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FEBRUARY 1989, VOLUME 6, NO. 2

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DEPARTMENTS

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Editorial

THERE, WE DID IT!

To our readers who knew us as **Hands-on Electronics,** our front cover now displays a new name at the top—**Popular Electronics.** That's a big change! To our first time readers, you may fall into two groups: those who read **Popular Electronics** several years ago and haven't seen it since, and those who have just discovered **Popular Electronics** for the first time. To all of you, it's good to have you as readers of the newsstand's leading hobbyist electronics magazine.

The previous readers of **Hands-on Electronics** will find cosmetic changes—we've changed type styles, artistic layout somewhat, even changed the titles of our regular columns. But the editorial slant has remained the same. Read us from cover to cover. We're still the same magazine that you purchased last year.

The previous readers of **Popular Electronics** will be amazed by the likeness of our format to the old issues. Read us from cover to cover—yes, you'll find us to be the old **Popular Electronics** reborn and that the editors are doing an even better job than before.

Most important to our hearts are the new readers who never before ventured to purchase a hobby-electronics magazine. What a treat you are in store for! Read us from cover to cover. Try a few issues in a row. If you are an electronics activist, then **Popular Electronics** will become a regular habit with you. Give us a chance and we will prove to you that we'll make you a regular reader. Now get on with the reading. Start up front and work your way back, and I'll bet you will say, "What do you know, they did it!"

Julian Martin

Julian S. Martin, KA2GUN
Editor

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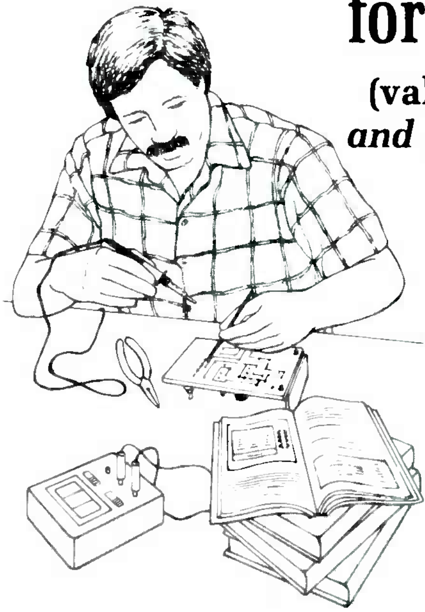

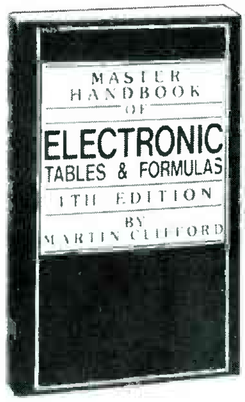

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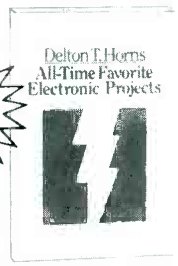

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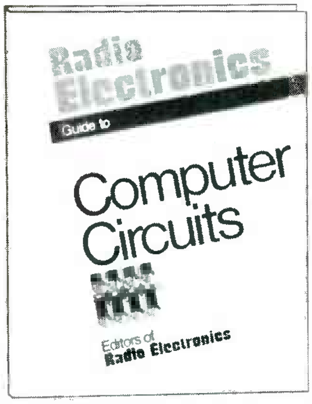

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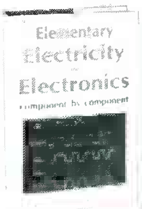

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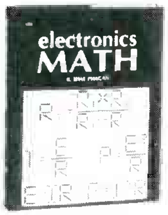

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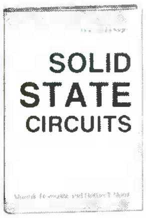

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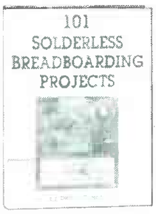

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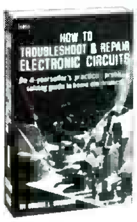

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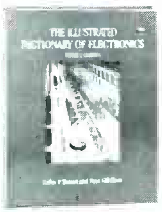

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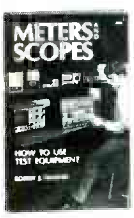

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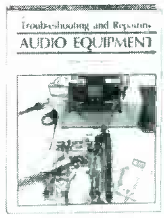

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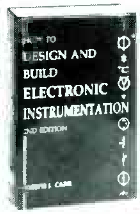

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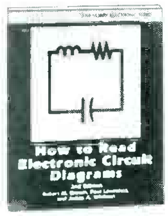

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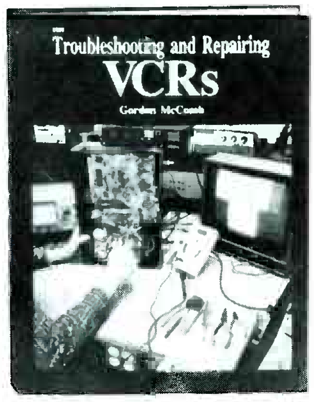

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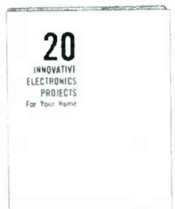

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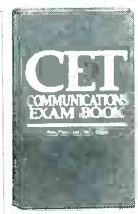

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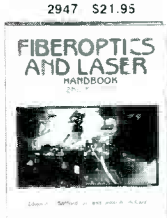

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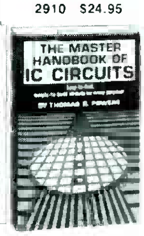

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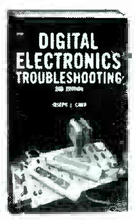

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Letters

A HAPPY HOBBYIST

I am writing this letter to let you know how much I've enjoyed building some of the projects that you have published. I am an electronics hobbyist who enjoys spending time at my workbench and I must say that your projects have been enjoyable. I hope you continue to print such fine articles.

I've enclosed a picture of the latest project that I've built—Charles D. Rakes' "Solid-State Tesla Coil" from the October 1988 issue of **Popular Electronics**. It has brought me many favorable comments, thanks to you. And I'd like to say thank you for the many hours of pleasure I've gotten from articles like that one.

J.V.
Tuscon, AZ

ATTENTION, ALUMNI

I enjoyed reading the editorial in the November issue, and I found the excellent blend of old and new in the same issue very fascinating indeed. Noting the experienced contributors like Marc Ellis (on vintage radio) and Don Jensen (on DX'ing) prompted me to write this letter.

My career in electronics started with a correspondence course from the "Hollywood Radio and Television Institute," which was located in Hollywood, CA until about 1960. For a long time now, I've wanted to contact past students of the Institute. I've tried various avenues, with no success so far. I am seeking your help in finding the present name of the Institute (if it is still in existence) or establishing if it was closed. I'd also like to find the names and addresses of any former students, or other individuals, whom I can contact for further information and correspondence.

Thank you for any information you may be able to supply.

B. ALI
710B Highpoint Avenue
Waterloo, Ontario Canada N2V 1G9

Can anyone out there help out on this? If so, contact Mr. Ali directly.—Editor

GOOD LUCK!

I wish you well in your new venture. **Popular Electronics** was always my favorite magazine; I was a subscriber for many, many years—until they decided to go into the computer bit. (There's a joke there somewhere, maybe "byte"?) Computers I can take or leave, but at my age I'll take the check.

I've been in electronics since the mid-30's. I served in the U.S.A.A.F. during WWII and in the U.S.A.F. until 1950. I worked for D.O.D. from 1951 to 1960, then General Electric from 1961 through 1987. My kids (ages 33 through 41) say "Hey Dad, you've seen it all." I say, "I hope not!"

When I was flying the big ones the saying was "Never say 'Good Luck'." But I said that to myself every time I took off. So, good luck!

W.E.M.
Melbourne, FL

Thanks for your kind wishes. We hope the new **Popular Electronics** *becomes your new all-time favorite. And you can be sure that we'll do everything we can to make that happen.—Editor*

LET THERE BE LIGHT BULBS

I read your article on Piezoelectric Generators (**Popular Electronics**, December 1988) with great interest. I paid particular attention to your question on whether large neon bulbs were still being made. Well, they are; our company sells G-40 type bulbs with various internal patterns including orchids, sunflowers, Christmas trees, and others. We also have one called a burning sun that has a wild, flickering effect that should look spectacular with your device. The bulbs are available for $6 each, postpaid.

Cindy Chipps
Sales Manager
Loyal-T-Lites, Inc.
1144 Brooks Hill Rd.
Brooks, KY 40109

WRITE IT RIGHT!

I just heard that your publication is changing its name to **Popular Electronics**. Way to go! I've missed that name for quite some time.

I've been involved in various aspects of electronics for over two decades, my first love being audio. For the past six years, however, I've been an operator and troubleshooter for a 50-kW shortwave transmitter that I helped design and build for a small religious organization. I have other ideas and designs, and was wondering if you'd be interested in seeing some articles.

How would I go about submitting manuscripts? Do you have author's guidelines available?

T.A.B.
Bethel, PA

Some of our best articles have come from just plain readers with good ideas! It's not necessary to be a professional author to get published, but there are certain things that the editors look for in any manuscript—originality and clarity are at the top of the list. If you'd like to try your hand at writing for **Popular Electronics,** *our guidelines will let you know exactly what we like to see in a story. Send an S.A.S.E. to* **Popular Electronics**, Writer's Guide, 500-B Bi-County Blvd., Farmingdale, NY 11735 *for your free copy.—Editor*

WHERE'S THE CHIP?

I would like to build the "Low-Battery Alarm" that was featured in the November 1988 issue of **Popular Electronics**. However, I am having trouble finding the 8211 chip. Can you tell me where I can get one? Or is there a substitute that I can use?

J.W.S.
Rivervale, NJ

Jameco Electronics (1355 Shoreway Road, Belmont, CA 94002; Tel. 415-592-8097) carries that chip. It costs $1.95, plus postage and handling, although they do have a $20 minimum order.—Editor

CASINO MIXUP

It seems that I have committed the sin of providing the wrong part numbers in one of my recent articles, Casino Dice Game (**Hands-on Electronics**, August 1988). In the Parts List, U5, U6, and U18 should be CD4075's, not CD4071's; the schematic diagram has the correct part designations. Also, the regulator should be a 7812, not a 7805 as stated in the article.

I am truly sorry for those errors and apologize for any difficulties they caused for your readers.

Walter W. Schopp

THANKS FOR THE MEMORIES

Thank you for your kind mention in the December editorial. I fondly remember all of the articles I did for the old **Popular Electronics** and am happy to see the old title revived.

It's true that I have been writing articles for the electronics hobbyist for many years. My first effort was a two-tube radio-broadcast receiver for the old *Radio & Television*. It appeared in August of 1940. Yet, even after all these years, the thrill I get when building electronics projects is still there.

Homer L. Davidson

THERMOCOUPLE CLARIFICATIONS

Your publication is excellent; I've been a subscriber since day one. Most of your articles are also excellent, but I regret to say that does not apply to your article on thermocouples in the November 1988 issue. The article completely fails to mention one of the most important considerations in the design of thermocouple-measuring circuits—namely, the *cold junction voltage*. If anyone new to the subject tries to use the article to do something practical, they'll become very confused.

To use a thermocouple in a simple circuit one must note both the output voltage and the cold junction temperature. Two courses are then open. The first, less precise, course is to look up the temperature equivalent of the output voltage (in mV) in the tables and then add to it the temperature at cold junction, less the reference-junction temperature. On the other hand, if it is reasonable to assume a constant cold-junction temperature, then add in the equivalent with a bias voltage. That is how the old-fashioned deflection/galvo-type instruments worked.

The second, more precise, method is to look up the output associated with the cold-junction temperature, add that to the observed (measured) output, and then look up the temperature associated with that new value.

As an example, let's assume that we take a simple (single thermocouple) measurement and find that the output is 12.572 mV at a cold-junction temperature of 80°F. The tables for the particular thermocouple we are using specify that that output is equivalent to a temperature of 500°F. Those tables also specify that the reference cold-junction temperature is 32°F.

Using the first method, we add the cold-junction temperature (80) minus the reference cold-junction temperature (32) to the value from the table (500). The result is $500 + (80 - 32) = 548$°F.

Using the second method, we look up the output for the cold-junction temperature of 80 (1.06 mV) and add that to the 12.572 to get 13.632. Looking that up in the table, we get 533.6°F. Obviously, there is a difference of 14.4°F between the two methods. That is because beteen 32 and 80°F the temp/mV coefficient is $1.06/48 = 0.022$ mV/°F. However, over the range between 500 and 533.5°F, the 1.06 mV represents only 33.6°F; that's a coefficient of $1.06/33.6 = .032$ mV/°F. That also demonstrates the non-linearity of the device (in this case, a copper/constantan type-T thermocouple).

(Continued on page 8)

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6.8	15V	.42
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1.0µf	35V	.45
2.2	35V	.19
4.7	35V	.39
10	35V	.69

DISC

10pf	50V	.05
22	50V	.05
33	50V	.05
47	50V	.05
100	50V	.05
220	50V	.05
.001µf	50V	.05
.005	50V	.05
.01	50V	.07
.05	50V	.07
.1	12V	.10
.1	50V	.12

ELECTROLYTIC

RADIAL

1µf	50V	.14
4.7	50V	.11
10	50V	.11
47	35V	.13
100	16V	.15
100	50V	.23
220	35V	.20
470	25V	.30
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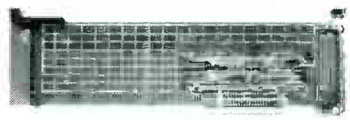

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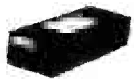

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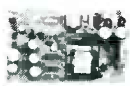

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BYPASS CAPACITORS

.01xx	CERAMIC DISC	100/5.00
.01xx	MONOLITHIC	100/10.00
.1xx	CERAMIC DISC	100/6.50
.1xx	MONOLITHIC	100/12.50

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MC146818	5.95	MM58174	9.95
MM58167	9.95	MSM5832	2.95

DISK CONTROLLERS

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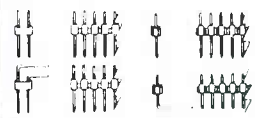

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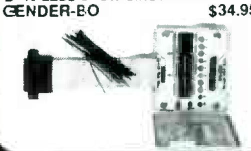


IDC CONNECTORS/RIBBON CABLE

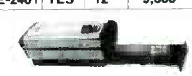
DESCRIPTION	ORDER BY	CONTACTS					
		10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WIREWRAP HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1.29	1.49	1.69
RIBBON HEADER	IDMxx	–	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	.85	1.25	1.35	1.75	2.05	2.45
10' PLASTIC RIBBON CABLE	RCxx	1.60	3.20	4.10	5.40	6.40	7.50

FOR ORDERING INSTRUCTIONS, SEE D-SUBMINIATURE CONNECTORS BELOW

EPROM ERASERS

SPECTRONICS CORPORATION

Model	Timer	# of Chips	Intensity (uW/Cm²)	Unit Cost
PE-140	NO	9	8,000	$ 89
PE-140T	YES	9	8,000	$139
PE-240T	YES	12	9,600	$189



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D-SUBMINIATURE CONNECTORS

DESCRIPTION		ORDER BY	CONTACTS					
			9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.69	1.35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	–	.79	2.27	–
	FEMALE	DBxxSR	.55	.75	–	.85	2.49	–
WIREWRAP	MALE	DBxxPWW	1.69	2.56	–	3.89	5.60	–
	FEMALE	DBxxSWW	2.76	4.27	–	6.84	9.95	–
IDC RIBBON CABLE	MALE	IDBxxP	1.39	1.99	–	2.25	4.25	–
	FEMALE	IDBxxS	1.45	2.05	–	2.35	4.49	–
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	–	–
	PLASTIC	HOODxx	.39	.39	–	.39	.69	.75

ORDERING INSTRUCTIONS:

INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED. EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

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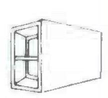
IC SOCKETS/DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS								
		8	14	16	18	20	22	24	28	40
SOLDERTAIL SOCKETS	xxST	.11	.11	.12	.15	.18	.15	.20	.22	.30
WIREWRAP SOCKETS	xxWW	.59	.69	.69	.99	1.09	1.39	1.49	1.69	1.99
ZIF SOCKETS	ZIFxx	–	4.95	4.95	–	5.95	–	5.95	6.95	9.95
TOOLED SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
TOOLED WW SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIERS	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
DIP PLUGS (IDC)	IDPxx	.95	.49	.59	1.29	1.49	–	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS ABOVE

SHORTING BLOCKS

5/$1.00



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CONTINENTAL U.S. AND CANADA

CIRCLE 48 ON FREE INFORMATION CARD

Letters
(Continued from page 5)

Another error—less significant, but still confusing to the uninitiated—s the way that you refer to the thermocouple materials. For example, the material is not "copper constantan;" it is copper and constantan. Constantan is an alloy of 60% copper/40% nickel. And the combination of metals for an iron constantan thermocouple is not iron and iron constantan as stated. It is, in fact, iron and constantan: one leg of iron and one leg of 60% copper/40% nickel.

It is also a little confusing to say that the copper/con thermocouple will produce about 1.5 mV at 100°F. It will do that only if the cold junction is at 32°F; it won't be at that temperature unless you specifically arrange it so. (In the old days that was done by immersing the cold junction in ice.) If you tried to measure a 100°F air temperature with the cold junction at 80°F you would you would get an output of only 0.46 mV—that might confuse you if you were looking for 1.5 mV.

It is normal practice to use cable made of the same materials (although usually less pure and, therefore, less expensive) as the thermocouple to make the connections between the measuring site and the measuring instrument. In modern instruments, the temperature is measured at the instrument terminals. Brass terminals represent two junctions—copper/brass and brass/constantan, which, by the law of intermediate metals, is the same as a copper/con junction if both terminals are at the same temperature.

W.B.
Katy, TX

OUR READERS COME THROUGH

Last May I wrote to **Hands-on Electronics** Letter Box" asking for help in finding a melody synthesizer, type AY-3-1350. When my letter appeared in the September issue, I started to receive letters, and even chips, from many generous readers.

I am really very grateful to you for printing my letter, and for the kindness of the readers who helped me a lot.

Elias M. Raffoul
Dearborn, MI

HAVES AND NEEDS

Ten years ago I purchased a radio that has the following information on various ID tags located inside the tube area: "Wm. O. Gurnow, Superheterodyne;" "Chassis Type No 5E;" "Model 560;" "Mfg. by General Household Utilities, Chicago, Ill.;" and "115 volts AC, 50/60 cycles, 60 watts." The tubes are 6A7, 42, 80, 6D6. There is also a 7-digit number stamped in the metal frame: 1827704.

I've been reading your Antique Radio column and it made me wonder if any of your readers have a schematic for the radio. The radio plays fine, and I've refinished the cabinet. There is one switch that allows shortwave, I think.

Lawrence R. Fay
3595 Santa Fe Ave., SP70
Long Beach, CA 90810

I am trying to locate an SN76495 Sound-Effects Synthesizer IC. That chip was carried by Radio Shack in 1985, but it is now discontinued. Can you or any of your readers tell me where I can obtain that device? Thank you.

Lowell Picklyk
R.R.#4, S.22, C.45
Kelowna, B.C.
Canada, V1Y 7R3

I have on old Tennelec Memoryscan scanner and am having problems programming it. Tennelec hasn't built these in years and no longer has any code books or programming information. They did send me a service manual.

I am looking for anyone who has information on how to convert frequencies into binary codes for entry into the scanner. I have gone through all of the formulas in computer math books and have come close a couple of times, but nothing has quite worked.

Scott Mackintosh
Box 25
Fort Lauderdale, FL 33302

TI-99/4A TRADE-IN

Readers who own TI-99/4As might be interested in a discovery I recentntntly made. If you have a problem with your unit, you can exchange it simply by returning the unit, along with $30.50 plus postage, to Texas Instruments, ATTN: Parts Department, 2305 North University, Lubbock, TX 79415. The phone number there is (806)741-2265 or 2268.

R.P.
Bisbee, AZ

We checked this out and its true. For those with dead or dying TI-99/4A's (once a rather popular machine), it's an inexpensive way to get back to computing. ■

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DIGITAL COMMUNICATIONS

by Simon Haykin

This comprehensive and timely discussion of the principles of digital communications focuses on basic issues. Wherever possible, theory is related to practical examples.

Aimed at electrical engineers and students, the book assumes that readers have a working knowledge of Fourier techniques and probability. However, for those without such a background, the author provides extensive indexes that review those topics, a full reference list, and suggestions for further reading.

The 597-page book includes complete coverage of such topics as error-control coding, sampling process, information-theory concepts, digital-modulation techniques, robust quantization for pulse-code modulation, coding speech at low-bit rates, and computer communications. Most chapters contain summaries and discussions of the salient points, and a set of problems that reinforce the material. Theoretical ideas are illustrated by numerous examples, worked out in detail to aid comprehension.

Digital Communications costs $59.30 in hardcover. It is available from John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012.

CIRCLE 71 ON FREE INFORMATION CARD

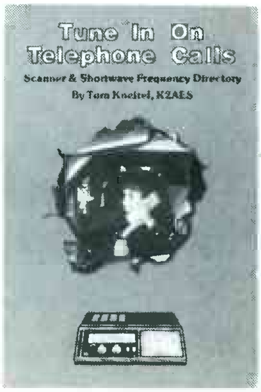
TUNE IN ON TELEPHONE CALLS: Scanner & Shortwave Frequency Directory

by Tom Kneitel, K2AES

Not many people are aware that their "private" conversations on cellular and cordless phones, and on many other modern communications devices, are being broadcast over the airwaves on HF, VHF, and UHF frequencies, where they can be overheard by anyone with a shortwave receiver or a police scanner. Despite (or, perhaps, because of) virtually unenforceable anti-eavesdropping laws, listening in has become a hot "insider" pastime—and a tool for intelligence-gathering and law-enforcement agencies, and for private investigators.

This book is an all-purpose manual and frequency guide to that new area of communications monitoring. It discusses the many radio services in the U.S. and Canada where such calls take place, including cellular, cordless, ship-to-shore, and high-seas transmissions, and the laws regarding those services. Written in an easy-to-understand style, the book discusses monitoring techniques, receiving equipment, and antennas.

The book contains thousands of listings of station locations. It also contains the actual operating frequencies within all shortwave and scanner bands for locating tele



phone conversations and one-way radio-pager messages. Readers will learn how to hear those—and even calls from *Air Force 1*—on base, handheld, and mobile receivers and scanners. No technical expertise or expensive equipment is required.

Tune in on Telephone Calls: Scanner & Shortwave Frequency Directory is available for $12.95 plus $2.00 shipping (N.Y. residents add sales tax) from CRB Research Books, Inc., P.O. Box 56, Commack, NY 11725.

CIRCLE 70 ON FREE INFORMATION CARD

BEGINNER'S GUIDE TO TV REPAIR (3rd Edition)

by George Zwick and Homer L. Davidson

Anyone who can get the back off a TV set will be able to fix a variety of TV problems by following the step-by-step instructions in this book. Even those who have no desire to tinker can gain a general understanding of how a TV receiver works—and why it sometimes fails.

The book sticks with those repairs that beginners can handle safely; it identifies those tasks that, for reasons of complexity or safety, should be left to the professional serviceman. Instead, the focus is on simple preventative- and corrective-maintenance techniques that require no special tools or equipment. It describes how to correct picture instability, improper contrast or brightness, loss of vertical hold, and loss of sound and/or picture.

Color and black-and-white units, older tube sets, and today's solid-state TV sets, are all covered. The information is presented in clear, non-technical language. Dozens of detailed schematics, matched to illustrations of corresponding circuit boards, help familiarize readers with the inner workings of their sets.

Beginner's Guide To TV Repair (3rd Edition) costs $13.95. It is available from Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

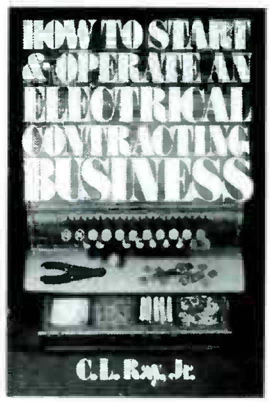
CIRCLE 98 ON FREE INFORMATION CARD

HOW TO START AND OPERATE AN ELECTRICAL CONTRACTING BUSINESS

by C.L. Ray, Jr.

The author has put his 25 years of experience in owning and running his own business to practical use in this book. In it, he details the approaches that lead to effective, profitable decisions and shows how to avoid costly mistakes. It is aimed at electricians who want to open their own companies, and for those who want to make existing electrical-contracting businesses operate more efficiently.

The book gives sound advice on how to start a business, and on how to keep it



going, and growing. The reader's professional capability is assumed; instead, the book focuses on the other factors needed for success—namely, dealing with people, finances, and marketing. Tips are given on how to hire and manage employees, and how to interact with customers and general contractors. The line of responsibility within the company is examined. Various methods of marketing the firm's services are explored, and ways to estimate job costs with pinpoint accuracy are detailed.

This practical guide uses easy to-understand language to explain the intricacies of financial planning. It discusses accounting procedures, profit-and-loss control, insurance requirements, tax planning, and how to set and achieve financial goals. Common causes for business failures are explained, with tips on how to avoid them.

How to Start and Operate an Electrical Contracting Business is available in hardcover for $29.95 from McGraw-Hill Book Company, 11 West 19th Street, New York, NY 10011; Tel. 1-800-2-MCGRAW.

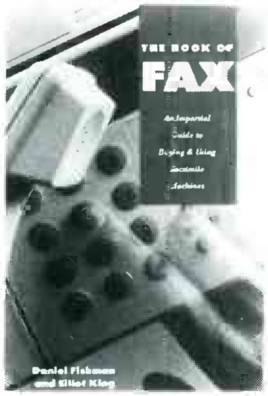
CIRCLE 96 ON FREE INFORMATION CARD

THE BOOK OF FAX: An Impartial Guide to Buying and Using Facsimile Equipment

by Daniel Fishman and Elliot King

The facsimile machine is one of the hottest items in today's consumer-electronics market. If you're considering the purchase of a fax machine, or if you've just bought one, this book is for you. Written in plain English, it teaches the basics of fax equipment, and its use and management.

The guide begins with an introduction to fax technology. It presents a step-by-



step analysis to help you determine if you actually need a fax machine, and, if so, how to choose a machine that will meet your communications needs and your budget. There is a comprehensive review of the features offered on facsimile machines, from the most basic to the most sophisticated. Each chapter contains charts, worksheets, and checklists to help you clarify needs and alternatives.

Tips on how to use fax equipment effectively and professionally are included, along with some cautions about practices to be avoided. There is a thorough overview of the pros and cons of PC fax, an important new alternative. The book also tells how to stop fax "junk mail" and how to take advantage of such features as polling and broadcasting.

The Book of Fax: An Impartial Guide to Buying & Using Facsimile Machines is available for $12.95 from Ventana Press, P.O. Box 2468, Chapel Hill, NC 27515.

CIRCLE 73 ON FREE INFORMATION CARD

WORDPERFECT: THE COMPLETE REFERENCE (Series 5 Edition)

by Karen L. Acerson

Every feature, key, menu, prompt, and error message of WordPerfect version 5 is explained in this 1200-page volume. The explanations are simple enough for beginners to understand, and detailed enough for pros to find valuable. The book is organized for quick reference, so that readers can easily find the information they need.

This comprehensive book is divided into four sections. The introduction includes the basics of installing, setting up, and beginning to use WordPerfect. It leads the reader, step-by-step, through creating, editing, formatting, printing, and filing a document; and explains macros and how to customize the program.

The bulk of the book is in the second section: "Commands and Features." That encyclopedic reference section details virtually everything about WordPerfect. It is arranged alphabetically, and filled with examples, hints, suggested applications, and related entries for each feature.

The book goes on to discuss printing and desktop publishing with version 5.0. The final section, on software integration, introduces the reader to programs that are compatible with WordPerfect, and how to share data between them. Appendixes include a table of ASCII characters, explanations of macros, a summary of the differences between versions 4.2 and 5.0, a printout of the art-graphics images included on the Font/Graphics disk, and a terminology reference that compares terms used in WordPerfect with those used in other popular word-processing programs.

WordPerfect: The Complete Reference, Series 5 Edition is available for $24.95 from Osborne McGraw-Hill, 2600 Tenth Street, Berkeley, CA 94710.

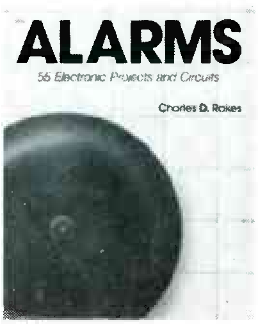
CIRCLE 96 ON FREE INFORMATION CARD

ALARMS: 55 ELECTRONIC PROJECTS AND CIRCUITS

by Charles D. Rakes

This comprehensive look at home and property security was written by a familiar author—Charles Rakes of "Circuit Circus" fame. In his usual easy-to-read style, he shows readers how to build different types of alarm circuits for a wide array of applications.

The book features alarm circuits for cars, including indicators for high/low battery-voltage, lamp burn-out, break-ins, brake-fluid levels, and water overheating. Intru



sion alarms include sensors for lignt, proximity, sound, glass-breakage, vibration, and fence intrusion; and burglar-alarm control systems include simple single-input, multi-input, and multi-input timed entry/exit. For the telephone-remote listening/alarm control system, there are directions for building a basic remote unit, for adding extra functions, and for using a telephone remote unit. The book includes fire- and smoke-alarm systems and an assortment of miscellaneous alarm circuits ranging from temperature and moisture alarms to radiation-level alarms.

Each alarm project is presented with clear, concise text accompanied by work-in-progress diagrams. Also included are troubleshooting hints and construction tips, and even advice on how to install the completed system in a home or automobile.

Alarms: 55 Electronic Projects and Circuits is available for $12.95 from TAB Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

CIRCLE 98 ON FREE INFORMATION CARD

COMPUTER DICTIONARY (Fourth Edition)

by Charles J. Sippl

This popular reference combines two books in one; it's both a dictionary of basic computer terminology, and a handbook of computer-related topics. From "A bus" to "zone," the more than 12,000 entries are more than simple definitions. They provide enough detail to give the reader a clear understanding of computer technology.

Explanations of micro-, mini-, and mainframe-computer technology; robotics; artificial intelligence; optical-disk memory; computer-aided design, engineering, and manufacturing; graphics; fiber optics; custom- and semi-custom-chip technologies; and computer-integrated manufacturing automation are included. The book also contains many photographs and illustrations for further clarification of terms.

Computer Dictionary (Fourth Edition) 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

MUSICAL APPLICATIONS OF THE ATARI ST'S

by R.A. Penfold

The Atari ST is the proven leader in the music-computer field, with its unrivaled and rapidly expanding range of available software and add-ons. Its built-in MIDI ports, large memory, high processing power, good graphics, and moderate cost have made it the computer of choice for demanding musical applications such as MIDI sequencing.

This book is aimed at musicians who want to exploit the full potential of the Atari ST in music applications. A fundamental knowledge of how to use the ST and run programs on it (basically, a solid grasp of the information provided in the user's manual) is necessary. For computer-enthusiasts, some simple hardware projects are presented, along with information on how to program the ST's sound chip and MIDI

programming, including some useful MIDI-processing routines.

Most of the material is easy for non-technical types to understand. Topics include applications programs such as sequencing and score-writing; and simple but useful add-on projects. MIDI is covered in depth, with particular emphasis on how it applies to Atari ST's. Full details of MIDI messages and coding are provided.

Musical Applications of the Atari ST's (order #BP246) is available for $11.95 (including shipping) from Electronics Technology Today, P.O. Box 240, Massapequa, NY 11762.

CIRCLE 97 ON FREE INFORMATION CARD

THE DIGITAL IC HANDBOOK

by Michael S. Morley

Integrated circuits from many major manufacturers are described in this book. Its format is designed to simplify the reader's search for the right digital IC, by providing instant access to exact information as needed.

The handbook presents an overview of all standard digital ICs. The differences in digital ICs are examined; the devices are compared not only by technology and key specification, but also by package and price. The data on current digital-IC technology is combined with practical selection guides in this text.

The basic operation, technological families, and key specifications are explained, and selection guides are included for a wide assortment of logic ICs. Those include gates, inverters, flip-flops, latches, multivibrators, buffers, decoders and encoders, counters, shift registers, transceivers, and arithmetic circuits. Also covered are such memory ICs as SRAMs, DRAMs, PROMs, and EPROMs. Microprocessor ICs—basic microprocessor systems and operations; addressing modes; and 8-, 16-, and 32-bit microprocessors—are featured as well.

The Digital IC Handbook costs $49.50 in hardcover. It is available from Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

CIRCLE 98 ON FREE INFORMATION CARD

PARADOX MADE EASY

by Edward Jones

By the end of this book's third chapter, its readers will be able to produce reports using Paradox, the new relational database from Borland International. Readers can learn to use the program easily and efficiently, simply by following the author's clear instructions.

Starting with a complete overview of the software's capabilities and of basic database concepts, the book proceeds with information on terms and phrases, creating a database, and manipulating data. More-advanced techniques, including Paradox's custom-form capability, macros, "query by example" function, and the Personal Programmer—an automated application-builder contained within the program—are introduced in later chapters. Readers also learn how to import their existing files from other databases and spreadsheets to Paradox. A tear-out reference card, summarizing commands and key functions, is also included.

Paradox Made Easy is available for $19.95 from Borland/Osborne McGraw-Hill, 2600 Tenth Street, Berkeley, CA 94710.

CIRCLE 72 ON FREE INFORMATION CARD

MASTERING WORDPERFECT 5

by Susan Baake Kelly

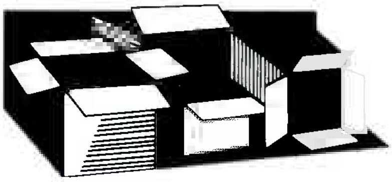
All the information needed for new users to start using WordPerfect, and for experienced users to explore its more-sophisticated features, can be found in this comprehensive, 709-page book. It has been updated to include the new desktop-publishing capabilities of WordPerfect 5—those are text formatting with several font sizes, adding graphics to documents, and laser printing.

"Fast Track" speed notes appear on clearly marked pages at the front of each chapter. Fast Tracks parallel the main text, outlining the chapters, listing the steps needed to complete certain tasks, and directing the reader to the specific pages that contain more detailed information. A convenient tear-out chart, that summarizes WordPerfect commands and functions, is also included.

The reader learns how to create high-quality documents for business presentations, reports, and newsletters, and how to enhance page appearance by using special formatting features, different fonts and type styles, and multiple-text columns. The book explains the use of macros to simplify tasks that are performed often, and the Speller and Thesaurus to produce more-accurate text. It describes how to generate indexes automatically from the text, or from itemized lists; how to add illustrations using WordPerfect's graphic files, or by importing graphics from other programs; how to control output to a variety of printers; and how to use the "Styles" feature for easy, consistent formatting of all of the user's documents.

Mastering WordPerfect 5 costs $21.95. It is available from SYBEX, Inc., 2021 Challenger Drive, #100, Alameda, CA 94501; 800-227-2346. ■

CIRCLE 74 ON FREE INFORMATION CARD



New Products

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

PHOTOTOUCH TELEPHONE

Northwestern Bell's PhotoTouch telephone has a flat, big-key dialing display that doubles as a photo display for up to nine pictures or symbol cards. Users can insert photographs of friends and relatives into the "window" memory keys, and then enter their phone numbers in the nine-number, two-step memory. Symbol cards can also be used to represent emergency numbers such as the police and fire departments.

Unlike other big-button phones, the PhotoTouch has a slim streamlined design that is attractive when wall-mounted or on a desk. Color cards and a template are included so that the PhotoTouch can match the decor of any room. With an easy-to-hold handset, oversized keys, touch-sensitive keypad, and quality craftsmanship, it is also highly functional.

The fully modular unit also features last-number re-dial, adjustable-volume electronic ringer, tone/pulse switching, 14-foot line cord, and 10-foot spring-handset cord. A sheet of symbol cards—including doctor, post office, pizza, ambulance, babysitter, and school—comes with the phone. The PhotoTouch is hearing-aid compatible.

Backed by a two-year limited warranty, the PhotoTouch telephone has a suggested retail price of $69.99. For more information, contact Northwestern Bell Phones, 9394 West Dodge Road, Suite 100, Omaha, NE 68114.

CIRCLE 78 ON FREE INFORMATION CARD

WEATHER-RESISTANT HEADSET RADIO

GE's model 7-1990 "Action" AM/FM stereo headset radio was specifically designed for use outdoors. The ultra-light receiver can be used in rain, sleet, or snow. Sports enthusiasts can listen to music without being hindered by the size, weight, or durability of the unit.

The radio comes in a small "Action Pak" carrying case, with an armband that keeps the headphones out of the way. Because the headphones are designed to rest securely in the ear without a headband, the listener can wear a hat or helmet at the same time. Thumb-wheel tuning and volume control make the radio easy to use while on the go, and vernier tuning ensures exact station selection.

The blue and yellow receiver measures only 1.7 × 3.3 inches, and runs on one AAA battery. The AM/FM-stereo reception offers clear sound; built-in automatic frequency control reduces station drift. There are no external antennas to get in the way. The FM antenna is built into the headphone cord and the AM antenna is built into the receiver.

The Model 7-1990 "Action" headset radio has a suggested retail price of $26.95. For more information, contact GE Audio Communications Products, Consumer Relations Department I-455, P.O. Box 1976, Indianapolis, IN 46026.

CIRCLE 79 ON FREE INFORMATION CARD

ALL-MODE TRANSCEIVER

Heath's SB-1400 transceiver provides all-mode, all-band coverage with 100 watts of transmit power on all nine HF amateur bands. It is aimed at beginning and experienced ham operators, as well as those who are interested in mobile operations.

The SB-1400 has 25-watt maximum AM output, and 0.25-μV (or better) sensitivity. It offers dual VFO's, RIT, a built-in 500-Hz CW filter, computer interface, receiver squelch in all modes, and "split" operation. Twenty memories hold favorite frequencies, and controls—including selectable AGC action—are conveniently arrayed on the front panel.

Available accessories include a 20-amp power supply with built-in speaker, FM module, handheld microphone, mobile bracket, and a switching relay that might be required for some linear amplifiers.

The SB-1400 all-mode transceiver, with user's manual, has a suggested net price of $799.95. For more information, contact Heath Company, Department 350-036, Benton Harbor, MI 49022; Tel. 1-800-44-HEATH.

CIRCLE 80 ON FREE INFORMATION CARD

LAPTOP COMPUTER

NEC's UltraLite computer has 90% of the original IBM-AT's power, yet it weighs only 4.4 pounds and measures just 8.3- × 11.75- × 1.4-inches—half the size of the smallest laptop currently available. Driven by an NEC V-30 processor running at 9.38 MHz, with 640K standard RAM and a built-in Hayes-compatible modem, the unit features all the storage, connectivity, and graphics capabilities needed for a broad range of applications.

The UltraLite is easy to read and to use. Its 9½-inch diagonal, blue-on-white backlit LCD screen supports both text and graphics functions at CGA level. A full-sized, industry-standard keyboard is comfortable and familiar for users, and built-in *MS-DOS Manager* software offers implementation of any application from a simple set of menus. For working where no AC-power source is available, the UltraLite features over two hours of battery life.

The laptop offers the power and storage of a desktop computer. A new silicon hard-disk technology provides high-speed access to data several times faster than traditional-storage technology. The UltraLite is available with either one- or two-megabyte silicon hard-disk storage; the disk is easily upgraded and contains no moving parts. (NEC plans silicon disks with up to 8 megabytes in the future.)

An advanced ROM card gives immediate, easy access to multiple applications, and eliminates the awkward swapping of floppy disks. Each ROM card, which is about the size of a credit card, will contain a complete applications-software package, such as Lotus 1-2-3, WordPerfect 5.0, or XyWrite III. (ROM cards will be sold through authorized NEC Home Electronics dealers.)

For added capability, an optional external $3^1/_2$-inch floppy-disk drive is available. Data and programs can be read from industry-standard 1.44-megabyte and 720K-capacity floppies. A printer port—standard on the floppy drive—allows connection of a parallel printer via a Centronix cable.

Easy connections permit the movement of data and programs between computers

or databases and the Ultralite laptop. Built-in "Laplink" software allows the unit to be connected to other PC's. A built-in 2400-baud modem provides easy communication with electronic-mail systems.

The UltraLite portable computer has a suggested retail price of $2,999.00 with 1-megabyte silicon hard-disk drive, and $3,699.00 with 2-megabyte hard-disk drive. For additional information, contact NEC Home Electronics (U.S.A.) Inc., 1255 Michael Drive, Wood Dale, IL 60191.

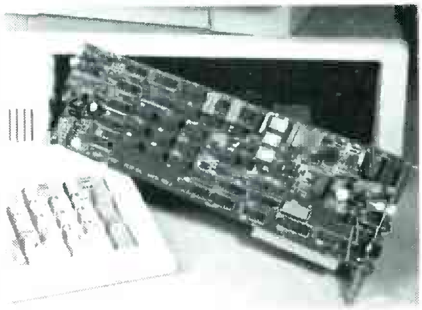
CIRCLE 81 ON FREE INFORMATION CARD

VOLTAGE-CALIBRATOR BOARD

MetraByte's PCIP-CAL is a ±19.999-volt voltage calibrator that provides all the features of a bench-top/rack-mount instrument. Eliminating the communication interface, display circuitry, cabling, and power supply needed for dedicated IEEE-488/GPIB bench/rack systems results in lower price and easier programming.

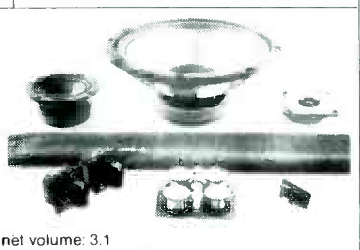
The PCIP-CAL provides $4^1/_2$-digit resolution in three scales—±19.999-volts at 1-mV resolution, ±1.9999-volts at 0.1-mV resolution, ±199.99-mV at 10-μV resolution. The short-circuit protected output will provide up to 25 mA of output current and is isolated from the host computer by 500-volts DC minimum.

The PCIP-CAL has two operating modes—bench emulation or programmed. Those simulate IEEE-488 "local" and "remote" operation respectively. For ease of use, all programming is done in simple English commands and is language independent. Software comes in the form of a de



vice driver that is loaded into the machine during the "system configuration" each time the computer is turned on or rebooted. That eliminates the complexity of primary/secondary addresses, listens/unlistens, high byte/low byte, and the need to adhere to protocalls associated with IEEE-488/GPIB-inspired cluster programming.

(Continued on page 18)



CIRCLE 15 ON FREE INFORMATION CARD

All instrument displays appear on the computer screen when activated by a user-defined "hot key" sequence. When activated, each display occupies one-third of the screen, allowing three instruments to be displayed at one time. Either the keyboard or a mouse can be used for functional control.

PCIP-CAL has a suggested list price of $895.00. For more information, contact MetraByte Corporation, 440 Myles Standish Blvd., Taunton, MA 02780.

CIRCLE 82 ON FREE INFORMATION CARD

ANTENNA TUNER

MFJ Enterprises' 3-kilowatt *Model MFJ-986* is a T-network tuner that uses a single differential capacitor in place of two variable capacitors. That makes tuning easier and more accurate due to minimum SWR at only one setting, with only two controls to adjust. It also gives users a broadband response that eliminates constant retuning.

The antenna tuner covers 1.8 to 30 MHz continuously, including all MARS and WARC bands. Its roller inductor allows the user to keep the SWR down to absolute minimum. A 3-digit turns counter and spinner knob offer the precise inductance control necessary to instantly return to a favorite frequency. A lighted, two-color, peak-and-average reading, cross-needle SWR/wattmeter lets the user read forward and reflected power and SWR at a glance. It also has a directional coupler for more

accurate SWR and power readings over a wider frequency range.

A 6-position antenna switch offers selection between two coaxial lines and/or random wires (direct or through the tuner), balanced line, and external dummy load. A current balun for balanced lines reduces feedline radiation that causes RF, field-pattern distortion, and TVI.

The MFJ-986 antenna tuner, complete with a one-year unconditional guarantee, costs $239.95. For further information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, MS 39762; Tel. 800-647-1800.

CIRCLE 83 ON FREE INFORMATION CARD

HANDHELD DIGITAL MULTIMETER

Triplett's Model 2200 handheld digital multimeter features overload protection of up to 450 volts on all ohmmeter circuitry for safety, and a ruggedized case for durability. The DMM also offers a large, high-contrast 3½-digit LCD readout, a single rotary switch, low-battery indicator, and auto-zero and auto-polarity functions. It

measures from 200-millivolts to 1000-volts DC in 5 ranges; from 200 volts to 750 volts AC in two ranges; 200-microamps to 2-amps DC in 5 ranges; 200 ohms to 2 megohms in two ranges; and diode-test and FE measurements.

The Model 2200 handheld digital multimeter—including a standard 9-volt battery, a pair of test leads, a spare 2-amp fuse, and an instruction manual—costs $45.00. For further information, contact Triplett Corporation, One Triplett Drive, Bluffton, OH 45817; Tel. 1-800-TRIPLET.

CIRCLE 84 ON FREE INFORMATION CARD

COMPUTER FURNITURE

Bush Industries' new line of computer furniture, designed for budget-conscious consumers, includes a computer desk with vertical hutch, a matching printer stand, and a corner unit to connect them. All are fully finished in a light-oak laminate, and the desktop is covered with a durable acrylic coating.

The desk, *Model CT222*, has two large drawers, a height-adjustable monitor shelf, and a roomy supply cabinet with sliding doors to hide the clutter of disks and accessories. Another shelf spans the top to hold books and manuals.

The *Model CT225* printer stand has an adjustable interior shelf and two paper slots in the back to handle the flow of computer printouts. The printer stand can

be connected to the desk with *Model CT223*, the corner unit. It increases the usable work area while preventing papers from falling into the space between desk and printer stand.

All three pieces feature Bush's "Quik'n'Easy" assembly system. Designed with much of the hardware already in place, furniture assembly is easier and faster than with traditional ready-to-assemble pieces. Adjustable leveling glides on the desk and printer stand assure level work surfaces.

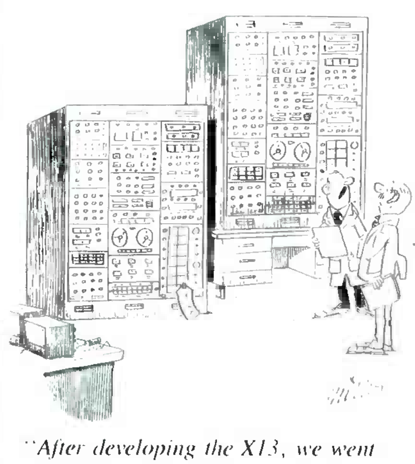
The Model CT222 desk with hutch costs $199.95. The Model CT225 printer stand and the Model CT223 corner connector cost $69.95 and $29.95, respectively. For more information, contact Bush Industries, One Mason Drive, P.O. Box 460, Jamestown, NY 14702-0460; Tel. 1-800-228-BUSH (in NY, 1-800-248-BUSH).

CIRCLE 85 ON FREE INFORMATION CARD

RECHARGEABLE COMPUTER BATTERY

Accumation's LAST.BAT provides protection from lost data due to battery failure in IBM-PC/AT computers and clones. A computer's lithium battery typically lasts for 12 to 18 months, and when it fails, setup data (time, date, peripheral connections) is lost.

(Continued on page 22)



"After developing the X13, we went to work on the desk-top model."

New Products

(Continued from page 18)

LAST.BAT (for "last battery") is designed to prevent such losses.

This patent-pending battery system automatically recharges itself from the computer's power supply, and will provide the current to maintain the computer's setup memory perpetually. Because it uses sealed nickel-cadmium rather than lead-acid or alkaline batteries, it will not damage the computer. LAST.BAT comes with a lifetime warranty for as long as the original purchaser uses it in the computer it was originally installed in, providing it was installed and used correctly.

The maintenance-free unit is easy to install—proficient end users can install it in less than 15 minutes, using only the tools needed to open the computer's case. To ensure proper connection, the socket connection to the computer's power supply is polarized. An additional plug is included to replace the one LAST.BAT uses to recharge itself from the power supply. The battery comes with a foam-tape backing for permanent mounting virtually anywhere inside the computer case.

LAST.BAT rechargeable computer battery has a suggested list price of $74.95. For more information, contact Accumation, Inc., 8817 Southwest 129th Terrace, Miami, FL 33176.

CIRCLE 89 ON FREE INFORMATION CARD

HANDHELD MULTIMETERS

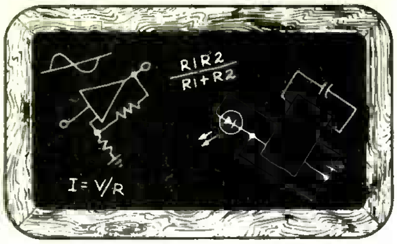
A.W. Sperry's Models SP-10A and *SP-15A* pocket-sized analog multimeters have the capacity to read up to 5 functions on up to 15 ranges. Although they are designed for professional field-service or lab work, they are simple enough for the hobbyist to use.

Model SP-10A's ranges are 10-/50-/250-/500-volts DC, 10-/50-/250-/500-volts AC, 1K-/10K-/100K-ohms resistance, 250-mA DC

current, and a battery check from 1.5 volts to 9 volts. Model SP-15A's ranges are 5-/25-/250-volts DC, 5-/25-/250-/1000-volts AC, 0.5-/5-/250-mA DC current, 1K-/10K-/1M-ohms resistance, and a continuity check in which a buzzer sounds at less than 200 ohms. Each unit comes with test leads, a battery, a fuse, and a one-year warranty.

Models SP-10A (shown) and SP-15A cost $25.95 and $29.95, respectively. For further information, contact A.W. Sperry Instruments Inc., 245 Marcus Boulevard, Hauppauge, NY 11788. ■

CIRCLE 87 ON FREE INFORMATION CARD



Think Tank

By Byron G. Wels

IC'S AND SMT—THE CONCEPT ISN'T NEW

When I was a mere stripling, I came up with what I thought was a brilliant idea. I took a type 30 triode tube and a product called "Copper Print," which was a liquid paint that dried as conductive as copper wire. With ordinary household cement, I attached the other components to the glass tube's surface and allowed that to dry.

Using the Copper Print, I connected the various components into the circuit and ran the necessary paint to the appropriate tube pins. When I finished, I simply connected the various power sources (with wire) to the tube's flush-mounted socket and plugged the tube in. Now don't get me wrong. The thing looked foolish. I admit that. But it *did* work, with that variable capacitor and tuning knob glued to the top of the tube.

Where I needed a cross-over, I used electrical tape under (or over) the conductor. My *integrated circuit* receiver really worked...pseudo surface-mounted technology and all. But as the tube heated up, the glue gave way, and I wound up with a "back-to-the-drawing-board" feeling.

So this month, we're going to be looking at some IC circuits that you readers have sent in, and we're also going to be handing out some new FIPS books to the winners!

Touch Switch. This is the kind of project I like—short, sweet and simple. I hope your other readers like it too. It's a sensitive touch-operated switch, that can also be used (if you like) as a rain detector. It starts with a piece of the striped perfboard, and you jumper the even-numbered stripes and the odd-numbered stripes. All you really need are about three of each, or a total of six stripes. I've wired mine in a small, flat box with S1 (used as a reset) and I keep it near the bed. Why? Well, my bedroom is particularly dark at night, and this allows me a safe trip to the facilities without having to waken my wife as putting the lights on might do. What's more, she's forever rearranging the furniture. The amount of light given off in a dark room is more-than adequate to the purpose.

See Fig. 1. Pin 3 of the IC is held by resistors R1 and R2. Inverting input (pin 2) is brought to the wiper of R3, which lets you set the operation threshold. When you touch the plate, bridging the odd and even stripes, pin 2 moves negative, and the effect is amplified, causing pin 6 to go positive.

The SCR doesn't conduct normally, leaving the lamp extinguished. Make its gate go positive, it conducts and will continue to conduct, lighting the lamp, and keeping it lit until the power circuit is broken by S1. I used a push-to-make, push-to-break switch. Potentiometer R4 is used as a sensitivity control. Power is provided by a 9-volt transistor-radio battery.

To get things set-up, connect a high-resistance voltmeter between pin 6 of the IC and ground and set R3 so the slider is near negative and slowly rotate until the rise in voltage at pin 6 triggers the VCR.

I hope this gets me a copy of the Fips book. I've heard a lot about the famous Mohammed Ulysses Fips, and would sure like to read his stories!
—Fred Holland, Laredo, TX

The Fips Book is on the way to you Fred, and I agree. This is exactly the kind of thing our readers want to see.

Miniature BC Receiver. My son's school teacher called me to her classroom one day and I wondered what the kid had been up to now. She explained that during one of her lectures, he seemed very nervous, his leg bouncing rhythmically, and tapping his pencil on the desk. She went over to investigate. Opening her desk drawer to remove this small device with a pair of earphones that she'd confiscated, she said "listen to the earphone." I held it to my ear and heard the latest rock 'n' roll sounds coming out of it.

I thanked her, and took the thing home. Later, after dinner, I confronted my son with it, placing it on the dining room table. "Oh-oh," he said. "You've been to my school." I began with "what's the meaning of this," worked my way up to "Is *this* why we're sending you to school," and finally got around to "where did you get it?" He knocked me over when he told me he built it himself.

I reacted the way you would when a kid comes home with his first black eye.

See Fig. 2. L1 is a ferrite loopstick that also serves as the antenna. It's tuned by variable capacitor C2. Together C1 and C2 serve as bypass capacitors. Resistor R1 (100,000-ohm unit) provides feedback from the output to the input,

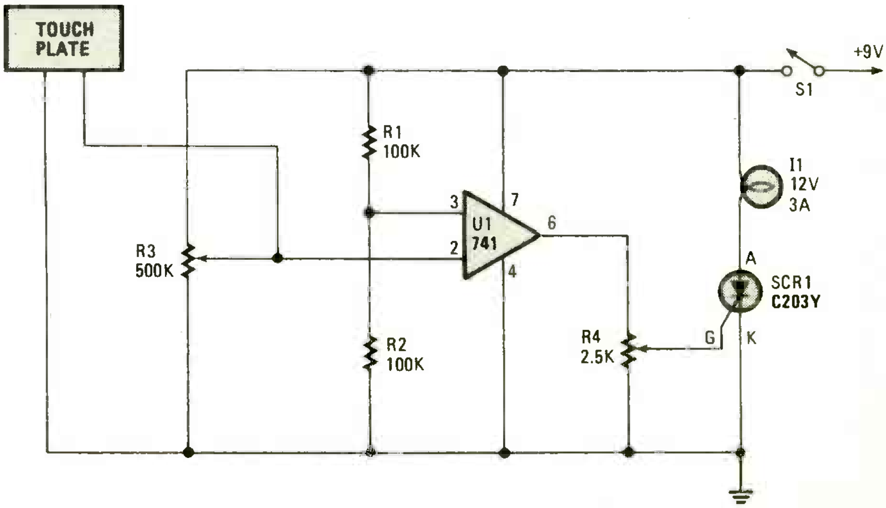


Fig. 1. The input from the touch-plate is fed to the inverting input of U1, which delivers a sufficient current to trigger SCR1.

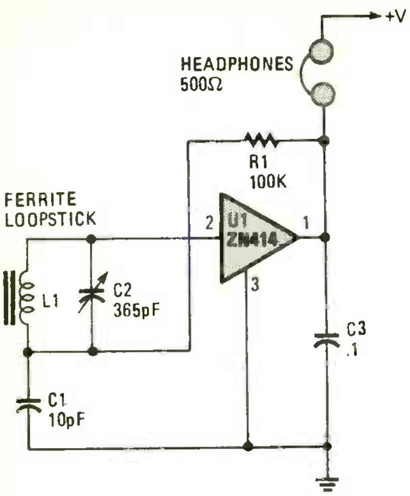


Fig. 2. In this circuit, L1 (a ferrite loopstick) serves as the antenna, which is tuned by variable capacitor C2.

and also takes care of AGC (automatic gain control).

Inductor L1 is capable of tuning the entire AM broadcast band. Use a capacitor salvaged from an old radio. You need 300 to 365 pF. Capacitor C1 is 10 pF and C3 is 0.1 µF.

The phone plug is connected by a jack into the B + circuit, so all you have to do to shut the thing off is pull out the plug. You'll get excellent results with a set of 500-ohm headphones, the battery supply can be 1.3 volts, and you can select any small mercury cell with an output anywhere from 1.2 to 1.6 volts. As the battery decays, sensitivity will fall off.

While I'm still keeping the kid grounded as punishment, I can't help but be proud of him, as I've been a devoted electronics experimenter all my life. If you send me a copy of the Fips book, I may even let him read it!
—Harry Kabel, Flint, MI

Harry, nobody ever told you that parenting was easy. When my own son came home with his first shiner, I commented, "Got into a fight, huh?" "Oh yeah?" he said, "Wait 'til you see what I did to *her*!" Your Fips book is on the way.

Speaker Amplifier. Wherever you've got earphone operation and prefer a loudspeaker, such as with a portable Walkman-type set-up, the circuit in Fig. 3 will do you nicely. Of course, for stereo operation, you're going to need two of them, so consider this when you etch your circuit board. I simply set up two circuits on one board and there doesn't seem to be any problems. I used a single 9-volt transistor-radio battery to power both sides. When you buy the components, get two of everything!

The nice thing about the circuit is that very few external components are required, and the whole thing fits nicely into a handy experimenter's box. Where you have to run the input cables, just make sure you use shielded wire. The amplifier is sensitive enough to pick up all kinds of hum and noise if you don't. The speaker (an 8-ohm unit) can be whatever size you find comfortable. The larger diameters will provide better reproduction, of course. Count on a cabinet for the speaker, or you'll lose volume and some of the low frequencies.

This amplifier provides about a 2-mW output, more than sufficient for most applications.

There's really nothing exotic here, but it is a functional circuit and will provide numerous satisfactory applications with a little experimenting, and that's what we're all about, isn't it? I have already started checking the

mail for my Fips book. Or am I being presumptuous?
—*Fred Cardwell, Omaha, NB*

No Fred, not at all. Keep checking, the book is on the way!

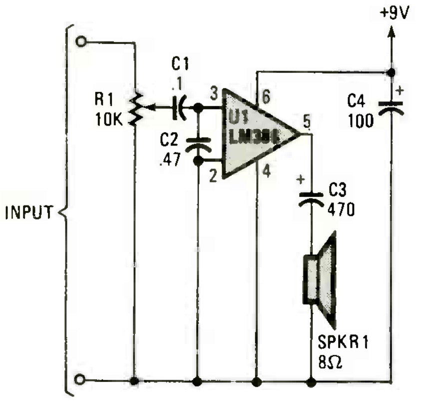


Fig. 3. The Speaker Amplifier is designed to plug into the earphone jack of Walkman-type receivers and provide enough power to drive external speakers.

Solar-Powered Radio. Getting something for nothing is usually as much of a dream as perpetual motion. It just doesn't happen. But getting power from the sun is pretty close, isn't it? You'll notice that this circuit (see Fig. 4) doesn't even have an on-off switch. Why bother? The unit will work in ordinary daylight, or under the light of a bright lamp.

Integrated circuit U1 is a ZN414 with the audio output available at lead 1. Since powerful signals may swamp the transistor, Q1, and potentiometer R2 are used as an audio-gain control. This might be a 500-ohm unit.

Since a ferrite loop is used for L1, some additional gain (or the reduction of additional gain) can be obtained by re-orienting the radio. The output from Q1 (any good audio NPN transistor) is meant for medium- or high-impedance headphones. They'll provide better volume than those dinky little mini-earphones.

Now here comes the best part. The power comes from three series-connected solar cells. Number 276-124 from Radio Shack will do just fine. Capacitor C4 is used to remove hum that might be picked up from the very lamp that's powering your unit.

The solar-powered radio makes for an interesting one-evening project and while I did have to buy the parts that I didn't have on hand, people do get a kick out of the fact that I'm getting "something for nothing." I'd like to take it all a step further by getting a Fips book for nothing too. Any chance?
—*Frank Esposito, Duluth, MN*

Sure thing Frank! Two freebies for one shot. Your book is on the way.

Enlarging Meter. If you do your own photo processing, you know how important an enlarging meter can be. Without one, your work is "by guess and by gosh." Or you go the expensive route, wasting photo paper to make test strips or rushing through the development when you think the print is right. The fact is, that the paper needs full development time to be perfect, and that's why the enlarging meter becomes an essential tool.

This unit (see Fig. 5) uses a light-dependent resistor, mount it in a suitable tube with a small hole at the top for the light to enter. If, after trying it, you decide you need more light on the LDR, you can always enlarge the hole. When not illuminated, the internal resistance of the LDR is very high. With any reasonably-strong light, its resistance drops to a couple of hundred ohms. When the LDR isn't illuminated, it becomes a voltage divider along with R2. Resistor R1 is the other arm of the divider. Pin 3 of the IC takes on a given

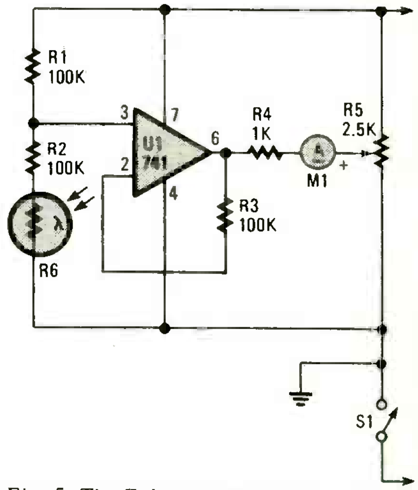


Fig. 5. The Enlarging Meter uses a light-dependent resistor mounted in a tube with a small hole at the end to allow light to enter.

voltage. The output (pin 6) depends on this fact. The output transistors in the IC form one arm of a bridge circuit, with R5 forming the other arm. Set the meter using R5 so you get a balance, and the 1-mA meter shows zero current.

This will happen when the voltage at pin 6 is the same as the wiper arm of R5. When illumination hits the LDR, its resistance falls so the voltage at pin 3 of the IC drops. Pin 6 follows this, producing a reading on the meter. R4 is there just as a current limiter.

You want to get full-scale deflection of the meter at the brightest illumination of the LDR. We tested our unit by putting it under the lens of the enlarger, with no negative in place. After a few sample tests, we worked out a calibration card in *f*-stops for the enlarger diaphragm, at 30 seconds exposure time. Since we've put the unit into service, we've produced better prints

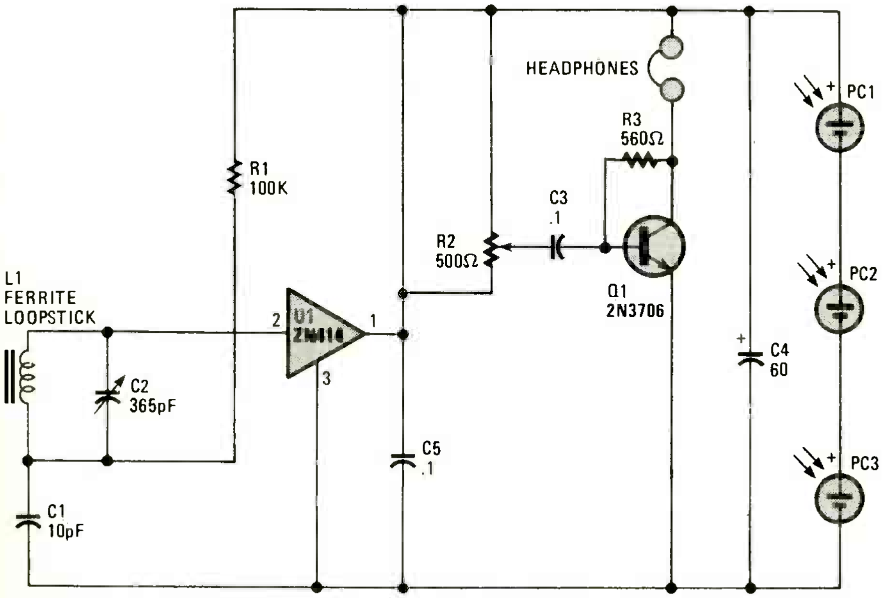


Fig. 4. Powered by sunlight or a bright lamp, the receiver is built around a ZN414.

and saved a lot of valuable enlarging paper. Now does that rate a Fips book?

—*Brian Alexander, Port Washington, NY*

Sure does, Brian! And it's on the way to you. Hope you enjoy it.

Dark Sensor. Let your imagination run riot, and you'll come up with more applications for this circuit than there are components (See Fig. 6). So far, it's been used to automatically turn on a front door or porch light, automatically turn on a night light in a child's room, the list is endless.

What happens, essentially, is that when darkness hits the LDR (light-dependent resistor), the relay operates. If you want the relay to operate a low-voltage device, select a relay with low-voltage contacts. If you want it to operate something heavier, pick one with contacts to handle the voltage (and current) you're planning to use. It's just that simple. Just make sure the relay coil is rated at 150 ohms.

With normal illumination, the LDR's resistance is low. The input at pin 3 of U1 is high, as is the output at pin 6. Transistor Q1 is a PNP transistor, and the collector current is low while you hold the base positive. So only a small amount of current (if any) passes through the relay's coil.

When light to the LDR goes low, its resistance goes up. Pin 3 moves in a negative direction, and the output of U1 at pin 6, supplies base current for Q1 through the 4700-ohm resistor, R4. Collector current goes up, and the relay pulls in. Using a nine-volt transistor-radio battery, "light-sensing" current through the relay is nearly at zero, and it goes up to about 55 mA under dark conditions. Diode D1, a 1N4002 unit, is used as a supressor for any back EMF.

You should be aware that the relay is a single-pole, double-throw type. That means that you can actually reverse the end effects. Wire it up so that light falling on the LDR can close the slave circuit, or open it, depending on which of the relay poles are used. Handy, huh? Did I just buy a Fips book?

—*Randolph Switzer, San Francisco, CA*

Yup Randy! The book is on the way. Hope you enjoy it as much as we enjoyed your circuit.

Rock Mixer. "Hey By," writes a young reader, "my friends and I have a rock

(Continued on page 103)

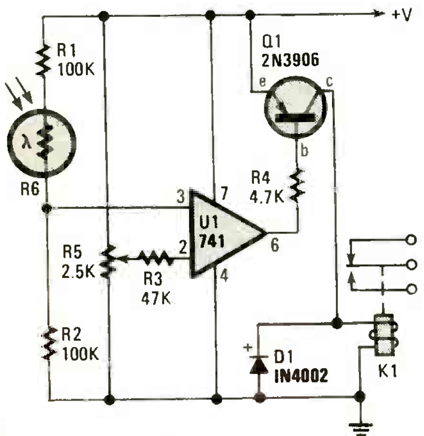


Fig. 6. The Dark Sensor is controlled by an LDR (light-dependant resistor).

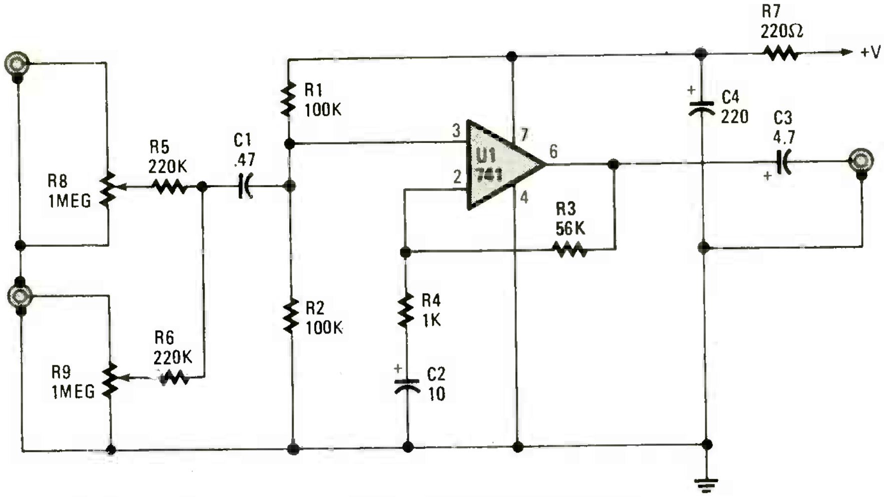


Fig. 7. The Rock Mixer allows one mike to cut while boosting another.

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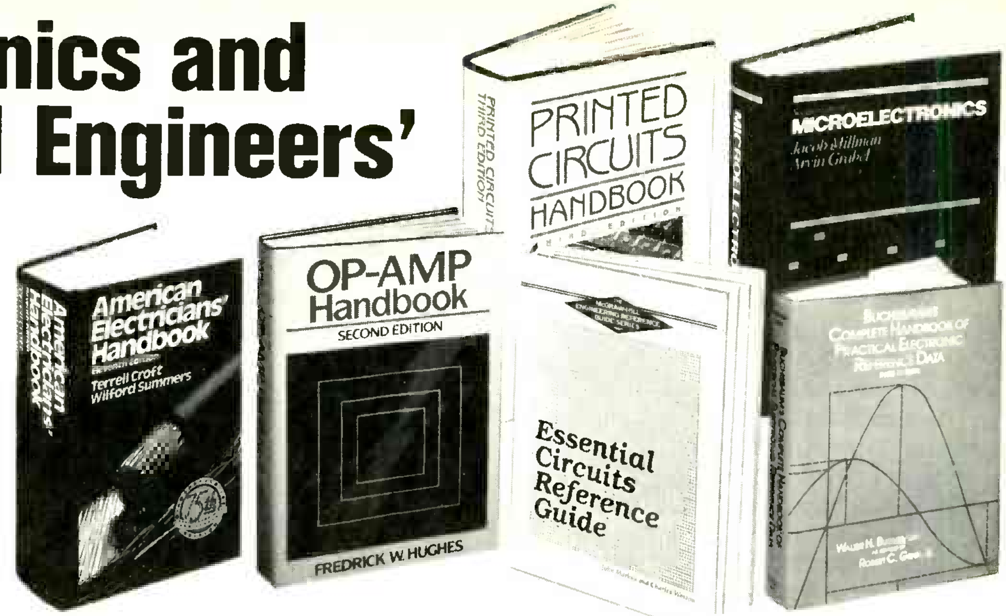

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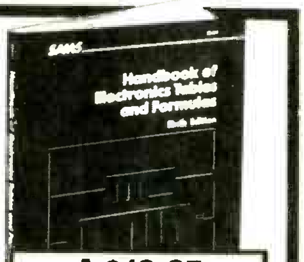

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Build the Lightning Bulb

Create an electrical storm in a light bulb with this easy-to-build project

BY VINNY VOLLONO

Since the dawn of civilization, mankind has been fascinated by lightning. And it was that fascination with lighting and electricity that has brought about many of the high-tech novelty items—like the Tesla Coil, *Eye of the Storm*, Jacob's Ladder, and the Van DeGraph Generator, for example—that are showing up in the market place.

Similar effects can be produced by the *Lightning Bulb*, which creates a stunning display, yet consists of little more than a modified clear incandescent lamp and a high-

(Continued on next page)

voltage power supply. The lamp is modified by taping a piece of aluminum foil to the back half of its glass envelope, forming a sort of make-shift capacitor. The electrode inside the lamp forms one plate of the capacitor, the glass envelope of the lamp serves as the dielectric, and the aluminum foil is used as the second plate.

The aluminum foil, like the negative plate of a polarized electrolytic capacitor, is grounded. A high voltage is discharged into the lamp through its inner electrode, ionizing the thin gas that remains in the envelope, creating a visual effect similar to an electrical storm.

Circuit Description. The Lightning Bulb circuit uses a quadrac (see Fig. 1)—a device that combines a triac and a diac trigger in a single package—to control the supplied current. Figure 1A shows the schematic symbol for the quadrac, while Fig. 1B shows the pinout for the unit used in our circuit. Note that quadracs are becoming increasingly more difficult to come by; if one can not be located, a discrete diac/triac combination of equal or higher rating can be used in its place.

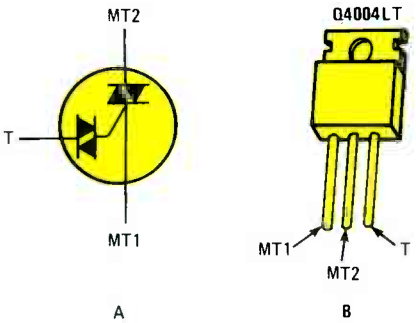

Fig. 1. The Lightning Bulb circuit uses a quadrac—a device that combines a triac and a diac trigger in a single package—to control the input power source. Shown in A is its schematic symbol for the quadrac, while B is the pinout for the unit used in our circuit.

Figure 2 shows a schematic diagram of the Lightning Bulb circuit. The heart of the circuit is a 12-volt automotive ignition coil, T1, which is used to deliver a high-voltage charge of sufficient magnitude to ionize the gases within the glass envelope of lamp I1.

Power for the circuit is taken directly from the AC line and applied through a phase-shift network (consisting of capacitor C1 and resistor R1) to the trigger input (T) of quadrac TR1, causing it to conduct.

With TR1 conducting, a short burst of energy is applied via C2 to the primary winding of T1. (Recall that when power is first applied to a capacitor, the capacitor acts as a short, and then the capacitor begins to charge to the applied voltage.) That burst of energy creates a magnetic field around the primary winding of T1, causing a high voltage to be induced in its secondary.

When capacitor C2 begins to charge to its highest level, the AC signal begins to collapse. As the signal collapses, the current needed to maintain triac conduction dips below the holding level (I_H), the triac turns off, and the second half of the AC signal begins.

As the AC signal becomes more negative, a signal is again applied to the triac's trigger input, causing it to conduct. Triacs conduct during both the positive and negative half cycles of an AC waveform, and can be activated by either a positive or negative trigger source. (For a better understanding of the operation of triacs and other thyristor devices, see *All About Thyristors*, which appeared in the March and April 1988 issues of *Hands-on Electronics.*)

With TR1 now conducting in the opposite direction, the charge on C2 is bled off, via TR1, and a burst of energy (of opposite polarity) is applied to the primary winding of T1, causing a voltage to be induced in its secondary winding. The high-voltage output (about 20,000 volts) at the secondary of T1 is applied to the lamp, I1, creating an electrical storm-like effect.

The value of C2 must be limited to between 2–2.5 µF to prevent damage to ignition coil T1. On the other hand, if the value of C2 is too small, the display will be somewhat insufficiently pronounced. Inductors L1 and L2 were added to block any switching transients from entering the AC line.

Safety First. As shown in the schematic diagram (Fig. 2), you'll be dealing with a high-voltage transformerless power source. Because of the possible safety hazard associated with projects of this type, it is strongly recommended

PARTS LIST FOR THE LIGHTNING BULB

- U1—Q4004 4-amp, 400-volt quadrac, or triac/diac combination (see text)
- C1—0.02-µF metal-film capacitor
- C2—2-µF, 400-WVDC metallized polyester or polycarbonate capacitor
- F1—3-amp 3AG fuse
- I1—G-400 clear incandescent lamp with 5-inch envelope
- L1, L2—10-µH hash choke
- R1—390,000-ohm ½-watt resistor
- S1—single-pole, single-throw toggle switch
- T1—12-volt automotive ignition coil
- Perfboard materials or printed-circuit board, plastic enclosure, 6-inch OD plexiglass tube, 1½-inch OD plexiglass tube, high-voltage cable, fuse holder, aluminum foil, electrical tape, wire, solder, hardware, etc.

Note: The following components are available from Edutronics, Inc., PO Box 2904 Grand Central Station, New York, NY 10163: A kit of parts, containing the lamp, lamp socket, etched and drilled printed-circuit board, and all the necessary components except T1 (the ignition coil) is available for $39.95, plus $3.50 for shipping and handling; high-output ignition coil for $12.00, plus $2.50 S/H; black phenolic plastic project box for $14.00, plus $2.50 S/H. New York State residents, add 8.25% sales tax. Please allow 6–8 weeks for delivery.

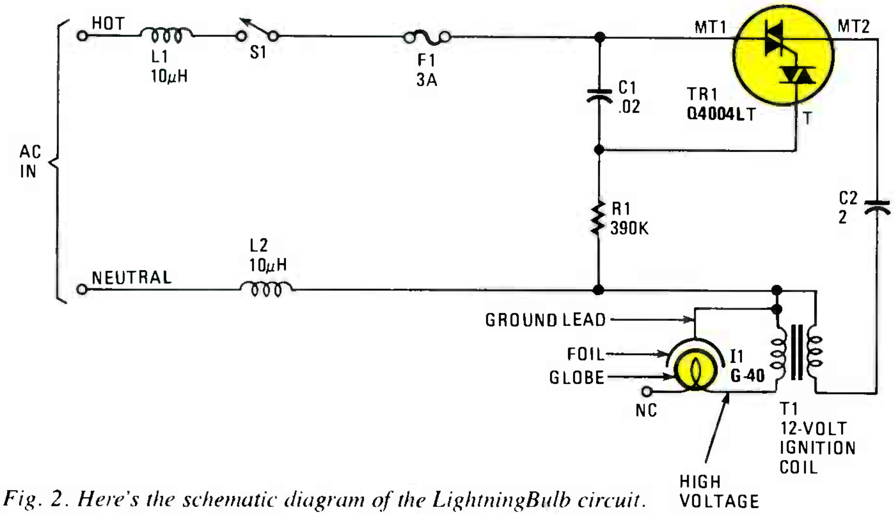

Fig. 2. Here's the schematic diagram of the LightningBulb circuit.

that you use an isolation transformer when testing and troubleshooting the circuit. For an extra margin of safety, always be sure to discharge the capacitors before performing any work on the circuit. A capacitor can store a charge large enough to melt a copper penny.

Caution: In assembling the Lightning Bulb, *do not* omit the protective plexiglass tube that covers the lamp. The clear ⅛-inch thick plexiglass tube helps to prevent an accidental shock. The high voltage can penetrate the glass and you could get a shock or worse. The safety cover is an absolute must.

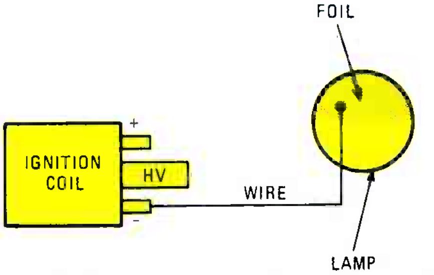

Fig. 3. A wire is connected from the ground lead of T1 to the aluminum foil that's been placed on the glass envelope of the lamp.

Construction. Because of the simplicity of the circuit, the author's prototype was built on a piece of perfboard (measuring about 3 × 4 inches), and the connection between the components were made using point-to-point wiring. Note that for those who wish to use a printed-circuit board, one is offered by the supplier given in the Parts List. However, printed-circuit board construction will not be discussed in this article.

Assemble the circuit board using Fig. 2 as a wiring guide, making the interconnections between the components as the components are installed on the board. Just about any 12-volt automotive ignition coil should do for T1. The .02-µF capacitor specified for C1 can be replaced by two .01-µF units connected in parallel, which is what the author used in his prototype.

When the circuit-board assembly is complete, set it aside for a while and begin modifying the lamp. The lamp used in the author's prototype is a 25-watt designer's bulb with a 5-inch clear-glass envelope. Contrary to common belief, the area within the envelope—particularly where larger envelopes are concerned—is not a total vacuum. Some gas still remains within the envelope even after the evacuation process. Lamps having large envelopes produce a more impressive display because of the higher concentration of gas (in comparison to standard household lamps) within the envelope.

Start the modification process by placing black electrical tape on what will be the back half of the lamp. Place a layer of aluminum foil over the tape and then add a second layer of tape over the aluminum foil to hold it in place. Starting from the outer edges of the foil, apply the tape, working your way inward toward the center. Leave a small portion of the foil exposed so that a wire can be attached. The author used aluminum solder to the attach a lead to the aluminum foil, but gluing or taping should work. Once the wire is attached, it should be connected to the ground terminal of T1 as shown in Fig. 3. Then cover the exposed aluminum and the wire with tape.

The author used a regular plug-in lamp socket to connect the lamp to the high-voltage output of T1. A high-voltage cable is connected across the two contacts of the lamp socket. The type of lead wire used in TV sets to bridge the high-voltage output of the flyback transformer to the anode of the CRT is ideal. Once the wires to the lamp are in place, mount the lamp and socket to their support column. It's a good idea to devise some sort of identification method for the leads; that will cut down on the confusion that may arise during the final electrical-assembly process.

The lamp-support column is a 5- to 6-inch length of plastic tubing with an outside diameter (OD) of 1½ inches. After threading the wires from the lamp-and-socket assembly through the tube, secure the lamp-and-socket assembly to the tube with glue or epoxy. (See Fig. 4.) Once the glue has dried, re-enforce the assembly where the lamp-and-socket assembly meets the support column with one or two wraps of tape.

The support-column assembly is then secured to the project box with glue, or is held in place with screws and "L" brackets. The two leads from the lamp are then connected to the circuit-board mounted components.

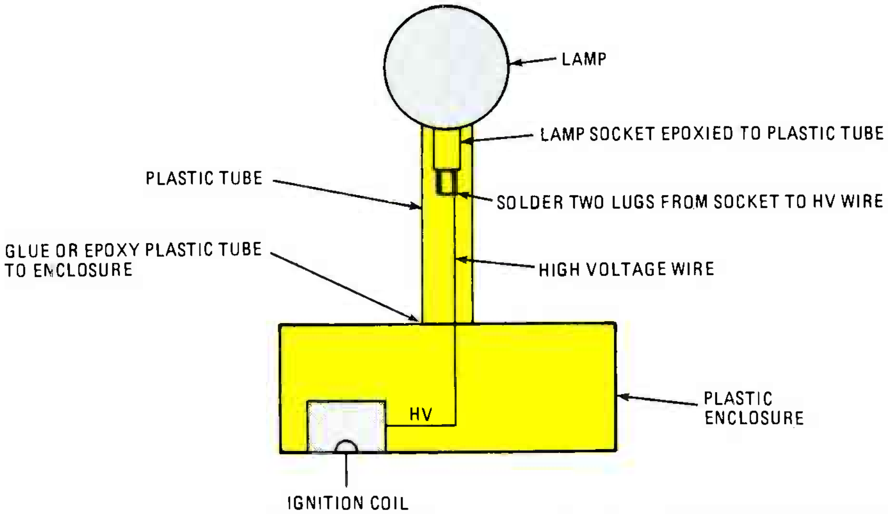

Fig. 4. Mount the lamp-and-socket assembly to its support column, and then mount the entire assembly on the project's plastic enclosure.

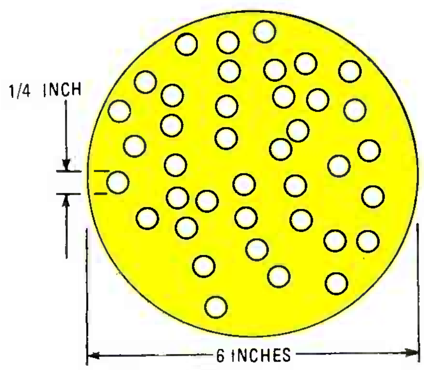

Fig. 5. A 6-inch diameter lid is fashioned from a piece of clear plexiglass. Quarter-inch holes are then drilled into the lid to help ventilate the lamp.

The "hot" side of T1's secondary is connected to the bridged lamp-socket terminals (as shown in Fig. 4), and the negative side is connected to the lead coming from the aluminum plate on the lamp. Feed a line cord through the enclosure wall to the circuit board. Connect one lead from the line cord directly to the circuit board. The other lead is then connected through S1 to the circuit board.

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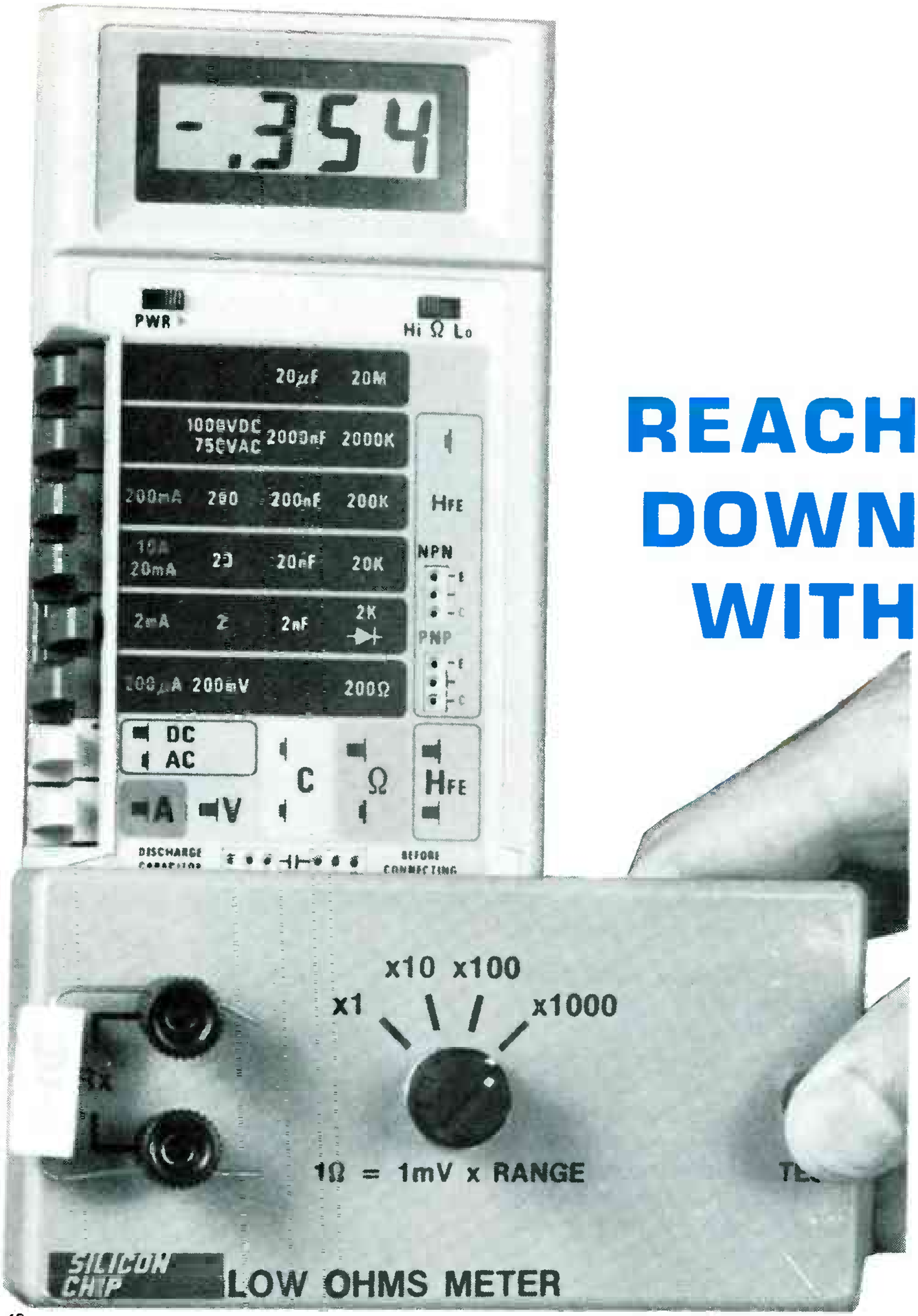

REACH DOWN WITH

Low-Ohms Adapter

Accurately measure resistances down to 0.01 ohm with this low-cost plug-in adapter. You can use it with any common DMM.

BY JOHN CLARKE

Most digital multimeters can accurately measure resistance values down to only about five ohms. Below that value, you quickly run into DMM- (digital multimeter) resolution problems and readings that are *nonsense*.

Let's see what we mean by nonsense. Normally, when measuring 0.1-ohm on a 3½-digit multimeter, you would have to switch to the meter's lowest range (typically the 200-ohm range). For most conventional DMM's, the resolution specification is given as ±1 digit. In other words, if the display reads 0.1 ohm, the actual value can range from 0 to 0.3 ohm. That translates to an accuracy of ±100%, which is not too useful for most applications.

Similarly, if you measure a 1-ohm resistor on the 200-ohm range of a DMM, the best you can expect is a reading of 1.0 ±1 digit; in other words, the best accuracy is ±10%. So meter resolution drastically reduces the accuracy of the measurement, even though most DMM's are accurate to within ±1% when measuring values at the top of their respective ranges.

But there are many situations where accurate low-ohm resistance measurements are necessary. Those include checking meter shunts, designing loudspeaker crossover networks and amplifier output stages, and servicing power supplies or any other circuitry where low-value resistors are used.

The Low-Ohms Adapter* overcomes the resolution limitations of conventional digital multimeters. It plugs straight into the terminals of your DMM and can accurately measure resistance values from 1000 ohms down to 0.01 ohm. The Low-Ohms Adapter has its limitations, however. Below 0.01 ohm, errors due to contact resistance in the test terminals and the ohmic resistance of connecting wires start to become significant. At the other end of the scale, readings above 1000 ohms are inaccurate due to limitations in the unit's constant-current source. In any case, digital multimeters by themselves are more than adequate to accurately measure resistance values above 100 ohms.

*This story first appeared in *Silicon Chip*, Australia (February 1988); reprinted with permission.

All the circuitry for the Low-Ohms Adapter is housed in a small plastic case. On the case's front panel are two multi-way binding-post terminals to which the resistor to be measured (R_X) is connected. There is also a rotary four-position range switch (×1, ×10, ×100, and ×1000) and a pushbutton TEST switch.

Two banana plugs protrude perpendicularly from the rear of the case; they are spaced to allow the Low-Ohms Adapter to plug into virtually any service or lab-type digital multimeter made. That spacing, by the way, is precisely ¾-inch between banana-plug centers.

The output from the Low-Ohms Adapter is a voltage that is directly proportional to the resistance being measured. In practice, the unit is calibrated so that 1 ohm gives an output of 1 millivolt times the range-switch setting. For example, on the ×1000 range, 1 ohm is equivalent to 1 mV × 1000 = 1 volt. On the ×10 range, 1 ohm is equivalent to 10 mV, and so on.

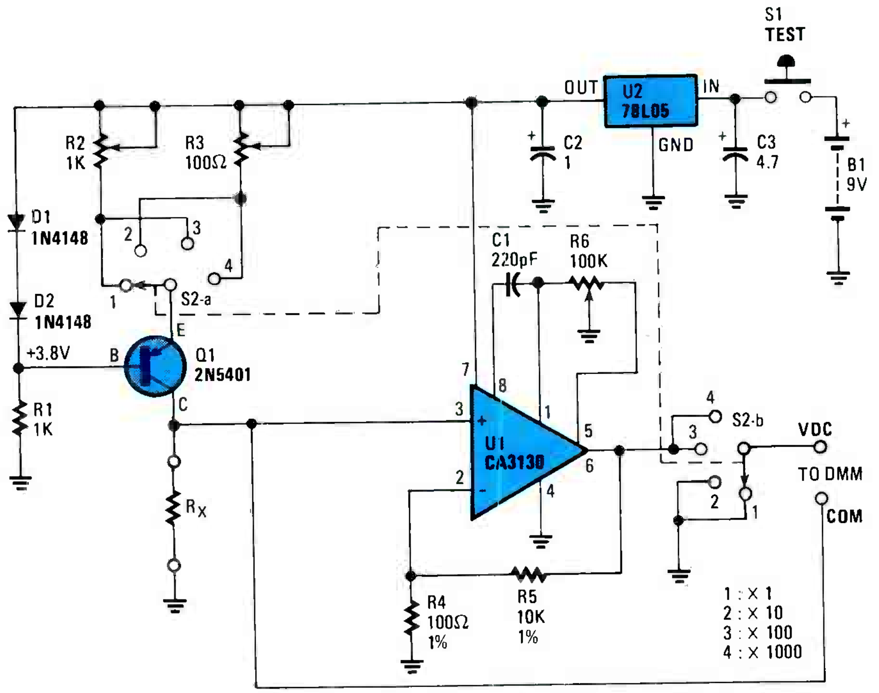

Fig. 1. The circuit consists of a 5-volt DC regulator (U2), a constant-current source (D1, D2, and Q1), and an op-amp voltage-gain stage (U1).

Inside the Circuit. The Low-Ohms Adapter circuit (see Fig. 1) consists of a 5-volt regulator, a constant-current source (D1, D2, and Q1), and an op-amp gain stage (U1).

Power for the circuit is provided by a 9-volt transistor-radio battery whose output is regulated to +5 volts (DC) by the 3-terminal regulator. That circuit provides a stable power supply for the constant current source and the op-amp. The battery is connected to the balance of the circuit only when test-switch S1 is closed, so current is drawn from the battery only while a measurement is being made, prolonging battery life.

Diodes D1 and D2, transistor Q1, and 1000-ohm resistor R1 make up the constant-current source. Transistor Q1 is connected in an emitter-follower configuration. It reproduces the voltage fed to its base at its emitter, minus the 0.6-volt base-emitter voltage drop. Series diodes D1 and D2 keep the base of Q1 at a constant 1.2 volts below the +5-volt DC supply line. That means that the emitter of Q1 is always 0.6 volt below the +5-volt line. Resistor R1 sets the current through both diodes D1 and D2 to 5 mA.

The resulting 0.6-volt DC across one of the multi-turn trimmer potentiometers, R2 or R3, as selected by switch section S2-a, sets the current through Q1 and the resistor under test, R_X. When R2 is selected, the test current is 1 mA; when R3 is selected, the test current is 10 mA.

On the lower two ranges (×1 and ×10), the voltage across the resistance under test, R_X, is applied directly to the DMM terminals via the banana plugs. On the upper two ranges, the op-amp gain stage (U1) is switched into the circuit and the DMM measures the voltage between the op-amp output (pin 6) and the test resistor, R_X.

The chip, U1, is connected as a non-inverting op-amp stage with a fixed gain of 1 + 10,000/100 = 101. Because we want a gain of precisely 100, we measure the voltage between the output of the op-amp and the voltage across R_X.

Therefore, when switch S2 is in position 3 (×100), the current set by the constant-current source is 1 mA; the multiplying factor for R_X is ×100. When S2 is in position 4 (×1000), the current is 10 mA and the multiplying factor is 100 × 10 = 1000.

Multi-turn trimmer-potentiometer R6 adjusts the offset of the op-amp so that, with no voltage across R_X (ie, with the measurement terminals short circuited), the output is zero.

Construction Considerations. Assembly of the Low-Ohms Adapter is fairly simple. Most of the parts, including rotary-switch S2, are mounted on a small (2⅜- × 3¾-inch) printed-circuit board. The board is small enough to fit into a plastic project box, preferably one with a plastic lid. A little of epoxy or RTV cement can be used to secure the board inside the box.

Of course, printed-circuit construction is not absolutely necessary. You could place the circuit parts on a perfboard and use point-to-point wiring, for instance. However, for the purposes of the discussion that follows, we will assume that you will go the printed-circuit route.

The printed-circuit board can be made in an evening. Copy the foil pattern from the same-size diagram in Fig. 2. A word of caution: The rotary range switch, S2, that you obtain may differ slightly from that used in the prototype. If so you will need to modify that part of the pattern. That can be done using etch-resist ink or rub-on patterns. Check the switch and foil-pattern layout and make any required modifications before you proceed.

Heat up the Iron. Begin construction by installing all the parts on the printed-circuit board, using Fig. 3 as a guide. Make sure that you don't confuse the transistor and the low-power 3-terminal regulator as they are housed in similar-type dark-plastic packages. Check the orientation of U1 before soldering it to the board. The notched end, adjacent to pin 1, goes towards the center of the board.

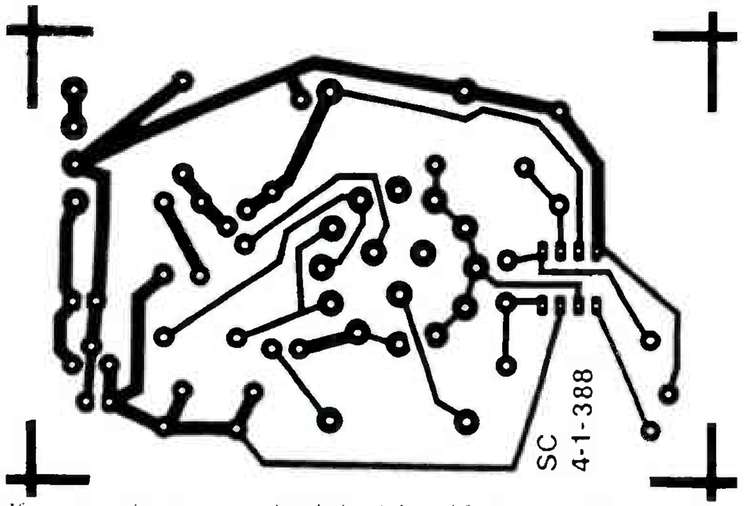

Fig. 2. If you are going to use a printed-circuit board for the Low-Ohms Adapter, as recommended, here is an appropriate full-size foil pattern.

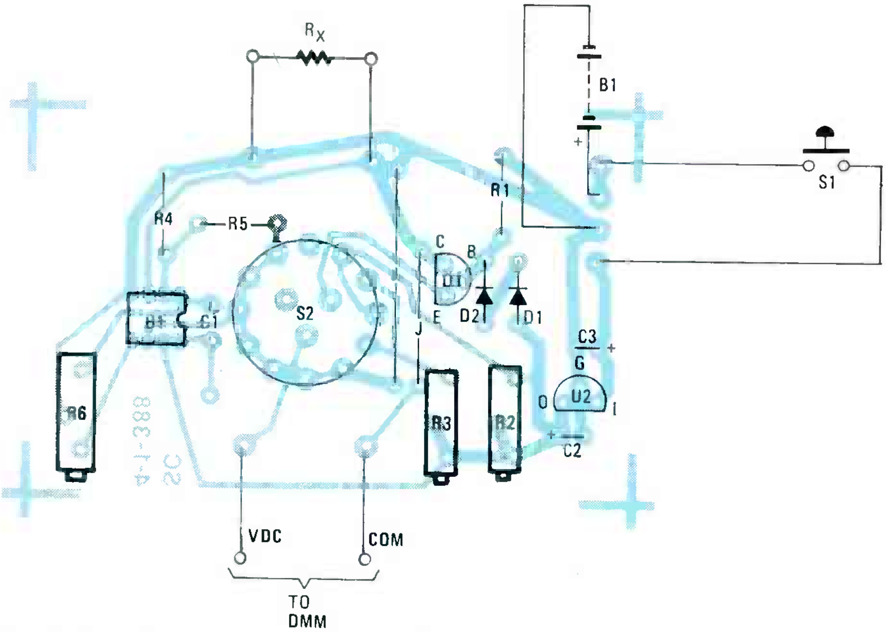

Fig. 3. Mount the components on the printed-circuit board using this parts-placement guide. Trim the shaft of switch S2 to a length of 3/8-in. before soldering it to the board, and don't forget the two wire jumpers on the board.

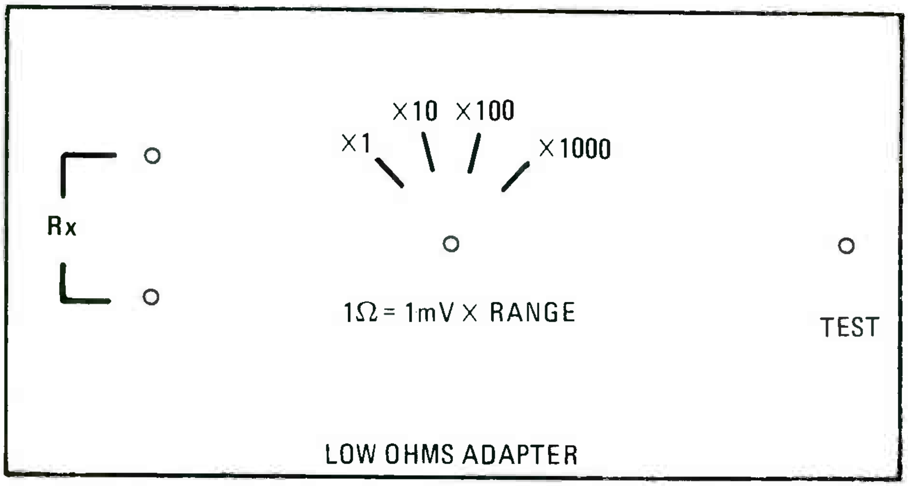

Fig. 4. This front-panel artwork can be used as a drilling template for the front panel provided the printed-circuit board and cabinet are of the sizes specified. If not, a little more layout designing will be required on your part.

PARTS LIST FOR LOW-OHMS ADAPTER

SEMICONDUCTORS

D1, D2—1N4148 or 1N914 silicon diode
Q1—2N5401, ECG-158, TCG-159, SK3118, or equivalent PNP transistor
U1—CA3130 op-amp, integrated circuit
U2—78L05 low-power 5-volt regulator

RESISTORS

R1—1000-ohm, ¼-watt, 5%
R2—1000-ohm, multi-turn, trimmer potentiometer
R3—100-ohm, multi-turn, trimmer potentiometer
R4—100-ohm, ¼-watt, 1%
R5—10,000-ohm, ¼-watt, 1%
R6—100,000-ohm, multi-turn, trimmer potentiometer

CAPACITORS

C1—220-pF, 16-WVDC, polystyrene capacitor
C2—1-µF, 16-WVDC electrolytic, PC mount
C3—4.7-µF, 16-WVDC, electrolytic, PC mount

ADDITIONAL PARTS AND MATERIALS

B1—9-volt DC transistor-radio battery (Eveready 215 or equivalent)
S1—Momentary pushbutton switch, normally open
S2—3-pole, 4-position rotary switch
Printed-circuit board materials; 5⅛- × 2⅝- × 1¾-in. or larger plastic case and cover; (2) multi-way binding posts; (2) bannana plugs; 9-volt battery clip; knob for S2; hookup wire; solder; tinned copper wire (for jumpers); hardware; plastic foam; cement; etc.

Carefully check the orientation of the diodes, electrolytic capacitors, transistor, and 3-terminal regulator before soldering them to the printed-circuit board. Trim the switch shaft to a length of ⅜-inch before soldering rotary-switch S2 directly to the printed-circuit board. Don't forget to mount and solder the two wire jumpers on the board.

Next, make the case for the project. Figure 4 shows a suggested layout for the front panel and can be used as a full-size template. Begin by applying the identifying labels for the range (S2) and test (S1) switches, and for the resistor-under-test (R_X) binding posts; use dry-transfer (rub-on) lettering for that. Drill the mounting holes for those components and ream them to size. Finish up the front panel by mounting the switches and binding posts and wiring them to the circuit board.

(Continued on page 98)

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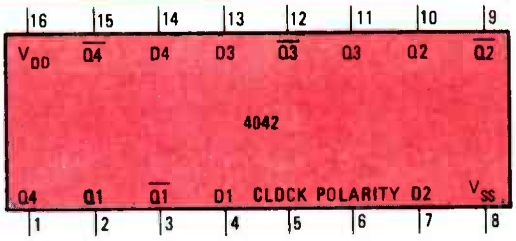
97 Popular Electronics FactCard — 4042: Quad Clocked D Latch



CLOCK	POLARITY	Q
0	0	D
⎍ (rising)	0	LATCH
1	1	D
⎍ (falling)	1	LATCH

GENERAL DESCRIPTION

The CD4042BM/CD4042BC quad clocked "D" latch is a monolithic complementary MOS (CMOS) integrated circuit constructed with P- and N-channel enhancement mode transistors. The outputs Q and $\overline{Q}$ either latch or follow the data input depending on the clock level which is programmed by the polarity input. For polarity = 0; the information present at the data input is transferred to Q and $\overline{Q}$ during 0 clock level; and for polarity = 1, the transfer occurs (positive for polarity = 0 and negtive for polarity = 1), the information present at the input during the clock transition is retained at the outputs until an opposite clock transition occurs.

ABSOLUTE MAXIMUM RATINGS

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

RECOMMENDED OPERATING CONDITIONS

V_{DD} Supply Voltage	3V to 15V
V_{IN} Input Voltage	0V to V_{DD}
T_A Operating Temperature Range	
CD4042BM	−65°C to +125°C
CD4042BC	−40°C to +85°C

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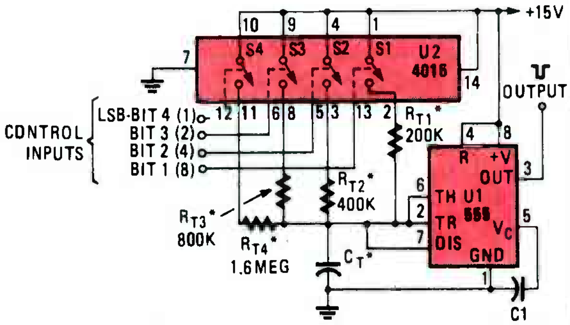
98 Popular Electronics FactCard — Application Circuits

PROGRAMMABLE-FREQUENCY ASTABLE CIRCUIT



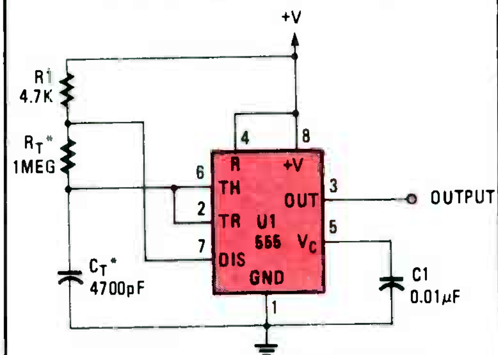
$*f_0 \cong n\left(\frac{1.44}{R_T C_T}\right)$

WHERE,

n is DIGITAL INPUT WORD: $1 \leq n \leq 15$

(AS SHOWN, WITH BASE R_T OF 1.6 MEG, 100 Hz $\leq f_0$ 1500 Hz).

BASIC SQUARE-WAVE ASTABLE CIRCUIT



*WITH $R1 < R_T$

$T = 1.368 R_T C_T$

$f_0 = \frac{0.722}{R_T C_T}$

(AS SHOWN, $f_0 \cong$ 150 Hz)

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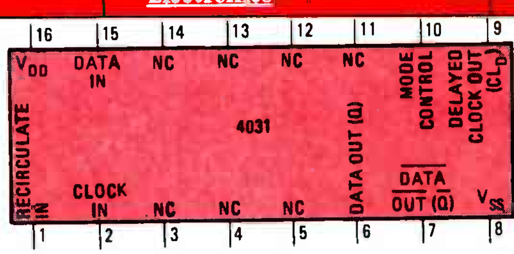
99 Popular Electronics FactCard — 4031: 64-Stage Static Shift Register



ABSOLUTE MAXIMUM RATINGS

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

RECOMMENDED OPERATING CONDITIONS

V_{DD} Supply Voltage	+3V to +15V
V_{IN} Input Voltage	0V to V_{DD}
T_A Operating Temperature Range	
CD4031BM	−55°C to +125°C
CD45031BC	−40°C to +85°C

GENERAL DESCRIPTION

The CD4031BM/CD4031BC is an integrated, complementary MOS (CMOS), 64-stage, fully static shift register. Two data inputs, DATA IN and RECIRCULATE IN, and a MODE CONTROL input are provided. Data at the DATA input (when MODE CONTROL is low) or data at the RECIRCULATE input (when MODE CONTROL is high), whichmeets the setup and hold time requirements, is entered into the first stage of the register and is shifted one stage at each positive transition of the CLOCK.

FEATURES

- Wide supply voltage range — 3.0V to 15V
- High noise immunity — 0.45V_{DD} (typ.)
- Low power TTL compatibility — fan out of 2 drivng 74L or 1 driving 72LS
- Fully static operation — DC to 8MHz V_{DD} = 10V (typ.)
- Fully buffered clock input — 5pF (typ.) Input capacitance
- Single phase clocking requirements
- Delayed clock output for reduced clock drive requirements
- Fully buffered outputs
- High current sinking capability Q output — 1.6mA @V_{DD} = 5V and 25°C

97 Popular Electronics FactCard 4042: Quad Clocked D Latch

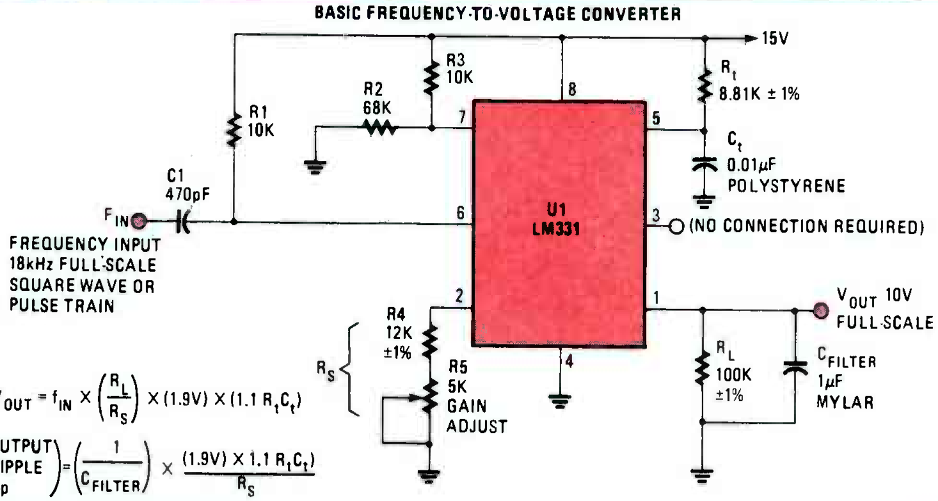
STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at +25°C (TYP)	UNITS
Quiescent	—	0,5	5	0.02	
Device	—	0,10	10	0.02	µA
Current,	—	0,15	15	0.02	
I_{DD} Max	—	0,20	20	0.04	
Output Low	0.4	0,5	5	1	
(Sink) Current	0.5	0,10	10	2.6	
I_{OL} Min.	1.5	0,15	15	6.8	
Output High	4.6	0,5	5	1	mA
(Source)	2.5	0,5	5	−3.2	
Current	9.5	0,10	10	−2.6	
I_{OH} Min.	13.5	0,15	15	−6.8	
Input Current I_{IN} Max.	—	0,18	18	$\pm 10^{-5}$	µA

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

98 Popular Electronics FactCard Application Circuits

BASIC FREQUENCY-TO-VOLTAGE CONVERTER



$$V_{OUT} = f_{IN} \times \left(\frac{R_L}{R_S}\right) \times (1.9V) \times (1.1\, R_tC_t)$$

$$\begin{pmatrix}\text{OUTPUT}\\ \text{RIPPLE}\\ \text{p-p}\end{pmatrix} = \left(\frac{1}{C_{FILTER}}\right) \times \frac{(1.9V) \times 1.1\, R_tC_t}{R_S}$$

99 Popular Electronics FactCard 4031: 64-Stage Static Shift Register

STATIC ELECTRICAL CHARACTERISTICS

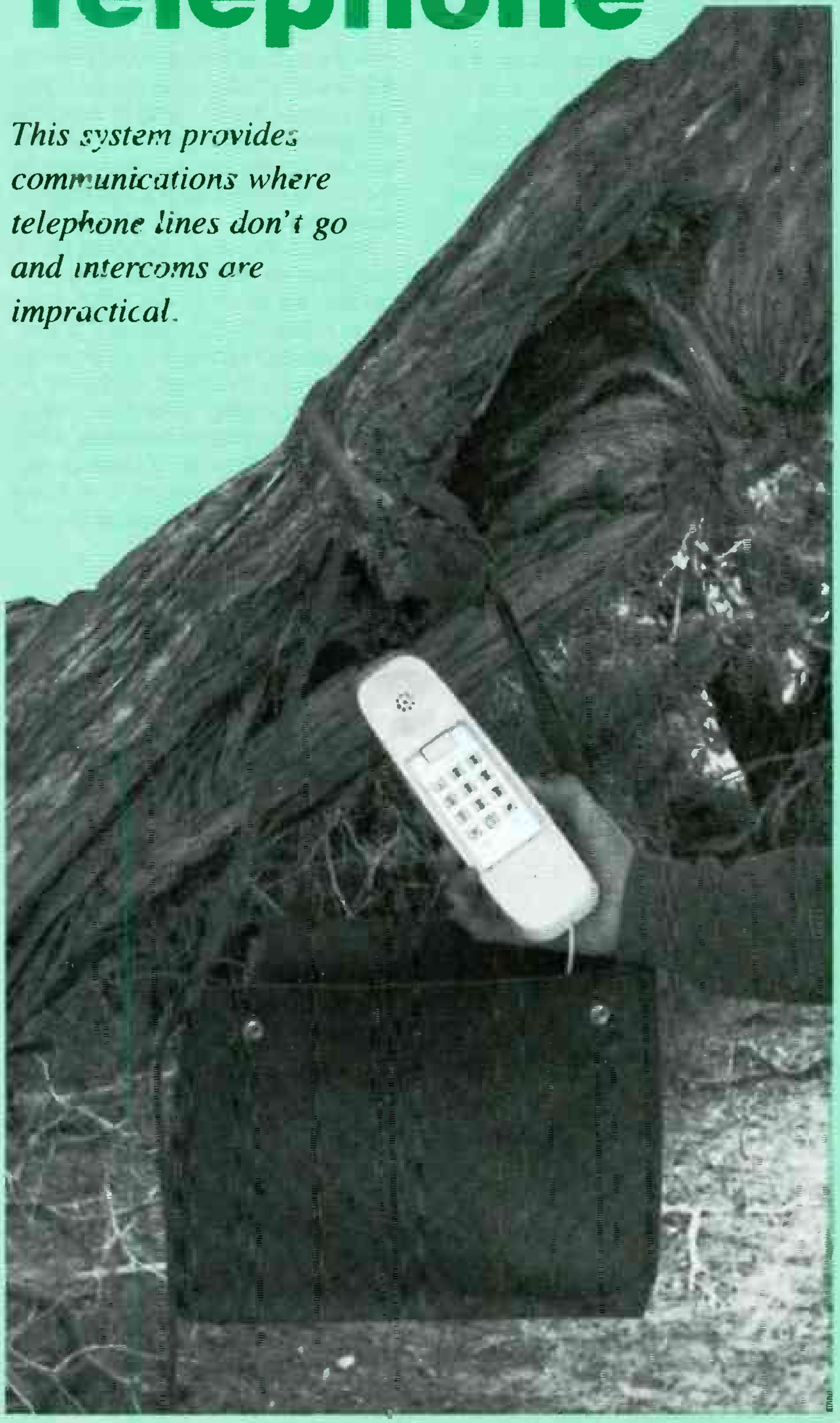
CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at +25°C (TYP)	UNITS
Quiescent	—	0,5	5	0.04	
Device	—	0,10	10	0.04	µA
Current,	—	0,15	15	0.04	
I_{DD} Max	—	0,20	20	0.08	
Output Low (Sink)	0.4	0,5	5	4	
Current I_{OL} Min.	0.5	0,10	10	10.4	
Q	1.5	0,15	15	27.2	
	0.4	0,5	5	1	
$\bar{Q}$, Q	0.5	0,10	10	2.6	
	1.5	0,15	15	6.8	mA
	0.4	0,5	5	1	
CL_D	0.5	0,10	10	2.6	
	1.5	0,15	15	6.8	
Output High	4.6	0,5	5	−1	
(Source) Current	2.5	0,5	5	−3.2	

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at +25°C (TYP)	UNITS
I_{OH} Min.	9.5	0,10	10	−2.6	mA
Q, $\bar{Q}$, Q, CL_D	13.5	0,15	15	−6.8	
Output Voltage	—	0,5	5	0	
Low-Level	—	0,10	10	0	
V_{OL} Max.	—	0,15	15	0	V
Output Voltage	—	0,5	5	5	
High-Level,	—	0,10	10	10	
V_{OH} Min.	—	0,15	15	15	
Input Low	0.5,4.5	—	5	—	
Voltage	1,9	—	10	—	
V_{IL} Max.	1.5,13.5	—	15	—	V
Input High	0.5,4.5	—	5	—	
Voltage	1,9	—	10	—	
V_{IH} Min.	1.5,13.5	—	15	—	
Input Current I_{IN} Max.	—	0,18	18	$\pm 10^{-5}$	µA

Build a DTMF Field Telephone

BY SAM ALLEN

This system provides communications where telephone lines don't go and intercoms are impractical.



A field phone is a handy way to communicate between tents at a scout camp, on a construction site, or anywhere else where a portable communications system is needed. Military field phones have been used in such applications for years, but standard field phones—which use a magneto ringing system—are getting hard to find.

Furthermore, a standard field-phone set up requires that a crank be turned to generate a voltage, which then causes all phones that are connected in the line to ring. That means that a field phone is unsuitable for any application where selective signaling is required. An intercom would allow selective signaling, but intercoms are unsuitable where long wire runs are required.

However, by combining a standard tone phone with a DTMF (dual-tone multi-frequency) decoder, the *DTMF Field Phone* described in this article overcomes both of those problems. Each station consists of a standard tone phone, which generates the encoded signal that's decoded by the other stations, and a DTMF decoder that's wired to respond to a particular number from 0–9, plus asterisk (*) and pound (#). The system also has one master station that contains the power source.

The system can have up to 10 stations, each responding only to its own call number. If more stations are needed, some call numbers can be duplicated; in which case, all stations with like numbers would ring simultaneously.

For special situations, emergencies for example, all decoders in the system can be wired to respond to the asterisk key (*). Or the pound key (#) can be used to signal a selected group of stations. Call-only stations—phones with no decoder—can also be added.

System Configuration. Figure 1 shows a block diagram of the DTMF Field Phone system. The system is powered by a 6-volt battery (located

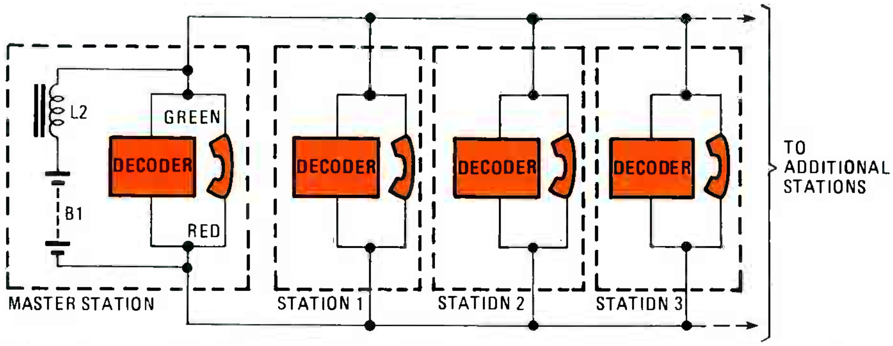


Fig. 1. Here is a block diagram of the field phone system, which is powered by a single battery that is located at the master station.

in the master station). In operation, the battery appears as a dead short to audio frequencies. Because of that, a choke is used to isolate the power source from the audio signal. Without the choke, the audio signal would not be audible at any of the other stations. In this project, an easy-to-find 24-volt transformer is used for the choke (L2).

The DTMF Field Phone takes advantage of the encoding circuits within the standard tone phone. For each key pressed on the tone phone, a tone pair is generated (see Fig. 2). A tone pair consists of a tone from a low frequency group and another from a high frequency group. The low frequencies represent the rows while the high frequencies represent the columns.

The tone pair generated by the tone phone is fed down the line and picked up by the other stations. Each station in the system is assigned one of the standard tone pairs. The DTMF decoder located at each station decodes the signal and activates a buzzer when its assigned tone pair is detected. While all other tone pairs are not exactly ignored (all tone pairs are decoded), only the outputs that are connected to the buzzer produce an audio signal. The advantage of using a separate decoder for each station is that the station can be located anywhere on the line and still respond only to its assigned number.

Figure 3 shows a functional block diagram of the SSI-202 tone decoder—the heart of the DTMF Field Phone. The SSI-202 contains a preprocessor (consisting of a 60-Hz reject circuit and a preamp), band-split filters, zero-crossing detectors, band-pass filters, amplitude detectors, a timing circuit, a flip-flop, a clock generator, a power regulator, a voltage reference, an output decoder, and an output register.

Circuit Operation. Figure 4 shows the schematic diagram of the DTMF Field Phone's decoder circuit. Power for the circuit is taken from the line. A metal-oxide varistor, MOV1, provides transient suppression to prevent damage to the IC's. (Long wire runs are prone to induced voltage spikes during electrical storms.)

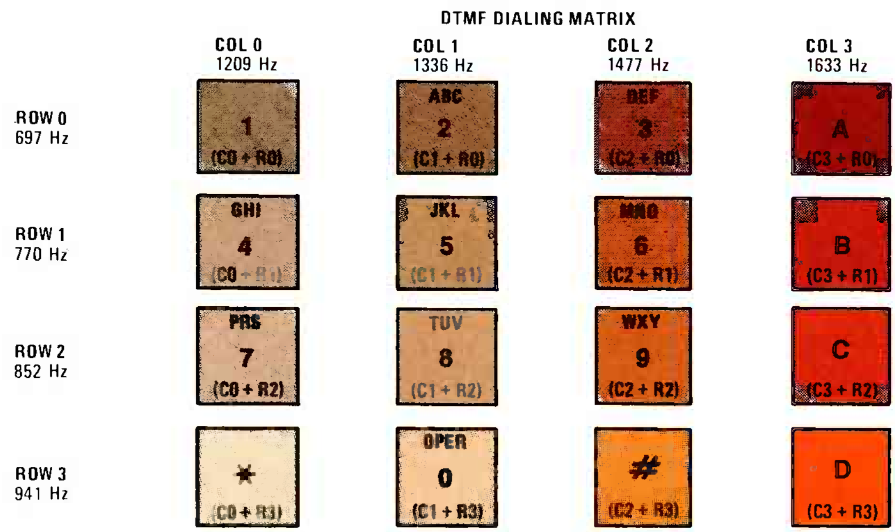
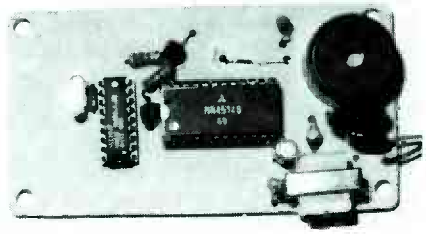


Fig. 2. This is the standard keypad layout for a DTMF phone. Low frequencies are assigned to rows and high frequencies are assigned to columns.

The input of U1 is coupled through C1 to the line (which also carries power for the circuit). Diode D1 provides some measure of protection to the IC's in the event that the circuit is wired into the line with its polarity reversed.

Choke L1 and capacitor C3 isolate the integrated circuits from the audio signal, while passing the DC component of the available signal to power the IC's. The color-burst crystal (XTAL1), connected across pins 11 and 12 of U1, provides a frequency reference for U1's internal clock generator.



This is the completed circuit board showing the parts layout.

Signals input to decoder U1 are first routed to the preprocessor, which removes extraneous noise, and are then fed to the band-split filters, where they are separated into two distinct tones. The tones are then identified by a band-pass filter.

From there, the two signals are input to both the timing and decoding circuits. The decoder circuits, in turn, output the 4-bit representation of that tone pair. After processing by U1, the 4-bit tone-pair information is input to U2 (a 4- to 16-line decoder). Transistor Q1, acting as an inverter, enables U2 when a valid tone pair is detected. When a number is decoded, one of the 16 outputs of U2 goes high.

A piezo buzzer, BZ1, (see Fig. 5A) is connected to the assigned number output of U2 and the other end of the buzzer is connected to the circuit ground. (The buzzer can also be connected to the * output on all stations so that pressing * key signals all stations at once. Selected stations can be wired to respond to the # key.)

The DTMF Field Phone can provide reliable communication in remote locations.

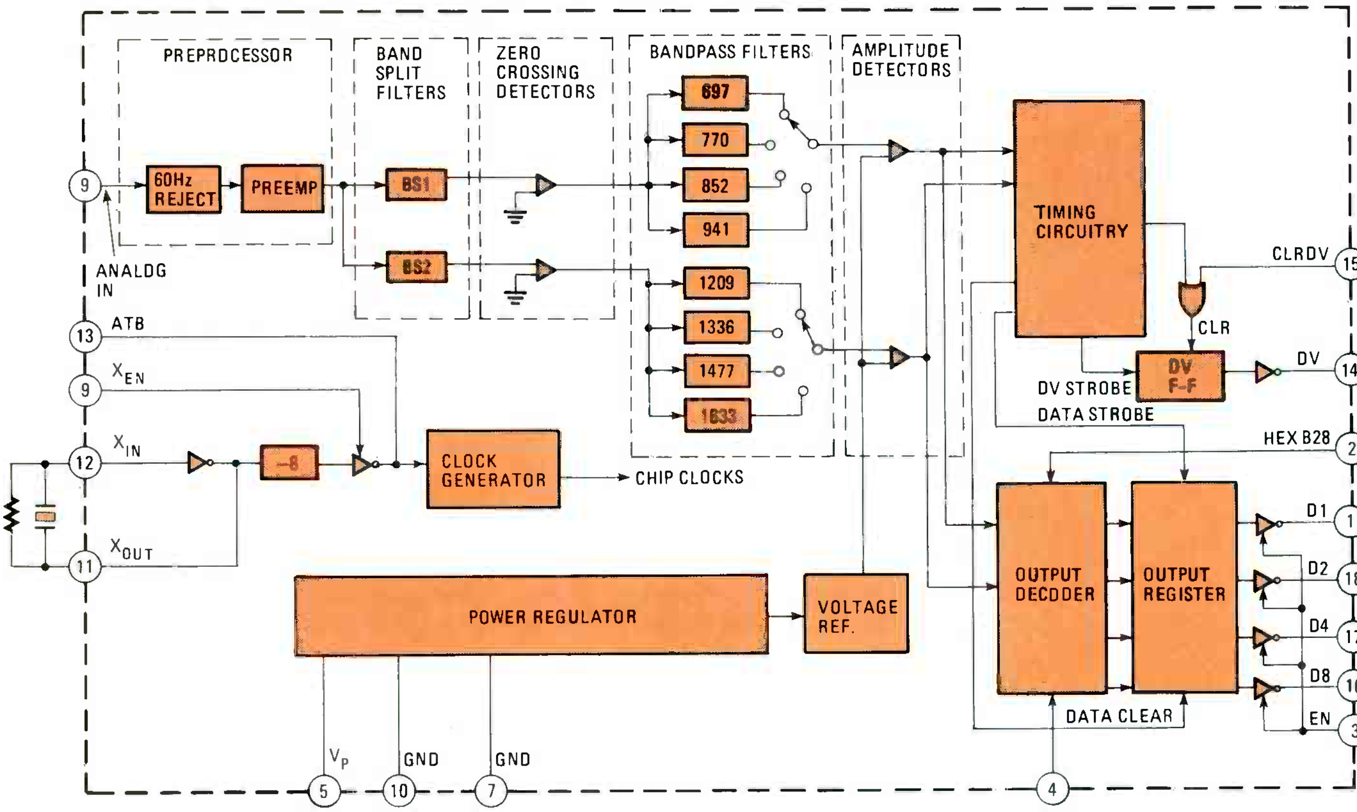


Fig. 3. This is a functional block diagram of the SSI-202 DTMF (dual-tone multi-frequency) decoder, which is the heart of the DTMF Field Phone circuit.

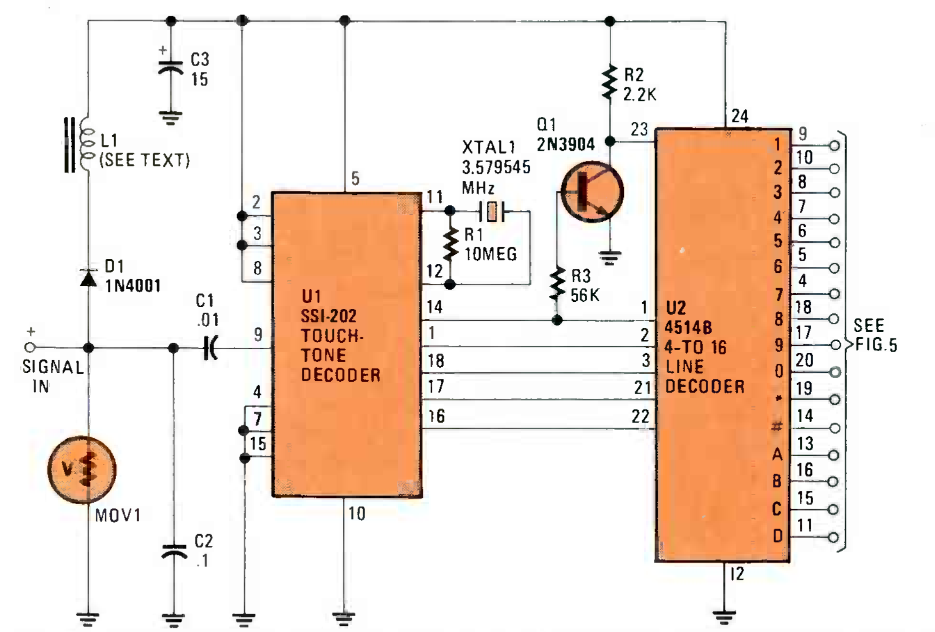


Fig. 4. The DTMF tone decoder (U1), which feeds a 4-bit signal to U2 (a 4- to 16-line decoder).

When multiple outputs (the assigned number, *, and #, for example) are connected to the buzzer, diodes (D2, D3, and D4 in Fig. 5A) are used to isolate the outputs from each other. When only one output is used, no diode is necessary. All unused outputs are routed to ground through R4 or R5 (see Fig. 5B), depending on which side of U2 that output is located.

Construction. Begin construction by making as many decoder circuits as needed for the system. Here's where printed-circuit construction really pays off. Since you will be building several decoders, you can mass produce the boards using one of the many photo-etching techniques. Figure 6 is the printed-circuit artwork used by the author to produce his prototype.

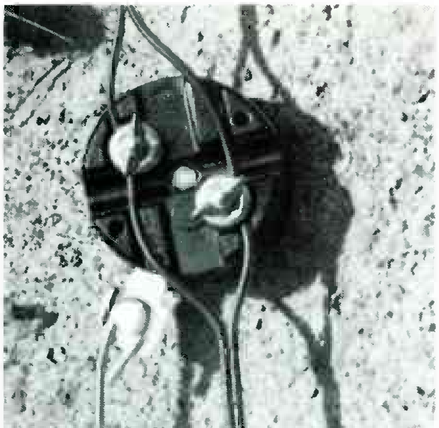
The circuit board is designed to be easily adaptable to any *available* output: Simply cut the appropriate trace on the printed-circuit board.

Note that in Fig. 7, the parts placement diagram, diodes D2, D3, and D4 are shown installed, although they are *only* necessary for multiple output configurations. To configure the decoder circuit for a particular output, cut the trace so that it is separated from R4 or R5, while making sure that the diode is not cut off from the rest of the circuit.

For instance, Fig. 7 shows a multiple output configuration, using outputs *, #, and 8. To configure a station to respond to those signals, cut the traces at a point below the lower diode/jumper mounting holes (where the heavy bus meets the traces coming off U2) for those outputs.

The desired output can be set by severing the trace once the pattern is transferred to the board but prior to being dipped into the etching solution or by simply scraping away the copper trace after the board has been etched.

Also note that if your decoder board is to respond to outputs 1, 2, 3, 4, 5, 6, and 7 at pins 9, 10, 8, 7, 6, 5, and 4 (respectively) of U2, it will be necessary to connect a diode or a jumper wire from the chosen output to the buzzer connection pads near the



An antenna-discharge unit helps to protect against equipment damage caused by induced voltage during lightning storms. But don't rely on it to protect against a direct lightning strike. And never ever use the system during electrical storms.

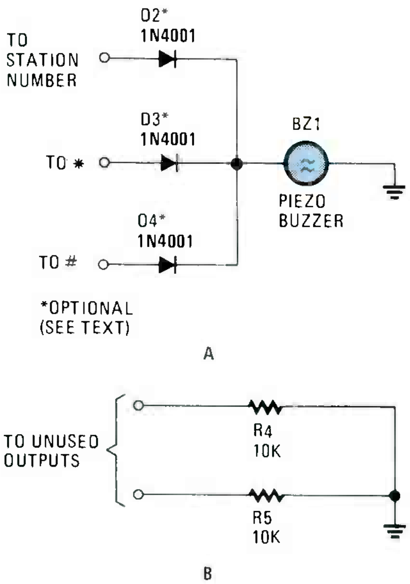


Fig. 5. If more than one output is to be used, diodes (as shown in A) should be connected between the chosen outputs and the buzzer. Unused outputs are routed to ground (as shown in B) through resistors R4 and R5.

lower lefthand corner of the board, where the cathodes of diodes D2–D5 are shown connected.

After you have etched, drilled, and configured the boards, mount the components as shown in Fig. 7. Begin with the IC sockets—but *do not* install the IC's at this point. The IC sockets can serve as a reference from which the locations of the support components can easily be found. When installing the components watch the polarity of the diodes and of the polarized capacitors.

Install a jumper between pin 24 of U2 and the positive-supply bus. Then install L1, which is really the 1000-ohm winding of an audio-output or impedance-matching transformer; the other winding is not used. Drill holes in the board to accommodate the transformer's metal tabs. Mount L1 on the board and solder the tabs of that transformer in place.

If the unit is to respond to a single tone pair, install a jumper between the desired output and the positive (+) terminal of the piezo buzzer. When more than one output is used, isolate the outputs from each other with diodes. That's the function of diodes D2, D3, and D4 in the layout diagram. If other outputs are chosen—1 (pin 9), 2 (pin 10), and 3 (pin 8), for example—it will be necessary to connect diodes between their respective pins to the pads where the cathodes of diodes D2, D3, and D4 are connected in the layout.

PARTS LIST FOR THE DTMF FIELD PHONE

SEMICONDUCTORS

U1—SS1-202 DTMF decoder (Radio Shack 276-1303 or similar), integrated circuit
U2—4514B 4-to-16 line decoder, integrated circuit
Q1—2N3904 general-purpose NPN silicon transistor
D1–D4—1N4001 1-amp, 50-PIV rectifier diode (D2–D3 optional, see text)

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1—10-megohm
R2—2200-ohm
R3—56,000-ohm
R4, R5—10,000-ohm

CAPACITORS

C1—0.01-µF, ceramic disc
C2—0.1-µF, ceramic disc
C3—15-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

L1—1000-ohm audio output transformer (Radio Shack 273-1380 or similar)
L2—24-volt step-down power transformer
XTAL1—3.579545-MHz TV color-burst crystal
MOV1—ERZC14DK201U metal-oxide varistor (Radio Shack 276-570 or similar)
BZ1—3–20-volt DC, PC-mount, piezo electric buzzer
Printed-circuit or perfboard materials, DTMF tone phone (IC type), modular jack, power supply or batteries and battery holder, IC sockets, plastic project box (4 × 2⁷⁄₁₆ × ⅟₁₆ inches), canvas pouch or plastic tool box, binding posts, enclosure, hook-up wire, solder, hardware, etc.

Once the decoder board is assembled, mount the board in a weatherproof plastic box. The printed-circuit board is sized to fit the box specified in the Parts List. Grind down the standoffs inside the box to a level that allows for the board and the mounted components. In that way, the board can be placed on the standoffs and the original lid will still fit. Drill a hole in line with the hole in the buzzer to let the sound out.

Mount two binding post (red for the positive lead and black for the negative one) to the outside of the decoder's housing. Connect leads from the decoder board to the binding post using the solder lugs provided. Clip the modular plug from the tone phone's line cord and strip the outer insulation to expose about two to three inches of the color-coded inner wires. Strip about an inch of the color-coded insulation from the red and green leads. Connect the green wire coming from the tone phone to the positive binding post, and the red to the negative binding post. When the circuit board is connected to the binding posts, you can button up the case.

The tone phone selected for use in this project should be of the more modern variety, which contain integrated circuitry. The older (early) models are not suitable for this project because of their heavy power requirements. In fact, you might consider purchasing one of the inexpensive tone phones (selling for from $10–20) that now flood the market. Those are ideal for this project.

Carrying Case. To make the DTMF Field Phone easy to carry, some type of case is needed. One type of carrying case is a canvas pouch like those used for the traditional GI-type field phone. The other is a plastic tool box, which makes a very weather-resistant enclosure. If you prefer the canvas pouch, check your area sporting-goods stores; you may be able to find a ready-made pouch that will work very well.

To accommodate the batteries, the master station requires a somewhat larger case than do the other stations. Usually you will only need one battery station unless you have a very long line. The exact size of the case will depend on the size of the tone phone selected for the project.

If a canvas pouch is used to house the Field Phone, make a plywood box

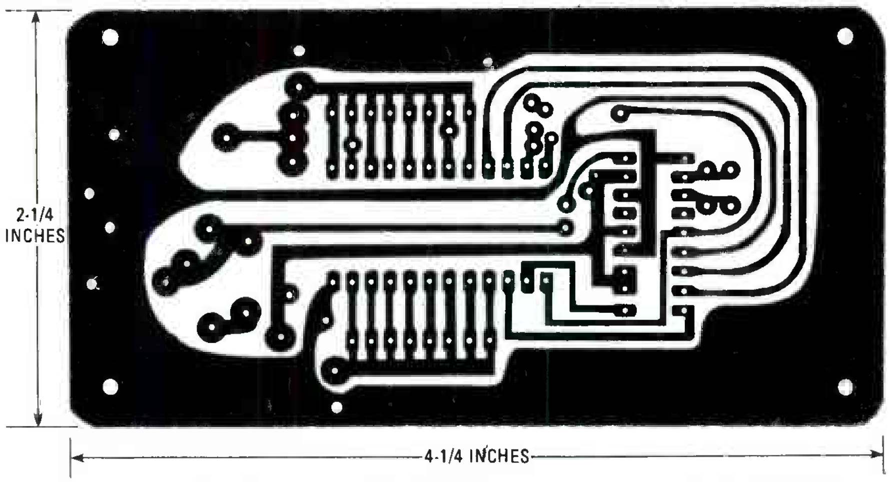


Fig. 6. Here is a full-scale template of the DTMF Field Phone's printed circuit board.

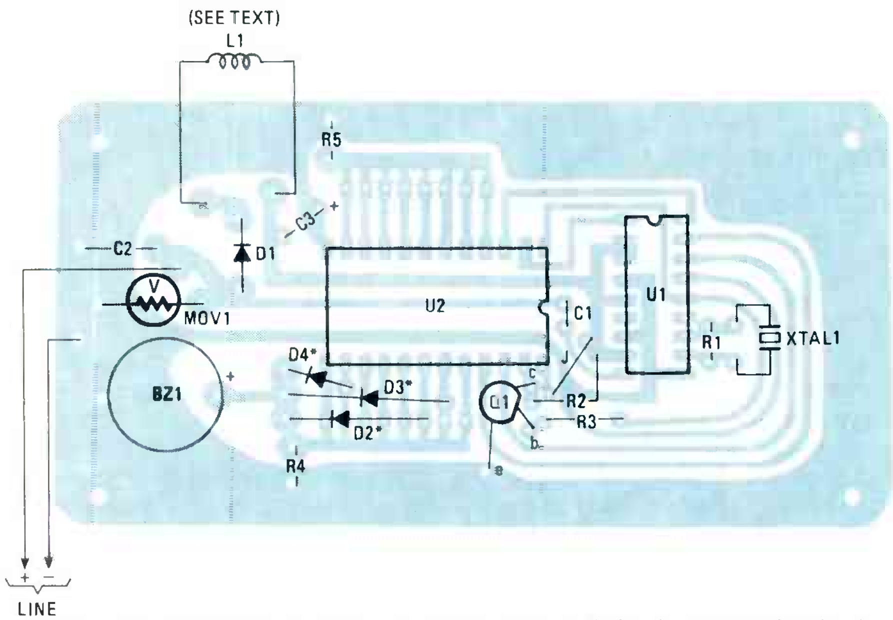


Fig. 7. Here is the parts-placement diagram for the DTMF Field Phone's decoder circuit. Cut the appropriate traces for the number to which the station is to respond. As for the unused outputs, the traces should be left as they are.

This inexpensive plastic tool box makes an ideal enclosure for the Field Phone.

of appropriate size to fit snugly inside the canvas pouch and mount the phone, the decoder, the battery, and the transformer in the box.

If a plastic tool box is used to house the unit, no modification to the box is needed. All that you need to do is to mount the battery, transformer, decoder, and phone in the box as shown in the photos.

Using the System. Practically any type of two-conductor wire can be used to connect the stations. Look for some large spools of surplus wire. Just run the system wire along the ground from one station location to the other, and connect the system wires to the binding posts. When connecting the Field Phone to the line, run wires from the binding post mounted on the decoder's case to the system line.

Diode D1 will make the decoder inoperative if the circuit is connected to the line with its polarity reversed. So if the Field Phone doesn't work, simply reverse the wires that connect the circuit to the line. At the master station, connect the negative lead from the battery to the negative binding post. Connect the positive lead from the battery to one end of the 24-volt winding of L2. The other end of L2 should be connected to the positive binding post. Use tape to insulate the remaining leads of the transformer; they are not used.

When the wire run is very long, install an antenna-discharge unit near each station. (Such units are available from Radio Shack and other electronics component suppliers.) The discharge units—which are normally used with 300-ohm antenna wire—help to protect the circuit against induced voltage spikes that may occur during electrical storms.

Connect the discharge unit to a good ground; usually that means driving a grounding rod into the earth. Even with the discharge units installed, a direct lightning strike would be hazardous; so under no circumstance should the Field Phone be used during an electrical storm.

Once you've wired up all the stations, you can test the system. You should be able to call any station by lifting the receiver and pressing the appropriate button. The buzzer at the selected station should sound for as long as you hold the button. When someone lifts the receiver at the called station, you can talk as you would over a normal telephone system.

Battery life depends on the number of stations in the system, since the decoders stay on all of the time. The current draw of each one is small, but they add up. You can increase the life by using a 6-volt lantern battery. You can also stretch the battery life by disconnecting the battery when the system is not expected to be in use for a long period.

If each station is equipped with a battery and a coil, you can install an on/off switch between the battery and the line. To call, switch on the battery at the calling station. Doing that powers up all of the decoders connected to the line. When the call is finished, switch off the battery. Using such an arrangement, the batteries are only under load during a call, so they'll last longer.

Battery operation makes the system useful in remote areas; but if there is 117-volt power available near one of the stations, you could build a 6-volt power supply to eliminate the batteries. The supply would need to be well filtered to eliminate any AC line hum. ■

The ULTRASONIC Receiver

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

BY CHARLES D. RAKES

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

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

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

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

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

Integrated circuit U2 (a quad bilateral switch) functions as an extremely clean balanced-mixer circuit for the superheterodyne receiver. Integrated circuit U1-a (½ of a dual op-amp) is connected in a variable-frequency squarewave-oscillator circuit. Resistors R5, R6, and capacitor C4 determine the frequency and tuning range of the oscillator.

The oscillator's squarewave output is fed along two paths. In one path, the output of U1-a is input to pins 12 and 13 of U2. In the other path, the signal is fed to the base of Q3, which is configured as an inverter. The inverter outputs a signal that's 180° out of phase with the input signal. The inverted output of Q3 is then fed to U2 at pins 5 and 6. There the two input signals (the ultrasonic input from MIC1 and the oscillator output) are mixed.

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

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

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

The receiver is housed in a 4-inch

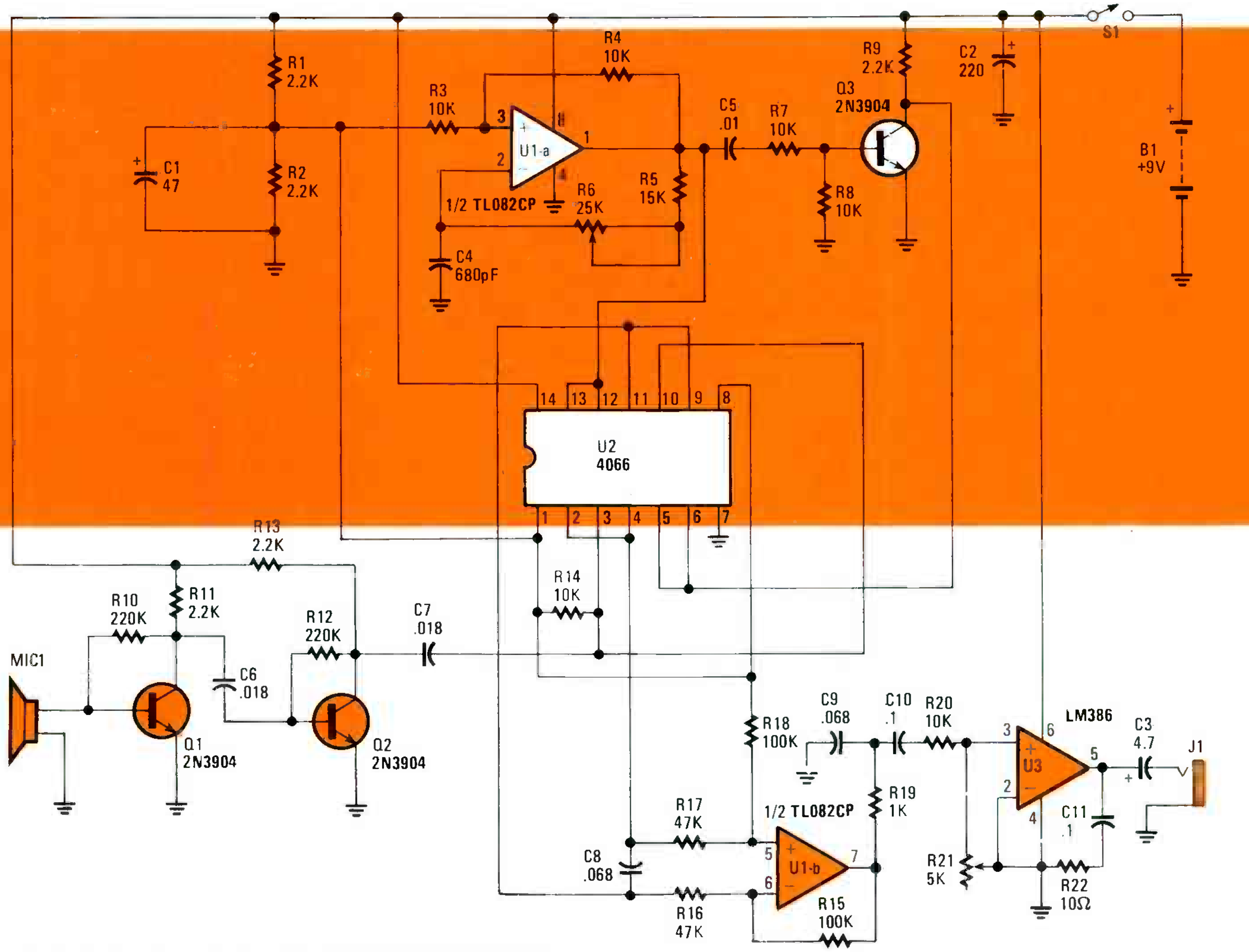
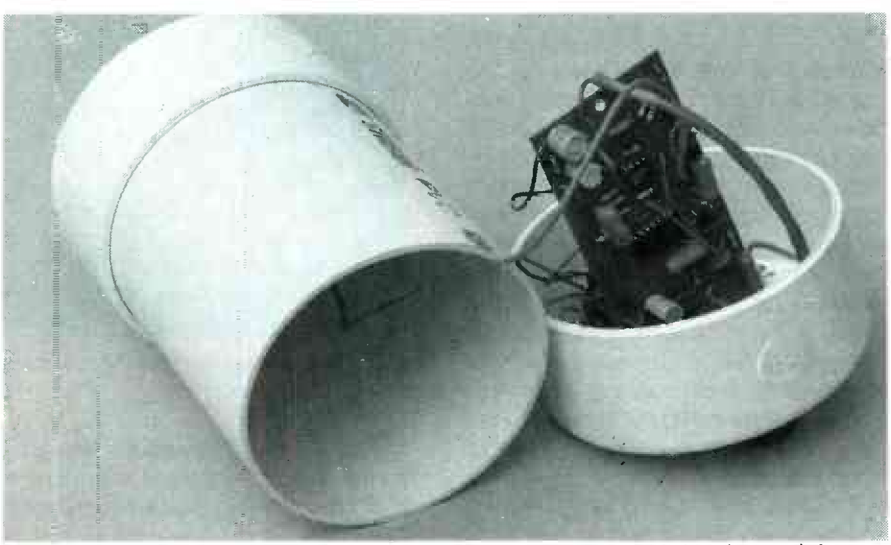


Fig. 1. Here's the schematic diagram of the Ultrasonic Receiver.



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

diameter 6-inch length of PVC sewer tubing, with two PVC end caps to complete the enclosure. The 3¾-inch piezo tweeter (MIC1) is mounted in the center of one end with phone jack (J1), tuning potentiometer (R6), and the volume control (R21) with off/on switch on the opposite end.

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

Mounting the 3¾-inch piezo tweeter in the center of the PVC end cap is easily accomplished by locating the center of the end cap and scribing a 2¾-inch circle around the center mark.

Drill as many ⅛-inch holes around the 2¾-inch circle as you can without overlapping, and use a small saw or knife to finishing cutting out the inner circle of material. Locate the tweeter on the end cap, mark and drill the four holes, and mount the speaker in place using 6-32 hardware.

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

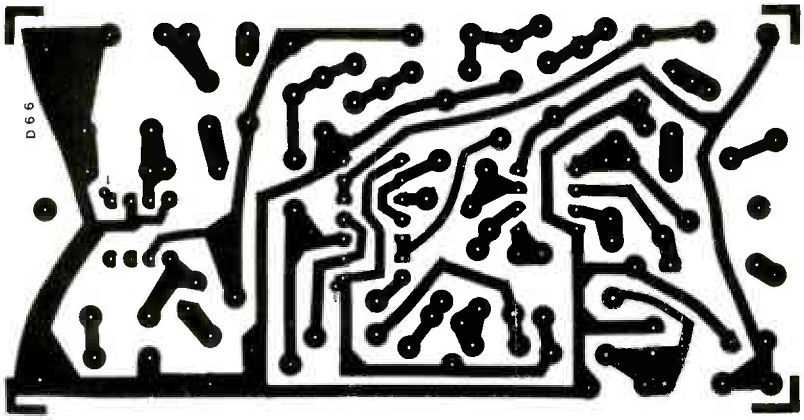


Fig. 2. For those who've opted to go the printed-circuit route, here is a full-scale template for the Ultrasonic Receiver's printed-circuit board.

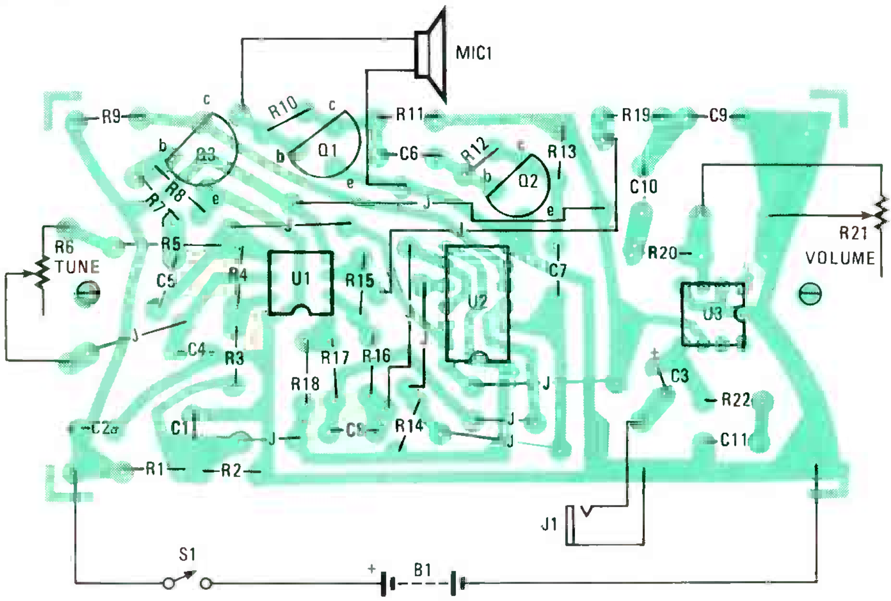
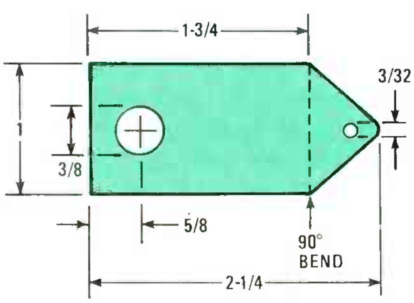


Fig. 3. Use this printed-circuit layout as a guide when installing the components on the printed-circuit board.



ALL DIMENSIONS IN INCHES

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

bracket that's held in place by way of R6, the tuning potentiometer. Figure 4 shows how to fabricate the "L" bracket. The battery holder is mounted to the back side of the circuit board's mounting screw with a ¼-inch spacer between the board and holder.

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

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

PARTS LIST FOR THE ULTRASONIC RECEIVER

SEMICONDUCTORS

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

RESISTORS

(All resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R2, R9, R11, R13—2200-ohm
R3, R4, R7, R8, R14, R20—10,000-ohm
R5—15,000-ohm
R6—25,000-ohm potentiometer
R10, R12—220,000-ohm
R15, R18—100,000-ohm
R16, R17—47,000-ohm
R19—1000-ohm
R21—5000-ohm potentiometer with on/off switch
R22—10-ohm

CAPACITORS

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

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor radio battery.
J1—¼-inch phone jack
MIC1—3¾-inch piezo tweeter (Radio Shack 40-1382, or similar piezo transducer)
S1—See text (part of R21)
Printed circuit or perfboard materials, enclosure (see text), IC sockets, knobs, battery and battery holder, wire, solder, "L" bracket (see text), hardware, etc.

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

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

Take a dog whistle and tune in to see

(Continued on page 103)

GIZMO®

FEBRUARY 1989 A CHRONICLE OF CONSUMER ELECTRONICS VOLUME 2, NUMBER 2

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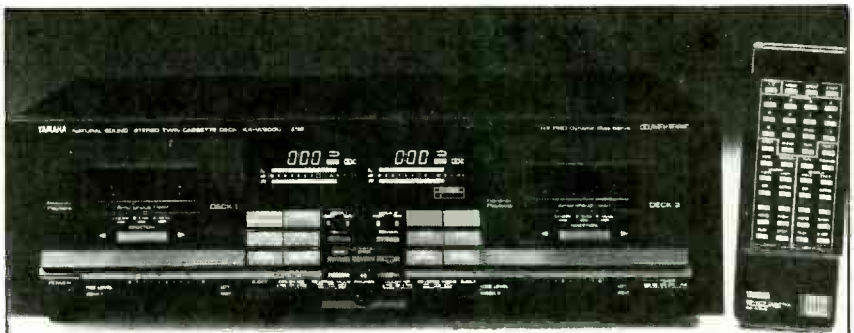

CIRCLE 32 ON FREE INFORMATION CARD

Full Deck

YAMAHA STEREO TWIN CASSETTE DECK (KX-W900U). Manufactured by: Yamaha Electronics Corp., U.S.A., 6660 Orangethorpe Ave., Buena Park, CA 90620. Price: $699.

Five years into the compact-disc era, and a few decades down the micro-groove long-play record road, what's the dominant medium for recorded music? Consumers have placed the audio-cassette tape at the top of that particular heap. The explosion in the use of personal stereos and boom boxes is just one indication of the tape cassette's reign. About a year ago, pre-recorded tapes moved past LP's as the consumer medium of choice.

As a colleague who covers the music industry points out, it seems odd that the least durable of the readily available recording mediums is the one that consumers depend on most for music. But, as our use of the *Yamaha Stereo Twin Cassette Deck* demonstrated, there are advantages to audio cassettes, especially when they're used with a sophisticated, versatile deck like the *KX-W900U*. With its twin cassette compartments and multi-faceted playback and recording capabilities, this Yamaha might well displace both turntable and CD player as the central component in a home-audio system.

Finished in the black matte that seems the current rage in home audio-component appearance, the KX-W900U at first glance is an intimidating collection of controls and adjustments. On its front panel, we counted no fewer than 35 separate buttons, switches, and sliders, along with headphone jack and infrared-reception window. Admittedly, the system incorporates two complete decks—but for the technologically wary, that array can be slightly disconcerting. Especially as the twin deck is outfitted with an infrared remote controller (Yamaha RS-KW9) that replicates the front panel controls (for the most part) and adds a thirteen-button programming function.

Looking at the remote, we got the notion that if we could master it we could probably go on to a career as an air-traffic controller. There's an abstract aspect to using a button-laden wand to control a component that we have yet to come to terms with completely. (Besides which, the size of the **GIZMO** audio testing room makes a remote control slightly superfluous.) Using it, we found ourselves most often planted directly in front of the Yamaha, checking the deck's excellent indicator displays to make sure that we'd pushed the right button or combination of controls.

In actual use, the KX-W900U proved to be, if not altogether user friendly, as least cooperative. Unlike some lower-priced decks and many portable dual systems, both of the cassette decks in this unit are fully operational; each not only plays back but records, too. Further, the Yamaha can link the two for both relay play and recording.

Slipping a cassette into a deck gives the first indication of how sophisticated this home system is. An indicator light on the cassette compartment door immediately displays cassette type: "I/Norm," "II/CrO2," or "IV/Metal." The instruction manual notes, "automatic tape selection does not function for the old-type metal tapes." Nor is the deck "suited for use with Ferrichrome tapes." Besides activating the proper indicator light, the unit's circuitry automatically adjusts for "proper bias, level and equalization."

It took us a while to get used to the unit's record-control sequence. Instead of pushing "play" and "record" to activate recording, the KX-W900U uses a "record/pause" button, marked in red, in conjunction with the "play" control. To record, the home audio engineer selects Dolby noise-reduction setting ("B" type, "C" type or "off"), sets tape direction (by punching a bar that is mounted on the cassette-compartment door and marked with green-light arrow indicators at each end), and selects a tape-reverse mode.

The deck can be set to record one side of a cassette and stop, or it can automatically reverse and continue recording on the second side. In the playback mode, a third option sets the cassette up to play continually, shuttling from one side to the other in an endless loop.

When the "rec/pause" control is engaged, the deck's level meters kick in. That allows the user to set optimum levels using a pair of slide controls designated "rec level." A push of the play button begins actual recording. Each system selection described here is indicated on the display. "Rec" glows when the pause is engaged and deepens to a bright red when recording is actually under way. Symbols indicate Dolby and tape-reverse modes while the level meter offers right- and left-track information. Above that, a tape counter rolls during recording and rewind. Essential, of course, but a look at the manual's description of that function left us a little light-headed.

Described as a "linear counter/tape length/remaining time display," the manual says the counter "displays the elapsed time of the tape's running," but that "the linear counter is not an actual watch and its accuracy . . . depends on the kind of tape used." That, besides being a little vague, raised the question of just what the counter is counting. Nonetheless, it does allow the user to keep track of segments and beginnings and ends of recorded sections on a cassette. It is especially useful during selective recording or in dubbing retakes of material previously taped. The counter is not replicated on the remote, which is another reason that we stayed close to the deck during recording and dubbing sessions.

Underneath each display panel are controls that bring up additional information. "Reset" rolls the counter back to zero, while "remain" will translate the elapsed tape figure into tape-remaining information. Another display control, "tape," activates the display to show cassette length (C-30, C-60 or C-90) for a few seconds. Oddly, our test unit inevitably displayed C-60, even when the cassette was a C-90.

Linking decks one and two for continuous recording on two cassettes is done with a "relay" button that engages a "relay" indicator light. Deck one rolls first. When its cassette is full (in relay mode, the user can still select tape-reverse mode for double- or single-side recording) deck two starts up. The KX-W900U also offers the options of simultaneous recording by both decks from a single source—creating two "first-generation" tapes in a single operation—or simultaneously recording from two sources.

The deck's dubbing functions are controlled with a trio of dubbing buttons. In duplicating tapes, deck two acts as the source. "Dubbing mode" selects automatic-, manual-, or skip-dub mode. Automatic-dub mode is described as being "convenient for creating an identical tape," while the skip-dub mode is especially useful for "effecting dubbing between cassettes of different length." Manual offers the most hands-on control of what is re-recorded in the dubbing process.

"Speed" offers the options of normal or "high speed" play. The high-speed mode duplicates a cassette in just under half its normal playing time. The instructions give one reason normal-speed dubbing may be preferred. "Normal speed dubbing permits cross-Dolby NR dubbing [in which] non Dolby NR encoded tape can be made from a Dolby NR encoded tape or vice-versa." The third button activates the dubbing process, all very neatly indicated in a lighted, boxed display directly over the dub controls.

A final measure of recording versatility comes with the addition of a separate audio timer. Connected to the amp and twin cassette deck, the timer allows audio recording to take on some of the convenience of time-shift video recording. A "timer" control on the deck's front panel can be set to "dual record," "record,""off," and "play." In the absence of a separate timer, "off" becomes the control's most important setting. A number of functions go awry if the switch is left on.

After our crash course in home recording, we had hopes that playback would be a less learning-intensive experience, but Yamaha's insistence on user convenience put us completely at sea. The problem was a sophisticated search-and-selection system, CD-like in its capabilities but demanding some programming obviously not necessary with LP's or CD's.

Maybe it was the use of the term "programming," but we came away from the KX-W900U thinking that we hadn't quite mastered the intricacies of "mute search" in either the record or playback mode—let alone recording's "auto rec mute" (cuts off "unwanted material during recording...provides blank sections between selections"), "blank skip," "intro scan," "single selection," the higher powers of "direct music search," or "random programmed playback." Call us old-fashioned or call us irresponsible, but after surveying the extensive documentation aimed at preparing the listener for the added convenience of each of those selection controls and capabilities, we just wanted to hear some music.

The entire system depends (reasonably enough) on unrecorded sections of the cassette as its referencing device. Meaning, for example, that if a user recorded a radio program in which music and talk were more or less continuous, without some hands-on editing the tape wouldn't provide the necessary referencing. How much silence is necessary for music-search capability isn't altogether clear from the informational literature. In the music-search mode during playback, three seconds is the necessary interval between one selection and the next. To our uncomplicated way of thinking, programming is not one of the pleasures of a music system. Prerecorded tapes, of course, present none of those problems.

Actually, dubbing tapes and recording material from a variety of sources did turn out to be one of the ways in which we enjoyed the Yamaha Twin Cassette Deck, so maybe with a little more exposure we'd warm to the task of creating selectable audio cassettes. The capability is certainly there.

We were disappointed in part with the configuration of the front-panel controls. Besides being mirror imaged for decks one and two, the main set of record and playback controls are all more or less identical rectangles. The black-matte finish and the stacked deck controls made it easy to misplace a finger and flub a dub. The information is all there, but its organization needs to be more self-evident and differentiated.

On the other hand, the design department may have decided that the remote control's panel was where the action is, or should be. The remote's small scale and extensive programming and search functions makes its operation no less a chore, requiring attention visual and otherwise. The deck itself at least has the advantage of an easy-to-read, extensive display.

As a central music-shipping and -receiving station, the KX-W900U was a sophisticated pleasure to use and listen to. Its virtues seemingly included boosting the fidelity of our well-worn speaker and amp, although that isn't anything we'd submit to laboratory confirmation. Pre-recorded audio cassettes and home-transferred tapes alike were clear and detailed. Listening to a tape of a well-worn, live-recorded LP side made with the KX-W900U via a sophisticated personal-stereo system, we heard background voices and even instruments we'd never picked up on in years of listening to the record. Yamaha's moniker for this deck is "natural sound stereo twin cassette deck" and, based on our experience with the unit, that doesn't seem to be hyperbole.

Deficiencies in the design and designation of audio-component controls is something approaching an industry-wide problem. Convenience, for many consumers, is a machine that doesn't demand new learning in order to use it. That's not always technologically possible. But in something as entertainment-oriented as home music equipment, there are some design breakthroughs waiting to be made in the interface between human and component. We don't think it too much to ask that, at the minimum, controls should assist in allowing the user to easily manipulate a system as splendidly multidimensional as this twin-cassette deck. ■

Hybrid Tech

IBM PRINTER OPTION FOR WHEELWRITER III ELECTRONIC TYPEWRITER. Manufactured by: IBM Old Orchard Road, Armonk, NY 10504-1783. Price (with installation): $220.

Owning an *IBM Wheelwriter III Series I Electronic Typewriter* and being regular home computer users, we were in a bit of a quandary. The typewriter itself is a beautiful instrument; it's the logical extension of the classic IBM Selectric, a monolith of a machine with smooth action and IBM-perfection printing. Its added features—character erase, automatic feeds, and spell checker—help set the standard for other electronic typewriters on the market.

Still, being attached to computer word processing, we weren't looking forward to hammering on a typewriter, no matter how good. For us, the computer is rendering the typewriter obsolete. Most software already provides spell checkers, thesauruses, and even grammar and punctuation guidance. That's why it seems downright kind of the folks at IBM to have developed a printer attachment that turns a regular IBM Wheelwriter III into a computer printer, without losing its utility as a typewriter.

Conversion is a simple procedure. Electronic do-it-yourselfers can probably transform their own Wheelwriters by following the typewriter's manual, which devotes an entire section to installation of the *IBM Printer Option*. The relatively simple directions are divided into two parts: disassembly and assembly, each non-technically worded with clear line illustrations. We decided to let the retailer who sold us the printer option install it; that added slightly to its price.

The transformed IBM looks pretty much like the non-altered Wheelwriter. There's a small integrated attachment, consisting of microcircuitry and a plastic shell, that is connected to the rear left of the typewriter. The Wheelwriter is interfaced with the computer with a standard printer cable (not included in the option package) stretching from the port in the back of the PC to the attachment unit. The weight of the printer cable tends to yank the unit away from the Wheelwriter, so make sure the locking ring screws are tight. Otherwise the attachment can fall off.

The tractor feed is an optional bar (again separate from the printer-option package) that runs the length of the carriage, snapping into place with cork-padded grips. Rattling the tractor feed or accidentally knocking it can cause it to slip out of place, but it snaps back easily.

Once the Wheelwriter is converted into a PC printer, don't worry. The computer illiterates in your household or office can still use it for hunting-and-pecking. Hitting the "code" key and the number 5 on the typewriter's keyboard turns on the printer option. "Code" and the numeral 6 moves it on and off line. Those codes—the only ones users need to know—are labeled with a template above the keys.

Don't disconnect your old Epson when you bring the Wheelwriter home after its minor surgery. It will still be handy to have a draft-quality back-up unit. In our experience, even with the tractor feed installed, the Wheelwriter is just not made for transporting continuous-form paper, and it can be a bulky, balky machine. Particularly when using continuous forms, the paper jams and bunches up, even with careful paper loading. For long documents it can be frustrating, requiring constant adjustment and tending. We've found it's often simpler to use an ordinary printer set to letter-quality mode. Unless it absolutely has to be perfect, a long document is just too much of a hassle to print out on a converted Wheelwriter.

The Wheelwriter's print quality, of course, is far superior to that of most PC printers. Documents look as though they've been typed by a secretary—even if you don't have a secretary. With some appropriate stationery and a personalized logo, the user can forgo professional-typing and -printing services. The only telltale mark a recipient might detect are the perforations on the form paper. As with any IBM typewriter, switching typefaces is only a matter of changing the machine's print element. A number of ASCII printwheels are available, including the popular courier and elite faces.

Getting a modified IBM Wheelwriter to run with a personal-computer system should be no problem. We're using ours with a Tandy 1000 and have tested it successfully with a Sharp PC-7000 and an AT&T 6300. With a second, or even a third, printer we recommend investing in a data switch to eliminate cable changeovers that can damage the pin heads.

Data switches are packaged in small metal boxes that fit inconspicuously on your computer table, and retail for prices ranging from $30 for a simple two-port switch to as much as $120 for a four-device, four-wire terminal-block switch. Computer printers have memory too, so protection is in order to prevent printer boards from being blasted by surges.

With a data switcher and two printers, the change from one unit to the second is a one-second operation. Drafts and informal material can be whipped off in the high-speed mode, but for important business letters and the like, a switch from "A" to "B" engages the Wheelwriter. Depending on software, the user may or may not have to redefine the printer. IBM boasts that input data and all interface-control signals are compatible with standard TTL-logic levels. But, in common with more conventional PC printers, the Wheelwriter will print garbage if defined incorrectly.

The IBM Wheelwriter is not for all printing chores. A possible drawback is that special fonts and styles can't be utilized during printing. It can be frustrating when using software like WordPerfect 5.0 to miss out on the program's features like line-drawing, graphics, and color printing. Bold print, underlining, and right justification are about the fanciest tricks in the Wheelwriter's repertoire. For multiple-page documents, The Wheelwriter with Printer Option can fall just a tad short. It can't do desktop publishing, but it can bring a professional appearance to traditionally typed materials like letters or manuscripts.

Limitations to the Wheelwriter's versatility as a PC-linked printer do exist. The machine can be slow, and some find it noisy; but, like an aging slugger, when it comes to the clutch situation, it's the one you want at the plate. ■

More than Ample

ONKYO QUARTZ SYNTHESIZED TUNER AMPLIFER (TX-850). Manufactured by: Onkyo U.S.A. Corp., 200 Williams Dr., Ramsey, NJ 07446. Price: $500.

Our major experience with amplifiers basically took place in the pre-quartz, pre-synthesized era when component stereo systems made their first big impact. For the most part, the experience has been positive. Amplifiers have seldom malfunctioned on us or burned out. That's why **GIZMO**'s look at the *Onkyo Quartz Synthesized Tuner Amplifier* constituted some kind of overdue update.

We always thought that the amps of the recent past were pretty much okay (and more than that in the longevity and durability departments). We wondered how much better the technology could have become in the years since silver finish, big volume, and station-selection dials were the cutting edge in amplifier appearance and features.

We came away from our test thinking that rather than becoming better, amplifiers have become different, designed along lines that suggest their function in the home-stereo universe has changed to an important degree. Remote controlled and featuring at least one proprietary system (Onkyo's "automatic precision reception"), the *TX-850* is the kind of component the word "sophisticated" might have been invented to describe. Technically speaking, the unit features "low impedance drive amplifiers," 68-watts-per-channel RMS, and a raft of special processors that polish the signal to a glossy, dimensional sound—gloriously resonant and with a stereo image (as in "stereo imaging") that won't stop.

Still, old-timers are going to find at least a couple of its features and characteristics slightly off-putting. When the power is turned on, the amp comes up with an audible "thunk" after warming up for a few seconds.

While that may be a reflection of our woefully outdated speaker system, we also thought the volume control was pitched rather high. With any of our system's three sources, the dial had to be set to 10 (on a scale ending at 40) to put out any listenable sound.

But the sound produced at that level was certainly listenable and well-articulated, even coming through our crummy speakers. Traditional amplifier controls ("bass," "treble," and "balance") are relegated to the lower-right corner. The unit display and station pre-set buttons are center-stage, surrounded by small black knobs, buttons, and slide switches.

In its radio-reception functions, the TX-850 strikes out on its boldest path. AM reception depends on an included loop antenna, and we used the unit with the Parsec LS-4 FM antenna. In conjunction with the tuner's "automatic precision reception system"(APR), that antenna furnished reliable, clear FM reception even in the highly urban setting of the **GIZMO** office.

According to the instruction manual, APR is "Onkyo's unique computer-controlled system" that automatically sets the "RF stage gain" (indicated on the display as "distance/local"), and engages noise reduction and "high blend" functions (both of which "reduce noise in weak stereo signals") and an automatic stereo/mono reception mode. When the system had a strong enough signal to work with, APR functioned well. But fringe and low-power broadcast signals, at least below a certain threshold, seemed to confuse APR. Its indicator lights would jump back and forth frantically, with functions engaging and disengaging to no discernible end. The decidedly low-tech method of moving the antenna around would usually allow the TX-850 to lock in, although drift and fade-out were not unknown.

The TX-850 also allows the user to electronically alter the signal. A "stereo image expander" is described in the instructions as adding "an extra feeling of width and depth to stereo sound." (Meaning, we guess, that nowadays amplifiers have "feelings," too.) If the user is unfortunate enough to be listening to a mono recording or radio signal, "simulated stereo" will dress up the sound. "Selective Tone/Loudness" requires both a switch and a sliding "level control" that will boost "a selective tone." Engaged but unadjusted, the feature is described as "creating a clear reproduction quality of the ultra low frequencies and the high frequencies." Similarly, the "dynamic bass expander" switch and level control gives "an extra feeling of power and realism to the low range." In case the user wonders, the instructions add, "its function is unlike that of the conventional bass control." "FM muting," controls "interstation noise" and also suppresses weak FM signals, which means that if the listener wants to hear one of the weak signals, the mute function can't be engaged.

There are speaker-selection switches, as the unit can drive two pairs of loudspeakers and, on the unit's back panel, a full set of inputs for VCR audio. Source selection is via a row of nine rectangular buttons stretching below the display and offering, from left to right: tape two monitor, tape one, VCR two, VCR one (or video-disc player), AM, FM, phono, CD

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and CD direct. That final source button allows the CD player to bypass the amp's bass/selection tone, treble, and balance controls.

The ten-button station pre-set panel allows the user to store two stations per key; a "shift" key differentiates between the pair of stations at each location. The bottom row of the panel is made up of station-up and -down controls and the "memory" button, with which presets are placed in memory.

The TX-850's display panel is a neatly organized information source. The main display is devoted to either source or, for radio reception, the station frequency. To the left of that is a signal-strength indicator, and below it are the four APR-indicator lights: "bass" and the indicators for stereo-image expander, selective-tone, and bass-expander functions. An indicator light labeled "stand-by/record" tells the user, when lit, that the unit can be switched off with the remote control.

The supplied infrared remote control (*RC-1185*) has a couple of ingenious features. One is control of the unit's "sleep timer," which allows the user to set the amplifier to turn off 30, 60, or 90 minutes from the control's engagement. In the audio industry's beloved "bells and whistles" category, the remote's volume-up and -down controls rotate the amplifier's volume dial—sure to be hit with kids of a certain age and adult gadgetry fans. The remote does a reasonable job of controlling operations (adjustments are another question) with a mere 33 buttons.

We were impressed, and somewhat intimidated, by the sophistication of the TX-850. It seemed clear that this tuner-amp surpassed the capabilities of our system to deliver fully on the promise of Onkyo's technology. Put more simply, the TX-850 is not an ideal first upgrade for a stereo system showing some wear and tear. As the base unit in a new system, however, this tuner amplifier will easily keep pace with whatever upgrades and expansions its owner might want to add. Flashy and formidable, the TX-850 Quartz Synthesized Tuner Amplifier is an unusual combination of basics and embellishments. For the right consumer, it undoubtedly would represent the happiest of mediums. ■

Memory Mate

DIRECTORY MATE. Distributed by: Executive Communications Systems 2622 Quaker Ridge Pl., Ontario, CA 91761-6347. Price: $29.95.

To walk free, arms swinging and head held high, unencumbered by the usual accessories of everyday life—that seems to

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be a pleasure reserved for joggers and preschoolers. For the rest of us, wallets stuffed to their seams form an ungainly lump in the hip pocket or handbags hang heavy on shoulders like some kind of modern-day ball-and-chain. And, for those with schedules to keep and people to seek, appointment books and calendar planners bursting with information are just one more impediment en route. The *Directory Mate* is one electronic tool that can at least lighten the load.

Manufactured in Hong Kong, the Directory Mate is about the size and weight of a charge card, so slipping it into a wallet or pocket adds about as much bulk as...a charge card. As most wallet users understand, charge cards are like Jello—there's always room for more. If the Directory Mate can reduce on-board bulk and increase organization, it's a small item doing a big job.

Harried executives pulling similar units out of their pockets are a common sight in cities nowadays. Directory Mate may not be unique but, for those with a predisposition for punching data onto a tiny screen (or at least a tolerance for the task), it will do the electronic data-storage job.

This unit is as simple to use as any palm-size calculator (and in fact is a five-function calculator), with the added capability of creating and storing a file system of names, addresses, and phone numbers, or whatever type of alpha-numeric information a user may want to enter into its 4,096 digit memory. The unit's "special memory" sets aside a separate file of 20 alarm settings that can be preset to remind the user of an upcoming date or appointment.

To turn the Directory Mate on, the user depresses the key marked "clock" next to the unit's display, which brings up the time and date. Although the display is diminutive (1½-inches long and ½-inch high), it's easy to read. The key marked "store" prepares the Directory Mate to receive information; a second push on the same key enters the data into memory. Each screen-size entry can contain up to 20 digits displayed on two lines. The "search" key brings each of the entries up on the screen, first in alphabetical order and then in numbered sequence. To bring up a particular file, the user enters the first digit or letter of the entry. If more than the 20 digits allotted per screen is needed for a file, the user can continue onto a second screen before pressing "store." When that file is on screen, pushing the "read" key will bring up the second screen of data.

In general, the Directory Mate was perfectly simple and easy to get the hang of. The key sequence used for data entry ("store;" enter; "store") is replicated in other functions performed by the unit, so the rhythm becomes nearly second nature once you've grown accustomed to it. Besides data storage and calculator functions, the unit can perform metric conversions and its message-alarm function can be programmed for up to a year's duration.

One feature we had trouble with is a security function activated with a key labeled "lock." That allows the user to create a file accessible only by those who know the three-digit programmable entry code. The security code is entered, the "lock" key is pushed, and secrets are safe. As we found out, if the code's forgotten, the secrets will be safe even from the user.

The only way to unlock the file without the triple-digit combination is to remove the tiny lithium battery from the Directory Mate's back panel and leave it out for an hour. When the battery is reinstalled, the code will be deactivated—and all the information painstakingly punched in will also be gone.

That gave us pause, and made us wonder if the "lock" mode is really that important for a data bank usually carried on your person. People in the espionage industry might want it, but it's unlikely that they depend on readily available consumer goods in their clandestine operations.

We really developed doubts about the usefulness of the security code when we accidentally pressed the "lock" key instead of the "clock" key located directly above it. A high-pitched whine began its pulsating alarm and the Directory Mate closed shop on us. We had not entered a three-digit code, but the security lock immediately engaged and there seemed to no way of stopping the unit's beeping racket short of removing the battery. After we pushed various keys in an effort to release ourselves from this mess, the Directory Mate began clicking its tongue at us like a scolding parent.

What the instructions do not mention is that a user can start all over without losing either the Directory Mate's memory, or his or her own sanity, by pushing a gold indentation on the back of the unit with a sharp point. That was discovered by old-fashioned trial and error.

The reviews from those who used, or at least played with, the Directory Mate were mixed. The traditional objection to electronic data storage (it's more bother than just writing the stuff down) was raised. But others, more electronically adept or at least more experienced, described it as a "handy little organizer." We found that the Directory Mate does just what its instruction booklet promises. It files and it organizes, and within those confines, it works very well. ■

Just the Fax

COBRA PRINT PHONE PORTABLE (PP-110). Manufactured by: Cobra Consumer Electronics Group/Dynascan Corp., 6500 W. Cortland St., Chicago, IL 60635. Price: $1,339.95.

A recent edition of the monthly humor magazine *Spy*, in a celebration of fictional spy James Bond ("how the real world has become an 007 world") listed fax machines as a primary example of "incredibly cool Bond-like stuff." That might be the missing dimension to the explosion of facsimile use. Besides speed and simplicity of transmission at unit prices businesses and even individuals can afford, the fact that many of the people buying and using fax machines were raised on James Bond movies and novels is not to be discounted.

The case for that hidden motivating factor is furthered by the popularity of the *Cobra Print Phone Portable*, a compact briefcase of a fax machine that the fictional British secret agent could easily have stowed in the boot of his Astin-Martin coupe. Designed for truly portable use, an optional fabric carry case ($39.95) and acoustic coupler (*PA-201*, $49.95) mean that the *PP-110* owner need never be faxless.

Weighing 7¼ pounds, the unit measures a compact 12¼-inches long, 9-inches wide, and 3-inches deep. Jacks for telephone and line connection, along with automatic-/manual-receive selection and a volume control for use with the acoustic coupler (its jack is concealed behind a pop-out shield on the same panel) are on the machine's left side. Stop/start and fine-adjustment (for sending or receiving material with fine or small detail) controls are located on the right support of the unit's built-in handle. LCD's indicate "power," "cover open," "paper empty," or transmission/reception "error."

We used the PP-110 in two different locations with mixed results—due, we're inclined to believe, to our own novice status as fax senders and receivers and to certain oddities of the New York telephone system. As with our previous use of the Toshiba 3300 facsimile device (**GIZMO**, January 1989), we never developed a foolproof relationship with the PP-110.

Most of our problems arose when we connected our touch-tone phone directly through the PP-110. Using the optional acoustic coupler (which Cobra explains is for use with "non modular" phones) brought the most uniform results, but at the price of some loss of flexibility and convenience.

Despite its portability (our tester called it the "transistor radio of fax machines"), the PP-110 performed its transmission, reception, and copying functions at the same level of sophistication as other, more expensive (and handset-equipped) machines we've examined. Whatever the price of portability, it isn't paid in the quality of document output. As for quantity of document output, the unit's rolls of thermal paper are each good for "60 full-size pages," meaning standard 8½-inch by 11-inch paper. Cobra paper is supplied in boxes of 6 rolls for $39.95 per package.

The manufacturer credits Cobra's "clear print circuitry" for the machine's excellent graphic resolution. According to a product release, the PP-110 scanner utilizes contact-image sensor technology" for "rugged durability and high quality resolution."

Loading paper, connections, and operation are simple, making it difficult to figure out where a user might be making a mistake. Everything seems so straightforward that problems aren't easily traced. The instruction manual's two-page "trouble-shooting" section is some help. In first using the Print Phone, it was embarrassingly easy to get mixed up about when to hit the start button to begin transmission. For other novices, it should be noted that, after establishing contact with the second fax machine, the telephone is hung up *before* hitting the start control.

The acoustic coupler fits directly onto a telephone handset, bypassing the necessity of plugging a phone directly into the PP-110. In this mode, the desired fax number is dialed, the answering tone is heard and the coupler is fastened over the handset's mouth and earpiece, making sure the handset is at least 2 feet away from the fax within 30 seconds of coupler connection. "This will prevent machine noise from interfering with coupler operation" according to Cobra. Either directly connected or via the coupler, transmission takes about 40 seconds per standard page.

Simple to use, compact, and stream-

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lined, our only complaint about the PP-110 is that we didn't get to know it better. Selected as one of the "most innovative consumer electronics products of 1988" at last year's summer Consumer Electronics Show, the Cobra Printphone Portable is as simple to use as a telephone and, with practice, as flawless in operation. James Bond may never have had a PP-110, but he should have. ■

CIRCLE 40 ON FREE INFORMATION CARD

Time Travel

WORLD TIME ALARM CLOCK (TT-24). Manufactured by: Ronde Division, Advanced Products & Technologies, P.O. Box 2014, Redmond, WA 98073. Price: $26.

The conquest of time and space might seem a heroic undertaking but, thanks to micro-chip technology, it comes down to a piece of clever consumer design. If the *Ronde TT-24 World Time Alarm Clock* doesn't exactly conquer those two dimensions, it at least helps clock-bound travelers stay abreast of one while passing through the other.

A slim rectangle of information, the World Clock proved its mettle on a real-life trek to Greece, where it was tossed into duffel bags, shoved into pants pockets, and dropped on floors throughout a three-week sojourn. It survived, and more importantly proved to be a useful article, well worth the small space it occupies in the traveler's tote bag.

Weighing only 1½ ounces, the clock is a mere ⅜-inch thick. Its 3¾- by 2-inch face incorporates an LCD display, alarm on/off, and combined snooze/calendar controls. At the right is a distinctly pre-electronic rotary dial surrounded by the names of 23 cities and the legend "G.M.T.," for "Greenwich Mean Time."

On the back are the three controls necessary to set the instrument's four functions—time, calendar, ten-second timer, and alarm. Setting those is the usual electronic-clock chore of mode selection and sequencing. The back also contains a reset button and the battery compartment for a watch-style power supply. There's also a fold-out brace that allows the TT-24 to be used as a bedside clock.

The time-selecting rotary dial is lined up with the desired location and the LCD shows the proper time for the indicated city as well as, on a second line, "local time," that is the time in the user's location. Next to the world time a discreet "wt" blinks to assure that the user won't mix up world with local time. A small "p" indicates p.m., leaving a.m. undesignated. When the alarm is set, a small bell symbol indicates it's engaged. A "World Time Table" printed in the directions provides further cities sharing the time zones of the cities listed on the clock.

GIZMO's testers praised the clock for its compact size and easy-to-read display, but thought the rotary route to correct time was a surprisingly archaic method of engaging the TT-24's electronic time-telling function. The alarm's electronic buzz fulfilled its alarm function without shocking users into wakefulness. As casual travelers they appreciated its sturdy construction. Especially considering that the supplied fabric carry case wasn't used, the Ronde World Time Alarm Clock came through unscathed, and provided a practical alternative to both wristwatches and more elaborate travel clocks. Its dual-indication display proved useful in timing overseas phone calls and figuring times of arrival in other zones. The clock's utility doesn't necessarily fade at the end of the vacation. It can fulfill its time-keeping and alarm functions even in the home. ■

Gizmo/Bytes

Lightweight Camcorder

For the video-camera user who records a lot of footage and wants to keep careful track of what's on each cassette, the Canovision 8mm *Lightweight Camcorder (E-77)*, from Canon U.S.A. Inc. (One Canon Plaza, Lake Success, NY 11042), offers a built-in clock that records time and date. The camcorder weighs 2.4 pounds (without battery pack) and is equipped with a 270,000-pixel CCD-image sensor, a power-zoom lens, a 1/1000-second high-speed shutter, and a center-weighted exposure system. Among other features are active infrared auto-focus, a self-timer, interval timer, full-automatic white balance and white-balance lock, electronic viewfinder, both audio- and video-fade capability, and flying erase head. The 6× power zoom features a wireless remote control that includes start/stop, fast-forward/search, rewind/review, and still capabilities. The machine is described as being as easy to use in playback as a tabletop VCR. Price: $1,699.
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Lightweight Camcorder

Gizmo/Bytes

Dynamic Stereo Headphones

Compact Zoom Camera

Winter Sports Watch

Camcorder with Telephoto Adapter

Camcorder sophistication takes another step forward with the announcement from the *Hitachi Sales Corp. of America* (401 W. Artesia Blvd., Compton, CA 90220) of a new full-size *Camcorder (VM3150A)* equipped with a telephoto lens adapter. Other features of the recently introduced VHS unit include a variable high-speed shutter, wind switch, and self-timer. The VM3150 also offers a 6-to-1 power macro zoom, and auto/manual white balance. Price: $1199.

CIRCLE 39 ON FREE INFORMATION CARD

Stereophones

Stereo headphones are everywhere these days—on the streets of big cities and in small town shopping centers across the country—and for consumers unsatisfied with the sound of mini-style or "bud" earphones, *Signet* (4701 Hudson Dr., Stow, OH 44224) has developed the *Open-back Dynamic Studiophones (EP700)*. "A dynamic audiophile model," the EP700 features full-sized, open-back earpieces and is outfitted with over-sized earpads. The studiophones are said to be comfortable and durable because of their special "double headband system." The cord features a gold-plated stereophone plug. Signet promises full-bodied sound even as you move through the streets of your town. Price: $149.95.

CIRCLE 36 ON FREE INFORMATION CARD

Avanti Plus Telephone

With the proliferation of special-feature telephones, combination answering machine/telephones, wireless instruments, and one-piece units, there must be some consumers still interested in basic home communications via a phone that looks like a phone. Introduced in August, the *Avanti Plus Telephone* from *TeleQuest* (7740 Kenamar Ct., San Diego, CA 92121) is a "new designer telephone" that looks reassuringly basic to us. Available in a range of colors, it features a memory that can store ten phone numbers of up to 16 digits, a hold button with LED indicator, and a tone/pulse switch. It can either be wall mounted or used on a horizontal surface. Its price is pretty basic, too. Price: $34.95.

CIRCLE 38 ON FREE INFORMATION CARD

Compact Zoom Camera

For photographers who are unsatisfied with 35mm compact cameras that provide less-than-creative options, the *Samurai 3x Compact Zoom Camera* from *Yashica* (100 Randolph Rd., CN 6700, Somerset, NJ 08873) promises to deliver quality work in an easy-to-handle package. The multi-coated, large-aperture lens allows three zoom capabilities that can be rapidly focused by the camera's "TTL phase detection system." The camera features a unique vertical configuration that allows easy handling and quick movement from one shot to another. The Samurai 3x includes a slow-shutter synchro flash for night photography. Price: $535.

CIRCLE 46 ON FREE INFORMATION CARD

Portable Air Conditioner

If next summer is anything like this past one, the air-conditioner industry is in for some real growth. One unusual entry in the home air-conditioning field comes from Italy. The *Pinguino Portable Air Conditioner*, distributed in the United States by *DeLonghi America, Inc.* (350 5th Ave., Suite 7712, New York, NY 10118), combines water and air cooling, and discharges warm air and high humidity through an exhaust hose. Mounted on casters, the unit comes with three different mounts for the three-inch exhaust hosing and a removable three-gallon plastic water tank. Controls include an adjustable thermostat, 24-hour programmable timer, two-speed ventilation and cooling and a warning light signaling the need for compressor servicing. The entire rig weighs in at 88 pounds. Price: $999.

CIRCLE 41 ON FREE INFORMATION CARD

Winter Sports Watch

Winter sporting enthusiasts are a hardy group who demand a tough, durable watch, like the *Winter Sports Watch (XC30)* from *Casio, Inc.* (570 Mt. Pleasant Ave., P.O. Box 7000, Dover, NJ 07801). The instrument is designed to withstand temperatures from as high as 122° to as low as 22° below zero. The easy-to-detach band can fit around ski gloves, while the watch itself includes calendar, alarm, and split-time functions with a thirty-lap memory. The digital face has a backlight for viewing in the dark and the XC30 is water resistant up to 50 meters below the water's surface. Price: $49.95.

CIRCLE 45 ON FREE INFORMATION CARD

Gizmo/Bytes

Audi 200 Car Music System

If you ve been searching for a new stereo system for your 1989 Audi 200, look no further. For the first time, a stereo system has been acoustically customized for an individual automobile. The *Audi 200 Car Music System* developed by the *Bose Corp.* (The Mountain, Framingham, MA 01701) is standard equipment on the 1989 Audi 200 Series, and will be offered as an option on the Audi 100 Series. The system includes a Blaupunkt cassette deck and AM/FM receiver modified by a trio of Bose circuits; two front door enclosures that contain 4.5-inch full-range drivers and separate amplifier/equalizer modules in each enclosure; and two 6- by 9-inch full-range loudspeakers, each with its own amplifier/equalizer module. The system is designed to work with the acoustics of the vehicle's interior and produce sound in keeping with the Audi's swank reputation. Price: Not Announced.

CIRCLE 50 ON FREE INFORMATION CARD

Custom Audio System

Cord Free Telephone

The wireless-telephone market continues to grow, but some manufacturers, like *GTE* (1 Stamford Forum, Stamford CT 06904), say that too often consumers are expected to give up quality for convenience. The company's new *Walkmate Cord Free Telephone* is said to retain "the sound and feel of corded phones" while featuring the handy mobility of cordless instruments. The GTE Walkmate features a 21-number one-touch memory feature, along with pause, last-number redial, and hold features. The handset fits comfortably on the user's shoulder for total, hands-free freedom. Price: $139.95.

CIRCLE 43 ON FREE INFORMATION CARD

Home Video Audio Mixer

If you don't like the way your home videos sound you can unleash your creative abilities with the *Video Soundmixer* from *Sima Products* (4001 W. Devon Ave., Chicago IL 60646). The system can be used to jazz up the soundtrack of your home productions with functions that allow the user to change or add narration, background music, and whatever else ended up on the original soundtrack. During video copying, the SoundMixer is connected between the play and record VCR's; as the audio signal is transferred, narration, sound effects, and music can be added to the duplicated tape without changing the original. And, if the final mix doesn't work out to your liking, you can repeat the process. Sima says "the final soundtrack is only limited by the creativity of the video maker." Price: $79.95.

CIRCLE 44 ON FREE INFORMATION CARD

Home Video Audio Mixer

Hand-Held Calculator

The search for an inexpensive, hand-held calculator is neverending in a market flooded with such products. One of the newest is the *TS-82 Hand-Held Calculator* from *Canon U.S.A., Inc.* (One Canon Plaza, Lake Success, NY 11042). The calculator runs off both batteries and solar power, so it can be used day and night even in the absence of conventional electrical outlets. It also features large keys and an easily adjusted tilt-display screen. The eight-digit, single-memory TS-82 includes the usual calculator features, plus percentage add-on/discount and a mark-up calculation key. Price: $9.95.

CIRCLE 42 ON FREE INFORMATION CARD

Hand-Held Calculator

Digital Ensemble System

We didn't know what a digital-ensemble system was, but we're not musicians. It is, of course, one of the new electronic instruments that are rapidly changing the production and sound of popular music. The recently introduced *Digital Ensemble System (SX-PR100)* features a new key design with a weight device similar to that of the traditional, acoustic piano. From *Technics* (One Panasonic Way, Secaucus, NJ 07094), the SX-PR100's 76 keys are weighted in the rear to speed up key return, providing what Technics calls a "concert touch." The ensemble uses a high-performance LSI (large-scale integrated circuit) to record and encode pure instrumental sounds into its digital PCM (pulse code modulation) format, resulting in "rich tones and sparkling overall sound performance." The unit offers keyboard percussion, full drum kit, and 35 tones including background sound effects like thunder, shattering glass, race-car noises, and bird songs. Balance adjustment is via a five-channel control. Player pianos were never like this. Price: $3,995.

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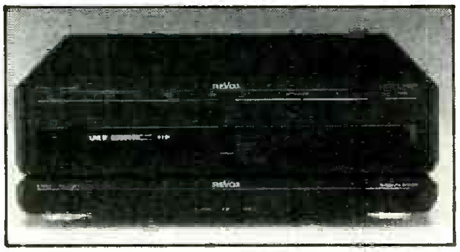
Digital Ensemble System

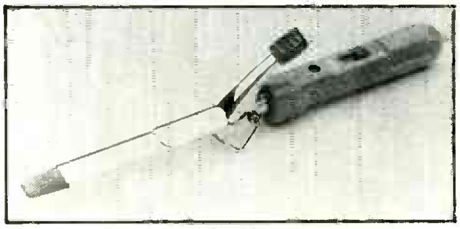
Gizmo/Bytes

Golf Training Club

Sports Wallet/Digital Watch



Integrated Amplifier



Styling Iron

Compact 35mm Camera

A newly introduced, fully automatic, motorized 35mm camera from *Konica U.S.A., Inc.* (440 Sylvan Ave., Englewood Cliffs, NJ 07632) is described as "setting a new price point" for cameras in its class. Translated from marketing jargon, this means the new *Pop-Super Compact 35mm Camera* is exceptionally low priced for a unit featuring built-in automatic electronic flash; automatic film loading, advance, and rewind; and a fixed-focus 35mm *f*/4.5 lens. Powered by a lithium battery, the Pop-Super's flash is rechargeable in 3 seconds. This new pocket camera is available in red, blue, and black. Price: $128.

CIRCLE 55 ON FREE INFORMATION CARD

Golf Training Club

Without ever hitting a single golf ball or even leaving your home, you can improve your golf game with the *Graphite Shaft Power Trainer*. Available from *The Sharper Image* (650 Davis St., San Francisco, CA 94111), the club features a series of spring-resistance levers that monitor the critical timing of a golfer's swing release, and shows how far the ball would travel on an electronic display panel built into what would normally be the business end of the club. If the duffer releases too soon, the club clicks far behind the tee for a big slice into the woods. Swing too late and the ball hooks into the pond. But with the Power Trainer, the novice golfer can learn to click the club at the precise moment and get the positive reinforcement represented by a 250-yard drive as registered on the display panel. Price: $129.

CIRCLE 51 ON FREE INFORMATION CARD

Sports Wallet/Digital Watch

Everyone knows that time is money and here's a product that combines those two essentials into one convenient, budget-priced package. The *Sports Wallet/ Digital Watch (MWS5)*, available through *NDQ Marketing* (989 Sixth Ave., New York, NY 10018) is designed for joggers, runners, walkers, and other exercise enthusiasts who are tired of lugging around bulky bags or wallets. A digital quartz watch is built into the wallet, equipped with a handy Velcro snap that closes securely around the wearer's wrist without binding. An included wrist band is made of terry cloth to absorb perspiration during work-outs. The accessory can be used for identification and cash, or whatever else the jogging, running, or walking user might need during an exercise session. The watch itself offers hour, minute, day, date, and month. The Wallet/Watch is available in red, white, or blue. Price: $7.95.

CIRCLE 54 ON FREE INFORMATION CARD

Integrated Amplifier

The Swiss have long been known for elegant electronic products. A new amplifier exemplifying that consumer tradition has been introduced to the North American market. From *Revox Division, Studer Revox America, Inc.* (1425 Elm Hill Pike, Nashville, TN 37210), this *Integrated Amplifier (B250-S)* features European design in both its cosmetic and electronic aspects. The amp offers six inputs with independently adjustable levels, optional video-switching capability, and simultaneous preamp and power-amplifier outputs for enhanced multi-room installations. A non-volatile memory assures that none of the programming will be lost because of accidental disconnection or a power failure. Programming controls are behind a glass door for further security from inadvertent resetting. The system's specifications match or exceed the wide dynamic range of digital-tape recordings and compact discs. Remote control is via the Revox hand-held *B208* unit and it can easily interface with the company's *B209* Easyline infrared multiroom remote system. The unit's sophisticated systems are housed in a case featuring a black-and-gold color scheme accented by high-gloss lacquer side panels, for what sounds like a fairly high-gloss amp. Price: $2,500.

CIRCLE 52 ON FREE INFORMATION CARD

Styling Iron

Perhaps the biggest problem with hair-curling irons is the danger of accident from a hot unit left in harm's way of unsuspecting children (or adults) who may burn themselves on an untended heating element. The *Automatic Shut-Off Insta-Heat Styling Iron (VS-181)* from *Vidal Sassoon Appliances* (6827 Market Ave., El Paso, TX 79915) is the answer to that potential household accident waiting to happen. The unit features a light that flashes every 30 seconds to indicate that the iron is hot, and has a switch that automatically turns the iron off when it is left unused. The model also comes with a safety stand and a spring grip. Price: $19.99.

CIRCLE 57 ON FREE INFORMATION CARD

Gizmo/Bytes

Video Camera/Recorder

Any problems users have in properly focusing video cameras are reportedly solved by the new Master Series Advanced VHS-C *Video Camera-Recorder (C-50)* from *Minolta Corp.* (101 Williams Dr., Ramsey, NJ 07446). The company calls the unit its "most advanced," incorporating the "latest video technology." What this comes down to is an auto-focus system offering increased versatility and ease of operation. Other advanced features for that compact-VHS camera/recorder include high-speed shutter and a high-resolution CCD sensor with 300,000 pixels that requires no warm-up time. A "multi-dimensional auto-focus system" will keep a moving subject in focus, and can be switched off to keep focus on a fixed object. A "dual-area auto-exposure" measures the light of two areas, the entire image and the central portion of the image. Exposure is continuously calculated and adjusted, providing good exposure while over-exposing the image background as little as possible. Other advanced systems include white-balance and a full-information electronic viewfinder. Minolta says its multi-dimensional auto-focus system is "the world's only." Price: To be announced.

CIRCLE 60 ON FREE INFORMATION CARD

Video Camera/Recorder

Multi-Media Storage File

It seems as though everyone is going multi-media these days, with compact discs, audio and video cassettes, and floppy disks—and each requires storage when not in use. A new system from *Centron Corp.* (1651 S. College Blvd., Anaheim CA 92806) promises to consolidate electronic-media storage. The *Amalifi Smartbox Multi-Media Storage File* features interchangeable inserts that allow it to be adapted to the needs of CD's, cassettes, or disks. As the user's needs change, the inserts can be reconfigured for maximum utility. The unit's two sliding drawers have a combined single-media capacity of 34 CD's and four double discs, 48 audio cassettes, and 24 VHS or Beta video cassettes. The box can easily hold 42 computer diskettes of the 5¼-inch variety. The box is made of high-impact polystyrene and engineering-grade ABS plastic with a steel-reinforced frame that allows it to be used as a base for a CD player, VCR, or even a TV. In addition, the boxes can be stacked. Price: $69.95.

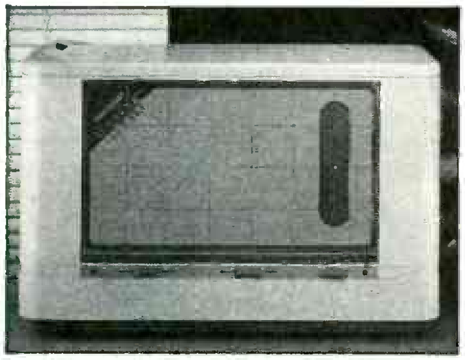
CIRCLE 56 ON FREE INFORMATION CARD

Multi-Media Storage File

Ultrasonic Humidifier

In dry apartments or houses, or in dry climates, a humidifier has become a near necessity for many. The purpose is simple—to keep air moist and comfortable. A new *Ultrasonic Humidifier (1822)* from *Soundesign Corp.* (Harborside Financial Center, 400 Plaza Two, Jersey City, NJ 07311) is described as doing that efficiently and easily. The unit produces a cool, vapor mist that helps alleviate dry skin, upper-respiratory ailments, and even dryness-related damage to furnishings. At full intensity, the unit can vaporize its 1.5-gallon tank of water in 15 hours. With mist intensity set to 70 percent, it takes as long as 36 hours to empty the tank. The mist nozzle can be rotated for pinpoint flow and the tank can be easily removed and refilled. The humidifier is 15⅞-inches wide by 6¼-inches deep by 10⅝-inches high. Price: $69.95.

CIRCLE 62 ON FREE INFORMATION CARD



Ultrasonic Humidifier

Three-Way Acoustic Suspension Loudspeaker

Stereo consoles used to be belittled by stereo buffs for being just so much furniture. But today, some of the most sophisticated audio components also happen to be beautiful examples of the art of cabinet making. The new *Series II Three-Way Acoustic Suspension Loudspeaker (T1000)* from *Boston Acoustics* (247 Lynnfield St., Peabody, MA 01960) is an impressive tower of audio sophistication, handsomely encased in walnut, oak, or black-ash vinyl finish. Inside, twin copolymer 8-inch woofers in individually sealed compartments, 6½-inch copolymer midrange, and a CFT 1-inch dome driver offer "greater power handling capacity and deep bass than" the T1000's predecessor model. The speaker stands 41½-inches tall. Price (per pair): $1,000–$1,200.

CIRCLE 59 ON FREE INFORMATION CARD

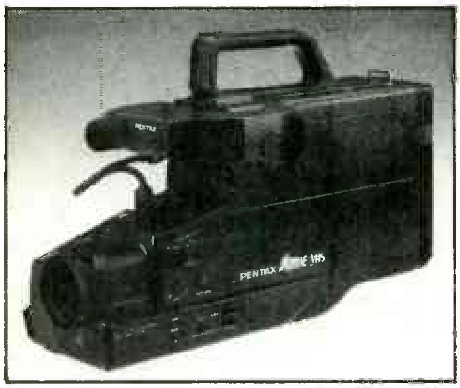
CD Disc Adapter

The 3-inch compact disc may not have set the CD market on fire, but that hasn't stopped *Discwasher* (4310 Transworld Rd., Schiller Park, IL 60176) from introducing its version of a *CD Disc Adapter*. Made of plastic, the gadget will allow players to handle the new, smaller CD. The adapter snaps into a CD single and can be left in place more or less permanently. Price (for two adapters): $3.99.

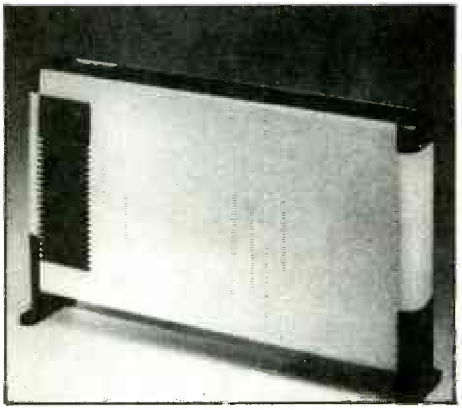
CIRCLE 58 ON FREE INFORMATION CARD

CD Disc Adapter

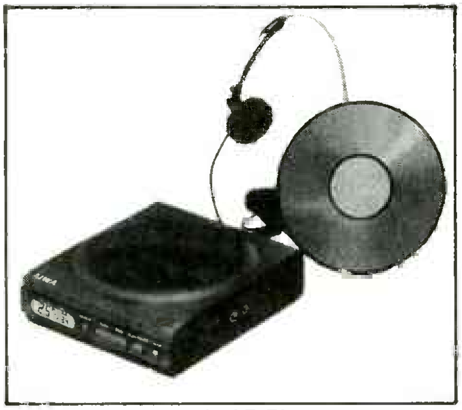
Gizmo/Bytes



VHS Camcorder



Convector Heater



Portable CD Player

Pocket "Terminator"

VHS Camcorder

Five speeds, available through high-speed shutter controls, allow blur-free slow motion and still playback from the *VHS Camcorder (PV-C67A)* from *Pentax* (35 Inverness Dr. E., Englewood, CO 80112). The PV-C67A employs a solid-state MOS image sensor incorporating 300,000 picture elements to help guarantee sharp images. The camcorder also features wind-noise cut and a macro feature that allows the user to shoot just an inch from the surface of the lens. The camcorder weighs just over 5 pounds and features an electronic viewfinder that displays information on battery condition, a tape counter, and a warning that indicates when only 5 minutes remain on the cassette. Price: $1,899.

CIRCLE 61 ON FREE INFORMATION CARD

Convector Heater

With heating costs a concern for many consumers, an additional heater is often useful for warming smaller areas in the home. The Dual Flow *Convector Heater (DF 15)* distributed by *DeLonghi America, Inc.* (625 Washington Ave., Carlstadt, NJ 07072) features top-panel louvered blades that, in combination with the heater's fan, quickly move heat through the unit and out into the room. Controls feature 750- and 1500-watt settings and a thermostat that maintains the desired temperature by automatically turning the heater on and off. In the summer, the same unit functions as a fan, controlled by a separate fan switch. Price: $69.99.

CIRCLE 66 ON FREE INFORMATION CARD

Automotive Music System

A problem that often crops up with car stereo is the need to fiddle with the dials and controls while driving, an action that can be as dangerous as it is irritating. In its new *Car Audio Head Unit (CQ-R9550), Technics* has developed an answer to that vexing problem. The unit features a "touch-sensitive face" that changes to match the system's full-logic cassette player, tuner, and an optional CD changer. Each source has its own illuminated function legends and when one of them is activated, the system produces a confirmation beep. In addition, a marker light corresponds to the source being accessed. With a supplied palm-size remote control, the driver can also control the unit without even looking at the display and control panel. The CQ-R9550 includes a mute switch, an illuminated power switch, and an automatic antenna lead. The system tuner, Technics' "Alpha-tuner," features 24 station presets and a preset scan. The user can tune manually by touching the face of the unit or by using the wireless control, making it simple to keep one's eyes on the road and one's ears on the music. Price: $750.

CIRCLE 64 ON FREE INFORMATION CARD

Portable CD Player

Music-to-go seems to be the dominant trend in audio tastes today, so it's not surprising that *Aiwa* (35 Oxford Dr., Moonachie, NJ 07074) is in the running (and walking and driving) with a new ultra-compact *Portable CD Player (DX-P1)*. Incorporating a three-beam laser pickup that prevents "the music from bouncing around under more strenuous portable conditions," the unit also includes a double over-sampling digital filter, two-way repeat, cue and review, and LCD back lighting for track number and elapsed playing time. Power is AC/DC (the player uses "AA" alkaline batteries, good for about 4½ hours of play) and is sold with battery case, carry strap, "Y" output cord, and a CD-single adapter. Price: $250.

CIRCLE 65 ON FREE INFORMATION CARD

Pocket Terminator

For the surprise of someone's life, why not use the sound of a death ray to startle that special friend? With the *Pocket Terminator* from *Hyman Products* (2392 Grissom Dr., St. Louis, MO 63146) you can produce an audio jolt anywhere you go. The Terminator uses two "AAA" batteries for complete portability and simulates the sound of a missile launcher, tommy gun, or death ray, modeled on the effects used in popular video games. The unit is finished in high-tech flat black and can be worn on a belt or attached to a car dashboard (or elsewhere) with a Velcro fastener. Price: $7.99.

CIRCLE 63 ON FREE INFORMATION CARD

Popular Electronics
HANDS-ON REPORT

LUNDIN LABORATORIES FAMILYCARE SOFTWARE

CIRCLE 86 ON FREE INFORMATION CARD

Have your computer perform the same diagnostic process as your pediatrician

There is no replacement for a trained and experienced doctor in the field of pediatric medicine. When your child needs a doctor, you go to the best physician you can. Nevertheless, the parents are the ones who make almost all the decisions with regard to the health care of their child. A parent knows what the child is like when healthy, so a parent is usually the first to notice the symptoms of illness and decides whether or not help from a professional practitioner is required.

Pity the poor parents, for their experience in childhood-illness diagnosis is nil, especially if it is their first child. Strangely, all too often they rely on the experience and advice of other parents. Very few parents have doctors in their families to call and assist them in minor health emergencies. Well,

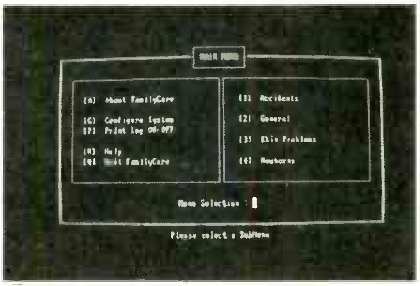


Fig. 1. The main menu is divided in two. The left hand portion is for first-time users and those who need orientation. The right side indicates the first step in the diagnostic process. To review accidents, simply type the number 1 and hit the <ENTER> key.

FamilyCare Software, a computer program, can help! It is a model of the diagnostic process that doctors use. It asks clear, easily understood questions about the child's medical condition which can be answered with a "yes" or a "no." Then it provides easy-to-follow directions and recommendations for non-emergency medical conditions. At times, it suggests over-the-counter medications to alleviate symptoms. Most importantly, it identifies the symptoms of serious problems so you can call for immediate assistance.

Starting Up. To run FamilyCare Software you will require an IBM PC, XT, AT, or other 100% compatible computer with at least 256K of RAM using DOS 2.0 or higher.

Macintosh users, do not despair. FamilyCare Software will run on your computer provided you have 512K of RAM and one 800K disk drive or two 400K disk drives. FamilyCare Software can be loaded onto a hard disk and it requires 720K of empty disk space.

The software has a configuration guide that will assist you in configuring the program to your system. Follow the configuration menu offered, and you'll be as smart and successful as the reviewer in getting started. Don't rush into copying of the software directly to your hard disk. The program must be configured for the hard disk before it is copied to it. A word of caution: make your back-up disks first!

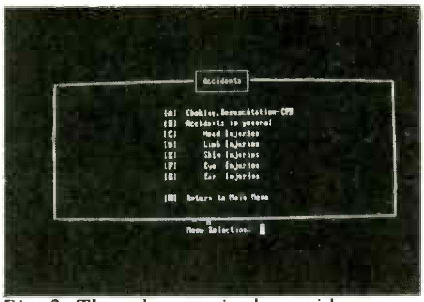


Fig. 2. The sub-menu in the accidents category contains seven choices, each of which is discussed in detail.

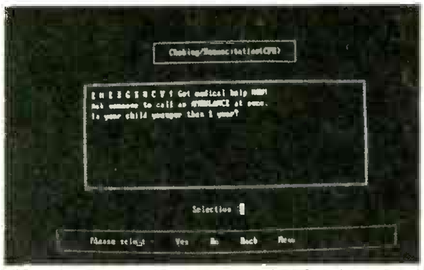


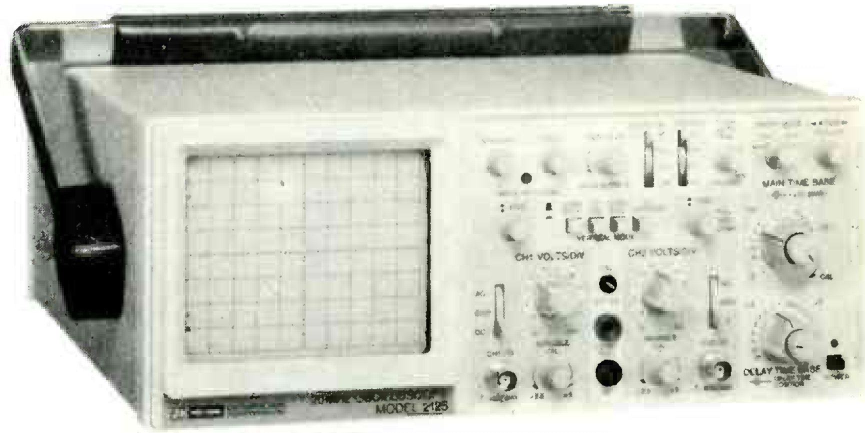
Fig. 3. The instructions make the first step clear. The following diagnostic questions move quickly and guide the parent to the proper emergency treatment.

Seeking Advice. Once loaded, you can call up FamilyCare Software by typing FAMCARE and pressing <ENTER>. The Main Menu (shown in Fig. 1) pops up on the screen and the health-topic choices are on the right. I selected "Accidents" and a different menu came up, see Fig. 2. So I selected "Choking, Resuscitation–CPR" be-

(Continued on page 105)

Choosing and Using an OSCILLOSCOPE

BY JOSEPH J. CARR



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

If you ask the best electronics professionals what instrument they would select if they were allowed only one, then you would see the extent to which the "pros" esteem the cathode-ray tube oscilloscope. The *CRO* is arguably the single-most valuable electronic instrument on the bench.

Briefly stated, an oscilloscope is an instrument that uses a cathode-ray tube (CRT)—a device similar to a television picture tube—to display a voltage waveform. The display may be a graph of voltage vs. time, or one voltage vs. another. In a CRT, a beam of electrons from an "electron gun" strikes a phosphor-coated viewing screen, creating a spot of light where the beam strikes. The beam can be deflected either magnetically or electrostatically to draw waveforms of light in the phosphor. Service-, workbench-, and laboratory-type oscilloscopes used in electronics use electrostatic deflection. Television receivers (and some medical patient-monitor oscilloscopes) use a magnetic deflection CRT in which an electromagnet (called a "yoke") around the neck of the CRT generates the controlling magnetic field. The poor frequency response and nonlinearity of magnetic deflection systems makes them unsuitable for use at frequencies above a few hundred hertz, but that's okay for medical use.

Deflection. Electrostatic-deflection CRT's use a pair of deflection plates (Fig. 1), to deflect the electron beam in the vertical and horizontal directions. When a the beam is centered, it indicates that the voltage across the horizontal plates and the voltage across the vertical plates are both zero. The beam is travelling straight down the neck of the CRT and striking the screen in the center without deflection. If the vertical plates remain balanced, while the horizontal plates are unbalanced so that the left side is now more positive (or less negative) than the right side, the beam (and light spot) is yanked to the left. Similarly, when the horizontal plates are balanced or zero, and the vertical plates are unbalanced (let's say the top vertical-deflection plate is more positive, or less negative, than the bottom plate) then the beam moves up the screen. You can use both sets of plates in unison to move the beam to any location on the tube face, as you can see from the photos.

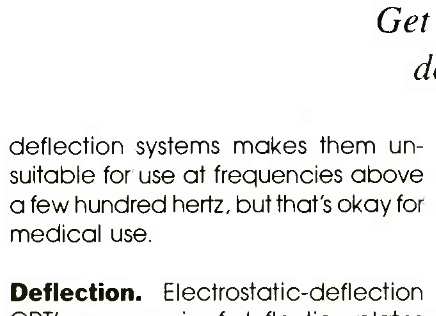


Fig. 1. Once a beam of electrons is generated by the electron gun, the deflection plates deflect the beam in the vertical and horizontal directions to trace patterns on the screen.

If a sawtooth waveform is applied between the horizontal deflection plates, then the beam will sweep from left to right, jumping back to the left suddenly. The time it takes the beam to sweep across the scope is called the timebase. If a time-varying input signal is applied across the vertical plates (see Fig. 2) while the sawtooth controls the horizontal deflection, then the electron beam will trace the signal on the CRT screen.

Similarly, instruments called "X-Y oscilloscopes" allow the user to apply input signals to both horizontal and vertical deflection plates to form a pattern that allows us to see the relationship between two signals. Such diagrams are called "Lissajous patterns."

You can measure audio frequencies using the Lissajous pattern. The ratio of the number of loops along the vertical and horizontal sides of the pattern tell you the relationship between frequencies applied to vertical and horizontal inputs (see Fig. 3A). In the case shown in Fig. 3A, the horizontal waveform is half the frequency of the vertical waveform, which is shown with various phase shifts. Notice there are two vertical peaks and only one horizontal peak no matter what phase shift is being examined. In the case shown in the photo, the two signal sources were a 6.3-VAC filament transformer (at 60-Hz) and a 180-Hz audio-signal generator. The signal generator was adjusted until the pattern became stable and "locked-in" on the CRT screen. The picture was taken when the frequency ratio 3:1 (i.e. 180:60) was reached. If you own an oscilloscope like that and a signal generator, you can determine the frequency of an unknown signal.

If the two input signals have the same frequency, then the pattern they make (an ellipse) can be used to determine the phase shift (θ) between them (see Fig. 3B).

Triggered Sweep. At one time only rich hobbyists and technicians could afford a decent oscilloscope. Although clever hobbyists always seemed to find a way to buy a military- or industrial-surplus oscilloscope, others had to content themselves with kit-built, low-frequency models. Today, however, the electronic hobbyist and amateur-radio enthusiasts can have their choice of good, high frequency, models that vary from cheap to back-breaking in cost. But, even top-name oscilloscopes are no longer that far out of reach if you compare their cost to the cost of other hobby equipment such as ham sets, cameras, or fishing boats.

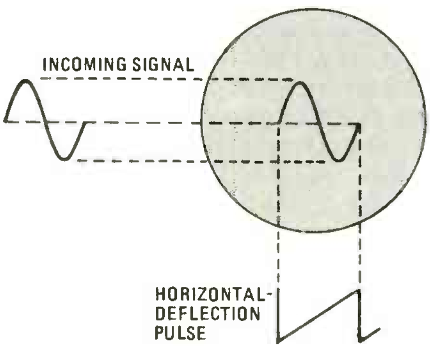
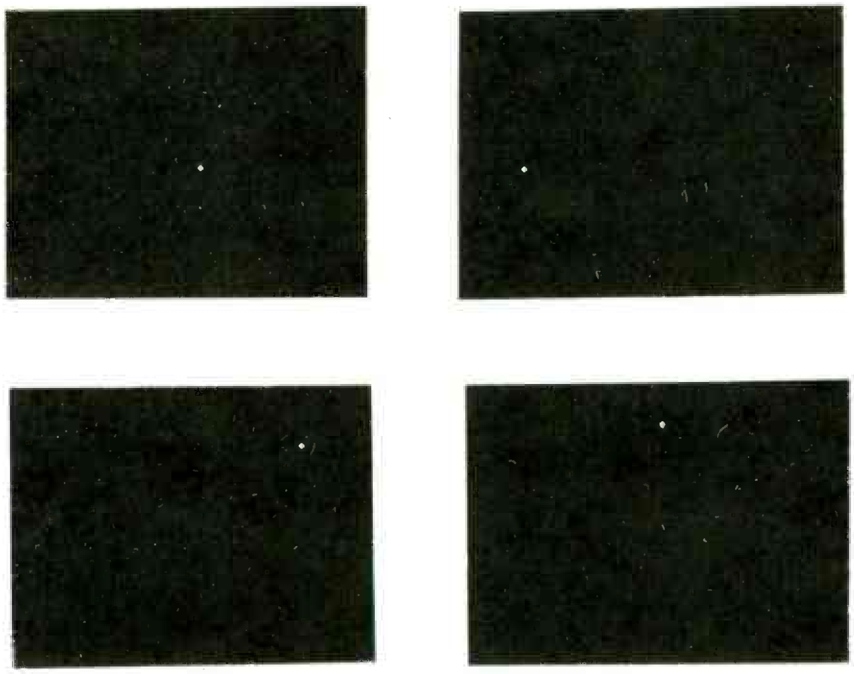
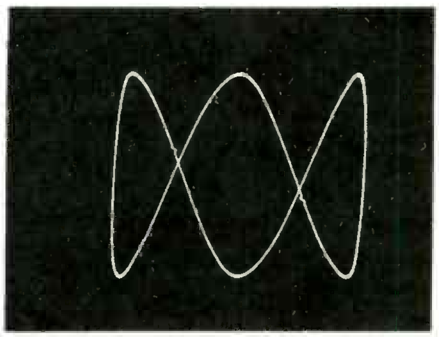


Fig. 2. If an input signal is applied across the vertical plates while a synchronized sawtooth controls the horizontal deflection, then the electron beam will trace the input signal on the CRT screen while it is swept by the sawtooth.



Starting from the upper-left and moving clockwise, you can see the beam in the middle of the screen when there is no potential across the plates, it shifts left for a positive potential on the left plate, it points up when the upper plate is positive, and the beam can be shifted anywhere on the screen by any combination of potentials.



When two waves control the beam position, a Lissajous pattern is formed from them.

No matter how much an oscilloscope costs they all have some features in common. Like all modern oscilloscopes, the ones shown in the photos have triggered-sweep capability. That means that the beam does not start to sweep left-to-right across the CRT screen until it receives a signal (called a trigger pulse) to tell it to. By controlling when the sweep is triggered, we can make the oscilloscope display a portion of a waveform beginning at a point we specify. Note that the CRT's shown have a screen with a graticule grid inscribed on the face. The divisions (usually 1-cm each) are used to measure voltage and time: we will discuss those in more depth later.

Older model oscilloscopes were not trigger swept. In those models, the horizontal deflection of the beam was asynchronous with respect to the input signal. The horizontal-sweep controls were calibrated roughly in units of frequency, i.e. the number of times per second the beam swept left to right. Such instruments are of limited usefulness today. Most of them have a low frequency vertical-amplifier bandwidth, and so cannot display many of the signals that are of interest to the modern electronics enthusiast.

Dual-Trace Features. Another boon to the hobbyist is the dual-trace oscilloscope. Those instruments were once rare and expensive. But today manufacturers can offer dual-trace capability in their most modest units, so the instruments are now quite common.

There are two separate vertical inputs on the CRO's, so two separate signals can be viewed simultaneously against the same timebase. Two vertical-position controls (one for each channel) can be adjusted to either su-

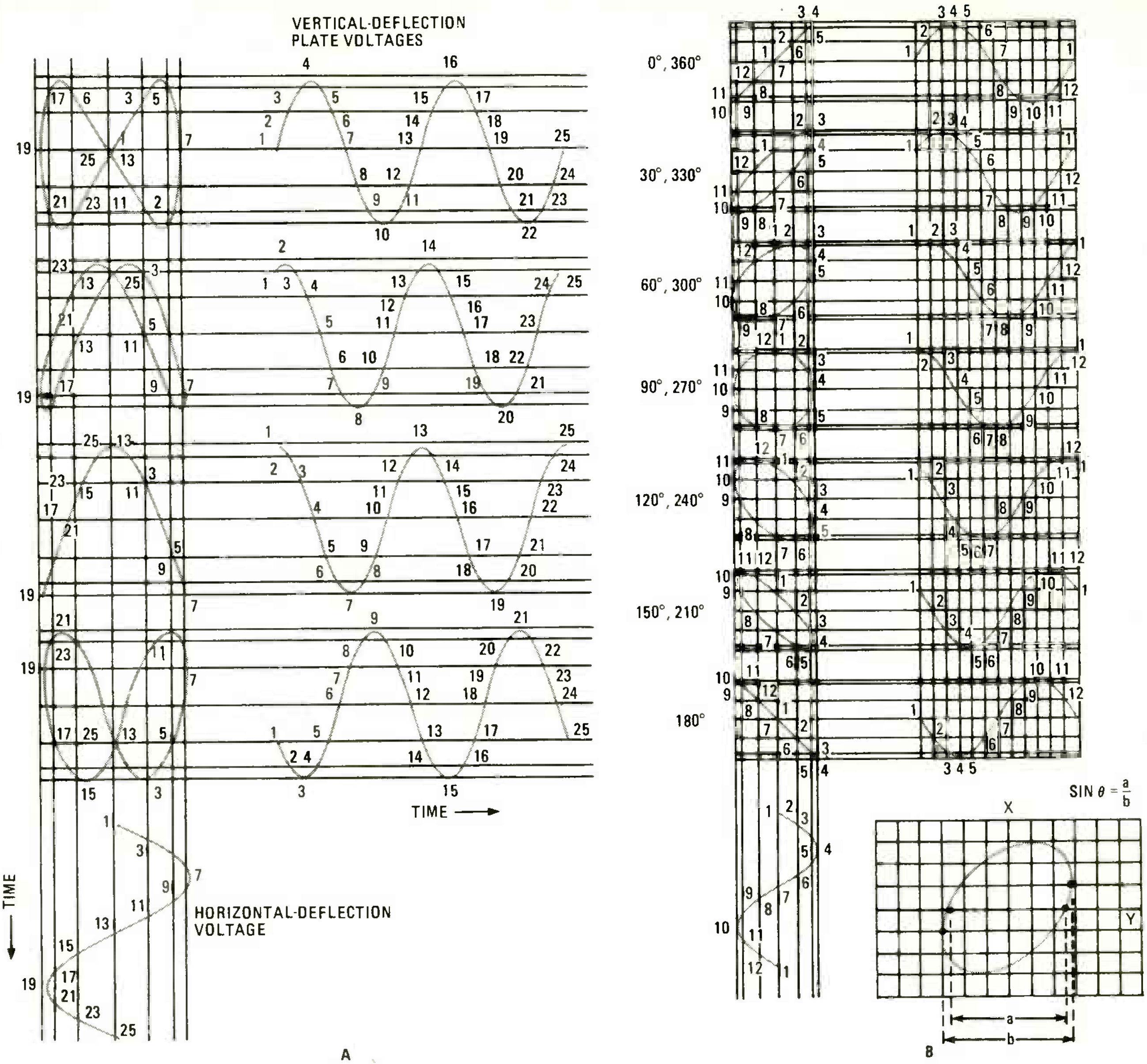


Fig. 3. The waveform used for horizontal control in A, is half the frequency of the input vertical waveform. That means that no matter what the phase difference is there are always two vertical peaks and only one horizontal. If the two input signals have the same frequency, then the ellipse they make can be used to determine the phase shift.

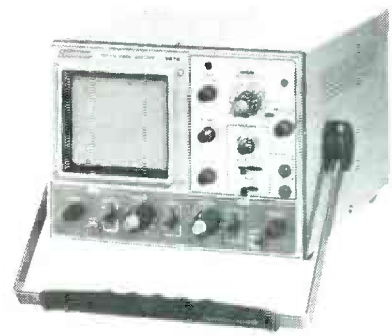
perimpose or vertically separate the input signals (more on that later).

Dual-trace capability is extremely useful for examining the time relationship between two signals, or comparing them closely. It's greatest application is in troubleshooting. For example, dual-trace CRO's can be used to simultaneously examine the input and output at one stage of a circuit to determine which stage is malfunctioning.

Bandwidth Importance. Vertical bandwidth is a specification of much interest in selecting an oscilloscope. At one time, high frequency vertical amplifiers were available only in the most expensive laboratory-grade instruments. For example, in the mid-1960's one expected to pay $4000 for a 35-MHz, two-channel oscilloscope (and those were 4000 "then-current dollars"). But today, we can buy 35-MHz oscilloscopes for less than 1000 current dollars, and 100-MHz models are only about $2300. As a general rule of thumb that is valid in most cases, select a model with as high a vertical bandwidth as you can afford. It is difficult to go wrong with too much vertical bandwidth, but too little can cost you capability.

Of course, even though domestic and imported models are inexpensive enough to allow you to obtain good performance at low cost, it is still possible to spend big bucks for a really fine laboratory-grade oscilloscope. Such a top-of-the-line model is a bit beyond the needs and price-class of hobbyists, but discussing them will help you to know what's out there. The *Tektronix Model 7104*, shown in one of the photos, works at frequencies up to 1000-MHz, and uses vertical and horizontal plug-in modules that allow the user to custom-configure the oscilloscope to specific tasks.

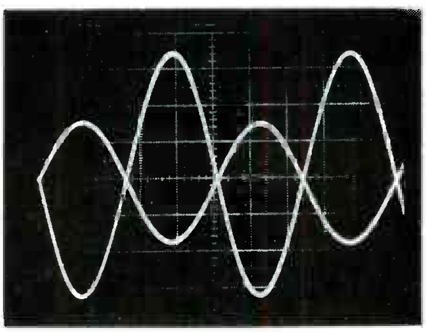
Now let's briefly discuss typical controls found on modern oscilloscopes to

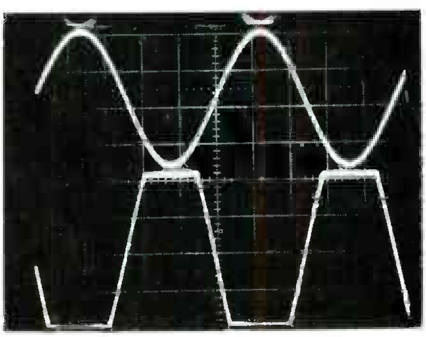


A 10-Mhz dual-trace oscilloscope, such as this B + K, is perhaps the most commonly used oscilloscope for hobbyist work.

give you some insight as to their features. Keep in mind that not all of the controls mentioned are on all oscilloscopes, especially some of the specialized triggered-sweep options that some models offer. Also, on some models the same controls may carry slightly different names on the labels, but function pretty much the same. We will divide the controls into the following groups: control, vertical, horizontal, and triggering. Occasionally we include a pertinent connector among the controls of a group to reveal its relevance to that group.

Control Group. The control group (some of which may appear on the rear of the oscilloscope), includes the ON-OFF (POWER), INTENSITY, FOCUS, ASTIGMATISM, ILLUMINATION, TRACE ROTATION, and BEAM FINDER controls, and the CALIBRATION-SIGNAL output. Let's discuss the most important one first.





The vertical position controls can superimpose two signals for amplitude and phase comparison, (upper photo) or separate them for easy viewing.

ON/OFF—The control that turns the instrument on and off it is the AC main power switch (or battery switch in portable models). On some oscilloscopes, the ON/OFF switch is part of another control (usually INTENSITY), similar to the ON/OFF switch on a radio being ganged to the VOLUME control. On other oscilloscopes the ON/OFF switch is a separate entity. When that is the case, on most modern oscilloscopes it is a pushbutton switch, while older models contained either a toggle or rotary switch.

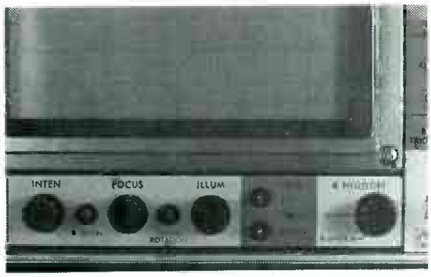
Intensity—The INTENSITY adjustment controls the brightness of the CRT beam. As a general rule, the INTENSITY control should be kept just high enough to see the entire waveform comfortably. If the same waveform is expected to remain on the CRT screen for a long time (or there is no waveform), then the intensity should be kept low in order to prevent burning the CRT phosphor.

Focus—The FOCUS control adjusts the size of the electron beam spot on the CRT screen. It often interacts with the ASTIGMATISM control (description following).

Astigmatism—The ASTIGMATISM control adjusts the "roundness" of the CRT spot, and often affects the FOCUS control. A good way to adjust the ASTIGMATISM control is to set it for a uniform line thickness when the CRT is swept horizontally (with no signal present in the vertical channel). On many oscilloscopes, the ASTIGMATISM control is a screwdriver adjustment available on either the front or rear panel, while the FOCUS control is knob-adjustable from the front panel.

Illumination—The ILLUMINATION control adjusts a lamp that lights up the graticule lines inscribed on the CRT screen. At the lowest setting, no light appears on the graticule. Care must be taken with the control when photographing the CRT screen, as the graticule lighting can overexpose the ASA 3000 film typically used in oscilloscope photography.

Trace Rotation—The TRACE ROTATION (also called TRACE ALIGN on some models) is a screw adjust that compensates for the effects of local magnetic fields on the CRT trace. The control is adjusted so that the CRT beam is horizontal with respect to the graticule.



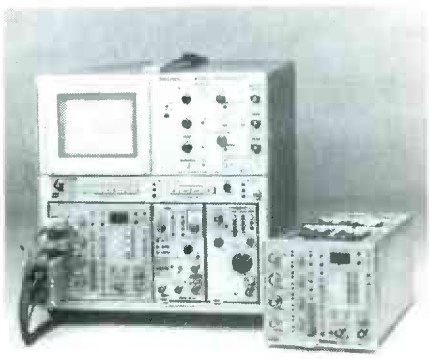
The main control group is shown here. The power switch on many scopes is ganged to the intensity control, but on this Kikusui, it is off to the left of the intensity adjust and is not shown here.

Beam Finder—This control disconnects the horizontal and vertical inputs, so that the beam collapses to a spot with higher intensity than the trace. It helps the operator locate the beam if it is off the screen or if the intensity is set too low.

Calibration—The CALIBRATION control provides a standard signal to calibrate the vertical-amplifier controls. Typically, such signals are 400 or 1000 Hz, at either1 or 2 volts peak-to-peak. In some cases it is a sinewave, in others a squarewave. In the closeup shown, the 1000-Hz squarewave has both 2-volt and 200-millivolt amplitudes.

The Vertical Group. The vertical group of controls adjust the vertical position of the beam, amplification factor, and input selection of the oscilloscope. Items in the group include: INPUT, INPUT SELECTOR, VERTICAL POSITION, STEP ATTENUATOR, VERNIER (VARIABLE) ATTENUATOR, GROUND, 5× MAGNIFICATION, CHANNEL-2 POLARITY, and VERTICAL MODE.

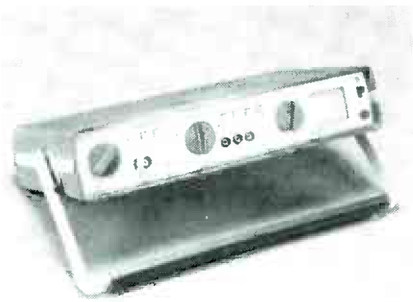
Shown in a photo with them is an INTERNAL TRIGGER selector (INT TRIG), which is technically part of the trigger-control group (its purpose is to select the channel that supplies the triggering signal).



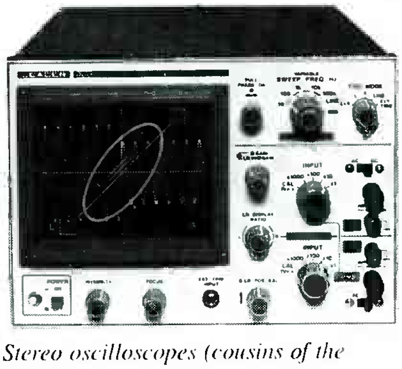
Super-colossal units, like this Tektronix, have plug-in modules (on the right) for specific applications.

Input Connector—The input connector is the point at which signal is applied from the external world to the oscilloscope's vertical amplifier. Today the input connector is often a coaxial BNC-style chassis-mounted connector, but on older oscilloscopes, the input connector might be an SO-239 female UHF coaxial connector, or even a pair of 5-way binding posts spaced on 0.75-inch centers. Because most modern probes and oscilloscope accessories are now BNC-equipped, owners of older models usually opt to buy either an SO239-to-BNC or Post-to-BNC adapter (as appropriate).

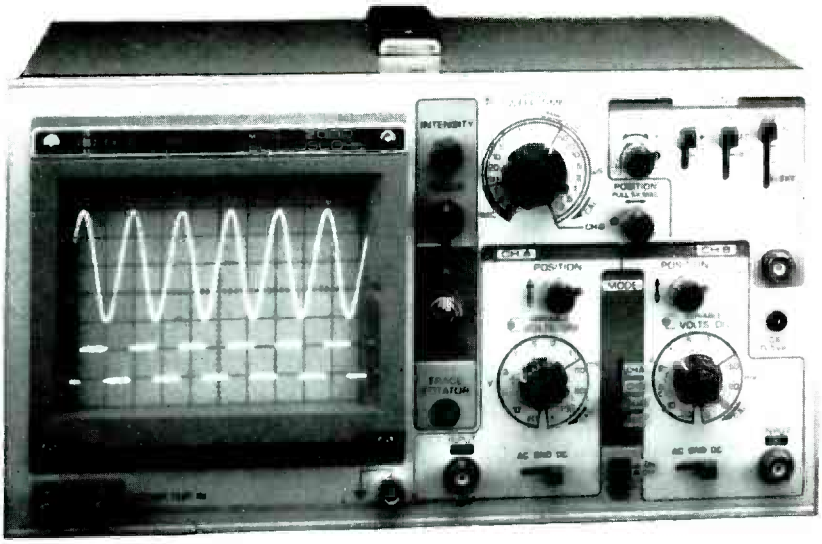
Input Selector—The selector switch is usually marked AC-GND-DC and is used to select the coupling mode of the input to the input of the vertical amplifier. The DC mode means that the connector is DC-coupled to the amplifier input; The AC setting means that a blocking capacitor is in series with the connector center conductor (so only AC signals will pass—DC is blocked); In the GND mode the input of the vertical amplifier is shorted to ground and the input-connector center conductor is open-circuited (the GND mode does *not* ground the input connector, which would short-circuit the signal source!).



Portable scopes, such as this O.K. Industries model, are great for jobs on the go or for really tight spaces.



Stereo oscilloscopes (cousins of the dual-trace models) like this Leader model, allow viewing of two waveforms side-by-side simultaneously.

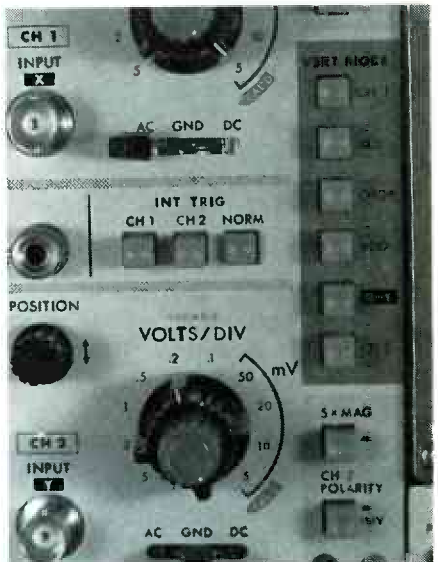


An interesting feature in this oscilloscope from JDR is Z-axis intensity modulation, which gives complex graphs a 3D feeling by altering the beam intensity.

Vertical Position—The VERTICAL-POSITION control moves the electron beam up and down on the CRT face. On a dual-trace oscilloscope the two VERTICAL-POSITION controls are normally used to prevent overlapping of the two traces (and the confusion that would result). Otherwise, the control can be used to precisely position the trace over the horizontal graticule markings for accurate amplitude measurements. It is common practice, for example, to set the AC-GND-DC input selector to "GND" and then use the position control to set the straight-line trace over either the bottom-most or center graticule line, making it the zero-volts reference point.

Step Attenuator—The sensitivity of the oscilloscope amplifier is a measure of its gain, and is expressed in terms of the voltage required to deflect the CRT beam a specified amount, i.e. volts/division (or volts/cm). The step attenuator is a resistor/capacitor voltage divider that allows the instrument to accommodate higher potentials that would otherwise overdeflect the CRT beam. Each position of the step attenuator is calibrated in volts- or millivolts-per-division (V/div or mV/div). The actual peak-to-peak voltage measure of the input signal is made by noting how many CRT screen divisions the signal occupies, and then multiplying that figure by the sensitivity factor in volts/div. For example, suppose a sinewave signal occupies 5.6 divisions peak-to-peak and the step attenuator is set to 0.2 V/div. The peak-to-peak voltage is:

$$5.6 \times 0.2 = 1.12 \text{ volts}$$



The vertical-control group (along with a trigger control). Notice the variety of modes available on the right.

Vernier Attenuator—This variable control is concentric with (in the center of) the step attenuator, and allows continuously variable adjustment of the signal attenuation, and so the trace vertical size as well. The calibration of the step attenuator is valid only when the vernier attenuator is in the "CAL" (calibrated) position, which on most oscilloscopes is detented for easy location. When the vernier control is not in the CAL position, a red *uncal* lamp on the front panel lights.

That's all we have room for this month. When we continue, we'll finish up our discussion of oscilloscope controls and how they are used. We'll then move on to show you how to get the most from this valuable instrument. ■

Grandpa's Shortwave Receiver

BY HOMER L. DAVIDSON

Build our regenerative receiver and enjoy shortwave as Grandpa did.

Back in the thirties, the regenerative shortwave receiver was the king of the road. Grandpa's regenerative receiver probably consisted of one or two tubes, a 1400-pF capacitor, and plug-in coils to tune in the 160-, 80-, 40- and 20-meter bands. Today, those parts are hard to get—in fact, they are nowhere in sight unless you are an antique-radio collector.

So how can you build *Grandpa's Radio* yourself without having to obtain all the hard-to-find parts? By building those components yourself and making some compromises on authenticity. Our version of grandpa's radio has homemade coils (including the choke). It even has a tickler coil that is used for all the bands. Since tube sockets and bases are hard to get for the plug-in coils, a multi-position switch is used to select the operating band.

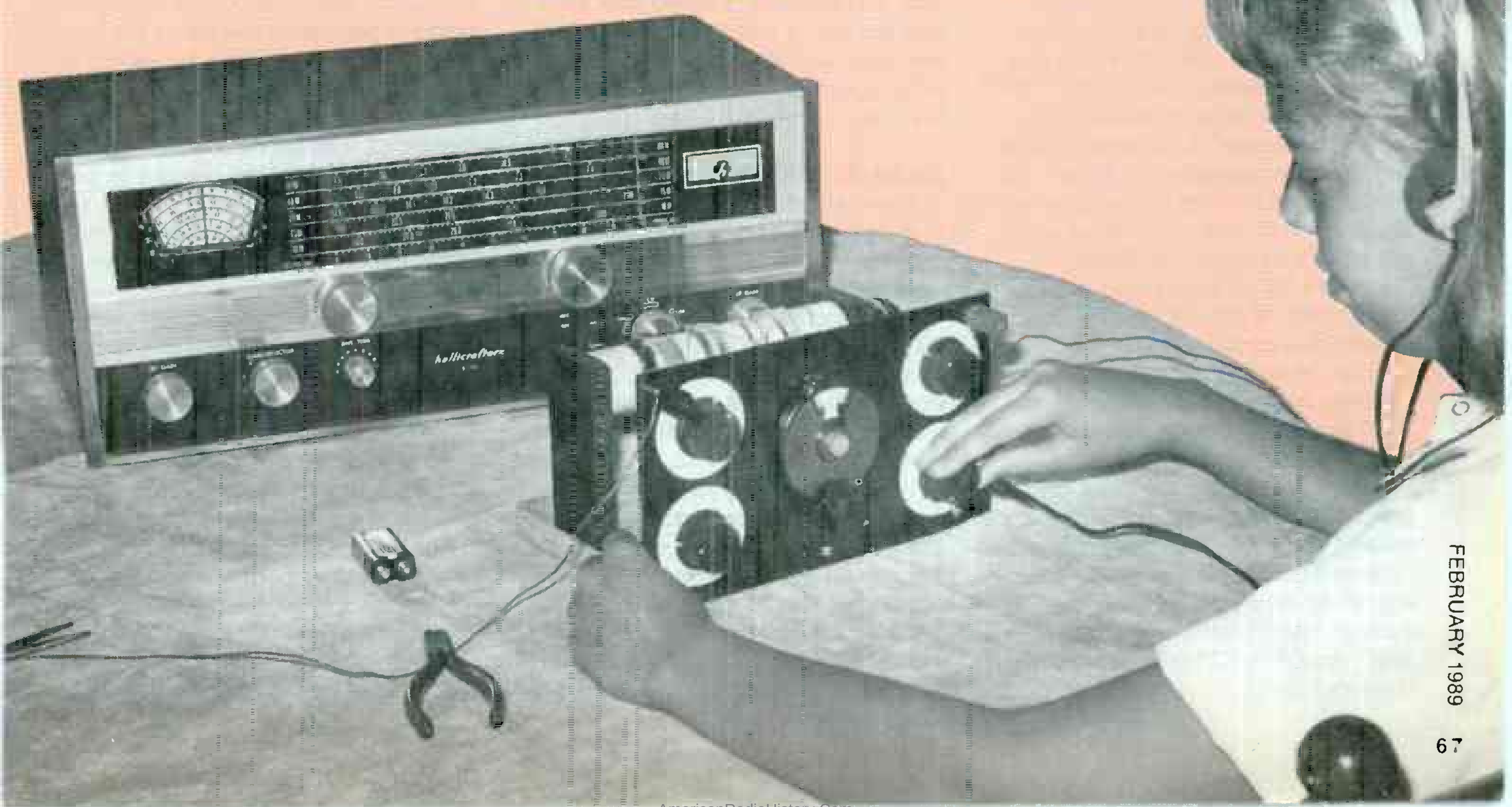
Because it's impossible to find 140-pF and 10-pF variable capacitors to use as the tuning and bandspread capacitors, varactor diodes are used instead.

Circuit Overview. The untuned RF stage (see Fig. 1) amplifies a wide band of frequencies, and prevents critical antenna-trimmer adjustments and unwanted regeneration noise that might be fed into the antenna system. The heart of the stage is built around an MFP102 FET, Q1. The external-antenna jack (J2) provides an AC-coupled antenna input to Q1. Resistors R1 and R2 act like a cathode-bias tube circuit for the FET. The amplified RF signal is inductively coupled to the main tuning coil through a coil selected by S1-a (the BAND switch).

Transistor Q2 is another MFP102, but it is used for regeneration. It receives its input from the tank circuit composed of the coil selected by S1-b and varactor diodes D1 and D2.

Varactor diodes are tuned by a biasing current applied to their cathode terminal. The varactors used here are tuned by adjusting two potentiometers R11 (the main tuning control) and R12 (the bandspread-tuning control). One of the great advantages of that type of tuning is that you do not have to worry about band capacity—if you do not want bandspread tuning, use only the main tuning control.

Since transistors make tuning more critical when used in regeneration circuits, a tickler circuit is used to provide positive feedback to help separate difficult stations. A tickler coil is operated by pushing it in and out of the band coil selected by the band switch. That fine tunes the band coil with feedback. Normally there would be a tickler coil for each band coil, but this tickler-coil assembly was de-



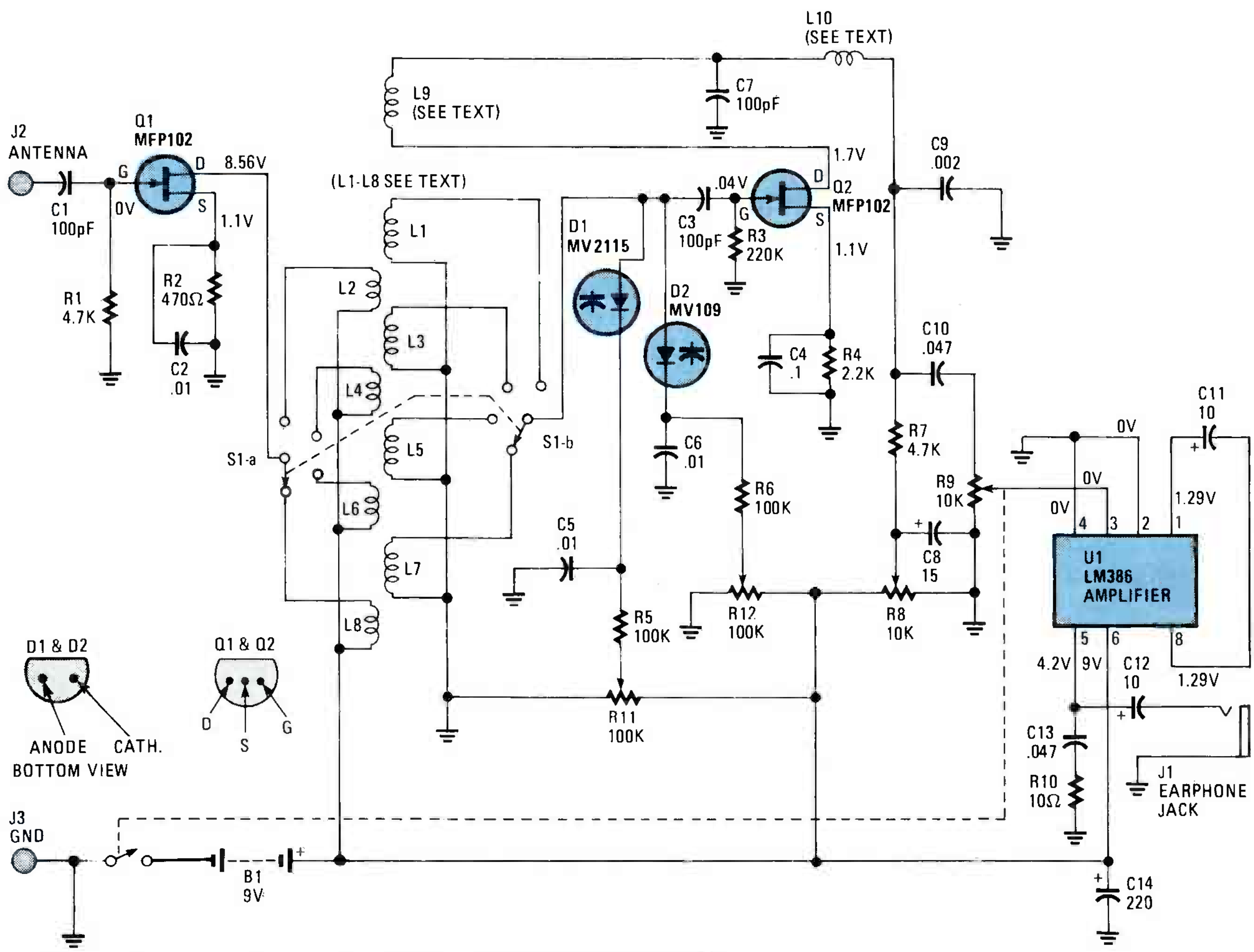


Fig. 1. Distant shortwave stations can be pulled in with two RF transistors (Q1 and Q2), and the often used audio IC (LM386). Here is the main schematic.

signed to allow the tickler to be moved deep enough into the main-coil assembly to interact with any of the windings.

Regeneration is controlled by positioning the tickler coil (L9) and adjusting a 10K potentiometer (R8). The potentiometer controls the voltage to the drain terminal of Q2, which is the regeneration feedback voltage. The control is quite critical in operation, so you must have a lot of patience when adjusting the point of oscillation.

Inductor L10 (2.5 mH), and capacitors C7 and C9 strip RF from the signal leaving the audio alone. Capacitor C9 can be made out of two .001 capacitors in parallel if necessary, but don't leave that capacitor out; it is a critical component!

Capacitor C10 couples the audio signal to the volume control, R9, which sends it to pin 3 of the audio amp, U1. Pin 5 of U1 couples the amplified audio signal to the earphone jack (J1) through capacitor C12. Resistor R10, and capacitors C11 and C13 provide feedback for U1.

You may be able to use an 8-ohm speaker for some stations, but headphones are recommended for best results. You can use a stereo jack for J1 with the left- and right-channel output terminals wired in parallel so a low-priced pair of stereo headphones can be used.

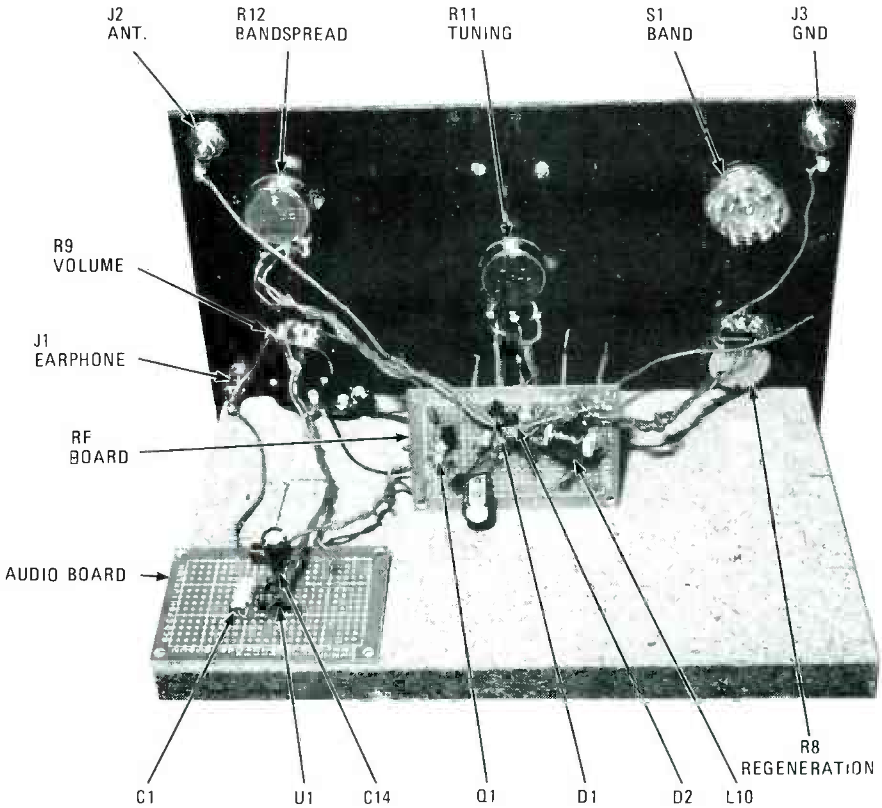
Choke it. The choke coil, L10, can be a store-bought 2.5-mH coil or a roll-your-own type. To make your own, start by selecting a 2-watt resistor of about 10K to use as the body and terminals of the choke coil. The wire should be No. 30 to 36 enameled wire that can be taken from an old transformer, an electromechanical bell, a DC-motor armature, or may be purchased at an electronics store.

Wind at least 250 turns of wire in a helter-skelter fashion (scramble wind) onto the body of the resistor. Solder each end of the coil to the resistor-wire terminals close to the body of the resistor. Winding the choke coil can be a nuisance, but it is often less troublesome than locating or ordering it.

Wiring Up the RF Board. The RF and audio parts are mounted on two 1-¾ × 2-¾-inch multi-purpose boards; those can be cut from a larger perfboard. The RF and AF circuits were placed on separate boards for more-stable regeneration feedback control. Prepare the RF board by using 5 pieces of stripped, No. 22 hookup wire to form tie points along one edge of the board. They will be used for soldering convenience. One piece is to be used as the B+ line for the project, so connect the positive side of the battery clip to the one you wish to use. Make a ground line using a long piece of wire along the opposing edge.

Mount and solder each of the on-board components that require connection to ground first. Interconnect those components as necessary, making use of the tie points you've made. Mount and solder the remaining components connecting them to those on the board already. Use a pair of long-nose pliers or a heat sink to prevent heat damage when soldering the transistors and tuning diodes.

Connect a hookup wire to the ground line for the amplifier board,



All audio components are mounted on the audio perfboard except the controls and earphone jack. Connections between the boards and outside components are made after they are mounted on the wood chassis.

PARTS LIST FOR GRANDPA'S SHORTWAVE RADIO

SEMICONDUCTORS

D1—MV2115, 100-pF varactor diode
D2—MV109, 35-pF varactor diode
Q1, Q2—MFP102 FET transistor
U1—LM386 audio-amplifier, integrated circuit

RESISTORS

(All fixed resistors are ¼-watt, 5% units unless otherwise noted.)
R1, R7—4700-ohm
R2—470-ohm
R3—220,000-ohm
R4—2200-ohm
R5, R6—100,000-ohm
R8—10,000-ohm, linear potentiometer
R9—10,000-ohm, linear potentiometer with a SPST switch
R10—10-ohm
R11, R12—100,000-ohm, potentiometer

CAPACITORS

(All capacitors are 50-WVDC units unless otherwise noted.)
C1, C3, C7—100-pF, ceramic disc
C2, C5, C6—.01-µF, ceramic disc
C4—0.1-µF, ceramic disc
C8—15-µF, electrolytic.
C9—.002-µF, ceramic disc
C10, C13—.047-µF, ceramic disc
C11, C12—10-µF, electrolytic
C14—220-µF, electrolytic

INDUCTORS

L1–L9—See text
L10–250–300 turns of No. 30–38 enameled wire (see text)

ADDITIONAL PARTS AND MATERIALS

B1—9-volt battery
J1—Miniature earphone jack
J2, J3—Binding post
S1—2-pole, 4-position (or 5-position) rotary-switch (see text)
S2—SPST switch (See R8)
Two small perfboards: No. 24 enameled wire; solid hookup wire; Boards for rear- and front-panel chassis; 8-pin IC socket; small speaker or earphone; solder, etc.
The varactor diodes D1 and D2 are available for $1.30 each from: Circuit Specialists Inc., PO Box 3047, Scottsdale, AZ 85257 (minimum order $2).

one for the coil assembly, and a third for the potentiometers. Connect wires for the off-board components (S1-a, S1-b, J2, the wipers of R8, R11, R12, one side of R9 and both sides of L9) to the mounted components. Label all wires for easy identification. Lastly, connect three wires to the B+ line—one to run to the coil assembly, another to run to some of the potentiometers, and a third for the amplifier board. Check the board's accuracy before you proceed.

Amplifier-Board Construction. Mount an 8-pin IC socket in the center of the board. Make a ground line as you did for the previous board and ground the appropriate socket pins. Interconnect pins as necessary with hookup wire. Solder capacitors C11–C14 to the IC socket and connect C14 to the ground line. Run R10 between C13 and ground and connect a hookup wire to the unconnected side of C12 for J1. It will be used for the audio signal. Connect one jumper to pin 3 for R9 and a hookup wire to the ground line for J1. Twist the ground and audio wires together. Check out the board for correct wiring. Once you're sure everything is okay, it's time to start winding the coils.

Tuning-Coil Winding. All coils except the tickler and choke coils are to be wound on a 6-½ inch piece of PVC pipe. The prototype's pipe was purchased from a local hardware store. Just search the plumbing department of a hardware store for yours. You must wind all coils in the same direction with No. 24 or 26 enameled wire. The wire can be purchased at most electronic parts stores.

Keep in mind that all primary coils (L2, L4, L6, and L8) are to be close-wound and the main turning coils (L1, L3, L5, and L7) are space-wound (see Fig. 2 for the dimensions).

First cut the PVC tube to size. Do not drill holes in the pipe to tuck in the coil ends since the tickler coil must be pushed back and forth inside it for regenerative feedback. As you wind each coil, you will secure it to the form with cellophane tape at each end instead.

Start coil L1 about 1-½ inches from the end of the coil form, leaving a 6-inch length at the start for hookup. Place a piece of cellophane tape over the starting turn to hold it down. Only the ends of the space-wound coils should be taped down so that the coils may be spread apart or pushed together when you calibrate the reciever later on. Wind 2-½ turns for L1 over a 3/16-inch wide area, and leave about another 6 inches of wire at the end for hookup. The wire will be trimmed later. Use an-

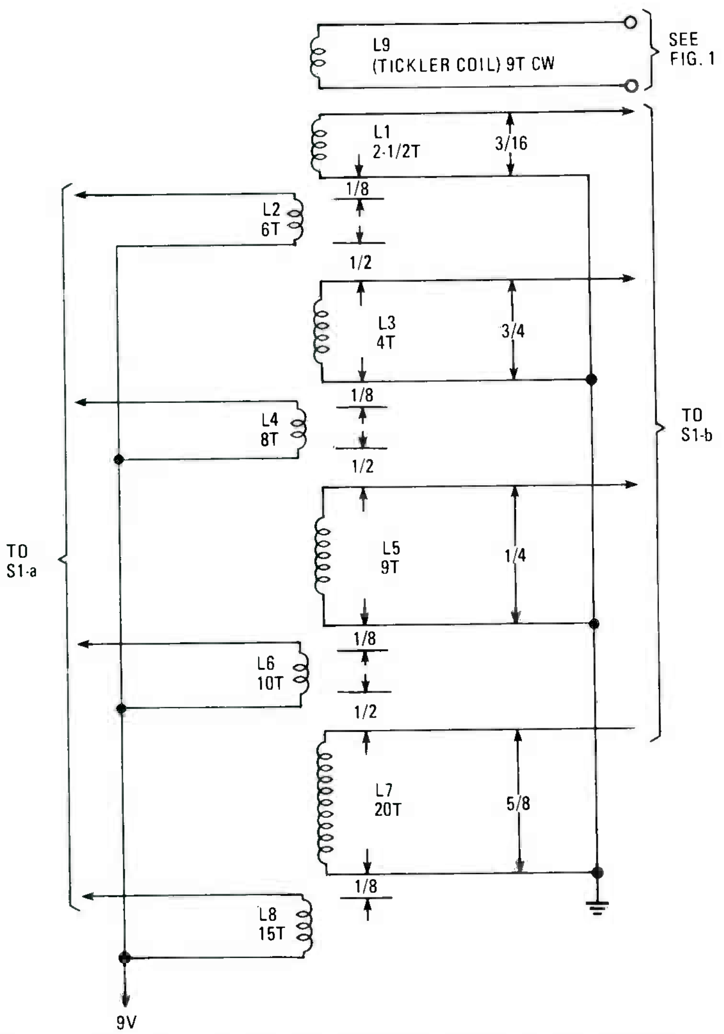


Fig. 2. Here are the coils- with turn, size, and spacing information. All coils are wound with number 24 enameled wire.

other piece of tape to hold down this end of the coil.

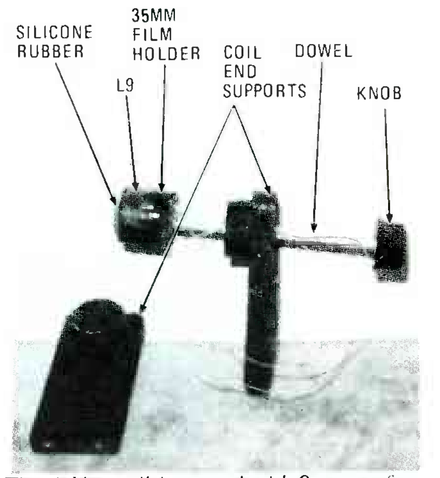
Start coil L2 ⅛-inch away from coil L1 leaving a length of wire for hookup and using the cellophane tape as before. Close-wind 6 turns in the same direction as L1's turns. Terminate the coil as before, and begin L3 ½-inch from L2's end, using 4 turns over a ¾-inch span. Close-wind L4 with 8 turns ⅛-inch away, taping the ends and leaving leads.

Now skip down ½-inch and wind coil L5. Space wind the 9-turn coil over a ¼-inch length. Wind coil L6 ⅛-inch down from L5. Likewise, finish up the remaining coils using Fig. 2 as a guide and using the same termination method.

You may wire up a coil for 160-meters and a portion of the broadcast band on the remaining end of the PVC pipe, if so desired. Wind a 45-turn (close wound) secondary and make a primary winding of 20 turns with a ¼-inch separation between the two coils. You'll need a rotary band switch with two poles and 5 positions instead of the one shown.

Burn off the enamel from the lead wires with a soldering iron, or scrape them bare with a pocket knife, and tin the ends. Using Fig. 2 as a guide for correct polarity, solder one end of each RF coil (L2, L4, L6, and L8) together and connect them to some hookup wire for connection to B+. Trim excess wire as you go. The ground ends of all main tuning coils are to be tied together and terminated in the same fashion paying attention to polarity.

Ticked Off. The tickler coil was wound with 9 turns of No. 26 enameled wire close-wound on a plastic 35-mm film container. Any plastic form that is at least one inch in diameter will do. Just make sure it will slide inside the main coil form. Connect two 10-inch flexible wire leads to the tickler coil ends. Make holes in the form near each coil end to run the wires into and a third



The tickler coil is wound with 9 turns of number 24 enameled wire over a 35-mm film container. Any 1-inch form will do. The container is cemented to a ¼ inch dowel rod for feedback operation.

hole out of the back of the coil form to run them out again.

Cut a long ¼-inch wood dowel. The rod should be long enough to push the coil all the way inside the large coil assembly. Epoxy the rod to the coil form, but do not attach a knob.

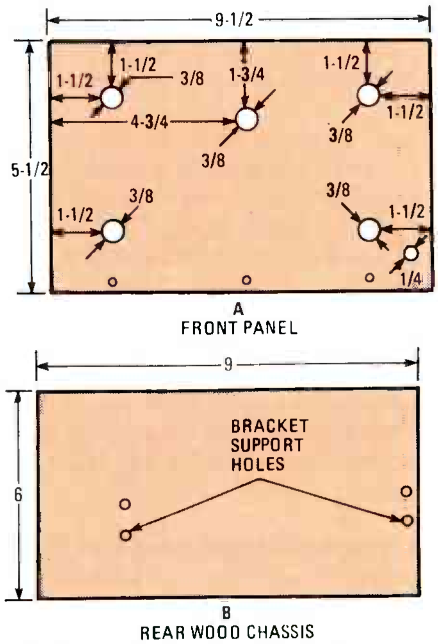


Fig. 3. Cut the front panel out of scrap Masonite and the back chassis from soft pinewood. Drill all holes in the front panel before spraying both sides with black enamel paint.

Chassis Construction. Cut the front panel out of a piece of Masonite and the main chassis out of pinewood. Drill all holes in the front panel as shown in Fig. 3. Do not forget to drill stop holes for the variable-resistor controls so the

(Continued on page 102)

TAMING THE WILD OP-AMP

Bring those misbehaving op-amps in line by following the practices and suggestions outlined in this article.

BY JOSEPH J. CARR

Although most of the time operational amplifiers and other linear IC's are well-behaved devices, they are sometimes subject to *spurious* and unexpected oscillation. When that occurs, it can render a circuit wildly unstable, and therefore unusable. In this article we will examine the mechanisms that cause those troublesome oscillations, learn how to diagnose them in your designs, and see some common circuit "fixes" that can be used to tame a wildly unstable circuit.

In general, oscillations can be categorized as one of two types: 1) those related to the feedback network, and 2) those caused by everything else. First, let's take a look at the feedback category.

Feedback Spasms. The graph in Fig. 1 shows the plot of the open-loop phase shift in degrees versus frequency in Hertz for a commonplace, uncompensated, open-loop op-amp. From DC to a certain frequency (about 100 kHz in the graph) there is essentially zero phase-shift error; but beyond that frequency, the phase shift changes rapidly. That change is due both to the internal resistances and capacitances of the amplifier, and RLC elements in the internal feedback network; above 100 kHz, both of those act as phase-shift networks. The phase-shift change that is produced is what is seen in Fig. 1; it is called the *propagation* phase shift.

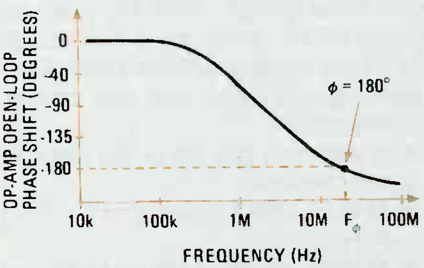


Fig. 1. This graph tells the story of how an innocent op-amp operating at low frequencies can produce parasitic oscillations beyond its frequency range.

At some high frequency (about 12 MHz), the overall propagation phase shift reaches 180-degrees. When that is added to the 180-degree inversion phase shift that is normal in inverting-follower amplifier circuits, it adds up to the 360-degree phase shift that meets the "in-phase" feedback criteria necessary for oscillation. If the closed-loop circuit gain at that frequency is unity or more, then the amplifier will become an oscillator.

To prevent that from happening, you need to reduce the gain at the frequencies where oscillation may occur. That can be done by using one of the techniques shown in Figs. 2 and 3, or a variant of those techniques.

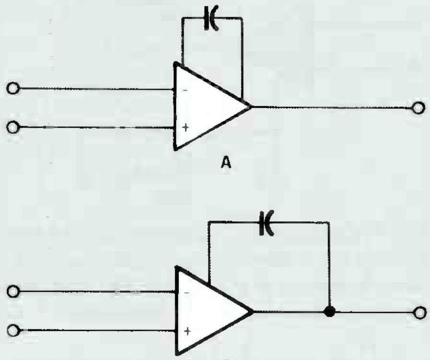


Fig. 2. In lead compensation, a small-value capacitor can be used to reduce the op-amp gain at frequencies where unwanted oscillations occur. Two different methods of lead compensation are shown here.

In Fig. 2 we see a method used called *lead compensation*. If the operational amplifier is equipped with *compensation* terminals (usually either pins 1 and 8, or 1 and 5, on standard DIP packages), then connect a low-value capacitor (20 to 100 pF) as shown in Fig. 2A. An alternate scheme is to connect the capacitor from a compensation terminal to the output terminal as shown in Fig. 2B.

The recommended capacitance in manufacturer's specification sheets is specifically for the unity-gain non-inverting follower configuration. For a gain follower the capacitance is reduced by the feedback factor, B:

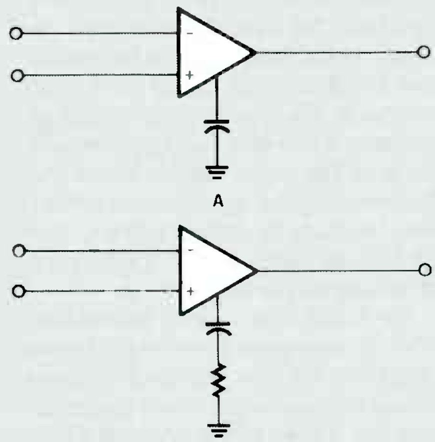


Fig 3. Another method of reducing oscillation is called lag compensation. In that technique, one of the op-amp's compensation terminals is connected to ground using a capacitor (A) or an RC network (B).

$$C = C_M B$$

where C is the required capacitance to be added, C_M is the recommended unity-gain capacitance, and B is the feedback factor $R_{IN}/(R_{IN} + R_F)$. Resistance R_{IN} is the series input resistance in ohms at the op-amp input, and resistance R_F is the resistance in ohms of the feedback network.

The technique shown in Fig. 3 is called *lag compensation*. In that technique we connect either a single capacitor (Fig. 3A) or a resistor-capacitor network (Fig. 3B) from the compensation terminal to ground. A related method places the resistor-capacitor series network between the inverting and non-inverting input terminals.

The object of the methods illustrated in Figs. 2 and 3 is to reduce the high-frequency gain of the circuit to less than unity at the frequency where the 180-degree propagation phase shift occurs. The amount of compensation required to accomplish that goal determines the maximum amount of feedback that can be used without violating the stability requirement.

There are several other factors that can conspire to cause an operational amplifier to break into unexpected oscillation. Quite often, those oscillations occur at frequencies that are far in excess of the band pass of the associated circuit.

One of those factors is positive feedback via the DC power supply. If the DC power supply presents a high AC impedance to ground at any frequency where the overall circuit gain exceeds unity, then positive feedback that is sufficient to cause oscillation may exist. The obvious solution to that problem is to make the output impedance of the power supply lower. The quickest and cheapest (yet very effective) method for accomplishing that job is to use decoupling capacitors on all power-supply lines.

The input and output waveforms from a unity-gain inverting-follower amplifier ($R_{IN} = R_F$) that lacked power-supply line decoupling capacitors are shown in the photograph of Fig. 4. Note the oscillation that is clearly visible on the output waveform (V_O). Since adding the capacitors to the V+ and V− terminals would clear up the problem, it is considered poor practice to use an uncompensated op-amp without such decoupling capacitors.

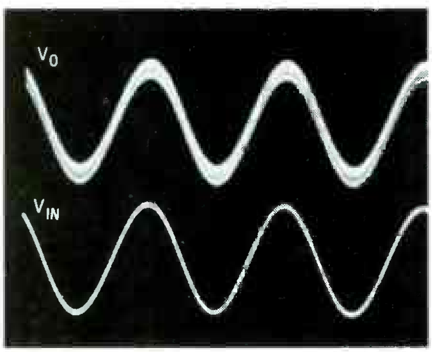


Fig. 4. Note the instability in the output signal of this op-amp circuit. The problem was remedied by adding decoupling capacitors to the circuit's DC power supply.

Finding and Fixing Instability. The process of finding and fixing sources of instability in linear IC op-amp circuits is sometimes believed to be partly magic, but in reality, the process is relatively straightforward. There may be, however, a certain amount of trial-and-error involved.

Be sure that the problem that you are trying to solve is indeed an instability in the circuit and not an external problem. Three kinds of external problems can mimic op-amp instability. One is a defective source signal. For example, a low-frequency "motorboating" oscillation may be due to a high AC impedance to ground in the amplifier's DC power supply (especially in multistage circuits), but it may also be due to an oscillation in the signal source. Another problem of that sort is 60-Hz AC hum caused by a broken shield or ground wire on the input line. In fact, don't look for any other cause if the "oscillation" is exactly 60-Hz (the AC power-line frequency) until that possibility is checked.

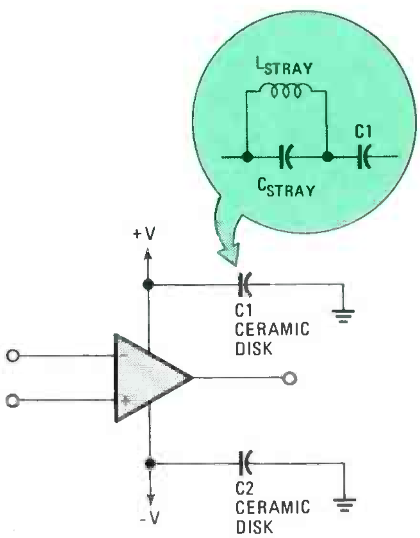


Fig. 5. Ceramic-disc capacitors can be your undoing when they are used to decouple the power supply from the circuit. The equivalent circuit for that capacitor is in the inset.

The second external problem is noisy or defective power-supply lines. Examine the V− and V+ lines using an oscilloscope to be sure that the power is clean. A 120-Hz oscillation could indicate an excessive ripple condition in a DC power supply. Adding ripple filtering or a voltage regulator in each DC line (V− and V+) will usually solve the problem.

Finally, we sometimes see interference problems in IC amplifiers. Strong local fields, such as RF interference from a local broadcasting station, may get into the circuit where they may be mistaken for high-frequency oscillations. Such interference may get into the circuit via direct radiation, or may be carried into the circuit on an input line, output line, or a DC power-supply line.

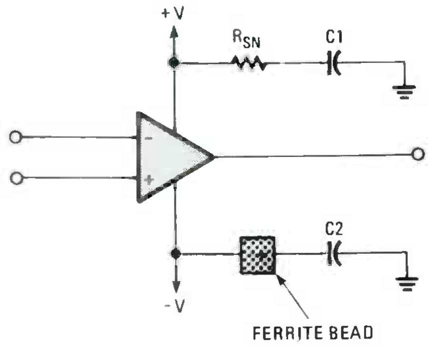


Fig. 6. To eliminate the unfortunate effect that ceramic-disc capacitors have at high frequencies, snubber resistors (R_{SN} in A) and ferrite beads (B) are used.

Getting rid of such interference can present quite a problem. One technique is to add RF filtering to the inputs, in the feedback loop, and in the positive and negative power-supply connections.

Zeroing In. Once external problems have been eliminated, it is time to zero-in on internal causes. First, examine the circuit for any unintended common impedances between input and output circuits, or between stages in a cascaded chain of amplifiers. Two areas of the circuit should receive special attention: the DC power-supply lines and the ground connections. Problems related to the power-supply connections can be handled using capacitors as discussed previously, so we won't dwell on that topic again.

Common impedances in the ground system, usually called *ground loops*, are suppressed by using large conductive ground planes (usually on the component side of the printed circuit board) in place of thin point-to-point traces. There are a few design guidlines to follow when trying to eliminate ground loops from your design. Those are:

- **1)** Use large ground-plane surfaces where possible.
- **2)** Use a single ground point, called a *star* point.
- **3)** Keep the DC power-supply and AC-signal ground lines separate except at the single star point.

(Continued on page 104)

E-Z MATH

BOOLEAN LAWS and REDUCTION

BY LOUIS E. FRENZEL, JR.

If you know a few Boolean laws, you can greatly simplify any logic circuit.

In last month's column we introduced you to Boolean algebra and showed you how binary logic signals could be represented with mathematical expressions. We then showed you how to derive a Boolean expression from any logic circuit. You also saw how to draw the logic circuit corresponding to a given Boolean expression. Finally, we explained the value and use of truth tables. We showed you how to write a truth table for a logic circuit or derive the Boolean expression from a truth table. This month, we will provide you with more advanced information on Boolean algebra. Specifically, we will introduce you to the basic rules (laws) that will allow you to apply Boolean algebra to the design of logic circuits.

Boolean algebra is a system of mathematics that is used to express how digital-logic circuits operate. It is very much like conventional algebra and most of the standard algebra rules and procedures work with Boolean expressions. You just have to remember that the only numeric values in Boolean algebra are 0 and 1. When those rules are combined with the Boolean laws you will learn in this article, you will be able to analyze and minimize the most complex digital-logic circuits.

Why Use Boolean? The two main benefits of using Boolean algebra come from its ability to represent and simplify digital-logic circuits for the purpose of reducing the amount of circuitry required to implement a function. Expressing digital logic in mathematical terms provides us with a compact and convenient way of designing and analyzing digital circuits. The complete operation of a computer or any other digital circuit can be fully expressed with Boolean equations rather than large complex logic diagrams. While logic diagrams, of course, have their place, most original design and analysis is done mathematically.

Using Boolean algebra to alter Boolean expressions (and so the corresponding circuits) to reduce the number of gates and other components required to implement them, is its best application. Many times in designing a digital circuit, the truth table will first be developed based on the desired inputs and outputs. The Boolean equation is then derived from the truth table. At that point, the equation can be represented by logic gates. However, if the equation derived from the truth table is manipulated using Boolean expressions, it can be simplified (minimized). That simplification generally results in a smaller circuit with fewer parts. Any time that you can reduce the number of components or logic gates, considerable savings can be realized. That is particularly true of a complex digital system such as a computer. Reducing the number of logic gates reduces the production cost, size, and power consumption. The reliability is increased, and operating speed is usually improved. Keep those benefits in mind as you are learning the Boolean rules.

The rules of Boolean algebra are stated in terms of laws that were originally layed down by mathematician George Boole in his book "The Laws of Thought," published in 1847. Let's explain each law in detail.

Laws of Intersection. The laws of intersection relate to the use of AND gates. Remember the basic Boolean expression for an AND gate is:

$$C = AB$$

where A and B are the inputs and C is the output. A or B may be either 0 or 1. In an AND gate, the output is only 1 if both inputs are binary 1. The laws of intersection simply state what the output of an AND gate will be if one input is binary 0 while the other is A or if one input is binary 1 and the other is A.

The basic laws of intersection are:

$$A(0) = 0$$
$$A(1) = A$$

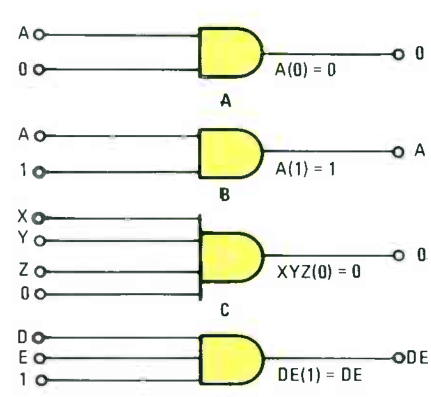


Fig. 1. Here we demonstrate the laws of intersection. In A, one input of the AND gate is 0, making the output 0. In B, a binary 1 is applied to an input, making the output simply A. Figures C and D demonstrate the same principle for multiple inputs.

We can illustrate those laws with AND-gate symbols as shown in Fig. 1. In Fig. 1A, one input of the AND gate is 0. The other input A can be either 0 or 1. Just remember that any time one input to an AND gate is 0, the output will always be 0 regardless of the state of A.

In Fig. 1B, a logic signal A is applied to one input of the AND gate while a binary 1 is applied to the other. Of course, A may be either 0 or 1. Under those conditions, the output is simply equal to the A input. If A is 0, the AND gate output will be 0. If A is 1, both inputs are 1, making the output 1. Use a truth table for the AND gate to verify both laws yourself.

What the laws of intersection are really stating are some special cases in the application of AND gates. If you know how an AND gate operates, those rules are pretty obvious. By remembering those special mathematical conditions, often a circuit can be simplified by applying them. Keep in mind that the rules also apply to AND gates with more than two inputs. Figures 1C and 1D are examples of that.

Laws of Union. The laws of union relate to the application of OR gates. Recall that the Boolean expression of an OR gate is:

$$C = A + B$$

Again, A and B are inputs that can be either 0 or 1. The laws of union simply state what the output will be if one input to an OR gate is either binary 0 or binary 1. The truth table in Fig. 2A illustrates this.

The laws of union are:

$$A + 1 = 1$$
$$A + 0 = A$$

In the circuit at Fig. 2A, one input to the OR gate is fixed at binary 1. The other input is A.

From your understanding of the operation of an OR gate, you can see that the output will always be binary 1 regardless of the state of A. The output of an OR gate is binary 1 if any one or all inputs to the OR gate are 1.

In Fig. 2B, one input to the OR gate is fixed at binary 0. As a result, the output will simply be a function of the input. If input A is 1, the output is 1. If input A is 0, the output will be 0. The laws of union are extremely easy to understand, particularly if you remember how an OR gate works. Again these basic expressions can often be applied to a Boolean expression for the purpose of changing its form or reducing its complexity. Don't forget that the rule also applies to OR gates with more than two inputs. Figures 2C and 2D are examples of that.

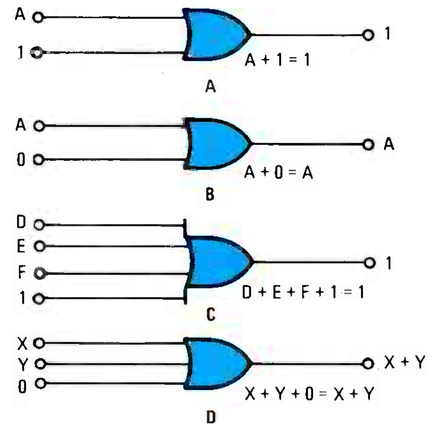


Fig. 2. In A, one input to the OR gate is fixed at binary 1, the other input is A, forcing the output to be binary 1. In B, one input is fixed at binary 0. As a result, the output will be a function of the input. The rule also applies to gates with more than two inputs, as in C and D.

Laws of Tautology. The laws of tautology indicate the effect of redundant inputs on logic gates. There are two forms of the law, one for AND gates and one for OR gates. They are:

$$AA = A$$
$$A + A = A$$

The circuits for those expressions are given in Figs. 3A and 3C. The laws of tautology state that when all of the same inputs are applied to a non-inverting logic gate, the output will simply be the same as the input. You can assume values of 0 and 1 for A on either circuit and determine that in every case the output will be A.

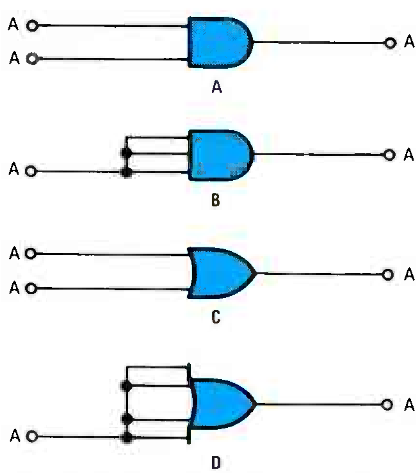


Fig. 3. The laws of tautology state that when all of the same inputs are applied to a non-inverting logic gate, the output will be the same as the input. The circuits for such expressions are given in A and C. For multiple-input gates, such as in B and D, the same holds true.

Suppose you had the Boolean expression:

$$Z = XXJ$$

you can generate that logic with the gate in Fig. 4A. By the laws of tautology, you can replace XX with X so the new expression is $Z = XJ$. Now you can implement the circuit with a 2-input AND gate as they are equivalent (see Fig. 4B).

Another example is shown in Fig. 4C for the relation:

$$M = D + D + R$$

Since $D + D = D$, the expression becomes $M = D + R$. So a 2-input gate can be used as Fig. 4D shows.

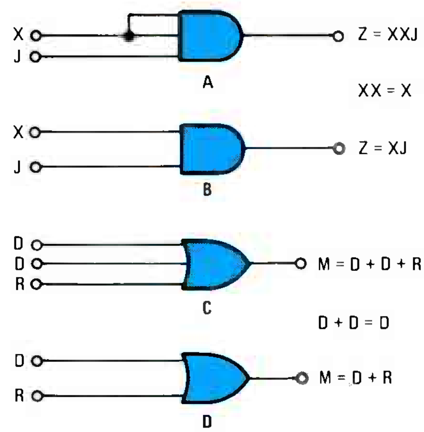


Fig. 4. By the laws of tautology, you can replace the XX in A with just X, so the new expression can be implemented with a 2-input gate as in B. The same is true for the OR gate in C, which is transformed to the one in D.

The Law of Complements. The law of complements tells what the output of a logic circuit is when both a logic signal and its complement are applied to a gate. There are two versions of the rule, one for AND gates and one for OR gates. Those are:

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

Figure 5 illustrates those rules with gates. In Fig. 5A, you can see that if you apply a signal and its complement to the AND gate, one of those signals will always be a binary 0. Therefore, the output will always be 0.

The opposite condition occurs in an OR gate (see Fig. 5B). If a signal and its complement both are applied simultaneously, one input will always be a binary 1. That, of course, will cause the output to be binary 1. Again, those laws apply even if the gate has more inputs. See Figs. 5C and 5D for examples.

The Law of the Double Negative. The law of the double negative states that if a binary signal is inverted twice, its value will not be changed, as follows:

$$\overline{(\overline{A})} = A$$

If we invert or complement a logic signal, we reverse its value. A 0 will become a 1 and a 1 will become a 0 (see Figs. 6A and 6B. If we complement (invert) again, the first inversion is undone and we end up with a signal at the output that is the same as the input. That is illustrated in Figures 6C and 6D. One complement simply cancels the other.

The Laws of Commutation. The laws of commutation state that you can write the variables in a Boolean expression in any order and the meaning or effect will be the same. The two basic variations of the law are:

$$AB = BA$$
$$D + E = E + D$$

You can see that it doesn't matter what order the variables are in. What that means is that it does not matter

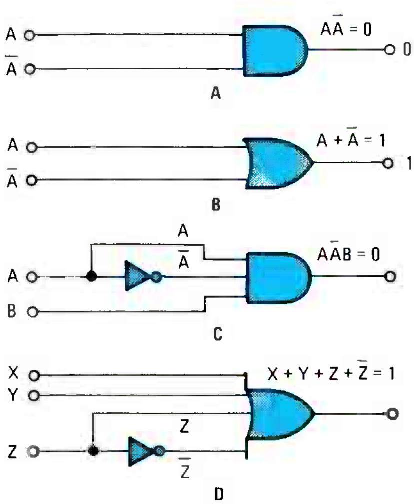


Fig. 5. In A you can see that if you apply a signal and its complement to the AND gate, one of those signals will be a binary 0, always making the output 0. The opposite occurs in an OR gate (B). Those laws apply even if the gate has more inputs as in C and D.

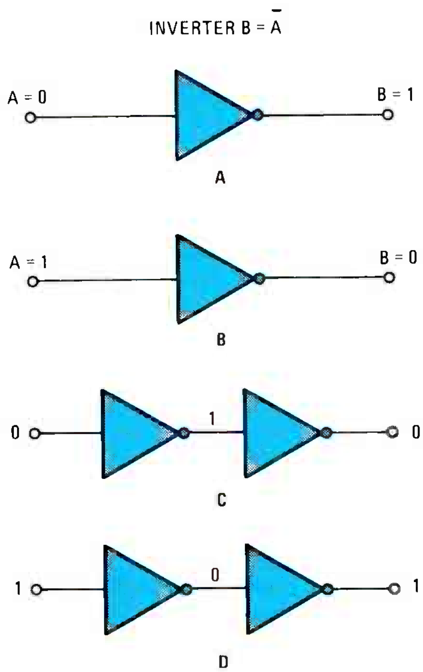


Fig. 6. If we invert or complement a logic signal as in A and B, we reverse its value. If we do it twice, the first inversion is undone and the output is the same as the input (see C and D).

which input of an AND gate or OR gate you send a variable's value to. The logical function is the same. As we have indicated before, that rule also applies to expressions containing three or more input variables. More typical examples are:

$$ABC = ACB = BAC = BCA = CAB = CBA$$
$$D + E + F = D + F + E = E + D + F =$$
$$E + F + D = F + D + E = F + E + D$$

The Laws of Distribution. The two forms of the law of distribution are:

$$A(B + C) = AB + AC$$
$$(A + B)(A + C) = A + BC$$

Those rules are similar to the standard algebra rules of factoring and expanding algebraic expressions. In the first version of the law of distribution, A is multiplied by the expression B + C. In ordinary algebra, we would multiply each term inside the parenthesis by A and add them together. The result being:

$$A(B + C) = AB + AC$$

You can also work the expression in the opposite direction. For example, starting with the expression:

$$AB + AC$$

you can see that A is common to both terms. Therefore, you could factor it out and simplify the expression. The result, of course, is simply:

$$A(B + C)$$

As you work with various Boolean expressions to simplify them or to change their form, you will regularly be either factoring or expanding them. Those two techniques will greatly speed up and simplify the process.

The other form of the laws of distribution is somewhat more complex. Take a look at this expression again:

$$(A + B)(A + C) \text{ Product-of-Sums} =$$
$$A + BC \text{ Sum-of-Products}$$

It says that a product-of-sums can be simplified into a sum-of-products. Fig. 7 shows those two expressions implemented with logic gates. You can see that the sum of products version is simpler as it uses one less gate.

To see how we arrived at that expression, let's use some standard al-

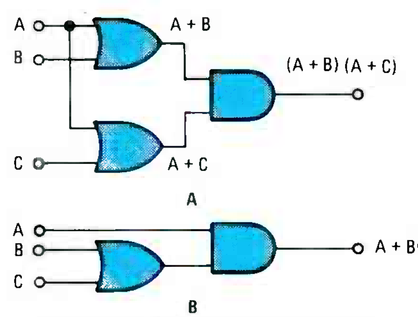


Fig. 7. A product-of-sums (A) can be simplified into a sum-of-products (B). You can see that the sum of products version (B) is much simpler.

gebra procedures. First, let's expand the expression on the left-hand side of the equation as we would a normal algebraic expression. We do that by multiplying each term inside the left-hand parentheses by each term in the right-hand parentheses, and adding all the terms together. The result of is:

$$(A + B)(A + C) = AA + AC + BA + BC$$

The expression to the right of the equals sign is correct algebraically and could be implemented directly with logic gates. However, it can be significantly reduced. We can use some of the previously described Boolean laws to reduce it.

First, take a look at the term AA on the right-hand side of the equation. Looking back, you should remember that AA = A as one of the laws of tautology. As a result, you can replace AA by A.

Next, notice that three of the terms

contain the letter A. You can factor out A, giving the expression:

$$A(1 + C + B) + BC$$

You can see that the term inside the parenthesis contains a binary 1 ORed with other variables. When you see a term such as that, you immediately know that you can apply one of the laws of union. That means that the entire expression inside the parenthesis can simply be replaced with a binary 1 giving:

$$A(1) + BC$$

Now you can use one of the laws of intersection to reduce the expression A(1) to A. The resulting expression then derived is:

$$A + BC$$

As you can see, the Boolean laws are in themselves extremely simple. Once you gain practice in recognizing their different uses inside longer, more complex expressions, you will be able to apply them and quickly reduce the expressions to something considerably simpler.

Laws of Association. The laws of association simply state that AND or OR expressions containing parentheses can be simplified by removing the parentheses. The two basic forms of this law are:

$$(AB)C = A(BC) = ABC$$
$$A + (B + C) = (A + B) + C = A + B + C$$

Normally, parentheses are used to set off two or more terms in groups to show that they are separate and distinct. However, when all the terms are ANDed (or multiplied as in algebra) or all of the terms are ORed (or added) together, then there is no need for the parentheses. They can be eliminated to simplify the final expression.

You can see the effect of those expressions when they are actually implemented with AND and OR gates. Figure 8A shows the AND expressions while Fig. 8B shows the OR expressions.

Laws of Absorption. There are four variations of the laws of absorption. Those are:

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

By looking at those expressions, you cannot really tell that they are actually

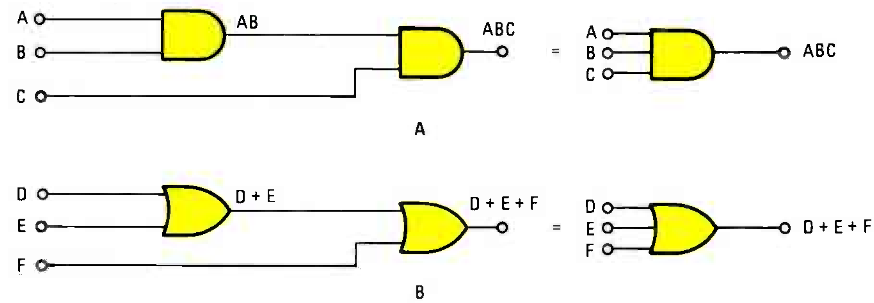


Fig. 8. Normally, parentheses are used to set off two or more terms in groups to show that they are distinct. When the same operation is being performed on all the terms then there is no need for the parentheses. When such expressions are implemented as in A and B without the parentheses, they are greatly simplified.

equivalent. However, you can see the expressions to the right of the equal signs are shorter and simpler than the expressions on the left.

As we did with the laws of distribution, we can use some Boolean laws to prove those expressions are equivalent to one another. Let's start with the first one:

$$A(A + B) = A$$

We will be working with the left-hand side of the expression to prove that it is indeed equal to A. The first thing we can do is to expand the expression by multiplying. That, of course, is the law of distribution. The result is:

$$A(A + B) = AA + AB$$

Of course, you can see that the term AA is redundant and it can be replaced by the letter A as the law of tautology indicates. Our new expression is simply:

$$A + AB$$

Again using the laws of distribution, we can factor an A out of both terms. That results in:

$$A + AB = A(1 + B)$$

The 1 + B indicates that the law of union applies. We can replace 1 + B by 1, giving the new expression:

$$A(1 + B) = A(1) = A$$

Of course, A(1) indicates that the law of intersection applies, and so the term A results. So, we proved the expression.

Now let's work on the second version of the laws of absorption:

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

Again we will be working with the left-hand side of the equation trying to make it equal to AB. We can start by applying the laws of distribution and expanding the expression. The result is:

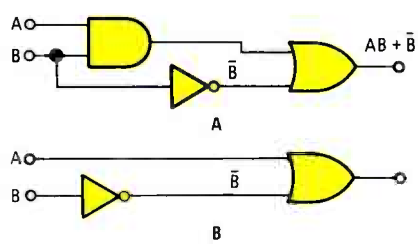
$$A(\overline{A} + B) = A\overline{A} + AB$$

The law of complements, of course, tells us that the expression $A\overline{A}$ is equal to 0. Therefore, our expression becomes:

$$A\overline{A} + AB = 0 + AB$$

The law of union applies here, therefore, the complete expression becomes equal to simply AB.

The last two forms of the law of absorption are relatively tricky to prove. There are ways to use algebraic techniques to do that, but we will avoid that here. Instead, we will show you another way to prove the equivalence of the



INPUTS		OUTPUTS		
A	B	AB	$\overline{B}$	AB + $\overline{B}$
0	0	0	1	1
0	1	0	0	0
1	0	0	1	1
1	1	1	0	1

AND THESE TO GET — OR THESE TO GET — THESE OUTPUTS ARE EQUAL

C

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

OR THESE TO GET

D

Fig. 9. Obviously, the circuit in B is easier than the one in A. To prove their equivalence you can compare the outputs of their truth tables given in C and D.

two Boolean expressions by using truth tables. Let's use a truth table to prove each of the remaining two versions of the laws of absorption.

Let's start with the expression:

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

First, you can see that if we implement each side of the equation with logic gates, we get the circuits shown in Fig. 9. Obviously, the circuit in Fig. 9B is a simpler and more desirable form. What we really don't know at this point is if the two circuits in Fig. 9 do actually produce the same logical output. Let's use a truth table to find out.

Since there are only two variables involved, then we have to develop a truth table containing all of the four different possible input combinations. Then we can develop a column in the truth table for each of the terms, such as AB. The table in Fig. 9C represents the circuit in Fig. 9A. Each column in the truth table is simply developed by observing the actual binary values of the expression and performing the logical operations.

The truth table for the circuit in Fig. 9B is given in Fig. 9D. You can see that the two columns representing the output expressions for the left- and right-hand sides of the equation are the same. Therefore, the simpler circuit does produce the same logical effect.

The truth table proving the last version of the laws of absorption is given in Fig. 10. Note that the columns for the left and right-hand sides of the equation are the same thereby proving equivalency.

The basic trick in using the laws of absorption is to become familiar with the different variations and recognizing them when they occur in larger expressions. That takes some practice, but after a while you will be able to spot them and immediately make the substitution. On occasion, when you do not recognize the different formats, it is possible that you may reduce the expression anyway using some of the other Boolean laws.

Reducing Logic Equations. Now let's apply the rules to simplifying Boolean expressions and the logic circuits they represent. Let's start with the circuit shown in Fig. 11A. The equation for that circuit is:

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

To solve a Boolean expression, the usual procedure is to first put it into a sum-of-products form. Remember that a sum of product format is two or more AND expressions ORed together. To do that, we must first expand the first expression by the law of distribution. The revised expression becomes:

$$D=AA+AB+\overline{C}$$

Next you should recognize that the laws of tautology allow you to replace AA by A. Doing that reduces the expression further.

$$D=A+AB+\overline{C}$$

You can now use the laws of distribution and factor out an A from the first two terms. That produces the revised equation:

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

Next you will recognize that the 1 + B term can be replaced by 1 according to the laws of union. That gives us:

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

Finally you will recognize that the A(1) term can be replaced by the letter A by the law of intersection, giving the final expression:

$$D=A+\overline{C}$$

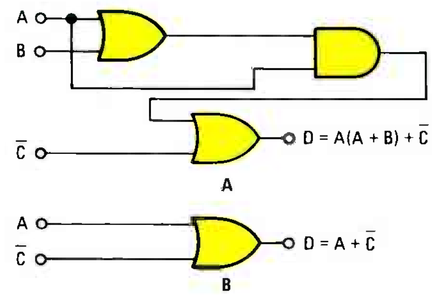


Fig. 11. By using the rules of Boolean algebra, the circuit in A can be converted into the circuit in B.

The revised circuit then is an OR gate as shown in Fig. 11B. What was previously a three-gate circuit is now a one gate circuit. Not only did you use fewer gates, but you also sped up the operation of the circuit. In Fig. 11A, three gates were used and the inputs must pass through each before reaching the output. Remembering that each gate has a finite amount of propagation delay, you can see that it will take longer for the output to be developed in Fig. 11A than it will in Fig. 11B. Assume the average gate propagation delay is 15 nanoseconds. With three gates or three levels of logic, the output would occur approximately:

$$3\times15=45$$

nanoseconds later. Using the revised circuit, the output would, of course, take only 15 nanoseconds to be developed.

Another example is shown in Fig. 12A. The Boolean expression representing that circuit is:

$$D=\overline{A}B\overline{C}+\overline{A}BC+A\overline{B}\overline{C}+AB\overline{C}$$

As you can see, four 3-input AND gates and a 4-input OR gate are needed to implement the circuit. There is a good possibility that the circuit can be simplified.

To begin simplifying you should first scan the equation to see if you can recognize any common factors. You should keep the law of distribution in mind and attempt to locate terms that can be factored out to simplify the expression. You should first recognize that the first and fourth terms contain the expression $B\overline{C}$. You should also notice that the second and third terms contain the expression $A\overline{B}$. Those, of course, can be factored out. But first to simplify that task, the expression can be rearranged using the laws of com-

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

THESE TWO ARE EQUAL

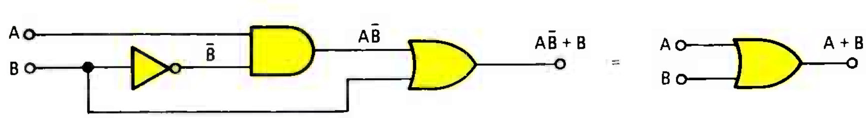


Fig. 10. Once again a truth table (A) shows the equivalence between two circuits (B) to prove another of the laws of absorption.

mutation, which means that the order in which the terms are listed is irrelevant. Therefore, let's rearrange the equation to group the last term with the first term since they both contain the same factor. The expression becomes:

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

Now you can use the law of distribution and factor out the common terms in the expressions. That results in:

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

Of course, you can see that the $(\overline{A} + A)$ and $(C + \overline{C})$ terms can be reduced to 1 by the law of complements. That produces the expression:

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

Finally, you can eliminate the 1's with the law of intersection producing the final equation:

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

Of course, the circuit for the reduced

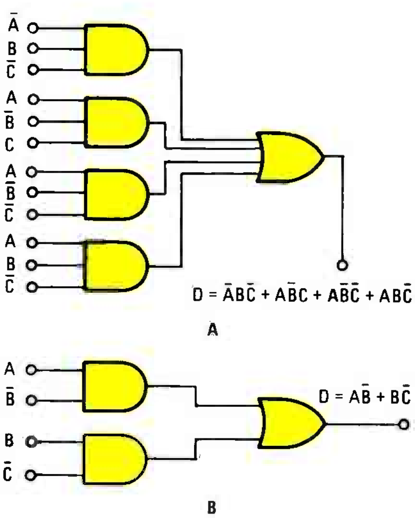


Fig. 12. As you can see, four 3-input AND *gates and a 4-input* OR *gate are used for A. The circuit can be simplified to look like B.*

equation is considerably simpler. It is illustrated in Figure 12B.

Here is another more complex example. Refer to the circuit in Fig. 13A and the equivalent Boolean expression:

$$Z = (\overline{W} + X + \overline{Y})(W + X + \overline{Y})$$

When you get a product-of-sums expression like that, your first job should be to use the law of distribution and expand it into sum-of-products expression. You do that by ANDing each term in the left-hand expression with each term in the right-hand expression and

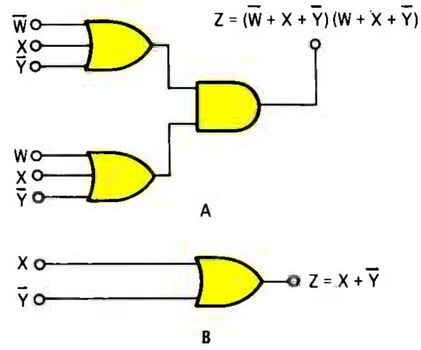


Fig. 13. It's hard to believe that circuits A and B are equivalent, but that shows you the value of Boolean algebra.

ORing the resulting terms together. By doing that you get:

$$Z = W\overline{W} + \overline{W}X + \overline{W}\,\overline{Y} + WX + XX + X\overline{Y} + W\overline{Y} + X\overline{Y} + \overline{Y}\,\overline{Y}$$

In ANDing the expression yourself, you may get the term XW. I wrote WX as it is common practice to put all terms in alphabetical order. Just remember, XW = WX because of the laws of commutation.

The way to reduce a long expression like that is to be able to recognize all of the various identities that can result in some reduction. The first thing you can do is to look through the expression and take care of the obvious. For example, the first $W\overline{W}$ term can be replaced with 0 by the law of complements. The term XX can easily be replaced by a single X by the law of tautology. The same is true of:

$$\overline{Y}\,\overline{Y}$$

which can be replaced by:

$$\overline{Y}$$

and the two $X\overline{Y}$ terms can be reduced to one term. Based on the laws of union the first expression (equal to 0) drops out. The resulting expression is:

$$Z = \overline{W}X + \overline{W}\,\overline{Y} + WX + X + X\overline{Y} + W\overline{Y} + \overline{Y}$$

Next, scan through this equation looking for various ways to group the expressions for further reduction by the laws of distribution. The key is to locate as many common input terms as possible and group them together. For example, the second, fifth, sixth, and seventh terms contain $\overline{Y}$. The first, third, and fourth terms contain X. Therefore, we can rearrange the expression as follows according to the laws of commutation.

$$Z = \overline{W}\,\overline{Y} + X\overline{Y} + W\overline{Y} + \overline{Y} + \overline{W}X + WX + X$$

Now, factor out the common terms, $\overline{Y}$ from the first four terms and X from the last three terms. The result is:

$$Z = \overline{Y}(\overline{W} + X + W + 1) + X(\overline{W} + W + 1)$$

You can see that the expressions containing the 1s can readily be reduced to 1 by the laws of union. The result is:

$$Z = \overline{Y}(1) + X(1)$$

Now by the laws of intersection, that simply becomes:

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

You could take that one step further and use the laws of commutation to get:

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

Normally in an expression such as that the letters are written in alphabetical order, although, of course, it is not necessary. Note that the W term just drops out altogether. The resulting new circuit configuration is just an OR gate as shown in Fig. 13B.

Now let's take an actual design example. Usually a design starts as a truth table that defines all of the inputs and designates the desired output state for each set of inputs. Let's suppose that we want to design a circuit that will detect invalid four-bit BCD codes. If you will recall, BCD means binary coded decimal. That is a system for representing decimal numbers in binary form. We only wish to represent the decimal numbers 0 through 9 and that is done by using the 4-bit binary equivalents. However, with four bits you can represent a total of 16 different binary codes. ($2^4 = 16$). Those, as it turns out, represent the decimal numbers 0 through 15. They are illustrated in the truth table in Fig. 14. Only the first ten of the 4-bit codes are valid for BCD. What we would like to do is create a circuit that will recognize the invalid codes and tells us when they occur. The invalid codes are, of course, the last six codes in the table, or those representing the decimal numbers 10 through 15 (1010–1111).

We can now complete the design truth table. We want to develop an output X that is a binary 1 when one of the invalid codes is detected. Therefore, we want the output of the circuit to be 0 when a valid BCD code exists and binary 1 when an invalid code exists. See column X in Fig. 14.

As you learned in the previous article, you can now write the Boolean expression from the truth table. You merely write down an AND expression of the terms corresponding to the inputs for each condition where a binary 1 appears in the output. As an example, a binary 1 output appears for the decimal number 10. That is the binary code 1010. In other words, at this time A is 1, B is 0, C is 1, and D is 0. To write a Boolean AND expression for this term, you write the input letter where a binary 1 occurs and the complement of the input letter where the 0 occurs. Therefore, the term for 1010 is:

$$A\bar{B}C\bar{D}$$

Using that technique, you can now write the complete expression. It is as follows:

$$X = A\bar{B}C\bar{D} + A\bar{B}CD + AB\bar{C}\bar{D} + AB\bar{C}D + ABC\bar{D} + ABCD$$

Note that the result is a standard sum of products Boolean expression which we derived from the truth table. Go through each of the terms in the expression to be sure that you see how they were obtained from the input states.

As usual, we have a Boolean expression which we now want to reduce to its minimum form. We could, of course, just implement it directly from the expression. The resulting circuit would appear as shown in Fig. 15A. It uses six 4-input AND gates and a 6-input OR gate. That would be a considerable nuisance to implement with integrated circuits, but it could be done although it would not be economical and it would take up considerable space. Based on what you have seen previously in this article, you can just about bet that the circuit will reduce to something simpler. All we have to do is reduce it using the same techniques used earlier.

	DECIMAL	BINARY A B C D	X
VALID BCD CODES	0	0 0 0 0	0
	1	0 0 0 1	0
	2	0 0 1 0	0
	3	0 0 1 1	0
	4	0 1 0 0	0
	5	0 1 0 1	0
	6	0 1 1 0	0
	7	0 1 1 1	0
	8	1 0 0 0	0
	9	1 0 0 1	0
INVALID BCD CODES	10	1 0 1 0	1
	11	1 0 1 1	1
	12	1 1 0 0	1
	13	1 1 0 1	1
	14	1 1 1 0	1
	15	1 1 1 1	1

$X = A\bar{B}C\bar{D} + A\bar{B}CD + AB\bar{C}\bar{D} + AB\bar{C}D + ABC\bar{D} + ABCD$

Fig. 14. The first step in the design of any logic circuit is to draw the truth table and generate an equation.

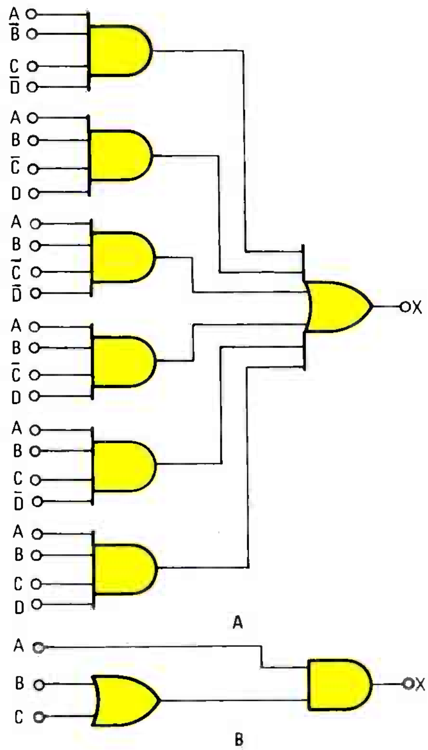


Fig. 15. The invalid-code detector generated directly from it's unsimplified equation is a monster in comparison to its Boolean-derived equivalent.

The first thing that you should do is scan through the expression looking for common terms and expressions. You can see, for example, that the first two terms contain the common expression $A\bar{B}C$. The next two terms contain the common expression $AB\bar{C}$, while the last two terms contain the common expression ABC. As a result, you can factor those terms out producing this expression:

$$X = A\bar{B}C(\bar{D}+D) + AB\bar{C}(\bar{D}+D) + ABC(\bar{D}+D)$$

Of course, by using the law of complements and the law of intersection, the term $(\bar{D}+D)$ can be eliminated, leaving the expression:

$$X = A\bar{B}C + AB\bar{C} + ABC$$

You can now look through the expression for common terms again. The second and third terms contain AB, therefore, it can be factored out. The revised expression then becomes:

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

Again using the law of complements and intersection, you can reduce the parenthesis $(\bar{C}+C)$ expression. The result is:

$$X = A\bar{B}C + AB$$

Again you can look for common factors. A is common to both terms so let's factor it out next.

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

If you have a sharp eye, you will recognize that the term $(\bar{B}C + B)$ can be reduced using the law of absorption to B + C. With that further simplification, the expression becomes:

$$X = A(B + C)$$

At this point, the expression is fairly simple. In fact, it can be implemented at this point with an AND gate and an OR gate as shown in Fig. 15B. That considerably simpler circuit will, of course, recognize the six invalid 4-bit codes, which are not BCD values.

A Design Example. Now let's take a look at how a designer would use Boolean algebra in creating some new digital product. As a simple example, let's assume that you wished to design a digital die.

You plan to use light-emitting diodes mounted in the standard die format to represent the numbers 1 through 6. That is illustrated in Fig. 16. Your job is to develop the digital circuit that will turn the lights on as desired.

The most obvious thing we know about the design is that there are six unique patterns that we wish to create. Therefore, the circuit must have six discrete states in which it can reside. We also know that we want the patterns

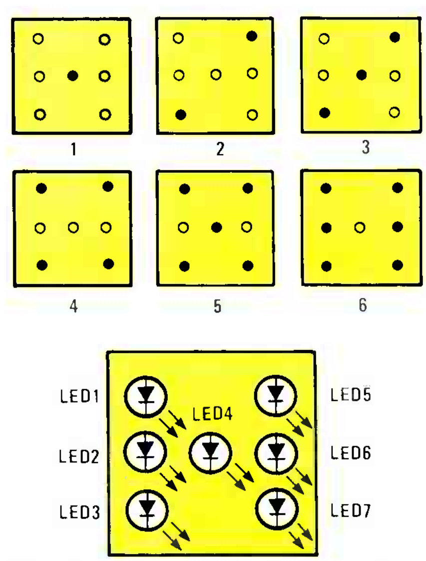


Fig. 16. An electronic die display can be easily made using six LED's.

shown in Fig. 16. The patterns define a total of seven different LED's (LED1–LED7). Therefore, we will need one signal to drive each LED.

The logic circuits driving the LED's will get their inputs from a signal source that defines the six desired states. The signal source will, in general, be some form of binary counter. We want a binary counter that has six states. In other words, it is a modulo six counter with six states and would also perform frequency division by 6. Naturally we can design such a circuit ourselves, but typically such circuits are already available. For example, we can use the 7492 TTL divide-by-12 counter. The device contains four flip-flops. One of them is independent while the other three are connected as a modulo 6 counter with the six binary states 000 through 101. Other counters are also available. Numerous CMOS divide-by-N counters are also available and are easily configured to produce a count of 6. For this example, we will assume the use of the 7492 counter with the six states described previously.

OK, at this point the problem is pretty well defined. The next step is to develop a truth table that fully defines every possible state. To start, let's write down the six counter states provided by the 7492 counter. We will use only the A, B, and C flip-flops which produce the binary count 000 through 101 as illustrated in Fig. 17. Note in the left-hand column we have recorded the decimal state that each of the binary counter states will represent. Those are the decimal numbers 1 through 6 that we want to represent in the form of an LED display. Just keep in mind that the binary value in this case does not equal the decimal state.

When N flip-flops are used for counting or frequency-division, it is possible to achieve a maximum count of 2^N states. That would give us a total number of:

$$2^3 = 8$$

With our 7492 counter, we are using only 6 of the 8 states. The two remaining states are 110 and 111. Since the counter will never go into those states, we do not care whether or not they exist. However, sometimes when we include the "don't care" states in expressions, we can more easily simplify the Boolean expressions we derive from the truth table. Therefore, we have recorded those two states in the truth table and labelled them "don't care."

DIE VALUE	COUNTER STATES A B C	LED OUTPUTS LED1	LED2	LED3	LED4	LED5	LED6	LED7
1	0 0 0	0	0	0	1	0	0	0
2	0 0 1	0	0	1	0	1	0	0
3	0 1 0	0	0	1	1	1	0	0
4	0 1 1	1	0	1	0	1	0	1
5	1 0 0	1	0	1	1	1	0	1
6	1 0 1	1	1	1	0	1	1	1
–	1 1 0	1	1	1	1	1	1	1
–	1 1 1	1	1	1	1	1	1	1

"DON'T CARE" STATES

Fig. 17. The truth table for the electronic die is shown here as the first design step.

We will use them in deriving the Boolean expressions as they will improve our ability to reduce them.

Next, let's develop the output states for the seven LED's. We have labelled the outputs as LED1 through LED7 in Fig. 17. Referring back to Fig. 16, you can see what LED's must be on to represent each digit. For example, to represent a decimal 1 on a die, LED4 will be on. For a die value of 1, the counter output states are 000. Therefore, we will record a binary 1 in the LED4 column and binary 0's in all other columns. To represent a 3, LED3, LED4, and LED5 are on, while the others are off. Look through the truth table and compare the LED entries for each of the six states. Finally note that we have recorded binary 1's in each column for the two "don't care" output states. Each LED value is entered in the table using the same reasoning until the table is complete.

The truth table now completely defines our design. At this point, we convert the truth table into the Boolean equations. We will develop a separate equation for each of the LED outputs. Let's start with LED1. Looking at the LED1 column, we note the input states where a binary 1 appears in the output. Then we write an AND expression involving inputs A, B, and C for each occurence of a binary 1 output. For a 1 input, we will write the input variable, while for a 0 input we'll write the complement of the input variable.

The equation is then written by ORing together each of the input terms. The input expression for LED1 is:

$$LED1 = \overline{A}BC + A\overline{B}\,\overline{C} + A\overline{B}C + AB\overline{C} + ABC$$

Work through the example yourself to be sure that you see how each of the terms was developed from the input code.

Now go through and derive all of the remaining Boolean expressions for LED2 through LED7. As shown here:

$$LED2 = A\overline{B}C + AB\overline{C} + ABC$$

$$LED3 = \overline{A}\,\overline{B}C + \overline{A}B\overline{C} + \overline{A}BC + A\overline{B}\,\overline{C} + A\overline{B}C + AB\overline{C} + ABC$$

$$LED4 = \overline{A}\,\overline{B}\,\overline{C} + \overline{A}B\overline{C} + A\overline{B}\,\overline{C} + AB\overline{C} + ABC$$

If you've examined the truth table closely enough, you should have discovered that the remaining three columns LED5, LED6, and LED7, are simply the same as columns LED1, LED2 and LED3. For example:

$$LED5 = LED3$$
$$LED6 = LED2$$
$$LED7 = LED1$$

Because the expressions are equal, it will certainly cut down on the amount of Boolean algebra we are going to have to do and the number of circuits we have to implement.

Now comes the fun part. Our job is to reduce the equations to the simplest possible form. Obviously, you can implement the equations just as they are written. That will require lots of 3-input AND gates and multiple-input OR gates. The resulting circuit will be very large and complex. By using Boolean algebra, we will be able to reduce the circuitry to a manageable level. Now let's use Boolean algebra to reduce each of the previous expressions to its simplest form. The reduction is done as follows and we provide you with the rule related to each step. Work through them yourself a step at a time to be sure that you understand them. Starting with the expression for LED1:

$$LED1 = \overline{A}BC + A\overline{B}\,\overline{C} + A\overline{B}C + AB\overline{C} + ABC$$

Rearrange by the laws of commutation:

$$LED1 = \overline{A}BC + ABC + A\overline{B}\,\overline{C} + A\overline{B}C + AB\overline{C}$$

Factor out by laws of distribution:

$$LED1 = BC(\overline{A} + A) + A\overline{B}(\overline{C} + C) + AB\overline{C}$$

Reduce with the laws of complements:

$$LED1 = BC(1) + A\bar{B}(1) + AB\bar{C}$$

Reduce by laws of intersection:

$$LED1 = BC + A\bar{B} + AB\bar{C}$$

Factor out by law of distribution:

$$LED1 = BC + A(\bar{B} + B\bar{C})$$

Reduce by laws of absorption:

$$LED1 = BC + A(\bar{B} + \bar{C})$$

Expand by laws of distribution:

$$LED1 = BC + A\bar{B} + A\bar{C}$$

This could be rearranged by the law of commutation to:

$$LED1 = A\bar{B} + A\bar{C} + BC$$

Now let's look at LED2:

$$LED2 = A\bar{B}C + AB\bar{C} + ABC$$

Factor by laws of distribution:

$$LED2 = A\bar{B}C + AB(\bar{C} + C)$$

Reduce by law of complements:

$$LED2 = A\bar{B}C + AB(1)$$

Reduce by law of intersection:

$$LED2 = A\bar{B}C + AB$$

Factor with law of distribution:

$$LED2 = A(\bar{B}C + B)$$

Reduce by law of absorption:

$$LED2 = A(B + C)$$

Expand by law of distribution:

$$LED2 = AB + AC$$

Going on to LED3 next, we get:

$$LED3 = \bar{A}\bar{B}C + \bar{A}B\bar{C} + \bar{A}BC + A\bar{B}\bar{C} + A\bar{B}C + AB\bar{C} + ABC$$

Rearrange terms by law of commutation:

$$LED3 = \bar{A}\bar{B}C + A\bar{B}C + \bar{A}B\bar{C} + \bar{A}BC + A\bar{B}\bar{C} + AB\bar{C} + ABC$$

Factor by law of distribution:

$$LED3 = \bar{B}C(\bar{A} + A) + \bar{A}B(\bar{C} + C) + A\bar{B}\bar{C} + AB(\bar{C} + C)$$

Now reduce by law of complements:

$$LED3 = \bar{B}C(1) + \bar{A}B(1) + A\bar{B}\bar{C} + AB(1)$$

Reduce by law of intersection:

$$LED3 = \bar{B}C + \bar{A}B + A\bar{B}\bar{C} + AB$$

Factor by law of distribution:

$$LED3 = \bar{B}C + \bar{A}B + A(\bar{B}\bar{C} + B)$$

Reduce by law of absorption:

$$LED3 = \bar{B}C + \bar{A}B + A(\bar{C} + B)$$

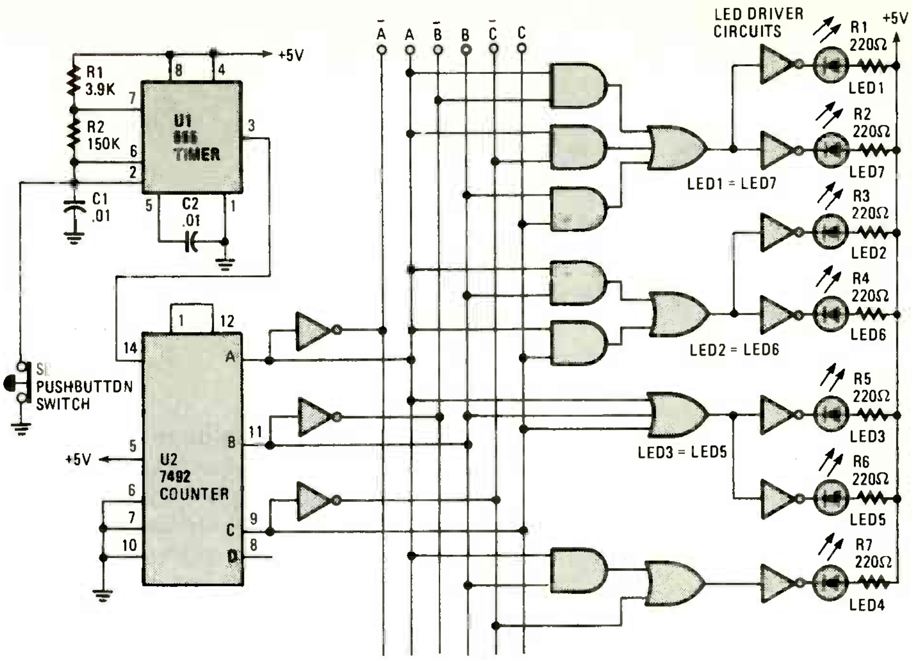


Fig. 18. At long last we arrive at the circuit for the electronic die.

Expand by law of distribution:

$$LED3 = \bar{B}C + \bar{A}B + A\bar{C} + AB$$

Rearrange by law of commutation:

$$LED3 = \bar{B}C + A\bar{C} + \bar{A}B + AB$$

Factor by law of distribution:

$$LED3 = \bar{B}C + A\bar{C} + B(\bar{A} + A)$$

Reduce by laws of complements and intersection:

$$LED3 = \bar{B}C + A\bar{C} + B$$

Rearrange by law of commutation:

$$LED3 = \bar{B}C + B + A\bar{C}$$

Reduce $(\bar{B}C + B)$ by law of absorption:

$$LED3 = B + C + A\bar{C}$$

Again reduce $(C + A\bar{C})$ by law of absorption:

$$LED3 = B + A + C$$

Finally rearrange by law of commutation:

$$LED3 = A + B + C$$

Moving on to LED4:

$$LED4 = \bar{A}\bar{B}\bar{C} + \bar{A}B\bar{C} + A\bar{B}\bar{C} + AB\bar{C} + ABC$$

Rearrange by law of commutation:

$$LED4 = \bar{A}\bar{B}\bar{C} + A\bar{B}\bar{C} + \bar{A}B\bar{C} + AB\bar{C} + ABC$$

Factor by law of distribution:

$$LED4 = \bar{B}\bar{C}(\bar{A} + A) + B\bar{C}(\bar{A} + A) + ABC$$

Reduce by laws of complements and intersection:

$$LED4 = \bar{B}\bar{C} + B\bar{C} + ABC$$

Factor by law of distribution:

$$LED4 = \bar{C}(\bar{B} + B) + ABC$$

Reduce by laws of complements and intersection:

$$LED4 = \bar{C} + ABC$$

Reduce by law of absorption:

$$LED4 = \bar{C} + AB$$

or rearranging by law of commutation:

$$LED4 = AB + \bar{C}$$

The remaining signals are redundant because:

$$LED5 = LED3$$
$$LED6 = LED2$$
$$LED7 = LED1$$

A summary of these equations:

$$LED1 = LED7 = A\bar{B} + A\bar{C} + BC$$
$$LED2 = LED6 = AB + AC$$
$$LED3 = LED5 = A + B + C$$
$$LED4 = AB + \bar{C}$$

At this point we have a set of minimal equations. We are now able to implement them with logic circuits. If you look through the set of equations, you will see that most consist of terms with two input variables ANDed together. Looking further, you probably noticed that some of the equations have the same term in them. For example, the term AB appears in both the expressions for LED2 and LED4. A single AND gate can be used to develop the expression AB which can then be used to implement both the LED2 and the LED4 outputs. That further reduces the *(Continued on page 105)*

Circuit Circus

By Charles D. Rakes

SOLVING PROBLEMS ELECTRONICALLY

Our Circus starts off this month with a problem to solve electronically. It all started when a local manufacturing company asked to have the temperature monitored in a number of gas-fired furnaces.

Their main concern was not the actual operating temperature, but the temperature's stability throughout a production run. A thermocouple was selected for the applicable temperature range. It was obvious that a very sensitive DC millivoltmeter would be required to measure that range. The temperature vs. voltage chart for it indicated all output readings would fall between 5 and 10 millivolts. I counted four different digital voltmeters within reach and not a single one would cover the range or offer the degree of resolution needed for the job.

Purchasing a new sensitive digital voltmeter would be nice, but that wouldn't be a very rewarding solution, so I decided to go another route. If the thermocouple's output could be increased at least 100 times, any of the voltmeters on hand would suffice for this task.

One of the most stable ways to amplify a minute DC signal is to convert it to AC and then do the processing. Following that approach, we can convert the thermocouple's output into an AC signal that can easily be amplified to a sufficient level and then rectified back to DC to be read out on any DVM.

Dual Chopper Amplifier. The Dual Chopper Amplifier circuit shown in Fig. 1 operates in this fashion. The four blocks of U1 (U1-a through U1-d) are independent bilateral solid-state switches. Switches U1-a and U1-b are connected in parallel and on command pass the DC input-signal voltage through to the input of the AC amplifier, U2-b.

Switches U1-c and U1-d are also connected in parallel. When activated, those switches tie the input of the AC amplifier to the circuit common. That

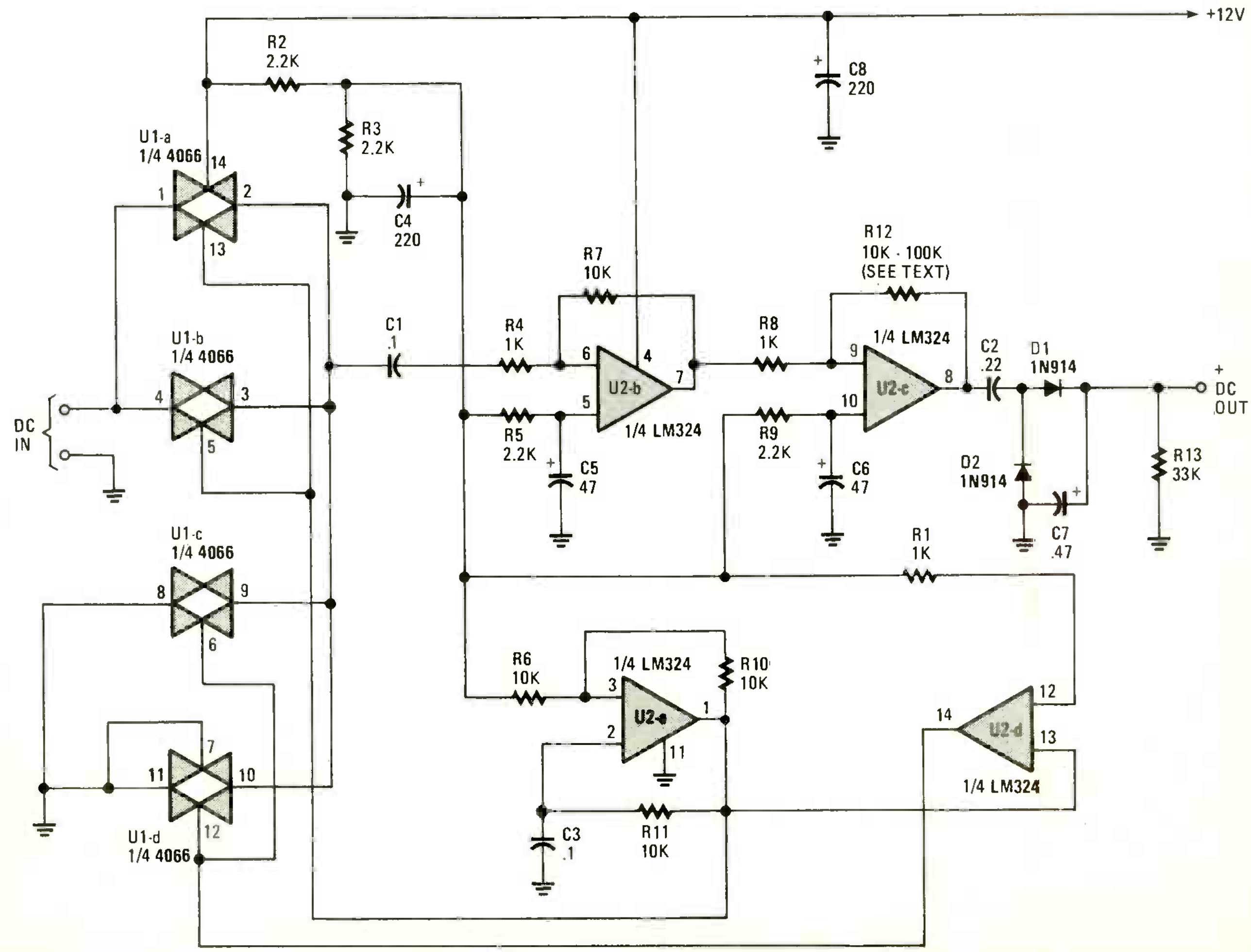


Fig. 1. The Dual Chopper Amplifier circuit is built around a 4066 quad bilateral switch and a quad op-amp.

converts the DC input signal into a near-perfect squarewave at the input of the AC amplifier.

Op-amp U2-a is connected in a squarewave-oscillator circuit operating near 500Hz. The output of U2-a at pin 1 connects to the control input of switches U1-a, U1-b and the input of U2-d (which is configured in this circuit as an inverter).

When the output of op-amp U2-a goes positive, switches U1-a and U1-b are activated, offering a low-resistance path for the incoming signal to pass through. At the same time, the output of U2-d at pin 14 is in the low state, keeping switches U1-c and U1-d open.

The typical "on" resistance of the bilateral switch is about 80-ohms and the "off" position produces leakage current in the 0.1-nA range. That's not bad for an electronic switch that can be picked up for less than a dollar at most electronics supply houses. In fact, one of **Popular Electronics'** advertisers recently offered the 4066 for less than 10 cents a switch, so shop our pages first when gathering parts for any of your projects.

Op-amp U2-b is connected as a conventional AC inverting amplifier with a gain of 10 (gain = R7/R4). The output of U2-b at pin 7 is direct coupled to the input of the second amplifier stage (U2-c) through R8. The gain

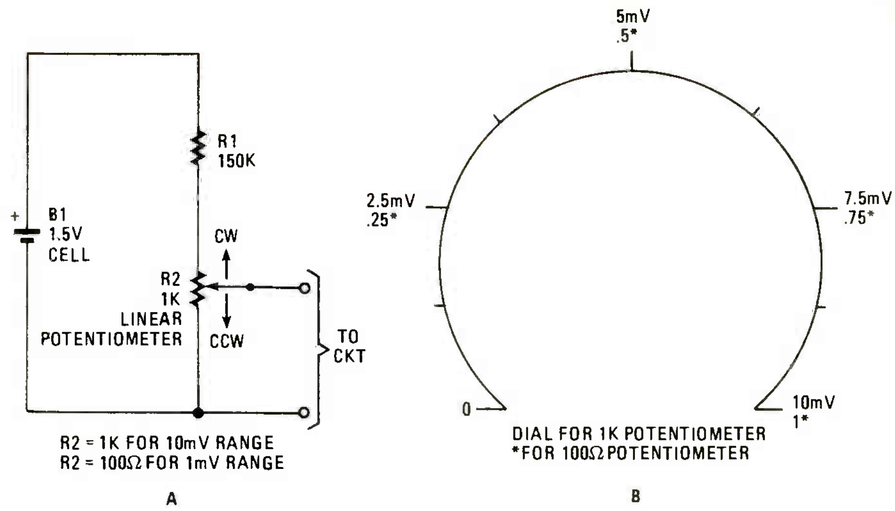


Fig. 2. This simple circuit can be used to calibrate the dual Chopper Amplifier.

of U2-c is set by the ratio of resistors R12 and R8 (gain = R12/R8).

The AC signal at the output of op-amp U2-c is fed to a voltage doubler/rectifier circuit made up of D1, D2, C2, and C7. That rectifier circuit converts the amplified signal back to DC for measurement with a DVM. Since the transformation back to DC isn't precise (due primarily, to the voltage loss of the two diodes at low input-signal levels), it is best to calibrate the amplifier with the simple circuit shown in Fig. 2.

To measure DC voltages with input levels of 1 to 10 millivolts use the calibration circuit in Fig. 2A with a 1K linear potentiometer for R2. When calibrating the amplifier for signal levels below 1-millivolt, use a 100-ohm linear potentiometer for R2 for a 0 to 1-millivolt calibration range. A simple hand-drawn dial can be a helpful addition to the calibrator circuit, [see Fig. 2B].

The amplifier's most-linear operation occurs when the DC output signal is between .6-volt to about 4.0-volts. Staying within that range will allow for a ten-to-one input level change. The amplifier's gain setting resistor, R12, should be 10K for monitoring input levels between 1 and 10-millivolts, and 100K for levels less than 1-millivolt.

Experimenting with different resistor values for R12 (using the gain formula R12/R8) is fine as long as the DC output is kept within the circuit's linear operating range. If you want to make the Chopper Amplifier a standard fixture in your shack, build the circuit on a section of perfboard with IC sockets, and follow a good layout scheme.

For convenience, mount the circuit in a medium-size plastic cabinet with the input/output terminals and switches on one surface of the enclosure. A two-position switch can be added to the circuit to select between a 10K and a 100K resistor for R12.

The simple calibrator circuit can be built into the same cabinet with a two position switch to select between a 1K and a 100-ohm potentiometer with a dial ecutcheon for both.

RC Timer. The next circuit in our menagerie, uses a modern version of an old component that's been around since the wheel, well almost that long. Not only is the new version of the timely component much larger in value than ever before, it is also much smaller in size. A paradox or what? No, actually it's one of the new memory capacitors that come in farad sizes (1 farad = 1,000,000 μF). Not too many years ago, a 1-farad capacitor wouldn't fit in a compact car, but today you could walk around with a pocket full of farads and not even know you were loaded down.

The circuit in Fig. 3 uses a 0.1-farad capacitor as the "C" in an RC timer circuit. Time delays of a few seconds to several hours can be set by selecting the proper charging resistor. The timer's output can be monitored by observing the status of the two LED's.

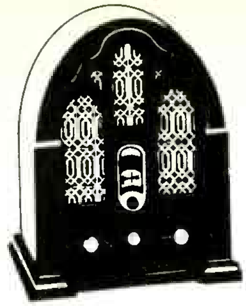
Lights, motors, or anything electrically operated can be controlled with the circuit by using an optocoupler at either or both the "A" and "B" output terminals.

The 0.1-farad capacitor is connected to the 5-volt supply through a charging resistor selected by S1. A JFET input op-amp is configured as a voltage-comparator circuit with the

(Continued on page 100)

PARTS LIST FOR THE DUAL CHOPPER AMPLIFIER

U1—40066 quad bilateral switch, integrated circuit
U2—LM324 quad JFET op-amp, integrated circuit
D1, D2—1N914 general-purpose diodes
R1, R4, R8—1000-ohm ¼-watt, 5% resistor
R2, R3, R5, R9—2200-ohm ¼-watt, 5% resistor
R6, R7, R10, R11—10,000-ohm ¼-watt, 5% resistor
R12—10,000 to 100,000-ohm ¼-watt, 5% resistor
R13—33,000-ohm ¼-watt, 5% resistor
C1, C3—0.1-μF Mylar capacitor
C2—0.22-μF Mylar capacitor
C4, C8—220-μF, 100-WVDC electrolytic capacitor
C5, C6—47-μF, 16-WVDC electrolytic capacitor
C7—0.47-μF ceramic disc capacitor
Printed circuit or perfboard materials, enclosure, IC sockets, battery and battery holder, wire, solder, hardware, etc.



Antique Radio

By Marc Ellis

Grid leak secrets

As promised in January, we're going to continue reviewing some of the interesting reader comments on the discussion of the Crosley 50 receiver published last year. These are letters that happened to come in after we had moved on to other topics. Up to now, there hasn't been a good opportunity to get back to them.

In the previous column, we led off by looking at Dan Damrow's most impressive re-creation of the little Crosley regenerative one-tube receiver. And now I'd like to continue with a question posed by reader Tim Kraemer (Roseglen, ND).

In my original "once over lightly" discussion of the Crosley's circuitry, I referred to the set's *grid-leak detector.* Tim wrote that he really would like to understand how that type of detector works and asked for a more detailed explanation. I'm happy to provide it because the grid-leak circuit is of key importance to most antique-radio enthusiasts.

The circuit was used in almost every commercial broadcast receiver produced from the dawn of broadcasting through the early 1930's. After that period, it became obsolete in broadcast receivers, but continued to be very popular in shortwave sets for several years thereafter. Yet few people really know how the circuit works, or understand the meaning of its colorful name.

Revealing My Sources. There's more than one way to analyze the action of the grid-leak detector, and I've pieced together what I'm about to tell you from several excellent sources. Because not everything that was published about that popular circuit can be considered definitive, I'm going to recommend these sources to anyone who'd like to do more intensive reading on the subject

First, there's *The Radio Amateur's Handbook*, published by The American Radio Relay League. Check the earliest edition of that yearly publication that you can get your hands on. I've found good material in the 1927, 1936, and 1947 books, but the circuit is covered in volumes dating well into the 1970's.

For a more recent treatment of the subject, take a look at the article *A 1935 Ham Receiver* in QST magazine for September, 1986. The article has a sidebar discussion, which is entitled *How Regenerative Detectors Work*, that includes an excellent explanation of grid-leak operation.

Finally, moving back into the past, Ghirardi's classic *Radio Physics Course* (Radio Technical & Publishing Co., 1933) provides quite a bit of detail on the grid-leak detector.

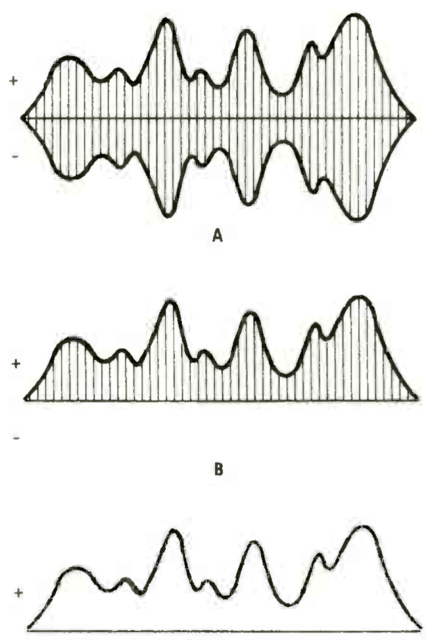


Fig. 1. The waveform in part "A" is a crude representation of an AM radio signal. Waveform B illustrates the rectification process, and C shows that the pulsations have been filtered out, resulting in a DC signal that varies in step with the original modulation.

The Detection Process. Before talking about how the grid-leak detector does its job, let's take a more generic look at the detection process. In order to convert the modulated radio signal from a broadcast station into a form that our ears can hear, we have to extract (detect) the audio frequencies in the signal, leaving behind the radio-frequency "carrier." For the amplitude-modulated signals encountered in the standard broadcast band, that is done by a rectification and filtering process.

For example, take a look at Fig. 1. The waveform shown in part "A" is a crude representation of an AM radio signal. Notice first that we're dealing with alternating current. The signal voltage alternates between positive and negative over a period of time. The pulsations of the radio-frequency carrier are denoted by the close-spaced vertical lines. They are traced within a varying envelope representing the modulating audio signal.

The waveform in Fig. 1B illustrates the rectification process. The negative component of the signal has been removed so that it's now direct current rather than alternating current. However, the pulsations of the radio frequency carrier are still present.

In Fig. 1C, the pulsations have been filtered out, leaving behind a direct current whose intensity varies in step with the original audio modulation. The varying direct current, after amplification, is capable of driving the electromagnets in a speaker or set of headphones to produce audible sound.

Inside the Grid Leak Detector. Now that you know what a detector has to accomplish in order to do its job, let's see how those operations are carried out by the grid-leak detector circuit. We'll trace the path of the signal through the circuit with the help of the diagram shown in Fig. 2—a rather simplified and generic schematic diagram (similar to that of the Crosley 50) representing *any* one-tube regenerative set.

In vacuum-tube V1, under no-signal conditions, a steady stream of electrons (which are negatively-charged particles) is emitted by the filament. That electron stream flows past the grid, and is attracted into the oppositely-charged (positive) plate. However, the electron stream is disrupted, as follows, when a modulated

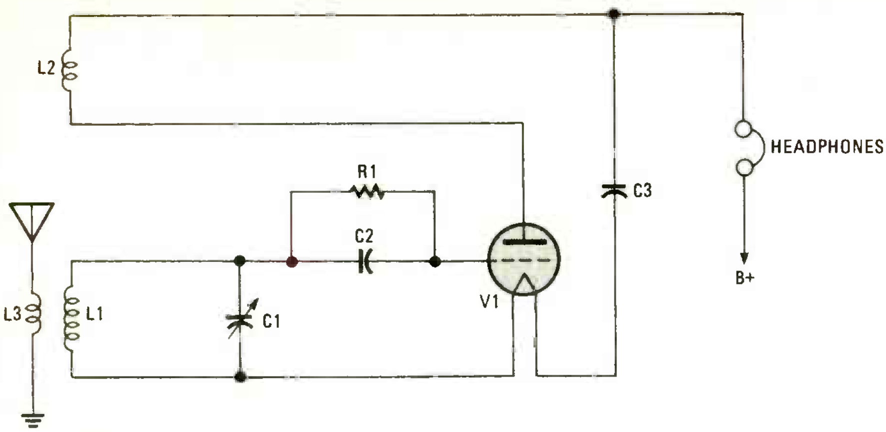


Fig. 2. This rather simplified generic schematic diagram, which is representative of one-tube regenerative sets, helps to illustrate the operation of grid-leak detectors.

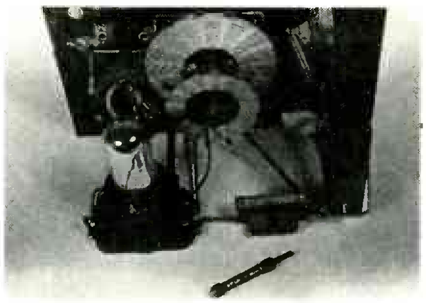
radio signal (like that in Fig. 1A) is picked up.

The radio signal first appears across the coil and tuning capacitor, L1/C1, making one plate (the left side) of grid capacitor C2 alternately positive and negative. During the positive periods, or half-cycles, electrons flow from the tube's electron stream through the grid to the opposite plate of the grid capacitor (on the right). They are attracted by the positive charge on the first plate but, of course, are prevented from reaching it by the insulating *dielectric* separating the plates.

During the half-cycles when the plate at on the left is negative, the electrons at the other plate (having the same charge) are repelled towards the grid of the tube. But they can't reenter the electron stream flowing past the grid because the stream also has a negative charge and repels them. When the plate on the left becomes positive again, more electrons are attracted from the stream, through the grid, and towards the plate on the right side of C2. They, in turn, become trapped and so on.

Here's where the grid-leak resistor (R1) comes in. Without it in the circuit, the number of trapped electrons would continue to build up, eventually giving the grid a strong negative charge. That charge would repel the electrons streaming from the tube filament and prevent them from reaching the plate, cutting off the tube. What actually happens, though, is that the excess electrons slowly flow, or "leak," back to the filament through the grid-leak resistor, R1, which has a value of a couple of million ohms.

The Grid Capacitor. The current passing through the grid resistor is direct current, DC. It moves in one direction only—from the grid to the filament. It can never move in the opposite direction because electrons on the grid cannot re-enter the electron stream flowing through the tube.



A look behind the Crosley 50 panel shows the grid-leak detector assembly just to the right of the tube socket. Below that is an Eagle adjustable grid-leak resistor of the same era. Its value could be changed by twisting a knurled thumbscrew on one end.

In other words, the action in the grid circuit has rectified the alternating current of the radio signal, turning it into direct current. But the strength of the current at any given time reflects the strength of the original radio wave as modulated by the audio signal it is carrying.

If it weren't for the action of grid-capacitor C2, the direct current flowing in the grid circuit would still have superimposed on it the radio-frequency oscillations from the original carrier wave (as in Fig. 1B). But capacitors are capable of filtering out oscillations through their ability to store energy.

During the half-cycles that electrons are flowing from the grid towards the right side of C2, the capacitor becomes charged (stores some electrons). But during each following half-cycle, when the electron flow stops, the capacitor discharges, releasing electrons into the circuit. By supplying electrons when none would otherwise be flowing, the capacitor smooths out the radio-frequency oscillations.

Although C2 is large enough to smooth out the radio-frequency oscillations of the carrier, it can't store enough energy to smooth out the much slower audio frequencies of the envelope. The result looks like the waveform shown in Fig. 1C. With the carrier filtered out, what's left is a direct current whose intensity varies in step with the original audio modulation. But the story is far from over.

Three Tubes in One. Besides acting as a detector—separating the audio signal from the radio frequency carrier—tube V1 also functions as an audio amplifier. The small current variations in its grid circuit control the much larger current flowing (through the earphones) in its plate circuit, causing that current to vary in a matching pattern. The result is a much stronger audio signal, giving comfortable headphone volume.

Here's a close-up of the Crosley's grid-leak detector assembly. The resistance unit looks a lot like a small fuse. It snaps into a couple of spring clips mounted directly on the grid capacitor.

Wait a minute, though, there's more! The receiver is *regenerative*, which means that some of the tube's plate-circuit energy is coupled back into the grid circuit (in this case, via the *tickler* coil, L2). When properly adjusted, that feedback loop results in a several thousandfold amplification of the incoming radio-frequency signal prior to detection by the grid-leak circuit.

So what we have is a single tube (a simple triode at that) functioning simultaneously as an RF amplifier, detector, and AF amplifier. No wonder regenerative receivers were so popular for so many years. They delivered unbelievable performance from just a few simple parts.

But grid-leak detectors weren't confined only to regenerative receivers. They were just as popular with other

(Continued on page 99)

Computer Bits

By Jeff Holtzman

BUYING YOUR FIRST COMPUTER

Herb Friedman, my friend, colleague, and mentor, used to write this column, but Herb passed away last fall. Because of Herb's tremendous presence in the electronics and computer industries the past thirty years, I feel greatly honored that the baton has been passed to me. I'll do my best to try to maintain Herb's standards, his enthusiasm, and his willingness to help.

I'm new here, the magazine itself has evolved into a new being, and you may well be new too. So I thought it would be wise to begin at the beginning: buying your first personal computer. I assume only that you've chosen a machine that runs MS-DOS, rather than one of the "A" machines (Apple, Atari, or Amiga).

For these first few columns, I'll discuss some of the issues that you should consider before buying: What type of CPU? How fast? What type of video? What type of hard disk? What type of floppy? How much memory? That sort of thing.

In addition, in each column, I'll examine an interesting new hardware or software product. If you find it interesting too, and decide to buy, let the manufacturer know you read about it here. If you don't find it interesing, let me know—I'll avoid similar products in the future. If you're interested in a specific product, let me know—I'll get a copy and put it through its paces.

Likewise, let me know your feelings about the column. Tell me what you like and what you don't like. Is it too technical? Not technical enough? What topics would you like to see covered?

Getting Started. You're thinking about buying a PC, but are overwhelmed by the staggering variety of available models. What should you buy? How much should you spend? Who should you buy it from?

Each of those is a difficult question; but depending on your background and experience, the last question may be most important. If you're just getting started with computers, you may want to buy from a local dealer who can help with the problems that inevitably arise.

If you feel confident, you can do well by buying from a reputable mail-order house—JDR, Jameco, 47th Street Photo, CompuAdd, etc. then do so.

Confident or not, don't just scan the pages of *Computer Shopper* for the company with the absolute lowest prices—you'll regret it in the long run, which may not be so long. Look at back issues of the big computer magazines (*Byte*, *PC*, etc.) for the companies who have been advertising consistently for several years.

If possible, join a local computer club before buying. Talk to other people about their experiences with both local and mail-order dealers. Don't be afraid to ask for help.

What should you buy? That depends on what you want to do with your PC, and on your budget. However, don't let your budget be your primary consideration. If you're like most people, you'll muddle your way through learning the basics, and then find yourself wanting to do more and more. A good rule of thumb is to estimate the computer power you need now and double it; that should hold you for a couple of years.

Also, buy with an eye toward the future. If (when) you upgrade your system later, which components will transfer? Which will be obsolete? Admittedly, those are hard questions, but you'll make a better decision now if you've at least tried to answer them.

System Types. At this time, there are three basic levels of computing power: 8088, 80286, and 80386. You can buy a minimally configured system at each level for about $500, $1000, and $2000, respectively. A 386 system provides roughly ten times more computing power than a basic 8088 system, but costs only four times as much, so in terms of raw computing power per dollar, it's a better buy.

A new hybrid, the 80386SX, has many features of the 80386, but with limited address and data buses. The 386SX should allow manufacturers to produce 386 machines at 286 prices.

Before laying out any cash, you should try to figure out what you want to do with your computer. If you want to do light word-processing or spreadsheet work, a 640K 8088 system without a hard disk may suffice, although a hard disk makes computing much more convenient.

To maintain a small database (for example, a club membership, or a record or stamp collection), you'll need a 20 or 30MB hard disk. Raw CPU speed won't make much difference, unless you expect the database to grow really large.

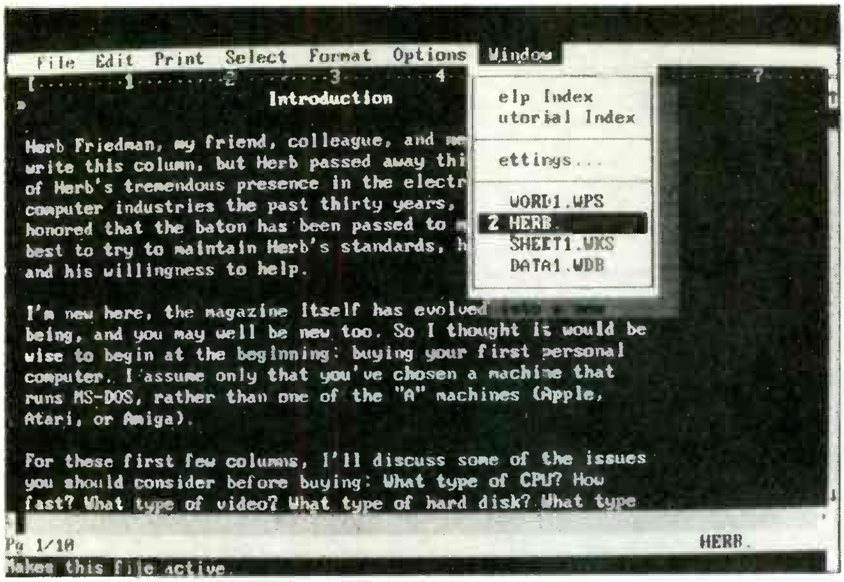
For graphics (CAD, drawing and painting, desktop publishing, etc.) and number-crunching work, you need an 80286 or 80386 CPU, and a large, fast hard disk. You'll probably need more than 640K of memory, too.

If you're interested in operating systems other than DOS (OS/2, UNIX) or operating environments (DESQview, OmniView), get a 286 or 386, and at least 2MB of RAM beyond the first 640K.

When you know what you want to do, you can try to find a pre-configured unit that meets your needs. Often, however, to get what you want, a pre-configured unit must be supplemented, or you may simply have to purchase bits and pieces. Good mail-order houses discount complete custom systems.

When assembling a custom PC, look at each subsystem separately: CPU, memory, video, and mass storage. We'll discuss the CPU this time, and take up other parts in future issues.

Choosing a CPU. The type of CPU and its clock speed have a big influence on the overall speed and power of a system. Because of that, although you can buy an 8088 motherboard these days for next to nothing, you should avoid the 8088 unless you're under an extremely tight budget, or are



Microsoft Works provides a word-processor, a spreadsheet, a database manager, and a communications program in a low-cost, easy-to-learn, and easy-to-use package.

quite sure that you have no interest in graphics and powerful operating environments.

You can buy a 4.77-MHz 8088 motherboard for under $100 now, and a high-speed 286 motherboard for about $300. Although that's three times as much, it's a relatively small part of the total cost of a system. And it'll take you a few years to outgrow a 286.

So the first component of my recommended medium-budget system consists of a 10- or 12-MHz 80286 motherboard.

Product of the Month. When just starting out, many people wonder what software to use. Typical questions include: Are the big-name (and high-priced) packages worth it? Or can you get everything you need from low-cost and shareware packages?

Shareware is great; I know from personal experience that PC-Outline and ProComm, for example, easily rival if not surpass many programs sold only through retail channels.

However, to assemble a collection of shareware programs that's right for you, you've got to spend a lot of time trying different programs. What you end up with will be somewhat eclectic—each will undoubtedly have a different user format, so what you learn in one will not be transferrable to another. You'll go crazy trying to remember that Alt-X means "save file and exit" in one program and "delete file" in another.

An alternative is a commercial all-in-one (or integrated) package. Microsoft Works, for example, is a low-cost ensemble that provides a word processor, a spreadsheet, a database manager, and a telecommunications program. It lists for $150, but is typically sold via mail order for about 66% of that price.

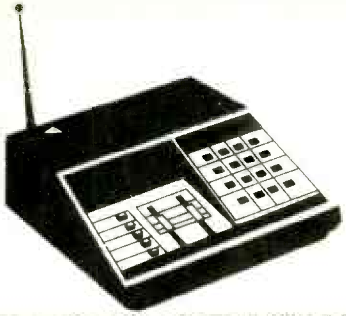
Taken separately, not one of the programs in Works could stand up to WordStar, dBASE III, Lotus 1-2-3, or even ProComm. But many users simply don't need all the power provided by the biggies.

Taken together, the whole adds up to more than the sum of the parts. The reason is that the keystrokes in each program correspond as much as possible with those in the others. So after learning how to use one, you're well on the way to knowing them all. And, perhaps most important, you can move data from one module of the program to another (for instance from the spreadsheet to the word processor).

Works' user format is similar to that in Quick BASIC and other Microsoft products. Works has menus that drop down from a title bar, and "dialog boxes" in which you enter information (tab stops in the word processor, for example). You can manipulate the menus and dialog boxes efficiently using the keyboard, a mouse, or both.

The program comes with a learn-by-doing tutorial that makes it easy to get up to speed quickly. One booklet helps raw beginners get started with personal computers, and another provides specific hints on how to use the various programs for different tasks.

Next month we'll talk about hard and floppy disks. See you then. ■



Scanner Scene

By Marc Saxon

PRIVATE PILOT'S HANDHELD SCANNER

Sony isn't a name that many people associate with scanners, nevertheless, the company produces a nifty and unusual little handheld that could easily be (since so many Sony dealers have never heard of it) one of the best kept secrets around! The scanner is called the *Sony Air-8*, and there's nothing else around that's quite like it.

The most unusual thing about Air-8 is its odd frequency range. For public-safety communications, it scans from 144 to 174 MHz. It also has the 108- to 136-MHz VHF aeronautical band; that's at least a little strange since most scanners that receive that band ignore the 108- to 118-MHz (VOR-range) portion of the band. From there on, the Air-8 coverage gets even stranger still. It's got the 200- to 400-kHz beacon/weather band, plus the AM and FM broadcast bands!

That unusual coverage comes about because the Sony Air-8 was primarily designed to meet the needs of private pilots, providing those frequencies that would most appeal to that particular user group. Other features of the unit include search/scan, selectable channel delays, lockouts, a 10-channel memory for each band, a backlit LCD display, keyboard locks, a priority channel, and (to top it off) it's keyboard programmable.

The Air-8 is housed in a rugged high-impact case, and comes with a shoulder strap and rubberized whip antenna. It weighs 21 ounces and operates on four "AA" batteries (you can use rechargeable nickel-cadmium units if you wish). Almost everybody who hears one in action comments on the unit's exceptionally good audio—the quality is better than that of many other scanners.

We liked the Air-8's unusual frequency range, as well as its ease-of-operation and general performance. It's not an *el-cheapo* special, either; it sells in the $270 ballpark. While a few of the larger communications equipment suppliers carry the Sony Air-8, they are more easily found at aviation suppliers. Probably the largest supplier is Sporty's Pilot Shop, Clermont Airport, Batavia, OH 45102-9747. Sporty's offers a free catalog.

The Sony Air-8—which is primarily designed for private pilots—features search/scan, selectable channel delays, lockouts, a 10-channel memory for each band, a backlit LCD display, keyboard locks, priority channel, and (to top it off) is keyboard programmable.

On the Record. A letter from Joe Azzara, Asbury Park, NJ brings up a question we have been asked many times before. Joe wants to tape record the activity on a particular channel (in Joe's case, his local fire-department frequency) while he's not at home. The problem is that tape cassettes get filled (often with gaps in the audio when used in such applications) and have to be flipped over or totally changed so often that it seems like an impossible concept.

Not so, for an innovative product has recently appeared to deal with that problem. It's the *Tape Saver TS-1* from Electron Processing, PO Box 708, Medford, NY 11763. The Tape Saver easily connects between your scanner and your cassette recorder via standard plugs. With the Tape Saver TS-1 on the job, the cassette recorder remains inoperative during periods when there is no activity on the frequency to which the scanner is tuned.

When the channel is active, the recorder comes to life. What you end up with is a continuous recording of communications activity and no wasted (blank) space on your tape. That way, one side of a C-90 tape cassette should be sufficient for many hours of monitoring. And the Tape Saver makes it easy to play it all back too.

The unit—which is equipped with an internal loudspeaker—operates from a 117-volt AC source and draws a mere 4 watts. All in all, it's a handy little device that solves a dilemma with which many scanner buffs have wrestled. The TS-1 sells for $49.95. For more information on the Tape Saver TS-1 write to Electron Processing, or call them at 516/764-9798.

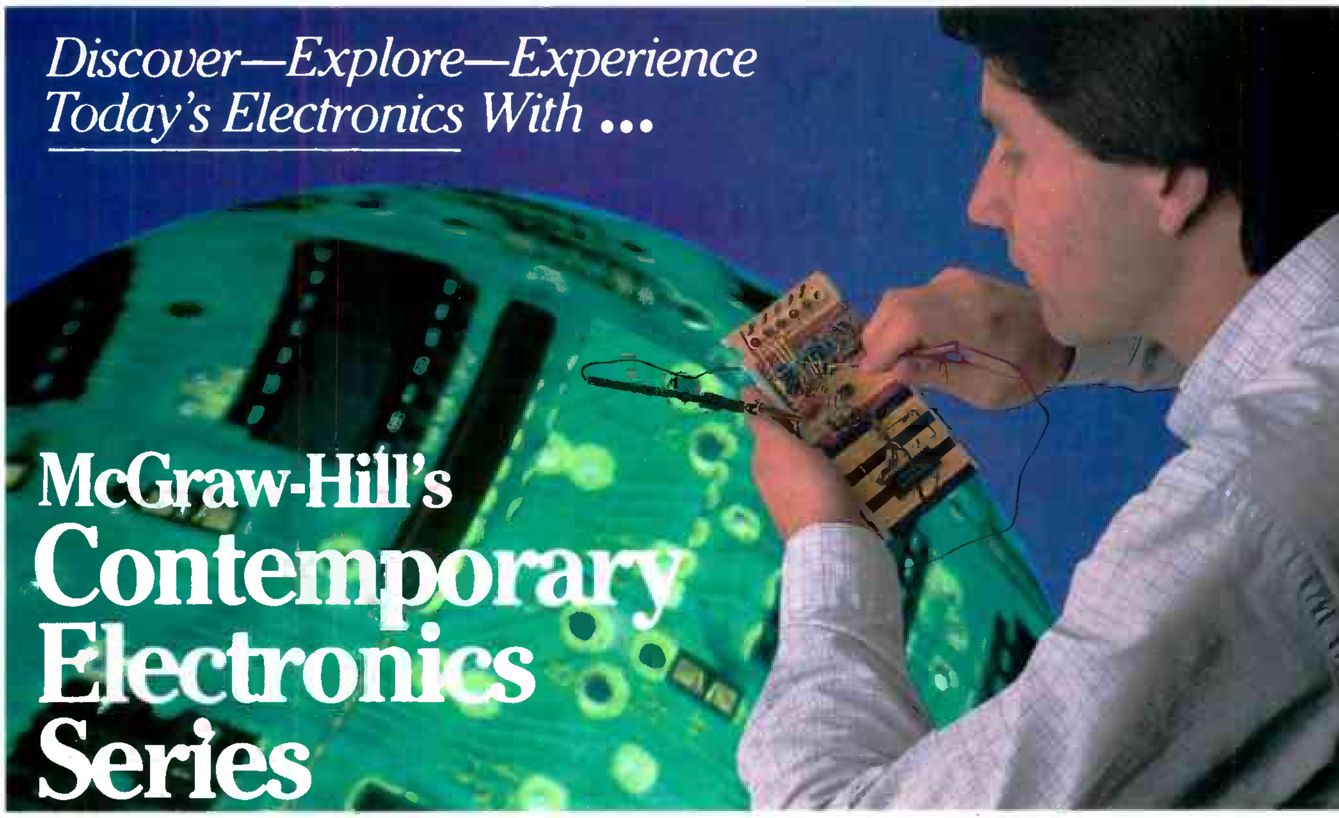
Communications Amok. Maybe the moon is full again, because the news clippings that relate to communications reveal that there are some eerie things taking place out there. Like the man in Spring Valley, CA who faces a year in the slammer and a $100,000 fine for deliberately jamming most of his local police communications over a two-month period.

That was no practical joke, the fellow was using an electronic jamming device that was mounted in his pickup truck. The thing produced electronic feedback on no less than five frequencies used by the San Diego Police Department. An entire task force armed with direction finding equipment was needed to track him down.

In Oklahoma City, two brothers ripped off a couple of handheld transceivers from the MK&T Railroad. Those radios were used for singing and chatting in a manner that appeared to be aimed at deliberately fouling up communications related to MK&T rail-yard operations.

They were finally caught when detectives from the Oklahoma City fel-

(Continued on page 108)



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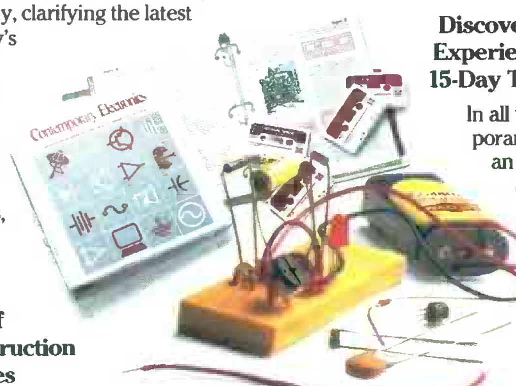

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DX Listening

DX'ing the world over

By Don Jensen

Last month, we took a look at shortwave listening in the Soviet Union. But how about the rest of the world? What is the global audience for shortwave radio?..Who are we?..and how many of us are there, anyway? Tough questions. But shortwave broadcasters need statistics to help them make programming and financial decisions. So studies have been commissioned to answer those questions. And the results, experts say, are encouraging to everyone interested in shortwave radio.

"The shortwave broadcasting bands are truly a window on the world," says George Jacobs, a former *Voice of America* (VOA) and *Radio Free Europe* (RFE) official, who now heads his own broadcast-engineering firm.

In a paper published last year by the institute of Electrical and Electronics Engineers, Jacobs cited a 1986 VOA study of its worldwide audience. That report concluded that there were more than a half a billion shortwave receivers outside the U.S., and the number is expected to exceed 600 million by next year!

The same study indicated that during the average week, more than 120-million listeners around the globe listen to VOA shortwave broadcasts.

According to Lawrence Magne, editor-in-chief of "Passport to World-Band Radio," which annually compiles and publishes SW-station frequencies and schedules, some 1600 shortwave-broadcasting countries cumulatively are on the air with more than 200,000 frequency-hours of programming each week.

*Credits: Rowland Archer, NC; Richard Eckman, CA; Andrew Rugg, QUE; Henry Loewer, OH; Sheryl Paszkiewicz, WI; Gerhard Buetow, AUSTRIA; Mitch Sams, KS; Richard D'Angelo, PA; Terry Weinhold, PA; Bryan Price, KY; Wally Rhyne, NC; Harold Levison, PA; Alan Laves, TX; North American SW Association, 45 Wildflower Road, Levittown, PA 19057.

Jacobs' IEEE paper notes that even in the U.S., where listening habits traditionally have favored regular AM and FM broadcasts, SWL'ing appears to be increasing in popularity.

He quotes the *Wall Street Journal* as saying that U.S. sales of shortwave radios are on the "leading edge of a growth market" and listenership here is expected to jump from about 4% to as much as 20% of all Americans in the next 15 years.

Today's American SWL audience is on the order of 11 million persons, Jacobs notes, which is why more than two-dozen countries broadcast to the U.S. each day on shortwave. The British Broadcasting Corp. (BBC) estimates that in an average week, 2 million Americans are listening in to its programs. The numbers are significant by any standard. And they're growing!

Whole Lotta Listening. Most of us listen for enjoyment. But there are also those whose job is listening-in—professional civilian and military monitors who regularly patrol the radio bands gathering information from the countless electronic signals that fill the air.

Dave Valko, with more than 200 different countries and 400 SW stations logged, has been a shortwave listener since 1976. His listening equipment includes a Kenwood R200 receiver and a hefty old "classic," a Collins R388 model.

When it comes to professional listening, few places in the world can match the level of eavesdropping activity on Cyprus. For decades, the U.S. and Britain have maintained networks of monitoring posts on that eastern Mediterranean island.

Not far from the heavily fortified U.S. Embassy, about a mile from the center of the Cypriot capital (Nicosia) is the extensive monitoring operation of the Foreign Broadcast Information Service, a branch of the Central Intelligence Agency (CIA). The Federal Bureau of Investigation (FBI) monitors shortwave programs from Mideast stations, keeping tabs on what others are saying about us, and themselves.

Other communications—military and diplomatic, marine and aeronautical traffic, radar signals, and other electromagnetic radiations—are picked up by monitors in the embassy itself, it is reported. The U.S., too, has acquired a large tract of land near the center of the city, a site for a new embassy complex that, according to reports, will eventually house the most elaborate monitoring station in that part of the world.

Britain, too, monitors radio traffic from Cyprus. Sources say that the 9th Signals Regiment (based at Aylow Nicolaos on the eastern end of the island) combs the airwaves for coded radio signals originating in places like Lebanon and Libya, Greece, Turkey, Iran, and Iraq. The intercepted traffic is routed back to a top-secret communications base in England for analysis.

Feedback. "Judging from your last name," writes M.G. Nielsen of La Junta, CO, "I could say you have a Danish or Norwegian background. But more importantly, my question for you concerns the frequency and times of broadcasts from Denmark, with programs in either Danish or English."

Indeed, M.G., my ethnic origins are Danish. My grandparents emigrated from Denmark to Wisconsin in the early years of this century, and I still have cousins there with whom I maintain contact. For that reason I've long regretted that Denmark is one of the few European countries that have pulled back from a commitment to international shortwave broadcasting.

Years ago, when I first began listening, I was thrilled to come across the nightly English-language programs from *Radio Denmark*. Back then, the Danish SW station was widely listened

ABBREVIATIONS

AM	amplitude modulation (modulated)
BBC	British Broadcasting Corporation
CIA	Central Intelligence Agency
FBI	Federal Bureau of Investigation
FM	frequency moculation (modulated)
kHz	kilohertz (1000 hertz or cycles)
RFE	Radio Free Europe
SFR	Spanish Foreign Radio
SW	shortwave
SWL('s)	shortwave listener('s)
SWL'ing	shortwave listening
US	United States
USSR	Russia (Union of Soviet Socialist Republic)
UTC/GMT	Universal Time Code/ Greenwich Mean Time
VOA	Voice of America
VOV	Voice of Vietnam
VOL	Voice of Lebanon

to in North America, and its Saturday-night musical show, hosted by Marianne Linard, was one of the top two or three programs popular on shortwave.

But technology passed by Radio Denmark. While other international broadcasters acquired newer and much more powerful transmitters, Denmark did not. And in not doing so, it passed from a shortwave front-runner to an also ran. Today, Radio Denmark has only Danish-language programs, but there are occasional English identifications.

As this column is written, Danish authorities reportedly are negotiating with *Radio Norway* (which has more modern transmitting facilities) to lease air time for its programs on the Norwegian station. That could be accomplished by the time you read this.

If not, M.G., I think your best bet to hear Radio Denmark is during its morning programs to North America on its own 15,165-kHz outlet. At 1300 UTC, after the piano-interval signal—a few bars of a Danish melody—you should catch the English ID, followed by Danish programming.

Despite the lack of English programs, Radio Denmark wants to hear from its English-speaking listeners. Letters may be sent to Radio Denmark, Shortwave Department, Radiohouse, Rosenorns Alle 22, DK-1999 Frederiksberg C, Denmark.

Down the Dial. What are you hearing? Do you have any questions or comments about SWL'ing? Send the details of some of your better loggings, like those that follow in this segment, as well as your questioins and commemts to *DX Listening*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

Here are some of the SW signals being logged by others who share our hobby. All frequencies are given in kilohertz (kHz), and all times are in UTC (Universal Coordinated Time)

Brazil—6,040. From the city of Curitiba, *Radio Clube Paranaense* broadcasts are heard on this frequency at about 0830 UTC with vocal music, Portuguese identifications, and requests for letters.

China—9,635. *Radio Beijing* has an English-language transmission on this frequency, parallel to 11,600 kHz, beginning at 1300 UTC.

Columbia—4,865. *La Voz del Cinaruco*, which is part of the CARACOL network, can be heard with Spanish programming, identifications, and lively music at around 0200 UTC.

Israel—11,605. *Kol Israel* should be audible throughout North America at 2130 UTC with English news.

Laos—7,384. The home service of *Lao National Radio* in the regional city of Savannakhet has been logged in North America at about 1150 UTC, with Laotian music and announcements, and a bell tuning signal at 1158 UTC.

Lebanon—6,550. Arabic music, and some classical selections as well, have been heard on the *Voice of Lebanon* (VOL) from Beirut at around 0230 to 0300 UTC.

Romania—11,940. News and commentary in English are broadcast nightly in English at 0200 UTC from Romania's *Radio Bucharest*.

Spain—6125. Madrid's international SW station, *Spanish Foreign Radio* (SFR), is logged with English programming on this 49-meter band outlet at 0015 UTC.

USSR—4,8910. Morning wake-up programming (sitting-up exercises with a piano keeping time) from *Radio Yerevan*, in the Soviet Armenian republic, has been logged here at 0200 UTC.

USSR—7,230. *Radio Rodina* is one of the lesser known of the several shortwave services coming from the Soviet Union. Its programs in Russian are intended for Soviet citizens abroad. Try this one around 0000 (midnight) UTC.

Vietnam—15,010. There is English programming from Hanoi and the *Voice of Vietnam* (VOV) on this 19-meter band frequency at 1330 UTC. ■

Ham Radio

By Joseph J. Carr, K4IPV

IMPORT YOUR OWN ANTENNA TUNER

About two years ago I visited G/GM-land (England) on business. While there, I took the opportunity to hop over to Ireland on the weekend to visit a friend (EI2CN/ex-K4WQZ) from my novice days. Of course, being an electronics-magazine freak, I had to pick up a couple of the UK amateur-radio magazines. In one of them, I found an ad for the Nevada series of antenna-tuning units (ATU) and ATU component parts.

Nevada Communications (Mike Devereux, G3SED, 1890 London Road, North End, Portsmouth, PO2 9AE, England) offers several products: TM-1000 ATU, TM-1000/B ATU (which is a TM-1000 with internal balun), plus the following ATU parts: TC-250 variable capacitor, TC-500 variable capacitor, RC26 1–27-μH roller inductor, TC-48 turns counter dial, and an empty ATU case that makes a home-built ATU look like a TM-1000. You will find the component prices low by US standards, even with the crummy currency-exchange rate now in force.

The TM-1000 is a broadband antenna-tuning unit that works over the range 1.8 to 30 MHz, at power levels up to 1,000-watts. That ATU was the Ultimate Transmatch T-network design. Unlike conventional T-networks, this design (see Fig. 1) suppresses harmonics of the operating frequency. When tuned to the correct frequency, the TM-1000 offers less than 0.5 dB insertion loss.

Fig. 2. Here is the front view of the TM-1000/B. It is shown perched atop a Heathkit SA-20060A antenna tuner.

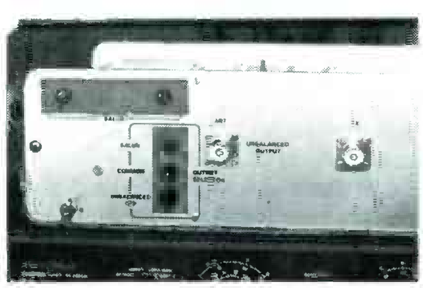


Fig. 3. Here is the rear panel of the Nevada TM-1000/B (with input and antenna connections).

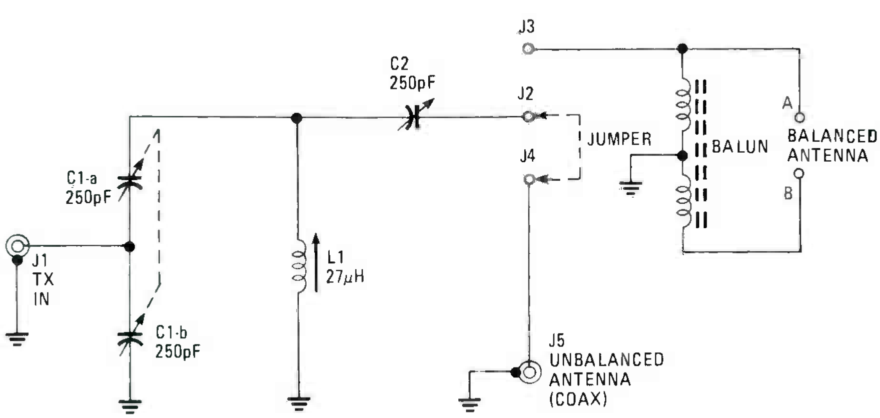


Fig. 1. The TM-1000 broadband antenna-tuning unit that works over the range 1.8 to 30 MHz, at power levels up to 1,000-watts, and suppresses harmonics of the operating frequency, while offering less than 0.5 dB insertion loss.

The front panel of the TM-1000/B is shown in Fig. 2, while the rear panel (with input and antenna connections) is shown in Fig. 3. An internal view, showing the TC-250 single-section 250-pF variable capacitor, the TC-500 dual-section variable capacitor (250-pF/section), and the RC-26 1–27-μH roller inductor is shown in Fig. 4.

Because the model that I bought was the TM-1000/B, there is a 4:1 balun network along the inside rear panel. I prefer the balun model because it gives me the ability to drive parallel transmission lines (300-ohm or 450-ohm), and for doing some of the antenna experiments that I am going to need for this column, as well as for my forthcoming TAB book—*Practical Antenna Handbook*.

The dimensions of the TM-1000 are 13-inches wide × 4.5-inches high × 10.5-inches deep, which makes it ideal for a shack with limited space at the operating position.

The only criticism I have of the TM-1000/B is that the turns-counter dial seems a little on the shabby side, especially when it comes to backlash. If you plan to build a custom ATU, then the parts offered by Nevada are a good low cost bet, but I would select another turns-counter dial. The problem is not really so bad as to justify not buying the assembled TM-1000, but it is annoying.

Installation of the ATU is easy, and is exactly the same as any other Transmatch design. Connect the antenna transmission line to either J5 (if coax) or terminals A-B (if balanced line is used).

Fig. 4. Here's a view of the TM-1000/B with its cover removed, revealing its component parts.

Set the jumper between J2 and either J3 or J4 as required for the type of line selected. If the transmitter has a built-in VSWR or reflected power meter, connect the input of the TM-1000 (J1) directly to the transmitter. Otherwise, you insert either an RF power meter or VSWR meter in the line between the

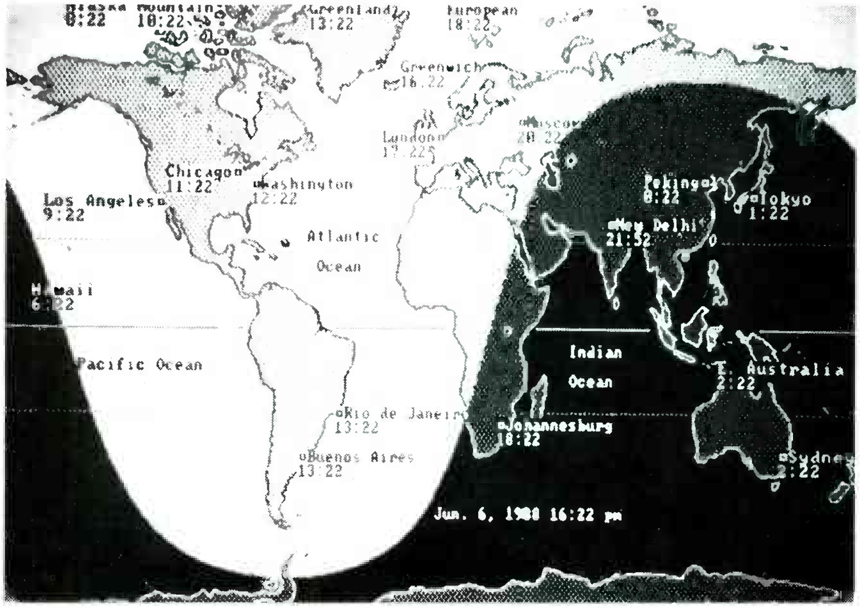


Fig. 5. Here's a typical screen for the MFJ-1286 Gray Line DX Advantage/Terminator.

transmitter output and the TM-1000 input.

Tuning the TM-1000 is relatively easy. Set the capacitors at fully meshed (dial setting 1) and the roller inductor at 1. Apply a signal, and watch for the VSWR or reflected power to drop dramatically as you tune the inductor. Note the readings of all three controls required for minimum VSWR (or reflected power) on all bands.

It takes a few minutes to find all of the correct settings when first tuning up any ATU, so use a dummy load to find the correct settings. Keep a record of the settings and use them in the future to preset the ATU before annoying everybody in both the western and eastern hemispheres with your tune-up procedure. It might be nice if Neveda would calibrate the unit for 50-ohm input/50-ohm output for the standard amateur-radio bands. Such a calibration chart would be useful as a starting point for calibrating your own unit to your own antenna.

Importing the TM-1000/B turned out to be no hassle. Nevada Communications accepts Visa, Mastercard, American Express, and Diners Club charge cards. The cost of the TM-1000/B at the time that I bought it was 108.70-pounds sterling, which appeared on my AMEX statement as $183.90 when American Express billed in U.S. dollars. The exchange rate at that time was $1.68/pound. Add another $20 or so for postage. The TM-1000/B will appear on your doorstep about 8 weeks later.

U.S. Customs has the right to charge an import duty on the TM-1000/B, but in my case the unit was passed duty free. There are some categories of personal purchase that apparently come in as freebies, so I didn't have to pay. Be prepared to pay about 15-percent duty, however, in case your customs inspector doesn't know the rule—or perhaps mine was asleep at the switch.

Ham Software. In a previous column we discussed DX'ing along the gray line, i.e. the terminator zone that runs between the daylight and nighttime portions of Earth. Strange propagation conditions occur on either side of the gray line, and you can exploit them if you plan it right. MFJ Enterprises, Inc. (PO Box 494, Mississippi State, MS 39762; Tel. 601/323-5869) now offers gray-line software for the IBM-PC personal computer.

Figure 5 shows a typical screen for the MFJ-1286 Gray Line DX Advantage/Terminator. It shows the moving gray line and the position of the sun over Earth. The display can be customized to 24 locations and the correct 12-hour or 24-hour time at each location. The MFJ-1286 is compatible with Hercules, CGA, EGA, and composite graphics formats.

We've once again used up all the space allotted to us for the month. As always, remember that your comments, criticisms, questions, and suggestions are always welcome. So take your pencil in hand and send your correspondence to *Ham Radio*, **Popular Electronics** 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

LOW-OHMS ADAPTER FOR DMM's

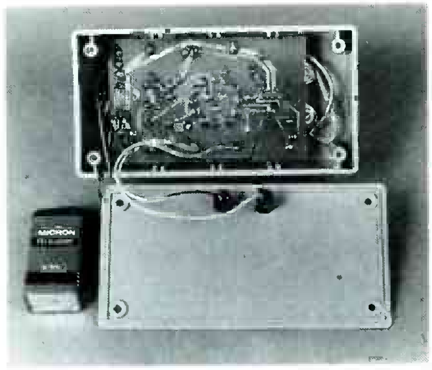
(Continued from page 38)

The next step is to trim the plastic shrouds of the two banana plugs to a length of ½ inch. The plugs can now be mounted on the lid of the case, adjacent to one edge as shown in the photographs. Before you drill any holes, check the location and spacing of the plugs against the inputs on the DMM with which the adapter will be most often used. In particular, be sure there is sufficient clearance before you proceed. Once you are sure that all is fine, drill the holes, mount the banana plugs, and wire the plugs to the appropriate points on the circuit board.

Finally, solder the battery connector leads to the board and clip on the 9-volt DC transistor-radio battery. That completes construction; the unit is now ready for calibration.

Calibration. Apply power by pressing S1. Check that there is +5-volts DC at the output of the regulator (U2) and about 3.8-volts DC across the 1000-ohm resistor (R1) in series with diodes D1 and D2.

Now connect your DMM across the R_X test terminals and set it to the DC 2-mA scale. Set switch S2 to the ×1 position and adjust R2 for a reading of 1 mA. That done, set your DMM to the DC 20-mA scale, set S2 to the ×10 position and adjust R3 for a reading of 10 mA.



The completed Low-Ohms Adapter is shown here just prior to buttoning up. The battery will bounce around in the box if stuffing or two-sided tape is not used.

Calibration can now be completed by adjusting the offset voltage. To do that, disconnect the meter and set it to the DC 200-mV range. That done, set S2 on the adapter to the ×100 position, short the R_X terminals with the shortest possible length of tinned copper wire, and insert the banana plugs of the Low-Ohms Adapter into the COM and VDC inputs of your DMM. Adjust potentiometer R6 for an initial DMM reading of just above 0 mV, then adjust back for a reading of exactly 0-mV on the DMM. That completes the calibration procedure.

The calibration of your unit will come to naught should your calibration procedure be sloppy or if you do not use 1% resistors as specified for resistors R4 and R5.

Final Assembly. You can now clip the printed-circuit board into the plastic case and secure the rotary switch to the front panel. After that, it's simply a matter of covering the copper tracks of the printed-circuit board with a layer of plastic foam (black electrical tape will do), securing the battery to the inside of the lid with a piece of double-sided foam tape, and screwing down the cover.

Your Low-Ohms Adapter is now complete and ready for work. One immediate application that popped up was to find a short in a twisted-pair cable that connected my intercom/phone to my neighbor's house 800 feet down the road. The DMM said that a short existed, but where? I walked the length of the line, most of which rested on top of a stone fence and found no cable damage. With the Low-Ohms Adapter I measured a shorted 50-foot length of leftover cable with the ends shorted. I did the same in my house and found that the cable resistance was 1.8 times the resistance of the 50-foot section. Thus, the short had to be about 90 feet down the line. I paced off the distance and immediately spotted cable damage where I previously hopped the fence to chase one of my boys in play. I had stepped on the cable and crushed the insulation on the sharp edge of a stone. The Low-Ohms Adapter is now the gem of my test bench. If you build one, it's sure to be the gem of your's. ■

(Continued from page 87)

types of radios, including the ubiquitous 5-tube, 3-dial Neutrodyne set. In fact, as we've already said, the grid leak was used in *most* radios from the early days of broadcasting through the early 1930's.

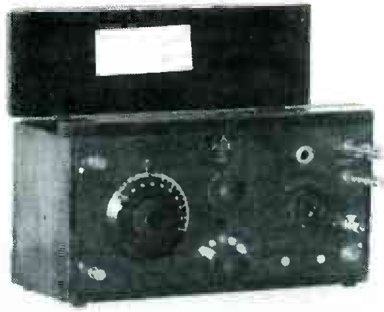
Crosley Comments. Joe Demke (Hillsboro, OR) writes that in 1934–35 he was working in a CCC (*Civilian Conservation Corps* for the youngsters in the crowd) camp deep in the forests of Northwest Oregon. His Crosley 50 kept him very good company. And since he was helping to build Forestry Department telephone lines, he once used one of the lines to help support his antenna.

If the radio programs happened to be boring, Joe found that he could use the Crosley to listen to the telephone conversations on the line being used

Because experimenting with different values of grid resistance was a common preoccupation of set owners, there was a brisk market in adjustable grid leaks. On this one, the value was changed by moving a plunger in and out.

for antenna support. All he had to do was cut off radio reception by slipping a piece of cardboard under the coil tap switch!

A letter from Al McChesner (Westerlo, NY) included some interesting photos of an Ace Type 5. The set looks very similar to the Crosley 50 both inside and out. According to the label on the inside cover (Al kindly included a Xerox), the Ace was manufactured by the Precision Equipment Co. of Cincinnati (Powel Crosley, Jr., President). It must have been a predecessor company to Crosley Radio Corp. Al has been collecting radios for about eight years, and has over 125 sets in his collection.



Al McChesney's Ace Type 5. It's set up very similar to the Crosley 50, except that it has a "porthole" for viewing the tube filament.

The Crosley 50 reminded George Kasdorf, Sr. of a Crosley Trirdyne that was given to him as a boy. "Back in the '30's," George remembers, "when people found you were interested in radio they hauled the old sets out of attics, basements and woodsheds and gave them to you." And I can relate to what George says because even in the 1940's, when I was a boy, people were doing the same thing—that's how I got the Crosley 50!

Right after reading the Crosley 50 article, Frank Schmidt (Tucson, AZ) was astonished to find a Crosley XJ at an outdoor antique market. Since the price was more then reasonable, Frank took the set home. He's had a lot of fun tracing the circuit, which he says is *not* regenerative. The XJ is a much larger radio than the '50, being a 4-tube job, but its construction is very similar. Frank dates the XJ as a year earlier than the '50, and my sources agree, pegging the former at 1922 and the latter at 1923.

George Bidwell (La Jolla, CA), the reader who took me to task for neglecting the Crosley comments (see last month's column), had sent a very long and interesting letter. I can't really do it full justice here, but the Crosley portion of the letter relates to a one-tuber purchased by his father.

George didn't mention the model, but says that it was probably a predecessor to the '50. While George's dad didn't buy the most expensive set on the market, he made sure the neighbors noticed his antenna! It consisted of a six-wire "flat-top" strung between two 125-foot steel-pipe masts set 150 feet apart.

That's all until next month. Until then, write and let me know about your activities! Send your correspondence to *Antique Radio*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

CIRCUIT CIRCUS
(Continued from page 85)

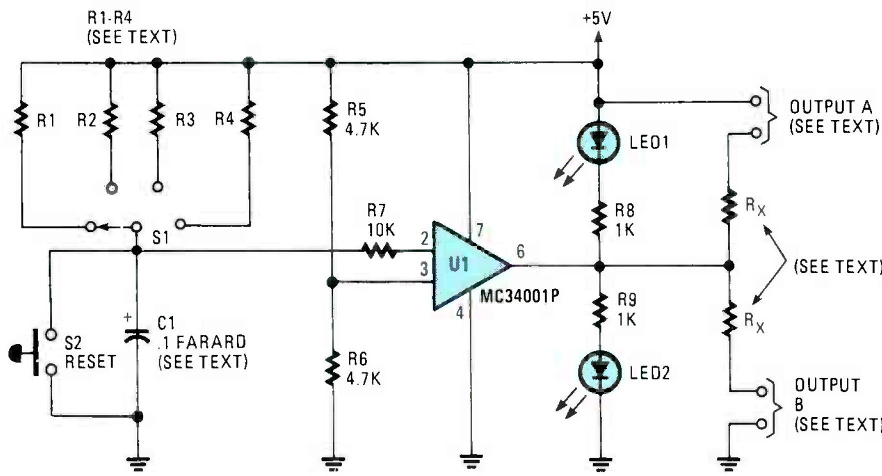


Fig. 3. This RC Timer, using a .1-farad capacitor, can provide time delays of up to one hour and 20 minutes.

positive input (pin 3) connected to a voltage divider set for 2.5 volts. As the charging cycle starts, the voltage across the timing capacitor is near zero.

The negative input of U1 at pin 2 connects to the timing capacitor through R7. As long as the voltage at pin 2 is more negative than the voltage at pin 3, the output of U1 at pin 6 is positive. That positive output voltage lights LED2, indicating that the circuit is in the charging state.

When the voltage across the timing capacitor goes slightly higher than the 2.5-volt preset level, the op-amp's output goes negative or to near circuit ground, turning on LED1 to indicate a timed-out condition. Closing S2 discharges the voltage across timing capacitor C1 and the cycle is repeated.

If the circuit is to be used to turn on a device after the timed-out period, a relay, transistor driver, or an optocoupler can be connected to the "A" output terminals. For operating an external circuit during the on-going time period, connect the control device across the "B" output terminals of the circuit.

Using a 1K resistor for the timing resistance (resistors R1 to R4) gives a delay of approximately 35 to 40 seconds. A 5K unit yields about 3 minutes and 30 seconds; a 10K = 7 minutes and 30 seconds, 50K = 42 minutes, and a 100K = 1 hour and 20 minutes. To come up with a time delay of your choice, drag out the resistance decade box and go to it.

PARTS LIST FOR THE RC TIMER

U1—MC34001P or TL0712CP JFET-input op-amp, integrated circuit
LED1, LED2—light-emitting diode (any color)
R1–R4—timing resistors, see text
R5, R6—4700-ohm ¼-watt, 5% resistor
R7—10,000-ohm ¼-watt, 5% resistor
R8, R9—1000-ohm, ¼-watt, 5% resistor
C1—0.1-farad memory capacitor
S1—Single-pole, four-position, rotary switch
S2—Normally-open, pushbutton switch
Printed circuit or perfboard materials, enclosure, IC sockets, battery and battery holder, wire, solder, hardware, etc.

Thirty-Minute Electronic Virus. The next circuit is mostly useful for fun applications, but it's remotely possible that it could have a practical value as well. The circuit shown in Fig. 4 is what I have dubbed the Thirty-Minute Electronic Virus. By placing the circuit in a piece of electronic equipment and applying the 5-volt power source, the circuit will do nothing as long as the equipment is in use. But when the equipment's power is turned off, the virus begins to send out a beep every two seconds for about 30 minutes.

The circuit could also be used as a power failure alarm on equipment that must operate continuously. Two gates of a 4001 quad two-input NOR gate are connected as a low-power low-frequency oscillator circuit, with a piezo buzzer (BZ1) connected to the circuit's output. Power is supplied to the circuit through diode D1, causing C1 to charge.

Diode D2 provides a positive bias to gate U1-a, keeping the oscillator shut down as long as power comes from the external 5-volt source. When the 5-volt power source is removed, D2 no longer supplies a bias to gate U1-a and the circuit begins to oscillate sending out a beep every cycle.

The circuit continues to oscillate until the charge on C1 has been depleted. As time wears on the piezo's volume drops and after about 30 minutes the sound ceases altogether until the power on/off cycle is repeated. Have fun with this one until we meet here again next month. ■

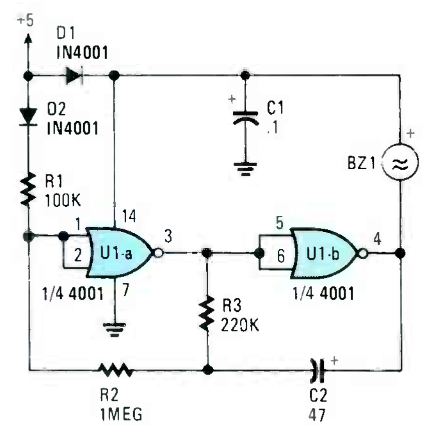


Fig. 4. The Thirty-Minute Electronic Virus does nothing as long as the equipment is in use. But when the power is turned off, the Virus sends out a beep every two seconds for about 30 minutes.

PARTS LIST FOR THE THIRTY-MINUTE ELECTRONIC VIRUS

U1—4001 quad two-input NOR gate, integrated circuit
D1, D2—1N4001 1-amp 50-PIV rectifier diode
R1—100,000-ohm ¼-watt, 5% resistor
R2—1-megohm ¼-watt, 5% resistor
R3—220,000-ohm ¼-watt, 5% resistor
C1—0.1-farad memory capacitor
C2—47-µF, 16-WVDC electrolytic capacitor
BZ1—Piezoelectric buzzer
Printed-circuit or perfboard materials, enclosure, IC sockets, battery and battery holder, wire, solder, hardware, etc.

LIGHTNING BULB

(Continued from page 35)

Once that is done, check your work. If everything looks okay, seal the board in its enclosure and place a 6-inch OD plexiglass tube over the lamp and column assembly. (The actual length of the protective tubing depends on the physical height of the lamp/support-column combination.) The tube provides the user with some measure of protection from high voltage that's present in the circuit.

The 6-inch tube can be secured in place with ½-inch wide angle brackets. (See photos.) A lid for the tube can be fashioned from a piece of clear plexiglass. Figure 5 gives details of how to make the lid. Holes, about ¼ inch in diameter, should be drilled in the lid to help ventilate the lamp. The lid can then be glued to the top of the protective tube.

You are now all set to give your Lightning Bulb a test run. As with all other projects of a similar nature, ambient light detracts from the visual effect of the display. The Lightning Bulb gives a much more impressive display in a darkened room.

When applying the second layer of tape, leave a small area of aluminum exposed, and connect a wire to the foil.

Even though we have added two inductors on the AC line to block switching transients generated by the circuit, there still may be radio-frequency interference (RFI) present. An AM radio can give a good indication of how far-reaching any interference may be. You most certainly do not want to cause any interference on your neighbor's TV or radio. ■

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P-289

GRANDPA'S SHORTWAVE

(Continued from page 70)

control will not rotate once mounted. Holes for the coil-support forms can be drilled after the forms are made. Drill three ¼-inch holes to hold the front panel to the rear wood chassis.

Cut two coil-form supports 4×1-¾-inches out of ½-inch thick soft wood. Trace the inner diameter ot each end of the coil form on the same type of wood. Cut out the pattern with a circle cutter, coping, or saber saw. Glue and nail the two circles to the top of the coil supports to hold the coil in place. Let the wood glue set for a couple of hours and drill a 5/16-inch hole through one of the board supports in the center of its circular piece. The dowel of the tickler-coil assembly will slide through it. Drill a small 3/16 inch hole next to it to pass the tickler-coil wires through.

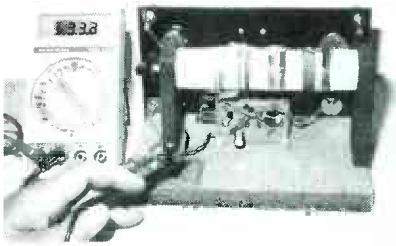
Spray the two wooden supports and the front panel with black enamel. Push the dowel through the larger hole on the circle side of the specially prepared support and attach a knob to it. Run the tickler-coil wires through the smaller hole from the same side.

Fit the circles on the two coil supports into the coil-form ends as though the assembly was ready for mounting. Place the assembly on the rear wood chassis for position, and drill 1/16-inch pilot holes (two per support) in the rear wood chassis. The main coil and supports are not to be mounted till later.

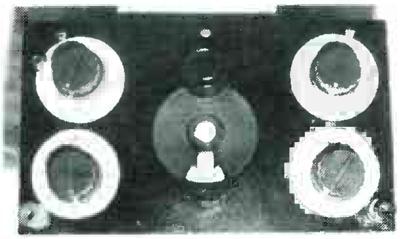
Mounting and Connection. First, mount the potentiometers and switches. Mount the audio amplifier board at the rear corner of the chassis. Temporarily place the RF board in the center of the main chassis until all wiring is completed.

Solder the ground and audio wires from the audio perfboard to the earphone jack. From the same board connect the wire from U1 pin 3 to the volume-control wiper. Connect a B+ and a ground wire from the RF board to appropriate points on the amplifier board.

Solder the black lead of the battery clip to one side of the on/off switch (on the volume control) and connect the other side of the switch to the ground jack. Connect the ground jack to the ground side of J1. Connect one end of potentiometers R8, R11, and R12 all together, and then to one of the B+ wires from the RF board. Connect the wipers



After all parts are connected and ready, the radio is ready for a trial.



For a nice touch, add plastic homemade dials with dry transfer labels. The dials shown here were cut from the bottom of margarine tubs!

of R8, R11, and R12, and one end of R9 to the appropriate jumpers from the RF board. Connect the remaining terminals of R8, R9, R11, and R12 together and then to one of the ground leads from the RF board.

Mount the coil support on the rear chassis and attach it with wood screws. Use No. 22 solid insulated wire to connect the coil terminals to the switch. Make sure that corresponding primaries and secondaries occupy the same switch position. Tie the coil's common-ground wire to the remaining RF-board ground wire. Connect the coil's B+ wire to the remaining RF-board B+ wire. Next, connect the RF-board switch wires to the two switch pole connections. Double check the switch and coil connections.

Finally, take the tickler-coil wires and connect them to the remaining two leads from the RF board, but without soldering. You will solder the leads after checking the polarity of the tickler during operation.

Check-Out Time. After completely going over the wiring and schematic connections one more time, the little receiver will be ready for a spin. The receiver will work best with an outside antenna and water-pipe ground. You should connect at least a 50-foot inverted-L antenna and a good ground for decent shortwave reception.

The best time to listen to shortwave bands are late in the evening or in the early morning hours. If a strong broadcast station is in your area at the high end, it maybe hard to tune out. Broadcast DX is much better after those strong local stations go off the air.

Plug in the 9-volt battery and earphones. Turn on the regenerative control. Run the volume control wide open. Start with coil-selector switch on the large coil (L7) setting. Push the tickler-coil knob clear in. Now advance the regeneration control until you start to hear some squealing and noise indicating feedback operation. Try to tune in a shortwave station with the main tuning control (R11). Reverse the tickler-coil wires at the RF board if no squealing noise is heard. Solder the connection when correct.

When a loud squealing noise is heard while tuning, lower the regeneration control until the squeal quits. You should hear a station. Code stations should be heard with the regeneration control more advanced. Carefully advance the control just a little bit for those stations. Lower the control if it goes into oscillation once again. Move the tickler coil for the loudest squeal or signal. Readjustment of the tickler coil is a little tricky at first, but after a few attempts it's a cinch.

Check the range of each band for proper coverage. The prototype was checked against a commercial Hallicrafters communication receiver to tune each coil. If bandwidth is poor on any band, calibrate it by spreading or compressing the corresponding space-wound coil to compensate. Mark the tickler coil rod with a marker to indicate its position for each band.

Troubled Waters. No sound in the earphones may indicate trouble in the audio board. You should hear a "plop" in the earphone when the unit's first turned on. Touch the center terminal of the volume control and you should hear a "click." If there's still no sound, measure the battery's current drain with the volume control lowered. A reading above 10.8 mA indicates a short or improper wire connection is pulling excess current. Measure the voltages at each IC pin and compare them with those in the schematic.

Check the voltages at both transistors if the audio board seems normal. Double check the setting of the tickler coil. Make sure it's inside the correct band coil. Remember, some bands have more active DX'ing during the evening. ■

THINK TANK
(Continued from page 27)

group, and we're into heavy metal, do you dig it?" Now look pal, the last time I danced, which was probably before you were born, I dipped. I can dig the Turkey Trot, the Continental, The Peabody, even the Charleston. I thank you for the offer of a tape, and wish you and your group only the best. But Rock 'n' Roll? Heavy Metal? Thanks, but no thanks.

On the other hand, I did like the idea you sent in. The rest of you readers dig Fig. 7. It's a schematic for a microphone mixer that allows John's group to cut one microphone and boost another, which is great (they tell me) for those long, dramatic solos. When they're playing a piece that requires harmony, they equalize both mikes.

Levels for both inputs are controlled by the potentiometers. Resistors R5 and R6 are there so that when one of the controls is set at zero, the other one is not shorted out. Capacitor C1 couples both inputs to the pin-3 input of the 741 op-ump (U1).

The output from the IC goes to a shielded coax and you can run this to an input on the main amplifier. Capacitor C4 and resistor R7 provide some decoupling so that you can draw current from the main amplifier power circuit. Use a polarized plug and receptacle for this so the plug can't be inverted by accident.

With 12 volts applied to the circuit , the current drain will be about 10 mA. With this in mind, you can alter the value of R7. Figure about one volt for every 100 ohms, but you should also be aware that U1 can stand a pretty-high range of voltages, so don't be overly concerned about it.

—*John Frakson, Boulder, CO*

John, like I said, good luck. And your luck's about to become good. I'm sending out a copy of the Fips book for you. I know you'll enjoy reading it from cover to cover.

And on that note, we'll call it thirty for this month. That's old newspaper talk, and I've got lots of old newspapers. Remember, we need your original schematics and descriptions, and we'll pay for each one we use with a copy of the Fips book, some of the funniest reading in electronics. Send your ideas to *Think Tank*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

ULTRASONIC RECEIVER
(Continued from page 48)

what Fido has been hearing. About any short length of small metal tubing can be turned into an ultrasonic generator simply by blowing across the open end. Other areas in which the Ultrasonic Receiver can be useful is in locating high-pressure air or gas leaks in tanks or supply lines.

The Ultrasonic Receiver can also be used to test for leakage in high-voltage cables, like those used to deliver AC power to homes and industry. A good example of the leakage problem (although it won't generate ultrasonic sound), can be demonstrated by a rather common household occurrence. We have all of us, at one time or another, grabbed hold of a line cord and received a shock from what had appeared to be well insulated conductor.

Although the insulation is intact, current can seep through. Leakage in power line insulation generates high-frequency sound. That sound can be detected by the Ultrasonic Receiver, and thereby help to avert a potentially dangerous situation. Ultra-high power lines (those carrying power above the normal household power range) put out an abundance of ultrasonic sound.

A number of experiments can be performed if a tunable audio generator is available. If so, connect a similar piezo tweeter to the output of the audio generator and set the frequency anywhere between 15 and 25 kHz and set the output level to maximum. Face both the receiver and the generator's speaker in the same direction spaced about one foot apart.

Tune the receiver to the frequency of the generator. As the receiver approaches the frequency of the generator, a beat tone will be heard that will go from a high-frequency tone down to a zero beat, where little or no sound will be heard. Wave a book up and down over the two speakers and you will hear sounds similar to the ones that normally come form a science-fiction movie sound track.

The audio generator can be used as a remote transmitter, which can be detected by the receiver at distances of several hundred feet. Since the receiver operates with a broadband front-end, loud noises close to the pickup can cut through, causing a distorted sound, but under normal use that should not be a problem. ■

TAMING OP AMPS

(Continued from page 72)

If ground-loop problems exist after the circuit is built, you pretty much have to resort to trial-and-error techniques to eliminate them. Basically, you need to experiment with the locations of the ground connections and/or components to find *cold* spots on the ground plane.

Another source of difficulty, especially (but not exclusively) in high-gain circuits, is poor circuit layout. Keep input and output circuits as physically separate as possible. When several stages are cascaded together, they can be a source of unintended feedback. In response to "real estate" constraints on the circuit board, some designers double a circuit back on itself on the board. That arrangement places the output circuit components next to either the input circuit components, or intermediate stages. Such a layout induces radiation feedback, which is especially likely to occur if the total propagation feedback is 360-degrees (as in non-inverting amplifiers, or circuits with an even number of inverting amplifiers).

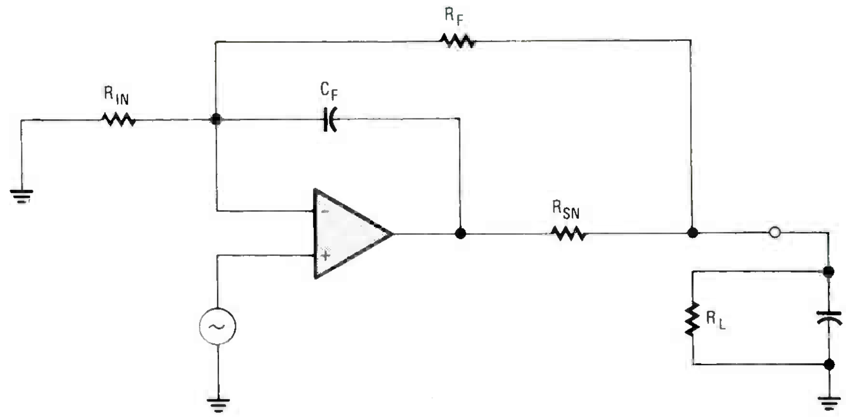


Fig. 7. Capacitor C_F rolls off the overall gain of the op-amp at high frequencies that are not within the desired frequency range. The snubber resistor (R_{SN}) provides some isolation between the load and op-amp's internal driver amplifier.

Once lay-out problems, common impedances, and other causes are ruled out, it is time to evaluate the linear IC amplifier circuit itself for instability problems. Two distinct areas must be investigated to track down the problem: the feedback network and the rest of the circuit.

Although not an absolute indicator, the frequency of oscillation often tells you where the problem is located. Measure the oscillation frequency (F_O) and compare it to the frequency at which the amplifier gain drops to unity (F_T); that frequency can be found in the specifications sheet or data book. If F_O is close to F_T, then it is probable that the problem is in the feedback network. A diagnostic aid is to temporarily increase the amplifier closed-loop gain by a factor of 2 to 10, and then observe the effect on stability. If the oscillation ceases, or F_O drops appreciably, then the problem is probably in the feedback network. If neither of those events occurs, then the problem is most likely in another part of the circuit.

Only a few linear IC devices (and practically no op-amps) operate in the VHF region. Yet op-amps and other low-frequency devices sometimes oscillate in the 50- to 200-MHz region, which is way beyond the bandwidth of the device. The cause of those VHF parasitic oscillations is the output power amplifier in the IC device. The effect is especially likely when resonances are present.

One source of a stray resonance that leads to parasitic oscillations is the use of the wrong capacitor type on the DC power-supply terminals. In Fig. 5, for example, we see ceramic-disk capacitors used for V− and V+ bypassing. Such capacitors have significant stray capacitance and inductance associated with them (see the inset in Fig. 5) that tend to resonate in the VHF region.

Fixes for that problem are shown in Fig. 6. For the V+ lead, a 2- to 12-ohm *snubber* resistor (R_{SN}) is placed in series with the bypass capacitor to lower the Q of the stray resonant LC-circuit elements. If the Q is lowered sufficiently, then the LC-circuit elements are unable to cause an oscillation. An alternate fix is used in the V− lead. There, a ferrite bead is slipped over the lead to the bypass capacitor. Those beads act like RF chokes at VHF frequencies, but are practically transparent to low-frequency signals.

An often-hidden source of feedback problems is capacitance in the amplifier's load. Such capacitance adds to the propagation phase shift of the feedback network, possibly causing oscillation. If a load is known to be capacitive, then identifying the problem is easy. But it often happens that other sources of capacitance are found in a circuit. For example, shielded cables have a high value of capacitance per unit of length. Similarly, some chassis or in-line connectors offer significant capacitances, and stray circuit capacitance may also be significant.

A circuit fix-it technique that isolates a capacitive load from an IC amplifier output is shown in Fig. 7. In that circuit, a small feedback capacitor (C_F) reduces the closed-loop gain at frequencies where oscillation is likely to occur, while essentially not affecting lower frequencies at all. Isolation is obtained by the series *snubber* resistor, R_{SN}. ■

EZ-MATH

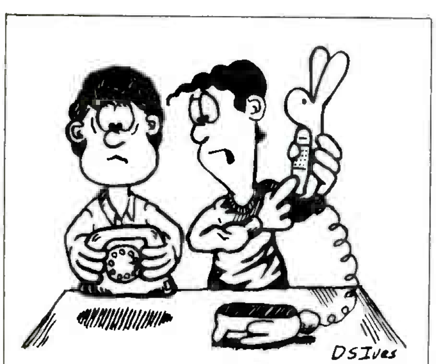
(Continued from page 83)

number of gates required. Also, since LED6 is equal to LED2, the AB term can also be used in it as well.

The final circuit is shown in Fig. 18. The outputs from the counter are passed through inverters so that both of the normal and complement signals will be available. Those are then connected to the various AND gates to form the two variable terms. Finally, the AND-gate outputs are fed to OR gates which create the final output signals. The signals then go to the LED driver circuits.

Referring back to Fig. 18, you can also see that the 7492 counter is driven by a clock oscillator made up of a 555 timer. When the normally closed pushbutton switch is depressed, the timer is enabled and it generates a series of output pulses which rapidly step the counter. The counter will continue cycling through its six states as long as the button is depressed. When the button is released, the oscillation stops and the counter will end up in one of its six states. Because of the randomness of starting and stopping the counter, the effect is as if a die has been rolled. The logic circuits look at the counter outputs and the correct state is displayed on the LED's.

Before all you hot-shot digital designers write in to tell me that the circuit in Fig. 18 is not the simplest way to implement a digital die, let me tell you that I already know that. The circuit is simply an example of one way Boolean algebra can be used to help design circuits. There are dozens of other ways to implement a digital die and many of them are simpler than the one described here. The main thing I wanted you to see from the example is how Boolean algebra is used in practice to arrive at a minimum workable circuit. ■



"That's the radio... this is the phone!"

LUNDIN LABORATORIES

(Continued from page 61)

cause I knew the least about that subject category. A question came up, "Is the child able to inhale with or without coughing? (Watch for chest movement and listen to the child's nose for air movement.)" I answered no to that question and instructions appeared immediately. (See the photo of the monitor screen shown in Fig. 3.) I continued answering questions and further instructions appeared, as shown in the screen shot of Fig. 4.

The instructions were very clear and exact. I was told what to do had I been required to provide the emergency medical treatment before professional help arrived. Now the question is, does a parent have enough time to use a computer under emergency conditions? I think not, but FamilyCare Software can be used as a training course for the procedures where time is of the essence. You can even hold your child and go through the motions of resuscitation so that should your child, or a child you come upon, require emergency assistance, *you are prepared*. You also must consider that an emergency condition may occur when you cannot reach professional medical help in time. It's better to boot up your computer and get the facts as quickly as you can, especially when you and your child are alone in a life-or-death situation.

There are many other conditions and treatments that allow the luxury of time. For example, I went into the Cradle Cap section (Fig. 5) of the software, because I knew nothing about the topic—my children never had it. FamilyCare Software gave a complete description of the malady and the home treatment. After studying the screen's comments, I felt that I was sufficiently informed to begin discussions with mothers whose children have cradle cap.

What I liked most about FamilyCare Software was that the software gives instructions for home care of minor conditions and suggests inexpensive, over-the-counter medications as part of the treatment.

Another feature of the software, Print Log, is that a hard-copy log of what you see on the screen may be obtained on your printer. I made copies of the cradle cap text and passed it on to a concerned mother.

The simplicity of the FamilyCare

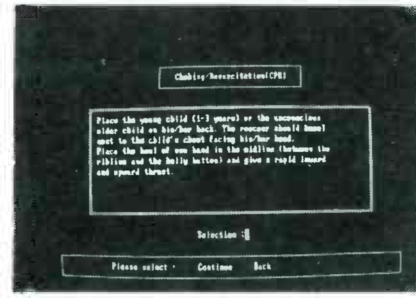


Fig. 4. After an age determination, treatment for a choking child is given.

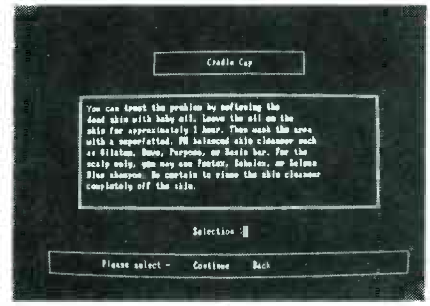


Fig. 5. Here's one of the screens devoted to the treatment of cradle cap. Its description and treatment gives the parent information to deal with the problem.

Software format would have permitted the publisher of the software to skimp on instruction-printing cost by providing one or two sheets of paper for a manual: Instead, a 40-page manual is shipped with the software, and the instructions are very easy to follow, even for those who are medical and computer neophytes.

Behind the Software. The answers to approximately 1500 medical questions concerning a child's health is more than just "encyclopedic information." An expert team of three medical doctors with extensive pediatric service experience, supplied the answers that appear on the FamilyCare Software screens. The computer specialists who worked with the physicians have produced a flawless program that is easy to use and rapid to step through.

FamilyCare Software retails for $99 and is available from many computer software stores and outlets. If you cannot find a copy locally, write to Susan Goodman, FamilyCare Software, Division of Lundin Laboratories, Inc., 29451 Greenfield Road, Southfield, MI 48076, or circle No. 86 on the Free Information Card. Have no children? Then think of giving a gift copy of FamilyCare Software to an expectant parent. It's among the more thoughtful gifts that anyone can give. ■

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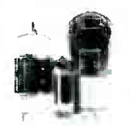
SOFTWARE: 1300+ public domain: IBM/etc. Catalog $2/trade. **McILWEE,** 1781 S. 74 St., Mesa, AZ 85208.



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SCANNER SCENE

(Continued from page 90)

ony apprehension surveillance team simultaneously engaged the brothers in radio conversation and tracked them down with direction-finding equipment. The brothers, who were in their mid-20's, were charged with the receiving and concealing of stolen property.

In New Hampshire, a man convicted of transmitting a false aircraft distress (crash) report during a blinding snowstorm was sent to federal prison for a year and told he would have to have a *shrink go over his noodle* to see what his problem was.

The man's fake distress call triggered a massive ground and air search that involved about 100 people, 20 aircraft, 6 police agencies, and ran up a tab of $50,000. More than just a short call for help, the hoaxer transmitted many times, supposedly from a downed jet with a severely injured pilot and three dead passengers. He described his loss of blood and suffering from the bitter cold in such harrowing detail that searchers were overcome with emotion.

Fortunately, one of the man's neighbors heard the chap's voice and the sound of the radio communications coming from his window. When the neighbor learned about the extensive search operation in progress, the police were alerted. And so, For the next year, the hoaxer will be thinking things over at the Federal Correctional Institution at Butner, NC.

Keep sending those clippings, questions, and ideas to *Scanner Scene*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

The Tape Saver TS-1 easily connects between your scanner and your cassette recorder via standard plugs. With the Tape Saver TS-1, the cassette recorder remains off during periods when there is no activity on the frequency to which the scanner is tuned. But when the channel is active, the recorder comes to life.

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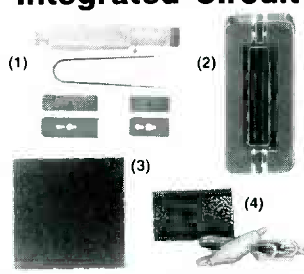
Integrated-Circuit Tools & Accessories



(1) IC Inserter/Extractor Set. Install and remove 6-pin to 40-pin DIPs without damage. #276-1581 .... 6.95

(2) IC Pin Aligner. Just a squeeze and bent pins become factory-straight. For 6- to 40-pin DIPs. #276-1594 ... 2.99

(3) Conductive Foam Block. Protects ICs, components from static. For bench or shipping. 5 × 5". #276-2400 .... 89¢

(4) Static-Draining Wrist Strap. Ideal for handling sensitive ICs. 24" ground lead with clip. #276-2399 ...... 2.79

Optoelectronics

IR Detector Module. Combines detector, amp, demodulator, limiter, bandpass filter, integrator, comparator. Requires 5VDC. #276-137 .... 3.49

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Super-Bright LED. Amazing 2000 mcd output! Requires 1.85V, 20 mA. #276-087 ...... 1.69

NEW!

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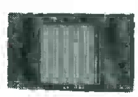

NEW! Flexible Solar Cell. Develops 1.2VDC and 65 mA. May be wired in series and/or parallel for greater output. 3¼ × 1⅞". #276-138 ...... 5.95

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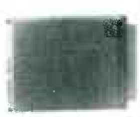
NEW! Plug-In PC Board



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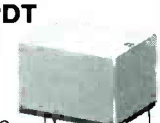

Contacts: 10A, 125VAC. Coil: 12VDC, 38 mA, 320Ω. #275-248

Panel Switches

Submini SPST Toggle. PC-mountable. 0.3A at 125VAC. #275-645 .. 1.99

Submini SPST Momentary. 0.5A at 125VAC. Normally open. ⅜" mtg. hole. #275-1571 .. Set of 2/2.39

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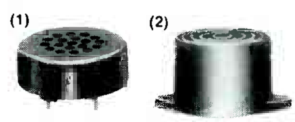

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(2) Melodic IC Chime. Pleasant "ding-dong" output. 6 to 18VDC. 80 dB at 12VDC. 5" leads. #273-071 .... 8.69

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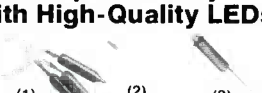

(1) Miniature 12-Volt Flashing Lamps. 95 mA. Yellow, red, green. #272-1097 .... Pkg. of 3/1.19

(2) NEW! Miniature 12-Volt Microlamp. 60 mA, T-1 size. With leads. #272-1092 .... Pkg. of 2/1.39

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