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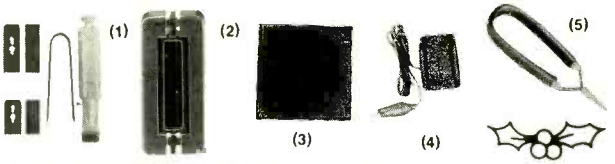

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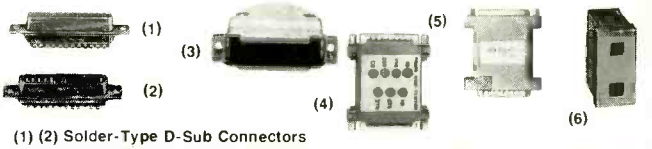

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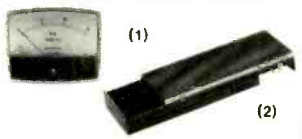

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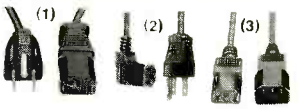

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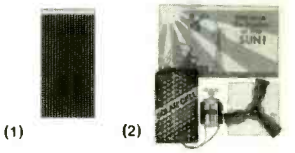

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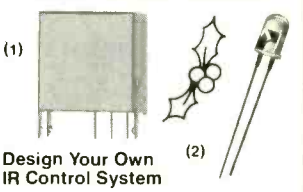

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Editorial

PASS IT ALONG

In an age when the public perceives an erosion in America's "technological superiority," it becomes ever more important to make certain that succeeding generations carry on this country's tradition of invention and ingenuity.

Many corporations are doing their bit to impart the spark of knowledge to young people. Companies like Westinghouse, Mallory (through their Duracell subsidiary), and others sponsor science and design competitions for youngsters. The best entries earn scholarships, recognition, and prestige. But everyone who competes is a winner; their prize is a better understanding of the creative process, and a head start toward their future.

We at **Popular Electronics** are also trying to do our part. Each issue features projects, how-to articles, and much more designed specifically for youngsters and beginning hobbyists. From time-to-time we offer articles that allow you to explore for yourself some of the basic principals of science and electronics. This month for instance, "Electrolysis of Water" (see page 73) allows you to recreate one of science's most famous experiments.

But, parents, we can't do our part if you don't help. When you are done with an issue, pass it along to your youngsters. Point out some of the things that you think might be of interest. Or, better yet, volunteer to help your child build one of our projects or perform one of the experiments. (And kids, if this is your issue, pass it along to your parents; they work hard and deserve some fun, too.)

And speaking of passing things along, you may have noticed a change on our Masthead. Julian Martin has left **Popular Electronics** to accept another assignment within our company. Julian has been with this magazine, and its predecessors (**Special Projects** and **Hands-on Electronics**), since its inception. He has seen it through its tough times and its good times, and has left an indelible mark on everything we do here. Now the job of making this magazine the best it can be for its readers has been passed to me. I have some big shoes to fill, and some high standards to live up to.

Carl Laron
Managing Editor

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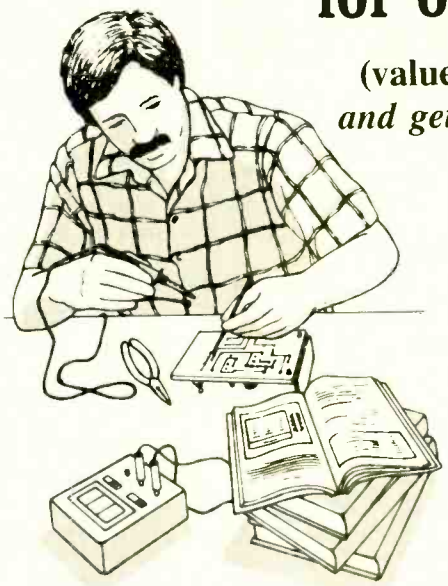

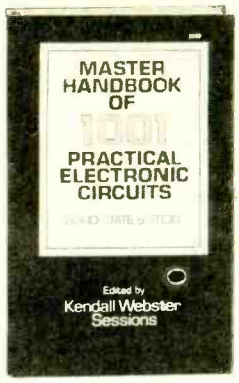

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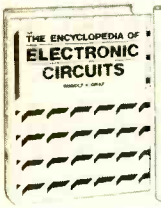

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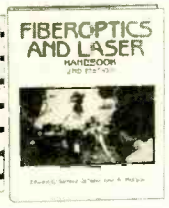

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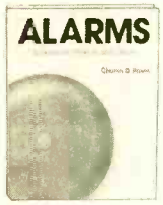

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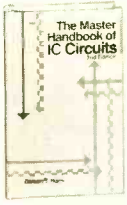

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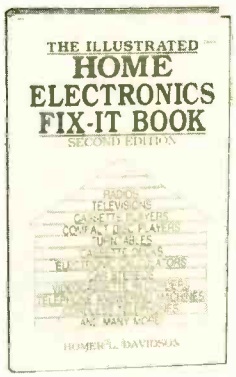

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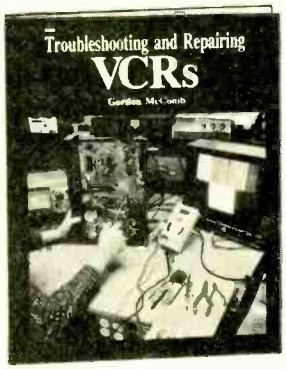

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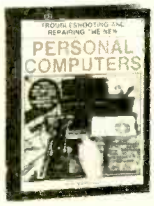

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Letters

PLENTIFUL PARTS

I found your article, "The Parts Connection," (**Popular Electronics**, July 1989) very informative. I would like to add one more name to your list of parts distributors. DC Electronics (P.O. Box 3203, Scottsdale, AZ, 85271-3203; 800-423-0070) carries a large stock of transistors, chips, voltage regulators, etc.—just about anything you'd need to build the projects that appear in **Popular Electronics**. They have a $15.00 minimum, but that is waived if you prepay your order. I have found them to be very helpful and courteous.

L.F.
Corona, NY

I found the article, "The Parts Connection," in the July issue to be an excellent guide to assist someone in understanding the various types of common electronic components. I'm a faculty member in an Electrical Engineering Technology program and I plan to distribute the article to some undergraduate classes (if I receive your permission, of course).

I'd like to point out the error in the power formula on page 59 of the article. Obviously, it should read:

$$\text{Power (in watts)} = V^2/R.$$

W.D.S.
Old Dominion University
Norfolk, VA

ANTI-GRAVITY UPDATE

I have two comments about the "Anti-Gravity Generator" that appeared in the May 1989 issue of **Popular Electronics**. I would suggest adding a reverse-biased diode (1N4001, for example) in parallel with L1, to prevent high (and damaging) voltages from developing across Q1 and Q2 if the current in L1 is abruptly turned off. Also, the inverting and non-inverting inputs of the op amps were incorrectly labeled in the schematic! The 741 pinouts were correct, (which finally tipped me off), but for someone using a dual op amp instead of the two 741's, it would surely cause major confusion.

P.C.
Dartmouth, Nova Scotia
Canada

HIGHER IS BETTER

I would like to call to your attention an error I found in "The Square Tesla Coil," which appeared in the August 1989 issue of **Popular Electronics**. The "Q" of a coil is a rating of its efficiency, and (yes) it is found by dividing the reactance by its internal resistance (the actual resistance of the wire itself): X_L/R.

However, the "Q" is better when it is higher, not lower. The expression X_L/R shows that when the resistance goes up, the efficiency goes down, and as the resistance goes down, the efficiency goes up. The resistance produces heat, which (of course) expends energy; therefore the efficiency drops instead of rising.

I felt that this information would be critical for all your readers who intend to build the fascinating static-field generator.

C.H.A.
Hartland, VT

A CHANGE OF HEART

As an "old-timer" (licensed 22 years), and dedicated CW operator, I have until recently adamantly opposed the "code-free" license. Within the last few years, however, I have come to realize that such a step may be necessary if the hobby is to attract enough new recruits to survive.

However, I think that any code-free license should be predicated on the following:

1) Strict FCC examination supervision. The idea of volunteer examiners invites temptation and abuse.

2) Promotion of code operation and recognition of CW-qualified operators via some sort of "honorary" license grade, certificate-of-merit, etc.

The usual good reasons for maintaining CW as a license requirement are: (1) simple and inexpensive transmitters, (2) narrow bandwidth, (3) very low transmission-error rate, and (4) international recognition.

An additional reason that I have noted is use of this mode by persons who do not have a good command of spoken English, have pronounced accents, have speech impediments, or who are too shy to communicate well verbally. Such individuals can still enjoy and contribute to hamming through the use of code.

Thanks for listening, and keep up the good work.

R.W.
Waukesha, WI

DOESN'T MAKE SENSE

I must respectfully take exception to your editorial in the September 1989 issue of **Popular Electronics**.

Given recent events, one might think that for a couple of hundred years this nation has labored under a gross delusion that the best test of what the public wants is what it is willing to spend its money on. Now comes a competing theory. The new idea is that since somebody would like to make and sell *H*igh *D*efinition *T*elevision (*HDTV*) sets, the government should force the public to pay the start-up cost and should disregard the question of what the buying public would spend for, given a free choice.

For the past couple of years, the American consumer-electronics industry has been saying that HDTV is coming and that HDTV sets could be America's last chance to hold on to its electronics industry. The problem, they say, is that American manufacturers would have to invest a lot of money to get started. My response is, "If you think it's a good bet, invest your own company's money and get ready to reap your reward. But if you're not confident, don't expect me to get too interested."

The electronics industry has not had much success so far in getting the government interested in either expeditiously setting HDTV standards or laying out a direct subsidy for research and development costs. It also apparently was not too skilled at lip reading during the 1988 elections. In May 1989, Jerry Pearlman, Chairman and CEO of Zenith Electronics Corp., a company which is a big would-be player in the HDTV field, suggested that the U.S. should support HDTV R&D by laying a new five-dollar tax on each TV set sold.

I may be looking at too small a slice of the population, but I have to ask: When was the last time someone told you that he was terribly dissatisfied with NTSC color television and just had to have a higher definition picture? An old-fashioned economist might be inclined to suggest that if a whole lot of people were clamoring to buy HDTV sets, there wouldn't be any need to ask the government for a handout to make the things. Does the industry's demand for an HDTV subsidy suggest that, just maybe, there's not much of a market for them?

The history of TV is littered with the carcasses of neat ideas that didn't make it in the market: Stratovision, the CBS color system, Electronic Video Recording, Beta cassettes, Direct Broadcast Satellite, and video disks, for example. While at least one of those enjoyed some success, those neat ideas didn't meet a demand of the market, and therefore failed.

It doesn't take a lot of market research to find telecommunications equipment that people *do* want in mass quantities: fax machines, two-way radios, cellular phones. And how do we know? Every day people reach into their pockets and willingly hand over hard-earned money to buy them. To make those goods and services available, the industry has taken its own risks and losses—and collected its own well-earned rewards.

D.C.B.
Washington, DC

HAVES AND NEEDS

I have a Zenith TV model SE2028W and would like to buy the service manual for it. I have written to two of their addresses and so far have been unsuccessful. I also have a Zenith 1929 radio, model 52, that I've had

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no luck getting information on, despite writing and calling the company. Can you help?

Carl F. McCormick
3151 Grand Lake Drive
Fremont, CA 94555

I own a Grundig model 101U AM/FM receiver and have encountered difficulty locating any service literature. Any information on the unit would be helpful.

Joe LaFrance
60 Sayles St.
Southbridge, MA 01550

My boss recently gave me an Allied AX-190 shortwave receiver. Unfortunately, he had lost the user manual and a check with Radio Shack proved useless. I hope that one of my fellow **Popular Electronics** readers can help me with this problem. I would be willing to pay for copying the manual.

John Daniels
Rt. 1, Box 162A
McDonald, TN 37353

MYSTERY STATION

Congratulations on the reborn **Popular Electronics**! I used to read the old **Popular Electronics** back in the late 1950's and early 1960's, and feel that the new magazine is even better. I especially appreciate your balance of material, which ranges from beginner's projects to the more advanced articles on theory, math, and computer programs for custom-designed projects.

The breadboard "Q-Multiplier" (May 1989) so intrigued me that I ordered the June 1988 issue so that I could build the "Simplest Ham Receiver" and check out how the combination worked. Wonderful! A great bonus was the explanation of how a direct-conversion receiver works—something I was unaware of until now.

The main reason for writing you is that when I use a 3579.545-kHz (color-burst) crystal with the receiver I get a Morse-code practice transmission at 8 PM (PDT) most evenings here in San Francisco from a station identified as W6QIE. I would like more information on who is so kindly providing this service for those of us on the West Coast who cannot receive W1AW's code-practice transmission. Can anyone help me out?

One short note before I end: Radio Shack now carries a 335-pF variable capacitor that could be used in projects requiring the impossible-to-get 365-pF variable. It is rather fragile, and great care is needed when soldering components to it, but it seems to do the job.

Again, thank you for providing a truly wonderful magazine that is a refreshing departure from other periodicals that concentrate on computer-related electronics.

G.R.
San Francisco, CA

If any of our readers know anything about that station, write in and tell us about it; we'll pass the information along. And thanks for the capacitor tip!—Editor ■

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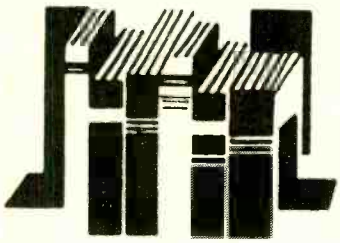

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DIGITAL LOGIC GATES AND FLIP-FLOPS: What They Do and How to Use Them

by Ian R. Sinclair

This book provides hobbyists, students, and technicians with an in-depth look at gates and flip-flops—the building blocks of digital electronics. Only a basic knowledge of electronics is needed for clear understanding of the concepts presented, which represent a firm foundation in digital electronics. Rather than presenting circuits to build, the book presents the knowledge needed to understand important principles and put them to use. By learning how to carry out logic actions with gates and flip-flops, readers also learn the basics of designing and troubleshooting digital circuits.

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Digital Logic Gates and Flip-Flops: What They Do and How To Use Them (Order No. PCP 107) is available for $12.00 (including shipping and handling) from Electronics Technology Today, P.O. Box 240, Massapequa, NY 11762.

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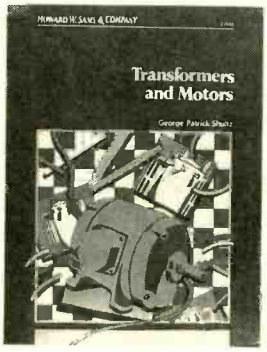
TRANSFORMERS AND MOTORS: A Single-Source Reference for Electricians

by George P. Shultz

Originally written for the National Joint Apprenticeship and Training Committee (*NJATC*) for use in training apprentice and journeymen electricians, this book is available for the first time to the general public. The material, which is written clearly and with a minimum of mathematics, ties electromagnetic theory to practical applications. Every chapter ends with self-test questions, with answers.

The book is divided into separate sections on transformers and motors. Each



section opens with a discussion of fundamental concepts and provides the detailed information needed for installing, maintaining, troubleshooting, repairing, and replacing transformers or motors. The transformer section also covers connections and distribution systems; the motor section also includes chapters on fractional-horsepower and polyphase motors.

Transformers and Motors: A Single-Source Reference for Electricians (No. 22636-7) is available for $24.95 from Howard W. Sams & Company, 4300 West 62nd St., Indianapolis, IN 46268; Tel. 800-428-SAMS.

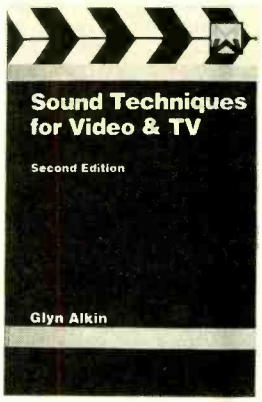
CIRCLE 95 ON FREE INFORMATION CARD

SOUND TECHNIQUES FOR VIDEO & TV Second Edition

by Glyn Alkin

The ever-growing popularity of camcorders has created a whole new group of "movie producers"—many of whom quickly discover that putting sound and pictures together isn't as easy as it looks. Those enthusiastic amateurs will find a wealth of practical information in this second edition of a book used for many years as an instruction manual in sound operations by television stations around the world.

The completely updated book provides detailed descriptions of the techniques used to produce effective sound in association with video. Methods for handling each type of production situation are presented, and the format—with a complete topic on each page—makes the book easy



to use as a quick reference guide. Audio theory is examined in a simple, nonmathematical fashion. The underlying principles of audio/video production are explained throughout the book, and pertinent technical information about basic equipment is included.

Sound Techniques for Video & TV: Second Edition is available for $16.50 from Focal Press, Division of Butterworths, 80 Montvale Avenue, Stoneham, MA 02180.

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INTEGRATED CIRCUIT FABRICATION TECHNOLOGY: Second Edition

by David J. Elliott

Designed to show engineers how to use promising technological innovations to achieve the highest performance standards in each phase of integrated-circuit fabrication, this book explores ways to improve IC process resolution, solve adhesion problems, achieve better images, and speed up production. Each production step is examined both as a separate entity and as it affects the whole process. This

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thoroughly revised and updated text includes discussions of recent developments such as excimer laser lithography, silyation, small-ring x-ray technology, new resist materials, and multilayer processes.

The book follows the fabrication process from crystal growth through the stages of etching, deposition, and doping. The discussions are augmented with technical data and illustrations. A wide variety of considerations are covered, including surface preparation, resist and wafer characterization, photoresist coating, softbake, exposure, postbaking, resist quality control, mask fabrication, and advanced imaging.

Integrated Circuit Fabrication Technology: Second Edition is available in hardcover for $44.95 from McGraw-Hill Book Company, 11 West 19th Street, New York, NY 10011; Tel. 1-800-2-MCGRAW.

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ILLUSTRATED WORDPERFECT 5.0

by Jordan Gold

Combining the features of an alphabetic reference guide with a step-by-step tutorial, this book uses a series of learning "modules" to teach readers the ins and outs of WordPerfect 5.0. The latest version of the popular word-processing software has been changed significantly. It now incorporates such features as integrated text and graphics, styles, automatic reference, document compare, forms selection, leading and kerning, and enhanced font support; and nearly every menu and keystroke has been redesigned and enhanced.

While retaining the powerful features of its predecessor, version 5.0 takes word-processing to the level of desktop-publishing software. With so many changes, users who are switching from previous WordPerfect versions will find this book valuable.

Hands-on exercises demonstrate the new menu structure and mnemonic command selection. The book includes hundreds of examples, practice problems, and training exercises. For those who are starting from scratch, a Recommended Learning Sequence will take them from one module lesson to the next, allowing them build upon previously learned materials to reach the level of expertise they desire. Useful appendices include advice on setting up a printer, troubleshooting tips, how to customize the Speller utility, and listings of codes and commands.

Illustrated WordPerfect 5.0 is available for $19.95 from Wordware Publishing Inc., 1506 Capital Avenue, Plano, TX 75074.

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FIBER OPTIC LAB MANUAL

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Written for experimenters and students building science projects as well as for fiber-optic labs and course studies in colleges and technical schools, this 60-page technical manual is easy to understand. It

(Continued on page 12)

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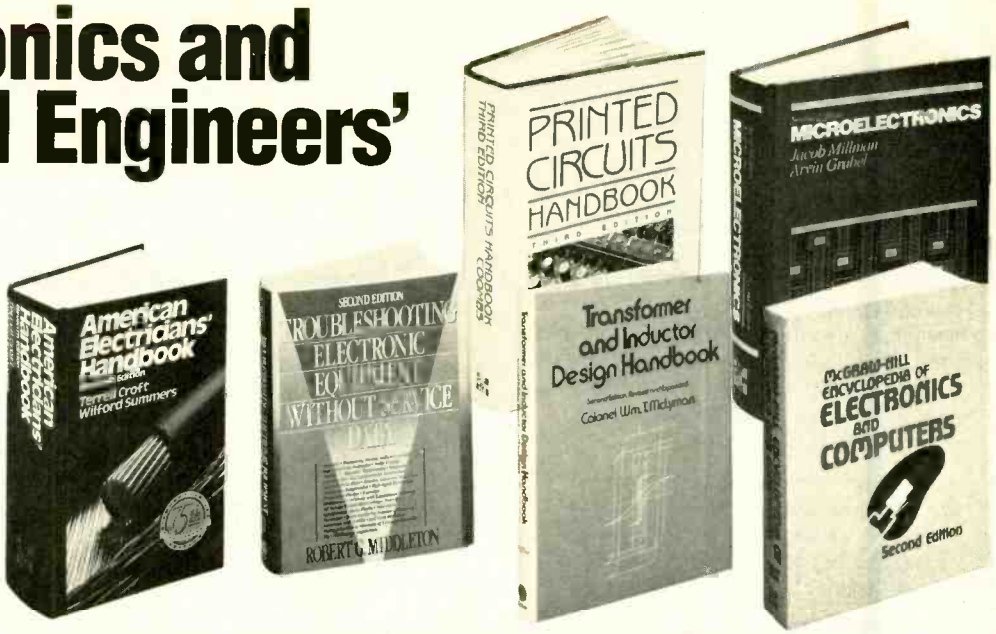

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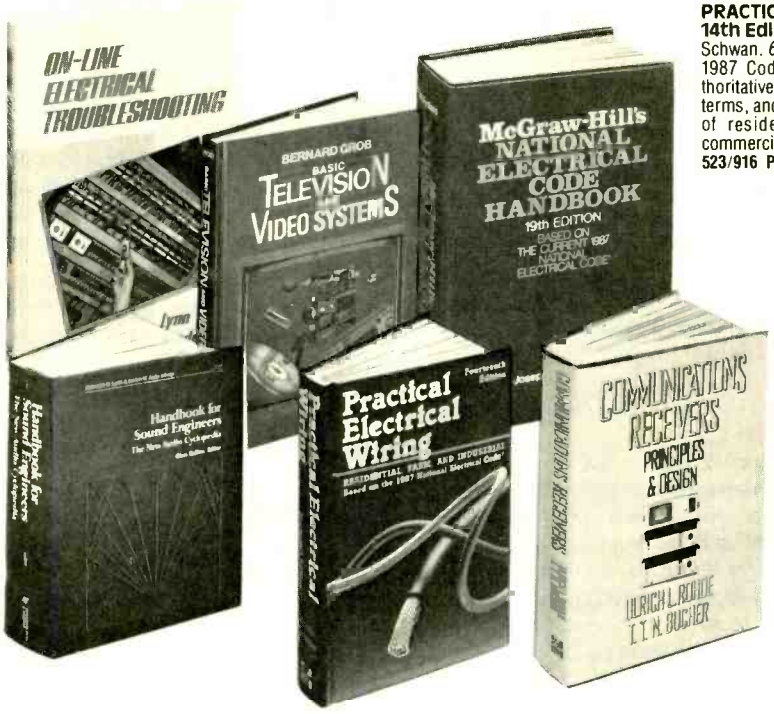

Be sure to consider these important titles as well!

BUCHSBAUM'S COMPLETE HANDBOOK OF PRACTICAL ELECTRONIC REFERENCE DATA, Third Ed. By W.H. Buchsbaum.
583880-X Pub. Pr., $34.95 Club Pr., $26.50

ELECTRONIC TEST EQUIPMENT: Principles and Applications. By T.J. Byers.
095/221 Pub. Pr., $44.95 Club Pr., $29.95

ESSENTIAL CIRCUITS REFERENCE GUIDE. By J. Markus & C. Weston.
404/623 Pub. Pr., $59.50 Club Pr., $47.50

McGRAW-HILL'S NATIONAL ELECTRICAL CODE HANDBOOK, 19th Ed. By J. F. McPartland.
457/077 Pub. Pr., $46.50 Club Pr., $31.95

HANDBOOK OF ELECTRONICS CALCULATIONS FOR ENGINEERS AND TECHNICIANS, Second Ed. Edited by M. Kaufman & A. H. Seidman.
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PROBABILITY, SIGNALS, NOISE. By J. Dupraz.
183/309 Pub. Pr., $49.95 Club Pr., $34.95

CIRCUIT DESIGN FOR ELECTRONIC INSTRUMENTATION: Analog and Digital Devices from Sensor to Display, Second Ed. By D. Wobschall.
712/31X Pub. Pr., $49.50 Club Pr., $36.95

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583865-6 Pub Pr., $29.95 Club Pr., $22.50

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Electronics Library

(Continued from page 7)

covers all the fundamentals of fiber-optic systems, and presents details of seven experiments, which help the reader to get started in working and designing with fiber optics, learn what is commercially available, and understand many of the measurement techniques used in fiber optics. A Lab Kit that contains all the fiber-optic and electronic components needed to complete the seven experiments is available separately. The experiments include a fiber-optic receiver and transmitters, a light pipe, and a star coupler.

A final design project provides a chance for readers to practice system design and to apply the information to a practical problem. The book also includes a glossary of fiber-optic terms and lists of references and periodicals.

Fiber Optic Lab Manual is available for $7.95, and the Lab Kit for $39.95, from Industrial Fiber Optics, P.O. Box 3576, Scottsdale, AZ 85257.

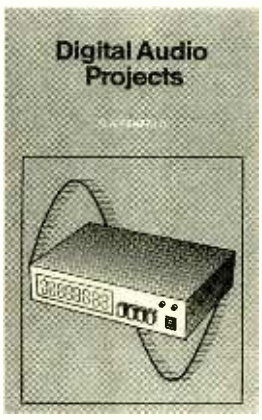
CIRCLE 88 ON FREE INFORMATION CARD

DIGITAL AUDIO PROJECTS

by R.A. Penfold

Digital electronics have been taking over just about every aspect of electronics over the last twenty years. And, although audio electronics remained stubbornly analog-oriented until just recently, digital is beginning to dominate that field too.

This book not only covers the theory of digital audio, but makes the field accessible to hobbyists with a section containing tested circuits for them to build. The first part of the book explores the basic principles involved in converting an audio signal into digital form and then back to an analog signal again. It also covers some practical aspects that must be considered when working with digital-audio projects. The actual projects presented include a "scope store" that allows an ordinary oscilloscope to operate as a storage scope, an A/D converter, a digital delay line, an echo effect, a control circuit, and an input amplifier. Most of the projects are beyond the ability of beginners, but hobbyists with a moderate amount of construction experience should have no trouble with them.



Digital Audio Projects (#BP245) is available for $7.95 (including shipping and handling) from Electronics Technology Today, P.O. Box 240, Massapequa, NY 11762.

CIRCLE 97 ON FREE INFORMATION CARD

SPACE ALMANAC

by Anthony R. Curtis

Coinciding with the renewed enthusiasm in the space program stirred by the passing of the 20th Anniversary of the moon landing, this book is sure to interest a lot of people. Anthony Curtis, the editor of *Space Today* monthly magazine, has gathered hundreds of stories, descriptions, reports, charts, maps, tables, photographs, and diagrams into one truly comprehensive volume.

Designed to provide an easy-to-read, one-stop database, in almost 1000 pages the book covers the history of space exploration right up to the most recent developments, from Earth to the edge of the universe. Topics covered include space stations, shuttles, unmanned satellites, rockets, our Solar System, the Milky Way and neighboring galaxies, quasars, pulsars, black holes, and supernovas. The roles of the U.S., Russia, and other spacefaring countries are examined—Japanese and Chinese launches, Russians living in their third-generation space station, and America's shuttle fleet. Providing more than just a group of facts and figures, the book captures and conveys the excitement of discovery.

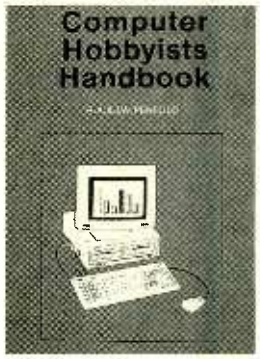
Space Almanac is available for $19.95 from Arcsoft Publishers, P.O. Box 132, Woodsboro, MD 21798.

CIRCLE 89 ON FREE INFORMATION CARD

COMPUTER HOBBYISTS HANDBOOK

by R.A. Penfold

Aiming to provide a useful range of data and general information on a variety of computer topics in one convenient volume, this book makes it easy to find what you need to know when you need to know it. While written specifically for the computer hobbyist, most of the information is presented clearly and explained thoroughly enough to be understood by students and other novices to the world of computing.



The broad range of subjects covered includes popular 8- and 16-bit microprocessors; serial and parallel interfaces for peripherals, games, and MIDI devices; computer languages; operating systems; and graphics. A dictionary of computer terms is provided, and appendices cover such topics as ASCII codes, flowchart symbols, and Epson control codes.

Computer Hobbyists Handbook (Order No. BP251) is available for $10.95 (including shipping and handling) from Electronics Technology Today, P.O. Box 240, Massapequa, NY 11762.

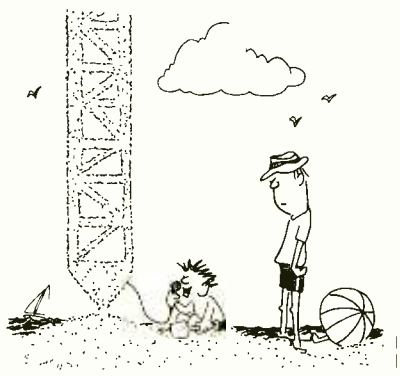
CIRCLE 97 ON FREE INFORMATION CARD

AUDIO ANTHOLOGY: When Audio Was Young, Volume Two

edited by C.G. McProud

This collection of articles that were first published between 1950 and 1952 in *Audio Engineering* magazine, have plenty to offer besides their historical value. They serve both as a reminder of how little some things have changed in 35 years—a landmark article on construction practice is still valid today—and as an illustration of how much our technology has evolved since those post-war days.

The book is divided into four sections. The first part includes nine power amplifiers followed by several articles on power-amp characteristics. Preamps are the sub-



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ject of the second section, which also includes the first article on stereophonic reproduction and how it might be achieved by filtering of the mono signal. The third section focuses on loudspeakers, including resonant enclosures and port sizes, reflexed cabinets, how to deal with resonance peaks, and a survey of horn types, along with how to build several bass-enhancing versions. The last section includes two tape-recording accessories—a portable interview amplifier and a tape playback preamp.

The book's editor, C.G. McProud, helped found the Audio Engineering society. He was editor and publisher of *Audio Engineering* in the pioneering days when many of the projects presented in the magazine weren't yet being produced commercially.

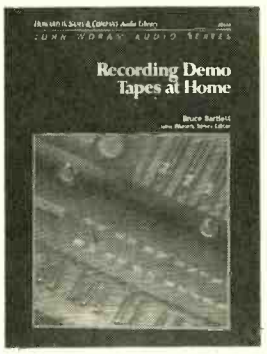
Audio Anthology: When Audio Was Young, Volume Two is available for $16.95 plus $1.75 shipping and handling from Old Colony Sound Lab, P.O. Box 243, Peterborough, NH 03458; Tel. 603-924-6371.

CIRCLE 84 ON FREE INFORMATION CARD

RECORDING DEMO TAPES AT HOME

by Bruce Bartlett

Demo tapes are valuable tools for musicians in many ways. They provide a way to document musical ideas and progress; to audition for potential managers, club owners, and record companies; to enter contests; to send copies to friends and relatives; to train new band members; and to start a professional studio production. With the new generation of small-scale sound equipment that's available today, it's possible to put together professional-



sounding demo tapes in a home "studio"—without spending a fortune.

The equipment might be small, but it's sophisticated, and getting the most out of it requires a thorough understanding of how it works, and of recording production in general. This book shows musicians all they need to know about how to put a home music studio to work, and does so in plain, easy-to-read English. Written by a professional recording engineer, it is full of tips and shortcuts on everything from what kind of equipment to choose to how to package and present demo tapes.

The book covers how to set up a studio for the best sound quality and acoustics, and how to get the best results from miking, recording, and mixing. It includes professional tips for training one's hearing, judging sound quality, and troubleshooting bad sound. Advice is given for on-location recording, and about protecting a musician's rights. The recent technology of digital sampling, sequencing, and MIDI are also discussed.

Recording Demo Tapes at Home is available for $19.95 from Howard W. Sams & Company, 4300 West 62nd St., Indianapolis, IN 46268; Tel. 800-428-SAMS.

CIRCLE 95 ON FREE INFORMATION CARD

GLOSSARY OF MICROCOMPUTER DATA ACQUISITION TERMS

compiled by MetraByte Corp.

Microcomputer data acquisition is used in research & development, industrial/process control, communications, and automatic test and measurements, to name just a few applications. This 23-page booklet is a handy reference source in which almost 300 terms are defined. The definitions encompass data conversion, signal conditioning, and microcomputer systems and software.

Glossary of Microcomputer Data Acquisition terms is available at no charge from MetraByte Corporation, 440 Myles Standish Boulevard, Taunton, MA 02780; Tel. 508-880-3000.

CIRCLE 83 ON FREE INFORMATION CARD

CUSTOMIZE YOUR HOME ENTERTAINMENT SYSTEM: TV AND VCR ENHANCEMENT PROJECTS

by Steve Sokolowski

An unfortunate side-effect of the fast pace of technological developments is that today's cutting-edge video equipment can become next month's "antique"—if not obsolete, then certainly no longer a state-of-the-art item. For those who are reluctant to invest big bucks in the consumer-electronics game of chance, this book provides an alternative in the form of do-it-yourself upgrades for your old (or new) equipment. Twenty-two original projects, each designed to transform TV's and VCR's into more-sophisticated systems, are included. Along with the projects, the book offers a hands-on guide to electronics, with full coverage of the fundamentals ranging from electronic theory and components to

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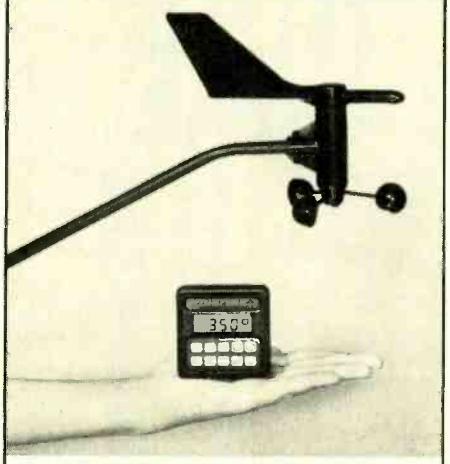

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techniques of project construction such as soldering and making printed-circuit boards.

Some of the projects include a TV-stereo adapter to convert an older TV or VCR to receive stereo broadcasts, and a stereo simulator to convert a mono output to a stereo sound-alike. A rear-speaker ambience amplifier can be used with stereo output to decode and simulate surround

sound, and a graphic equalizer lets the user tune the audio output to his preference. Noise-reduction circuits are also presented.

Customize Your Home Entertainment System: TV and VCR Enhancement Projects is available for $15.95 from TAB Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

CIRCLE 98 ON FREE INFORMATION CARD

USEFUL NETWORK THEOREMS with Applications

by Dr. Harry E. Stockman

The author of this book, a former U.S.A.F. scientist, professor of electrical engineering, and independent researcher has assembled a no-nonsense, direct presentation of common network theorems, as well as several of his own new theorems. While intended for Electrical Engineering students, the book provides a reference source and historical notes that will interest engineers as well.

The book begins with a review of common network theorems—such as the Superposition Theorem, the Reciprocity Theorem, and dependent-source theorems—and proceeds to more specific theorems. The basic Helmholtz' Equivalent Generator Theorem is considered in depth. That and the useful Mayer's Source Transformation Theorem, are explained in detail in many of the worked-out problems that are presented in the book's "Applications" section.

Time-saving techniques are used wherever possible. Many of the problems are applied in the cisoidal state, with complex frequency aiding a quick solution. For instant reference, each solution is indexed with the number of each theorem used. The appendix includes a number of useful techniques, including coverage of matrices, twoports, initial conditions, and similar tabulations.

Useful Network Theorems with Applications is available for $11.25 (including shipping) in the U.S. and Canada from Sercolab Company, Box 767, East Dennis, MA 02641.

CIRCLE 82 ON FREE INFORMATION CARD

RF FILTERS FOR HF, VHF, UHF RADIO & OTHER RF SYSTEMS: 5–1000 MHZ

Microwave Filter Company, Inc.

This catalog describes a variety of filters for aerospace, defense electronics, and VHF/UHF radio. It features medium- and high-power lowpass filters (handling up to 1,400 watts) for suppression of transmitter harmonics. Custom high-power notch filters are also described.

The brochure depicts diplexers for combining two transmitters or receivers to a common antenna, or two antenna ports to a cable for remote transport. Also included are highpass filters for subharmonic suppression or receiver protection, general-purpose high- and low-pass filters that are made to order, and narrowband helical

resonator filters that offer wide choices of center frequencies for RF systems, broadband local area networks, or cable systems. Specifications, frequency curves, dimension drawings, and applications are provided for all units.

RF Filters for HF, VHF, UHF Radio and other RF Systems 5–1000 MHz is free upon request from Microwave Filter Company, Inc., 6743 Kinne Street, East Syracuse, NY 13057; Tel. 1-800-448-1666 (in NY, HI, and AK call 315-437-3953, collect). ■

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CIRCLE 8 ON FREE INFORMATION CARD

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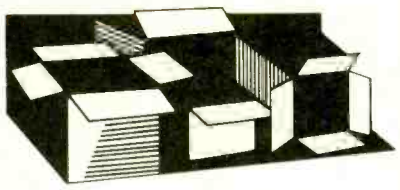

New Products

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AUTO-SOUND SYSTEM

Direct access to any selection on any CD at the touch of a button is the special attraction of *Kenwood's* auto-sound system, which combines the *KRC-878* AM/FM tuner/cassette deck (pictured) and the *KDC-C200* 10-disc CD changer. The tuner features integrated 3-way controls for the tape, tuner, and CD changer via a 10-key numeric input pad.

Kenwood's *D*irect *P*rogram *S*earch *S*ystem (*DPSS*), which has been used in their home-audio equipment, is included in the KRC-878. The computer-guided DPSS function allows the user to choose a tape selection, either forward or before the current track, by touching the FAST FORWARD or REWIND key during play mode. Each tap of the key represents one of the 10 forward and 9 reverse selections. "Index scan" provides "previews" of the first 10 seconds of each track.

The tuner provides total control of the CD-player, with such features as 10-key direct track and disc selection, random play, track repeat, track scan, music search, manual search, and disc search. The KDC-C200 can be installed either vertically or horizontally anywhere in the vehicle. It has "Optimum Servo Control," a home-audio-quality servo system that maintains the integrity of the 3-beam laser tracking mechanism through all surface dirt and defects. The CD-player also has an anti-vibration "multi-point mechanism insulator" that provides stability even under rough road conditions.

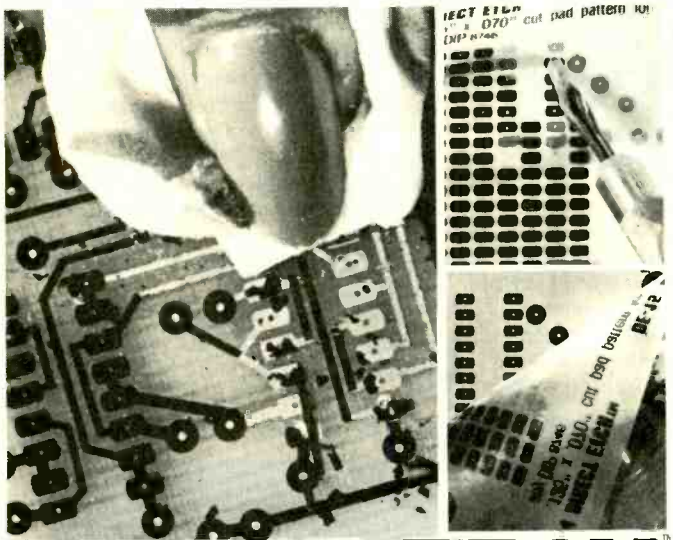
The KRC-878 tuner/cassette deck and the KDC-C200 CD player have suggested retail prices of $699.00 and $749.00, respectively. For further information, contact Kenwood U.S.A., Inc., 75 Seaview Drive, Secaucus, NJ 07094.

CIRCLE 101 ON FREE INFORMATION CARD

DUAL-TRACE OSCILLOSCOPE

Small enough to fit inside a standard attache case, the model *1422* dual-trace 20-MHz oscilloscope from *B&K-PRECISION*, was designed for field-service applications in a variety of industries. The portable scope can be powered from AC, an optional internal battery pack, or an external 10–16-volt DC source. The battery pack fits entirely within the scope, which measures only 4½ (H) × 8½ (W) × 12 (D) inches.

Field engineers will appreciate the rugged 1422's 10-mV/division vertical sensitivity; an 8×10 division, high-brightness, rectangular CRT; and front-panel X-Y operation. Eighteen sweep ranges span from 1 µs/division to 0.5 seconds/division in a



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1/2/5 sequence, which is variable between ranges. Sweep magnification is 10 times, extending the maximum sweep rate to 100-ns per division. A video-sync separator is built-in for use with video circuits or computer terminals. The flat in-band re-

sponse is helpful in using the scope to observe the sync and color levels in video equipment.

The model 1422 oscilloscope, including two 10:1 probes, has a suggested user price of $1099.00. For additional information, contact B&K-PRECISION, Maxtec International Corp., 6470 West Cortland Street, Chicago, IL 60635.

CIRCLE 102 ON FREE INFORMATION CARD

STEREOPHONE

Koss' PRO/450 is a reference-quality stereophone that combines an ultra-wide frequency response (10 – 30,000 Hz) with a wide dynamic range and is both sturdy and comfortable. Part of the company's state-of-the-art "Studio Pro" line, the PRO/450 offers increased bass performance. Its copper-clad aluminum voice coil reduces moving mass and increases diaphragm velocity.

Designed for listening comfort, the stereophone has a "multi-pivoting spider design" that frees the ear plate to float on the listener's head, and ear cushions that seal out outside sounds to provide full frequency response with low distortion. Two

detachable, coiled audio cords are included; the 8- and 25-foot cords are easily interchangeable and feature oxygen-free copper strands.

The PRO/450 stereophone, complete with a microphone mount for studio use and a one-year warranty, has a suggested retail price of $174.95. For more information, contact Koss Corporation, 4129 North Port Washington Ave., Milwaukee, WI 53212.

CIRCLE 000 ON FREE INFORMATION CARD

SPEECH-PROCESSOR CB SYSTEM

Combining three proven products to create one CB-radio system, the *K40 System* includes the *K40 Speech Processor CB Radio*, the *K40 CB Microphone*, and the *K40 CB Antenna*. Patented speech-processor circuitry, using computer-chip technology, electronically adjusts the loud and soft portions of voices. That results in increased dB gain for clearer voice signals.

The compact 40-channel transceiver features full-time ANL and 7-watts audio output. The contour microphone offers a TPR-jacketed retractable coil cord, and a unique magnetic disc makes it easy to

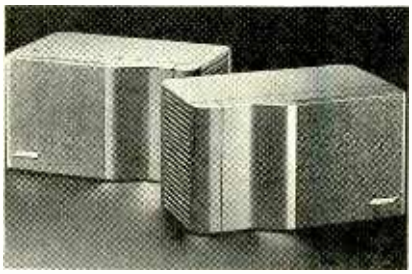
hang up. The antenna was designed with a quarter-turn, quick-release loading coil, a 30°-angle adjustable mounting base, and rust-free, stainless-steel components. The system can be installed in any vehicle.

The K40 Speech Processor CB Radio System—guaranteed to transmit farther and receive more clearly or your money back—has a suggested retail price of $159.95. For further information, contact K40 Electronics, 1500 Executive Drive, Elgin, IL 60123; Tel. 800-323-5608, or 800-942-8175 in IL.

CIRCLE 104 ON FREE INFORMATION CARD

BOOKSHELF SPEAKER SYSTEM

Sleek European styling and advanced injection-molding techniques create an exciting visual statement in the *Freestyle* speaker system from *Bose*. The bookshelf speakers are available in a black version that resembles ebonized wood and in "Ferrari" red. Each speaker is 9 1/2-inches tall, 6-inches deep, and 5 1/2-inches high.



The Freestyle speakers offer high-quality sound, thanks to a version of the Bose 4 1/2-inch, high-sensitivity, full-range driver, which allows excellent power handling. With the addition of a copper-clad pole piece and a newly-developed cone, the driver insures superb high-frequency response. Bass performance is enhanced by the patented curved and flared port design, which provides optimum bass extension while reducing the distortion that is typical of small, ported speakers.

The Freestyle Bookshelf loudspeaker system will be available in the fall for $339.00 per pair. For additional information, contact Bose Corporation, The Mountain, Framingham, MA 01701.

CIRCLE 105 ON FREE INFORMATION CARD

MIDI SYSTEM

Providing a complete, turnkey-synthesized, computer music system that can simulate an entire orchestra and recording studio on a personal computer, the *CMS-1 Complete MIDI Studio* from Computer Music Supply includes a synthesizer, software, and interface. The electronic-music starter system uses the portable Casio *MT-540* synthesizer/keyboard, acclaimed *Cakewalk* recording/editing software, and an industry-standard *MPU-401* half-slot interface card for the PC.

Users can build complex orchestral compositions with up to four simultaneous instruments and up to 16 simultaneous notes. There are 210 high-fidelity instrument sounds and 30 digitally-sampled

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sound effects—including applause, ocean, traffic, and gun shots—to choose from. Music can be played on the synthesizer's built-in speakers or on any stereo system.

Cakewalk software allows users with no musical skills to build a composition note-by-note. It has an intuitive user interface and context-sensitive help. Notes can be edited and time corrected, and special effects include cloning, reverse playback, changing instruments on the fly, and the ability to edit or play along with prerecorded music.

The CMS-1 supports CGA, MDA, Hercules, and EGA monitors and serial mice. It requires 384K of memory. The interface card supports any MIDI device and is compatible with more than 100 other PC-music programs.

The CMS-1 complete MIDI studio has a suggested retail price of $399.00, or $249.00 for users who already have a synthesizer or MIDI device. A $14.95 (reimbursable) trial pack containing a demo audio tape, tutorial booklet, and software demo disk is also available. For further information, contact Computer Music Supply, 382 Lemon, Walnut, CA 91789; Tel. 800-322-MIDI.

CIRCLE 106 ON FREE INFORMATION CARD

CD PLAYER

Luxman's "entry-level" CD player, the *DZ-111*, is a full-featured unit. It incorporates a 4× oversampling digital filter with 16-bit dual digital-to-analog converters, and its "error concealment" system corrects all misread information prior to conversion so that it can play through fingerprints, dust, and scratches.

Users can program up to 32 selections to be played in any sequence, and the sequence can be repeated. The DZ-111 also features random play, auto-scan, and auto-pause. Its external AC timer can be set so that the unit begins playing at a

specified time. The remote control activates most of the player's functions, and can be used to program the 32 memory locations and to directly access any track by entering the track number.

The DZ-111 CD player has a suggested retail price of $350.00. For more information, contact Luxman, Division of Alpine Electronics of America, 19145 Gramercy Place, Torrance, CA 90501.

CIRCLE 101 ON FREE INFORMATION CARD

AM/FM DAT PLAYER

Clarion's Audia 8100 is a single-chassis automotive AM/FM-DAT (*D*igital *A*udio *T*ape) player that also has CD-changer control capability. Multi-function control buttons—which are used to operate the radio, DAT, and CD-changer—give the Audio 8100 a sleek, clean look. The unit includes a computer-controlled anti-theft system. If the unit is removed from a vehicle, it cannot be played unless the owner's personal security code is reentered.

The tuner features 12 FM and 6 AM pre-

sets, seek up/down tuning, preset-station scan, and automatic station retune, which seeks the next highest station when the tuned-in station becomes weak.

The tape player allows the listener to select DAT functions such as selection repeat, intro scan, or return to the beginning

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V-1065	100MHz	D.T., 2mV sens, Delayed Sweep, CRT Readout, Cursor Meas	$1,895	$1,670	$225
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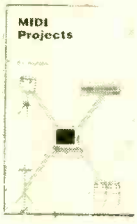

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of the tape. With Automatic Program Control, the listener can locate any musical selection on the tape with the touch of a button. Three sampling frequencies are provided: 48 kHz, 44.1 kHz, and 32 kHz. A moisture detector automatically activates a heater to remove any moisture before it condenses and possibly damages the drum areas.

In CD mode, the Audia 8100 can operate the Clarion *Audia 6100* CD changer.

The Audia 8100 AM/FM-DAT player has a suggested retail price of $2,299.00. For further information, contact Clarion Corporation of America, 5500 Rosecrans Avenue, Lawndale, CA 90260.

CIRCLE 108 ON FREE INFORMATION CARD

CORDLESS TELEPHONE

Featuring "Clarity Plus" technology, *AT&T's 5320* cordless telephone offers virtually interference-free sound quality wherever it is being used. Two channels, selectable instantly from the handset, allow the user to choose the clearest channel. Automatic receiver-volume control adjusts the incoming voice volume to correct for poor connections.

The handset works for seven days without recharging, so the base can be tucked in an out-of-the-way place. A portable handset cradle can be wall-mounted or placed on any flat surface. Replacement

antennas and batteries can be easily installed by the customer, eliminating the need for factory repair.

The 5320 has an automatic digital security system to prevent unauthorized use of the phone line. It operates in pulse or touch-tone modes; "temporary tone" allows users with rotary service to temporarily switch to touch-tone when needed for remote access of answering machines or banking-by-phone services. The hearing-aid compatible phone also features speed dial, two-way paging and intercom, out-of-range alert, and last-number redial.

The 5320 cordless telephone has a suggested retail price of $219.00. For further information, contact AT&T Consumer Products, 5 Woodhollow Road, Parsippiny, NJ 07054.

CIRCLE 109 ON FREE INFORMATION CARD

VHS CAMCORDER

Samsung's first entry in the camcorder market is the model *SCF500*, a full-featured VHS unit that offers a half-inch CCD with seven-lux light sensitivity. The camcorder comes with a 6-to-1 power-zoom lens with macro, auto-focus, and auto-iris.

Other standard features on the SCF500 include HQ picture circuitry, full record and playback capability, on-screen counter/calendar, and a built-in monaural microphone. The unit weighs 4 pounds, 13

ounces and measures $4^{15}/_{16}$ (W) × $8^{13}/_{16}$ (H) × $13^{3}/_{16}$ (D). It comes with cables, a battery, and a battery recharger.

The SCF500 camcorder has a suggested retail price of $1,199.00. For more information, contact Samsung Electronics America, 301 Mayhill Street, Saddle Brook, NJ 07662.

CIRCLE 110 ON FREE INFORMATION CARD

COMPACT-DISC CLEANER

The leading audio-care accessory manufacturer in Europe, *Trackmate*, is now marketing their products in the U.S. Their *TM-351* CD-care system is designed to maintain CD performance quality by "maintaining the cleanliness and perfection of the mirror on the label side." The music is recorded in tracks of microscopic "pits" that are covered by a thin aluminum mirror, which reflects the laser light and allows a sensor to decode the music. Even the tiniest scratch can damage the mirror, and the audio quality will suffer.

The TM-351 uses a delicate gear-driven brush that radially cleans the disc inside

(Continued on page 22)

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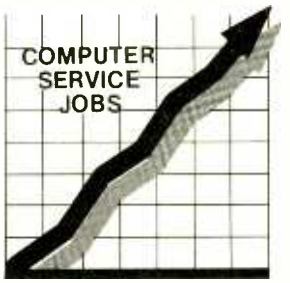
5 sure steps to a fast start as a high-paid computer service technician

1. Choose training that's right for today's good jobs



Jobs for computer service technicians will almost double in the next 10 years, according to the latest Department of Labor projections. For you, that means unlimited opportunities for advancement, a new career, or even a computer service business of your own.

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New Products

(Continued from page18)

its storage case—with no unnecessary handling. A small central platform supports the disc and allows the CD to "float" in its box. The brush connects to the center of the disc case and maintains even contact with the disc, gently cleaning the mirror side while the other side floats. That

method prevents dirt from being forced into the surface of the CD.

The Trackmate system also includes a felt pen that contains a proprietary cleaning solution to "assure optical perfection for maximum laser transmission." The pen precisely controls the amount of cleaning solution released, preventing dripping and over-dosing.

The TM-351 CD-cleaning system has a suggested retail price of $19.95. For more information, contact Trackmate, I.D.A. Enterprise Centre, East Wall Road, Dublin 3, Ireland.

CIRCLE 112 ON FREE INFORMATION CARD

SPEAKER PROTECTION DEVICE

For those who like their music *loud*, *Allison Acoustics' Power Shield* could come in handy. Tne loudspeaker-protection device, designed to prevent driver failure due to excessive volume levels, can be easily intstalled by the consumer in line with any loudspeaker. It differs from a fuse in that

the Power Shield automatically resets when the volume level is reduced.

Four power ratings, which equate to eight different wattages depending on the impedance of the speakers, are available. The lower wattages are well suited to automotive applications.

Power Shield has a suggested retail price of $39.95 per pair. For further information, contact Allison Acoustics Inc., 1590 Concord Street, Framingham, MA 01701.

CIRCLE 107 ON FREE INFORMATION CARD

VOLT/OHM METER

KAPPA/VIZ's model *WV-595 VoltOhmyst III* is a versatile 50,000-ohm/volt meter for use in school labs and workshops as well as in engineering, maintenance, and R&D applications. It features a taut band, high-sensitivity meter with mirrored scale; 52 measurement ranges; and a mid-scale switch for increased measuring capabili-

ties. The instrument offers separate dB measurements of 1.5-, 1.55-, and 9-volt batteries. It also has two functions not normally associated with an analog meter: a measurement of NPN and PNP transistor h_{FE} gain, and continuity-testing that activates an internal buzzer.

The WV-595 VoltOhmyst III has a suggested price of $69.96. For additional information, contact KAPPA/VIZ Test Equipment, 175 Commerce Drive, Fort Washington, PA 19034-2496; Tel. 1-800-523-3696.

CIRCLE 114 ON FREE INFORMATION CARD

PORTABLE CB RADIO

Full 5-watt power and 40-channel synthesized circuitry are featured in *Maxon's 27-LP* portable Citizens Band radio. It has a dual-conversion superheterodyne receiver with noise-limiting circuitry and an adjustable squelch for crisp reception and quiet standby. Controls and indicators include a large, easy-to-read LED display; "transmit"

and "battery-low" LED's; and a battery-saving "Hi-Low" power switch.

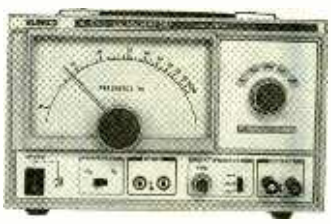
The compact two-way radio weighs only one pound and measures $7^{1}/_{4}$ (H) × $2^{7}/_{8}$ (W) × $1^{15}/_{16}$ (D). It runs on 8 alkaline or 10 nickel-cadmium "AA" batteries, and comes with a durable case equipped with a belt clip. A removable "rubber-duck" antenna is also included.

The 27-LP CB radio has a suggested retail price of $99.95. For more information, contact Maxon Systems, Inc., Department 777, 10828 NW Air World Drive, Kansas City, MO 64153.

CIRCLE 115 ON FREE INFORMATION CARD

AUDIO GENERATOR

Designed for use by students, hobbyists, and service technicians, the model *SG-9200* audio generator from *Elenco* produces sine and square waves from 10 Hz to 1 MHz in five increments. The instrument is accurate to ±7% plus 2 Hz. Its output impedance is 600 ohms unbalanced. The output has a 3-position switch,



which can be set to 0, −20, and −40 dB with a fine adjustment control. The square-wave output range is 10 Hz to 10 kHz at 10 volts P.P. max, with rise time at 0.5 microseconds.

The SG-9200 audio generator has a suggested retail price of $195.00. For additional information, contact Elenco Electronics, Inc., 150 West Carpenter Ave., Wheeling, IL 60090. ■

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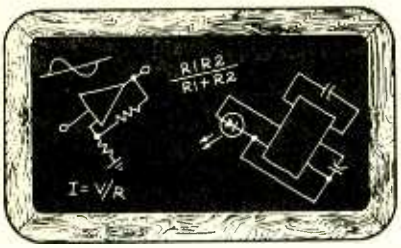

Think Tank

By Byron G. Wels

I REALLY DON'T BELIEVE IT!

The boss gave me an assignment. We're going to examine the possibility of making up an electronics trivia quiz, he said. Prepare a thousand questions in several categories—general electronics, servicing, computers, scientists, and inventors, etc.

I started with general electronics, then went to scientists and inventors. Know what? After researching and studying, and several trips to the library, I wasn't able to come up with a hundred names. What that showed me, is that there's more-than ample room for all of us! That's right! you can easily add your own name to that august list. All you have to do is create a major breakthrough, and fame and fortune will be yours!

Ask anybody how many famous inventors there are in electronics, and they'll tell you "there must be a million of 'em." Which reminds me of the story about the young machinist who brought his work to the foreman. The foreman put his micrometer on the work and said, "that's supposed to be three thousandths of an inch! You know how many thousandths there are in an inch? There must be a *million* of 'em!"

To answer last month's question, how to bring back exactly seven gallons of water when all you've got is a three-gallon bucket and a five-gallon bucket, first fill the five-gallon bucket and then fill the three-gallon bucket from the five-gallon. That will leave exactly two gallons remaining in the five-gallon bucket. Now empty the three-gallon bucket and pour what's left in the five, into the three. Fill the five-gallon bucket, and there you have it! Seven gallons of water.

Now let's see what was in this month's mail...

Heater Monitor. If you have to worry about ice-dam build-up on your roof, the way I do, you probably have a heating cable going around the eves for your home to prevent ice build-up. Ice can get pretty heavy, and you don't want to risk damage to the roof. So when the cable burns out, or the plug gets disconnected, a fast trip to the roof, perhaps in a snowstorm, is usually in order.

But with the circuit shown in Fig. 1 you'll know at a glance the status of the heating cable. The Heater Monitor is little more than a choke core (on which a homebrew transformer is wound) and

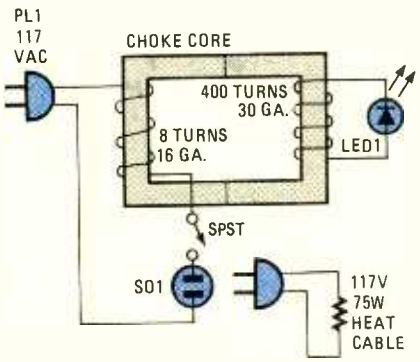

Fig. 1. The Heater Monitor is made from little more than a choke core (on which a homebrew transformer is wound) and an LED, along with an AC socket and plug.

LED, along with an AC socket and plug. The transformer, switch, and LED fit easily into a standard wall box.

Obviously, if the cable is disconnected or open, no primary current flows so no secondary voltage is developed to energize the LED. I know immediately that there is a problem. It sure beats going on the roof to feel if the cable is warm. I can sit down by the fire and read my Fips Books. Isn't that right, Byron?

—*Boyd F. Ewing, Depew, NY*

Wow, Boyd! Reading your letter just gave me the shivers. Not that it's so warm here on Long Island, but I don't have an ice-melter on my roof. I think that you've taken a novel approach to solving a chilling problem, and yes, I hope you do enjoy your copy of the Fips Book by your fireplace.

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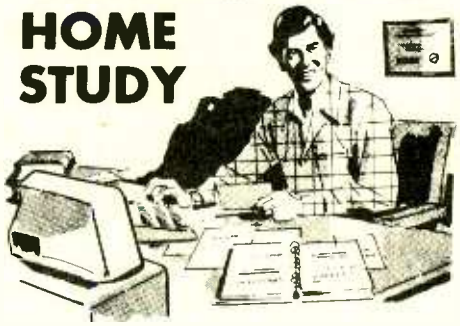

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THINK TANK

Power Sources. I can remember the old "cure or kill" system for servicing electronic equipment, where you'd take a unit working intermittently, plug it into a variable transformer, and gradually bring up the AC voltage. Next thing you knew, there would be a crack, a puff of smoke, and the intermittent part would give up the ghost! From that point, servicing was a snap.

Having located the problem part, it was an easy matter to replace it, thereby restoring the unit to normal operation. But, variable transformers can be expensive. The circuit shown in Fig. 2 is excellent for slow start-up testing of intermittent circuits. And it can also be applied to many tasks on the experimenter's test bench.

The circuit (the upper half of Fig. 2) is actually a variable AC supply; the lower half of the schematic diagram is an optional circuit that can be added to provide a variable DC output.

All the necessary parts can probably be found in your junkbox, and what you don't have on hand is easily obtainable from your local electronic supply house. Either version of the circuit can be built on perfboard, and housed (for protection) in a small metal box or cabinet.

I've found both supplies to be handy for experimentation; AC and/or DC voltmeters at the outputs would make the circuit even more useful.

I'd like to see more on test-equipment circuits. Technicians are interested in things that help them do their jobs easier.

—Dewey G. Parlier, Pfafftown, NC

Okay Dewey, I'd like to see some additional test-equipment circuits and tips too. C'mon, you guys! Get 'em in. And Dewey, you didn't have to request a Fips Book. It's on the way.

Commercial Zapper. While watching TV with my wife one evening, it seemed that the program was interrupted by one commercial after another. I excused myself and went to my basement workshop where I whipped up the Commercial Zapper (see Fig. 3), then returned to the living room, turned off the TV set, and before my wife could say "what are you doing?" I turned the set on again, and sat down with her on the sofa.

When the station broke for commercials again, I shined my flashlight at that little circuit, and the sound dropped out. In time, it came on again, and peace reigned supreme!

The circuit is connected in series with the wire going to the speaker. Because the relay contacts are normally closed, the audio portion of the TV signal is output by the speaker in the normal manner. But when a high intensity light beam (in this case from a flashlight) is focused on phototransistor Q1, a voltage is fed to the base of Q2, turning it on. Turning on Q1 energizes relay K1, causing its contacts to open, disrupting the signal to the speaker. As long as the flashlight is focused on Q1, no audio signal is applied to the speaker.

I breadboarded the circuit to make sure that it worked, and finally installed it in a suitable plastic box that sits atop the TV set. "It isn't a big thing, but it does justify my interest in my hobby. Every once in awhile, I like to make something that the entire family can use and enjoy. It makes them a bit more tolerant of my own selfish interests."

—Ben Conklin, Omaha, NB

Right Ben, and we love those quick-and-dirty experiments. Your Fips Book is on the way, and we hope you've got a lot more circuits like this one.

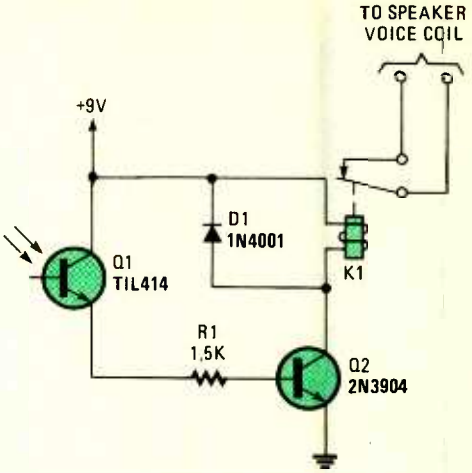

Fig. 3. Commercial Zapper is connected in series with the speaker wire, so that when a high intensity light beam is focused on Q1, the signal to the speaker is disrupted.

Patio Light. I put this simple circuit together to light the area between my house and detached garage. The 300-watt lamp comes on only when it is dark outside and the automatic garage-door operater has been activated.

Refer to Fig. 4. Light striking the light-dependant resistor (R2, a cadmium-sulphide unit) keeps the voltage across capacitor C1 from charging sufficiently to fire neon lamp NE1, so the triac (TR1) is turned off. As evening approaches, the resistance of the cell increases and C1 begins to charge. When the charge on C1 reaches about 60 volts, NE1 fires and supplies gate current to TR1, turning it on, which in turn, causes the lamp to light. Unless the garage-door opener has been activated, relay K1 prevents the circuit from being completed, and the lamp remains off.

The relay is connected to the garage-door opener and its operation allows the lamp to come on. Parts are not critical and any triac capable of handling the lamp's current will suffice.

The timing circuit in the opener allows me enough time to park the car in the garage and walk through the patio before it shuts the lamp off.

I used a "Y" lamp and socket-to-plug connector to provide a simple way to obtain 117 volts for the circuit as well as

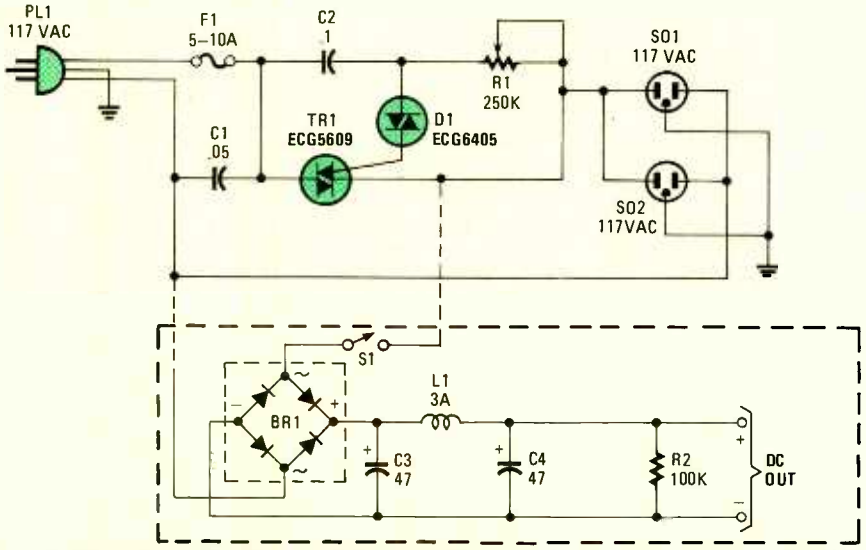

Fig. 2. The upper half of the circuit is a variable AC power supply; the lower half of the circuit is optional and can be added to the AC circuit to provide a DC output.

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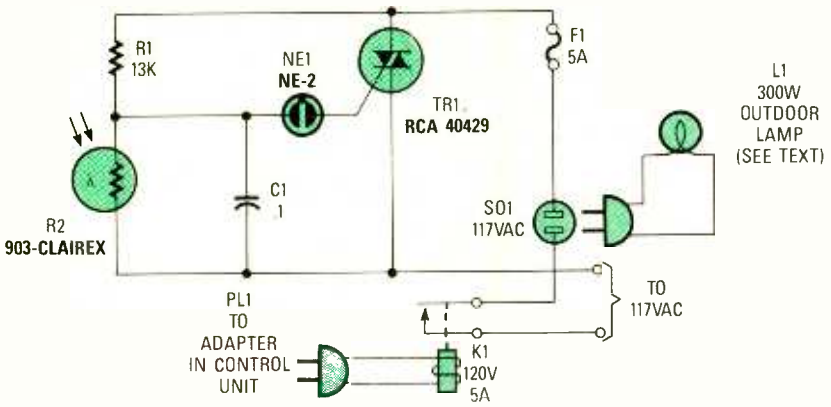

Fig. 4. The Patio Light circuit is nothing more that a simple AC switch that's controlled by a light-dependant resistor, R2. When light striking R2 decreases sufficiently, a trigger voltage is applied to the gate of TR1, turning it on.

keeping a lamp on in the garage. The photocell was mounted outside the garage, under the eave to protect it from weather. A 5-amp fuse protects the circuit. After a steady two years of operation, it's still working flawlessly.

—*Roy E. Kneale, Walnut, CA*

Thank you Roy. Now that's an interesting circuit with a practical application. I'm certain that other readers will be able to use a tip like that. Hope you enjoy the Fips Book!

Two-Meter Preamp. Byron, I've noticed that there aren't a lot of ham ideas in *Think Tank*, and hope you can accept one occasionally. The following circuit (see Fig. 5) is a real gem. Run your two-meter antenna to the input of that circuit, and connect the output for the circuit to the antenna terminals on your receiver, then stand back! It really improves all the specs. The circuit can be built on a small printed-circuit board. As for the coils, L1–L4, they can be wound on Miller 60A022-4 forms, or any other small brass-slug ceramic form. Coil L1 consists of 5¼ turns of 26-gauge wire, tapped at 1¼ turns; L2 consists of 9½ turns of 34-gauge wire; L3 is five turns of 26-gauge wire; L4 is 1¼ of 26-gauge wire wound at the bottom end of L3. All capacitors in the circuit are rated for 10-volt operation, and all resistors are ½ -watt units.

That little circuit so improved my receiver on two meters, that I put off my plans to purchase a new one. Now that just *has* to be good enough to earn a copy of that Fips Book!

—*George Appleton, Madison, WI*

Right George, and let's get a few things straight. Amateur-radio contributions are more-than welcome in this column, We'll take all we can get. I just wonder if things wouldn't be further improved by adding a small coupling capacitor at the output?

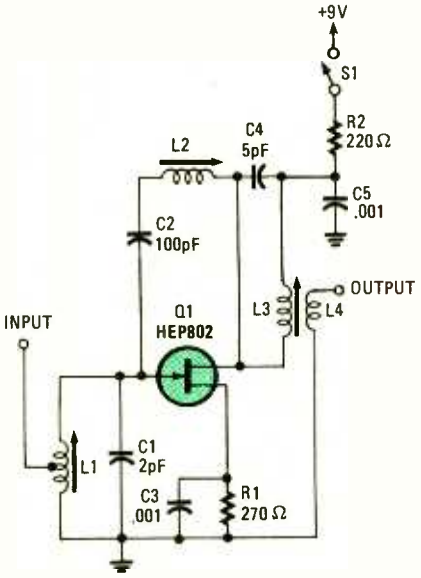

Fig. 5. The Two-Meter Preamp contains four hand-wound coils, which were wound on Miller 60A022-4 forms; see text for construction details.

Polarity Probe. This project, see Fig. 6, is so simple that it hurts! With the red clip connected to the positive-supply rail and the black clip connected to ground, the LED's will indicate a positive or ground potential at the probe tip.

With the tip positive, LED2 is biased on and the voltage drop across LED1 is too small for conduction. With the probe tip at ground, the roles of the LED's are reversed. Resistors R1 and R2 limit the current through the LED's. With the probe tip floating, both LED's are on. The device will work between 3 and 40 volts.

(Continued on page 27)

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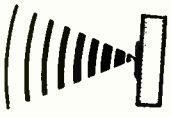

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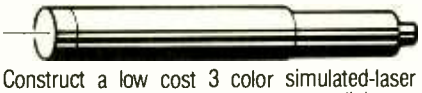

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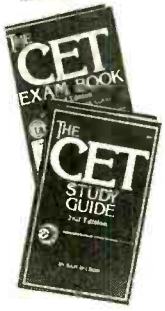

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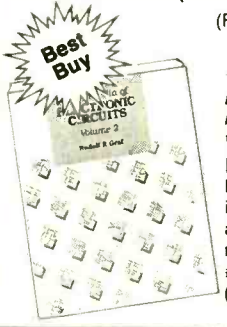

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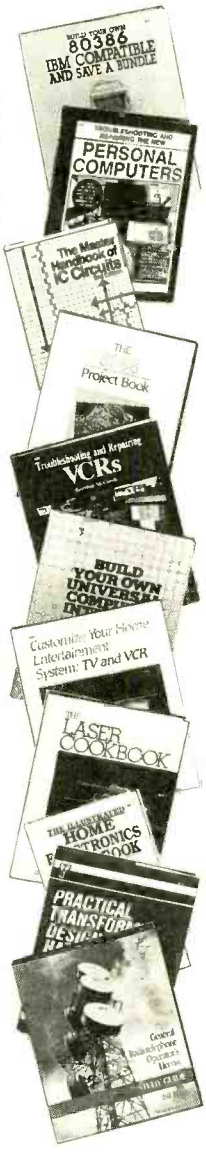

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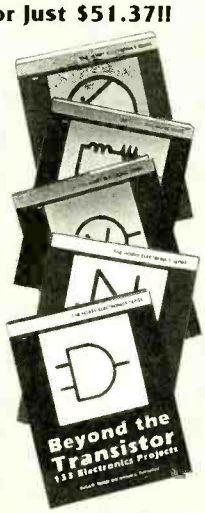

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THINK TANK

(Continued from page 25)

If only positive polarity is of interest, only the ground clip need be connected. If just negative polarity is in question, only the positive clip need be used. The relative brightness of the red and green LED's with respect to each other will also indicate voltages which are not quite down to ground or up to positive supply. If both clips are connected to ground, and the probe tip is touched to a trace in a circuit both LED's will light alternately to indicate the presence of AC.

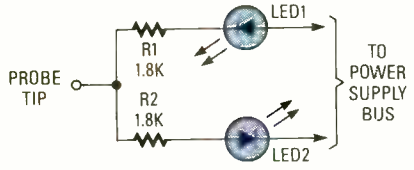

Fig. 6. The Polarity Probe is great for checking IC's, automobile wiring, headers, and I/O ports.

The Polarity Probe is great for checking the supply pins of IC's without having to juggle two test leads back and forth (as with a VOM). The probe is also handy for checking automobile wiring by sliding the probe tip into the back of wiring-harness connectors without having to disconnect them. The same holds true for headers and I/O ports.

Do not attempt to use the circuit as a digital logic probe. The current draw is too high for most logic chips. However, if R1 and R2 are increased to about 6.8K or so, the current through the probe will be quite a bit less, but the minimum voltage will be higher. Finally, the circuit is so inexpensive to build and so easy to repair, that you can avoid risking your DMM by assigning the Polarity Probe to dangerous missions and uncertain circumstances.

—Keith Rawlinson, Berea, OH

I can't recall seeing such a simple schematic that's capable of doing so much. You asked if I could "flip you a Fips." It's on the way!

NiCd Battery Zapper. After prolonged use and repeated chargings, NiCd batteries develop memory—that's a buildup of an internal resistance that keeps the battery from taking and holding a charge. The circuit in Fig. 7 seems to cure about 90% of all NiCd battery problems. I've used it often to save and restore many costly NiCds.

When switch S1 is in the CHARGE position, I set the external power supply to about 60 volts. I leave the supply on until the voltmeter reads the same voltage. That indicates that capacitor C1 has charged. The external power supply is then shut off (for safety's sake) and the bad NiCds are attached to the battery terminals. When ready, switch S1 is switched to the ZAP position.

A spark will probably be seen because of the shorted NiCd. The current is blowing away the NiCd short. If the short is cleared, the voltmeter should now be reading the battery voltage (normally 1.5 volt) and the Zapper was successful. The battery should be removed and then charged through more-conventional methods. If not, repeated zaps can be tried to save the NiCd from the garbage heap.

Care should be exercised when using the circuit because a 60-volt charge is stored in the capacitor. It should also be understood that this is a last-resort device to save a dead NiCd.

—Scott B. Zederbau,, Edison, NJ

Scott, this one reminds of the old "cure-or-kill" method we used on old

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THINK TANK

CRT's, in which a high voltage is fed to the filament that had opened, and if our luck was good, the filament might weld itself back into operating condition!

Tape Timer. When a younger brother enjoys falling asleep with the music from his little tape recorder, and wakes up to find the batteries dead, what do you do? You buy him another set of batteries, but how long can you afford to keep it up? The obvious answer was a timer that would automatically shut off the tape recorder at some point *after* he fell asleep!

The circuit shown in Fig. 8 does the job nicely. When switch S1-a is on, switch S1-b is off and the timer is not in the circuit. When S1-a is off S1-b is on, the timer is in the circuit, and the LED lights to indicate that the timer is on. Various time intervals can easily be set via potentiometer R2.

To turn the timer on, all you have to do is flip S1 so that S1-a is closed, and then flip it back again.

—*Afshin Tavakoli, Middle East*

We should point out that the tape recorder shown uses an outboard power supply, but don't be tripped up by that. With a little judicious circuit tracing, you can easily adapt the Tape Timer to an internal supply and at the most, have to break a trace or two.

Well, that's about all the space allotted to us for this month, but be sure to join us next time around. In the meantime, though, remember, your ideas and schematics are always in demand here. Send them to *Think Tank*, **Popular Electronics,** 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

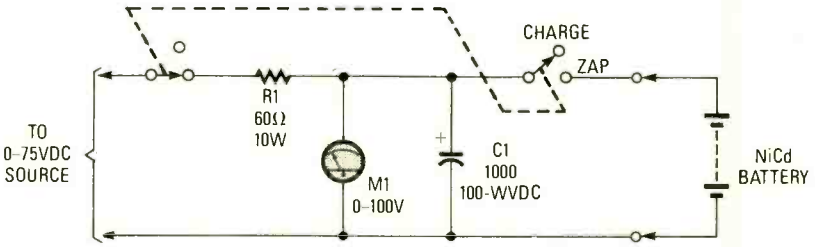


Fig. 7. When switch S1 is in the CHARGE position, capacitor C1 charges to the applied potential; when set to the ZAP position, the charge on C1 is dumped to the battery, curing the battery's memory problem.

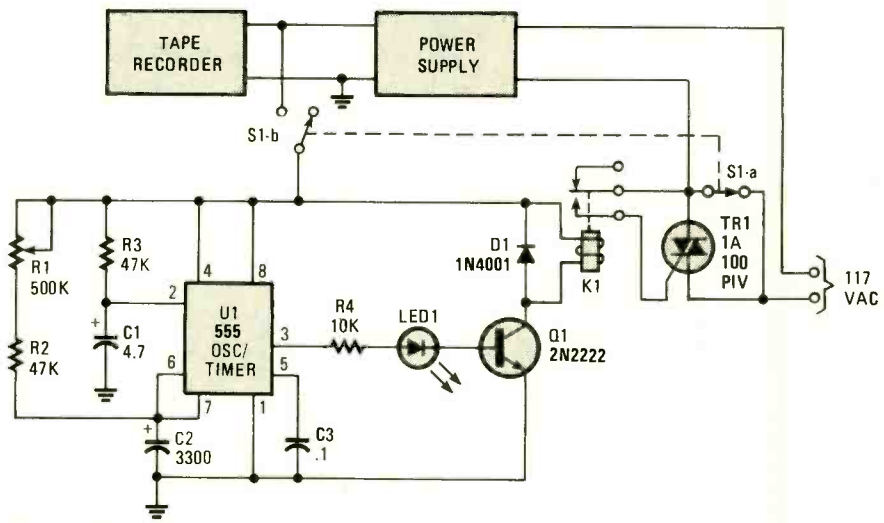
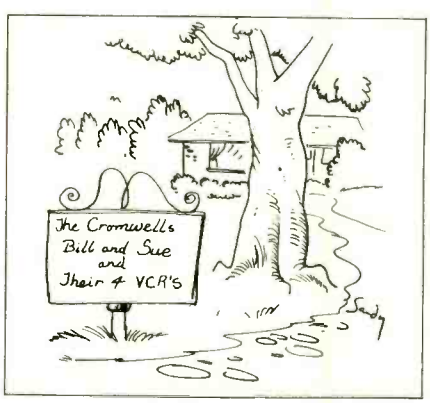


Fig. 8. When switch S1-a is on, switch S1-b is off and the timer is not in the circuit. When S1-a is off and S1-b is on, the LED lights to indicate that the timer is on.



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7401N	35
7402N	35
7403N	35
7404N	43
7405N	43
7406N	48
7407N	48
7408N	43
7409N	43
7410N	43
7411N	56
7412N	56
7413N	85
7414N	1.75
7416N	58
7417N	58
7420N	33
7425N	52
7426N	58
7427N	43
7430N	30
7432N	45
7437N	40
7438N	40
7440N	48
7442N	55
7445N	1.98
7446AN	98
7447AN	1.20
7450N	42
7451N	48
7453N	34
7460N	30
7470N	48
7473N	1.05
7474N	48
7475N	50
7476N	48
7480N	70
7482N	1.75
7483N	1.98
7485N	1.50
7486N	48
7489N	3.50
7490AN	1.05
7491AN	1.20
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7493AN	1.05
7494N	1.38
7495N	1.43
7496N	1.62
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74109N	63
74110N	80
74116N	2.50
74121N	1.18
74122N	1.40
74123N	1.45
74125N	1.05
74126N	1.05
74128N	1.05
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74136N	1.98
74141N	1.98
74142N	7.50
74143N	7.50
74144N	7.50
74145N	1.98
74147N	3.50
74148N	3.50
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74151AN	63
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74251N	1.17
74365N	65
74367N	70
74368N	70
74390N	70
74451N	50
74452N	1.12
74453N	1.38
74454N	1.38

74LS00 TTL

Part	Price
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74LS01N	32
74LS02N	32
74LS03N	32
74LS04N	31
74LS08N	32
74LS09N	32
74LS10N	32
74LS11N	32
74LS12N	22
74LS14N	56
74LS15N	38
74LS20N	32
74LS21N	32
74LS26N	32
74LS27N	32
74LS30N	32
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74LS37N	33
74LS38N	33
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74LS51N	38
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74LS86N	38
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74LS92N	66
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74LS373N	66
74LS374N	66
74LS640AN	1.05
74LS645N	1.98
74LS670N	1.95
74LS688CN	1.98
74HC266AN	1.10
74HC273N	1.10
74HC280N	90
74HC299N	1.25
74HC374N	1.10

74S00 TTL

Part	Price
74S00N	35
74S02N	35
74S03N	35
74S04N	35
74S05N	35
74S08N	35
74S09N	35
74S10N	38
74S11N	38
74S20N	38

74S22N	56
74S32N	46
74S40N	46
74S64N	46
74S74AN	75
74S86N	45
74S112N	75
74S113N	50
74S114N	75
74S133N	45
74S134N	71
74S140N	1.75
74S151N	1.05
74S153N	1.05
74S157N	1.05
74S158N	1.05
74S174N	1.75
74S175N	1.75
74S181N	6.50
74S194N	1.75
74S195N	1.75
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74S244N	2.16
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74S260N	1.05
74S287N	3.50
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74S289N	7.50
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74S374N	2.16
74S471N	3.75
74S472N	4.50
74S473N	3.75
74S474N	4.80
74S475N	4.80
74S476N	4.80
74S570N	3.50
74S571N	3.75
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74S574N	4.20
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74S576N	3.75
74S577N	4.20
74S841N	3.50

4000 CMOS

Part	Price
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4001BCN	27
4002BCN	28
4007CN	28
4008CN	65
4009UBCN	33
4010BCN	33
4011BCN	28
4012BCN	28
4013BCN	28
4014BCN	70
4015BCN	70
4016BCN	36
4017BCN	70
4018BCN	70
4019BCN	35
4020BCN	70
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4023BCN	28
4024BCN	45
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4027BCN	33
4028BCN	56
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4030CN	30
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4072BCN	50
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4085BCN	83
4086BCN	1.00
4089BCN	1.00
4093BCN	70
4098BCN	78
4099BCN	1.00
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4529BCN	83
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4536BCN	1.90
4538BCN	1.06
4539BCN	1.06
4543BCN	1.90
4555BCN	80
4556BCN	80
4560BCN	1.90
4566BCN	1.90
4568BCN	3.50
4572BCN	1.00
4583BCN	1.06
4584BCN	1.06

Linear

Part	Price
LF347N	1.20
LF351N	60
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NOVEMBER 1989

BUILD AN ELECTRONIC DARKROOM TIMER

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

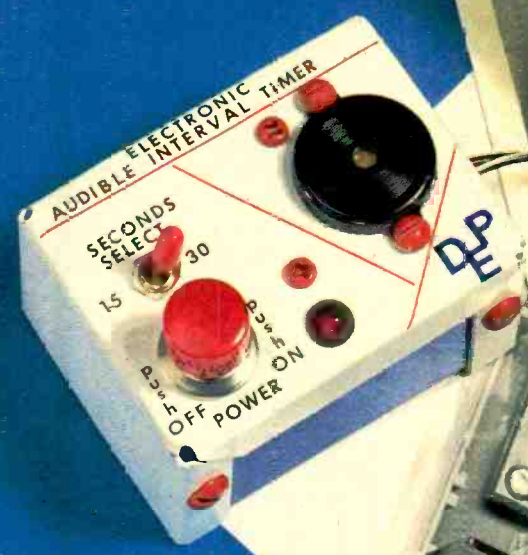
BY DOUGLAS E. POPE

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.



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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 milliamps, 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 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 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 104)

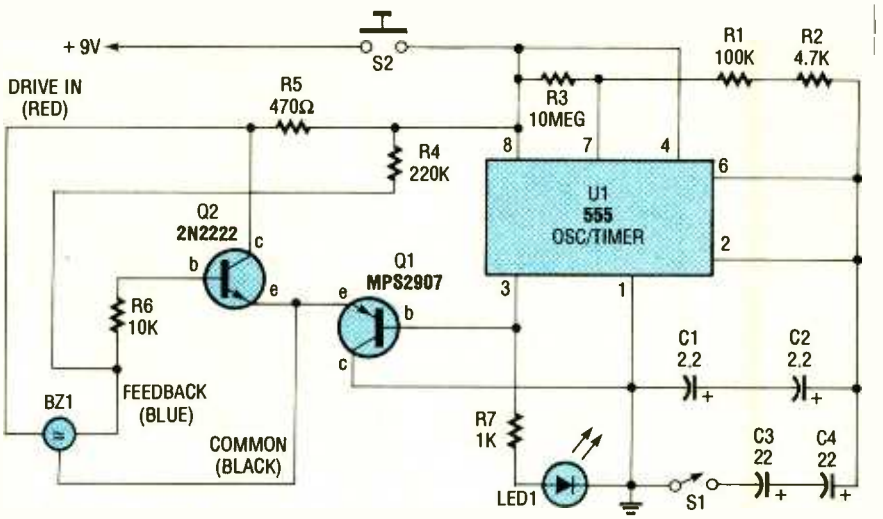

Fig. 1. The Electronic Darkroom Timer is built around a 555 oscillator/timer, a pair of general-purpose transistors, an LED, and a buzzer.

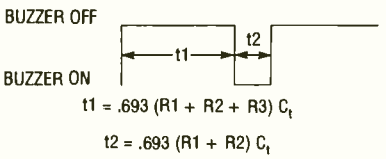

Fig. 2. Here is the output waveform of the 555 oscillator/timer (U1).

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 ¼-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-μF, 16-WVDC, tantalum
C3, C4—22-μF, 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.

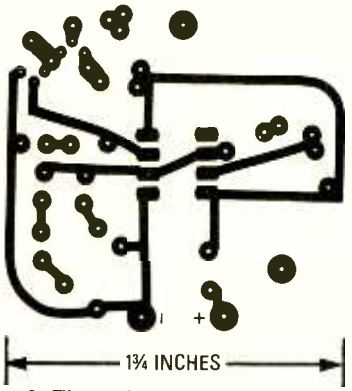

Fig. 3. The author assembled his prototype of the Electronic Darkroom Timer on a printed-circuit board, the template for which is shown here.

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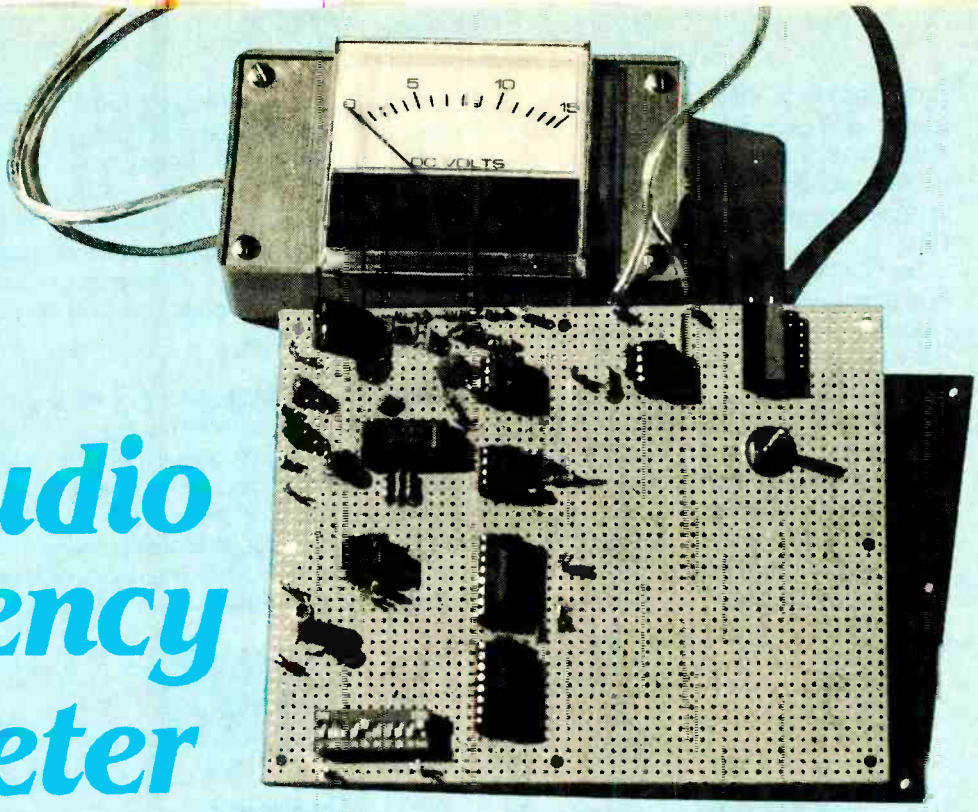

Sub-Audio Frequency Meter

This simple add-on circuit extends the lower range of your digital-frequency counter into the sub-audio region

BY JOSEPH J. CARR, K4IPV

Frequency is defined as "events per unit of time," or, in the case of electronic circuits, "cycles per second" or hertz (Hz). Today, it is standard practice to measure frequency with a digital frequency counter. In such instruments, the input signal is first conditioned into a train of pulses (with the pulses occurring at the same frequency as the input signal), and then counted by an event counter and displayed. In electronic circuitry, those circuits are called *decimal counting units*, and consist of decade counters, display decoder/drivers, and a numerical display.

The train of signal pulses is allowed into the event counter through a main gate that is, in turn, controlled by a timebase circuit. The timebase produces command signals that open and close the gate at standardized intervals (e.g., 0.01 second, 0.1 second, or 1 second). The "frequency" is then read as the number of signal pulses that passed into the event counter during the gate-open time.

Digital frequency counters that use the *direct-count method* discussed above to count from 10 Hz to well into the gigahertz region are available. Unfortunately, most counters will not accurately measure low-frequency audio and sub-audio frequencies—e.g., frequencies below 100 Hz. Sub-audio frequencies are those that are below the range of human hearing (less than 30 Hz), while low audio frequencies extend to about 100 Hz, depending upon whose definition is used.

Those low frequencies are notoriously difficult to measure using regular digital frequency counters because the required gate times are too long. In some models, short gate times (1 second) are used, and then the result is extrapolated to the actual frequency based on the count during the gate time. While that method works to some extent, it also produces relatively large errors.

A better (but more complex) method that is used in some models is to measure the period (T) of the input signal, and then take its reciprocal ($f = 1/T$) in an arithmetic logic circuit. That method is used extensively in very low frequency counters, but is rather complex and more costly.

Still another method, which has certain definite advantages when looking at sub-audio frequencies, is to multiply the input frequency by 100 or 1000 in a phase-locked loop (PLL), and then measure the output of the PLL oscillator on a conventional digital frequency counter. In such counters, a reading of 7,500 Hz would be interpreted as 75 Hz, provided that the multiplication factor is 100, and 7.5 Hz if the factor is 1000.

PLL Circuits. The PLL was invented in the 1930's as a synchronous AM demodulator. Oddly enough, its first intended use never caught on except in a few *Voice of America* shortwave-relay receiver sites right after World War II. Few, if any, other AM detectors are based on the PLL. A host of other applications for the PLL were found, however; tone decoding, frequency-shift keying (FSK) decoding, FM demodulation, FM/FM telemetry-data recovery, FM multiplex stereo decoding (to reconstruct the 38-kHz subcarrier from the 19-kHz pilot signal), motor-speed control, and transmitter-frequency control.

In this article, the PLL will form the basis of a *Sub-Audio Frequency Meter* with both digital- and analog-display options. Figure 1 shows the block diagram for a basic phase-locked loop. The main elements of the PLL circuit are a voltage-controlled oscillator (VCO),

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phase detector, reference-frequency source, and a low-pass filter (LPF). A DC amplifier may also be used for scaling or level translation of the DC control voltage from the output of the low-pass filter.

The VCO is a special form of variable-frequency oscillator (VFO) in which the output frequency, $f_o$sbo, is a function of the input control voltage (V_{in}). In Fig. 1, the VCO input voltage is also the output voltage from the DC amplifier.

The reference-frequency source is a stable oscillator operating at a fixed frequency. The reference frequency (f_{ref}) in Fig. 1 is equal to f_o. When f_{ref} is an external signal, the VCO in the PLL will track that frequency.

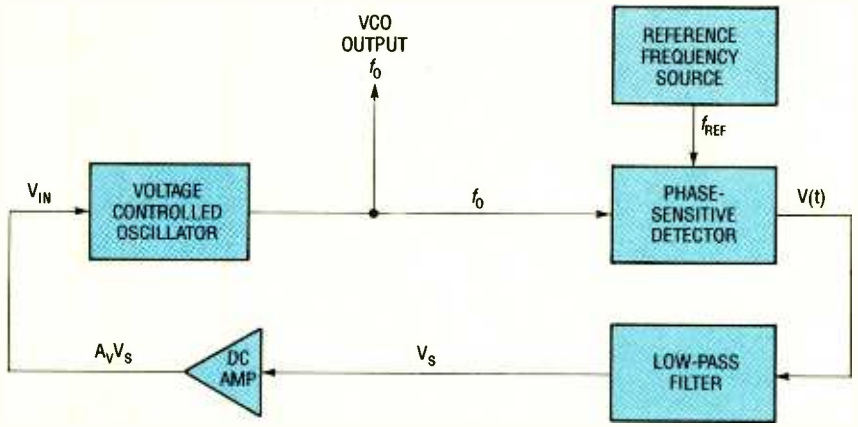

Fig. 1. The main elements of a PLL are a voltage-controlled oscillator (VCO), phase detector, reference frequency source, and a low-pass filter.

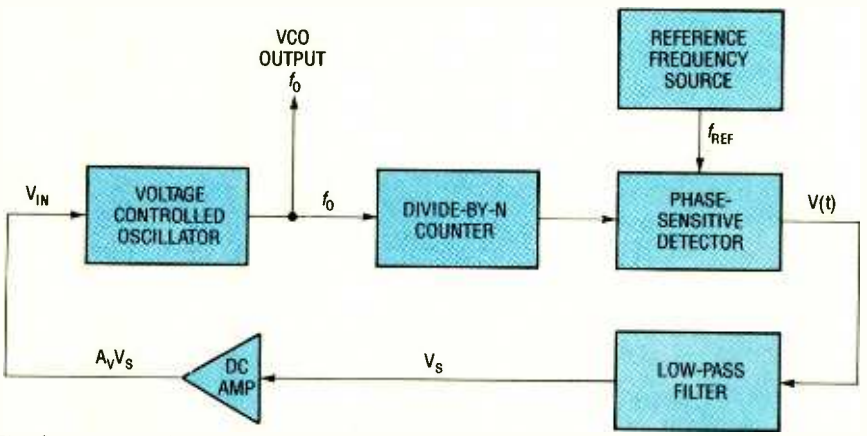

Fig. 2. This modified phase-locked loop differs from the one shown in Fig. 1 in only one respect; a divide-by-N counter has been added between the VCO output and the phase-detector input. The divide-by-N counter is used to reduce the VCO's output frequency by a predetermined factor.

The phase detector is a circuit that compares two signals and generates an output that is proportional to the phase difference between them. In a PLL, the phase-detector output signal, V_t, will be either a pulse train (in digital phase detectors) or a DC voltage (analog phase detectors). In both digital and analog phase-detector circuits, the output must be processed in a low-pass filter in order to remove residuals of f_o and f_{ref}.

In the digital case, the low-pass filter also serves to create the DC control voltage by integrating (*i.e.*, time-averaging) the pulse train produced by the phase detector.

Modified PLL. A modified form of the phase-locked loop is shown in Fig. 2. That circuit is the more common of the two in transmitter-frequency control, signal generators, and other applications where presentable, discrete frequencies are needed. The basic difference between the two circuits is the divide-by-N counter between the VCO output and the phase-detector input port. The reference frequency must be an integer sub-harmonic of the desired output frequency that must be produced by the VCO: $f_{ref} = f_o/N$.

The divide-by-N digital counter can be used to change the frequency of the VCO. If the division ratio of the counter is changed, then the VCO will be pulled to the one new frequency that maintains the equality $f_{ref} = f_o/N$. The pulling is caused by the DC control voltage that changes when the difference between the two frequencies is applied to the phase-sensitive detector (PSD).

There are three modes of operation in a PLL: free-running, capture (also called search), and locked. In the free-running mode, the VCO is not under control, and operates on an essentially random frequency within its range. That condition is also called "unlocked" operation. The PLL is typically in the free-running mode for a brief period after turn/on, and after that will be free-running only if a defect is present.

In the capture mode, the PLL is attempting to lock onto the correct frequency, so the VCO frequency tends to converge toward the desired frequency. When the VCO reaches the correct frequency, and remains there, the PLL is said to be in the locked mode.

The reference frequency controls the output frequency because it is compared to the VCO output in the phase detector. When there is a difference between the VCO output and the reference frequency, a DC control voltage is generated, which tends to pull the VCO onto the correct frequency. Thus, the PLL is a form of feedback control system, or "electronic servomechanism." The reference frequency also sets the minimum step between discrete VCO frequencies.

The stability of the PLL is set by the stability of the reference-frequency source. In the most stable systems, such as signal generators or transmitter-channel controllers, the reference frequency is provided by a crystal oscillator that is either temperature compensated or operated inside a stabilization oven. The output frequency of the crystal oscillator may be divided in a divide-by-N chain of digital counters to produce a low frequency, such as 5 kHz, 1 kHz, or 100 Hz (those frequencies are not easily obtained in crystal oscillators).

Sub-Audio Frequency Meter. The block diagram of Fig. 2 can be used as the basis for a phase-locked loop Sub-Audio Frequency Meter. The VCO operates over a range that is either 100 or 1000 times the input frequency range. The VCO output is divided in a divide-by-N counter (where N is either 100 or

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1000) before being applied to the VCO port of the phase-sensitive detector. The sub-audio input frequency is applied to the alternate input port of the PSD in place of the reference-frequency source.

If N equals 100, the VCO will oscillate at a frequency that is 100 times higher than the input signal applied to the reference-frequency input of the PSD. For example, if a 10-Hz signal is applied to the PSD, the VCO output will read "1000 Hz" on the output counter used to measure the frequency. That reading should be interpreted as 10.00 Hz.

For our Sub-Audio Frequency Meter, we'll use the CMOS 4046 PLL, a block pinout diagram of which is shown in Fig. 3A. That chip will operate at frequencies from only a few hertz up to 1 MHz, so it's ideally suited to our purpose. The 4046 PLL includes a VCO and a pair of phase detectors (each for slightly different purposes), but the low-pass loop filter is part of a feedback network that is external to the 4046 (see Fig. 3B).

If the circuit uses one of the internal PSD circuits, the output of the loop filter is applied to either pin 2 or 13 of the 4046. The programing resistors (R1 and R2) set the minimum and maximum frequencies of the 4046 VCO. The minimum-frequency resistor connected to pin 12 is optional, but the maximum-frequency resistor at pin 11 is *not*.

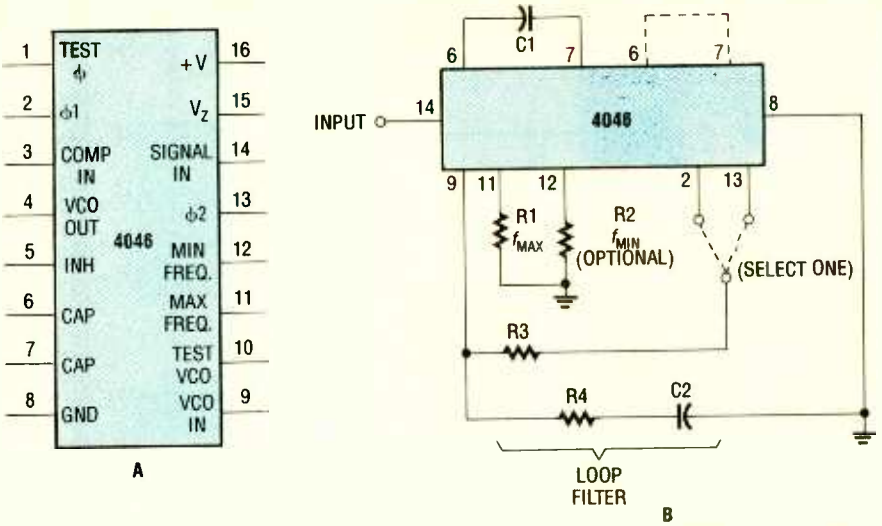
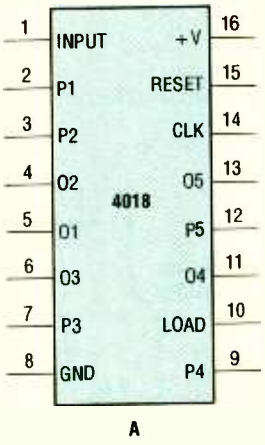


Fig. 3. The block diagram in A gives the pinout for 4046 CMOS PLL. Shown in B is the typical 4046 circuit configuration.



	TO DIVIDE BY:				
	2	4	6	8	10
CONNECT PIN1 TO PIN:	5	4	6	11	13

B

	TO DIVIDE BY:			
	3	5	7	9
CONNECT INPUT PIN1 TO AND GATE OUTPUT:	5	4	6	11
CONNECT GATE INPUTS TO 4018 PINS:	A N D 4	A N D 6	A N D 11	A N D 13

C

Fig. 4. The 4018 (the pinouts for which are shown in A) is a programmable CMOS divide-by-N counter. The tables in B and C indicate which pin should be connected back to pin 1 to make the counter divide the input signal by a particular number; B is for even division ratios, while C is for odd division ratios.

PARTS LIST FOR THE SUB-AUDIO FREQUENCY METER

SEMICONDUCTORS

U1—LM311 voltage-comparator, integrated circuit
U2—4046 CMOS phase-locked loop, integrated circuit
U3, U4—4018 divide-by-N counter, integrated circuit
U5—78L05 5-volt, 100-mA voltage-regulator, integrated circuit

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—3300-ohm
R2—1-megohm
R3—100,000-ohm
R4—680,000-ohm
R5—6800-ohm

CAPACITORS

C1—.01-μF, ceramic disc
C2, C4, C5—2.2-μF, 16-WVDC, electrolytic
C3—0.1-μF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

J1, J2—RCA jack
Printed-circuit or perfboard materials, enclosure, 12-volt source, etc.

The 4046 does not have an internal divide-by-N counter. In our circuit, the divide-by-N function is handled by a pair of CMOS 4018 programmable divide-by-N counters connected in cascade. The 4018 (see Fig. 4A) is a "walking ring" synchronous counter that is programmed via external feedback. The even divide-by-N (2,4,6,8 and 10) ratios are easily obtained. The input terminal (pin 1) is connected to one of the "0" outputs (01, 02, 03, 04, or 05) according to the table in Fig. 4B. Because our project needs a divide-by-100 counter, two 4018's set as decade dividers ($f = f_{in}/10$) are used.

The 4018's are set to divide-by-10 by connecting the "05" output (pin 13) to pin 1. The 4018 will also do odd-integer division ratios (3, 5, 7, and 9), but the circuit is a little more complicated. The input (pin 1) is driven from an external AND gate. The two inputs of the AND gate are connected to two of the "0" outputs according to the protocols in Fig. 4C.

Figure 5 shows the schematic diagram for the Sub-Audio Frequency Meter based on the 4046 phase-locked loop. The circuit will operate from 3 Hz to more than 100 Hz. The input signal from J1 is first conditioned to produce a square wave. Signal conditioning is handled by an LM311 comparator (U1). The output of U1 is used to drive the input of U2 (pin 14). The VCO output of U2 is sent to output jack J2, where it is routed to a regular digital frequency counter for display. That frequency is designated f_o, and is 100-times the frequency applied to J1.

The VCO output of the 4046 also drives a cascaded pair of 4018's, U3 and U4 (each set for divide-by-10), for an over-

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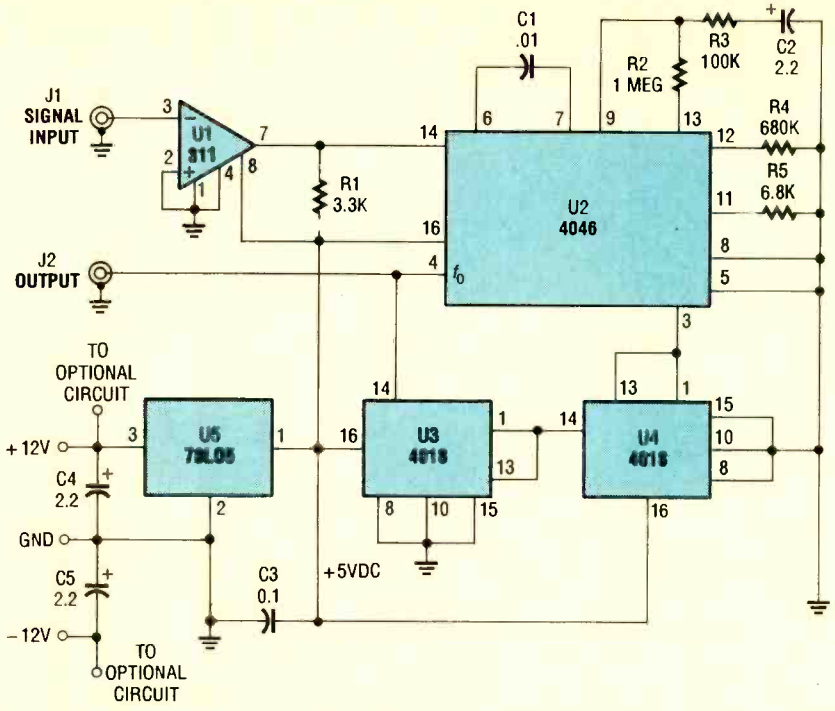

Fig. 5. The schematic diagram for the Sub-Audio Frequency Meter. The circuit operates from 3-Hz to more than 100-Hz.

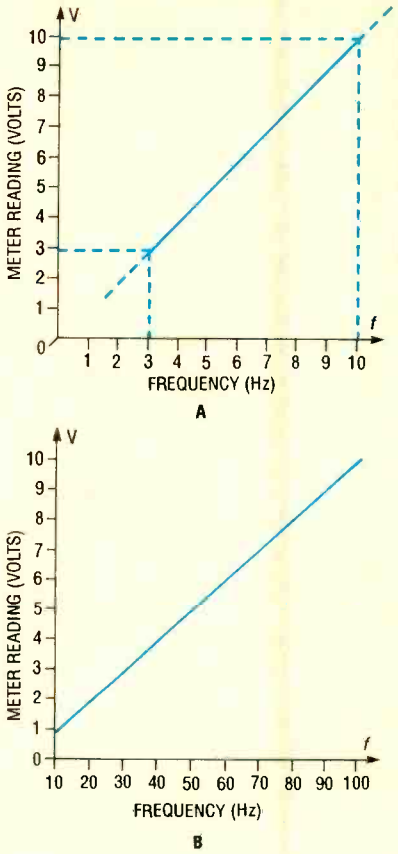

Fig. 7. Here's the output transfer function for the analog-display circuit. From 0 to 10-Hz is shown in A, while 0 to 100-Hz is shown in B. The voltages can be read on either a digital voltmeter (which makes the display quasi-digital) or an analog meter.

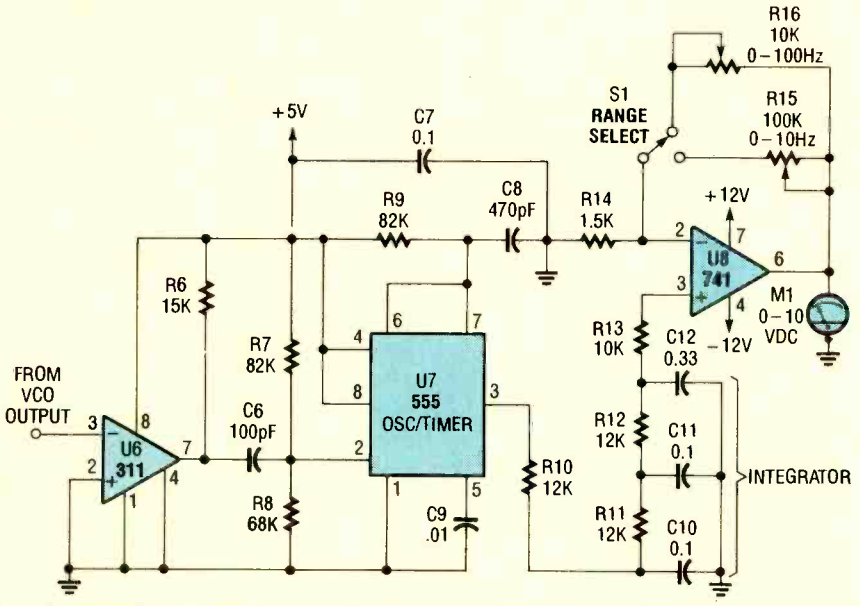

Fig. 6. An analog display can be added to the Sub-Audio Frequency Meter by adding this optional circuit—a frequency-to-voltage converter based on the 555 oscillator/timer—to the one shown in Fig. 5.

all frequency division of 100. The output of U4 is at a frequency of $f/100$, and is applied to the phase comparator input of U2 where it is used to lock the VCO on a frequency of 100 × f_{in}.

We can measure the sub-audio frequencies that the typical low-cost counter finds difficult by monitoring the VCO output frequency on an external digital-frequency counter. But what about readers who don't own a digital frequency counter? For them, an analog indicator is also provided.

Analog Display Circuit. An analog display can be added to the Sub-Audio Frequency Meter by incorporating the optional circuit in Fig. 6 to the circuit shown in Fig. 5. The circuit in Fig. 6 is a frequency-to-voltage converter based on the 555 oscillator/timer.

That circuit takes the time-average of the input pulses. If the pulses are controlled so that the only variable is the number of pulses per unit of time, then the time-average will be a DC voltage that's proportional to the applied frequency. That requires that the pulses have a constant amplitude and constant duration. The minor inadequacy is easily corrected by a simple signal-conditioning circuit.

The input signal is conditioned by U6 (an LM311 comparator) to overcome any sloppiness due to drive-limitation problems in the 4046. The output of U6 is a square wave, and it is differentiated in the RC network consisting of C6, R7, and R8. The differentiated signal is used to trigger U7 (a 555 oscillator/timer, configured as a one-shot).

The 555 one-shot produces one constant-amplitude, constant-duration output pulse every time it is triggered. Thus, the output pulse train varies only in repetition rate according to the input frequency. If the pulses are integrated to find the time-average of the pulse train, a DC level that's proportional to the applied frequency is produced. An RC integrator consisting of R10–R12/C10–C12 produces the DC input. If the

(Continued on page 104)

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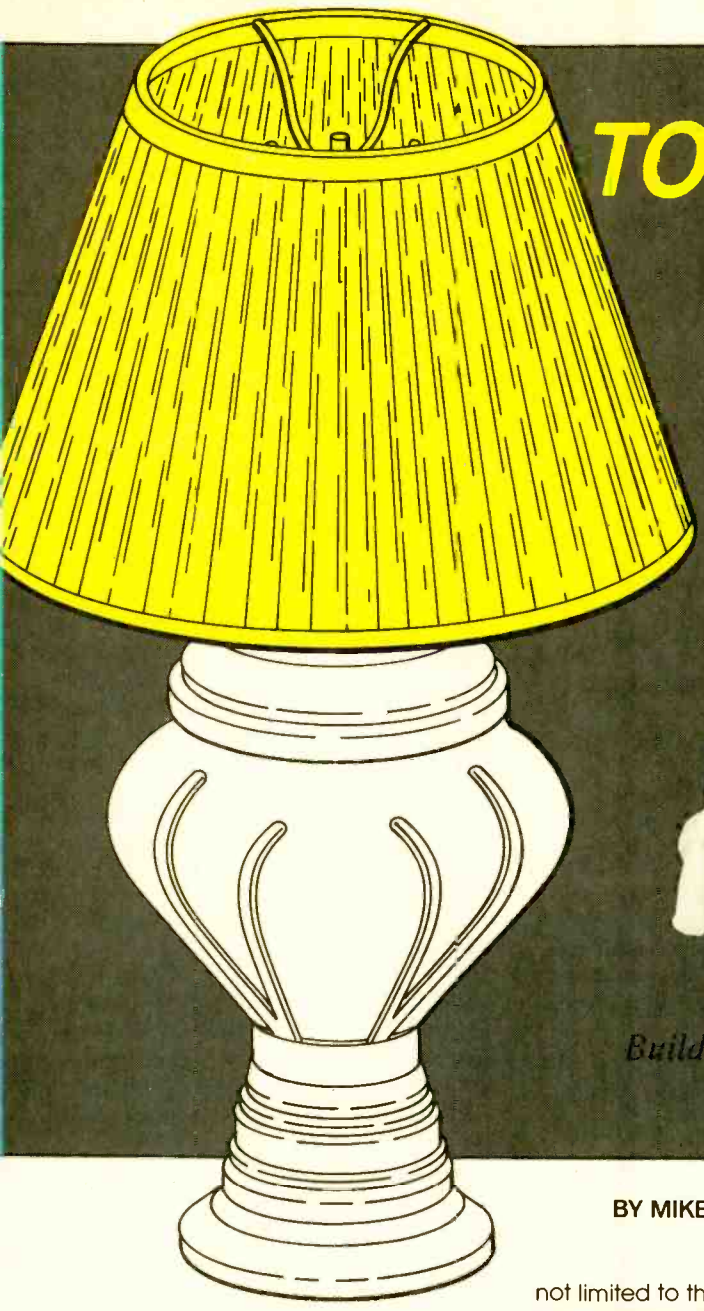
TOUCH-CONTROL DIMMER SWITCH



Build this lamp-control circuit and never buy a 3-way bulb again!

BY MIKE GIAMPORTONE

Touch-controlled lamps are very popular home-furnishing and electronic gadgets, but do you find them to be a bit pricey? Would you like to build your own without putting a big dent in your hobby budget? Are you tired of buying expensive 3-way light bulbs? Do you have an existing lamp or wall switch that you'd like to control by a touch?

If you can answer yes to any of those questions, then you'll certainly be interested in the *Touch-Control Dimmer Switch*—a one-evening project. The circuit can be easily built for $10 to $15.

The circuit allows you to operate table or ceiling lamps by touching the metal base of a table lamp, a metal sensor plate, or a blank metal wall-switch cover plate. In addition, you are not limited to the simple on/off operation provided by most similar hobby-level circuits. You can build an on/off, a 3-way, or a 4-way touch switch.

All of that and more can be implemented on a single printed-circuit board, using LSI Computer Systems' LS7237 IC. The LS7237 is a monolithic, ion-implanted, MOS (*M*etal-*O*xide *S*emiconductor) device that's designed for AC (*A*lternating *C*urrent) power-control applications.

How It Works. Figure 1 is the schematic diagram of the Touch-Control Dimmer Switch. The circuit consists of U1 (the LS7237), a Triac, and a handful of support components. When the circuit is plugged into an AC outlet, U1's output (at pin 8) is in the off state. (The output of U1 is positive, so D2 is reverse-biased and passes no current, except, of course, some small leakage current.)

Touching the sensor plate causes a signal to be applied to pin 5 of U1. That in turn, causes U1 to output a negative pulse of fixed duration at pin 8. The negative output of U1 is fed to diode D2, forward-biasing it. With D2 forward-biased, a trigger pulse is applied to the gate of TR1, causing it to conduct.

Triac TR1 is connected in series with the load—in this case, an incandescent lamp represented in Fig. 1 by I1. After that, every time the sensor plate is touched, the output steps to the next level of brightness. The next step following the maximum brightness is the off state, initiating a new sequence.

The lamp's brightness is determined by the output phase angle (Triac triggering angle) in relation to the AC-line frequency. The output angle can be easily varied by applying a low-level pulse to the SEN input (pin 5) or a high-level pulse to the SLV input (pin 6) of U1.

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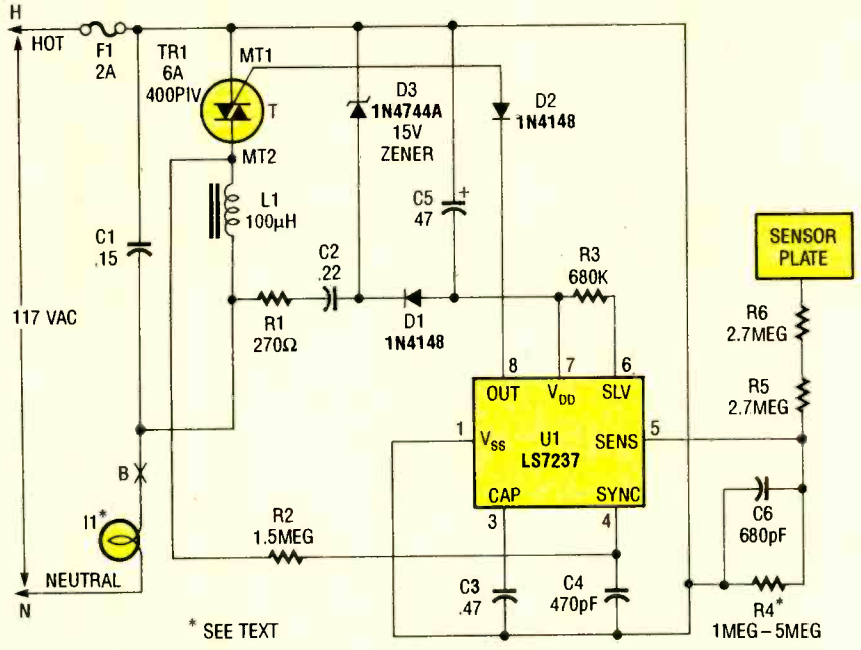

Fig. 1. The Touch-Control Dimmer Switch consists of little more than U1 (an LS7237 touch-controlled dimmer switch), a triac, and a handful of support components.

That's accomplished by touching the appropriate sensor plate. The internal PLL (*P*hase-*L*ocked *L*oop) guarantees the exact same brightness levels from IC to IC.

Power for U1 is derived from the AC line by feeding the line voltage through a 15-volt Zener diode (D3) and D1. Capacitors C2 and C5 are included in the circuit to help maintain a constant voltage for the circuit. Resistor R2 and capacitor C4 filter the signal fed to the SYNC input (pin 4) of U1, which is used to synchronize the internal PLL with the line frequency.

Resistor R3 is used to limit current in the circuit in the event that the extension circuits (if used) are incorrectly polarized. If extensions are not used, the SLV input (pin 6) should be tied to pin 7 (V_{DD}). Resistor R4 determines the sensitivity of the SEN input. Its value, which can range between 1 and 5 megohms, must be selected through the trial and error method.

Resistors R5 and R6 are two series resistors placed between you and the circuit, and are required by Underwriters Laboratories standards for your protection. In case of one resistor shorting out, you'll still have protection from the household lines. Capacitor C3 is used as a filter for U1's internal PLL. Diode D2 is used to decouple the Triac from U1, thereby protecting the IC from excursions that may occur during the triggered state of some Triacs.

Capacitor C1 and inductor L1 form an RFI (*R*adio-*F*requency *I*nterference) filter circuit, to prevent interference to radios, TV's, etc.

In case of a momentary power failure, the circuit remains unchanged for a period of up to one second. For longer power interruptions, the power is shut off.

The circuit may be programmed to operate in one of three modes by tying the MODE input (pin 2) to a specific voltage level. (See Table 1).

Construction. Before we get into the construction details of the project, a word of caution is in order: When working with household current, you must be especially careful. The Touch-Control Dimmer Switch should be installed in a plastic enclosure. Testing or operating the circuit outside of the enclosure or in one that is open is dangerous, because the circuit-board traces and heat sink carry household current.

Before assembly can begin, you must first decide where your Touch-Control Dimmer Switch is to be installed—in a wall junction box, in the base of a lamp, in a separate project box, etc. The intended location of the board will determine its shape. For instance, if the circuit is to control a table lamp, the round-shaped, printed-circuit template shown in Fig. 2 should be used. But, if the circuit is to control an overhead light, the template shown in Fig. 3 is the way to go. Choose the printed-circuit template that best suits your situation.

The round template shown in Fig. 2 fits under or in the base of many table lamps. The center hole should be the proper size for your lamp. I used a ½-inch (O.D.), .062-inch wall, ⅞-inch long, piece of polyethylene tubing, for a shim or insulator between the lamp rod and the circuit board. That makes the hole in the center of the round board about ½ inch in diameter.

The round printed-circuit board fits nicely in a discarded plastic enclosure from a roll of electric tape (like those that 3M's Super 33+ comes in). If you decide to replace an existing wall switch, the rectangular pattern (see Fig. 3) fits neatly into most wall junction boxes. The rectangular pattern also fits well in many plastic enclosures and can be located away from the lamp being controlled, like under a table or couch.

After etching the printed-circuit board(s), drill holes for all the components. The size of holes required for the fuse clips, Triac, RFI filter, and R1 will have to be a little larger than those for the rest of the components. It's a good idea to drill the center hole in the round circuit board at this point, if the circuit is to be mounted on the lamp rod.

Once the board has been prepared, install the parts on the board using the appropriate parts-placement diagram; the parts-placement diagram for the round version is shown in Fig. 4, while the rectangular version's parts-placement diagram is in Fig. 5. Note: The lamp, I1, in either parts-placement diagram is not part of the circuit: it represents the lamp being controlled by the circuit. Whichever version you choose to assemble, it may be necessary to reduce the size of the heat sink. Heat sinks come in various sizes, depending on the manufacturer.

Mount the Triac in the well of the heat sink, using heat sink compound and the necessary hardware. Insulators of the type used when mounting transistors to

TABLE 1—MODE SELECTION CHART

Mode	Brightness sequence	Tie pin 2 to:
0	Off/max/off	Vss (pin 1)
1	Off/mood/med/max/off	Vdd (pin 7)
2	Off/night/mood/med/max/off	Float (no conn.)

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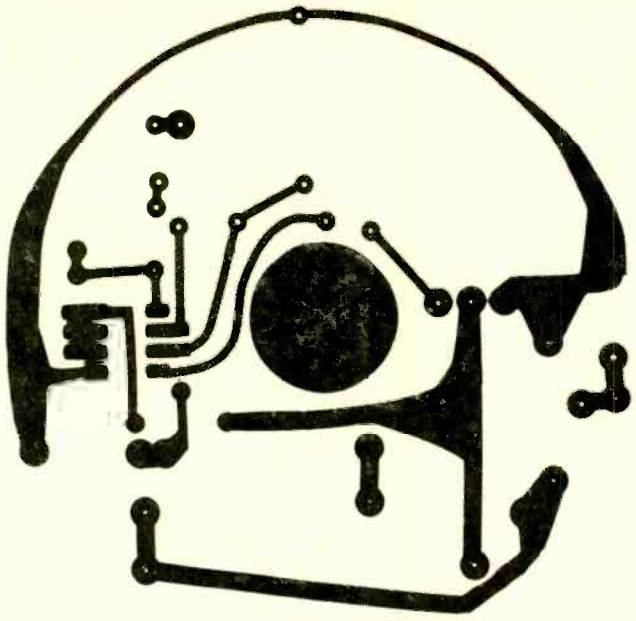

Fig. 2. This round version of the Touch-Control Dimmer Switch mounts easily into the base of a table lamp. The large circular pad at the center of the board should be bored with an appropriate size bit to accommodate the lamp rod (that's the metal tubing that runs through the center of most lamps to support the bulb socket).

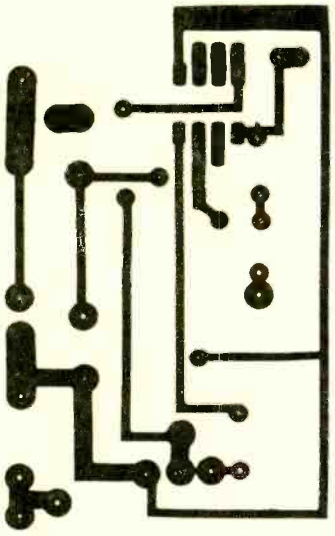

Fig. 3. The size and shape of this printed-circuit template fits neatly into a wall junction box, or a separate project box for those who prefer to keep the project separate from the lamp it controls.

heat sinks should also be used. When you are sure of the heat sink and Triac positioning, place a drop of nail polish on the screw where it meets the nut. The Triac should be mounted vertically on the rectangular board, and horizontally on the round version.

Next, install all of the polarized components; D1, D2, D3, C5, and an IC socket for U1. Then place and solder the rest of the components on the board. Once that's completed, solder a 3-inch piece of 18-gauge stranded wire to point H (hot) on the board, and another 3-inch piece of 18-gauge stranded wire to point B (bulb). The author color-coded his unit by connecting a black wire to the H terminal and a white wire to the B terminal, which conforms to the electrical wiring code.

Then a length of 22-gauge wire can be soldered to point SP (sensor plate). Very large sensor plates or very long runs of sensor-plate wire (greater than 3 feet) may require that an amplifier be added between the sensor plate and the input to U1.

If you haven't set the circuit's mode of operation, do it now using Table 1 as a guide. That's done by connecting either V_{SS} or V_{DD} to pin 2 (MODE), or by letting pin 2 float. For instance, to program the circuit for Mode 2 operation, pin 2 of U1 is left floating (unconnected).

Before going any further, clean all flux from the solder side of the board with a wire brush and flux remover. Place U1 into its socket and check the resistance between the sensor-plate wire and both AC leads (H and B). You should get a reading in the range of between of 5 to 10 megohms. If there is significantly less resistance, do not use the unit until you've found and corrected the problem as an electrical shock might occur. Inspect your work for solder bridges, and incorrectly placed or faulty components.

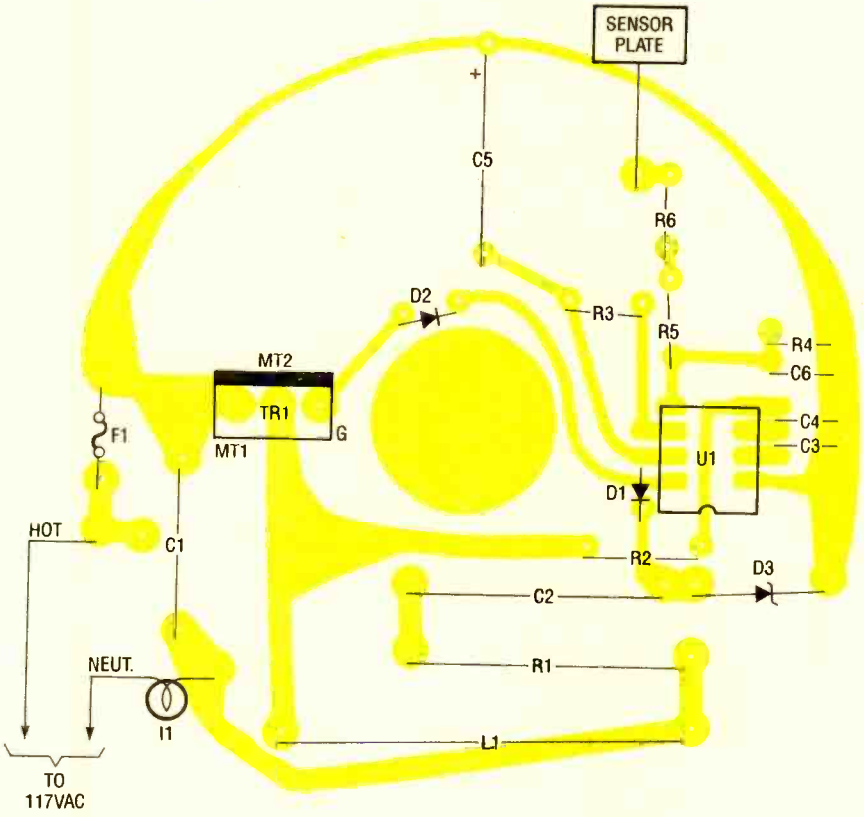

Fig. 4. When assembling the round version of the circuit, populate the board using this parts-placement diagram as a guide.

Hook Up. The wire coming from point H on the board must be connected to the hot side of the AC outlet and point B must be connected to one of the bulb

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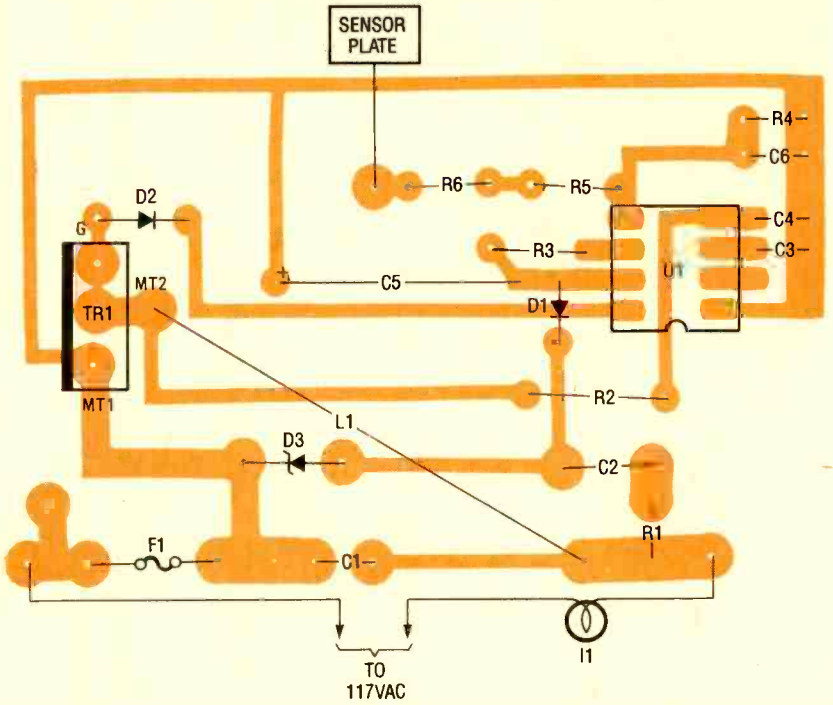

Fig. 5. Follow this parts-placement diagram when assembling the rectangular version of the circuit.

wires. The second wire from the bulb is connected to the neutral side of the AC outlet. Refer to Fig. 6.

The neutral line can be determined by using a multimeter or voltmeter. To do so, place the meter on the 250-volt (or higher) AC scale, and carefully place the probe tips into a 117-volt outlet. You should get a reading of between 110 and 120 volts AC from the small spade slot (hot) to the large spade (neutral or common), and a similar reading between the small slot (hot) and the round hole (ground). You should also get a reading of zero volts between the large spade slot and the ground hole, indicating that the small spade slot is hot.

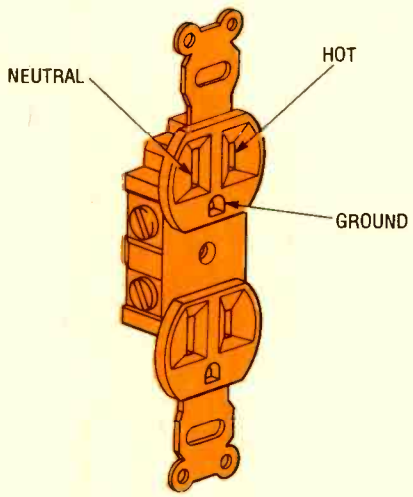

Fig. 6. This simple diagram can help simplify wiring the circuit into a table-lamp base. Simply follow the instructions in text and you should breeze right through the installation.

If you get any readings other than those mentioned, the outlet is most likely wired incorrectly. (Contact an electrician to correct the situation.) If you are not comfortable working with AC line voltage, get help. Note: The project will not work unless correctly wired. A polarized power plug, the type with two spades (one larger than the other) should be used to power table-lamp projects. That guarantees proper polarity going to the project. If your lamp does not already have a polarized plug and you have a problem finding one, use a 3-prong plug, even if you don't use the round ground spade.

For wall socket installations, if you haven't been trained to work with household wiring, have an electrician wire the project into the junction box. The author used a plastic wall junction box to house the rectangular version of the board. If, however, your circuit is mounted into an existing metal junction box that contains bare ground or other wires, the project and/or wires must be insulated to prevent electrical contact with the circuit board. A plastic shield cut from a butter-bowl lid and glued to the solder side of the circuit board can serve as the insulator. Don't forget to check local building codes before installing the circuit.

The polarity of the wiring within the junction box can be determined in much the same manner as described above. Turn off power to the light switch at the fuse box. Remove the cover plate and the switch-retaining screws. Pull the switch out into the open without touching or removing wires at this time. Turn power back on and determine polarity. (Don't forget that one of the wires at the switch is the hot lead and the other is the bulb wire.)

Behind the switch, there should be a set of twisted white wires; they should be the neutral wire from the household breaker box; the neutral wire to the fixture; and possibly a third wire for the

(Continued on page 102)

PARTS LIST FOR THE TOUCH-CONTROL DIMMER SWITCH

SEMICONDUCTORS

U1—LS7237 touch-control dimmer/AC motor controller, integrated circuit
TR1—6-amp, 400-PIV Triac
D1, D2—1N4148 general-purpose, small-signal, silicon diode
D3—1N4744A 15-volt, 1-watt, Zener diode

RESISTORS

(All resistors are ¼-watt, 5% fixed units, unless otherwise noted.)
R1—270-ohm, ½-watt
R2—1.5-megohm
R3—680,000-ohm
R4—1–5-megohm, see text
R5, R6—2.7-megohm

CAPACITORS

C1—0.15-µF, tubular metallized-polyester
C2—0.22-µF, tubular metallized-polyester
C3—0.47-µF, Mylar
C4—470-pF, ceramic-disc
C5—47-µF, 25-WVDC, electrolytic
C6—680-pF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

F1—2-amp fuse (Mouser #44M052)
L1—100-µH, filter choke (Mouser #542-5248, or similar)
Printed-circuit materials, enclosure (see text), IC socket, fuse holder (Mouser #44FH052, two required), heat sink, wire, solder, hardware, etc.

Note: The LS7237 is available from Belco Electronics, 194 N. Myrtle Ave., Elmhurst, IL 60126; Tel. 312/953-1115. The price is two for $8.90, or three for $11.40, payable by check or money order. Charge cards not accepted. Price includes UPS shipping, handling, and insurance. When ordering, request data sheets. Illinois residents add appropriate sales tax.

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Booster Amp for Your Car Stereo

Add audio "umph" to your car radio, and travel the highways in high-fidelity splendor!

BY GORDON KAYE

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 lot's 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 impedance 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. The amplified output of U1 is fed to a loudspeaker for audio reproduction. Note the unusual output circuitry; Instead of a single-ended output, dual amplifiers in the chip provide a push-pull output.

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 6⅞- by 3¾-inch printed-circuit board, an extruded rectangular aluminum channel 6⅞-inches long, and a plastic zip-bag

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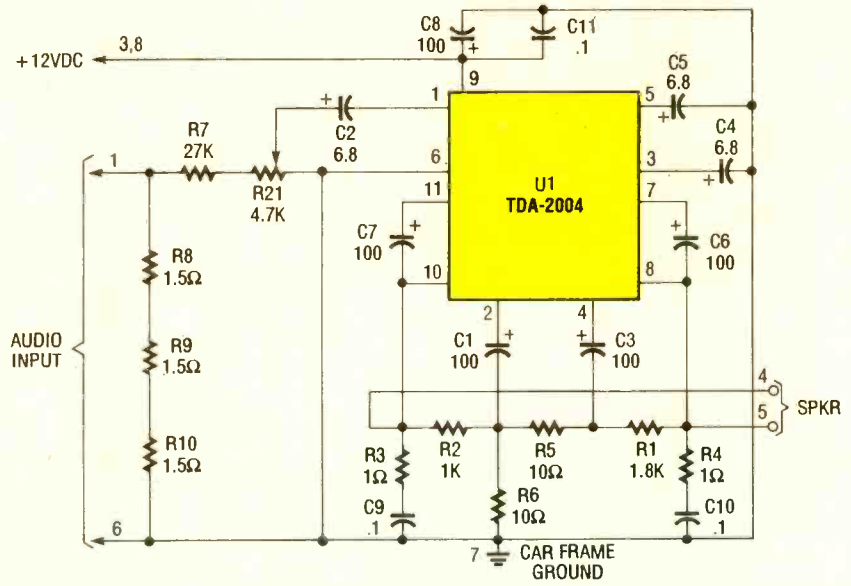

Fig. 1. The two channels of the the Car-Radio Booster Amplifier are identical so only half of the circuit is shown. The numbered terminals (input, output, etc.) correspond to the eleven-pin connector detailed in Fig. 3.

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-μF units for capacitors C1, C3, C6–C8, C12, C16, C17, C19, and C20; and 6.8- or 10-μF 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

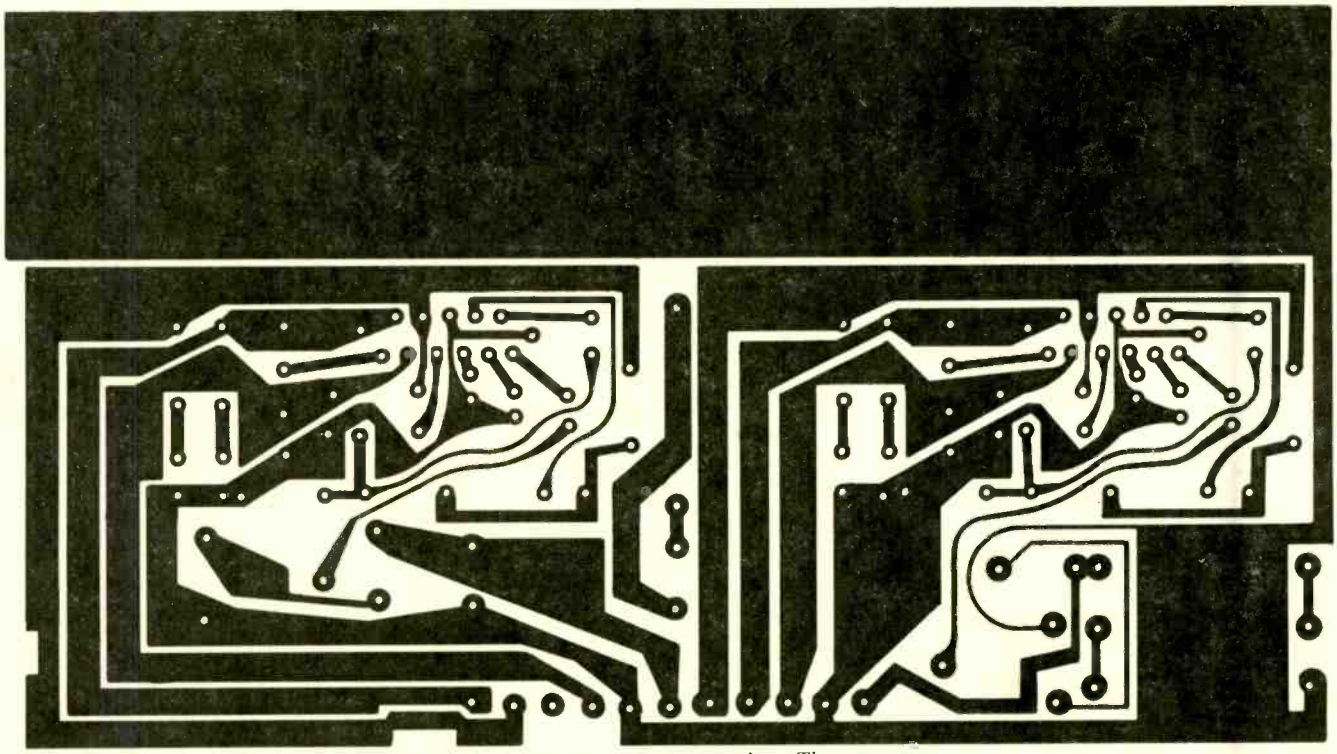

Fig. 2. If you wish to make your own circuit board, use this same-size template. The extra heavy copper runs are use to permit safe handling of heavy currents.

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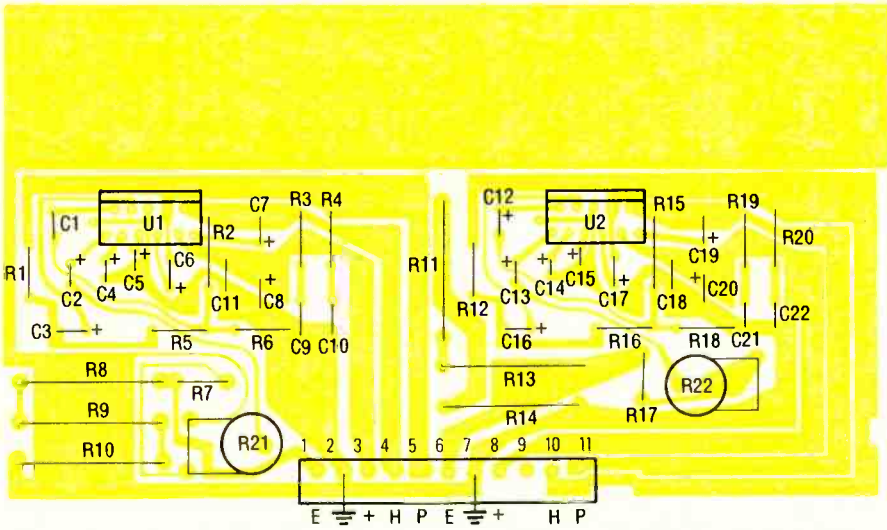

Fig. 3. Parts layout for the Car-Radio Booster Amplifier are shown here. Note that the board is divided into two sections keeping the amplifiers apart.

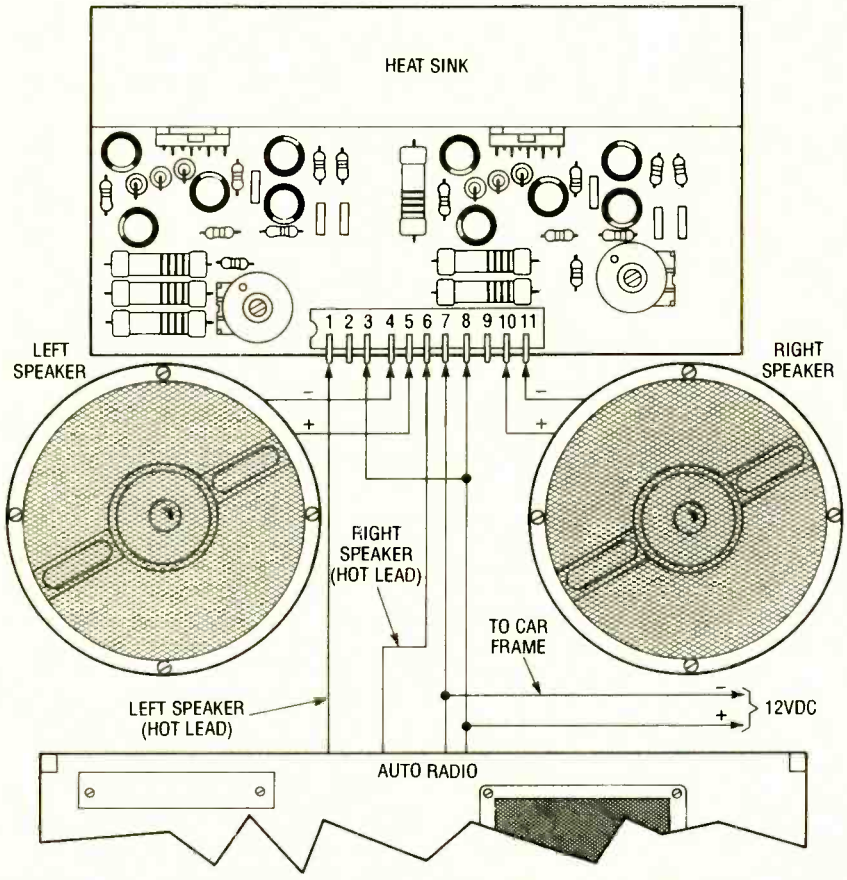

Fig. 4. The installation diagram is simple to follow. Power is taken directly from the auto's battery. There is sufficient filtering on the circuit board to eliminate alternator whine and noise usually found riding on DC voltage.

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 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 102)

PARTS LIST FOR THE AUTO-RADIO BOOSTER AMPLIFIER

SEMICONDUCTORS

U1, U2—TDA-2004, 20-watt rms, audio amplifier, integrated circuit

RESISTORS

(All resistors are ¼-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-μF, 16-WVDC, electrolytic
C2, C4, C5, C13—C15—6.8-μF, 16-WVDC, electrolytic
C9–C11, C18, C21, C22–0.1-μF, 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.

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Popular HANDS-ON REPORT Electronics

CIRCLE 125 ON FREE INFORMATION CARD

Beckman Industrial Circuitmate DM27 Digital Multimeter

It's light, easy to use, multi-purpose, and a project builder's most valuable instrument!

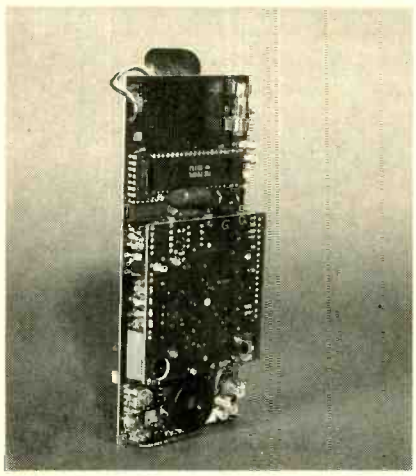
It can happen to you! While working on the ignition system of a car, you forget that the multimeter is under the hood and you start the engine (as I did). Before you can say "Oops!" the fan snares the test leads and whips the multimeter around for a few turns, banging it about the engine compartment before it flips the meter onto the driveway surface in practically three equal pieces. (Even my test leads were not salvageable.)

A trip to the local electronic-parts distributor made me aware of *Beckman Industrial's Circuitmate DM27 Digital Multimeter*. I guess I had my old multimeter too long because the DM27 was less expensive, exhibited superior construction and design quality, and it provided not only the basic functions you would expect to find in a hand-held meter, but it had several additional functions to boot! Hat's off to inflation in reverse.

Specifications. The DM27 Digital Multimeter has a 3-½-digit, liquid-crystal display (LCD) with a maximum reading of 1999. Negative going DC at the test leads causes the LCD to generate a negative sign—there's no chance of blowing the meter's DC circuitry. What is special about the LCD is that the dense contrast between the dark numeral elements and the "silvery" background offers a sharp image even in poor lighting situations.

The meter reads zero when the test leads are disconnected or left floating—that's done automatically by the unit's circuitry. Also, the LCD provides a visual low-battery indicator, and an annunciator tells you if the range setting is too low.

Volts and Amps. There are five DC/AC voltage ranges spanning from 0.2 to 1000 volts DC, and 0.2 to 750 volts AC. The input resistance is 120 megohms. The DC scale's accuracy is 0.8%, ±1 digit; the AC scale's is 1.2%, ±3 digits. Maximum voltage overload is 1200 volts DC, and 850 volts AC for a 60-second maximum period. However, for the the lowest voltage ranges, the maximums are 500 volts DC, and 350 volts AC for a 15-second maximum period.


Although you'll never need to take the cover off, this is what the feature-filled DM27 looks like in the buff. There's a lot in there, especially for the money.

Four DC ampere ranges allow the instrument to cover from 200 μA to 10 amps. AC ampere readings are stepped in three ranges from 20 mA to 10 amps. That covers almost all the test-bench current measurements you'll ever make. Except for the 10-amp range, the DC ampere reading accuracy is 1.25%, ±3 digits and the AC ampere reading accuracy is 1.8%, ±4 digits. On the 10 amp range, the DC accuracy is 2.5%, ±3 digits; the AC accuracy is 3.0%, ±4 digits.

Getting Resistance. For measuring resistance there are seven ranges from 200 ohms to 2000 megohms. Except for the two top ranges (20 megohms and 2000 megohms), the scale accuracy is 1.2%, ±2 digits (it's ±4 digits on the lowest scale).

Here we put the DM27 to the test. Using 1% precision wire-wound resistors at their rated temperature, the DM27 measured a 1000-ohm resistor as 1.001 kilohms, well within the tolerance of the DM27 multimeter. A 15,000-ohm precision resistor measured 14.94 kilohms; again, well within the tolerance of the unit. A few other checks were made and all tests on all scales proved the reading accuracy to be within the limits of the manufacturer's claims.

Whenever the measured resistance was 100 ohms or less, a high-frequency squeal came from the DM27. That's a

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GIZMO®

NOVEMBER 1989

VOLUME 2, NUMBER 11

A CHRONICLE OF CONSUMER ELECTRONICS

Culinary Calculations

KITCHEN WHIZ KITCHEN COMPUTER. Manufactured by Seiko Instruments, U.S.A., Inc., 2990 W. Lomita Blvd., Torrance, CA 90505. Price: $59.95.

CIRCLE 50 ON FREE INFORMATION CARD

If *Seiko Instruments* can get itself organized, it may have a real winner of a product in its *Kitchen Whiz*, a calculator designed specifically for simplifying food-preparation problems.

Using conversion algorithms based on a patent held by MIT (U.S. patent number 4,100,602) the Kitchen Whiz's stated purpose in life is to help you to convert recipes to serve numbers of people different from those for which they were intended, or to provide a different number of servings. Say, for example, that you have a recipe that serves four people, but that you want to make enough for seven. After informing the calculator of the original number of servings and of the number you intend to make, you enter the original quantity of an ingredient in the recipe and press the CONVERT key—and there's the proper amount you'll need. Do that for each ingredient and you'll be able to make enough of your "Chicken Caroline" for everyone.

The Kitchen Whiz will take you a step further, too. With it you can recalculate recipes not only to make a different number of portions but, in addition, to make the portions a different size. You can go from, say, five five-ounce portions to twelve four-and-a-half-ounce ones. And that brings us to another neat feature of this kitchen computer—you can enter numbers with fractional parts without having to convert them to decimal form. For example, you don't have to stop and convert 3⅓ cups to 3.333 cups, but can enter the fraction directly. It takes a couple of extra keypresses to inform the calculator that a number is a fraction, but if you don't have the decimal equivalent handy, that feature can make work simpler for you. Fractions appear in a special space at the right of the display and get rounded off to the nearest sixteenth—close enough for just about any recipe. The calculator can also be used simply to convert decimal numbers to their fractional equivalents, or vice-versa.

The Kitchen Whiz performs other conversions too, from just about any common English measurement—cups, ounces, gallons, tablespoons, even pinches (which equal ½ teaspoon in the Kitchen Whiz world)—to any other, or to its metric equivalent. The calculator performs not only weight and volumetric conversions, but also metric-to-English conversions for distance. (That makes the Kitchen Whiz doubly useful, perhaps, if you're entered in a cooking competition in Paris to prepare your grandmother's New England clam chowder, and want to know how far in miles you have to travel from Lyons to get there.) You can also convert temperatures from Celsius to Fahrenheit and back. Finally, using its recipe-conversion function, the Kitchen Whiz can also perform ratiometric calculations on lengths. But if you try to perform conversions on incommensurable units—from length, say, to volume—the computer senses the error of your ways and beeps at you.

This device also works as an ordinary four-function calculator with memory. And, oh yes, there's a built in clock to tell you the time of day or the date, as well as a countdown timer that can be preset for up to 23 hours and 59 minutes.

The Kitchen Whiz has a large LCD readout that's easy to read under typical kitchen lighting. Although the numbers are large, the words that tell you what mode it's in are tiny and difficult to make out. The device is powered by two "AA" batteries and is housed in a white plastic case that's just the right size for countertop use. A bracket at the rear of the case allows the calculator to be propped forward, or to be hung from a couple of hooks on the wall. A membrane keyboard prevents damage from inadvertent spills and makes the unit easy to clean.

Now for the "gotchas." As we said at the start, there are some problems with the Kitchen Whiz. These are by no means insurmountable, but they can be confusing to the first-time user. (We have been told by Seiko Instruments that a second-generation, slightly different version of the calculator will be available later this year and that not the least of its improvements will be a much improved manual.)

As an example of the Kitchen Whiz's peculiarities, there is something funny in the algorithm used to convert from one English measure to another. While metric-to-metric conversions work fine, English-to-English ones seem to be off by just a *little* bit. For example, converting a gallon to its equivalent in ounces gives a result of 128.000013 ounces. Strange, but since this is much less than a "pinch," it can be ignored.

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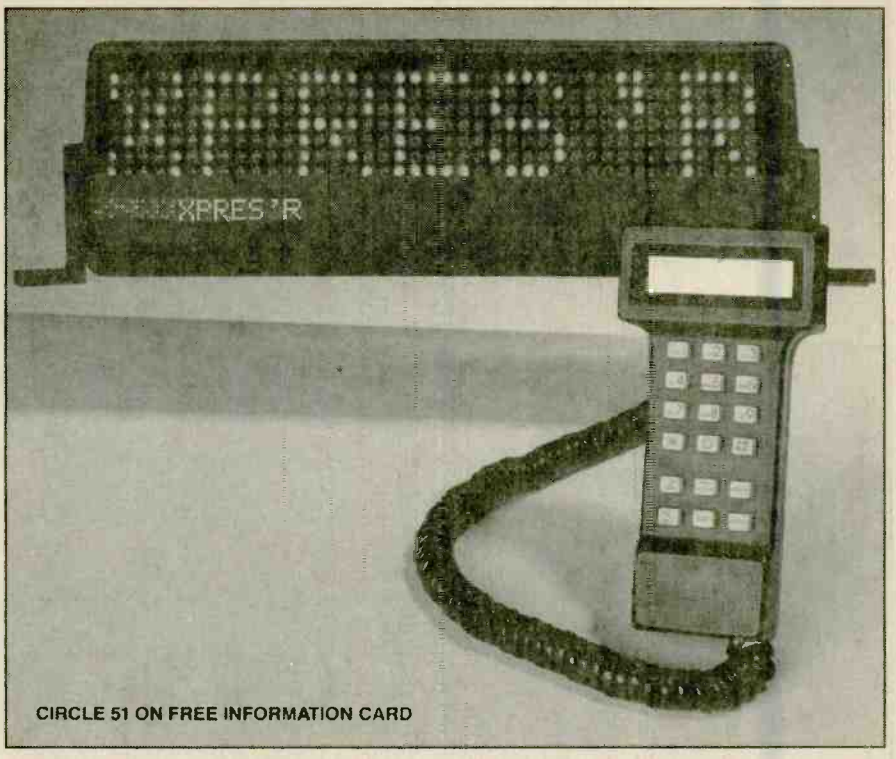

CIRCLE 51 ON FREE INFORMATION CARD

Xpres Yourself

XPRES'R AUTOMOTIVE MOVING-LED SIGN. Manufactured by: XPRES Communications, Inc., 755-601 West Broadway, Vancouver, B.C., Canada V5Z 4C2. Price: $400.

Wouldn't it be great if you had a way to let that jerk who's tailgating you down the highway at 65 miles an hour know what you thought of him? Or to ask him to *please* dim his high beams? Or to invite that cute chick in the car behind you at the traffic light out for a drink? Well, thanks to a device from *XPRES Communications*, you can.

XPRES'R is the automotive equivalent of the big Spectracolor sign in New York's Times Square. It's a 2-inch by 12-inch LED array that you mount facing out the rear window of your car. With it you can flash a variety of messages—either "canned" from the manufacturer or of your own device—to those close enough behind you to make them out.

The LED matrix consists of 287 "superbright" red LED's and can display seven letters or graphics symbols at a time. The LED's are said to be visible even in the light of day. We had some difficulty making them out in the bright sunlight prevalent in our area, although at dusk and thereafter they were quite visible. Actually, you could read them during the day, too, but you had to know what to look for in advance—the display wasn't bright enough to attract attention all by itself under daylight conditions.

XPRES'R comes with 198 preprogrammed messages and words, many of which relate to highway safety. The messages range from "Don't drink and drive" to "Not so close please" to "Can you believe that?" The messages are displayed by pressing two digits on the numeric keypad of a cellular-telephone-like control device, which also contains an LCD used in programming the device. XPRES'R's ROM also contains a collection of individual words that you can combine to make long messages of your own. And, rounding out the built-in messages, is a small library of graphics symbols that can be assembled in various ways to make such things as arrows, cars, helicopters, and human stick figures.

To supplement the built-in messages and words, you can program your own message letter-by-letter from the telephone-like keypad. Each button, identical to the buttons found on ordinary *Touch-Tone* pads, contains two or three letters and a number. By pressing the button repeatedly, you can cycle through the letters, the number, and in the case of some keys, a few punctuation marks. There is a simple editing facility that allows you to correct your mistakes or modify messages after the fact. You cannot, however, change the messages or words burned into the unit's ROM—which includes the glaring spelling error in the word "conjestion."

Quite a liberal selection of words and phrases is provided, including such useful components as "I like," "Honk if," and "On board." Surprisingly, the word "please" is absent. Fortunately, you can add it to XPRES'R's vocabulary yourself.

Built-in messages and words are se-

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lected for display by pressing the number 1–99 on the keypad. Additional words are called up by pressing "star-number" and "double-star-number" sequences. The messages you create yourself are accessed with the "pound-sign-number" combination, where the number can be anything from "01" to "64." XPRES'R can store 1750 bytes (characters) of user-programmed words and messages in addition to its preprogrammed ones. They are saved in non-volatile EEPROM (*E*lectrically *E*rasable *P*rogrammable *R*ead-*O*nly *M*emory), which can be reprogrammed about 10,000 times.

When you compose messages, you have a choice of several ways to display them. The attributes you can attach to a message include: SCROLL, which allows you to scroll a message of any length across the display; POP, which causes a seven-letter(s)-or-fewer word or message to "grow" from the bottom of the display up; and BIG, which causes the display to appear in bold italic characters. Except for the case of scrolling messages, which can be of any length, screens, as they are called by XPRES, cannot exceed seven characters, which is the maximum the display can show at a time. Screens can be made to blink and flash at several different rates, even permitting a kind of crude animation effect. You can also set the duration of the display; your choices include running a message from one to five times, or repeating it for from five seconds to eight hours, or just repeating it continuously.

Incidentally, the unit consumes less than 100 mA in its standby mode, and about 700 mA when it's displaying a message. The manufacturer says that you can leave the display running for 48 hours in your car and still have enough juice left in the battery to start the engine.

Putting together messages is a lot like programming a computer, only not as intimidating to the novice. In fact, many of the principles that you apply in creating an XPRES'R message are directly applicable to computer programming. XPRES'R's programming facility includes a function called LINK, which permits you to attach bits and pieces of your own and XPRES'R's words and messages to one another to create longer ones. You can bring along most, although not all, of a screen's attributes when you link it to another screen.

This is how linking works: Each preprogrammed XPRES'R item has, as we've seen, a number assigned to it. Similarly, when you create a screen you also assign a number to that. Using LINK, you create a message (which has its own number) by telling XPRES'R's 80C31 microcomputer brain which numbers to call in a particular sequence to display the words and messages they represent. The process of assigning a number to a piece of data and then referring to that number to get at the data is exactly what happens inside a computer program. For frustrated programmers, putting together XPRES'R messages can be a lot of fun, especially when you use numbers to refer to other numbers to refer to still other numbers.

And that brings us to several pieces of advice about using XPRES'R. The XPRES'R instructions, and even a message on the box, warn you not to use XPRES'R when you're driving the car it's mounted in. Calling up a message requires that you enter a two- or three-digit number from the keypad. While you can do that one-handed, and even—after a little practice—more-or-less by touch, there is always the tendency to look down at the handset's LCD (which echoes what's going on on the LED device facing out the rear window) to verify that you hit the right keys and are getting the message you expected. Please don't try that while driving.

XPRES also cautions you that a device such as this may be illegal in some parts of the country. What we're even more concerned about is that the guy with his high beams on behind us at the stop light is also carrying a .22 under the seat of his pickup and will take it upon himself to deliver a reply to our message.

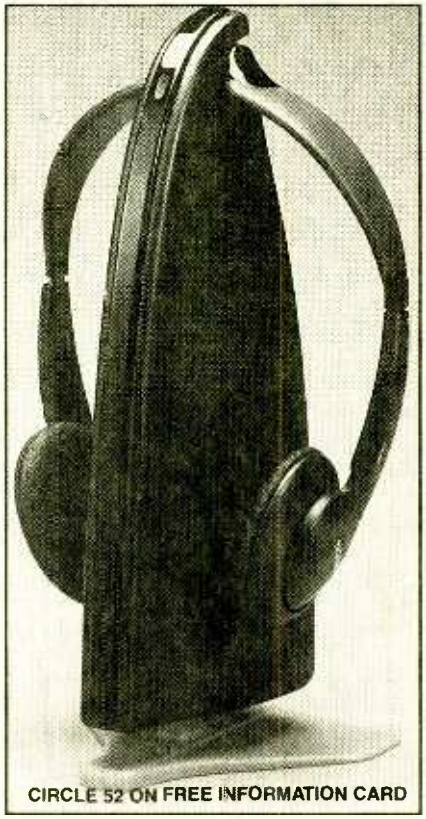
We're not certain just how useful XPRES'R is—you have to be pretty close to it to make out the messages spelled out by its two-inch-high letters (for reference, we measured the letters on an interstate highway sign to be about a foot high). And by the time someone is close enough to read your message—at least in traffic moving at any appreciable rate of speed—that message had better be "PLEASE DON'T TAILGATE." ■

Look Ma, No Cables!

SONY MDR-IF5K INFRARED CORDLESS HEADPHONES. Manufactured by: Sony Corporation of America, 9 W. 57th St., New York, NY 10019. Price: $200.

It seems that every time you add a new piece of equipment to your audio/video system you also add new cables: cables for audio, cables for video, cables for speakers, cables that run from one piece of equipment *here* to another piece *there*. That's why there are such things as wireless remote controls—to cut down on the number of wires and cables you have to connect, and route, and maybe trip over as you encounter them in their meanderings from one part of the room to another.

Cordless headphones offer a good example of how doing away with a cable or two can simplify life. Not only do they give you one less cable to stumble over as you cross your living-room or media-room floor, they also free you from getting tangled up in that trailing cord where you sit.



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Furthermore, they promise a freedom of movement that would be impossible at the end of an electronic umbilical cord. And, phones—of any variety—allow you to listen to things that would otherwise drive everyone else in the house crazy.

Sony's new entry in the cordless-headphone marketplace, the *MDR-IF5K* infrared cordless headphone, provides not only cordless operation, but stylish good looks as well—a feature that seems to be as important in some circles as performance itself. The lightweight (98 grams, about 3½ ounces), open-air-design phones are sleekly and curvily designed (and probably have a drag coefficient lower than that of an RX-7, which would keep them glued to your ears through a hurricane!). Even their charging unit, which doubles as a stand when the phones are not in use and as the transmitter when they are, could pass as modern sculpture.

The phones themselves fit comfortably on the head and, after you learn which way to put them on—a number of visual clues are provided as to which is the front and which is the back—you can almost forget that you're wearing them. Again, their open-air design does not suffocate the ears, and they also allow outside sounds to be heard with ease.

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The lack of an ear-seal could make for some bass deficiency, but Sony has taken that into account. The phones use what it calls *S.A.T.C.*, which stands for "*S*ony *A*coustic *T*urbo *C*ircuit." That is a system intended to boost the bass response of devices such as these phones, whose small size prohibits full-frequency response without such enhancement. It works somewhat like the bass-reflex enclosures used in full-size speaker systems. If S.A.T.C. is not enough for you, you can add more bass using your amplifier's tone and loudness controls. Overall, the sound was quite good.

The MDR-IF5K transmitter uses infrared LED's built into the charger/stand to transmit to the phones. Left-channel information is frequency modulated on a carrier of 2.3 MHz, and right-channel information on a 2.8-MHz one. The transmitter contains a vertical row of eight LED's, which can be seen to glow red (not the same as infrared, which you can't see—apparently the LED's radiate over a spectrum broad enough to contain both visible and invisible light) when an audio signal is applied to the transmitter. If no audio signal is applied to the transmitter for three minutes, it turns itself off.

Power for the charger/transmitter comes from a little 9-volt, plug-in AC adapter, and audio comes in through a cable (you just can't get away from cables, no matter how hard you try!) terminated with a stereo mini-plug. Sony provides a ¼-inch adapter for the plug, as well as a cable that allows you to feed the transmitter from any line-level output on your amplifier.

Charging is indicated by a two-color LED near the top of the charger/stand. Green indicates a trickle-charge mode, which, Sony says, requires fifty hours to put a full charge on the phones' small nickel-cadmium battery. Red indicates that the charger is in its fast-charge mode, entered by pressing a small button at the back. That mode puts three hours' worth of charge on the phones' built-in battery in three hours. At the end of that period, the charger reverts to its trickle-charge mode, but another three hours of fast charge can be applied to the phones without harm.

While the red FAST-CHARGE LED is pretty visible, the green one, indicating a trickle charge, is dim and difficult to make out. That may lead to a situation where you think the phones are charging, but are not. The problem is exacerbated by the fact that the lightness of the phones sometimes results in their not seating firmly on the two small pins in the charging stand that supply the charging current. If you are unable to tell if the green charge indicator is on, you might eventually discover that the headphone hasn't recharged when you thought it had.

The transmitter base contains holes that permit it to be screwed tightly against a wall, and the transmitter pivots on that base so it can be oriented to face up or down toward the anticipated position of the receiver. However, you have to return the transmitter to its upright position on its pivot to make the phones sit on their charging pins at the top of the unit.

The headphones have three infrared receptors, one on the left earpiece, one on the right, and a third one in a small bump at the top of the headband, which also contains an ON-OFF switch and another very dim red LED that, we suppose, is intended to serve as a POWER ON indicator. The two earpiece sensors seem to be oriented toward the front of the phones, and the third one seems to be aimed up and toward the rear.

Each of the earpieces has its own volume control. That makes it easy to balance the sound (using a monophonic source when you do it makes it even easier) but the small knurled-edge discs that serve as adjustment knobs are very easy to turn—*too* easy—and are located so that if you're not careful when you put the phones on or reach up to adjust them you will upset their settings. On a couple of occasions we thought that something had gone wrong with the phones' transmitter or receiver, but it turned out to be that we had knocked the volume controls down to their "zero" position. We quickly learned that that was the first thing to check for if the phones seemed to go dead.

While we presume that these phones are intended for use from a single "couch potato" location, such as a favorite sofa or easy chair that faces the sound or video system whose output is being listened to, they can, to a limited degree, be used from other positions. Sony tells you in the instructions that the phones have a range of about 27 feet. The output from the transmitter has a vertical angle of 120 degrees, and a horizontal spread of 70 degrees (35 degrees to each side of center) and we found that we could move about the room with relative freedom as long as we stayed more-or-less within the area just described. We could even turn our back on the transmitter at a distance of about 15 feet and still get good, if a little bit hissy, sound. We suspect that the third photoreceptor in the bump at the top of the headband has something to do with that. The sensor is probably intended to aid reception in cases where the transmitter is wall-mounted above headphone height. Going into the kitchen for a snack during commercials, though, is still out of the question.

If you have range or reception problems with these (or other infrared) phones, remember that infrared, like visible light, is reflected by light-colored surfaces. Results may be a bit better in a small room with a brightly painted ceiling and walls than in a large airy one. If you're reluctant to pack up all your sound equipment and move it into more cramped quarters, try adding some reflecting surfaces to the room in which it's already installed.

The Sony MDR-IF5K infrared cordless headphones can do a lot to add to your listening comfort and possibly preserve domestic harmony. Just make sure that you have someone else around to go and refill your bowl of pretzels for you when it runs out so you won't miss anything. ■

KITCHEN WHIZ

(Continued from page 1)

Also, the clock display—which is what the Kitchen Whiz normally shows when you're not using it—is a bit unsettling until you get used to it. Instead of using the conventional *hh:mm:ss (hours:minutes:seconds)* format, Seiko's designers chose to display the time with hyphens rather than colons between the units.

Seiko's big problem, though, arises from the quality of its documentation. The instruction manual, while slickly produced, seems to have been written by someone who knew of the Kitchen Whiz only by rumor and had never actually used one. Lest this be a deterrent to your purchasing an otherwise useful device, here are a few of the things we discovered about the Kitchen Whiz on our own and with a little of Seiko's help:

If you have finished one recipe conversion and are going to start a different one, you must press the RECIPE CLEAR key. If you don't, the calculator will continue to remember the old conversion factors and will not accept the new ones. The manual does not even mention that key.

The manual states that you can choose to have the time displayed in either 12- or 24-hour (as is used in most parts of the world other than this country) format. That is not so; the key that's supposed to do that only causes the display to read "AM" or "PM." And, while we're on the subject of time, the display can also show the day of the week. Of course, the manual does not mention that either, and it is impossible to tell from the keyboard how to change the day. The secret lies in the mislabeled SET PM/SET key, which *should* be labeled SET PM/SET DAY. Once you know about the labeling error, it all becomes clear.

Finally, the instructions for setting the countdown timer are backwards ... we think. They are so confusing that it's hard to tell. However, while they led us to believe that we first had to enter the minutes figure and then the one for the hours, in actuality setting the timer works the other way: first the hours, then the minutes.

All that aside, the Kitchen Whiz really is an extremely useful device for someone who does a lot of cooking from recipes published in cookbooks or newspapers and has to up- or downsize them. Just don't try using it on recipes that include diced turnips or carrot sticks—the calculator doesn't do square roots. ■

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F/X

OLYMPUS VX-S405 SUPER-VHS CAMCORDER. Olympus Corporation, Crossways Park, Woodbury, NY 11797. Price: $2500.

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There's a sign over our desk that reads: "Why? Because I *can*!" It's a reminder that sometimes things happen (or features show up in a piece of equipment) just because it is possible for them to. There need not always be a good reason. Simply having the technological capability to do so is often reason enough to add to the features (and price) of an already sophisticated piece of equipment.

That seems to be the case with *Olympus*' top-of-the-line entry into the Super-VHS camcorder market, the model *VX-S405*. It was not enough to produce a full-size VHS camcorder with superior resolution, 8:1 zoom lens (Olympus, you should know, is highly respected in the area of 35mm photography), flying erase head, electronic viewfinder, etc. By adding about 250 kilobytes of low-power memory chips, Olympus has expanded the capabilities of the camcorder into the realm of special effects. The unit can not only perform fade-ins and fade-outs (which everyone else's camcorder also seems to do), but also such things as dissolves (one scene fades out as the other fades in), several varieties of wipes (one scene replaces another by pushing it out of the way), and even picture-in-picture. It has several other virtues due to its memory, and we'll get to them too. First, though, it's time for some philosophy about the necessity, and practicality, of owning a camcorder that will do all that.

When you go to a movie, or watch one at home on tape, you see professional examples of what this camcorder can do on an amateur basis. You don't see those effects too often in today's films, but they are there. When we think of wipes and picture-in-picture, or split-screen, what comes to mind are the Rock Hudson-Doris Day films of the 1960's where one side of the screen showed one of them on the phone in one location (usually a bathtub) talking to the other on the other side of the screen (in another bathtub, somewhere else). The scene usually ended with one side of the frame expanding lengthwise to wipe out the other and fill the screen. That was the heyday of that kind of special effect. You hardly ever see that these days, and even fade-ins and -outs are rare. Most transitions are simply quick cuts that you don't even notice (the transition may be eased by "leading" the visual portion with the sound track by a fraction of a second). When you sit down to study how today's films are put together, you'll see little other than these quick cuts. Most special effects of any other sort now show up in TV commercials or music videos.

In the very early days of motion-picture production, effects such as fades, which were used more often then, were done in-camera. That is, scenes were shot sequentially when necessary so that a fade, or some sort of transition leading to the next scene, could be produced in the camera on the original film. That is how camcorder effects work. Now, however, Hollywood creates all that sort of thing in post-production—an optical printer or other device is used in the film laboratory to create all the fades, wipes, dissolves, etc. long after the film has been shot. There are a couple of good reasons for that, not the least of which are flexibility and economy. Scenes can be shot in whatever sequence is most convenient and later arranged in their final form. The method of transition from one scene to another need not even be decided upon until all the pieces of film are ready to be put together in the editing room.

With a special-effects camcorder, such as the VX-S405, you don't have the luxury of post-production facilities. That leads to a number of practical difficulties. Ideally, the video you shoot with this sort of camcorder should be scripted. You should have it all planned out in advance—which scene comes first, which second, how you'll get from the first to the second, and so on. Otherwise you're liable to fade out on a scene and have nothing to fade into again. But who scripts videos? One of the big features of a 6.9-pound (without batteries) camcorder is that it's a grab-and-shoot device. See something you want to put on tape? Pick up the camcorder, point it so the autofocus mechanism works, and push the button. You'll worry about what to do with your footage afterward. That philosophy, unfortunately, does not go well with in-camera special effects.

And, as wonderful as Olympus' technology is, it has its limits—and those limits can cramp your style. The quarter-of-a-megabyte of RAM built into the VX-S450 is sufficient to hold a single frame of high-quality video. What that boils down to is that one of the two images you use in producing your effects—sequentially, the first one—has to be a *still* image, that single frame. For shots where the first image is immobile anyway—a parked car, for example—that is not too important. But, if you're working with live action, you're going to have to settle for a sudden freeze-frame of the first scene as you wipe into the second. (Freeze frames were very big a couple of years ago, but they quickly become gimmicky and tiresome.)

Furthermore, the Olympus camcorder will only retain a scene in memory for five minutes or so (until it puts itself in STANDBY mode to prevent wear on the record head and conserve battery power), and also has no provision for "remembering" once it's turned off. That means that if you're going to do an in-camera transition from one scene to another, you have to shoot the second scene within five minutes of the first. *Good luck!* Fades are the exception to that rule, since they don't rely on the camcorder's memory capabilities.

One feature resulting from all that RAM that does seem useful—and quite impressed us—is the camera's low-light capabilities. By averaging several successive frames in memory, the camcorder, in effect, collects photons and allows you to record scenes in light levels as low as one lux. Cameras without this feature are usually not very useful below light levels of six or seven lux. The high-gain image is somewhat noisy, contrasty, and prone to

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CIRCLE 54 ON FREE INFORMATION CARD

What, Another One?

DATADESK TURBO-101 KEYBOARD. Manufactured by: DataDesk, 7651 Haskell Ave., Van Nuys, CA 91406. Price: $149.95.

What, *another* computer keyboard? Yes. In **Gizmo's** unrelenting search for the ultimate in IBM-PC-compatible computer keyboards, we've found another one and put it through its paces. This time it's the *DataDesk Turbo-101*.

Like most new keyboard designs, the DataDesk Turbo-101 keyboard follows the "enhanced" layout established by IBM for its PS/2 line—the one that added F11 and F12 function keys, and moved *all* the function keys from their "natural" place on the left (the layout used on the original PC and on many of the versions that followed it) up to a horizontal row across the top where everyone would have to relearn function-key touch typing. DataDesk was smarter than IBM, though. It realized that most software on the market doesn't even recognize the F11 and F12 keys, so it defined the scan codes generated by those keys (scan codes are the binary sequences that are sent each time a key is pressed, and that serve to identify that key to the computer) as ALT-F9 and ALT-F10. That rather defeats IBM's move, but makes the keyboard more useful with programs such as those from Borland that make frequent use of this ALT-F-key combination. If your software does understand the F11 and F12 keys, clipping two diodes inside the keyboard's case will redefine the keys to provide those scan codes. However, DataDesk feels that, considering the software generally available in today's market, the ALT-F-key definitions are more useful for the majority of situations that are typically encountered.

Aside from the redefinition of the two F-keys, the layout of the DataDesk keyboard is standard, at least as current IBM style goes. Cursor-movement keys, for example, are located in that upside-down-T formation to the lower right of the alphanumeric section of the keyboard. For those of us who have become irrevocably accustomed to the older layout where those keys are embedded in the numeric keypad, they are—thankfully—there too, and either set performs equally well. It's a matter of what you are accustomed to, and of which way your fingers are most comfortable bending.

One nice touch that the DataDesk people have thought of is allowing you to swap the scan codes for the CTRL and CAPS LOCK keys (whose positions in IBM's latest layout put them in unfamiliar locations) so they remain where your fingers are accustomed to finding them. And, since one of those keycaps is larger than the other, a spare set, where the sizes are reversed, is provided. Installing the keycaps is a simple matter of prying the old ones off, and snapping the new ones onto, the keyswitch shafts.

What that all boils down to is that DataDesk has provided a means for multi-computer operations—in which some units may be new PS/2's (using the new IBM keyboard layout) and other older types using more "traditional" keyboard layouts—to standardize with one keyboard design for all its systems. You can't retrofit a PS/2 with an older-design keyboard, but you can upgrade an older computer with a DataDesk Turbo-101.

Much has been made—by us and by others—of the *touch* of a keyboard. That is, of how it feels beneath your fingers as you type. If you're just a hunt-and-peck typist and are not interested in speed and comfort as much as you are in simply hitting the right keys now and then, that may not be an important factor to you. Even programmers may not be especially sensitive to the way a keyboard responds beneath their fingers as long as the keys work properly.

If, however, you spend hours at a time at the keyboard in an effort to crank out enough words to satisfy your editor and readers—as we do—then the feel of a keyboard becomes very important. And, in that regard, we found the DataDesk keyboard something of a disappointment. Certainly, the feel of the unit was better than the Taiwanese-clone keyboard we had used for several years, but it still fell short of our ideal in several respects. And, while *you* may prefer this keyboard for just those qualities, we feel obliged to point them out.

To us, the most important quality of a keyboard is the way the keys respond when pressed. Again, much has been written about the keyboard that IBM puts on its Selectric typewriters. Usually the writer talks about the layout and wonders why computer keyboards can't be arranged the same way. (We suppose they could, but you would then have to forego such things as "greater-than" and "less-than" keys, curly braces, and characters such as circumflexes and tildes. While those may not be important to business-administration types, most programmers would be stuck without them.)

The Selectric keyboard, however, has another virtue: the way its keys respond when pressed. They offer a slight resistance going down, come to a definite stop at the bottom of their travel, and then seem to push up against your fingers as they move back to their rest positions. It's more than just a spring action; the keys seem to (and probably do) have an *active* return system, and you can feel the power of the unit beneath your fingers. That, at least in our experience, really makes your fingers fly—it gives them a kind of lift in moving from one key to the next. We've never found a computer keyboard that could do that, but we've found several that have

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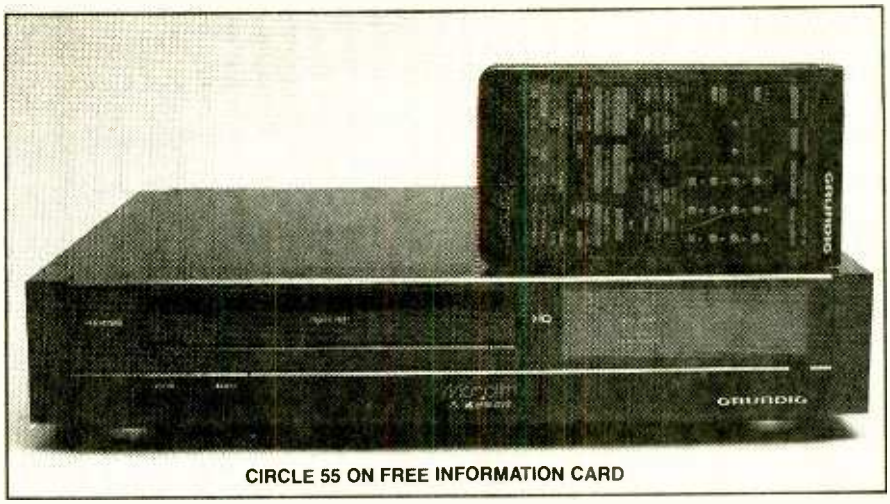
Time Machine

GRUNDIG MONOLITH VCR (VS-9500). Distributed by: Lextronix, Inc., 3520 Haven Ave., Unit L, Redwood City, CA 94063. Price: $899.



CIRCLE 55 ON FREE INFORMATION CARD

What may not be apparent to veteran VCR owners is that today's multi-featured machines constitute nothing less than an upgrade of your existing television set. Unless you're some sort of model consumer, regularly upgrading equipment each new model year, chances are that either (or both) your TV or VCR is beginning to show its age.

Enter the *Monolith VCR (VS-9500)* from Germany's *Grundig* concern, among Europe's leading consumer-electronic brands. The Monolith is Grundig's initial entry into the U.S. home-video market. Connected to a 6-year-old set for our tests, the VS-9500 provided features not yet available when the set rolled off the assembly line. In essence, the arrival of the Grundig catapulted our barely cable-era TV into the digital viewing and stereo-listening age.

Predictably sleek and compact, the Monolith is a four-head, two-channel hi-fi powerhouse of special effects. To connect it to the TV, we plugged the cable directly into the VCR, which immediately freed us from dependence on the stationery cable box, and provided us with remote control. The next upgrade came when we hooked the Monolith into our stereo tuner, via the auxilary jack.

Before living with stereo TV, we were inclined to dismiss it as a frill. After the Monolith, we would count ourselves as enthusiasts. We especially appreciated the fact that we could turn off the TV and continue to listen to cable-music broadcasts sans the distracting visuals. (MTV and VH1 in their audio manifestations give actual music radio a run for its listening money.)

We were also able to record the stereo-broadcast signal onto audio cassette for later listening, or just to stay abreast of the hits. Either way, it was a brand new use for our video system. Since our TV set isn't equipped for remote control, we were unable to select the set's volume or turn it on using the Monolith remote. But since we were listening via a stereo system (which brought yet another remote equipped component into play), the audio limitation hardly mattered.

The slight inconvenience of operating the TV via the VCR for even ordinary viewing was outweighed by the host of new TV capabilities the unit made possible. Those included channel memory, picture-in-picture, "TV memory," "channel search," and the ability to watch one program while recording another on the previously cable-bound set. "TV memory" freeze-frames a broadcast image, storing it and then displaying it again, picture-in-picture style.

"Channel search" shows the screen in a pale blue overtone, while down the right side are displayed still images for three broadcast/cable signals, with each station's numerical designation blinking in sequence next to the boxed image on the blue background. A touch of the CHANNEL SEARCH button on the remote when the desired station number blinks brings that station to the full screen. The next time CHANNEL SEARCH is called up, the topmost station displayed is the next in sequence, and so on through all stations received and in the VCR's memory.

The video-viewing equivalent of that feature is "multi." In that mode, the VCR displays a trio of strobing, sequential images from the main screen's cassette-originated image. A second touch of the "multi" button freezes them, and a third push makes them disappear. That feature is sure to win the approval of sports fanatics, and has utility for other types of programming as well—freeze-framing a useful diagram from an instructional tape, for example.

With "picture-in-picture," a TV image can be monitored against the main-screen video image. A second touch of that control switches the images, putting the VCR-originated program in the box and the broadcast image on the main screen. In ordinary TV viewing, at least on this slightly obsolete set, the picture-in-picture capacity merely selects a portion of the image being viewed. The P-I-P box can be shifted as desired to each of the screen's four corners.

To paraphrase a famous line from George Orwell's *Animal Farm*, two heads good, four heads better. The remarkable clarity of the Grundig's slow motion and pause/still images is one of the unit's chief attractions. In the SLOW-MOTION mode, the viewer can either speed up or slow down the already snail-paced tape. In PAUSE/STILL a "frame-advance" control allows the viewer to pump the image forward frame-by-frame. Going directly from PLAY to REWIND/SEARCH or FAST FORWARD/SEARCH retains the speeded up image on screen. Pressing STOP first returns the TV set to the broadcast channel while the tape is rewound or fast-forwarded. An on-screen counter is available to keep track of where the cassette is in its transport.

The recorder's display also provides a useful array of operating information, with symbols indicating if a tape is loaded and which mode the machine is in, along with the usual time-of-day and channel-number information.

Besides upgrading our TV, the Monolith upgraded our motley collection of dubbed tapes. Colors seemed truer and visual static less distracting when playing VHS tapes, which were originally recorded on a two-headed machine, via the Grundig.

The remote control's programming, channel-memory loading, and timer-record setting seemed models of straightforward procedure. After a half-dozen runthoughs, we were able to discard the manual entirely, relying solely on the on-screen cues and instructions.

Further remote-located features, ones we didn't get to know well, include "index," which will mark a selected point or points on a cassette, allowing the viewer to fast forward to those spots in later viewings. "Tracking" and tape "speed" controls went unused because they weren't needed in ordinary video viewing.

Careful home-entertainment consumers will definitely want to consider the Monolith as an option in upgrading video equipment. For some hundreds more than a less-featured VCR would cost, the Monolith buyer can upgrade home viewing at a cost much less than that represented by a new VCR and TV/monitor's combined price tags. We admit we've been living in the VCR/TV past, but life with the VS-9500 brought us up-to-date. Upgrading and updating are two non-electronic capabilities that make this new market entry an outstanding contender. ■

AmericanRadioHistory.Com

F/X

(Continued from page 5)

image smear and lag (resembling comet tails) on fast pans or on moving objects, but the feature does allow you to shoot under otherwise-impossible conditions and the results are not bad.

The basic VX-S405 appears to be built by Matsushita for Olympus. This mechanism, which we've used in camcorders bearing other manufacturers' names, leaves something to be desired in a few areas. As with all full-size VHS camcorders, it's heavy. A weight of just under seven pounds does not look heavy on paper, but it does tend to wear you down after a bit. The battery, which is a gelled-electrolyte lead-acid type, affords over an hour-and-a-half of shooting or playback and recharges in just under two hours—not bad at all. However, lead weighing what it does, the battery does contribute significantly to the weight you have to carry around. (A note: This type of battery, unlike nickel-cadmium rechargeables, is happiest when kept fully charged. You should bring it up to its full capacity as soon as possible after using it. Allowing the battery to discharge and remain that way can cut into its longevity.)

We frequently had trouble getting the special effects we wanted. It wasn't that the camcorder couldn't do them, but there are so many controls—pushbuttons of various shapes and sizes, slide switches, and LED indicators—that we found it hard to locate the ones we wanted just by touch. We'd fumble around for a while (often hitting the wrong button) until finally, in frustration, we had to take the camera from our shoulder and look for what we wanted, thereby ruining the shot.

One other thing that particularly annoyed us about this Matsushita design is its "backlight control." That is a means of overriding the camera's automatic-exposure circuitry to allow you to get proper exposure when you're shooting into the light. To use it, you have to keep your finger on the BACKLIGHT button; there's no way of locking it. That is not only uncomfortable, but also prevents you from operating other controls at the same time—unless, perhaps, you're double jointed. A lockable mechanism would make life a lot easier. There is also no provision for overriding the camcorder's automatic white-balance mechanism, which is intended to make sure that colors look "true" under any lighting conditions. Under some conditions, you may find that this mechanism is not as smart as you are, but that there's nothing you can do to override its "smarts" with yours.

Finally, we thought that we might be able to use some of the VX-S405's special effects after the fact by connecting it as the recording deck in an editing setup with another and calling on its capabilities to jazz up the transitions between scenes. No such luck! The effects seem to be available only when you're recording through the lens.

If we were writing this on a VX-S405, we could now . . . dissolve . . . to . . . ■

COMPUTER KEYBOARD

(Continued from page 6)

come closer to it than did the DataDesk unit.

The DataDesk keyboard is a high-quality device, well and solidly constructed, but the keyswitches are lacking in response. They appear to be dome-type switches, which have fewer moving parts than the more traditional type, and that might be part of the problem. While there is resistance going down, and some spring-feel coming back up, there is also the feeling that something is rubbing or binding—the movement is just not as effortless or snappy as we feel it should be.

The keyboard's other shortcoming—which you may feel is actually a virtue—is its silence. Typewriters, and some computer keyboards, make noise when you use them. Some computers even have built in key-click generators to provide that when it would otherwise be absent. And, while a roomful of clicking and clacking keyboards might not be your idea of beautiful music (unless you're an office manager responsible for productivity), to us the sound of keys clicking or of type elements slapping against paper is a concerto sounding of accomplishment. Alas, the DataDesk keyboard is, for all intents and purposes, silent. While keyboard silence may be a useful factor in reducing environmental noise pollution and making conversation easier in the typing pool, to us it's frustrating.

There is an incentive for buying the DataDesk keyboard, although you should not, of course, allow it to be the factor that sways you. DataDesk throws in free software—your choice of either Borland's Turbo Lightning, a spell-checker/thesaurus, or its SuperKey, a keyboard redefiner. However, there are better reasons for buying a keyboard than free software. And what we consider to be the DataDesk Turbo-101's shortcomings, you may consider to be its merits. It's not a bad keyboard at all. ■

ELECTRONICS WISH LIST

For more information on any product in this section, circle the appropriate number on the Free Information Card.

Dauphin Laptop Computer

Computer To Go

Said to be ahead of its time in features, design, and pricing, the *LapPRO-286* laptop computer from *Dauphin Technology Inc.* (1125 E. St. Charles Road, Lombard, IL 60148) offers a number of advanced features. The 13-pound IBM PC/AT-compatible portable measures 15.95 × 12.6 × 3 inches. It uses the 16-bit 80286 microprocessor, running at 12 MHz (selectable to 6 MHz with one wait state), and comes with one megabyte of 120-ns. Its RAM is expandable to four megabytes. The computer contains a 1.44MB 3½-inch floppy-disk drive that will also support the 720KB disk format. Also built in is a 40MB, 28-ms hard-disk drive that can be turned off as desired to extend battery life. The display is a custom-designed, high-resolution backlighted supertwist LCD, which offers a resolution of 720 × 400 pixels and operates in Hercules monochrome and CGA modes. The LapPRO-286 can operate from 110- or 220-volts AC, from an external 12-volt source, or from an internal 12-volt removable rechargeable battery pack, making it usable almost anywhere in the world. Built-in interfaces include an RGB/monochrome external-monitor port, a Centronics parallel port, and two RS-232 serial ports. Price: $3495.

CIRCLE 56 ON FREE INFORMATION CARD

AmericanRadioHistory.Com

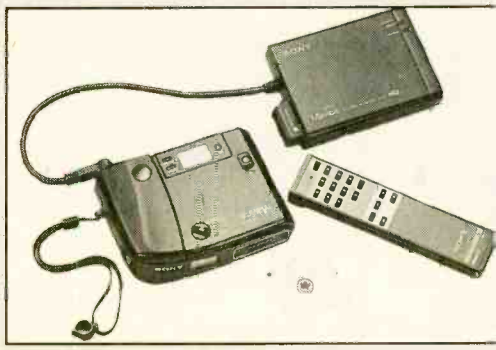
For more information on any product in this section, circle the appropriate number on the Free Information Card.

ELECTRONICS WISH LIST

Electronic Still Camera

You'll never run out of film again if you're using *Sony's* (Sony Corporation of America, 9 W. 57th St., New York, NY 10019) *MVC-C1 Mavica* electronic still camera. The all-electronic camera uses a 2-inch floppy disk to record up to 50 video still images in color that can be played back immediately on a television screen or monitor. The palm-sized point-and-shoot camera weighs just over a pound, and measures 5¾ × 2¼ × 4¼ inches. The Mavica camera system provides still images with up to 300 lines of resolution, which is better than many production TV receivers can display. The fixed-focus 15-mm *f*/2.8 lens provides sharp images of subjects at distances from about 4½ feet to infinity. An automatic iris-and-shutter system with speeds from 1/60th to 1/500th of a second ensures simple, reliable operation. In addition to single-picture shooting, the camera offers continuous high-speed recording at 4 or 9 pictures per second. The camera is powered by a six-volt nickel-cadmium battery. Available as options are a *MAP-T1* playback adapter that permits images to be played back on any TV screen, and an *RM-C1K* wireless remote control for that adapter. The 2-inch Mavipak disks are erasable and reusable. Price: $650.

CIRCLE 57 ON FREE INFORMATION CARD



Sony Electronic Still Camera

Compact Multi-Band Radio

Panasonic's (One Panasonic Way, Secaucus, NJ 07094) *RF-B65 Compact Multi-Band Radio* is equipped to receive the new single side-band (SSB) broadcasts. For "outstanding sensitivity, stability and selection" the receiver incorporates a microcomputer-controlled PLL quartz-synthesized system. There's a 6-way tuning system, 36-station memory, direct-access frequency tuning, and "meter-band direct-access" tuning. If the user knows the meter band of a station but not its exact frequency, the receiver will tune the lowest frequency of the band. Using either electronic rotary, up/down manual, or auto-scan, the user can then fine tune the station. The RF-B65 also features a multi-information LCD showing clock/timer readouts (time is simultaneously kept for two separate time zones) and indicators for a sleep-function, 60-minute auto-turn-off, and a timer that will turn the receiver on at a preset time. The multi-band unit requires 6 "AA" batteries; four for the radio and two for the clock memory. Accessories include an extension antenna wire, an earphone, and a carrying case. Price: $279.95

CIRCLE 58 ON FREE INFORMATION CARD

Panasonic Compact Multi-Band Radio

Integrated Telephone-Answering Device

If you're in the market for a low-priced telephone-answering machine with lots of features, the *Model 840* from *Record a Call* (19200 South Laurel Park Road, Compton, CA 90220) just might have everything you're looking for. The Model 840 is a combination telephone and beeperless remote telephone-answering device that can record up to 20 minutes of messages. A single button controls all operations. The answerer's VOX feature conserves tape by eliminating silences and also lets you play back messages without dial-tone interruptions. Other features of the unit include call screening, changeable one-minute outgoing messages, and expanded beeperless remote operation. The last feature includes such opions as a 3-digit security code, a "toll-saver" that saves you long distance charges if there are no messages on your machine when you call in to check, and the ability to turn on the device (toll-free) by phone if you forgot to do so before you left. Price: $89.95.

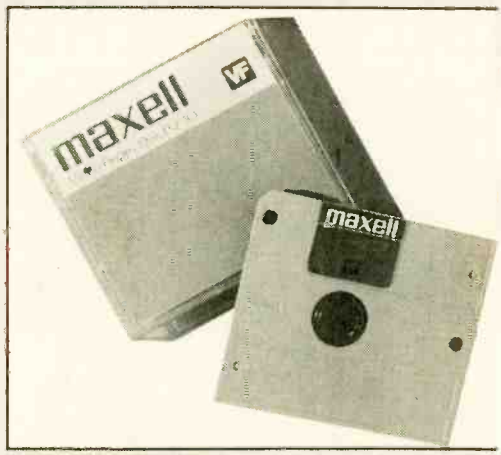
CIRCLE 59 ON FREE INFORMATION CARD

Record a Call Integrated Telephone Answerer

Two-inch Photo Album

A 2-inch floppy disk, type *VF-10*, intended for use in electronic still cameras such as those developed by Canon, Casio, and Kodak, has been introduced by *Maxell Corporation of America* (22-08 Route 208, Fairlawn, NJ 07410). The tiny 47mm-diameter floppy is housed in a compact, high-precision cartridge with a sliding metal shutter. The disk uses an ultra-fine metal particle with high coercivity to record the short-wavelength signals used in that new photographic medium. Each disk is capable of storing as many as 50 pictures in field-recording mode, or 25 in frame mode. The disk is intended to operate at 3600 rpm, and has a track pitch of 100 micrometers. The cartridge measures 54 × 60 × 3.6 mm, and weighs only 8.34 grams. Price: $22.80/disk.

CIRCLE 60 ON FREE INFORMATION CARD



Maxell Two-Inch Disk

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ELECTRONICS WISH LIST

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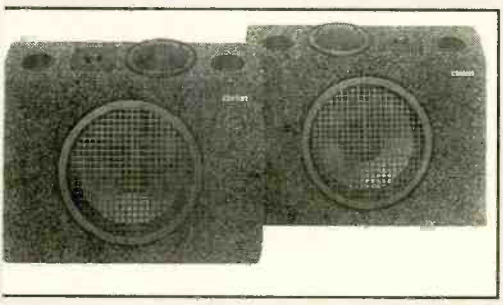
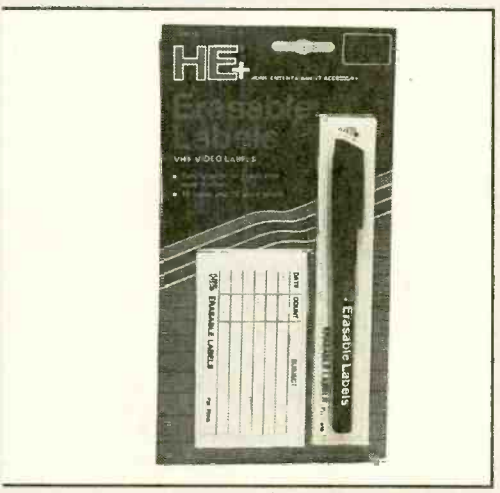
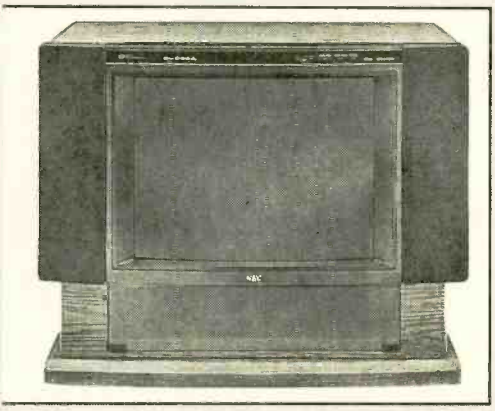


Clarion Box Speakers

Lloyd's Portable Clock Radio



Jasco Erasable Labels



NEC Surround-Sound TV

Box Speakers

Especially for trucks and hatchbacks, *Clarion Corporation* (5500 Rosecrans Avenue, Lawndale, CA 90260) has introduced three box-speaker products—two truck speaker systems and one hatchback version. The *CL821* has two eight-inch polycarbon-cone woofers and two one-inch soft dome tweeters contained in a single box designed to fit into a wide variety of hatchback vehicles. The *CL820* is a 2-way system for trucks; each box contains an 8-inch polycarbon-cone woofer and 1-inch soft-dome tweeter. The *CL101* is a 3-way system that features a 10-inch polycarbon-cone woofer, 5-inch midrange driver, and 1-inch soft-dome tweeter. All of the systems are contained in plush, carpeted boxes; carrying handles are built into the two truck speaker models. Push-type speaker connectors make it easy to disconnect and remove the speakers, if desired. Price: $329.95-$399.95.

CIRCLE 61 ON FREE INFORMATION CARD

Portable Clock Radio . . . Plus

For campers who have trouble sleeping in the dark and lonely night, *Lloyd's Electronics* (200 Clearview Road, Edison, NJ 08818-7811) has the answer. Its model *J-144 Security Light* is a portable clock radio with a built-in, full-size rechargeable searchlight that's revealed by opening a flap at one end of the unit. The AM/FM portable operates either from batteries or from AC (an AC adapter/recharger is included). The radio has two antenna systems—a telescoping whip for portable-FM use, and built-in AM/FM antennas for tabletop operation. The clock features a ¾-inch LCD panel with pushbutton backlighting for night-time time checks. Price: $39.95.

CIRCLE 62 ON FREE INFORMATION CARD

Cassette-Deck Cleaner

Allsop's (P.O. Box 23, Bellingham, WA 98227) *Ultraline (Product 73000)* head cleaner for audio cassette decks comes with an "omnipod" base that holds both the cleaning cassette and solution. The Ultraline cassette is bright white, a color that Allsop says "is perceived as ... *clean*." There's no denying that. Price: $11.95.

CIRCLE 63 ON FREE INFORMATION CARD

Erasable Labels

If you're having trouble keeping track of all your VHS cassettes, a few sets of model *8618 HE* erasable labels from *Jasco Products* (P.O. Box 466, Oklahoma City, OK 73101) may set you straight. Each package includes ten reusable index labels, ten reusable spine labels, and a special marking pen. Consumer-oriented instructions are printed on the back of the package. Price: $4.99.

CIRCLE 64 ON FREE INFORMATION CARD

Surround-Sound TV

For surround-sound devotees who want it all in one package, *NEC's* (NEC Home Electronics [U.S.A.] Inc, 1255 Michael Drive, Wood Dale, IL 60191) 27-inch TV console, model *KX-2792S*, has it. When equipped with four speakers (the set comes with built-in stereo speakers; you add the rear pair), the KX-2792S provides three surround-sound modes: Hall Surround, to recreate concert hall realism; Matrix Surround for adding a you-are-there effect to sports viewing; and Dolby Surround for material prepared using that encoding method. The unit includes a 40-watt (4 × 10 watts) amplifier and stereo audio system. The amplifier has both fixed- and variable-level line-level outputs; the variable-level outputs can be controlled from the set's remote control. The tuner can receive and decode MTS (stereo) and SAP (Second Audio Program) broadcasts. The KX-2792S is equipped with S-Video inputs for optimum reproduction from Super VHS and ED-Beta VCR's. A comb filter and a wide-band amplifier produce more than 500 lines of horizontal resolution, and NEC's Dynamic Black System improves color contrast and gray differentiation. Other features include provision for direct cable-box hookup, parental channel lock for screening out selected channels, and (of course) a wireless remote control. Price: $1599.

CIRCLE 65 ON FREE INFORMATION CARD

AmericanRadioHistory.Com

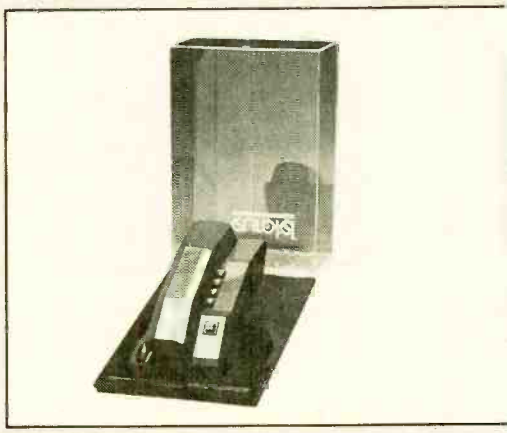
For more information on any product in this section, circle the appropriate number on the Free Information Card.

ELECTRONICS WISH LIST

Fashionable Phones

The *Eurotel Collection* is a line of "designer" phones from Europe now being marketed by *Eurotel* (25500 Hawthorne Blvd., Suite 1150, Torrance, CA 90505). The phones in the collection bear such names as "Geneva," "Milano," "Parisienne," and "Copenhagen," representing their countries of origin—Switzerland, Italy, France, and Denmark. These phones have been in use in Europe for several years and are modified to meet American standards. To qualify for the Eurotel Collection, a phone must be an outstanding example of European design and engineering; be accepted and proven through extensive use in Europe; and be manufactured in Europe, not the Far East. Each phone in the collection carries a five-year limited warranty. Price: $79.95–$599.95.

CIRCLE 66 ON FREE INFORMATION CARD

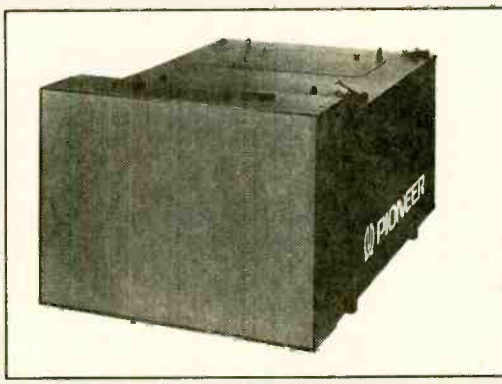


Eurotel Telephone

Rear-Projection Video

Pioneer Communications of America, Inc. (Sherbrooke Office Centre, 600 East Crescent Avenue, Upper Saddle River, NJ 07458-1827) claims that its 40-inch multi-projection system cube, model *RM-V1000*, is unprecedented in its clarity, color value, size, and flexibility. The rear-projection video display—intended for showrooms, convention centers, and lobbies—incorporates several major innovations and improvements. Among those are: 560 lines of horizontal resolution; a new screen that is said to reduce reflections to almost zero; a brightness of 350 foot-lamberts; automatic white balance; and a variety of terminals to provide more flexible connectivity. RM-V1000 units can be combined to form video "walls" up to three units high and of any length. Price: $13,000.

CIRCLE 67 ON FREE INFORMATION CARD



Pioneer Rear-Projection Monitor

Auto CD Changer

The *CDX-A30 DiskJockey* car CD changer from *Sony Corporation* (9 W. 57th St., New York, NY 10019) can be mounted either horizontally or vertically, as space permits, and uses an "Oil Damper" suspension system to improve vibration resistance under rough driving conditions. The changer features 4× oversampling and a signal-to-noise ratio of 93 dB. The CDX-A30 accepts the same 10-disc magazine used in other Sony home and car CD changers and has a wide range of control options available. Among those are: the full-function *RM-X2* wired remote with optional tuner and cassette player; control by in-dash AM/FM/cassette units; the *RM-X1* remote interfacing with an existing FM stereo unit through an optional FM modulator; and the same remote interfacing with an existing head unit having preamp inputs. Price: $700.

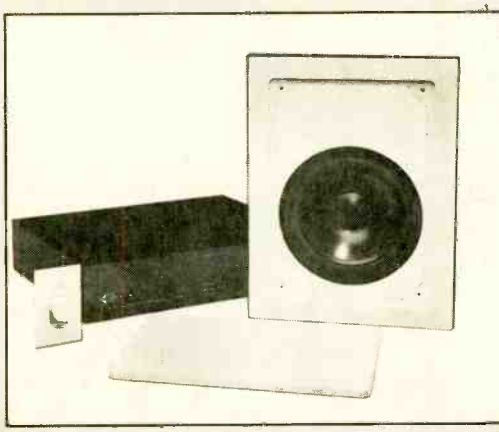
CIRCLE 68 ON FREE INFORMATION CARD

Sony Automotive CD Changer

In-the-Wall Subwoofer System

One of the problems with speaker systems using subwoofers is where to put all the pieces. *Sonance* (32992 Calle Perfecto, San Juan Capistrano, CA 92675) can help take care of that with its *VCA-1* powered-subwoofer system intended for in-wall installation. The three-component system consists of the subwoofer speaker itself—an 8-inch woofer that easily fits in walls using standard 2 × 4 construction; a three-channel amplifier; and a wall-mounted switch resembling a light dimmer. The bass module requires a cutout measuring 10⅝ by 14¾ inches. The 60-watt amplifier has two conventional STEREO IN inputs, and three outputs: one for the left-channel satellite speaker, one for the right one, and a third subwoofer channel derived by summing the two stereo inputs. The subwoofer-crossover point is adjustable to either 50, 75, or 100 Hz. Amplifier adjustment is made using "set-and-forget" controls located behind the wall-switch's cover plate. Those controls are for subwoofer level, maximum system level, and phase. Once they are set, an ordinary wall plate (you can provide your own to match your decor if you like) covers them, and access to only ON-OFF and master volume functions is permitted. The switch is designed to be installed in the same room as the speakers, while the amplifier can be stacked, rack-mounted, or installed free-standing elsewhere with the rest of the system. Price: $1250.

CIRCLE 69 ON FREE INFORMATION CARD



Sonance Subwoofer System

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ELECTRONICS WISH LIST

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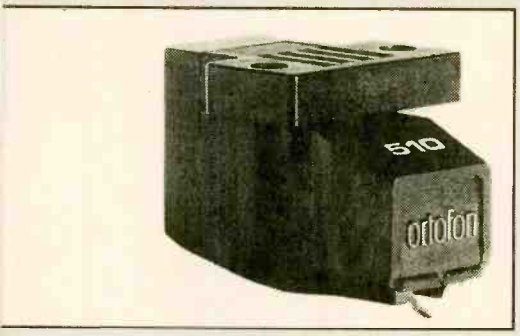
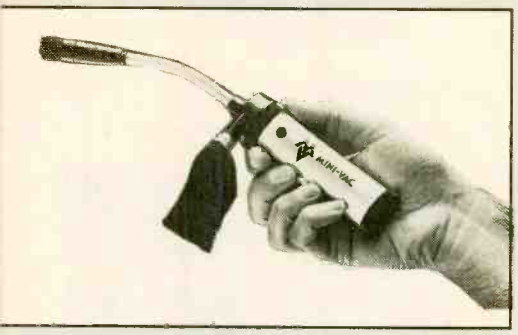
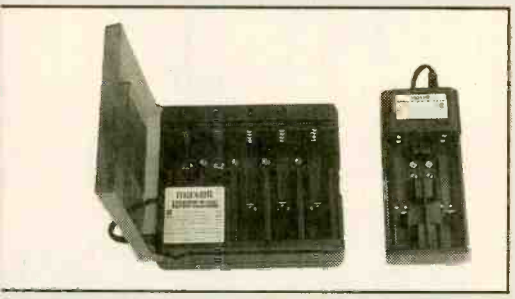


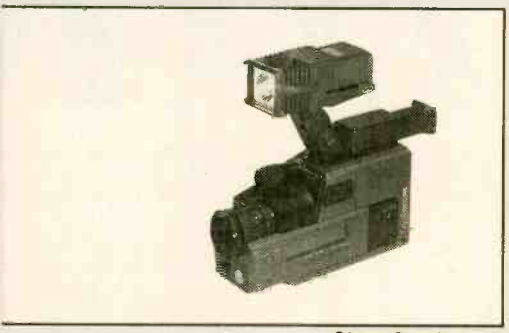
Ortofon Phono Cartridge



Mini-Vac Vacuum Cleaner



Maxell Battery Chargers



Sima Camlight 3

Citizen Portable CD Player

Magnetic Phono Cartridge

Ortofon (122 Dupont St., Plainview, NY 11803) a long-time leader in phonograph-cartridge design and manufacture, has added the model *510* moving-magnet phono cartridge to its *Series 500* line. The model 510 features a Noryl-fiber plastic and melted-glass cartridge body that is extremely inert and rigid, and that delivers improved linearity and reduced distortion. The cartridge was designed using CAD/CAM methods to define the natural pivot point of the cantilever system, providing optimum oscillation balance. The cartridge, which has a response of 20–23,000 Hz (+4, -1.5 dB) has an equivalent tip mass of only 0.3 mg. The model 510, which is available in standard and P-mount versions, uses a patented stylus guard that functions as a three-position stylus lock. One position is for normal play, the second locks the stylus to prevent damage during installation and shipping, and the third makes it easy to remove the stylus from the cartridge body. Price: $75.

CIRCLE 70 ON FREE INFORMATION CARD

Micro-Cleaner

If you want to get your electronics equipment a little cleaner, get it a *Mini-Vac*. The Mini-Vac, developed and marketed by *Mini-Vac, Inc.* (217 S. Orange Street, Suite 4, Glendale, CA 91204) is a palm-sized device designed to remove minute particles of dust and debris from hidden or hard-to-reach areas. Because it is a suction device, the Mini-Vac removes such contaminants permanently, unlike compressed air that simply disperses them. Its manufacturers recommend the Mini-Vac for cleaning delicate areas of computers, stereo and video equipment, tape decks, records and CDs, keyboards, and turntables, to name a few applications. The Mini-Vac is equipped with two interchangeable wands, two fine-bristle brushes, and a cloth vacuum bag. It can be operated from DC or from AC with an optional adapter. Price: $29.95.

CIRCLE 71 ON FREE INFORMATION CARD

Battery Rechargers

Maxell Corporation of America's (22-08 Route 208, Fairlawn, NJ 07410) battery division has introduced two nickel-cadmium battery rechargers. The *KB-8E* recharger allows you to charge up to four "AAA," "AA," "C," "D," or two 9-volt-size cells simultaneously or in combination. Charging time is 14–16 hours for all but "AAA"-size cells, which require only five hours. The *KB-88A* charger can charge up to four 9-volt cells. Price: About $12.00 (KB-8E), about $28.50 (KB-88A).

CIRCLE 72 ON FREE INFORMATION CARD

Camcorder Light

The *Camlight 3* is a self-powered cordless light from *Sima Products Corporation* (8707 North Skokie Boulevard, Skokie, IL 60077) that combines a nickel-cadmium battery pack and a high-efficiency halogen bulb in a single compact unit that can be mounted directly on a camcorder's accessory shoe. The Camlight 3's rechargeable power pack requires between five and six hours for a full charge, and can then supply from 27 to 30 minutes of illumination. The 14.9-ounce unit features a faceted-mirror lamp reflector and an adjustable lighting angle for bounce lighting, which helps eliminate shadows. The battery can be recharged up to 1000 times, and additional power packs are available for use as spares. Price: $159.99.

CIRCLE 73 ON FREE INFORMATION CARD

Portable CD Player

Looking a little bit like a George Adamski flying saucer, *Citizen's* model *50 CP* portable CD player plays both 5- and 3-inch compact discs. The unit makes use of double oversampling and digital filtering, and has a three-beam laser system for accuracy in tracking. The 50 CP operates from a built-in rechargeable battery pack. An external battery pack, as well as an AM/FM tuner, can be attached. Controls include: PLAY/PAUSE, STOP, FORWARD/BACKWARD SKIP, REPEAT, and HOLD. The player comes with a shoulder strap, an earphone, an AC adapter, and a patchcord with RCA-type connectors. A wired remote control is available as an option. Price: $249.95.

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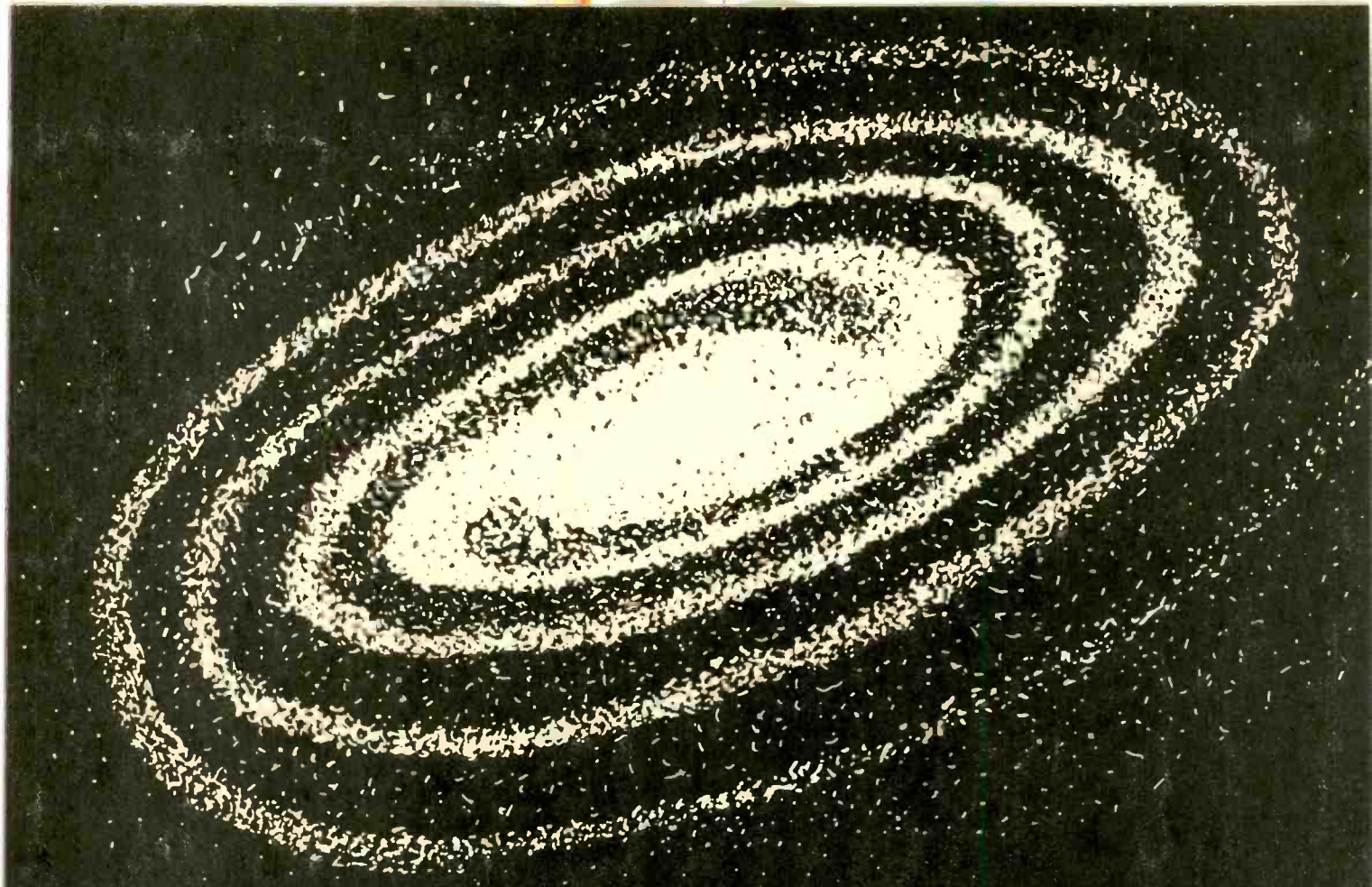

Quantum Mechanics, The Universe, and Electronics

Explore the the world of subatomic particles, where everything is not quite what it seems to be.

JOSEPH J. CARR

Electronics is what this magazine is all about, and that is the reason why readers buy it. The subject's very name tells us that *electronics* deals with the sub-atomic micro-world where electrons, protons, and other particles are the principal players. The theories that we learn as the basis for electronics make sense, they work, they're knowable, and they are based on the physics of those micro-world particles.

Unfortunately, they are also lies...or at least are only partial truths. When you delve deeper into the science of *Quantum Mechanics*, which is the name given the physics of sub-atomic particles, you find a weird, seemingly contradictory world whose nature has befuddled science's greatest minds.

Consider the tunnel diode, for example. The usual tunnel diode explanation goes something like this: Unpaired and relatively immobile negative and positive charges accumulate in the transition region that surrounds the PN junction of an ordinary diode. Due to the presence of those charges an electric field of up to 10 kV/cm in an unbiased junction, and even more in a reverse-biased junction, exists. Although the band-gap energy (E_G) is the same on both sides of the junction, a difference in the potential energy on the two sides results in a potential barrier. See Fig. 1. The potential barrier forms a blockade—an electrical brick wall—to electrons trying to pass over the junction. Unless an electron has sufficient energy (E_B) it can not "leap over the wall."

Now enter the tunnel diode. The transition region between P-type and N-type semiconductor materials in a tunnel diode is on the order of 100 angstroms wide, rather than the 10,000 angstroms that is typical in ordinary PN-junction diodes. In addition, very high doping levels result in much greater

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charge-carrier concentrations. Those two conditions taken together alter the situation so that certain quantum "magic" can take place. As an electron approaches the junction there is a small, but finite, probability that it will somehow pass through the junction, even though it lacks sufficient energy to pass over the top of the "brick wall."

Let's consider a macro-world analogy to the tunnel diode. Suppose there is a player on a racquetball court. The "particle" is not an electron, but rather it is the racquet ball. The ball receives its energy when it is smacked by the player. Assume that the walls of the court are so high that the ball can not fly high enough to get over it no matter how hard the player whacks it. According to the standard wisdom, the ball should spend eternity bouncing around the one racquetball court.

But now suppose that the court is a special "quantum" court. According to quantum mechanics (QM) theory, there is a small but finite chance that the ball will approach the wall, seem to pass right through it, and bonk the player in the court next to yours on the head. Furthermore, the ball will have the same energy on both sides of the wall. In other words, the "tunneling" phenomena does not really exist in the way we normally learn it. Instead, according to QM, an electron disappears on one side of the barrier, and another identical electron appears on the other side. It's not that the electron passed through, but that something "magic-like" happened.

In electronics we tend to glibly toss around electrons as if they were actually micro-ping-pong balls. But while that "works" in our circuit descriptions, according to physicists, that is not what is really going on.

Physics and Reality. For more than two centuries, from the time of Isaac Newton (1642-1727) until 1900, the world of physics was mechanical and deterministic, and made "sense." "Classical physics," as Newton's science is called, saw the universe as an immense clockwork whose motions are predictable in the future and decipherable in the past, given enough knowledge. Physics was a hard-nosed, practical science, and was congenial to the common-sense mind. However, the long and successful reign of classical physics was threatened in the late 19th century, in part because various experimental results did not fit nicely into Newton's

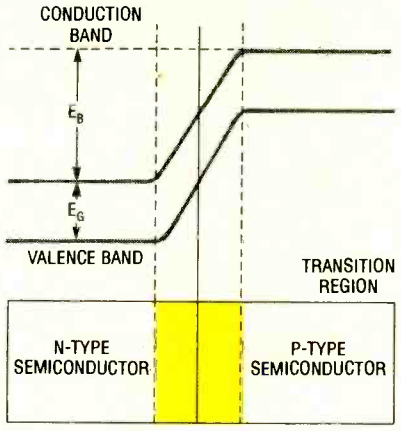

Fig. 1. In a diode, the potential-barrier energy (E_B) at the PN junction forms a blockade that prevents the passage of electrons.

way of looking at things. Discoveries regarding black-body thermal radiation, radioactivity, X-rays, and the nature of light perplexed Newtonian physicists.

Black-body radiation is the infrared and visible light given off by a black body (such as a hunk of iron) when it is heated to incandescence. Physicists in the 19th century couldn't make their theories fit the experimental data. But at the very dawn of the 20th century (December 1900, to be exact), German physicist Max Planck discovered that the data could be explained if only discrete values of energy were allowed (Einstein subsequently called them "quanta"). Planck's theory initiated the quantum-mechanics revolution.

The Nature of Light. The problem that scientists found with light was that various experiments seem to contradict each other. Some experiments show conclusively (or so it seems) that light has a wave nature. For example, in one experiment we find that light refracts when passing from air into water. In another experiment, passing a light beam through a pair of closely spaced slits forms a characteristic light-dark interference pattern. Both experiments show purely wave-like results.

Paradoxically, other experiments show just as "conclusively" that light has a particle nature. Consider the photoelectric effect, for example. When a light beam falls on certain types of metallic plate, electrons are emitted from the plate. If light has a wave nature, then we would expect the emissions to increase when the light intensity increases. But a curious thing was noted in photoelectric experiments. The light intensity has no effect at all on the magnitude of the electron emissions, yet the color (frequency) of the light *does* affect it.

Albert Einstein won the Nobel Prize in physics by applying Planck's theory of "quantized energy" to the photoelectric-effect problem. Einstein's 1905 paper on the photoelectric effect upset the Newtonian apple cart because it presented an essentially particle view of light to a world that had become accustomed to thinking of light in terms of waves. So now scientists had a paradox that was not allowed for by Newton's classical physics. Light seems to be both a particle and a wave. How could that possibly be true?

Light seems to be a wave in some experiments and a particle in others. To the classical mind such a situation is disastrous because the particle and wave descriptions are mutually exclusive. In the 1920's, however, physicist Neils Bohr postulated that those two descriptions were merely complementary to each other, not contradictory. Bohr's Complementary Principle holds that neither description alone is entirely sufficient to describe light—both are needed together.

The Nature of the Atom. During the first three decades of the twentieth century, Bohr and a relatively small band of scientists working in Copenhagen devised a system that seems to explain atomic phenomena. That system is quantum mechanics, and it displaced the comfortable cause-and-effect definitions of classical physics, and put in their place a new set of definitions that are based on probabilities and "tendencies to exist."

The seeming paradox is that "unpredictability and uncertainty appear intrinsic to the universe at the deepest levels." Yet QM is accepted by scientists as the mathematical construct that best predicts the behavior of matter at the subatomic level. Even though mind-shattering problems persist, QM became for scientists a cause for nearly religious veneration.

Part of the problem faced by the scientists is the utter inadequacy of human language to express the realities of the quantum world. Consider, for example, our ordinary "solar system" view of the atom. Called the Bohr model of the atom, it consists of a nucleus of positively charged protons and

(Continued on page 100)

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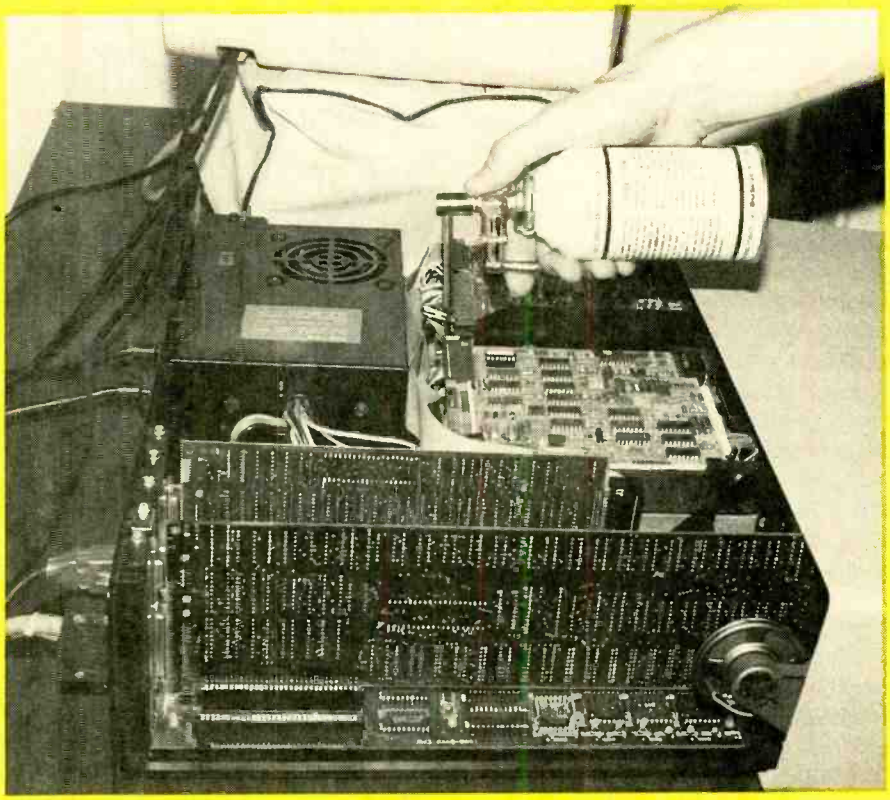
BY ISAAC SZLECHTER

Looking for a sure-fire way to cut down on the never-ending stream of computer-repair bills? Then why not try some tender loving care!



Preventive Computer Maintenance

When his computer disk drive started to make funny noises, a New York City computer programmer I know sent his computer out for repairs. When he picked it up two weeks later, the repairman told him that dust and dirt in the disk drive, which is partially a mechanical device, had caused the problem.

My friend is not alone. Experts estimate that personal-computer users will pay more than 2 billion dollars in repair bills this year. While most repairs to computers and their peripherals will require returning the unit to the dealer, there is much a computer user can do to lessen the frequency of downtime and breakdowns. A little preventive maintenance may be drudgery, but it could save you from a big repair bill.

Ideally, preventive computer maintenance should begin when you bring your computer home and set it up. It is highly suggested that you put your computer system away from open windows, sunlight, heat vents, radiators, and air conditioners. That helps reduce dust, smoke, and other airborne particles that may settle on your equipment, as well as variations in temperature and humidity.

Environment. If you have a room air conditioner, change its filter often. Operate your computer at a low room temperature. Too cold is better than too hot. However, if you have a choice between an air conditioner that affects the power circuits by constantly cutting in and out, and slightly warmer temperatures, stay with the warmer room.

Leaving the computer on if you are going to step away from it for a telephone call or even an hour-long lunch is better than flicking the switch on and off repeatedly in the course of a day. When you leave your computer on, lower the intensity of the monitor so as not to burn an image onto the screen.

You should not smoke, eat, or drink around your computer system. Smoke is especially harmful because tobacco tar can jam between a disk and disk head, which reads and stores data.

To protect against voltage variations, which can damage your computer system, use a power line not shared by other appliances or equipment and, if necessary, buy a surge suppressor. They absorb most power surges that come from utilities or electric storms.

Since magnetism can distort or erase data, do not put stereo speakers, tape recorders, or devices with motors or magnets next to the computer. It's also a good idea to place an antistatic mat on the floor to eliminate static electricity. Keep in mind that it is impossible for floor mats to draw static electricity from people wearing rubber- or synthetic-soled shoes.

To prevent inadvertent damage to your computer and peripherals, it is important to follow its manuals closely.

Disk Drives. The major cause of computer downtime is disk failure. Every user at some point will go to boot up a disk and get a data error, seek error, or some other such annoying message in return. But if you keep the disk drives clean and lubricated, you minimize repair bills and lost time.

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Disk drives tend to get dirty and become oxidized from constantly moving over disks. You can easily clean them yourself with a commercial head-cleaning kit. Some manufacturers say heads should be cleaned after 100 hours of continuous use. Others say every 6 months, so as not to wear down the heads. But even if your computer is on 10 hours a day, your disk drive heads usually won't be active for the entire period. We recommend that heads be cleaned at the first sign of read/write trouble if there is no obvious cause.

One of the real problem areas is disk-head alignment, which can result in malfunction. Older IBM's have single-sided drives, whereas the newer computers come with double-sided drives. Of course dual-headed drives are more susceptible to misalignment than single-headed drives.

Although disk alignment is a job for a service center, you can prevent the need for such repairs by avoiding sudden jolts to the drive. Keeping your equipment stationary will also help reduce the amount of servicing your disk drives will need. If you do have to move the equipment around, use the original cardboard disk-drive braces to help protect them from jolts and bumps.

Keyboard. The keyboard is a most sensitive part of your system, so be very careful with it. Dust is one of the most destructive elements in the microcomputer environment. Using a small soft-brush attachment, vacuum your computer's keyboard. Dusting it with a cloth simply will not remove all the minute particles that get between the keys and the keyboard case.

Specks of dirt can also interfere with the functioning of the electronic components in the keyboard. Use a can of compressed air, which you can also buy at Radio Shack, to force accumulated debris out from beneath and between the keyboard keys, then vacuum up any debris.

The spilling of coffee or other liquids can cause problems. If a spill occurs, take the keyboard to a service center right away for a good cleaning. If you give a harmful chemical a chance to do its work, you may shortly need a new keyboard.

The Cabinet. Vacuum all the small air vents of the computer and the disk-drive openings, as well as any other openings in the case where air can enter. Do not vacuum the inside of the computer itself. It is all too easy to damage electronic components with something as large as a vacuum cleaner attachment. When you do open the case, it is a good idea to blow all the accessible dust away with a canister of compressed air.

Using a small soft attachment, clean the keyboard with a small hand vacuum.

Vacuum all the small air vents of the computer and disk drive openings, as well as any other openings in the case where air can enter.

To avoid dust and dirt on your computer and peripherals cover them with vinyl dust covers.

Printer. By doing occasional maintenance checks and cleaning the printer regularly, you can reduce its malfunctions. Clean the ribbon guides, the print shield, and the inside of the machine. A build-up of ink or paper dust can cause problems, so vacuum periodically.

Do not oil your printer. It does not need oil. Most of the bearings and moving parts are self-lubricating. If you have a daisy wheel printer, clean clogged recessed type areas with a Printwheel Cleaning kit, available at many stationary stores.

Monitor. With the monitor unplugged, spray some contact cleaner, available at Radio Shack and other electronics-supply stores, into the openings of the brightness- and contrast-control knobs. Dirt accumulated internally around the shafts of the controls can lead to a static-riddled screen. Also clean the screen with a glass cleaner. It will restore brightness and clarity.

To prolong the life of the monitor, turn the brightness control on the monitor all the way down when you take even a short break from your computer work. Continuous long periods of a fixed image will harm picture clarity.

Disks. Although 3-½-inch self-encased disks are more durable and worry-free than floppy diskettes, you should still be careful with them.

Keep floppy disks clean. Do not touch the exposed recording surface. Small scratches, dust, food, or tobacco particles can make them unusable. Put the disks in their envelopes as soon as you remove them from the drive.

Store the disks away from the heat and magnetic-field sources such as telephones, dictation equipment, and electronic calculators.

Make back-ups regularly and keep a copy of any disk storing permanent data, master files, operating systems, or programs. If something happens to the original, the backup copies are peace-of-mind insurance. A good backup program can automate the process and quickly whiz through long lists of files with little effort on your part.

Dust Cover. To avoid dust, dirt, and surface scratches on your hardware cover them with vinyl dust covers. Not only does dust build up on the keys, the casing, and the cracks in the keyboard, but it can seep through the computer's air vents and into the disk drives, where it causes serious problems. By keeping a dust cover on your computer and peripherals when not in use, you can save yourself considerable aggravation, as well as vacuuming time.

You may find some of these suggestions, hints, and procedures new and some of them not so new. Follow them and you can lessen the frequency of downtime and breakdowns. ■

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INNOVATIONS '89

BY BYRON G. WELS

We present the cream of the crop in consumer-electronics products for your consideration.

In order to understand electronic innovation at all, you've got to begin by tracing the history of the subject. Consumer electronics really began with the crystal receiver, and then moved on with the three-tube TRF (*T*uned *R*adio-*F*requency) receiver. That was quickly superseded by Armstrong's 5-tube "Superheterodyne", or Super-Het. "Obviously, if a five-tuber was better than a three-tuber, then," people thought, "the more tubes, the better the set!" Since Mr. John Q. Public knew little about electronics, many were concerned with the look of those tubes. The radio tube took on fancy shapes, and even colored glass was used to make a bigger and better impression.

The "Battle of the Bulbs" was on. An eight-tube receiver was considered innovative in its day, until it was surpassed by a twelve-tube set. One manufacturer even brought out a 16-tube receiver, and you could open the back of the big cabinet and count the tubes. Only five or six of the tubes really functioned. The rest only had their filaments connected, so you could see them glow and know that they were "working." Manufacturers claimed (to the trade only) that the other tubes were duplicates of the working tubes, to be used as spares, and hooking up the filaments allowed the tubes to "age."

Time Marches On. People quickly became too sophisticated to accept that, but such "innovations" didn't stop there. When stereo radio first appeared on the market, it was impossible to sell a monophonic tuner or amplifier unless it had some kind of jack on the rear panel marked "Stereo Adapter." The jack wasn't connected to anything on the inside of the unit, but a salesman could now tell a prospective buyer that when stereo adapters did become available, he would be all set.

Time passed and manufacturers were hard-pressed to come up with something new that would make people buy. One manufacturer I recall, did something *really* drastic. He changed the knobs on the previous year's models from round to square. That was the extent of innovation in its day. Today, the buying public is a good-deal more knowledgeable. Such minor changes are not sufficient to compel the buyer to buy. That and competition has forced the engineers to really produce, and we, the purchasers, are the beneficiaries of that effort.

The CES Contest. At each year's Consumer Electronics Show, manufacturers are invited to submit one or more products for judging in the Innovations Design and Engineering Exhibition contest. The judging is handled by members of the electronic press. Those men spend their lives evaluating new products, and they've seen it all. At the very least they're jaded, and to impress that crew with your product, it has to be good. Each of them, in addition to being very involved in electronics in general, is a specialist in some area of electronics. And each product is subjected to close scrutiny by all of them. They can be truly objective in their evaluations, for they have nothing to gain or lose by their votes.

To the manufacturers, being selected for an award is much like a movie actor being awarded an "Oscar." It is truly a high accolade, and one that must be well-deserved by the recipient.

Due to space limitations we cannot show each and every product. The very-best we can do is highlight some of the winners. We have second-guessed the judges and selected the products we feel are among the most-interesting of the winners. These products are amoung the best-of-the-best introduced in the past year.

And Now For the Winners... Our first item contains a verbal instruction manual. It actually talks you step-by-step through the complicated act of VCR set-up and programming.

The Voice Coach Remote Control, from *Sharp/Optonica*, is a product I

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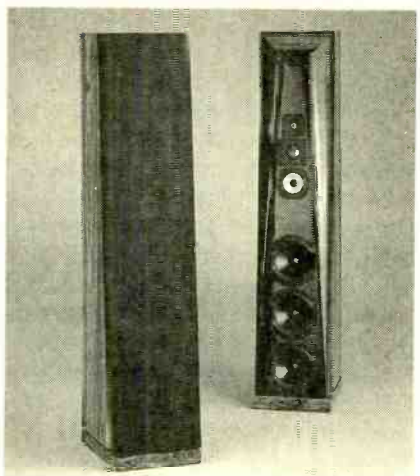
The Voice Coach, from Sharp/Optonica.



Coherent Source Loudspeakers from Thiel.

would not be surprised to find copied and packaged with nearly every electronic product, even ones of the least complexity, in the near future. The unit has a 50-phrase, 500-word vocabulary, and a synthesized computer voice that gives instructions for easy programming from start to finish.

Next on our list are 5-way speakers that offer excellent musical reproduction, with such attention to detail as to have three-dimensional marble-polymer composite front baffles that provide extremely rigid mounting of the drivers. The baffles are even shaped to nearly eliminate cabinet-edge diffraction.

Another startling feature is their unusual synthesized-first-order acoustic crossover. It is designed to preserve all three types of musical information: phase, amplitude, and power. The crossover network contains 116 high quality components such as polystyrene and polypropylene capacitors all connected with high purity copper wiring.

There's no skimping on the drivers either. The driver diaphragms are made of either alumunim, Kevlar, or a Kevlar/foam sandwich to reduce "cone breakup". They even have special distortion-reducing magnet systems.

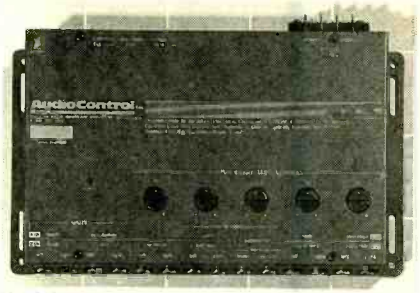
Specifications include −3-dB bandwidth of 20 Hz–22k Hz, and a frequency response of ±1 dB from 25 Hz–20k Hz.

On the telecommunications home front, *Code-A-Phone* has effectively placed two complete telephone answering machines in one cabinet. Their *Model 2880* separates messages into two groups. The patent-pending message director allows two different individuals separate access to their messages, if the calls are recorded and stored separately.

Calls can also be divided by subject

Code-A-Phone's Model 2880 Answering Machine.

The FM+ Antenna from Terk Technologies.



The 4XS Crossover from AudioControl.

matter—business and personal calls, for example. Or imagine using one partition for yourself and the other for your children. That added consumer flexibility obviates the need to install separate phone lines and answering machines.

For a busy executive, *Ricoh's PDIS System* is an office-on-the-go. It'll give you all of your office capabilities in an attache-case sized design. The three components of the PDIS include an MC-50 copier, that provides notebook-sized copies, and it runs on rechargeable batteries! The IM-A image controller/scanner expands the copier's capabilities, allowing you to enlarge or reduce, copy photos, and to make negative copies.

Connect it to your computer (it comes with its own software) and you can store material for later use. A fax unit that allows you to send and receive facsimile transmissions is included. It sends 4 × 5-inch documents that come out as full-size sheets at the receiving end.

Terk Technologies Corp., is offering the *FM+ Antenna* which not only looks a lot nicer than that piece of twin-lead folded dipole that you threw behind the couch, it out-performs it by far as well. The attractive unit is a scant 1-¾ inches high.

If you're looking for the ultimate in crossover design, *AudioControl* has a unit that does it all. You can get four-channel, two-way operation, or two-channel, three-way operation, and the crossover points are selected by using plug-in modules.

The *4XS Crossover/Controller*, is an 18-dB/octave state-variable electronic crossover with subwoofer outputs. Additional features include switchable, nonfading bass; a programmable frequency-match circuit to tune speaker enclosures and protect power amplifiers; output-gain controls; mono-bass output; bridging adapter; and a noise-rejection power supply.

To get the last word, try using a speak-

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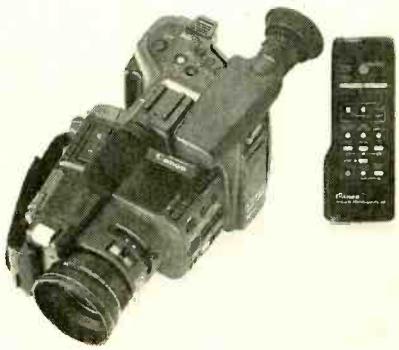
ing dictionary that is a dictionary, thesaurus, phonetic spelling corrector, and word-game player.

Franklin Computer's Language Master 4000 Speaking Dictionary, actually *pronounces* over 83,000 words and provides more than 274,000 definitions, 487,000 synonyms, and phonetic spelling for over 83,000 words. It also has a 3,300-word advanced SAT (*Sudent Aptitude Test*) word list that it uses in a wide variety of challenging word games.

In the camcorder market, *Canon's* 8mm *Model A1* makes use of the Hi-8 standard to provide increased horizontal resolution, improved signal-to-noise

Franklin Computer's Language Master 4000 Electronic Dictionary.



The Model A1 Camcorder from Canon.

performance, and better color resolution. It also features a unique body shape with two grips, each with independently functioning start/stop and zoom controls, so any shooting position becomes comfortable and stable. Other features include wireless remote control of record/playback functions, high-fidelity stereo sound, and an 8–80mm power-zoom lens.

Yamaha Electronics, USA introduced their *CS-642 Concert System*. While it's essentially a rack system made of discrete components, if you're starting from scratch, you could do a great deal worse. It features a single-brand system in a unique, high-fashion bleached-oak cabinet with matching speaker systems, consisting of main and surround-

1989 Summer CES Winners

Audio Control
22313 70th Avenue West
Mountlake Terrace, WA 98043
CIRCLE 40 ON FREE INFORMATION CARD

Beyerdynamic, Inc.
5-05 Burns Avenue
Hicksville, NY 11801
CIRCLE 41 ON FREE INFORMATION CARD

Canon USA, Inc.
Video Division
One Canon Plaza
Lake Success, NY 11042
CIRCLE 42 ON FREE INFORMATION CARD

Code-A-Phone Corporation
P.O. Box 5656
Portland, OR 97228
CIRCLE 31 ON FREE INFORMATION CARD

Franklin Computer Corporation
122 Burrs Road
Mt. Holly, NJ 08060
CIRCLE 32 ON FREE INFORMATION CARD

National Captioning Institute
5203 Leesburg Pike
Falls Church, VA 22041
CIRCLE 33 ON FREE INFORMATION CARD

Ricoh Corporation
5 Dedrick Place
Caldwell, NJ 07006
CIRCLE 34 ON FREE INFORMATION CARD

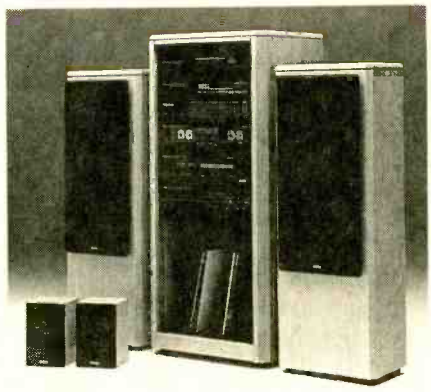
Sharp Electronics Corporation
Sharp Plaza
Mahwah, NJ 07430-2135
CIRCLE 35 ON FREE INFORMATION CARD

Terk Technologies Corporation
56 Harrison Street
New Rochelle, NY 10801
CIRCLE 36 ON FREE INFORMATION CARD

Thiel
1042 Nandino Boulevard
Lexington, KY 40511
CIRCLE 37 ON FREE INFORMATION CARD

Yamaha Electronics Corporation, USA
6722 Orangethorpe Avenue
Buena Park, CA 90620
CIRCLE 38 ON FREE INFORMATION CARD

Southwestern Bell Freedom Phone
7486 Shadeland Station Way
Indianapolis, IN 46256
CIRCLE 39 ON FREE INFORMATION CARD



The CS-642 Concert System from Yamaha Electronics, USA.

Beyerdynamic's DT690 Wireless Headphones.

sound units. The system also boasts a carousel CD changer and 4-channel surround amplifier.

If you really want good quality stereo, you buy the best components you can afford. And when others that you share your domicile with object to the sound level, the only solution is a good pair of headphones. Unfortunately, headphones, because of the connecting cord, can be very restricting.

Beyerdynamic has solved that problem by doing away with the connecting umbilical and replacing it with an infrared beam. The *DT 690* phones come with the IS 690 infrared transmitter and the LG 690 power supply. You won't be sacrificing quality, either: it has a 20–20,000 Hz frequency response. You get a built-in rechargeable 9-volt battery, a volume control, and MONO/STEREO switch to boot.

National Captioning Institute's TeleCaption 4000.

You've seen those "Closed Captioned for the Hearing Inmpaired" notices on your TV screen. That means a television program is transmitted with encoded subtitles so that those who can't hear can still enjoy the full benefits of TV.

(Continued on page 101)

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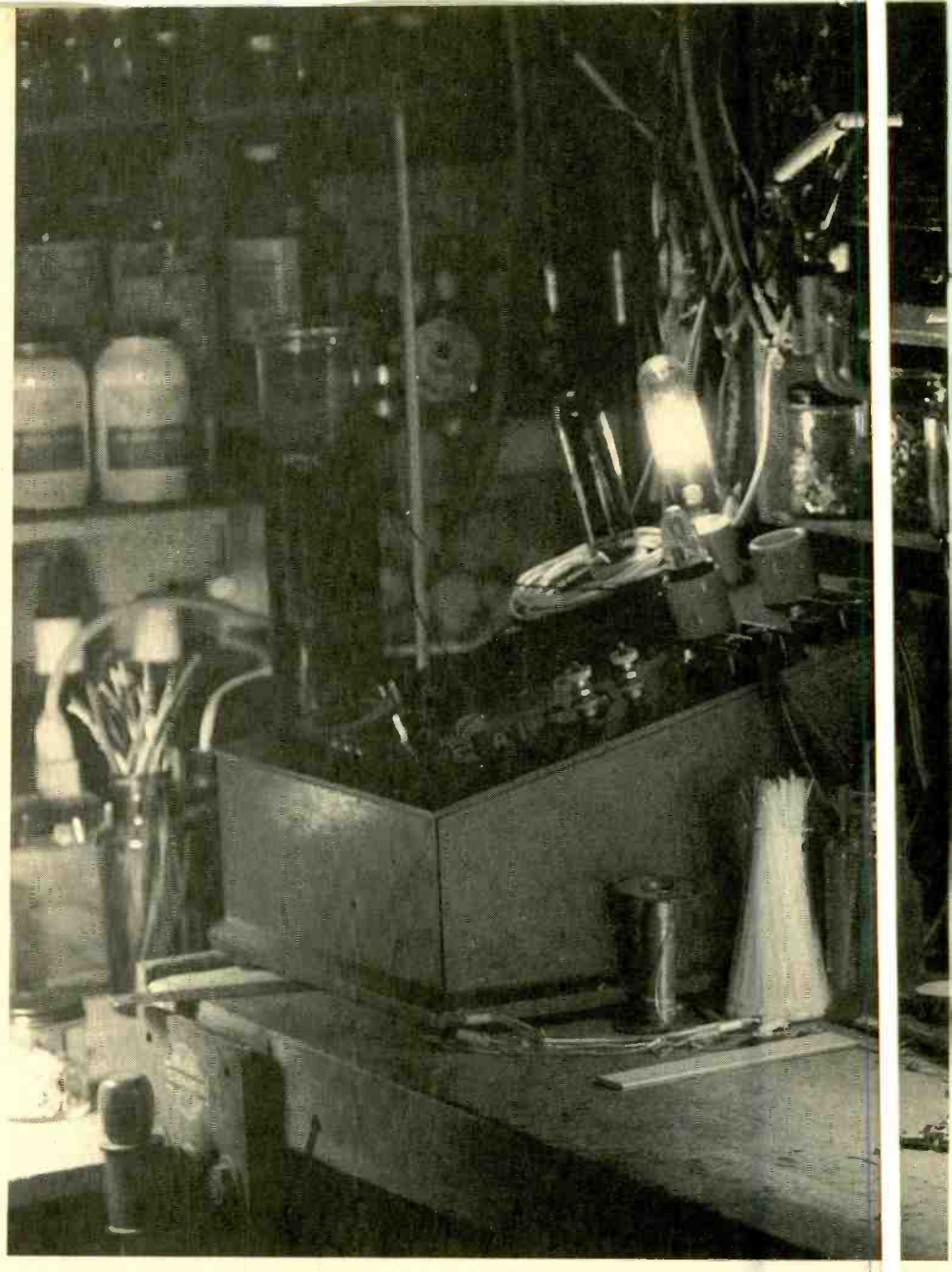
SUPPLYING THE ELECTRONICS



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-

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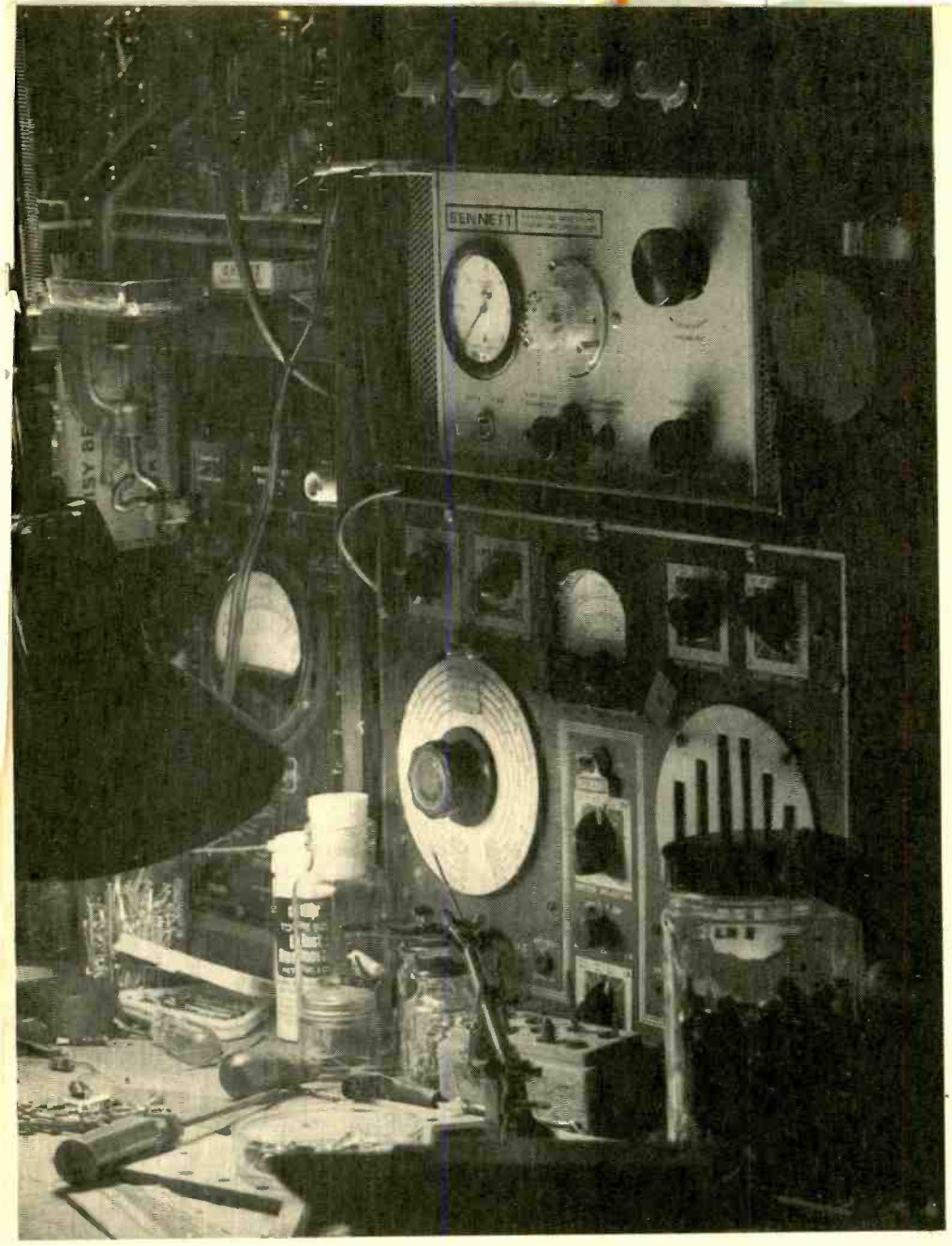

Where to turn when that something special that makes your project or experiment worthwhile is nowhere to be found

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

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NAMES AND ADDRESSES

All-Electronics Corporation
P.O. Box 567
Van Nuys, CA 91408.
CIRCLE 27 ON FREE INFORMATION CARD

Antique Electronic Supply
688 W. First St.
Tempe, AZ 85281
CIRCLE 28 ON FREE INFORMATION CARD

B & L Scientific
P.O. Box 1054
Duvall, WA 98019-1054
CIRCLE 29 ON FREE INFORMATION CARD

Chem-Lab
13814 Inglewood Ave.
Hawthrone, CA 90250
CIRCLE 30 ON FREE INFORMATION CARD

Consolidated Electronics Incorporated
705 Watervliet Ave.
Dayton, OH 45420-2599
CIRCLE 75 ON FREE INFORMATION CARD

Dick Smith Electronics USA
P.O. Box 468
Greenwood, IN 46142
CIRCLE 76 ON FREE INFORMATION CARD

Electronic Liquidators
P.O. Box 27656
Lansing, MI 48901
CIRCLE 77 ON FREE INFORMATION CARD

Fair Radio Sales
1016 E. Eureka
Lima, OH 45802
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JerryCo Inc.
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Evanston, IL 60202
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Hagenow Laboratories
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Manitowoc, WI 54220
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Halted Specialties
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Santa Clara, CA 95951
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Lindsay Publications
P.O. Box 12-WF5
Bradley, IL 60915
CIRCLE 22 ON FREE INFORMATION CARD

Mark V Electronics
8019 E. Slauson Ave.
Montebello, CA 90640
CIRCLE 23 ON FREE INFORMATION CARD

Newark Electronics
4801 Ravenswood Ave.
Chicago, IL, 60640
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Yeary Communications
12922 Harbor Blvd., Suite 800
Garden Grove, CA 92640
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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. It 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 98)

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THE ELECTROLYSIS OF WATER

You'll enjoy busting molecules with this inexpensive and easy-to-perform experiment.

BY STANLEY A. CZARNIK

In the early years of the 19th century, an analytical device of great power became available to the chemists and physicists of Western Europe. That device was the original wet-cell battery, called the *voltaic pile*, created by Allessandro Volta in 1800. For the first time, scientists were able to control and manipulate a continuous current of electricity.

Within a few months of Volta's discovery, British experimenters William Nicholson and Anthony Carlisle set out to investigate the new invention for themselves. Nicholson and Carlisle connected a couple of wires to a voltaic battery and then dipped the wires into a small glass of water. The wires were about 2 inches apart. The men were surprised to find that the wires in the water became covered with bubbles.

Bubbles? How strange. It was quickly recognized that the gas evolved at one pole was hydrogen and that the gas at the other pole was oxygen. But how, exactly, were the bubbles being produced? And, why did the gases appear only at the poles and not somewhere near the center of the vessel? The electrical decomposition of water revealed a thence-unknown relation between electricity and chemistry.

Wild Theories. Everybody had some kind of an explanation. Some accounts were just odd, while others made no sense at all. According to one idea, the hydrogen and oxygen were somehow transported through the wires and then released at the poles where they bubbled up.

An Italian theoretician by the name of Luigi Brugnatelli figured it like this: since electricity decomposes things, and since many strong acids also decompose things, it follows that electricity is actually a new kind of acid. Even the German physicist, Joahann Ritter, stretched the limits of reason with his claim that water was not really a compound at all.

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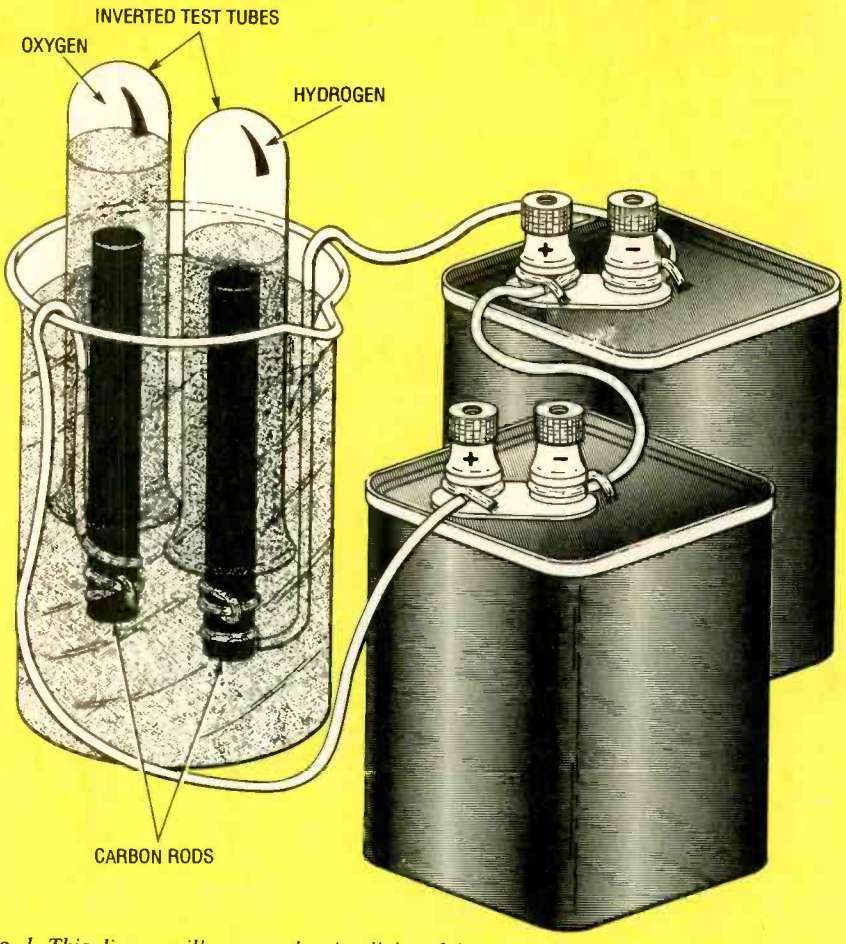

Fig. 1. This diagram illustrates the simplicity of the electrolysis circuit. Any source of low-voltage direct current may be used. Hydrogen appears in the test tube over the negative electrode; oxygen appears over the positive electrode as shown.

The history of science abounds with novel phenomena for which any explanation, however fantastic, seems better than no explanation at all, and the electrolysis of water is certainly no exception.

Physics and Metaphysics. In 1786 the great German philosopher, Immanuel Kant, published a treatise on the Metaphysical Foundations of Natural Science in which he argued that a new system of physics might be based on the attraction and repulsion of elementary forces. Kant's ideas were brought to England by the poet Samuel Taylor Coleridge. Coleridge conveyed the new metaphysical system to another competent poet, Humphrey Davy, better known to historians as the founder of modern electrochemistry.

Davy decided that the electrical decomposition of water and other chemical compounds occurs because the force holding matter together is itself electrical. In other words, chemical combination is caused by the force of attraction between points of particles with different electrical characteristics. He reasoned that the poles of a battery force the particles to travel in opposite directions: chemical units carrying a positive charge (like hydrogen) are attracted to the negative electrode while those carrying a negative charge (like oxygen) are attracted to the positive electrode. Davy's ideas were summarized in a lecture entitled "On Some Chemical Agencies of Electricity" presented originally in 1806.

Humphrey Davy was the first to work out a consistent, coherent theory of electrochemical activity. Our modern notion of ionic migration (which we'll discuss) is built on Davy's belief in the identity of electrical forces and chemical affinity. As Davy himself phrased it: "It is not impossible that matter of the same kind, possessed of different electrical powers, may exhibit different chemical forms."

H_2O. The electrical decomposition of chemical compounds provided early 19th-century philosophers with a view into the very nature of matter itself. You can reproduce some of the effects in your home laboratory. With a couple of test tubes and a DC power supply, you can actually take water apart and create a visual representation of the formula, H_2O. The electrolysis of water is an enjoyable, educational demonstration that just happens to make a superior science project as well.

Preparation. First, you'll need a couple of electrodes. Obtain two carbon rods each about 2 inches long. You can salvage them from two old 1.5-volt dry cells in which they are used as anodes. It doesn't matter whether the dry cells are dead or not, but do not take apart NiCd's or lithium batteries as they contain no carbon rods.

Now cut two pieces of hook-up wire; they should be about 18 inches long. Strip at least 1 inch of insulation off one end of each of the wires. Wind the bare wire around one end of each of the carbon rods and secure the windings with a few drops of solder. Insulate the carbon-copper joints with some silicone rubber sealing material or something similar.

PARTS LIST
MATERIALS LIST FOR THE ELECTROLYSIS EXPERIMENT

Burette Clamps (2)
Carbon rods (2)
Corks (2) to fit test tubes
Low-voltage, DC power supply
Large beaker, jar, or bowl
Ringstand
Sodium carbonate (washing soda)
Test tubes (2)
Silicone-rubber sealant
Hookup wire
Solder.

Laboratory hardware, glassware, and chemicals are available from Hagenow Laboratories Inc., 1302 Washington Street, Manitowoc, Wisconsin 54220. The Hagenow catalog is $1.00.
Carbon rods are sometimes available from JerryCo Inc., 601 Linden Place, Evanston, Illinois 60202. The JerryCo catalog is 50 cents.

Next, you'll need two large test tubes, two corks that fit the tubes, a container (like a large beaker or deep bowl) for the aqueous solution (more on that in a moment), and some means of supporting the test tubes in a vertical position. The best and easiest way of filling that last requirement is with a laboratory ringstand and a couple of burette clamps. Ringstands and clamps come in very handy for all sorts of experi-

(Continued on page 98)

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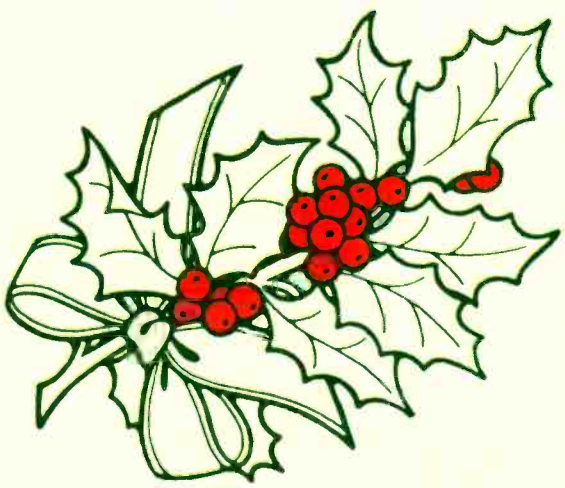

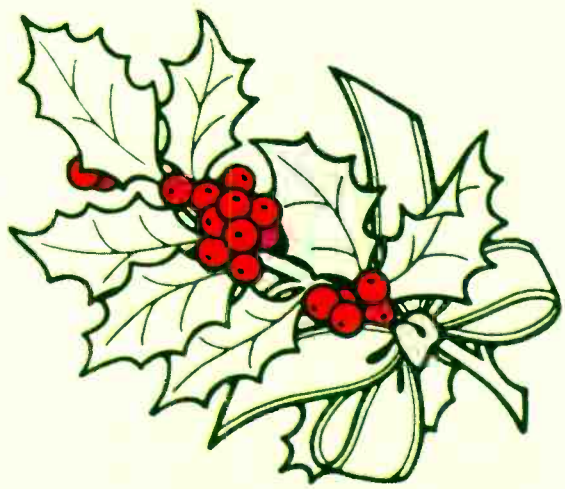

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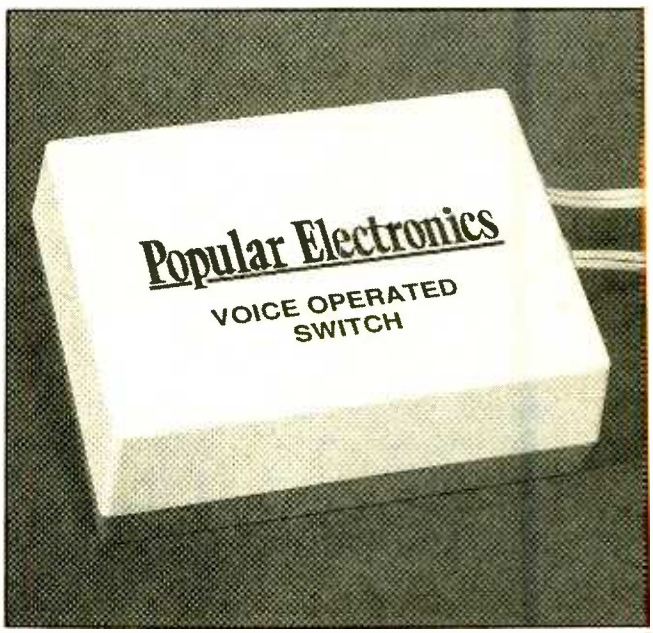
Voice Operated Switch

BY LUTHER M. STROUD



This electronic genie understands and obeys your spoken commands

Futuristic looking, intelligent machines often play an important role in stories created by science-fiction writers. Common among those devices is a vocal user interface—they spoke and understood spoken commands. But, yesteryear's science fiction is often a prelude to today's science fact.

Today speech synthesis is common in industrial applications and can also be found in toys for children and adults. However, there is another story; at the industrial level, voice recognition requires lots of sophisticated hardware, even though breakthroughs are occurring daily.

One such breakthrough is a speech recognition chip—the VCP200 Speaker-Independent Word Recognizer manufactured by Voice Control Products Inc., 1140 Broadway, Suite 1402, New York, NY 10001—recently added to Radio Shack's line of hobby-level components. Speaker independent refers to the fact that there is a high probability that the IC will recognize a spoken command regardless of who the speaker is, as long as the command is spoken in a manner that is compatible with the VCP200's internal programing.

The VCP200 (whose block pinout diagram is shown in Fig. 1) comes packaged with an in-depth tutorial on its use. Included in the tutorial are schematic diagrams for a band-pass speech filter/clipper circuit and a latch circuit for controlling a toy car. In addition, it requires a minimum of support hardware and is of reasonable cost to the experimenter. The device has two operating modes—*command* and *yes-no/on-off*—which are selected via the control logic presented to its mode-select input at pin 19. In the command mode, five motion commands are recognized, while in the yes-no/on-off mode, the chip responds to the commands "yes/no" or "off/on."

About the Circuit. In a nutshell, spoken commands are broken down into broad phoneme classes, which are then compared to stored strings of selected commands. When a command is recognized, an output is generated, which is used to toggle a flip-flop. The Q output of the flip-flop triggers a Triac which controls AC power to a lamp.

Lets take a closer look at the circuit. Refer to Fig. 2 At first glance, the circuit may appear to be hardware heavy, but don't be fooled; its really a rather simple circuit. The spoken command is picked up by an electret microphone element (MIC1) and is converted to an electrical signal. That signal is then fed to half of a 4069 hex inverter (U1-a, U1-b, and U1-c), which is set up as an amplifier. Together those three gates offer very high audio gain.

The value of the feedback resistors and coupling capacitors of each stage are chosen to shape the overall audio response so that it is essentially flat between 300–5000 Hz. The output of the amplifier section is fed through potentiometer R5 to the remaining gates of U1 which form a Schmitt trigger. Potentiometer R5 allows the circuit's sensitivity to easily be adjusted to ambient sound thereby reducing the possibility of the spoken command being misinterpreted by the circuit.

Gates U1-d, U1-e, and U1-f are used to convert the incoming audio signal to the logic-compatible, 5-volt peak-to-peak level that's required by U3 (the VCP200). The output of the Schmitt trigger circuit is fed to the audio input of U3 at pin 7, where the signal is processed and compared. The VCP200 provides two output signals, pins 8 and 9, that are used to trigger U2—a 556 dual oscillator/timer wired as a dual monostable with periods of 2 and 4 seconds.

If U3 signals that the command "on" is recognized (placing a logic 1 on pin 8), a short negative-going pulse is fed to U2 at pin 6. That pulse causes U2, pin 5 to be held at logic 0 for a period of two seconds. If U3 recognizes the command "turn right," a logic 0 is produced at pin 9. That signal is fed through C11 to the other half of U2 (at pin 8), causing it to turn on, thereby beginning a four-second delay.

The two outputs of U2 at pins 5 and 6 are fed to U7-a (¼ of a 7400 2-input NAND gate). In this application, the NAND gate functions as comparator; when both outputs of U2 are low, the output of U7-a is forced high. The high output of

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Fig. 1. This pinout diagram will prove invaluable if you choose to wire your Voice-Operated Switch on perfboard as the author did in building his prototype.

U7-a is fed to the clock input of U4 (½ of a dual J-K flip-flop).

Because the Q output of U4 at pin 9 is normally logic 1 at power up, the output of U7-a forces the output of U4 at pin 9 low. That low is applied to the pin 2 input of U5 (an MOC3010 optoisolator/coupler), forward biasing its internal LED, causing its output to turn on. The optoisolator/coupler, U5, isolates the AC line voltage from the logic circuitry.

With U5 turned on, a bias voltage is applied to the gate of TR1, triggering it into conduction, which then applies AC power to the load; TR1 is biased on as long as pin 9 of U4 is at logic 0.

Fuse F2 (a slow-blow type) handles the momentary peak in-rush current that occurs when full line voltage is applied to a cold incandescent-lamp filament, while still protecting TR1 from overload. Fuse F1 (a fast-blow unit) protects power transformer T1 and other components in the event of an accidental short circuit.

Putting It Together. The author's prototype of the Voice-Operated Switch was built on perfboard with component connections made using point-to-point wiring. Two sections of perfboard were used to maintain total isolation between the logic and power-control circuits. It's recommended that the integrated circuits be socketed.

Start assembly by installing the IC sockets on the perfboard; it's a good idea to mark the sockets for the IC's that will occupy them (U1, U2, etc.). That helps to minimize confusion when components are being interconnected. Although component layout is not critical, try to keep lead lengths short to minimize the possibility of feedback.

Capacitor C15 should be placed

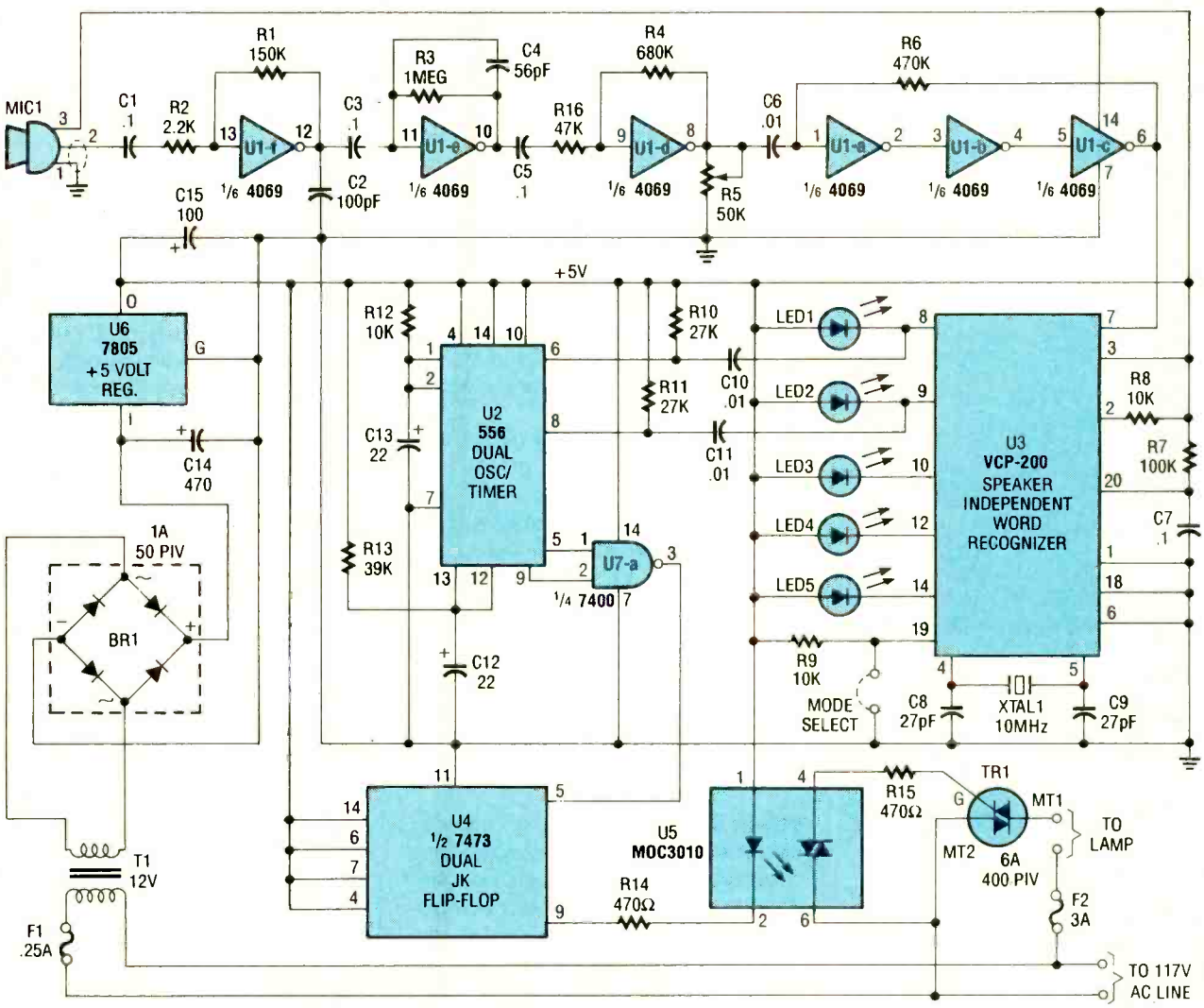

Fig. 2. At the heart of the Voice-Operated Switch is the VCP200 voice-recognition chip, which is supported by five other integrated circuits (not including the regulator IC, U6). If additional gain is required to increase the sensitivity of your circuit, it can be provided by the leftover gates of U7, the quad two-input NAND gate.

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PARTS LIST FOR THE VOICE-OPERATED SWITCH

SEMICONDUCTORS

U1—CD4069B hex inverter, integrated circuit
U2—556 dual oscillator/timer, integrated circuit
U3—VCP200 speech/word recognizer, integrated circuit (Radio Shack 276-1308 or equivalent)
U4—7473 dual J-K flip-flop, integrated circuit
U5—MOC3010 optoisolator/coupler, integrated circuit (Radio Shack 276-134 or equivalent)
U6—LM7805 5-volt, 1-amp, voltage-regulator, integrated circuit
U7—7400 quad, 2-input NAND-gate, integrated circuit
TR1—6-amp, 400-PIV triac (Radio Shack 276-1000 equivalent)
BR1—1-amp, 50-PIV, full-wave, bridge rectifier
LED1—Light-emitting diode (any color)

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1—150,000-ohm
R2—2200-ohm
R3—1-megohm
R4—680,000-ohm
R5—50,000-ohm trimmer potentiometer
R6—470,000-ohm
R7—100,000-ohm
R8, R9, R12—10,000-ohm
R10, R11—27,000-ohm
R13—39,000-ohm
R14, R15—470-ohm
R16—47,000-ohm

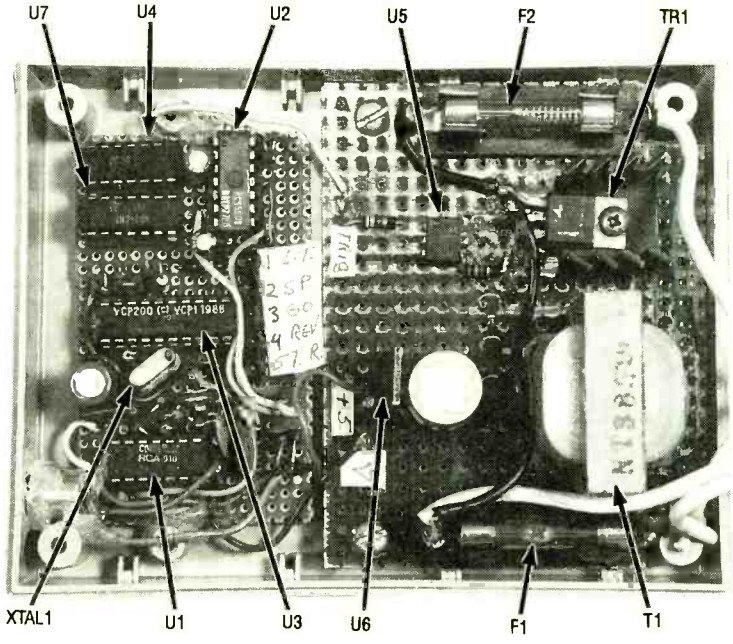
CAPACITORS

C1, C3, C5, C7—0.1-μF, ceramic-disc
C2—100-pF, ceramic-disc
C8, C9—27-pF, ceramic-disc
C4—56-pF, ceramic-disc
C6, C10, C11—0.01-μF, ceramic-disc
C12, C13—22-μF, 16-WVDC, electrolytic
C14—470-μF, 16-WVDC, electrolytic
C15—100-μF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

F1—¼-amp, fast-blow fuse
F2—3-amp, slow-blow fuse
M1—Electret microphone element (Radio Shack 270-092 or similar)
T1—12-volt, 300-mA, step-down power transformer
XTAL1—10-MHz crystal
Perfboard material, enclosure, IC sockets, fuseholder, heat sink, wire, solder, hardware, etc.

NOTE: The following items are available from Pershing Technical Services, PO Box 1951, Fort Worth, TX 76101: A partial kit of parts containing all capacitors, transformer, and semiconductors (except VCP200) for $35.00 (shipping included). Please allow from 6 to 8 weeks for delivery.



The author's prototype of the Voice-Operated Switch was built on perfboard. Two sections of perfboard were used to maintain total isolation between the logic and power-control circuits. Although component layout is not critical, try to keep lead lengths short to minimize the possibility of feedback.

near U2 and U3 to filter the regulated 5-volt supply. Note the unusual power-supply connections of U4. Also, only one NAND gate of U7 is used, the other sections of the integrated circuit are not needed.

Check the polarity of the electrolytic capacitors when installing them in the circuit. If you anticipate a lamp load of over 100 watts, a larger heat sink will be needed for TR1.

The author's prototype circuit was housed in a mid-sized plastic enclosure, measuring about 5½ × 4 inches. The larger perfboard sub-assembly, containing the power-supply components, was secured in place with screws. The smaller sub-assembly, on which the logic circuits are located, was fastened in place with a little silicone rubber cement. The case has only two holes, through which an extension cord enters and leaves the enclosure.

Check Out. Before doing anything else, check your work for possible wiring or construction errors—shorts, poor solder connections, misoriented components, etc., and correct any problems that you may find. Once you are satisfied that all is well, check out the logic circuitry. A safe way to do so is to apply an external current-limited 5-volt source to the logic portion of the circuit.

The current drain should be about 50 mA. LED3 should blink as power is applied, indicating that a power-up reset has occurred on U3 pin 20. Adjust R5 to its center of rotation and speak a command in U3's vocabulary; a status LED should light to indicate that the command has been understood. If not recheck your wiring of U1. Normal conversation-level speech should cause a 5-volt peak-to-peak signal to be developed at pin 7 of U3.

To check the operation of U2, momentarily ground pin 6 or 8 and check the corresponding outputs at pin 5 or 9 for the proper delay times as stated earlier. Due to the tolerances of the timing capacitors, the values of R12 and R13 may require adjustment. As U7-a detects a coincidence of two logic 0 inputs, the output of U7-a clocks U4, toggling its Q output at pin 9.

To check the power-control circuitry, use an ohmmeter to measure T1's primary resistance. If all is okay, proceed by attaching a 100-watt incandescent lamp to the load side and advance to the "smoke test" by plugging the power cord into a wall socket. Apply 5-volts between U5 pin 1 and pin 9 of U4's socket. Note: in order for the optoisolator/coupler to function, pin 1 of U5 must be positive with respect to pin 2. If your circuit is properly wired, pin 9 of U4 will be connected to pin 2 of U5, and the test signal will be properly polarized.

(Continued on page 97)

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THE DIGITAL ELECTRONICS COURSE

UNLOCKING THE GATES

Learn about the building blocks that make computers possible.

BY ROBERT A. YOUNG

Discounting the buffer, there are seven basic gates in digital circuitry: AND, NAND, OR, NOR, XOR (or exclusive OR), and XNOR, and inverter gates. Knowing about each is essential before you can design logic circuits. But, before we get into this month's discussion, let's review some basic characteristics that distinguish TTL logic from CMOS. For a TTL IC, a logic high (or 1) is represented by 2 to 5 volts, and a logic low (or 0) is represented by 0 to 0.8 volt. For CMOS circuits, a logic high is represented by 70 to 100% of the supply voltage, and a logic low is represented by 0 to 30% of the supply voltage.

CMOS circuits require considerably less power than do TTL circuits, but they also operate at somewhat slower speeds than TTL circuits. CMOS logic circuits are easily damaged by static charges, so their storage and handling requires greater care than TTL circuits. If an input to a TTL gate is "floating" (not connected), it appears to the circuit as a logic high, and the circuit reacts accordingly (that's an important feature to remember). However, it is not recommended that logic highs be derived by leaving TTL input lines floating.

Basic Logic Gates. The simplest of gates is the inverter. The truth table and schematic symbol for the inverter are shown in Fig. 1A. The inverter (often referred to as a NOT gate) is merely an amplifier designed so that it is at full conduction (saturated) when its input is high, and cut-off when the input is low. It is used in logic circuits to provide the inverse (or complement) of the input signal. That is, if the input to the inverter is a logic low, the output will be a logic high. Conversely, if the input is logic high, the output will be at logic low.

Figure 1B shows the truth table and schematic symbol for the AND. Recall from our previous discussion that the output of an AND gate goes high only when all its inputs are high. That's one way to recognize the truth table of an AND gate.

The NAND, or NOT-AND, gate is simply an AND gate with a negated (inverted) output. The NAND gate can easily be fabricated by combining an AND gate with

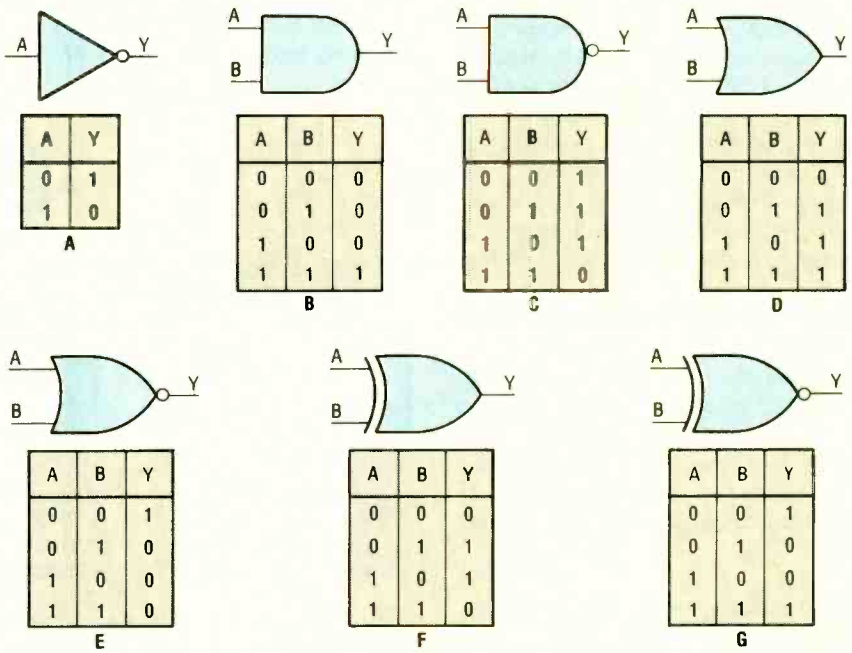

Fig. 1. Shown here are the truth tables and schematic symbols for the AND, NAND, OR, NOR, inverter, XOR, and XNOR gates.

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an inverter. The output of a NAND gate goes to logic high whenever any one of its inputs are at logic low. The truth table and schematic symbol for the NAND gate are shown in Fig. 1C.

The OR gate functions as the name implies; that is, in order for its output to go to the logic-high state, at least one of its inputs must be at logic high. The logic truth table and schematic symbol for the OR gate are shown in Fig. 1D.

The NOR, or NOT-OR, gate is simply an OR gate with a negated (inverted) output. A functionally equivalent circuit can be made by simply feeding the output of an OR gate through an inverter. The output of the NOR gate is a logic high when all inputs are logic low. But if a single input should go to logic high, its output toggles to logic low. The truth table and schematic symbol for the NOR gate are shown in Fig. 1E.

The XOR (Exclusive-OR) gate is a special gate that provides a logic-high output whenever either, but not both, inputs are high. (Note that the regular OR gate provides a logic-high output whenever any or all inputs are at logic high.) If an XOR gate has multiple inputs, and if the number of inputs that are high is even, the output is low. If there are an odd number of high inputs, then the output is high. One seldom sees more than two inputs on an XOR gate, so just remember the rule for the two-input form. The truth table and schematic symbol for the XOR are shown in Fig. 1F.

The XNOR, or NOT-XOR, gate (commonly known as a digital comparator) is simply an XOR gate with a negated (inverted) output. A functionally equivalent circuit can be implemented by feeding the output of an XOR gate through an inverter. The output of an XNOR gate is at logic high whenever all inputs to the gate are at logic high or logic low. When only one input is high, its output is logic low. The truth table and schematic symbol for the XNOR gate are shown in Fig. 1G.

Aside from the logic families mentioned earlier, logic integrated circuits are fabricated in different densities. Digital-IC packages (often called chips) can contain a small number of gates using *S*mall *S*cale *I*ntegration (SSI), or hundreds of gates, which is referred to as *L*arge *S*cale *I*ntegration (LSI).

How to Make Logic Truth Tables. The logic truth tables shown in Fig. 1 are two-variable truth tables—the variables being A and B, which can represent either a high or a low. As shown in those truth tables, the two variables can be applied to the inputs of the circuit in four unique combinations: A is low and B is low; A is high and B is low; A is low and B is high; and A is high and B is high.

TABLE 1—GATE OUTPUTS

INPUT		OUTPUT						
A	B	Inverter	OR	NOR	AND	NAND	XOR	XNOR
0	0							
0	1							
1	0							
1	1							

The logic truth table denotes the four unique combinations with 0's and 1's. A two-variable truth table is simple to make, but what about a three-variable or four-variable truth table? To make a truth table for any logic circuit, you must first determine the total number of unique input combinations that can be applied to the circuit. The total number of input combinations is determined by the number of input variables as follows:

$$2^n$$

where "n" is the number of input variables in the circuit. So, a two input variable circuit has:

$$2^n = 2^2 = 2 \times 2 = 4$$

unique combinations. Note that the truth tables for the two-input devices shown do indeed have four possible input combinations. Three-input devices are handled in a like manner; a three-variable circuit would have:

$$2^n = 2^3 = 2 \times 2 \times 2 = 8$$

unique combinations; and, a four input-variable circuit would have:

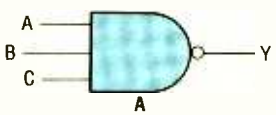
$$2^n = 2^4 = 2 \times 2 \times 2 \times 2 = 16$$

unique combinations, and so on.

In systems with three or more inputs, it is usually a good idea to set up a complete logic truth table. By doing so you will be able to examine all possible input conditions, and assign either a logic 0 or 1 to the output for each combination. A complete truth table will also aid in troubleshooting a complex system.

There is an easy method for setting up the input combinations in a truth table. Let's set up a truth table for the three-input NAND gate shown in Fig. 2A. Draw a column for each input and the output labeling each with one of the letters assigned to the input and output terminals, as shown in Fig. 2B. Starting with the input column farthest to the right (in this case column C), alternate zeros and ones (see Fig. 2C).

In the next input column to the left (B), alternate pairs of zeros and ones; and in the next column (A) alternate four zeros and four ones. (Note that as we progress from right to left, the number of input ones and zeros doubles.) The final column (Y) is reserved for output



A

A	B	C	Y

B

A	B	C	Y
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

C

A	B	C	Y
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

D

Fig. 2. To make a logic truth table, first draw a column for each input and the output (A), and label each column with one of the letters assigned to the input and output terminals (B). Starting with the input column farthest to the right, alternate zeros and ones (C). The final column is reserved for output information.

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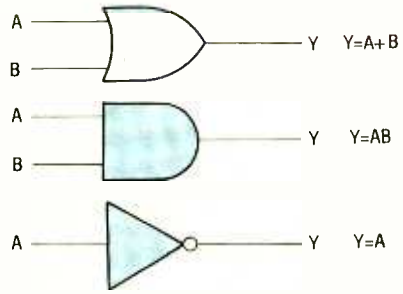

Fig. 3. Boolean expressions are used to define the operation of the basic logic gates. Note how a bar denotes logic inversion.

PARTS LIST FOR THE GATE EXERCISE

U1—7400 quad NAND-gate integrated circuit
U2—7402 quad NOR-gate integrated circuit
U3—7404 hex inverter, integrated circuit
U4—7408 quad AND-gate integrated circuit
U5—7432 quad OR-gate integrated circuit
U6—7486 quad XOR-gate integrated circuit
Logic probe, breadboard, ohmmeter, and No. 22 wire

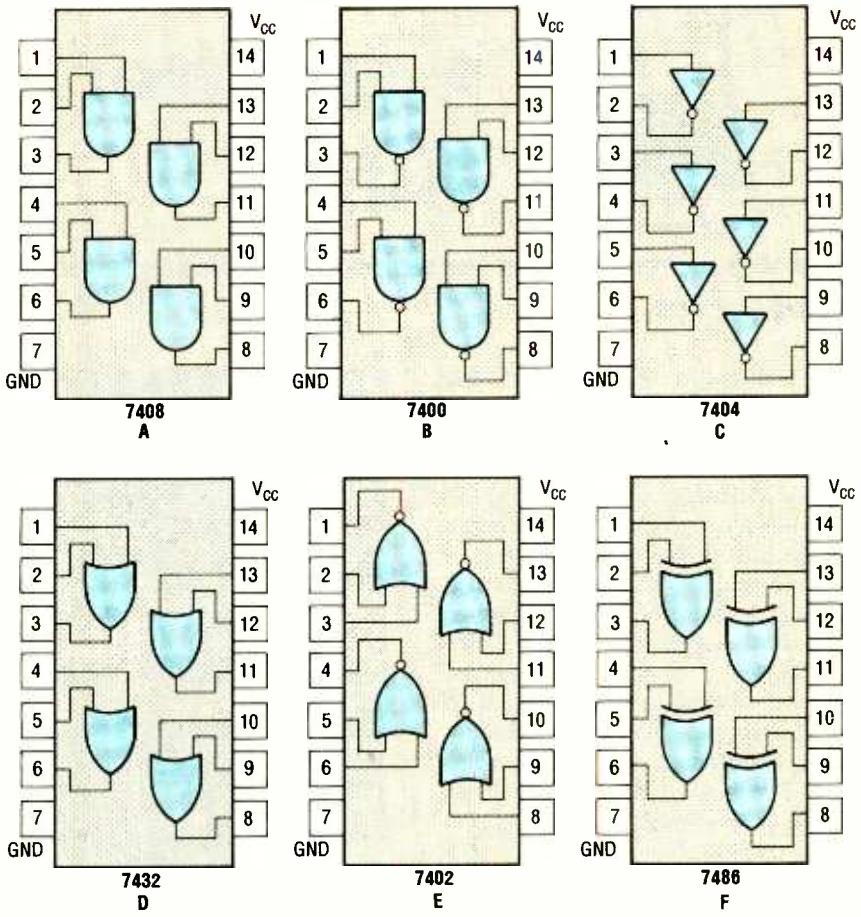

Fig. 5. Here are the pinout diagrams of the digital integrated circuits that we'll be using in our lab exercise. Assign variables to the inputs of one gate in each IC package (A, B, etc.).

information. The output of the three-input NAND gate, like any other NAND gate, is low only when all inputs are high, as the truth table in Fig. 2D shows.

Boolean Expressions. Boolean algebra is the universal language used by digital engineers and technicians to write and analyze logical operations. Boolean expressions—which can be considered a form of "shorthand"—can be used to accurately define the operation of any logic circuit. For example, the AND gate can be written as the Boolean expression:

$$Y = A \times B$$

The multiplication sign, × simply means that the input signals are ANDed together. The equations can be read as, "if inputs A AND B are both high (1) then output Y will be high."

Because Boolean algebra follows some of the rules of regular algebra, the multiplication sign can be omitted so the expression can be written:

$$Y = AB$$

An AND gate having more than two inputs is handled in a similar manner. For instance, a Boolean expression defining a four-input AND gate might be written:

$$Y = A \times B \times C \times D = ABCD$$

The Boolean expression for the OR gate is:

$$Y = A + B$$

The plus (+) sign signifies that the two input variables (A and B) are to be ORed together. The equation could be read, "if input A is at logic 1, or input B is at logic 1, then output Y will be a logic 1." That's usually shortened to simply Y = A OR B.

An OR gate having more than two inputs is handled similarly. For example, a three-input OR gate is defined by the expression:

$$Y = A + B + C$$

An inverter is indicated in a Boolean expression by a bar over the quantity being inverted. For example, if the input signal "A" is fed through an inverter, the output is $\bar{A}$. Generally, that is read as "NOT A." The quantities A and $\bar{A}$ are defined in Boolean algebra as always being in opposite states. That is, A and $\bar{A}$ can never be equal. If the A input is logic 1, then $\bar{A}$ must be logic 0, and vice-versa.

The most important thing to remember is that the signal applied to the input of an inverter will appear as its complement at the output. The input signal can be comprised of more than one quantity, for instance the expres-

(Continued on poge 99)

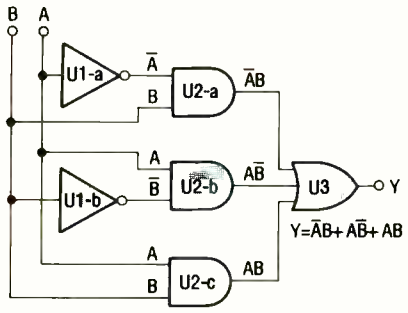

Fig. 4. In addition to defining the operation of simple logic gates, Boolean terms can also be used to indicate the state of all the various signals at different points in the circuit.

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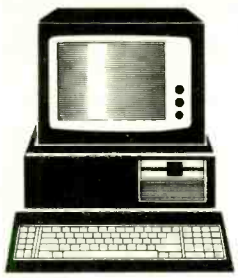

Computer Bits

USING MACROS

By Jeff Holtzman

If you're new to personal computers, the macro is a time-saving mechanism you'll want to add to your repertoire of PC tools. Generally speaking, a macro is a way of abbreviating an often-used, long, or complex (or some combination thereof) string of text or commands. The abbreviation itself generally consists of a single keystroke or keystroke combination (<CTRL-F1>, for example).

Many modern applications have their own macro languages. With entire books devoted to the subject, Lotus 1-2-3 is probably the most famous example; but even DOS, via the ANSI.SYS driver, allows rudimentary macro capabilities. For example, using ANSI.SYS you could devise a macro equivalent to typing DIR plus the <ENTER> key, and assign the macro to <F1> or to any key you like.

However, ANSI.SYS is limited in several ways, as are the macro "languages" of many application programs. In addition, a unified or general solution to the problem of keystroke redefinition would be nice. That way, a single tool would be useful in DOS and in any number of applications.

What's a Macro Good For? Suppose you're writing a story, and you get tired of typing in the names of your characters over and over again. Just define a macro for each and let SmartKey (a macro processor) do the dirty work.

Or suppose you're writing a double-spaced report with lots of quotations that must be single spaced and indented. Your word processor lets you change margins easily, but doing so manually requires a lot of time, not to mention wasted mental energy. Just define two macros: one that sets wide double-spaced margins for the main text, and one that sets narrow single-spaced margins for the quotations.

Or maybe you're just plain tired of typing DIR A: all the time. Or maybe you write Pascal programs and get tired of writing function and procedure blocks. Or maybe you've got a word processor whose power you like, but whose choice of keystrokes for commands seems totally illogical. Or maybe you'd like to reprogram the entire keyboard to conform to the Dvorak layout. Or maybe you'd like a single keystroke command for inserting a row or column into a spreadsheet. Or a single keystroke command for logging onto your favorite on-line telecommunications system and downloading new messages. Any repetitive, boring PC task is a candidate for a macro.

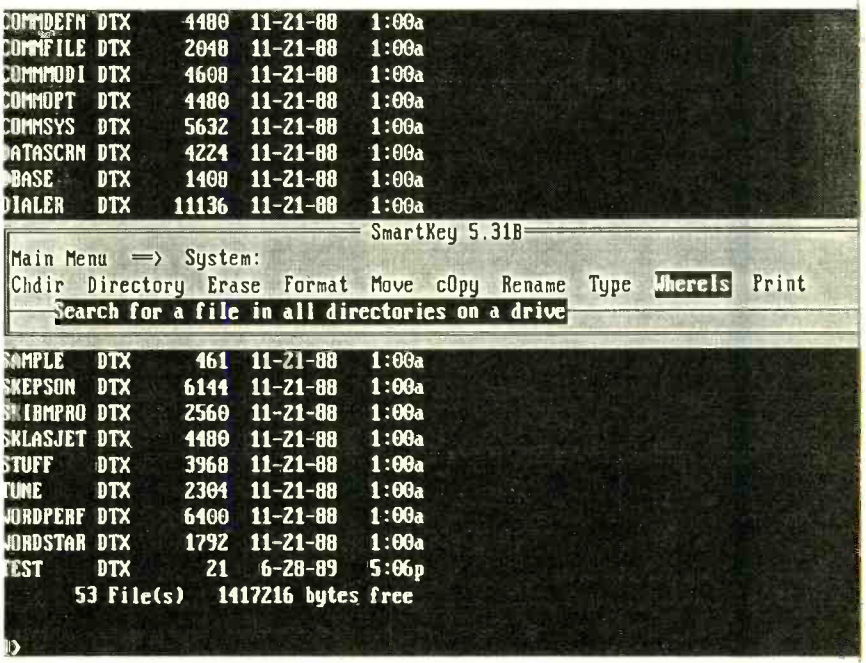

Fig. 1. SmartKey is a macro processor for IBM-compatible PC's. The program lets yo expand single keystrokes into many; and it has advanced features including menus, scree capture, automatic timed execution, and more.

SmartKey. SmartKey is probably the oldest macro processor; I used version II in the early 1980's on a CP/M machine. The current version (5.3) is much more powerful than the CP/M version, of course; in fact, calling SmartKey a macro processor is like referring to a Swiss Army Knife as a pocketknife.

SmartKey uses about 45K of DOS memory. However, if you have EM memory, most of the code is loade there, so DOS memory usage drops about 2K!

To create a macro, you press th Smart Key (nominally the gray < + key on the numeric keypad, but yo can reassign it). SmartKey then allow you either to record the macro "live (typing the actual keystrokes within yo application) or in an editor.

That's all it takes to create and edit macro. Of course you can copy, move and erase macros within a file, as we as load, merge, and save macro file from within SmartKey. You can convert text file into a macro; you can eve capture information from the scree and store it as a macro! Using the latte capability, you might cut informatio from a spreadsheet, load your wor processor, and then paste the informa tion into it. Who needs Windows?

You can load a macro file when yo start the program, and even force it t execute a "startup" macro. For exam ple, starting the program like this:

C>smartkey mymacros <ALT A>

would load the file MYMACROS an then execute the macro associate with <ALT-A>.

Say you've just completed a comple sequence of commands and realize would be nice to make it a macro. N problem; SmartKey keeps a buffer o your last 64 keystrokes. A special com

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mand converts the buffer into a macro that you're free to edit with the usual tools.

SmartKey macros can also get fancy. For example, you can halt a macro temporarily, allow the user to enter some information, and then continue. You can allow the user to type any number of keystrokes, or just a specific number of keystrokes; you can even force input to be a valid time or date. Going the other way, you can tell SmartKey to expand time and date strings in a macro. With that ability, you could press a "smart" key in your word processor and have formatted time and date strings entered into your document automatically.

Other advanced macro commands allow you to send strings to your printer, thus enabling special fonts, etc. Similarly, you can send strings to a modem, thus using it as an autodialer.

VENDOR INFORMATION

SmartKey, version 5.3 ($89.95)
Command Software Systems, Inc.
28990 PC Highway., Suite 208
Malibu, CA 90265
800/423-9147; 213/457-1789

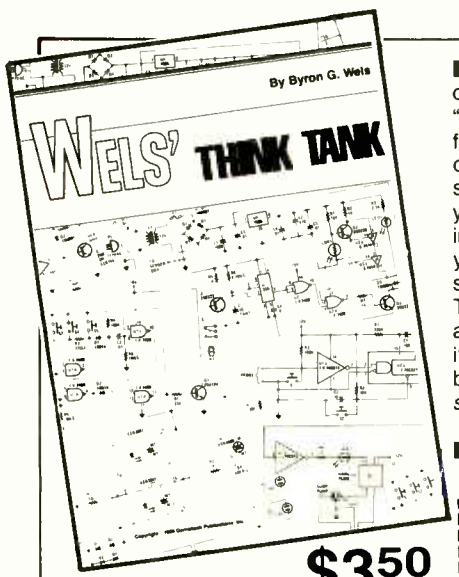
One of SmartKey's most powerful features is what the company calls an *OmniKey*, a means of executing a macro automatically when a macro file is loaded, at a specific time of day, after a specific time interval, or when a specific string of text appears on the screen. For example, using the time-interval option, you could force your word processor to back up your work every five minutes. You can have a total of four OmniKeys in memory at one time.

You can also include conditional processing in your macros. Using the "Until" command, you can cause a macro to pause until a specific time of day or until a specific text string appears on the screen. The "If" command allows a macro to execute in one of two ways, depending on whether a specified text string appears on the screen. The commands "If and Until" are useful, but would be even more useful if you could specify the exact screen location at which the desired text should appear.

SmartKey includes several other features that take it beyond the realm of macro processing. For one, the program includes its own set of DOS functions: making and changing directories; copying, moving, erasing, typing, printing, and locating files (by name, by a text string, or both); and formatting floppy disks.

SmartKey also includes facilities for generating on-screen windows and menus. A window has a border, can appear anywhere on the screen in any size, and text can be placed anywhere within a window. You can also create a menu inside a window, and force different actions to occur depending on which item a user chooses. With the menu facility, you could create your own on-line help system for any program, a pop-up printer controller (several examples of these are supplied), or even a DOS shell.

In addition, SmartKey includes several utility programs: one allows you to "move" keyboard keys, another encrypts and decrypts files, another blanks the screen after a specified period of inactivity, and another, called SmartPrint, that acts as macro processor for your printer. Several public domain programs (DOSEDIT and a sorted directory lister) that make life with DOS a little more pleasant are also included. ■



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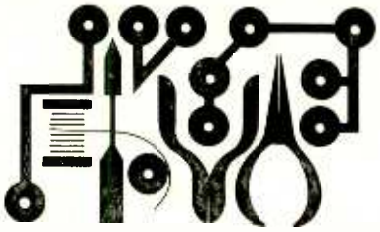

Circuit Circus

By Charles D. Rakes

SOME ADDITIONS TO THE WORKBENCH, AND MORE!

This month's Circus starts with a current-detection circuit that can be used to solve many printed-circuit board troubleshooting problems. When checking a breadboarded circuit, it's not too difficult to break a lead and check for current flow; but with a printed-circuit board, it's not quite as easy. Cutting a circuit board trace during troubleshooting is certainly not a good practice, and should *not* be performed except as a last-ditch effort.

High-Gain Current Sensor. Our first circuit, see Fig. 1, is a rather simple circuit built around a single op-amp. That circuit, a *High-Gain Current Sensor,* can be used to detect the presence of low-level current circulating through a printed-circuit board's copper traces. Two straight-pin probes are used to make contact with the circuit board's copper trace, diverting some small portion of the current in the circuit-under-test to the current-sensing circuit.

Voltage picked up by the probes is fed to both inputs of U1 (a 741 op-amp, configured as an inverting amplifier), which inverts the input signal and amplifies it by a factor of over 1000. The output of U1 is fed to two parallel-opposing LED's (LED1 and LED2), causing one to light to indicate current flow and polarity.

The op-amp's output (with zero input) is set to half the supply voltage via R5. The voltage at the junction formed by R3 and R4 is half the supply voltage. That arrangement makes up a simple bridge circuit with U1 being the variable element and the two LED's operating as output indicators. The resistance of R2 determines the op-amp's gain; for normal use, a 5-megohm resistor will suffice, but when it comes to ferreting out lower current levels, the value of R2 can be increased to 10 megohms for maximum sensitivity. Diodes D1 and D2 are used in the circuit to protect U1 from over-voltage inputs, while capacitor C1 is used to reduce the circuit's response to AC.

When assembling the circuit, mount the IC and all other components (except LED1, LED2, and R5) on a small piece of perfboard. The perfboard assembly can then be housed in a small plastic cabinet. The LED's and R5 (which is used in this circuit as a null adjust) should be mounted to one end of the project's enclosure.

The probes can be made of nothing more than a pair of finishing nails connected to the circuit board through short lengths of hook-up wire.

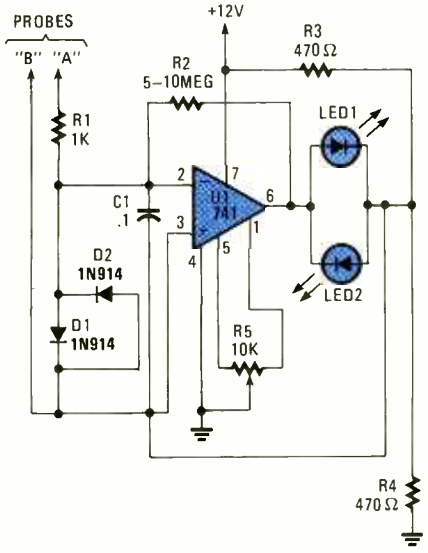

Fig. 1. The High-Gain Current Sensor is a rather simple circuit built around a 741 op-amp, which can be used to detect low-level current in a printed-circuit board's copper traces.

To use the circuit, first short the probes together and adjust R5 so that both LED's are off. Press the probes firmly on the circuit-board trace in question. If LED2 lights, the current flowing through the trace is in a direction that produces a positive voltage at probe "A" (relative to the voltage to probe "B"). A negative input at probe "A" (relative to probe "B") turns on LED1.

Inductive Current Sensor. Our second electronic detection circuit, an *Inductive Current Sensor,* is designed t seek out AC current flow in electric wiring and electronic circuitry. The ci cuit, see Fig. 2, is designed to detect ju about anything moving through a wir or through a component lead with frequency of from 60 Hz to over 10 kH

If you get stuck with the job of repai ing a washer, dryer, or other applianc the Inductive Current Sensor just migl make you the hero of the day. The ci cuit can also be helpful in working on car's electrical system.

The Inductive Current Sensor is bu around a 1458 dual op-amp (U1). Th signal input to the circuit is inductive coupled to the circuit through L1 (whic is actually a 10K to 2K audio tran former; the 2K winding is not usec When L1 is brought near a conduct carrying a varying voltage, a voltage induced in the coil. The voltage acro L1 is fed to the inputs of U1-a, where it amplified to provide a gain of approx mately 100.

The output of U1-a is fed through pc tentiometer R7 (the GAIN control) to th inverting input of U1-b, which also pro vides a gain of 100. The output of U1-b fed through a voltage-doubler/rectifie circuit made up of C3, C4, D1, and D The output of the doubler/rectifier is fe to the base of Q1, turning it on. That, turn, applies a voltage to the anode LED1 through R6, which is used to lim current through the LED.

The pickup coil, L1, was fabricated b removing the mounting frame from 10K-to-2K miniature audio transforme and then removing the "E" and "I" lam nations from the transformer core. Th "I" sections were discarded and th leads to the 2K winding clipped clos to the windings of the transformer. Afte that, all the "E" pieces were reinserte into the core opening (forming a open-loop core), and taped or glue in place. Doing so increases the ser sitivity of the pick-up element.

The remaining circuit componen were then mounted on perfboard c PC board and housed in a small plasti enclosure. The GAIN control, R7, th power switch, and the LED were on on side of the cabinet. Inductor L1 can e ther be mounted in one end of th cabinet with the winding flush and pa allel with the cabinet's end, or for ma imum sensitivity, it can be located o the outside end of the cabinet. Th pickup's maximum sensitivity to an e ternal field is realized when the cor ductor is parallel with L1.

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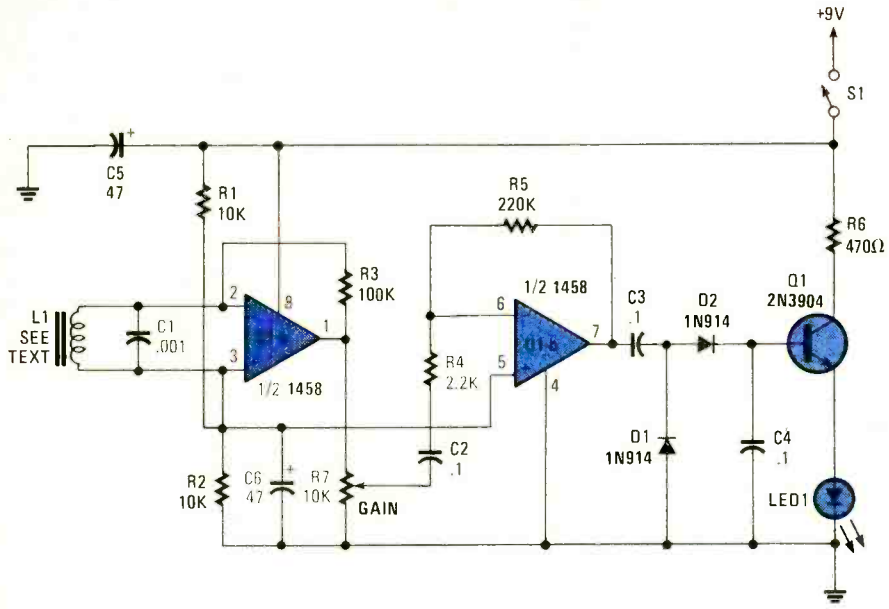

Fig. 2. The Inductive Current Sensor—built around a 1458 dual op-amp—is designed to seek out AC current flowing in electrical wiring and electronic circuitry.

PARTS LIST FOR THE HIGH-GAIN CURRENT SENSOR

SEMICONDUCTORS

U1—741 op-amp, integrated circuit
D1, D2—1N914 general-purpose silicon diode
LED1,LED2—Jumbo light-emitting diode

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1—1000-ohm
R2—5- to 10-megohm (see text)
R3, R4—470-ohm
R5—10,000-ohm potentiometer

ADDITIONAL PARTS AND MATERIALS

C1—0.1-µF, ceramic-disc capacitor
Printed-circuit or perfboard materials, probes, enclosure, IC sockets, battery and battery holder, wire, solder, hardware, etc.

PARTS LIST FOR THE INDUCTIVE CURRENT SENSOR

SEMICONDUCTORS

U1—1458 dual op-amp, integrated circuit
Q1—2N3904 general-purpose silicon NPN transistor
D1, D2—1N914 general-purpose silicon diode
LED1—Jumbo light-emitting diode

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1, R2—10,000-ohm
R3—100,000-ohm
R4—2200-ohm
R5—220,000-ohm
R6—470-ohm
R7—10,000-ohm potentiometer

CAPACITORS

C1—.001-µF, ceramic-disc
C2–C4—0.1-µF, ceramic-disc
C5, C6—47-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

L1—10K to 2K miniature audio transformer (see text)
Printed-circuit or perfboard materials, enclosure, IC sockets, battery and battery holder, wire, solder, hardware, etc.

Signal Conditioner. Our next offering, see Fig. 3, is a *Signal Conditioner* circuit that's ideal for cleaning up weak and noisy audio or Morse-code signals. The circuit can also be used to clean up digital tone signals (tones of the same frequency) in a remote-control extender circuit.

The audio signal is coupled through C1 and R9 to the input of U1—a 567 phase-locked loop (PLL)—at pin 3. The values of R1, R7, and C2 determine the detector's operating frequency. When a tone is detected, U1's output at pin 8 is pulled to ground for the duration of the input signal. If the tone is pulsed on and off, U1's output follows in step with the input signal.

The output of U1 is fed to the base of Q1 (a 2N3906 general-purpose PNP transistor), which is used to switch power to a second 567 PLL (U2) on and off. LED1 blinks on and off in step with the coded input signal. Integrated circuit U2 operates as a keyed oscillator, creating a new constant-amplitude output signal.

The rejuvenated tone need not be of the same frequency as the input, but can be set to a different frequency by way of R8. The circuit's output frequency is determined by the combined values of R4, R8, and C4. Transistor Q2 is used to isolate the output of U2 at pin 5 from external loading.

The actual values of frequency-determining components (as given in the Parts List) allow the two PLL's to tune from a low of a few hundred hertz to a high of several thousand hertz. The easiest way to raise or lower the tuning range is by increasing or decreasing the values of C2 and C4.

If you enjoy listening to CW (Morse code) and would like to clean up those weak and noisy signals, just connect the receiver's audio output to the input of

(Continued on page 101)

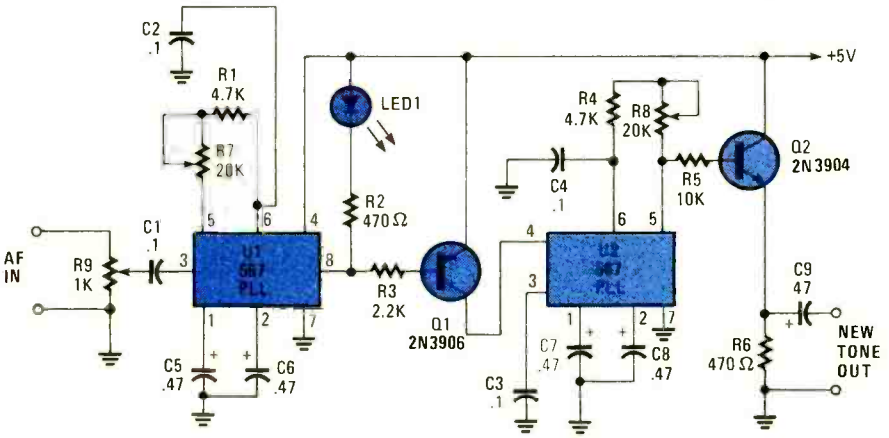

Fig. 3. The input to the Signal Conditioner (which is built around a pair of 567 PLL IC's) is coupled through C1 and R9 to the input of U1. The output of U1 is fed to the base of Q1, which is used to switch power to a second 567 PLL (U2) on and off.

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Ham Radio

By Joseph J. Carr, K4IPV

A LOOK AT THE CUSHCRAFT R-5 VERTICAL ANTENNA

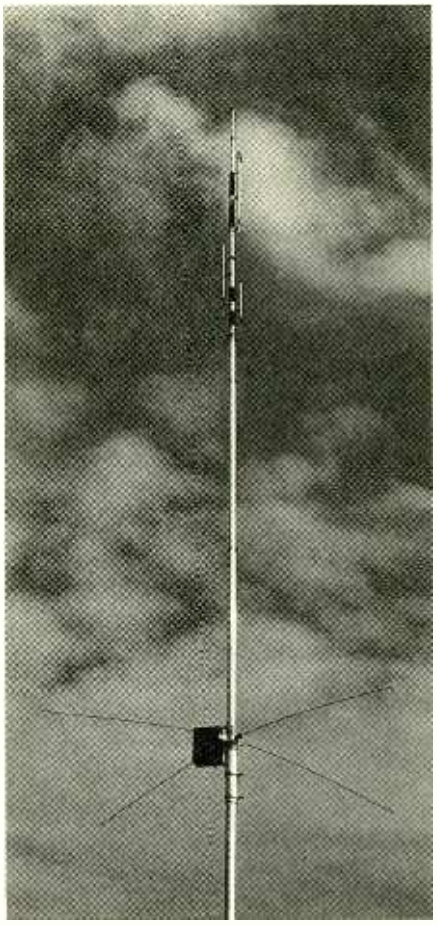
There are many vertical antennas sold for amateur-radio operation, but most of them fall into only one or two categories. One such category is the multi-band, quarter-wavelength trap vertical. Such antennas are so much alike that the offerings of various makes are electrically just clones of the same idea. At least that's what I used to believe, but that was before I installed my present vertical: a Cushcraft model R-5, which operates on five bands: 10, 12, 15, 17, and 20-meters.

The R-5 is a different sort of vertical, and if you like to work DX and have a limited amount of space, then the R-5 is the antenna for you. Why is the R-5 different from other verticals? Let me count the ways:

1. It doesn't have any radials.
2. It is a half wavelength on each band rather than the traditional quarter wavelength.

One reason a half-wavelength vertical antenna is capable of better DX performance than the traditional quarter-wavelength types is because it has a lower angle of radiation. That's the angle at which the signal leaves the antenna and propagates into space. Skip distances are generally longer when the angle of radiation is lower. The best selection for DX, therefore, is an antenna with a real horizon-hugging angle of radiation.

I've installed verticals in the past where the best I could do from my Virginia QTH was South Carolina (or so it seemed). If you check the logbook here at K4IPV, then you'll find that the first QSO out of the box on the R-5 (excited with 100-watts from my transceiver) was an RA3 in the Soviet Union. The second was a VU2 in India, and all that afternoon I scored QSO's with the likes of LU2, KC4, and the usual gaggle of western and eastern European stations. While band conditions were certainly a factor, it's also true that some of my antennas would simply not have the angle of radiation to work those stations at all.



Cushcraft R-5 half-wavelength, multi-band vertical antenna. The "radials" at the base are actually a decoupling stub...and are not the type of radials normally seen on verticals.

There are no radials on the R-5, although there is a decoupling section at the base that looks (on first glance) like very short radials. Those four rods are each 48-inches long, so are not radials in any sense of the word (radials must be quarter wavelength). Because the R-5 is half wavelength, and fed at one end, it is essentially a voltage-fed antenna (which means high impedance).

In order to allow the R-5 to work into ordinary 52-ohm coaxial cable, there is a matching network in a black, weather-proof housing mounted at the base. That network is an improvement over the network used on the R-3 (the R-5's three-band predecessor) because it is passive and requires no operator adjustment.

Assembly. The Cushcraft R-5 comes in sections that have to be assembled. The antenna can be put together initially in two sections at a convenient place (such as my basement workshop on a rainy day). The lower section consists of the base and the first tube (which forms the 10-meter section), while the other is the top section including all of the traps. The two sections can then be joined together at the installation site.

Alternatively, if assembly at the site is desired, there is no reason not to. Assembly and installation should take about two-hours if two people work together. I did mine alone, but that was dumb. I violated my own rule of assembling any form of antenna: always use the buddy system.

The Cushcraft R-5 can be mounted on any steel pipe of antenna mast that is more than 1.5-inches, but less than 1.875-inches, in outside diameter. Mine sits atop a 12-foot section salvaged from a TV-type telescoping mast that my previous vertical was mounted on.

Adjusting the R-5. Actually there are no adjustments. The R-5 is the *only* commercially made vertical that I've installed (and there have been more than a few) that did not need adjustment after it was installed. The usual problem is that the dimensions for lengths of the various sections are good, educated guesses, but are not usually found to be valid at any given location. Local installation conditions change the actual lengths required, so the vertical sections have to be adjusted band-by-band.

However, in the case of the R-5, the VSWR profile closely matched those published in the Cushcraft instructions... so I left it as is. I was able to check resonance with several instruments: a VSWR meter, a noise bridge, and an MFJ impedance bridge. In all three cases, the resonant points agreed... and were as specified. But my experience does not mean that yours will be the same.

Initially, install the antenna with the lengths set as shown in the instructions. Start at 10-meters and work down to 20-meters, checking the resonance with a

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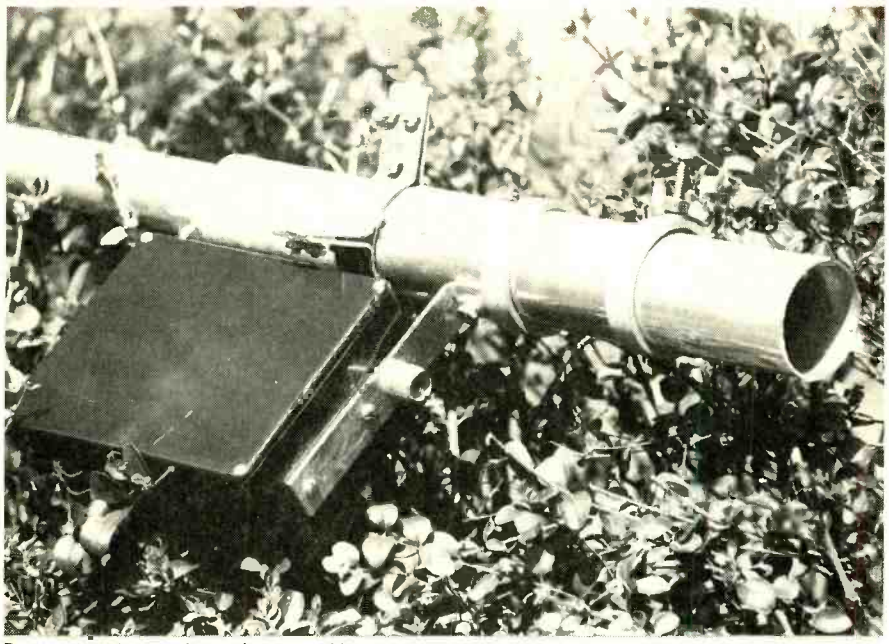


Base mounting and weather-proof housing for the impedance-matching network.

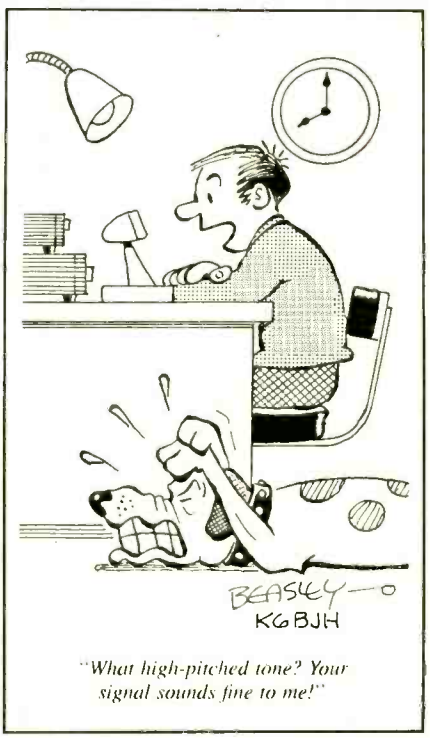
VSWR meter or other means. At any band where the antenna is not resonant, adjust the length. The section should be lengthened if the resonant point is too high, and shortened if it is too low.

Faults? The Cushcraft R-5 is well-designed and well-built. There are no glaring faults with the antenna. But I did sense that the instructions might confuse some people on one point. The method for securing the R-5 to the mast is a little unclear and could use a simple illustration. It is a "coaxial" mount and is actually easier and more clever than the offset U-bolt method used on other antennas. But I had to tinker with it for a bit before the mounting method became clear.

Conclusion. The Cushcraft R-5 is a quality antenna of unique design. It serves as a decent DX antenna for anyone, but is especially useful for those readers who either prefer the omnidirectional pattern of a vertical or have (as I do) a space problem. DX and limited space are not normally found together... except in the R-5.

The Cushcraft R-5 is the latest improvement in a family of half-wavelength verticals that started with the R-3 several years ago. The R-3 used an adjustable impedance-matching network. The R-4 came along and added 12-meters and replaced the adjustable network with a broadband model. The R-5 is the latest in the family, and offers all five bands from 20-meters through 10-meters. Owners of the R-4 can, I understand, obtain the R45K 18-MHz conversion kit from Cushcraft (48 Perimeter Rd., Manchester, NH 03108; tel. 603-627-7877) or its dealers. The R45K kit will convert the R-4 into an R-5.

Alas, the time has come to say good bye for another month. In the meantime, don't forget that your tips, comments, questions, suggestions, and what have you are always welcome. Send them to *Ham Radio*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■



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CIRCLE 6 ON FREE INFORMATION CARD

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Antique Radio

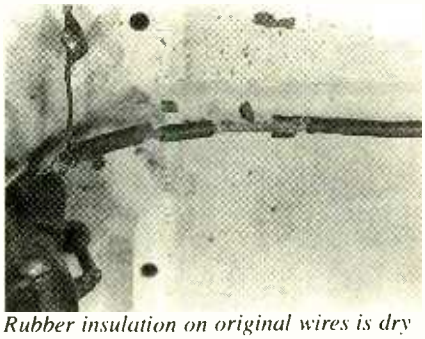
By Marc Ellis

PUTTING THE "WASP" TOGETHER AGAIN!

For the past four issues, we've been studying a charming relic of the late 1920's. One of the most fascinating things about this set, known as the "Pilot A.C. Super-Wasp," is its transitional design. It was among the first of the radios designed to operate from the AC line, and was still built very much like the battery sets it replaced. Another point of interest is that this radio (through use of five sets of interchangeable plug-in coils) covers not only the broadcast band, but also the medium and short-wave bands through about 18.5 megahertz.

In the previous issues, we discussed the history of the "Wasp," reviewed its circuitry, checked its components, and made necessary repairs. Some of the work required that we partially dismantle the radio, and this month we're going to put everything back together again. When we're through, the set restoration will be complete, and the unit will be ready to power-up and test.

Taking Stock. Those who've been with us from the beginning have followed the dismantling procedures required for the study, inspection, and repair phases of the A.C. Super-Wasp project. The rear halves of the 2-part square cans that shield the RF amplifier and detector stages were the first to go. They came off so that I could have easy access to all of the components for checking and circuit tracing. Next to be removed were the front panel and the remaining (forward) half of the detector-stage shield can. Those went to clear the way for removal of the detector-stage tuning capacitor, which had had several rotor plates removed and needed to be rebuilt.



Rubber insulation on original wires is dry and brittle; it cracks and crumbles if disturbed even slightly.

Flea-market shopping uncovered a coil of wire that was suitable for pilot-lamp lead replacement.

While taking off the front panel, I had noted that the wires supplying current to the dial lamps were in pretty bad shape. The rubber insulation was dried out and quite brittle. Everything was fine until a wire had to be moved—even very slighly. Then the insulation at the point of flexing would crumble to bits and fall off. Because the wires to each lamp were tightly twisted around each other (a standard hum-reduction technique used with AC supply circuits) the loss of insulation could easily allow a short circuit to occur.

The good news was that the pilot-lamp wiring could be replaced fairly easily. The bad news was that virtually *all* of the hook-up wire used in the radio was identical to that used in the pilot-lamp circuits, and thus could be expected to be equally deteriorated.

From an aesthetic point of view, the radio wasn't in very bad shape. As might be expected in a 60-year-old set, everything was covered by a fine layer of dust. Though dark and slightly oily, the dust was easy to pick up and wouldn't present much of a removal problem.

There was no sign of corrosion on any of the aluminum chassis components. And aside from some minor scratches, the cabinet and metal front panel were quite presentable—requiring only a bit of cleaning and polishing to look virtually mint. But all of the screw-heads and other plated parts had a dark-grey coating of tarnish. That included the knurled binding-post nuts scattered liberally throughout the radio (each tube socket has a set of five, and each audio transformer has a set of four).

Strategy for Reassembly. Before proceeding with reassembly of the A.C. Super-Wasp, I had to make some decisions about how far to take the restoration process. There's no doubt that a meticulous restorer (and one with quite a bit of time to spend) would now dismantle the set virtually down to the last screw-head and thumb nut. Then each plated part could be carefully polished, and all of the brittle wiring replaced with new material that would be a close match to the original.

My decision not to take the project that far was actually not very difficult to make. I once did such a screw-by-screw restoration of an *Atwater Kent* breadboard model, and I remember very well how time-consuming the process can be. If I wanted to continue coming up with a new *Antique Radio* column every month, working at my regular gainful employment, and spending some time with my family every once in a while, I'd have to do something less ambitious.

Accordingly, I decided against any further dismantling. The plated hardware would have to stay gray and (except for replacing the destroyed pilot-lamp leads) I was going to have to rely on the integrity of the old hook-up wire. I was pretty sure the insulation would stay intact and usable as long as I avoided flexing any of the wires while putting the receiver back together.

While I did plan to do a certain amount of cleaning and polishing, my goal would *not* be to restore the Wasp's appearance to showroom condition. Instead I'd concentrate on making the radio *operate* much as it did when new.

Some readers may object to that philosophy. If you're one of them, ask yourself this question: Would you rather take on an over-ambitious restoration that you might never finish, or successfully complete a well-planned project that has realizable goals? I maintain that you'll do the set more good by finishing

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Q-tips came in handy for removing dust from odd nooks and crannies.

your project than by leaving it in pieces. Then the radio will still be there for some future restorer who may choose to take your work a little further.

If you're sure you have the time, and are bent on coming up with a radio that is mint-appearing in every detail, then go to it. But if you don't have the time or inclination to remove and polish every screw-head and thumb nut, don't feel guilty. You aren't *required* to do those things in order to enjoy our hobby.

By the way, if you start restoring antique radios (as I did) in your twenties or thirties, and if you're not storing your sets under museum conditions, you'll easily live long enough to see Father Time reverse the effects of your most careful spit-and-polish work. After all, the passage of time is what dulled the factory newness in the first place. (There's probably a philosophy of life there somewhere!)

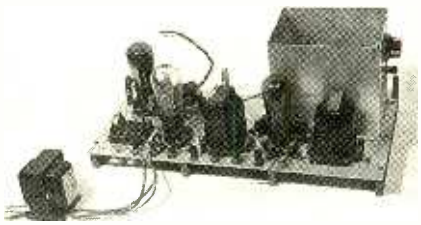
Before Putting It Together. Now that I've been so eloquent about what I decided *not* to do for the radio, let's talk about what I *did* choose to do. Before beginning reassembly, I wiped most of the black dust from the chassis. I used a soft cloth to clean the larger areas and switched to Q-tips for the nooks and crannies. The next step was to replace the pilot-lamp leads, since they had to be connected to tube sockets that would be inaccessible after the shield cans were replaced.

The hook-up wire used for those leads (and, as has been mentioned, for most of the other wiring in the radio) had a stranded conductor (about No. 18) covered with a dark-brown rubber insulation. I didn't have anything even close among my supplies, but a trip through one of our local hamfest flea markets turned up some wire that would serve. The insulation was black vinyl rather than brown rubber and the stranded conductor was a little bigger (No. 16), but the outer diameter of the wire was almost identical.

That replacement wire is far from an exact match, but its general appearance is in harmony with the rest of the radio. And in any case, given the limited free time available to me, it was all I could lay my hands on. I intend to document the substitution on the information card I always attach to any radio that I work on. Then a future, more meticulous, restorer will be able to discard the wire with a clear conscience and substitute something better.

Using the new wire, I twisted up two new pairs of pilot-lamp leads—each a little bit longer than the one to be replaced. Those were wired, in place of the originals, across the heater terminals of the tube sockets in the RF amplifier and detector shield cans. I was able to accomplish the amplifier-socket connection without disturbing any of the other wiring attached to the socket, but I wasn't so lucky with the detector connection.

In the latter case, I had to disturb the wires delivering heater voltage *to* the socket—breaking the insulation at a point where that tightly-twisted pair made a right-angle turn up through a hole in the aluminum chassis. Rather than attempting to replace that pair of wires, which probably would have resulted in the disturbance and breakage of yet another pair—starting a chain reaction that would have led to the replacement of every heater wire in the radio—I decided to repair the damage instead.



Prior to completing reassembly, the heater circuit was powered up and "smoke tested" to uncover possible short circuits due to defective insulation.

My supply cabinet yielded some antique-looking fabric-type spaghetti large enough to slip over the damaged wires. Cutting a couple of short pieces, I worked one over each of the wires—down through the hole in the chassis—to cover the area where insulation was missing. This resulted in a very satisfactory and natural-looking "fix" which, of course, I intend to document on the set's information card.

Smoke Test and Reassembly. With the new pilot-lamp supply wires con-

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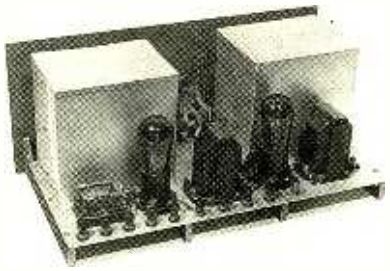
nected to the tube sockets, I started to reassemble the shield cans. But before I got very far, it occurred to me that I should probably stop and test the heater/pilot-lamp circuit for shorts. It looked like the can reassembly would be a tedious process, and I didn't want to have to undo my work in order to troubleshoot some bad insulation I'd overlooked.

A simple ohmmeter check wouldn't work because of the hum-suppression resistors connected across the filament terminals of a couple of the sockets. Those would give me a low-ohms reading regardless of whether or not I had a short-circuit condition. The only thing to do would be to plug in the tubes, apply power to the circuit, and check to see that no wires were burning and that the tubes were lighting.

Luckily, I had already purchased a 2.5-volt filament transformer to use in the power supply I plan to build for this set. It took only a few moments to hook up a temporary line cord to the transformer and connect its secondary to the 2.5-volt binding posts at the rear of the A.C. Super-Wasp's chassis. Plugging in the tubes and powering up the transformer soon proved that everything was operating as it should.

Now I was free to return to the shield-can reassembly project—which turned out to be a real test of patience. When I had originally disassembled the cans, I noted that there were a lot of missing fasteners. At the time, I commented that I intended to correct that. Regenerative circuits are touchy, and the



Reassembled A.C. Super-Wasp is ready to try out. We'll do that as soon as suitable power supply is completed.

shields were there to minimize interaction between stages as well as detuning effects caused by the operator's "hand capacitance."

It seemed to me that the electrical integrity of the shields was highly important—and that meant that the fasteners attaching the shield halves to each other, and to the chassis, all had to be in place. However, it turned out to be much easier to say that than to accomplish it. In the end, I succeeded—but it's easy to see why the last person to work on the set got a little sloppy!

The screws holding the bottoms of the can-halves to each other are obstructed by components and, in any case, are too deep to reach with fingers or conventional tools. The only way I could install the lock washers was to dangle the washers (using sticky tape) from the business end of a long screwdriver and "hook" them over the screw ends. Nuts were installed in similar fashion, except that they were stuck against a "flat" of the screwdriver using a sticky-tape "hinge." Then they could be pressed against the end of the screw while the screw-head was turned from the outside.

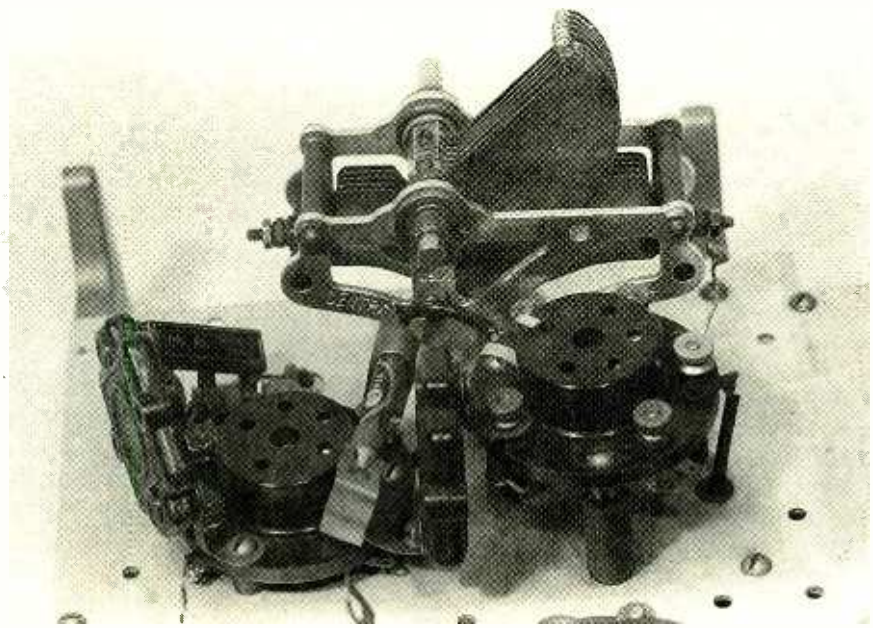
The screws holding the can-halves to the chassis were easy to install; I was able to push them down through their holes using a long screwdriver with a screw-holding attachment. Placing lock washers and nuts on them, though, was another matter; the job was occasionally a downright nightmare. The front halves of these cans had obviously been originally installed before any of the over- or under-chassis components—and some of the latter were now very much in the way.

Dropping washer and nut onto a screw-end half-buried between components is hard enough. If, at the same time, you have to steady and turn a screw-head located deep at the bottom of a shield can on the other side of the chassis, you need the patience of a saint or the dexterity of an acrobat. I don't have either, but somehow I kept my promise to myself and installed every single fastener. If I had to do it all over again, though, I don't know if I'd make it!

The rest of the reassembly process was fairly easy. Though some of the nuts and washers holding the metal front panel to the chassis had to be slipped into fairly tight places, there wasn't nearly as much of a problem as with the shield cans. Once the panel was secured, hooking up the free ends of the pilot-lamp leads to the lamp assemblies went very quickly. After that, it was only necessary to reattach the speaker jack and AC switch to the front panel—and the set was complete once again.

And now that the A.C. Super-Wasp is ready to try out, the focus of our project will shift to constructing a power supply suitable for operating it. What I have in mind is a circuit loosely based on the original Pilot unit that was sold as an accessory for the Wasp. But more on that later!

That's It For Now! In the meantime let's hear from you! Remember, at the end of this series I hope to have a roundup of reader comments, reminiscences, and information relating to the Wasp radios. I've already received a couple of very interesting letters; act now to make sure *yours* is included also. Address your correspondence to *Antique Radio*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■



Repaired tuning capacitor (background) is wired into circuit before shield can is reassembled around detector stage.

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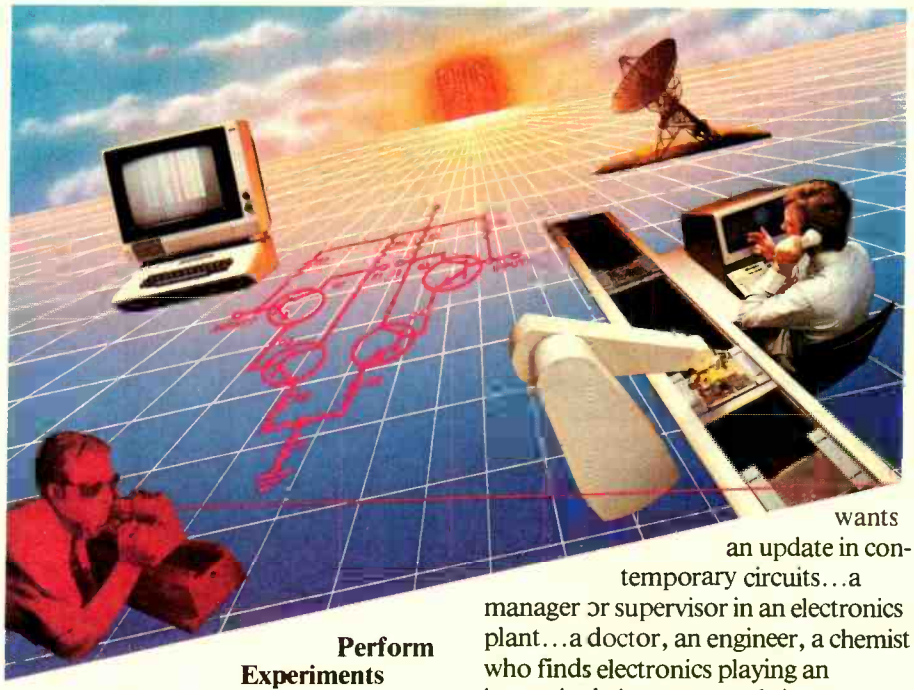

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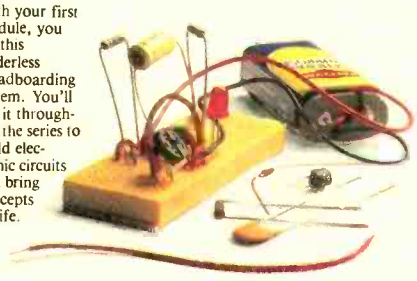

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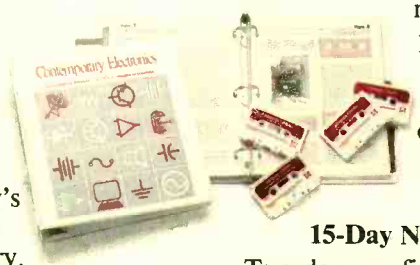

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DX Listening

By Don Jensen

TWR PROVIDES LISTENING TARGETS FOR SWL'S

One of the most extensive religious broadcasting operations today is *Trans World Radio*—headquartered in New Jersey—which operates a series of shortwave stations around the world. The TWR stations in Europe, Africa, Asia, the Pacific, and Caribbean areas pump out more than 1.5-million watts of shortwave power daily from some 15 transmitters.

Additionally, the evangelical broadcaster operates or leases time on powerful medium-wave stations overseas. The TWR shortwavers provide listening targets for SWL's with its stations in Monaco, Swaziland, Sri Lanka, Guam, and Bonaire. Those stations have different regional targets, broadcasting in over 20 different languages and dialects.

Happily for DX listeners, the TWR stations all have reputations for being excellent verifiers, replying to accurate, useful reception reports with QSL cards. However, as a bonus for faithful SWL's, Trans World Radio is offering a special award certificate. It was announced recently by Chuck Roswell, the frequency coordinator for TWR's station on the island of Bonaire in the Netherlands Antilles, off the northern coast of South America.

Roswell, in addition to being a radio ham himself, is the host of the station's program for SWL's, "Bonaire Wavelengths," which is aired Saturdays at 1145 hours Universal Coordinated Time (UTC) on 1,815 and 15,345 kHz, and repeated Sundays at 0330 UTC (remember UTC is 5 hours ahead of EST, 6 hours ahead of CST, etc., so that is actually Saturday night in North America) on 9,535 and 11,930 kHz.

A "Confirmed All TWR Shortwave Transmitter Sites" award is available for listeners who can submit photocopies of their QSL's from the five Trans World Radio stations. There is a nominal fee for the award to cover TWR Bonaire's costs—5 International Reply Coupons, available from your local post office. The award application and fee should be sent to Roswell, "Bonaire Wavelengths," Trans World Radio, Bonaire, Netherlands Antilles.

Peter Pompe of Kraainem, Belgium, is a longtime shortwave listener. The 52-year-old DX enthusiast works as a conference interpreter at the European Common Market headquarters in Brussels. Here Peter does his listening on four different SW receivers, including the Hallicrafters SX-122A and Collins 51-S1, shown here.

Logging the TWR Stations. If you're a veteran SWL, you may already have your QSL's from the five TWR stations. If not, collecting them is the first step toward obtaining the award. Here is how you may be able to do just that.

TWR *Monaco*—This outlet announces its location as Monte Carlo, which is the famed casino capital of that tiny southern European principality on the Mediterranean. Because the mini-nation is so small, the transmitter site is actually outside Monaco's borders in adjoining France.

Many of the TWR religious broadcasts from here go out to eastern Europe and the Soviet Union in a variety of languages. But you may tune English programs, primarily intended for European audiences, from around 0630 to about 0900 UTC on 7,105 or 9,480 kHz.

To obtain your QSL, send your reception report to TWR, Post Office Box 349, MC-98007, Monaco.

TWR *Swaziland*—The African outlet of Trans World Radio is located at Manzini, where its station operates mostly 25-kilowatt transmitters on shortwave. Those less powerful stations are a bit more difficult to tune in North America. Also adding to the difficulties are the choices of frequencies, most of which are in the lower-frequency SW bands.

Programming is aired in a variety of African languages, including such exotic tongues as Lingala, Tswana, Umbundu, and Shangaan, as well as French, Portuguese, and English. A best-bet frequency to try is 3,200 kHz at around 0300 UTC. Other chances include around 0430 UTC during its English program schedule; frequencies to try then include 7,270 and 9,720 kHz.

Trans World Radio has also been reported operating on 5,055 kHz, signing on at 0354 UTC in German, but with an English identification too. This is parallel to 6,070 kHz, where you can expect interference. The address for reports is TWR, PO Box 64, Manzini, Swaziland.

TWR *Sri Lanka*—This South Asian country (formerly Ceylon) has a number of shortwave broadcasting operations, including the relay stations of Germany's *Deutsch Welle* and the

*CREDITS: Brian Alexander, PA; John Tuchscherer, WI; Dale Park, HI; Sheryl Paszkiewicz, WI; Richard D'Angelo, PA; Dan Sheedy, CA; North American SW Association, 45 Wildflower Road, Levittown, PA 19057.

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Voice of America, plus the national *Sri Lanka Broadcasting Corp.* transmitters.

TWR leases shortwave broadcasting time from the latter, although it owns its own powerful medium-wave transmitter on that island nation. The station has been noted on 11,830 kHz at its 1200 UTC sign on, and at other times and frequencies. Reports may be sent to TWR, PO Box 364, Columbo, Sri Lanka.

TWR *Guam*—This station announces as Trans World Radio Pacific and, since it is in U.S. Territory, it carries the call letters of KTWR. The station (located in Agana, Guam) operates four 100-kW, SW transmitters that at times can be heard rather well in our part of the world.

Like Bonaire's outlet, this TWR broadcaster also has a program especially for shortwave listeners. It is called "Pacific DX Magazine," and is broadcast Saturdays at 0380 UTC on 11,830 kHz. Or tune in for English programming on 11,650 kHz at around 1530 UTC. Another frequency for the Trans World Radio Pacific station is 11,650, which can be heard in English with religious talk and hymns from just before 1600 UTC. The address for your reports and QSL requests is TWR Pacific, KTWR, Box CC, Agana, Guam, 96910.

TWR *Bonaire*—This outlet is, without doubt, the easiest of the Trans World Radio outlets to hear. English programming is broadcast from 0300 to 0540 UTC on 9,535 kHz, and again during the 0115–1300 UTC period on 11,815 and 15,345 kHz. The address is Trans World Radio, Bonaire, Netherlands Antilles.

As with most shortwave stations, the frequencies, and sometimes the broadcasting hours as well, do change with the seasons. So if you have some difficulty in finding those stations, tune around a bit and you may find them on other frequencies or bands. Also, those are stations financed by religious supporters, hence they do appreciate return postage—in the form of International Reply Coupons—if you would like an airmail reply to your reports and QSL requests.

Good luck in your quest for the TWR award!

Feedback. Keep those letters coming. Your comments, questions, and logging tips are always most welcome. I'll include as many of them as I can in the feedback section of this column. Address your correspondence to *DX Listening*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

Bill Smith, Weatland, WY, writes with the sort of message that warms the heart—and, I hope, catches the attentive eye of my editor. "Great column!" says Bill. "Keep it up. With columns like yours in it, I'm hooked on **Popular Electronics**."

Thanks, Bill!

Next out of the mailbag is a question directed to me and also to you, the readers of *DX Listening*.

Art Ervin, Richmond, VA, has this query? "Which shortwave station has the best QSL card? I have my own opinion, based on those I've received," notes Art. "I know it's an opinion question, but I wonder what you think Don? And I'd also like to hear what other readers think about this."

That is a bit of a toughie, Art. Going back a goodly number of years, a long-silent shortwave outlet in the Canary Islands had a gorgeous embossed red, gold, and black card featuring a map grid of the Atlantic Ocean, with the Spanish-owned island chain prominently located. That surely must be one of my favorites.

Today there probably are a number of legitimate claimants to the title, *Radio Japan* and *HCJB* in Quito, Ecuador, being just a couple of candidates that come quickly to mind.

Turning to the last part of Art's query, what do readers think is the best looking QSL card? Why? Send me your ideas on this question and we'll go over them in a future column.

Down the Dial. Here are some of the loggings that your fellow readers have been reporting recently.

Brazil—4,845 kHz. From the heart of the Amazon comes the Portuguese language programming of *Radio Nacional Manaus*. This station has been reported in the eastern U.S. during the evening hours until sign off, just after 0400 UTC.

Iceland—15,770 kHz. The *Iceland Station Broadcasting Service* at Reykjavik has news in Icelandic, with a bit of English too, noted at 1410 UTC, which is also transmitted on 17,530 kHz at the same time.

Mexico—9,555 kHz. *La Hora Exacts*, "the exact time station," in Mexico City, has time signals each minute, surrounded by Spanish-language commercials, announcements, and jingles.

Qatar—7,320 kHz. The shortwave outlet at Doah, capital of this Mid-East nation, can be heard until sign off at about 2130 UTC with Arabic music and Islamic religious programming. ■

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Scanner Scene

By Marc Saxon

A BACK-TO-BASICS SCANNER

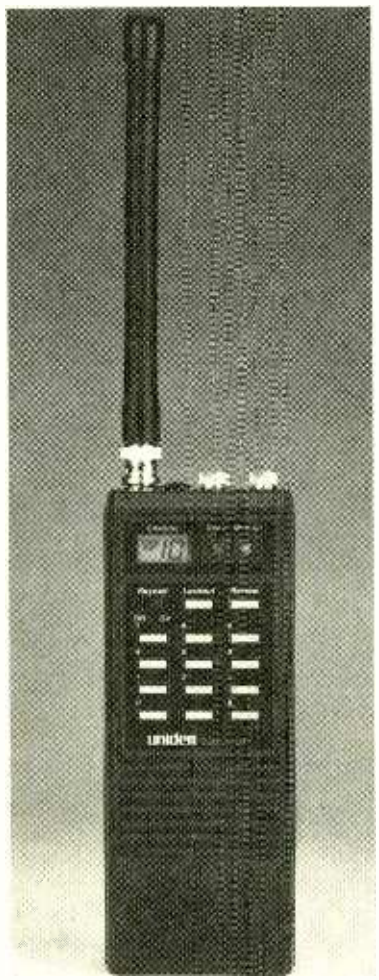
Uniden's *Bearcat BC-55XLT* fills the bill for an economical, programmable, handheld scanner. The bands covered in the BC-55XLT are 29 to 54 MHz, 126 to 174 MHz, and 406 to 512 MHz. That takes in all of the most popular public-safety, federal, land-transportation, maritime, and industrial frequencies.

This handheld has 10 memory banks, and scans at 15 channels per second. Other features include individual channel lockouts, low-battery indicator, built-in 3-second delay, direct channel access, and manual step-through of all memory channels. There's also a "Track" feature that permits the unit to peak-tune each transmission for optimum reception at band edges. Also, the memory backup will hold all programmed frequencies for half an hour without any batteries in the unit.

Uniden rates the sensitivity at 0.4 μV in the VHF "low band," 0.5 μV in the VHF "high band," and 0.7 μV on UHF. Those ratings are all for 12 dB SINAD. Selectivity is rated at -55 dB at ±25 kHz. The BC-55XLT weighs just over 10 ounces, requires five standard "AA" batteries, or nickel-cadmium cells.

Optional accessories include a 117-volt-AC battery charger and power adapter, a carrying case, and a cigarette-lighter power cable. It's supplied with a flexible rubberized antenna having a BNC connector. List price is $219.95, but it usually sells for less.

For more information, contact any Uniden Bearcat dealer, or write to Uniden Corporation of America, 4700 Amon Carter Boulevard, Fort Worth, TX 76155.



Avoid crystal hassles with Uniden's BC-55XLT 10-band, 10-channel scanner. The BC-55XLT uses synthesizer control for frequency accuracy.

Frequency Information. Dennis Musick, Coatsburg, IL, wrote to ask for information on better-grade scanner-frequency guides. The same day the letter from Dennis arrived, so did one from Dean Lutz, Ephrata, PA. Dean said that when he bought his *PRO-2004* scanner, the clerk sold him a Police Call directory. Dean observes, "It's okay to start out with, but now I want something more comprehensive."

We have been quite well impressed with the new series of directories put out under the Regency banner. This is a series of seven regional books, each covering a group of from six to eleven states. Stations are listed by states, alphabetized by location, and categorized by service. They cover police, fire, ambulances, rescue squads, local government, conservation agencies, transportation, weather, maritime, and more. Information provided includes call signs, licensee names, and base/mobile frequencies. Additional text is provided on scanner use, communications systems, frequency usage, etc.

These directories are accurate and comprehensive. They're carried in the latest CRB Research catalog at a substantial saving from the nationally advertised price of $14.95 each. Ask CRB Research for one of their free catalogs. Their address is: CRB Research Books, Inc., P.O. Box 56-PE, Commack, NY 11725.

More Reader Letters. A few issues back, we mentioned some of the Space Shuttle frequencies in the UHF aeronautic band. That brought us a note from Daniel Murphy of Hazel Crest, IL, who advises that Space Shuttle communications can be heard in the Chicago area on 145.21 MHz—thanks to the efforts of local ham operators who rebroadcast the signals through one of their own 2-meter band facilities. Chances are that similar rebroadcasts take place (on this or other 2-meter band frequencies) in various metro areas around the nation during Shuttle missions. Look for them. The 2-meter band extends form 144 to 148 MHz, although certain portions of it are set aside for specific ham purposes.

Lots of mail keeps coming in asking for scanner modifications above and beyond the several we offered here recently for the Realistic *PRO-34* and *PRO-2004*.

Although the modifications we offered didn't include increasing the scanning rate of the Realistic PRO-2004 from 8- and 16-channels-per-second to something faster, many readers say they've heard it can be done. W. L. Hoskins, KW7HV, of Lander, WY, says that it can be accomplished by placing a 1N914 diode across the D514 terminals on the CPU-chip sub-chassis. That increases the scanning rate to 10- to 20-channels-per-second. Don't forget to unplug the power cord while performing that modification!

A letter from Bryan M. Calhoun sits atop a mountain of requests from readers asking for how to restore the missing 806- to 906-MHz band in the Realistic *PRO-2021*. Our friend Jeff Caudill, of Richmond, KY, was kind enough to work this out. It's a bit too long to carry here in the column and won't mean much to those who don't own a PRO-2021. How-

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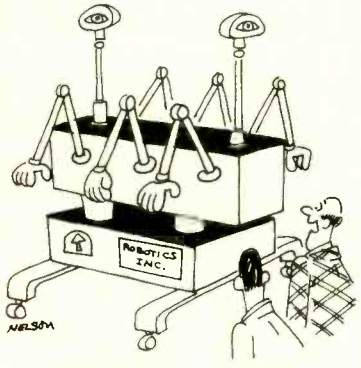
ever, if you want that information, I'll be happy to send it if you send me a stamped self-addressed envelope. Use the address at the end of this column.

Manny Lopez, Jamaica, NY, says that he's interested in monitoring FAA ground and operational communications that take place at larger airports, since he's within monitoring range of two major airports.

Monitors, nationally, might wish to tune in on the operations of the FAA, which are often interesting as they handle the behind-the-scenes logistics of air safety and navigation. I have found that 166.175 MHz is pretty active at many FAA facilities. Also note that the agency has frequencies between 172.125 and 172.175 MHz, and 172.825 and 172.975 MHz (25-kHz spacing) that you might wish to check. As previously mentioned here, monitor 135.85 and 135.95 MHz for FAA "Flight Check" aircraft communicating with ground facilities while checking on the operations of airport radio-navigation facilities. There are some additional frequencies used nationally, but those mentioned here are the most popularly encountered in all areas.

Ed Voscovik, of Alberta says that frequencies 36.25 and 40.01 MHz have produced activity during "skip" openings. Those have related to cleaning up the big oil spill in Alaskan waters. Ed passes along the information so that we can share it with all of our readers. Thanks Ed!

If you have loggings or frequencies to share, or questions, or photos of your station, or if you've got a scanner-related newspaper clipping, we are waiting to hear from you. Write to us at: *Scanner Scene*, **Popular Electronics**, 500-B Bi-County Boulevard, Farmingdale, NY 11735. Let's hear from you soon! ■



"I'm not sure what it does— but I had to have it!"

VOICE OPERATED SWITCH

(Continued from page 78)

With a signal of proper polarity applied to U5, TR1 will be activated, switching AC power to the lamp. If the application of the proper signal doesn't trigger TR1 into conduction, disconnect AC power and troubleshoot the wiring. Check the 5-volt source with a voltmeter; if it's okay, remove power, install U4, and finish assembly.

Using the Project. The lamp should flash once, indicating a system power-up reset and that the circuit is awaiting your verbal command of "turn light on" to activate the lamp. Follow with the command "turn light off" to extinguish the light. The author found that the circuit also responds to "go light go" followed by "go light gone" for lamp control.

The Voice-Operated Switch preforms best if you limit the audio gain of the amplifier by adjusting R5 to no more than needed to avoid false triggering from random noise. The use of a directional microphone can also help. Placing a length of cardboard tubing over the condenser microphone can help make it directional.

The circuit is particularly useful for controlling a light where the switch is in a poor location or for the mobility impaired person in your household. You can't help feeling a sense of power when walking into a dark room, asking for the light, and having it obey your command. Certainly, it should impress your friends. ■

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SUPPLYING THE WORKSHOP

(Continued from page 72)

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 hookup wire. The catalog is $2.00.

Parts for old radios, crystal sets especially, are also available from Yeary 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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EIA COURSE

(Continued from page 81)

sion AB + C. The signal at the output of the inverter would then be $\overline{AB} + C$.

Applying Boolean Algebra. The equations and expressions of Boolean algebra are very useful in defining what happens in a circuit. Also, once a circuit is written as a Boolean expression, the circuit can often be simplified by using Boolean algebra to reduce the expression to its simplest form, thereby allowing complex logic to be implemented using less hardware, which cuts production costs.

Figure 3 illustrates how Boolean expressions are used to define the OR, AND, and inverter gates. Boolean expressions can also be used to indicate the state of the various signals at different points in the circuit, as shown in Fig. 4. Note that the signal at the output of gate U1-a—and hence, the signal applied to the input of U2-a—is $\overline{A}$.

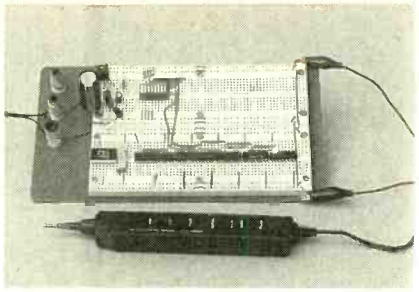
Gate U2-a is an AND gate, so the $\overline{AB}$ signal is produced at its output. The other AND gates (U2-b and U2-c) produce the signals indicated at their outputs. Gate U3 performs an OR function on the input signals; thus three different Boolean terms representing the three input signals appear ORed together at its output.

It may be difficult for you to understand how the output expression and/or the terms at the outputs of the different gates are related to the truth table. That relationship will be discussed in a later article. For now, the important thing is that you are able to determine the terms that are produced at the output of each gate.

Working With Logic Circuits. The operation of the basic logic gates is best understood after some hands-on experience. Assuming that your breadboarded power supply has not been dismantled, you will need the components listed in the Parts List. (If you have disassembled the power-supply circuit, it will be necessary to rebuild it; see the July, 1989 issue of **Popular Electronics**.)

Figure 5 shows the pinout diagrams

Our gratitude is extended to the EIA/CEG for the creation of this course, especially to the consultants who brought it to fruition: Dr. William Mast, Appalachian State University; Mr. Joseph Sloop, Surry Community College; Dr. Elmer Poe, Eastern Kentucky University.



You can actually get almost every type of basic gate to fit on a single protoboard, even if they're packaged four gates to a chip. If you set up a board like that you can perform a number of different logic experiments.

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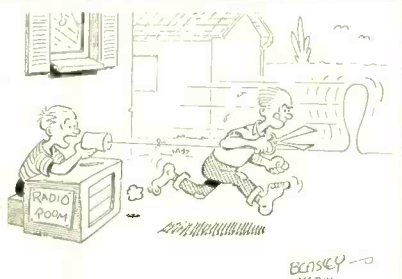
of the digital integrated circuits that we'll be using in our lab exercise. Insert the logic IC's into the breadboard, and connect the V_{CC} pin (pin 14) of each IC to the +V bus and the GND pin (pin 7) to the ground bus. Next set up a table like Table 1. Assign variables to the inputs of one gate in each IC package (A, B, etc.) using Fig. 5 as a guide. In the case of the inverter, there can be only one input variable.

Apply +5 volts or ground to the inputs of the gates in the combinations given in the table, and test the outputs for highs and lows. Record your observations in the blanks of the table. Compare your findings, to the output column (Y) in Fig. 1 for each gate.

When you have finished, put the breadboard away without removing any of the components. The power supply and integrated circuits will again be put to use in future exercises. ■



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QUANTUM MECHANICS

(Continued from page 62)

electrically neutral neutrons surrounded by a cloud of negatively charged electrons orbiting around the nucleus in fixed paths. Our inadequate model, no-doubt graphically reinforced by pictures in textbooks and ping-pong-ball models in the classroom, leads us to view subatomic particles as merely different colored billiard balls of differing sizes and weights. The problems with the "solar-system and billiard-ball" model become apparent when electrons and protons show some very un-billiard-ball-like behavior.

Erwin Schrodinger disputed Bohr's solar-system model of the atom. Instead of a billiard ball nucleus surrounded by billiard ball electrons, Schrodinger proposed an entirely new model. Like light waves, elementary subatomic particles sometime behave like particles and other times like waves. Again we have a complementary system, but in this case the waves are the "matter waves" postulated by Prince Louis De Broglie. According to Schrodinger's view, the atom consists of a matter-wave nucleus surrounded by matter-wave electrons.

Schrodinger's wave equation describes the matter waves in terms of probability, or the tendency to exist. It is important to realize that matter-wave equations do not describe a real chain of events the way water-wave equations describe real movement by real water particles. The equations describe only the probabilities of finding a real particle at a given place and time.

Matter and Reality. Physicists developed a world of weirdness where matter (including electrons)—the hard stuff of reality—has a complementary wave-particle nature. Instead of a mass of tiny ping-pong balls, electrons and protons are a ghostly dance of probability waves.

To those factors we must now add another ghostly facet: the Uncertainty Principle. In 1927 Werner Heisenberg proposed the Uncertainty Principle, which states that certain pairs of properties of atomic particles cannot both be measured with accuracy. For example, it is impossible to precisely measure both the position and momentum of an electron.

Do not confound the Uncertainty Principle with the mere inability to measure some parameters due to some kind of "disturbance" effect. Many physical measurements are inaccurate because the act of measurement (or the nature of the instruments) disturbs the system and thereby changes the value of the measurement enough to introduce very large errors. Instead, what the QM scientist is telling us is that the electron actually does not possess both a precise location and a precise momentum. Truly astounding!

Taken together, the Uncertainty Principle and the Complementary Principle are called the "Copenhagen Interpretation" of quantum mechanics. The name is derived from the fact that most of the work was done at the Niels Bohr Institute in Copenhagen.

Consider the implications of the Copenhagen Interpretation. The electron only tends to exist (weird enough a concept in its own right). An implication of that quantum reality is that there are several possible Schrodinger wave-functions for the electron until someone tries to measure either the position or the momentum.

Albert Einstein never fully accepted the Copenhagen Interpretation of QM, even though he contributed much to the field. Throughout the 1920's and 1930's he engaged in a public debate with Bohr and others on the implications of QM. Suspecting an underlying "hidden variable," Einstein maintained a modified classical-physics position saying: "Surely God doesn't play dice with the universe." And on another occasion: "The Lord is subtle, but He is not malicious."

In a paper published in 1935, Albert Einstein, Boris Podolsky, and Nathan Rosen challenged QM with what is now called the "EPR Paradox" (after the authors' initials). Suppose, states the EPR Paradox, there is an atom with two electrons ("A" and "B") in the same orbit (hydrogen, for example). According to QM, the "spin" of those electrons will be opposite each other (there are only two possible spin states). According to QM, however, neither electron has a definite spin until some experimenter comes along and measures that spin. Now, suppose enough energy is imparted to the atom to force those electrons miles apart, even though still in the same now-immense system. A scientist comes along with a "spinometer" and measures the spin of electron A. Its wave function immediately collapses and the electron assumes one of the two possible spin states. At the same time, however, the wave function of electron B must also collapse to assume the opposite spin because there were only two possibilities. The point made by EPR was "how does electron B know from many miles away which spin was assumed by A?" Remember, A had neither spin until it was measured; it had only a tendency to either possible spin.

A possible consequence of the EPR paradox is that the universe may contain a communications medium not presently known. Some people postulated so-called "tachyon" particles that travel faster than the speed of light (despite Einstein). So far, however, no evidence of tachyonic communication has surfaced and new theories place their existence in doubt. Other thinkers concede that the universe might be interconnected in some way that is presently unknown. Although many physicists refuse to accept any "hidden variable" explanations at all, others have jumped off the scientific bandwagon into mystical religious realms.

The Bottom Line. So what is matter made of at the most fundamental quantum level? Some people say that it is made of nothing. Others say that it's a ghostly something that's really there but it's totally indefinable in human language. One such author calls it Quantumstuff, while another calls it Quons. Whatever it is, it is certainly fascinating. If you want to find out more, try some of the selections in the Reading List provided elsewhere in this article. ■

Selections for Further Reading

John Bell (Interview), *OMNI*, May 1988 (pp. 85-92 — 121).

George Gamow, *Thirty Years That Shook Physics; The Story of Quantum Mechanics*, Dover Publications, Inc. (New York, 1966).

Martin Gardner, "Quantum Weirdness," *Discover*, Oct. 1982, pp. 69-75.

John Gribbon, *In Search of Schrodinger's Cat: Quantum Physics and Reality*, Bantam Books (New York, 1984).

Nick Herbert, *Quantum Reality: Beyond the New Physics*, Anchor Press (Garden City, NY 1987).

Heinz Pagels, *The Cosmic Code*, Simon & Schuster (New York, 1982); Bantam New Age Books paperback edition 1983.

Michael Talbot, *Beyond the Quantum*, Macmillan Publishing Company (New York, 1986).

Fred Alan Wolf, *Taking the Quantum Leap: The New Physics for Nonscientists*, Harper & Row (San Francisco, 1981).

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INNOVATIONS

(Continued from page 69)

The newest closed-caption decoder from *National Captioning Institute* is a blessing for people with hearing problems. The device allows the captions to appear on the screen so that those who do have hearing disfunctions are able to read them and thereby enjoy the shows with others in the household. The *TeleCaption 4000* features a cable- and broadcast-capable tuner as well as a wireless remote with on/off control, volume adjustment, random-access channel selection, parental-guidance programming, favorite-channel programming, and last-channel recall. The portable unit is also equipped with an audio-output jack.

Southwestern Bell was honored for its new *Model FW 2000* wireless phone. Unlike cordless phones, it uses standard

The Model FW 2000 Wireless Phone from Southwestern Bell.

"C" cells so there's no need for AC power or rechargeable batteries. The batteries used will last up to six months.

To operate it, all you do is pick up the phone as you would an ordinary handset; there's no ON/OFF switch. You can put it anywhere you can't install a jack, such as on a patio, a deck, or in a garage.

Making a Short Story Long. Innovation is described in the dictionary as a new idea, method, or device. An innovative concept need not be complex; the paper clip or the safety pin, in their days, were innovative. You can depend on the fact that the mind of man is going to continue to innovate, to the amazement, wonder, and benefit of all of us. ■

CIRCUIT CIRCUS

(Continued from page 85)

the rejuvenating circuit and tune R7 until the LED1 responds in step with the dit-dah's.

Tunable Audio Filter. If you are dealing with signals that are heavily affected by noise, the circuit in Fig. 4 will help clean them up so they can be fed to either of the rejuvenating circuits.

A 741 op-amp is the heart of a simple *Tunable Audio Filter* circuit that takes the incoming signal and amplifies it, while attenuating all other frequencies. The values of C1, C2, and R8 determine the filter's operating frequency; with the values given, the circuit covers the tuning range of the two rejuvenating circuits.

To calibrate the circuit, connect a scope to pin 6 of U1 and adjust R7 until the gain of the circuit is increased to the point where the circuit goes into self oscillation. Connect a frequency counter to pin 6 and adjust R8 for the desired input frequency. Observe the scope and slowly back R7 off until the oscillation ceases. That sets the "Q" of the filter, which will probably need to be readjusted slightly when receiving a signal.

The value of R9 also effects the circuit's "Q" and should be as large as possible. If the circuit's gain is set too high, the output will "ring" and the continuity of a coded signal will be lost. If

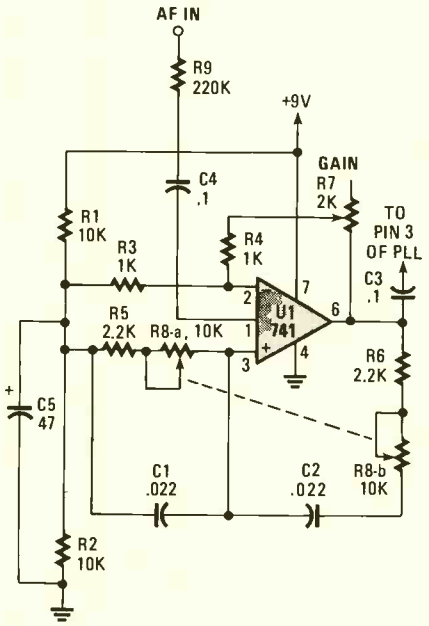

Fig. 4. At the heart of the Tunable Audio Filter is a 741 op-amp. The values of C1, C2, and R8 determine the filter's operating frequency.

PARTS LIST FOR THE SIGNAL CONDITIONER

SEMICONDUCTORS

U1, U2—567 tone decoder, integrated circuit
Q1—2N3906 general-purpose silicon PNP transistor
Q2—2N3904 general-purpose silicon NPN transistor
LED1—Light-emitting doide

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1, R4—4700-ohm
R2, R6—470-ohm
R3—2200-ohm
R5—10,000-ohm
R7, R8—20,000-ohm potentiometer
R9—1000-ohm potentiometer

CAPACITORS

C1–C4—0.1-µF, ceramic-disc
C5–C8—0.47-µF, 15-WVDC, electrolytic
C9—47-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

Printed-circuit or perfboard materials, enclosure, IC sockets, 5-volt power source, wire, solder, hardware, etc.

PARTS LIST FOR THE TUNABLE AUDIO FILTER

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R1, R2—10,000-ohm
R3, R4—1000-ohm
R5, R6—2200-ohm
R7—2000-ohm, potentiometer
R8—10,000-ohm dual-gang potentiometer
R9—220,000-ohm (see text)

CAPACITORS

C1, C2—.022-µF, Mylar or similar
C3, C4—0.1-µF, ceramic-disc
C5—47-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

U1—741 op-amp, integrated circuit
Printed-circuit or perfboard materials, enclosure, IC sockets, 9-volt power source, wire, solder, hardware, etc.

fixed-frequency operation is desired, replace R8 (a dual gang potentiometer) with two ¼-watt, 5% resistors. Two resistor decade boxes can be used to determine the exact values needed.

That's all the time and space allotted to us for this month, but be sure to tune in again next month, when we'll present another group of fun circuits designed to entertain and educate you in the ways of electronics. ■

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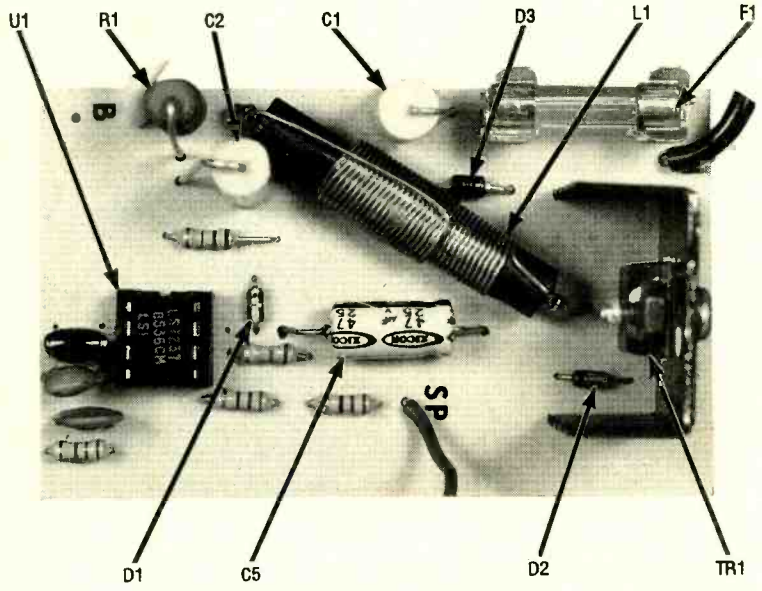
TOUCH-CONTROL SWITCH

(Continued from page 42)

next junction box on the circuit. You will likely find some bare wires twisted together also; they are the ground wires. Neither the ground or neutral wires are needed by the project. Before disconnecting the switch from the wires, turn off the power going to the switch. Remove the switch, tuck the ground wire that went to the switch all the way back in the box and insulate it. You may, if you wish, mount the project inside a plastic enclosure and then mount the project inside the junction box, or insulate the solder side of the project.

The sensor-plate wire may be wrapped around a cover-plate mounting screw, allowing the cover plate to serve as the sensor plate (assuming that you are using a metal cover plate).



Here is the completely assembled rectangular version of the Touch-Control Dimmer Switch. If you look closely, you'll notice the rough edges on the top edge of TR1's heat sink. The author found it necessary to cut down the heat sink to make the board more compact for mounting.

Note that the back side of the cover plate must be insulated from the project. The Mason Company offers a blank cover plate that comes with a gasket for the back of the cover plate (order Part C-340). The cover plate costs about a buck, and is available through various retail outlets (for instance, K-Mart).

When mounting the round circuit board in the base of a table lamp, the lamp rod (about ⅜ inch in diameter) will go through the project box, the insulator, and the board. It may be necessary to lengthen the lamp rod by loosening it from the lamp base and unscrewing some of the rod from the bulb holder. If you need to replace the rod with a longer one, lamp rod is available at most hardware stores.

If you have not done so yet, connect the sensor-plate wire to your sensor plate; a coin-size plate works well, and old items such as knick-knacks or fancy belt buckles you'd never wear will also work. Power up the project and try it out.

Troubleshooting. If after touching the sensor plate, nothing happens, try touching the sensor plate while holding someone's hand. If the circuit now works, adjust the sensitivity of the circuit by changing the value of R4.

If the circuit still does not work, check the polarity of the board-mounted components, the wiring to the project, and that power is available to the project. Did you have the polarity of all the components right? Is the IC in backwards? Shorten the sensor-plate wire or disconnect it from the sensor plate, and then try again. If after an honest effort, you still have an inoperative project, write me a letter with the problems you are having, and give me as many voltage readings as you can. Be sure to enclose a SASE and I will be glad to help you. (Send all inquiries to Mike Giamportone in care of **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.) ■

BOOSTER AMP

(Continued from page 45)

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 ⅜-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,

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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. ■

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ELECTROLYSIS

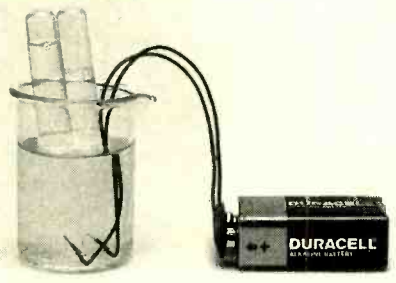
(Continued from page 74)

ments; but, if lab equipment is not available to you, just fashion a temporary support out of wood, coat-hanger wire, or whatever else you may happen to have around.

The Setup. The demonstration requires an aqueous solution with a resistance lower than that of ordinary tap water. To achieve that resistance, something must be added to the water. One such substance is sodium carbonate (also known as sal soda or washing soda). Do not use salt. You will need 1 tablespoon of sodium carbonate for every 16 ounces (1 pint) of water you use. Treat all chemicals, whatever they are, with respect.

And now, for the tricky part: getting the sodium carbonate solution into the upside down test tubes without letting air in them. Fill the two test tubes up to the very top with the solution and gently insert the corks into the tubes allowing some of the liquid to overflow. Invert the tubes and place them into your container. Then pour the conductive solution into the container until the container is about ¾ full. Pry the corks off the test tubes with an old pencil or some other pointed object while keeping the open ends of the tubes above the surface of the solution. When the corks are free, they will rise obediently to the surface where they can be removed easily. By the way, do not use rubber stoppers for your experiment—they don't float!

Finally, insert one carbon electrode into each of the two test tubes. Make certain that the entire electrode is actually inside the tube. Now connect the wire leads to a battery or a low-voltage DC power supply and turn on the current. The electrodes will begin to bubble immediately. One electrode will produce roughly twice the volume of gas as the other.



For those of you who prefer small-scale demonstrations, the electrolysis experiment can be conducted with an ordinary 9-volt battery, a tiny cup or beaker, and two very small test tubes. The oxygen is in the tube on the left; the hydrogen is in the tube on the right.

What happens. The positive hydrogen ions (cations) move toward the negative pole of the battery; the result is gaseous hydrogen in the test tube over the negative electrode (cathode). The negative oxygen ions (anions) move toward the positive pole of the battery; the result is that gaseous oxygen will accumulate in the tube over the positive electrode (anode).

The solution will bubble gently or furiously, depending on how much power you are using. Electrochemical activity is proportional to the quantity of current passing through the conductive solution. With a variable power supply, you can see that for yourself: turn up the current, and the electrode bubbling will increase; turn down the current, and the bubbling will decrease. And that, incidentally, illustrates the First Law of Electrolysis devised in 1833 by Humphrey Davy's famous follower, Michael Faraday.

You may find that the ratio of gas over the cathode to the gas over the anode is a little more than 2:1. Why? One reason is that some of the oxygen reacts with the positive electrode.

A Further Note. The electrolysis of water is a safe experiment. However, remember that **hydrogen mixed with air is an extremely explosive combination.** So, do not generate large amounts of hydrogen and make absolutely sure that there are **no open flames in the vicinity** when you dismantle your apparatus. As always, keep safety in mind as you proceed.

For more information on the history of electrolysis and electrochemistry, see the reading list entitled "Works of Interest" that is presented elsewhere in this article. ■

Works of Interest

Great Scientific Experiments, by R. Harre, Oxford University Press, New York, 1983.

The Founders of Electrochemistry, by S. Ruben, Dorrance, Philadelphia, 1975.

"Humphrey Davy," by L.P. Williams, *Scientific American*, June 1960, pp. 106-116.

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SUB AUDIO METER

(Continued from page 38)

DC voltage across C12 is plotted as a function of input frequency, it would be found to be linear.

The output stage of the circuit is configured around a 741 op-amp (U8), which is operated as a non-inverting follower. The DC gain is set by the RANGE SELECT switch, S1. The meter is calibrated by adjusting R15 and R16. The purpose of the op-amp is to boost the integrator's output signal six times in the 0- to 100-Hz range, or sixty times in the 0- to 10-Hz range. That scaling makes the output voltage numerically the same as the input frequency. Thus, in the 0- to 10-Hz range, an output of 10 volts represents "10 Hz," and in the 0- to 100-Hz range, 10 volts represents "100 Hz."

Figure 7 shows the output transfer function for the analog-display circuit. The corresponding voltages for from 0 to 10 Hz is shown in Fig. 7A, while the voltages for 0 to 100-Hz range is shown in Fig. 7B. Those voltages can be read on either a digital voltmeter (which makes the display quasi-digital) or on an analog meter. The analog meter might be preferred in some cases because the meter movement's inertia tends to add a little additional low-pass filtering to the reading.

Putting It Together. There is nothing critical about the construction of the Sub-Audio Frequency Meter. The circuit can be laid out on perfboard or you can devise a printed-circuit board of your own design. All components are readily available.

As for the power supply, all you'll need is a suitable transformer and a bridge rectifier. Note: If you do not plan to build the optional analog meter circuit, it will not be necessary to supply a negative 12-volt source, since the only component that requires a negative source is the 741 op-amp (U8 in Fig. 6) that is used to the drive the meter.

Once the board is assembled and tested, the circuit may housed in any suitable enclosure. It will be necessary to drill holes in the front panel of the enclosure for a few off-board-mounted components. In fact, the only components in the project that need to be mounted off-board are the two RCA jacks (J1 and J2), the RANGE-SELECT switch (S1), and meter M1. All other components can be mounted to the board. ■

PARTS LIST FOR THE ANALOG DISPLAY CIRCUIT

SEMICONDUCTORS

U6—LM311 voltage comparator, integrated circuit
U7—555 oscillator/timer, integrated circuit
U8—741 op-amp, integated circuit

RESISTORS

(All resistors are ¼-watt, 5% units, unless otherwise noted.)
R6—15,000-ohm
R7, R9—82,000-ohm
R8—68,000-ohm
R10–R12—12,000-ohm
R13—10,000-ohm
R14—1500-ohm
R15—100,000-ohm potentiometer
R16—10,000-ohm potentiometer

CAPACITORS

C6—100-pF, ceramic disc
C7, C9–C11—0.1-μF, ceramic disc
C8—470-pF, ceramic disc
C12—0.33-μF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

M1—0–10-volt meter
S1—SPST switch
Printed-circuit or perfboard materials, enclosure, IC sockets, power source, wire, solder, hardware, etc.

DARKROOM TIMER

(Continued from page 34)

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 2¾ × 2¼ × 1¾ 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 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.

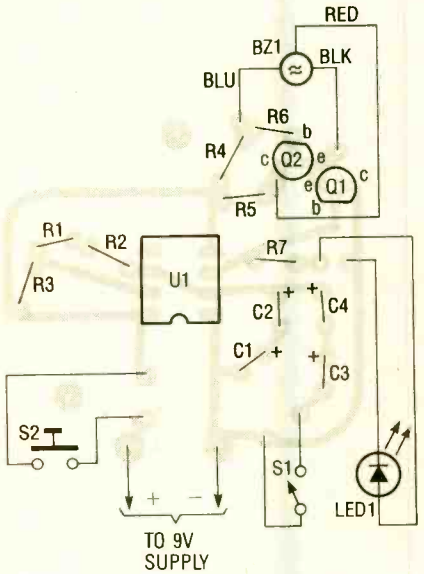

Fig. 4. Follow this parts-placement diagram when installing the components on the board. The four components that are not installed on the board are connected to the circuit board though short lengths of hook-up wire.

If the circuit operates as described earlier, close up the project enclosure; your Electronic Darkroom Timer is ready for use.

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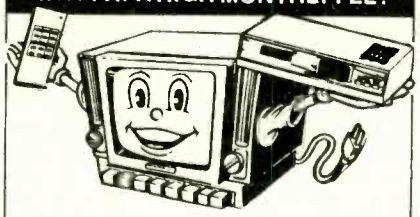

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DM27 MULTIMETER

(Continued from page 46)

good feature for checking continuity in cables and on circuit boards. However, you may find it bothersome in an application where the meter is tied into a circuit; the squeal cannot be turned off except with the unit's ON/OFF switch.

The Bonuses! Since the DM27 replaced a *golden oldie* from another generation, a couple of windfall features were realized. Diodes can be tested with the DM27 to find their forward voltage drop (about 700 millivolts for silicon types; 200 millivolts for germanium types). You can also perform a reverse-leakage test in which a good/bad indication is given. The test current is about 1.0 milliampere. Diodes may be checked in circuit, provided that shunt resistance exceeds 1000 ohms.

The h_{fe} of a transistor can be measured by properly orienting it in the appropriate socket. Transistors under test must be removed from their original circuit.

Five capacitance ranges are provided, spanning 2 nanofarads to 20 microfarads, to permit checking capacitors used in most bench-top projects. Two pads of 4 solderless terminals each are provided to connect the test capacitor. That's a design feature that permits most capacitors to be tested without bending their leads. Accuracy was excellent for all fixed capacitors tested except electrolytic units. Many electrolytic capacitors are rated at +200/−25, or worse. The best we would expect the meter to indicate is that a 4.7-μF electrolytic capacitor is usable when it reads 5.25 on the LCD. The test frequency for testing capacitors is 400 Hz and the test excitation voltage is a low 120 millivolts. Electrolytic capacitors provide different readings for different voltages and frequencies. The capacitor test section of the DM27 works fine, it's the electrolytic capacitors that don't cooperate too well!

The DM27 can detect logic pulses as narrow as 25 nanoseconds. When the meter is set to LOGIC, a numeral 1 appears at the extreme left on the LCD. When a logic high is detected, an up arrow appears to the left of the "1." At a logic low, a down arrow appears and the beeper sounds.

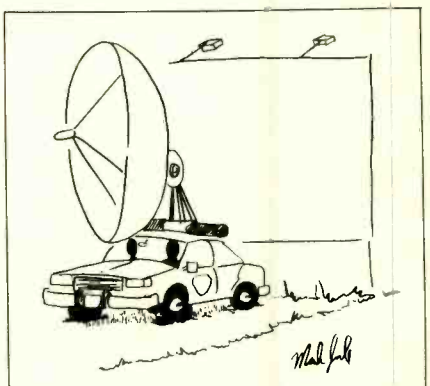
Frequency checks are simple to do. Set the meter to one of five ranges (2 kHz to 20 MHz) and place the test leads across the terminals to be checked. Pulses must be at least 1.6-volts peak on all ranges for TTL and CMOS squarewaves. All other waveforms require at least a 100-millivolt signal for up to 2 MHz, and a 200-millivolt signal for frequencies from 2 MHz to 20 MHz. Overload protection is up to 500-volts AC/DC. Frequency tests at 60, 400, 1000, 500,000 and 1,000,000 Hz were well within the unit's 1% tolerance.

Inside the DM27. There's no reason to peek inside the DM27 except to replace a battery. You'll know when to replace the battery when the unit's "LO BAT" indication appears on the LCD. Be sure to turn the meter off before replacing the battery, otherwise you may accidentally damage the unit. To replace the battery you must first remove the battery cover. Use a small Phillips-head screwdriver to remove a locking screw, then use your thumb to gently slide the battery cover free of the unit. Replace the battery with a standard 9-volt transistor-radio battery (NEDA type 1604).

Should the unit fail to measure current when the test probe is connected to the "A" plug, the 0.8-amp fuse may be blown. The fuse and a spare fuse are located in the battery compartment. Replace the defective fuse with the spare fuse and then make it a point to pick up a replacement spare. Replace the cover and its locking screw.

The Beckman Industrial Circuitmate DM27 digital multimeter comes with test leads and an operator's manual. The DM27 design permits immediate operation without the manual, but the well written manual is a bonus for the first-time user.

The DM27 lists for $129.95. For more information on the DM27, write to Beckman Industrial Corporation, Instrumentation, 3883 Ruffin Road, San Diego, CA 92123-1898, or circle No. 125 on the Free Information card. ■



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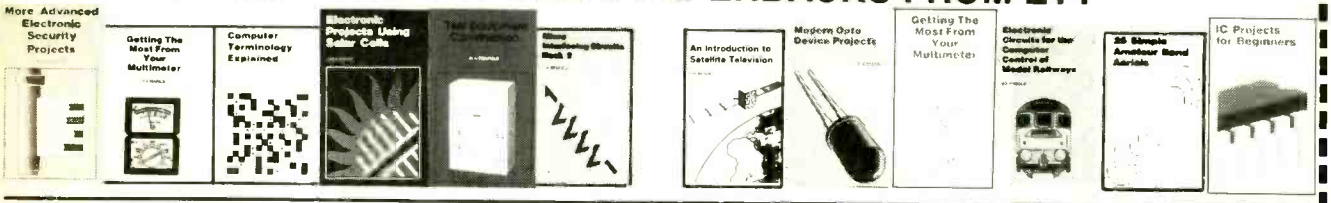

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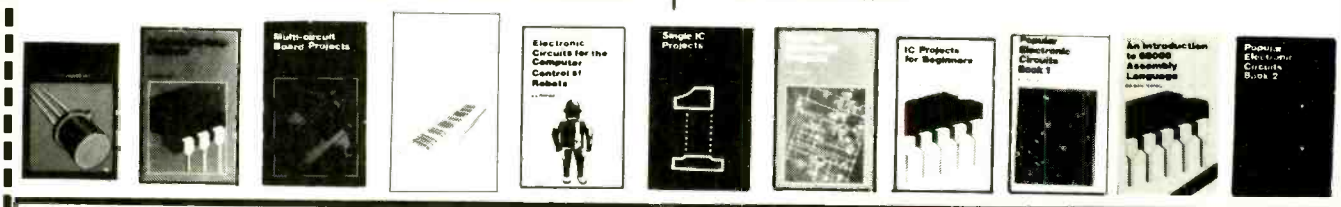

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List price $509.95/**CE price $239.95/SPECIAL**
12-Band, 200 Channel • 800 MHz. Handheld Search • Limit • Hold • Priority • Lockout
Frequency range: 29-54, 118-174, 406-512, 806-956 MHz. Excludes 823.9875-849.0125 and 868.9875-894.0125 MHz.
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Bearcat® 800XLT-T

List price $549.95/**CE price $239.95/SPECIAL**
12-Band, 40 Channel • No-crystal scanner Priority control • Search/Scan • AC/DC
Bands: 29-54, 118-174, 406-512, 806-912 MHz. Excludes 823.9875-849.0125 and 868.9875-894.0125 MHz.
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Bearcat® 145XL-T

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Bands: 29-54, 136-174, 406-512 MHz.
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The *President* HR2510 Mobile 10 Meter Transceiver made by Uniden, has everything you need for amateur radio communications. Up to 25 Watt PEP USB/LSB and 25 Watt CW mode. Noise Blanker. PA mode. Digital VFO. Built-in S/RF/MOD/SWR meter. Channel switch on the microphone, and much more! The HR2510 lets you operate AM, FM, USB, LSB or CW. The digitally synthesized frequency control gives you maximum stability and you may choose either pre-programmed 10 KHz. channel steps, or use the built-in VFO for steps down to 100 Hz. There's also RIT (Receiver Incremental Tuning) to give you perfectly tuned signals. With receive scanning, you can scan 50 channels in any one of four band segments to find out where the action is. Order your HR2510 from CEI today.

NEW! President® HR2600-T

List price $599.95/**CE price $299.95/SPECIAL**
10 Meter Mobile Transceiver • New Features
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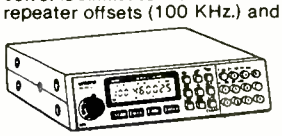

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