 5½-inch floppy disk containing the original source files for all five modes of operation) \$19.95; Deluxe hacker-pak, \$39.95 (includes all of the above, plus a full-size print of the schematic).

Make check or money order payable to John Emerson, PO Box 43, Elgin, IL 60121. Please specify item(s) and quantity desired. All orders subject to \$2.00 postage and handling. Illinois residents please include 6% sales tax.

Popular Electronics will send a print out of the program listing at no cost provided the sender submits a self-addressed envelope with sufficient postage for two ounces of first class mail (currently \$.45). Mail your request to Buffer/Spooler, **Popular Electronics**, 500-B Bicounty Boulevard, Farmingdale, New York 11735. Requests without a self-addressed envelope with proper postage will not be honored.

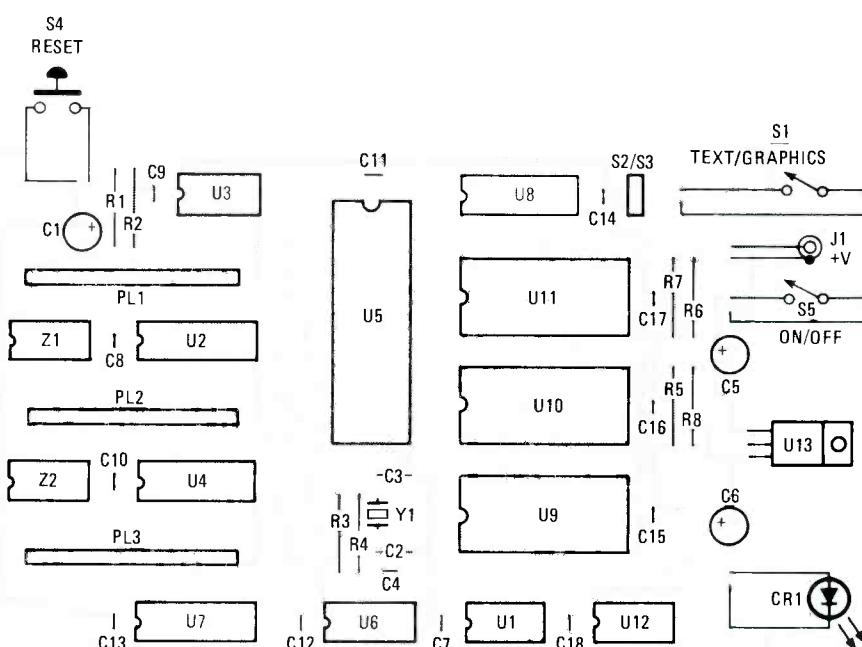


Fig. 3—Using this layout diagram as a guide, install the circuit elements, being mindful of component orientation and positioning—particularly the ICs, electrolytic capacitors, the power connector, and the LED.

If only one RAM is used in the circuit, it should be installed in the U9 location. In fact, because the RAM integrated circuits are the most costly circuit elements in the project, it is recommended that the circuit be assembled and tested without them in place to avoid the chance of damaging \$24 worth of silicon. If the circuit works without the RAM installed, it should work when they are installed.

Unless you are a real wizard with a soldering iron, it's a good idea to invest in sockets for all the ICs, especially if you are getting some of them from your junkbox. Even if you are the definitive expert on soldering and desoldering, socket the EPROM.

If you buy the EPROM from the supplier given in the Parts List, there is still a possibility of a bug being found later. Fear not, for if that should occur, you'll be informed and a replacement EPROM will be made available on an exchange basis.

Assuming that you've purchased the printed-circuit board from the supplier

(or etched your own from the foil pattern provided), install the components using Fig. 3 as a guide. Be careful of the orientation of all ICs, electrolytic capacitors, the power connector, and the LED. If you've purchased the circuit board from the supplier mentioned in the Parts List, the marked corner of the IC outlines and connectors is pin 1; a plus sign (+) indicates the positive lead of electrolytic capacitors, and the cathode of the power indicator LED.

The connectors specified for PL1, PL2, and PL3 are inexpensive headers that mate with T&B Ansley P/N 609-3430 ribbon-cable connectors. For wire-wrap construction, substitute T&B Ansley P/N 609-3457 for PL1-PL3. Similar connectors are available from other sources, including AMP, 3M, and Molex. The pinout for the ribbon cables directly match the 34-pin card-edge connectors used by Radio Shack on TRS-80 models I-IV. The cable pinout also matches the first 34 pins of the standard 36-pin, parallel printer connector (pins 18 and 36 are not used).

For the 25-pin D connector used on PCs and clones, use a 25-conductor ribbon cable connected to the first 25 pins of the 34-pin connector on the unit. Carefully cut the number 2, 4, and 6 conductors of the ribbon cable. The rest of the ribbon-cable's conductors match correctly and will provide all of the necessary signals.

Power for the circuit is provided by a Radio Shack, part No. 277-1026, AC-to-DC adaptor, but any unit capable of supplying between 8 and 24-volts of filtered DC at 650 milliamps will do. Power input jack J1 is then selected to mate with the plug of the power supply. The 7805, properly heat sunk, does an excellent job of regulating with inputs in that range. For heat sinking, the regulator was bolted directly to the cabinet. The mounting tab of its TO-220 package is connected to ground. Mounting the regulator that way provides two benefits; no insulator is required and, by connecting the metal cabinet directly to logic ground at the regulator, the unit's immunity to noise and ESD (electrostatic discharge) is increased.

The circuit was housed in a Radio Shack 270-274A cabinet, but any metal enclosure of ample size will do. A metal cabinet is specified primarily for heat sinking the 7805, but the extra noise and ESD immunity that such a cabinet provides can't hurt.

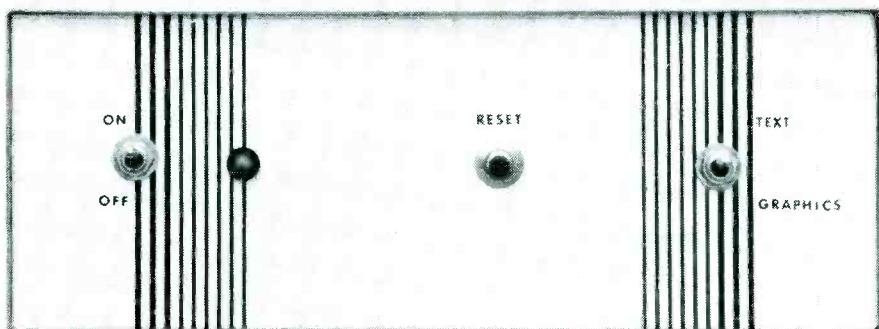
Software. The software required to make the buffer work is fairly clever. However, it is also fairly complex. Because of that, and due to space reasons, we will not be able to go into its details in this article.

Of course, you still need the software if the buffer is going to do anything useful. There are three ways to obtain it: The easiest way is to purchase the pre-programmed EPROM from the source mentioned in the Parts List. Plug it into the U11 socket on the board and you are ready to go. If you are into burning your own EPROMs, or would like to make some modifications to the code, you can purchase an MS-DOS format, 5 1/4-inch floppy disk with the complete source code from that same supplier.

that the actual printing begins on a clean sheet of paper.

Troubleshooting. The most likely source of trouble is the ribbon cables used to connect the Print Spooler/Buffer to the printer and computers. If the PSB doesn't sign on, check that there is power to the ICs (a bad or mis-installed U13 would allow the power LED come on, but the ICs would be dead). Then check the printer cable for continuity and shorts. If the unit signs on, but doesn't pass data from one or the other computer, check the computer cable for continuity and shorts. Be sure to observe the proper polarity when building and connecting all of the cables used by the unit.

Find out what's working and what's



Here's the finished prototype. If desired, dry-transfer lettering can be used to label the front-panel controls and provide a more professional look.

Finally, for those true hackers (masochists) who have the time, typing ability, and desire to key in the hex data required for the buffer/spooler program, you can request a copy of the complete source code, in Intel hex format, from the address given in the Parts List.

Operation. When the unit is connected to a printer (both are powered up) and the printer is placed on line, it should immediately print the message: TESTING RAM. Less than 6 seconds later (immediately if no RAM is installed), it should print a status message similar to:

PRINTER SHARER/32K BUFFER
COPYRIGHT 1988 - JOHN EMERSON
IN TAB EXPAND MODE

Note: The buffer size displayed varies with the amount of RAM installed, and the mode displayed depends on the settings of S1, S2, and S3, which are set according to the instructions given in Fig. 1. After the message is output, the printer should then form feed to the top of the next page, so

not. If the sign-on message prints, the problem is in an input section. If nothing prints, check the processor. A logic probe or scope should see pulses on U5 pin 30. If the printer is ready for data, U5 pin 15 should be a steady low. Probe U5 pin 15 and press the reset button. When you release the button, if the processor is working, you should see a series of pulses as the processor sends the sign-on message. Probe U6 pin 1 and repeat the procedure. If there are no pulses, chances are that U6 is the culprit.

If an input problem is indicated, U1 and U3 will probably affect both inputs, while U2 will only affect input A and U4 will affect input B, probably with scrambled characters. Scrambled characters at sign-on point to U7. Total failure with an indication that the processor is running can probably be traced to U8 or U11. An indication, at sign on, that less memory is available than is installed, could be caused by a bad RAM or a bad U12.

Good luck, and may the data flow be with you. ■

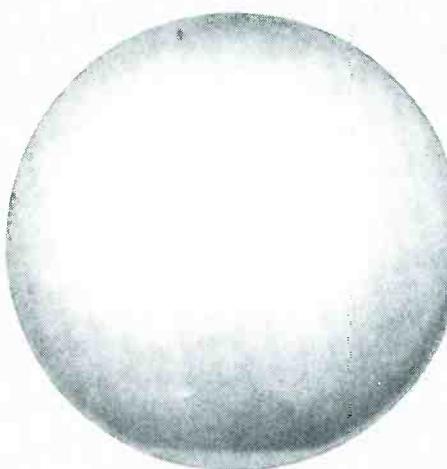
Overcoming the pull of gravity has long been a dream of the scientific community, so much so that countless experiments about it have been conducted over the years. Many of those experiments have dealt with reversing the gravitational effects of the Earth's magnetic pull to free large masses for space travel.

The "Anti-Gravity" Generator described in this article will not send some object hurling through the endless realms of space, but it will give the appearance of having overcome Earth's gravitational pull. The project incorporates a hollow plastic ball with a permanent magnet placed inside and a feedback-controlled electromagnet. When the electromagnet is under power and the ball is brought near it, the ball can be made to float, appearing as though an anti-gravity condition exists.

The feedback control, consisting of both an IR transmitter and detector circuit, is used to influence the amount of energy delivered to the electromagnet, and thereby its magnetic strength. The IR transmitter and receiver are placed so that if the ball is pulled within a certain distance of the electromagnet, it blocks some portion of the IR signal, which reduces the amount of energy picked up by the receiver. That, in turn, causes the pull of the electromagnet to be reduced so that the ball drops out of the transmitter/receiver's line-of-sight, keeping the ball suspended in mid-air creating the illusion of antigravity.

Circuit Description. Figure 1 shows a schematic diagram of the Anti-Gravity Generator. The infrared transmitter consists of a 555 oscillator/timer (U3), and an infrared-light emitting diode (LED1). Timer U3 feeds a pulsing signal to LED1. The output frequency of U3 (and therefore the pulse rate of LED1) is determined by R10 and C4. Resistor R8 is used to limit current to LED1.

The receiver consists of a solar cell (PC1), two op-amps (U1 and U2), and a Darlington amplifier made from two discrete transistors (Q1 and Q2). Op-amp U1 is configured as a current-to-voltage



The "Antigravity" Generator

Astound and amaze
your friends
with this
gravity-defying
project!

BY VINNEY VOLLONO

converter. Infrared light picked up by PC1 is converted to an electrical signal and fed to the non-inverting input of U1 at pin 3. Because the non-inverting input of U1 is tied to the negative lead of PC1, its output at pin 6 is negative.

Resistors R1 and R2 form a voltage divider and the feedback loop to U1's inverting input to control the gain of the op-amp. The output of U1 is fed through R3 to the inverting input of U2 at pin 2. Resistor R4 sets the gain of U2, while C3, R6, and R7 set the hysteresis to control the oscillations. The output of U2 is fed to the base of Q1, a TIP41A power transistor, through R5. Resistor R5 limits current to the base of Q1.

Transistors Q1 and Q2 control the flow of current to the electromagnet. When the output of U2 is high, that high causes Q1 to turn on, placing a high at the base of Q2. That high causes Q2 to turn on, grounding one end of the electromagnet, turning it on.

Power for the Anti-Gravity Generator is provided by an unregulated dual (\pm) 12-volt power supply, consisting of T1, BR1, C1, and C2. The center tap of T1 is used as a ground, while the other two leads connect to the AC inputs of BR1. Capacitors C1 and C2 are used to filter the output of BR1.

Note that the schematic diagram contains a resistor labeled R_C . That unit may or may not be necessary for the proper operation of the project. If the impedance of the electromagnet is lower than about 30 ohms, inclusion of that resistor will restrict the flow of current to protect the Darlington amplifier and the electromagnet.

Design Variables. Because the circuit needs all conditions to be just right to create the anti-gravity effect, we need some way of offsetting the electromagnet and certain other components. The height of the electromagnet should be adjustable to help compensate for the weight of the ball and the strength of the permanent magnet within the ball.

Another factor in building the Anti-Gravity Generator is the size of the unit that you decide to build. Depending on how large you intend to build the project, the IR emitter and

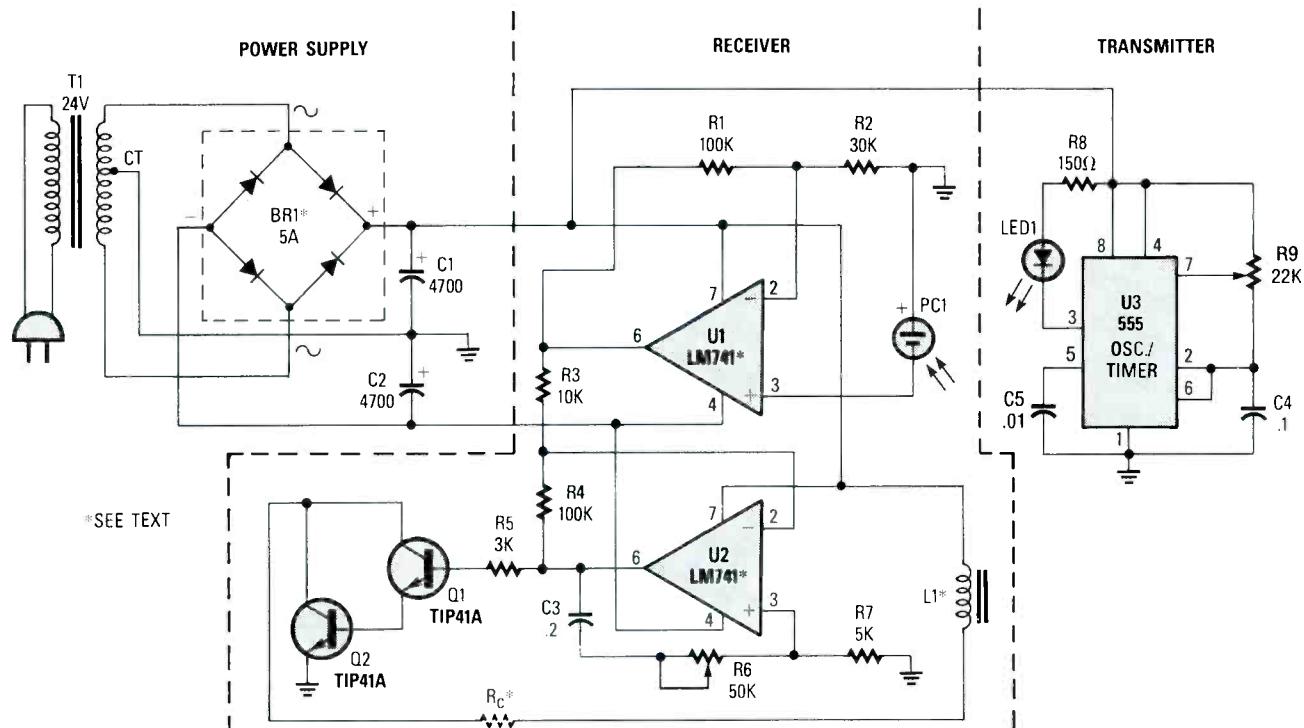


Fig. 1. The Anti-Gravity Generator is really a rather simple circuit, built around several readily available components. In fact, the only component that's not an off-the-shelf item is L_1 , which you must wind yourself.

receiver will need to be focused accordingly. In the author's prototype, lenses are used because the unit is fairly wide, placing the receiver and transmitter unit a sizable distance apart.

If you wish to build yours only six inches wide, you may not need to use lenses. The reason is that the farther the transmitter and receiver are apart, the more the infrared light is dispersed (spread out). The thinner (more concentrated) the beam, the more accurately the receiver circuit can sense the position of the ball.

A dispersed beam provides much less control, resulting in the anti-gravity effect being much more difficult (or, more likely, impossible) to achieve, because of the lower levels of IR energy striking the receiver. In addition, a dispersed IR beam will be hard to block. Those factors must be taken into consideration or the project will not operate.

While two 741 op-amp IC's were used for U_1 and U_2 , both units can be replaced by a single 1458 dual op-amp.

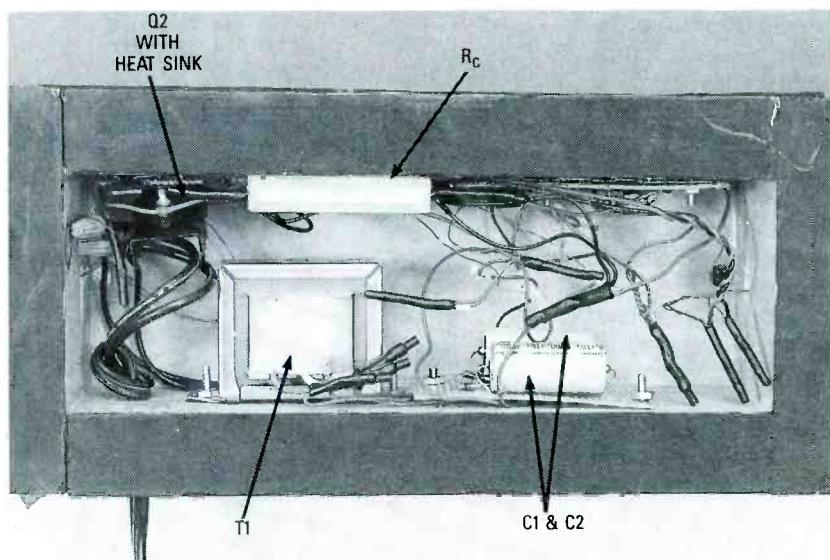
Construction. The author's prototype was built on three small sections of perfboard. When assembling your Anti-Gravity Generator, follow Fig. 1 as a guide. Transistor Q_2 should be heat-sinked to prevent it from overheating

during operation. The bridge rectifier, BR_1 , can be made from discrete rectifier diodes, or a pre-packaged bridge can be used. Just make sure that the rectifiers have the proper current rating. After the three perfboard circuits have been assembled, place them to the side for a while and move on to the rest of the project.

The electromagnet (L_1 in Fig. 1) is a home-made coil wound on a half-inch diameter, 6-inch long bolt. Two layers of black electrical tape are placed

over the bolt, and the coil is wound on top of the tape. The author wound about 1/4-pound of 28-gauge magnet wire onto the bolt, covering only about three inches of the bolt at the head end.

The easiest way to wind the coil is to place the bolt in a hand drill, wind three or four turns onto the bolt to get things started, and let the drill do the rest. DO NOT cut off the extra bolt length, and be sure to leave enough lead length to allow the coil to be attached to the receiver circuit board. The remaining three inches of the bolt



Here's an inside view of the sectionized circuit mounted in the base of the Anti-Gravity Generator. The large high-wattage resistor (R_c) is connected in series with the electromagnet (L_1) to bring L_1 's impedance up to at least 30 ohms.

is needed to make height adjustments on the electromagnetic and secure it in place.

When L1 is finished, it should have an impedance of about 30 ohms. The electromagnet has a great effect on the current through the Darlington pair. If the coil's impedance is too low, both

PARTS LIST FOR THE ANTI-GRAVITY GENERATOR

SEMICONDUCTORS

U1, U2—741 op-amp (or 1458 dual op-amp, see text), integrated circuit

U3—555 oscillator/timer, integrated circuit

Q1, Q2—TIP41A NPN transistor

BR1—5-amp, 100-PIV bridge rectifier (see text)

LED1—Ultra-bright light-emitting diode

RESISTORS

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

R1, R4—100,000-ohm

R2—30,000-ohm

R3—10,000-ohm

R5—3000-ohm

R6—50,000-ohm

R7—5,000-ohm

R8—150-ohm

R9—22,000-ohm, potentiometer

CAPACITORS

C1, C2—4700- μ F, 16-WVDC, electrolytic

C3—0.2- μ F, 50-WVDC, ceramic disc

C4, C5—.01- μ F, 50-WVDC, mylar

ADDITIONAL PARTS AND MATERIALS

L1—See text

T1—25-volt, center-tapped, 2-amp transformer

PC1—Solar cell, $\frac{1}{2}$ -inch square, 0.5-volt, 55-mA

PL1—117-volt AC plug with line cord

Perboard materials, 6-inch lone, $\frac{1}{2}$ -inch thread bolt and nut, $\frac{1}{4}$ -pound of #28 magnet wire, two 19mm diameter convex lenses, permanent magnets, hollow plastic ball, wood, electrical tape, heat sink, IC socket(s), hook-up wire, solder, hardware, etc.

Note: For technical assistance on the construction of the Anti-Gravity generator, call 203/672-0123 (weekday mornings only).

The photo cell (PC1), as well as suitable magnets, can be purchased from Edmund Scientific, 101 E. Gloucester Pike, Barrington, NH 08007, Tel. 609-573-6250. Contact them directly for pricing, shipping and handling charges, etc.

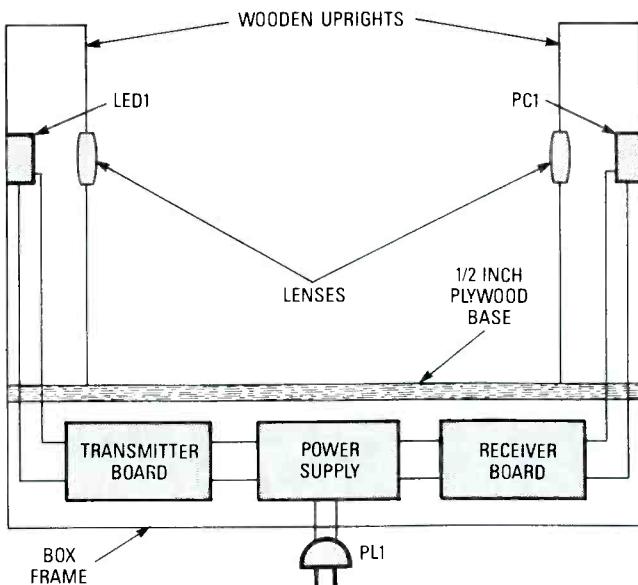


Fig. 2. In the author's prototype, the wires between the receiver and transmitter boards, and the electromagnet (L1), the solar cell (PC1), and the IR diode (LED1) were run through ducts drilled into the wood uprights, and cross brace.

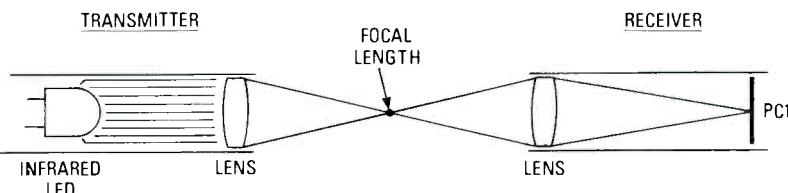


Fig. 3. The transmitter, receiver, lenses (if used)—which are located in the uprights—must be properly aligned and focused in order for the Anti-Gravity Generator to function.

the electromagnet and the Darlington pair will overheat. The impedance of the coil can be compensated by placing an appropriate resistor (R_C in Fig. 1) in series with the coil, as previously mentioned.

After the coil has been wound onto the bolt, cover it with several layers of electrical tape to keep the wire from unraveling. Once that's done place the electromagnet coil to the side for a while and move on to the next stage of construction.

The Frame. The author built the frame for his prototype from wood because it is easy to work with. However, you can build the frame from whatever materials you may have on hand—for example, acrylic plastic can be used for a snazzier look. For obvious reasons, metal should not be used. Use your own imagination.

Figure 2 shows the construction details of the frame. Start by taping two pieces of the framing material together. Those two pieces of wood will be used to form the uprights (the frame-work where the IR emitter and

solar cell are to be located). The author used 11 x 2-inch lumber. With the lumber still taped together, cut them to equal lengths and sand the ends smooth. Drill a half-inch hole through both wood pieces at about 4-1/2 inches from what will hereafter be considered the top of the upright.

As far as the wiring goes, the author drilled holes straight through the wood with an 18-inch drill bit in order to conceal the wiring. That is not necessary; you could just as easily tape the wires to the outside of the wood if you wish. Drill a hole lengthwise through the centers of each piece of the framing wood.

Alignment. The infrared transmitter and receiver must be aligned in order to permit proper operation. The author used lenses in his prototype (see Fig. 3) because of the distance between the transmitter and the receiver. Note that the lenses must be focused for maximum IR energy to strike the receiver.

Place LED1 into the hole in one piece of the framing wood and the solar cell (Continued on page 157)

The ULTRASONIC Receiver

Extend the upper frequency range of the human ear with this high frequency superheterodyne receiver

Scientific advancements can be greatly enhanced when man's senses are extended beyond their normal range. Modern technology has provided us with the starlight scope, allowing us to see in almost total darkness; telescopes and microscopes with titanic magnification capabilities to view the near invisible; audio amplifiers of every description to tweak the ear's sensitivity to minuscule sound levels; and numerous other high-tech aids to extend the scope and sensitivity of our two major senses.

But if you want to explore the fascinating world of ultrasonic sound, you're going to find very little, if anything, on the proverbial "goodie shelf" to use. Motion detectors, range finders, remote-control units, and cleaners make up the majority of equipment that's available in today's market. So if you want to explore new frontiers, you'll have to do what the electronic hobbyist does best—build the equipment yourself.

To listen to sound that's above our normal hearing range requires a special type of audio-frequency converter, like the one found in the *Ultrasonic Receiver*. If the time-proven superheterodyne design is applied to the ultrasonic-detection problem, a highly successful receiver is possible.

Generally, the most difficult problem in building a good Ultrasonic Receiver

BY CHARLES D. RAKES

is not in the circuit design itself, but hinges on the limited bandwidth of most available pickup transducers. But thanks to the number of piezo tweeters that are now available, selecting a suitable broadband pickup transducer is a breeze. In fact, after testing a number of the piezo speakers, the majority proved to be very broadband and super sensitive to low sound levels.

How it Works. Refer to the schematic diagram shown in Fig. 1. The piezo speaker, MIC1, picks up the incoming ultrasonic signal and feeds it to the base of Q1. The two-transistor booster amplifier (consisting of Q1 and Q2) raises the signal to a level that's sufficient to drive one input of a most-unusual mixer circuit.

Integrated circuit U2 (a quad bilateral switch) functions as an extremely clean balanced-mixer circuit for the superheterodyne receiver. Integrated circuit U1-a ($\frac{1}{2}$ of a dual op-amp) is connected in a variable-frequency squarewave-oscillator circuit. Resistors R5, R6, and capacitor C4 determine the frequency and tuning range of the oscillator.

The oscillator's squarewave output is fed along two paths. In one path, the output of U1-a is input to pins 12 and 13

of U2. In the other path, the signal is fed to the base of Q3, which is configured as an inverter. The inverter outputs a signal that's 180° out of phase with the input signal. The inverted output of Q3 is then fed to U2 at pins 5 and 6. There the two input signals (the ultrasonic input from MIC1 and the oscillator output) are mixed.

The mixing of the ultrasonic input and the squarewave signal produces an audible product that's fed to the input of a differential amplifier, U1-b (the second half of the dual op-amp), which has a voltage gain of 2. The output of U1-b at pin 7 is filtered by R19 and C9 to remove the high frequency content of the mixed signal.

Since only the difference frequency is important, the sum frequency (the incoming ultrasonic signal added to the oscillator frequency), which is too high for the human ear to hear, is removed by R19 and C9 to give a clean output signal to feed power-amplifier U3. Resistor R21 functions as the circuit's volume control.

Putting it Together. As long as a neat wiring approach is taken just about any construction scheme will suffice, but for a compact and portable receiver, a PC board would be the best way to go. A full-scale template of the Ultrasonic Receiver's printed-circuit board is shown in Fig. 2.

The receiver is housed in a 4-inch



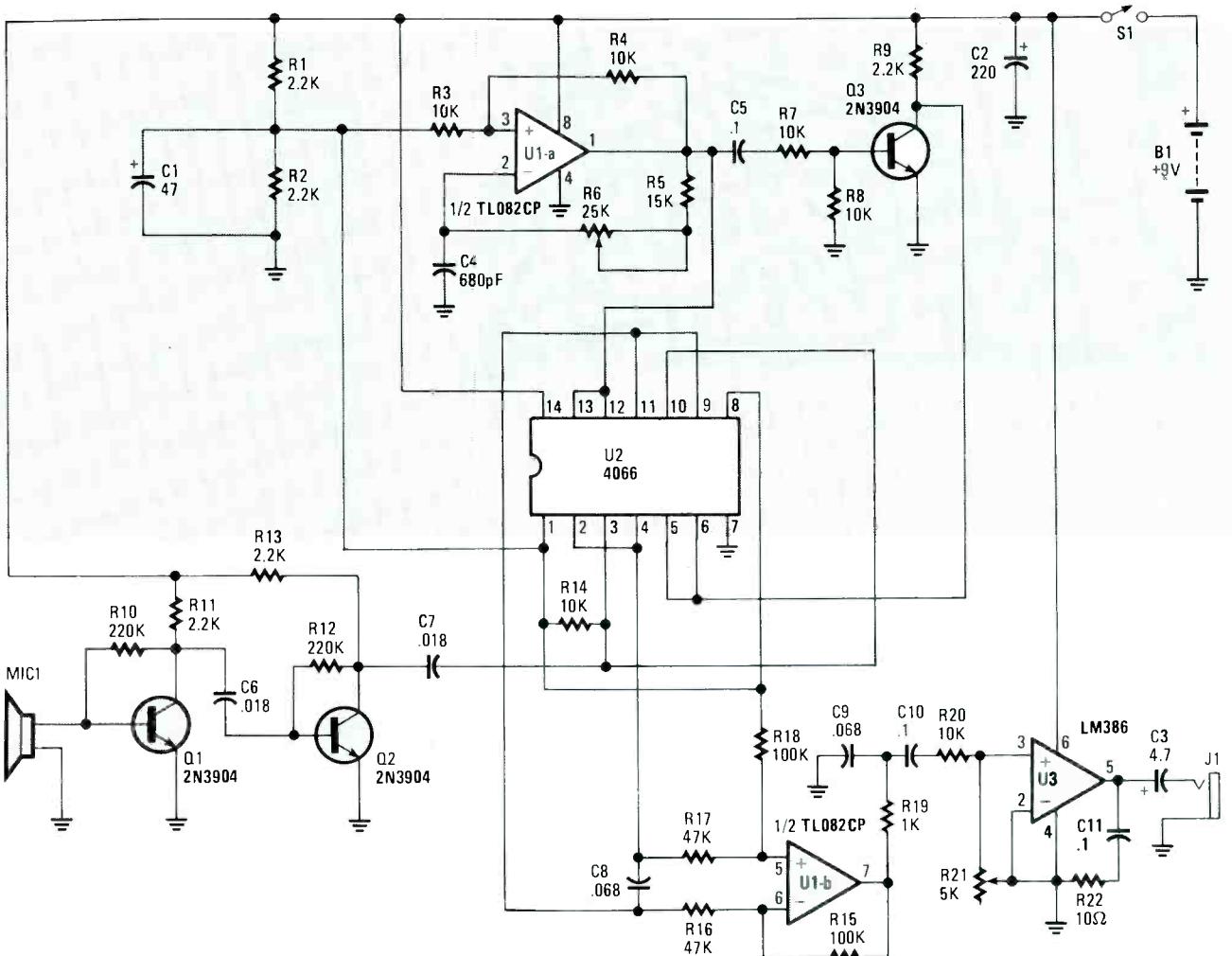
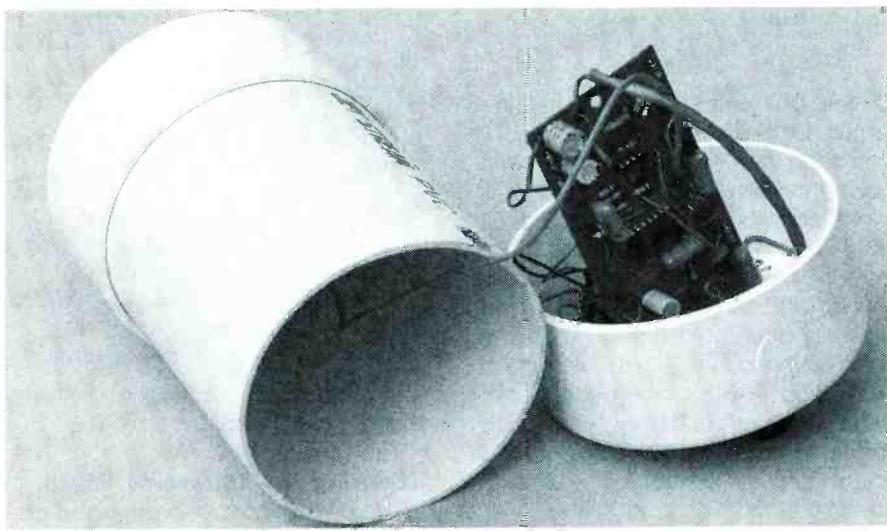


Fig. 1. Here's the schematic diagram of the Ultrasonic Receiver.



The Ultrasonic Receiver's printed-circuit board is mounted to an "L" bracket, and the bracket is then mounted on the shaft of R21 which, when mounted to the end-cap that serves as the front panel of the project, holds the printed-circuit board in place.

diameter 6-inch length of PVC sewer tubing, with two PVC end caps to complete the enclosure. The 3 1/4-inch piezo tweeter (MIC1) is mounted in the center of one end with phone jack (J1),

tuning potentiometer (R6), and the volume control (R21) with off/on switch on the opposite end.

If you've opted to go the printed-circuit route, install the parts on the

board using Fig. 3 as a guide. Take care in placing all of the components and wire jumpers in their correct location, and check the polarity of the electrolytic capacitors. Double check all transistor and IC positions before soldering them in place. If a perfboard, or other non printed-circuit method is taken, use IC sockets and keep all of the interconnecting leads as short as possible.

Mounting the 3 1/4-inch piezo tweeter in the center of the PVC end cap is easily accomplished by locating the center of the end cap and scribing a 2 3/4-inch circle around the center mark.

Drill as many 1/8-inch holes around the 2 3/4-inch circle as you can without overlapping, and use a small saw or knife to finishing cutting out the inner circle of material. Locate the tweeter on the end cap, mark and drill the four holes, and mount the speaker in place using 6-32 hardware.

The circuit board is mounted to the front cap with a small metal "L"

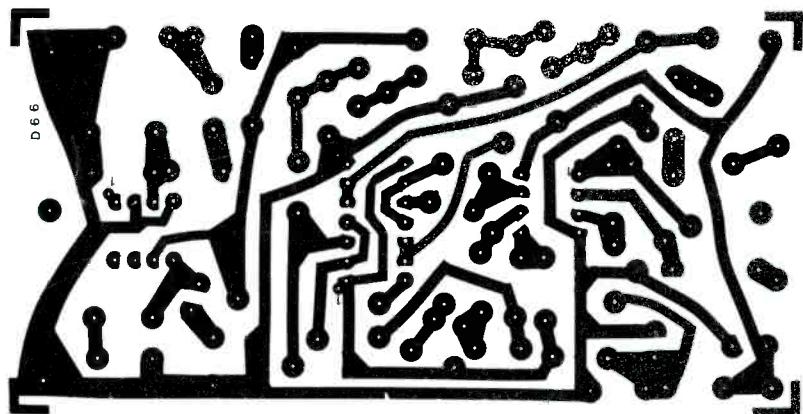


Fig. 2. For those who've opted to go the printed-circuit route, here is a full-scale template for the Ultrasonic Receiver's printed-circuit board.

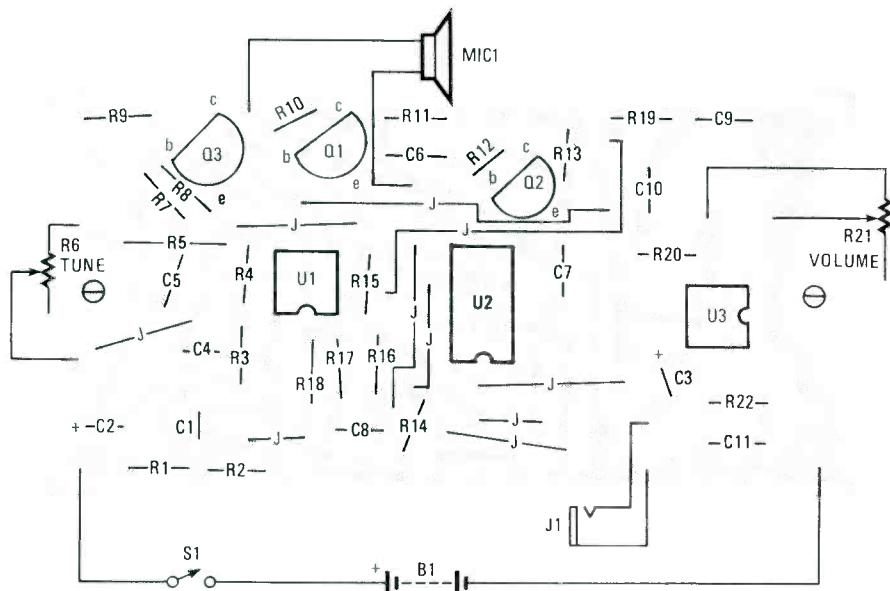
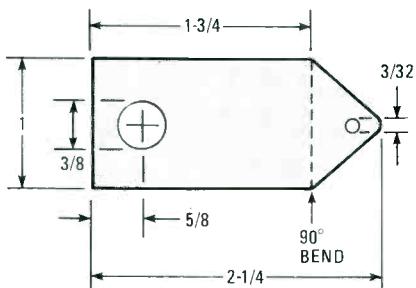


Fig. 3. Use this printed-circuit layout as a guide when installing the components on the printed-circuit board.



ALL DIMENSIONS IN INCHES

Fig. 4. Shown here are the construction details of the small metal "L" bracket that's used to hold the Receiver's circuit board in place.

bracket that's held in place by way of R6, the tuning potentiometer. Figure 4 shows how to fabricate the "L" bracket. The battery holder is mounted to the back side of the circuit board's mounting screw with a 1/4-inch spacer between the board and holder.

Check Out and Use. Power up the circuit, set the volume and tuning controls to a center position and, with headphones in place, rub your fingers together in front of the piezo pickup. If all is working, you should hear a sandpaper-like sound. Fill your hand with a few small metal screws, nuts, and washers and shake them around in front of the pickup. It should sound something like a Chinese New Year celebration. While running those tests rotate the tuning potentiometer and you should get an ear full of unusual sound effects.

The oscillator's tuning range should fall between 15 kHz and 35 kHz. That allows sound to be heard within a range of less than 15 kHz to near 40 kHz. The low-frequency end may seem too low, but a number of people, for one reason or another, cannot hear sounds much higher than 10 to 12 kHz. Also that extended low-end feature can be

PARTS LIST FOR THE ULTRASONIC RECEIVER

SEMICONDUCTORS

- U1—TL082CP or MC34002P dual JFET-input op-amp
- U2—4066 Quad bilateral switch integrated circuit
- U3—LM386 Audio power amp integrated circuit
- Q1-Q3—2N3904 NPN general-purpose transistor or similar device

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted.)

- R1, R2, R9, R11, R13—2200-ohm
- R3, R4, R7, R8, R14, R20—10,000-ohm
- R5—15,000-ohm
- R6—25,000-ohm potentiometer
- R10, R12—220,000-ohm
- R15, R18—100,000-ohm
- R16, R17—47,000-ohm
- R19—1000-ohm
- R21—5000-ohm potentiometer with on/off switch
- R22—10-ohm

CAPACITORS

- C1, C3—47- μ F, 16-WVDC electrolytic
- C2—220- μ F, 16-WVDC electrolytic
- C4—680-pF ceramic disc
- C5, C10, C11—0.1- μ F ceramic disc
- C6, C7—.018- μ F mylar or similar
- C8, C9—.068- μ F mylar or similar

ADDITIONAL PARTS AND MATERIALS

- B1—9-volt transistor radio battery.
- J1—1/4-inch phone jack
- MIC1—3 1/4-inch piezo tweeter (Radio Shack 40-1382, or similar piezo transducer)

S1—See text (part of R21)

Printed circuit or perfboard materials, enclosure (see text), IC sockets, knobs, battery and battery holder, wire, solder, "L" bracket (see text), hardware, etc.

Note: A complete kit of parts (excluding the piezo speaker and small "L" bracket) is available for \$34.95 postage paid from Krystal Kits, PO Box 445, Bentonville, AK 72712. Please allow 6 to 8 weeks for delivery.

useful in medium-frequency, low-level sound experiments.

Exploring the Ultrasonic World. If you're an outdoor person, there's plenty of tiny crawling creatures out there that produce a wide range of ultrasonic sounds. Also many mechanical moving objects, such as engines, office equipment, etc., emit a wide range of sound and noise that can fall within the tuning range of the receiver.

Take a dog whistle and tune in to see
(Continued on page 161)



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.

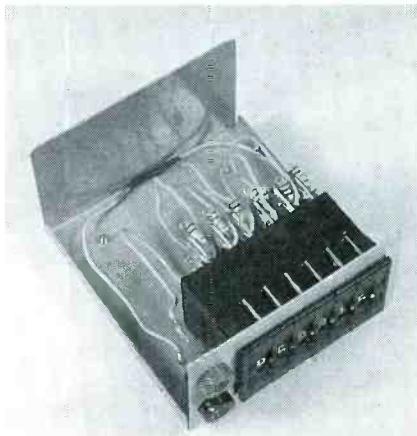
Our version of that circuit aid, the Easy-Dial R-Box, provides a wide range of resistances—adjustable in one-ohm steps—ready to plug into your circuits. Selecting a value is simple with the Easy-Dial R-Box: Six thumbwheel switches let you choose any value from 0 to 999,999 ohms. And, as an added benefit,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



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

result is that the resistance between each COMMON and a terminal is proportional to the number displayed on the thumbwheel.

For example, if you set S1 to position 9, there are nine 1-ohm resistors in series between S1's COMMON and a 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

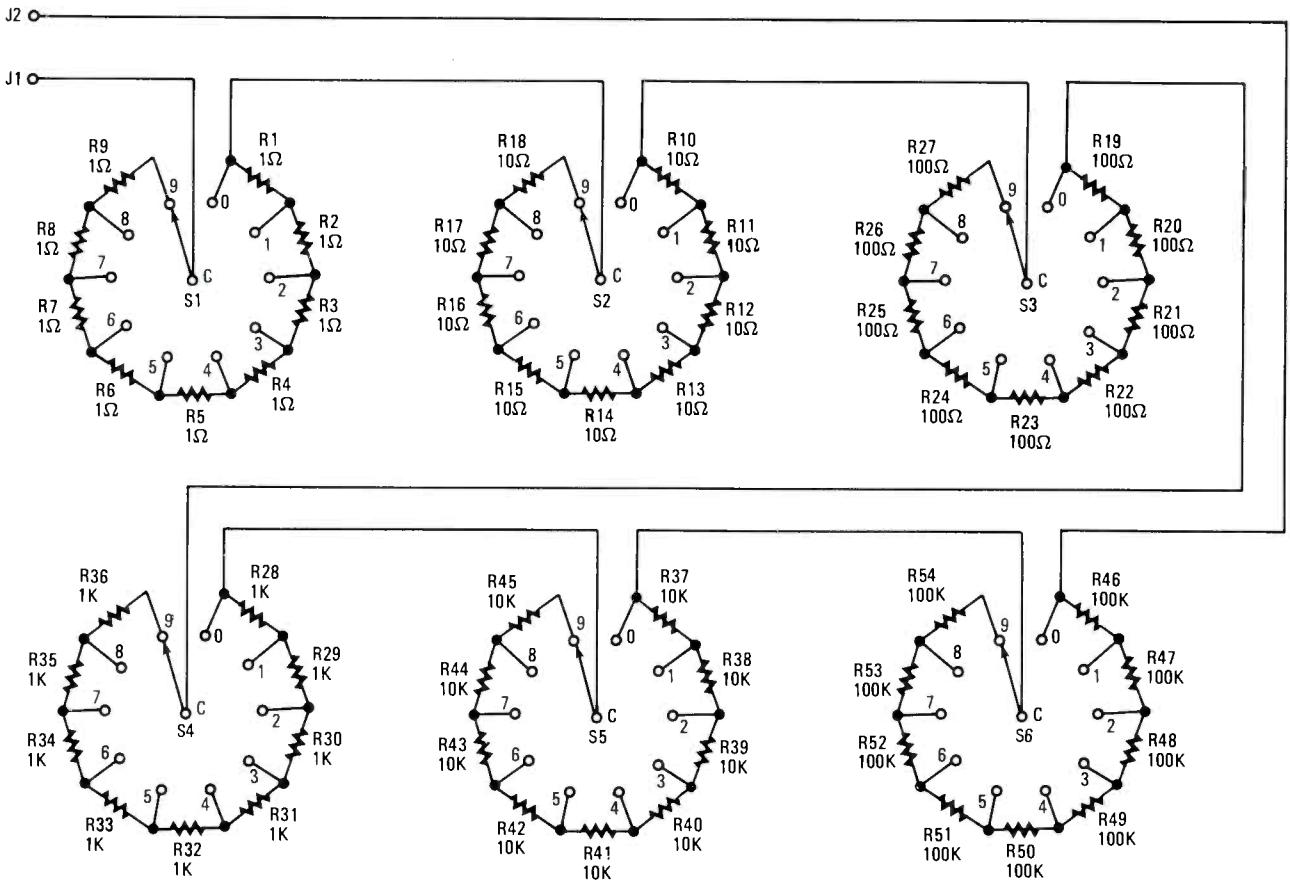


Fig. 1. The R-Box contains six decimal thumbwheel switches wired in series. The resistance between J1 and J2 can be adjusted in 1-ohm steps from 0-ohm to 999,999-ohm.

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 $\frac{3}{8}$ -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 $\frac{1}{4}$ inch of insulation from the ends of

PARTS LIST FOR THE EASY-DIAL R-BOX

(All resistors are $\frac{1}{2}$ -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.

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.

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 155)

Photoflash Power System

BY W. E. BABCOCK

How often have you missed that "once in a lifetime" indoor shot because the batteries in your electronic flash unit had gone dead at the most inopportune time; or missed a shot because the time required for the flash unit to charge was 20 seconds or longer?

Most modern flash units are powered from four "AA" size batteries. Although the manufacturer's specifications may state that 75 flashes or more can be obtained from one set of alkaline batteries, the recycling time becomes very long after a relatively small number of flashes. Heavy-duty units (with larger batteries and/or a higher voltage capacity) are readily available, but they are very expensive.

Recently, I became aware of the availability of compact, gelled-electrolyte, lead-acid storage batteries. Such gel-cell batteries can be used in any position with no danger of spilling the electrolyte, and are available in a fairly wide range of ampere-hour capacities and physical sizes. So I decided to adapt one such battery to power my flash unit.

It seemed to me that I should be able to fashion a battery holder that would allow the battery to be clipped to my belt; then a flexible cable could be used to connect the battery to the flash unit.

A Successful Venture. The conversion of my flash unit so as to allow it to operate from the gelled-electrolyte storage battery was, in my opinion, a great success. I have just returned from a 2-week tour of Germany and Austria, where I used the unit every day of the tour. There were many occasions when the flash unit was left on continuously for periods of up to 2 hours.

In no case was the recycle time after a flash longer than 3 seconds; and when the unit was operated in the "au-

Build a high capacity power system for your electronic flash unit and never miss a shot!

tomatic" mode, the recycling time was essentially instantaneous. The battery used weighed 23.2 ounces, but, with it clipped on my belt, I was hardly aware of it at all.

My flash unit is a Vivitar model 283. Other makes and/or models may require some modification of the following instructions, however it should be relatively easy to adapt the instructions to almost any flash unit. However, before you dive head-on into converting your flash unit, a word of caution is in order: If your flash unit is still under warranty, you should consider the fact that altering the unit (no matter how slight) in all likelihood will void the warranty.

Making the Change. The gelled-electrolyte lead-acid battery used for the conversion is available (as part P129) from Digi-Key Corporation, PO Box 677, Thief River Falls, MN 56701, for \$15 (plus shipping and handling). The battery's dimensions are 4 $\frac{1}{8}$ inches high by 2 $\frac{1}{16}$ inches wide by 1 $\frac{1}{16}$ inches thick.

The battery has quick-disconnect type terminals similar to those used in an automobile's electrical wiring system. In my case, all the other parts used were taken from my moderately stocked junkbox, but if you don't have such parts in your junkbox, they can be purchased and are readily available from local electronics stores.

Prepare the battery by connecting a short length of cable to the battery terminals. Those terminals, and the bare ends of the cable, are then covered with black-vinyl electrical tape. A 30-



inch length of cable, with an appropriate connector attached to one end, is plugged into the jack on the short cable when the battery is used to power the flash unit.

When the battery is in need of charging, another length of cable from a suitable battery charger plugs into the jack. For the connecting cable, I used a length of shielded cable salvaged from

an old tape recorder. The cable was only about $\frac{1}{8}$ inch in diameter and already had a phono plug at one end. I merely soldered a phono jack to the other end to complete the cable.

Figure 1 shows details of the home-made belt clip, which was glued on the back of the battery to allow it to be hung from a belt. The clip was cut, using tin snips, from a piece of aluminum flashing material (any other thin sheet metal that may be available can also be used) and bent as shown. About a dozen $\frac{3}{16}$ -inch holes were drilled through the end that attaches to the battery in order to increase the holding power of the adhesive.

The author used Duco cement, an

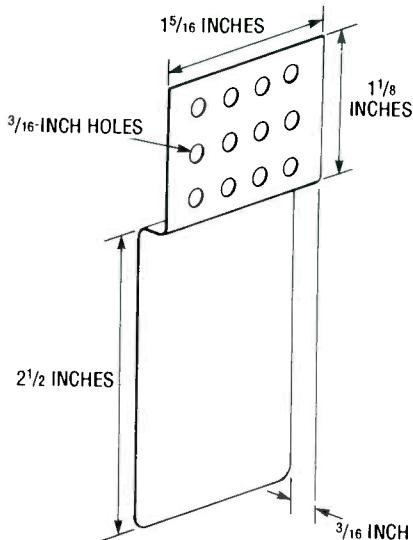


Fig. 1. Here are the construction details of the home-made belt clip, which was glued on the back of the battery so as to allow it to be hung from a belt.

adhesive that bonds very well to the outer casing of the battery. A liberal quantity of the cement was first spread on the battery case so that when the clip is put in place, the adhesive oozes through the holes in the clip. Then a liberal quantity of cement was spread on the back of the clip so that the area where the holes are drilled is completely covered. That makes for a more secure bond between the battery casting and the belt clip.

Allow the cement to dry overnight before attempting to hang the battery on your belt. If you wish, you can paint the clip black so it will blend with the case of the battery.

If you examine the battery compartment of your flash unit, you will see that metal straps are used to connect the batteries in series, so that four 1.5-volt batteries provide 6 volts to the internal

circuitry of the flash unit. The battery case, which fits into the flash unit's battery compartment, has cavities (see Fig. 2) to hold four "AA" cells.

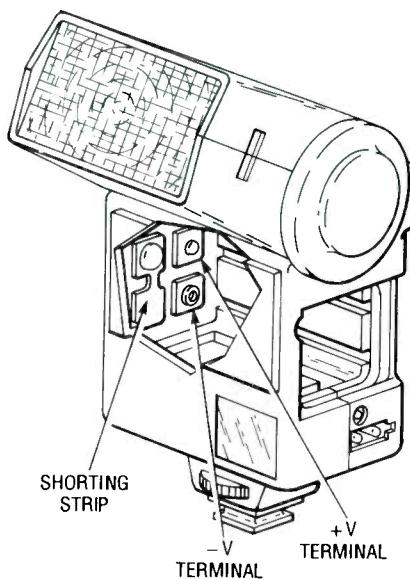


Fig. 2. The battery compartment within the flash unit contains a holder having four cavities with metal shorting strips to place the batteries in series.

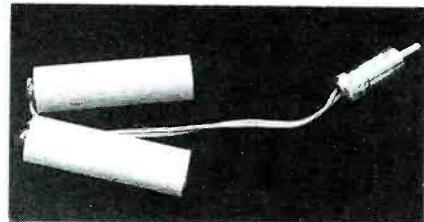
The two cavities corresponding to the shorting strap in Fig. 2 can be left empty. The other two cavities correspond to the positive and negative 6-volt terminals of the flash unit. Half-inch wooden dowels, cut to the length of an "AA" battery (about 1 1/8 inch) are placed in those two cavities. A #6 round head, brass wood screw is screwed into the end of each dowel.

A short length (about 4 1/2-inch) of cable is soldered to the two screw heads. In my conversion, I used a short length of 2-conductor loudspeaker wire as the connecting cable, but almost any type of insulated wire could be used.

However, remember that the wire must be fed around the battery case and through the gap around the cover, which secures the battery holder in

PARTS LIST FOR THE ELECTRONIC FLASH UNIT

- B1—1.5-amp, 50-PIV, full-wave bridge rectifier
- T1—6.3-volt, 300-mA, filament transformer
- R1—10-ohm, 1-watt, 5% resistor
- PL1—117-VAC plug with line cord
- PL2—Plug selected to mate with battery connector (J1)
- J1—See text
- Gelled-electrolyte lead-acid battery, wire, solder, hardware, etc.



To connect the high-capacity battery to the flash unit, speaker wire with a phono plug at one end is connected to a couple of wood dowels (cut to the length of "AA" batteries) with screws.

place, so the outer diameter of the wire should be as small as practical.

To ensure good flexibility of the cable and to prolong its life, the wire should be of the stranded variety. When the dowels are inserted into the battery holder within the flash unit, the heads of the screws contact the positive and negative terminals, so that power is applied to the flash-unit circuitry in the usual manner.

Note: You may need to file a little of the plastic from the edge of the battery compartment, and possibly from the battery cover, in order to bring the wire out of the flash unit and still be able to keep the battery holder and cover in place.

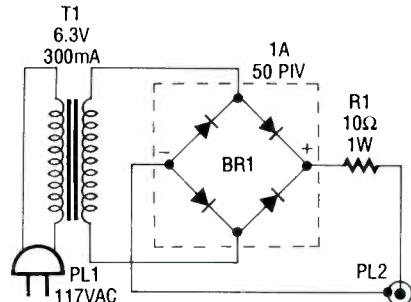


Fig. 3. Although rather simple in design, this circuit can be used to charge the gelled-electrolyte, lead-acid battery used to convert the flash unit.

Battery Charger. A charger for the battery can be made from a 6.3-volt filament transformer, a bridge rectifier (or 4 individual rectifier diodes with the proper rating), and a current-limiting resistor. A schematic diagram of the charging circuit used by the author is shown in Fig. 3.

The high-capacity power source for your flash unit should pay for itself in a remarkably short time, since you will no longer need to buy any more "AA" batteries. More important, you will be saved the aggravation and missed shots resulting from low or dead batteries.

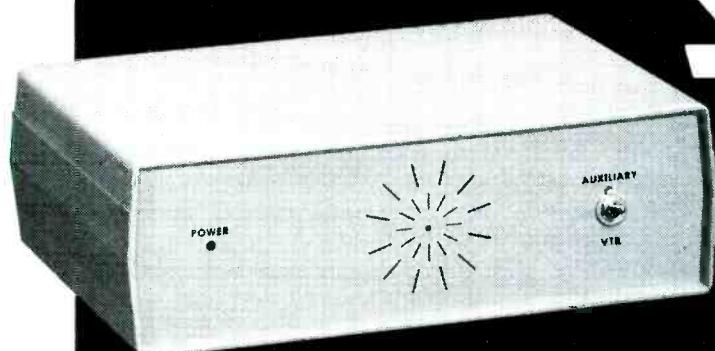
When television broadcasting began, it was impossible to foresee the large variety of video sources that would someday be available to the consumer; for instance, cable TV converters, videc cassette recorders (VCR's), video games, satellite receivers, and a host of products as yet unheard of in the video marketplace. Thus, TV manufacturers did not see fit to endow their receivers (except for the more recent units) with multiple-input capabilities, and so today we suffer from that unfortunate handicap.

To compensate for that oversight, multiple-input capability has been handled (through after-market devices) in a rather cumbersome way: all video devices modulate their output signal to an unused TV channel, and an external RF switch is used to select which video source is to be viewed.

Why Baseband Switching? To illustrate the awkwardness of the modulate/switch/demodulate scheme, imagine a hi-fi system in which all audio sources (turntable, cassette recorder, CD player, etc.) are FM modulated before being sent to a receiver, where the desired program material is selected.

Aside from the obvious cost increase (extra circuitry can add a couple hundred bucks to equipment prices), no serious audiophile would ever consider degrading the high-quality output of a CD player by modulating the signal and then demodulating it again to produce a considerably degraded adaptation (with

The Video/Audio Switcher



BY FERNANDO GARCIA VIESCA

Add this baseband-signal switcher to your home-entertainment center and preserve the audio/video clarity lost to modulation/demodulation schemes!

bandwidth and dynamic-range limitations, noise, and distortion products) of the CD output.

The same holds true for video. Why modulate a video signal and thereafter be subjected to a demodulated and degraded signal? Fortunately, most new video products have been endowed with baseband video and audio input/output capabilities. Only the cheaper television receivers provide only RF inputs. In fact, baseband video and audio inputs, once only found on very expensive monitors, are appearing on medium-priced sets.

Although signal-source switching must still be handled through external equipment, the availability of baseband signals allows us to switch video signals in the same way that a hi-fi system switches audio.

Signal Comparisons. Since a picture is worth a thousand words, let's compare the waveforms taken from a good modulator/demodulator arrangement to those taken from the *Baseband Video Switcher* described in this article. Figure 1 shows a video test signal known as a *multiburst* signal. That signal has several frequency bursts at 0.5, 1.0, 2.0, 3.0, 3.58, and 4.0 MHz. Note that the amplitude of the signal is diminished ever so slightly from the low-frequency burst (0.5 MHz) to the high-frequency burst (4.0 MHz).

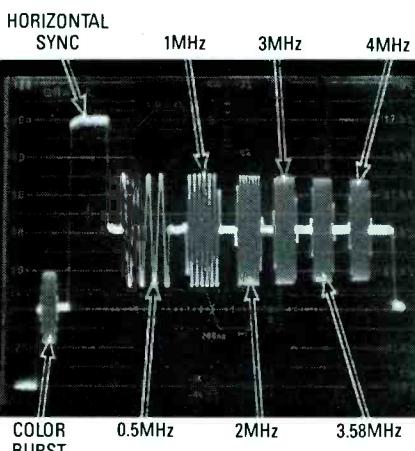


Fig. 1. This video test signal, known as a multiburst, has several frequency bursts at 0.5, 1.0, 2.0, 3.0, 3.58 and 4.0 MHz. Note that amplitude of the signal is diminished ever so slightly from the low-frequency burst (0.5 MHz) to the high-frequency burst (4.0 MHz).

Now look at Fig. 2, which shows the same signal after RF modulation and demodulation; the differences in amplitude between bursts are more ap-

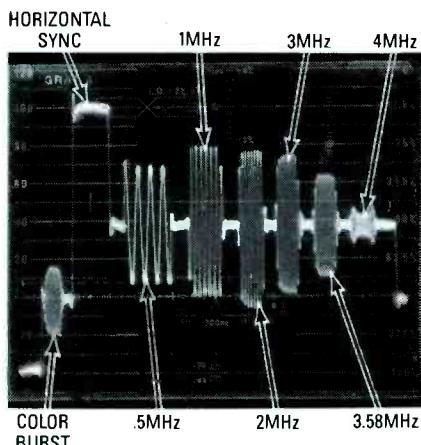


Fig. 2. Here is another view of the multiburst test pattern after being fed through a modulator/demodulator network. Note that the differences in amplitude between bursts are more apparent, and that the 4.0 MHz burst has almost vanished.

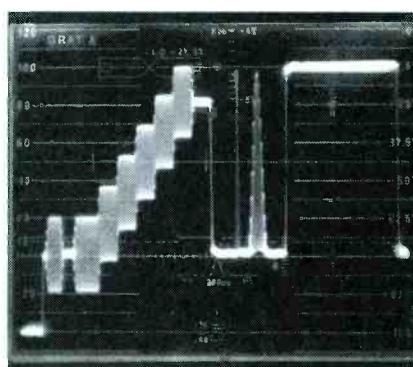


Fig. 3. The composite video pattern includes a chroma-modulated staircase, a fast-risetime pulse, and a 2T burst signal. Note the fast risetime and negligible overshoot in the waveform through the baseband-switching device.

parent. Note that the 4.0 MHz burst has almost vanished. Many will point out that actual TV signals contain no significant information above 3.58-MHz, therefore its useless to care about 4.0 MHz. That is only partly true: To explain, lets return to the audio analogy.

Although even rock-and-roll music seldom has any worthwhile signal content above 15 kHz, studies have shown that a much wider bandwidth is required to accurately reproduce the signal. Audio manufacturers strive to make their products usable to at least 20 kHz.

Figure 3 shows another test pattern, known as a *composite video* signal. That pattern includes a chroma-modulated staircase, a fast-risetime pulse, and a 2T burst signal. Note the fast risetime and negligible overshoot in the waveform through the baseband switching device.

Now refer to Fig. 4, which shows the

same signal after passing through a modulator/demodulator combination. Note the distortion in the signals. In particular, the 2T burst signal shows a curved deformation at the bottom, indicating chroma/luminance delay. We could show you other test patterns, but by now you should have become a believer. Its better to perform the most critical test, viewing the TV image, to see what you have been missing.

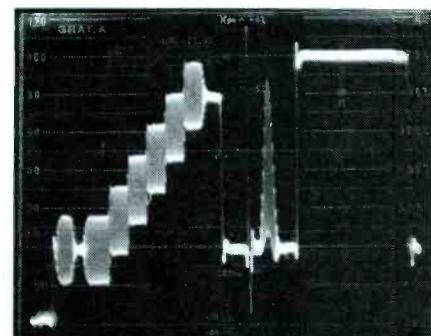


Fig. 4. Here's the Composite Video signal after being fed through a modulator/demodulator combination. Note the distortion in the signals. In particular, the 2T burst signal shows a curved deformation at the bottom, indicating chroma/luma delay.

General Circuit Description. Figure 5 is the schematic diagram for a two-channel version of the Baseband Video Switcher. (Note: Additional channels can be added as desired.) At first glance, the circuit may appear complicated, but don't let that worry you—the circuit is mostly wiring and switching devices.

The circuit provides 75-ohm, buffered-video input/output ports; stereo-compatible buffered audio inputs and outputs; and tape monitor and second-source-viewing capabilities (the ability to view one source while recording another). Video-signal switching is accomplished via DIP reed relays (K1 through K3). Audio switching is handled by a pair of 4053 analog multiplexer/demultiplexers (U7 and U8). Relays are used for the video signal because of the very low impedance involved in video; the residual "on" resistance of the analog IC switches would create undesirable attenuation.

Each audio/video source is divided into three individual signals: video, left audio, and right audio. Before any switching is done, each signal is fed to a buffer circuit in the channel to which it is connected; two channels (denoted Channel A and Channel B)—consisting of U1 through U3 and U4 through U6, respectively—are shown.

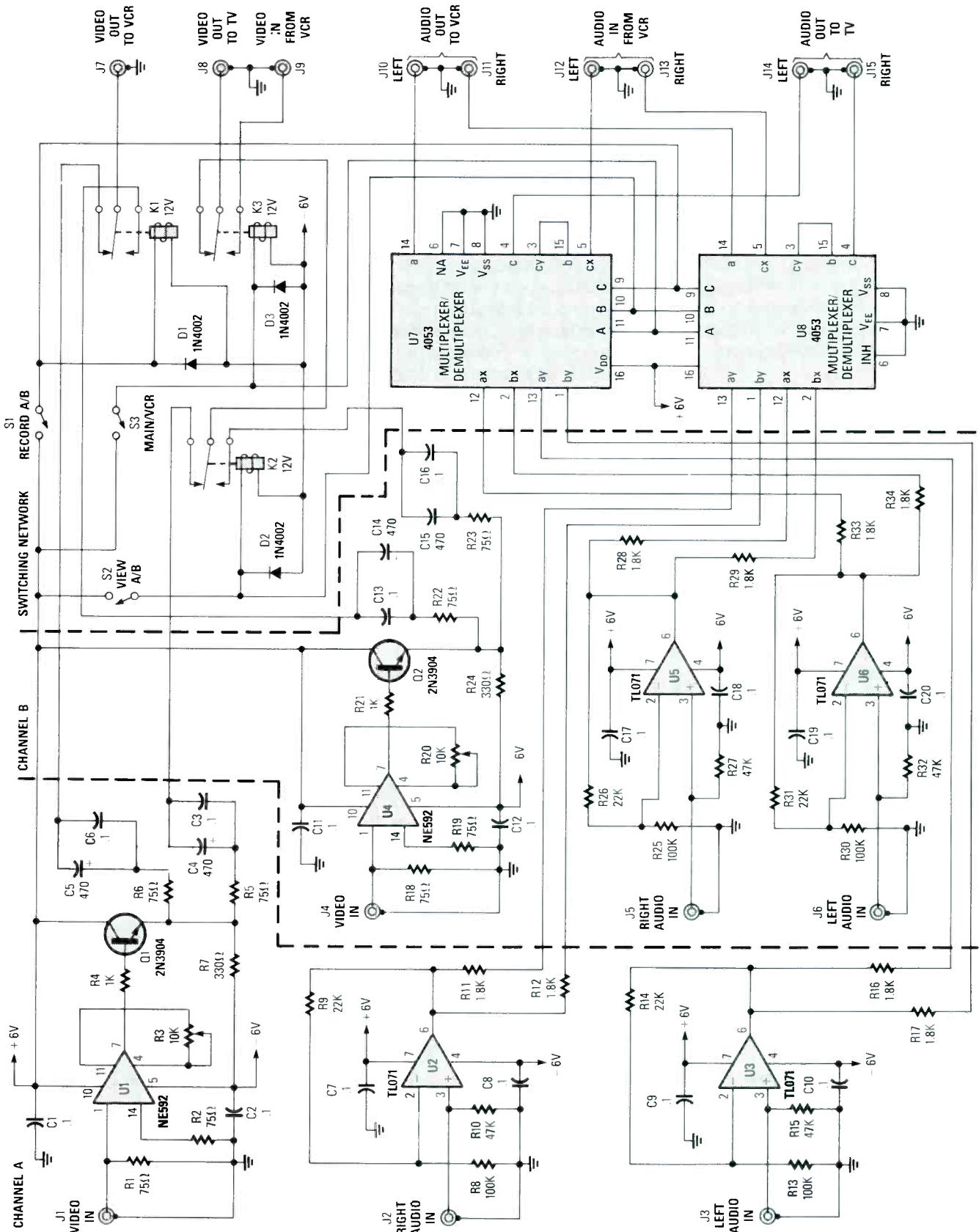


Fig. 5. Here is a schematic diagram of the two-channel version of the Baseband Video Switcher. (Note: Additional channels can be added as desired.) The circuit provides 75-ohm buffered, video-input/output ports, stereo-compatible buffered audio I/O's, and tape-monitoring capabilities. It also allows you to record a different source from the one being viewed.

Each buffer circuit has two outputs. The two outputs of the audio buffers are fed to a pair analog multiplexer/demultiplexers (U7 and U8), which are controlled by switches S1–S3. The video outputs are switched via K1–K3, and are also controlled by S1–S3.

Whenever switch S1 is open, K1, U7, and U8 route the Channel A signal to the VCR input; when closed, the Channel B signal is routed to the input of the VCR. Before being fed to the TV monitor input, we have another level of switching, handled by K3, U7, and U8, and controlled by the TV/VCR switch, S3. That switch allows you to view the main video signals (the signal fed through the buffer circuitry) or you can monitor the VCR output.

Buffer Circuits. Now let's concentrate our attention on the Channel-A portion of the circuit as we take a closer look at the buffering circuits. The right audio input of U2—a TLO71 low-noise bi-FET op-amp—which provides a slight signal gain to compensate for expected signal losses across R11 and R12, which protect U2 against short-circuit conditions. (The left audio input to Channel A is handled in an identical fashion by U3 and its associated components.)

Aside from protecting U2, R11 and R12 passively divide the output of U2 along two paths, while preventing interference between the two outputs. The outputs of the audio buffers (left and right) are fed to U7 and U8.

Video-signal buffering is handled by U1 (an NE592 video amplifier). The video-buffer circuit has an input impedance of 75 ohms (as determined by R1). The gain of U1 is set by R3 (a 10,000-ohm unit, connected between pins 11 and 4), which should be adjusted to yield a 1-volt peak-to-peak output (a gain of slightly higher than two).

The output of U1 is fed through R4 to the base of Q1 (a 2N3904 general-purpose transistor, configured as an emitter-follower), which provides sufficient current to drive a pair of 75-ohm loads.

Because of the large output-voltage offset, direct-coupling is not possible. So capacitors C4 and C5 are included in the circuit to block the DC content of the video signal. Since electrolytic capacitors have a fairly high, equivalent series resistance, C4 and C5 are bypassed by a pair of 0.1- μ F ceramic capacitors (C3 and C6 in Fig. 5) to maintain good frequency response of the circuit.

Audio/Video Switching. Separate switching networks are provided for the audio and video signals. Audio switching (as mentioned earlier in this article) is handled by a pair of 4053 triple 2-input analog multiplexer/demultiplexers (U7 and U8). The 4053 can be viewed as little more than three electronically controlled, single-pole, double-throw semiconductor switches. Each switch has one terminal connected to Channel A and the other connected to Channel B.

The right audio input of Channel A is fed to U8 at pins 1 and 13, while the left audio input is fed to U7 at pins 1 and 13. (Remember that Channels A and B perform identical operations, so any description of Channel A's operation is also applicable to Channel B.)

The control terminals (pins 9, 10, and 11) of U7 and U8 are connected to switches S1, S2, and S3 (which also control the video outputs). When S1 and S2 are open, no +6-volt trigger signal is applied to the pin 9 and 10 control inputs of U7 and U8, so the left and right Channel A signals are then routed to the final stage of switching. When S1 and S2 are closed, however, the Channel B input is routed to the final stage of switching.

Video signal switching is handled in much the same manner, except that instead of multiplexer/demultiplexers, the switching is done by three single-pole, double-throw DIP reed relays. As with the audio section, the signal source is selected via S1, S2, and S3, and follows the same sequence as the audio section. That is, when S1 and S2 are open, the Channel A video source is fed to the final stage of switching; with those switches closed, the Channel B source is routed to the final stage of

switching. Note that regardless of which source channel (A or B) is selected, its signal will always be present at J7.

The output of K2 is routed to K3, which determines which video source is displayed on the TV screen. Switch S3 determines which source—main (buffered signal source) or VCR output—is routed to the TV receiver. With S3 open, the selected buffered source is output to the TV; with it closed, the VCR output is routed to the TV.

Power Supply. Figure 6 is the schematic diagram of the power-supply portion of the AV switch circuit. Power for the circuit is provided by a bipolar (+/-) 6-volt supply, consisting of a transformer (T1), a bridge rectifier (made up of D4 to D7), a pair of voltage regulators, and four capacitors (C21 through C24). A series resistor/LED combination (R35 and LED1)—which is connected across the positive and negative supply rails—is included in the circuit as a power-on indicator.

There is nothing critical about the power supply for the circuit; in fact, any power supply capable of supplying +/-6 volts of reasonably ripple-free DC will suffice. Power-supply component substitutions are also permissible. For instance, the four diodes that make up the bridge rectifier can be replaced by a 1-amp, 50-volt (50-PIV), or better, full-wave bridge rectifier. And T1 can be replaced by any center-tapped unit capable of supplying 18-volts peak-to-peak (perhaps, a 24-volt unit) with a current rating of at least 100 mA.

No AC switch is provided since power consumption is so small; but one may be included if desired. To add an on/off switch, simply insert a switch in series with one of the transformer's AC inputs.

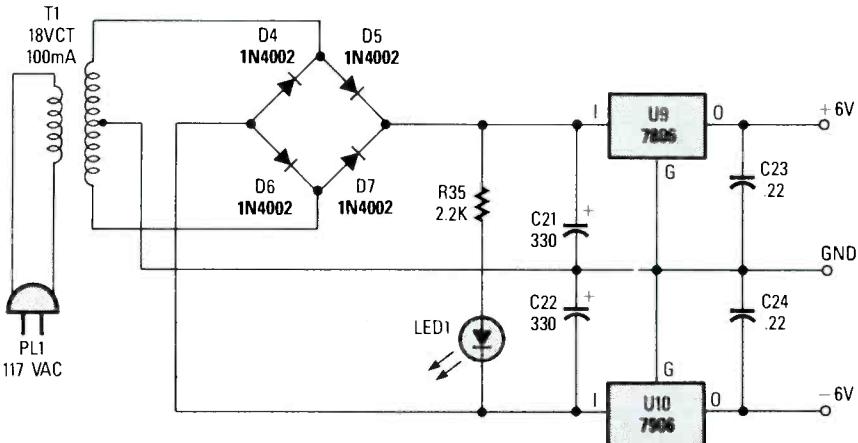


Fig. 6. The audio/video switch is powered from a bipolar 6-volt supply like the one shown here. Since the switcher's current draw is so low, no on/off switch is included, but one can be added in series with the AC line if desired.

Construction. There is nothing critical about the construction of the Baseband Video Switcher. Either point-to-point wiring or the printed-circuit method may be used. But whichever method you opt for, remember that high-frequency signals can pose some coupling problems. Therefore, it is recommended that signal-input runs be kept

PARTS LIST FOR THE BASEBAND VIDEO SWITCHER

SEMICONDUCTORS

- U1, U4—NE592 video amplifier, integrated circuit
- U2, U3, U5, U6—TL071 low-noise, bi-FET op-amp, integrated circuit
- U7, U8—CD4053 triple 2-channel analog multiplexer/demultiplexer, integrated circuit
- U9—7806 6-volt, 1-amp, positive-voltage regulator, integrated circuit
- U10—7906 6-volt, 1-amp, negative-voltage regulator, integrated circuit
- Q1, Q2—2N3904 general-purpose NPN transistor
- DI—D7—IN4002 rectifier diode
- LED1—Miniature light-emitting diode

RESISTORS

- (All resistors are $\frac{1}{4}$ -watt, 5% units, unless otherwise noted.)
- R1, R2, R5, R6, R18, R19, R22, R23—75-ohm
 - R3, R20—10,000-ohm trimmer potentiometer
 - R4, R21—1000-ohm
 - R7, R24—330-ohm
 - R8, R13, R25, R30—100,000-ohm
 - R9, R14, R26, R31—22,000-ohm
 - R10, R15, R27, R32—47,000-ohm
 - R11, R12, R16, R17, R28, R29, R33, R34—1800-ohm
 - R35—2200-ohm, $\frac{1}{2}$ -watt, 5%

CAPACITORS

- C1—C3, C6—C13, C16—C20—0.1- μ F ceramic-disc
- C4, C5, C14, C15—470- μ F, 16-WVDC electrolytic
- C21, C22—330- μ F, 16-WVDC, electrolytic
- C23, C24—0.22- μ F, 50-WVDC, ceramic disc

SWITCHES

- S1, S2, S3—SPST miniature toggle switch
- K1, K2, K3—12-volt DIP reed relay (form C)

ADDITIONAL PARTS AND MATERIALS

- J1—J15—RCA phono jack
- T1—18-volt, CT, 100-mA, power transformer
- Printed circuit or perfboard materials, enclosure, IC sockets, coax cable, wire, solder, hardware, etc.

separate (*i.e.*, do not run them close together). In addition, signal wires should be kept as short as possible, and be made using coax cable.

The author's prototype was built entirely on perfboard, but for convenience a printed-circuit board for the buffer section is shown in Fig. 7. Note: For a two-channel unit like that shown in the Fig. 5 schematic diagram, it will be necessary to etch two such boards. The purpose of doing things that way is to allow for flexible switching arrangements.

For example, you may wish to use more sources than the two shown in the schematic diagram. It is very easy to do; you need only use the appropriate number of relays and analog switches, and buffer each source with the buffer board shown in Fig. 7.

No printed-circuit board is provided for the switching network (U7, U8, and K1-K3), so that section of the Baseband Video Switcher will have to be hard-wired to the buffer board(s). As an alternative to hard-wiring the switching network, you might consider developing your own printed-circuit pattern for that section, and combine the switching-

network pattern with the buffer-board pattern in the etching process. In that way, all that you'll need to do is jumper the two patterns together at the appropriate points. Or, if you are a fairly competent PC-pattern draftsman, you might consider developing a complete circuit-board pattern with all components on a single board.

The parts-placement diagram for the Baseband Video Switcher's buffer board is shown in Fig. 8. Once you've obtained the components listed in the Parts List and etched your board(s), begin assembly by first installing IC sockets at the appropriate points on the printed-circuit board(s). The IC sockets will function as reference points when attempting to locate the proper positions for the other components.

Calibration. The Baseband Video Switcher circuit is very stable; any noise or spurious oscillation will be mainly due to poor grounding or routing techniques. Note that each buffer board has a pair of outputs for each signal path, those outputs are identical and may be interchanged.

The only adjustment required is to

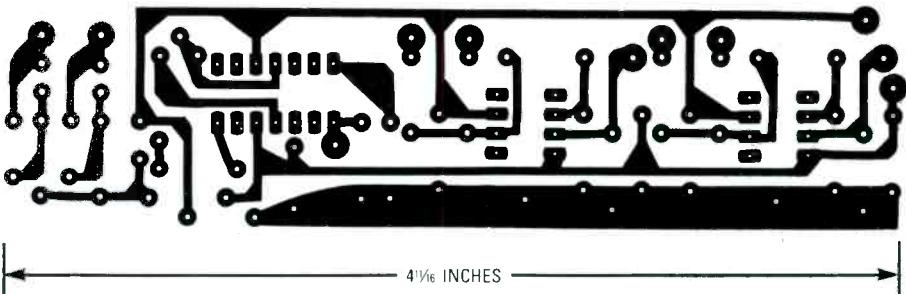


Fig. 7. A printed-circuit board for the buffer portion of the Baseband Video Switcher is shown here. For a two-channel unit, like that shown in the schematic diagram, it will be necessary to etch two such boards. The purpose of doing things that way is to allow for flexible switching arrangements.

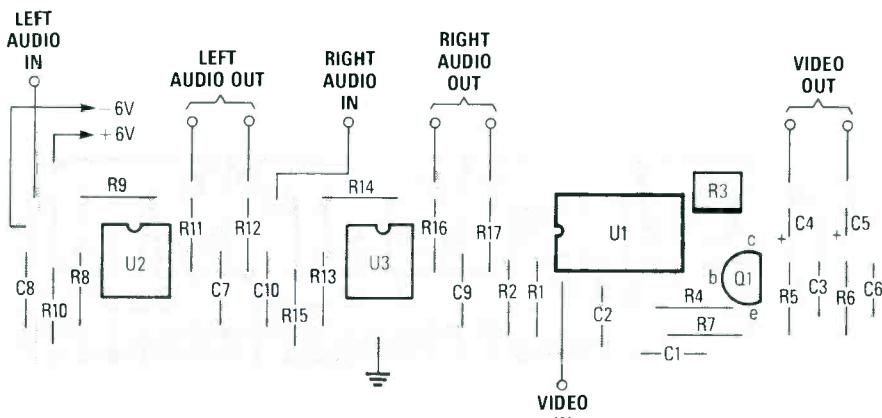


Fig. 8. Don't let this parts-placement diagram fool you. Only half of the buffer-board components listed in the Parts List are indicated here. A second board (identical to this one) contains the remaining buffer components. The switching network and power supply were hard-wired to the circuit.

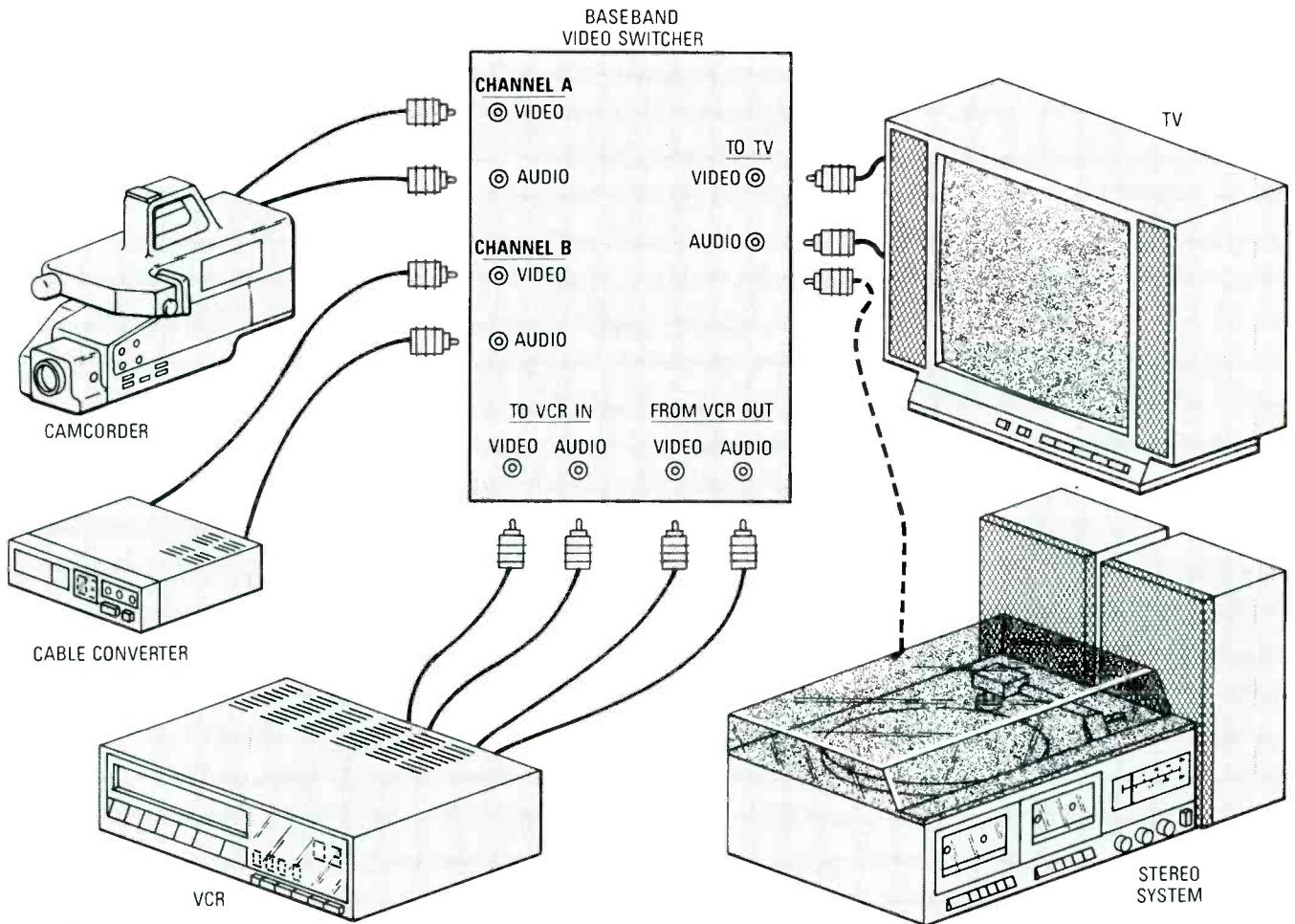
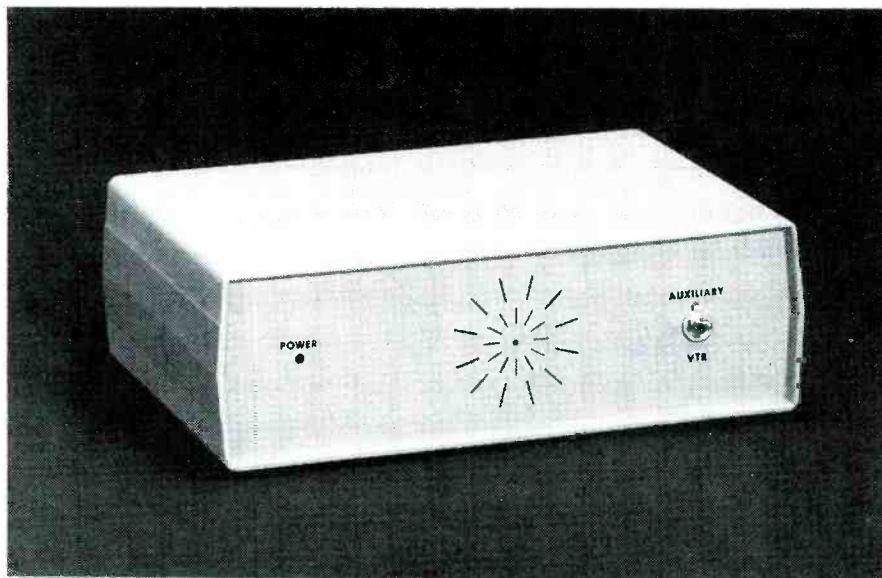


Fig. 9. For the sake of sanity and clarity, only one audio channel is shown in this connection diagram, which assumes that your TV has baseband inputs. Note that the audio-output signal need not go to the TV: It may be fed to the auxiliary inputs of a hi-fi stereo system to obtain a tone-rich, full-spectrum audio output.



Here's the author's completed prototype. The type of cabinet used is not critical, but dressing it up will make it a more welcome addition to your living room.

calibrate for unity gain in the video amplifiers (U1 and U3 in the schematic diagram). The best way of accomplishing that is to feed a video test signal that has a saturated white field and adjust

R3 (and its equivalent) in each buffer board for a 1-volt peak-to-peak output with a 75-ohm termination. If you don't have access to a video-pattern generator, you may use a "live" video signal

and a dual-channel scope; set both channels for 0.5-volt per division and adjust R3 (or its equivalent) so that the output trace is identical in amplitude to the input trace.

For the audio channels, just check that about 10% extra gain is available at the output with a 10,000-ohm load.

After the calibration procedure is completed, install the project in a suitable enclosure, and you are ready to view the difference.

Hooking Up. A suitable hookup is shown in Fig. 9. For the sake of sanity and clarity, only one audio channel is shown. Note that up to this point we are assuming that your TV has baseband inputs. (It may sound obvious, but better safe than sorry). Otherwise this project is not for you.

Note that your audio need not go to the TV. It may be fed to the auxiliary inputs of your hi-fi system to obtain a tone-rich, full-spectrum audio output.

Speaking of audio, a problem may arise if one of your sources is monophonic, and another stereo. In that case, it would be wise to split the signal via a "Y" adapter and feed the monophonic source to both channels. ■

Booster Amp for Your Car Stereo

You drive your new car home from the dealer's showroom, but you're not as happy as you should be. Sure, the car is new; nice color, too! And there's lots of pep coming from the 5-liter engine, and the rack-and-pinion steering is smooth as silk. So why are you unhappy? The radio simply isn't what you expected or paid for!

You got an AM/FM-stereo radio/cassette player with digital tuning. "Top of the line," or so the salesman said, but it doesn't put out enough sound for your listening habits. Oh, it sounds fine if you're just sitting in the driveway listening to the radio; but when tooling down the highway at 45 miles an hour with the windows down, the rear speakers are just barely audible. The road noise drowns them out!

Don't do anything rash, like dump the car, for **Popular Electronics** has the solution—install this dual 20-watt rms Auto-Radio Booster Amplifier in your auto. The Auto-Radio Booster Amplifier (which comes in kit form) is an inexpensive alternative to purchasing and installing one of the commercial units.

The Circuit. What can be said about a dual 20-watt rms amplifier circuit that has all its amplification circuitry buried in two identical semiconductor chips? Examine Fig. 1; only one channel is shown. The other is practically a carbon copy.

The input to the circuit, taken from your car radio's speaker output, is divided along two paths; in one path, a high-power divider network (consisting of R8-R10) provides 4.5-ohm resistance to make the circuit's input impedance compatible with the output imped-



Add audio "umph" to your car radio, and travel the highways in high-fidelity splendor!

BY GORDON KAYE

ance of the car radio. In the other path, the signal is fed to the input of U1 through resistor R7, trimmer potentiometer R21, and capacitor C2. Together R7 and R21 offer a minimum resistance of 27,000 ohms.

Integrated circuit U1 (a TDA-2004 audio power amplifier) amplifies the signal, which is then output at pins 8 and 10 and fed to the loudspeaker. Note:

This amp is designed for use only with car radios whose speaker outputs are referenced to ground; **do not use it with radios that have balanced outputs.**

Putting It Together. There are two ways you can assemble the Auto-Radio Booster Amplifier. You can do it the old fashioned way: Buy the parts, etch a printed-circuit board, drill holes in the board, attach the heat sink, and solder the parts in place. Or, you can do as the author did, purchase the TSM Car-Radio Booster Amplifier Kit (TSM 89).

The latter technique saves considerable shopping time, keeps the cost low, and eliminates the need for the messy process involved with etching a printed-circuit board. If you have a fairly complete junkbox, then the former may be cheaper. And if you design as you build, certainly, the former method is best. It's all up to you!

Refer to Figs. 2 and 3 if you decide to make your own printed-circuit board. Use commonly available inexpensive, one-sided copper-clad board available locally at most electronics-parts stores. The heat sink specified in the Parts List can be any piece of aluminum of the approximate surface size. You can opt for standard store-bought types, but it's cheaper to visit the local hardware store and buy an extruded aluminum channel. The excess aluminum can be used in other projects.

About the Kit. Inspect the kit and you will discover that there is one 6 7/8- by 3 1/4-inch printed-circuit board, an extruded rectangular aluminum channel 6 7/8-inches long, and a plastic zip-bag

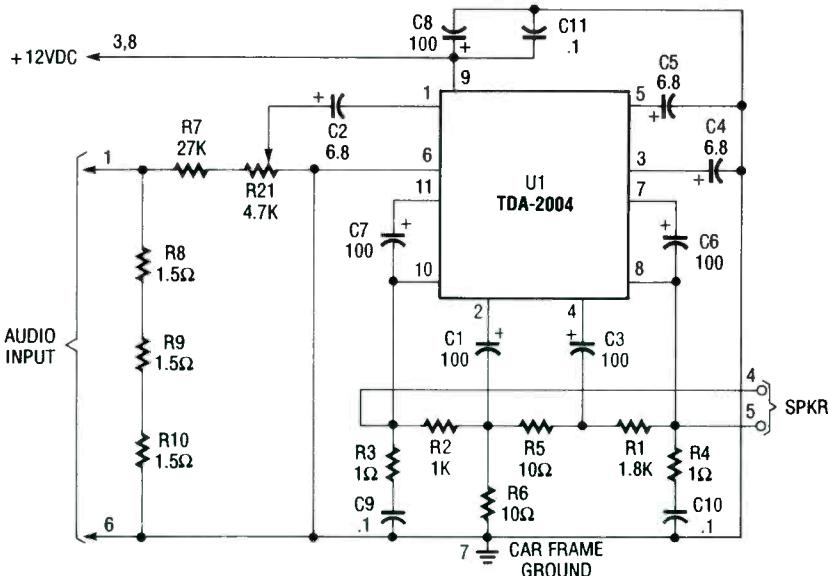


Fig. 1. The two channels of the the Car-Radio Booster Amplifier are identical so only half of the circuit is shown. The numbered terminals (input, output, etc.) correspond to the eleven-pin connector detailed in Fig. 3.

of parts with instruction sheets packaged in a book-like plastic container.

Wiring the printed-circuit board is fairly easy. The printed-circuit board is not densely packed so opportunities for solder bridges are few. Solder all of the parts in place except the audio amplifier IC's. Those IC's are loosely bolted to the holes in the extruded aluminum channel, which serves as a heat sink.

The channel is then placed on the

board while carefully fitting the IC leads into their respective mating holes. The IC's are polarized (so to speak) by their pin orientation, and as such those units will mate with the pre-drilled printed-circuit board only one way. The aluminum channel is then bolted in place and the hardware attaching the IC's tightened.

In addition, there are 16 polarized capacitors (C1–C8, C12–C17, C19, and C20), which must be inserted correctly

before soldering and then rechecked after all are in place. The values of those capacitors are not super critical; in fact, the kit may contain either 100- or 220- μ F units for capacitors C1, C3, C6–C8, C12, C16, C17, C19, and C20; and 6.8- or 10- μ F units for capacitors C2, C4, C5, and C13–C15.

The kit also contains an 11-pin connector, through which power, the input signal, and the output loudspeakers are connected to the board. That connector may be used, or it can be omitted and lead connections soldered to the board at time of installation. You may elect to use a male and female polarized connector (such as the Molex type, which are used in many auto sound system installations) to make installing the circuit a bit easier.

Testing. Working in the trunk of a car, even a hatch back, especially in the summer's sun is not a wise practice. The winter months are just as hostile, so plan to test the Auto-Radio Booster Amplifier indoors.

Connect the loudspeakers (see Fig. 4) to the correct terminals of the booster amplifier. Connect the output from your high-fidelity amplifier to the booster amplifier's input terminals. Connect a 12-volt DC supply to the amplifier using the fuse and fuse holder specified in the Parts List. Connect the fuse holder in the positive line as close to the power

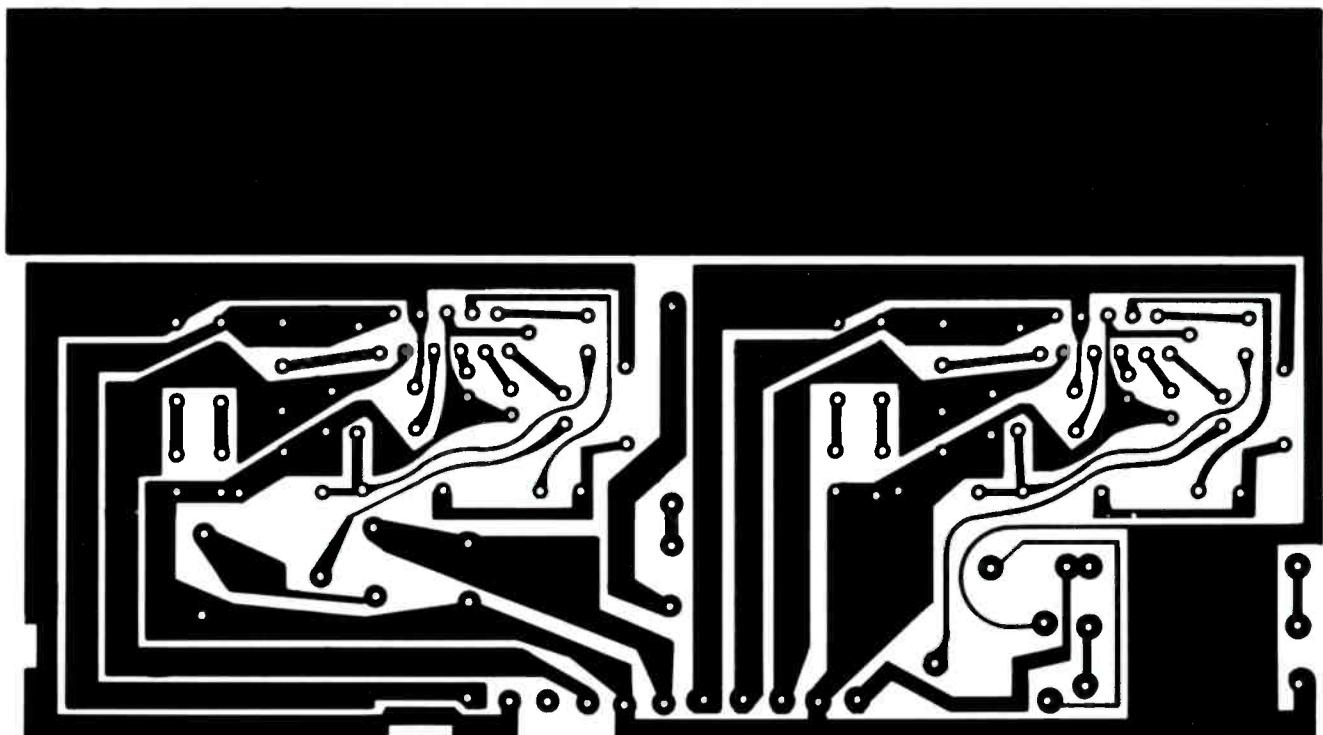


Fig. 2. If you wish to make your own circuit board, use this same-size template. The extra heavy copper runs are use to permit safe handling of heavy currents.

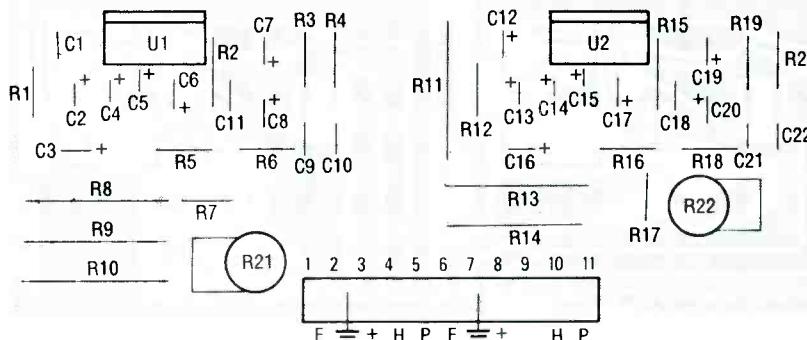


Fig. 3. Parts layout for the Car-Radio Booster Amplifier are shown here. Note that the board is divided into two sections keeping the amplifiers apart.

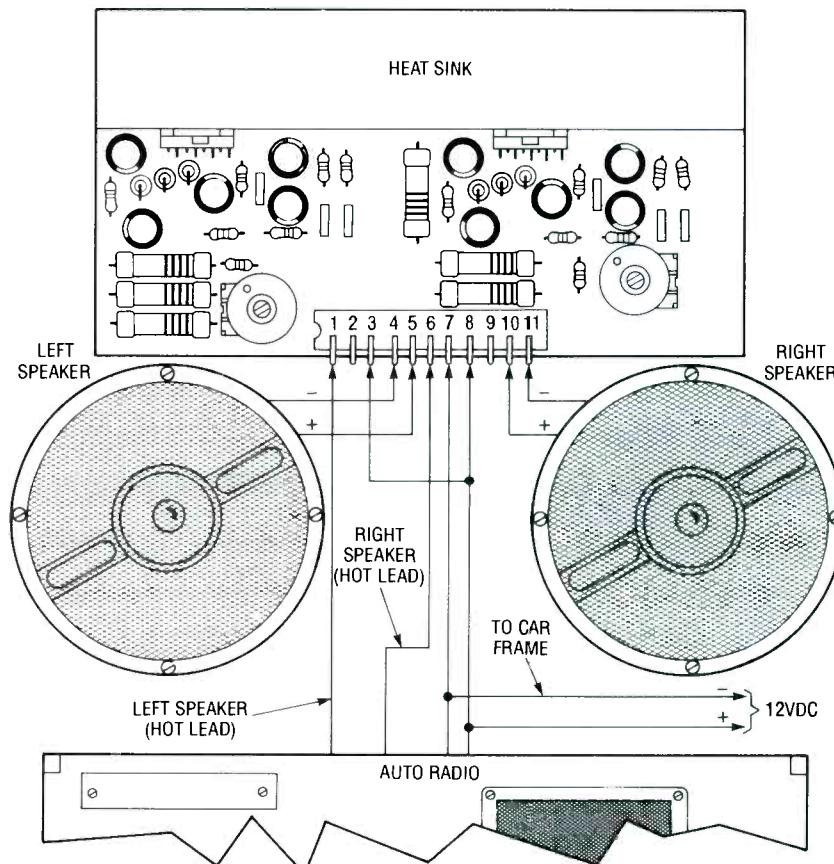


Fig. 4. The installation diagram is simple to follow. Power is taken directly from the auto's battery. There is sufficient filtering on the circuit board to eliminate alternator whine and noise usually found riding on DC voltage.

source as possible. A regulated supply may be used; but, if you use a battery-charger power supply for the amplifier, you must add suitable filtering.

Most battery chargers deliver raw half-wave or full-wave (pulsed) DC. The author avoided power supply problems by connecting a fused line from the car's battery and bringing it into the

house. That allowed the author to use an ordinary high-fidelity home-stereo system as the signal source. Do not power up just yet; be sure that the hi-fi's volume is reduced to its lowest level—even if it's inaudible.

Next, set level-potentiometers R21 and R22 (RV1 and RV2 if your are assembling the project from the kit) to their

PARTS LIST FOR THE AUTO-RADIO BOOSTER AMPLIFIER

SEMICONDUCTORS

U1, U2—TDA-2004, 20-watt rms, audio amplifier, integrated circuit

RESISTORS

(All resistors are $\frac{1}{4}$ -watt, 5% units, unless otherwise noted.)

R1, R12—1800-ohm

R2, R15—1000-ohm

R3, R4, R19, R20—1-ohm

R5, R6, R16, R18—10-ohm

R7, R17—27,000-ohm

R8—R11, R13, R14—1.5-ohm, 2-watt

R21, R22—4700-ohm, PC-mount trimmer potentiometer

CAPACITORS

C1, C3, C6—C8, C12, C16, C17, C19, C20—100- μ F, 16-WVDC, electrolytic

C2, C4, C5, C13—C15—6.8- μ F, 16-WVDC, electrolytic

C9—C11, C18, C21, C22—0.1- μ F, ceramic disk

ADDITIONAL PARTS AND MATERIALS

F1—6-ampere, slow-blow, type 3AG fuse
Printed-circuit board, aluminum heat sink, 3AG-type fuse holder, 11-contact connector (optional), wire, solder, hardware, etc.

Note: A complete kit of parts is available by mail order from Prospect Electronics (PO Box 9144, Allentown, PA 18105; Tel. 215/770-9029) for \$30.38, plus \$2.50 S/H for the first kit (add \$1.00 S/H per kit thereafter). Pennsylvania residents add appropriate sales tax. Please allow 6 to 8 weeks for delivery.

Note: The TDA-2004 is available from Parts Express (340 E. First St., Dayton, OH 45402; Tel. 513/222-0173; Fax 513/461-3391) for about \$4.80. Contact Parts Express for availability and information on shipping and handling.

mid-point setting, and apply power to the circuit. Since the hi-fi amplifier is off, nothing should be heard. You might hear some very low hum or rushing noise when your ear is near the speakers' cones.

Power up the hi-fi. Be sure some programming material is on. Slowly advance the hi-fi's volume control. Caution: Do not advance the hi-fi's volume control past the point of normal low-level listening; your hi-fi may put out more power than the booster amplifier is designed to handle! As the volume control on the hi-fi is advanced, the loudspeakers connected to the (Continued on page 154)

FUN WITH INDUCTION COILS

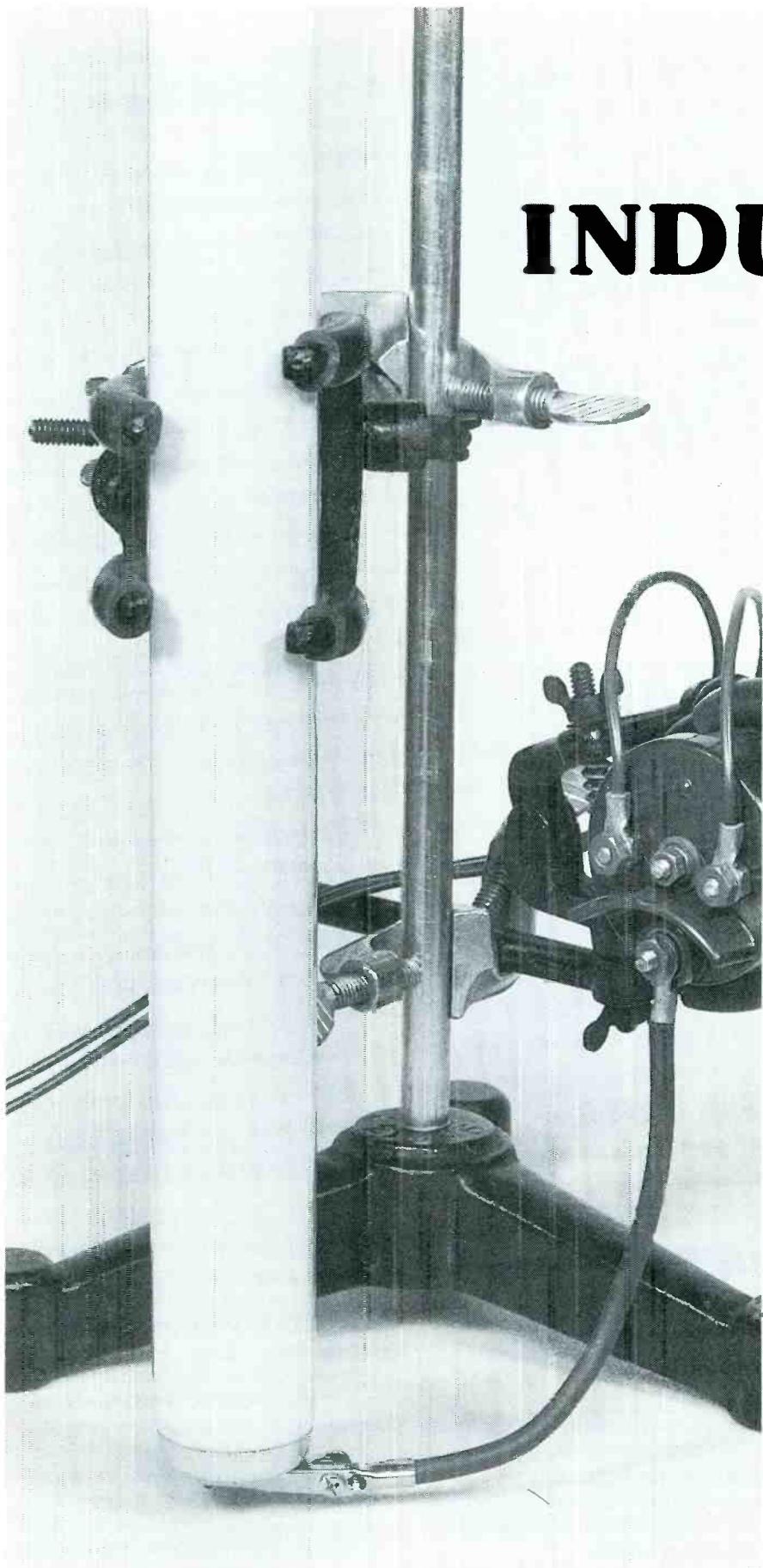
BY STAN CZARNIK

Read about the path induction coils have traveled over the years, and try a fascinating experiment of your own.

In 1831, Michael Faraday (1791–1867) found that if two coils of wire are wound around the opposite sides of an iron ring and if a current is switched on or off in one coil (the primary), a momentary pulse of electricity is created in the other coil (the secondary).

Faraday's great experiment marks the discovery of electromagnetic induction. Other developments followed in rapid succession. It was soon noticed that if the secondary coil consists of a large number of turns of wire relative to a small number of turns in the primary, a strong alternating current of low potential in the primary would induce a weaker current of high potential in the secondary. Such induction coils provided electrical science with a means of transforming low-voltage currents into high-voltage currents. The problem was that the conversion worked for pulsed DC or AC only. It happened only when the circuit was opened or closed. What was needed was a way to make-and-break the circuit quickly, repeatedly, and automatically.

The Trembler. No sooner said than done: In 1836, or thereabouts, an American experimenter by the name of Charles Page (1812–1868) came up



with the necessary innovation, it was a trembling mechanism similar to that found on an electrical bell. The device became known as a "trembler" or "vibrator." The entire arrangement was perfected by a German physicist, Heinrich Ruhmkorff (1803-1877). Ruhmkorff improved the mechanism so significantly that induction coils in general were soon called "Ruhmkorff Coils."

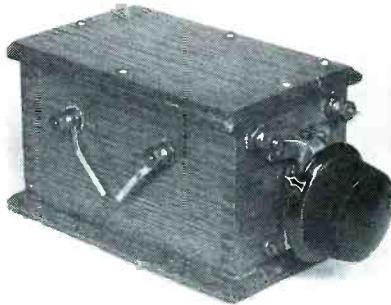
Antique Discharges. What first attracted experimenters to the high-voltage induction coil was the same thing that attracts people today: sparks! Early high-energy discharges from induction coils were small. The original sparks reported by Charles Page were only 1.57 millimeters long, or about $\frac{1}{16}$ inch. In Paris in 1855, Heinrich Ruhmkorff exhibited a coil capable of producing sparks that were 40 centimeters (about 16 inches) long. Thirty years after that, in 1886, an English craftsman named Apps built a coil that generated sparks of up to 1.05 meters long. That's over 3 feet, which is some spark! Apps' machine contained almost one-half ton of wire. The creation of longer and longer sparks had become a kind of contest.

The historical situation here is actually very interesting. It is a case in which utilitarian necessity was not the mother of invention. The invention, the high-voltage induction coil, came first. The practical applications, like X-ray machinery, wireless telegraphy, and automobile-ignition systems, came later.

By the beginning of the 20th Century, the induction coil had become a common piece of laboratory equipment. Plans for building coils appeared in science books. All it took was a lot of patience and a lot of wire. No serious amateur experimenter was without a spark machine. The induction coil was, and still is, a fascinating device.

A Coil For You. Over the years, a variety of induction coils have been manufactured for a variety of purposes, and many of you probably already own one (especially if you own a gas-burning car). But, if you don't, you can order a very good one from an antique automobile parts supplier called Vintage Auto Parts located in Washington state. See the Materials List for more information.

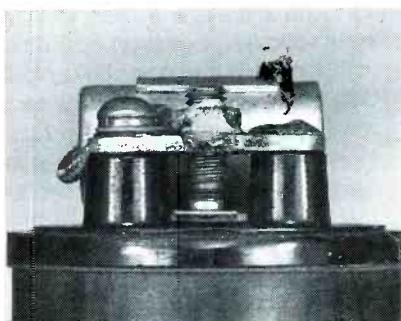
The coil, made by Delco-Remy, is a cylinder about 5 inches long and 2



Back in the 1950s, high-voltage induction coils like this were designed for use in high school and college physics classes. Note the large plastic knob for adjusting the vibrator points.



Here's a profile of the induction coil from Vintage Auto Parts. The vibrator mechanism is concealed beneath the metal cap on the right. The input and output connections are on the left.



The points on the coil should be just barely touching. The capacitor (once called a condenser) is visible just behind them. To avoid damaging yourself or the coil, make no attempt to adjust the points while the coil is operating.

inches in diameter. The low-voltage input and high-voltage output connections are both at one end. The vibrator mechanism and capacitor—concealed and protected under a metal cap—are at the other end. The cap is held in place by two screws and can be easily removed.

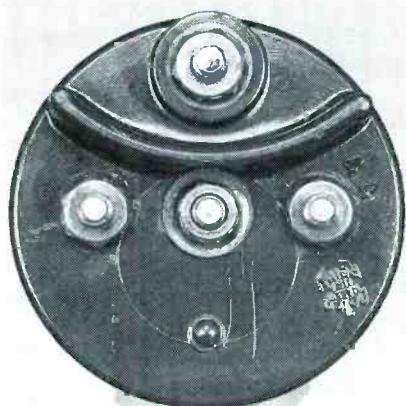
When you receive your coil, take off the metal cap and look at the contact points. They should be just barely touching. If the points are too far apart or too close together, the coil will not work; adjust the points with a screwdriver. Never attempt to adjust the points while the coil is operating.

If you look dead on at the input-output end of the coil, the connection at the very center of the coil is ground. Close to the ground connection, to the immediate right and immediate left, are the low-voltage input terminals. The last connection—separated from the others by a ridge of plastic—is the high-voltage output.

The coil requires no assembly and comes ready for use. So, let's get right down to work!

Testing and Operation. Attach one end of a 3- or 4-inch piece of stiff hook-up wire to the ground terminal of the induction coil. Bend the wire up and over the plastic ridge so that the other end remains stationary about $\frac{1}{2}$ inch from the high-voltage output terminal. Now connect a 6- to 12-volt DC power supply to the input of the coil. If at all possible, use a power supply with an on-off switch and a continuously variable range of output voltages for the experiments.

The coil is round and also quite heavy, and I had a very hard time getting it to stay still on the surface of my workbench. I recommend clamping the coil to some sort of stand or building a simple base out of wood, plastic, or some other non-conductive material. High-voltage experimentation requires equipment that is stable, steady, and secure. Under no circumstances should the coil be permitted to roll around the surface of your work area. That can be very irritating and, much more importantly, just plain dangerous.



The ignition coil has input and output connections just like any other transformer. The ground terminal is dead center. Low-voltage input and output are to the immediate right and immediate left of ground. The remaining terminal, separated from the others by a ridge of plastic, is the high-voltage output.

MATERIALS LIST FOR THE INDUCTION-COIL EXPERIMENT

Automobile spark plug cable (or equivalent)
Binding posts or fahnestock clips
6- to 12-volt DC power supply
Fluorescent tube
Vibrator-type 12-volt ignition coil
Iron filings
Metal strips
Salt shaker
Wood block

ADDITIONAL MATERIALS

Alligator clips, soldering lugs, hardware, hook-up wire, solder, etc.

Ignition coils, complete with vibrator mechanism, are available for \$29.50 plus \$3.00 shipping and handling by requesting a "12-volt spark coil" from Vintage Auto Parts, Inc., 24300 Highway Nine, Woodinville, Washington, 98072.

Small containers of iron filings (catalog number C-10276) are available for \$1.25 (with a minimum order of \$10) from JerryCo Inc., 601 Linden Place, Evanston, Illinois 60202. The JerryCo catalog is 50-cents.

Make sure that the input wires are clear of the output connections and you're ready to test the coil. Turn on your power supply. If the points are set properly, a strong spark will jump between the end of the test wire and the high-voltage output terminal. The coil should work perfectly. If not, turn off and unplug the power supply and check the points. Once again, the points should be touching, but just barely.

As noted earlier, an induction coil with a mechanical vibrator works a lot like an electric bell. The cycle of actions is as follows:

1. A current flows in the primary winding and creates a magnetic field around the core of the coil.

2. The magnetized core attracts the vibrator and the primary circuit is broken.

3. The magnetic field around the core collapses and the vibrator returns to its original position.

4. The vibrator, now back where it started, closes the primary circuit, and the cycle begins again.

The capacitor shunted across the vibrator points absorbs some of the self-induced energy of the primary winding and prevents the points from being prematurely burned away.

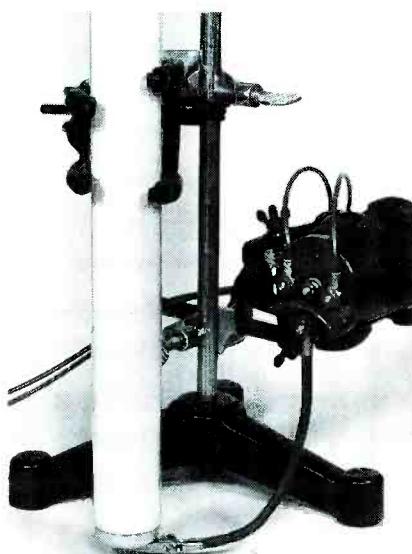
And now for a couple of experi-

ments guaranteed to awaken the mad scientist in everyone!

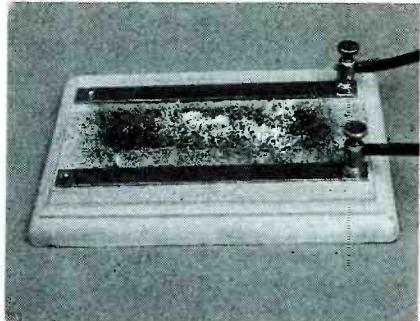
Ghostly Flashes. Obtain a piece of flexible wire 6 to 10 inches long. Automobile spark-plug cable works very well, but any kind of heavily insulated wire will do fine. With the power off, attach an alligator clip to one end of the wire and connect the other end to the high-voltage output of the induction coil. Now get a large fluorescent tube and connect the alligator clip to the pins at one end of the tube. Suspend the tube from a stand or lean it against a table, a bookshelf, or something similar. Make absolutely certain that the fluorescent tube will not move or fall down.

Your work area should be free of things that conduct electricity; that includes tools, soldering irons, desk lamps, aluminum soda-pop cans, and so on. It should also be very dry and very clean; high-voltage discharge can travel easily across a thin layer of ordinary household dust.

When everything is ready, darken the room and turn on the coil. The vibrator will buzz and the fluorescent tube will flicker with a grayish-white light. The entire effect is very weird. Low input voltages, between, say, 6 and 9 volts, produce the most obvious pulses. With an input voltage at or close to 12 volts, the flashes become too rapid for the eye to catch and the illumination begins to appear almost continuous.



Connect the high-voltage terminal of the coil to one end of a long fluorescent tube and turn on the power supply. The tube will flicker in a most mysterious fashion. Do not touch the tube while running the equipment.



The spark platform is a simple device. Two metal strips about two inches apart are screwed to a block of wood. Iron filings are sprinkled onto the surface between the strips with an old salt shaker. The high-voltage discharge will dance among the filings. The display that results resembles a miniature lightning storm.

Warning: Do not touch the fluorescent tube while the coil is operating. There is enough energy in the tube to give you a nasty electric shock!

Spark Platform. If you liked that experiment, you'll love this one. Locate a piece of wood 6 or 7 inches long and 4 or 5 inches wide. Now get a couple of stiff metal strips about $\frac{1}{2}$ inch wide. Brass and aluminum strips are often available at large hobby shops. Cut the strips to match the length of the wood block. The strips should be placed on the block parallel to one another about 2 inches apart; that is very important. Fasten the strips to the wood. A binding post or fahnestock clip attached to one end of each strip will facilitate wiring.

You will need some iron filings and an old salt shaker. See the Materials List for information on how to obtain some. Fill the shaker with the filings and sprinkle the iron on the wood block between the metal strips. The layer of iron should not be too thick or too thin, and as even as possible. If you overdo it the first time, just clean off the platform and try again.

Now, without moving the board or disturbing the filings, connect the strips to the induction coil. Again, darken the room and turn on the coil. If you have used just the right amount of iron, the sparks will move between the strips and among the particles of metal. What you will see is simply fantastic. The display resembles a miniature lightning storm on your workbench. And, of course, remember not to touch the coil or the platform while running the experiment.



The EXTENSION Silencer

BY TERRANCE KELLY

This project keeps your modem communications and important private conversations from being interrupted by locking out extension phones when the line is in use

Are you tired of others listening in on your conversations on an extension phone? Do you live with a computer hacker who always seems to want to dial out with his modem in the middle of your conversations? Fear no more, three inexpensive parts—which comprise the *Extension Silencer*—will solve all of your problems.

The Extension Silencer described in this article is a simple circuit that, when placed in series with each of your extension telephones, allows privacy at each location without interference from the others. All phones will ring normally and the first one to answer locks out the others. Someone picking up an extension will hear nothing if the phone is already in use. If you need to switch

extensions all you have to do is pick up one extension and hang up the other.

In order to fully understand the operation of the Extension Silencer, a little discussion on telephone operation is in order.

Telephone Operation. Each subscriber telephone is connected in what's called a *local loop* (see Fig. 1) to a central office, which contains switching equipment, signaling equipment, and a power source that supplies direct current (DC) for the operation of the telephone system within its coverage area.

Switches in the central office respond to a string of dial pulses to connect the calling station with the station being called. The switching array within the

central office feeds an AC ring signal down the line to the station being called. When a link is established (the telephone receiver is taken off-hook), the two stations communicate via transformer-coupled loops using DC power supplied by the central office.

When the telephone receiver is on-hook, the receiver holds down the hook-switch buttons in the base of the unit, creating an open circuit to DC between the receiver and the central office. The signaling circuit, which is AC operated, is always connected to the central office; a capacitor in the signaling circuit blocks the flow of DC, while passing the AC ring signal.

As long as the hook-switch buttons on the telephone are depressed, no com-

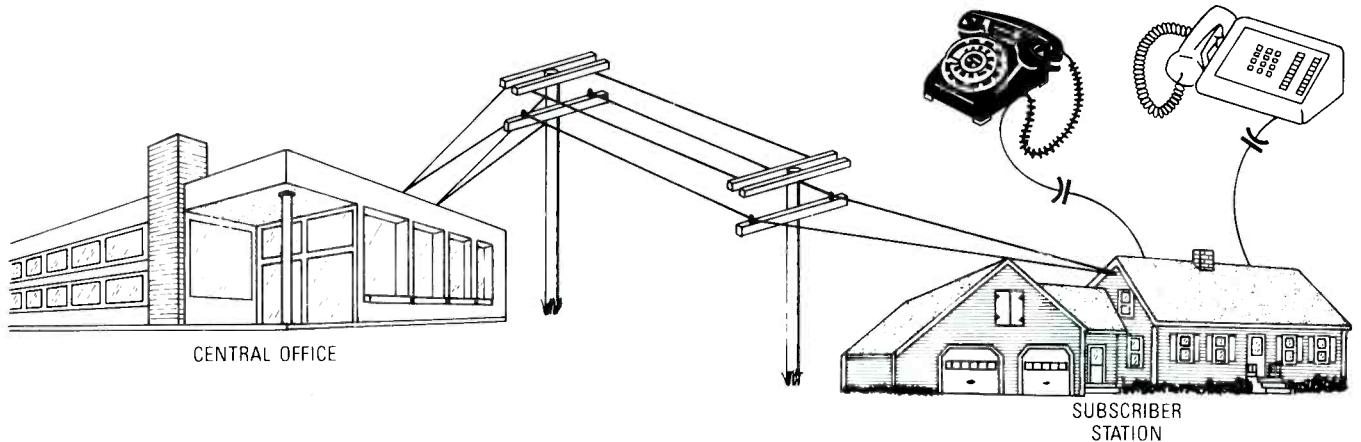


Fig. 1. Each subscriber telephone is connected in a local loop to a central office, which contains switching equipment, signaling equipment, and a power source that supplies direct current (DC) for the operation of the telephone system within its coverage area.

munications can take place. However, when the receiver is taken off-hook, the hook-switch closes contacts, passing DC to the telephone, activating the communications circuits, and causing the normal DC line voltage to drop due to the loading effect of the telephone.

Circuit Operation. Figure 2 shows the schematic diagram for the Extension Silencer. The circuit is little more than an electronic cut-off switch built around a Triac (the switching element). Two phone stations, A and B, are shown to make the circuit's operation easy to understand. (Component designations for only one circuit are given in the Parts List.) Note that an Extension Silencer circuit is connected in series with each station.

Normally when a phone is on hook,

the voltage across the phone line is 48-volts DC; when the receiver is taken off hook (is picked up), the DC voltage across the line drops to between 2- and 12-volts DC (typically about eight volts). That's due to the off-hook impedance of the telephone and the loop resistance between the subscriber station and the telephone company's central office.

As long as both the station A and station B receivers are on-hook, the voltage at the gates of TR1 and TR2 is sufficient to trigger TR1 and TR2 into conduction. That means that both Extension Silencer circuits connected to the line are conducting. But when one of the receivers—say station A—is lifted from its cradle, closing the hook-switch contacts, that telephone draws considerably more power, causing the line

PARTS LIST FOR THE EXTENSION SILENCER

TR1—1-amp, 50-PIV Triac
R1—1000-ohm, $\frac{1}{4}$ -watt, 5% resistor
D1—1N4744, 15-volt, 1-watt Zener diode (Radio Shack 276-564, or similar)
Dual component perfboard (Radio Shack 276-148), quick-connect modular jack (Radio Shack 279-355), clear view speaker wire (Radio Shack 287-008), solder, hardware, etc.

voltage at TR2 to drop to around 0.6-volt DC.

The operational characteristics of the Triac are key to the operation of the Extension Silencer circuit. Remember that once a Triac is triggered (via a gate trigger voltage), it continues to conduct as long as the current through it remains above its holding-current (I_H) requirement, even if the trigger source is removed. And will cease to conduct, only when the current through the device is brought below its holding-current level. (In the case of an AC signal, a Triac would be triggered into conduction twice during a single cycle: once during the positive half-cycle, and again during the negative half-cycle. Therefore the 20-Hz ring signal is passed to the phone uninhibited.)

The 0.6-volt level at the main terminals of TR2 is too small to generate sufficient current through TR2 to satisfy its holding-current requirement, so it turns off, disallowing any communications through station B.

If the station B extension is taken off-hook and station A is hung up, a similar, but reversed action occurs, with station B absorbing the majority of the line-fed power, reducing the current through TR1 to a level insufficient to sustain conduction through that unit. And that in turn locks out station A.

A 15-volt Zener diode was used be-
(Continued on page 153)

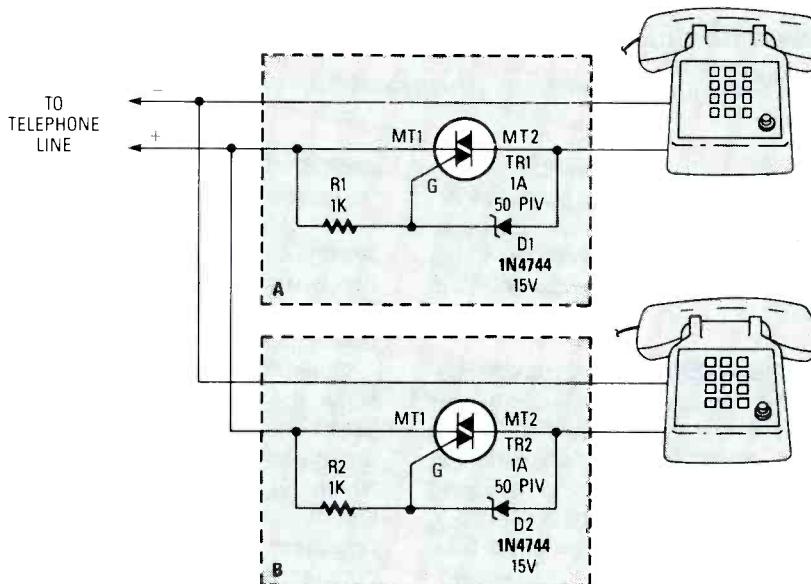


Fig. 2. The Extension Silencer is little more than an electronic cut-off switch, built around a Triac. The Triac's operating characteristics are key to the operation of the Extension Silencer circuit.

BEGINNERS GUIDE TO VINTAGE RADIO

Is your latest find a gem from radio's "golden age," or just a flea-market special? Once you know what to look for, you'll be able to tell at a glance.

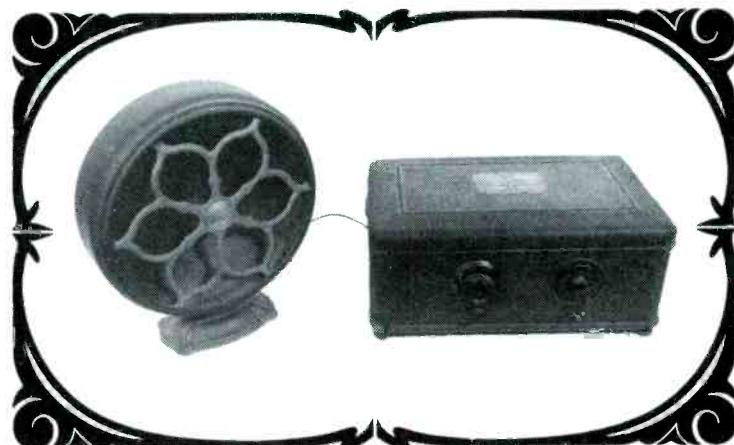
BY MARC ELLIS

Maybe you already have a couple of vintage radios in your possession; a set or two that caught your eye at a rummage sale or in a relative's attic. Or maybe you don't own anything right now, but know that you have an affinity for the look and feel of decades-old electronic equipment. No matter how you developed your interest, if you're new to the radio-collecting hobby, this guide will give you the background you need to evaluate your "finds" with a knowledgeable eye.

When the Classics Were Made. The radios of greatest interest to most of today's collectors span the years from the beginning of serious broadcast radio (early 1920's) to the onset of World War II (early 1940's). Of course, there are collectors who are interested in the relics of the earliest days of radio. Unfortunately, however, Fleming Valves, DeForest Audions, or other very early pieces of point-to-point communications gear are museum-quality items. They don't often show up at flea markets, house sales, or the other channels normally available to the average collector.

Conversely, the sets made after World War II may be the collectables of tomorrow—but I don't sense much interest in collecting that period today. I'm sure that there are readers who will disagree, but those later sets just don't seem to have the classic appearance or romantic associations that the earlier ones do.

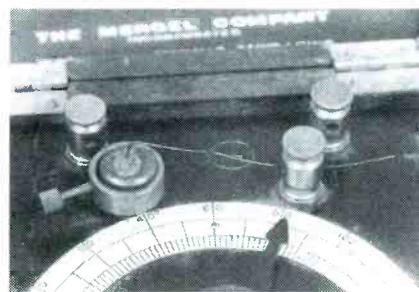
The "classic-radio" period spans less than twenty years. But within that small



slice of time, sets were manufactured by the millions in a bewildering variety of types and styles. Technological advances came so rapidly that new designs were rendered obsolete almost as soon as they came on the market. The sociological and economic changes that occurred as an era of national prosperity was replaced, in turn, by the Great Depression and the gathering storm clouds of World War II, also had profound effects on the radio industry.

Let's take a trip, now, through that fascinating period and look at some typical sets manufactured at various times within it. In the process, you'll learn the sign-posts that will help you relate the radios that you find to the years in which they were made.

The Earliest Broadcast Sets. If I were to ask you to identify the first type of radio in general use during the early



A crystal detector consisted of a fine wire (the "cat's whisker") in contact with a fragment of galena (lead ore). The version shown does not have the usual swivel-arm mount for the wire.

days of broadcasting, you'd probably answer "the crystal set," and you would certainly be right. The wonderful thing about the crystal set was that it required no external power. The detection properties of the "crystal" (a small piece of lead ore, or *galena*) extracted the sound portion of the signal from the radio frequency "carrier" and made it audible in the headphones. The only energy used was the energy of the radio signal itself.

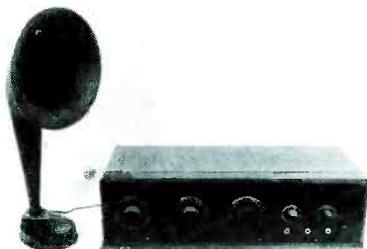
Regrettably, crystal sets aren't easy to find. By the time the broadcasting industry became big enough to create a mass market for radio receivers, the vacuum tube was becoming generally available. And even a small one-tube radio could easily outperform the most elaborately made crystal set. By 1925, crystal sets were largely relegated to the status of kid's toys. A survey of mid-1920's advertising in two prestigious radio magazines did not show one serious crystal set for sale. If you do find a vintage crystal set, you'll have no trouble identifying it. It won't have any tubes, of course, and the bit of rock-like galena—mounted in a small metal cup—will be in plain sight. You'll also find a short length of springy wire (the "cat's whisker"), typically attached to one end of a pivoted metal arm. The arm is arranged so that the wire tip can be placed in contact with various locations on the surface of the crystal. In practice, the listener tried various spots until he or she found one that provided the loudest volume.

However, watch out! Not every set having a crystal is a 1920's model. Crystal sets were made as toys, educational kits, and novelty items at least into the 1950's. Look at your find with a critical eye before you make a purchase. Should you have your heart set on adding a good example of an early twenties crystal set to your collection, your best bet would be to attend the swap meet at an antique-radio convention. You'll have a good chance of locating one there. But, of course, it's not likely to be cheap.

Battery Radios of the 1920's.

During most of the 1920's, the radio most likely to be found in the family living room was a vacuum-tube set powered by batteries. The development of practical technology for plug-in AC operation did not occur until near the end of the decade, and, like all new technologies, it was high-priced when introduced and therefore not widely adopted at first.

Battery radios were made in many sizes and styles. And if you're new to collecting, it would be natural for you to assume that a simple-looking one- or two-tube receiver might be an older design than, say, a five-tube set with multiple controls. Don't make that mistake, though.



The three-dial battery-operated TRF was common in the 1920's. The one shown in this photo is a Neutrodyne and was originally built from a kit.

There were three major storage-battery-operated tube-receiver designs in use throughout the 1920's: the regenerative, the TRF (tuned radio frequency), and the superheterodyne. The first and last of those were the brainchildren of the legendary radio inventor, Howard Armstrong. A searching technical discussion of the designs is beyond the scope of this article, but the regenerative circuit was by far the most efficient.

Inside the Regenerative Radio. A tube that was set up for regenerative service was basically an amplifier. But,



The RCA Radiola III is good example of a typical regenerative receiver. Its two-tube circuit made loudspeaker operation possible, especially on strong local signals.

using an adjustable-feedback arrangement, part of the output was coupled back into the input. Because of that set up, received signals could be amplified over and over again, resulting in tremendous gain.

If too much of the output were to be fed back to the input, however, the tube would begin to oscillate like a radio transmitter, causing an unearthly howl in the headphones and sending out a signal that would interfere with reception throughout the neighborhood. To obtain maximum amplification, then, the trick was to stay just below the point of oscillation.

Not only did the single tube act as an RF amplifier—boosting the signals from the antenna—it performed another function as well. While going about its job as an amplifier, it could also serve as a detector—separating the audio signals from the radio "carrier wave" so that they could be heard in the headphones.

Though there are certainly exceptions, the typical regenerative receiver of the period had one tube functioning as described. Sometimes an extra tube was included, as an audio amplifier, for louder headphone volume. Occasionally, a couple of added tubes (either built into the set or available as an "add-on" amplifier) were used to drive a loudspeaker.

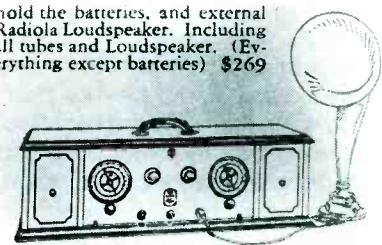
To determine if your flea-market find is regenerative, first look at the controls and tubes. If it has a limited number of tubes, a control marked "regeneration" or "amplification" and only one "tuning" or "station selection" control, there isn't much doubt. The "regeneration" or "amplification" control typically operates a mechanical arrangement that changes the physical relationship between two coils; one in the tube's output circuit, the other in the input circuit.

The tubes used in those sets were

quite often of the variety designed to be lit by dry cells (look for types 11, 12 or 99). However, storage-battery types (most often the 01-A) are also found. Though regenerative sets were made by many manufacturers, you're most likely to find sets made by Crosley—a company that saturated the market with inexpensive sets—and RCA, which used regeneration in most of its low-end line.

The TRF Scene. During the early 1920's radio manufacturers could secure a license to use regenerative circuits directly from Armstrong, their inventor. The license could be obtained fairly easily, and on reasonable terms. Towards the middle of the decade, after Westinghouse bought the patent rights, regenerative licenses were difficult—or impossible—to get.

Hold the batteries, and external Radiola Loudspeaker. Including all tubes and Loudspeaker. (Everything except batteries) \$269



A typical mid-1920's RCA superheterodyne used six tubes. A set like the one shown here was considered to be a "semi-portable."

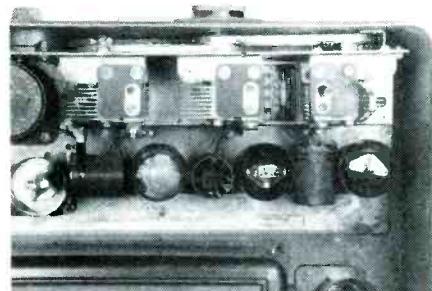
Manufacturers who couldn't (or chose not to) secure a regenerative license had to use more tubes. Generally speaking, it required two RF amplifier tubes and a separate detector tube to get approximately the same results obtained from a single tube operating as a regenerative amplifier-detector. Three tuned circuits (coil and variable-condenser—condensers are now called capacitors—combinations) were required for efficient operation of the two RF stages. Radios of that design were called TRF (tuned radio-frequency) sets.

Most TRF sets of that era also had the two additional audio-amplifier tubes, which were needed to operate a horn-type loudspeaker. The theory apparently was that anyone willing to purchase (and buy batteries for) a three-tube radio, would just as soon invest in the two additional tubes and have a more versatile set.

You might think that the cumbersome and expensive TRFs wouldn't be able to compete with the more efficient little regenerative radios. But the

"regen" sets were more difficult to tune and adjust. And the multiple tuned-circuits of the TRFs made them a little more selective (able to separate closely-spaced stations). That proved to be an important factor as the number of stations broadcasting at once began to increase.

The five-tube (generally all type 01-A's), three-dial basic TRF set eventually became an industry standard. It was made by scores of manufacturers, but a couple of the better-known ones were Atwater Kent and Freed-Eisemann. The *Neutrodyne* circuit, made famous by Freed-Eisemann, was a method for preventing un-



A "straight-down" view of an open Model 42 cabinet shows belts and pulleys linking the tuning condensers for single-control operation. The corner of the separate power-supply box is seen at the lower left of the photo.

wanted oscillation in RF amplifiers. (A common problem with triode RF-amplifier tubes whose inputs and outputs were tuned to the same frequency). The three-dial TRF set fell into disuse only when the first plug-in sets appeared on the market.

Armstrong's Other Masterpiece.

The superheterodyne, Howard Armstrong's other masterpiece of radio circuitry, wasn't in widespread use during the 1920's battery-set era. In later decades it was to become the dominant radio design. However at this time, RCA—the patent owner—retained exclusive manufacturing rights.

The superheterodyne circuit represents yet another approach to amplifying radio frequencies. Signals coming in from the antenna are converted to a much lower frequency by mixing (heterodyning) them with a signal generated by an internal oscillator.

The lower frequency, typically between 150 and 450 kHz, is called the IF, or the *intermediate frequency*. The IF signal is amplified and detected much as it would be in a TRF receiver. But by amplifying at a lower frequen-



The Cathedral-style Gloritone screen-grid set represents the transitional period of radio-receiver development. Note that the tuning dial is viewed through a tiny window.

cy, greater gain can be obtained without danger of oscillation, and greater selectivity can also be achieved.

Identifying a superheterodyne set of the 1920's by its physical appearance requires a fairly sophisticated knowledge of radio circuitry. However if the set is a pre-1930 battery model, has six tubes or more (usually type 99's), and was made by RCA, it's probably a superhet.

Enter the "Socket-Power" Radio.

Broadcast-radio listening entered a brand-new era when the first practical plug-in, or "socket-power" radios appeared on the market. Though many prior schemes had been tried for powering battery sets from the AC power line, the necessary "battery-eliminator" units tended to be heavy, bulky, and expensive.

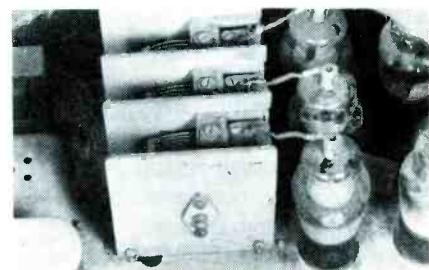
The true breakthrough came in the late 1920's, when amplifying tubes especially designed for alternating-current service became available. Clumsy external batteries or battery eliminators could now be replaced by a compact power supply unit (usually using a type-80 rectifier tube) built right into the receiver cabinet. The power lead coming out of the radio now terminated in a simple AC plug rather than a tangle of individual wires intended for connection to various DC voltage sources.

These first AC radios were generally TRF sets (except for RCA's, which were generally superheterodynes). But the familiar array of three tuning knobs had all but disappeared. The three tuning condensers formerly operated by those knobs were still in the radios. But, in most models, their shafts were ganged by belt-and-pulley arrangements that permitted turning all three with a single control. The rheostats for-

merly required for controlling current flow from the batteries through the tube filaments also disappeared—leaving the front panel of the late-1920's AC radio with just three controls: power (typically a separate toggle switch), volume, and tuning.

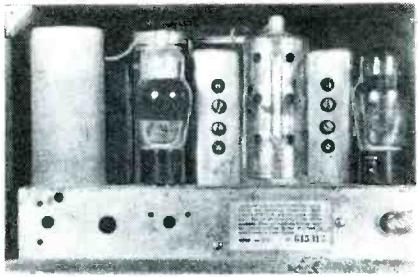
For some reason, the preferred material for the cabinets of those sleek new radios was now metal rather than wood, or wood and Bakelite. And the hinged top of the older-style sets was replaced by a friction-fitting metal lid that could be lifted off for tube replacement. External loudspeakers were still the rule, housed in matching metal cases. But a more compact paper-cone style had replaced the earlier horn design. Late 1920's AC-powered sets by Crosley and Atwater-Kent are good examples of this "new look" in radio. RCA, however, opted for furniture-style cabinets with rich wood-grain finishes.

Transition-Period Radios. From the final years of the 1920's through the early years of the 1930's, the evolution of radio receivers passed through what I think of as the "transitional period." All of the basic receiver circuits had been invented, and further advances in circuitry would be refinements of design. Those were paralleled by refinements being made on the mechanical aspects of the radio chassis.



This view of the Gloritone's chassis shows the 24-A screen-grid tubes wired to the three-section tuning condenser. The power transformer, with its ventilating cover, is seen just to the left of the tuning condenser.

For example, the three tuning condensers so typical of the TRF radio were no longer ganged by belts and pulleys. Instead, they were combined in one frame and turned by a common shaft. This broke up the familiar "row-style" arrangement of the RF amplifier stages. Now the RF amplifier tubes and coils tended to be grouped around the common variable capacitor so that they could be arranged for max-



The rear view of this depression-era AC-DC radio shows its tall glass tubes. This set uses a line-cord resistor.

imum compactness and minimum lead length.

The power-supply circuitry, formerly housed on a separate chassis within the radio cabinet, moved onto the radio chassis itself—achieving still greater compactness and design integration. The functional groups of the receiver were no longer separate “building blocks” but blended together as a unified whole.

Finally the loudspeaker, stripped of its decorative case and reduced in diameter, was placed inside the radio cabinet. The design of the speaker also changed. Formerly nothing more than a scaled-up earphone movement incorporating relatively weak permanent magnets, the new unit (called a *dynamic* speaker) contained a powerful electromagnet operated from the receiver's power supply.

The new speaker required four leads (one pair for electromagnet power) compared with the original two. Though smaller in size than the old-style separate speaker, the built-in speaker delivered much more sound—particularly since the audio tube that drove it, no longer having to rely on a limited battery supply, was delivering more power.

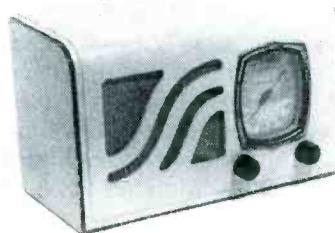
The presence of the speaker inside the cabinet caused another major change in the radio's physical appearance. Previously, the hinged-lid, coffin-shaped, wooden box of the mid-1920's battery TRF had been replaced by the more rectangular box of the late 1920's socket-power radio with its built-in power supply. Now, because of its more compact chassis, the cabinet of the “transitional” radio took up less table space, but required more vertical space to accommodate the speaker.

One of the resulting cabinet styles, the familiar *cathedral*, curved upward to form a dome around the speaker. Another common style, the

tombstone, took the shape of a vertically oriented rectangular slab. But however they were shaped, cabinets were now made of hardwood veneers, metal having virtually disappeared as a material for radio enclosures.

It's worth noting, too, that the late-1920's release of screen-grid tubes (which were highly efficient RF amplifiers) gave the TRF design a last breath of life before the superhet became king. And the screen-grid TRF, with its distinctive group of three top-capped 24-A tubes is a common relic of that era.

By now, radio broadcasting had become such an important feature of American family life that it was natural for a radio receiver to become the focal point of the living room. Thus, the “transitional period” was also the period of the magnificent living-room console. The speakers of those big consoles were mounted below the chassis, and the cabinets were made tall enough so that the knobs and dial could be elevated for easy visibility. Cabinets were as massive and elegantly crafted as the family could afford.



The 1939 Philco set shown here was one of the last wood-cabinet table models in the line. Note the large tuning dial with rotating pointer.

But whether it was a table model or a console, the typical “transitional period” set had moved into the modern era of vacuum-tube radio design. Inside, the radio no longer looked like a hand-assembled laboratory prototype, but more like the mass-produced home appliance it had become. Outside, the “apparatus” look was gone. The multi-knobbed Bakelite front panel or neutral metal enclosure was replaced by a cabinet made of fine wood in a furniture style and finish.

Impact of the Depression. As you might imagine, the financial crash of 1929 and the deepening depression of the 1930's had quite an impact on the

burgeoning radio industry. But, if anything, the number of radio listeners was increasing. Broadcasting was in its Golden Age, when some of the most popular radio series of all time had their beginnings. The programs were a blessing to the cash-starved depression family; they were free, and could be enjoyed without leaving the home.

However, if the manufacturers wanted to continue to sell radio sets, they'd have to develop economy versions. The market for the elaborate consoles and table models of the late 1920's was definitely dwindling. Luckily, radio stations were increasing in number and power—so the new sets didn't have to be supersensitive. And the improvements in the efficiency of vacuum tubes and components made it possible to downsize receivers and still maintain reasonable performance.

In creating the “depression radio” two bulky and expensive power-supply components—the filter choke and the power transformer—were eliminated completely. By wiring the field coil (electromagnet) of the dynamic speaker in place of the filter choke, the field coil could replace the choke and still receive the DC power it needed to function. The transformer was eliminated by devising a new method for lighting the tube heaters.

Formerly connected in parallel and operated from a low-voltage winding on the transformer, the heaters were now wired in series to build up as large a voltage-drop as possible. That series string of heaters was connected, in turn, with a series resistor to increase the voltage drop still further. The combined voltage drops of the tubes and series resistor totaled 115 or so, and the entire “shooting match” could be operated directly from the AC (or, as we shall see, DC) line without benefit of a power transformer.

Recognizing Depression AC-DC's. The elimination of the power transformer resulted in an interesting fringe benefit; a radio without a power trans-



A 1940's Emerson, like the one shown here, is a typical “second-generation” AC-DC set.

former could be operated from DC as well as AC current. During the 1930's, the downtown sections of many large cities were supplied *only* with DC power. Conventional radios having power transformers could be operated downtown only by using a costly power inverter. Here was a ready-made market for the new "bare-bones" radios, which quickly became known in the trade as "AC-DC sets."

The first AC-DC "depression radios" make interesting collectibles. Cabinets were generally made of wood in a variety of fanciful styles. They look nice on a bookshelf, and are much easier to store and display than the full-size models.

Besides the distinctive cabinet, you can also recognize the first-generation AC-DC set by its series resistor and the types of tubes used. The tubes were a mixture of 6-volt types originally developed for auto use (6A7, 6D6, 6Q7—to name a few) and higher-voltage types designed especially to help build up the voltage drop in the series string (typical were the 25Z5 and 25L6). You'll also often see the 43, a 6-volt type designed especially for use in AC-DC sets.

Series resistors were sometimes included in the set's line cord as an asbestos-covered third wire; sometimes housed in metal plug-in tube-like enclosures mounted on the set's chassis. The former type were commonly called *line-cord resistors*; the latter were known as *ballasts*.

Those little radios were made both as TRFs and as superheterodynes. But construction practices were such that it isn't always easy to tell the difference without a knowledgeable eye or a circuit diagram!

The Second Generation of AC-DC sets. The design of the AC-DC set slowly evolved through the 1930's, and by the early 1940's it had quite a different look. The cabinet was now generally made of Bakelite, often in a dark-brown color. That plastic material could be formed much more easily into the soft curves of the streamlined, or "moderne" look then in vogue.

The old tall-glass ("G" style) tubes had been replaced by the shorter metal, or "GT"-style glass versions—resulting in a more compact cabinet. By the way, don't confuse the "GT"-type glass tubes with the even smaller miniature glass tubes of a later era. The former have a separate metal or plas-

tic base equipped with an octal (8-prong) plug. The latter are one-piece glass types having no separate base; the connecting pins (usually 7) pass directly out through the tube's glass bottom.

The speaker of that second-generation AC-DC set was frequently a permanent-magnet type rather than the older style dynamic version. Through the development of better magnetic materials, permanent magnets could now be made much more powerful than before, making obsolete the need for a speaker field coil. And improvements in power-supply components over the years had done away with the necessity of having a field coil to play the part of a filter choke. One easy way to identify a permanent-magnet speaker is to check the number of leads going to it; there are only two of them, compared with the four wires required for a dynamic speaker.



The Zenith 1940 portable had an "airplane luggage" case and a removable loop antenna with suction cups for mounting on car windows.

Second-generation AC-DC sets were usually superheterodynes rather than TRF's. And the superheterodyne sets of that period were easily recognizable by the pair of tall, square-topped aluminum enclosures housing the IF transformers. The top of each transformer normally contained a pair of access holes used for reaching the tuning adjustments.

Enter the Portables! Lightweight, battery-powered radios that could be carried anywhere appeared in the late 1930's. Like most earlier innovations in radio receivers, that one was made possible through development of a new variety of vacuum tube. The new battery-radio tubes required much less power (especially to light their filaments) than "normal" types. That meant that the portable could be operated for a long time by a compact battery pack housed within the case.

The battery portables of that era have a romance all of their own. Most came in suitcase-style cases, often

covered with "airplane-luggage" fabric. Some had shortwave bands as well as standard broadcast. And a few had special arrangements to remove and orient the antenna for best reception.

The little battery portables were often marvels of mechanical ingenuity and organization of interior space. It was quite a trick to find places for a full set of batteries without coming up with a cabinet size appreciably larger than the standard AC-DC table model. And since those sets were generally designed for plug-in operation as well, designers also had to provide a spot to store the line cord when not in use.

As you might imagine, the "3-way" portables (so named because they would operate from the AC line, DC line, or internal battery power) were enormously popular with teenagers,—who lugged them to beaches, parks, or other recreational areas to add a little extra romance and excitement to the proceedings.

You can identify the first-generation 3-way portable not only by its case style and battery compartments, but also by its tube complement. The tubes will be in the octal-based "GT" style described previously, and you'll see types such as 1A5, 1A6, 1A7, 1B7, 1H5, 1N5, etc. The "1" at the beginning of the type number indicates that the tube operates from a 1.4-volt DC source.

Other Trends in Radio. So far we've covered the evolution of broadcast radio receivers during the 1920's. Then we skipped rather abruptly from the early to the late 1930's as we discussed the AC-DC sets and 3-way portables—types that were quite dominant during that era.

But it should be stressed that—throughout this period—plenty of full-size, full-featured, wood-cabinet table models and consoles were also being made. So I'd like to finish this beginner's guide to vintage radio by discussing some of the other developments that took place during the 1930's and early 1940's. Developments that apply generally to the full-sized radios and, in many cases, to the scaled-down models as well.

You already know that, during this period, the tall glass "G"-type tubes were replaced by the much shorter and more compact, octal-based, GT-type (glass) and metal tubes. You know, too, that the dynamic speaker

(Continued on page 150)

FLASHING BRAKE LIGHT

Everyone seems to have a third brake light on their car. Distinguish yours 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.

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 its 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 inhib-

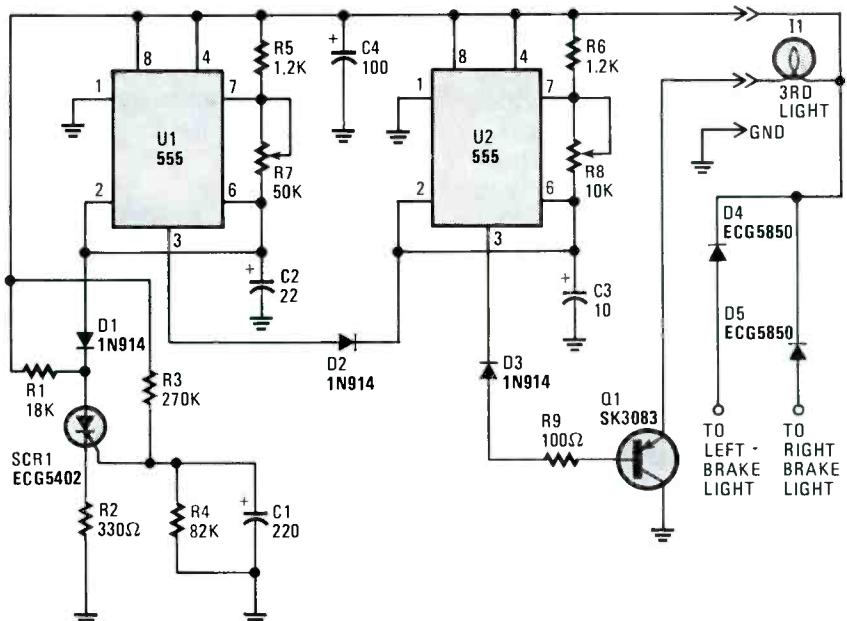


Fig. 1. The flasher consists of two timers with specially configured trigger connections. Integrated circuit U1 controls when and how long the flashing should take place. Integrated circuit U2 oscillates to control the flashing itself.

iting 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 *It* 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

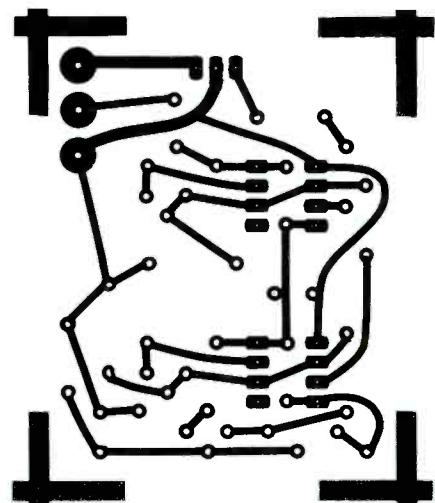


Fig. 2. This foil pattern will allow you to make a printed-circuit board of your own on which to mount the components.

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 controlled rectifier

Q1—SK3083 PNP switching transistor
D1, D2, D3—IN914 rectifying diode
D4, D5—6-amp, 50-PIV, rectifying diode (ECG5850 or equivalent)

CAPACITORS

(All capacitors are 16-WVDC electrolytic units.)

C1—220- μ F
C2—22- μ F
C3—10- μ F
C4—100- μ F

RESISTORS

(All fixed resistors are $\frac{1}{4}$ -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.

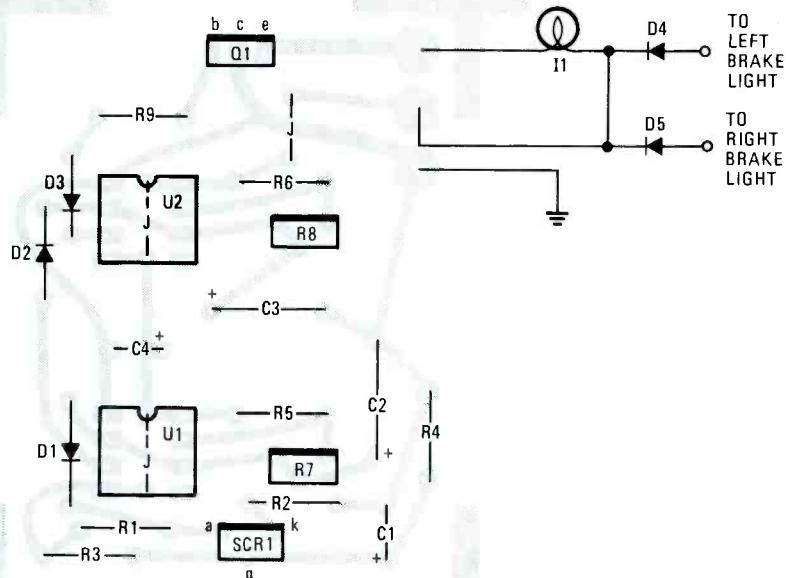


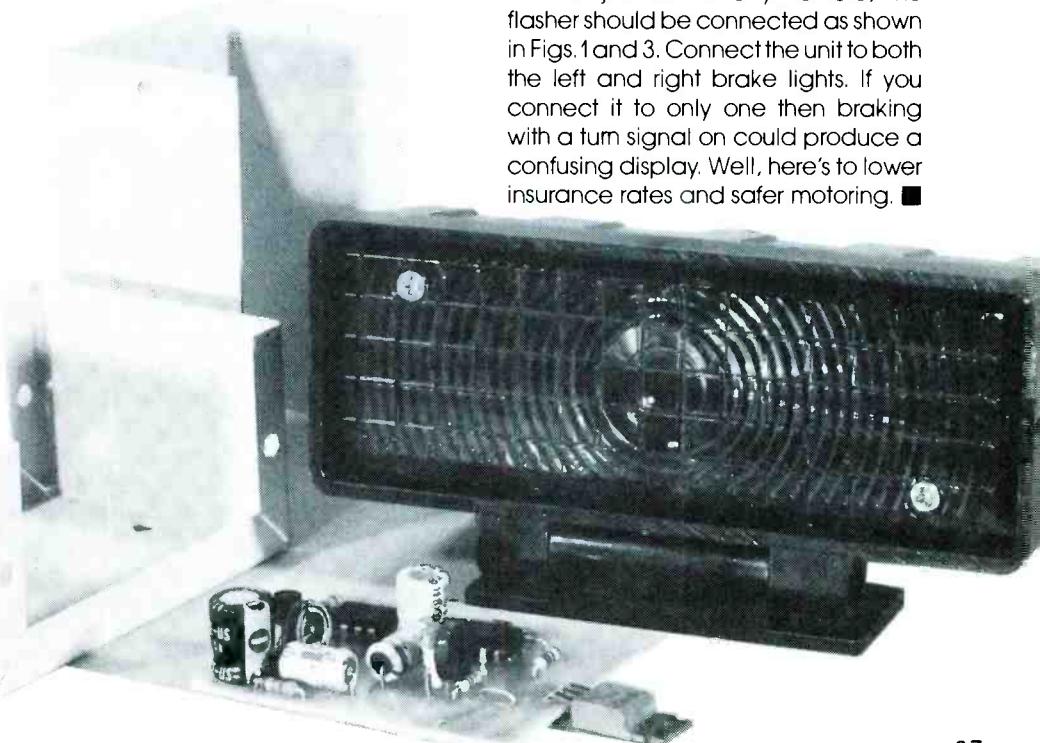
Fig. 3. You should use this parts-placement diagram as a guide for stuffing the parts on the PC board.

(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.

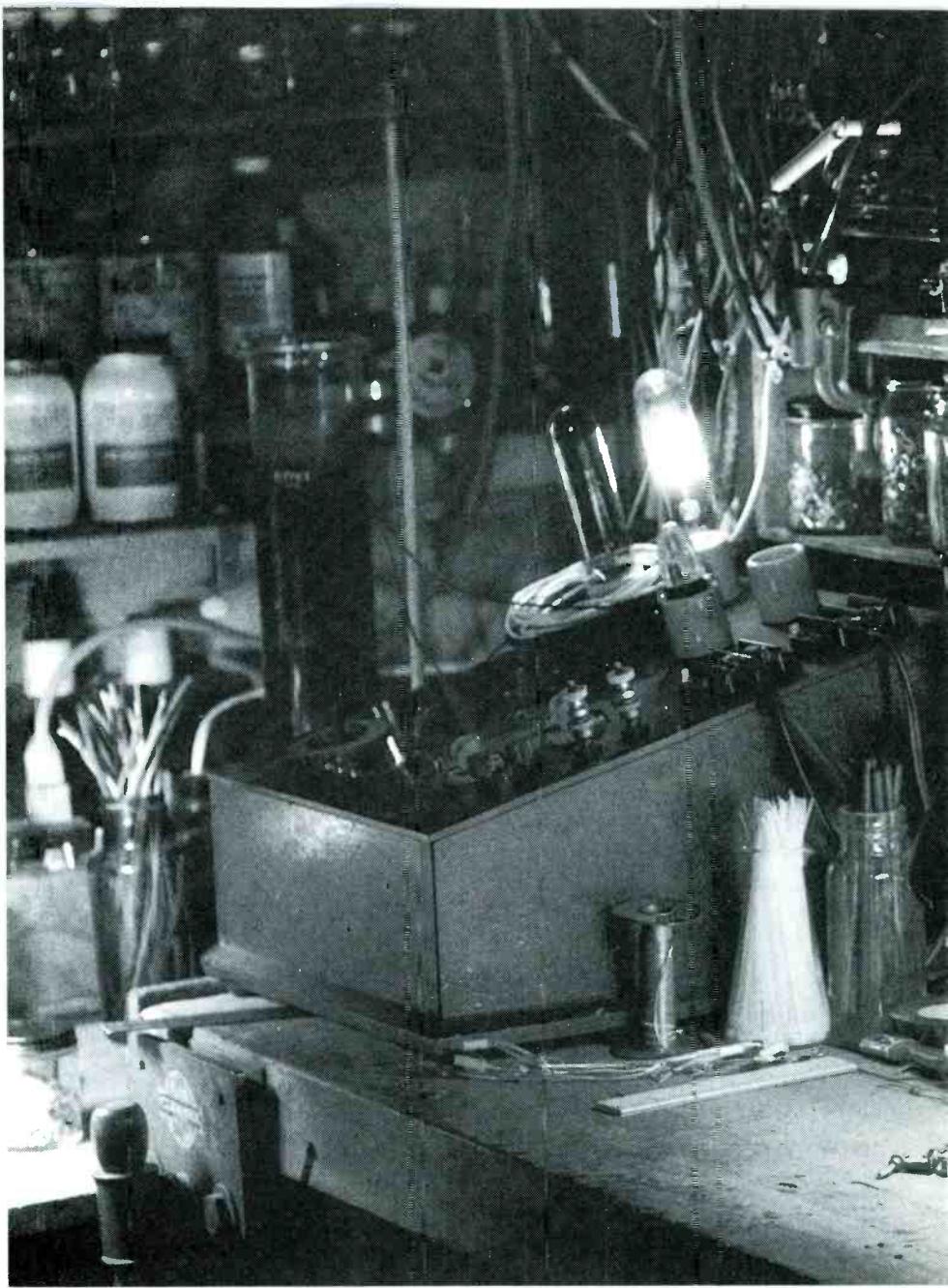
In incandescent bulbs, there is a time lag between the introduction of

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. ■



SUPPLYING THE ELECTRONICS



For the dedicated hobbyist, a well-stocked workplace is, all by itself, a source of great pleasure. It can also be a source of security. On a cold winter evening, it's nice to know that everything you need to complete some project or run some experiment rests no further than the top shelf of the supply cabinet or the other end of the workbench.

Often, however, we are not so lucky. There are things we do not have. The missing pieces nearly always translate into an unwelcome delay, and that is bad enough. But it can get worse.

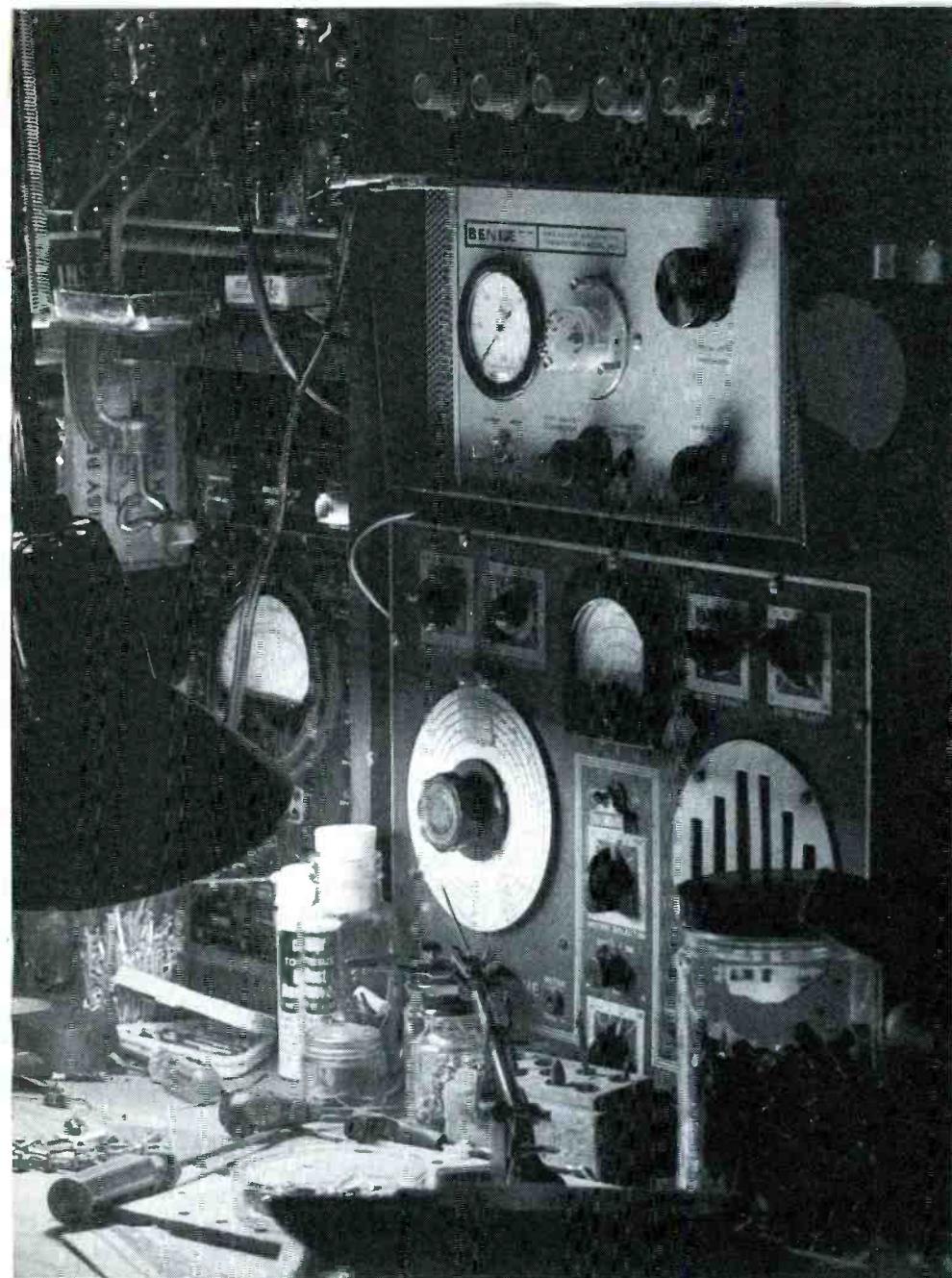
Sometimes, the search for parts and materials means a direct confrontation with the uncertain, unpredictable, or apparently unavailable, and that can drive you nuts.

The experiences of no two people are alike. A lot depends on special needs and particular interests. The individual interested in restoring antique radios and other old electrical equipment will have requirements quite different from those who enjoy working with integrated circuits. And then again, people who enjoy "open-ended" experimentation may need things not

usually required by people who prefer well-defined construction projects.

Looking Around. Unless you are very new to electronics as a hobby, the chances are that you already possess more parts and materials than you think you do. I refer, of course, to the contents of your junkbox. Every few months, poking through your collection of unclassified components is a worthwhile way to spend a Sunday afternoon. You are likely to find things you never knew you had.

Furthermore, you may find some-



*Where to turn when
that something special
that makes your
project or experiment
worthwhile is nowhere
to be found*

BY STANLEY BLACK

WORKSHOP

thing that puts you in possession of something very valuable: a good idea. Not too long ago, I decided to go through some stuff I had not been through in a long time. I ran across a small number of scrap copper bars. The copper reminded me of some electrochemical experiments I had seen in an old science book. In a few days, I found myself planning to build my own electric batteries.

Occult Components. Unfortunately, even the largest junkbox will usually not have all the parts or all the materials we

require. To complicate matters, the part we do not have often seems odd or exotic. So the question comes up: Why is there always something that is so hard to get?

Actually, there is a good reason for that. The exotic device is often the very thing that makes the project so exciting. And the unusual material may be just what makes the experiment so interesting. It follows that many of the best projects will normally require things not normally required.

Even fairly common objects turn out to be not-so-common once you start

looking for them. My voltaic batteries required heavy strips of zinc. I did not have zinc in that form: Zinc powder, yes; zinc strips, no. The pieces had to be ordered from a laboratory supply house in another state. Writing up an order is always a bother. But without the zinc strips, I could not make the batteries I wanted to make.

Being Prepared. No one can expect a single supplier to carry everything. Radio Shack is a good example. It would be very unrealistic to expect Radio Shack to carry zinc strips. In fact, a

NAMES AND ADDRESSES**All-Electronics Corporation**

P.O. Box 567

Van Nuys, CA 91408.

CIRCLE 84 ON FREE INFORMATION CARD**Antique Electronic Supply**

688 W. First St.

Tempe, AZ 85281

CIRCLE 85 ON FREE INFORMATION CARD**B & L Scientific**

P.O. Box 1054

Duvall, WA 98019-1054

CIRCLE 86 ON FREE INFORMATION CARD**Chem-Lab**

13814 Inglewood Ave.

Hawthorne, CA 90250

CIRCLE 87 ON FREE INFORMATION CARD**Consolidated Electronics Incorporated**

705 Watervliet Ave.

Dayton, OH 45420-2599

CIRCLE 88 ON FREE INFORMATION CARD**Dick Smith Electronics USA**

P.O. Box 468

Greenwood, IN 46142

CIRCLE 89 ON FREE INFORMATION CARD**Electronic Liquidators**

P.O. Box 27656

Lansing, MI 48901

CIRCLE 90 ON FREE INFORMATION CARD**Fair Radio Sales**

1016 E. Eureka

Lima, OH 45802

CIRCLE 91 ON FREE INFORMATION CARD**JerryCo Inc.**

601 Linden Pl.

Evanston, IL 60202

CIRCLE 92 ON FREE INFORMATION CARD**Hagenow Laboratories**

1302 Washington St.

Manitowoc, WI 54220

CIRCLE 93 ON FREE INFORMATION CARD**Halted Specialties**

3500 Ryder St.

Santa Clara, CA 95051-0717

CIRCLE 94 ON FREE INFORMATION CARD**Lindsay Publications**

P.O. Box 12-WF5

Bradley, IL 60915

CIRCLE 95 ON FREE INFORMATION CARD**Mark V Electronics**

8019 E. Slauson Ave.

Montebello, CA 90640

CIRCLE 96 ON FREE INFORMATION CARD**Newark Electronics**

4801 Ravenswood Ave.

Chicago, IL, 60640

CIRCLE 97 ON FREE INFORMATION CARD**Yeary Communications**

12922 Harbor Blvd., Suite 800

Garden Grove, CA 92640

CIRCLE 98 ON FREE INFORMATION CARD

trip to the local hardware store ended with the discovery that it is unrealistic to expect some people to know what a zinc strip is!

So, for many of us, getting parts usually means getting them from a mail-order company. This does not have to

be a frustrating, disappointing, or time-consuming activity. If all, I suppose, comes down to preparation. It is good to know beforehand where you are likely to find the parts or materials you are looking for. That means being familiar with what at least a few of the companies have to offer. Such is the purpose of this article.

The first step is to become familiar with the large number of companies out there and what they carry. And a good place to start is the relatively comprehensive list that appeared in the article "The Parts Connection" by Jack Cunkleman (**Popular Electronics**, July 1989). If what you need is a currently manufactured part from all but the most obscure company, the odds are pretty good that one or more of them can come through.

We are not going to duplicate Jack's work here. Instead, we are going to look at where to turn to when our needs are more esoteric. Who carries surplus components? Who stocks fun gear for the electronics experimenter? Where can you get odd materials or chemicals? And so forth.

An Excellent Selection. One of the electronic supply, mail-order companies I regularly turn to is the All-Electronics Corporation. The All-Electronics inventory features a superior selection of parts and components. This includes a wide variety of semiconductors (transistors, diodes etc.), resistors, capacitors, switches, connectors, fasteners, project cases, batteries, and power supplies. Most components are available in the small quantities generally required by hobbyists. In addition, however, every free quarterly catalog introduces new items of special interest to experimenters, like a polarity switch, strobe unit, giant pushbutton, musical telephone ringer, or light-activated motion sensor and many others.

In addition, the All-Electronics catalog is actually fun to look through, and I recommend saving them. The minimum order from the company is \$10.00 and there is a \$3.00 charge for shipping and handling within the USA.

Another company that offers a similar merchandise line up is Halted Specialties. Along with a good selection of components, they sell lasers, optical gear, and surplus equipment for experimenters. Their catalog costs \$1.00 by mail, but is available free of charge with orders or if you stop in at any of their three California stores.

Kits and Plans. For those of you who enjoy working with a variety of kits and plans, however, it may be necessary to widen your search. One place to look is called Electronic Liquidators. A recent catalog from this company featured a number of very interesting kits, most of which are available for less than \$15.00; some are less than \$5.00. Included in the selection are a transistor tester, capacitor tester, resistance box, function generator, LED level meter, microwave-oven leak detector, wireless microphone, electronic roulette circuit, and other items. An Electronic Liquidators catalog is \$3.50.

Dick Smith is alive and well, and is now living in Indiana. Dick Smith Electronics USA offers a potpourri of interesting gear and components from down under, along with many of the popular Dick Smith kits. Catalogs are available for \$2.00.

Audio enthusiasts will want to become familiar with the offerings of Mark V Electronics. They are the sole U.S. agents for Sound Master (H.K.) Electronics and Tung Yung Electrical Company, two of the most popular kit makers in Asia and Europe. The projects available range from test instruments to talking clocks, but their line-up of audio equipment is especially impressive. The kits are rated according to ease-of-assembly, and are reasonably priced. The Mark V catalog is available free of charge.

High-voltage construction projects have been popular with amateur experimenters for a long time. A west-coast company called B & L Scientific seems to specialize in things of that sort. From B & L Scientific you can get information on how to build electrophotographic equipment, lightning bulbs, Tesla coils, as well as some other very strange devices that date clear back to the late 19th century. The B & L catalog, which is well-written and highly informative, is free of charge.

Another good source for plans for electronics projects and experiments is Lindsay Publications. Their library consists of books on antique receivers, spark-gap transmitters, Tesla coils, Wimshurst lightning-bolt generators, lasers, and even the so-called "fringe sciences." The *Lindsay's Electrical Books* catalog costs \$1.00.

Miscellaneous Materials. And speaking of a good catalog, not to mention a great collection of unusual (*Continued on page 156*)

Voltage, by definition, is the electrical pressure that causes current to flow through a conductor. When that pressure is sufficiently high, a high voltage is produced. But how do we define high voltage? Is 100, 1000, or 10,000 volts considered high voltage? When compared to 10 volts, they all can be considered high voltage.

As far as safety goes, high voltage can be considered any voltage that endangers human life. It's obvious that 1000 volts poses a greater hazard than does 100 volts, but that does not mean that 100 volts is safe to handle. As far as safety goes, 100 volts is still considered high voltage—and that fact must be understood.

The *Miniature High-Voltage DC Generator*, presented in this article, is capable of generating around 10,000-volts DC. So high a voltage can ionize air and gases, charge high-voltage capacitors, and can also be used to power a small laser or image tube, and has many other applications that are useful to both the experimenter and the researcher.

Learn how very-high voltages are generated from relatively low power sources and apply the same techniques to your own experimental circuits

BY VINCENT VOLONO

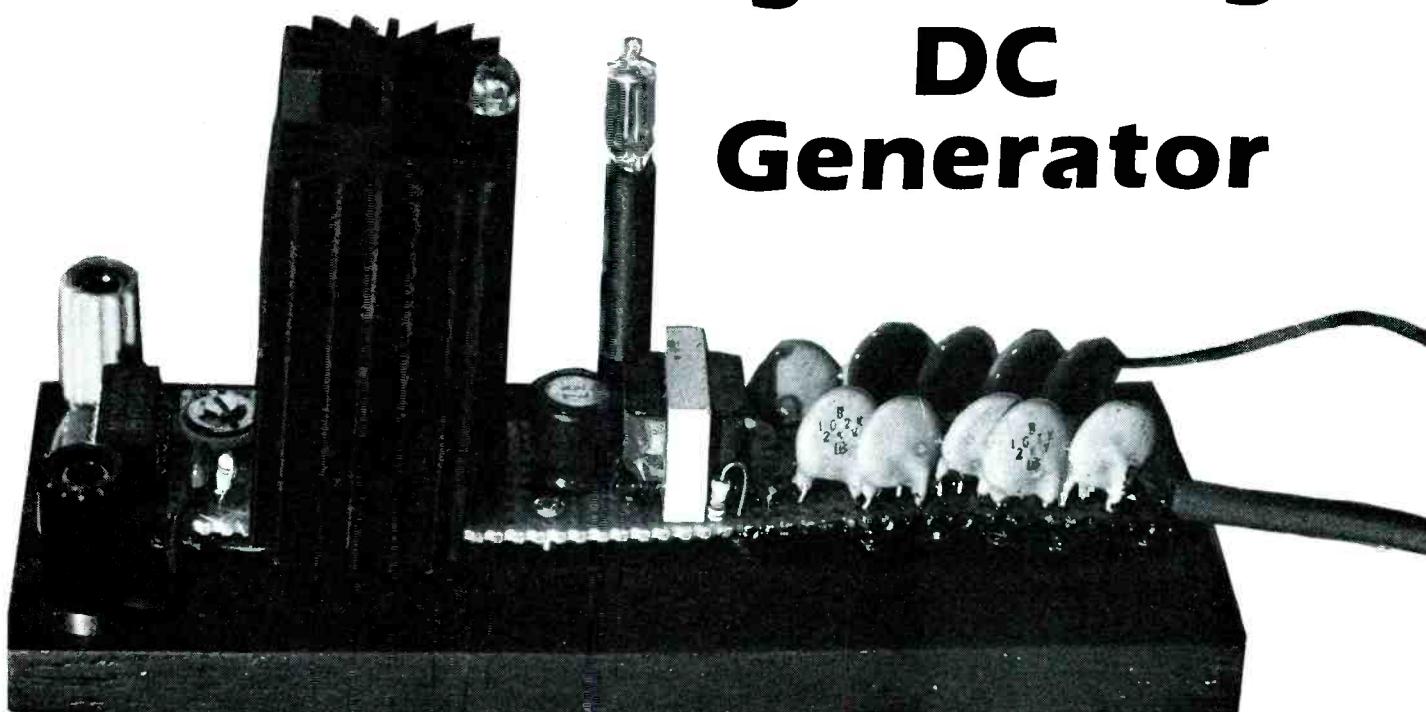
input to the circuit is then amplified to provide a 10,000-volt DC output. That's made possible by feeding the 12-volt output of the power supply to a DC-to-DC up converter. The output of the up-converter is then fed into a 10-stage, high-voltage multiplier to produce an output of 10,000-volts DC.

Let's see how the circuit works. First, let's start with U1 (a 14584 hex Schmitt trigger). Gate U1-a is set up as a square-wave pulse generator, which provides a very clean square-wave (pulsating DC) output. The output of U1-a is fed to the inputs of U1-b to U1-f, which are connected in parallel to increase the available drive current.

The pulsating output of the paralleled gates is fed to the base of Q1, causing it to toggle on and off in time with the oscillations of U1-a. The collector of Q1 is connected in series with the primary winding of T1. The other end of T1 is connected through C2 (a 220- μ F unit) to ground. Capacitor C1 retards the rise and fall times (sloping leading and trailing edges) of the square-wave DC signal, producing an AC-like, DC waveform.

The on/off action of the transistor, caused by the pulsating-signal applied to Q1, creates a rising and collapsing field in the primary winding of T1 (a small ferrite-core, step-up transformer).

High-Voltage DC Generator



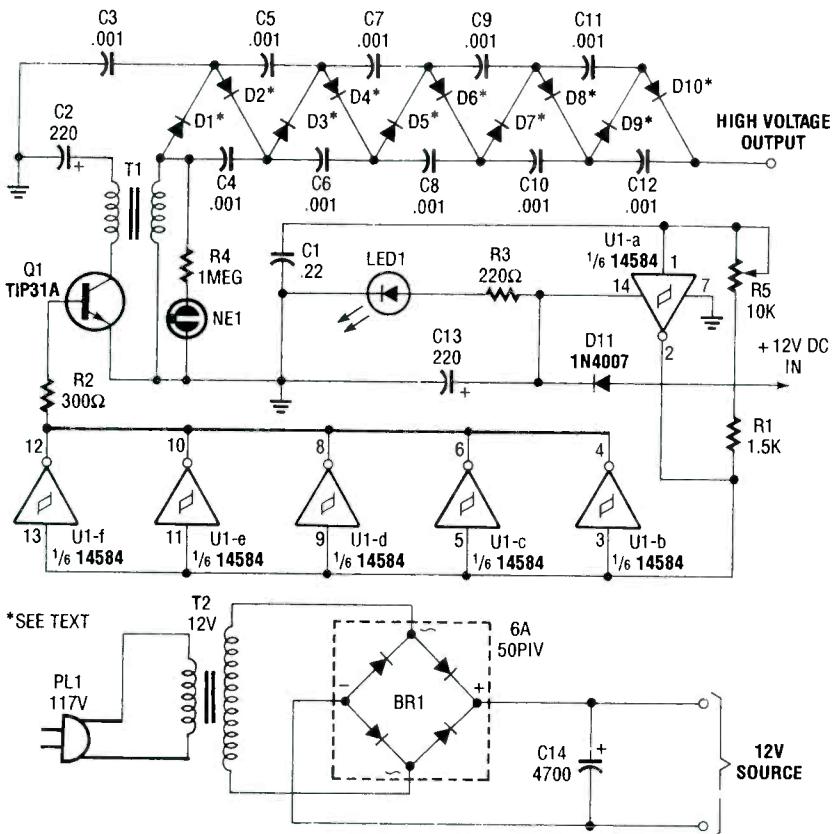


Fig. 1. In the Miniature High-Voltage DC Generator, the input to the circuit, taken from a 12-volt DC power supply, is magnified to provide a 10,000-volt DC output.

That causes a pulsating signal, of opposite polarity, to be induced in T1's secondary winding.

The pulsating DC output at the secondary winding of T1 (ranging from 800 to 1000 volts) is applied to a 10-stage voltage-multiplier circuit—consisting of D1 through D10, and C3 through C12. The multiplier circuit increases the voltage 10 times, producing an output of up to 10,000-volts DC. The multiplier accomplishes its task by charging the capacitors (C3 through C12), through the diodes (D1 through D10); the output is a series addition of all the capacitors in the multiplier.

In order for the circuit to operate efficiently, the frequency of the square-wave, and therefore the signal applied to the multiplier, must be considered. The output frequency of the oscillator (U1-a) is set by the combined values of R1, R5, and C1 (which with the values specified is approximately 15 kHz). Potentiometer R5 is used to fine tune the output frequency of the oscillator. The higher the frequency of the oscillator, the lower the capacitive reactance in the multiplier.

Light-emitting diode LED1 serves as an input-power indicator, while neon lamp NE1 indicates an output at the

secondary of T1. A good way to get the maximum output at the multiplier is to connect an oscilloscope to the high-voltage output of the multiplier, via a high-voltage probe, and adjust potentiometer R5 for the maximum voltage output. If you don't have the appropriate test gear, you can place the output wire of the multiplier about a half-inch away from a ground wire and draw a spark, while adjusting R5 for a maximum spark output.

Caution: The output of the multiplier will cause a strong electric shock. In addition, be aware that even after the multiplier has been turned off, there is still a charge stored in the capacitors, which, depending on the state of discharge, can be dangerous if contacted. That charge can be bled off by shorting the output of the circuit to ground. (In fact, it's a good idea to get in the habit of discharging all electronic circuits before handling or working on them.)

Also, U1 is a CMOS device and, as such, is static sensitive. It can handle a maximum input of 15 volts DC. Do not go beyond the 15-volt DC limit or the IC will be destroyed. Diode D11 is used to prevent reverse polarity of the input voltage source.

PARTS LIST FOR THE MINIATURE HIGH-VOLTAGE DC GENERATOR

SEMICONDUCTORS

- U1—MC14584BAL hex, inverting Schmitt trigger, integrated circuit
- Q1—TIP31A Darlington transistor
- BR1—6-amp, 50-PIV full-wave bridge rectifier
- D1-D10—Two 1N4007 1-amp, 1000-PIV, silicon rectifier diodes connected in series (see text)
- D11—1N4007 1-amp, 1000-PIV, silicon rectifier diode
- LED1—Jumbo green light-emitting diode

RESISTORS

(All resistors are $\frac{1}{4}$ -watt, 5% units, unless otherwise noted.)

- R1—1500-ohm
- R2—300-ohm
- R3—220-ohm
- R4—1-megohm
- R5—10,000-ohm potentiometer

CAPACITORS

- C1—0.22- μ F, 50-WVDC metallized-film
- C2, C13—220- μ F, 16-WVDC electrolytic
- C3-C12—.001- μ F, 2000-WVDC ceramic-disc
- C14—4700- μ F, 35-WVDC electrolytic

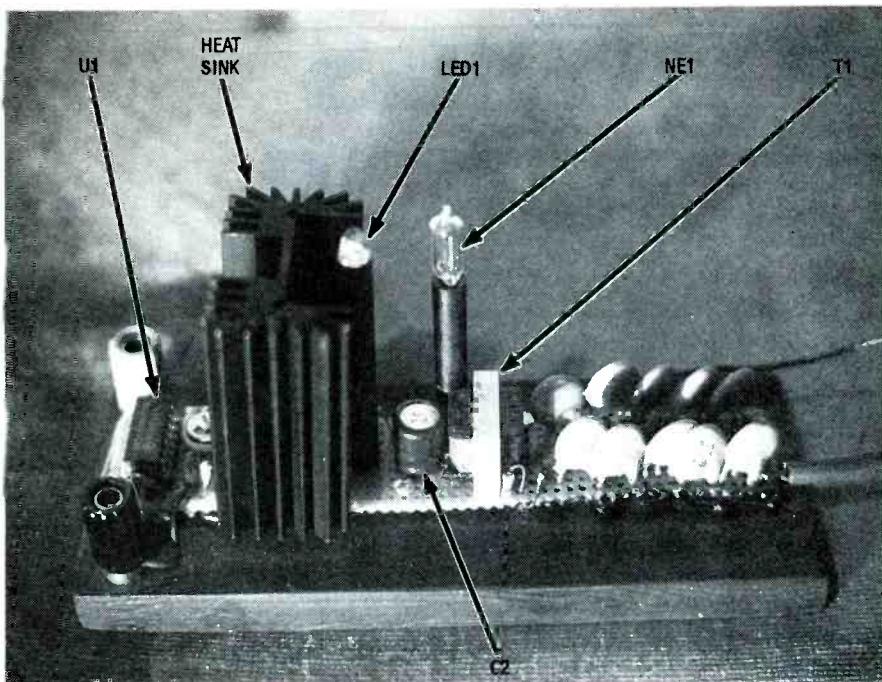
ADDITIONAL PARTS AND MATERIALS

- NE1—NE2 neon lamp
- T1—Ferrite core step-up transformer (see source below)
- T2—12-volt, 2-amp power transformer
- PL1—117-volt AC plug with line cord
- Perboard materials, enclosure, heat sink, IC sockets, battery and battery holder, Banana jack, hook-up wire, solder, hardware, etc.

Note: The following is available from Allegro Electronics Systemis, Dept. HVM, 3 Mine Mountain Road, Cornwell Bridge, CT 06754: Transformer T1 with data and applications notes (part HVM-COR-2), \$5.00 (postage paid). A catalog of high-voltage parts is also available free of charge. Connecticut residents please add appropriate sales tax. Please allow 6 to 8 weeks for delivery.

Free technical assistance on the construction of high-voltage multipliers is available by phone by calling 203/672-0123 weekday mornings, or by writing to the above address.

As far as the voltage multiplier goes, the diodes and the capacitors must be rated for at least twice the anticipated input voltage. So, if we have a 1000-volt input, all of the diodes and the capaci-



In the author's prototype, LED1 and NE1 were mounted to 1½-inch stand-offs, and the entire circuit (minus the power supply) was mounted to a block of wood. The wood block helps to isolate and insulate the circuit board from any metallic objects.

tors must be rated for at least 2000 volts each. Because diodes with that voltage rating can be hard to find and expensive, D1 through D10 are each really two series-connected 1-amp, 1000-volt rectifier diodes.

Construction. The unit can be assembled on perfboard, as is the case with author's prototype shown in the photo. Transistor Q1 must be properly heat sunk or it will overheat quickly and self destruct.

The multiplier must be assembled in such a way so as to prevent any ion leakage. When a high-voltage source is terminated at a sharp point, the density of charge is concentrated at that point. The ions both on the point and near the point are like charges, so they repel each other and quickly leak off. So it is very important when soldering the multiplier to keep all connections rounded by using enough solder to make a smooth, ball-like joint.

The solder side of the multiplier should be insulated to prevent contact with any metallic object. On the author's prototype, A high-voltage insulating compound was used on the solder side of the board. High-voltage putty can also be used. Also in the prototype, the output of the circuit is simply a heavily shielded wire, like that used to feed high voltage to the anode of a TV picture tube. That type of wire can safely handle voltages in the 15,000- to

20,000-volt range, and will also help to prevent leakage.

Positive and Negative Ions. The polarity of the diodes in the multiplier will determine the polarity of the ions. In the author's prototype, the multiplier is set up to generate positive ions. If the diodes were reversed, negative ions would be produced.

In a positive-ion generating multiplier, like that used in the author's prototype, which generates approximately 10,000 volts DC, the output is a shock hazard. A negative-ion generating multiplier with a -10,000-volt DC output, offers the same shock hazard as the positive +10,000-volt output.

Experiments. If you place the high-voltage output wire about ½ to ¾ inch from a ground wire, you will draw a spark of 10,000 volts. But remember, the oscillator is built around a CMOS device, which is static sensitive, and any high-voltage kickback will toast the unit. So when experimenting with the spark, do not use the circuit ground. A more reliable method would be to draw a spark to an earth ground.

Flash Lamp Electric Storm. When the output of the Miniature High-Voltage DC Generator is connected to a small flash tube, the high voltage ionizes the Xenon gas in the tube, creating a small electrical storm within the tube's glass envelope.

Getting Different Voltages. By tapping the multiplier circuit at various stages you'll get output voltages ranging from 1,000 volts to 10,000 volts DC. For instance, by placing a tap at the cathodes of D2, D6, voltages of 2000, and 6000 volts are made available.

Troubleshooting. If you get no output or a low output from the circuit, check that the input to logic gates is below 15 volts. The application of an input voltage exceeding that limit will blow out the IC. Also check (with an oscilloscope) that you get a square-wave output of approximately 12 kHz at pin 6 of U1.

The switching transistor must be mounted on a heat sink or it will overheat. Make sure the heat sink is of a suitable size to keep the transistor cool.

If a 2-kilovolt (kV) diode is placed at the output of transformer T1, you should get an unloaded output of approximately 800 to 1000 volts DC.

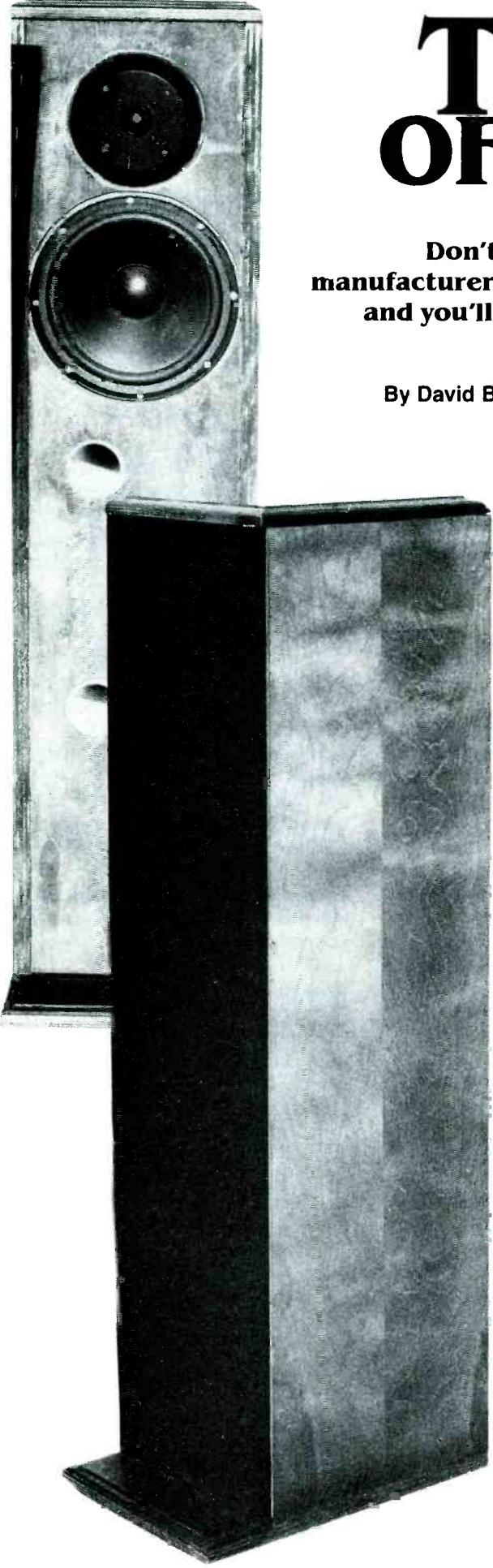
If you have a problem with the output of the unit, it is best to disconnect the multiplier from the oscillator and check the output of the transformer. In that way you will know if the problem lies in the oscillator or the multiplier.

The multiplier components must be rated for at least twice the input voltage. The diodes and capacitors used in the multiplier circuit should be rated at 2000 volts. However, you may choose to do as the author did; use two series-connected 1-kV units for each diode in the multiplier to give an effective rating per pair of 2 kV.

Safety. The output of the circuit is high-voltage DC, which will cause an electric shock if touched. So use caution. Also with the circuit turned off, the capacitors in the multiplier are still charged, and will discharge through the path of least resistance—your body—if you come in contact with the circuit. So discharge the circuit by connecting the output lead to ground with the power off.

The Miniature High-Voltage DC Generator emits a fair amount of ozone. If the circuit is to be operated for a long period of time, make sure that you do so in a well ventilated room. Ozone is harmful in moderate to large quantities.

When drawing a spark discharge, the circuit emits radio and television interference. That can be seen as static lines on your television set or heard as noise on your AM radio.



TOWERS OF POWER

Don't be at the mercy of a speaker manufacturer's specs. Build your own loudspeakers and you'll know exactly what you're getting.

By David B. Weems

If you have visited any audio showrooms recently, you have surely seen plenty of tower speakers. There are good reasons for their popularity. First, a tower puts the tweeter closer to "normal" ear height, eliminating the need for a stand. Also, towers are narrow, giving good horizontal sound distribution and better stereo imaging than wider enclosures. And they occupy very little floor space.

Even with their advantages, getting good sound from a tower can be tricky. There is the danger of nasty resonances when the longest dimension of a speaker enclosure is equal to or greater than three times the shortest dimension. Such enclosures can act like pipes, which are notoriously resonant.

Pipe resonance can be reduced by placing stuffing in the enclosure, but it can also be stifled by breaking the pipe into sections. For that, the double-chamber reflex speaker is a natural.

Double-Chamber Reflex Design

Double-chamber reflex designs have been around for years, but are often overlooked. The compartments of a double-chamber box are tuned to two frequencies, one an octave above the other. Double tuning keeps the woofer(s) under control and reduces distortion. At the frequency of the lower resonance, the two chambers act as one and the driver sees their combined volumes as the real size of the box.

Double-chamber reflex enclosures were originally designed for use with any good eight-inch speaker with a specified volume of about 2.7 cubic feet, generous enough to avoid the problems that occur when a box is too small. That is one of the advantages of the double-chamber design—it works well even without a careful match between the enclosure and the driver. Now, modern design techniques allow us to tailor the enclosure to suit any specific driver. However, the techniques involved are beyond the scope of this article. Instead, we will concentrate on a design that the author has found successful. It is one that can be readily reproduced, and uses easy-to-obtain parts.

The speaker described here consists of an eight-inch woofer and a one-inch tweeter in a double-chamber reflex tower that's 10-inches wide \times 40-inches tall \times 12 $\frac{1}{4}$ -inches deep. The woofer is the Peerless 1556; the tweeter, a soft dome Audax HD 100 D 25. Both the speakers and the crossover components, are available from McGee Radio (see the Parts List). The total cubic volume of the two reflex chambers is about 36 liters or 1.27 cubic feet. The tuned frequencies are 40 and 80 Hz.

Special Precautions

It is desirable to use any reflex speaker with an amplifier or receiver with a good infrasonic (subsonic) filter. If such a filter is not available on your audio equipment, you can still use tower speakers. Just use

care in feeding a signal that contains pulses into your speakers at high power. Such pulses can be produced by some turntables, FM tuners, and other sources. You can check your equipment for subsonic garbage by removing the grille from your speakers and watching the woofer cones. If the cones show excessive movement (also called throw) with any audio source, use that source with care.

When you select materials for a part of the enclosures, put solidity above appearance. If you use plywood—a logical choice for the external panels—make sure it has no voids or loose layers. Good-quality hardwood plywood is usually adequate. Particle board (the suggested material for part of the enclosure) is more solid, but even it varies in density. The sections, the quantity required, the materials used, and their dimensions, are listed in Table 1.

Take Note

Be aware that the drawings in this article show the dimensions of the chambers before any special treatment of the panels, as described later. The final dimensions of the larger chamber are about $7\frac{1}{2} \times 9\frac{3}{4} \times 20$ -inches. The second chamber has the same width and depth, but the height is about half that of the larger one.

One difference between the photographs and drawings can be seen in the edges of the top and bottom pieces. Those parts in the towers shown in the photographs were run through a shaper to add an interesting curve to the edges. If a shaper isn't available, a simple square edge will suffice. You can cover the raw edges of the plywood with thin strips of wood veneer, which is available at building-supply stores. Or you can alter the dimensions of the top and bottom pieces and add a solid wood trim of your own choice.

Speaker-Board Construction

Start out by making the woofer and tweeter cut-outs on the speaker board using the dimensions given in Fig. 1A. The speaker board requires careful handling because of the small amount of material left at each side of the woofer hole. Set the woofer in the cut-out and rotate it until two opposite mounting holes in the woofer frame are in a horizontal position over the narrow sections of the board. Those two holes will not be used. Mark the locations of the *other* bolt holes and remove

TABLE 1—SECTION INFORMATION

Section	Quantity	Material	Thickness (Inches)	Dimensions (Inches)
Top	2	Hardwood Plywood	$\frac{3}{4}$	$12\frac{1}{4} \times 10$
Partition	4	" "	"	$10 \times 8\frac{1}{2}$
Bottom	2	" "	"	$15\frac{1}{2} \times 10$
Side Panels	4	" "	"	$12 \times 38\frac{1}{2}$
Speaker Board	2	Particle Board or Plywood	"	$8\frac{1}{2} \times 38\frac{1}{2}$
Back Panel	2	"	"	$8\frac{1}{2} \times 32\frac{1}{2}$
Faceplate	2	Plywood	$\frac{1}{4}$	$8\frac{1}{2} \times 38\frac{1}{2}$
Cleat ①	4	Pine	$\frac{3}{4} \times \frac{3}{4}$	10
Cleat ②	8	"	"	$19\frac{3}{4}$
Cleat ③	8	"	"	$8\frac{1}{2}$
Cleat ④	4	"	"	$5\frac{1}{2}$
Cleat ⑤ & ⑨	14	"	"	7
& Brace				
Cleat ⑥	4	"	"	$6\frac{1}{4}$
Cleat ⑦	2	"	"	$8\frac{1}{2}$
Cleat ⑧	8	"	"	$10\frac{1}{4}$
Lattice ④	8	Lattice Work	$1\frac{1}{8}$	$7\frac{1}{16}$
Lattice ⑤	4	"	"	$38\frac{7}{16}$
Lattice ⑥	4	"	"	Cut to Fit
Port	6	PVC Tube	2 Dia.	$5\frac{1}{2}$

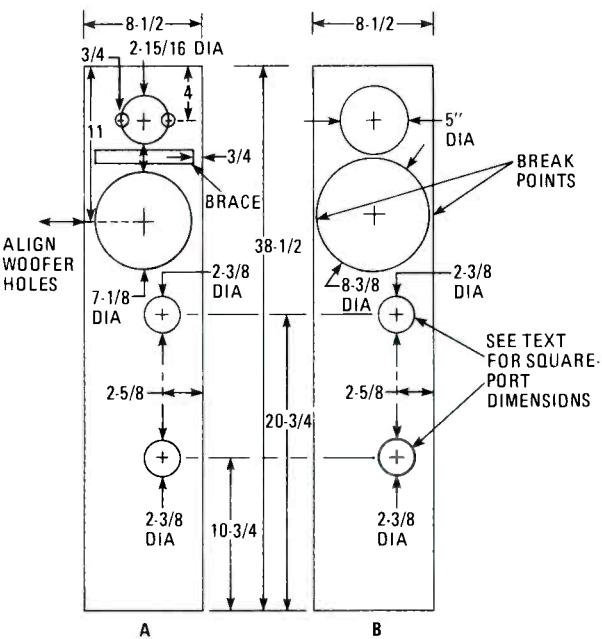


Fig. 1—All dimensions for the speaker board (A) and the faceplate (B) are given in inches. Allow your saw to cut through the remaining thin pieces of board on the faceplate while cutting the hole for the woofer.

the speaker. Drill a $\frac{1}{4}$ -in. hole in each marked location. Place the speaker board face down on a large flat surface to support it. Drive a $\frac{3}{16}$ -inch T-nut into the back of the board into each of the drilled holes.

Don't be concerned about the strength of the speaker panel. It will be strong enough when it is glued into the enclosure with the cleats behind bonded to it. However, while working on other sections it may be advisable to clamp a board over the woofer hole. Do not cut the port holes yet.

Attaching The Faceplate

Now you can cut the speaker holes in the $\frac{1}{4}$ -inch plywood faceplate section. When cutting the woofer hole allow the saw to cut the face plate in two at the two indicated breakpoints (see Fig. 1B). After making the cut-out for the tweeter, round off the edges of the faceplate at the tweeter hole. Glue the two faceplate pieces to the speaker board before cutting the holes for the ports.

Finally, you will need to cut the port holes as shown. The left tower should have port holes to the right of center and the right tower should have its ports to the left of center, so remember to flip the pattern when cutting the port holes for the right tower.

If you have no way to mark and cut a perfect circle of the precise diameter needed ($2\frac{3}{8}$ -inches for most 2-inch I.D. pipe), you can stencil around the pipe or even change to a port with a square cross-section. In the last case, make the internal dimensions of the port $1\frac{3}{4} \times 1\frac{3}{4} \times 5\frac{1}{2}$ -inches.

After cutting the holes for the ports, attach a $\frac{3}{4} \times \frac{3}{4}$ -inch brace across the back of the speaker board in the space between the woofer and the tweeter holes.

Assembly with Cleats

Of course you will need to cut the large sections shown in Fig. 2 before proceeding further. Refer back to Table 1 to determine the proper material for each section. Please note that only two of the four partitions (as shown in Fig. 2B) should have holes.

You will also need to cut the cleats using Table 1 as a guide. Pre-drill the vertical cleats (the even-numbered ones) for wood screws that will be used for the complete sectional assembly. They will require no less than four holes each. Then attach those cleats to the sides with glue and 1½-inch nails (see Fig. 3), placing the pre-drilled holes in position for later use. Pre-drill and install the remaining cleats on the top, the partitions, and the bottom. Wait until the glue sets well before proceeding with the assembly of the tower.

Sectional Assembly

When the glue has set, glue and screw the bottom, partitions, and top to the sides using wood screws put through the pre-drilled holes. Use care when matching panels so that they fit well enough to make strong, air-tight joints. Also, caulk all joints with a good grade of caulking material, preferably silicone rubber. Caulk only on the inside of the cabinet for

best appearance. The caulking is required because it is absolutely essential to have no air leaks or the reflex system will not perform according to plan.

Next, install the speaker panel with glue and nails. Again, when the glue is set, caulk the joints around the edge of the panel. Prepare the back by drilling it for air-tight speaker terminals.

The L-Pad

You can install the L-pad in the upper back, if you wish, but that complicates the wiring a bit. It is much simpler to put the L-pad on a small board as part of the crossover network at the bottom of the tower. Once it is set, it is unlikely you will ever change the tweeter level unless you move the speakers to a different listening environment.

Since you will put all the crossover components in the base, you'll need to run wire, such as lamp cord, up the back to separate terminals for the woofer and tweeter. Drill holes for the terminal lugs and solder about 18-inches of inner-box cable to the lugs before you glue down the terminal strip on the back. Caulk the holes on the inside of the back with silicone rubber. If you prefer, you can simply run the speaker cables through small holes in the back and caulk the holes.

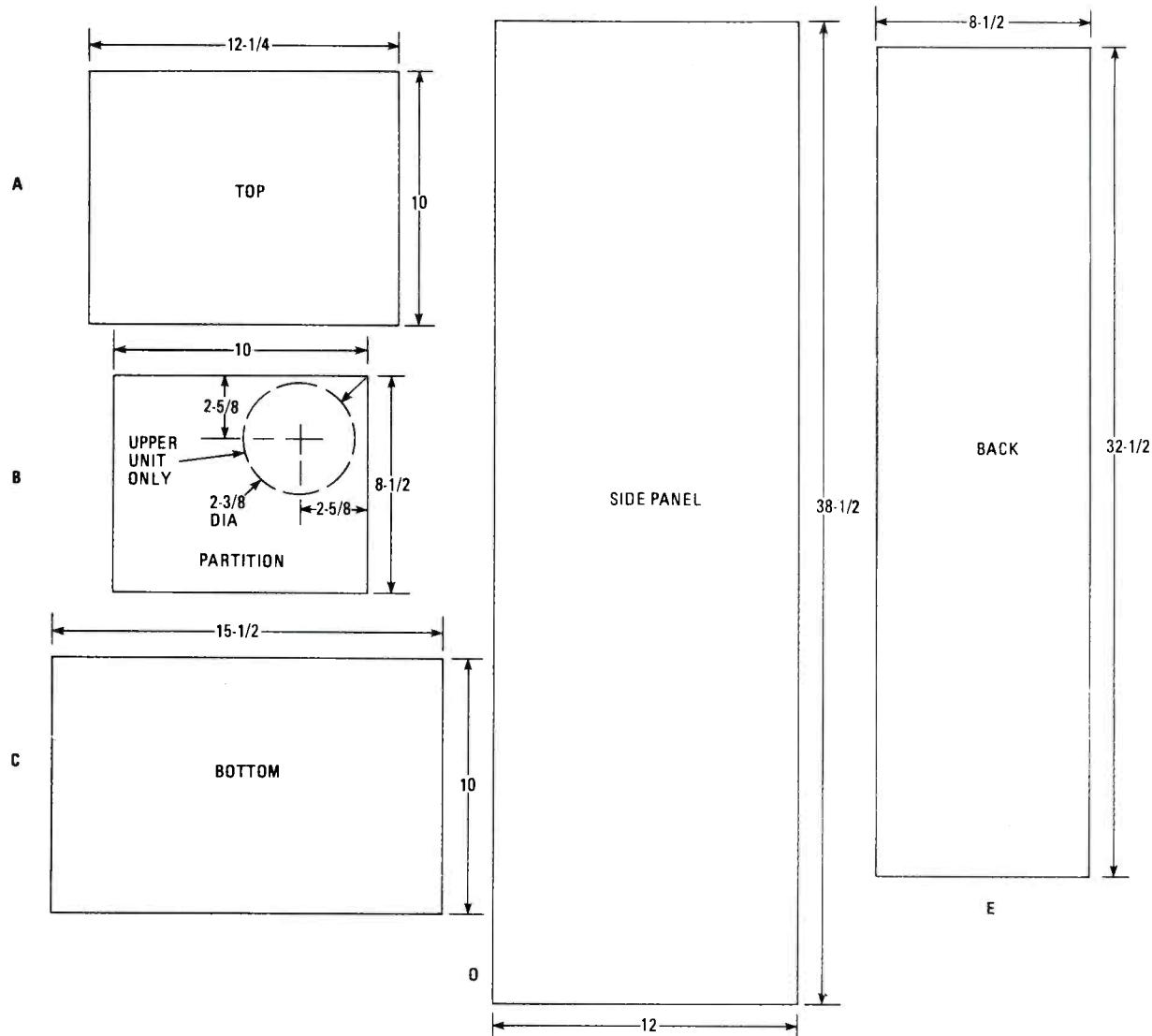


Fig. 2—Note that only two of the four partitions (B) require holes. The partitions with the holes must be placed inside the cabinet so that the holes will be on the same side as the front ports. See Table 1 for the materials list.

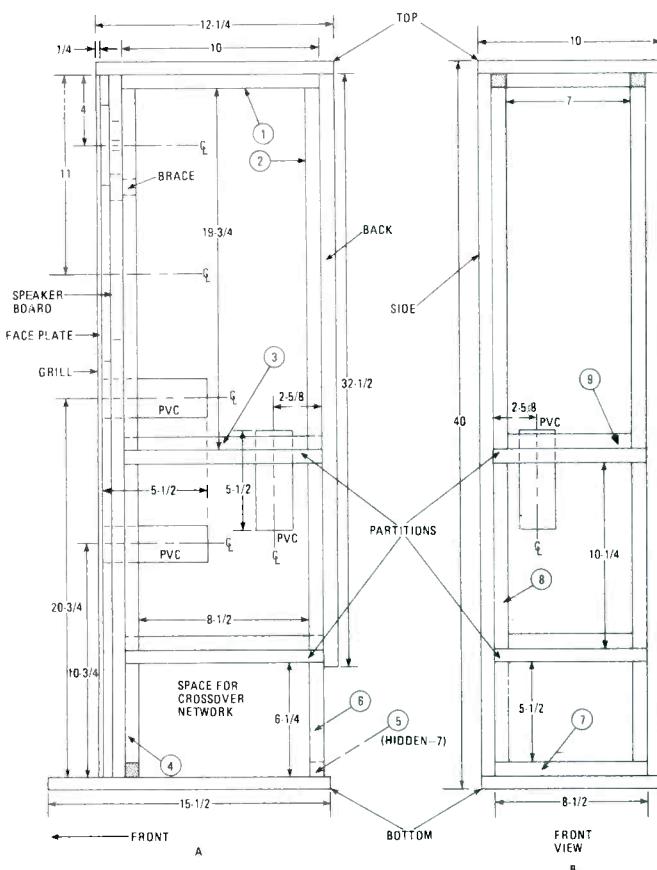


Fig. 3—All dimensions for the cabinet are given in inches. The side view (A) is what you would see with one of the sides removed. The front view (B) is what you would see with the front taken off. One brace of each type is numbered and the numbers correspond to those in Table 1. Brace 5 is hidden from both views, but is pointed to.

Special Treatment

It's important to add some stiffening and damping material to the walls. Asphalt roofing material makes an excellent cabinet liner. You can find scraps of roofing at many building sites (you only need a few shingles).

The adhesive called "Liquid Nails" works well as a glue for the shingles. Builders usually recommend an asphalt-base adhesive for shingles, but they are concerned with performance on the roofs of buildings where weathering occurs. The asphalt adhesives seem to take weeks to set so Liquid Nails is strongly recommended.

Apply a coating of the adhesive on the enclosure wall, then quickly staple a piece of shingle over it. Do that for all the inner surfaces of the larger chamber except the speaker board. In the smaller chamber it should be added to the sides, back, and bottom partition.

Acoustical Touches

When the adhesive has set, apply another thin coat of Liquid Nails and staple sections of thin indoor/outdoor carpet over the roofing material, with the foam side facing the wood. The ideal carpet for this job is about $\frac{1}{4}$ -inch thick. Half of the thickness consists of a polyurethane foam backing. The combination of carpet and roofing does a good job of deadening the enclosure walls.

Staple pieces of acoustical Fibreglas, 1-inch thick, to each inner surface of the large chamber except the speaker panel.

Place a small piece on the upper surface of the bottom partition in the second chamber. If you have any left, add it to the layer of Fibreglas on the inside of the back panel in the large chamber, directly behind the woofer.

The Back and Grille

Install the back panel. If you want to conduct any experiments with damping material, run a strip of foam weather stripping around the edges and across each partition; then install the panel with screws. For the final installation, use a liberal bead of silicone rubber sealer on the rear cleats and nail down the back. The silicone rubber makes a perfect seal for any joint that you can't reach to caulk later. After gluing down the back you can still gain access to the interior of the larger chamber by removing the woofer.

Cut the $1\frac{1}{8}$ -inch lattice material to the lengths described in Table 1. Make the grille frame from it by stapling it together with heavy-duty staples using Fig. 4 as a guide. Spray the frame's front surface flat black and drape the grille cloth around the frame. Wrap the cloth around the lattice work and attach it with staples to back side of the grille.

Put the grille in place, and if any part of the speaker panel shows through the grille cloth, darken it with stain or black paint. Finish all the external wood surfaces before installing your speakers or crossover network.

Crossover Network

If you apply the usual formulas to the values shown in the schematic diagram of the crossover network in Fig. 5, you will notice some variation from common practice. The values

PARTS LIST FOR ONE TOWER SPEAKER

CAPACITORS

(All capacitors are nonpolarized and rated at 100-VVDC; see text)

C1, C3— $4.7\mu F$

C2— $12\mu F$

C4— $50\mu F$

C5— $24\mu F$

RESISTORS

R1—5.2-ohm, 25-watt

R2—8-ohm, 25-watt

R3—8-ohm, L-pad

INDUCTORS

L1—0.26-mH, coil

L2—1-mH, coil

L3—0.51-mH, coil

ADDITIONAL PARTS AND MATERIALS

SPKR1—Audax HD-100 D-25

SPKR2—Peerless 1556

Terminal blocks; wood supplies and 2-in. I.D., PVC tubing (see Table 1 for materials and quantities); polyester-knit-grille cloth 12-in. \times 40-in.; wood glue; Liquid Nails; silicone-rubber sealer; foam-backed carpeting; lamp cord, #18 or heavier; 3 doz. #8 \times 1 $\frac{1}{4}$ -in. wood screws, for glue blocks; 6 $\frac{1}{4}$ -in. T-nuts; 6 $\frac{1}{4}$ -in. round-head bolts; nails 1 $\frac{1}{4}$ -in. long; $\frac{1}{2}$ -yd.² of 1-in. thick acoustical Fibreglas; asphalt roofing pieces.

Speakers and crossover components are available from McGee Radio Co., 1901 McGee St., Kansas City, MO 64108. Radio Shack sells a package containing 1 yd.², 1-in. thick acoustical Fiberglas (enough for both enclosures).

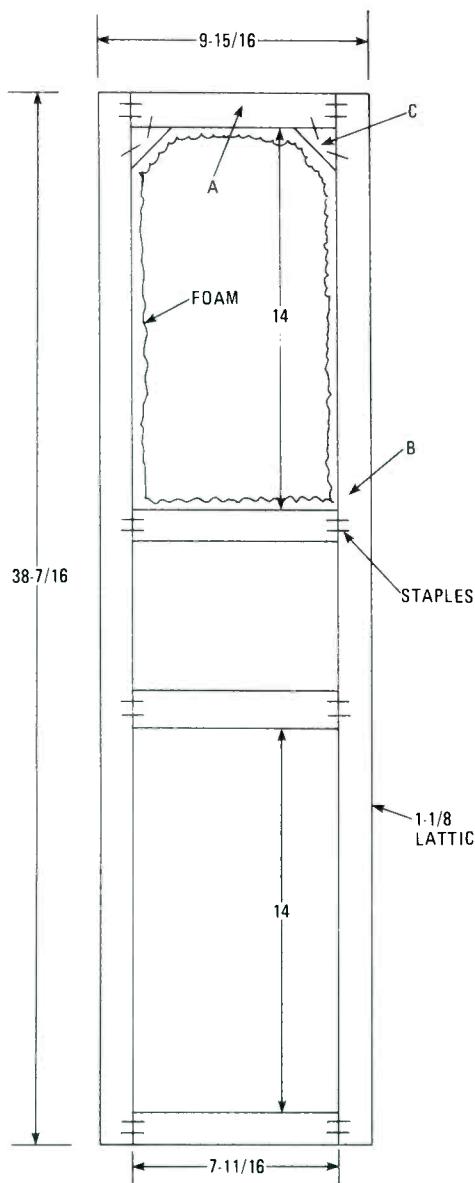


Fig. 4—The dimensions in this drawing of the speaker grille are all given in inches. The lattice-work pieces are lettered to correspond to those in Table 1.

shown in the diagram were selected after testing the system, rather than by formula alone.

The Parts List specifies ordinary non-polarized electrolytic capacitors, which work well. Some speaker-design engineers insist on Mylar or polypropylene speaker capacitors, particularly in the tweeter circuit. If you decide to substitute the more expensive Mylar or polypropylene units, you should change the values of C1 and C2 because the typical non-polarized capacitor runs lower than its polarized counterpart. To make the change, reduce the value of C1 to $4\mu F$ and the value of C2 to $10\mu F$.

In setting up the crossover network, don't install the various coils too close to each other. If you must place one within a couple of inches of another coil, set the two at right angles to each other. And keep them away from pieces of iron or steel.

You can use a small wooden board as a chassis for the network. Mount each component securely by using an adhesive, such as mounting tape or epoxy, to hold it in place. Point-to-point soldering is a suitable connection method. The

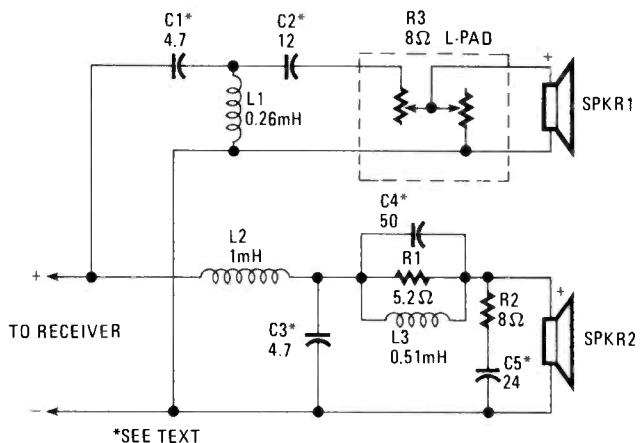


Fig. 5—The crossover circuitry is simple to build and its schematic diagram is shown here. The dashed box around the L-pad indicates that its wiring is internal to that unit.

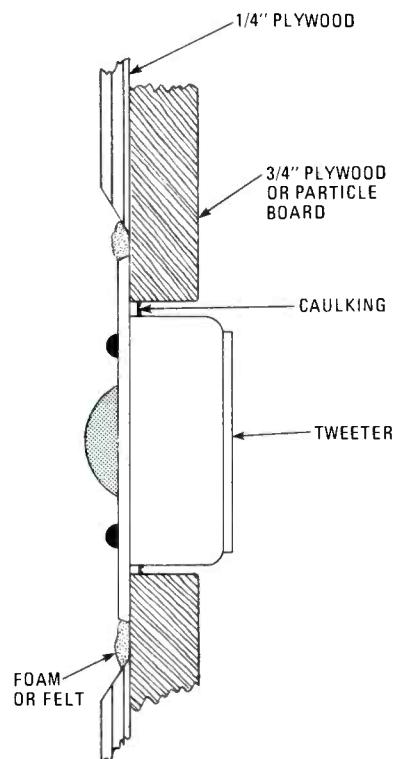


Fig. 6—If done with care, the tweeter can be seated in the faceplate without fasteners. The caulk should hold it in place. Attach the foam after the caulk has dried.

board should be securely mounted to the cabinet floor to prevent rattling.

Once in place, connect the driver wires to the appropriate points in the circuit. Speaker polarity is important, so be sure you know the polarity of the driver leads.

Tweeter Mounting

Set each tower on its back to install the drivers. Draw the tweeter cable out through the tweeter cut-out and solder the leads to the tweeter lugs (be sure to observe the correct polarity).

Run a thin bead of silicone rubber sealer around the edge of the cut-out and press the tweeter into it (see Fig. 6). Twist the tweeter gently to make sure the sealer is evenly dispersed under it. Mounting screws are unnecessary. Glue a ring of

(Continued on page 146)

*Avoid the dead
battery blues by
installing this circuit
to let you know when
you've left your
auto lights on.*

BY CHARLES R. BALL, JR.

Remember that foggy, rainy morning that you rushed into the office and left your lights on? Remember how long it took the service man to get out to jump start your car? Remember how much that little bit of forgetfulness cost? Well you don't have to worry about that ever again, if you install the simple *Light Warning System* described in this article.

The Light Warning System automatically sounds an alarm if you turn off the vehicle's ignition while the headlights or parking lights are on. The alarm ceases once the lights are turned off. That's peace of mind for under \$15.

Circuit Operation. The circuit shown in Fig. 1 is built around the everpopular 555 oscillator/timer. When the ignition and either the headlights or parking lights are on, little or no voltage dif-

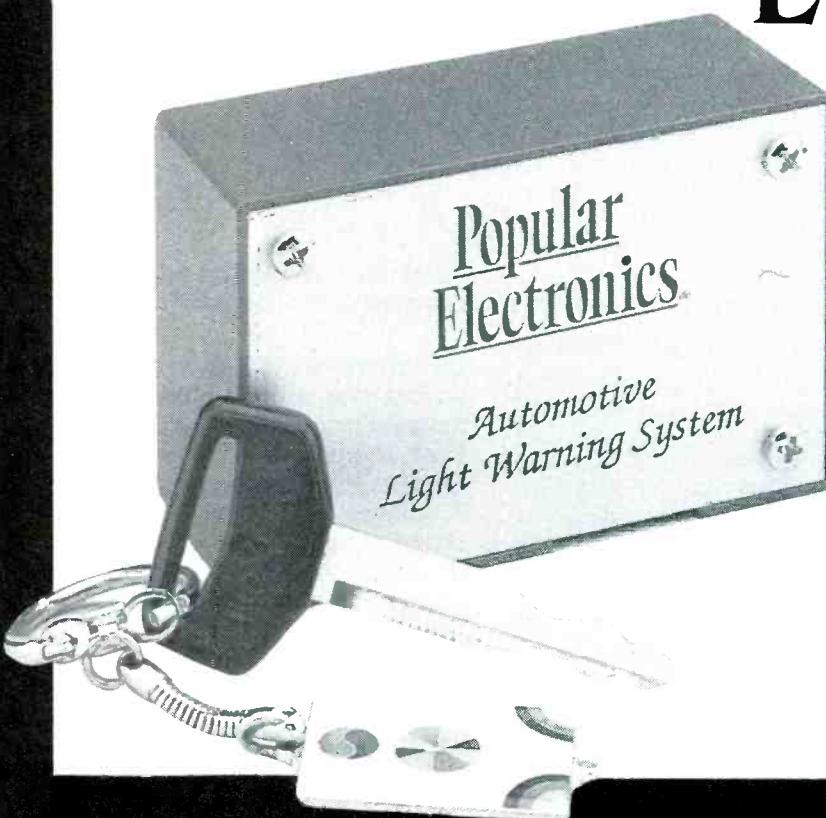
ference exists between the headlight/parking-light circuits and the ignition circuit.

If either the headlight or the parking-light circuit is active and the ignition circuit is off, a voltage difference that is sufficient for alarm operation develops across U1. Diodes D1 and D2 are connected in an OR-gate arrangement, so that either will pass a positive voltage from its anode to U1.

The oscillator starts, and sounds a warning tone via the piezo buzzer. The frequency of the tone may be changed (within limits of piezo response) by varying the values of R1, R2, or C1, or any combination thereof. Potentiometer R3 serves as a volume control to set the sound to a suitable level for the user.

Diode D3 blocks reverse current when the ignition alone is on. Zener diode D4 may be required to provide

BUILD THIS Lights-On Warning System for your Car



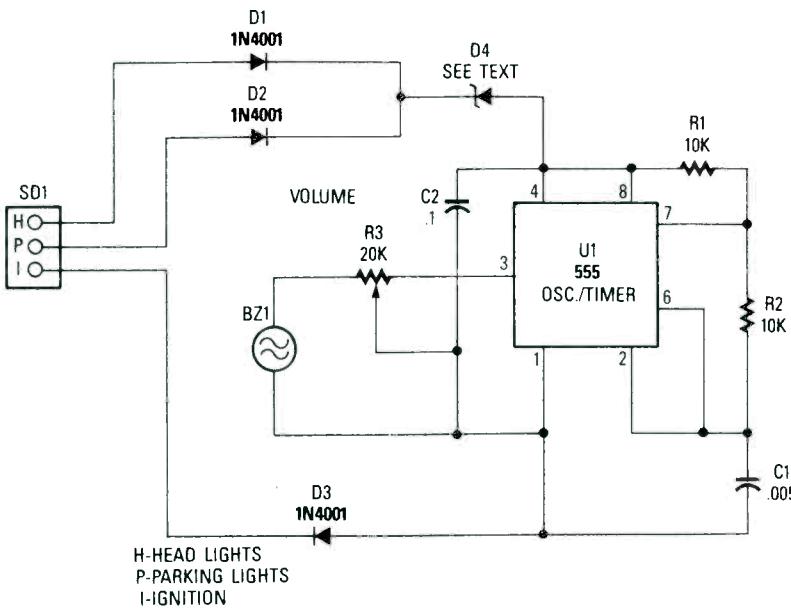


Fig. 1. The automobile Light Warning System is built around the a 555 oscillator/timer, and receives power from the car's battery.

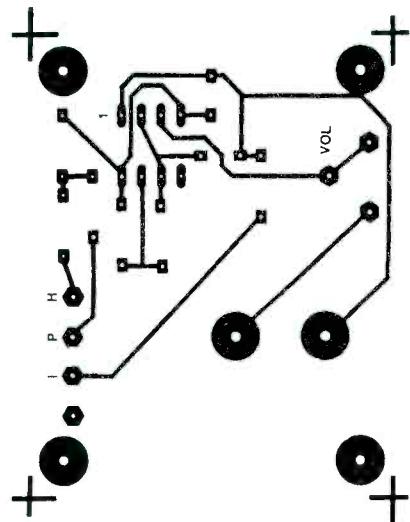


Fig. 2. Here's a template of the board layout used by the author in the production of his prototype unit. For those who choose not to etch their own boards, a printed-circuit board can be purchased from the supplier given in the Parts List.

PARTS LIST FOR THE LIGHT WARNING SYSTEM

- U1—555 oscillator/timer, integrated circuit
- D1-D3—1N4001 1-amp, 50-PIV (or similar) rectifier diode
- D4—Zener diode, see text
- R1, R2—10,000-ohm, 1/4-watt, 5% resistor
- R3—20,000-ohm, PC-mount, trimmer potentiometer
- C1—0.005- μ F, 100-VVDC, mylar capacitor
- C2—0.1- μ F, 25-VVDC, ceramic-disc capacitor
- BZ1—Piezo buzzer (Panasonic part No. EFB-RD or similar)

S01—3-position, enclosed terminal block (Mouser part No. ME153-2103)

Printed-circuit or perfboard materials, enclosure, IC socket, splice connectors, wire, solder, etc.

Note: The following items are available from BALLCO, Inc., PO Box 1078, Snellville, GA 30278-1078; Tel. 404/979-5900: printed-circuit board (part No. 881101-A) \$9.95; complete kit of parts (excluding case and terminal block) \$15.95, postage paid. An optional enclosure is available for \$3.95, postpaid. Georgia residents must include appropriate sales tax.

a threshold to prevent false alarm operation if there is a small voltage difference in the DC supply circuit during normal operation. To determine the necessity and/or the value of D4, with the headlights and ignition both on, measure the voltage between the headlights and parking lights (points H and P in Fig. 1).

If you measure more than 1.4 volts, the Zener is required. The Zener's voltage rating should be slightly higher than the difference between the measured voltage and 1.4 volts. For example, if the measured difference is, say, 1.76 volts, the Zener should have a voltage rating of 1.4 + 1.76 volts or 3.16 volts. The closest off-the-shelf Zener would be a 3.3-volt unit.

For low voltage differences, one or more forward-biased silicon diodes can be substituted for the Zener. Each forward biased silicon diode drops about 0.7 volts.

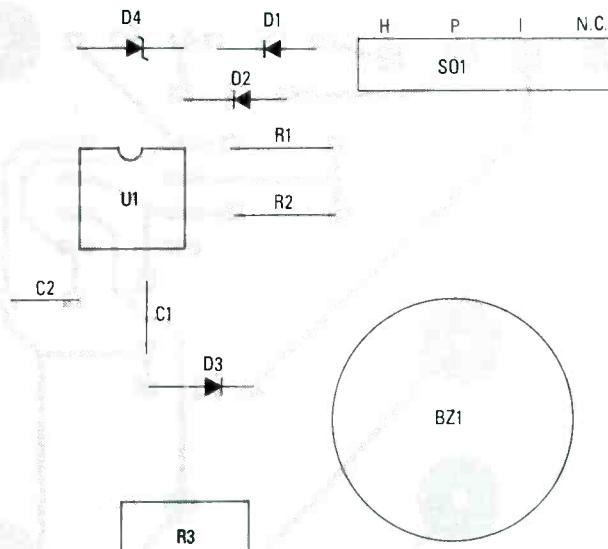


Fig. 3. Assuming that you've opted to go the printed-circuit route, using the foil pattern shown in Fig. 2, assemble the components on that board using this diagram as a guide.

Construction. The system can be assembled on a small piece of perfboard or on printed-circuit board. For those who choose to go the printed-circuit route, a full-size template of the PC artwork is shown in Fig. 2. Or, if you're not into etching your own boards, a printed-circuit board can be purchased from the supplier given in the Parts List.

Once you've obtained the parts outlined in the Parts List, assemble the project using Fig. 3 as a guide. When installing the semiconductors, be sure (Continued on page 143)

Build a 10-MHz Frequency Counter

Anyone interested in electronics sooner or later (usually sooner) needs some sort of test equipment. Almost every electronics hobbyist has a digital or analog multimeter, but there are times when simple voltage, current, and resistance measurements just won't do. Sometimes, such as when working with digital circuits, a frequency measurement is needed. That's the time when you need an oscilloscope or frequency counter.

Unfortunately, a low-end oscilloscope or a frequency counter will cost \$200 to \$300, or more; that's more than many beginning hobbyists want to spend. Unless, of course, it is a **Popular Electronics** 10-MHz Frequency Counter! Built around three integrated circuits, that useful instrument can be put together for about \$40 by anyone who is reasonably adept at soldering.

Circuit Operation. Figure 1 shows the schematic diagram of the 10-MHz Frequency Counter. The circuit consists of an ICM7208 seven-decade counter (U1), an ICM7207A oscillator controller (U2), and a CA3130 biFET op-amp (U3). Integrated circuit U1 counts input signals, decodes them to 7-segment format, and outputs signals that are used to drive a 7-digit display.

Integrated circuit U2 provides the timing for U1, while U3 conditions the input signal to provide a suitable waveform for input to U1. The 5.24288-MHz crystal frequency is divided by U2 to produce a 1280-MHz multiplexing signal at pin 12 of U2. That signal is input to U1 at pin 16 and is used to scan the display digits in sequence.

The cathodes of each digit are taken to ground several times each second, activating any segments of the digits whose anodes are high as the result of decoding by U1. The crystal frequency is further divided to pro-



*Need a frequency counter that won't cost a mint?
This hobbyist-grade instrument is just the ticket for budding techs on a tight budget!*

PAUL AMAN

duce a short "store" pulse at pin 2 of U2, followed (after about 0.4 milliseconds) by a short "reset" pulse at pin 14 of U2. The frequency of the pulses is determined by the state of U2 pin 11.

When pin 11 of U2 is taken to ground through S1, the pulses occur every 2 seconds and cause U2 pin 13 to go

high for one second, which prevents additional input signals from entering U1. That causes the count latched in U1's internal counters to be transferred to the display.

Integrated circuit U2 pin 13 then goes low for one second, allowing a new count to be entered into the seven decade counters of U1. That cycle is repeated, continuously updating the display every two seconds.

When U2 pin 11 is taken to the positive supply rail (+5V), the "store" and "reset" pulses occur at 0.2-second intervals, resulting in a 0.1-second count period. Ten input pulses must be counted in order for a "1" to appear on the first digit, D1, so the frequency being measured is obviously ten times larger than the frequency that is shown on the display.

In that mode, the decimal points are driven by R1 and visually indicate that the 0.1-second count period is being used.

Display. The display must have at least seven 7-segment common-cathode multiplexed LED digits. Any common-cathode seven-segment display may be used, so no particular display is specified. If the display chosen has more than seven digits, the extras are not used. For example, the display used in the author's prototype, which was salvaged from an old calculator, has nine digits, only seven of which are used in this project.

Don't be put off by the term "multiplexed." Multiplexed simply means that all like segments of all digits are connected by a single conductor, and that the cathodes of all segments of any one digit are connected to a common terminal. That's accomplished by a printed circuit within the display and limits the number of wires or traces needed to operate the dis-

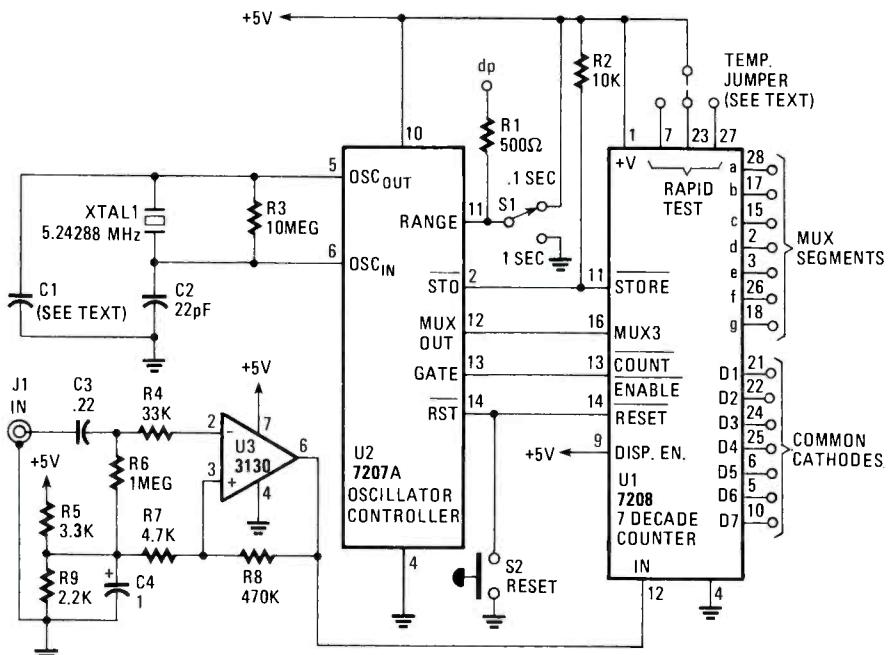


Fig. 1. The 10-MHz Frequency Counter consists of U1, an ICM7208 seven-decade counter; U2, an ICM7207 oscillator controller; and U3, a CA3130 biFET op-amp. The display for the circuit can be any seven-digit, seven-segment common-cathode multiplexed unit.

play. Such units may be salvaged from an appropriate old calculator or purchased from electronic surplus stores.

A multiplexed display can also be fabricated from discrete seven-segment display modules as shown in Fig. 2. More display modules can be added as needed. Duplicating the display shown in Fig. 2 is easy; simply connect all like pins in parallel as shown. For example, pin 1 of the first seven-segment unit—which, for this particular display, is segment “a”—is connected to pin 1 of all the other modules. Pin 3 is the common-cathode connection—it is not connected to the other pin 3 terminals in the set—which is used as the digit-driver (D1–D7) input.

Note that for the display modules

used to illustrate the multiplexing concept, there are two common-cathode terminals, pins 3 and 14; since the two pins are internally connected, only one of those terminals need be connected to the circuit in order for the display to function properly, although connecting both would not cause any problems. While the pinouts may vary from one display type to another, the concept remains the same.

If you opt to go with a salvaged display unit, it will be necessary to determine the pinout and configuration; common cathode or common anode. To test a salvaged display when the pinout is not known, temporarily connect a 1000-ohm resistor from a 5- to 9-volt source to pin 1, then touch the

source ground to each of the other pins in sequence. If any segment lights, the pin at the resistor is the anode for all like segments in all digits and the pin at ground is the common cathode for the digit with the lighted segment.

Repeat that procedure to identify all segments and cathodes by moving the resistor to the other pins. Make a record similar to that shown in Fig. 1-b for use as a reference during circuit assembly. If no segments light, but do light when the source leads are reversed, the unit is a common-anode type and is not suitable for use in the counter. Do not discard the display; make a record and save the display for some other project.

Power Supply. When all digits are lit, the circuit draws about 160 millamps. A 5-volt bench supply that is rated at more than 1 ampere may be used, however, a heavy-duty 6-volt battery with a 1-ampere diode connected in series with one of the leads will work, and makes the unit portable.

Space is available on the circuit board (at the top) to mount a 5-volt regulator and capacitors, if desired. If a regulator is used, a 6- to 9-volt AC adaptor may be used to supply the basic DC voltage. To preclude damaging the integrated circuits, U1 and U2 must be powered up before or simultaneously with the application of input signals to U3. The entire circuit is designed to be powered by one common supply.

Assembly. See Fig. 3. The author's prototype of the 10-MHz Frequency Counter was built on a universal printed-circuit board (Radio Shack catalog number 276-170). Note that the horizontal holes in Fig. 3 are la-

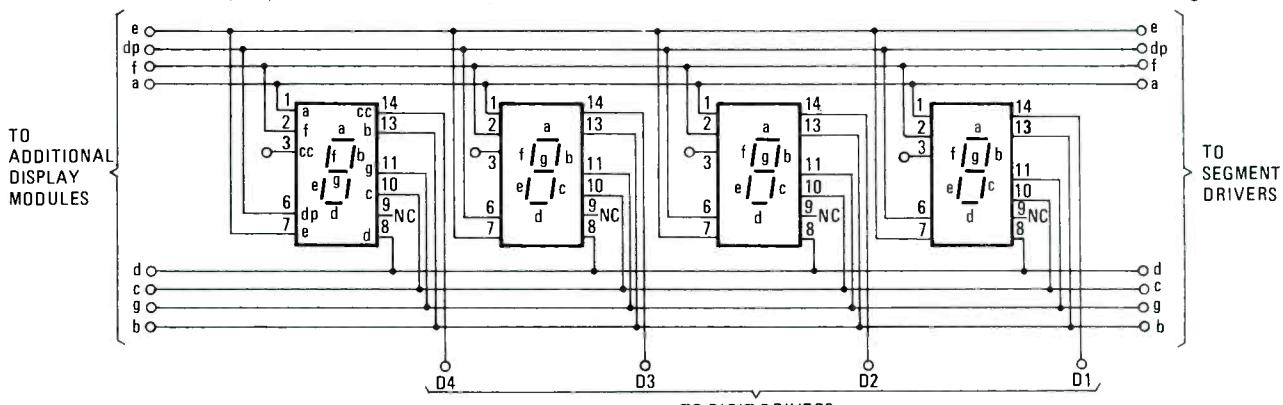


Fig. 2. A multiplexed display can be fabricated from discrete seven-segment display modules by connecting all like pins in parallel. For example, pin 1 of the first seven-segment unit connects to pin 1 of all the other modules.

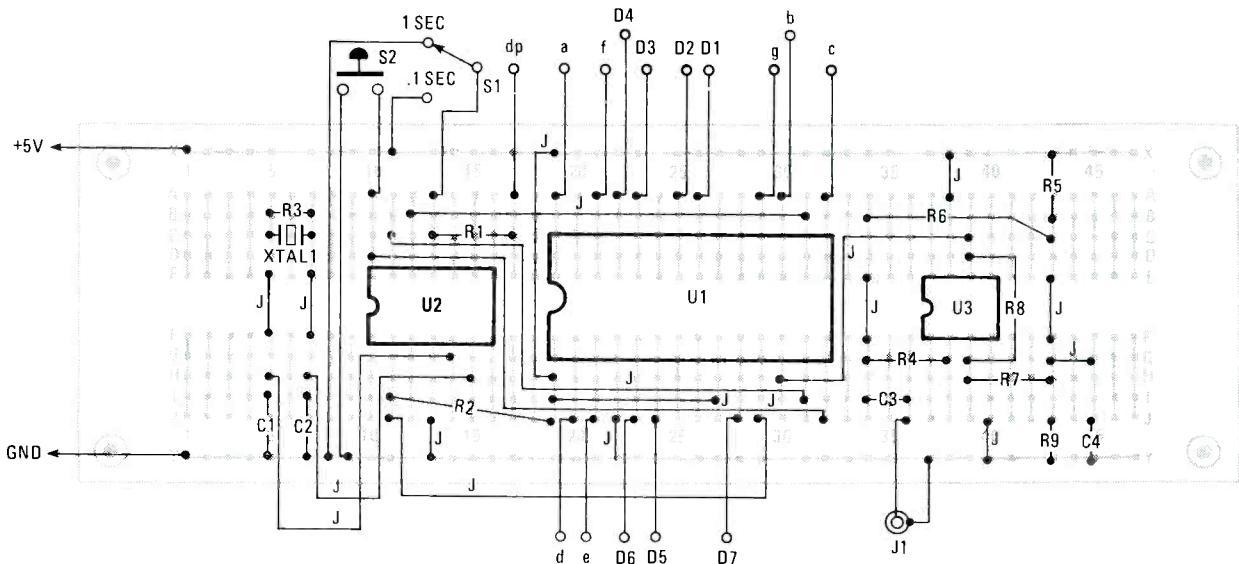


Fig. 3. Here is the parts-placement diagram for the author's prototype of the 10-MHz Frequency Counter. It was assembled on a universal printed-circuit board. Note that the display is not shown in the layout. However, by following the connection scheme outlined in Fig. 2, almost any common-cathode display can be used with the circuit.

beled A through J and that the vertical holes are number 1 through 47. Columns of holes designated X and Y are the +5V and ground buses, respectively.

Carefully locate the positions of the IC's and mark the pin 1 holes with a felt-tipped pen. For example, pins 1 of U1, U2, and U3 are located in holes 19G, 10F, and 37F, respectively. It's a good idea to use sockets (as the author did) for the IC's; aside from making IC replacement easier, doing so also prevents possible damage to those parts during soldering.

After the sockets have been mounted in the proper locations, install the jumper connections (designated J) guided by Fig. 3. The horizontal jumpers may be bare wire, all others should be insulated to prevent shorts. Next begin installing the support components, starting with the resistors, then the capacitors, and finally the crystal (XTAL1).

Solder extra-long color-coded wires to the board for the off-board components. Then, as the positions of the off-board components are established with respect to the case, cut the wires to the proper length and solder them to the components. If you suspect that the wires will interfere with IC installation, insert the IC's before soldering the wires to the off-board components.

Enclosure. Any suitable case may be drafted to house the finished circuit. Mount the power-supply terminals or jack, the input jack, the switches (S1

PARTS LIST FOR THE 10-MHZ FREQUENCY COUNTER

SEMICONDUCTORS

U1—ICM7208 seven-decade counter, integrated circuit
U2—ICM7207A 5-MHz oscillator controller, integrated circuit
U3—CA3130 biFET op-amp, integrated circuit

RESISTORS

(All resistors are $\frac{1}{4}$ watts, 5% units, unless otherwise noted.)

R1—500-ohm
R2—10,000-ohm
R3—10-megohm
R4—33,000-ohm
R5—3300-ohm
R6—1-megohm
R7—4700-ohm
R8—470,000-ohm
R9—2200-ohm

CAPACITORS

C1—See text
C2—22-pF, ceramic disc
C3—0.22- μ F, ceramic disc
C4—1- μ F, 50-WVDC, subminiature electrolytic

ADDITIONAL PARTS AND MATERIALS

J1—Miniature closed-circuit phono jack
S1—Single-pole, double-throw toggle switch
S2—Single-pole, single-throw momentary-contact pushbutton switch
XTAL1—5.24288-MHz crystal
Universal printed-circuit board; seven-digit, seven-segment, common-cathode, multiplexed, LED display (see text); enclosure; IC sockets; power source (see text); wire; solder; hardware; etc.

and S2), and the display on the front panel of the case. The circuit board may be trimmed to about 5-inches long to keep case size at a minimum.

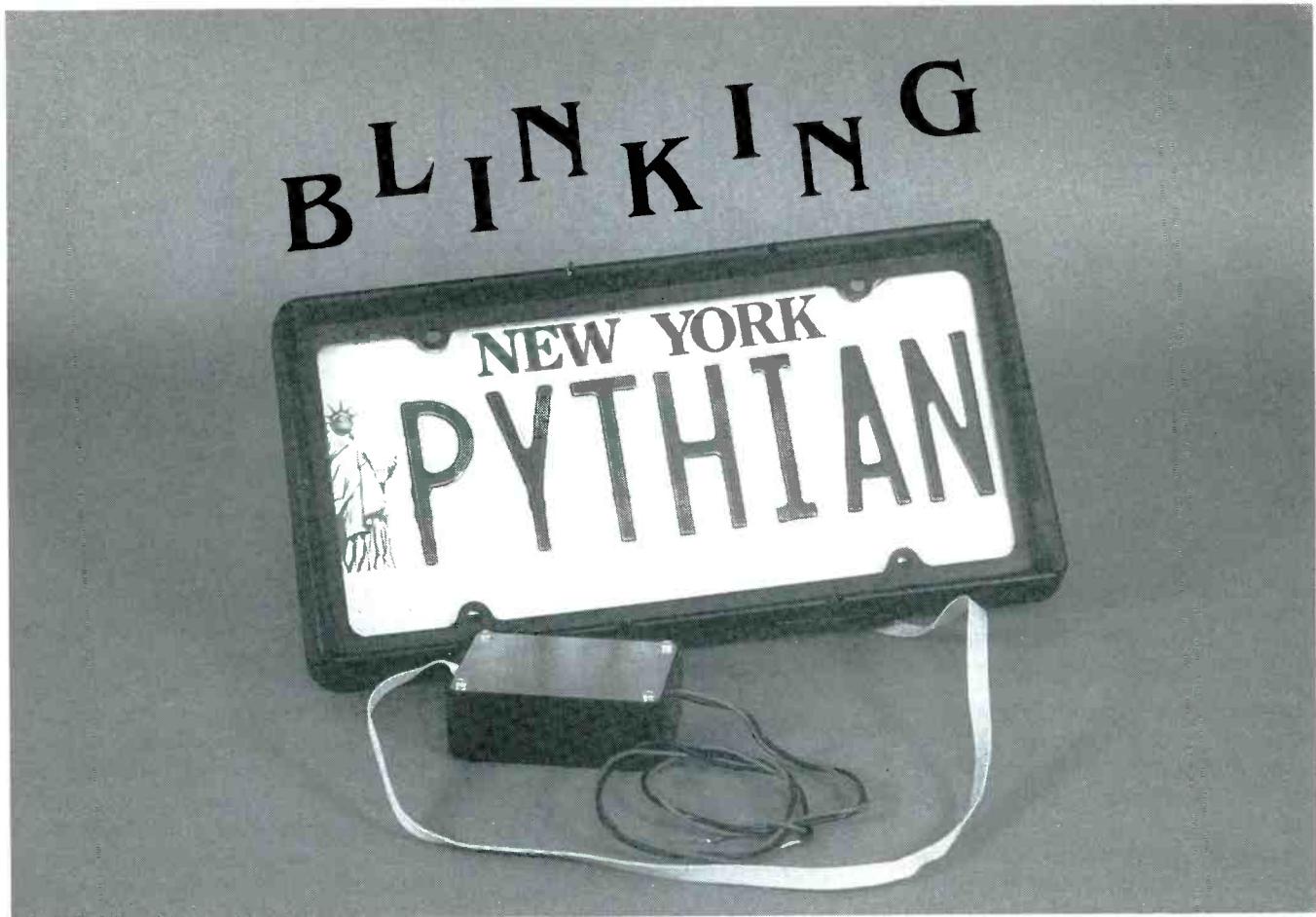
Use a nibbling tool to cut an opening for the display, but do not secure the display to the case until wires from the board have been connected. If a trimmer capacitor is used for C1, as will be discussed later, drill a hole at the proper location to allow for any adjustments without removing the front panel of the enclosure.

Testing. To rapid-test the circuit with a frequency that is less than 100 Hz, use a temporary jumper to take U1 pin 7, 23, or 27 to +5V as indicated by the dashed line shown in Fig. 1. Integrated circuit U1 then applies the count to all digits higher than D2.

Data for U2 indicates that C1 may be a trimmer, however, a 22-pF fixed-disc capacitor is satisfactory for most applications, and provides accuracy to .005%. If a closer tolerance is required, use a 6–50-pF trimmer capacitor (such as a Radio Shack 272-1340). Set the range switch to 1 second, apply the multiplexing frequency from U2 pin 12 to the input of U3, and adjust the trimmer for a readout of 1280 Hz.

Frequency Counting. When S1 is in the 1-second position, the count range is 1Hz to 1MHz and can be read directly from the display. When S1 is in the 0.1-second position, the count range is 10 Hz to 10 MHz. The number then appearing on the display is $\frac{1}{10}$ the frequency being measured. (1 kHz appears as 100).

When a new frequency is being
(Continued on page 145)



License-Plate Holder

Frame your license plate in lights with this decorative, flashing license-plate holder!

BY JIM STEPHENS

Those little, blinking, license-plate holders you've seen on autos in front of you at the stop lights is one way that digital electronics has been put to use for something other than calculators and computers. I saw right away that the blinking lights were nothing more than the outputs of a digital ring counter in disguise. And I felt it would be a simple matter to assemble one from scratch at far less than the cost of those sold at local, retail, auto-accessory stores.

The *Blinking License-Plate Holder* described in this article can be put together in one evening, and the result is truly fascinating and educational. Component selection presented the greatest challenge. After all, a digital light sequencer could be built in several ways: around transistors, individual

flip-flops, or even from a digital shift register circuit.

I chose the flip-flop method, but elected to use a CMOS IC (the 4017 decade counter) that had flip-flops wired internally to give the sequence I needed. The 4017 has ten outputs (0 to 9) that are sequenced in perfect steps, thereby enabling me to use only two chips and a few support components.

My first intent was to have one little light traveling around the outside of the plate each time the brake lights were activated. However, I noticed there were other sequences. I chose an opposite-rotation light pattern, in which the lighting sequence begins at the top center of the license-plate holder. From there, two sequential light strings travel outward (in opposite directions) and meet at bottom center, pause momen-

tarily, and return to the top center in an oscillating manner.

It is the latter configuration that (in my opinion) provides the most eye-catching display, and so it is the one used here. However, other patterns are possible by simply rearranging the lamps on the plate holder.

About the Circuit. At the heart of the light-sequencing circuit is a 4017 decade, counter/divider. A functional block diagram of the 4017 is shown in Fig. 1. The outputs of the counter are numbered from zero to nine, and are shown in quotations.

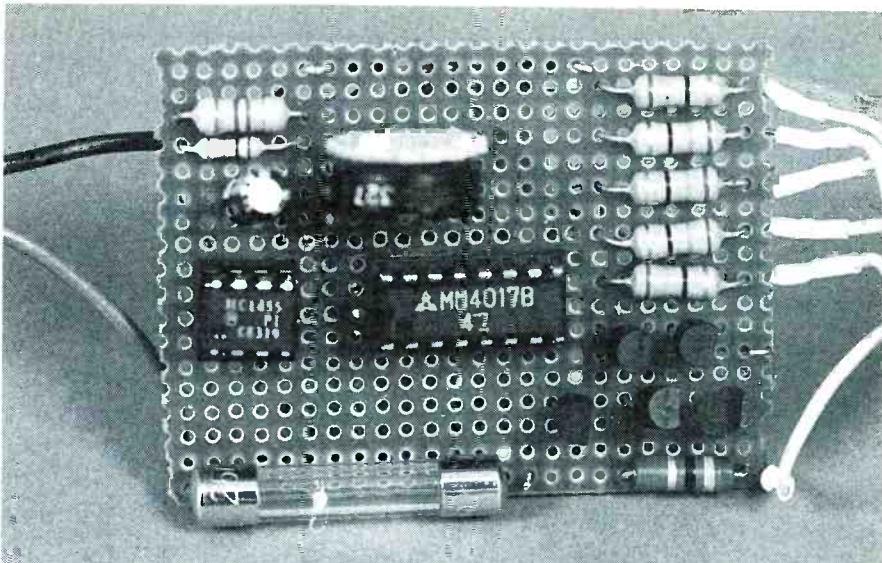
The 4017 is a 5-stage Johnson counter, consisting of a string of flip-flop circuits that are internally chained together so that they shift a binary "one" along the chain for each

positive-going pulse presented to its clock input at pin 14. Each flip-flop has a pin to the outside world.

After output 9 returns to a low state, output zero goes high and the pattern is repeated. Only one output is high at a time; all others are in the low state. The outputs from the five flip-flops (taken from their associated output pins) are used to trigger 5-pairs of lamps through driver transistors.

Figure 2 is the complete schematic diagram of the blinking sequencer. Two chips, U1 (the 4017 decade counter/divider) and U2 (a 7555 oscillator/timer), perform the timing and trigger functions. Ten lamps (l1 through l10), which are controlled through driver transistors Q1-Q5, flash in relation to the pulses that are output by the decade counter, U1. Because I wanted two lamps lit at any one time, each transistor drives a pair of parallel-connected lamps. Configuring the circuit in that manner saves considerably in parts (and cost).

In this application, the 7555 is configured for astable (free-running) operation. When power is applied to the circuit, U2 begins to oscillate at a frequency determined by the value of R8 and setting of R2, which are connected between pins 6 and 7 of U2, by controlling the IC's discharge rate. The potentiometer (R2) allows you to adjust the blink rate to your individual liking. Poten-



There is nothing critical about the component layout, but it would be in your best interests to follow the general layout shown here. The points to be wired to the off-board components are conveniently located near the edge of the board.

tometer R2 can be set as low as one cycle per second or as high as 20 cycles per second.

The square-wave output of U2 at pin 3 is fed to the clock input of U1 at pin 14. The clock enable (pin 13) and reset (pin 15) of U1 are permanently grounded so that the pattern is continuous and the 4017 does not constantly clear the states as it would if those pins were left unconnected. That causes U2 to advance one count for each positive transition of the clock signal. As previously noted, the 10 outputs of U1 are tied together in pairs, with each output pair feeding a driver transistor. Because of that arrangement, each driver transistor is triggered on twice during the 0-9 output sequence.

Let's take a closer look at that process. Refer to Figs. 2 and 3. When power is initially applied to the circuit, output 0 is high, so Q4 turns on, immediately lighting lamps l7 and l8 (which in the author's prototype are located at the top of the license-plate holder).

On the first clock pulse received from U2, output "1" of U1 at pin 2 goes high, causing Q4, and thus lamps l7 and l8 to remain on for a second clock pulse. The next positive transition of the clock causes output "2" to go high, biasing Q1 on, which causes lamps l1 and l2 to light. The third clock pulse causes output "3" to go high, turning on Q3 which, in turn, causes l5 and l6 to light.

That sequence continues until count 5 is reached, lighting the bottom-center lamps (l9 and l10). Count 6 keeps l9 and l10 lit for an additional count, so that the sequence appears to pause.

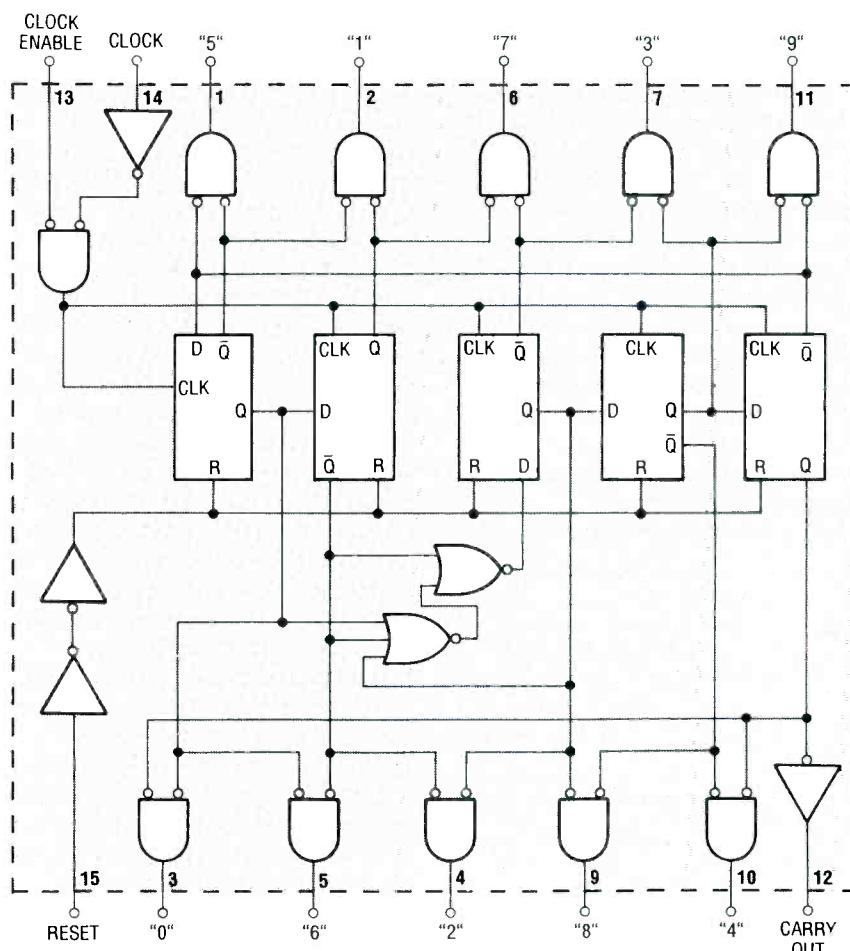


Fig. 1. The 4017 is a 5-stage Johnson counter, consisting of a string of flip-flop circuits that are internally chained together. Its outputs (0 through 9) are shown in quotations.

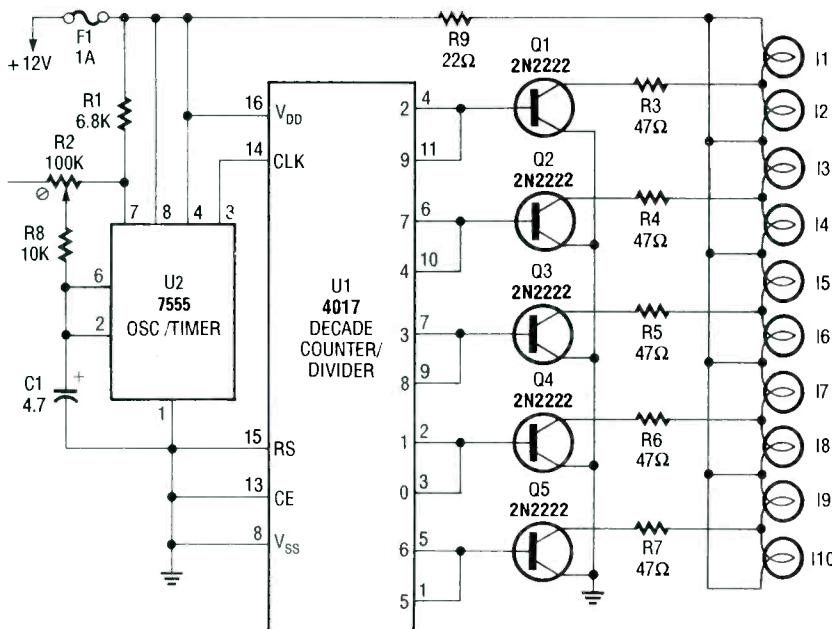


Fig. 2. The complete schematic diagram of the blinking sequencer. The circuit is built around a 4017 CMOS decade counter/divider and a 7555 CMOS oscillator/timer.

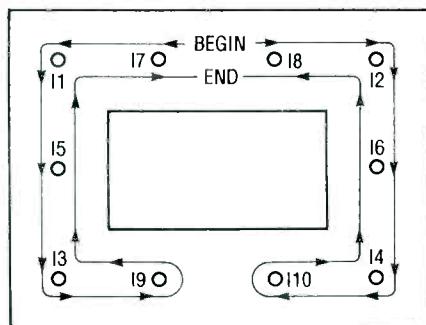


Fig. 3. The lighting sequence begins at the top center of the license-plate holder; two light paths branch out, traveling in opposite directions and down both sides, meet bottom center, and retrace the original path, returning to the top-center position.

On the seventh count, the retrace sequence begins, lighting lamps I3 and I4; count 8 lights I5 and I6; count 9 lights I1 and I2, and count 0 lights I7 and I8 (top center of the license-plate holder). At that point the sequence begins anew.

In short, the way the circuit is set up, the lighting sequence appears to pause twice during the cycle—once at the top center of the frame and again at the bottom center. After pausing at the bottom center lamps, the sequence continues, retracing the same path to the top of the license-plate holder, where the sequence starts all over again.

Miniature incandescent lamps (pea lamps) were used instead of LED's be-

cause the luminance given off by LED's is somewhat less than desirable for this application. The units used give off a large amount of light and can be seen from a distance with no trouble. To ensure that the lamps glow sufficiently bright, five 2N2222 transistors were used as drivers that switch the lamps on and off at the proper time.

Construction. Because the circuit contains so few parts, all components (except the lamps) were mounted on a small perfboard chassis. In the author's prototype, the inter-component connections were made with lengths of wire-wrap wire, using the point-to-point wiring technique. The use of IC sockets is recommended to avoid soldering directly to the pins of the IC's, which could possibly cause damage.

CMOS IC's are very sensitive, and

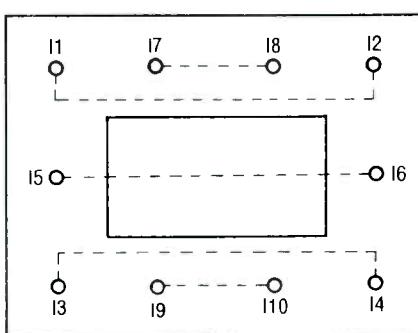


Fig. 4. The actual lighting sequence depends heavily upon the positioning of the ten lamps. The dashed lines show how the lamps are paired off.

PARTS LIST FOR THE BLINKING LICENSE-PLATE HOLDER

SEMICONDUCTORS

U1—CMOS 4017 decade counter/divider, integrated circuit

U2—7555 CMOS oscillator/timer, integrated circuit

Q1-Q5—2N2222 general-purpose NPN silicon transistor

RESISTORS

(All resistors are $\frac{1}{2}$ -watt, 5% units, unless otherwise noted.)

R1—6800-ohm

R2—100,000-ohm, miniature, PC-mount potentiometer

R3-R7—47-ohm

R8—10,000-ohm

R9—22-ohm

ADDITIONAL PARTS AND MATERIALS

C1—4.7- μ F, 35-WVDC, miniature electrolytic

I1-I10—Miniature 60-mA, 6-volt, colored lamps, (RS 272-1098)

F1—1-amp, slow-blow fuse

Perfboard material, plastic license-plate holder (see text), enclosure, IC sockets, ribbon cable (6 strand) (see text), 18 gauge automotive hook-up wire, silicon-rubber sealant compound, wire tap-in connector (RS 64-3052), wire, solder, hardware, etc.

special care should always be used to avoid too much heat. Static build-up can be avoided by touching a ground before handling the IC's. Note that the 12-volt bus is protected by a 1-amp fuse. That fuse protects the wiring of the brake lights in case of a short in the wiring or a shorted transistor. Once the board is completed, the next step is to prepare the plate-holder assembly.

Most auto-supply stores stock plastic license-plate frames with a hollow around the back edge. The wires that connect the lamps to the circuit board will run inside that hollow channel. The lamps are mounted through $\frac{3}{32}$ -inch holes drilled through the plastic bezel at the locations shown in Fig. 4.

Note that each set of lamps (as mentioned previously) are placed opposite from its parallel twin in the author's configuration. The lamps should be pushed into the hole so that no more than $\frac{1}{8}$ inch shows through the front. The lamps are then secured in place with a small amount of silicon-rubber cement.

The connections from the lamps to the board-mounted components in the author's prototype were made
(Continued on page 144)



Build the “Whistler” VLF Receiver

*Investigate solved and unsolved
mysteries with this super-sensitive VLF receiver*

BY TOM FOX

It was a dark, foggy night several years ago when I first turned on the original version of the Whistler Receiver described in this article. Seconds after I'd flicked on the power switch, an unearthly, high-pitched sound was heard. Was I in luck? Had I tuned in the famous VLF (Very Low Frequency) sound known as a "whistler?" Apparently not.

While the tones changed, they did not descend in pitch as a whistler is supposed to do; the sound also repeated itself exactly every 10 seconds. Numerous thoughts quickly flashed through my mind—it's probably just oscillation in the amplifier's circuits; it's just feedback from the loop antenna; maybe the darn thing's haunted! None of those speculations added up since the sound repeated itself exactly every 10 seconds (even ghosts aren't that punctual).

Apparently, some rational entity was controlling those signals. Mulling over the logical, earthly possibilities, I re-

called reading about a VLF Naval-submarine communication project. The Navy, like much of the U.S. military, usually is quite helpful in solving mysteries, so I didn't hesitate to write them. After about a week, I received an informative letter, along with an inch thick pile of fact sheets, from the Deputy Director of the Naval Communications Division.

The letter suggested that the mysterious signal that I was receiving was probably transmitted by the Navy's OMEGA transmitter located near LaMoure, North Dakota. OMEGA is a VLF radio-navigational system operating between 10 and 14 kHz. (The VLF band extends from 3 kHz to 30 kHz). Figure 1 gives the OMEGA "signal transmission format." One mystery solved (thanks Navy!), several more to go.

While the project described herein will enable you to receive the OMEGA signals, the real fun starts when you pick up a whistler. That strange sound starts as a high-pitched whine, at about 20

kHz, and sweeps down in frequency to a pitch like that of a high-soprano singer; it lasts about a second.

While whistlers—which apparently are produced by lightning—at one time were an unsolved mystery, today they are fairly well understood. The strongest ones (in the U.S.A.) are produced by lightning occurring in the southern hemisphere at a geomagnetic conjugate point (a point in the southern hemisphere that's on the same magnetic line of force as you are).

Roughly, your magnetic conjugate point is at your same geographic longitude. To find the approximate southern latitude, add 10 degrees to your position. Simply put, the theory goes like this: Lightning produces a wide range of radio waves. Some of the VLF waves are bent by the atmosphere and follow the earth's magnetic fields. The ionosphere acts as a prism, in that the higher frequency radio waves travel faster through the ionosphere than do the

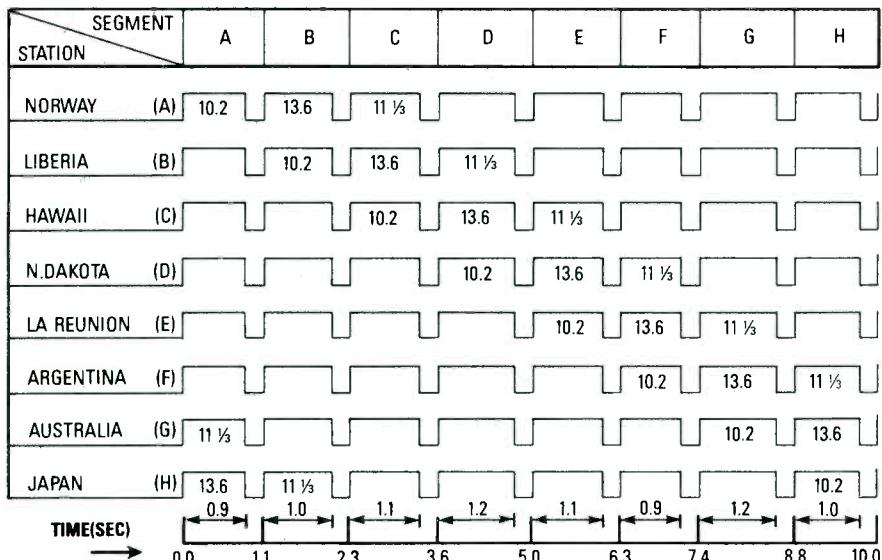


Fig. 1. Here is the OMEGA Signal Transmission Format. OMEGA is a VLF radio-navigational system operating between 10 and 14 kHz.

lower frequency ones. That seems to explain why one hears the whistler's high-frequency tones first.

A Low Tech Whistler Receiver. One doesn't need sophisticated equipment to hear a whistler. I've read that one can hear whistlers by simply connecting a high-impedance headphone to a wire fence that has insulated fence posts (such as those supported by wood). Not believing everything I read or hear, I checked it out. Because I didn't have a wire fence, I strung 125 feet of #22 wire along the top horizontal support of the wood fence that encircles my children's play yard.

I connected one lead of a high-impedance headphone to the wire and

the other lead to a good ground. Since I tried the experiment during the day, I really didn't expect to hear a whistler (whistlers are generally heard between midnight and dawn). However, I did receive a very weak OMEGA signal. Since a good whistler produces a stronger signal than OMEGA (at least in my area), I had little doubt that one could indeed hear a whistler on such low-tech equipment.

While a wire fence may make a usable whistler receiver, its weak signal and ungainly size can't compare to the solid-state receiver described herein. Of course, you may prefer to listen to whistlers using a wire fence VLF receiver. Such a receiver may light up your life—literally—when a thunderstorm approaches. In other words, don't attempt

to connect earphones to a wire fence during a thunderstorm; lightning doesn't have to hit the fence to turn you into a rather unique statistic!

A Solid-State Whistler Receiver.

The receiver is basically a high-gain audio amplifier designed specifically to have a rather poor low-frequency response to reduce 60-cycle hum. The antenna is a large loop. Actually, three different loop antennas were built and tested. While the circuit is simple, the basic design was achieved by some trial and error.

Originally, several different audio-amplifier designs were tested. The setup that seemed to work best used a single transistor Class-A power amplifier with the bulk of the amplification accomplished via two op-amps.

Referring to the schematic diagram shown in Fig. 2, the signal picked up by the loop antenna, L1, is fed to the inverting input of op-amp U1-a at pin 2, which provides a gain of about 10 at 5 kHz. The amplified output of U1-a is then fed to the non-inverting input of U1-b (at pin 10), which again boosts the signal to provide a gain of about 120 at 5 kHz. (If you wish to experiment with more gain try increasing R7 to 150k. That will boost the gain to about 150).

The output of U1-b is input to the base of Q1 (a 2N3053 general-purpose transistor configured for Class-A operation), which provides sufficient output power to drive speaker SPKR1. If you wish, the signal can also be fed to an external power amplifier via jack J2.

Since a single battery is used for

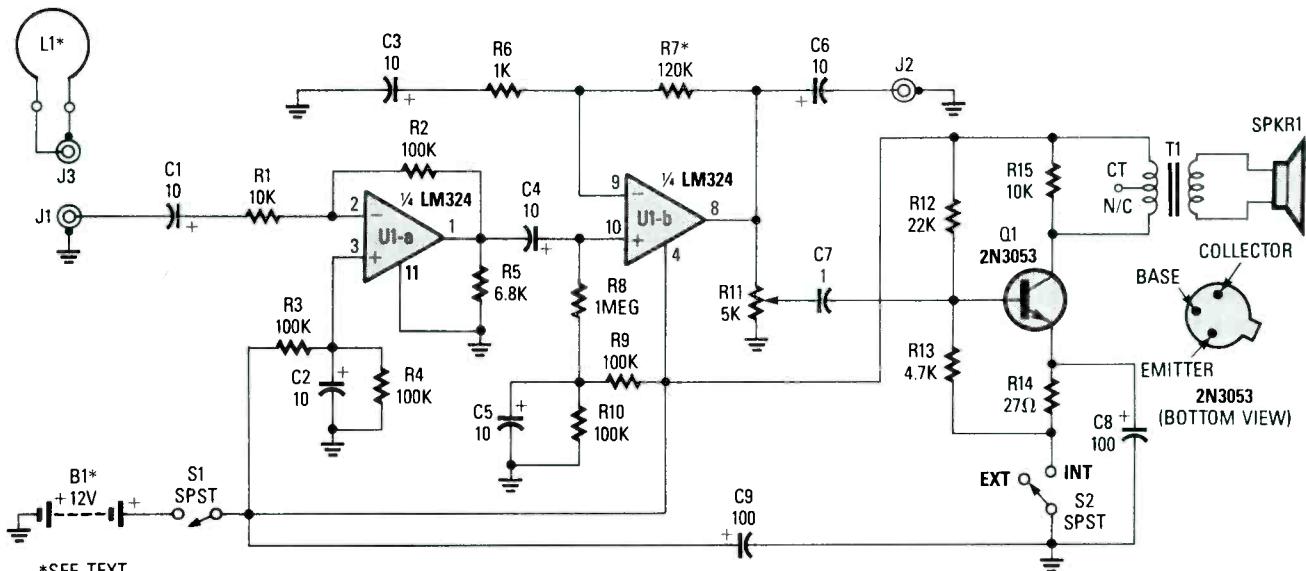


Fig. 2. The signal picked up by antenna L1 is fed to the inverting input of U1-a (which provides a gain of about 10). The output of U1-a is fed to the non-inverting input of U1-b (which again boosts the signal to provide a gain of about 120 at 5 kHz).

economy (+9 to +12 volts), R3, R4, R9, and R10 are required to provide a suitable bias voltage for U1-a and U1-b. If you are using an external amplifier, switch S2, which is connected in the emitter circuit of Q1, should be placed in the EXT position. When that's done, transistor Q1 is effectively removed from the circuit, thereby greatly extending the life of the battery.

Capacitor C9 is included in the circuit to help maintain a stable supply voltage over the life of the battery. The circuit, if operated near power lines, may pick-up the 60-cycle AC hum. If that occurs, the situation can be corrected (somewhat) by reducing C6 and C7 to 0.1 μ F.

PARTS LIST FOR THE WHISTLER RECEIVER

SEMICONDUCTORS

U1—LM324 quad low-power op-amp, integrated circuit
Q1—2N3053, or equivalent, general-purpose NPN silicon transistor

RESISTORS

(All resistors are $\frac{1}{4}$ -watt, 5% units, unless otherwise noted.)
R1, R15—10,000-ohm
R2-R4, R9, R10—100,000-ohm
R5—6800-ohm
R6—1000-ohm
R7—120,000-ohm (see text)
R8—1-megohm
R11—5000-ohm-potentiometer
R12—22,000-ohm
R13—4700-ohm
R14—27-ohm, $\frac{1}{2}$ -watt

CAPACITORS

C1-C6—10- μ F, 25-WVDC, electrolytic
C7—1- μ F, 25-WVDC, non-polarized electrolytic
C8, C9—100- μ F, 25-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor-radio battery or 8 AA cells in series (see text)
T1—1000-ohm to 8-ohm audio-output transformer (Radio Shack 273-1380 or equivalent)
L1—home-made VLF loop antenna, see text
J1-J3—RCA phono jack
S1, S2—SPST slide or toggle switch
SPKR1—Miniature 8-ohm speaker (see text)
Printed-circuit materials, enclosure, RCA phono plugs, (2) audio cables, IC socket (optional), 9-volt battery holder and snap-on connector or battery pack (see text), wood (1 \times 2 or 1 \times 3, see text), knob, insulated magnet wire (#28, #22 and #22; see text), wood glue, hook-up wire, solder, hardware, etc.

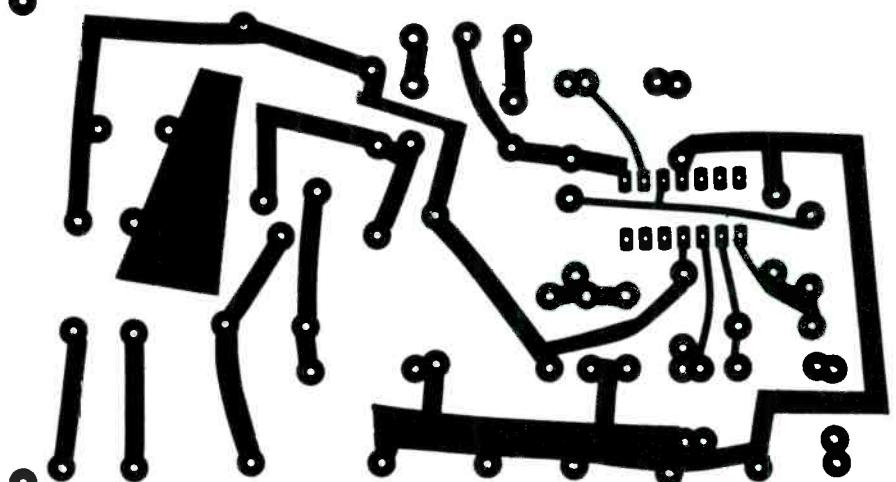


Fig. 3. Here is the full-size foil pattern for the Whistler Receiver's circuit board.

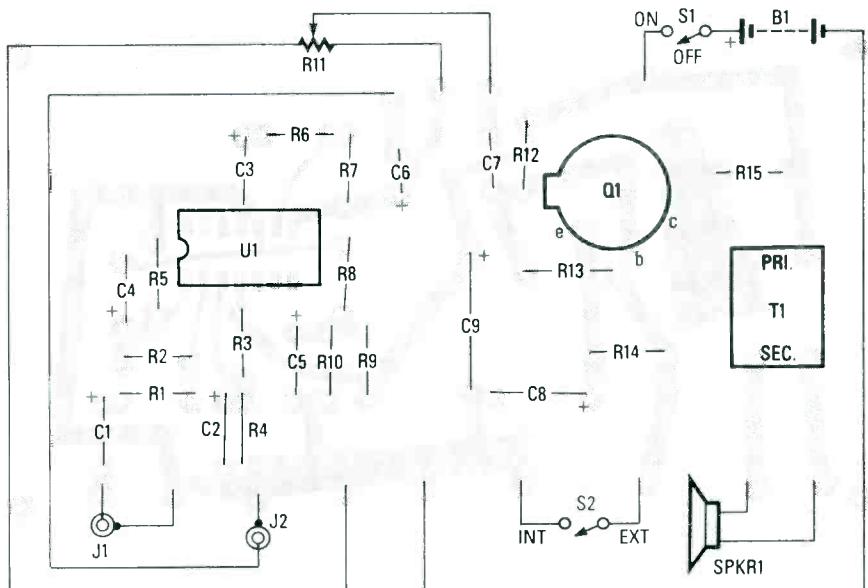


Fig. 4. Once you've etched a board, and collected the necessary components to complete the project, install the parts according to this component-placement diagram.

Putting it Together. Because of the relative simplicity of the project, one might be tempted to go with perfboard construction. However, because of the circuit's high gain (which can cause instability problems) perfboard construction is not recommended. The author built his unit on a printed-circuit board measuring about 5 \times 2 $\frac{3}{4}$ inches.

Figure 3 shows the suitable foil pattern/drilling guide for the Whistler Receiver's printed-circuit board. Once you've etched a board and collected the necessary components to complete the project (see Parts List), construction can begin. Install the parts according to Fig. 4, the component-placement diagram.

It is recommended that an IC socket be used for U1. Note, from Fig. 4, that all parts except L1, J1-J3, R11, S1, S2, B1,

and SPKR1, are mounted on the circuit board. Jacks J1-J3 are RCA phono type.

Once all of the on-board components have been installed, connect lengths of wire to the points on the board slated for off-board components, with the exception of J1 and J2; coaxial audio cables should be used when making connections between those jacks and the circuit board. Also when wiring J1 and J2, be sure that the connections are made exactly like those shown in Fig. 4; if you reverse the connections to the jacks, the circuit will not work.

When making the connections between the volume-control potentiometer (R11) and the circuit board, or between the speaker (SPKR1), and the circuit board, use short, twisted wires. The speaker should be of the miniature

type with an impedance in the 8- to 16-ohm range. Refer to Fig. 2 (the schematic diagram) and Fig. 4 (the parts-placement diagram) when connecting R11, S1, S2, B1, and speaker SPKR1 to the circuit.

Power for the circuit can be derived from any 9 to 12-volt DC source. The author's circuit was powered from a 9-volt transistor-radio battery. An alternative battery arrangement would be to use a 9- or 12-volt (multi-battery) battery pack—a plastic battery holder, which when loaded with the appropriate size batteries, connects them in series. Battery packs are available from Radio Shack in both the 9 and 12 volt versions. The 9-volt version holds six 1.5-volt cells, while the 12-volt version holds eight 1.5-volt cells. Be advised that a 12-volt battery results in slightly improved performance as well as extended battery life.

Looping the Loop. I built and tested three sizes of loop antennas (designated A, B, and C). The form for each antenna can be made from 1 × 2 or 1 × 3 lumber. Table 1, and Fig. 5 give details of the antenna's construction.

Since whistlers are about as dependable as a white Christmas at the White House, I compared each antenna's ability to pick up the Navy's OMEGA signal. I was a bit surprised to find that all three antennas were able to receive the OMEGA signal. Perhaps because of its high gain, when antenna A was connected to the circuit it was not possible to turn the volume of the receiver all the way up and still have the circuit operate properly.

On the other hand, there was little detectable difference between antennas B and C, and the A antenna. Although antenna C probably gives the best and most reliable reception, the improvement over the A and B antennas is hardly worth its awkwardness. In general, I recommend antenna B. But feel free to experiment for yourself.

Except for the size of the loop and number of wire turns, the construction of antennas A and B are nearly identical. To build the A or B antennas, cut two pieces of 1 by 2- or 1 by 3-inch lumber to the lengths given in Table 1. Cut notches in the wood as shown in Fig. 5A. Assemble the two pieces of wood with wood glue, as shown in Fig. 5B. The C antenna is constructed similarly, but instead of a single notch at the ends of each piece of wood, five notches are used, as shown in Fig. 5C. Next make a

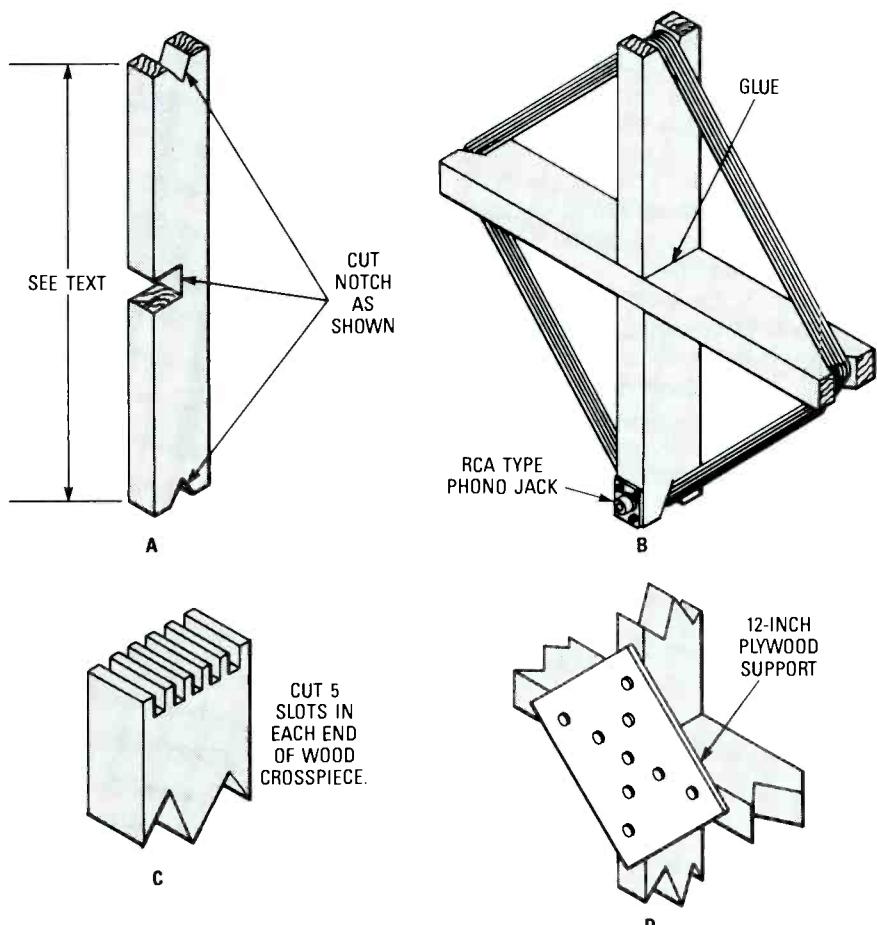


Fig. 5. Here are the construction details for the three antennas tested by the author. This diagram along with Table 1 should make assembling any version of the antennas a snap.

TABLE 1—ANTENNA CONSTRUCTION GUIDE

ANTENNA (L1)	CROSSPIECES (wood length in feet)	WIRE (turns/gauge)
A	3	80-turns/#28
B	4	28-turns/#22
C	6.5	5-slots (two turns each slot)/#22

wooden brace, 12-inches square as shown in Fig. 5D, from a piece of plywood.

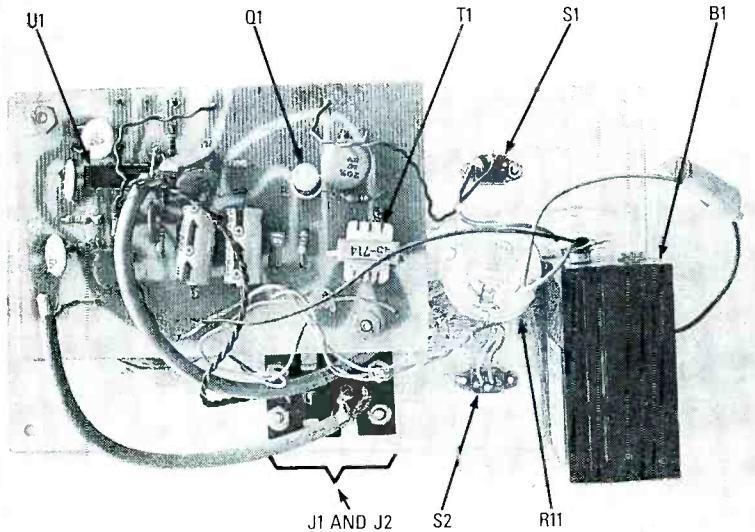
Now guided by Table 1 for the wire size and number of turns, wind the loop antennas on their respective forms. The wires from each loop should be connected to its own RCA phono jack (J3). Connections between the circuit board and the antennas can be made through a home-made 10- to 15-foot audio patch cord.

The Thrills Begin. Connect the antenna to the receiver using the audio cable. Place the antenna at least 6 feet from the receiver and position it so that its plane is vertical. Flip S2 to the INT position. For those who desire a room

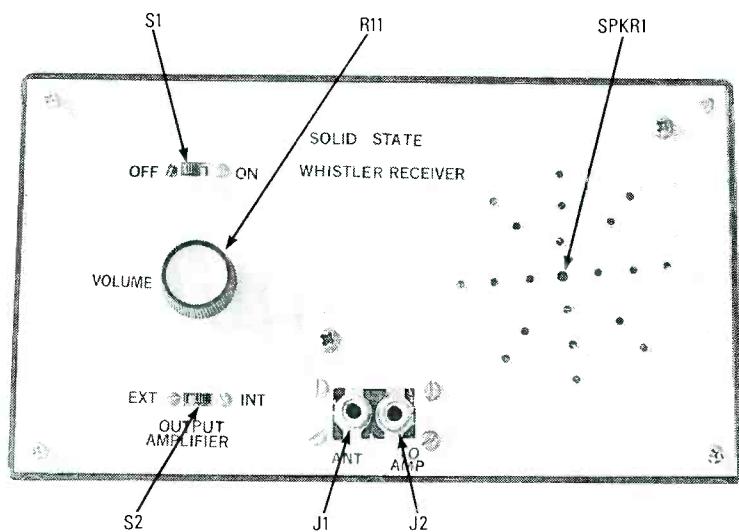
full of whistles, plug one end of an audio cable into J2 and the other end into a 100-watt, hi-fi amplifier. Flip S2 to the EXT position and set the VOLUME control (R11) near its maximum position. A mild hiss should be heard. If a hum or loud buzz is heard, move the antenna to a different location. And be sure to keep it away from the power line!

For test purposes, position the antenna for good reception of the OMEGA signal. Of course, since the OMEGA signal is at such a high pitch, one must have at least normal hearing to hear it reliably. (You must be able to hear sounds as high as 14 kHz). Even with normal hearing, one must listen intently to differentiate the OMEGA signal from background noise.

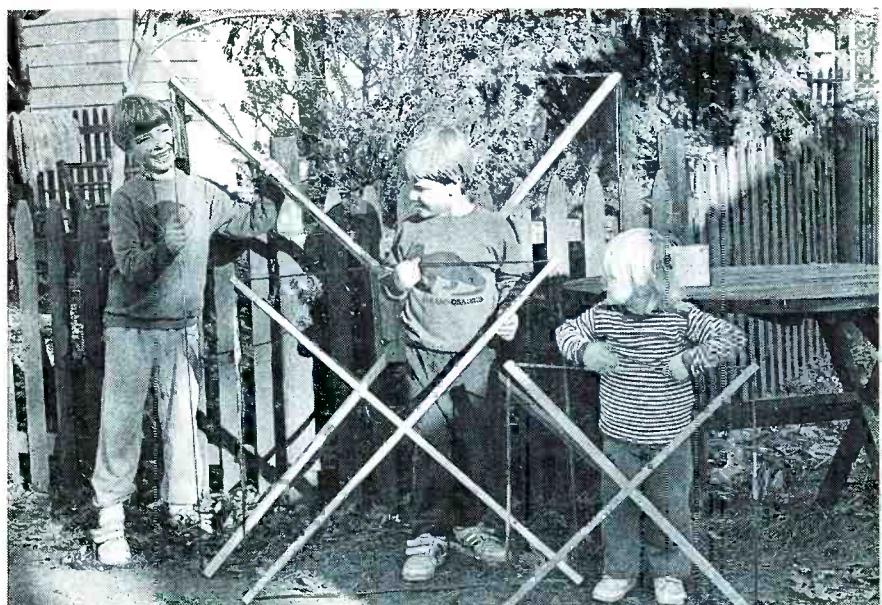
Listening for Whistlers. If you assume that as soon as you flick on the whistler receiver's switch you are going to hear all sorts of weird sounds, you'll probably soon wind up using the loop antenna's frame for kindling. Other than a weak OMEGA signal, you'll most likely only hear noise. However, patience will pay off.



Here is the fully assembled solid-state Whistler Receiver's printed-circuit board.



Close-up of the front panel of author's prototype of his Solid State Whistler Receiver.



The three portable loop antennas, built and tested by the author.

Whistlers are normally heard only when most people are asleep in their beds; they occur most frequently between midnight and dawn. They also are associated with sunspot activity—the more sunspots, the more whistlers. Since we are starting on sunspot Cycle 22, and it appears to be a biggie, the number of whistlers should be increasing in the next few years. During periods of high sunspot activity, one may hear as many as 10 whistlers a minute from 2 to 4 AM.

Another fascinating electromagnetic phenomenon that you can pick up on your Whistler Receiver is the "dawn chorus." While this sound is said to be similar to the songs of a flock of birds at the first sign of daylight, a more precise description would be a random series of rising tones in the mid-audio range (1 kHz–4 kHz).

While listening to the dawn chorus early one morning, I also heard for the first time distinct, metallic, clinking noises referred to as tweaks and chinks by VLF researchers. Their origin is an unsolved mystery, although some scientists speculate they may also be related to lightning.

Other Applications. In addition to listening to VLF radio waves, there is an almost unlimited range of phenomena one can listen to. For instance, take a photovoltaic cell (such as a silicon solar cell) and plug it into the receiver's input. Light a match close to the cell. You will "hear" the match light. Pass your hand in front of the cell and you should hear a click every time a shadow passes across the cell. Point the cell at a fluorescent light and you will "hear" the light turn off and on 120 times per second. (An incandescent lamp will produce a similar sound only it won't be as loud).

By putting the cell near a TV screen, you will hear a similar buzz, only its loudness will vary with the scene. Stick the cell out a window during a thunderstorm and you will "hear" lightning. In fact, you can use the whistler receiver as a thunderstorm detector at night since you will "hear" the lightning well before you can see it. Can you think of another type of sensor to connect to the Whistler Receiver to experiment with? No? How about a small coil of wire such as a telephone pickup coil? Or maybe a UHF TV loop antenna in series with a germanium or Schottky barrier diode? Try them all out for countless hours of experimenting fun.

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

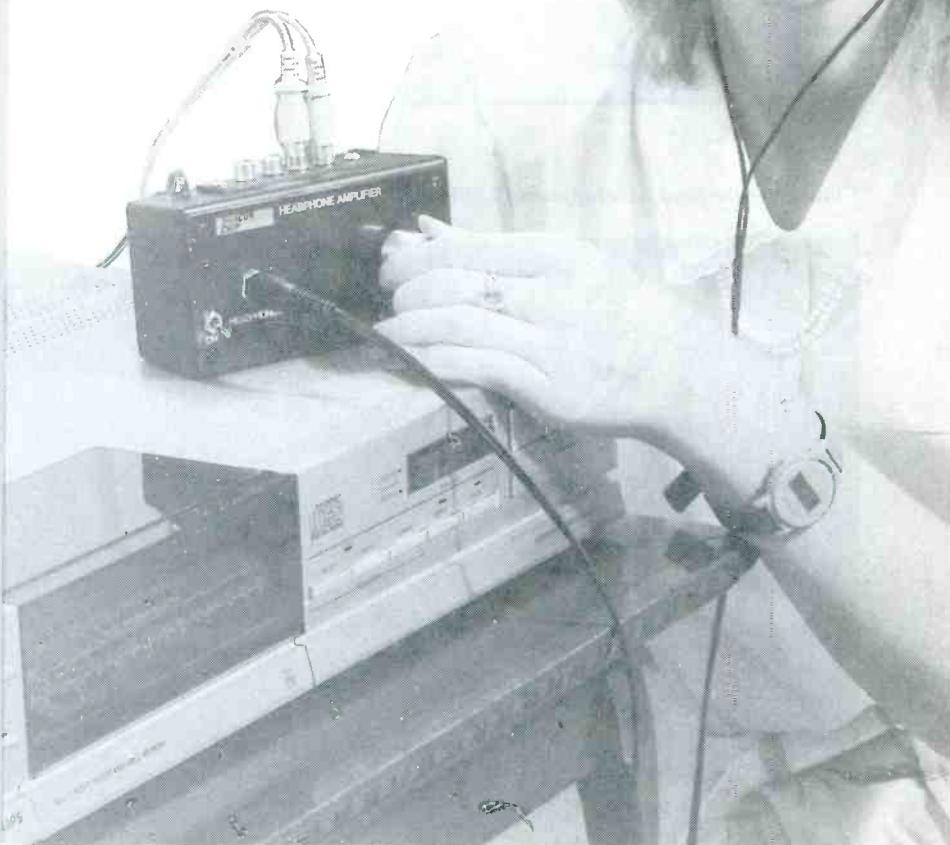
channel. Keep in mind, however, that the left channel operates in exactly the same manner.

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

HEADPHONE AMP FOR CD PLAYERS

BY JOHN CLARKE AND LEO SIMPSON



*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- μ F 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!

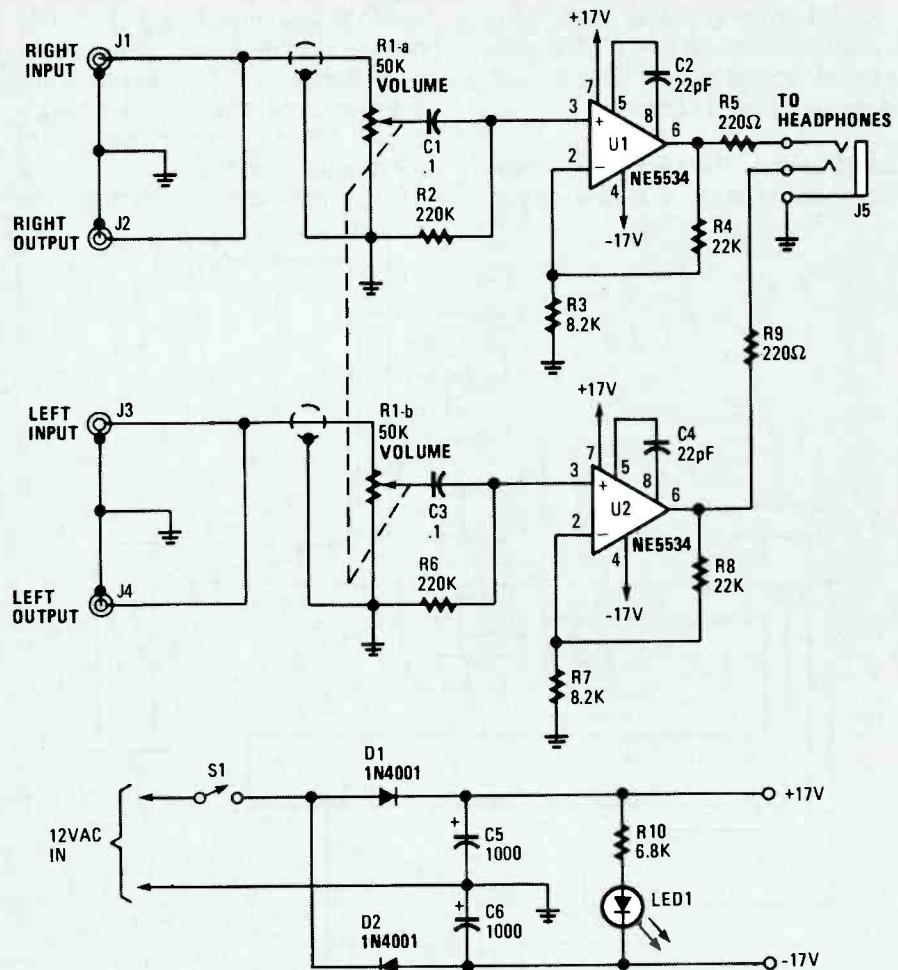


Fig. 1. The circuit—which is built around a pair of 5534 low-noise op-amps, allowing a very simple power supply to be used—gives excellent sound reproduction.

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 \pm 17 volts of unfiltered DC. The resulting DC output is filtered by C5 and C6 (two 1000- μ F 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 \pm 15 volts. But the 5534 op-amp is rated for operation up to \pm 22 volts, which means that we can dispense with 3-terminal regulators. The op-amps also have excellent power-sup-

ply rejection, which means that any variations in the unregulated 17-volt supplies are ignored. That results in extremely quiet and hum-free amplifiers.

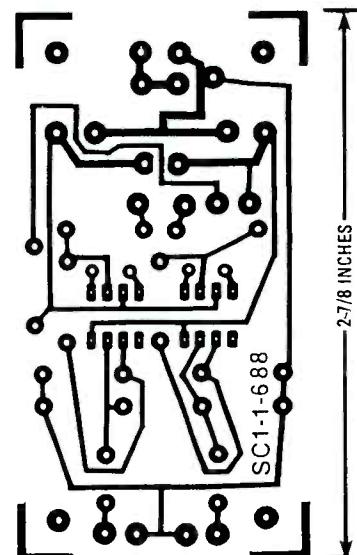


Fig. 2. Actual-size template for the CD Player Headphone Amplifier's printed-circuit board.

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

Construction. The Headphone Amplifier was built on a printed-circuit

board (PCB), measuring $2\frac{1}{8} \times 1\frac{1}{2}$ inches and housed in an enclosure measuring $5\frac{1}{4} \times 2\frac{3}{4} \times 2$ 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 mis-oriented. For instance, installing just one of the rectifier diodes (D1 or D2) incorrectly would result in an inoperative circuit.

PARTS LIST FOR THE CD-PLAYER HEADPHONE AMPLIFIER

U1, U2—NE5534 op-amp, integrated circuit
 D1, D2—IN4002 I-amp, 100-PIV rectifier diode
 LED1—Jumbo red light-emitting diode
 R1—50,000-ohm dual-ganged potentiometer
 R2, R6—220,000-ohm, $\frac{1}{4}$ -watt, 5% resistor
 R3, R7—8200-ohm, $\frac{1}{4}$ -watt, 5% resistor
 R4, R8—22,000-ohm, $\frac{1}{4}$ -watt, 5% resistor
 R5, R9—220-ohm, $\frac{1}{4}$ -watt, 5% resistor
 R10—6800-ohm, $\frac{1}{4}$ -watt, 5% resistor
 C1, C3—0.1- μ F, metallized-polyester capacitor
 C2, C4—22-pF, ceramic-disc capacitor
 C5, C6—1000- μ F, 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.

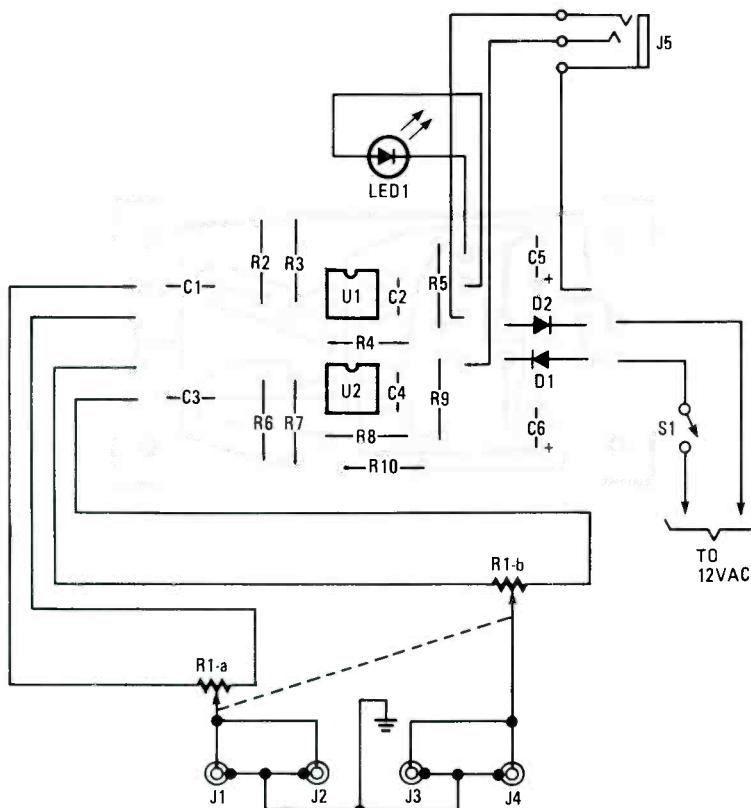


Fig. 3. Here is the parts layout for the CD Headphone Amplifier's printed-circuit board. Use shielded cable to connect J1-J4 though R1 to the circuit board.

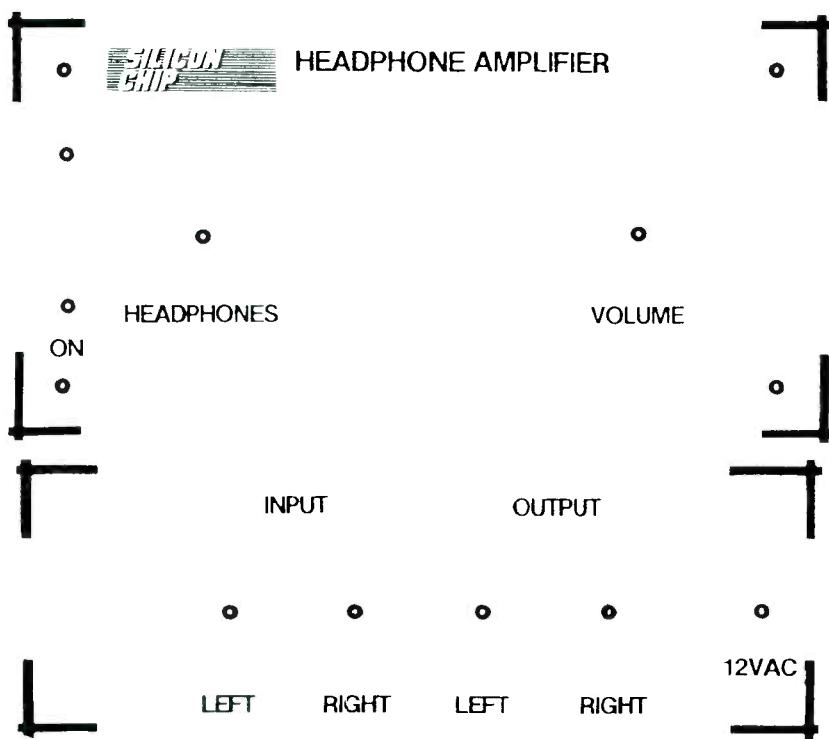


Fig. 4. This is a template of the author's front- and rear-panel layouts.

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 164)

For convenient testing of digital circuits, a logic probe is hard to beat. To use a logic probe, you just clip the probe's power-supply leads to the supply bus of the circuit under test, then touch the probe tip to the point in the circuit you want to monitor.

Light-emitting diodes on the probe tell you if the point being monitored is a logic high, low, or in-between, as well as showing changes in logic state. Because the LED's are on the probe itself, you can easily see your results without having to shift your attention from circuit to test equipment and back.

The *Experimenter's Logic Probe* described in this article is one that you can build for yourself, using readily available parts. In reading about and building the probe, you'll also learn how the probe works, what its capabilities (and limits) are, and how to use the probe in testing and troubleshooting digital circuits.

Logic Basics. A review of some of the

basic logic standards for electronic devices will aid in understanding the operation of the logic probe. Digital-logic circuits include circuits that are built out of logic gates (such as AND, NAND, OR, etc.), as well as circuits that include other digital IC's such as latches, counters, or even microprocessors.

The inputs and outputs of digital IC's are considered to be either high or low, with the high and low levels represented by voltages. The actual voltage required for a high or low depends on the family of IC's being used: TTL (Transistor-Transistor-Logic) and CMOS (Complementary-Metal-Oxide-Semiconductor) are the most popular types in use today.

TTL devices require a power-supply voltage of +5 volts, with a high input defined as 2.0 volts or greater, and a low input defined as 0.8 volt or less. Inputs that fall between 0.8 volt and 2.0 volts are undefined—there's no guarantee of how an input will respond to them. Those standards apply to just

about all TTL devices, including standard TTL (the 7400 series), Schottky TTL (74S), and low-powered Schottky TTL (74LS).

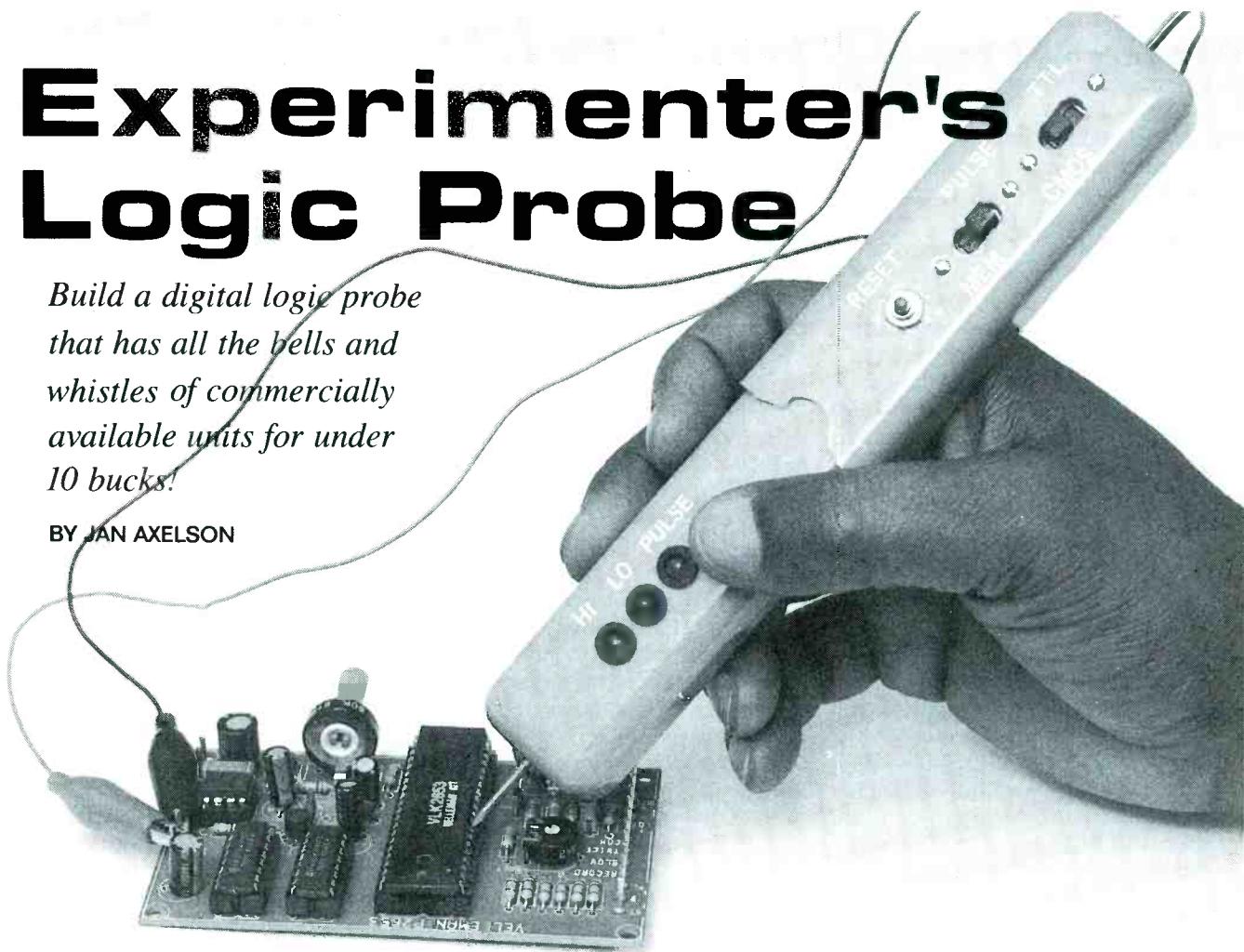
In contrast to TTL, most CMOS devices can be powered by a wide range of supply voltages. Because of that, high and low logic levels for CMOS are defined as a proportion of the power-supply voltage. In most cases, a high input to a CMOS device must be at least seven tenths of the supply voltage, and a low input to a CMOS device must be less than or equal to three tenths of the supply voltage.

For example, when a CMOS IC is powered at 5 volts, an input of 3.5 volts or greater is a high, while an input of 1.5 volts or less is a low. But with a supply of 15 volts, 10.5 volts are required for a high, and 4.5 volts for a low. As with TTL, CMOS inputs between the high and low limits are undefined. Our Experimenter's Logic Probe uses those logic-level constraints in detecting various logic levels.

Experimenter's Logic Probe

Build a digital logic probe that has all the bells and whistles of commercially available units for under 10 bucks!

BY JAN AXELSON



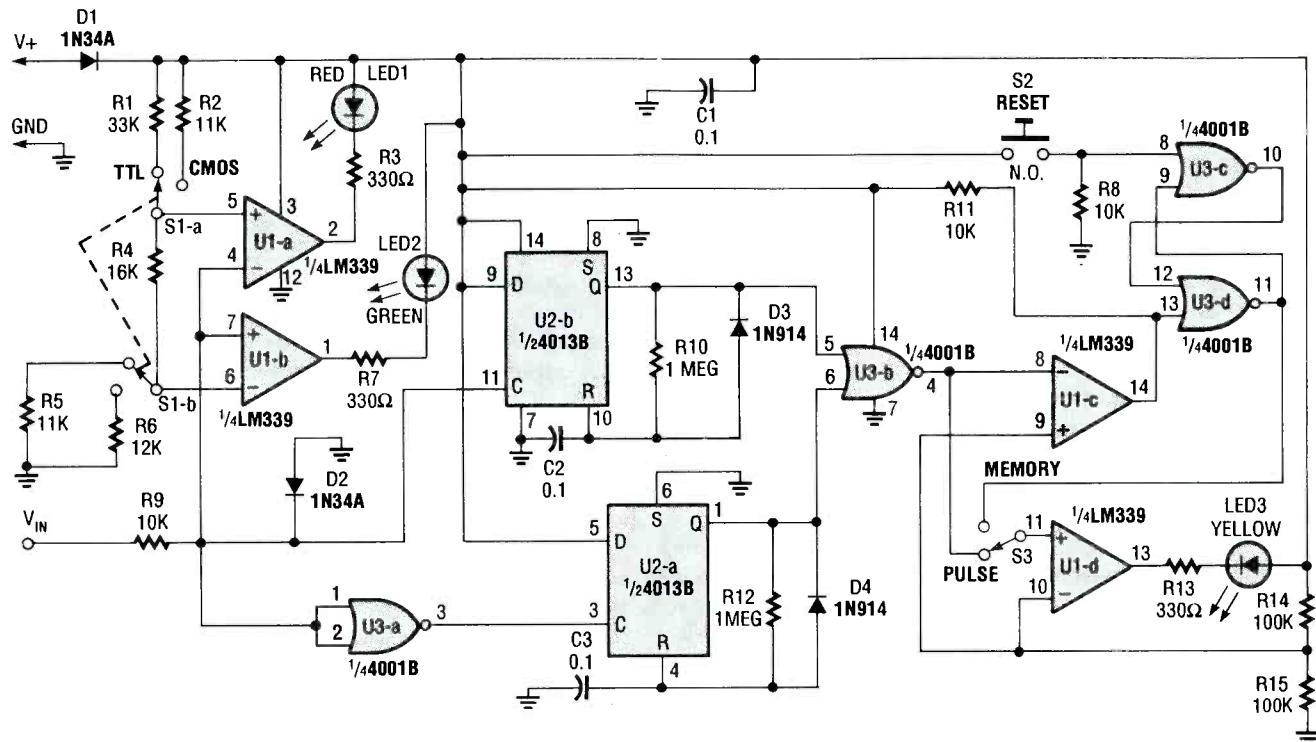


Fig. 1. The Experimenter's Logic Probe detects high and low logic levels, and level transitions for both TTL and CMOS integrated circuits.

Inside the Probe. Figure 1 is a schematic diagram of the Experimenter's Logic Probe. The circuit contains three integrated circuits—an LM339 quad comparator (U1), a 4013B dual D-type flip-flop (U2), and a 4001B quad two-input NOR gate (U3).

The circuit receives its power from two leads that clip to V+ and ground of the circuit under test. Because logic probes are normally used with a variety of circuits, mistakes in hooking up the leads are possible. To protect the probe's circuitry, diode D1 is added in series with the V+ bus to prevent supply current from flowing in the wrong direction if the power-supply leads are accidentally reversed. A germanium diode is used because of its lower forward voltage drop compared to that of a silicon diode. Capacitor C1 provides power-supply decoupling.

For circuit protection at V_{in} (the probe tip), resistor R9 limits the input current and diode D2 prevents the inputs to U1 through U3 from going negative.

Comparators U1-a and U1-b sense high and low logic levels at V_{in} . Each comparator's output is high when its positive input (+) is greater than its negative input (-), and low when its negative input is greater than its positive input.

The V_{in} terminal (probe tip) provides both the negative input to comparator

U1-a and the positive input to U1-b. A voltage divider sets the reference voltages for the other inputs to the comparators. Separate dividers are provided for TTL and for CMOS, because of their different logic-level standards.

Switch S1 selects the appropriate divider for the circuit being tested. For TTL measurements, R1, R4, and R5 set pin 5 of U1-a to about 2.0 volts, and set pin 6 of U1-b to about 0.7 volt. For CMOS measurements, R2, R4, and R6 set the same inputs to about seven-tenths and three-tenths of V+.

For example, let's say V_{in} is connected to a TTL input of +2.4 volts. Switch S1 is moved to the TTL position. At U1-a, pin 4 is greater than pin 5, so pin 2 goes low and the red LED (LED1) lights, to show that a logic high has been detected. At U1-b, pin 7 is greater than pin 6, so pin 1 is high and LED2 remains off.

If V_{in} drops to 0.4 volt, the situation is reversed. Pin 5 of U1-a is greater than pin 4, and LED1 is off. But at U1-b, pin 6 is now greater than pin 7, so the green LED (LED2) lights, to show that a logic low has been detected. Resistors R3 and R7 limit the current through the LED's to safe levels.

If V_{in} is between 0.8 and 2.0 volts, neither LED lights, indicating that V_{in} is at an invalid logic level. CMOS circuits are measured in the same way as TTL circuits, except that S1 is moved to the

CMOS position to give the proper switching voltages for the comparators.

The rest of the logic probe's circuitry is used to detect and display logic-level transitions. The probe has two modes of operation. In the PULSE mode, LED3 is flashed briefly each time a transition is detected, while in the MEMORY mode, LED3 is latched on when a single transition is detected.

Flip-flops U2-a and U2-b are configured to operate as one-shots, or monostable multivibrators. The one-shots "stretch" any transitions detected into short pulses. The signal input to the circuit at V_{in} is fed to the clock input of U2-b at pin 11.

When the input to pin 11 of U2-b goes high, the high at the d input (pin 9) is transferred to the q output at pin 13. That allows C2 to charge through R10. Capacitor C2 charges until U2-b's reset input (pin 10) goes high, causing the flip-flop to reset. That forces U2-b pin 13 to go low again, allowing C2 to discharge through D3 and R10, producing a high pulse at pin 13 of U2-b each time the flip-flop is clocked.

The other flip-flop, U2-a, is configured much like U2-b, except that V_{in} is inverted by U3-a before it clocks U2-a. That causes pin 1 of U2-a to generate a pulse after a high-to-low transition of V_{in} , instead of the low-to-high transitions that U1-b responds to.

The Q outputs of the two flip-flops (U2-a and U2-b) are fed to NOR gate U3-b. Pin 4 of U3-b is low whenever the Q output of either U2-a or U2-b is high.

Switch S3 selects the PULSE or MEMORY mode. In pulse mode, pin 4 of U3-b is the negative input to comparator U1-d. Resistors R14 and R15 set pin 10 of U1-d midway between V₊ and ground. Each time pin 4 of U3-b pulses low, pin 13 of U1-d also goes low and causes LED3 to flash briefly. Resistor R13 limits the current through LED3.

When switch S2 selects the MEMORY mode, comparator U1-c inverts the pulses at pin 4 of U3-b. Pull-up resistor R11 enables pin 14 of U1-c to drive pin 13 of U3-d. Cross-coupled NOR gates U3-c and U3-d create a set/reset flip-flop, with pin 13 of U3-d as the set input and pin 8 of U3-c as the reset input. Resistor R8 pulls pin 8 of U3-c low until momentary switch S2 is pressed.

When pin 14 of U1-c goes high, the flip-flop (U3-c/U3-d) is set. Pin 10 of U3-c is high and pin 11 of U3-d is low. The low level at pin 11 of U1-d causes its pin 13 output to go low, lighting LED3. The LED remains lit until switch S2 is pressed, bringing pin 8 of U3-c high. Pin 11 of U3-d can then go high, which causes pin 13 of U1-d to go high, turning off LED3 until another transition is detected.

Building the Probe. The first step in building your logic probe is to gather the components and select an enclosure for them. The ideal project case is something roughly in the shape of a pencil or probe, yet large enough to hold the switches, LED's, IC's, and other assorted components it requires. An interior that's easily accessible is helpful, too, to make project construction (and maintenance) convenient.

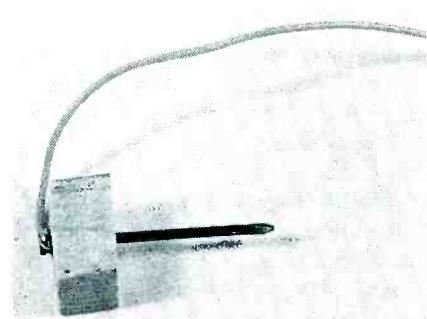
The logic probe in the photos uses a

plastic toothbrush case as an enclosure. If you come up with another idea, feel free to go ahead and use that for your case instead. When selecting components for your logic probe, think small. For switches S1-S3, choose subminiature types. Resistors with $\frac{1}{8}$ -watt ratings can be used for all except R3, R7, and R13, and will help to keep the project compact. (Current-limiting resistors R3, R7, and R13 should be rated at $\frac{1}{2}$ watt for use at 15 volts.)

The circuitry for the Experimenter's Logic Probe can be assembled on a small piece of perfboard with point-to-point wiring used to make the interconnections between the components. A board with solder-ringed holes is recommended for ease in mounting and wiring the components. Wire-wrapping is less suitable as a means of construction for this project, because of the extra space required for the wire-wrap sockets.

Because compact size is important for the Experimenter's Logic Probe, advance planning is essential. Carefully plan the positioning of all components before you proceed with any irreversible steps (such as drilling holes in the case). All of the circuitry except switches S1-S3 will fit on a board measuring about 1×3 inches. Resistors R1, R2, R5, and R6 can be soldered directly to S1 if space permits, or they can be mounted on the circuit board. Sockets are recommended for U1-U3.

Mount LED1-LED3 on the circuit board at the correct placement and height so that they'll match up with their planned openings when the circuit board is inserted in the case. Use narrow-gauge wire, such as AWG #30, to make connections between components in the circuit, again to keep the circuit as compact as possible.



The probe tip is nothing more than a nail driven into a small wooden block. A length of wire connects the nail to the circuit board.

Begin by installing the sockets for U1-U3, but don't plug the IC's into their sockets until all circuit wiring has been completed. Use Fig. 1 as a guide when wiring the circuit to the board, installing the components as required. Be sure to observe the proper polarity for D1-D3 and LED1-LED3.

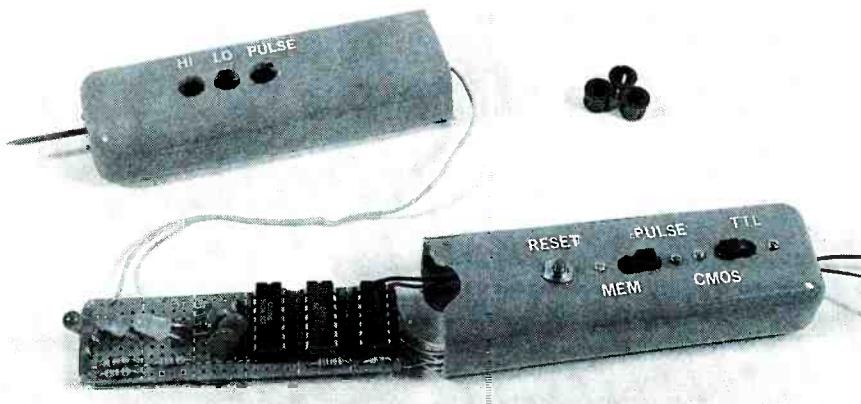
Use 6-inch lengths of #30 wire to make the connections between S1-S3 and the components on the circuit board. Use any convenient method to label the switch positions of S1 and S2, so that you'll know how to orient them when it's time to install them.

For the power-supply leads, cut 40-inch lengths of red and black stranded hook-up wire and strip about a $\frac{1}{2}$ -inch of insulation from the ends of each. Solder the red wire to V₊ and the black wire to ground on the circuit board. Leave the other ends of those wires free for now.

To construct the probe's tip, you'll need a nail (4d or similar), a small block of wood, and a 6-inch length of stranded hook-up wire. Strip about $\frac{1}{2}$ -inch of insulation from each end of the wire. Cut a block of wood small enough to fit inside the tip of your project case, then drive a nail about half-way through the center of the block.

Before driving the nail all the way in, wrap the bare end of the prepared wire tightly around the nail, just below the nail's head. Then drive the nail into the block, making a sound electrical and mechanical connection between the nail and the wire as you do so.

The project case requires an opening at one end for the probe tip, an opening at the opposite end for the power-supply leads, and holes for LED1-LED3 and S1-S3. Make the openings as required for your components. Now is a good time to label the switches and LED's on the probe's case. You can use rub-on transfer labels followed



The Experimenter's Logic Probe is wired on a small piece of perfboard that neatly fits inside a toothbrush case.

by three coats of clear spray-on acrylic, or any other method that's convenient and durable. Install U1-U3 in their sockets, observing the proper pin-1 orientation for each.

Probe Checkout. When all of the circuit components are wired, but prior to installing the circuit in its case, stop to check out the operation of your probe. Figure 2 shows a simple test circuit that allows you to test the probe by varying V_{in} . Just about any value potentiometer can be used in the circuit. As you adjust the wiper of the potentiometer, use your voltmeter to verify that the red and green LED's light at the appropriate voltages of V_{in} , as described above. Test the probe in both the CMOS and TTL positions of S1.

When S2 is set to the PULSE mode, the

PARTS LIST FOR THE EXPERIMENTER'S LOGIC PROBE

SEMICONDUCTORS

- U1—LM339 quad comparator, integrated circuit
- U2—4013B CMOS dual D-type flip-flop, integrated circuit
- U3—4001B CMOS quad 2-input NOR gate, integrated circuit
- D1, D2—IN34A general-purpose germanium diode
- D3, D4—IN914 general-purpose silicon diode
- LED1—light-emitting diode, red
- LED2—light-emitting diode, green
- LED3—light-emitting diode, yellow

RESISTORS

(All resistors are $\frac{1}{8}$ -watt, 5% units, unless otherwise noted.)

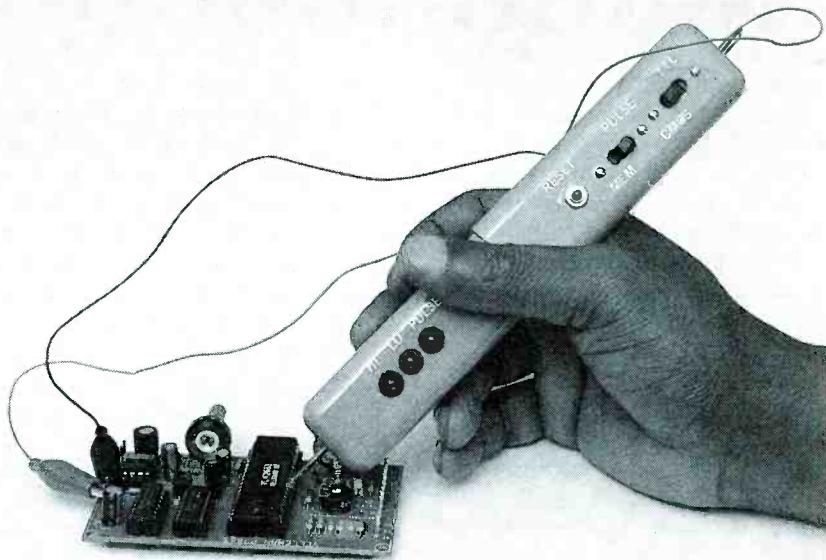
- R1—33,000-ohm
- R2—11,000-ohm
- R3, R7, R13—330-ohm, $\frac{1}{2}$ -watt
- R4—16,000-ohm
- R5—11,000-ohm
- R6—12,000-ohm
- R8, R9, R11—10,000-ohm
- R10, R12—1-megohm
- R14, R15—100,000-ohm

SWITCHES

- S1—DPDT slide switch
- S2—SPST normally-open momentary-contact pushbutton switch
- S3—SPST slide switch

ADDITIONAL PARTS AND MATERIALS

- C1, C2, C3—0.1- μ F, ceramic-disc capacitor
- Perforboard material, enclosure, LED holders, alligator or mini test clips, nail, small piece of wood hookup wire, solder, hardware, etc.



Because operational power for the Experiment's Logic Probe is derived from the circuit under-test, you must connect the alligator clips of its power-supply leads to the +V and ground buses of the circuit to be monitored.

yellow LED should flash each time V_{in} changes from high to low or from low to high. When set to the MEMORY mode, a single transition should cause the LED to light, and pressing S3 should turn the LED off until the next transition takes place at V_{in} .

If you detect any problems in your probe's operation, carefully look over your wiring, checking especially for missing or incorrect connections, or solder shorts. (It's too bad you don't yet have a logic probe to help you troubleshoot!) When all is working as it should, you're ready to install the circuitry in the case.

Insert the prepared block of wood into the case so that the nail extends through the probe-tip opening. With a project case that pulls apart in the middle (like a toothbrush holder), use this method to hold the block in position as you fasten it in place: Slide a small-diameter post into the half of the case containing the probe tip. Stand the post on end so that the probe tip points up and the post holds the wood block against the end of the case. With the case in this position, drive two small nails or wire brads through the end of the project case and into the wood block.

Remove the case from the post and solder the free end of the wire connected to the nail to V_{in} on the circuit board. Now you're ready to install the circuit board. Trim all leads on the bottom of the board to minimize the height of the board assembly. Cover the bottom of the circuit board with electrical

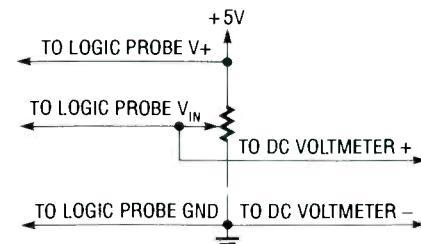


Fig. 2. This circuit can be used to test the operation of the Experimenter's Logic Probe. By varying the voltage across the potentiometer, you can check the response of the unit to different values of V_{in} .

tape, to help protect the wiring from damage as you install the board. Carefully bend the legs of the LED's toward the probe-tip end of the circuit board until the board can slide into the case.

Gently push the board into the case until the LED's are directly below the appropriate holes. Use a small screwdriver or other pointed tool to pry the LED's upward into position, gently sliding the circuit board into place as you do so.

At the other end of the case, tie a knot to act as a strain relief in the V+ and ground leads and route the leads out the opening prepared for them. Solder or crimp an alligator or mini test clip to the end of each wire.

To install the switches, use long-nose pliers to hold each switch as you insert it into the case and screw on the mounting hardware. Be sure to orient S1 and S2 so that the labels on the probe case match the ones on the switches. When all three switches are mounted, close

(Continued on page 144)

Experimenter's Logic Pulser



Add this digital signal source to your collection of troubleshooting aids

BY JAN AXELSON

A logic pulser is a tool for "active" testing of digital circuits. The pulser injects a series of pulses into an input and allows you to track down any components that aren't responding as they should.

The *Experimenter's Logic Pulser* described in this article generates pulses at a user-selected frequency of 0.5 or 500 Hz, with a pulse width of around 5 microseconds. If the input to be pulsed is already being driven high or low by another output, the pulser automatically pulses the input to the opposite logic state.

The pulser is powered by the circuit under test, and operates from supplies of from +5 to +15 volts DC. To use the pulser, you just connect its supply leads to the circuit's power-supply bus, select your pulse frequency, and touch the probe tip to the input you want to pulse. A logic probe or oscilloscope can then be used to monitor the circuit's response.

Pulser Circuitry. Figure 1 is a schematic of the *Experimenter's Logic Pulser*. The circuit contains three IC's—U1, a 556 dual oscillator/timer; U2, a 4013B CMOS dual D-type flip-flop; and U3, a 4066B CMOS quad bilateral switch—all of which are commonly available from local electronics hobbyist outlets and through mail-order electronics suppliers.

Diode D1 is placed in series with the +V power lead of the circuit to prevent "wrong-way" supply current from flowing into the pulser if the supply leads are accidentally connected in reverse. A germanium diode is used for D1 (instead of silicon) because of its lower forward voltage drop.

Timer U1-a is configured to operate in

the astable mode—its output at pin 5 alternates high and low at a frequency determined by C1, R1, R2, R3, and S1. With switch S1 open, R1 and R2 are the timing resistors for U1-a and pin 5 oscillates at about 0.5 Hz. With S1 closed, R3 is placed in parallel with R2, bringing the circuit's oscillating frequency to about 500 Hz.

Capacitor C2 provides noise immunity at pin 3, which is otherwise unused. Pin 5 of U1-a clocks both halves of a dual flip-flop (U2). The logic state of U2-b's D input (pin 9) matches V_{out} , the point being pulsed. When pin 11 of U2-b goes high, the logic state at pin 9 is transferred to pin 13, and the logical complement of pin 9 is transferred to pin 12.

At the same time, the low-to-high transition at pin 3 of U2-a causes pin 1 to go high. Capacitor C5 charges through R6 until a sufficient charge is developed across C5 to force pin 4 (RESET) of U2-a high, causing the flip-flop to reset. Pin 1 then goes low and C5 discharges through D2. The result is a short, high pulse at pin 1 of U2-a each time the flip-flop is clocked.

Integrated circuit U3 contains four electronically controlled CMOS switches. A high at a switch's control pin (pin 5, 6, 12, or 13) closes the switch; a low opens it. When closed, each switch acts like a resistor of 90 to 250 ohms (depending on the supply voltage). The four switches are wired in two parallel sets, to give a lower combined resistance and to make full use of the four switching elements within the quad IC package.

When pin 1 of U2-a is high, all four switches are closed, allowing the bases of transistors Q1 and Q2 to be driven by pins 12 and 13 of U2-b. Transistors Q1

and Q2 form a push-pull amplifier that can pulse V_{out} either high or low as required by the circuit under test.

If V_{out} is connected to an input that's normally high, pin 13 of U2-b will also be high. When the switches close, Q2 turns on, Q1 remains off, and V_{out} pulses low. If V_{out} is connected to an input that's normally low, pin 12 of U2-b goes high. In this case, when the switches close, Q1 turns on, Q2 remains off, and V_{out} pulses high.

When V_{out} is connected to an input that is already being driven by another output, Q1 or Q2 may draw a considerable amount of current in forcing V_{out} to the opposite state. To prevent damage to the circuit being tested, the pulses are kept very short in relation to the pulse frequency. Even at 500 Hz, the pulser is actively pulsing for just 5 out of every 2000 microseconds—about 0.25% of the time.

Transistors Q1 and Q2 are 2N3904 saturated-switching types, which have the fast response required for creating the *Experimenter's Logic Pulser*'s sharp output pulses.

Resistor R5 provides a path for Q2's collector current when V_{out} is connected to an open input. Resistor R4 limits current in case V_{out} is accidentally connected to a voltage that is greater than +V.

The final element in the pulser's circuitry is a pulse indicator. Pin 2 of U2-a provides the trigger input for timer U1-b. Each time pin 8 of U2-b goes low, pin 9 generates a high pulse that turns on LED1. The pulse width at pin 9 (as set by R7 and C6) is about a $\frac{1}{10}$ second, long enough to provide a visible flash of the LED. When the *Experimenter's Logic Pulser* operates at 0.5 Hz, the LED flashes once every 2 seconds. At 500 Hz, the

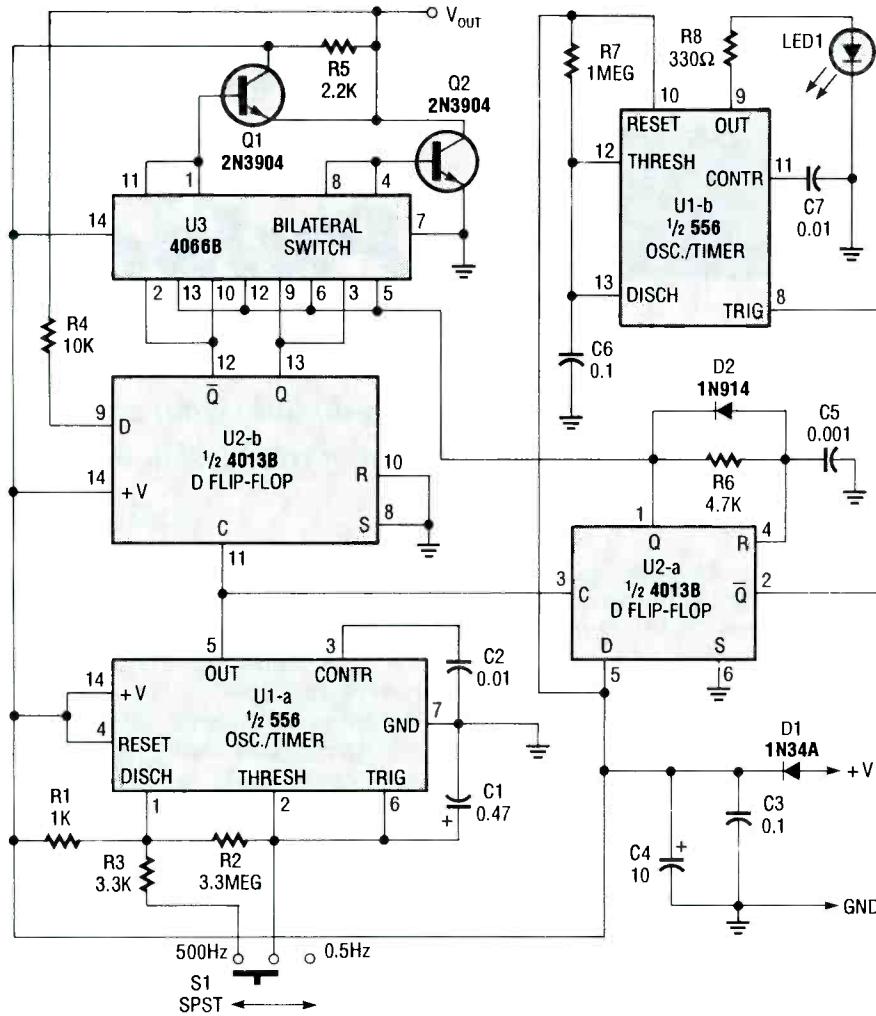


Fig. 1. The logic pulser generates pulses at 500 Hz or 0.5 Hz. When the pulser's tip connects to an input that is already being driven high or low, the pulser senses the logic state and automatically pulses the input briefly to the opposite state.

LED flashes so fast that it appears constantly lit.

Capacitor C1 provides noise immunity at pin 11 of U2-b, and R8 limits current through LED1. Capacitors C3 and C4 provide power-supply decoupling.

Let's look at an example of the pulser in operation. Say that we want to pulse an input that is normally driven high.

Pin 9 of U2-b senses the logic high at V_{out} . Pin 5 of U1-a oscillates at the frequency selected via S1. As pin 5 of U1-a goes high, the high at pin 9 of U2-b is transferred to pin 13, and a low is transferred to pin 12. At the same time, pin 1 of U2-a goes high, closing the switches in U3.

The high at pin 13 of U2-b turns on Q2, which pulls V_{out} low. After a few microseconds, pin 1 of U2-a goes low again, the switches in U3 open, base current is removed from Q2, and V_{out} can go high again.

If the input to be pulsed is normally low, the pulser responds in much the same way, except that pin 13 of U2-a

goes low and pin 12 goes high, causing Q1 to turn on and bring V_{out} high. When the pulser drives an open input, R5 pulls V_{out} high, and the Experimenter's Logic Pulser pulses it low.

Building the Pulser. It may not be a conventional project enclosure, but a plastic toothbrush case is just about the right size and shape to house the Experimenter's Logic Pulser. Whatever you choose, aim for a case that's conveniently shaped for use as a handheld tester.

Because you'll want the project to be as compact as possible, choose components that are physically small when possible. For example, switch S1 can be a subminiature type. For C1, use a Tantalum or other type of capacitor suitable for timing applications. Current-limiting resistor R8 should be rated at $\frac{1}{2}$ watt for use at 15 volts.

Point-to-point soldering on perfboard is fine for wiring the Experimenter's Logic Pulser's circuitry. Use a

board with solder-ringed holes to make the installation and wiring of the components easier.

A small circuit board, say about 1 by 3 inches will hold all of the pulser's circuitry except switch S1, which mounts directly to the case. Sockets are recommended for U1-U3. Plan your layout before beginning to wire the circuits. LED1 must be mounted at the correct height and position so that it fits its planned opening in the case when the circuit board is installed. Use narrow-gauge wire, such as AWG #30, to wire the connections between components, again to help reduce the circuit assembly's bulk.

Begin by installing the sockets for U1-U3 (but don't insert the IC's in their sockets until the circuit-board wiring is complete). Use Fig. 1 as a guide as you insert and wire the components of the

PARTS LIST FOR THE EXPERIMENTER'S LOGIC PULSER

SEMICONDUCTORS

- U1—556 dual oscillator/timer, integrated circuit
- U2—4013B CMOS dual D-type flip-flop, integrated circuit
- U3—4066B CMOS quad bilateral switch, integrated circuit
- Q1, Q2—2N3904 general-purpose NPN silicon transistor
- D1—1N34A general-purpose germanium diode
- D2—1N914 general-purpose silicon diode
- LED1—light-emitting diode

CAPACITORS

- C1—0.47- μ F, Tantalum
- C2, C7—0.01- μ F, ceramic-disc
- C3, C6—0.1- μ F, ceramic-disc
- C4—10- μ F, Tantalum
- C5—0.001- μ F, ceramic-disc

RESISTORS

- (All resistors are $\frac{1}{4}$ -watt, 5% units, unless otherwise noted.)

- R1—1000-ohm
- R2—3.3-megohm
- R3—3300-ohm
- R4—10,000-ohm
- R5—2200-ohm
- R6—4700-ohm
- R7—1-megohm
- R8—330-ohm, $\frac{1}{2}$ -watt

ADDITIONAL PARTS AND MATERIALS

- S1—SPST slide switch
- Perboard materials, enclosure, IC sockets, alligator or mini test clips, nail (4d), LED holder, hookup wire, solder, hardware, etc.

circuit. Observe the proper polarity for D1, D2, C1, C4, and LED1, and be mindful of the orientation of Q1, Q2, and the IC sockets as you wire them.

Cut 40-inch lengths of red and black stranded hookup wire for the power-supply leads, and strip a $\frac{1}{2}$ inch of insulation from the ends of each lead. Solder the red wire to +V and the black wire to ground on the circuit board. Wire S1 to the appropriate points on the circuit board using 6-inch lengths of #30 wire.

The probe tip can be constructed from a nail (4d or similar), a small block of wood that fits inside the tip of the case, and a 6-inch length of wire.

Strip about a $\frac{1}{2}$ inch of insulation from the ends of the wire. Drive the nail part-way through the center of the wooden block, then wrap one end of the prepared wire tightly around the nail, just under the nail's head. Drive the nail into the block to form a sound mechanical and electrical connection between the wire and the nail.

On the project case, make openings for LED1 and S1, and make an opening on each end of the case for the probe tip and power-supply leads. Label the switch positions on the case with rub-on transfer labels followed by three or four coats of clear acrylic spray.

Pulser Checkout. It's a good idea to check the circuit's operation before installing the circuit board in its case. Install U1-U3 in their sockets, observing the pin-1 orientation for each. Connect a DC supply of from +5 to +15 volts to +V and ground on the board. (A nine-volt battery is fine for this test.)

The pulser's LED should flash about once every 2 seconds with S1 set at 0.5 Hz and should appear constantly lit at 500 Hz. If you monitor V_{out} with a logic probe or oscilloscope, V_{out} should be

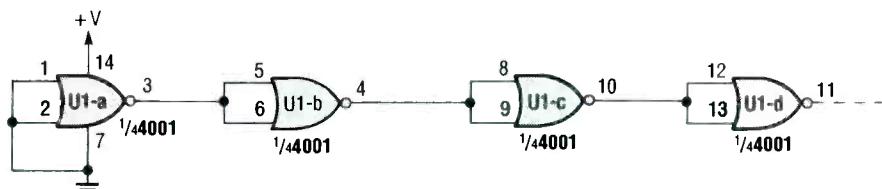


Fig. 2. Use this circuit to test the operation of the logic pulser. Points A and C are normally high, so the pulser will pulse them low. Point B is normally low and so will be pulsed high.

normally high, with short, low-going pulses about every 2 seconds or 2 milliseconds, depending on S1's setting.

The exact output frequencies of the pulser aren't critical. Frequencies within 20 percent of the specified values are fine.

Figure 2 shows a simple circuit for testing the pulser in an active circuit. Points A and C in the circuit are normally high, and point B is normally low.

If you connect the V_{out} on the pulser to point A or point C, the pulser should generate short, low pulses at the frequency selected. If V_{out} goes to point B, the pulser should generate high-going pulses. You can also try this test with a TTL IC such as a 7402. (Be sure to use a 5-volt supply with TTL.)

If you detect any problems in the operation of your Experimenter's Logic Pulser, stop now to find and fix them. Look the circuit over for incorrect or missing connections or solder bridges. When all is working, you're ready to finish putting the pulser together.

The first step is to fasten the probe tip inside the case. To do that, insert the prepared wooden block into the case with the nail extending out its opening. To hold the block in place as you fasten it, find a block or post that fits into the case, and is longer than the case.

Insert the block or post into the case and stand it on end so that the block is pushed against the end of the case. Drive two small nails or wire brads

through the case and into the wooden block. Solder the free end of the wire that connects to the pulser tip to V_{out} on the circuit board.

Before installing the circuit board, trim all leads on the bottom of the board and cover the bottom with electrical tape to protect the wiring as the board is inserted. Carefully bend the legs of the LED toward the probe-tip end of the circuit board and slide the circuit board into its case.

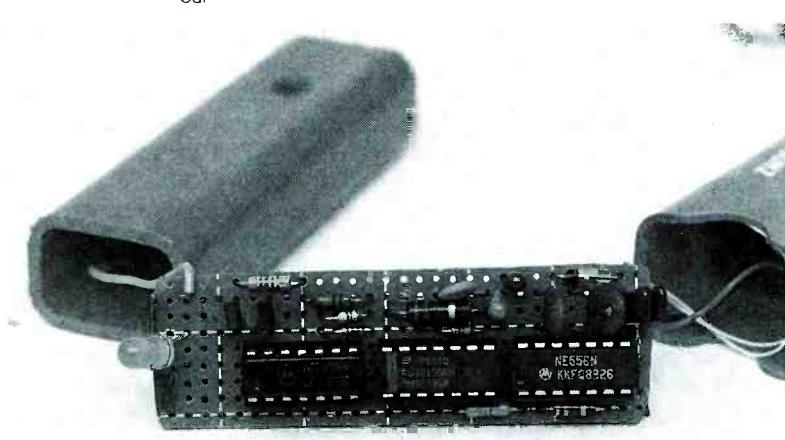
When the LED is directly below its opening, gently pry it up into place with a small screwdriver or other pointed tool, pushing the circuit board into the case slightly as you do so.

Tie a knot in the +V and ground leads to act as a strain relief, and insert the leads through their hole in the end of the case. Crimp or solder an alligator or mini test clip to the end of each wire. When mounting switch S1, be sure to orient it so that the "open" switch position matches your 0.5-Hz label on the case. Use a long-nose pliers to hold the switch in position inside the case as you fasten its mounting screws.

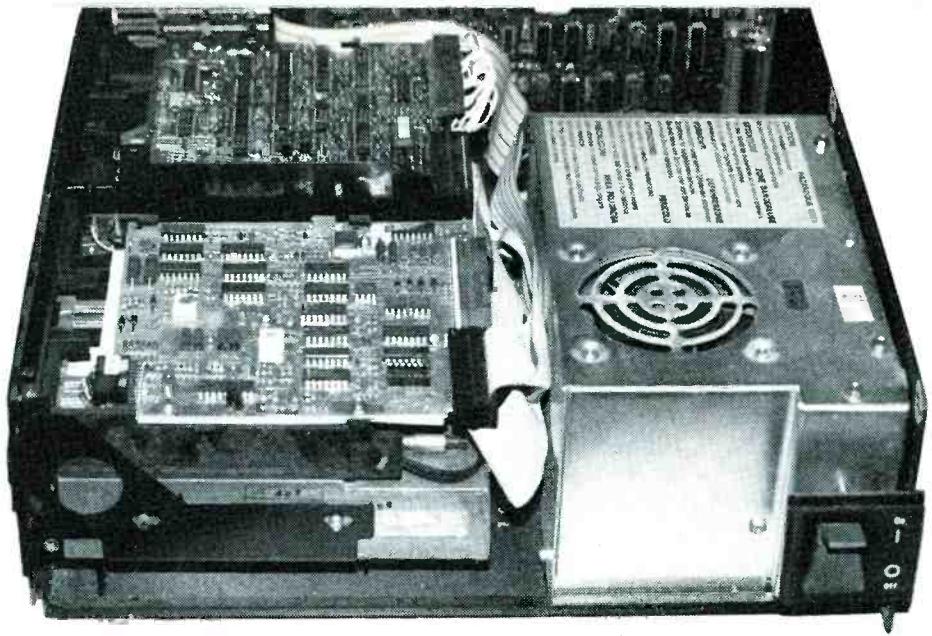
Finally, carefully close the case and check the operation of the pulser once more, to be sure that the final installation did no damage. When all is functioning correctly, complete your project by pressing the top half of a two-part LED holder around the LED on the case. The pulser is now ready for use.

Using the Pulser. To use the pulser to verify that a logic gate in a circuit is operating properly, clip the power leads of the Experimenter's Logic Pulser to +V and ground buses of the circuit under test and touch its tip to an input. Use a logic probe, oscilloscope, or other logic monitor to observe the outputs of the gates in question.

Because the Experimenter's Logic Pulser is powered by the circuit under test, it automatically generates pulses of the correct amplitude for your circuit. Use the 0.5-Hz setting when you want to watch the effect of a single pulse on an input, and 500 Hz when you want to see the effects of a pulse train.



Most of the circuitry for the logic pulser is wired on a small circuit board that fits neatly inside an ordinary toothbrush case.



Upgrading Your PC

BY JOSEPH J. CARR

Who says you have to junk your faithful old clunker. Instead, learn how to squeeze more performance from your current machine.

The personal computer revolutionized my working life. I routinely use several personal computers in my work as an electronics professional and as a technical writer. My main computer is an IBM-PC, and it was one of the first B-series (i.e. 256K motherboard instead of 64K) computers to arrive at the local dealer. That machine has served me well for several years, but now it's obsolete. Some software won't run on it at all, and other software is inconvenient to use because the machine lacks a hard-disk drive.

Starting about two years ago I slowly updated the old PC, to take advantage of current technology. In this article I'll show you how to upgrade your old PC (in steps or in one big swoop).

My IBM-PC has 256K of Dynamic Random Access Memory (DRAM) made up of four banks of 4164-150 DRAM chips, with nine chips per bank. Almost all modern software appearing on the market today requires at least 512K of RAM, therefore, my first upgrade was to add memory. MS-DOS and PC-DOS recognize up to 640K of memory, so I had to add 384K in order to bring the machine up to date.

The old PC had a parallel-printer port, a monochrome text-only TTL monitor, and a pair of 360K, 5.25-inch, Full-Height (FH) Double-Sided Double-Density (DSDD) floppy-disk drives. No RS-232C serial port was available, which makes using modems and some printers difficult. Today's systems almost

exclusively use Half-Height (HH) floppy-disk drives. And many current machines use HH quad density (1.44m) 5.25-inch drives, 720K 3.5-inch HH disk drives, or 1.44-megabyte 3.5-inch HH disk drives.

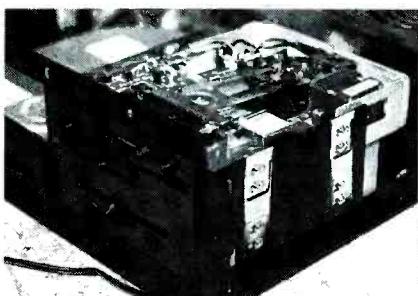
Avoid ESD Damage. A word of caution is in order before I describe my upgrade: Personal-computer motherboards, plug-in cards, and the electronics sections of disk drives use components that are sensitive to electrostatic potentials that can build up on your body. Static charges that you might not even feel can blow out or shorten the life expectancy of those electronic components. When working on your PC, always follow good anti-ESD (ElectroStatic Discharge) procedures.

For example, don't wear wool or garments made from synthetic fabrics that generate a lot of static electricity. Discharge yourself by touching a grounded point before starting to work. Ideally, wear a grounded ESD wriststrap (available at many electronics parts distributors), and use soldering tools that have grounded tips.

Lastly, don't remove boards or components from their packaging until you are ready to use them. Those translucent tubes and plastic bags are treated to prevent damage from any static electricity that may be present.

Basic Upgrade. The most basic upgrade that I, and most older-PC owners, needed was to add more DRAM and a serial port. There are a number of add-on boards that fit into the accessory slots on the motherboard to accomplish that. External connectors, if any, for the plug-in boards protrude through the rear panel of the computer. For my basic upgrade I selected the AST Six-pack expansion card because it offers up to 384K of additional memory, an asynchronous RS-232C serial port, an additional parallel printer port, a game port, and an on-board clock/date function that eliminates the need for typing in the date and time every time I boot-up—all on one card!

Shopping around for DRAM chips is definitely worthwhile. Don't take the prices in mailorder ads too seriously, however; Ads are prepared several months in advance, but the DRAM mar-



This old B-series IBM-PC with two full-height 360K floppy-disk drives should give you some idea of the waste of space permitted way back when.

ket changes almost schizophrenically. I found the actual prices of DRAM's were lower than their advertised price. In one case, the DRAM price was 40-percent less than the advertised price. Although the price of memory is now on the upswing, it is worthwhile to call and ask the current price before buying.

When adding a product like the Six-pack you will have to configure the board and the motherboard to recognize the new memory size. Consult the owner's manuals for both the new board and the computer to find out how to set the DIP switches or on-board jumpers for the specific memory size that you select.

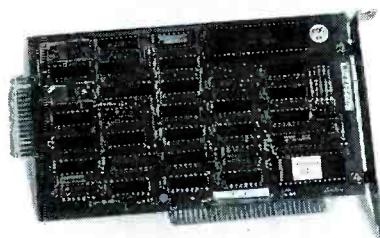
I also decided to add a simple graphics card to allow my IBM-PC to work with certain software. I selected the Hercules-format graphics card because it is minimally acceptable, and primarily because it would work with the standard green-screen TTL monitor that came with the machine many years ago. A new Hercules-format (or clone) card usually costs less than \$80, so it is a reasonable selection for an old computer. Those who want to add a modern monitor, and one that works a whole lot better, can use an EGA or VGA monitor with the appropriate card.

Adding/Changing Disk Drives.

When I bought my PC there was only one type of disk drive: the 5.25-inch FH, DSDD 360K model. But today there are several different types, sizes, and capacities such as the 5.25-inch HH 360K DSDD, the 5.25-inch HH 1.2-megabyte, the 3.5-inch HH 720K, and the 3.5-inch 1.44M HH. While I paid \$395 for an additional DSDD disk drive "way back when," current prices run from around \$60 to \$80 for 360K DSDD drives, to about \$120 to \$150 for one of the larger capacity 3.5-inch drives. If you hunt around a bit you will likely find them for even less.

One of the things that prompted me

to upgrade the old PC was the fact that one of my 5.25-inch 360K FH DSDD drives bit the dust. Instead of just replacing the drive with another of the same type, I opted to install a mix of drives. Because many software manufacturers may soon offer their wares only in the 3.5-inch, 720K format, it is wise to get one of those drives. The combination that I selected consisted of one 3.5-inch, 720K HH for drive B, and one of the original 5.25-inch, 360K drives for drive A. You can, however, use several drives



This floppy-drive controller card can only operate a floppy disk drive. It lacks the hardware to service input/output ports or a hard disk.

in differing mixes according to your own needs.

There is a mechanical problem that confronts owners of older PC's who wish to add a half-height drive: there are more holes, in a slightly different arrangement in the newer models. Owners of older machines will have to either fashion an adapter plate of their own, or buy a commercially made mounting plate such as Jameco Electronics' Model TMHD mounting plate selling for about \$3. Also offered by Jameco are other disk-drive mounting hardware that may be needed by some people. In my case, replacing an FH drive with an HH drive left an empty space. I bought a bezel from Jameco for about \$1, which covered up the unsightly hole.

Adding a 3.5-inch disk drive to an older machine may not be the straightforward task that it seems. There might be problems with the internal BIOS (Basic Input/Output System) and the version of MS-DOS or PC-DOS that you have.

The BIOS is contained in a Read-Only Memory (ROM) chip on the motherboard inside the computer. It allows the computer to read disks (among other tasks) so that the disk operating system (DOS) and applications programs can be input to the computer. An old BIOS might not support newer drives, how-

ever, so you will have to buy a later version. Some authorized IBM dealers will sell the latest BIOS for your machine, although you might have to look hard to find one locally. Alternatively, you can use one of the many good clone BIOS available today. I selected the latest one (Version 2.52) from a company called Phoenix Computer Products.

One note when buying a new BIOS: These "firmware" programs come in two formats: one 28-pin DIP ROM chip or two chips. According to one dealer I consulted, some motherboards will not work properly with the two-chip version of the BIOS, so he recommends ordering only the single-chip version unless specific information is available on the particular motherboard being used. Note: the existence of two ROM sockets on the motherboard does not signify that the motherboard will only accept the two-ROM version of the BIOS.

Older versions of MS-DOS or PC-DOS will not support the latest floppy disk drives. I used DOS 1.1 and 2.0 for years, but they won't work with the newer 3.5-



Half-height hard-disk drives designed to fit into one of the slots intended for floppy disk drives, can give you super storage in a very tiny space. Technology has really changed!

inch drives. Use DOS 3.2 or higher for 720K drives, and 3.3 or higher for 1.44M drives. An anomaly reported on some versions of 3.30 is that the 3.5-inch drive must be drive A; version 3.30A allows any type of drive to be used as the A or B drives.

You may also need to obtain a newer floppy-disk controller card, and therein lies a pitfall for the unwary. There are several different forms of 3.5-inch drive, and the controller card must be capable of accepting the one that you buy. For that reason I recommend that you buy the disk drive and the controller card from the same source. I bought a Toshiba Model 352KU (720K) drive and the JE-1043 controller card from Jameco because their catalog specifically

listed those components as compatible with each other. The JE-1043 will control two drives, they can be any of the standard types discussed above, and they can be separately configured on the JE-1043 by moving jumpers around according to the instructions supplied.

When I finished with the first and most basic upgrade of my old IBM-PC, it was configured with 640K of memory, a parallel port, a serial port, one of the original 360K FH 5.25-inch floppy drives, a new 3.5-inch 720K drive, and a Hercules graphics card.

Higher Upgrades. The basic upgrade that I performed on my old IBM-PC was sufficient for my needs at the time, and it is still in use. But there are other things that could also be done to improve the machine. However, some of these are so extensive that one has to consider whether the task ought to be refurbishing an old machine, or building a new one. Both are viable alternatives for any electronics buff who knows how to use a screwdriver.

Hard-Disk Drives. All modern computers should use either an external or internal (preferable) hard-disk drive. Although the original IBM-PC/XT hard disk had only ten megabytes of storage (which seemed vast in 1985), currently several options are available to you for adding hard-disk capability. One recent catalog offers hard disks from 20-megabytes to 120-megabytes, and I've seen ads for models up to 350-megabytes.

Owners of older machines, especially the IBM-PC (or clones) that did not have a hard disk, may wish to use a "hard card." Those products are standard IBM-compatible plug-in cards that fit into one of the expansion slots. It contains a disk drive and a controller card on one plug-in assembly. I recently added a Shamrock Lepracard Model 330 30-megabyte hard card to my old IBM-PC, completing the upgrade.

Various manufacturers offer FH and HH hard-disk drives that can boost the usefulness of your computer considerably. Those drives can fit into one of the floppy-drive positions on your computer. A common configuration is to use a FH or HH hard disk in the right hand position formerly occupied by drive B, and the HH floppies in the left position formerly occupied by the FH drive A. Many people place a 5.25-inch, 360K (drive A) and a 3.5-inch 720K drive



This is a 150-watt replacement power supply for the PC/XT installed in a PC/XT cabinet. The number of screws to mount your power supply will depend on your cabinet.

(drive B) in the left side position, and a HH or FH hard disk in the right side.

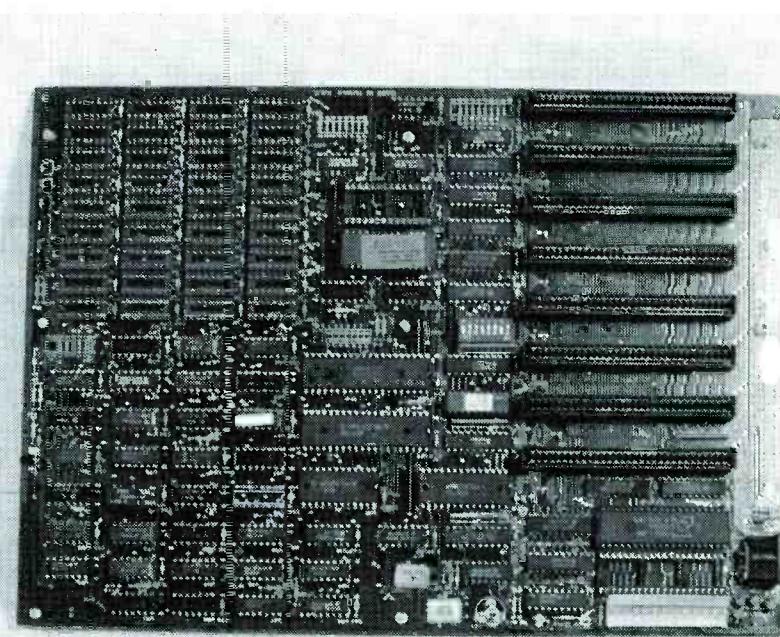
In my own situation, I recently built an XT-turbo class machine using a Seagate ST-238R 30-megabyte hard disk. That same drive (or one of the others) can be used in either a newly constructed machine or an upgraded or refurbished older machine. A hard-disk controller will be needed, and they can be bought from the same source as the drive. In fact, it is the best policy to buy both the drive and the controller from the same source so that you can make certain that they are compatible. Most mailorder companies will designate the controllers and drives that go together, and many of them offer a special price when the two are purchased together. Buying a "bargain" may produce unforeseen headaches!

In particular, you may run into prob-

lems if you've previously upgraded your PC with higher capacity 5.25- or 3.5-inch floppies, or if you plan to in the future. Your best bet then is one of the new breed of versatile controllers that can handle all of the popular floppy formats, as well as hard disks. One example of those is RMT Systems' RMT2001-F2H2 controller. That single-board controller can handle two 3.5- or 5.25-inch floppies, as well as most popular hard-disk drives, and free up an expansion slot in the bargain.

More Power To You. The original IBM-PC used a 67-watt DC power supply. If you add a lot of special-purpose expansion cards (with the full 640K of memory), or a hard-disk drive, then it may become necessary to beef up the DC power supply. Many sources exist for new power supplies in 135-watt, 150-watt, and even 250-watt capacities; I recommend at least 150 watts. The supplies fit directly into either the IBM-PC/XT type chassis, or the IBM-AT type chassis, and now cost less than \$100 (I've seen some 150-watt models advertised by mailorder sources for less than \$50). The DC supply fits into the computer case at the right rear corner, and is attached by two to five screws (depending upon its origin) to the rear panel. It can be replaced easily (in minutes) with only a screwdriver or 1/4-inch nut driver.

New Motherboards. The old IBM-PC operated at 4.77-MHz, so it is very slow



Here's an XT-turbo 8/10-MHz replacement motherboard. The on-board DRAM memory used on modern boards like this consists of 41256 chips or higher.

by modern standards. Along with improved speed, newer motherboards offer various features and later versions of the BIOS ROM. There are a lot of new "turbo" XT-compatible boards on the market, usually for less than \$100, that fit directly into the chassis of the IBM-PC or IBM-XT type of machine. The straight turbo boards usually feature either the same 8088 processor as the originals, or the supposedly faster 8088 replacement NEC V-20, but run at faster clock speeds. Common turbo boards operate at both the standard 4.77-MHz clock speed and a faster speed in "turbo mode" (either 8-MHz or 10-MHz).

You can also buy new motherboards that are AT-compatible, but fit into the PC/XT-size cabinet. Those boards are usually designated "baby-AT" or "mini-AT." Straight AT-compatible boards are a little larger, so must be installed in an AT-class cabinet. The AT boards are equipped with an 80286 processor. It is

SOURCES OF PARTS

The list of sources below is not intended to be complete, but rather offers a point of departure for you in locating adequate sources of computer parts. Check the advertisements in this magazine for other sources.

American Design Components

815 Fairview Ave.
Fairview, NJ 07022
Tel. 800-776-3700, or
201-941-5000

CIRCLE 41 ON FREE INFORMATION CARD

AST Research, Inc.

2121 Alton Ave.

Irvine CA 92714-4992

Tel. 714-863-0181

CIRCLE 42 ON FREE INFORMATION CARD

Jameco Electronics

1355 Shoreway Road

Berkeley, CA 94002

Tel. 415-592-8097

CIRCLE 43 ON FREE INFORMATION CARD

JDR Microdevices

2233 Branham Lane

San Jose, CA 95124

Tel. 408-866-6200

CIRCLE 44 ON FREE INFORMATION CARD

Jinco Computers, Inc.

5122 Walnut Grove Ave.

San Gabriel, CA 91776

Tel. 818-309-1108

CIRCLE 45 ON FREE INFORMATION CARD

RMT Systems, Inc.

18226 McDermott West, Suite E

Irvine, CA 92714

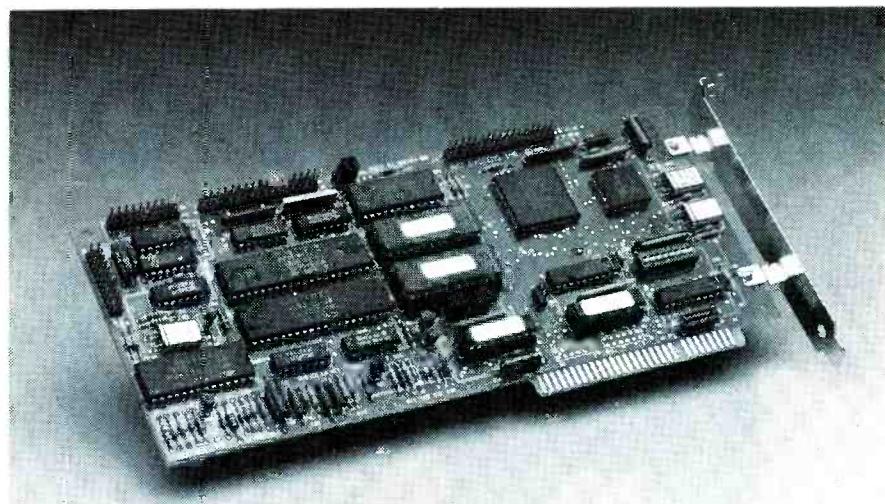
CIRCLE 46 ON FREE INFORMATION CARD

Shamrock

733-AA Lakefield Rd.

Westlake Village, CA 91361

CIRCLE 47 ON FREE INFORMATION CARD



If you want to conserve expansion slots on an 8-bit machine, a multi-purpose card is the way to go. This RMT2001-F2H2 controller card can support two floppy drives and two hard-disk drives simultaneously. To top it all off, it comes with an on-board BIOS so you can vary the configuration of the drives.

also possible to buy different speed AT-class motherboards. Models from 8 MHz to 33 MHz are available.

Speed is sometimes a red-herring issue, and it's not always true that faster is better. But in general, there is good reason to buy a faster board if you have the money. But a word of warning is in order. Some manufacturers reportedly offer speedy boards that use a less speedy processor chip. Although the chip works at the higher speed, the internal semiconductor-junction temperatures could rise above the maximum specified level. Reliability engineers tell us that a 10°C rise of junction temperature halves the mean time between failure (MTBF) rating of the device!

The prices on motherboards are dropping rapidly, and the picture of what's available is changing. You will have to check the mailorder ads and catalogs from mailorder companies to find the current offerings, but you are almost sure to be pleased with what you find.

Sources of Supply. Although there are dealers in some localities who handle a full line of components for either the builder or refurbisher of personal computers, most readers will probably want to buy mailorder. I experienced no difficulty in buying from mailorder sources, but you might want to use a little caution when dealing with unknown sources or sources that exist only as a post-office box. In general, the sources that advertise in national magazines are straight shooters (at least,

that's been my personal experience), and so can be a quality source of parts and components.

In general, unless you are familiar with the capabilities of the equipment you are acquiring, it is best to buy from a single source when purchasing items that must work together in an integrated manner. Examples include floppy-disk drives and floppy controller cards, hard-disk drives and hard-drive controllers, etc. It is also sometimes a problem mixing unknown motherboards with plug-in controller cards because of BIOS compatibility.

The only time I got "stung" on a part was at a hamfest/computerfest. One dealer offered motherboards at a good (but not great) price. I bought one, but when I fired it up at home I found certain read errors were happening. On calling Phoenix I found out that the BIOS chip it contained was an older version (2.27), and did, in fact, contain errors. They recommended that I buy Version 2.52 and provided a reasonably local telephone number for a "nearby" dealer. The new BIOS cost \$35 and solved the problem.

Some Common Sense. It is easy to rush out and buy all the parts that your bank account or credit-card limit can tolerate. If you're like me, then you're tantalized by the best and most recent of everything electronic. But when a dose of old-fashioned reality sets in, you may find that the latest and greatest is not needed. For example, your old PC

(Continued on page 154)

Build a Hot Socket

Here's a fun project that's bound to generate a shocking response!

BY WALTER W. SCHOPP

What would you think if you saw a small box that had an AC socket mounted on it, just laying on a desk? Your first impression might be "this can't be real so why is it here?" The next thing you'd do is pick it up for closer examination. About that time you'd be the recipient of a small jolt that will make you put it down in a hurry, most likely while mumbling a few choice words to yourself.

The circuit described in this article—the *Hot Socket*—is designed to deliver a mild shock to anyone inquisitive enough to pick it up. Shocks can be dangerous when they are received across a vital organ such as the heart. But with the *Hot Socket*, the startle factor is much greater than the actual danger.

In fact, the voltage and current generated (about 70 to 80 volts) by the *Hot Socket* is but a fraction of that produced by a stun gun or cattle prod. But, it is enough to establish in your mind that you just received a shock from an outlet that, from all ap-

pearances, has no power connected to it.

However, as safe as the unit may be, common sense should prevail when using the project. Don't leave it turned on and accessible to just about anyone who might happen along (such as a heart patient). Use it only under controlled circumstances.

Power for the circuit is turned on and off via a slide switch hidden on the bottom of the project's enclosure. When the switch is flipped to the on position, the circuit goes into sort of a semi-dormant condition until it is picked up and tilted slightly. The actual turn on is accomplished by way of four miniature-mercury switches oriented in four different directions.

When the *Hot Socket* is tilted, one of those switches closes, applying power to the circuit. At that point, a low-frequency oscillator is activated, which energizes a relay, causing its contacts to close momentarily. That produces a short pulse through the primary of a home-made transformer.

The secondary of the transformer is connected to the four aluminum-foil plates mounted on the sides of the enclosure. The opposing plates are connected across the secondary of the transformer.

How It Works. Figure 1 shows the schematic diagram of the *Hot Socket*. The circuit consists of two general-purpose transistors (Q1 and Q2) and a few support components, including a home-made transformer. When S1 is flipped to the on position and the circuit is not tilted in any direction, no power is delivered to the circuit. But when the circuit is tilted, power is applied through one of the mercury switches and a voltage divider network (consisting of R2 and R4) to the base of transistor Q1, turning it on. At the same time, a short-duration pulse is applied to the emitter of that transistor via capacitor C1.

With Q1 turned on, the base of transistor Q2 is pulled low. Normally that would turn on Q2, but the short pulse

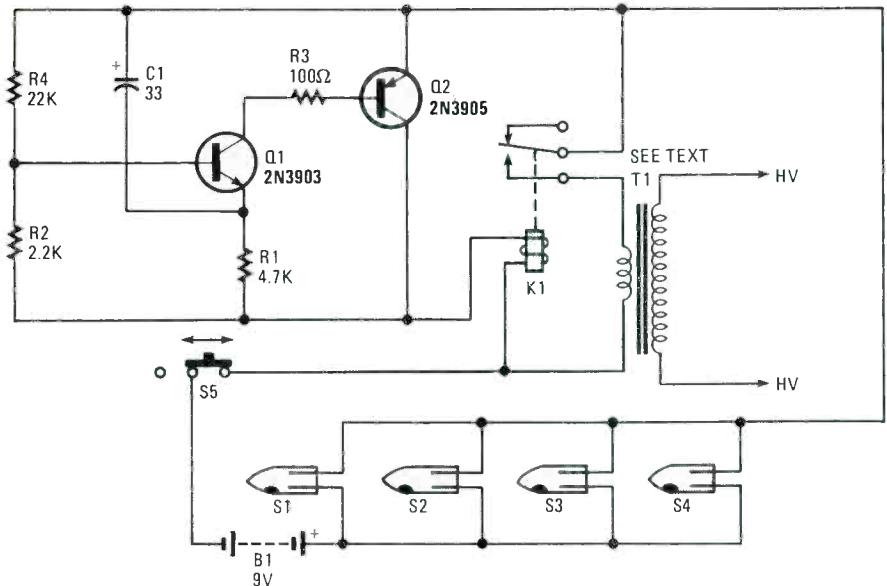


Fig. 1. The Hot Socket consists of nothing more than two general-purpose transistors (Q_1 and Q_2) and a few support components, including a home-made transformer.

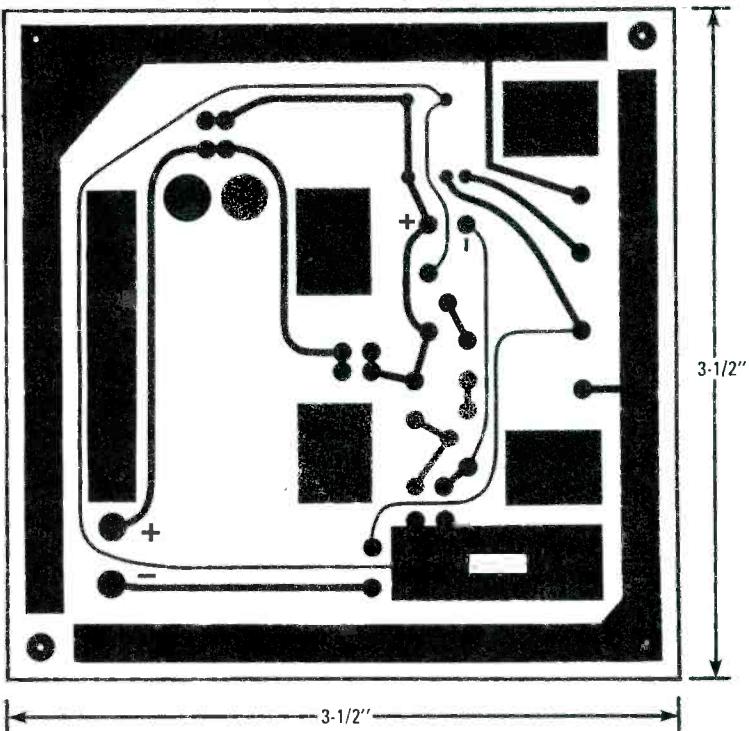


Fig. 2. Here is a template of the Hot Socket's printed-circuit board. The board has a dual role: it serves as the chassis on which the components are mounted, and as the bottom cover for the enclosure.

through capacitor C_1 momentarily holds Q_2 off. As C_1 starts to charge toward the supply potential, Q_2 turns on, delivering a pulse of energy to relay K_1 , energizing it. Relay K_1 , which is connected across the positive and negative supply rails, applies a short burst of energy across the primary of transformer T_1 . That causes a higher voltage to be induced in the secondary winding of the transformer. The output of T_1 is then applied across the four aluminum-foil plates.

Construction. The author's prototype of the Hot Socket was built on printed-circuit board, measuring about $3\frac{1}{2}$ square. All components were surface mounted to the foil side of the board. Figure 2 shows a template of the Hot Socket's printed-circuit board. The PC board has a dual role: it serves as the chassis on which the components are mounted, and as the bottom cover for the enclosure.

The parts-placement diagram for the Hot Socket's printed-circuit board is

shown in Fig. 3. The 9-volt battery, B_1 , is held in place by two loops of No. 14 solid-copper wire formed around the battery and soldered to the board. A small loop is also soldered to the board at the bottom of the battery to keep the battery from sliding into the mercury switches located near the bottom end of the battery.

The leads of a snap-on battery connector are cut short and soldered to the terminals marked plus and minus on the PC board. The resistors were vertically mounted to the board to conserve space. The electrolytic capacitor, C_1 , can be of either radial- or axial-lead type. However, if an axial-lead unit is used, it will be necessary to mount it vertically.

The pins of the relay were bent outward and soldered to the pads on the board. A small slot was cut in the PC board to allow access to the slide switch handle and the slide switch was soldered to the pad provided. Small foot pads were mounted on the corners of the board to keep the project from resting on the slide switch handle when the project is completed.

The four miniature mercury switches are mounted with the lead ends elevated about $\frac{1}{16}$ inch above the board with the tops pointing downward. That mounting scheme guarantees that no power is applied to the circuit when it is laying on a flat, level surface. The miniature mercury switches (S_1 to S_4) are not readily available from most electronic-parts suppliers, but are available in sets of four from the supplier given in the Parts List.

The miniature mercury switches are encased in metal and the metal cover is not insulated from the circuit. In order to prevent the cover from shorting against other board components or circuit-board traces, slip a small piece of heat-shrinkable tubing over each unit before mounting. When the switches are mounted and adjusted, secure them to the board with a drop of epoxy cement.

The transformer is not available from any supplier and must be made by the experimenter. Figure 4 gives details for the construction of the home-made transformer used in the Hot Socket. Start by cutting two small pieces of single-sided printed-circuit board material to a half inch square. Drill a hole, using a No. 35 bit, in the center of each square.

Next, heat a 3-inch No. 10D finishing nail over the burner of a kitchen stove

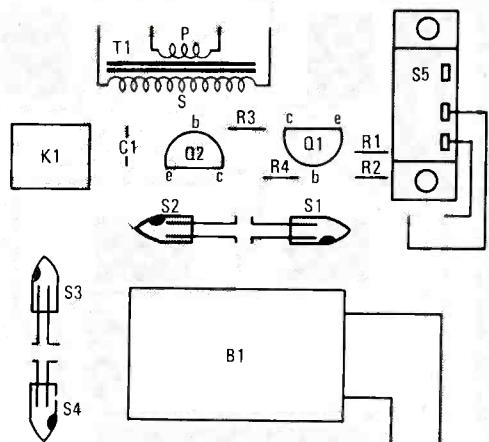


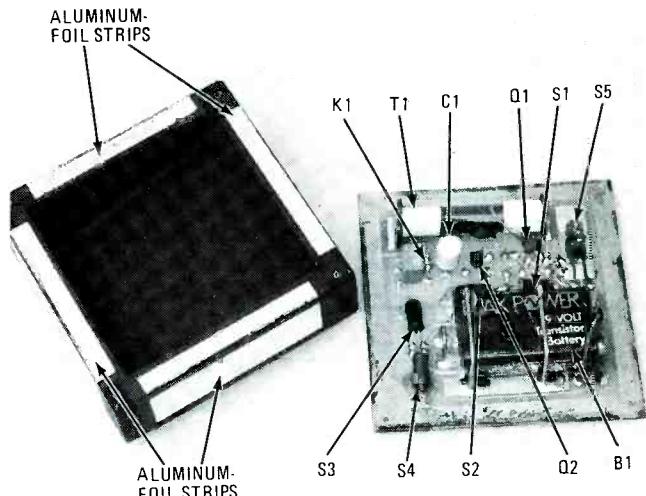
Fig. 3. This parts-placement and orientation diagram makes assembly of the Hot Socket a snap. Just be careful when installing the transformer; incorrect installation of that component will result in step-down operation, instead of step-up operation.

PARTS LIST FOR THE HOT SOCKET

- Q1—2N3903 general-purpose NPN silicon transistor
- Q2—2N3905 general-purpose PNP silicon transistor
- R1—4700-ohm, 1/4 watt, 5% resistor
- R2—2200-ohm, 1/4 watt, 5% resistor
- R3—100-ohm, 1/4 watt, 5% resistor
- R4—22,000-ohm, 1/4 watt, 5% resistor
- C1—33- μ F, 16-WVDC, electrolytic capacitor
- K1—12-volt micro-miniature relay (Radio Shack 275-241)
- S1-S4—Miniature mercury switch, see text
- S5—SPST or SPDT miniature slide switch
- T1—see text
- B1—9-volt transistor radio battery
- Printed-circuit materials, wood, hard board, nail, battery, No. 36 AWG magnet wire, No. 14 wire, snap-on battery connector, etc.
- Note:** A set of four miniature mercury switches (part No. 3004) is available at \$10.00 (postage paid) from Electronic Enterprises, 3305 Pestana Way, Livermore, CA 94550. California residents please add appropriate sales tax. Please allow 6 to 8 weeks for delivery.

until it is cherry red, and let it cool slowly without quenching. That annealing process improves the ferromagnetic properties of the nail. After it has cooled, remove any scale by the placing it in an electric power drill and sanding it.

Once that's done, push the nail into one of the small circuit-board squares



Here is the fully assembled printed-circuit board ready to be joined with its wooden enclosure. The white strips on the enclosure are actually the aluminum foil. When the project is fully assembled, the foil contacts the L-shaped circuit traces on the board, which are connected to the secondary of the transformer. When the project is tilted in any direction, a mild shock is delivered through the strips.

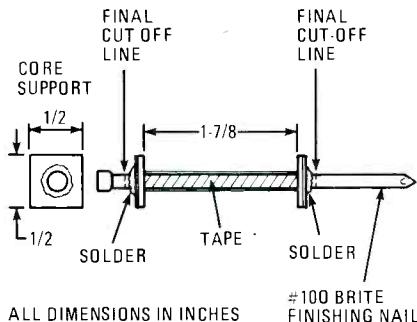


Fig. 4. The form on which T1 is wound must be fabricated by the builder. This illustration shows construction details for fabricating the form.

from the foil side until the head is about a quarter-inch above the copper surface. Solder the nail to the copper surface of the board. Next, drive the nail into the other square from the fiberglass side until the two squares are about two inches apart, as measured from the outside edges of the square end pieces.

Set the form on a flat surface and align the second square with the first so that it can be mounted on two flat edges. Solder the nail to the square to complete the coil form. Do not cut the excess nail length off at this time.

Cover the nail between the two ends with a single layer of scotch tape to keep the wire from shorting to the nail during winding. Wind a single layer of No. 36 AWG magnet wire the full length of the form (about 325 turns) between the end squares. That winding will serve as the primary of the transformer.

Next, place the pointed end of the nail into an electric drill and wind about 100 feet of No. 36 wire over the full length of the form. Lightly sand the insulating varnish from the ends of the four transformer leads and solder them to short pieces of light-gauge stranded wire and tape them to the coil with masking tape. That allows for easier handling without the fear of breaking off the fine magnet wires.

The ends of the nail can now be cut off almost flush to the printed circuit squares. The primary of the transformer is soldered to their pads on the printed-circuit board. The secondary wires are soldered to the pads and also connected to the L-shaped, printed-circuit traces. Those traces, when the board is fitted into its enclosure, contact the aluminum strips that are glued to the project's enclosure.

Building the Enclosure. The enclosure itself can be made from scraps of wood that you may have laying around. Start by making a frame about 3½-inches square, and ½-inch high (see Fig. 5) from a ¾-inch thick piece of wood. The author's enclosure was made from molding strips of the type that is readily found at most lumber yards.

Cover the top of the frame with a ⅛- or ¼-inch thick square piece of hardwood. Sand smooth and paint the enclosure. The side plates—which are made from aluminum foil—are glued

(Continued on page 151)

Anyone who participates in hobby electronics sooner or later needs electronic test equipment. For most of us who've been into it for a while that means a multimeter and perhaps a low-end oscilloscope. Later many hobbyists spring for a cheap transistor checker, overlooking the need for a capacitance meter or a frequency counter.

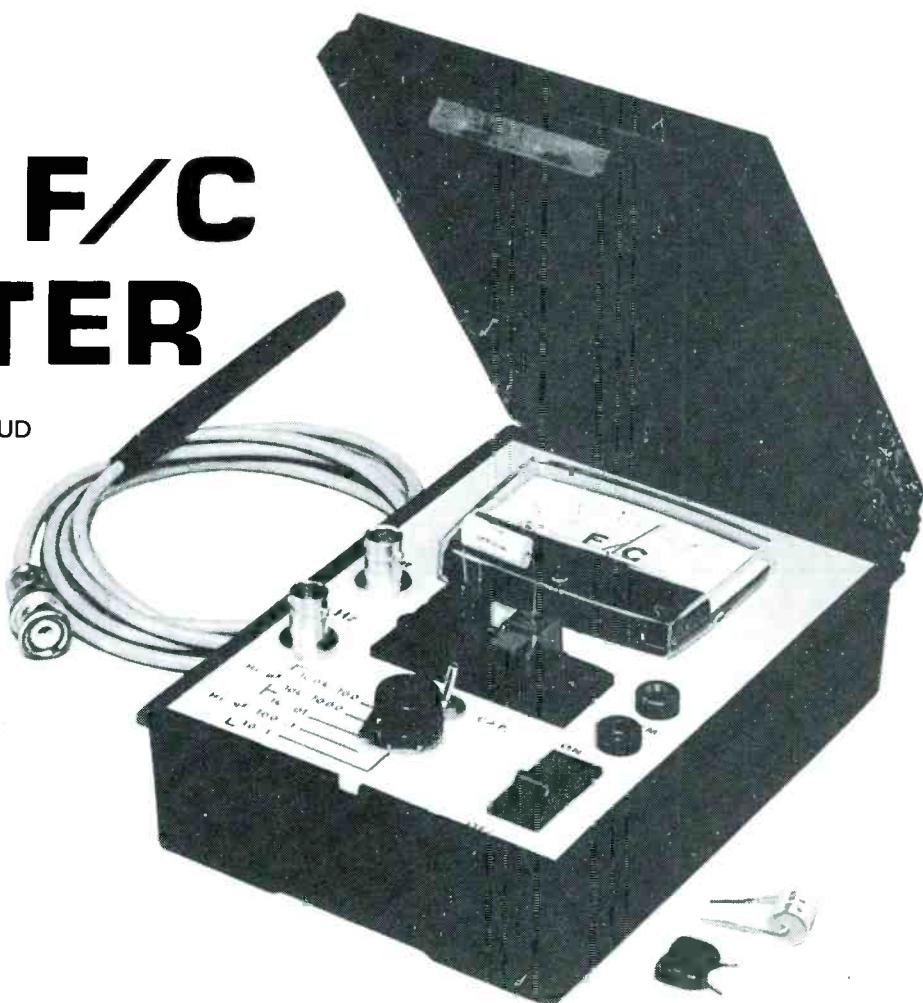
After all, if you all ready have an oscilloscope and a multimeter, you can test capacitors (using the multimeter) on a go/no-go basis, or count grids on an oscilloscope to get a pretty close approximation of the frequency in a given circuit. So, at first glance, there appears to be no need for those pieces of test gear.

One reason—the main

THE F/C METER

BY LUTHER M. STROUD

Measure capacitance, frequency, RPM, and more with this easy-to-build and easy-to-use instrument



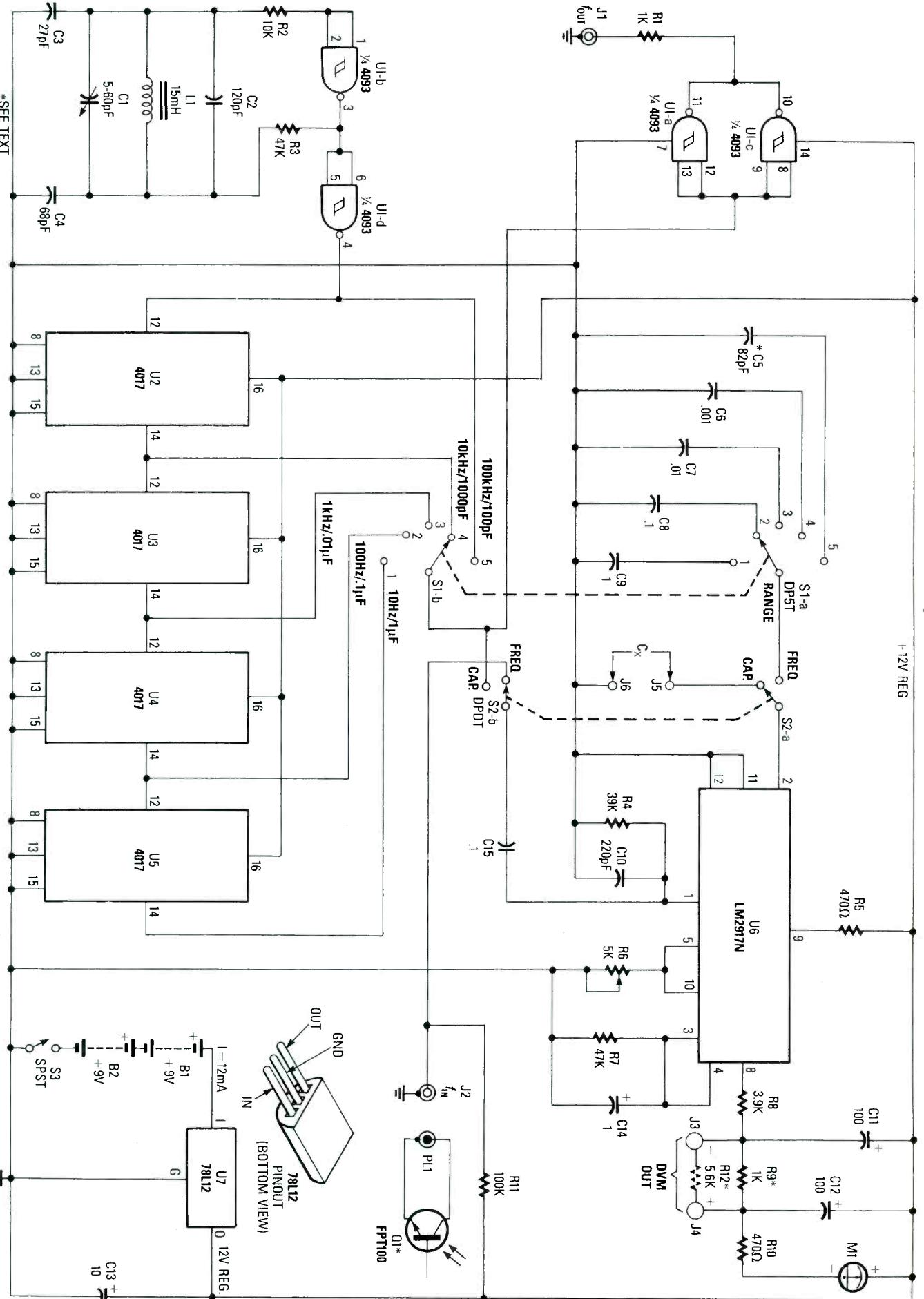
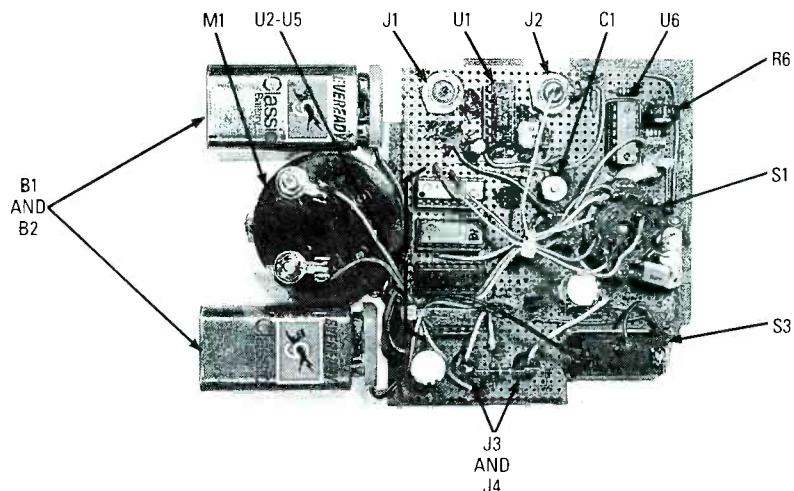


Fig. 1. The F/C Meter can be broken down into two subassemblies: the frequency standard/dividers and the frequency-to-voltage converter circuits.

one—that other instruments are needed is for greater precision. For instance, a frequency counter, whose only purpose in life is to count pulses, will usually read a frequency to within a few hertz, whereas, the same frequency calculated from an oscilloscope screen might be off by as much as 500 Hz or more. That's why specialized "data collectors"—like the F/C Meter presented in this article—are needed.

The F/C Meter is a low-cost project that allows you to measure frequencies from 1 Hz to 100 kHz and capacitance from 5 pF to 1 μ F over five ranges. It can also provide a frequency standard, or be used as an oscilloscope calibrator, squarewave signal injector, and a marker for audio-sweep generators. If you add the optional optical pick-up probe, you can use the project as a non-contact tachometer. I'm sure you can come up with many more uses.

Circuit Description. Figure 1 is the schematic diagram of the F/C Meter. The circuit can be divided into two parts; the frequency standard/dividers and the frequency-to-voltage converter circuit. The frequency-standard portion of the circuit consists of a 4093 hex NAND Schmitt trigger (U1), four 4017



The circuit board for the F/C Meter and its power source are mounted to an inner front panel of the enclosure. The board is held in place by the mounting hardware that secures J1 and J2 in place, while the dual-battery power source is held in place with strips of double-sided tape.

decade counter/dividers (U2 through U5), and a handful of support components.

When power is applied to the circuit, an L/C oscillator—consisting of U1-a, R2, R3, C1-C4, and L1—begins to oscillate at 100 kHz. The necessary phase shift to start and maintain U1-a's oscillation is provided by R3, C3, and C4. Resistor R2 isolates U1-a's internal input protection,

allowing the output frequency to be independent of supply-voltage changes.

The output of the oscillator is fed through U1-b (which is used as a buffer/inverter in this application) to the clock input of U2 at pin 12 and to contact 5 of switch S1-b. Integrated circuit U2 divides the 100 kHz output of the oscillator by 10, outputting a 10 kHz signal at pin 14. The output of U2 is applied to both pin 12 of U3 and to contact 4 of switch S1-b. Integrated circuit U3 divides the 10-kHz input to produce a 1-kHz signal, which is applied to contact 3 of S1-b. That signal is also fed to U4 and U5, each dividing the output signal of the previous stage by 10, to provide 100-Hz and 10-Hz signals that are fed to contacts 2 and 1, respectively.

The signal selected through S1-b is fed to the parallel buffer/inverter combination, U1-c and U1-d, and output at J1 to provide a frequency standard that can be used to calibrate an oscilloscope, provide a clock signal for testing and experimenting, etc.

Conversion Circuit. At the heart of the conversion circuit is an LM2917 frequency-to-voltage converter, which was originally designed to convert pulses from an automotive ignition system into a current that's used to drive a meter that's calibrated in RPM.

With S2 in the FREQ. position, a signal can be fed to pin 1 (the tachometer input) of U6. Integrated circuit U6 charges a capacitor (of known value) to a voltage that varies in direct proportion to the incoming signal frequency.

(Continued on page 138)

PARTS LIST FOR THE F/C METER

SEMICONDUCTORS

- U1—CD4093B quad 2-input NAND Schmitt trigger
- U2-U5—CD4017B decade counter/divider
- U6—LM2917N frequency-to-voltage converter
- U7—LM78L12 low-power, 12-volt, voltage regulator
- Q1—FPT100, TIL63, or similar NPN silicon phototransistor

RESISTORS

- (All resistors are $\frac{1}{4}$ -watt, 5% units, unless otherwise noted.)
- R1, R9—1000-ohm
- R2—10,000-ohm
- R3—47,000-ohm
- R4—39,000-ohm
- R5, R10—470-ohm
- R6—5000-ohm trimmer potentiometer
- R7—47,000-ohm
- R8—3900-ohm
- R11—100,000-ohm

CAPACITORS

- C1—5-60-pF, trimmer
- C2—120-pF, ceramic disc
- C3—27-pF, ceramic disc
- C4—68-pF, ceramic disc
- C5—82-pF, ceramic disc (see text)
- C6—.001- μ F, 5%, ceramic disc

- C7—0.01- μ F, 5%, Mylar
- C8—0.1- μ F, 5%, Mylar
- C9, C14—1- μ F, 5%, Mylar
- C10—220-pF ceramic disc
- C11, C12—100- μ F, 16-WVDC, electrolytic
- C13—10- μ F, 16-WVDC, electrolytic
- C15—0.1- μ F, ceramic disc

SWITCHES

- S1—DPST rotary switch
- S2—DPDT toggle switch
- S3—SPST rocker switch

ADDITIONAL PARTS AND MATERIALS

- L1—15-mH ferrite choke coil
- M1—0-to-1-mA, full-scale, D'Arsonval panel meter
- Perfboard materials, enclosure, BNC connectors, IC sockets (optional), knobs, 9-volt transistor-radio batteries and battery holders, snap-on battery connectors, wire, solder, etc.

Note: The following items are available from Pershing Technical Services, PO Box 1951, Fort Worth, TX 76101; A kit of parts containing all intergrated circuits and capacitors, plus L1 for \$25.00 (shipping included). TX residents must add sales tax. Please allow 6 to 8 weeks for delivery.

AM/FM/SW ACTIVE ANTENNA

Here's a one-evening project you can build that'll pull in shortwave or AM broadcasts like a magnet!



How much shortwave reception can you get with an 18-inch antenna? Would you believe you could log Radio Australia, all the major European broadcasters, and a few Latin-American locals? The catch is, you must use an active 18-inch antenna. Our *Simple Active Antenna* includes a FET amplifier to boost the signal with almost no load felt by the antenna. After all, a short antenna picks up the same RF signals as a long one—the signals are just weaker.

The Unit's Advantages. Most active antennas are much more complicated than ours (shown in Fig. 1). Ours is the simplest circuit that works reliably. I've tried it with a Sony ICF-2010, a Realistic DX-40, and an old Toyota car radio with success.

On the shortwave bands, it's comparable to a 20- to 30-foot wire antenna. On the AM-broadcast band, it's amazing—stations that were weak and scratchy (even when using a 40-foot wire antenna and an antenna tuner) come in loud and clear. It's even usable on the FM-broadcast band, though it's not that much better than an unamplified whip.

The circuit is so simple because it has an untuned high-impedance output. That works well with lower priced re-

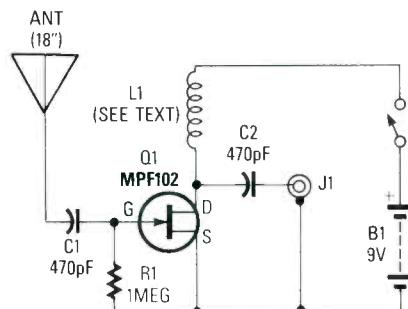


Fig. 1. Transistor Q1 amplifies the signal from the 18-inch whip to emulate the performance of a much larger antenna.

ceivers that are designed to take an untuned wire antenna, as well as car radios. Performance may be disappointing with ham receivers that have low-impedance inputs.

Before You Start. You must choose coil L1 to work well with your receiver on the frequency bands that most interest you. I used a 470- μ H coil because I wanted lots of amplification at lower frequencies. If you're mainly interested in shortwave, and want to avoid overloading from local AM stations, you can make L1 as small as 20 μ H.

Radio Shack carries a 100- μ H RF choke that you can use for L1, but it's bulky. An alternative is to buy a pack-

(Continued on page 139)

THE TELE MONITOR

BY CHARLES R. BALL, JR.
AND W.K. BALL

Remember when your sister called to tell you about this year's family reunion, but in the excitement of hearing from her, you forgot to write down the date, time, or even the city? How often have you talked on the phone with a client for an extended period and after hanging up, remembered that you hadn't taken any notes?

Well, such memory lapses need not be a problem if you build the *Tele Monitor* described in this article. The Tele Monitor automatically activates a recorder to keep a perpetual log (within the limits of the tape's capacity) of all calls, incoming or outgoing. Best of all, it can be built for less than \$25, excluding the recorder.

How it Works. Figure 1 is the schematic diagram of the Tele Monitor. The circuit is connected between the telephone line and the tape recorder. The telephone line—the conductors are designated **tip** and **ring**—normally has -48 volts across it when the telephone is on hook. When the telephone is taken off hook, that voltage changes to about -10 volts, depending on the subscriber loop resistance (see information in Table 1).

A full-wave bridge rectifier (consisting of D1 through D4) connected across **tip** and **ring** allows the circuit to

Now you can keep an audible record of your telephone conversations with the aid of this simple circuit.

TABLE 1—TELEPHONE SUBSCRIBER LINE SPECIFICATIONS

Parameter	Value	Condition
Central Office voltage, tip to ring	-48 VDC	On-hook
Central Office voltage, tip to ring	-10 VDC	Off-hook
Central Office voltage, tip to ring	105 VAC, 20/30 Hz	On-hook, Ringing
Subscriber loop current, tip to ring	-20 to -80 mA	Off-hook, CO Seizure
Subscriber loop resistance, tip to ring	0 to 1200 ohms	Off-hook

NOTE: Telephone C. O. is positive ground.

be tied to the telephone line without regard to polarity. The voltage applied across **tip** and **ring** appears, polarity corrected, at the + and - ends of the diode bridge. When the phone is on hook, the voltage through D5 keeps Q1 on and Q2 off, so the recorder is in an idle state.

When any telephone tied to the circuit is picked up (goes off-hook), the voltage across **tip** and **ring** drops to about -10 volts, causing Q1 to turn off

and Q2 to turn on, activating the recorder through J2. Incoming calls also activate the recorder with each ringing cycle.

When the phone is off hook and the recorder is running, voice is coupled through R1 and the C1/C2 combination. Because the central-office ringing voltage is 105-volts AC, C1 and C2—which must have a voltage rating of 150 volts or better—are connected back-to-back to simulate a non-polar-

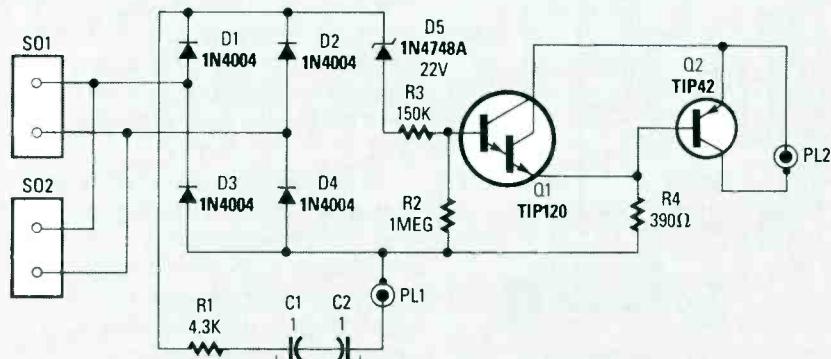


Fig. 1. Schematic Diagram of the *Tele Monitor*. Note that no relays are used.

WARNING: The use of the Tele Monitor and the parts therein is governed by Federal and State law. Federal law prohibits the taping of telephone conversation by one party without the knowledge and/or consent of the other party. Many states have adopted identical or similar provisions. Prospective users are advised to obtain independent advice as to the propriety of the purchase and use of the parts and use of the Tele Monitor, including (but not limited to) taping conversations therewith. We make no representations concerning the parts referred to in this article or their use or the legality of the use of the Tele Monitor, or any other such equipment referred to in this article. Readers are advised to obtain independent advice as to the propriety of their use of the parts, the Tele Monitor, or similar equipment based on their individual circumstances and jurisdiction.

ized capacitor. The diodes, D1 through D4, should have a peak inverse-voltage (PIV) rating of 200 volts or better.

Power for Tele Monitor is derived from the telephone line. A very small current (less than 80 μ A) is derived from the telephone line through the diode bridge when the phone is on-hook, so that Q1 remains off, keeping the recorder in an idle state. (**CAUTION:** For use in this application, the recorder must be battery operated or powered with a UL/CSA/FCC approved adaptor. Neither the telephone company or the FCC take kindly to having 120-volts AC suddenly appear on the telephone line. See box copy for additional warnings.)

It is recommended that the Tele Monitor circuit be coupled to a recorder with automatic volume control to compensate for varying signal levels on different calls and varying speech characteristics. The recorder mentioned in the Parts List is one such recorder. Other recorders can be used, but you must be sure that the internal remote-jack connections

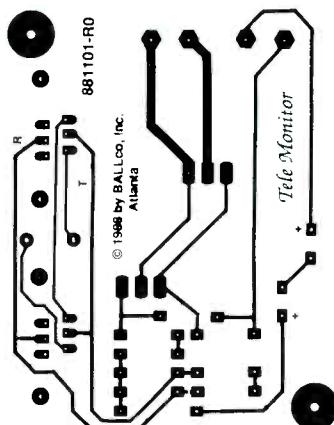


Fig. 2. Here's a full size template of the foil pattern for the Tele Monitor.

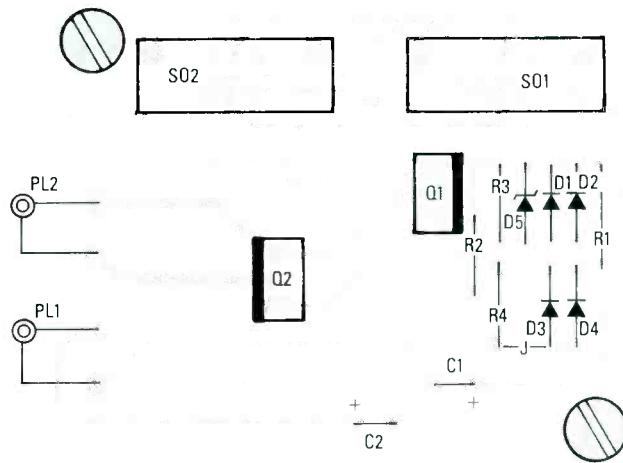


Fig. 3. This parts-placement diagram, like the schematic diagram (Fig. 1), shows two modular telephone sockets. If the second socket (SO2) is not needed, it can be eliminated without consequence.

PARTS LIST FOR THE TELE MONITOR

SEMICONDUCTORS

- Q1—TIP120, NPN Darlington transistor
- Q2—TIP42, PNP silicon power transistor
- D1-D4—IN4004 1-amp, 400-PIV rectifier diode
- D5—IN4748A, 22-volt, 1-watt Zener diode

RESISTORS

- (All resistors are $\frac{1}{4}$ -watt, 5% units.)
- R1—4300-ohm, $\frac{1}{2}$ -watt, 5%
- R2—1-megohm, metal film
- R3—150,000-ohm
- R4—390-ohm

ADDITIONAL PARTS AND MATERIALS

- C1, C2—1- μ F, 200-WVDC, electrolytic
- SO1, SO2—Modular telephone socket
- PL1—See text
- PL2—See text

have the proper polarity for Q2 to turn on the recorder.

Assembly. The author's prototype of the Tele-Monitor was assembled on a printed-circuit board measuring about $2\frac{3}{4} \times 2\frac{1}{4}$ inches. A template for the printed-circuit board—which is available from the source given in the Parts List—is shown in Fig. 2. The layout provides for two modular connectors that allow you to connect your phone and the Tele Monitor to the same wall jack.

Once you have obtained or etched the board and are in possession of all the components, begin assembling the project using Fig. 3 as a guide. When stuffing the board, be careful of component orientations, particularly the diodes, capacitors, and transistors. Mount Q1 and Q2 as shown in Fig. 3.

Printed circuit, enclosure (Radio Shack 270-283 or equivalent), IC socket (optional), heat sink (AAVID 5741B or equivalent), modular telephone plug with cable (Radio Shack 279-397, 279-374, or similar) recorder (Radio Shack CTR 70 or equivalent) etc.

Note: The following items are available from BALLCO, Inc., PO Box 1078, Snellville, GA 30278-1078; 404/979-5900; Etched, drilled, plated and silk screened printed-circuit board (#881101-R0). \$9.95 post paid in the USA; a complete kit (#TM88) less case and recorder plugs for \$24.95 + 2.50 shipping and handling. An assembled Tele Monitor is available for \$39.95, plus \$2.50 S/H. A case for unit is available for \$3.99 post paid. Florida and Georgia residents please add appropriate sales tax.

Transistor Q2 should be heat sunk because the combination of the saturation drop in Q2 and motor current in the recorder may exceed the transistor's ambient thermal rating. Usually a small clip-on heat sink is adequate.

Next, prepare a cable for connection to the remote jack of the recorder. Select a plug that's suitable for mating with the remote jack of your recorder. Almost any wire will do, but for ease of soldering to the plug, 24- to 26-gauge stranded wire is recommended. Make sure that the circuit-board pad marked "T" is connected to the "tip" of the remote plug and "R" to the other lug of the plug.

After soldering the wires to the plug, twisting the wires about 2 turns per inch will prevent the cable from tangling. If you are using a recorder other than the

(Continued on page 142)

EXECUTIVE'S DING-A-LING

By WALTER W. SCHOPP

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 3½-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

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

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

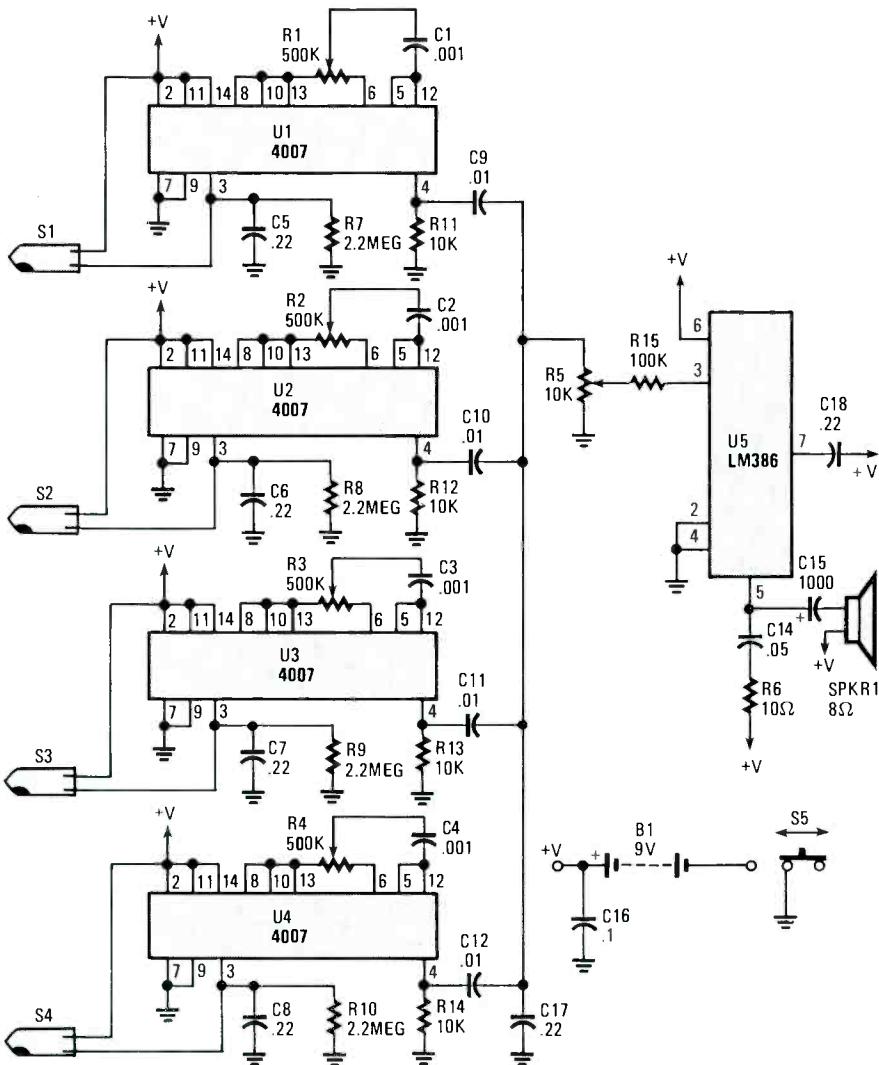
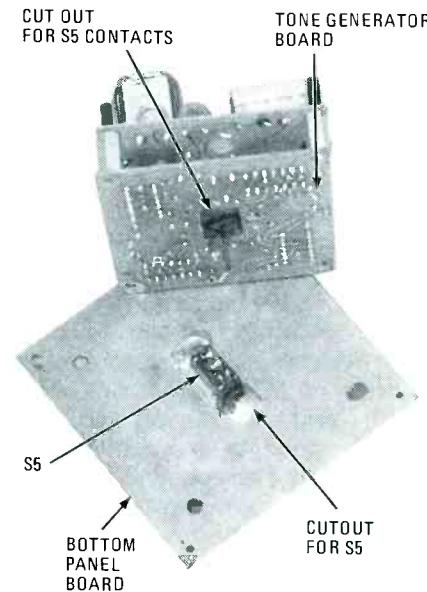


Fig. 1. The Executive Ding-A-Ling consists of four independent, adjustable tone generators (each built around a 4007 dual complementary pair plus inverter) that are tuned to the four musical desired notes.

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 $\frac{1}{8}$ 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 $\frac{1}{4}$ -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- μ F ceramic disc
C5-C8, C17, C18—0.22- μ F Tantalum
C9-C12—.01- μ F, ceramic disc
C13—not used
C14—.05- μ F, ceramic disc
C15—1000- μ F, 16-WVDC radial-lead electrolytic
C16—0.1- μ F, 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

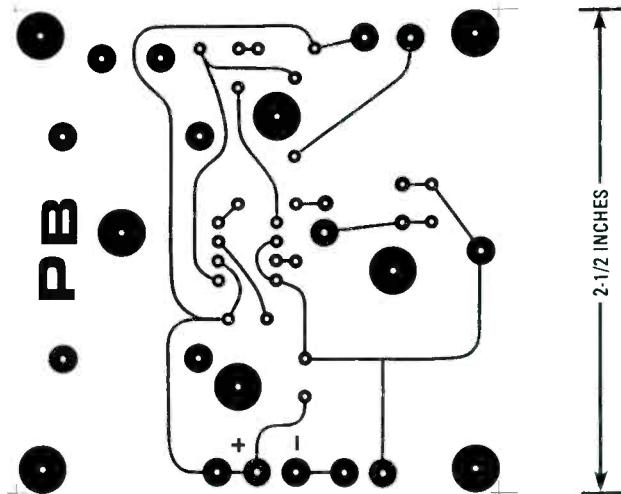


Fig. 2. Here is the printed-circuit pattern for the tone-generator board.

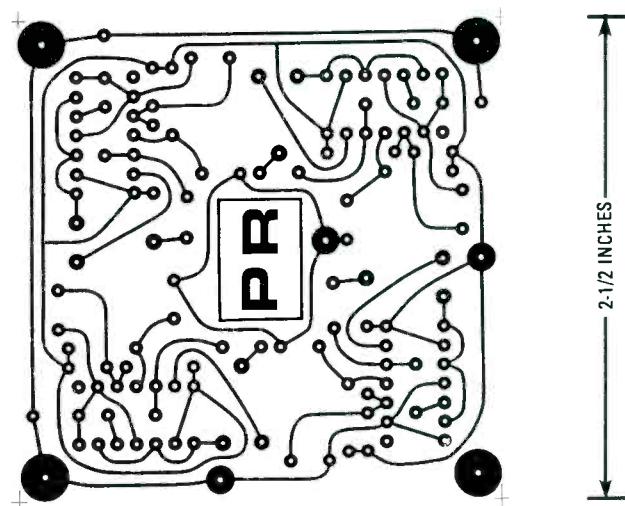
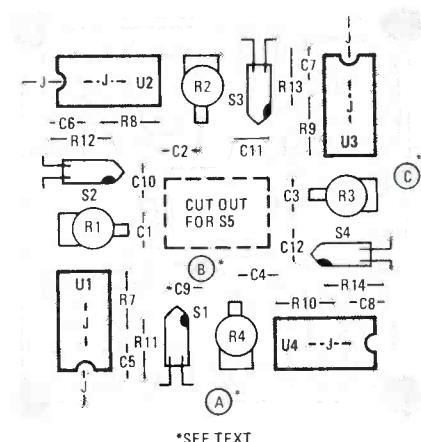


Fig. 3. Here is the printed-circuit pattern for the battery/amplifier board.



*SEE TEXT

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 $\frac{1}{8}$ 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

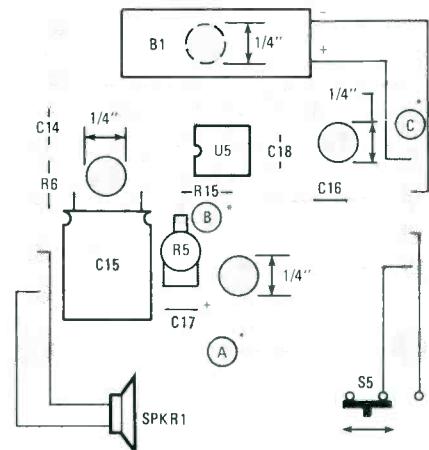
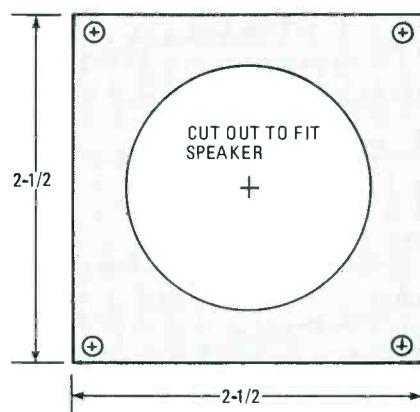


Fig. 5. Assemble the battery/amplifier board, using this layout diagram as a guide. Note the location of the battery, which is mounted on the board (located between four $\frac{1}{4}$ -inch donut pads as shown), and is held in place by a home-brew (wire) retaining system.



ALL DIMENSIONS IN INCHES

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.

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 162)

F/C METER

(Continued from page 131)

That varying voltage is converted to a current, which is then displayed as a frequency on the meter, M1.

The frequency range for the counter function is selected through S1-a. Depending on the setting of S1-a, a capacitor (C5, C6, C7, C8, or C9) is connected to U6 at pin 2.

When S2 is placed in the CAP position, the circuit can be used to read the value of an unknown capacitor. With S2 set to CAP and a capacitor connected across J5 and J6, S1 is used to set the range of measurement, by applying the appropriate clock signal to pin 1 of U6. Integrated circuit U6 then feeds a voltage that's proportional to its input signal to meter M1. The current to drive the meter coil leaves U6 pin 8 and is low-pass filtered by the network consisting of R8, R9, R10, C11, and C12.

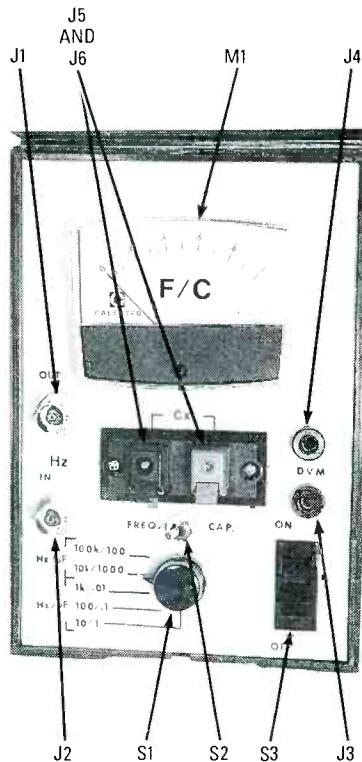
Filtering helps steady the meter reading with input frequencies below 5 Hz. Resistor R9 is placed in the current output loop for easy use of a DVM for improved accuracy in measurements. For a full-scale reading of 1 mA, the voltage drop across the resistor, by Ohms law, is 1 volt.

The LM2917 operates down to 15 mV of signal input and is internally protected from input overload damage up to 28 volts at pin 1. Resistor R4 and C10 reduce the sensitivity to about 50 mV to minimize false readings. Resistors R6 and R7, and capacitor C14, allow calibration for a full-scale meter reading on the 10-Hz range. The calibrations of the higher ranges are determined by the tolerance of capacitors C6-C9; more about that later.

Two series-connected 9-volt batteries provide power for the circuit, which draws about 12 mA. Integrated circuit U7 (a 78L12, 12-volt, 100-mA voltage regulator) and C13 provide a regulated 12-volt source so that aging batteries will not vary calibration.

Putting It Together. The prototype of the F/C Meter was built on perfboard, with component connections accomplished through point-to-point wiring techniques. Perfboard construction was used because the component layout is not especially critical.

It is recommended that all of the integrated circuits be socketed. Start by installing the IC sockets on the perfboard;



Here is a front view of the inner front-panel layout. Dry-transfer lettering can be used to enhance the project's appearance and make it easier to use.

it's a good idea to mark (U1, U2, etc.) the sockets for the IC's that will occupy them. That helps to cut down on confusion when the components are being interconnected.

Once the sockets are installed, begin assembling the project, making all connections as you go. When assembling the circuit, be sure that the wires that go to the 100-kHz oscillator are kept short; the wiring to U7 pin 2, S1 and S2, and capacitors C5 thru C9 should also be short to minimize distributed capacitance, which can affect the readings of capacitors on the low end of the 100-pF range.

Once the circuit board has been assembled, connect short lengths of insulated hook-up wire to the points in the circuit that go to the off-board components. The author used a silicone sealer to cover exposed wires and leads in and around the fully assembled circuit to prevent accidentally short circuiting the project, or destroying some vital component.

Next choose a suitable enclosure in which to house the circuit board. The author used a plastic enclosure, with an attached cover, that measures about 6½ × 4¾ × 2 inches. The circuit board was mounted to an inner front-panel, which simply snaps securely into position.

Also mounted to the front panel are J1 and J2 (BNC jacks), J3 and J4 (banana jacks), J4 and J5 (two position pushbutton terminals), S1 (2-pole, 5-position switch), S2 (double-pole, double-throw switch), S3 (single-pole, single-throw switch), M1 (0-1 mA meter), and two 9-volt batteries (B1 and B2).

The circuit board is held in place by the mounting hardware that secures J1 and J2 to the front panel. The batteries are secured to the panel on either side of the meter with double-sided tape; the same method might be used to secure battery holders in the same positions to allow easy replacement of the power source.

Checking it Out. Apply power to the circuit and, guided by the schematic diagram, check for 12 volts at the output of the regulator. If an oscilloscope is available, check pin 4 of U1 for a clean squarewave. Use a frequency counter to adjust C1 for an output frequency of exactly 100 kHz at pin 4.

The value of C2 may need to be changed slightly to allow C1 to adjust properly. Check the decade counters (using an oscilloscope) at pin 14 of each stage for a divide-by-10 output. The output at jack J1 should follow the frequencies selected by S1. Now that you have accurate test frequencies available, let's get the frequency-to-voltage converter (U6) going.

Select the 10-Hz/1-pF range and set S2 to the FREQ. position. Jumper a wire from output connector J1 to the switch side of C15. Adjust R6 for a full-scale reading on meter M1. Select the upper ranges. Each upper range should yield a reading within 5% of full-scale. That should be satisfactory calibration for all practical applications.

If you are a purist, R6 can be adjusted slightly lower than full scale, then each range capacitor can be trimmed individually by adding a small-value capacitor in parallel. The 100-kHz/100-pF range is affected by lead dress and layout. Capacitor C5 is about 82 pF; its actual value should be selected for a correct full-scale reading to compensate for distributed capacitance in the wiring. Remove the jumper. Calibration is now complete.

Using the Project. When the CAP. position of S2 is selected and an unknown capacitor is placed in the test jacks, the correct value will be indicated on the meter. There is a slight offset

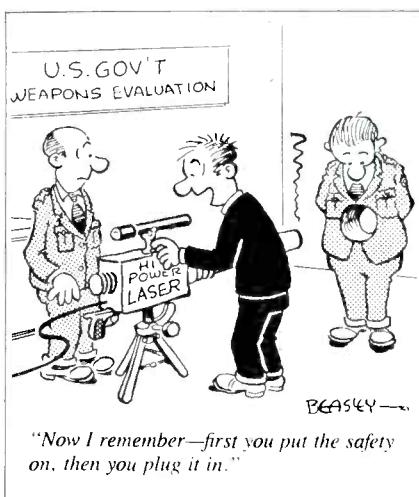
of about 10 pF when using the 100-pF range, due to distributed circuit capacitance. So when using the 100-pF range, just subtract 10 from the reading.

If you are using a DVM to monitor the readings rather than the meter used in the project, replace M1 with a 100-ohm resistor. The value of R9 may be adjusted slightly for best accuracy, with your DVM set to read 1 volt DC.

An optional phototransistor, attached to an appropriate plug to mate with J2, can be added to allow the circuit to be used as a non-contact phototachometer. The probe is assembled on a scrap of double-sided PC board material and housed inside of a discarded felt-tip pen case. A four foot shielded cable is used to couple the signal into the circuit at J2.

Resistor R11 is added to the frequency-input connector J2 for operating bias voltage for the phototransistor. To measure the speed of a rotating object, place the probe where light reaching it will be interrupted by the moving object. The light source must be DC operated or sunlight. AC-operated lights will interfere with the readings. Remember, however, that the readings obtained are in pulses-per-second (Hz); RPM has to be calculated by the user ($\text{RPM} = \text{Hz} \times 60$).

Readings of up to 38,000 pulses per second were obtained with the prototype. When the cap is placed over the probe (blocking light), the phototransistor becomes a high impedance. Placing the probe near a spark-plug wire triggers the F/C meter, allowing you to measure the speed of gasoline engines without any electrical connection. I'm sure you will find many uses for this handy instrument and it will be a welcome addition to your workbench. ■



ACTIVE ANTENNA

(Continued from page 132)

age of surplus inductors (Radio Shack 273-1601) and try several until you find one that works well. Many inductors are color-coded like resistors (they even have the same color-coding scheme), and should be read starting at the top. For example, an inductor marked yellow-purple-brown is 470 μ H and orange-orange-black is 33 μ H. Others are marked with three digits. The third digit tells you how many zeros to put after the first two, so that 471 on an inductor means the inductance is 470 μ H, and an inductor marked 332 would be 3300 μ H.

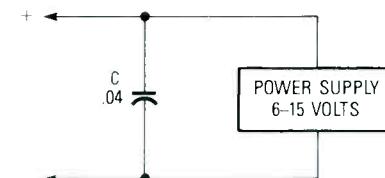


Fig. 2. Power can come from any source of 6 to 15 volts. Bypass the power supply with an 0.04- μ F capacitor to prevent noise pickup from a remote power supply if one is used.



Surplus inductors are often color-coded like resistors, starting at the top. Yellow-purple-brown means 470 μ H.

Construction. I built the amplifier on perfboard and housed the device in a store-bought project box. However, if you want to use the circuit as an AM car-radio antenna booster, build it in a grounded metal case to reduce noise pickup. You can build yours on perfboard also, using point-to-point soldering with Fig. 1 as a guide. If you wire-wrap the project, you may not achieve desirable results because of the high frequencies of the signals involved.

Build the circuit compactly; keep all leads short and keep the antenna and output jack and wires well separated. Connect the output to the receiver with a short piece of 50- or 75-ohm coaxial cable—a long cable will cause signal

PARTS LIST FOR THE SIMPLE ACTIVE ANTENNA

Q1—MPF102 field-effect transistor
R1—1-megohm, $\frac{1}{4}$ -watt resistor
C1, C2—470-pF ceramic-disc capacitor
L1—20- to 470- μ H inductor (see text)
J1—RCA phono jack
S1—Miniature SPST switch
B1—9-volt battery

18-inch collapsible whip (Radio Shack 270-1409 or equivalent) enclosure, battery connector, perfboard materials, hardware, etc.



The active antenna fits neatly into a small plastic case; the whip folds down for storage. Keep wires short and keep the antenna input away from the output jack.

loss. Better yet, use low-capacitance car-radio antenna cable. Don't use unshielded wire.

Troubleshooting. Two problems may arise: If you hear strong squeals and chirps, but few radio stations, the active antenna and the receiver may be oscillating. That happened to me with a 50-year-old Hallicrafters S-38 that has no RF stage. If that happens to you, the cure is to make L1 smaller. If the battery runs down too quickly, replace Q1; the quiescent current of an MPF102 is normally about 5 mA, but it can be as high as 20 mA, which will drain the battery quickly.

You can use an external power supply if you filter it with an 0.04- μ F capacitor placed near Q1 (see Fig. 2). ■

TESLA COIL

(Continued from page 16)

tion. Before mounting T2, make sure that the transformer leads are long enough to connect to the perfboard assembly.

After mounting T2 in the enclosure, mount the perfboard assembly on the enclosure using standoffs, and then complete the wiring between the perfboard assembly and the off-board components. With that done, plug in the line cord and rotate the wiper of R2, making sure that as you do the motor speed increases and decreases. If the circuit does not operate as described, it will be necessary to recheck your work, correct any errors found, and try it again. If everything checks out, the ro-

grounded. You must use a 3-conductor AC power cord that is grounded (earth grounded) in the Tesla Coil itself. **Do not** touch the Tesla Coil while it's in operation. However if you want to show-off your creation, a fluorescent lamp may be placed near L4 to demonstrate the ionizing power of the Tesla Coil.

Only use properly rated components. Do not use an overrated power transformer. A 3-kV transformer with a 2-kV AC capacitor is out of the question. An overrated capacitor (for instance, a 6-kV AC unit) is fine in the circuit. Remember the capacitors are AC rated not DC rated.

The rotary gap will work well with this unit, but it may not work well with a larger unit. A larger unit will require that the rotary gap be redesigned. You must

clip with the power off. Tuning L3 and adjusting the spark gap greatly effects the output of the Tesla Coil. If you place a grounded wire near the output sphere, you should get 3- to 4-inch sparks.

If you are using a rotary gap, make sure that the screws on the rotor and the screws on the stationary post are as close as possible. Remember, the speed of the motor effects the output, so adjust the motor speed with the variable power supply.

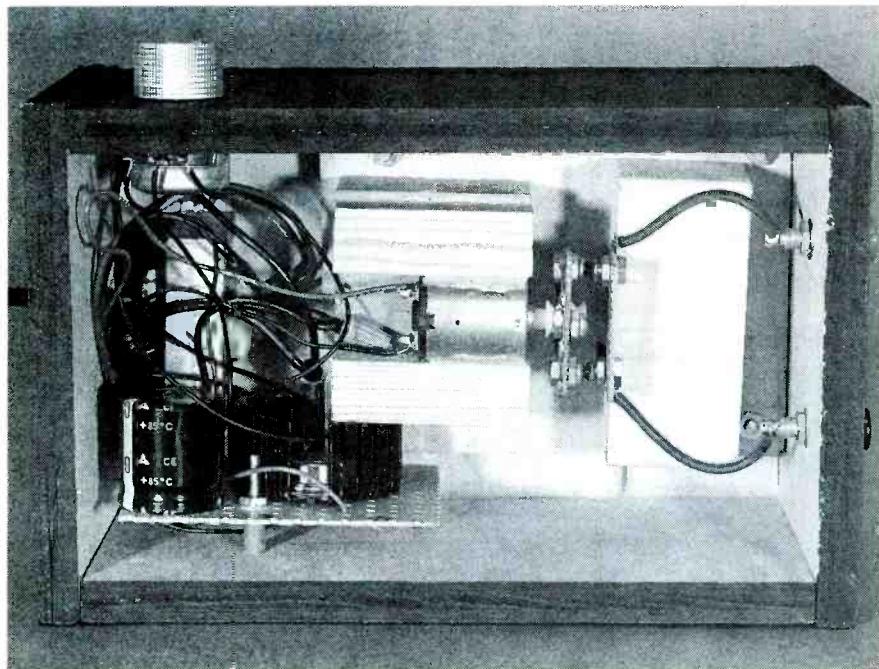
There should be no arcing anywhere. All arcing must be corrected or you'll burn out the turns in the secondary. If L3 is too close to L4, arcing can occur. You may place a 4-inch OD plexiglass tubing over the secondary coil to help prevent arcing between L3 and L4.

Be aware that corona discharge (a bluish-purple ionization, of the air around the Tesla Coil) can cause breakdown along the secondary coil, and loss of power at the output of the sphere. Proper insulation of L4 will limit corona discharge. You may also notice an output at the top of the secondary coil coming out of the sides. That will take away from the output at the sphere, you could place several layers of tape (turn off the power first!) around the upper-portion of L4, until the output from the sides of the Tesla Coil is reduced.

In operation, the Tesla Coil emits ozone gas, which in large quantities can be dangerous. So use the Tesla Coil in a well ventilated room, and do not operate it for periods of more than 3 to 5 minutes at a time.

In addition, the Tesla Coil emits a fair amount of Radio-Frequency Interference (RFI). Coils L1 and L2 help to limit the amount of high-voltage kickback introduced to the AC power line, and help to prevent the high voltage kickback from damaging the power transformer. Even with such precautions, RFI will still be generated at the spark gap and the output of the Tesla Coil. RFI will effect both AM radio and television reception. That's why you should not operate your Tesla Coil for more than a few minutes.

The Tesla Coil is an excellent introduction to high-voltage, high-frequency, and tuned circuits. And after building this one, you may wish to build a larger unit. The author does not recommend building a larger unit until you've learned enough about such circuits, and the safety precautions that must be followed when using them.



Here's an inside view of the rotary spark gap; note the tight spacing between the perfboard rotor and the stationary post. The wires coming from the stationary post are connected to J4 and J5, through which the rotary spark gap is connected to the Tesla Coil circuit.

tary gap is complete.

Caution!!! The most important part of using the Tesla Coil is safety. Never tune (adjust the tap on L3) the Tesla Coil when power is applied to the circuit. Use a phenolic plastic box or a wooden box to house the Tesla Coil and the rotary gap—avoid metal enclosures like the plague. In addition, it is recommended that you use one hand only while working with high voltage, and wear rubber soled shoes to reduce the potential of shock hazard.

The power transformer, capacitor C1, and coils L3 and L4 must be properly

also protect your eyes: Do not stare at the stationary or rotary spark gaps; doing so can cause eye damage.

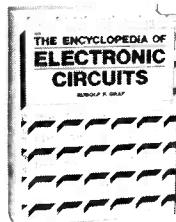
Operating the Tesla Coil. With the unit completely assembled, make sure that all the components are properly installed and oriented. If you are using the stationary gap, start with a gap distance of about a 1/4 inch and tune L3 at any point on the third turn from ground. At that point turn the power on; you should get an output at the sphere. Adjust the spark gap for maximum output.

Tune L3 for maximum output, by changing the position of the alligator

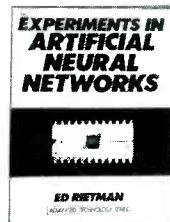
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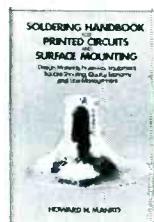
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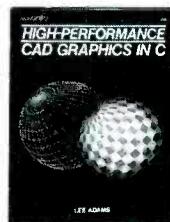
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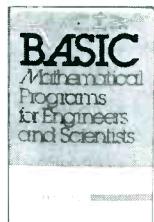
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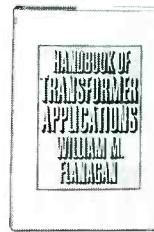


3094 \$42.95

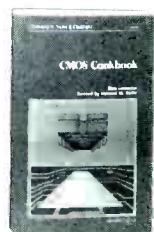
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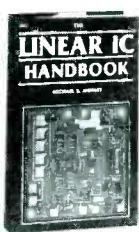
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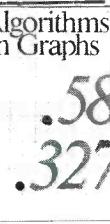
3131 \$24.95



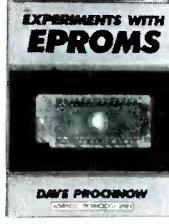
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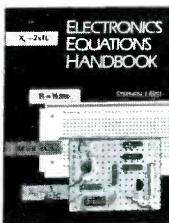
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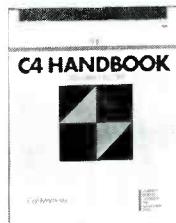
3002 \$49.50



3241 \$24.95



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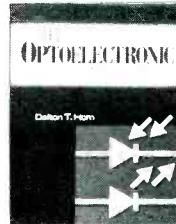
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THE TELE MONITOR

(Continued from page 134)

one listed, check the recorder schematic to ensure that the circuit is properly connected to the recorder.

Next, prepare a cable for connection to the mike jack. Again, you must select a plug that's suitable for mating with the jack of your recorder. The use of shielded audio cable is recommended. Solder the prepared cable to the appropriate circuit-board pads.

Once the board is assembled and the cables connected, clean the flux from the board, especially in the area of the modular connectors. Solder flux, when damp, is conductive and can cause erratic operation. Also check for misoriented or misplaced components, solder bridges, cold solder joints, and all the other construction errors common to hobby electronic projects.

You must also prepare or purchase modular plug-to-plug telephone cable (both ends terminated in modular plugs), which will be used to connect the circuit to the telephone line. Radio Shack sells them in varying lengths, with either coiled and flat cable. If a cable of greater length than is available is needed, it will be necessary to make your own. All of the equipment and material needed to handle that task is available from Radio Shack as well.

Preparing the Enclosure. Prepare the case according to the drawing in Fig. 4. A cutout is required for the modular telephone sockets, SO1 and SO2. Two cutouts can be made (one for

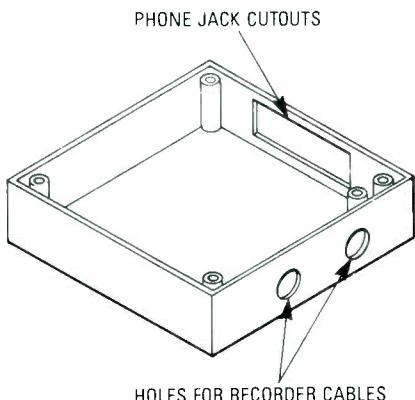
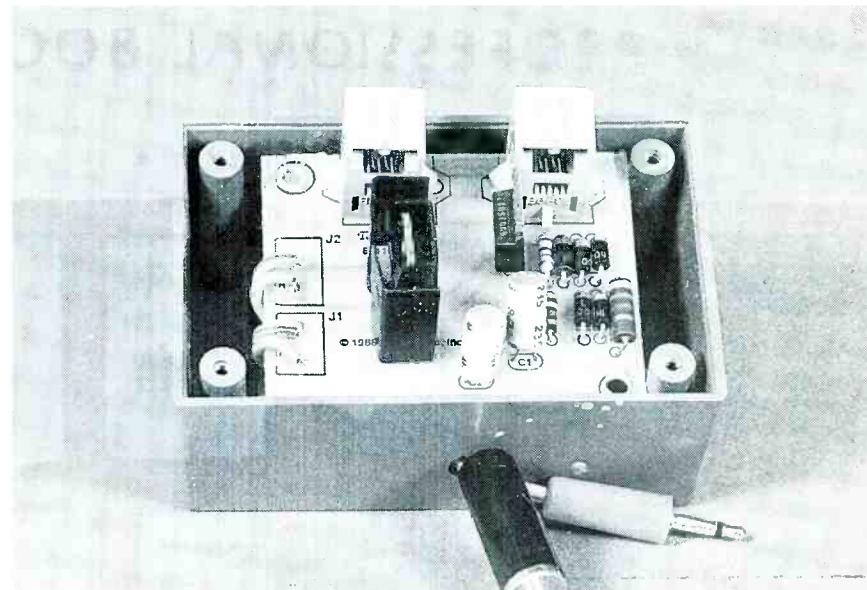


Fig. 4. The enclosure cutouts for the jacks and cables are shown. Note that the enclosure only has two posts for mounting the board. Align the board in the enclosure before cutting to ensure cutting in the correct location.



Here's the finished printed circuit board ready to be mounted in its case. Before mounting, however, it is necessary to drill holes into the side of the case for the cables that connect to the mike and remote jack if the recorder. Don't forget the cutouts to allow access to the modular telephone sockets.

each socket), or a single long one, as shown. A nibbling tool, available at electronic stores, is ideal for performing that task.

Make sure that you check the orientation of the board before making the cutout; the enclosure has only two posts for mounting the board. Position the board, component-side down with the two mounting holes lining up with the mounting posts to determine which part of the enclosure to cut!

Next, drill two holes for the recorder remote and mike cables. A $\frac{3}{8}$ -inch hole for each will be adequate. It is recommended, however, that a $\frac{3}{16}$ -inch hole be drilled and a reamer used to enlarge the hole to the desired size. Plastic is tricky to drill, and some plastics drill easier than others. The plastic used to make the enclosure listed in the Parts List will chip, crack, grab, or self destruct if you use large size bits. Drill speed is also important; generally, the slower the drill speed the better.

Checkout. There are a number of ways to check out the circuit. First, check the orientation of each component against the diagram and check all solder joints.

If you have a power supply capable of providing at least 50-volts DC, you can check the Tele Monitor without connecting it to the telephone line. Attach the power supply leads to the TIP and RING leads of the modular sockets. Connect J2 to the remote jack of the

recorder. Press RECORD and PLAY as you normally would to record. With the 50-volt DC power supply on, the recorder should be "off;" with the supply off, the recorder should be running.

If you don't have access to a 50-volt DC supply, it will be necessary to use the telephone line as your power source. As before, connect the circuit to the recorder. Install one of the modular plug-to-plug cable in one of the Tele Monitor sockets and the other end in the wall. Either connect a phone to the Tele Monitor or use another phone

TELE TRIVIA

The terms "tip" and "ring" originated from the telephone switchboard days when patch cords were used by operators to connect calls. The plug used to patch those calls is familiar to us as the $\frac{1}{4}$ -inch stereo phone plug.

The parts of the plug were (and still are) called tip, ring, and sleeve. Consequently, the circuits and circuit lead names took on the names of their physical representations on the plug, and remain that way today.

on the same line for the following test.

Pick up the telephone. The recorder should start; press "1" on the telephone to eliminate the dial tone, and speak a few words into the mouthpiece in a normal voice and hang up. The recorder should stop once you have hung up. Remove the remote plug from the recorder, rewind the tape, press play and then check the voice quality.

Popular Electronics

Tele Monitor

Fig. 5. This full size nameplate can be cut out and mounted on the front of the enclosure using double sided tape.

Final Assembly. Once the case is prepared and the circuit checked out, route the recorder cables through the proper holes, position the board in the case with the components facing down and the modular sockets lined up with the cutout. Secure with the two screws supplied with the enclosure. Mount the cover using the remaining four screws.

A full size nameplate is shown in Fig. 5. If desired, the nameplate can be cut out and attached to the lid of the enclosure with double sided carpet tape or rubber cement, thus providing a professional appearance.

If everything checks out, you are ready to monitor. Make sure the remote and mike plugs are connected, that the modular jack is connected to the telephone wall jack, press record and play and you are all set. Happy monitoring. ■



"Where did we get this program?"

LIGHTS ON (Continued from page 100)

Once you've obtained the parts outlined in the Parts List, assemble the project using Fig. 3 as a guide. When installing the semiconductors, be sure to observe the proper polarity.

To check the circuit's operation, connect either point "H" or "P" to the positive terminal of a 12-volt DC source and connect "I" to the same terminal. Adjust the volume to suit.

After completion, the board can be mounted in an enclosure or coated with plastic spray and wired directly to the auto's parking-light, headlight, and ignition circuits. If the circuit is mounted in an enclosure, a cutout should be made for the terminal strip,

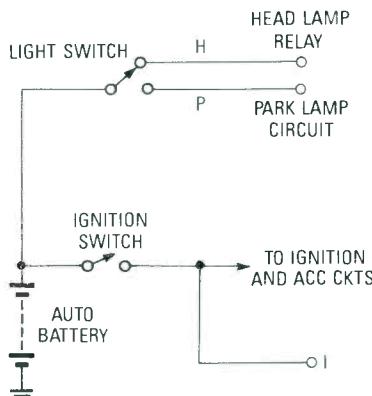


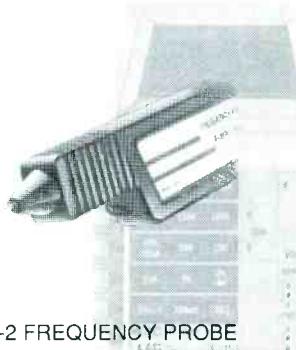
Fig. 4. Before installing the Light Warning System in your auto, first determine whether a Zener diode must be included in the circuit (see text for details).

and a few small holes should be drilled in the bottom to allow sound from the piezo buzzer to escape.

Installation. Refer to Fig. 4 for details on connecting the circuit to your automobile. The pad marked "I" is connected to the vehicle's ignition lead (at some point after the ignition switch). The pad marked "H" connects to the headlight power line, and "P" goes to the parking-light line.

The wires are easily attached without disrupting the vehicle's wiring by using parallel splice connectors (available as Radio Shack part No. 64-3052). Once connected and checked, the unit can be mounted to the fire wall or inside the dash with double-sided tape or velcro strips. To allow the lights to be used with the ignition off without sounding an alarm, a single-pole single-throw (SPST) switch can be connected in series with D3 to defeat the alarm. ■

PROBES MEASURE FREQUENCY



F-2 FREQUENCY PROBE

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CIRCLE 14 ON FREE INFORMATION CARD 143

BLINKING LICENSE-PLATE

(Continued from page 106)

through a flat, 6-conductor, ribbon cable, like that used for the interconnections between computers and their peripherals. However, telephone hook-up wire or any small-gauge wire can be used since the circuit draws very little current.

The author chose ribbon cable because it lays flat and allows the trunk to close without pinching. The color-coded wires help with the final wiring of the cable to the circuit board. The end of the ribbon cable is held securely to the bezel with a liberal amount of silicon compound.

Ribbon cable is available locally through various outlets (such as Radio Shack). The cable, which comes in 25- and 34-conductor configurations, can be split to provide the 6-conductor cable required.

Five of the cable's conductors go to the lamps, which are mounted on the license-plate holder, and the remaining wire connects to the +12-volt source through F1. Each lamp wire connects to one set of lamps. The lamps are not mounted to the license-plate holder in side-by-side pairs, but instead are separated as shown in Fig. 4. The dashed line between lamps indicate pairs, and shows their location on the license-plate holder in relation to one another.

Heavy 18-gauge automotive wire was used in the author's prototype to feed power to the circuit. That type of wire was chosen for the power leads (ground and the fused +V wires) because the author decided to make the connections to the brake-light power leads through small crimp-type "tap-in" connectors, which eliminated the need to actually splice into the brake-light wires. That type of connector is available from Radio Shack (in packages of 10) and other electronic supply stores.

The fused +V lead from the circuit board is connected to the positive brake-light lead inside the trunk through a tap-in connector. Simply position the fused wire from the circuit next to the brake-light wire and squeeze the tap-in connector around both; then fold the hold-down clip of the connector around the tap-in.

Once the tap has been made, use a voltmeter to determine whether +12 volts is being fed to the circuit when the brake pedal is depressed. As for the ground wire, it can be connected to



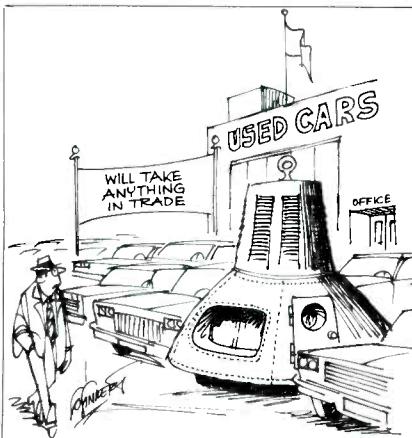
The finished project is shown here. All components, except for the lamps, are housed in a small plastic project box. Heavy, 18-gauge wires connect the circuit to the power source, and flat ribbon cable connects the lamps to the circuit board.

the auto's chassis, or to the black ground lead at the brake light (if there is one) using a second tap-in connector.

Troubleshooting. Once the circuit is under power, the lights on the bezel should start blinking immediately. If they do not, several things should be checked. Of course, a voltmeter must be connected to the power-supply pins of the IC's to verify that they are getting the correct power. For the 4017, pin 16 is +V and pin 8 is ground; for the 555, +V is pin 8 and ground is pin 1.

A logic probe can be placed on pin 3 of the timer to verify that clock pulses are being sent to the 4017. The rate should be fairly fast and the high and low transitions should be clear. If not, either R2 must be adjusted, or the value of R1 (connected to pin 7 of U2) may need to be reduced.

The Blinking License-Plate Holder is a great little project to show off your true genius, since it will be seen by everyone. Both my kids want one for their cars, and I expect orders to be pouring in from the neighbors anytime now. ■



LOGIC PROBE

(Continued from page 118)

the case, carefully folding any loose wires inside as you do so. Check the operation of the probe once more, to be sure all of the connections have survived the installation procedure.

When all has checked out, press the top half of a plastic LED holder in place around each LED to complete your project's construction.

Using the Probe. Here are some tips on using the Experimenter's Logic Probe: The probe can be used in circuits with power supplies of between +5 and +15 volts. To use the probe, connect its power-supply leads to V+ and ground of the circuit you'll be testing. Your first test each time you use the probe should be to verify that the power-supply leads have been hooked up correctly. Do so by touching the probe tip to V+ and ground in your circuit and observing the red and green LED's as you do so.

You can then proceed to monitor the inputs and outputs of digital IC's by touching the probe tip to the points of interest. The red and green LED's will show whether or not you have valid and correct logic levels at inputs and outputs. The pulse indicator will show transitions in logic levels.

The pulse-stretching feature of the Probe's pulse detector allows you to detect pulses that occur too quickly to cause visible indications on the red and green level-detecting LED's. For example, assume that V_{in} is high. A single low-going 1-microsecond pulse at V_{in} is too short to cause a visible flash of the green LED. But the pulse-detector circuit stretches the pulse, causing the yellow LED to flash. The Experimenter's Logic Probe should respond to pulses as short as 0.25 microsecond.

Set the probe to the MEMORY mode when you want to be sure not to miss seeing a transition—you might use it to monitor for noise spikes at an input, for example. Whatever the situation, the next time you need to test the operation of a digital circuit, just reach for your Experimenter's Logic Probe, and you'll be well on your way to quick and accurate diagnosis of your circuit's operation.

You've now completed one half of your digital-electronics troubleshooting toolkit. Turn to page 119 to begin building the second half—the Experimenter's Logic Pulser. ■

FREQUENCY COUNTER

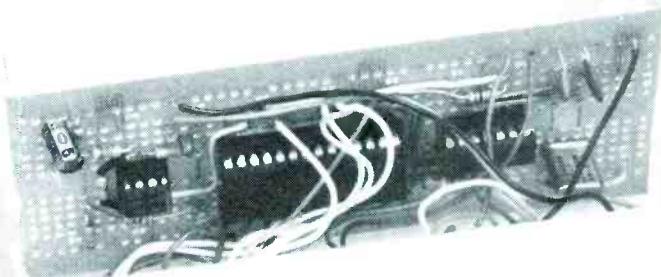
(Continued from page 103)

measured, the initial readout will be the previous frequency that was latched in the counters. Wait for two or more count periods for the circuit to stabilize on the new frequency. Optionally, the RESET switch (S2) may be pressed to reset the display to "00," and then released.

The display is basically jitter free and all digits are significant. If the frequency itself is somewhat unstable, D1 may vary by one or two counts.

Notes. The input signal voltage must not overshoot the +5V to ground limits, and rise and fall times may not exceed 10 nanoseconds. Integrated circuit U3 provides those safeguards, so do not be tempted to apply random signals directly to U1 pin 12. For special circumstances, knowledgeable builders may substitute other signal conditioning circuits for the CA3130, U3. Do not substitute a ICM7207 for the newer ICM7207A used in the circuit, and use only the 5.24288-MHz crystal specified.

You can use the Counter to perform



Assembled on a universal printed-circuit board, the Counter requires several jumper wires to complete the circuit paths.

numerous functions, including: Measure the input and output frequencies of digital devices, measure the speed of motor shafts, precisely adjust the output of signal generators, set audio signals to the exact pitch, determine

the exact values of RC timing components, and measure any frequency between 1 Hz and 10 MHz.

It's a sure bet that once you've used your counter for a while, you won't be able to get along without it. ■

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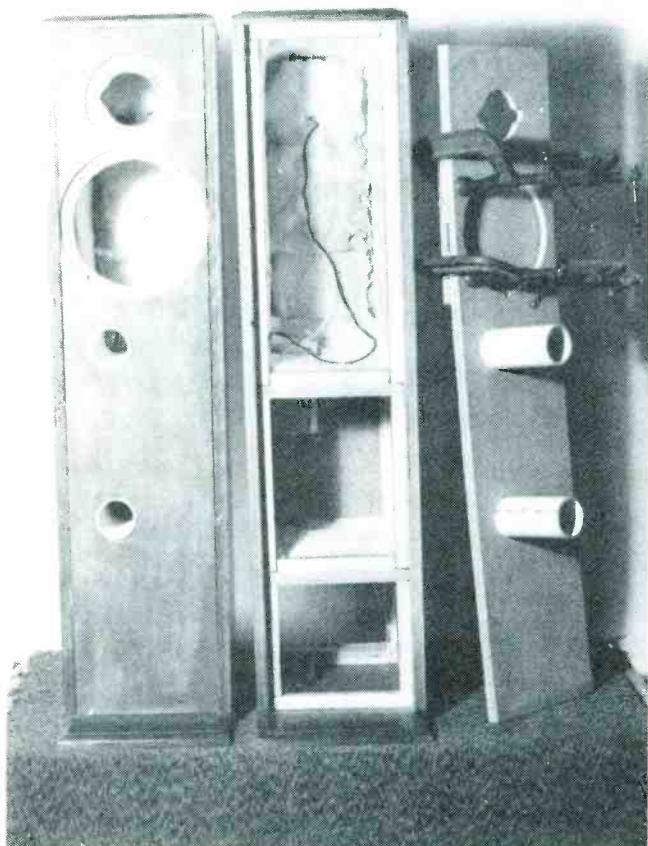


CIRCLE 8 ON FREE INFORMATION CARD

TOWER SPEAKERS

(Continued from page 98)

foam or felt damping material in the recess between the tweeter frame and the 1/4-inch plywood faceplate.



Here are the two enclosures with the speaker board removed from one to show its' internal construction. The board clamped over the woofer hole protects the speaker panel from breaking during work on the enclosures.

Woofer Mounting

If you're unsure of the woofer's polarity, test it by connecting a 1.5-volt battery to the woofer terminals. Mark the terminal connected to the positive pole of the battery if the cone moves outward upon contact. Mark the other terminal if the cone sinks backward into the cabinet. The mark identifies the positive speaker terminal.

At this time it is a good idea to temporarily mount the woofer, using foam weather stripping instead of sealer. Apply the weather stripping around the cut-out, and connect the speaker cable (being mindful of the polarity), but don't solder. Install the woofer by threading the 3/16-inch bolts into the T-nuts you've inserted into the back of the speaker board. The temporary mounting permits you to make further changes in box damping or wiring, if necessary.

Leave the cabinet in the reclining position until the silicone rubber behind the driver has set.

Adjustment

Connect your new speakers to an amplifier or receiver, and test them at low volume. Rotate the L-pad shaft to see that it controls the tweeter output correctly. Then adjust it to the point that makes the sound from the woofer and tweeter blend into one voice.

You should find that your towers perform well with any kind of music. If you want to hear how they reproduce unusual sound effects, try them with the Pink Floyd disc of *Dark Side of the Moon*. Their clarity of sound with that recording is startling at times.

If you hear any coloration, remove the woofer and rearrange the Fibreglas damping material. Or add some loose polyester batting behind the woofer.

When you are satisfied with the sound, remove the woofer and solder the connections to it. Once again lay the entire unit down. Remove the foam weather stripping around the woofer cut-out and apply a ring of silicone rubber sealer. If you don't want to replace the mounting bolts, fill the bolt holes with sealer. Set the woofer down, twist it a bit for better sealing, and leave it until the sealer has set.

Your towers are now ready to play and play. ■



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■ THE THINK TANK originally appeared in Hands-On

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VINTAGE RADIO

(Continued from page 85)

with its 4-wire connection gave way to the 2-wire permanent magnet speaker. It's also important to note that the superheterodyne circuit became dominant as RCA finally began licensing other manufacturers to use it, and the TRF design finally faded slowly into oblivion.

Once the superheterodyne was well-established, the 1930's would see no further basic changes in radio receiver circuits. There were, however, many developments that made radios easier and more pleasurable to use. One of them was the improvement of the tuning dial.

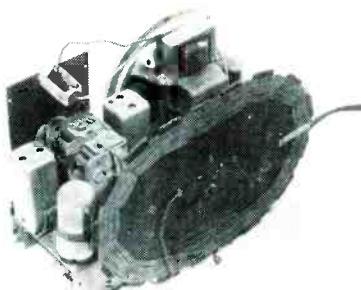
Better Dials and More Bands. The tuning dial entered the 1930's as a small window just big enough to show the frequency being received and a couple of divisions to either side. As the set was tuned, the scale moved by under a fixed indicator line in the window.

By the middle of the decade, that window (usually in the form of a semi-circular arc) was becoming much larger, so more of the scale was visible at once. A little later on, the functions of the scale and pointer became interchanged, with the scale becoming fixed—printed on a large oval, square or circular dial—and the indicator becoming a movable pointer. That meant that the entire tuning scale of the set was visible at once.

Also during the 1930's, radios began to sprout extra bands. Some sets had one labeled "police" beginning just a little higher in frequency than the standard broadcast band. Tuning around that band, patient listeners could eavesdrop on some of the first police car-dispatcher communications.

Still later in the decade, as European countries began to be drawn into the conflict that was to become World War II, there was heightened interest in a higher frequency band sometimes labeled "Shortwave," and sometimes labeled "Foreign Broadcast." There, the international broadcasters could be heard—country after country reporting on world events, each with its own unique point of view.

Multiband sets now had several concentric scales representing the different frequency ranges. It wasn't uncommon for the broadcast scales to have the call letters of major-market



This view of the Emerson's chassis shows the loop antenna, the "GT"-type tubes, and its square-topped IF-transformer cans.

radio stations printed near their operating frequencies. Likewise—on the shortwave scale—the names of different countries would often be shown near frequencies typically used by them. Generic markings (such as "Police," "Aircraft," "Amateur," and "Ships") were also sometimes used.

By the end of the 1930's, many manufacturers had "straightened out" their dial scales, turning them into horizontal lines. Multiband sets had two or more straight lines arranged parallel to each other—each with its appropriate range of markings. The pointers of those easier-to-read *slide rule* dials moved horizontally, of course, instead of describing a circular arc as did the earlier "clock-type" pointers.

Pushbuttons that could be set to select frequently-tuned-in local stations were also common as the decade ended. These supplemented the main tuning dial, but did not replace it. One type was entirely mechanical and worked by physically moving the tuning condenser to the proper position. Another was electronic and worked by switching individual fixed capacitances in and out of the tuning circuit. The craze for pushbuttons affected other controls on the set as well. Some sets bristled with buttons to control station selection, bandswitching, tone, and even the "on-off" function.

Other Developments. No discussion of dials would be complete without mentioning the *tuning eye*. That innovative tuning aid of the mid-1930's was a specialized vacuum tube known as an *electron ray tube*. It was mounted horizontally; you looked into its top end through a circular opening in—or above—the tuning dial. With the set turned on, the end of the tube lit up with a phosphorescent green glow and a pair of shadows became visible on a circular target. The stronger the

station, the closer together the shadows moved—looking vaguely like the closing of the pupil of an eye.

The tuning eye was actually a fringe benefit of the automatic volume-control circuitry that was coming into use during that era. The AVC, as it was called, automatically reduced set sensitivity when strong stations were tuned in—preventing overloading—and increased sensitivity as weak stations were tuned in. The control voltage generated during that AVC action, applied to the grid of the tuning-eye tube, was responsible for the opening and closing effect.

Let's complete our coverage of events during the 1930's and early 1940's with a word or two about the all-important topic of antennas. Throughout the 1920's, an elaborate outside antenna system had generally been required for adequate reception. But because of the superior sensitivity of the early 1930's radios, and the more powerful and more numerous broadcast stations on the air then, a less elaborate antenna would now do the job quite well.



This RCA table model from about 1940 boasted a slide-rule dial and pushbuttons for station selection.

By the late 1930's, there was no need even for that wire. A multiple-turn loop antenna mounted inside the set cabinet pulled in all the local stations with no trouble at all. External antennas were used only for more distant stations or to enhance shortwave reception for the really serious listener.

Wrapping it Up. Those of you who are new collectors should now have a solid orientation to the types of sets that might fall into your hands and the era of radio development to which each of those radios belongs. That information will help you make intelligent acquisitions and give you a knowledge base that you can expand on yourself as you dig deeper into this fascinating hobby. Happy collecting! ■

BUILD THE HOT SOCKET

(Continued from page 128)

to the sides of the enclosure with contact cement. The foil pieces are folded around the bottom edge of the enclosure and extend about $\frac{1}{4}$ inch inward from the outside edge.

Contact is made between the foil and the secondary of the transformer when the printed-circuit board is installed. The aluminum foil at the bottom edge of the enclosure is painted the same color as the enclosure itself to hide the fact that it goes around the bottom and into the enclosure. When completed, the aluminum plates

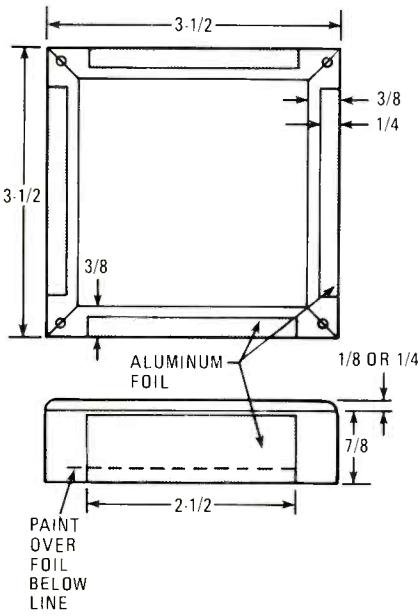


Fig. 5. When making the enclosure for your Hot Socket, start forming a frame (about 3½-inches square, and 7/8-inch high) from a 1/8-inch thick piece of wood. All dimensions here are in inches.

should appear as though they were applied for decoration only.

The AC socket was salvaged from an old 117-volt AC double socket. It was sawed in half to get a single socket and then the top of the socket was cut off with a hack saw. The back surface was sanded down until the face of the plug was about $\frac{3}{16}$ -inch thick. That part must be made thin enough so that it is difficult to pick up the box by the socket. The socket is then fastened to the top of the box with epoxy.

Once the enclosure is completed, the board can be screwed to the bottom of the enclosure with four No. 2 wood screws about $\frac{1}{4}$ -inch long. Pre-drill the pilot holes to keep from splitting the glue joint at the corners of the enclosure. ■

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THE EXTENSION SILENCER

(Continued from page 80)

cause that is all the local Radio Shack had in stock, but anything between 12 and 24 volts would have done just fine. The value specified for R1 (1000-ohms) was chosen to yield 35 mA of Zener current. That amount of Zener current may seem excessive, but keep in mind that it is on for a very short time. Before a call is answered there is no loop current because the phone-hook switch is open, so there is no Zener current.

Construction. There is nothing critical about the construction of the Extension Silencer. In fact the author's prototype of the circuit was assembled on a small section of perfboard—half of Radio Shack's 276-148 snap-apart perfboard—measuring about 1-3/4-inches square. The circuit-board assembly was then housed in a modular quick-connect phone-jack cover.

Before assembling any components on the board, the two sections must be separated and a hole drilled (through the center of the board) for a wood screw. The wood screw will be used for mounting the assembly to the wall. Next, solder the three parts onto the perfboard, interconnecting the components as they are installed.

Cut the black and yellow leads from the modular jack as they will not be used. Solder the red and green leads to the Extension Silencer perfboard since all telephones use the center two conductors of the six position jack. Take another short twisted pair of wires and solder them to the board for the phone line. Observe the proper polarity of those wires because the one that attaches to the red wire of the modular jack must connect to the minus terminal of the phone line.

Installation. Warning: Remember that all equipment installed on the telephone line must meet FCC part 68 requirements. The equipment must be certified by an authorized agent before it is used on the network. (This article is meant to be of instructional value and not as a certification for FCC approval.)

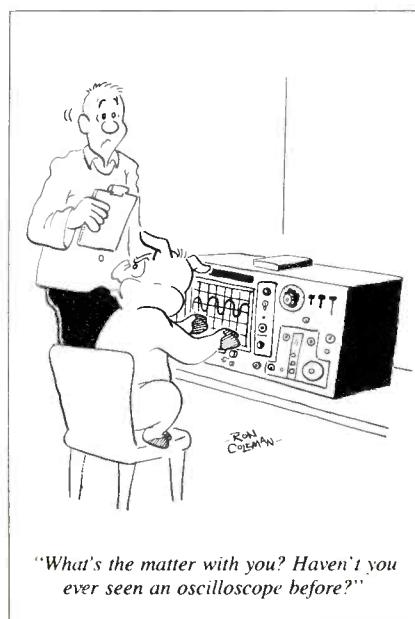
Since my house had phone jacks with screw terminals inside all I had to do was remove the face-plate and measure the voltage across the connection-block terminals. The connection block has four screw terminals

labeled L1-L4. In most cases, the terminals of the connection block are tied to the telephone line via a quad color-coded cable—red, green, yellow, and black. (Older installations use twisted twin lead tied into the telephone line.) Normally, the red and green wires are used as the communications pair, and are connected to the L1 and L2 terminals.

With my VOM, I determined the polarity of the phone line. If the positive lead of the meter is on L1 and the negative lead is on L2 and the meter reads a positive 48-volts DC, then L1 is positive with respect to L2. If it reads negative, then L2 is positive with respect to L1. In my own installation, the minus lead was attached in parallel with the L2 terminal (you may find it to be the L1 terminal) on the phone jack.

The plus terminal was then connected in parallel with the L1 lead. Remove the phone from the normal jack and insert its plug into the Extension Silencer jack, and you are ready to go. Pick up the phone with the silencer and listen for dial tone and hang up. Pick up the extension without the silencer and leave it off hook.

Pick up the phone with the silencer and it should be "dead." Hang up the phone without the silencer and there should be audio from the "dead" phone. You can add as many Extension Silencers as you have phones. For those readers who have a "smart modem," set it to return "no dial tone" if the line is in use. Also set it to keep retrying so that you can capture the line should it ever become free.



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CIRCLE 10 ON FREE INFORMATION CARD

BOOSTER AMP

(Continued from page 75)

booster amplifier should begin to deliver the program material.

It should sound good, without any hum or noise. If not, power down at once and check your connections and external equipment. Look for signs of overheating on the printed-circuit board. If you did the wiring carefully and correctly, the booster amplifier will deliver quality audio on the first try.

Installation. Select a site for the booster amplifier where it won't be banged around and there is sufficient "breathing room" for the circuit. If the circuit is tightly boxed in, there will be little or no air flow and the heat sink may be unable to do its job efficiently. That could prove detrimental to the integrated amplifier chips (U1 and U2).

The ideal space for mounting the booster amplifier is underneath the rear deck next to the rear window in most sedans. The author mounted the booster amplifier on a $\frac{3}{8}$ -inch plywood base which, in turn, was mounted under the rear deck. Connections were made as in the house and the test procedure was the same.

There is usually no hot lead in the trunk area that comes alive with battery voltage when the engine is running or the ignition switch is in the accessory-mode position. You may find a hot lead that connects to the fuel-cutoff system—**don't use it! Make no connection to any circuit that controls or affects the safe operation of the car.**

The best technique is to run a length of automotive wire rated for 10–15 amps under the carpets from the trunk to under the dashboard. Use an old CB antenna or other stiff wire to snake the power wire from front to rear.

Connect the wire through the fuse holder to the hot lead of the radio. That lead comes on whenever the ignition switch is in the accessory or engine position. (There is another hot lead that goes to the radio. It's the lead to the lamp that comes on when the car's running lights are activated. Do not connect to that lead.) Connect the other end of the power lead to the two + terminals on the booster amplifier. See Fig. 4.

The power ground connection poses a problem. With all the non-metallic material used in modern cars, what appears to be a ground connection may, in fact, be isolated from ground. Use

your voltmeter to be certain that the ground terminal you use is what it appears to be.

Leads from the radio to the loudspeakers do not indicate which one is at ground level. That must be determined before connecting the booster amplifier to the radio's leads. Turn the radio off and remove the key from the ignition. Play it safe—check the leads to the loudspeaker for DC voltage. Once assured that no voltage exists, check the leads to determine which one is at ground level using an ohmmeter. Mark the leads to both rear speakers so that you'll never connect them improperly to the booster amplifier.

Final Touches. Have the radio's volume control at its minimum setting and the two potentiometers on the booster amplifier at their mid-positions. Turn on the car's radio and slowly advance the volume control. The rear speakers will come on strong. The ideal setting for the potentiometers on the booster amplifier is when the car's volume control is at its three-quarter position and the speakers are delivering the maximum sound level you want. Adjust potentiometers R21 and R22 to achieve that setup. That's it, your booster amplifier is ready for the road.

A complete kit of parts is available by mail order from the supplier given in the Parts List. You may consider getting additional kits. One can be used to power the front speakers provided they are replaced (most through-the-dash speakers aren't worth boosting). You may want to add speakers in the doors or other sites to replace the front speakers. Whatever you do, keep your eye on the road, drive safely and enjoy the new sound you have installed.

UPGRADING YOUR PC

(Continued from page 125)

with 640K of memory, a 20-megabyte hardcard, and a simple Hercules graphics card may be sufficient for a long time to come. In other cases, a turbo motherboard may be needed. The point is to scale the job to your foreseeable needs. A lot of wasted capability is simply lost money.

Also, when deciding on the refurbishment and updating that needs to be done, try to ascertain whether or not a new machine is what is actually needed. It is possible to change so much that only the cabinet is left from the old machine. In those cases it is probably worthwhile to simply build a new machine (a new cabinet is less than \$50). Besides buying a whole new machine might cost less than buying the parts for one piecemeal.

Nonetheless, just because your IBM or clone PC/XT machine is old and approaching obsolescence does not mean that you have to toss it out. You can easily refurbish or update your old machine. If you do want to build a new machine, however, the parts and assemblies are available and the job can be easily accomplished.



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THE EASY-DIAL R-BOX

(Continued from page 64)

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

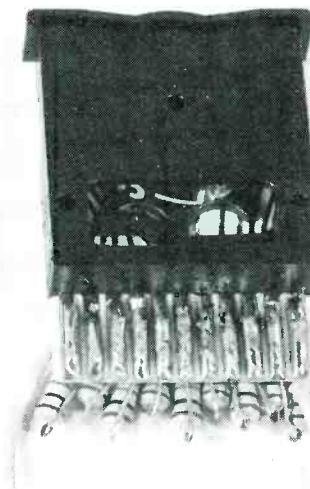
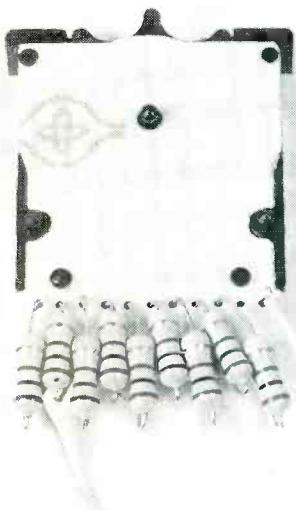
way out the front of the opening, snap on the end plates, and push the set of switches into place. Brackets on the endplates will snap open and hold the switches in place. You might also add a few rubber feet, stacked underneath and on top of the switches, to give additional support.

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.)

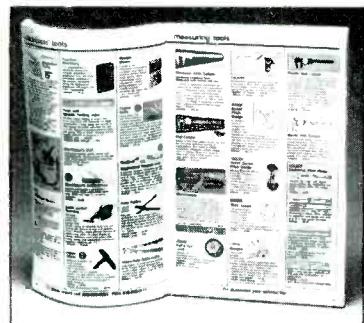
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CIRCLE 12 ON FREE INFORMATION CARD

SUPPLYING THE WORKSHOP *(Continued from page 90)*

stuff, the first prize must certainly go to JerryCo, Inc. The selection of scientific, industrial, and military surplus offered by that company is simply amazing, and the prices are generally quite low. The best way to convey some idea of the JerryCo inventory is to dip into it. One recent catalog features the following: a spark coil, tube tester, laser unit, air compressor, robot motor, magnets, lenses, prisms, fiber optics, project boxes, pharmaceutical bottles, steel balls, carbide drills, heat sinks, quartz tubing, rubber tubing, vinyl tubing, filter paper, and a huge 5-volt, 115-amp transformer.

For those of you interested in expanding the range of your experimental work and construction activities, JerryCo is an excellent place to begin. The catalog, which comes out about six times a year, is \$0.50.

Each year, the U.S. Government discards tons of serviceable but unneeded or unwanted goods. Where does it all wind up? Well, if it is electronics oriented, a good deal of it winds up in the hands of Fair Radio Sales. Their catalog, which is free, is chock full of interesting components, subassemblies, complete units, and wonderful oddities.

The serious amateur scientist will occasionally require materials, like chemicals, available only from a laboratory supply house. This does not necessarily mean buying 5 pounds of something when you only need a few ounces. Chemicals in small quantities, as well as professional laboratory equipment, can be ordered from a couple of excellent companies, one in the Midwest, the other on the west coast. These are: Hagenow Laboratories and Chem-Lab. The Hagenow catalog is \$1.00. Chem-Lab puts out two catalogs, a chemical listing for \$3.00 and an equipment listing for \$4.00 (or both for \$5.00).

Those who enjoy servicing video or audio equipment will want to obtain a catalog from Consolidated Electronics. There you will find such items as video and audio tape head, motors, flyback transformers, speakers, turntable belts, semiconductors, and even vacuum tubes! Their catalog costs \$3.00 and there is a \$10 minimum order.

Antique Parts. Perhaps the most difficult area to discuss is that of antique

parts and materials. Some of those things can be very hard to locate. But even that is not always true. Needs vary enormously and where you happen to live can make a big difference. In certain urban areas, the large number of flea markets and antique stores can make looking for old components a pleasure. In certain newly developed suburban regions, the antique-radio enthusiast may just go hungry.

The most general recommendation I can make is this: Keep your eyes peeled and never overlook anything.

A couple of years ago I spotted a very large old vacuum tube in the window of a resale store near my home in Chicago. So I walked in and asked how much. It was \$3.00. Sold! Then, I looked around. Half the store was covered—and I mean covered—with electronic parts, some of them going back to the 1940's and 1950's. It was really a lot of stuff. I thought of buying it all. I figured it would cost too much money. Oh well.

But lust is lust, and as I headed for the door, I inquired, just for the heck of it: "What do you want for the whole bunch?" I couldn't believe my ears. They wanted \$50.00 for what amounted to ten cardboard cartons and one shabby suitcase full of switches, coils, controls, tubes, knobs, and hardware—just about everything you could imagine.

As I packed my car, I became curious. I wanted to know where it all came from. I was told that it was the entire contents of someone's basement workshop.

"Doesn't the man want it anymore?" I asked.

"Nope."

"How come?"

"He's dead."

Someday, something like that may happen again. But I think I'm in for a long wait. In the meantime, I keep a catalog from Antique Electronic Supply handy. This company stocks a wide variety of pre-transistor components guaranteed to make the antique-radio fan very happy. The selection includes high-voltage capacitors, power transformers, old style binding posts, tubes, tube sockets, speakers, grill cloths, and (believe it or not) cloth covered hook-up wire. The catalog is \$2.00.

Parts for old radios, crystal sets especially, are also available from Yearly Communications. For a free catalog, send them one large SASE.

A Last Resort. When all else fails, or

sometimes when I'm simply too lazy to do the necessary consumer research, I generally turn to Newark Electronics, a very large organization with branch offices all over the country. The Newark inventory is utterly tremendous. Even their catalog, which is nearly 2 inches thick, is tremendous. If you really, really need something (other than antique parts, of course), and if you're on the edge of giving up, look to Newark Electronics. The chances are good that Newark will have what you want, or something close to it.

Several months ago, I needed some large 1.5-volt dry cells. Newark had them. Then I needed a spool of heavy-gauge magnet wire. Newark had it. Then I needed a large, deep, cube-shaped project box. Of course, Newark had that too.

I find it comforting to know that I can get this kind of stuff when I need it. But, Newark is definitely not cheap. And, since the minimum sale is \$25.00, you may be forced to order things that you do not actually require at the moment. The Newark catalog, which also makes a pretty good technical reference manual, is free. Check the phone book for the branch office nearest you.

Everything is Somewhere. I should like to end on an optimistic note. My experience is that no matter how strange, unusual, or downright bizarre your needs become, the thing you want exists somewhere. The companies I've mentioned here are the ones that have come through regularly for me. But they are by no means the only ones that carry items of interest for the electronics enthusiast. Just keep looking, and don't forget the junkbox. ■

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ANTIGRAVITY

(Continued from page 59)

into the hole in the other piece of wood (as shown in Fig. 2). Now using a $\frac{1}{2}$ -inch thick piece of plywood as a base, attach the piece of wood (using screws or glue) containing LED1 to the base and hook up the transmitter circuitry.

Next attach the other piece of wood, containing the solar cell, to the base. Attach a voltmeter to the solar cell, and align the piece of wood containing the solar cell with the one containing LED1, adjusting the two framing pieces until you get the maximum voltage reading—about 0.2 volt. Once properly aligned and focused, apply some wood glue to the bottom side of the wood that has the solar cell, and let it dry without moving the wood.

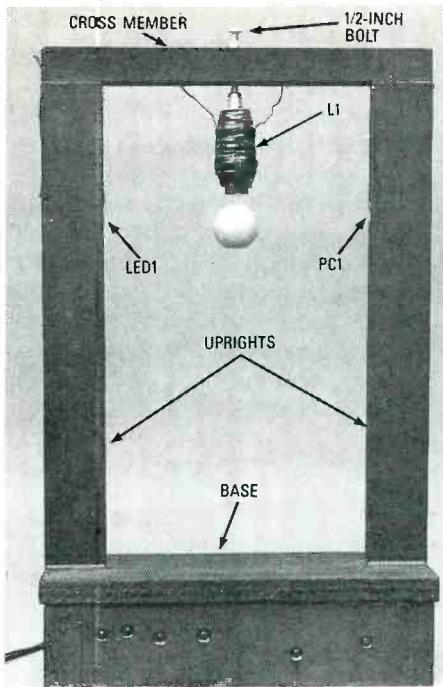
Once the first upright secured in position, place the second upright on the base board, moving it around to find the optimum position. Once the proper position is located, secure the second upright in place with glue or screws.

After securing the two uprights, cut a 1×1 -inch piece of wood (the cross brace) to a length to fit across the top of the two uprights. Drill a $\frac{1}{2}$ -inch hole directly in the center of the cross brace to fit the bolt that serves as the core of the electromagnet. Then attach the cross brace to the top of the uprights with screws or glue.

Thread the bolt through the cross brace, and screw a $\frac{1}{2}$ -inch nut onto the top of the electromagnet's bolt to hold it in place. The cross brace, like the two uprights, has a hole drilled lengthwise through the center to provide a duct for the wires of the electromagnet. You may, if you choose, tape the wire to the outside of the frame.

Now interconnect the three circuit boards, as shown in Fig. 1. Connect PC1, LED1, and L1 to the appropriate points in the circuit and you are nearly done.

The Magnetic Ball. A light, hollow plastic ball is used as the floating sphere in this project. It must be opaque (not able to pass any light) or it will be useless because the proper operation of the circuit depends on the ability of the ball to block IR emis-



When the Anti-Gravity Generator is completed, you can sand and paint or stain the frame to improve its appearance.

sions. The author used a ping-pong ball.

A hole is cut (drilled) in the ball and a permanent magnet is glued inside. The magnet must be fairly strong, yet small in size. A source for such a magnet is given in the Parts List. The prototype of the magnetic ball has two such magnets glued inside. If the electromagnet is at a polarity that opposes the polarity of the magnetic ball, the unit will not work. The ball will tend to roll over and fall. So if that is the case, reverse the wires of the electromagnet to remedy that condition.

Operation. With the unit powered up, the electromagnet should be at full power, with the transmitter and the receiver not blocked. Test the project by placing a small screwdriver or any magnetic material near the electromagnet. The electromagnet should attract it and when the IR receiver is blocked, the screwdriver should fall.

If all is well, position the electromagnet so that it is located just about 1 inch above the transmitter and receiver, and slowly move the ball up toward the electromagnet. There should be a point where the ball will float by itself.

Troubleshooting. If the ball opposes the electromagnet, reverse the wires of

the electromagnet. If the ball is drawn toward the electromagnet too quickly, raise the position of the electromagnet. If the ball shows no response near the transmitter and receiver, lower the electromagnet, until a response occurs.

Room lights may effect the unit. A simple diaphragm could be fabricated from tape and placed so that it shields the edges of the solar cell. That cuts down on the room lights that can hit the solar cell. The wider the receiver and transmitter are apart, the more likely it is that ambient light can effect the unit.

It may take a bit of experimenting with the adjustment of the electromagnet's position and with the aperture of the receiver, using black tape to control the ambient light hitting the solar cell in the receiver unit, in order to get the unit to function properly.

Make sure the infrared transmitter and receiver are in alignment. If you are using lenses, make sure that they are in focus. Focusing the lens helps to keep the beam as thin as possible. The plastic ball must be opaque and as light-weight as possible.

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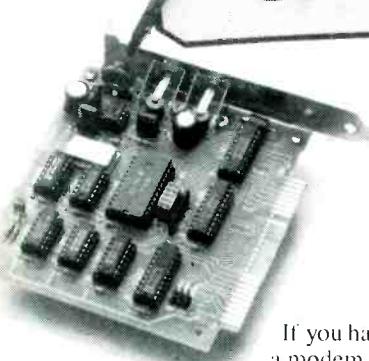
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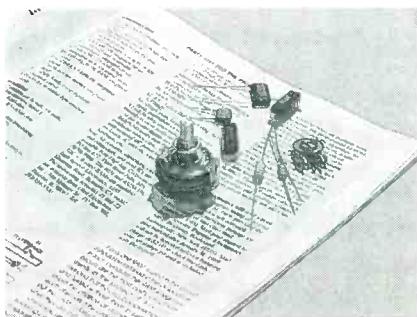
CIRCLE 18 ON FREE INFORMATION CARD

PARTS CONNECTION

(Continued from page 44)

needed minimum.

The method of payment for big distributors is usually another matter to be dealt with. Most require an open account before you can buy from them. With the widespread acceptance of credit cards, that is no longer much of a problem for most. With most cards, if you pay your credit-card bill the same month you receive it, the convenience costs you only the price of the card's yearly fee (if any).



If you have a well stocked shop, you can move from reading any parts list right into project construction hassle free.

A certain number of first-line distributors specialize in only the more popular parts and some imported parts. If you buy parts from such a place, you'll find the prices are a little lower because the companies specialize in the faster moving parts and do not have to tie up their money stocking slower moving items. They also have minimum orders, but the terms tend to be more liberal. The minimum order is a fact of life in this day and age. Credit cards can be used, but most of these distributors will also accept personal checks as payment. Payment policies do vary, so be sure to inquire first before placing an order.

Another source of parts are the surplus-parts distributors. They deal with manufacturers' overruns, excess inventories, buy-outs, used, and some new parts. You can get the best bargains with this group, but the chances of getting something unexpected is also higher. If you understand that when you make your purchase, you usually won't be too disappointed. Over the years I have had some good experiences and some bad ones, but the good far outnumber the bad.

A list of some of the more popular distributors is given elsewhere in this article. No guarantee is offered and I ob-

viously cannot stand behind what they will or will not do, but I have had dealings with most of them and came away satisfied. Contact them for their catalogs and take it from there. The toll free numbers most now provide are a very convenient way to deal quickly with a lot of the distributors listed.

Using a Database Program. The job of keeping all of your parts-supplier information organized is a natural use for a database program. The various database programs available for most types of computers can be setup for that task.

I have been using a database for some time now that has all of the important information on various suppliers in my field of interest. As I get a new catalog its ordering information immediately goes into the database along with a few key words to help me recall the information. The keywords identify special deals on items or good sources of particular items. The keywords are listed on a piece of paper that I can refer to when I start a search. That's the way I do it, but the beauty of most databases is that you can set them up to suit your own particular needs. The point is to avoid the "I know I saw it somewhere, but I don't remember where" syndrome.

For those of you that would like a good place to start and have IBM/MS-DOS computers, a simple shareware database called "3by5" might suit your needs. The program organizes data as you might do manually with 3x5 index cards. It can be downloaded from Gernsback Publication's RE-BBS; board: Tel. 516/293-2283. The file name is 3by5.ARC. The archived file contains a user's manual and several examples. Also included are two files called PARTS.3x5 and PARTS.MAP. They are for use with the database and contain the names and addresses of electronic-parts suppliers that cater to small-quantity buyers.

A disk (5 1/4-inch, of 360k) containing the supplier listings as an ASCII text file along with the listings in the 3by5 file format is also available. Included free on the disk is a copy of the 3by5.ARC file along with a copy PKXARC to unarchive the program. The cost of the disk is \$5 postpaid (OH residents add appropriate sales tax). Send requests to:

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SHORTWAVE CONVERTER

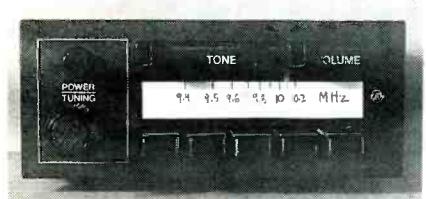
(Continued from page 36)

Adjustment. After assembling the HPS Converter, set it up as diagrammed in Fig. 4, power up the system, turn the gain control to maximum, and tune-in a shortwave station near the middle of the band. Then adjust the tuning slug in T1 for the strongest (loudest) signal. Once adjusted, T1 is broad enough to cover the whole band.

Next, calibrate the dial. There are several ways to do that. I used a calibrated



The HPS Converter is shown here with its cover on. The ON/OFF switch bypasses the converter for normal AM operation of the receiver, and the GAIN knob controls the amount of antenna signal delivered to the converter.



A custom-made dial scale is the finishing touch: manually tune the receiver to pull in signals on the 10-MHz band and mark them off on the scale.

signal generator to make my own dial markings. Alternatively, you can just tune in shortwave stations and wait for them to announce their frequencies. Also, you can tune in AM broadcasters without the converter, then add the crystal frequency to the frequency of the AM station.

Other Considerations. If your radio is digitally tuned, you face a challenge. Digital radios can only tune to multiples of 10 kHz (1000, 1010, 1020, etc.), while many shortwave broadcasters are on multiples of 5 kHz (9.575, 9.915, etc.). Figure 5 shows a possible solution: use two crystals in the converter, 5-kHz apart, and choose between them with an SPST switch (S2). That will allow you to tune in 5-kHz increments. ■

DARKROOM TIMER

U1. Then install the resistors and capacitors, followed by the transistors. Take a moment at this point to check the orientation of the capacitors; they are all polarized, and installing them incorrectly will destroy them if reverse voltage is applied.

Once the printed-circuit-mounted components have all been installed, put the circuit board to the side for a while, and prepare the enclosure for the project. The author's prototype was housed in a metal enclosure measuring about $2\frac{3}{4} \times 2\frac{1}{4} \times 1\frac{3}{4}$ inches, but any suitable enclosure can be used. Drill holes in the enclosure for LED1 and switches S1 and S2. Note: The buzzer (BZ1) requires no hole for mounting other than a pair of small holes for its mounting hardware; however, it will be necessary to drill a small hole near the place where BZ1 will be mounted in order to pass its connecting leads through the case to the circuit board.

If your circuit is to be powered from a 9-volt wall adapter (as in the author's prototype), it will be necessary to drill a hole at some convenient location for the adapter's line cord. It's also a good idea to used a strain relief in the line-cord hole, to prevent the line cord from being accidentally pulled away from the board. The strain relief also prevents the cord insulation from being stripped

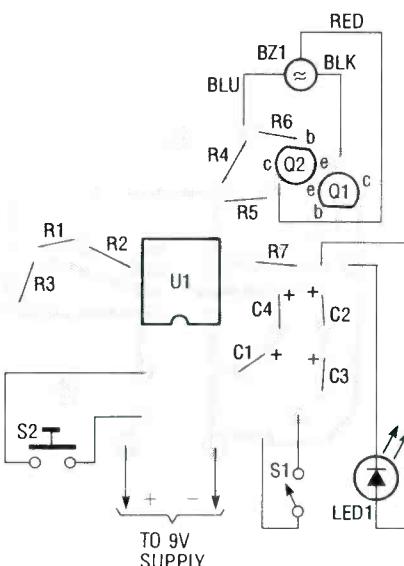


Fig. 4. Follow this parts-placement diagram when installing the components on the board. The four components that are not installed on the board are connected to the circuit board through short lengths of hook-up wire.

away by sharp or jagged edges.

Once the off-board components have been mounted in place and connected to the circuit board, power up the circuit for a test run: LED1 should immediately come on, and after an interval of 15 to 30 seconds (depending upon the position of S1), the circuit should give out a short beep. If after, say, 35 seconds the buzzer does not sound, go back and check your work for errors. For instance, are Q1 and Q2 in the proper place, are the capacitors and/or the 555 correctly oriented, are there solder bridges, and so on.

If the circuit operates as described earlier, close up the project enclosure; your Electronic Darkroom Timer is ready for use.

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RADIO COLLECTIBLES

(Continued from page 33)

Though they all worked the same way, the physical appearances of horns varied quite a bit. Some were made of wood; some of metal; some of what appears to be a paper-based composition material. The neck of the horn might be straight, curved, or of the familiar goose-neck shape that has become the *cliche* of what an antique radio horn should look like.

By the mid 1920's, a more sophisticated form of radio speaker had begun to appear. In that type, the electromagnets acted not on a diaphragm, but on a rod-like metal armature. The rod was attached to the apex of a paper cone much like that of the cone speakers with which we are familiar today. Because of the direct transfer of sound vibrations to the cone, the new speakers had improved fidelity and power.

With some speakers of that type, such as the Crosley Musicone, the paper cone (mounted within a protective frame) was exposed, decorated, and intended to be looked at. With others (the RCA Models 100 and 103 are good examples), the cone was concealed within a decorative enclosure.

I also once owned a 1920's-era speaker (made by Sonora) mounted within a box containing a wooden horn-like structure. Unfortunately, though, I never looked inside—so I can't make a definite statement about what the sound-producing unit was like. But I strongly suspect that it was "earphone style."

You're obviously going to need a few of those speakers if you intend to play the larger battery sets in your collection. But you'll also find that a display featuring horn and cone speakers will be a sure-fire attention-getter. The different sizes, shapes and styles lend themselves to interesting and attractive groupings.

No discussion of early reproducing equipment would be complete without touching on the subject of headsets (otherwise known as earphones). The collector who gets involved with the said items can certainly have lots of fun acquiring examples produced by famous manufacturers such as Baldwin, Brandes, Murdock, Western Electric, and Dictaphone. Headsets are still fairly easy to find at radio swap meets and, as antique equipment goes, tend to be reasonably priced.

I've found that headsets without a head inside are really difficult to display (my best success so far has been to suspend them by cup hooks from the bottoms of shelves). And, since the differences from model to model are fairly subtle to the non-initiated, collections of those units almost always seem to have a "ho-hum" appearance. If you like headsets, though, don't let me discourage you!

Though they don't turn up very often, phonograph-conversion units should also be mentioned. Those devices are similar to the earphone-type devices that drive horn speakers. However, they're made to fit on the arm of an acoustical phonograph in place of the normal needle unit, making it possible to use the "acoustical labyrinth"

within the phonograph cabinet as a kind of a radio horn gone to heaven.

Vintage Test Equipment. As you've seen, many of the pieces we've discussed so far have an obvious dual purpose. They're useful for repairing and operating vintage radios, and they're also valuable collectibles in themselves. But, odd as it may seem, I don't consider most antique test equipment to be in that category.

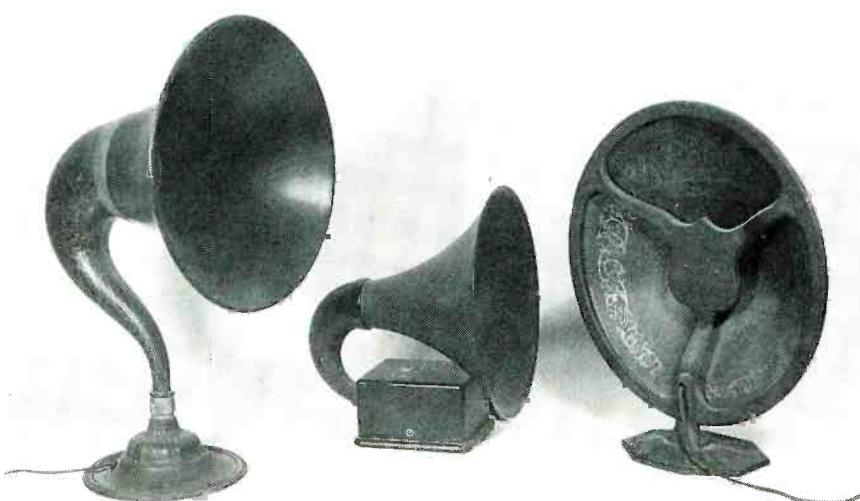
Such apparatus can really be wonderful to look at with its Bakelite panels, hardwood cases, engraved dials, and quaint meter styles. However, by today's standards, much of it isn't worth a darn as test equipment. First of all, design concepts have improved by quantum leaps since the vintage equipment was made. Secondly, test equipment that has been used and stored (under unknown conditions) for over half a century isn't exactly equipment you'd want to rely on. Component values may well have changed and user abuse taken its toll.

Diehard radio buffs who feel that old radios should be fixed with old equipment have a legitimate position, and I can see how they might derive quite a bit of enjoyment from the practice. In fact, I can think of a couple of situations (to be discussed) where the old equipment might be quite valuable. But I'd strongly suggest checking calibration and accuracy against reliable modern equipment (borrowing it, if necessary) before relying on the relic instruments.

Most types of antique test equipment that you're apt to find have counterparts familiar to any electronic experimenter of today. Electronic technicians of the 1920's, 1930's, and 1940's used multimeters, tube testers, and RF and audio oscillators similar in function, if not in design, to the ones used now. You'll even come across vintage oscilloscopes, although the units will not generally predate the late 1930's.

One type of commonly seen vintage test equipment, the set tester, really has no modern equivalent. It was used to expedite the diagnostic process back in the days when radio chassis could be large and heavy monsters indeed. The set tester made it possible to measure voltages and currents at the tube socket connections—while the set was running and without removing it from the cabinet.

To use the tester, the tube in question



Horn-type speakers of the 1920's took many shapes and forms; two typical horn speakers are the ones made by Music Master (left) and Dictaphone (center). Cone-type speakers, like the Crosley unit (right), began to appear by the middle 1920's.



Early multimeters are visually interesting, and also useful when checking set voltages against manufacturers original specs (see text).

was removed from the set, a special adapter (having a cable running to the tester) was plugged into the tube socket, and the tube was plugged into a socket on the adapter. Now, at the touch of a lever or button, measurements could be made on any desired tube pin using the meters built into the tester.

Most such testers were also set up to be used as normal multimeters, receiving input from standard test probes instead of the special adapters. The set tester often made it possible for a serviceman to arrive at an accurate diagnosis, and sometimes even effect a repair, without removing the radio from the customer's home.

Equipment You Can Use. Which kinds of early test equipment do I feel could be useful for repairing antique radios today? I'd recommend a late 1930's or early 1940's multimeter having 1000-ohm-per-volt sensitivity for DC measurements and an RF oscillator that will hit frequencies as low as 100 kHz or so.

The multimeter will hardly take the place of your modern one, but it will come in handy when you're checking voltage readings in a set against values published in a manufacturer's chart. The reason: all voltmeters load down the circuits they are measuring, making the measured voltage lower than the voltage present without the tester in the circuit. Less sensitive meters (having a lower ohms-per-volt figure)

load down the circuit more, and reduce the voltage more than do meters of greater sensitivity.

That's why the ohms-per-volt rating of the meter used to do the original testing is generally specified on the "normal" voltage charts. Use a meter of the same sensitivity specified by the manufacturer and you'll have a better chance of matching his readings. Since many of the early charts specified a 1000 ohms-per-volt meter, it's a nice idea to have one on hand.

The least expensive pocket multimeter in the Radio Shack catalogue today has a 2000 ohms-per-volt rating, and more serious multimeters of even average quality are rated at least 20,000 ohms-per volt. So the best way to get a 1000 ohms-per-volt unit would be to look for a vintage model.

The RF oscillator with the low-frequency range will be helpful in aligning IF transformers of early superheterodyne receivers. They were often tuned to much lower frequencies than the modern "standard" of 455 kHz. That's why modern units often don't go low enough!

In Conclusion. I'd like to stress one more time that a relatively short article such as this one can't even begin to cover all possible radio-related collectibles. What I've tried to do is orient those who might be new to the field by touching most of the important bases. To find out more, my advice is get involved and start collecting! ■

ULTRASONIC RECEIVER (Continued from page 62)

what Fido has been hearing. About any short length of small metal tubing can be turned into an ultrasonic generator simply by blowing across the open end. Other areas in which the Ultrasonic Receiver can be useful is in locating high-pressure air or gas leaks in tanks or supply lines.

The Ultrasonic Receiver can also be used to test for leakage in high-voltage cables, like those used to deliver AC power to homes and industry. A good example of the leakage problem (although it won't generate ultrasonic sound), can be demonstrated by a rather common household occurrence. We have all of us, at one time or another, grabbed hold of a line cord and received a shock from what had appeared to be well insulated conductor.

Although the insulation is intact, current can seep through. Leakage in power line insulation generates high-frequency sound. That sound can be detected by the Ultrasonic Receiver, and thereby help to avert a potentially dangerous situation. Ultra-high power lines (those carrying power above the normal household power range) put out an abundance of ultrasonic sound.

A number of experiments can be performed if a tunable audio generator is available. If so, connect a similar piezo tweeter to the output of the audio generator and set the frequency anywhere between 15 and 25 kHz and set the output level to maximum. Face both the receiver and the generator's speaker in the same direction spaced about one foot apart.

Tune the receiver to the frequency of the generator. As the receiver approaches the frequency of the generator, a beat tone will be heard that will go from a high-frequency tone down to a zero beat, where little or no sound will be heard. Wave a book up and down over the two speakers and you will hear sounds similar to the ones that normally come from a science-fiction movie sound track.

The audio generator can be used as a remote transmitter, which can be detected by the receiver at distances of several hundred feet. Since the receiver operates with a broadband front-end, loud noises close to the pickup can cut through, causing a distorted sound, but under normal use that should not be a problem. ■

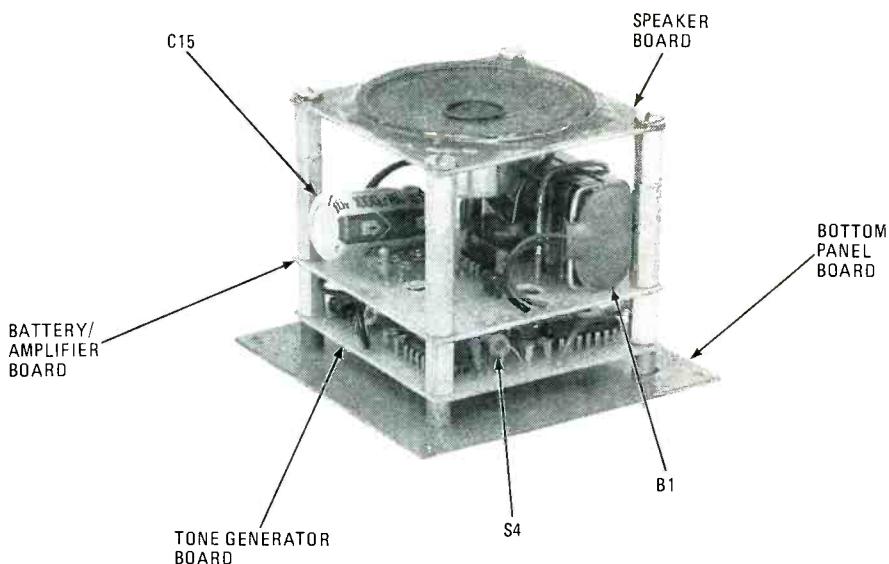
EXECUTIVE DING-A-LING

(Continued from page 137)

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 $\frac{3}{4}$ -inch or longer. Afterward, temporarily put the battery/amplifier board aside. Solder two leads to S5 (located on the bottom-panel board).

Install $1\frac{1}{2}$ -inch screw-on spacers to the speaker board, using $1\frac{3}{4}$ - to 2-inch screws. That should leave about $\frac{1}{4}$ to $\frac{1}{2}$ -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 $1\frac{1}{2}$ -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 corre-



This is what the completed assembly should look like once the boards are stacked.

sponding pads on the tone-generator board, and solder in place.

Finally, mount the bottom-panel board, separated by $\frac{1}{4}$ -inch spacers, to the tone-generator board, using $\frac{1}{2}$ -inch screws. Those screws should be long enough to go through the $\frac{1}{4}$ -inch spacers, both boards, and into the $\frac{1}{2}$ -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 $\frac{1}{4}$ -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 $1\frac{1}{2}$ -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. ■

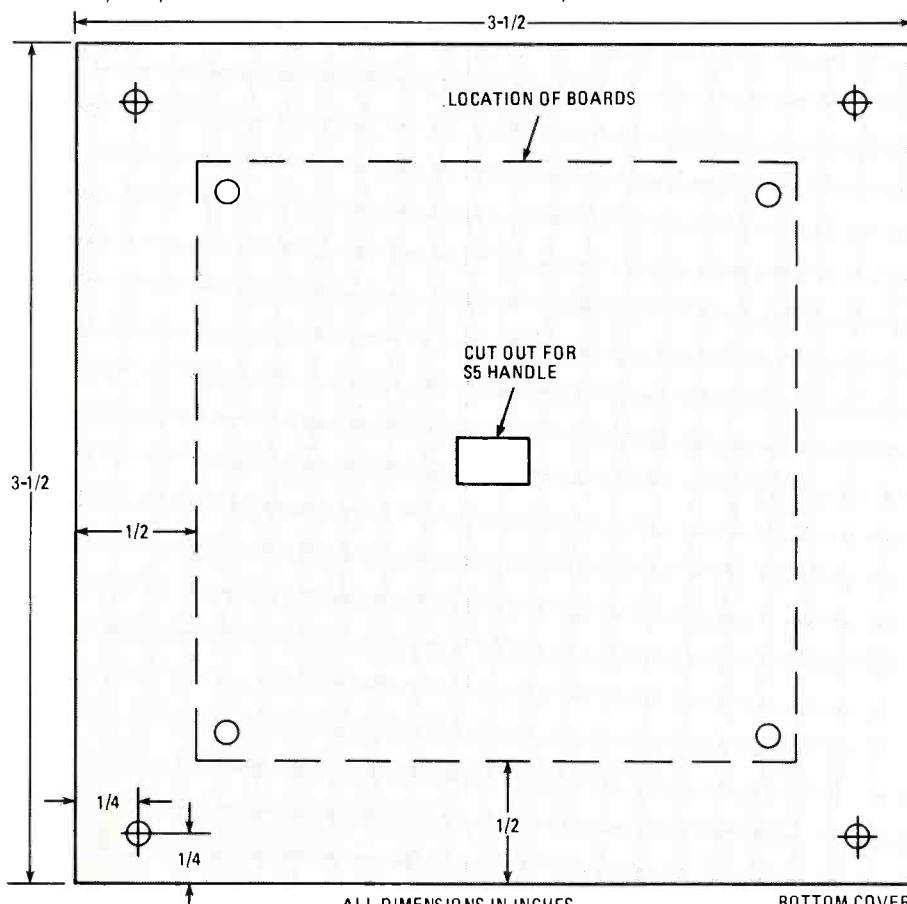


Fig. 7. A piece of printed-circuit material is cut to the dimensions shown, and serves as the bottom panel of the enclosure. Note the square hole cut in the center of the board. That hole allows the control lever of S5 to be accessed when the project is completed.

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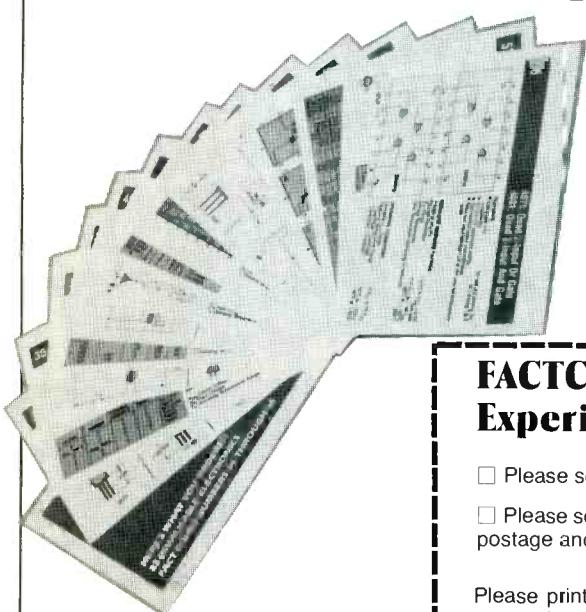
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CD HEADPHONE (Continued from page 114)

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 $\frac{1}{8}$ -inch plugs, you may be tempted to use a $\frac{1}{4}$ -inch stereo jack. But be warned, however, that most $\frac{1}{8}$ -inch jacks do not stand up well to prolonged use and are difficult to solder. It is suggested that you install a $\frac{1}{4}$ -inch jack and then use a $\frac{1}{8}$ -inch to $\frac{1}{4}$ -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 through the hole provided, one

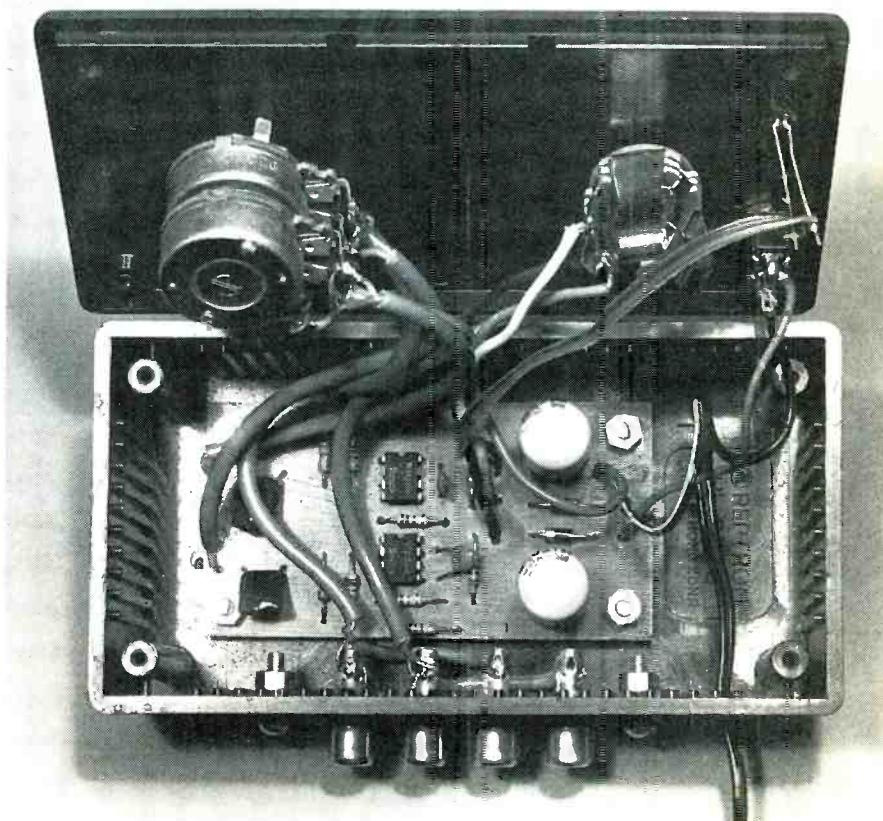


The finished project may be compact, but it can drive most stereo headphones to ear-splitting volume.

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.

The Electronic Industries Association/Consumer Electronics Group has recently completed the first in a series of videocassette training tapes.

EIA/CEG ANNOUNCES COMPLETION OF NEW "BASIC CAR AUDIO INSTALLATION" VIDEO TAPE

If you are thinking of "cashing in" on the profits in the ever growing car audio service business, the troubleshooting—service—installation—and removal of car audio products is a large, non-competitive profit center for your service facility. This thirty minute video introduces you to the ever increasing complex world of car stereo installation. It guides the new installer or owner in the correct layout and design of a car stereo installa-

tion facility, covering basic as well as specialized tools needed for the installation business.

This informative videotape is also an excellent aid to the electronics technician in that it gives the correct procedure for removing and replacing "any" car radio from the dashboard of any car and shows the installer's, salesperson's and customer's role in the installation and sale of car audio products.

KEY TOPICS COVERED IN THIS VIDEO

- The design and layout of a car stereo installation center.
- Basic and specialized tools needed for car audio installation work.
- Safety in the shop.
- How to treat the customer's car, from pre-installation checkout to demonstrating to the customer the completed job.
- The proper procedure



for installing car audio equipment.

- The technical resources available for information about specific types of vehicles, dashboard dismantling, speaker sizes and antenna locations.
- Speaker wiring types found in the automobile. Common and floating ground systems—how to differentiate. Proper wiring procedures used in the car.

The cost of the videocassette is \$30.00. Use the order form below to order yours now!

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