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C&E HOBBY HANDBOOKS

FALL 1987

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ELECTRONICS HANDBOOK

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BUILD YOUR OWN SURROUND SOUND

REPAIRING MULTIMETERS

BUILD A DARKROOM TIMER

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Get switched on

In case you're not all that familiar with us, we're not a publication for electrical engineers and other wizards. No way, ELECTRONICS HANDBOOK is expressly for people who like to build their own projects and gadgets—and maybe get a little knee-deep in tape, solder and wire clippings in the process.

In fact, we have a sneaking suspicion that our readers like us because they think we're just as bug-eyed and downright crazy over great new project ideas as they are. And I guess they're right!

ELECTRONICS HANDBOOK thinks of you who dig electronics as the last of a special breed. It's more than just the "do-it-yourself" angle—it's also the spirit of adventure. In this pre-packaged, deodorized world, building your own stereo system, shortwave receiver, darkroom timer or CB outfit is like constructing a fine-tuned little universe all your own. And when it all works perfectly—it really takes you to another world.

ELECTRONICS HANDBOOK knows the kinds of projects you like—and we bring 'em to you by the truckload!

Ever hanker to build a sharp-looking digital clock radio? Or to hook up an electronic game to your TV? Or an easy-to-build photometer that makes perfect picture enlargements? Or a space-age Lite-Com so you and the family can talk to each other on a light beam? We've got it all to get you started.

Has your sound system gone blooey just when the party's going great? Do you shudder when your friendly neighborhood electrician hands you the bill? ELECTRONICS HANDBOOK can help.

Of course, we can't make you a master electrician overnight. But we can show you the fundamentals of repair plus maintenance tips.

IF YOU'RE NEW TO ELECTRONICS YOU GET A "BASIC COURSE"!

It gives you a complete, ground-floor lowdown on a variety of important electronic subjects. For example—Understanding Transistors...How Radio Receivers Pull in Signals...Cathode Ray Tubes Explained...How Capacitors Work...Using Magnetism in Electronics, and much, much more!

TRY A FEW ISSUES AND EVALUATE OUR...

- **HOW-TO-DO-IT HELP** Tips and pointers that add up to money saved. For example—tuning up your tape player...all about radios ...whys and hows of turntables...care and feeding of speakers.

- **EXCITING DISCOVERIES.** Whatever your particular interest in electronics, you'll be entering a world of discovery in the pages of the ELECTRONICS HANDBOOK

ELECTRONICS HANDBOOK

PUBLISHER
Don Gabree

SECRETARY/TREASURER
L. M. Gabree

EDITOR
Charles Graham

CONTRIBUTING AUTHORS
Homer Davidson
Ed Noll
Walter Sikonowiz

CIRCULATION DIRECTOR
Gary Spencer

ART DIRECTION
Kraig Bacele

COVER PHOTOGRAPH
Courtesy National Radio Institute

ADVERTISING SALES
C&E Hobby Handbooks
P.O. Box #5148
North Branch, N.J. 08876
(201) 231-1518

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ELECTRONICS HANDBOOK

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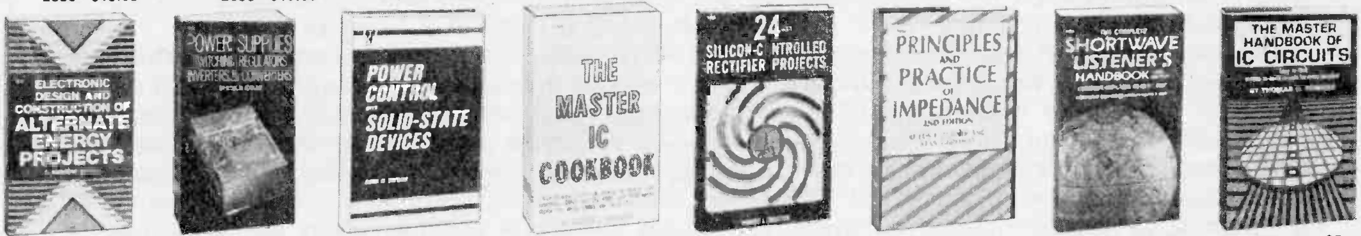

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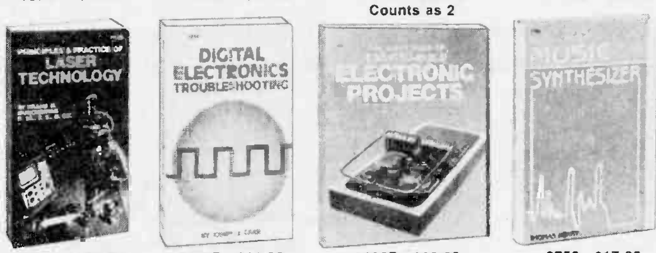

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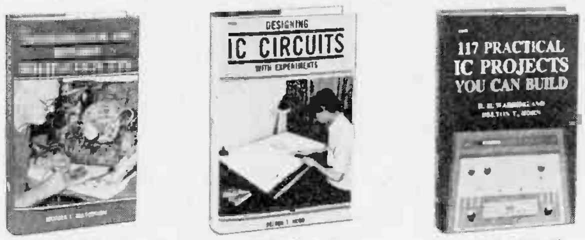

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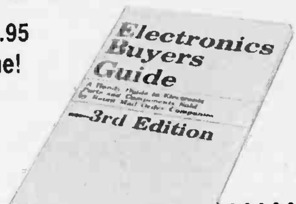

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PUTTING THE "C" BACK IN C&E

As we complete this 4th (Fall 1987) issue of the ELECTRONICS HANDBOOK, it's time to pause and take a look at where we have been and where we are going.

Getting off the ground was not easy but we do seem to be gathering some momentum. To be quite candid, I did not ancitipate some of the hurdles we had to overcome during this transition from a "Series" publication to a quarterly magazine. Hopefully, those days are now behind us and we can look forward to less hectic times.

Obviously, some of our earlier plans (dreams) for the "Handbook" had to be discarded during our "shakedown cruise", however, that was to be expected and we are establishing a pattern that we can expand and make future issues more appealing to the readers and advertisers.

We are now getting a fairly continous flow of letters from readers of our earlier issues and it pleases us to read their favorable comments. The vast majority of this mail confirms our original contention that the ELECTRONICS HANDBOOK readers are primarily interested in "projects for the hobbyist".....with varying degrees of complexity. Readers are tuning in to our idea of a magazine devoted to "A Fun Way To Learn Electronics".

While we are on the Subject of "Tuning In" (note our cover), some readers have asked for an explanation of the letters "C&E" in our corporate title. It was never our intention to make this a mystery. C&E is an abbreviation for "Communication & Electronics", since it was our original intention to incorporate "Communications World" magazine into the ELECTRONICS HANDBOOK.

The idea was put on a back burner for awhile but we have discovered from our mailbag, that this may have been a mistake. Apparently, there is still a very healthy interest in "communications" and related "projects" among our readers, including various aspects of the radio world, such as Shortwave and Broadcast band DX'ing, Radio Theory, Antique Radios, Antennas, and I gather, some very interesting developments in the "Ham" radio world. Add these to the obvious growth in satellite TV, fiber optics, the use of lasers for copying machines, CD players and the newest entry in this wonderful world of electronics,....superconductors, which are just around the corner and could very easily change the course of mankind.

It's an exciting future and we plan to be writing more about each of these subjects in future issues of the ELECTRONICS HANDBOOK. Along with a continuation of "projects for the hobbyist", we will be putting a little more emphasis on the "C" in C&E.

Don Gabree

Don Gabree,
—Publisher

WANTED: WRITERS

ELECTRONICS HANDBOOK is looking for some alert Electronics Hobbyists to add to our staff as part-time or regular authors. Whether you have just one short project, or several, we would like to hear from you.

You don't have to be an accomplished author or writer (Our editor once got a "D" in English. Fortunately, he's improved since then!). What you do need is an active interest in Hands-on, Do-it-Yourself Electronics. If you've had some experience in putting your own projects together, there's a good chance we can rewrite a description of your project and publish it in these pages.

We can use projects suited to absolute beginners, as well as intermediate or more advanced projects. Anything from one-transistor to three-IC projects may be submitted.

Here's your chance to see your own article or idea, long or short, with your name on it.....and you'll get paid in cash when we accept it.

Write to the editor at the following address:

ELECTRONICS HANDBOOK
P.O. BOX #5148
NORTH BRANCH, N.J. 08876

FROM THE EDITOR'S DESK

Ask The Editor, He Knows!

Got a question or a problem with a project—ask The Editor. Please remember that The Editors' column is limited to answering specific electronic project questions that you send to him. Personal replies cannot be made. Sorry, he isn't offering a circuit design service. Write to:

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C&E HOBBY HANDBOOKS INC.
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VHS Video Taping

I bought a Sony Beta VCR (video tape recorder) several years ago and it records and plays back great (good TV details). I bought it because I carefully read everything I could find on VHS vs Beta and the writers seemed to agree that Beta was capable of sightly higher video fidelity than VHS. Now my friends tell me I made a mistake, and that my machine is obsolete. I notice that most stores sell only VHS machines these days, and that video movie rental places stock only VHS. Should I get rid of my Beta-type machine for a VHS?

Also, how could Sony make such a mistake? Their products are always the best, it seems to me.

—Jim Rattigan, Durham, NC

Millions of consumers agree with you that Sony products are as good as or better than those of most other companies. Sony started home videotaping with Betamax recorders (reel-to-reel) in the mid-Sixties. Then they developed the Beta (video cassette) Sanyo, Magnavox, Toshiba, Sears and others followed.

Then JVC developed VHS to get around Sony's patents. And even more companies followed JVC into VHS camp. And VHS forged ahead of Beta, until now it's the clear winner. But Beta will be around for many years here's why:

If you're interested only in taping off-the air TV programs you have no problem. Although many more VHS machines are in use now than Beta, blank Beta tapes are still widely available, and will continue to be so many years because there are still several million Beta machines in use.

People who watch prerecorded tapes at home must have VHS machines. The differences in quality between Beta and VHS are small enough so that most people wouldn't notice them.

Pen-Pals Use Cassettes

Many of your readers, especially those with elderly or shut-in friends or relatives may be intersted in a cassette tape exchange group through which they can get together with people in countries all around the world, using audio cassettes.

This is a strictly non-profit group, and all people, but particularly shut-ins, disabled persons and relatives or other friends interested in exchanging ideas with them can get detailed information free of charge. Send an addressed, stamped envelope.

—James K. Jobson Sr., Austell, Ga.

You will get information about this non-profit group if you send your self-addressed, stamped envelope. Use the longer, letter-size envelope, and include correct overseas postage. Send to Mrs. Phyll Moore, S.F. Recording Club, 9 Kamahi Pl., Rotorua, New Zealand.

Cheap vs Costly CD Players

Some people claim all CD players sound the same. Others say the expensive ones ($600-800) sound audibly better than the cheapies ($150 and even less). There were ads on TV this week for an Emerson CD player at $99 from a local chain store, Newmark and Lewis who have 48 stores in this area.

All CD players use similar laser pickups to play CDs, and they all need the same precision motors to handle the discs. So shouldn't they cost about the same?

Are there differences in sound (I can't hear any)? And why the enormous spread in price?

—Jennifer Kittredge, Atlanta, GA

Long articles have been written attempting to explain the alleged differences in sound. According to the theory of Compact (digital) Discs, there shouldn't be any audible difference between players. Expensive units have more bells and whistles (programming and repeat-play features, display lights, etc.)

Some manufacturers offer low-cost units (around $200 list) which are further discounted as loss leaders (a way of getting customers into the store). I can't hear any difference in the sound produced by various CD players. It's very easy to hear what you think you hear in the big wide world of audio equipment.

Ham Radio's New, Easier Entry Rules

Your readers might be interested in learning that the FCC (Federal Communications Commission) recently made it easier than before for beginners to get on the air with their own transmitters. It's also pertinent to note that new hams can now operate by using voice, instead of using only Morse Code.

—Mark Gilred, Denver CO.

Thanks for the tip, Mark. Electronics Handbook has a major article in the works which explains

the new rules and how you can get started in ham radio. As you point out, it is now easier than ever to get your ham operator's beginners license.

You still have to pass your Morse code test at five words a minute, but the exam on rules which would-be Novices must pass has been simplified. In addition, there are radio frequencies available to Novices which permit voice operation. Previously they had to stick to CW (Morse code) operation until they could pass exams for a higher grade of license (Technician, General, and Advanced).

Interested people can get details by writing to the ARRL (American Radio Relay League), in Newington CT. 06111.

Getting Rid of Rats and Insects?

I see advertisements on TV and in magazines for a machine claiming to rid the house of rats, mice and/or insects including roaches. They say it makes ultra-sound, and most of them go for $39.95, $49.95 etc. Some are offered with what sounds like an iron-clad money back guarantee, no questions asked.

Do these machines really work? And how?

—James Wilson, Endicott, WI.

It's difficult to give you an absolute answer on this one. I've heard they work with mice and rats, but not against insects. These little boxes generate high energy sounds in the ultrasonic range (above 35 kilohertz) and probably warble the sound also. I once got one though an advetisement in a national magazine and used it for a week in a basement kitchen which had roaches. They stayed, despite the machine. I returned it and had no problem with getting my refund (from Mastercharge).

About that time (two years ago) a new roach chemical called ***Combat*** *appeared. I bought some and it worked like magic. No more roaches!*

Who Invented Radio?

When I went to school I learned that the Italian experimenter Marconi invented radio. We were told that he was the "father" of radio transmitting and receiving because he was the first to send and receive radio messages across the Atlantic, in (I think) 1909.

Lately I've read articles about other people, including Fessenden (Canada) and Fleming (England) and DeForest (US). I know DeForest invented the triode vacuum tube, but radio worked (crystal sets) before that. Maybe radio was the invention (discovery) of several people, just as the automobile and the airplane were developed by several people, not just one.

Who really invented radio?

—Roger Wiley, Bellvue, WA

You're absolutely right, Roger, Radio, as well as the automobile and airplane, was developed through the contributions of many men, including those you mention. Fleming developed the diode vacuum tube, which Deforest improved by adding a third element, the control grid making it a ***triode.*** *There was also Major Amstrong (US) who invented FM radio, the superhertrodyne (99 per cent of all radios today are superhets) and lots more. In fact there were more inventors and developers who contributed importantly to radio than I could properly tell about if I used all the pages in this magazine.*

We have major articles scheduled in upcoming issues on giants of radio including Armstrong, Fessenden, DeForest, Marconi and others. If you can't wait for these stories, go to your library and check out some books on radio.

Radio Mystery

I was working on my portable cassette machine with the back off, adjusting the mechanism to fix a speed problem, when I accidentally touched a small screwdriver to a part on the circuit board. I suddenly heard a radio station playing music. I was also able to pick up the same sounds by touching the board in several other places.

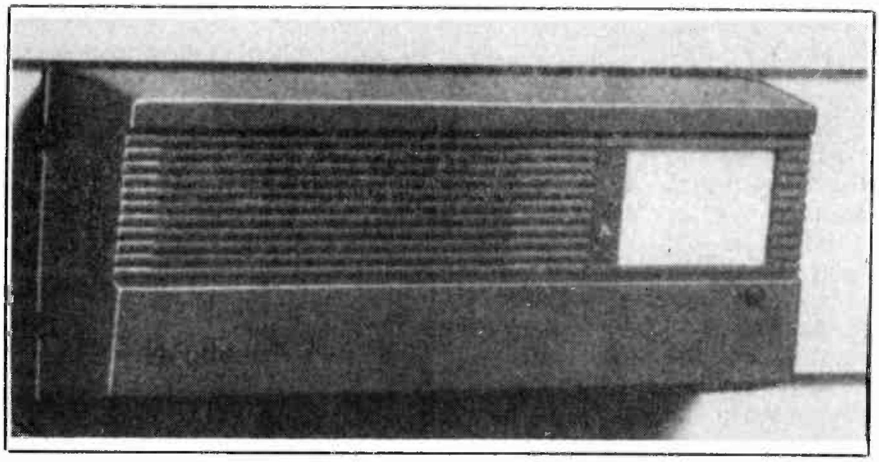
I tried many points on the board but couldn't receive any other stations. And it only worked at a few special points in the circuit. What gives? There is no tuner in the set, nor are there any tuned circuits (inductors) for radio stations. Is this normal? How does it happen?

—Fadhil Maaris, Toldeo. Ohio.

Congratulations. You have created (temporarily) an AM radio (non-tuneable). That is, you changed your cassette recorder into an untuned AM radio receiver. Actually you didn't do anything new at all, except to provide an antenna by touching parts with the screwdriver (and possibly your body too), if the screwdriver was a metal one, so your body could add its area to the size of the antenna. This enabled you to pick up nearby radio stations. Some part of the circuit is rectifying (detecting) the radio frequency signals and giving you audio from the (demodulated) rectified RF. The audio was then amplified by the same audio amplifying stages in the set that would normally amplify the (weak) tape head signals.

Unshielded tape heads frequently picked up local, unwanted radio station transmissions before the makers of tape recorders discovered they could prevent this by putting metal shields around the tape heads (and the leads) going from the tape heads to the first amplifier (high gain) stage.

NEW PRODUCTS PARADE



SECURITY SENTINEL (LIGHT/SOUND ALARM) KIT

Here's a new security alarm system which you can buy as a kit and put together yourself for super protection from burglars. It's Heath's new model 3810 Security Sentinel. After you've assembled its circuitry into the strong steel enclosure, it mounts anywhere near the area to be protected, up high enough to prevent easy tampering.

An infrared sensor behind the small window (right in photo) detects even small changes in heat, such as those produced by a human body (or even a dog, if desired). When the alarm is tripped it sounds a stern message of warning such as "You are entering a secured area, Leave at once!" The system also turns on floodlights, if desired, to further reinforce the alarm and message.

It can be set up to leave the lights on, or turn them off after a preset amount of time, and the message can be repeated, or reset to repeat after a desired period of time. Same with the floodlights of course.

The model 3510 Security Sentinel kit is $159.50 plus shipping from the Heath Company. For a catalog listing hundreds of Heathkits, drop a card to the company with your name and address, and the words "Catalog, please." Send to Dept EH at Benton Harbor, MI 49022.

LOUDSPEAKER FROM A KIT

Years ago you could buy kits for putting together amplifiers, receivers, and just about any other audio gear from many firms including Fisher and Scoot, and of course the biggest kit maker of all, The Heath Company. With most of these kits you could save between 30 and 40% by putting the kit together, compared to a similar unit factory-assembled. But by the Sixties everybody was out of the kit business except Heath, Dynaco, and a few small loudspeaker companies.

Fortunately Heath is alive and well, and selling thousands of kits of all kinds (electronics only) today. And there are a few firms still offering speakers in kits. By far the largest of these is Speakerlab (address below).

They have an extensive line of kits which can be had either with the driver units (woofer, tweeter, etc.) and a set of plans for building your own box(es), or with the wood parts for the enclosure precut, ready to screw together and finish. You can save about 40% over the cost of their finished units this way, and they have 12 different speakers available, ranging from $100 to over $500 each. **Write to Spearkerlab at 735 Northlake Way, Seattle, WA 98103.**

DIGITAL READOUT MULTIMETERS

The series 70 digital multimeters from Fluke, who bill themselves correctly as the world leader in these instruments, consists of three models, 73, 75, and 77. Small enough to fit into a portable field service tool kit, yet with readout numbers large enough to be read several feet away, these multimeters guarantee voltage, resistance and other readings accurate to within 0.7% (0.5 and 0.3% for models 75 & 77).

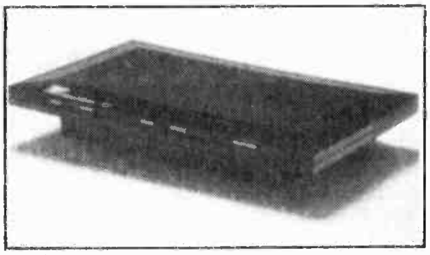
In addition to the volts and ohms ranges, current up to 10 amperes can be read, making it usable for small electrical appliances, as well as measuring current drain in devices such as radios, TVs, VCRs, etc., where internal currents range from a few milliamps up a maximum of an amp or two.

These multimeters operate on standard batteries, and with heavy duty batteries will operate for 200 hours. **To get a free brochure describing the series 70, telephone toll-free 1-800-227-3800, extension 229.**

MULTIVISION (TWO PICTURES) TV

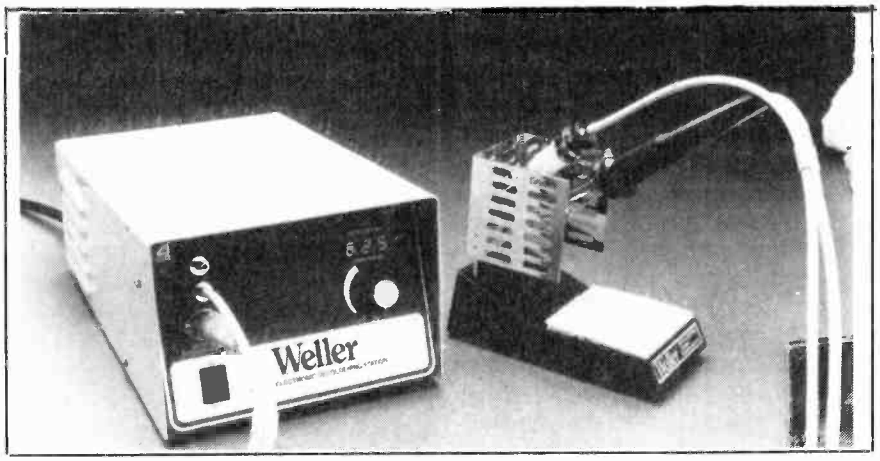
The Multivision two-picture model 3.1 includes two television tuners to provide the two pictures. One picture fills a corner of the main picture. The user can choose which picture will be the main one and which will be the smaller (corner) picture. The viewer can also swap pictures, change corners, and pick any of four different sizes for the smaller picture.

In addition pictures can be frozen by pressing a Hold button. The two pictures can be taken from broadcasts off the air, from VCRs, a video camera, or any



combination of these picture sources.

The Multivision model 3.1 also has MTS decoding for multichannel TV sound, as well as surround-sound. It comes with a remote control which handles all functions. **Price is $449, from Mutivision, Dept. EH, 1751 Fox Drive, San Jose, CA 95131.**



SOLDERING STATION/PENCIL HAS COOLING WATER JET

Weller is a name radiomen and electronics technicians have known for many years as a manufacturer of soldering irons and soldering pencils. I remember it as one of the first, probably the first company to offer interchangeable tips for small soldering irons. That was 'way back in the Fifties, even before they were called "pencils."

Now Weller, like many other companies we remember for dependable products, has become part of a bigger firm most of us never heard of before. In this case it's Coopertools, Inc. of Apex, North Carolina. This firm is offering the Weller model WTCPS soldering station & soldering pencil for serious electronics assembly.

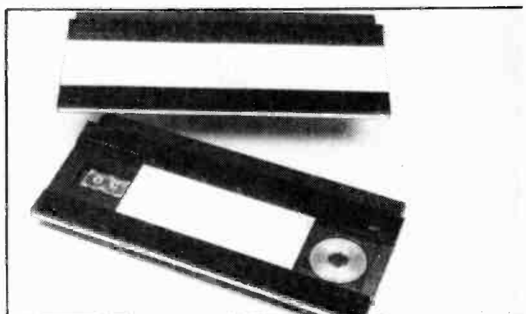
This setup has the main station (left, in the photo) placed at the back of the workbench, or anywhere else convenient where it's out of the user's way. Once the proper heat has been set (using the small knob on the front panel of the station) the pencil and its stand can be placed several feet away from the station. The stand has a self-feeding water reservoir, which gets its cooling water from the station. A lever on the handle of the pencil lets you apply a tiny jet of cooling water to the solder joint to speed its cooling. **The model WTCPS (Weller Tools cooling pencil/station) costs $119.50 from P.O. Box 728, Apex NC, 27502.**

PROGRAMMABLE MUSIC CENTER

B & O, long known for elegant styling and advanced electronic features, has brought out what may be the most advanced music center yet. It includes everything except an LP player, which may be added externally of course, as well as sound inputs from a VCR or laserdisc player.

The FM/AM tuner includes auto-search tuning, or any of up to 20 preset FM or AM stations. The cassette machine is auto-reversing, with Dolby B and C in addition to B & O-developed Dolby HX Pro which increases high-frequency headroom up to 7 dB at 10 kHz.

An infrared remote control terminal (hand-held) permits selection of all functions from anywhere in the room. And all programming and functions are displayed in large LEDs in the glass operating panel (large rectangle in photo) in the middle of



the receiver. To operate any function or command, instead of operating a protruding knob or button, the user merely touches the glass panel. To program the unit, words (prompts) appear on the panel to guide the user in setting up functions and commands.

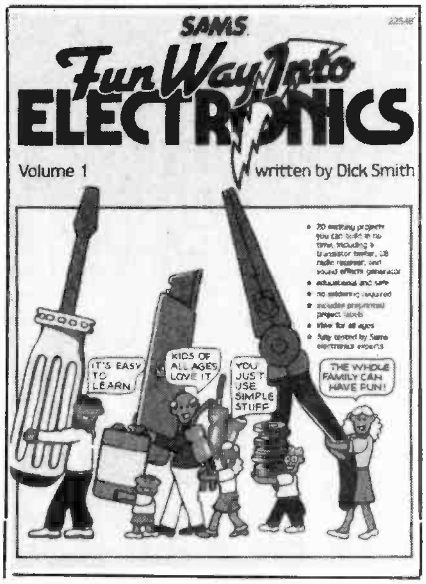
Available at B & O dealers nationwide, the Beocenter 9000 is priced at $2,995.

NEW BOOK REVIEWS

FUN WAY INTO ELECTRONICS by Dick Smith 79 (large) pages, paperback $9.95. Howard W. Sams Co., Indianapolis, IN 46268

The title of this book (the first of a series) describes it accurately. Printed in large type so that young people will feel comfortable with it, and with excellent drawings showing everything do be done clearly, it explains the basics of electronics through putting together 20 beginners' projects.

The projects start off with a simple tester which can tell when one's flower pot needs more water. This project has only six components, plus battery and wires. Next is a light/dark indicator (7 components).



The following projects become slightly more complex. A flashing light, a siren, a Morse code practice set, a crystal (radio) set, a one-transistor amplifier (for the crystal set), a two-transistor amplifier, the world's simplest radio transmitter, a CB radio receiver (a dozen parts), an amateur radio receiver (for the ham bands), and so on.

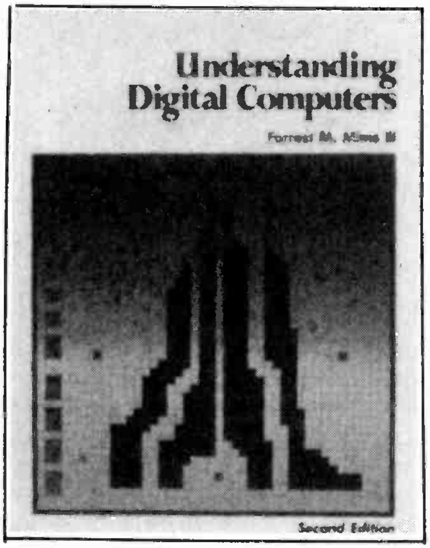
Also included is what has to be the world's greatest (beginning) project. It's a beer-powered radio, using headphones and three glasses of beer; no batteries! The book concludes with a section explaining radio transmission and radio reception very simply and clearly.

This book is a perfect, and a very easy and enjoyable, way to introduce oneself, or any young person, to radio and electronics. Highly recommended.

Charles Graham

UNDERSTAND CIRCUITS & PRINCIPLES OF DIGITAL COMPUTERS by Forest H. Mims, III. 320 pages, paperback. $15.95. Sams Div. MacMillan. Indianapolis, IN 46268

For people who want to understand the fascinating circuits and principles of digital computers, this book explains it all.



Mims' writing style is second to none in this field. Anyone interested in understanding microcomputers can learn a great deal from studying this book.

I predict it will become a classic on the subject.

- What's a Computer?
- Number Systems
- Binary Logic
- Combinational Logic
- Sequential Logic
- Arithmetic Logic
- Memories
- Computer Programming

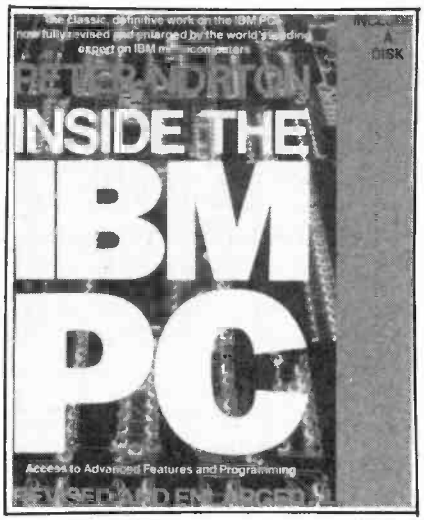
Forrest Mims, III is the author of 60 books and more than 500 of his articles have appeared in electronics magazines. He has designed digital and analog computers, laser system, remotely triggered aerial cameras, and miniature guide rockets.

INSIDE THE IBM PC by Peter Norton. Including 17-program diskette. 387 pages. Paperback. $17.95. Prentice-Hall Press, Inc. New York, NY 10023

Written by one of the (probably The) world's best-known writer on IBM micros IBM-clones, this is The definitive, and most comprehensive book on the best-selling IBM PC.

Good for Clones, Too.

It's also a guide to many computers called "IBM-*Compatibles*", modeled after the PC, including the Compaq, ATT, Data General and other clones.



And it's just as good for any of the scores of low-price clones now flooding the market at prices under $1000. (Editor's note: most of these low-priced clones are very good values, and potential buyers need not be put off from buying one by their incredibly low prices.)

In addition, this book describes the three versions of the IBM PC, the XT (Extra Technology) and the AT (Advanced Technology). It starts with the basics (what a computer is) and goes all the way up bits and bytes, through binary numbers, to octal and hexadecimal numbering systems.

Besides telling readers how the machine(s) work and how to understand them, it goes into such useful areas as how to install hard disks, printers, and modems (internal as well as external). Finally, it has many chapters on the structure of DOS (disk operating system) and how its parts fit together. This will be of interest only to experienced hackers and programmers.

A free program disk is included, consisting of utilities, hence is useful only to them.

PHOTOFACTS ON TV SETS, RADIOS, AND COMPUTERS by the Sams Staff. Various numbers of pages. Prices: below. Howard W. Sams & Co. 4300 West 62nd Street, Indianapolis, IN 46268

What do you do if you want to repair a radio or TV set, ot want to get its schematic diagram so your neighborhood repairman can work on it. Where can you get such informtion? That's been the need of radiomen for a long time, and the Sams company has been filling this need for many years.

In case you have a radio or a TV set, or a VCR, or car cassete/radio, or portable phonograph, or even a microcomputer. If you need such info on it, Sams has it. They supply it in Photofacts—with detailed photos clearly referenced for every resistor, capacitor and every other part, small as well as large, inside the set.

What Photofacts Includes

In addition to block diagrams and detailed schematics, with resistances and voltages at all points in the circuit, there is alignment information, disassembly instructions, parts replacement lists, and everything else the most demanding repair technician might possibly need.

What They Cost

Most radio/TV service dealers subscribe to Sams Photofact service, which for a fixed monthly fee regularly (monthly), supplies Photofacts on just about every TV sets and radio made, a year or so after the units first appear in dealers' stores.

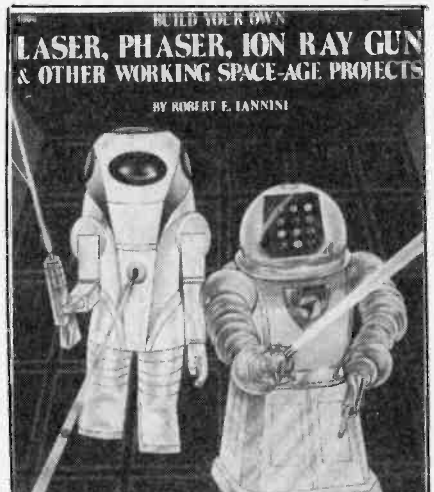
As a technicial writer of repair manuals for both Fisher Radio and Sony, I can testify that Photofacts are as nearly perfect as can be. Indispensable for every repair shop.

Photofacts can be ordered by anyone, either from Sams at the address above, or from any of several hundred distributors all around the country. Look 'em up in your Yellow Pages. Individual Photofact folders cost $9.95 each. You pay for a folder to get the particular set you want, and the folder also contains complete information on several other sets sold at the same time.

BUILD YOUR OWN LASER, PHASER, RAY GUN ETC. by Robert E. Iannini. 390 pages. Paperback. $15.95. TAB Books Inc. Blue Ridge Summit PA, 17214

This oversized volume of how-to-do-it information includes *laser* projects (five: 100 pages), as well as five *phasers*, high-frequency, very high sound-level generators. It also includes good projects for more everyday use such as wireless transmitters, a "snooperphone" (parabolic long-distance microphone), infrared darkness viewers, and other unusual devices.

None of these can be built overnight. They're fairly advanced projects, though by no means beyond your ability if you've put together a number of simpler projects like the ones Electronics Handbook has in every issue. The author is a leading authority on such devices, and executive of a company selling parts for such projects not readily available elsewhere (see ad on page 1 in this issue of Electronic Handbook).



If you're ready for advanced projects, this is the book for you. Plenty of excellent drawings and detailed photos along with all the instruction needed to put together any of these unusual devices. Highly recommended, for intermediate and advanced constructors.

TIMELESS TWENTIES RADIO KITS

Two Old-Time Radios From a Correspondence School

by Ed Noll, W3FQJ

During World War II, the US Army (there was no separate Air Force back then) sent out a call for thousands of radio operators and radio technicians. Although there were lots of ham operators, most of whom signed up for further training in the Army as soon as possible, Uncle Sam needed thousands more to fill the ranks and keep the lines of communication operating. Many new radio technicians were trained by the National Radio Institute

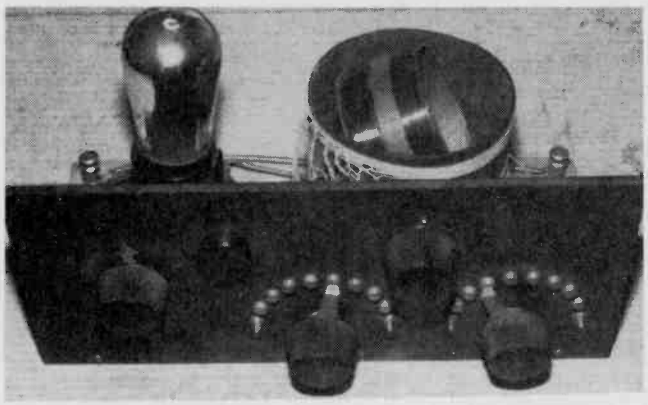
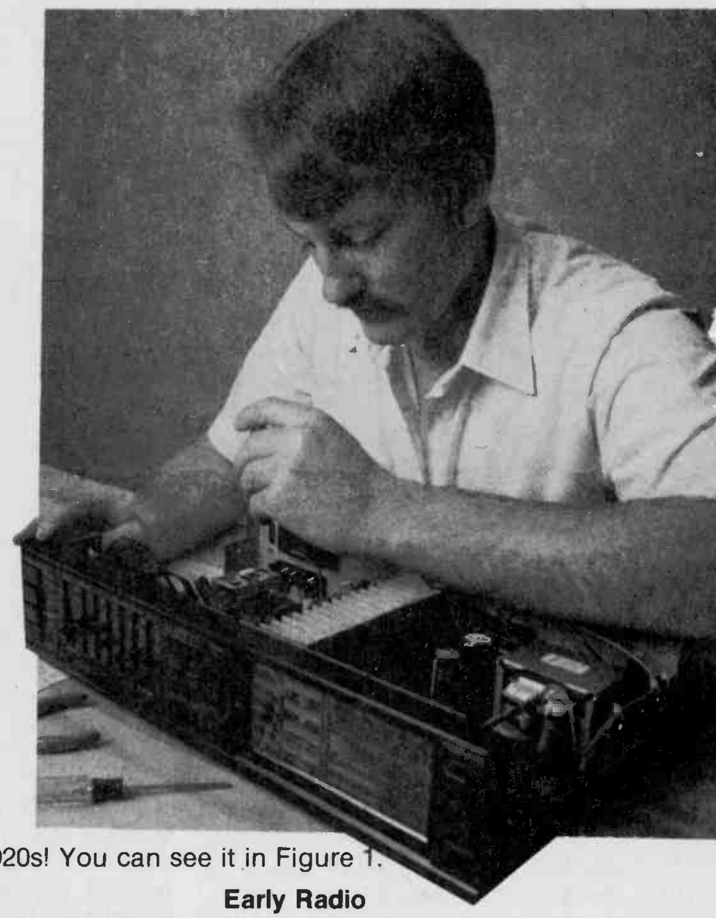


Figure 1. Here's the old-time, one-tube radio kit. Two knobs (middle and left) tune the stations by adjusting the number of coil turns in use. Smaller knob at right controls voltage to the tube filament.

which sent out lessons and kits through the mail.

I recently got hold of one these early radio kits which a friend of mine found. It had apparently been lying in the attic of his house, unused, for most of the sixty years since it was first assembled in the late



1920s! You can see it in Figure 1.

Early Radio

In the early days of radio (the Twenties) you couldn't buy a radio for much less than a hundred

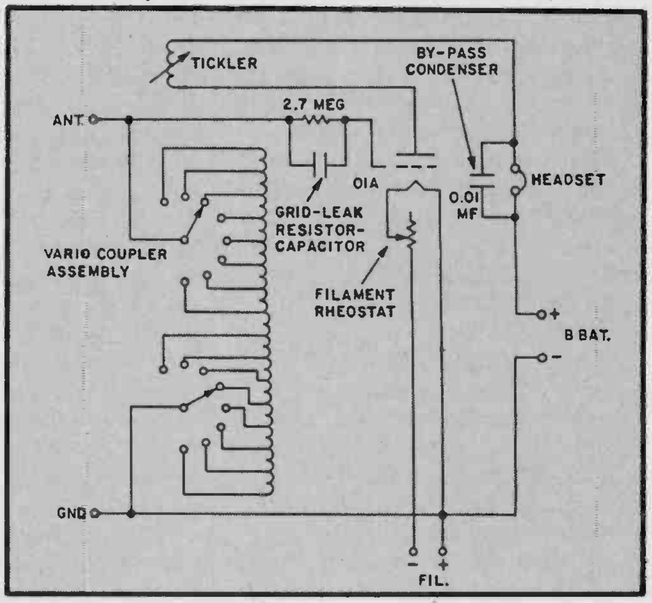


Figure 2. One-tube NRI kit radio schematic dating back to 1926.

dollars, but you could build a little crystal set which used no batteries and if you connected it to a good outside aerial you could pick up a strong local station if you were near one. At night you could often pull in far away radio stations, though the really distant ones usually faded in and out while you were listening.

You listened on a pair of little telephone receivers, a headset. And you tuned in the stations by adjusting a coil in the set with a front-panel knob (sometimes two or even three knobs).

Improved Reception

Reception improved a lot when the one-tube *regenerative* set appeared. More stations could be heard during the day. Skywave signals coming in at night were better, and reception of some high-powered broadcast stations became regular. In fact, some dedicated DX (long-distance) listeners were able to receive foreign broadcasts on those early one-tube radio sets.

Coil Is Heart of Kit

In the late 1920s the first kit the correspondence school student received in the mail was a set of parts for building a crystal set. First the coil was wound, and then it was assembled into the circuit shown in Figure 2.

Winding the coil took careful work. A small winding at the top of the form was tapped each turn and connected to the eight contacts of a single-pole,

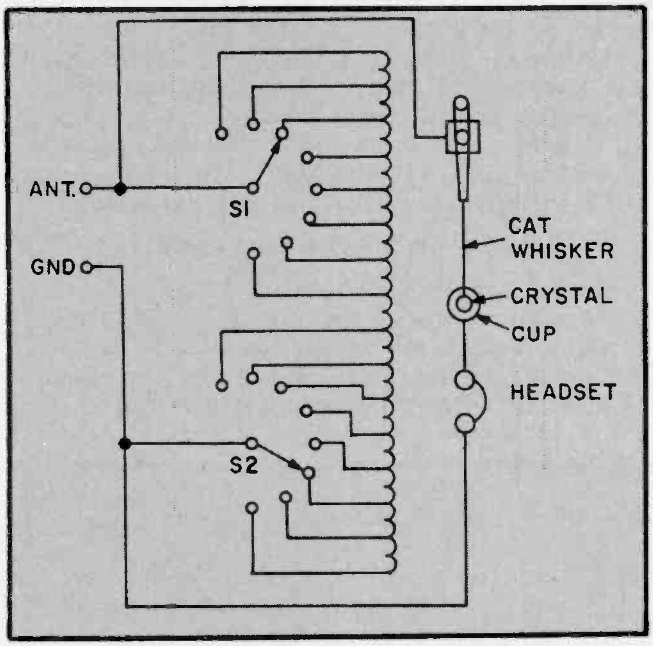


Figure 3. Here's the circuit of the two-coil (vario-coupler) crystal set. Today's diode rectifiers detect AM radio signals better, with no tricky adjustment, and they cost only a few cents.

eight-position switch. The larger bottom winding had many more turns. This coil was tapped at each seventh turn. Setting switches S1 and S2 in combination permitted setting the coil one turn at a time. There was no variable capacitor (it was called a "condenser" in those days). The basic crystal circuit design shown here in Fig. 3 goes back to the very early twenties. I've seen this circuit in a book copyrighted 1922.

Because diode rectifiers weren't available, early radio sets used a *galena* crystal. This was mounted in a metallic cup, and connections were made to the surface of the galena and to the cup (See Fig 1). In operating a crystal set a tiny sensitive spot must be found on the galena crystal. A piece of stiff, thin wire called a *cat's whisker* makes this delicate contact. A moveable arm and bracket for the cat's whisker permit the listener to search for the sensitive spot. It was often very tedious to find the most sensitive spot and hold it, and this was further complicated by the need to simultaneously adjust the two coil switches to locate a station. And that's how home radio reception was born.

The Beginnings of Home Radio

The advent of the vacuum tube and the regenerative circuit really brought radio into thousands of homes. Consequently correspondence schools sent

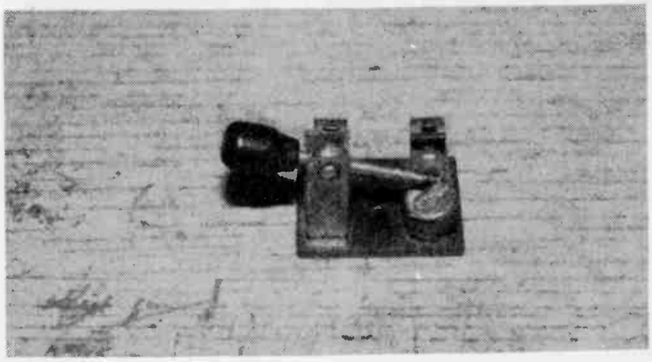


Figure 4. Early radios used a cat's whisker to rectify (detect) AM radio signals. You moved the handle around on the surface of the galena crystal until you heard the loudest sound.

out additional parts to students so they could construct a one-tuber and enjoy good radio reception as they proceeded with their radio studies. In the one-tube radio the same coil was used. This basic tube circuit also goes back to the early twenties but it is an excellent way to teach radio theory and practice at a minimum cost, right up until today. Bigger multi-tube radios were available later and all of these later

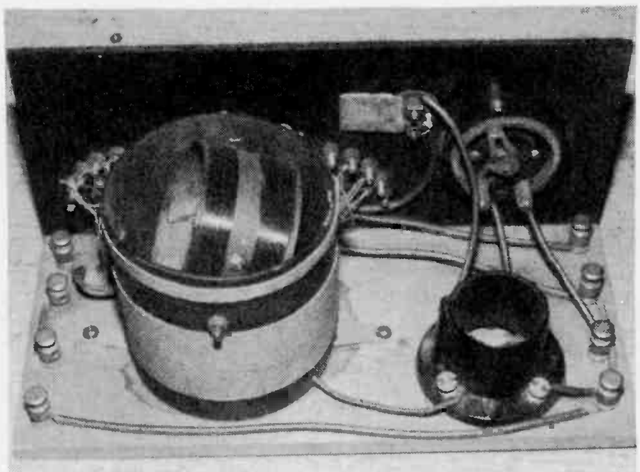
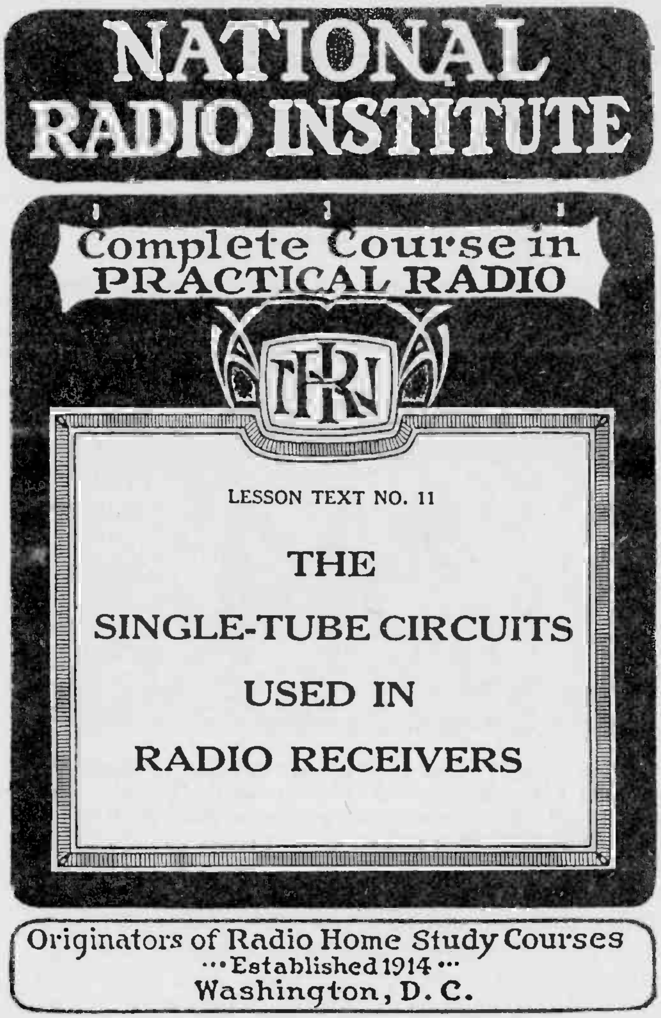


Figure 5. One-tube radio seen from the rear. Unit at right is two-coil vario-coupler for tuning stations. Empty tube socket is at left.

circuits and models were detailed in a 24-lesson course. Each lesson was about 30 pages long, with lots of pictures and diagrams. Practical installation guidance was given, along with instruction on repair of commercial radios, and tips on putting up good antennas for improved reception.


NATIONAL RADIO INSTITUTE

Complete Course in PRACTICAL RADIO

LESSON TEXT NO. 11

THE

SINGLE-TUBE CIRCUITS

USED IN

RADIO RECEIVERS

Originators of Radio Home Study Courses
···Established 1914···
Washington, D. C.

Here's a reproduction of the cover from the 1920's NRI lesson which taught radio theory using the crystal and one-tube radio kits.

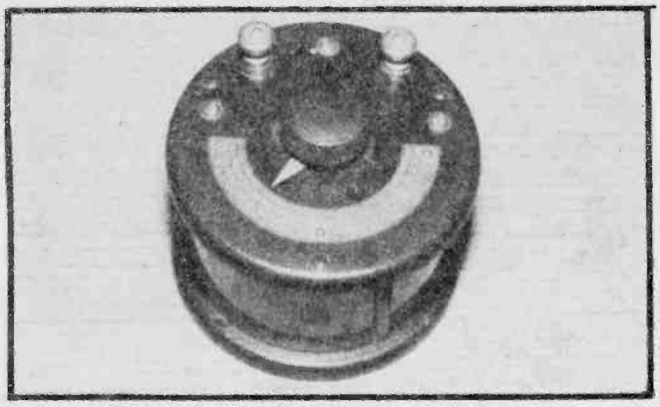


Figure 6. This variable capacitor was added to improve tuning radio stations. It is enclosed in a metal case to reduce the mistuning produced when one's hand was taken away.

Parts of the Radio

The one-tuber assembled by a learn-by-mail student many years ago is shown in Figs. 1 and 5. It was mounted on a 10" by 4" breadboard with the coil switches, filament rheostat, coil control and grid leak resistor attached to the bakelite front panel. The combined tuning coil, tickler coil, and switch is called a *variocoupler*. The tube socket and the variocoupler coils bracket were screwed down to the breadboard. The 01A vacuum tube had a five-volt filament, powered by a six-volt car battery. The rheostat was used to cut down the battery voltage to five volts.

Improving the One-tube Radio

The grid leak resistance was replaced with a new 2.7 megohm resistor. Also a 0.01 mf capacitor was connected across the headset terminals. In those early radio days high-value capacitors just weren't available, but today you can get them easily at any Radio Shack store.

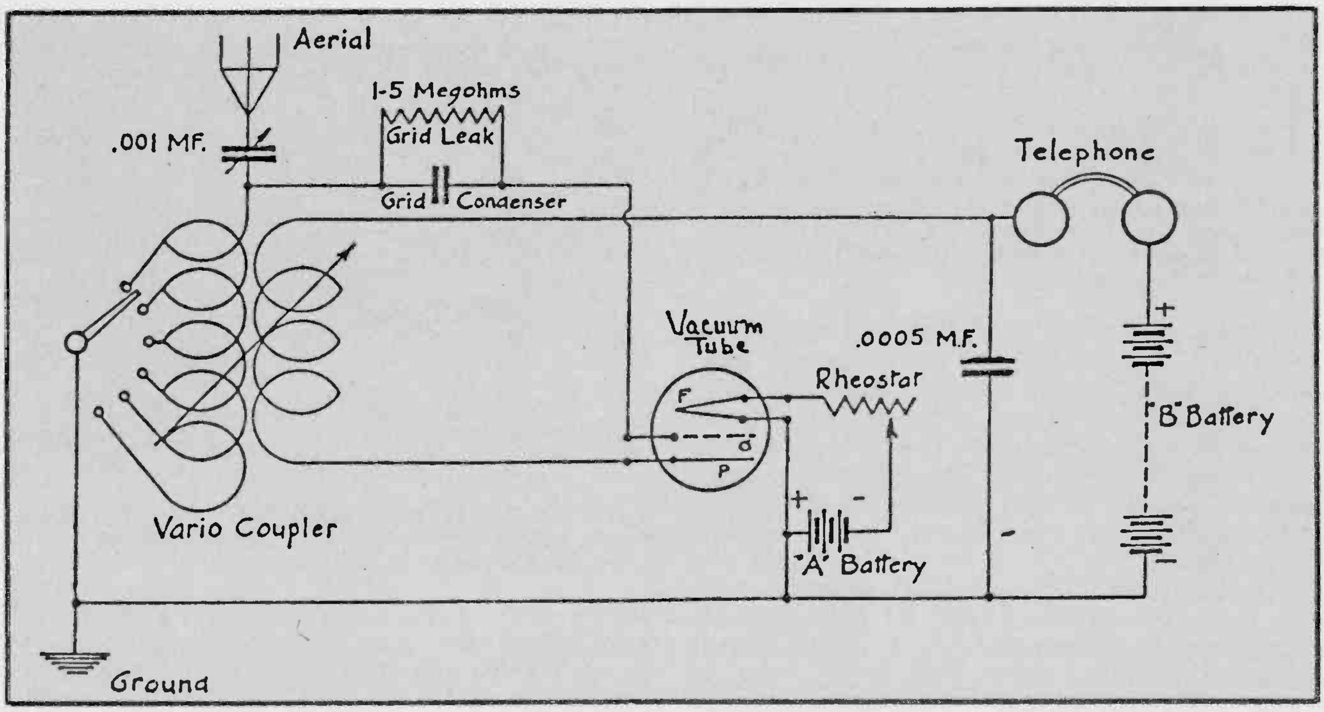


Figure 7. Pictorial diagram of two-coil, one-tube radio. Same coils are used in this radio as in the simpler crystal radio. Two batteries are required. The B battery is 22 or 45 volts. Tube filament is heated by a six-volt battery.

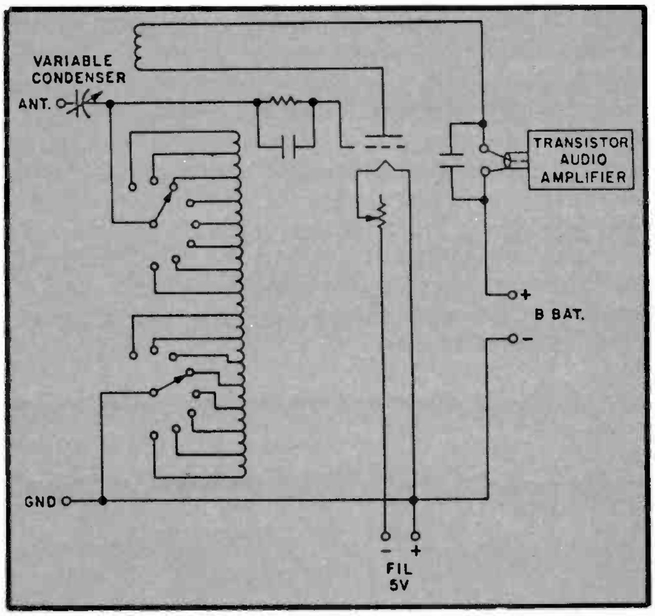


Figure 8. Some simple improvements without altering the original circuit.

Initially no other changes were made and the receiver perfomed very well. For local "day" stations and strong "night skywave" stations the radio signals were stable with strong headset volume, the regeneration control (coil rotator) set below the point of regeneration squeal. When looking for weak DX signals at night, I got the best results with the regeneration control set just at the point where the set was almost into oscillation (squealing). In searching for weak, far-away radio stations it's necessary to juggle the one turn-at-a-time variocoupler control and the regeneration control to a zero beat and listen to the station without moving one's hand away from the regeneration knob because of hand capacity. Hand capacity is especially troublesome with this type of receiver. Even touching or stepping on the antenna wire can change the frequency of the receiver because the antenna reactance itself is a part of the receiver's tuning circuit. I was able to get better results by adding a variable capacitor in series with the antenna lead, as shown in Figure 8. This capacitor is an old-time tuning condenser which has a metal case and dust cover protecting it.

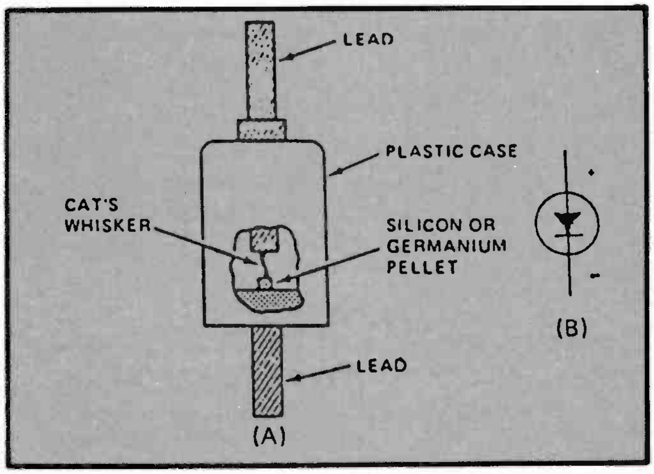


Figure 9. Early germanium diode (1955) shown in today's National Radio Intitute lesson looks much like the cat's whisker of yesteryear.

To further improve the crystal radio, I replaced the headset with a small audio amplifier and speaker picked up at a local Radio Shack store. These let me walk around my shop while still listening to radio programs.

Then and Now

This crystal set from the early days of radio is very much like the crystal sets you can put together today. The biggest improvement is the use of a modern diode to rectify the incoming radio frequency signals. This eliminates the tricky business of finding just the right spot on the surface of the galena crystal with the cat's whisker. Radio Shack has kits for this kind of radio and also includes such radios in its various electronics instruction kits. These are highly recommended if you want to ease into learning something about how radio works next weekend. The crystal radio kit and the one-tube radio kit from the Twenties pictured and described in this article were developed by the *National Radio Institute* for training learning-by-mail students. They are much simpler than the radios, TV sets and computers that today's National Radio Institute students learn about. But the basic principles of radio (and TV) today are the same as the basic principles taught by putting together the crystal radio kit and the one-tube radio kits of the Twenties.

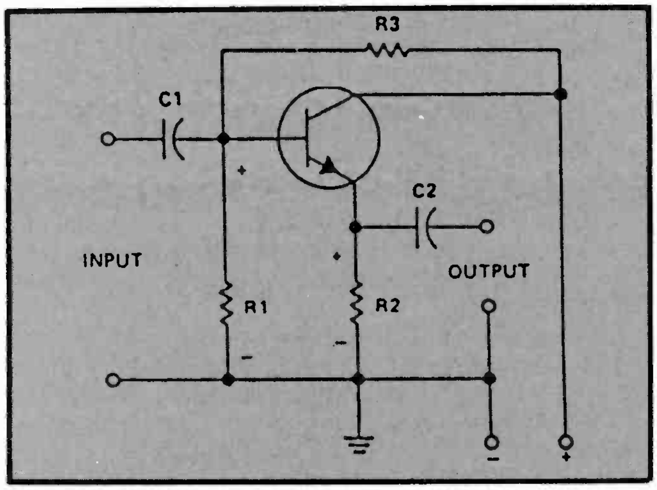


Figure 10. Diagram from a lesson on transistors in today's NRI course. Compare the input and output here with the antenna input and headset output in Figures 2 and 3.

Today's Radio & TV Sets

The radio receiver of yesteryear used a sensitive receiver to pick up radio frequency (RF) signals from the antenna and amplified those weak signals. The old-time radio set also amplified the RF signals and then *detected* (rectified) them to leave the *audio* available for listening. Just so today's more advanced radio and TV sets pick up RF signals from an antenna, amplify them, detect them down to the audio (or video) information, and then amplify that audio or video to drive loudspeakers and/or cathode ray (CRT) video tubes.

Radio Repair Then and Now

Repairing a radio set in the old days was usually a matter of substituting tubes, checking the condition of the batteries, and seeing that the wires from the antenna, the batteries and the speaker (s) were intact, and properly connected (a complete circuit). Today's servicing concentrates on similar facets of the radio (or TV) set. But there are no tubes any more except the big cathode ray video tube (CRT).

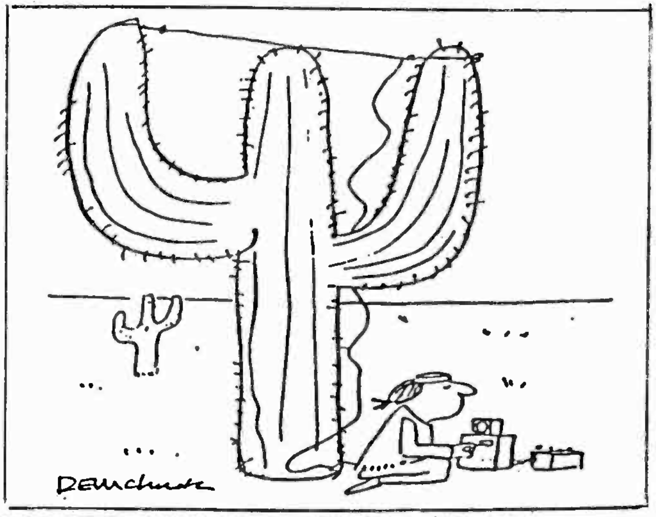
Today's students in NRI's modern electonics courses learn to repair and assemble parts in modern circuits. The block diagram shown here in Figure 11, compares with the much simpler schematic diagrams of Figures 2 and 3. But the basic principles are still the same. It's just that many new details have been added, to create today's more advanced (and more sensitive) receivers.

NRI is currently teaching more than 50,000 students by mail order in the US and Canada. It offers nearly 30 different mail-order courses in electronics and also in servicing air conditioning, small gasoline engines, and many other career subjects.

More Than Electronics

In addition to courses in TV servicing, Industrial Electronics, Communications, Electronics Servicing, Robotics, and other electronics careers, NRI courses can be studied by mail to prepare students for work as Appliance Repair Technicians, Photography and Video Production (studio work), Automibile Servicing, Electricians, and Air Conditioning, Refrigeration and Heating and Building Construction Careers.

All these courses qualify for government tuition assistance for servicemen and for ex-servicemen. NRI educational information can be had with no obligation by writing to NRI using the free postcard in their advertisement (Pages 32-33) in this issue of Electronics Handbook. ■



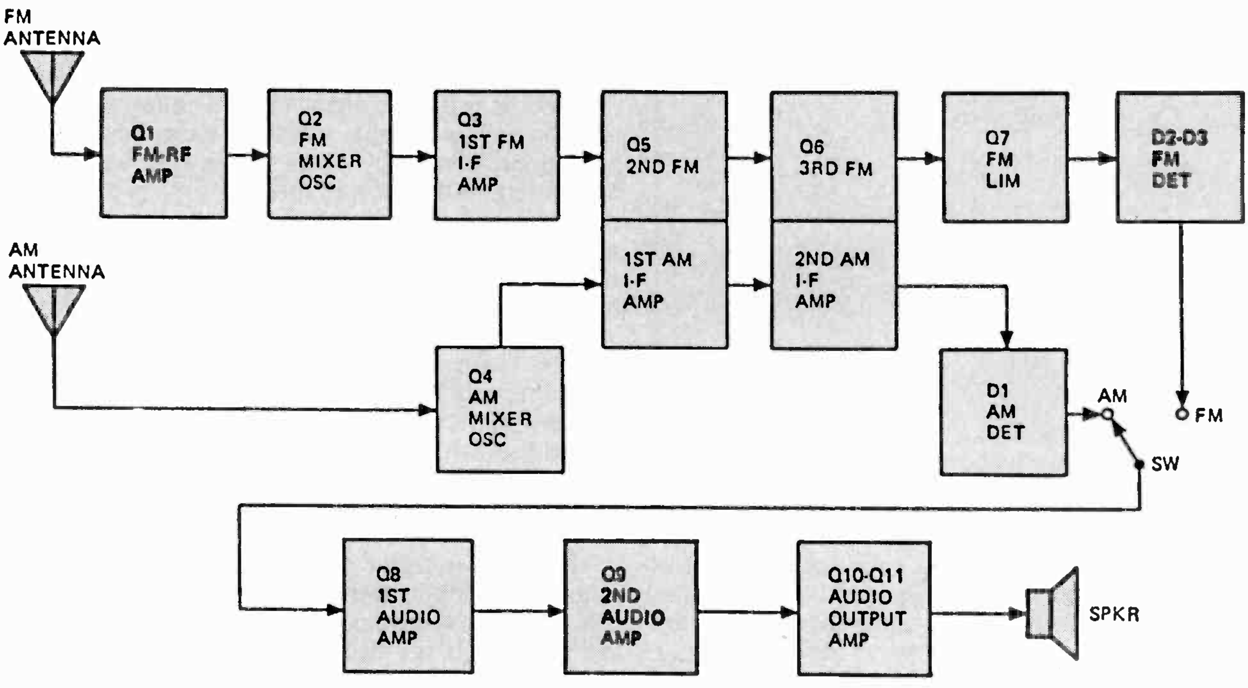
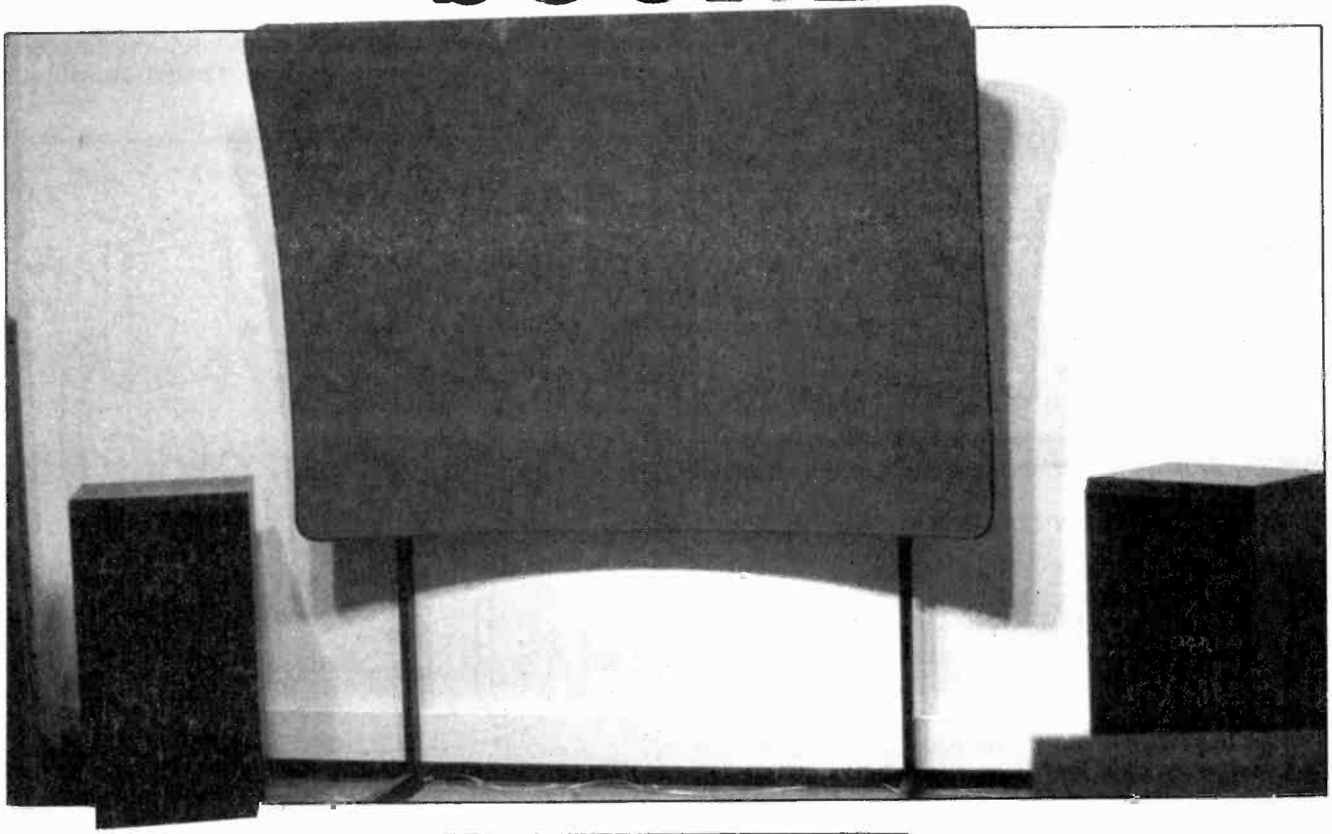


Figure 11. This block diagram from today's NRI course on AM-FM receivers shows how an up-to-date radio works.

VIDEO SURROUND SOUND



by William R. Hoffman

Now that the marriage of audio and video has taken place, the excitement of theater sound is available to the average person in their home. Film soundtracks made with the Dolby system abound everywhere—the majority of current films now are recorded in stereo, and most are available with stereo Hi-Fi soundtracks as prerecorded video cassettes, both VHS and Beta. The typical Dolby stereo release is actually taken from a film supplied by the distributor, and rerecorded for mass duplication, including the dual optical soundtracks which contain not only the front speaker sounds, but the rear, or surround sounds as well. With this, then, all the home viewer has to do is to have the proper decoding equipment to fully enjoy this extra sound dimension, just like in a theater.

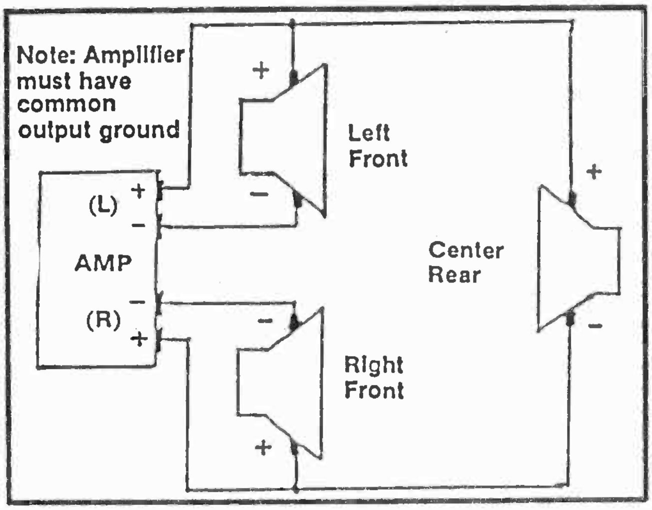


Figure 1. Schematic of simple matrix circuit.

But now, just what is required to do this decoding? Obviously, the big names in high fidelity equipment, such as Sony, Yamaha, Pioneer, etc. all have complete systems available, including decoders, amplifiers, and systems with enhancement circuits to allow special effects even with non-Dolby movies. But where does that leave the average person, just starting out, and maybe on a limited budget. Well, all it takes is a stereo VCR, a stereo amplifier, and a couple of extra speakers to get started with. In fact, you could be enjoying it right tonight even. It's really quite simple.

To begin with, two simple yet effective circuits are shown here, in Figure 1, the other in Figure 3. Notice, that all we are doing is adding another speaker, or two, to a current stereo system, plus a little extra wiring. This is all.

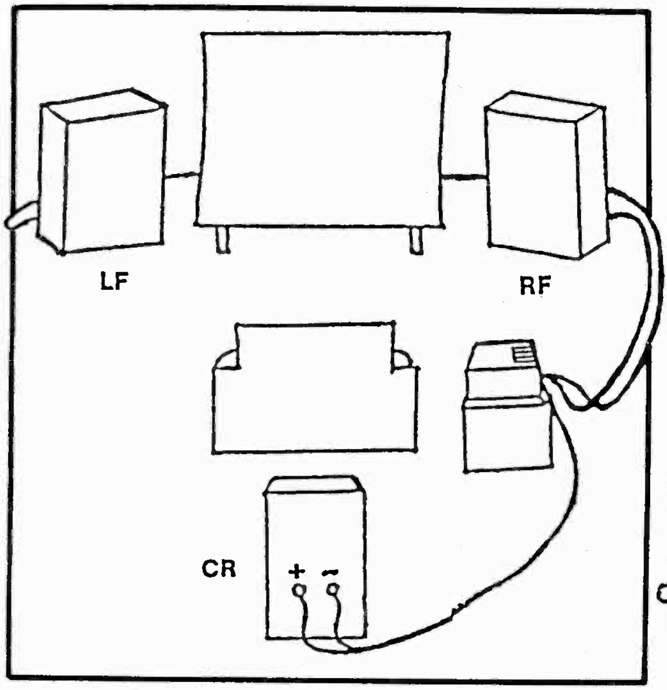


Figure 2. Wiring and speaker layout for simple matrix circuit.

HOW IT WORKS

Because the typical video stereo soundtrack not only contains the normal left front (LF) and right front (RF) soundtracks, but also the rear or surround track as a simple out-of-phase addition to the front channels, it is quite easy to decode this rear information by a simple speaker connection arrangement as shown in the two figures. Since the rear sound is encoded in the "+" sense in the left channel, and the "–" in the right, a speaker connected between the two amplifier "+" outputs will only see this out-of-phase component of the signal, and will then reproduce it. See "Matrix Theory" below for how this works.

HOW TO SET UP THE SYSTEM

The proper arrangement of the amplifier and speakers of the system is shown in Figures 2 and 4.

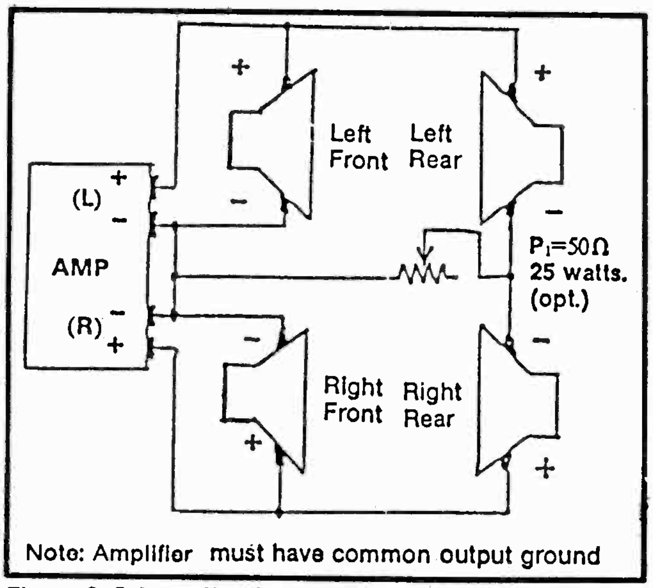


Figure 3. Schematic of augmented matrix circuit.

Figure 2, is the schematic of Figure 1 as it might be actually set up. Note that the single rear speaker does not have to be set on the floor. Rather, it is good to experiment with its placement; setting it up so its sound reflects off the ceiling or rear wall can be a big help in adding spaciousness to the sonic effect. Also note, that the rear speaker does not need to be a big or expensive system, Typically, it will have to handle only a small amount of power, so even small bookshelf types should do just fine. An old, unused extension speaker from a garage or playroom would be quite fine.

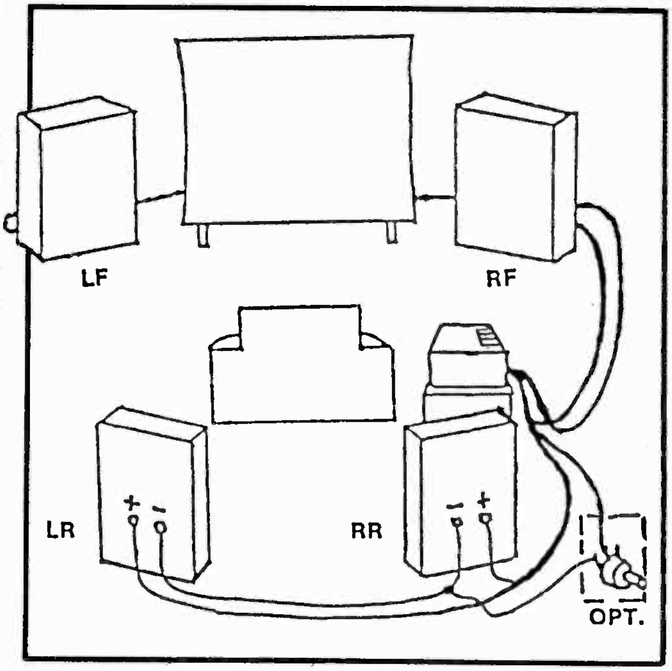


Figure 4. Wiring and speaker layout for augmented matrix circuit.

And finally, Figure 4 is the room arrangement of the circuit of Figure 3. As mentioned above, feel free to experiment with the placement of the speakers for best effect. Also, note the optional potentiometer shown in the schematic. This may help some systems in that it can allow adjustment of the output of the rear speakers, as well as slightly changing the separation of their sounds. In addition, in the event of a non-Dolby soundtrack, with only a little of the out-of-phase information available, this will allow you to mix in some of the front speakers sounds for an improved sonic balance.

NOW, A MORE COMPLEX CIRCUIT.

For those even more interested, and willing to spend a little time and money to build a simple op-amp matrix circuit, the effect can be even better. With active circuitry, a more complete and accurate cancellation of the non-rear channel information is possible. In addition, since an additional amplifier will be used, with its own tone and volume controls, you can further enhance the rear sounds.

Figure 5 is the additional circuit. Note that it uses only one op-amp, and four resistors and two capacitors; a very simple circuit. The op-amp can be almost any kind available, and the component values will work very well without any changes. Using the

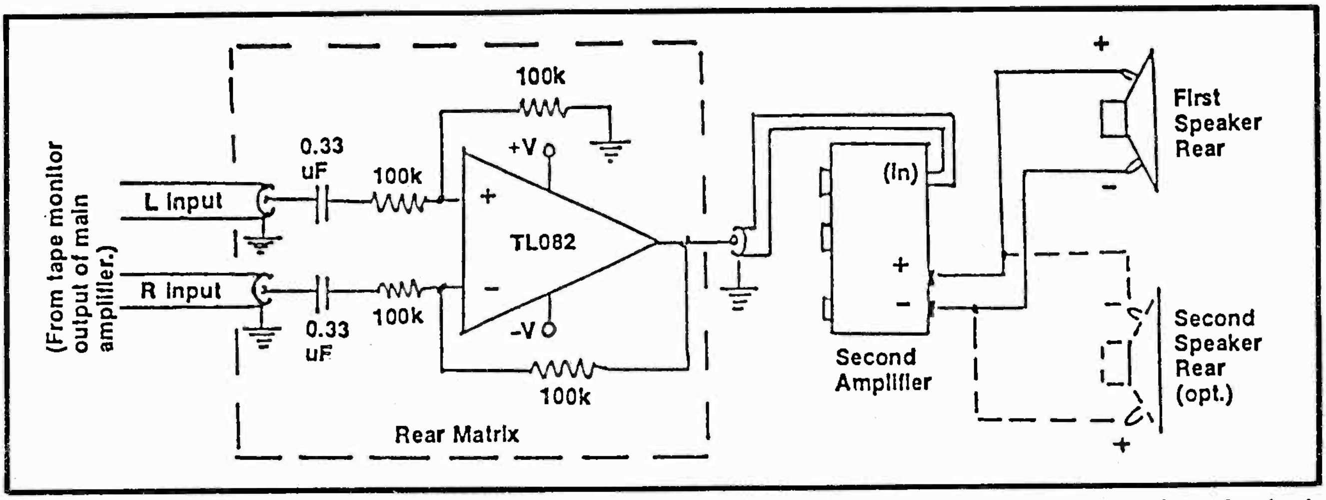


Figure 5. Complete schematic of rear surround matrix circuit. All resistors are ¼ watt rated. All inputs and outputs use shielded cables. Capacitors are 50V.

inverting/non-inverting functions of the differential inputs, it does electronically what our two speaker connection circuits just presented do, except here the cancellation is more exact, and unlike the other previous circuits, it will not affect the separation of the regular front speakers.

Building the circuit should be simple and straightforward. All the parts are easily obtainable at most electronics parts distributors, or most Radio Shack stores. The well stocked experimenter may even have most of the things he needs already on hand. If you need an AC supply to run the circuit, a simple one is shown in Figure 6. Both the op-amp circuit and the power supply can easily be constructed on a scrap piece of perfboard, and mounted on or in a small aluminum box, as desired. Since the circuit has very low gain, there is no possibility of oscillation or other problems, and it should work first time. Once the circuit is complete, simply connect it between the tape output jacks of the main amplifier, and any high level inputs of the second amplifier.

THE COMPLETE SYSTEM

And finally, for those who would like the entire Dolby stereo theater system, one more addition will provide most of the features that a complete theater system can provide. Along with the front and back channels, and the out-of-phase rear ambience channel, there is even one more source available. Encoded in the stereo soundtrack is also a common center channel, usually sent to a speaker located behind the main screen itself. But for a home system, a smaller speaker in front of and beneath the video

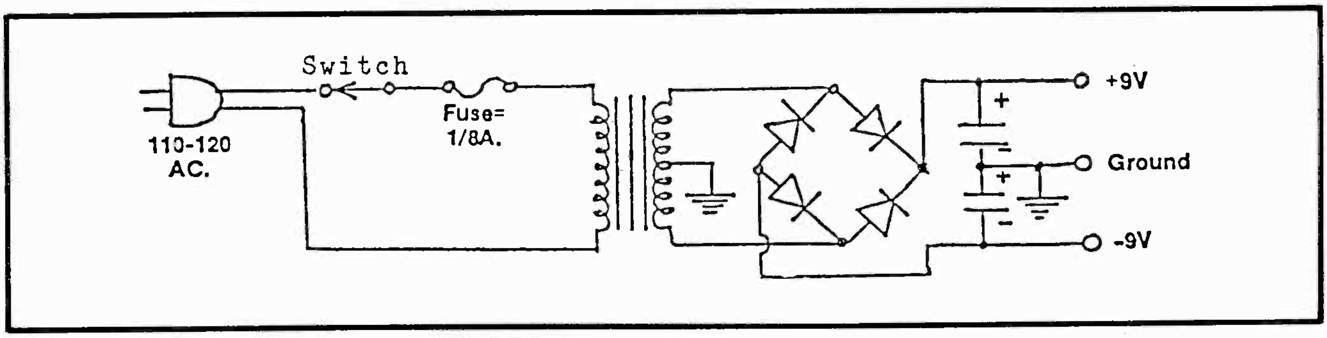


Figure 6. Power supply for electronic matrix circuit. Transformer has 12.6V center taped secondary at 100mA. Diodes are each 50V. @ 1A. Filter capacitors are each 470uf @ 16V.

MATRIX THEORY

The theory of the rear channel surround system as used in Dolby cinema soundtracks, and as discussed here, is really quite simple. Let's take a quick look at it now.

To begin with, we have the two incoming stereo soundtrack channels, which are:

Left incoming channel =(+LF+Rear)

Right incoming channel=(+RF−Rear)

Notice that the rear channel is inserted in the two signals with the phase reversed, one to the other.

Now if we were to simply add the two signals, we would get:

(+LF+Rear) + (+RF−Rear) = (+LF+RF)

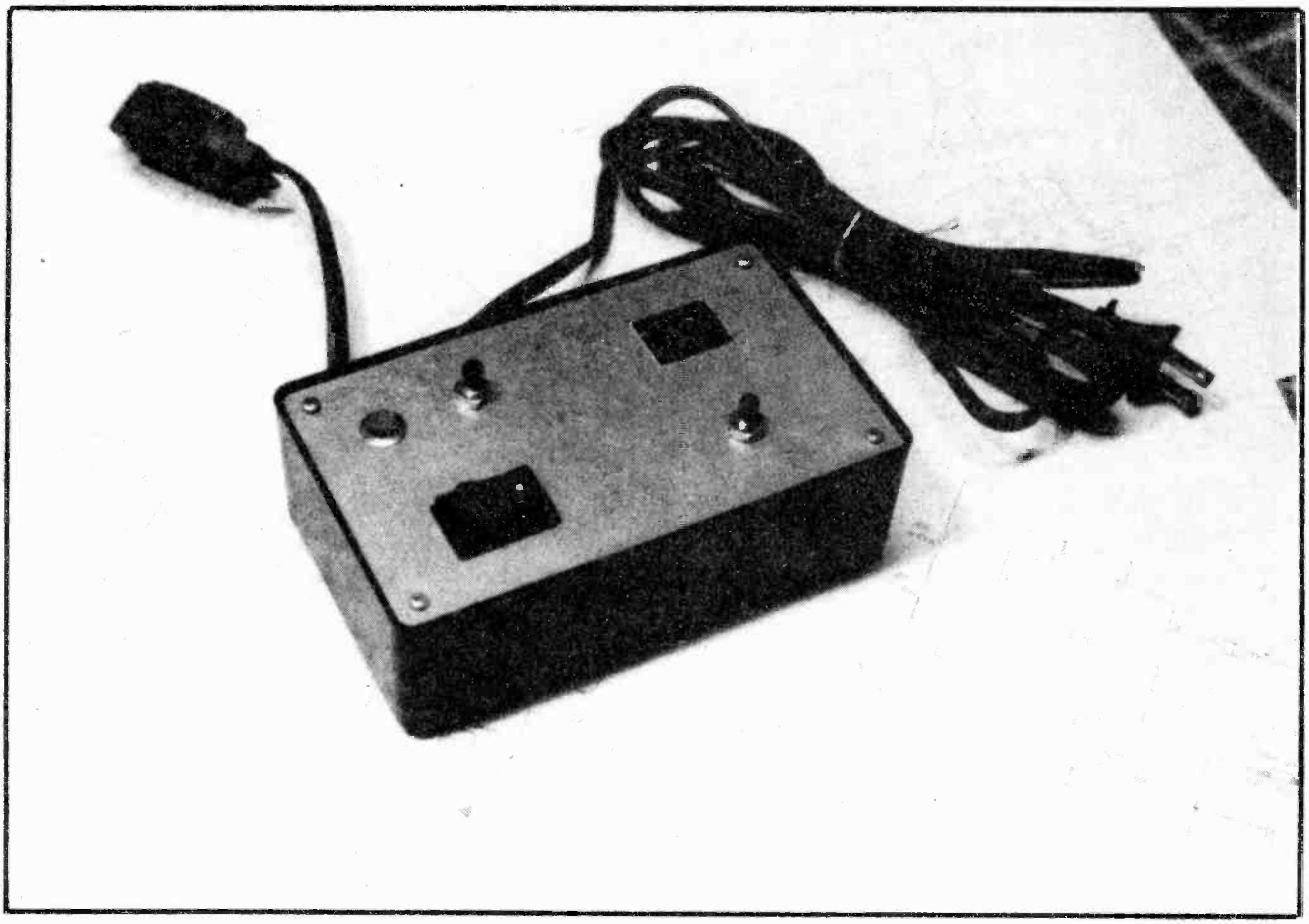
with no rear signal at all; it would be cancelled out.

But because we are placing the rear speakers in series with the + amplifier outputs, we only can reproduce the out-of-phase Common signals (the +LF and +RF signals have nothing in common, and are eliminated) which leaves:

(+Rear)−(−Rear)=(+2 Rear)

which is the signal we are looking for.

(Continued on page 95)



DIGITAL DARKROOM TIMER

Anyone who has developed pictures knows the importance of a darkroom timer. It is basically the control for the entire developing process. The timer ensures that you get the right exposure time needed to produce quality pictures. Our design of the Digital Darkroom Timer was made as simple as possible to provide easy operation.

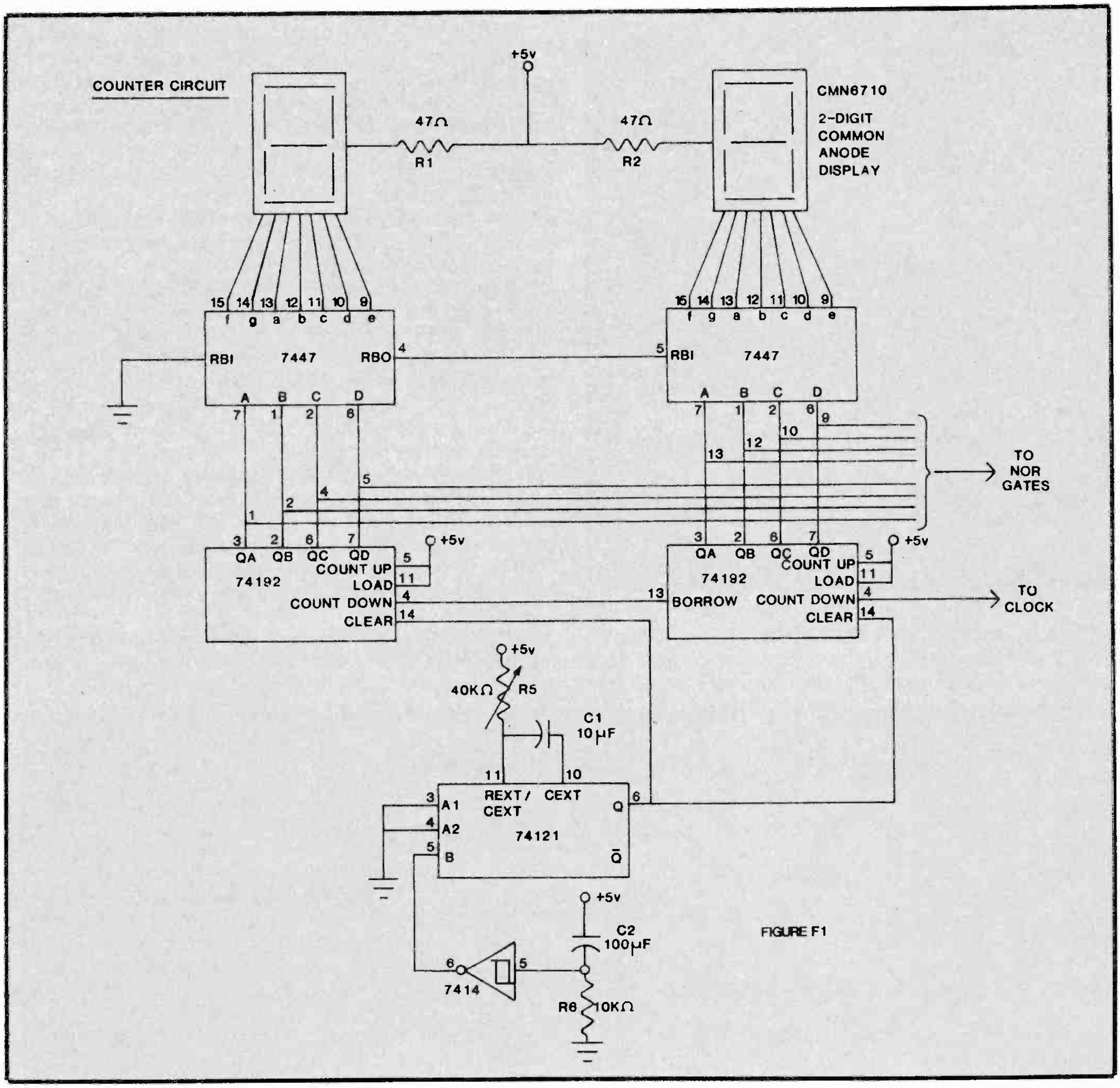
The Digital Darkroom Timer is a single-touch-activated timer that includes an ON/OFF switch to allow focusing and paper adjustment, a double-digit LED (light-emitting diode) display with blanking zeros, and both a FAST and SLOW time-set button. The schematic diagram for the timer is given in three drawings for ease of understanding. Put all three together to make the timer.

The Counter Circuit

The counter circuit in the Digital Darkroom Timer (Fig. 1) uses two 74192 synchronous up/down decade counters (U1 and U2) which are designed to count down by connecting the clock to the count-down pin (pin 4) on the counter chip (U2) representing the least significant digit (LSD), and the borrow pin (pin 5) of the same counter to the count-down pin (pin 4 of U1) of the counter representing the most significant digit (MSD). The count-up and load pins on both counters (pins 5 and 11, U1 and U2) are connected to the 5-volt DC supply.

The BCD outputs of the 74192's (U1 and U2) are connected to the BCD inputs of two 7447 BCD-to-seven-segment decoder/drivers (U4 and U5). The outputs of the 7447's are connected to a 2-digit, common-anode, seven-segment displays—DIS1 and DIS2. Rather than using current-limiting resistors between the anodes of the display and the supply voltage, a common resistor value of 47 ohms (R1 and R2 for each display) was enough to limit the current. Ripple blanking is achieved by connecting the ripple-blanking input of the 7447 (LSD) to the ripple-blanking output of the 7447 (MSD), and the ripple-blanking input of the 7447 (MSD), to ground.

Clearing of the counters is accomplished using a 74121 monostable multivibrator (U3). The Q of U3 is tied to clear input on both of the 74192's (Pin 14 of U1 and U2), which are active high. The one-shot (U3) is triggered by connecting the A1 and A2 inputs (pins 3 and 4) to ground, and applying a positive going pulse to the B input (pin 5). This pulse is generated from a



7414 Schmitt trigger inverter (U6C). The input of the the Schmitt trigger (U6C) is tied to a common point between a 100 micro-farad capacitor C2 and 10,000-ohm resistor R6. When power is initially supplied to the circuit, the output of the Schmitt trigger is low. However, as the voltage across the capacitor increases, it creates a negative-going edge at the input, providing the necessary high on the B input of U3, triggering the one-shot and clearing the counters. The duration of the pulse from the one-shot is 280 msec, and is accomplished by using a 10-microfarad capacitor (C1), a 50,000-ohm potentiometer (R5) set to 40,000 ohms, and the equation:

$$tw = 0.7(R5 \times C1).$$

Timing Circuit

The timing circuit (Fig. 2) uses a 555 timer (U7) as an astable clock generator. A frequency of 1 Hz is obtained by using the values;

R6 = 4800-ohm
R7 = 47000-ohm (10,000-ohm potentiometer setting)
C3 = 100-microfarads.

When setting the display, to the desired count, the frequency of the 555 (U7) can be increased by depresing the normally closed switch (S2), which puts a 10-microfarad capacitor (C5), in series with the 100-microfarad capacitor (C3), and delivers a frequency of approximately 9 Hz to the counters. The output from the 555 is fed through a Schmitt trigger inverter (U6B) to clean up the pulse.

Control Logic

The counters are clocked from a 7408 2-input AND gate U9B (Fig. 3). The inputs to this AND gate are the

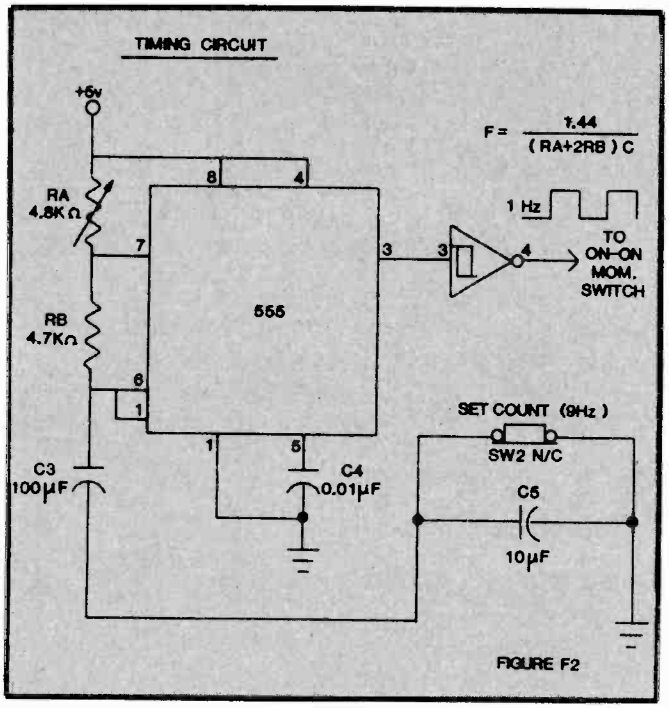


FIGURE F2

clock pulse, (through an on-on momentary switch), and the Q output of a 7474 dual flip-flop (U10). When Q is low, the AND gate (U9B) produces a low output, and the clock is disconnected from the counters. When the Q output of U10 is high, the counters are clocked at a frequency of 1 Hz (one pulse per second). The counters can also be clocked by depressing the on-on momentary switch (S1), which bypasses the AND gate (U9B) entirely. An SK3087 switching diode (D1) is used at the output of U9B to prevent "wire-ANDing". A germanium diode was chosen in order to keep the voltage drop down to 0.3 volts.

Two 7425 NOR gates (U8A and U8B), along with a 2-input AND gate (U9A), a Schmitt trigger inverter (U6A), and normally open switch (S3), are used for controlling the output of the flip-flop (U10). When all of the BCD outputs of the counters are low, the displays are blanked, and the outputs of the NOR gates (U8) are high. That action results in a high output from the AND gate (U9A) and a low output from the Schmitt trigger inverter (U9A), which is tied to D and the clear input and clears the flip-flop (U10). With Q now low, the counters cannot be clocked.

Setting the desired count requires depressing the on-on momentary switch (S1), which clocks the counters at a rate of 1 Hz. As was previously mentioned, by simultaneously depressing the switch (S2), a frequency approximately equal to 9 Hz is applied to the counters, allowing the count to be set at a faster rate.

With the count set, the outputs from the 7425 (U8B) and the 7408 (U9A) are low, which produces a high output from the Schmitt trigger inverter (U6A). This

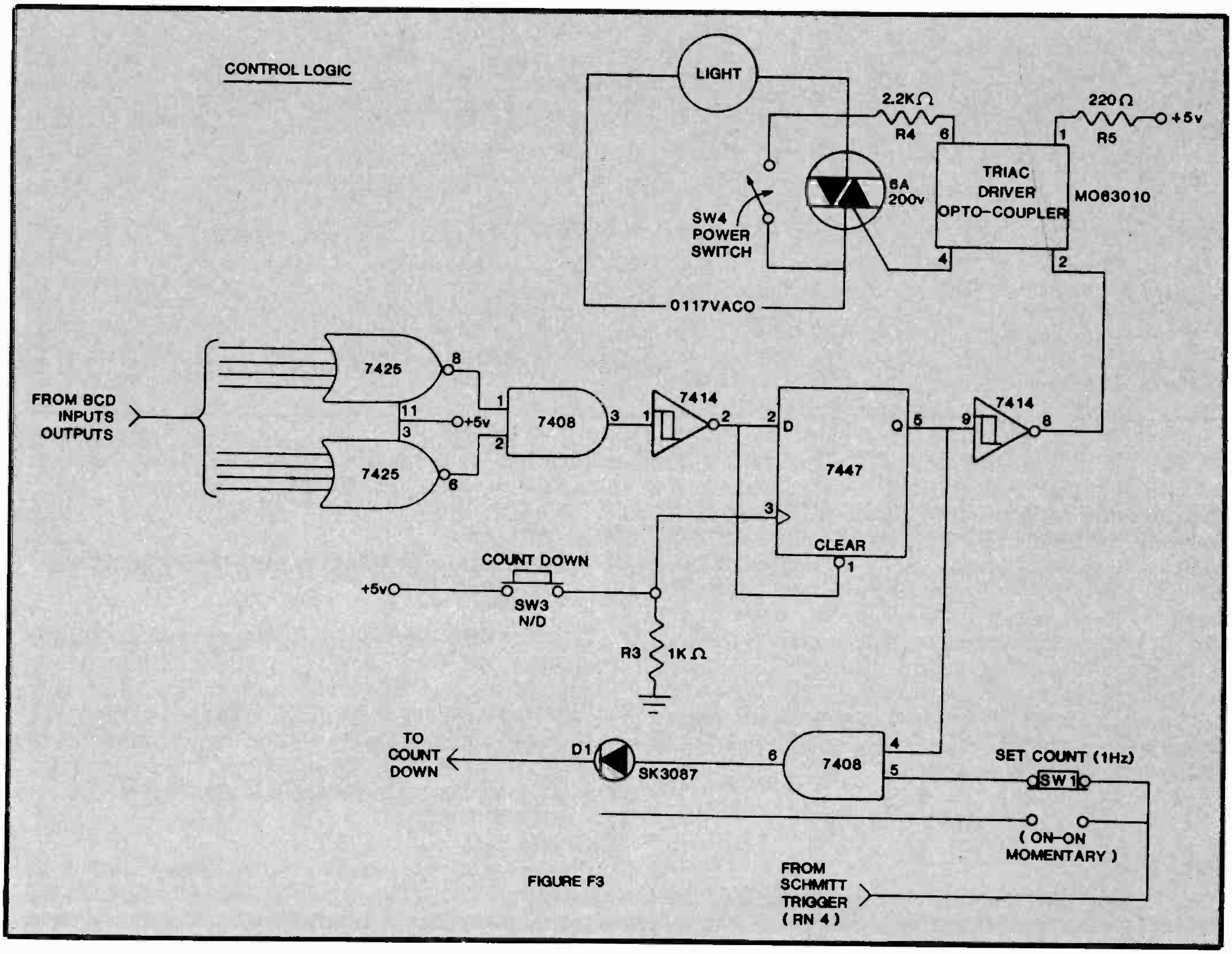


FIGURE F3

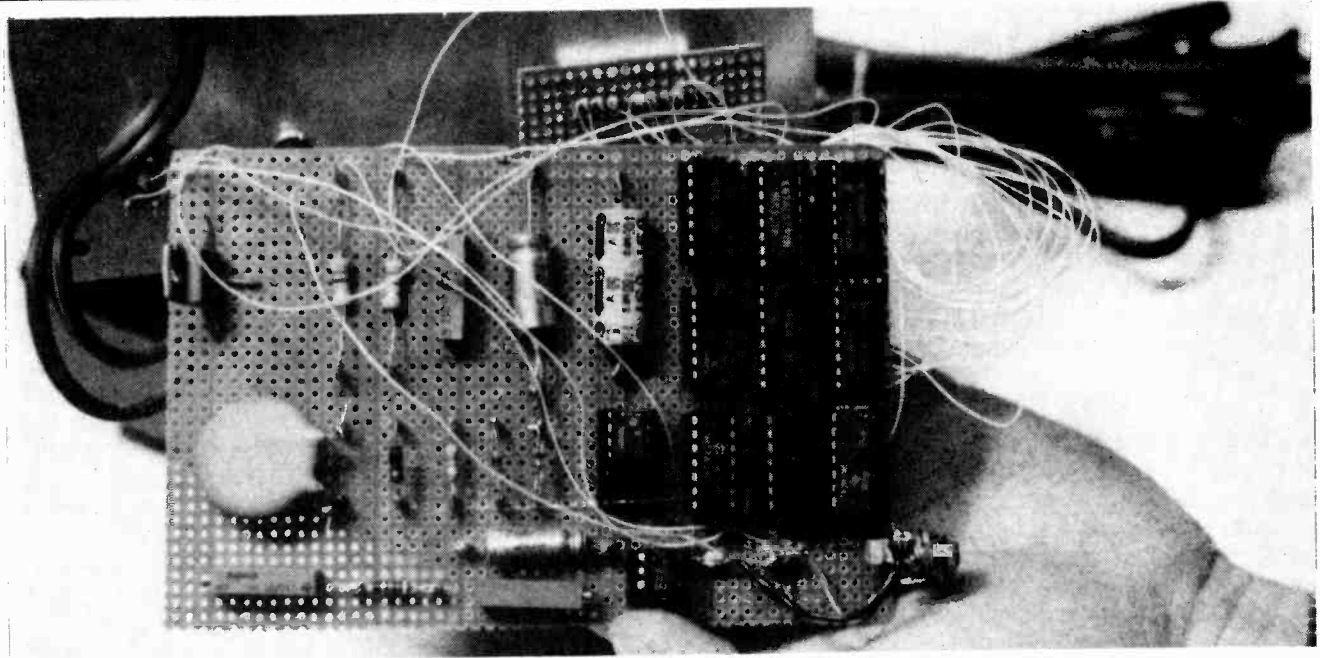
puts a high on the D input of U10 and de-activates the clear input of the flip-flop. By depressing the switch (S3), a positive-going edge is applied to the clock of the flip-flop, and Q goes high. With Q high, the clock pulse from the 555 (U7 in Fig. 2) is connected to the counters, through the AND gate (U9B), and the counter begin counting down. When a count of "O" is reached, the low output from the Schmitt trigger inverter (U6A) clears the 7474 (U10), and the output from the 555 is disconnected from the counters.

The on-off state of the enlarger light is controlled by a triac (TR1 in Fig. 3) an optocoupler (OC1), and the output of the flip-flop (U10). The Q output of the flip-flop is connected, through a Schmitt trigger inverter (U9D), to the optocoupler. When Q is high, which would be the case when the 74192's (U1 and U2 in Fig. 1) are in counting sequence, the optocoupler fires the triac and the enlarger light is turned on. The enlarger light can also turned on or off by means of a rocker switch (S4), which is connected in parallel with the triac. Resistor R8 is the current-limiting resistor for the LED in OC1.

Construction Hints

The prototype of the Digital Darkroom Timer illustrated in the photographs tells you that the unit need not look fancy to perform the service it is intended to do. The enlarger light can be either hard-wired to the unit or connected by means of a receptable mounted on the unit. Point-to-point wiring is best accomplished using the wire-wrap technique. If you have a darkroom, or are in need of a countdown timer, the Digital Darkroom Timer is the project you should build.

One other point! The text is presented in a style that promotes an understanding of digital circuits. It is suggested that should you have some of the parts in your junkbox, you should assemble those portions of the circuit you are able to on a solderless breadboard so that the hand will reinforce what the mind has learned. ■



Layout the parts on a perfboard and wire the terminals together using the wire-wrap technique. The long white wires are used to interconnect the display element that is not on the main board.

PARTS LIST FOR DIGITAL DARKROOM TIMER

SEMICONDUCTORS
D1—SK3087 silicon, switching diode (most silicon switching diodes will do)
DIS1, DIS2—CMN6710 2-digit, 7-segment, common-anode, light-emitting diode display
OC1—MOC3010 triac driver-optocoupler
TR1—Triac rated at 6 A, 200-VAC
U1, U2— 74192 Synchronous up/down decade counter
U3—74121 monostable multivibrator
U4, U5—7447 BCD to 7-segment decoder/driver
U6—7414 Schmitt trigger inverter
U7—555 timer
U8—7425 dual 4-input NOR gate with strobe
U9—7408 quad 2-input AND gate
U10—7474 dual D flip-flop

RESISTORS
R1, R2—47-ohm, ½-watt
R3—1000-ohm, ¼-watt
R4—2200-ohm, ½-watt
R5—50,000-ohm, linear-taper, ¾-watt potentiometer
R6—10,000-ohm, ¼-watt
R7—10,000-ohm, linear-taper, ¾-watt potentiometer
R8—220-ohm, ½-watt

CAPACITORS
C2, C3—100-uF, 16-WVDC, electrolytic
C4—.01-uF, ceramic
C1, C5—10-uF, 16-WVDC, electrolytic

SWITCHES
S1—DPDT, momentary, pushbutton switch
S2—SPST, normally-closed, momentary pushbutton switch
S3—SPST, normally-open, momentary, pushbutton switch
S4—SPST, rocker-type switch rated at 6A at 125 VAC

MISCELLANEOUS
Line cord with AC plug, plastic hobby cabinet with aluminum cover, suitable power output socket, perfboard, IC sockets (1 24-pin, 4 16-pin, 6 14-pin, and 1 8-pin), wire, hardware, solder, etc.

BUILD A COKE-BOTTLE ANTENNA

Build Your Own Base-Station CB Antenna for Under $10. Here's a CB Antenna for apartment dwellers, people living in small quarters, or anybody with a limited amount of money to spend on a base station CB antenna. It works almost as well as expensive factory-made antennas and it has amazing reception and range for a home-built antenna.

By Ellis Eldred

The author was able to get the SWR (standing wave ratio) which is the way antennas are adjusted and measured, down to 1.1. You can't do much better than that. Because this antenna includes a "capacitance hat" in its design, you can use it in either the vertical or horizontal-polarization mode.

Uses Coke Bottle

I call it the Four-Liter Indoor CB Antenna because it uses two 2-liter Coke bottles. The first thing you must do, after you read this article through to understand what parts are needed and how they will be used, is to take the Parts List and get your material together. After you do that, you're ready to start building your low-cost CB base station antenna.

Construction

From the 10-foot length of PVC pipe cut a piece 4½-feet long, leaving the remaining 5½ feet to be used later as a mount. Mark the center of the 4½ foot length (2 feet, 3 inches) using a ball-point pen or marker.

Next, make two adaptors to couple the ¾-inch pipe and the two 2-liter Coke bottles together. This can be done by using two 3-inch pieces of broom stick. Our broom stick fit snugly into the ¾-inch pipe. Cutting the broom stick down so that approximately one and a half inches fit into the bottle neck was a little more difficult.

Lacking the proper wood-working tools, I was forced to use a pocket knife for the job. (I discovered that I am not a good whittler.) However, I finally shaped the adapters to get a proper fit in the neck of the bottles.

A small amount of two-part epoxy was used to secure the bottles, broom stick adapters and PVC pipe together.

Next I cut two pieces of 18-gauge hookup wire, each nine feet long. I used stranded wire, but solid will work just as well. As a matter of fact, almost any wire will do, but a large gauge works better, both electrically and mechanically.

Starting from the center mark on the PVC pipe, you will need to make two separate helical windings. Start the windings one inch from either side of center by tying a simple knot, with about two inches on the free end. Wrap the wire clockwise, with approximately seven turns spaced evenly, with an eighth turn being made on the bottle neck.

I used small strips of nylon strapping tape to secure the turns of wire to the ¾-inch PVC pipe and bottle.

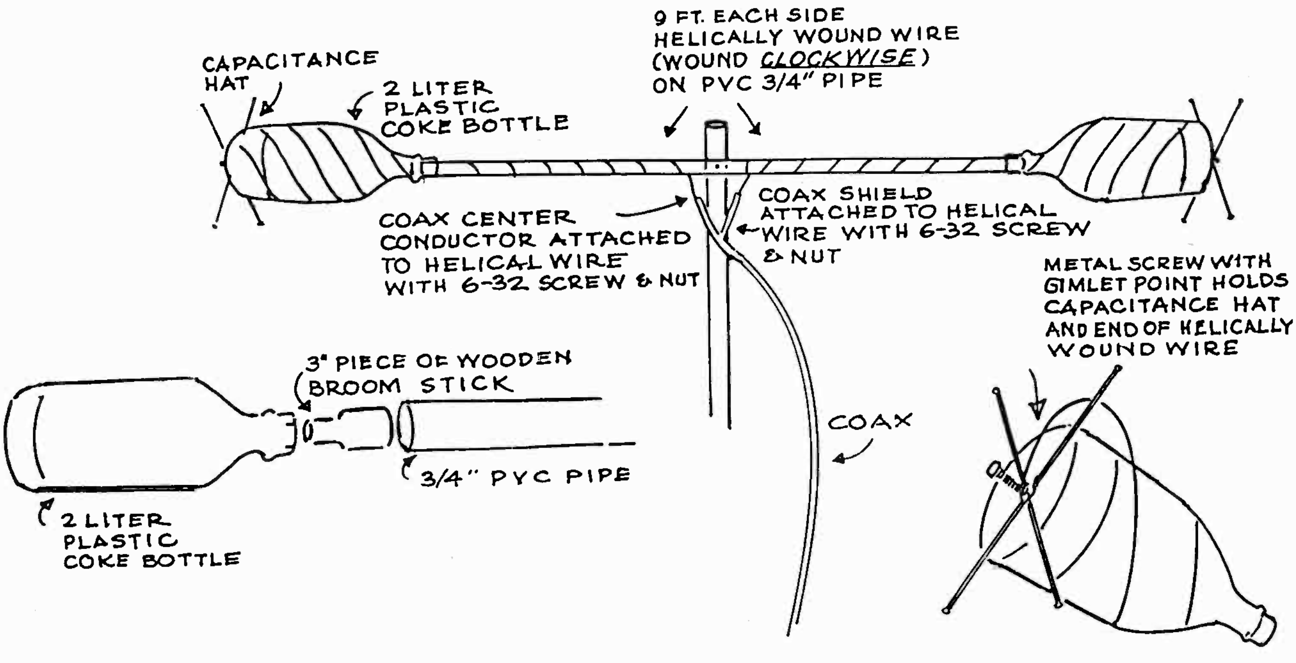
At this point you should have enough wire to make four staggered turns on the flat (cylindrical) part of the bottle, with about four inches of wire left over to attach to the screws holding the capacitive hat (See illustration).

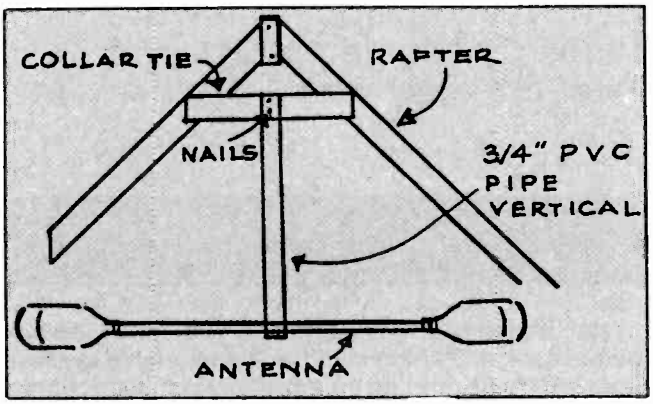
Next, punch a starting hole in the bottom center of each of the coke bottles, using a knife or sharp instrument. Start the #10 metal screws in the end of each bottle.

Capacitance Hat

To fabricate the capacitance hat pieces, cut four 18-inch lengths of the #8 wire and form each to loop around the #10 screws. Flatten the #8 wire slightly at the loop, using a hammer. This will help mechanically when attaching the two wires to each bottle end, forming the cross of the capacitance hat. (See illustration)

Now place the 5½-foot length of PVC in the center hole of an 18-inch wooden wire reel to hold it vertical, and secure the antenna to the top, using a cross wrap of nylon strapping tape.





If you are going to use the antenna indoors and in a horizontal position, the nylon tape is suitable.

However, if you wish to go from horizontal to vertical polarization, a hole drilled for a ¼-inch × 3-inch stove bolt and wing nut should be made at the center mark of the antenna, and near the top of the vertical mast.

If you do not have a wooden wire reel handy to use as a stand for the vertical PVC, a large diameter plastic bucket with a lid will work just as well. Fill the bucket with dry sand to add stability.

In fact, any non-metallic material can be used as a stand for the vertical mast. If the installation is made in an attic, you can suspend the vertical PVC from the ridge pole, collar tie or rafter. Two small holes drilled near the end of the PVC pipe and two nails will do the trick. (See illustration)

Tuning

Once you have your antenna finished attach a 20-foot length of RG/58 coax as a feed line from your CB. Do not use less than 20 feet. Attach the coax to the free ends of the center, helically-wound 18-gauge wire, with two 6-32 screws and nuts. (See illustration)

Attach the shield of the coax to one side and the center conductor to the other side. Here again I used a piece of nylon strapping tape to support the coax to the vertical mast.

It is absolutely necessary that the antenna be placed away from any metal. Metal objects will increase the capacitance and make a low SWR (Standing Wave Ratio) impossible to achieve. and SWR reading at this point should show as SWR in excess of 1:3. If you have fabricated the capacitance hat correctly, each should now be near 16½ inches overall.

Tune your CB set to channel 19, 20 or 21. Two people can make tuning the antenna a little easier. One can key the microphone and take the SWR reading, while the second person trims the antenna. However, a strict procedure must be followed.

The individual doing the trimming must step completely away from the antenna while an SWR

(Continued on page 95)

PARTS LIST FOR COKE-BOTTLE ANTENNA

Two 2-liter Coke bottles (empty!)
One 10-foot. length ¾-inch PVC plastic water pipe 18-gauge insulated hookup wire
Two-part epoxy (just a little bit is needed)
Old broom stick handle
Two pieces of heavy copper or aluminum wire, about 18-inches each
Nylon strapping tape (non-metallic; don't use duct tape)
Two 10 × ¾ inch metal screws
Two 6-32 screws, ½-inch long, w/nuts

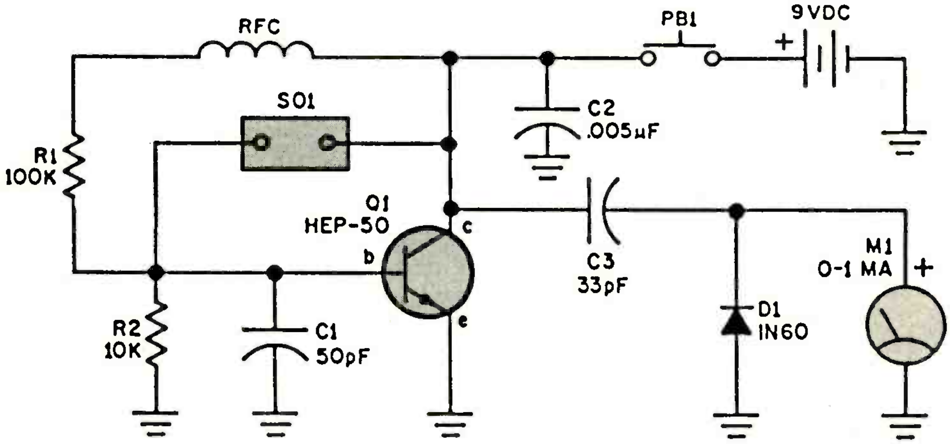
CIRCUIT FRAGMENTS

As this title suggests, these projects can be added to other circuits or devices to expand their use. They are simpler than those in the other two sections (Workbench Projects and IC Testbench) in this issue. They use only one or two diodes or transistors, while the projects in the other two sections use multiple integrated circuits (ICs) and/or Transistors. Most projects in this section such as Slide Show Stopper and Photo Print Meter also increase your enjoyment of other hobbies such as photography. They are good if you're just becoming involved with electronics and want to get your feet wet the easy way.

CRYSTAL CHECKER

A fast way to see if the crystal from your transmitter or receiver is properly "active" is to compare its output against that of a known good crystal. This crystal checker will handle both fundamental and overtone type crystals. Socket SO1 must match the pins on your crystals. If you use more than one type of crystal, install two (or more) sockets in parallel. The unit can be assembled in any type of cabinet.

To test a crystal's activity, first plug in a known good crystal, depress push button switch PB1 and note the meter reading. Then install the questionable crystal, press PB1 and note its meter reading; if it's good its output will approximate that of the reference crystal. Take care that you don't compare apples with oranges; the reference crystal must be the same type as the crystal to be tested. If good crystals drive the meter off scale, install a 1000-ohm, ½-watt, 10 percent resistor in series with meter M1.



PARTS LIST FOR CRYSTAL CHECKER

B1—9-volt transistor radio battery
C1—50-pF capacitor, 100VDC
C2—0.005-uF capacitor, 25VDC
C3—33-pF capacitor, 100 VDC
D1—Diode, 1N60
M1—Meter, 0-1 mA DC
PB1—Normally open switch
Q1—NPN transistor, HEP-50 (Radio Shack 276-2009)
R1—100,000-ohm resistor
R2—10,000-ohm resistor
RFC—2.5-mH RF choke
SO1—Socket to match crystal

PHOTO PRINT METER

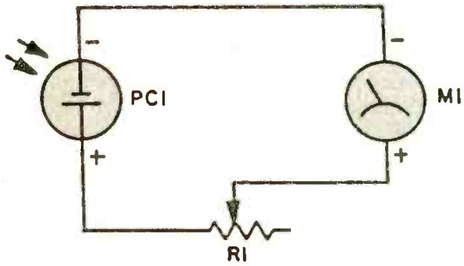
Every print a good one! That's what you get with the photo print meter.

Meter M1 can be just about anything up to 0-1 DC mA. But if you prefer low light levels and long exposures, install a meter of 500 uA or less.

When light from the enlarger falls on the solar cell (PC1), a voltage is generated that is in proportion to the amount of light. Sensitivity control R1 allows you to set the meter indication to a convenient value.

To use the meter, first make a good normal print in your normal manner from a medium-contrast negative. Then, do not disturb the enlarger setting, but integrate the light by placing a diffusing disc or opal glass under the lens. Place the solar cell on the easel and adjust R1 for a convenient meter reading, say, full scale. The meter is now calibrated.

When using it, focus the enlarger, use the diffuser, and adjust the lens diaphragm until you get the reference meter reading. Then use the exposure time previously found for the calibration print. Suggested reading: Ilford Manual of Photography, obtainable from any photo store. Also, check Kodak publications available at the same place.



PARTS LIST FOR PHOTO PRINT METER

M1—100, 250, or 500-uA DC meter
PC1—Solar cell (Calectro J4-801)
R1—5000-ohm potentiometer linear taper

CB SCOPE MONITOR

Any scope from the cheapest to most expensive, with provisions for direct connections to the vertical CRT plates, can be used for direct observation of the modulated RF waveform of a CB transmitter; not just the modulation itself, but the actual RF output at 27 MHz.

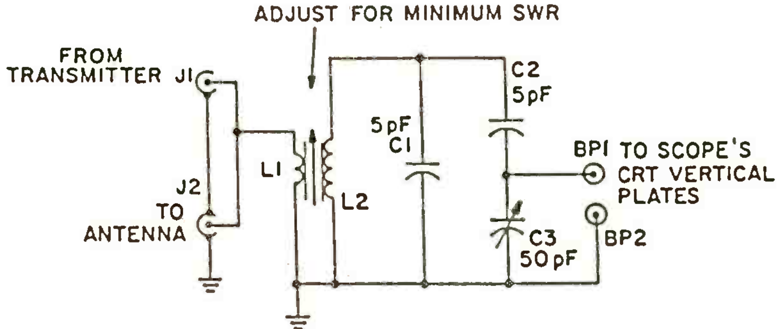
Taking virtually no energy from the CB rig's output signal, this scope monitor adaptor continuously samples the RF fed to the antenna system, providing a *real-time* monitor of what's being received on the other end of the two way communications circuit.

The adaptor must be assembled in a metal cabinet. J1 and J2 UHF coaxial jacks spaced as close together as possible.

L2 is wound first, in the center of a ⅜-inch, slug-tuned coil form. Then L1 is wound adjacent to the "ground" end of L2. Install the L1/L2 assembly so the tuning slug protrudes through the cabinet.

To use the adaptor, set your scope for direct vertical plate connection, and connect the plate jacks to binding posts BP1 and BP2. Connect an SWR meter between your CB transmitter and the adaptor, and then connect the adaptor to the transmission line. Key the transmitter and adjust L1/L2 for minimun SWR. (It should read as low as without the adaptor.) Adjust C3 for the desired trace size on the CRT. There is some C3/coil interaction, so it will probably be necessary to readjust L1/L2 for minimum SWR each time you adjust C3.

(Note: The adaptor must connect to the scope's vertical plate connection(s). The 27 MHZ RF can't pass through a scope's vertical amplifier unless it happens to be a lab-grade RF scope.)



PARTS LIST FOR CB SCOPE MONITOR

BP1, BP2—insulated 5-way binding posts
C1, C2—5-pF silver mica capacitor
C3—5-pF trimmer capacitor
J1, J2—PL-259 UHF coaxial jacks
L1—3 turns of #22 solid, plastic-insulated wire, see text
L2—4 turns of #18 enameled wire, see text
Misc.—⅜-inch RF slug-tuned coil form (Miller #4400-2)

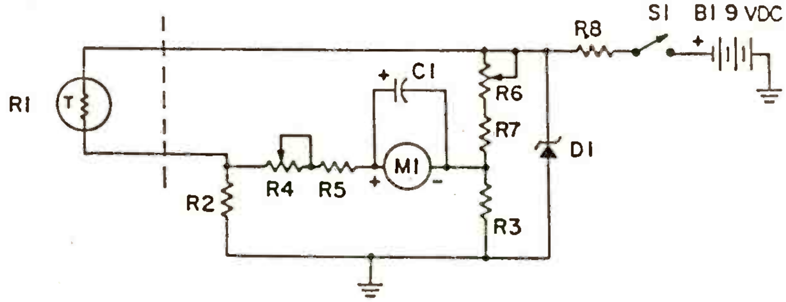
LONG—DISTANCE THERMOMETER

With this electronic thermometer you can be sitting by a nice, cozy fire and reading the temperature outdoors, however frigid it may be, without ever catching a chill yourself. The circuit is a simple one based on a readily available Fenwal thermistor (Burstein-Aplebee, among others, sell them). For the sake of accuracy, only thermistor R1 should be exposed to temperature extremes, the rest of the components should be kept indoors in an environment where the temperature is reasonably constant.

To calibrate, you'll need a thermometer of known accuracy, and access to temperatures near 0° and 100° F, the lower and upper limits respectively of this thermometer's range. Set R4 and R6 to their midpoints. Subject R1 to the hot temperature and adjust R4 until M1 reads the correct temperature. Now subject R1 to the cold temperature and adjust R6 to get the right reading on M1. Because the two adjustments interact, repeat the entire procedure two more times.

PARTS LIST FOR LONG—DISTANCE THERMOMETER

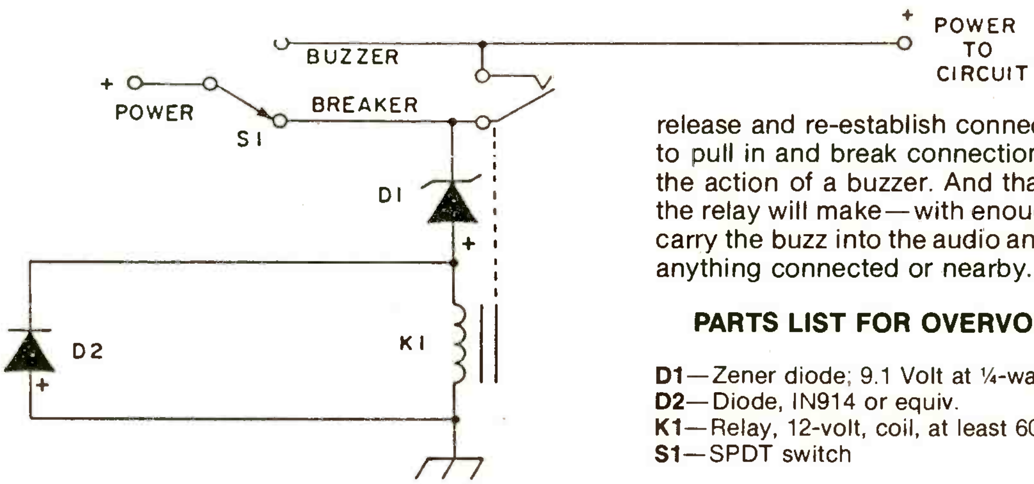
B1—9-volt transistor battery
C1—50-uF, 16-VDC capacitor
D1—1N746A, 3.3-volt, ½-watt zener diode
M1—0 to 100 microamp DC ammeter
R1—thermistor rated 1,000-ohms @ 25° C (Fenwall part # JB31J1)
R2, R3—1,800-ohms
R4—10,000-ohm trimmer potentiometer
R5—12,000-ohms
R6—5,000-ohm trimmer potentiometer
R7—3,900-ohms
R8—820-ohms
S1—SPST toggle switch
Note: All resistors 5% tolerance.



OVERVOLTAGE ALARM

Too high a voltage can damage any number of electronic components. Many other components can withstand high voltages, but only for a limited time. This circuit provides either protection against too much voltage in much the same way a circuit breaker protects against too much current, or a warning that an overvoltage condition is occurring.

In the Breaker position, power is applied to the protected circuit only so long as relay K1 is not energized. K1 *will* energize whenever the input voltage exceeds the Zener voltage of diode D1, because above its zener voltage, a reverse-biased Zener diode like this one will conduct. In the *Buzzer* position, power remains applied to the circuit through the relay itself. When an overvoltage is present, the relay pulls in, disconnecting itself, which allows it to release and re-establish connection, which causes it to pull in and break connection and so on—exactly the action of a buzzer. And that's exactly the sound the relay will make—with enough noise generated to carry the buzz into the audio and IF circuits of almost anything connected or nearby.



PARTS LIST FOR OVERVOLTAGE ALARM

D1—Zener diode; 9.1 Volt at ¼-watt
D2—Diode, IN914 or equiv.
K1—Relay, 12-volt, coil, at least 600-ohm
S1—SPDT switch

EASY-READ VOM ADAPTER

Ever notice how confusing it is to read the OHMS scales on your multimeter? The numbers are so crowded together at the high end that meaningful readings are almost impossible to make. Top-of-the-line meters get around the problem by employing a constant-current source, and so can you with this adapter. You'll be able to read resistances accurately and unambiguously on the *linear* voltage scales of your meter.

In the schematic, note that the resistor under test is tied between BP1 and BP2. Whenever S2 is pressed, a regulated current flows out of Q1's collector and through the resistor. By Ohm's Law, this current generates a voltage across the resistor that's directly proportional to its resistance. Any one of five test currents—from 10-mA to 0.001mA—can be selected via S1.

To calibrate the test currents, hitch a multimeter to the adapter's output terminals; make sure the meter is set to measure current. Press S2 and adjust the trimmers one at a time to obtain the five required currents. No resistor should be connected to BP1 and BP2 during calibration.

When measuring resistance, use the following conversion formula:

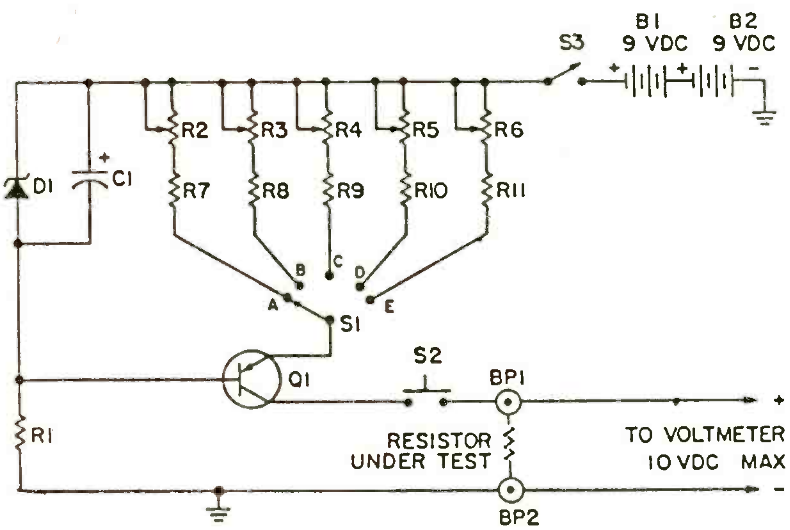
$$\text{RESISTANCE (kilOhms)} = \frac{\text{VOLTAGE}}{\text{CURRENT (mA)}}$$

For example, a resistor that produces a 7.56-volt reading when fed a current of 0.01-mA must have a resistance of 756-kilOhms (756K). Use smaller currents with larger resistances, and don't exceed a level of 10-volts during testing. If you do, switch S1 to the next smaller current. Finally, for best accuracy, make sure that the input resistance of your meter is much greater than that of the resistor under test. With a 10-megOhm meter, the resistor under test must be no larger than 1-megOhm to keep errors under 10%.

PARTS LIST FOR EASY-READ VOM ADAPTER

B1, B2—9-volt transistor battery
BP1, BP2—binding posts
C1—10-uF, 20-VDC capacitor
D1—1N748A, 3.9-volt, ½-watt zener diode
Q1—2N3676 PNP transistor
Note: All 5%
R1—2,200-ohms
R2—100-ohm trimmer potentiometer
R3—1,000-ohm trimmer potentiometer
R4—10,000-ohm trimmer potentiometer
R5—100,000-ohm trimmer potentiometer
R6—1,000,000-ohm trimmer potentiometer
R7—270-ohms
R8—2,700-ohms
R9—27,000-ohms
R10—270,000-ohms
R11—2,700,000-ohms
S1—single pole, 5-position rotary switch
S2—normally open SPST pushbutton switch
S3—SPST toggle switch

RANGE	CURRENT
A	10mA
B	1 mA
C	0.1mA
D	0.01mA
E	0.001mA



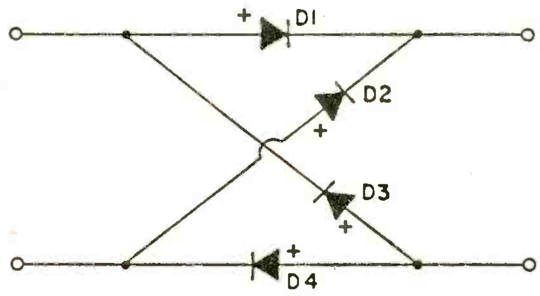
WRONG-WAY BATTERY PROTECTOR

Want to ruin an expensive piece of solid state equipment? Just hook the battery or supply up backwards. But by adding these four diodes to your equipment, you can say goodbye to backwards forever. This diode arrangement is one you may recognize as a full wave bridge. In power supplies, it's used to rectify both halves of the AC waveform.

Here, it makes sure that no matter which way you connect the battery, the positive and negative supply terminals in your equipment get the right polarity voltage. Remember, since the forward bias of two diodes are introduced, your equipment will be getting about a volt less than your battery is delivering. And remember, choose your diodes so they're rated for all the current your circuit will draw.

PARTS LIST FOR WRONG-WAY BATTERY PROTECTOR

D1, D2, D3, D4—Diode, 1N914 or equiv.



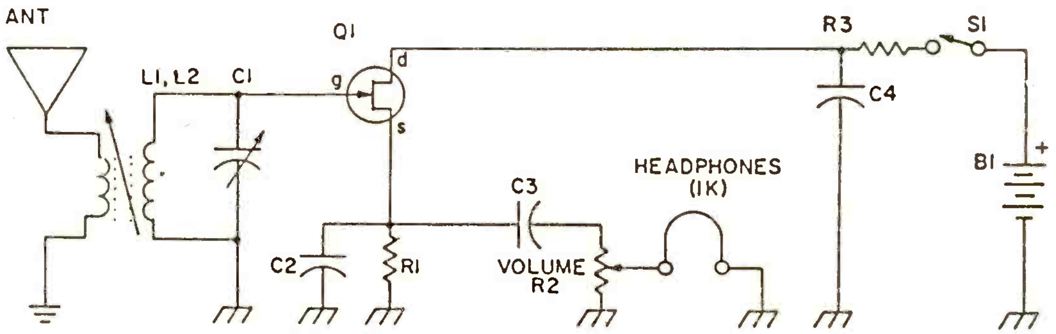
HIGH PERFORMANCE "CRYSTAL" SET

Here's a neat way to update your crystal set, assuming you can still find it. Or use these few inexpensive parts to build from scratch. Instead of using a cat's whisker or a diode, this radio uses the very sensitive junction of a junction FET as its detector. This makes it a very "hot," very sensitive high impedance detector. And the JFET does double duty by converting the high input impedance to a lower output impedance—low enough and with enough drive to power a set of high impedance headphones or a high impedance earphone (about 1K or so), or a stereo system.

The antenna coil is one of those simple loopsticks you've seen at the parts stores. (Or you, might want to wind your own on an oatmeal box.) The broadcast variable capacitor is one of the tuning capacitors taken from and old, defunct radio. You can use any long wire for the antenna, but if you string it outdoors, be sure to use a lightning arrestor. You can also clip an alligator clip to your bed spring, a windowscreen, or anything similar.

PARTS LIST FOR HIGH PERFORMANCE CRYSTAL SET

B1—6-15 VDC battery
C1—356-pF variable capacitor
C2—300-600-pF capacitor
C3—0.5-5uF capacitor
C4—.22-1.0-uF capacitor
L1/L2—Ferrite loopstick
Q1—N channel JFET 2N-5458, MPF102 or equiv.
R1—18,000-47,000-ohm resistor
R2—20,000-100,0000-ohm potentiometer
R3—4700-10,000-ohm resistor



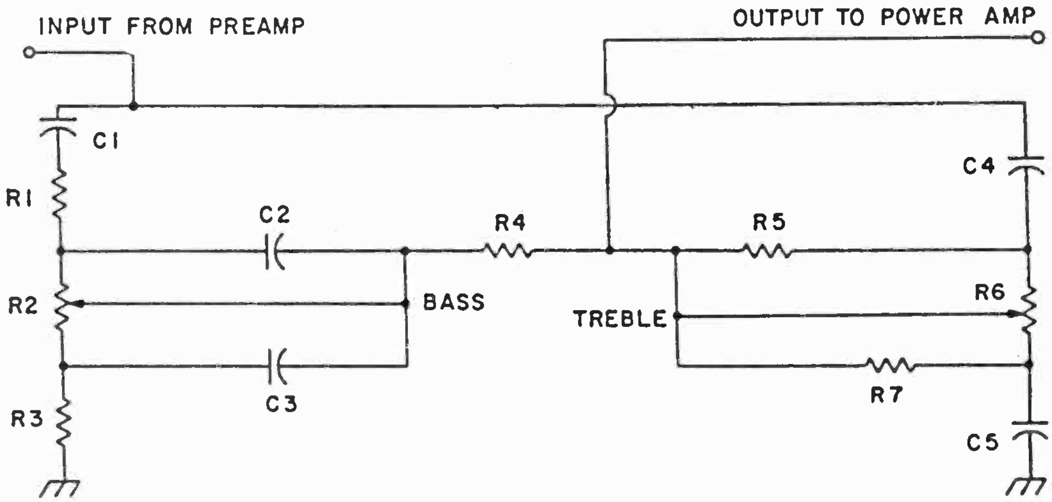
BASS AND TREBLE TONE CONTROLS

Since there are no active devices in this circuit (transistors or ICs) it can provide no amplification on its own to offset the lossy characteristic of these networks. Fortunately, most audio systems have more than enough oomph to accommodate this network loss.

Once you have learned by experimenting with the effects of various component values, just how you can alter the characteristics of these networks, you may want to construct your own graphic equalizer. Just include more stages similar to the two basic types of filters you see here: R1, R2, R3, R4, C1, C2 and C3 form one of the filters, the rest of the components the other. Just remember, the more stages of passive filtering you add, the more loss you introduce into your system. For that reason, most commercial graphic equalizers include built-in amplifiers. And, of course, you will have to duplicate your filter(s) for each channel if you're working in two or more tracks.

PARTS LIST FOR BASS & TREBLE TONE CONTROLS

C1, C5—.068-2-uF capacitors
C2—.033-.068-uF capacitor
C3—.33-.68-uF capacitor
C4—.055-.02-uF capacitor
R1, R4, R5—1500-ohm resistors
R2, R6—50,000-200,000-ohm potentiometer
R3, R7—820-1500-ohm resistors



SLIDE SHOW STOPPER

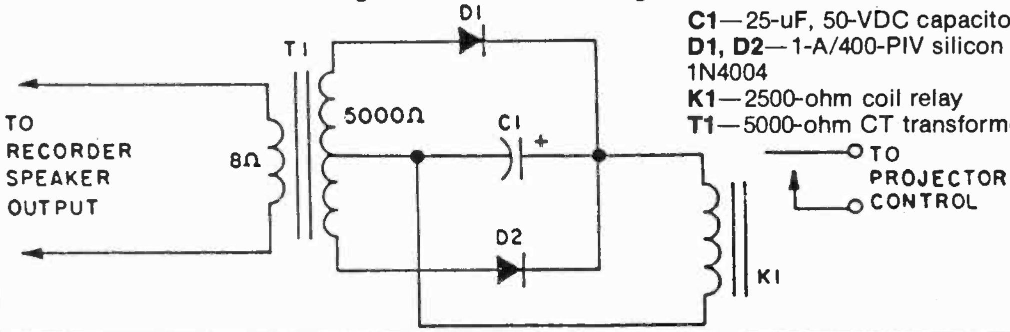
Soundless slide shows are dull, dull, dull! But a stereo recorder can automate the whole show so slides change automatically in step with the commentary.

Record your commentary on the left track. At the instant you want slides to change, record a one-second noise or tone burst on the right track. Connect the programmer between the recorder's right speaker output and the projector's remote control cable. Make a test run to determine the right-track volume setting to make noise or tone bursts activate relay K1. No fancy tone generators needed here. Just give a hearty Bronx cheer into the mike of the left channel only!

Then start the tape from the beginning. The audience will hear your commentary or spectacular music-and-sound reproduction through a speaker connected to the recorder's left channel, while the signal on the right channel automatically changes the slides.

PARTS LIST FOR SLIDE SHOW STOPPER

C1—25-uF, 50-VDC capacitor
D1, D2—1-A/400-PIV silicon rectifier, Motorola 1N4004
K1—2500-ohm coil relay
T1—5000-ohm CT transformer to voice coil



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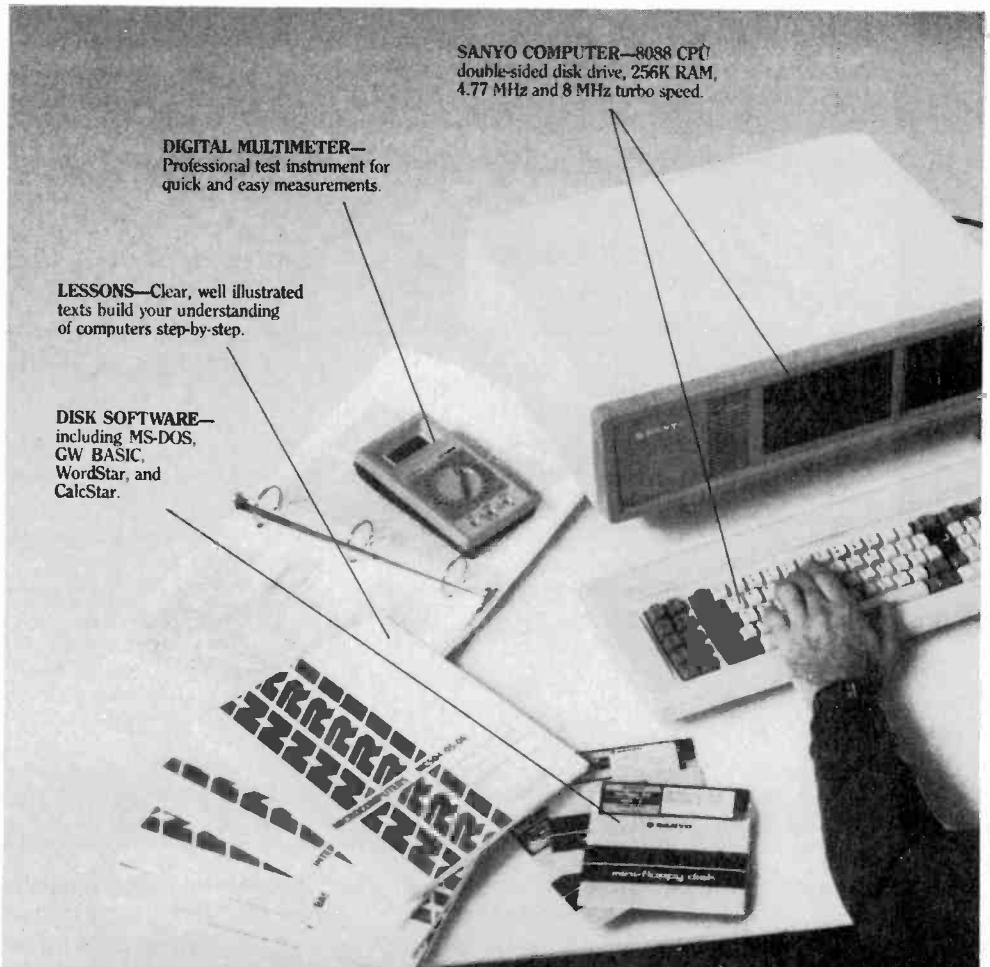

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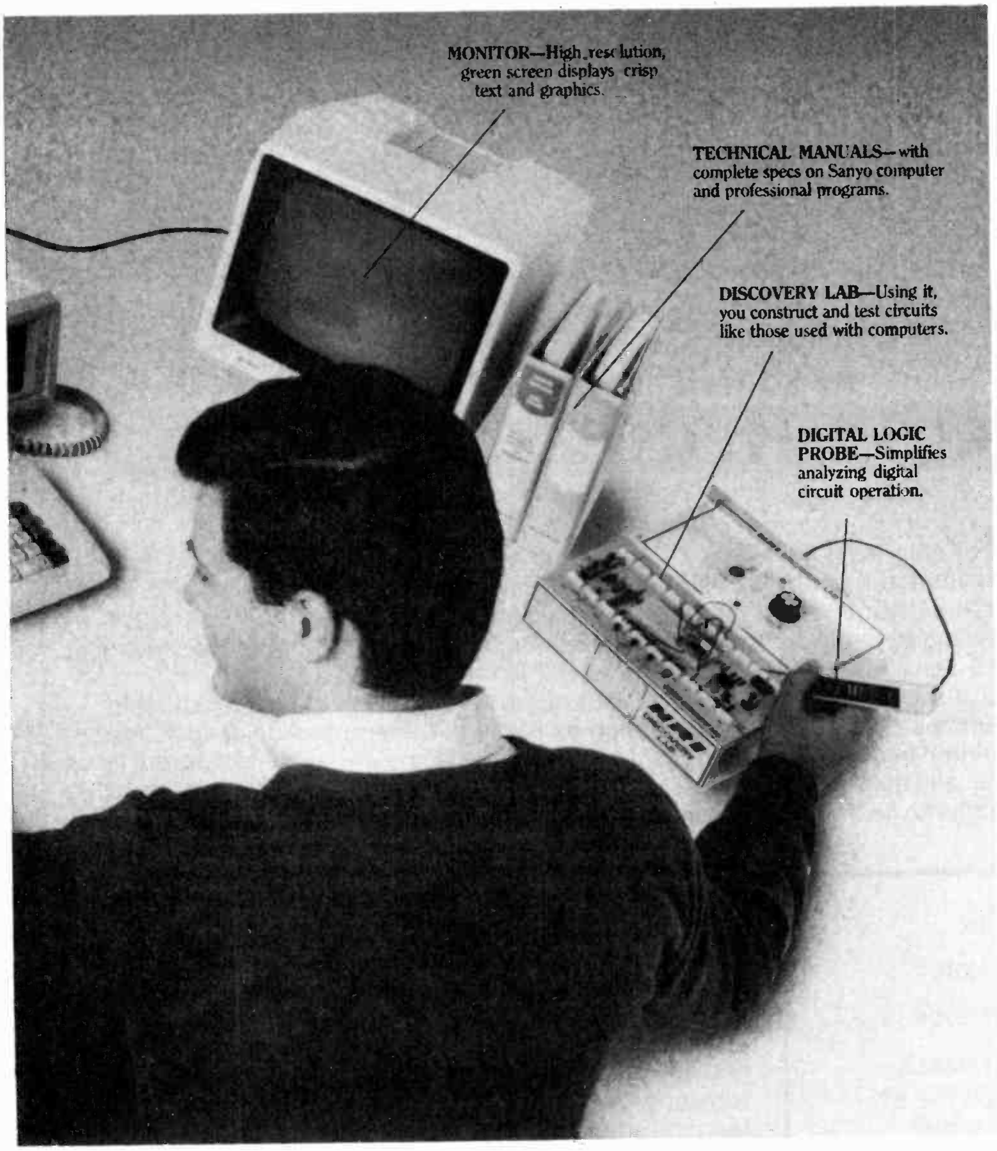

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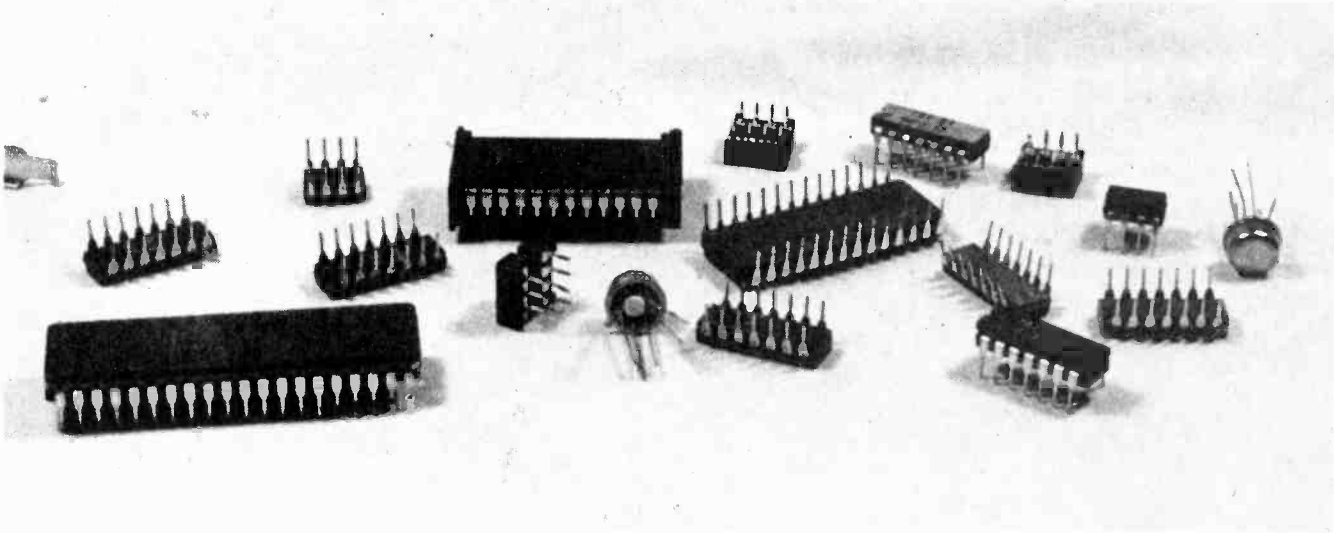


by Ed Noll

THE 4017 IC COUNTER

The 4017 is a quite different sort of chip from the 555 timer and the 4049 divider/inverter chip, described in our previous Chip-By-Chip column and an interesting one because it can be made to divide by any number between two and ten. Alternate connections permit it to operate as a *sequencer* as well and, in association with an accurate clock, it can be made to do precise timing of either periodic or non-periodic events. The 4017 will be used quite often in our chip-by-chip circuits. In this column its *divider* capabilities are demonstrated.

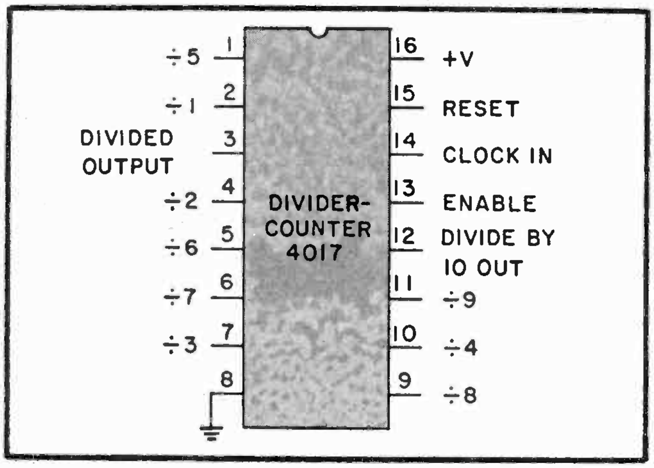


Figure 1. 4017 divider pin-out connections

Parts are inexpensive and readily available as shown in the parts list. If you missed the first column of Chip-by-Chip (previous issue), a copy can be purchased by writing to the publisher. It contained the first column of our Chip-By-Chip series and described the objectives of this column as well as detailed construction information about the clock and inverter that are important to most of the "chip" columns that will follow.

The pin-out of the 4017 is given in Fig. 1. Note that for operation as a *divide-by-ten* (decade divider) the clock *input* is pin 14, while the divide-by-ten *output* is taken at pin 12. Division by other than 10 requires a different wiring plan, which will be detailed as we go along.

The democircuit wiring plan for operation as a decade divider is presented in Fig. 2. Note that the 555 clock output is applied to pin 14 of the counter. Divide-by-ten output is removed at pin 12 and is applied to pins 3 and 5 of the 4049 inverter which was discussed in our previous column. The 555 clock component values are the same as those used in the first set-up demonstrated at that time. Recall that the turn-ons and turn-offs between LEDs was moderately fast and that the clock logic 0 output was shorter in duration than its logic 1 output.

Wiring is shown in Fig. 3. Observe that the 4049 has been moved down and the 4017 placed in the center to permit more direct and convenient wiring. The schematic drawing and the chip wiring are quite similar so you can gain useful experience using a solderless board and jumpers. After this column, I will leave you more on your own. Planning an effective layout is part of the satisfaction you obtain setting up demonstration circuits.

Wire the 4017 into the board and position the 4049 beneath it. Check and double check your wiring. It is easy to miss a connection or make a wrong one. This

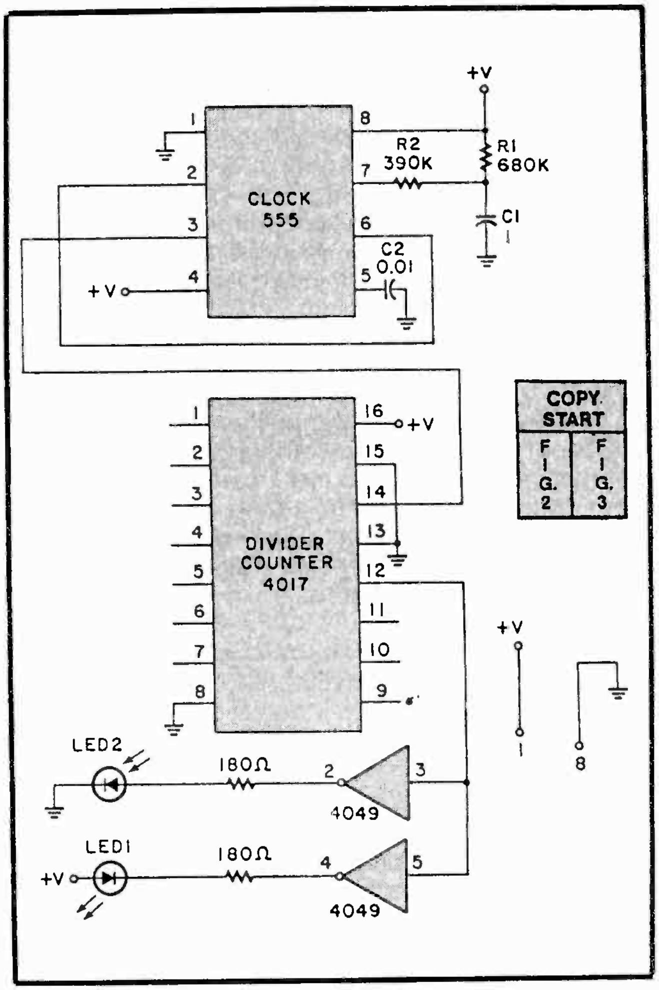


Figure 2. Clock and basic decade divider circuit

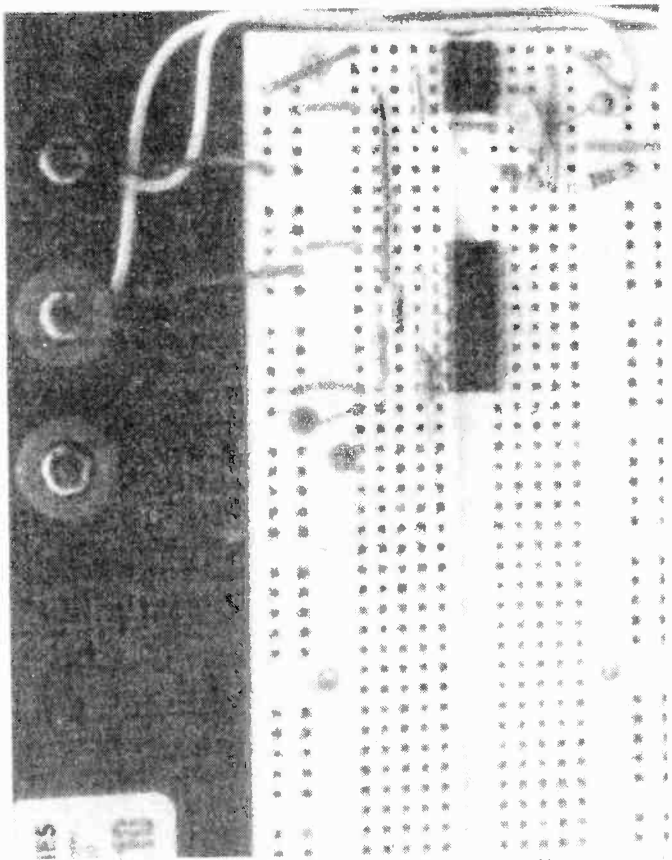


Figure 3. 4017 decade counter wired in circuit between clock and inverter.

will be my last warning but always keep it in mind.

Apply power. Observe the slower switchover between LEDs. The clock frequency is being divided by 10. Note in particular that each of the LEDs are on for the same duration. Stated another way, the 4017 decade output is a true square wave, with a frequency that is one tenth the clock frequency. If you like you can check the operation using one or more of the other timing capacitors for the 555 clock.

The counter is advanced (triggered) by the first positive leading edge of the clock. And it is recycled again by the tenth positive leading edge. In this manner the counter is synchronized by every tenth positive leading edge of the clock. All of this can be better demonstrated with the waveform drawing of Fig. 4. At the very top left of the 555 clock output notice the initial positive leading edge representing time zero. It is this leading edge that initiates the leading edge of the 4017 decade output as shown. The clock output itself goes through ten complete cycles before it reaches the time 10 positive leading edge, which again initiates the positive leading edge of the next decade period. Thus the decade output goes through one complete square-wave cycle for each ten periods of the clock output. In effect the clock output itself must not be a square wave in order make the 4017 generate a square-wave output. In fact

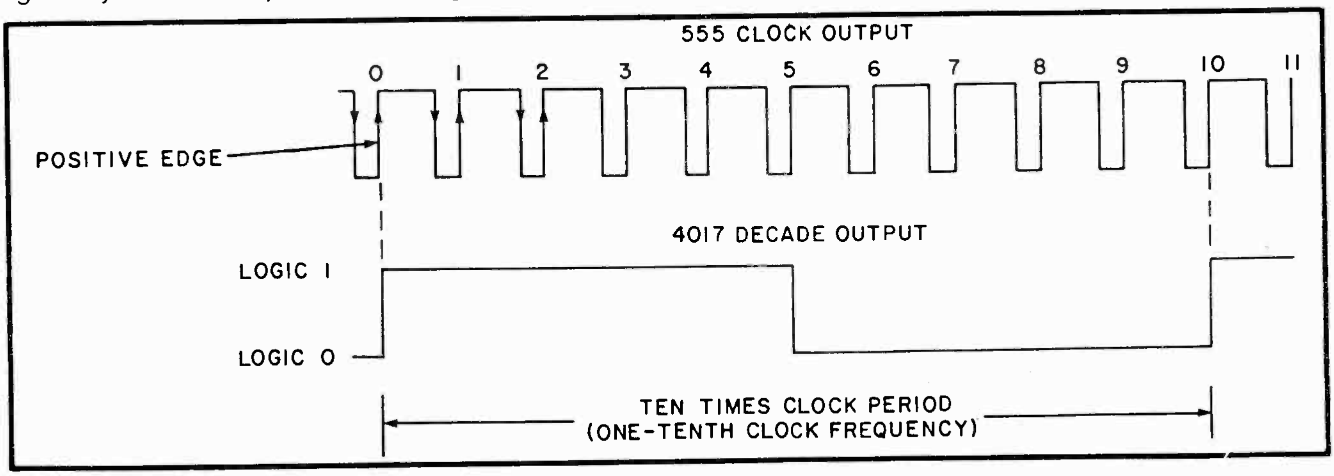


Figure 4. Comparison of clock output and 4017 decade output.

the clock output could be simply a very short duration positive spike to operate the decade counter. Note again that for both waveforms there is strictly a two-level output, the activity switching quickly between logic 0 and back to logic 1 and so on. All digital circuits produce the same two-level output. Very much like a switch but capable of switching many, many times faster.

Use a watch with a second hand to determine just how long each one of the LEDs are turned on. For the components used because of the parts tolerance, the time will be between 4 and 5 seconds. Convert the 4017 for divide-by-five operation using the circuit of Fig. 5 Wire the circuit as shown. Note that reset pin 15 connects to pin 1 to obtain divide-by-five operation. You may wish to make the lead you connect to pin 15 a bit longer so you can obtain other divisions if you desire. For example connecting pin 15 to pin 9 will give you divide-by-eight operation and, connected to pin 7 divide-by-three operation. Refer back to Fig. 1 to show you the various counts that can be obtained by connecting pin 15 to the appropriate pin. As in the decade counter arrangement the clock output is applied to pin 14. This time however no connection is made to pin 12 and the output for any other count is derived from pin 3.

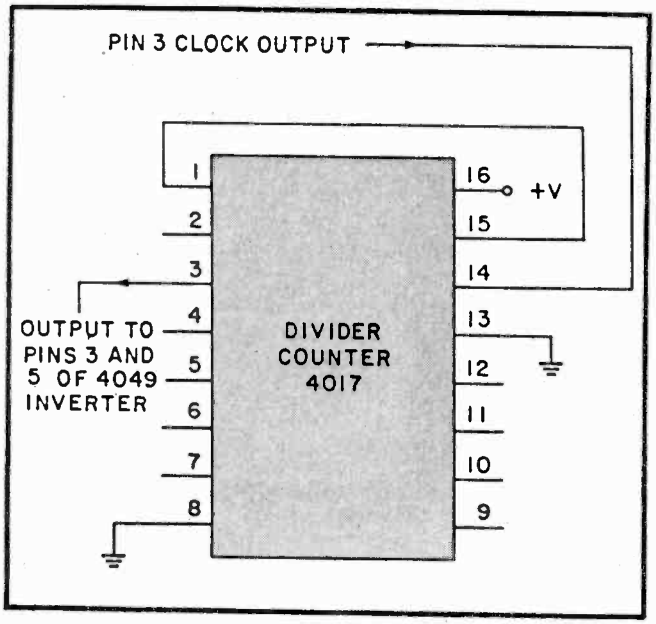


Figure 5. Operation of 4017 as a divide-by-five counter.

Connect your circuit and observe the LED operation. In this mode of operation a perfect square wave is not obtained. However by timing the *on* periods of the two LEDs in sequence you will notice that it is approximately half of the time period of the previous decade connection. In this case the period of the output wave is five times the period of the clock and the frequency is one-fifth of the clock frequency.

You may wish now to connect pin 15 to pin 4. In this mode of operation the output will be half-clock frequency and twice the clock period. You may wish to try other divisions simply by connecting pin 15 to the appropriate terminal. The 4017 is indeed an interesting chip and more applications will be explored in future columns. ■

PARTS LIST

Integrated Circuits:—Radio Shack
- 555 Timer
- 4049 Inverter
- 4017 Divider-Counter

6-Volt Lantern Battery—Everready 731 or 5-VDC power supply (well-filtered, for digital circuits)

2 LEDs— Radio Shack

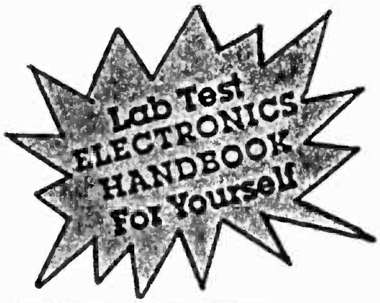
Capacitors—Radio Shack
- 0.01 uFD
- 0.1 uFD
- 1.0 uFD
- 10 uFD

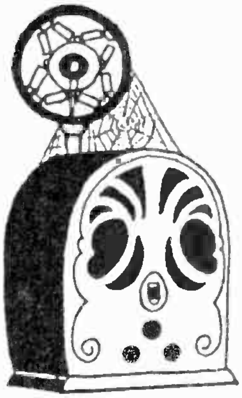
Resistors—Radio Shack
- 180 ohms (two)
- 390 Kohms
- 680 Kohms
- 2.2 Megohms

Solderless circuit board—Radio Shack or Global (see below)

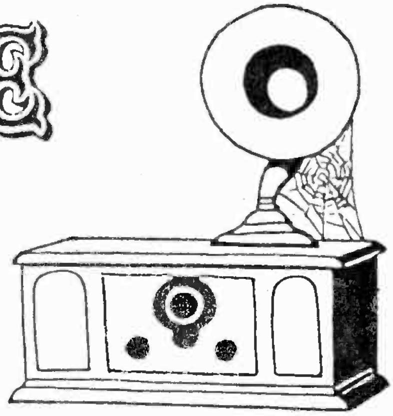
Wire jumpers—(assortment) Global, or make your own

If no Radio Shack store is near you write to Global Specialties, P.O. Box 1405 New Haven, CT 06505





ANTIQUE RADIO



REPLACING HARD-TO-FIND TUBES

Many collectors of antique radios and phonographs just collect them for their looks, fixing up the cabinet, grille cloth and knobs, but they don't bother making them work. This seems like cheating, kind of. We think much of the fun of collecting old radios and phonographs is in getting them to work just as in the early days. Therefore, in this and in future *Antique Radio* columns we'll deal with methods for restoring those marvellous old sets to full operating condition, working like new.

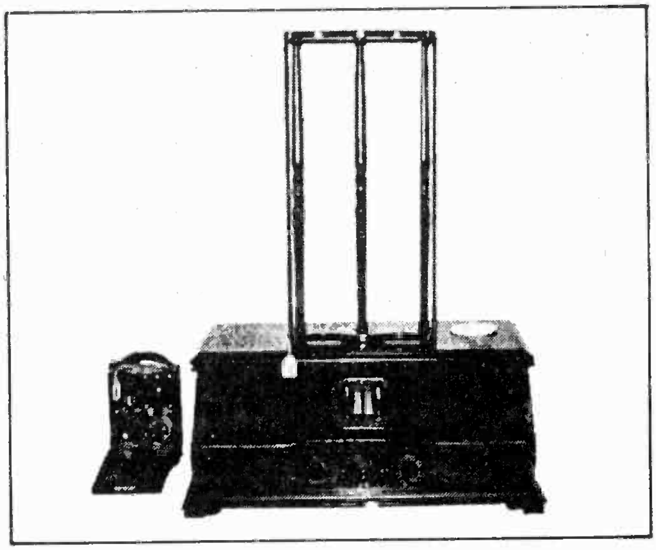
There are many tubes still available for radios of the Thirties, and they pose little problem with sets that use them. However, there are some sets that use types more difficult to find. What to do with radios that use the WD11, WX12, UX199, 201A, etc, is becoming a major problem to collectors. Some collectors have decided to wire transistors underneath the tube sockets and leave dummy tubes in the sockets. Now that may be fine for the collector who doesn't care about retaining the integrity of an old radio. I am opposed to this practice as is every other serious minded collector who is trying to preserve his old radios for posterity.

Some Good Tube Substitutions

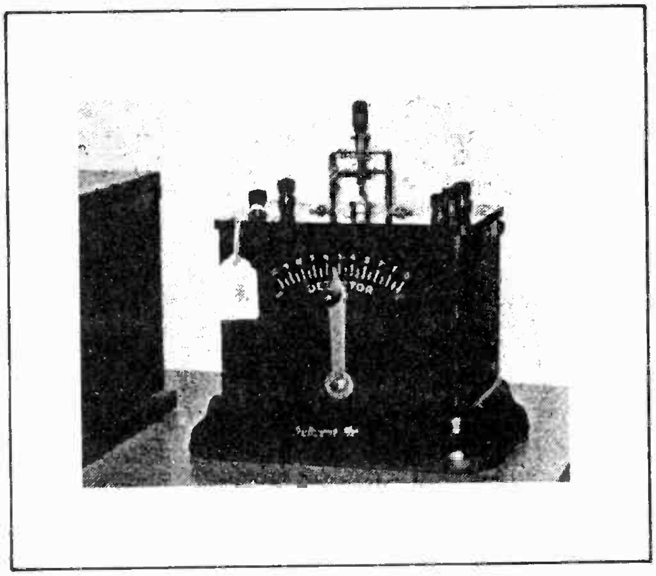
We will deal with several methods of providing substitute tubes to make some of the older radios (1920-1924) operate in their original way. That is to say I won't suggest changing tube sockets or mutilating the radio in any way, but will tell you how to alter tube bases or suggest tubes that can be plugged in and give results equal to the original set of tubes.

To begin our discussion an easy conversion is to use a type 40 in place of a 200A or 201A. There are a few differences in the characteristic of the 40 and 201A. These aren't serious to the collector, but I would not recommend using the 40 in the last audio stage to drive a speaker. The 40 requires 5 VDC at .25 amps, just as the 201 A does. The amplification factor of the 40 tube is 30, while the 201A's is 8. The plate current of the 40 is .2 mA while the 201A draws 3 mA. The 40 will tolerate a higher plate voltage because its plate resistance is higher.

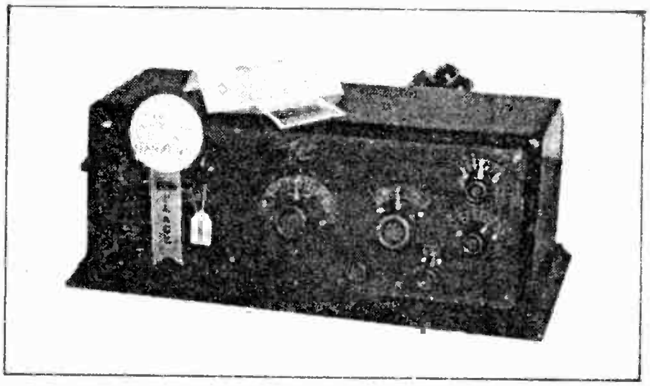
Another substitution is the type 112A or 71A in place of the 201A in the audio output stage of a 5-tube battery radio. Since the 71A was used in many of the early AC receivers there seems to be a good supply



This Radiola model 25 had its own antenna, which could be rotated for best reception (broadside to the station). Courtesy of Lionel Hald, of Richmond, Indiana.



A rare Federal Junior crystal set, in the display of Indiana Historical Radio Society, Auburn, Indiana. Note the adjusting handle for the crystal, under the catswhisker, atop the set.



Zenith Model 3R receiver has three dials to adjust for best reception. A real winner in historial radio!

available. Usually a C-bias battery is recommended when using the 112A. or 71A.

Of course we shouldn't forget the type 30 tube which is a 2 VDC filament triode. If you want to replace all the 201As in a set and have a 3-volt battery to supply the filaments you can plug in type 30s and get good results. Just be sure the radio has the right sockets to accept the 30. You can also replace the WX12, and UX199 with a type 30 if you use the proper filament voltage.

Some Tougher Tube Substitutions

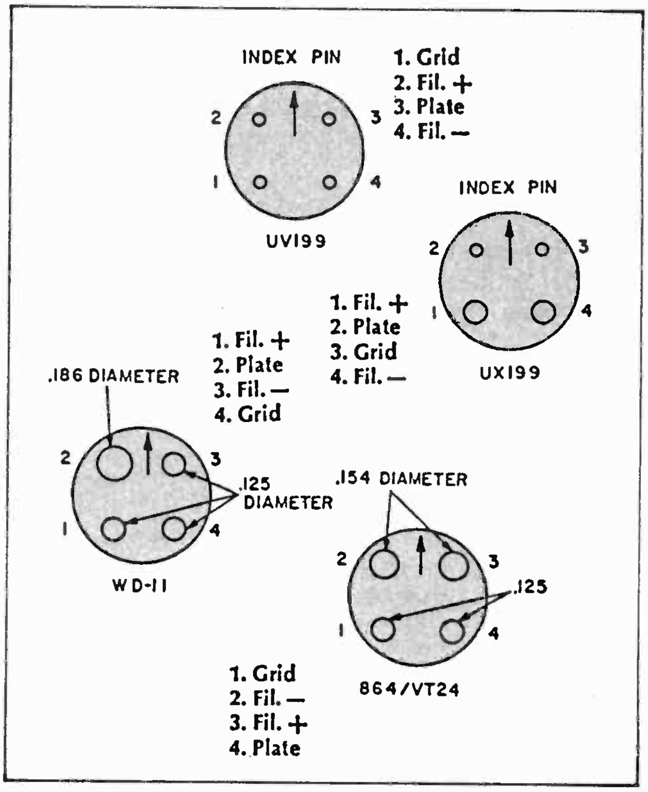
Now that we have discussed the simple plug-in replacements let's get to the more difficult UV199 for the UX199. The UV199 has a different base pin arrangement from the UX199, which has the normal pin size and location. The tube pins are small nubs that only extend about ⅛ inch from the tube base and the filament pins are 180 degrees apart rather than side by side. Here's a sketch of the tube pins as viewed from the bottom of the tube. Note that the UX199 has two larger diameter filament pins which makes it difficult to insert it improperly into the socket. Back in the 20s adapters were made so you could use a UV199 in the UX199 socket, or even use it in place of a WX12 or 201A. The 99s required only 3.0 to 3.3 volts DC on the filament which meant that you could use 2 No. 6 dry cells in series for the filament supply. In remote areas this was more convenient than using a storage battery that had to be recharged every few weeks. You can make an adapter by mounting a socket which will hold the UV199 on top of a 4-pin tube base and wiring the socket lugs to the proper base pins. Likewise you can make an adapter for the UX199 tube to be used in a set intended for 201As. The photo shows one such adapter. A long screw can be used to hold the socket and base together.

The Toughest

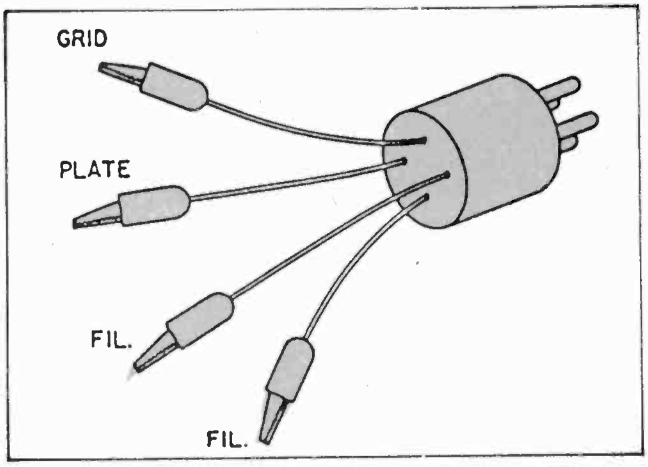
We have saved the most difficult substitution for the last. This is the substitution of an 864/VT24, a type 30, or a 1H4G for a WD11. It is nearly impossible to find a WD11, which many collectors need for the Radiola III, the Balanced Amplifier, Radiola IIIA, and the Radiola Grand as well as other radios sets. Nearly every collector has one of these Radiolas, but very few have working tubes in them. The 864/VT24 is a non-microphonic version of the WD11 developed by the Army Signals Corps, except that it has the small, regular, 4-pin base with two large and two small pins. The large pins are for the 1.1 VDC filament which is the same as the WD11 requires. This makes the 864/VT24 compatible with the WD11 except for the base pin locations. There have been many methods used to adapt the 864 to the WD11 configuration. You can remove the base from a defunct WD11 and by grinding out the base, force an 864 into it. The main trouble with this idea is that you have made the WD11 unfit for use as a non-working display tube. A better way is to leave the WD11 as is and use it for display only. Some collectors have no desire for their sets to play, but only want them to look like new.

The next step is to remove the glass bulb from the base. The wires soldered into the tube pins help hold the base to the bulb plus there is cement holding the base to the bulb. Over the years much of the cement will have dried out and left the base loose on the glass. Put on a pair of leather gloves and grasp the bulb in one hand and the base in your other hand and twist. Some bulbs will come loose this way and others won't. If the bulb doesn't come loose place the tube in the coldest part of your freezer for several hours then remove it and push the base only down into some boiling water. The uneven coefficient of expansion will sometimes break the cement loose. We usually have success this way, but as a last resort you could use a solvent.

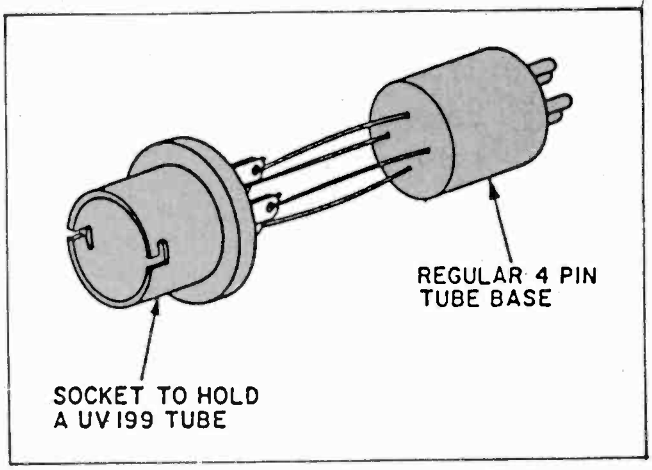
Next take a double-cut file and file away the solder from the ends of the pins. With a soldering iron or gun heat the pin tip and flip the tube to throw the melted solder out of the pin. You should now be able to see the lead wires through the holes in the ends of the pins. When all four wires are unsoldered you will be



Old-time radio tubes followed no standard. The two filament prongs, and those for plate and grid connections are shown in the diagrams above.



Four insulated clips hooked to the prongs of a tube base let you test old tubes in actual circuit.



Here's how to make an adapter to use a UV199 tube in place of the older, harder-to-find UX199.

WHERE CAN YOU GET HELP?

The following firms and people will answer you if you send a large SASE (stamped, self-addressed envelope) telling them what parts, schematics, or other help you need to repair antique radios.

CIRCUIT DIAGRAMS AND/OR LITERATURE

Antique Radio Press, Box 42, Rossville, IN 46065
Byron Ladue, 13 Revere Drive, Rochester, NY 14624
Comtech Electronics, Box 686, Wyandotte, MI 48912
Historical Radio Services, Box 15370, Long Beach, CA 90815
John Scaramella, Box 1, Woonsocket, RI 02895
E.G. Rountree, Box 269 Norris City, IL 62869
Vestal Press, 320 North Jensen St., Vestal, NY 13850
Vintage Radio Books, Box 2045, Palos Verdes, CA 90274

TUBES AND OTHER PARTS

Antique Radio Parts, Box 42, Rossville, IN 46065
Antique Radio Tube Company, 1725 University St., Tempe, AR 85281
Barry Electronics, 512 Broadway, New York, NY 10013
Maurer Television, 29 South Fourth St., Lebanon , PA 17042
Steinmetz ELectronics, 7519 Maplewood Ave., Hammond, IN 46324
Richardson Electronics, 3030 N. River Rd. Franklin Park, IL 60131
John Grey, 3348 Wildridge Road NE, Grand Rapids, MI 49505
George Haymans, Box 468, Gainesville, GA 30501
Historical Radio Services, Box 15370, Long Beach, CA 90815
Unity Electronics, Box 213, Elizabeth, NJ 07026
Puette Electronics, 3008 Abston Drive, Mesquite, TX 75149

SPEAKERS AND/OR TRANSFORMERS

Amprite Speaker Repairs, 655 Sixth Ave, New York, NY 10011
Antique Radio Restorers, Box 42, Rosville, IN 46065
Lloyd V. Williams, Rte 5, Frankfort, IN 46061

able to pull the bulb loose from the base. Whatever you do, don't forget which wires go to the plate, grid, and filaments. You can identify the filament wires with a low-range, low-current ohmmeter, but if you loose the grid and plate wires you will have to look inside the bulb to trace the wires to their respective tube elements. The 864 will have two grid leads inserted into one pin. You will find the lead wires are an alloy that bonds readily to glass, but is difficult to solder to. Tin the leads for at least a half inch when you reassemble the bulb to the base. You may need to polish the leads with sandpaper and use a flux when tinning the leads.

Preferred Method

The best way to do it is to remove the glass bulb from the base (either the 864/VT24, type 30, or the newer 1H4G), remove the two larger pins from the base, make a new larger (plate) and stake it in the proper position along with a new small pin for the other filament lead. Now this isn't at all difficult if you have patience, and are reasonably handy with tools, and have a source for the pins needed.

The first thing you must do is to obtain a supply of 864s, 30s, or 1H4Gs. Check with your friends, old radio repair shops, war surplus electronic part stores, or send an SASE to me, c/o ELECTRONICS HANDBOOK for a list of suppliers of old vacuum tubes. The type 30 was made in two bulb shapes. One is tubular about the same diameter as a small 4-pin base, the other has the small dome shaped bulb. The 864/VT24 has a tubular bulb 1-3/16-inch in diameter which is nearly the same as the WD11. The 1H4G is an octal tube with a tubular glass bulb 1-9/16-inch in diameter. This diameter may be too large for some of the older radios. The 1H4G tube has the same characteristics as 30.

You are now ready to remove the two larger filament pins from the tube base. If you have access to a drill press this will be easy. Otherwise use a handheld electric drill. Use a no. 28 drill bit and carefully drill out (from the inside of the base) most of the staked portion of the brass pin. With a sharp pick remove the remaining parts of the staking, grasp the pin with a pair of pliers gently pull and twist until the

(Continued on page 94)

How LED was installed on Stromberg-Carlson telephone.

TELEPHONE BUSY LIGHT

By A.N. Wingate

The chances are that if you have more than one telephone in your home on a single line, you have picked up one of them to make a call only to find that you have interrupted what the other person felt was a very important and/or private conversation. With the circuit described herein installed at each of your telephones, you, and others, can avoid that fateful and unintended "eavesdropping". You can have this convenience at a cost of about $8.00 per telephone.

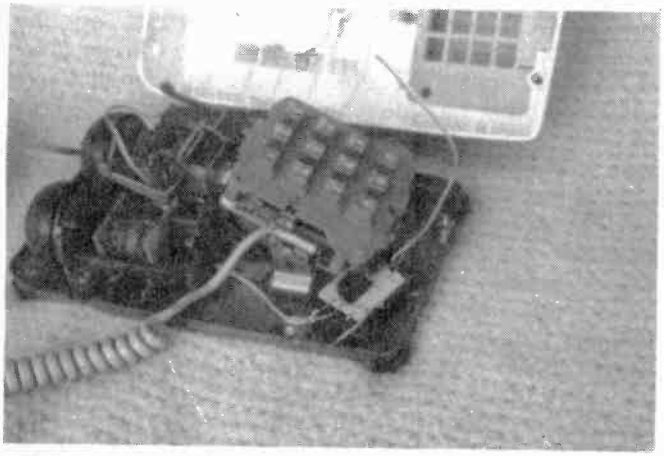


Figure 1. Unit above was installed in a Stromberg-Carlson telephone. Two AAA Nicads were wrapped in tape and glued to the base. Then the perfboard circuit was glued on top of the batteries.

With this little circuit you can tell immediately if someone is using another telephone merely by looking to see if a small LED is lit. It lights each time one of the telephones on your line is picked up. The electronic device which senses the line condition and controls the LED can be mounted inside the housing of most of the larger desk type telephones. See Figures #1 and #2. Or, if space inside the telephone is limited, it may be installed in a small box and connected between the instrument and the wall jack (Figure #3). You many also just connect it in parallell without making the connection between the set and the jack. It is assumed here that your telephone uses a modular connection, however the unit can also be used in the older 4-prong system. The LED is mounted in a convenient place on the telephone or on the small box as shown in the illustrations.

How It Works

The circuit (Figure #4) is really very simple to build as it consists of a total of 5 electronic components on a small piece of perfboard and two type AAA or N nickel cadmium batteries, and of course a red LED (you may use any color you wish). The unit is

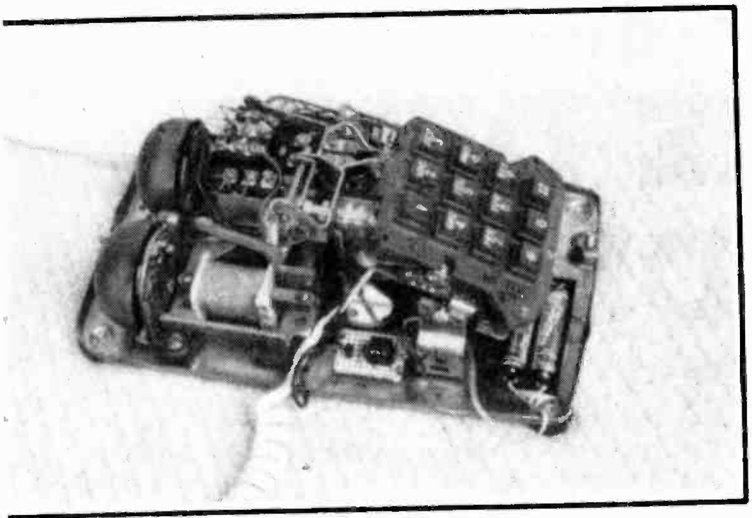


Figure 2. This is how the unit and batteries were installed in an ITT telephone. The AAA batteries were placed in a holder and then glued in a separate location from the circuit board.

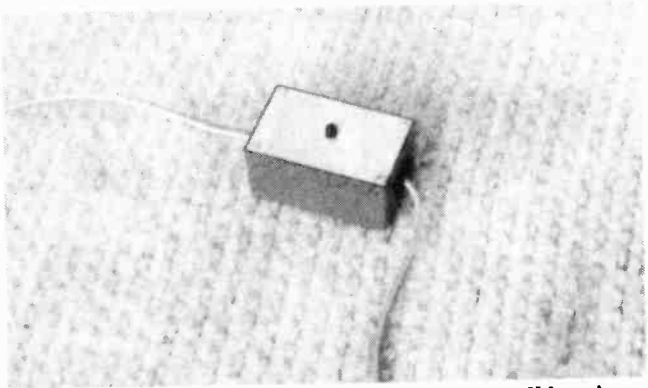


Figure 3. Above, the unit is installed in a small box to be placed near the telephone. A view inside the small box.

connected across your telephone line at all times and senses the on-hook or off-hook condition of the line.

In operation, when all telephone receivers are on-hook, the voltage on the telephone line is about 48 volts and a very small current flows through R1, IC1 and B1, causing the IC1 internal LED to light and the phototransistor to conduct. The voltage at pin 5 is very low (0.5 volts). Under these conditions Q1 is cut off and since no current flows in the LED, it is dark. No current is drawn from B1 in this case, but a tiny bit of current does flow from the telephone line to Q1.

When a telephone handset is lifted off the hook, the telephone line voltage drops to about 5 volts, and the current through R1, IC1 and B1 drops to an even lower value resulting in 1.25 volts at pin 5, thus Q1 is biased on and LED 1 lights.

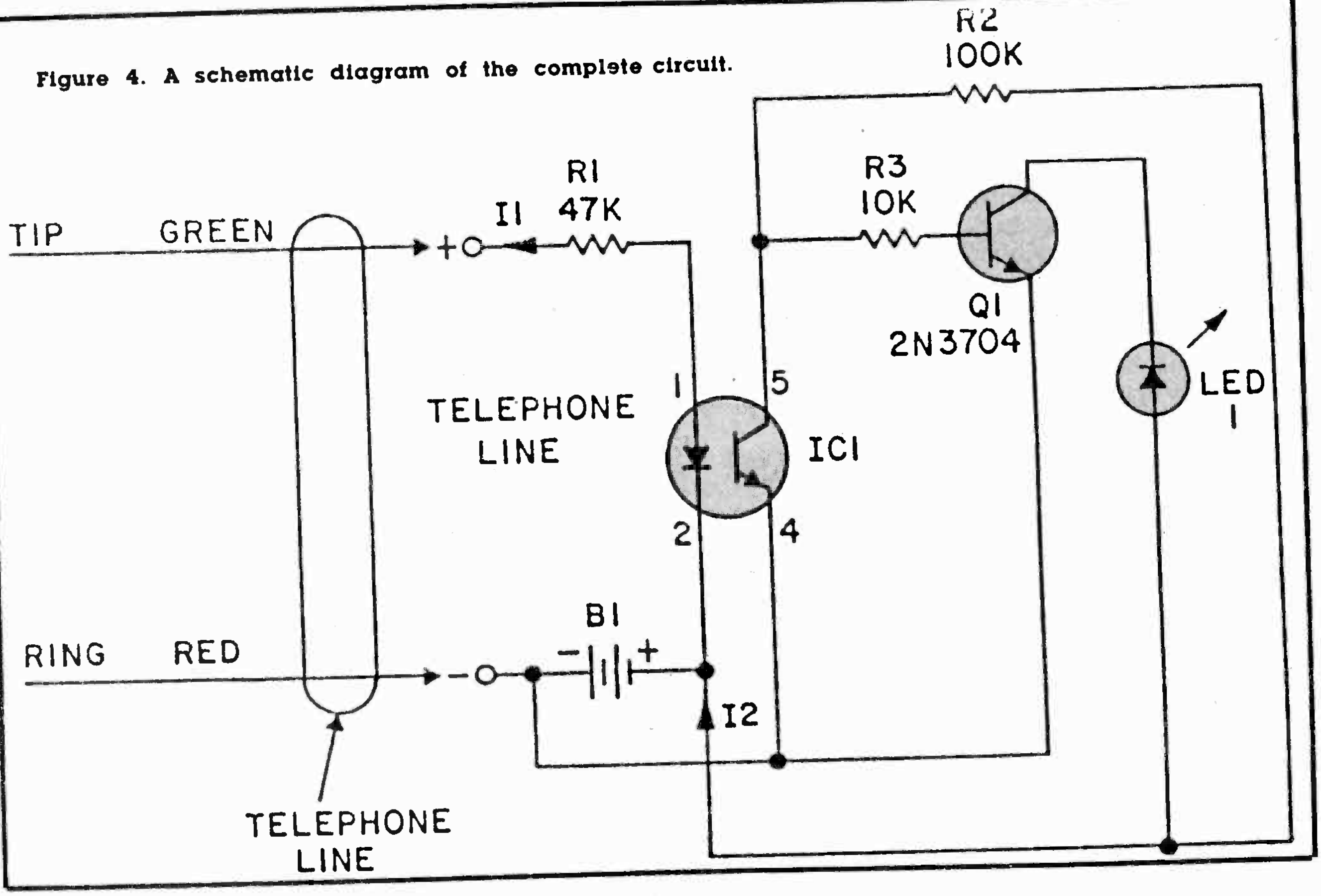
The table below shows the status of the voltage across the line, currents I1 and I2 and the voltage at E1 as indicated in Figure #4 for on-hook and off-hook conditions.

CONDITION	TEL. LINE VOLTAGE	I1	I2	E1
On-hook	48	840 uamp	105 uamp	0.54 volts
Off-hook	5	120 uamp	2.2 ma	1.25 volts

Note that at no time does the unit draw more than 840 microamps from the telephone line and since 105

(Continued on page 96)

Figure 4. A schematic diagram of the complete circuit.



WHAT THE DEVIL IS A DB?

By Glenn M. Rawlings

Ever since Ben Franklin's key drew an arc, it seems like one of the most difficult things for the average electronics enthusiast to comprehend has been the decibel. But actually, the decibel wasn't "invented" until the country was being wired for telephone service. As the phone wired were being strung from house to house, it was only natural that some loss of signal occurred. When the power level of the signal had dropped to 1/10 of what it started out from, the phone people decided to call this a unit of 1 Bell (Named after the inventor of the telephone). With some form of measurement like this, it would be easy to "balance out" all of the phones in town, so that they all received a reasonably similar signal level. When the power level dropped by a 10 to 1 loss, the loss was called 1 Bell. This system worked pretty well out in the open farm land, but when the homes were closer together, it was just too large of a unit to work with, as 1 Bell could represent a telephone wire loss of ten to twelve miles distance. Another thing that had to be considered, was the wide deviations in the signal power levels at different points in the phone system. If the Bell unit had been *linear,* it would have been a little more difficult to work with, requiring zeros and decimal points for every measuring point made, due to the wide deviations in the power levels.

In order to bring the Bell down to a better working size, it was decided to divide each Bell into 10 units. These units would be called a "decibel", or simply dB. We started out by saying that the original "Bell", was to indicate when the power level of the phone line had dropped to 1/10 of what it started from originally. It is very important to note here, that the Bell, or the decibel (dB) is a *Ratio* expression of two levels, ie. a Bell of loss would occur when the power was down to 1/10 of its original value. (10:1)

So, the decibel is not a linear unit. Instead, it is based on a *logarithmic* scale. This may be why the dB has created so much confusion over the years.

We must now see what a logarithm is. It is based upon our everyday number system, where we count up to 10. Our "deci"-mal system has a *base* of 10. (Our "deci"-bel system also has a base of ten.) The logarithm of any number is the *exponential* power of the base 10, which will equal that number. Let's look at that a little closer.

Now we know that 10^2 equals 100. The "2" is the exponent of 10. In like manner 10^3=1,000 and 10^1=10. In these examples, we say the logarithm of 100 is 2. The logarithm of 1,000 is 3, and the logarithm of 10 is 1. It is in this manner that we develop a logarithmic scale. By considering only the exponents (logs) above, you can see that any number between 100 and 1,000 can be represented by some "power of ten", which lies between the exponent values of 2 and 3. Similarly, values between 100 and 1,000,000,000 can be represented by exponents (logs) between 2 and 9.

From the preceding, we can see that that the logarithmic decibel should be much easier to work with than actual levels of power, *especially* in a system where *great differences* of level occur. In a physical scale representation, the distance between levels of 1 and 10, 10 and 100, 100 and 1,000 dB, would each be the same number of inches apart, since the base is related to 10. It is between these points, that a logarithmic progression takes place. 10^1, 10^2, and 10^3 are all multiples of the base 10, whereas $10^{1.241}$ would not be. Look at the following chart:

ACTUAL NUMBER	RAISED TO POWER OF 10	LOGARITHM (BASE 10)
10,000	10^4	4
1,000	10^3	3
100	10^2	2
10	10^1	1
1	10^0	0
0.1	10^{-1}	-1
0.01	10^{-2}	-2
0.001	10^{-3}	-3

From this, it can be seen that any number between 10,000 and 0.001 can be represented by a simple log value (between 4 and -3). Also note how easy it is to multiply any two numbers between 10,000 and 0.001, by just adding the logarithms to each other. The answer wil also be a log value.

The power loss (or gain) of any system, is the *ratio* of its input to its output power. The *logarithm* of this ratio is the power gain or loss, expressed in Bells. As previously noted, the Bell is too large for practical use, so the logarithm of the ratio is multiplied by 10 to convert to "decibels".

Power Loss in *Bells* $= \log_{10}$ times the $\frac{\text{input power}}{\text{output power}}$

Loss in *dB* $= 10 \log_{10}$ times the $\frac{\text{input power}}{\text{output power}}$

To obtain the Gain, the input and output are just reversed in the formula:

Power Gain
in decibels (dB) $= 10 \log_{10}$ times the $\frac{\text{output power}}{\text{input power}}$

All of this works pretty well for power levels, but what if we are measuring voltages, which is actually more common? Well, from Ohms Law, we know that

$$\text{Power} = \frac{E^2}{R}$$

and if the resistance (R) doesn't change, the following relationship must be true:

$$\frac{\text{input power}}{\text{output power}} = \frac{(\text{input voltage})^2}{(\text{output voltage})^2}$$

which is equivalent to:

$$10\,(2 \log_{10} \frac{\text{input voltage}}{\text{output voltage}}) = 20 \log_{10} \frac{\text{input voltage}}{\text{output voltage}}$$

So 20 times the logarithm of the ratio of input/output voltages is a value expressed in decibels. For a voltage gain:

$$\text{Gain (dB)} = 20 \log_{10} \frac{\text{output voltage}}{\text{input voltage}}$$

These formulas can be used when comparing any two levels in a system, as long as the resistance or impedance at the two points is the same.

There are many charts available which make it easy to convert voltage and power ratios to dB. Many of these are related to a specific reference level. That is, they start out with 0 dB equal to a specific reference number. As an example one is shown below.

CONVERSION OF VOLTAGE/POWER RATIOS TO DECIBELS

(-) VOLTAGE RATIO	(-) POWER RATIO	dB	(+) POWER RATIO	(+) VOLTAGE RATIO
1.000	1.000	0	1.000	1.000
.891	.794	1	1.259	1.122
.794	.631	2	1.585	1.259
.708	.501	3	1.995	1.413
.631	.398	4	2.512	1.585
.562	.316	5	3.162	1.778
.501	.251	6	3.981	1.995
.447	.200	7	5.012	2.239
.398	.159	8	6.310	2.512
.355	.126	9	7.943	2.818
.316	.100	10	10.000	3.162
.282	.0794	11	12.59	3.548
.251	.0631	12	15.85	3.981
.224	.0501	13	19.95	4.467
.200	.0398	14	25.12	5.012
.178	.0316	15	31.62	5.623
.159	.0251	16	39.81	6.310
.141	.0200	17	50.12	7.079
.126	.0159	18	63.10	7.943
.112	.0126	19	79.43	8.913
.100	.0100	20	100.00	10.000
10^{-2}	10^{-4}	40	10^{4}	10^{2}
10^{-3}	10^{-6}	60	10^{6}	10^{3}
10^{-4}	10^{-8}	80	10^{8}	10^{4}
10^{-5}	10^{-10}	100	10^{10}	10^{5}

All we have talked about so far, is the comparison or ratio of two signals to each other. This is OK if that is all we want to know. But in practice, several "standard" levels of reference decibels have been established. For instance, in the Broadcast industry the power dissipation of 1 milliwatt across a 600 ohm impedance is referenced as 0 dB. In the Cable TV industry, 0 dB is a reference level of 1,000 microvolts across an impedance of 75 ohms, and in acoustical work the 0 dB reference level is established as 10^{-16} watts of audio power per square centimeter.

In addition to these, there are a number of other systems that are in use, so once again, it is important to remember that the decibels is always a *Ratio* of two levels. A dB is not a value within itself; *it is ratio only.*

Usually when the dB designation is meant to be related to some specific reference level, (ie. 1 mw across 600 ohms) an additional leter is added. Some examples are dBm, dBj, dBmv, each with its own *zero dB* reference point. A system with an output level of +42 dB, for instance, has no meaning at all, unless the 0 dB reference point for the *Ratio* is stated. If we want to establish the gain or loss of something, we can just reference the input to the output. If we are talking about some dB level at a point within the sytem, we must know the reference level being used for 0 dB in order to establish the required ratio.

In the case of a signal level like +42 dB, we must have the reference level to which it relates, as previously mentioned. Is it +42 dB above 1 milliwatt in 600 ohms? Or is it +42 dB above 1,000 microvolts across 75 ohms? In problems involving the gain of an amplifier, we can determine the input and output power and then get our ratio from this. In the case of just stating a level, we must know the reference. In order to obtain the *ratio*, the reference is just plugged into the formula shown before, and compared with a stated level. If the stated level is a larger dB than the reference, the stated level is a positive dB. If it is smaller than the reference, it is a negative dB. If the 0 dB reference were 6 milliwatts, and the stated level 600 milliwatts, we can see that it would be positive. It is a dB level of +20 dB, as shown below.

$$\text{Gain dB} = 10 \log_{10} \frac{600}{6} = 10 \log 100 = 10(2) = +20 \text{ dB}$$

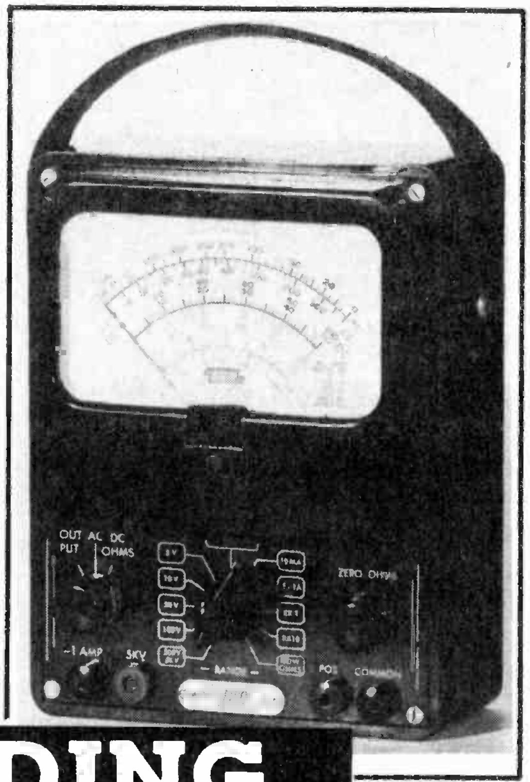
If the 0 dB reference happened to be 600 milliwatts, and the 0 dB reference was level 6 milliwatts, we would then get the formula:

$$\text{Loss dB} = 10 \log (10) \frac{6}{600} = 10 \log (.01) = 10\,(-2) = -20 \text{ dB.}$$

Also note what this tells us about the ease of using decibels. In the two examples above, we are swinging 594 milliwatts above and below a reference level. This is pretty cumbersome. However it can easily be stated in decibels as a change from +20 to −20 dB.

In the case of something like an audio amplifier, it would be quite normal to have, say, 6 milliwatts at the input being amplified to 10 watts at the output. The *9994 milliwatt* difference can be more simply stated at *+32.2 dB.* ■

The VOM is a high-quality, yet rugged Simpson model 260. Until recent years, it was by far the most famous and widely used multimeter in the world. It is similar to the type discussed in this text.



UNDERSTANDING AND REPAIRING MULTIMETERS

How voltohmmeters work, with tips on fixing them.

By Hugh Gordon

Although digital meters abound, no instrument is about to replace the analog multimeter, or VOM. It's inexpensive, rugged and accurate. It's also easy to read, especially when carrying out a quick analysis in troubleshooting, or if you're observing a slowly-changing voltage or current. You'll find one in all professional electronics shops and also in all serious electronics hobbyist's workshops.

Basic Construction

The heart of the VOM is a small, current-carrying coil wound of very fine wire on an aluminum frame. A pointer is attached to this coil. As the coil moves, so does the pointer. The coil is set inside a high flux density, permanent magnetic field. When current flows through the windings a magnetic polarity is generated which reacts with the permanent field, causing movement of the coil and pointer. The amount of pointer deflection is directly proportional to coil current.

The moving coil is usually suspended in jewelled bearings similar to those in good, non-electronic watches. Two small hairsprings, wound in opposite directions (to compensate for temperature changes) are fastened to the coil. When the meter is disconnected, these springs retain the pointer in zero position. The **Zero Adjust Screw** on the meter cover just below the scale plate adjusts the tension on the upper spring to allow you to set the pointer to zero before using the meter.

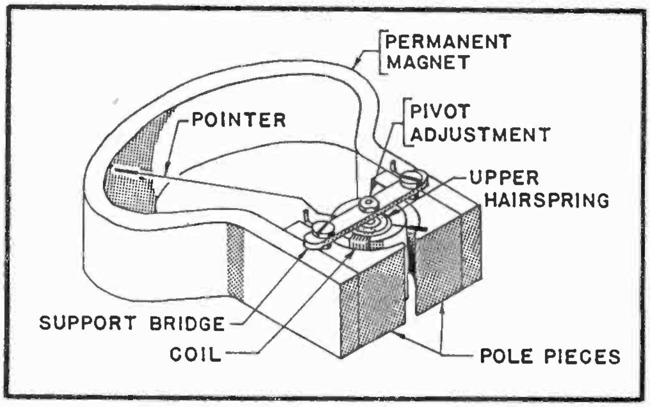


Figure 1. Typical meter movement. There's another pivot support and hairspring at bottom of the coil. Zero adjust screw is not visible here.

Another system of suspending the coil which eliminates jewelled bearings is known as the taut band suspension. Although expensive, it is more rugged. Its coil is suspended by torsion bands, a micro-miniature version of the torsion suspension in automobiles.

The complete assembly of the coil, frame, springs, pointer and permanent magnet is usually referred to as the meter movement and is shown in Fig. 1.

Apart from the movement there are several resistors and diodes and at least one capacitor in a VOM. These components govern the direction, and limit the magnitude of current through the coil. Current must flow through the windings in only one direction (DC) for proper upscale movement of the pointer.

Coil current is stated in terms of the amount required for full scale deflection (FSD). FSD is the movement of the pointer from zero to the extreme right side of the scale. Typical safe maximum values of current for FSD vary from 50 microamps to 1 milliamp, although some very sensitive meters handle only 10 uA.

You can determine the maximum FSD coil current (in amperes) for your meter by calculating the inverse of its ohm-per-volt rating. For example: if the meter is rated at 20,000 ohms-per-volt, then the inverse is 1/20,000 or 0.000050 amperes, or 50 microamps.

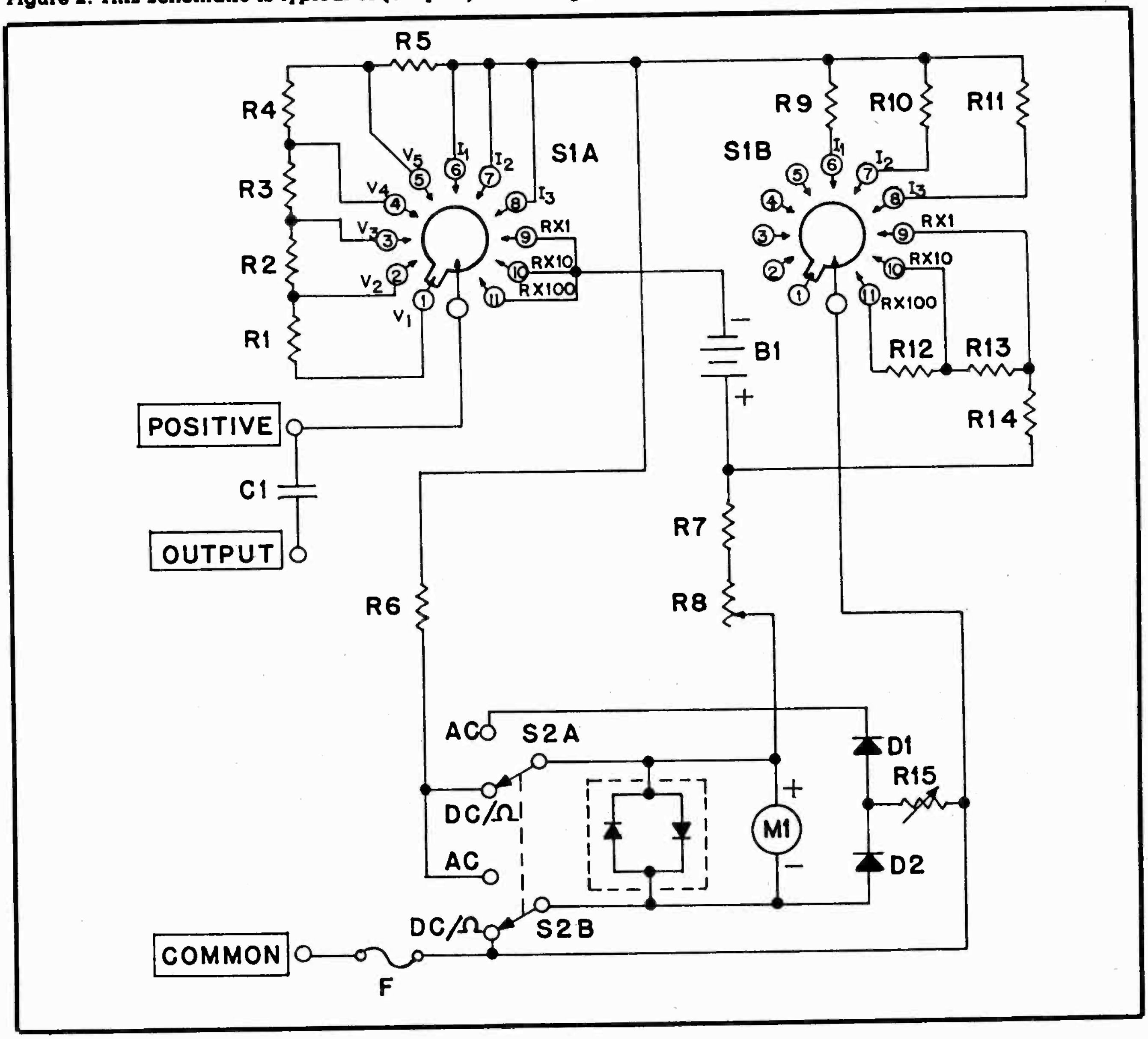
Externally, you control meter current by the operator controls. The function switch chooses DC or AC operation to direct current flow through the coil in the proper direction. The range switch selects the maximum voltage or current reading, which, in turn, determines the maximum current required for FSD. Often, the two controls are combined.

How the Circuit Operates

To repair any VOM you must first understand its circuit operation and the components associated with each function. A typical, partially simplified schematic of a VOM is shown in Fig. 2. Briefly, here's how it works.

The two rotary switches, S1A and S1B, are ganged. Terminals 1 to 5 are for voltage, 6 to 8 for current, and

Figure 2. This schematic is typical of (simpler) multirange VOMs. It is discussed in detail in this article.



9 to 11 for resistance. An additional DPDT switch, S2, is used to select DC/OHMS or AC functions.

When set for measuring DC volts, current is directed through one or more resistors, called multiplier resistors, which limit meter current and contribute to the correct reading. Current enters the COMMON jack, flows through S2B, the meter coil M1, S2A, R6 and one or all of the series multiplier resistors, R5 to R1, depending upon the range selected, then to the POSITIVE jack.

For AC volts, two diodes, D1 and D2, rectify the AC so that only DC current flows through the meter coil. Many meters employ a bridge rectifier for this function. The electron current, for the first half-cycle, flows from the COMMON jack through to R15, then through diode D2, S2B, R6, the multiplier resistors, then on to the POSITIVE jack. R15, in some meters, may be variable to permit calibration.

For the second half-cycle, current enters the POSITIVE jack, through the multiplier resistors, R6, S2B, M1, S2A, D1, R15, and on to the COMMON jack.

In each DC current range there are two circuits in parallel; one including the meter movement, the other a precision resistor. The majority of the current entering the instrument flows through the parallel resistive branch while only a small portion flows through the meter coil. For example: if the meter coil is rated at 50 uA for FSD, then, for an input current of 10 mA FSD reading, 9.950 mA flows through the resistive branch while only 0.050 mA or 50 uA flows through the coil.

When DC current is selected, say at position 7, one branch current enters the COMMON jack, flows through S1B, R10, S1A, and out to the POSITIVE jack. The other branch current flows through S2B, M1, S2A and R6. For other current ranges, only the values of the parallel or shunt resistors, R9 to R11, are changed; the current path through M1 remains the same.

As with the current ranges, there are, for each resistance range, two circuits in pararell. When a resistance range is selected, say RX1, the selector switch, S1, is set to position 9, and the function switch to position DC/OHMS. The current to operate the meter coil is supplied by the internal battery, B1.

Assume a resistor to be measured is connected across the input jacks. Current then flows from the negative terminal of the battery, through S1A, out through the external resistor, and back through the COMMON jack, then through S2B, M1, R8, R7 to the positive terminal of B1. R8 is the ZERO OHMS ADJUST control.

As well, in parallel with the meter circuit, current, after entering the COMMON jack, flows to S1B, through it to R14, then back to the battery.

With this type of circuit, the value of R14 is the same as the half-scale reading on that range. On RX1, for example, if the half-scale reading is 10 ohms, R14 is 10 ohms. Then, for RX10, if the half-scale reading is 100 ohms, the sum of R13 and R14 would be 100 ohms. Thus, if R14 is 10 ohms, R13 would be 90 ohms. The same reasoning applies to other ranges.

Balance Test and Zero Setting

A properly balanced pointer is the mark of a quality meter that hasn't been abused. It is a mechanical rather than an electronic aspect of the meter. If the meter is properly balanced and no current is flowing through its coil, the pointer should remain at the zero position regardless of how the meter or coil is turned.

Check your own VOM. Lay it face up on a level table or bench. Using your fingernail or a fine screwdriver, carefully turn the zero adjust screw until the pointer rests exactly on zero. Now, place the instrument in a vertical position. Does the pointer stay at zero? Tilt the meter to left and right. Does the pointer still stay on zero?

If the pointer moves off zero in any of these positions, the meter movement is out of balance. Cause of imbalance may include a pointer bent by striking the stops when the meter was heavily overloaded or from a misapplied DC voltage causing a reverse kickback. The hair springs could be damaged or tangled if the entire meter was subjected to mechanical shock.

Performing any work on the meter movement is delicate and best left to the professional. However, if you have some experience with fine instruments and possess a light touch, you could safely attempt some minor repairs.

If a hairspring is tangled you may be able to shift it back into position. Work only in a clean area. Use magnification. Use non-magnetic tweezers or make your own tool from thin brass wire bent to appropriate shape.

Never work around the meter movement with any magnetic material. It will be violently attracted to the permanent magnet and could cause irrepairable damage.

Gently, and with a very light touch, "persuade" the coils to separate and return to their original position. Take care not to bend or twist them out of shape.

If the meter is only slightly out of balance, you may have to learn to live with it. Just remember to either use the meter in only one position, say horizontal—which is often the most accurate—or be prepared to zero the pointer when changing positions.

Bearings and Damping

The coil is suspended on pointed pivots which rest in jewelled bearings. Any excess friction or dirt in these can produce erratic readings. To test, apply a voltage, and after the pointer has come to rest, lightly tap the meter face. If the tap causes the pointer to move slightly to a different reading, there is friction. Here, the cure is a professional repair, but you can avoid the expense if you remember to tap each time you want a precision reading.

The pointer of an improperly damped meter will rapidly come up to its position and oscillate a few times before settling down. Damping is a quality that is built in by the manufacturer and one you should test when buying a new meter. A damped meter's pointer will come up smoothly and not overshoot.

Meter Completely Inoperative

If a meter is completely inoperative, check the fuse, if the meter is so equipped. Next, look for the obvious, such as a broken wire at an input terminal or meter connector. Then, examine for obvious burnt resistors, although they're seldom responsible for no operation

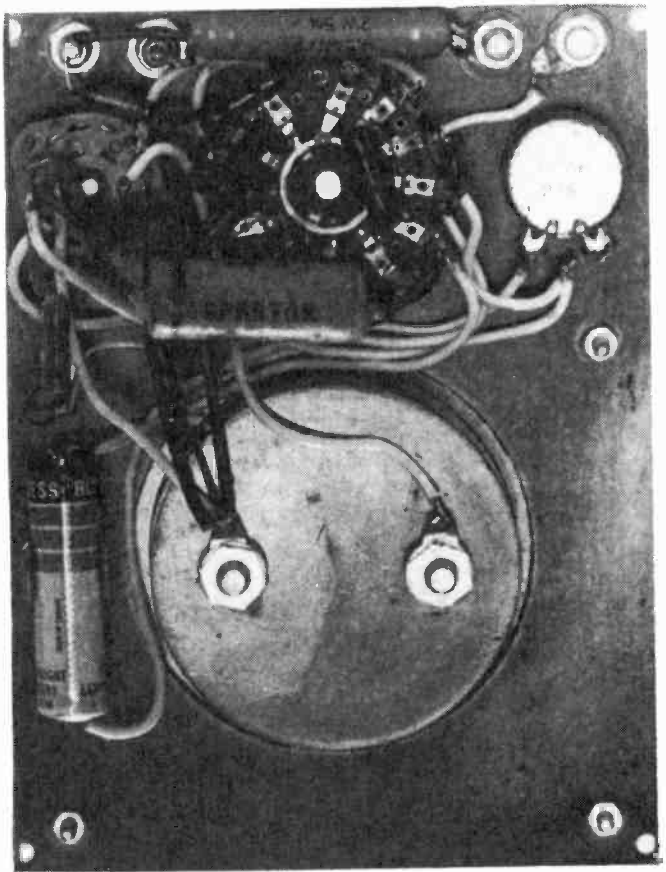


Figure 3. Here's the inside of the Simpson model 260. The rotary range switch is in the middle, under the meter movement. Zero-ohms adjust potentiometer is at the left. AC/DC/Ohms selector switch is at right.

on all functions and ranges.

Note that two diodes are often connected across the meter movement. These diodes protect the meter coil from damage by acting as a bypass path for excessive current. They burn out if overloaded, and if open, give no sign of their failure. To check them it is necessary to disconnect one end and use an ohmmeter or diode tester.

Although an open diode gives no sign of its failure, a shorted one will cause a completely inoperative meter. Check by disconnecting one end of both diodes. If the meter now works, you've found your trouble.

If exact replacement diodes are unavailable install germanium 1N34 type or similar.

Sometimes, but seldom, an inoperative meter results when the coil spring separates at its solder point at the top or bottom anchor. Since these springs act as conductors for current entering and leaving the coil, a break here stops coil current. It's easy to solder back into place. Use a pencil iron, 63/37 solder, magnification and care.

Voltage Problems

Should you connect to a DC voltage that is higher than the range setting, current in the meter's DC circuit would be excessive. If the power rating of any circuit resistor is exceeded to a large degree, it will burn out. This sometimes can be detected by inspection. The common resistor, R6, often burns out before any in the main multiplier circuit, R1 to R5.

Always replace these resistors (or any other in the meter) with the exact value. These will be very precise with small tolerance, probably one per cent, and not available at your local electronics store. You need to get them from the manufacturer or his distributor. But, if the meter is made by a company no longer in business, you'll have to make your own precision resistor. Here's how to do it.

Making Precision Resistors

Suppose R6 has a value of 940 ohms. To arrive at this value when a replacement is unavailable, take a number of standard value resistors, say 910 ohms. Measure them with a bridge or DVM until one is obtained that is within one or two percent of the

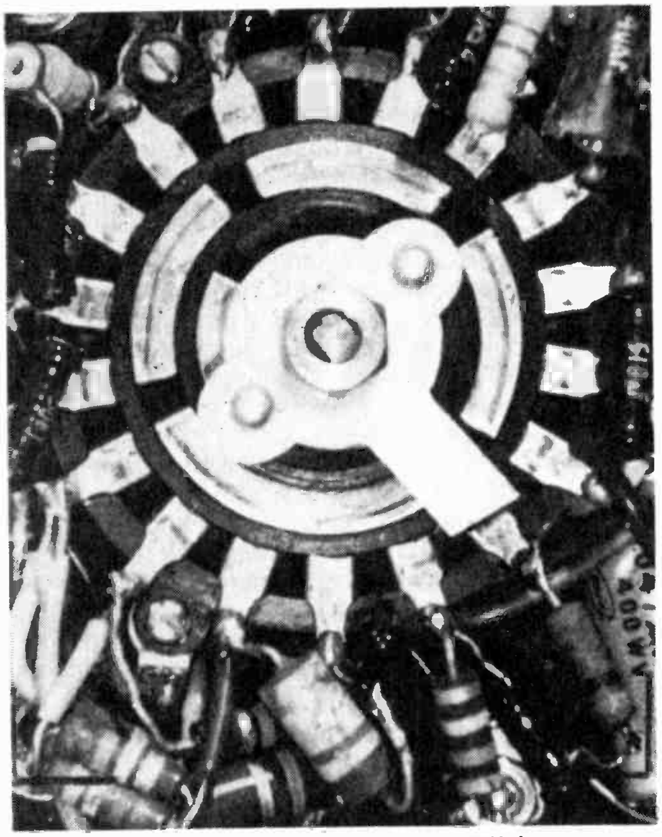


Figure 4. This shows a common rotary switch similar to the range switch of the Simpson model 260. Closeup view shows details and individual contacts. This switch was inside a meter which was repaired. Several single resistors were replaced with paralleled resistors, to get the correct values.

proper value required. It's not as hard as you think. Most standard resistors are actually higher than their rated value. A 910 ohm, 5% resistor most often has an actual value between 910 and 955.5 ohms.

Usually, if all voltage ranges are out, R6 is the culprit. But, if only one or two ranges are down, check the respective multiplier resistors, R1 to R5.

If a similar problem exists for AC volts, you have also to consider additional components: R15 and diodes, D1 and D2. Often, replacement diodes are sold in sets of two or four in a single component package.

Current Problems

On current ranges, it's easy to exceed the maximum

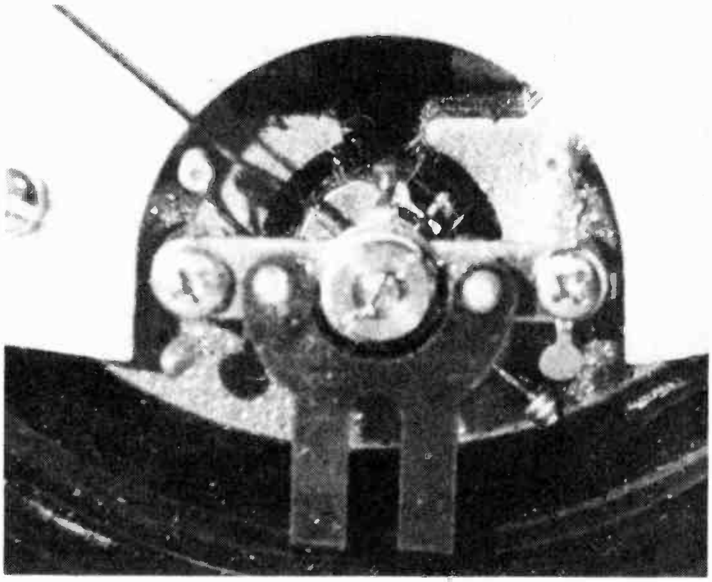


Figure 5. Coil assembly of a badly neglected meter which needs repairs. The plastic scale cover has been broken, allowing entry of dust particles that have accumulated between coil armature and pole pieces. These cause meter pointer to stick and give erroneous readings. The fork-shaped projection at the bottom is the mechanical zero adjust, controlled by the screw on meter face plate. Other white specks in photo are dust particles inside meter.

value of current and burn out a shunt resistor. These are R9, 10 and 11 in Fig. 2. You'll find they are very precise and of low ohmic value. It's best obtain an exact replacement.

Some technicians, if they can't find an exact value, will parallel carbon resistors, checking until an almost exact combination is achieved. You can also wind your own by using a specific length of copper or resistance wire. Check the wire tables for ohmic value per unit length and cut the wire just a bit longer than needed to allow for trimming.

Once the new resistor is installed, check the meter and the resistor for accuracy using the empirical method. Set up a simple circuit with a known source voltage and a precision or low tolerance resistor, so that current flow will fall about half scale on the range in question. With the resistance wire too long, or the resistor of too large a value, the current will read high. Simply shorten the wire or reduce the resistance as needed to reduce current to the correct value.

Check This First

If resistance ranges are not working or providing improper readings, check the battery and its electrical contacts. These contacts should be clean and shiny. If okay, inspect the circuit for faulty, open or changed value resistors.

Sometimes, when a meter is suddenly overloaded, the pointer slams against the stop and is badly bent. These can be straightened, but you must use extreme care and have a light touch. Hold the coil end of the pointer securely and bend the tip slowly back into position. You may never get it perfectly straight but it'll be good enough for most purposes. Replacing the pointer and coil assembly is quite expensive and a job for the professional.

It's quite common for dirt or metallic material to lodge between the moving coil and the stationary parts of the meter. Such an object will cause the pointer to stick part way along the scale, usually noticed when it fails to return to zero unless the meter is tapped.

Careful examination under magnification is needed to reveal such objects. Remove them with a fine brush or try to blow them out with air pressure from a syringe. Should the particle be stubborn or magnetic, touch it with a fine non-magnetic tool and slowly lift it free.

If your meter has a plastic scale face, avoid rubbing it with your fingers. That action generates a static charge in the plastic, attracting the pointer and holding it in one position. It usually won't return to zero when tapped. A few days of waiting and the charge usually bleeds off.

Calibration

To calibrate or check the accuracy of voltage readings, you need a known, preferably precision, source of DC voltage. A number are available and you may have access to one or more.

The Weston cell, precise at 1.0183 V. is the best, though usually not available in a home workshop. You might find one you could borrow in a high school or college laboratory.

Other sources, more readily available, include mercury cells at 1.35 V each, NiCad cells at 1.2 to 1.25 V each, and fresh dry cells at 1.55 to 1.56 V each. It's always wise to check the manufacturer's specifications for exact voltages.

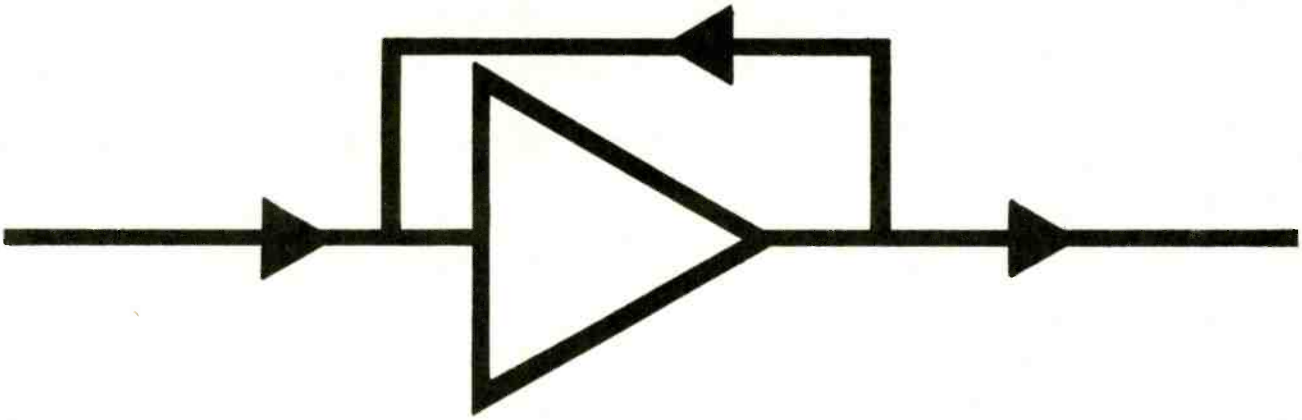
To check AC calibration, use your house AC power line. Most power companies try to provide a standard 117 V delivered to your home. Check this value with your local power company and also inquire about the best time of the day to calibrate your meter. During peak hours the voltage will not be standard.

Some VOMs will register a reading when set on AC volts, even with a DC source applied. If yours is one, then you can check the low-voltage AC calibration using any of the DC sources above. Simply multiply the value of the DC source by 1.11 or 2.22, depending upon the meter you have. If the source is 1.55 V, then the meter, on ACV, would read either 1.72 V or 3.44 V respectively.

To check current calibration, the easiest way is to set up a simple resistive circuit as mentioned previously.

To check resistance ranges, you'll need a few accurate or precision resistors. Don't expect a VOM to give precise values of resistance on all ranges, especially in the upper end of the non-linear scale.■

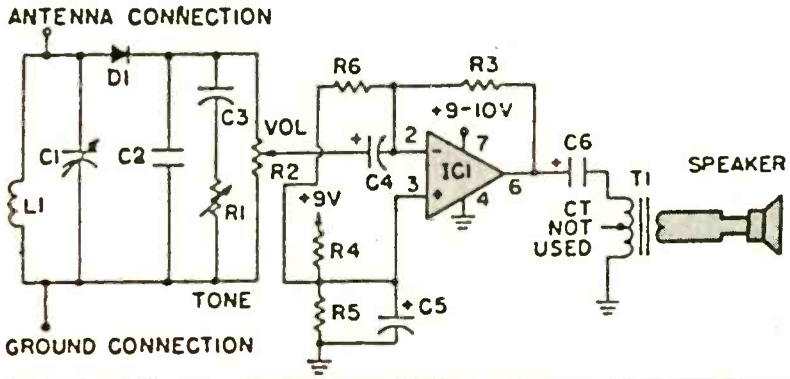
IC TESTBENCH



Each project in this section uses an integrated circuit along with other components to do its job. As you study the way each IC connects to the other parts you'll see that each IC, just like complete circuits, has an input and an output, and also at least two points connecting the power supply; plus and minus. You may ask where the inputs in the Square Wave Generator are located. The answer will show you how an oscillator works. The **output** connects back to the **input**. Once the power is turned on the generator just keeps on going. Most ICs can be used to do more complicated jobs than those shown here. In such applications, some of the IC terminals which are tied together in the schematics shown here are connected to additional circuit components, and often to additional ICs.

MODERN CRYSTAL RADIO

This modern-day "crystal" set uses one of today's diode rectifiers instead of a galenium cats-whisker. They both just rectify (detect) the radio frequency waves from the broadcast station to make the audio



PARTS LIST

C1—365-pF variable capacitor
C2—0.01-uF capacitor
C3—0.1-uF capacitor
C4, C5—100-uF capacitor
C6—50-100-uF capacitor
D1—1N34 diode
IC1—741 op amp
L1—loopstick coil
R1—25,000-ohm linear potentiometer
R2—25K to 50,000-ohm audio potentiometer
R3—1,000,000-ohm resistor
R4, R5—4,700-ohm resistor
R6—10,000-ohm resistor
T1—500 to 3.2/8-ohms transformer
MISC.—3.2-8-ohm speaker; 9V battery clip

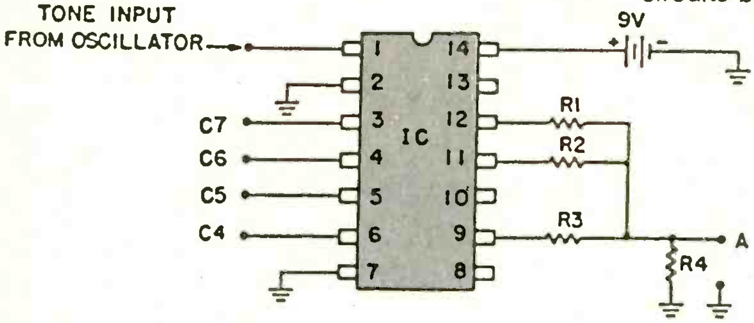
into useable sound.

Depending on how good your antenna is (long wire outdoor antennas are much better than a short wire indoors) and if you use as good ground connection, you can usually get good reception on many distant stations, especially at night.

Any speaker, even an old one from a broken TV set or table radio, will do fine, though you can always get a new (small) one from Radio Shack for a couple of dollars.

OCTAVE-ADD SYNTHESIZER

This circuit will provide you with added octaves that are reproduced from the top octave you feed as an input. Putting in any tone, like the tone from an electric guitar, or from an organ, or from a CMOS oscillator, will cause C4 to be four octaves lower, C5 to be five octaves lower, and so on. Output A is a special waveform that is a saw-tooth made up of octaves that are one, two, and three times lower than the input. The sounds of these outputs can be changed with other, added resistor and capacitor circuits before feeding into your hi-fi.



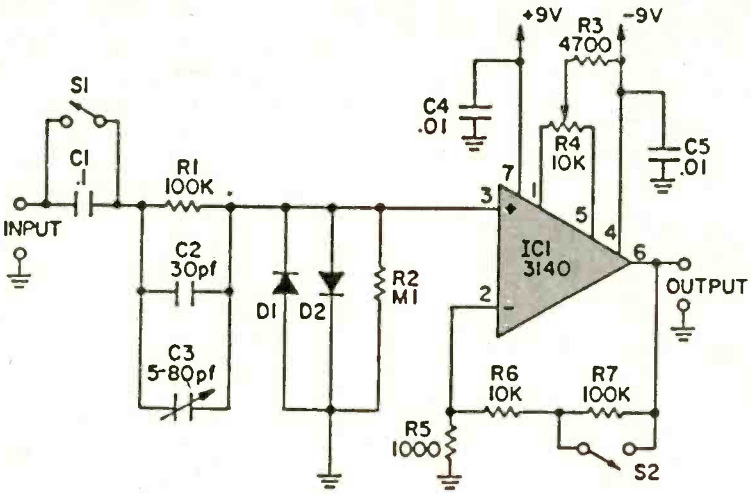
PARTS LIST FOR OCTAVE-ADD SYNTHESIZER MAKER

IC1—4024 binary counter
R1—12,000-ohm resistor
R2—22,000-ohm resistor
R3—47,000-ohm resistor
R4—1,000-ohm resistor

VOLTMETER/SCOPE BOOSTER

This tiny, high-impedance amplifier will boost the sensitivity of your oscilloscope or voltmeter by a factor of 10 or 100. So, if your oscilloscope's maximum sensitivity at present is 10mV/div, you can boost it to 1mV/div or .1mV/div. Signals you previously could not measure, such as the output of your magnetic phono cartridge, will now be visible. Note also that if all you own is a 20K-ohms-per-volt VOM, the sensitivity booster will not only let you measure smaller voltages, it will give you a 1-megohm input impedance besides.

Switch S2 selects the gain—10 if closed and 100 if open. When you need direct coupling to measure DC voltages, close S1. Otherwise, leave it open for AC coupling. If the booster is to be used with a scope, feed a 20-kHz square wave to its input, and adjust C3 for the best-looking square wave at the output. For use with just a VOM, C2 and C3 will have little effect; therefore, you can leave them out. The amp can be nulled by grounding its input and adjusting R4 for zero output. Sinewave response extends to 400 kHz at a gain of 10, and 40 kHz at a gain of 100. Limit input signals to less than ± 100 mV.



PARTS LIST FOR VOLTMETER SCOPE BOOSTER

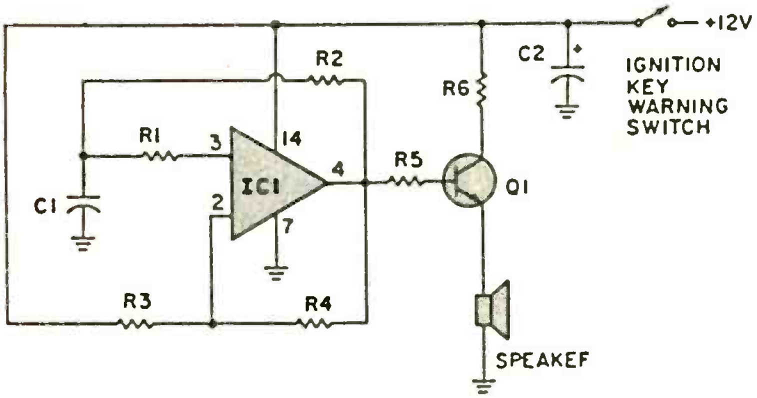
C1—0.1-uF capacitor
C2—30-pF capacitor
C3—5-80-pF trimmer capacitor
C4, C5—0.01-uF capacitor
D1, D2—IN914 diode
IC1—3140 FET-input op amp (RCA or equivalent)
R1, R7—100,000-ohm, ½-watt resistor (all resistors 5% unless noted.)
R2—1,000,000-ohm resistor
R3—4,700-ohm resistor
R4—10,000-ohm linear potentiometer
R5—1,000-ohm resistor
R6—10,000-ohm resistor
S1, S2—SPST switches

CAR KEY ALARM

Have you ever wanted to bash the loud annoying buzzer your ignition key activates when it wants to remind you to take it with you when you leave the car? Or thought of disabling that alarm the next time it reminds you your car door is open?

Now you can replace that disturbing loud buzzer with a mellow, gentle tone (it's about 2000 Hertz) which sweetly reminds you every time it goes on. It'll also remind your friends that you know how to make life a tiny bit more agreeable, instead of always putting up with that rasping, buzzing rowl!

One section of the LM3900 quad operational amplifier IC is connected as a square wave generator which is rich in harmonics yet makes a pleasing sound. Transistor Q1 provides enough power to make that tone drive the little loudspeaker, which can be any small unit you find from an old radio or TV set (or new for a couple of bucks at Radio Shack).

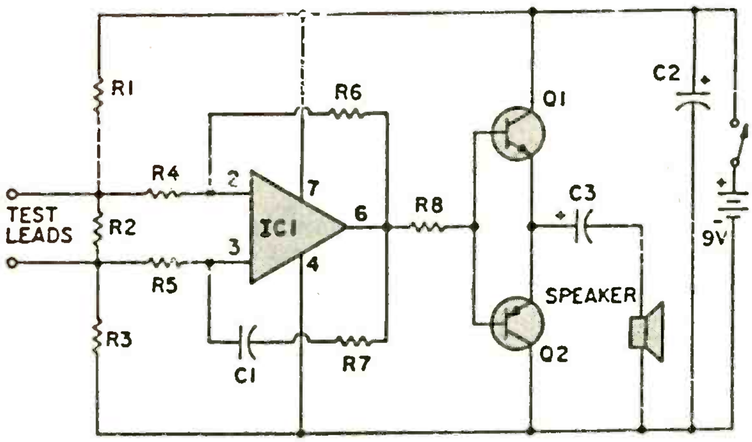


PARTS LIST
CAR KEY ALARM

C1—0.01-uF capacitor 15 VDC
C2—10-uF capacitor, 20 VDC
IC1—LM 3900 quad amplifier
Q1—2N4401
R1—2,700,000-ohm resistor
R2—33,000-ohm resistor
R3, R4—10,000,000-ohm resistor
R5—10,000-ohm resistor
R6—100,000-ohm resistor
SPKR—3.2-8-ohm speaker

CONTINUITY CHECKER

After wiring a new electronic project or troubleshooting an old one, it is good practice to make continuity checks to be sure that all connections in the circuit are correct. In the days of vacuum tubes this was accomplished with an ohmmeter, but for today's solid state circuitry you can't use most ohmmeters for several reasons. Some ohmmeters have far too much battery voltage and deliver up to hundreds of milliamperes into a short circuit. This can easily damage solid state devices. Also, the ohmmeter is an unreliable method to measure circuit continuity, since it will read through an emitter-base or diode junction. This continuity checker is a handy accessory for troubleshooting circuits, and is safe to use on any solid state device or circuit. The maximum voltage at the input terminals is about 40 millivolts, and negligible current is passed through the circuit when continuity is indicated. The circuit will not indicate continuity for resistance values of 35 ohms or greater, and will not register through an emitter-base junction or diode. The circuit is powered by a standard 9 volt transistor battery and draws about 1 milliampere when the input leads are open. Shorting the leads causes an audio tone to be generated and draws only about 15 milliamperes of battery current.



PARTS LIST FOR
CONTINUITY CHECKER

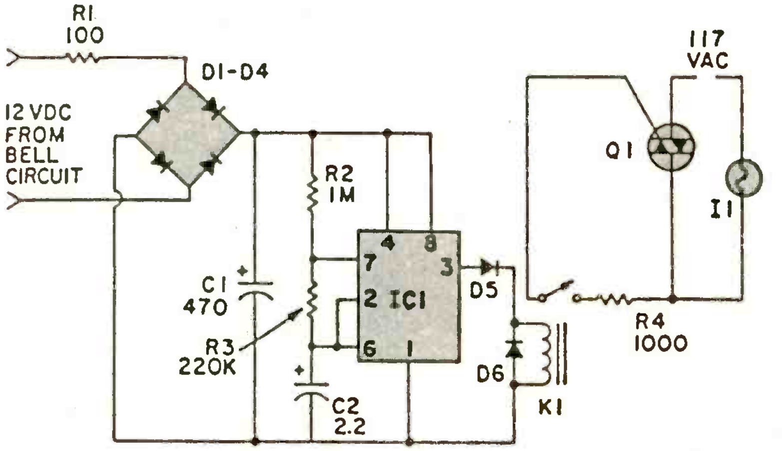
C1—.001-uF capacitor, 15 VDC capacitor, 15 VDC
C2—10-uF electrolytic
C3—15-uF electrolytic capacitor, 15 VDC
IC1—741 op amp
Q1—2N4401
Q2—2N4403
R1, R3, R4, R5, R8—10,000-ohm resistor
R2—100-ohm resistor
R6—4,600,000-ohm resistor
R9, R10—10-ohm resistor
SPKR—8-ohm speaker

ALARM ADD-A-LITE

This circuit evolved as an attempt to add lights to a commercial alarm system equipped only with a bell. There is no need to modify your present alarm system, since this modification is powered by the 12-volt bell circuit.

When your alarm bell is triggered, current flows through the rectifiers (D1-D4) and charges capacitor C1. Although the rectifiers are not absolutely essential, they are a handy convenience because they allow you to tap into the bell circuit wiring without worrying about the polarity of the conductors.

Once powered up, timer IC1 proceeds to oscillate slowly and drive relay K1, which controls a high current triac, Q1. Flood lamp I1 is subsequently energized by the triac in a 2-second-on/.5 second-off pattern that illuminates the culprit and attracts attention.



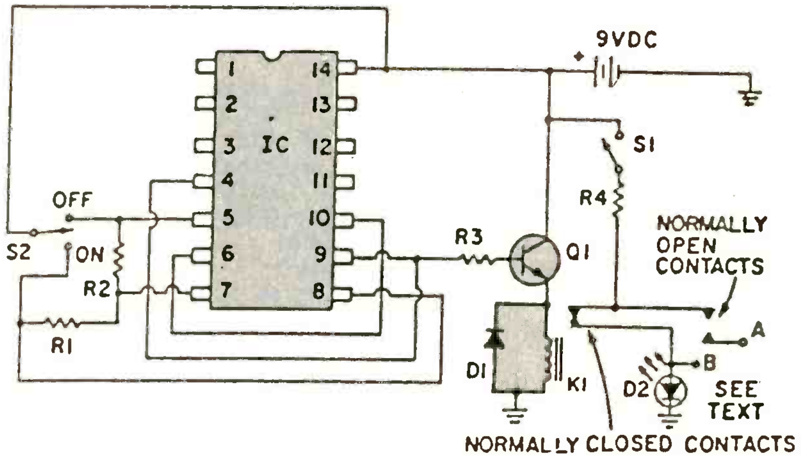
PARTS LIST FOR ALARM-ADD-A-LITE

C1—470 uF, 35V capacitor
C2—2.2 uF, 35V capacitor
D1 thru D6—IN4002 rectifier diodes
I1—250 or 500-watt flood lamp
IC1—555 timer
K1—12 volt, 1,200-ohm relay (Radio Shack 275-003)
Q1—Motorola MAC11-4 200V 10-amp triac, or equivalent
R1—100-ohm resistor
R2—1 Meg-ohm resistor
R3—220,000-ohm resistor

REFLEX (SPEED) TESTER

Two people are required to play this circuit; one, the "tester," and the other, the "testee." By building two of these circuits (as discussed below), one "referee" can test two players against each other. In the "tester-testee" version, the tester opearates S1 out of sight of the testee. This causes D1 to light, which the testee must extinguish as fast as possible by operating S2. The flip-flop circuit of the CD4001 assures that testee begins with his switch in the full "off" position, not somewhere in the middle, as D1 will not extinguish unless this condition is met. Also, the relay assures that there is enough of a time delay to see how long D1 is on and compare, visually, that "on" time with that of a competitor. S2 is then opened and closed to restart the game.

In the dual-circuit (competitive) version, two identical circuits are built and S1 becomes a DPST switch. The two circuits are interconnected by using a second set of normally open contacts on the relay. Point "A" of one competitor's circuit is connected to point "B" on the other's. When this is done, the winning competitor not only extinguishes his own LED, but "locks" the other competitor's "On," So the slow one gets the "glow."



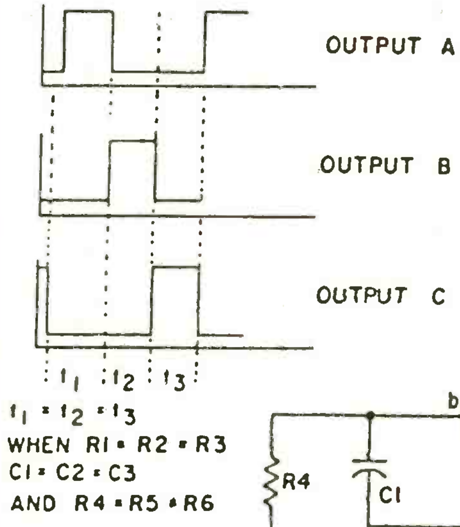
PARTS LIST FOR REFLEX TESTER

D1—1n4001 diode
D2—LED
IC1—4001 quad NOR gate
Q1—2N4401 transistor
R1, R2—870,000-ohm resistor
R3—2,000-ohm resistor
R4—510-ohm resistor
RL1—relay, w/9 VDC coil; one set normally open contacts, and one set normally closed contacts
S1—SPST toggle switch
S2—SPDT toggle switch

SQUARE WAVE GENERATOR

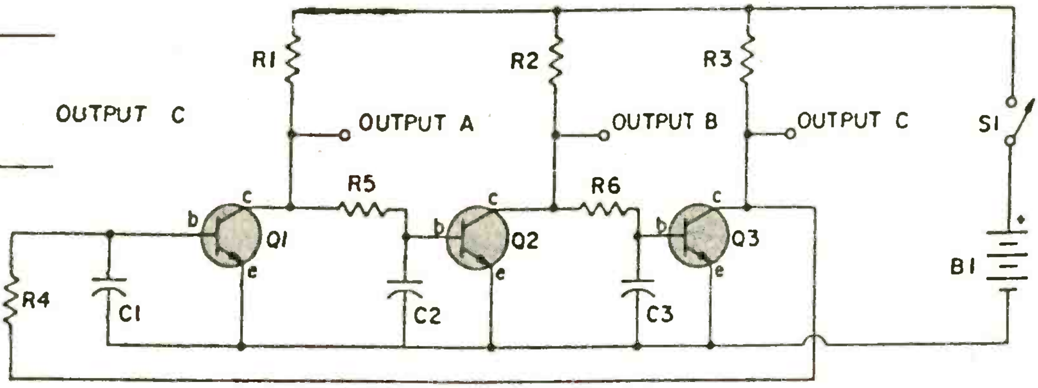
Here is a versatile square wave generator capable of surprising performance. It can deliver clock or switching pulses, act as a signal source, and more. And because the outputs take turns switching, it can be used as a simple sequence generator or as a multiple-phase clock.

The component values indicated will support a range of output frequencies from a few pulses per second up into the high audio range. And this square wave output is rich in harmonics. If you use a 5 volt-power supply, this circuit can trigger TTL logic directly.



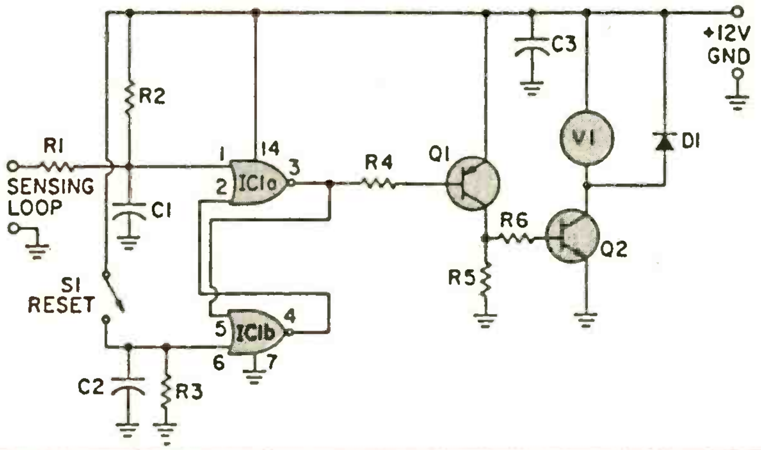
PARTS LIST FOR SQUARE WAVE GENERATOR

B1—6-15 VDC battery
C1, C2, C3—.5-uF capacitor
Q1, Q2, Q3—NPN (2N2222, 2N3904 or equiv.)
R1, R2, R3—500-2700-ohm resistors
R4, R5, R6—10,000-47,000-ohm resistors
S1—SPST switch



BATTERY-SAVING BURGLAR ALARM

This burglar alarm circuit uses one integrated circuit and operates from a 6 volt battery. It is activated upon the breaking of a circuit. Since the sensing loop operates in a high impedance circuit, there is virtually no limit to the length of wire you can use. You can protect every window and door in your house. Practical operation by using four D cells for power is accomplished through the use of a four-section CMOS integrated circuit which draws only a few microamperes from the battery. Thus, battery life will be equivalent to its shelf life unless the alarm is activated. The heart of the circuit is a pair of NOR gates connected in a bistable configuration called a flip-flop or latch circuit. When the circuit is on standby, pin 1 of IC1 is held to almost zero volts by the continuous loop of sensing wire. This causes pin 3 to assume a voltage of 6 volts, cutting off Q1 and Q2. When the sensing circuit is broken, C1 charges to battery voltage through R2. This causes the latch circuit to change state and pin 3 goes to zero volts. B1 becomes forward-biased through R4 and turns on Q2 which operates the buzzer. The circuit will remain in an activated state once the alarm is set off, even though the broken circuit is restored. A reset switch has been provided to return the latch circuit to its original state and shut off the alarm.



PARTS LIST FOR BATTERY-SAVING ALARM

C1—0.1-uF capacitor, 15 VDC
C2—0.1-uF capacitor, 15 VDC
C3—0.47-uF capacitor, 15 VDC
D1—1N4148 diode
IC1—4001 quad NOR gate
Q1—2N4403
Q2—2N4401
R1, R3—100,000-ohm resistor
R2—4,700,000-ohm resistor
R4, R5—10,000-ohm resistor
R6—100-ohm resistor
S1—SPST momentary-contact switch
V1—6 VDC buzzer

ALL ABOUT CORDLESS PHONES

How Those Two-Way Radios Work, and How To Choose the Best One For Your Home

Portable (carry-about) telephones that go anywhere around the house without connecting wires, have been around for several years. But until recently they've been bulky, expensive, and often unreliable. but not any more. Today's advanced cordless phones are small, reliable, and eminently affordable.

There are nearly five millions cordless telephones in use today (that's about one in every 20 households already) with nearly two million of these little marvels sold just last year alone. It's reliable estimated that by 1990 that number will double of more, with 25 to 30 million in use in the next ten years or less. In many places (affluent neighborhoods, especially) the craze for cordless phones is raging with the same fire the CB radio fad went with a few years ago. But there's a difference!

Different From the CB Craze.

During the CB craze the millions of people who had CBs at home and in their cars stopped using them as the novelty wore off. That's because they were (mostly) enjoying the fun of being "on the air", but weren't using them for a really useful purpose. Today only truckers and other drivers who are on the road a lot use CB sets much or even at all. But cordless telephones serve a real purpose, just like *corded* telephones, so they won't be discarded and stashed in the attic, basement or back of closets the way most CBs sold are today (or in the garbage can). Wireless telephones fill a real need.

What about the prices?

Most cordless telephones are priced from $75 to $260 list, and are generally available for somewhat less. For under $200 you can get a setup with all the important features and often some you don't even need. These prices shouldn't scare you, however, because most department stores and other sales outlets discount most telephones substantially. One caution when you shop for price. Be very carefully about the terms of the service warranty, and be sure the repair department isn't somewhere half a continent or more away from where you are.

Two-piece System

A cordless telephone system comes in two separate pieces. These are the base (main) station, a combination radio transmitter and receiver, and the much smaller cordelss handset itself. This also includes a tiny receiver and transmitter, powered by its own rechargeable battery. When the handset is not in use, it is stored in the base station's cradle. When you want to go to another room or outside without missing any phone calls, you take the handset with you. Some handsets are so small they can actually be carried in a man's shirt pocket. If someone calls you while you're away from the base station, the handset rings and you use it just like a regular wired telephone. Most handsets can originate outgoing calls too, though some of the least expensive units can only accept in coming calls.

How Far Away

Manufacturers claims as to how far from the base station the handset will operate usually refer to how far apart the system would work if the two parts were separated only by open space, not accounting for walls other obstruction, or electrical or radio interference. Most sets will work over much shorter distance than claimed when in actual operating conditions. Thus a cordless advertised to be "good up to 1,000 feet" may actually work well only up to a few hundred feet, depending on your home construction (metal or wooden walls) and the amount of man-made interference—radio transmitters and other hash-making machines—nearby.

Most sets, however, can be counted on to give a range of about one-third of their advertised operating distance. And most will work fine throughout the house, and out into your backyard. It's only if you want to operate from several hundred feet away, or if you have very severe interference, that you're likely to have distance problems.

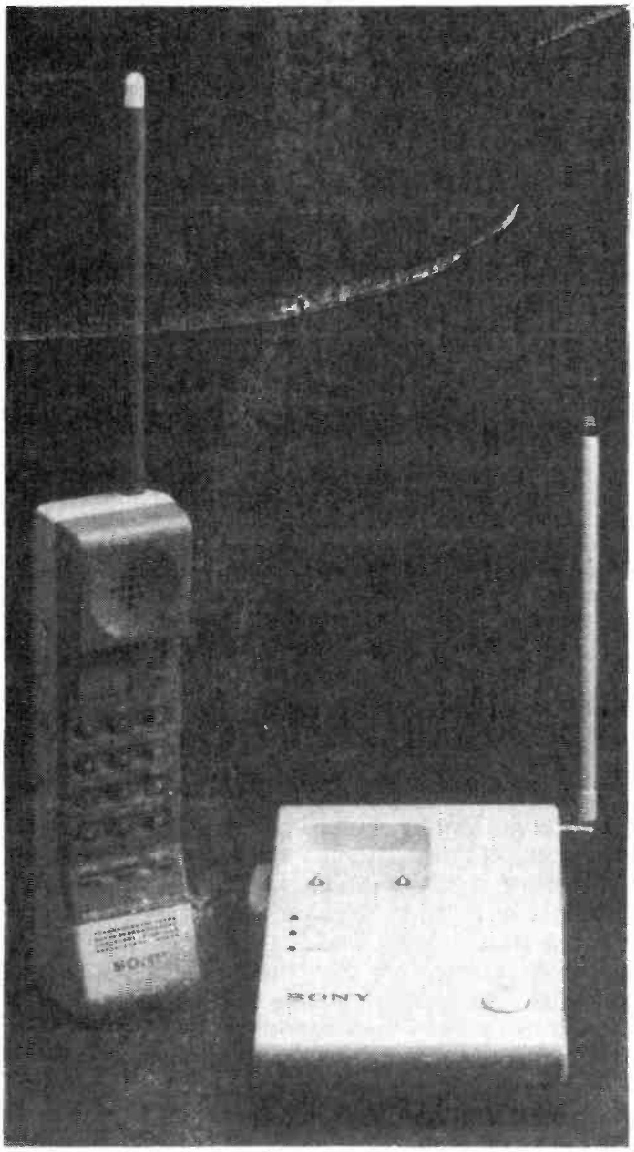
The best cordless phones transmit and receive speech almost as clearly as a good wired telephone does. Other cordless units have noticeably lower fidelity and may sound slightly muffled, though still intelligible. When shopping for a cordless phone you should test the set out in the store, calling someone you know at their home, and conversing with them to check the speech quality at both ends of the conversation.

Installation

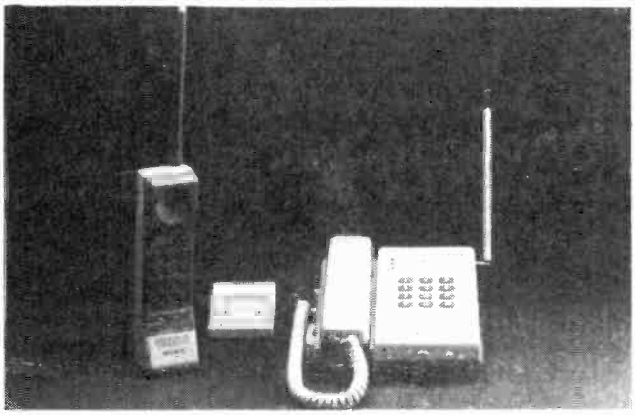
It's almost as easy to install a new cordless system as it is to install a new telephone. If you have a standard modular phone jack in the wall (as do most installations made in the last 10 years), you just remove the plug connecting your regular telephone to the socket and plug in the similar plug from the base station of your new cordless. Then you can usually plug your old set into a socket on the base station. You'll also have to connect the base station to an AC power wall socket. In some cases you may have to get an inexpensive two phone adapter to allow you to plug your wired set into the modular wall station. This permits you to use your wired phone when someone else has taken the wireless handset for use elsewhere.

When the set is brand new it may be necessary to leave the handset in its cradle for a few hours to charge up its nickel-cadmium battery. These batteries can be charged and used hundreds of times, so they'll last at least a couple of years or more. New ones cost less than ten dollars.

All cordless base stations can be set on a table, and take up only about a square foot of space. But it may be more convenient for some people to hang it on a wall. Some sets permit this while others don't, so you



Sony Freeline insures interference-free talking via 10-channel access. SPP-100 scans ten channels when interference threatens. One button searches for interference-free channel. Dual battery packs assure constantly-ready battery. Sony SPP-100 lists for $190.



Dual telephone system has two phones, permitting intercom paging. Base unit mounts on wall or desk. Incorporates all features of SPP-100. Sony SPP-300 lists for $300.

Pocket-sized cordless has mini folding handset, fits in shirt pocket folded. Selectable security code, one-touch redial, rechargeable nicad batteries, doubles as pager with button on base station. Radio Shack ET-415 costs $160.

should consider exactly where it's going to be installed before you buy.

Service Warranties

Service warranties on cordless phones vary widely, from as little as three months for parts and labor to as two years. Warranties which say "One year parts, 90 days labor" aren't nearly as good as they sound, since labor costs are unknown and can be jacket up to more than compensate for the "free" parts. Cordless telephones are usually reliable, but because they're more complicated than standard telephones, the service guarantee and the repair shop facilities are more important than with regular phones. Remember, a cordless includes the same parts as a wired phone, plus two radio transmitters and two radio receivers.

Possible Problems

There are two possible problems with using a cordless telephone. These both relate to the transmit-receive radio frequencies used between the base station and the handset. In crowded metropolitan areas with lots of apartment houses and many cordless telephone in use, you can get interference from other people's calls. At the present time there are ten separate channels set aside for cordless telephone communication, so there's always a chance you'll be set up on the same channel as someone else nearby. In such a case you may have to take the set back to the dealer to have it set for another channel.

Another possible problem relates to what we call dial tone security: the possibility of someone else accessing your base station to get your dial tone on their handset, and then using your system to make long distance calls, which of course will be charged to you. This "theft of dial tone" hasn't happened much, but it's a possibility which the manufactures are taking care to prevent. They do this in several ways.

Virtually all systems are set up so that no outside can access your dial tone while the handset is its cradle. In addition, the better cordless sets now have "lockout" codes which permit you, and only you, to access the base station for your dial tone. You set up the access code by punching in a secret code number, or by hitting a special button which dials the coded access number for you, before you make an outside call. This feature is a sure-fire safeguard against dial tone theft. There are also special "guard tones" on some cordless systems which only you can access to prevent theft of your dial tone.

Other Features

Many cordless sets can be used as intercoms, so that when you're away from the base station, you can talk to anyone who's near it. Most sets permit either party to originate an intercom call, but some of the less-expensive ones only let an intercom call be made by someone at the base station.

Another cordless feature is the inclusion of a loudspeaker on the base station, enabling someone in the same room to use it as a speakerphone while washing dishes or doing other chores. And two or more people in that room can use the speakerphone setup to talk to someone at the other end.

A feature that's being included on more and more wired phones today, automatic redial, also is included on most cordless instruments. It's an extra button which lets the handset automatically redial the number you're trying to get if it's busy the first time you try it.

The less-expensive cordless units can only send out pulses, not tones, and this is true even though they may have buttons for touch "dialing". The phone's electronics converts the pushbutton signals into pulses instead of sending out separate tones. This takes a little longer then when "dialing" on real touch-tone buttons. But unless you're going to be using a special non-Bell long distance service such as Sprint or MCI. The absence of true tone signaling shouldn't bother you.

Another useful feature many cordless phones incorporate is a *memory* in which to store numbers. Some even let you store frequently-called numbers by coded abbreviations. For example, to store Grandma's number you might punch in "Mom", or for the police department, punch in "Cops".

Some better systems now include an LCD (liquid crystal display) which shows the time of day, or time elapsed (for timing your long distance calls), or the number you're dialing. This last lets you know when you've misdialed a number so you can hang up before the call is completed.

Finally, some of the more elaborate cordless phones let you operate on either of two incoming telephone numbers, a convenience when you have more than one telephone line (number) for different family members.

There are several ways to extend the distance between base station and the remote handset, or to make the signals between them overcome troublesome interference. Most sets have telescoping antennas, both on the base station and on the handset. Some handsets do not have such antennas,

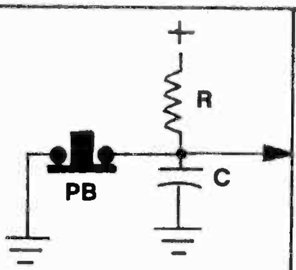
(Continued on page 93)

THE ELECTROPAGE

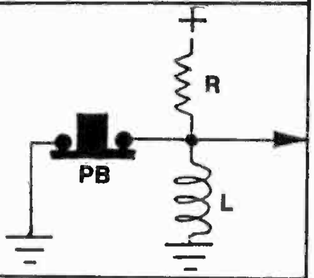
By Glenn M. Rawlings

Here is a fun way to check your electronic knowledge, or perhaps brush up on some fundamentals — and at the same time you will get some experience at "folding papers". Study each circuit below, notice what the INPUT conditions are as stated.... Your job is to figure out what the OUTPUT VOLTAGE will be for each circuit shown, and then to actually draw a sketch of the output in the blank space to the right.

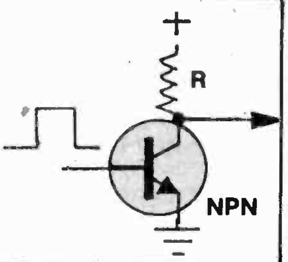
WHEN THE NORMALLY CLOSED PUSH BUTTON IS HELD DOWN, WHAT WOULD THE OUTPUT VOLTAGE LOOK LIKE?



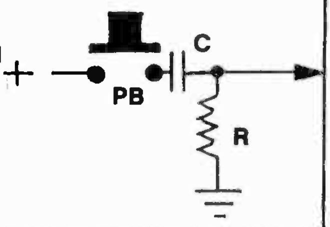
WHEN THE COIL IS UNSHORTED BY PRESSING THE NORMALLY CLOSED SWITCH, WHAT WOULD A TYPICAL OUTPUT VOLTAGE LOOK LIKE?



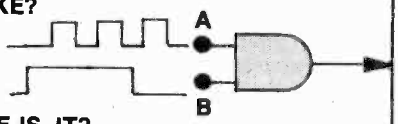
WITH A POSITIVE PULSE AT THE INPUT OF THIS TRANSISTOR, WHAT WOULD A TYPICAL OUTPUT AT THE COLLECTOR LOOK LIKE?



AT THE MOMENT THAT YOU CLOSE THIS SWITCH OF A "DIFFERENTIATOR CIRCUIT", WHAT WOULD THE OUTPUT VOLTAGE LOOK LIKE?



WHAT WOULD THE OUTPUT VOLTAGE OF THIS GATE LOOK LIKE?



WHAT KIND OF GATE IS IT?

TO SEE ANSWERS, FOLD OVER PAGE AT THIS DOTTED LINE

When you have completed all your answers, (and it might be a good idea to check them twice) then and ONLY THEN, fold the page at the dotted line to see how you did.

Some of the answers will be in the form of a plain old DC voltage above or below ground, but on the other hand, some of the outputs will be of a more "dynamic" nature, such as you might see on a piece of test equipment called the Oscilloscope.

Remember this is just a fun way to check your knowledge, and perhaps learn a little more about the wonderful world that we call electronics. So don't feel bad if you should happen to miss one or two of the answers, at least the first time through! When you completely turn this page, you will find an explanation in detail of each circuit.

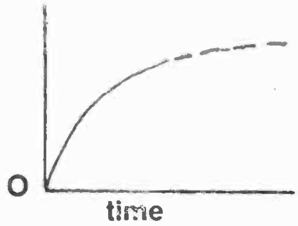
HAVE FUN!

LOOK FOR THE ELECTROPAGE IN THE NEXT ELECTRONICS HANDBOOK.

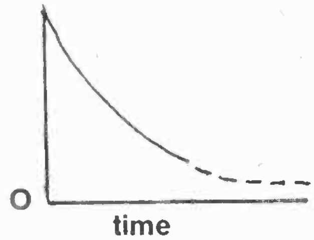
THE ELECTROPAGE

HERE ARE THE ANSWERS TO THE "ELECTROPAGE"!

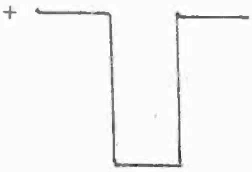
Congratulations for completing the "Electropage". The following explanations may help to clear up some of the answers. While space does not allow a complete coverage of all things related to the circuits, enough is given to allow a pretty good understanding of the principles involved for each circuit action.



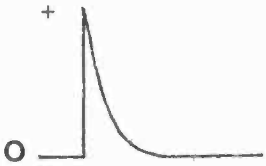
When the push button switch is in the closed position, it is apparent that the voltage output will have to start from a zero level, and the charge on the capacitor will be zero. When the switch is opened, the capacitor begins to charge towards the level of the supply voltage, quickly at first, and then gradually slowing down. When the capacitor has reached 63.2% of the supply voltage, it is called "One time constant". Also in a circuit like this, the capacitive reactance causes the voltage across the capacitor to be delayed behind its current.



As in the capacitor, the voltage will have to start from zero. When the push button is opened, the initial current will be zero, and all of the voltage will appear across the coil for an instant since there is no IR drop across the resistor. As the current begins to flow, more voltage appears across the resistor and less across the inductive coil. When the current has reached 63.2% of its maximum, it is one time constant. While the capacitor gives the appearance of resisting a change in voltage, the coil gives the appearance of resisting a change in current, The inductive reactance causes the current to be delayed behind the voltage.



If the NPN transistor were not conducting at all, it can be seen that the full supply voltage would appear at collector. (No IR drop across R) when the positive pulse is applied to the base of the NPN transistor, it biases the transistor to turn on. When the transistor is on, current begins to flow through the resistor at the collector and the output voltage drops down accordingly, since the transistor can be turned on or off with a small signal gain. Also note the collector signal is inverted from the base.

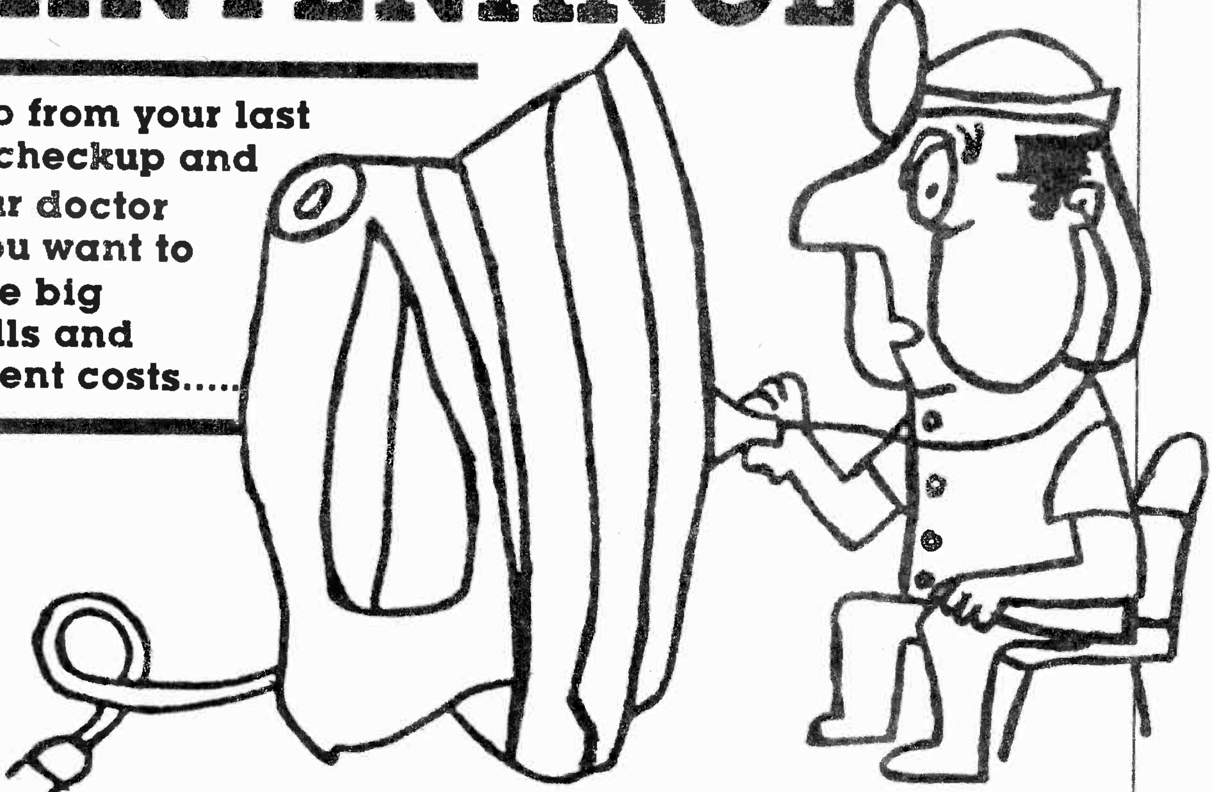


This type of circuit is sometimes used to make a "pulse", which in turn is used to "trigger" some other device into action. Since the moment of closing the switch generates a fast change of voltage to the capacitor, (a high frequency change) this portion of the signal shows up as an IR drop across R. Then as the capacitor gradually charges toward the supply voltage, the drop across R becomes less and less, as is indicated by the shape of the output pulse.

This is a symbol for the "AND" gate, One way to remember what the output will be, is when input A "AND" input B are positive, the output will also be positive. The higher repetition rate pulses on input A, only show up on the output when input B is also positive. The AND gate is equivalent to having two simple switches wired in series, one labeled A, and the other B. Only when both are closed would you have an output from them. Also note, if the inputs to the gate are reversed, output is same.

Rx FOR PREVENTIVE MAINTENANCE

Take a tip from your last physical checkup and do as your doctor does if you want to pocket the big repair bills and replacement costs.....



You may have been pronounced perfectly healthy during your last physical checkup, and yet your doctor may have advised that you have an electrocardiogram (EKG) made. Why? To provide a record of the normal electrical characteristics of your heartbeat. If diagnostic EKGs need to be made in the future, they can be compared with the normal EKG for faster and more accurate evaluation of your health problems. In like manner, troubleshooting your small appliances when they break down will be much easier if you now prepare a set of appliance ECGs—electro*conductivity*grams—while the gadgets are still in good working condition.

Actually, you'll measure the *resistance* to conductivity exhibited by the total circuitry of each appliance because resistance is faster and easier to measure than is conducitivity. All you need for the job is a voltohmmeter (VOM) that can be purchased from a retail audio supply store. Prices start about ten dollars at your local Radio Shack store.

Measure the Resistance

To measure the total circuit resistance of an appliance, unplug it from the wall socket and apply the meter probes to the prongs of the power cord plug. Adjust the meter control to provide an easy-to-read resistance value when the apliance switch is turned on. If the appliance has several settings (cool, hot, low, medium, high) take a reading at each setting.

You should end up with a "Typical Appliance Resistance Chart" much like the one shown here. So why not just file away this ready-made chart for your own use? Because your brands and models of appliances may have different resistance characteristics, although in most instances they probably will be fairly close to those indicated here. And you can't always be wholly certain that each unit of the identical brand and model will behave in the same manner, for example, two seemingly identical cool-mist humidifiers exhibited resistance of 14 and 25 ohms respectively.

If you don't get around to making up your own chart before something breaks down, use our chart as a rough guide to the *probable* resistance your similar appliance should have. Note that in some cases a resistance range is indicated. The resistance of a power drill may climb from 12 ohms up to an apparent "infinity" reading as the speed control is adjusted. A food mixer may have several separate resistances (32/60/90 ohms, for example) for the high medium, and low speed settings.

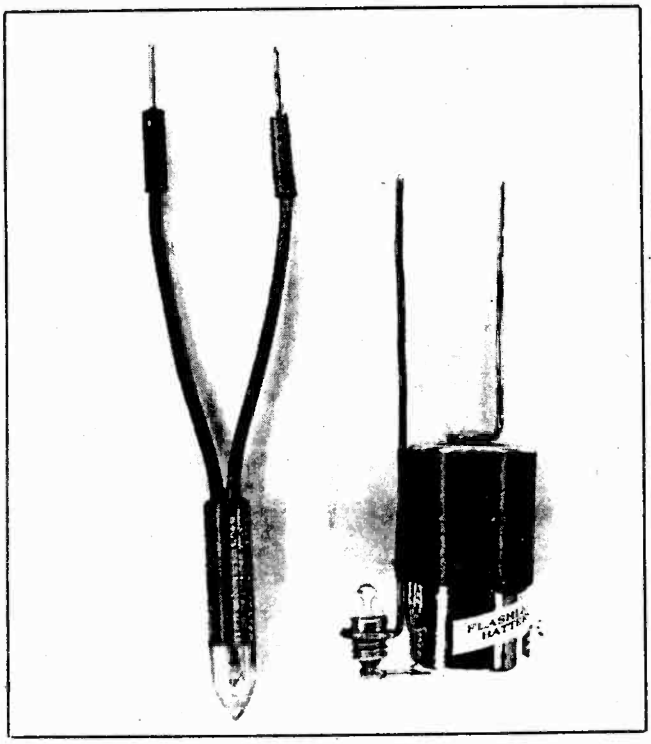
Compare Resistance

By comparing the measured resistance of a defective appliance against the same unit's normal resistance, you can speed diagnosis of the problem. If the appliance still has the proper resistance, look for *mechanical* rather than electrical trouble—stuck gears, for example. If the measured resistance is zero, you should suspect a short circuit in the power cord or elsewhere. If the resistance is very high (infinity) when it should be in tens or hundreds of ohms, search for an open (break) in the circuit; this could be a broken wire, a wire worked loose from a terminal connection, a defective component such as a resistor of thermostat, or maybe nothing more than the accumulation of corrosion products that impede current flow. If the measured resistance is a readable value (other than zero or infinity) but considerably higher than normal, look for a break where only part of the total circuit is affected, thus allowing current to flow through an alternate route having a higher resistance than the combined normal routes. In this case you could pretty well rule out the power cord because a break here would knock out the entire circuit and exhibit "infinity" resistance. Finally if the observed resistance is significantly lower than normal (but still not zero), hunt for a place where current might be leaking from one part of the circuit to another to flow through a shortened, lower resistance path than normal.

TYPICAL APPLIANCE RESISTANCE READINGS

(Measured Across Power Cord Plug Prongs)

Shop Tools	**Ohms**
Power drill, single speed	55
Power drill, variable speed	12 to 8
Soldering gun, 30 watts	28
Saber saw	
Radial arm saw	1.5
Circular saw, portable	3.8
Belt sander, portable	2
Orbital sander	28
Router	2.5
Drill press	1.5
Shop vacuum	3
Tool grinder	5
Kitchen Appliances	**Ohms**
Toaster, 2-slice	12
Toaster, 4-slice	8
Toaster oven	10 to 18
Waffle iron, 550 watts	24
Knife sharpener	10
Food mixer, hand-held	65 to 110
Coffee maker, 4 to 8 cups	30
Personal Items	**Ohms**
Shaver,	1000
Hair dryer, hand-held, 275 watts	28/55
Face massager	90
Electric blanket, 2-contact jack	115
Misc. Appliances	**Ohms**
Steam iron	12
Vacuum cleaner	13
Space heater	17
Hedge clipper	17
Humidifier, hot mist	3000 to 4000
Dehumidifier	7
Slide projector, 300 watts	2
Shoe buffer	32
Timer clock	900

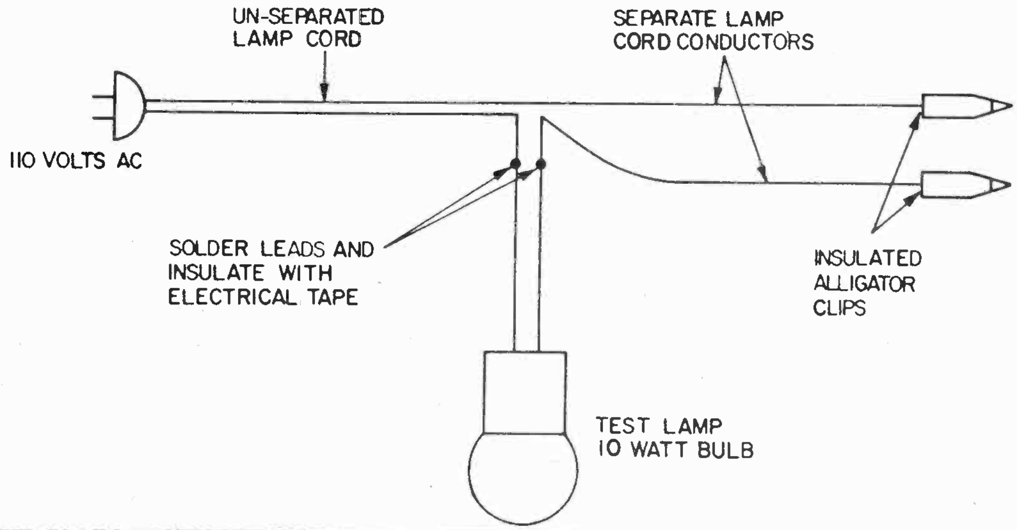


A handy continuity tester can be made by soldering a stiff copper wire to the end terminal of a size D flashlight battery, and taping a second wire to the body of the battery after forming a loop to hold a ½-volt flashlight bulb. Solder a short length of wire from the end contact of the battery to the bottom of the battery. Other ready-made neon test lamp is handy for checking 110-volt circuits, as in home wall outlets to make certain that fuses or circuit breakers have not blown to cause seeming malfunction of appliances.

Once you learn the very simple technique of making resistance measurements with a VOM, and get the hang of interpreting the results, your trouble shooting skills increase greatly. Obviously the VOM provides much more significant information than you could obtain with a simple continuity tester (such as the battery-bulb tester shown in this article) which usually shows only whether a given circuit will or will not pass current of low voltage. However, the continuity tester is worth building because a great many appliance problems can be found with this simple device.

Testing for Continuity

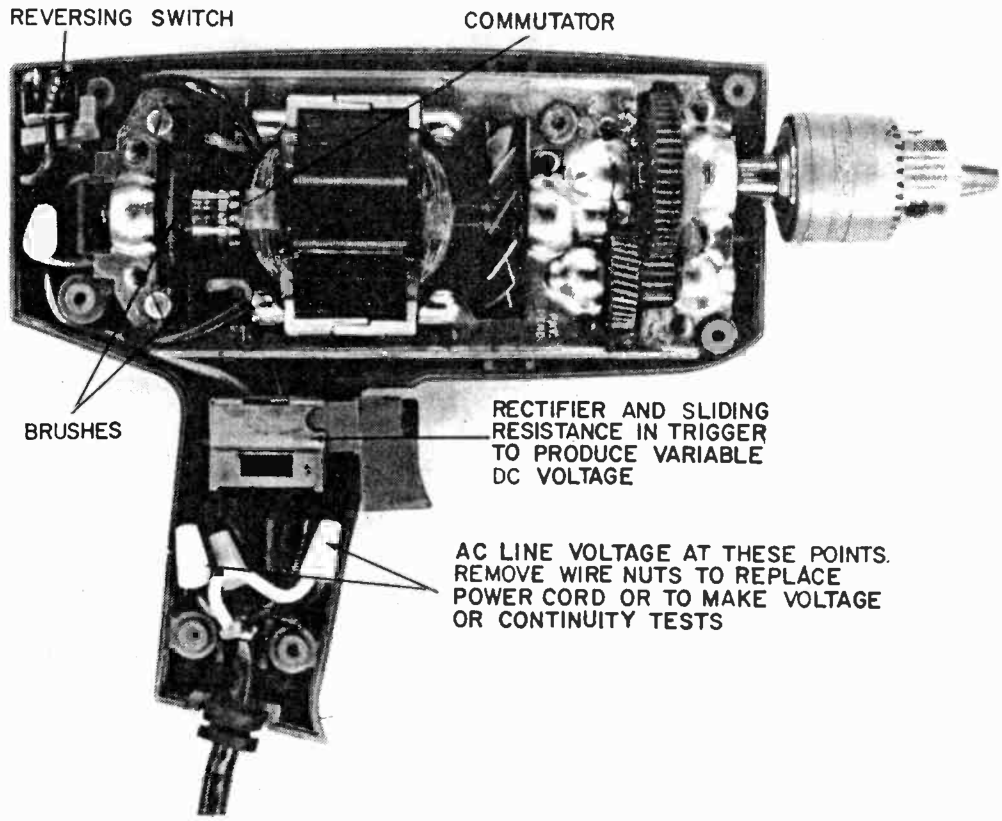
If you have reason to suspect the power cord of a defective appliance, either the VOM or bulb continuity tester can be used to check the cord. If the cord can be separated from the appliance, hold one probe of the continuity tester or VOM to a contact in the plug-in section, and touch the other probe to each of the wall plug prongs, one at time. If the bulb lights when touched to the other, you know that one conductor is free of breaks and has no short circuit to the other conductor. Now move the probe to the other contact in the plug-in section, and test the prongs again. If the bulb lights when touched to one prong, but not when touched to the other, the second conductor is OK. If the bulb fails to light when the probe is touched to either prong, a break in the wire or a loose connection inside one or other of the end



Operational safety of a repaired appliance can be determined with this easy-to-build tester consisting of a trouble light with a 10-watt bulb, a few feet of lamp cord, a plug, and two insulated alligator clips.

sections is indicated. If the bulb lights no matter which prong is touched, look for a short circuit. The VOM provides the same information except that a break is indicated if you get an infinity resistance reading no matter which prong of the wall plug you touch while the meter's other probe is held against one contact at the other end of the power cord. If you get zero resistance reading at both plug prongs while the other probe remains in contact with the same terminal at the other end of the cord, a short circuit is indicated.

If the power cord is permanently wired to the appliance, open the appliance and disconnect the power cord before making the test. Be sure to reconnect the wires as they were before—black to black and white to white in most cases. If the cord has



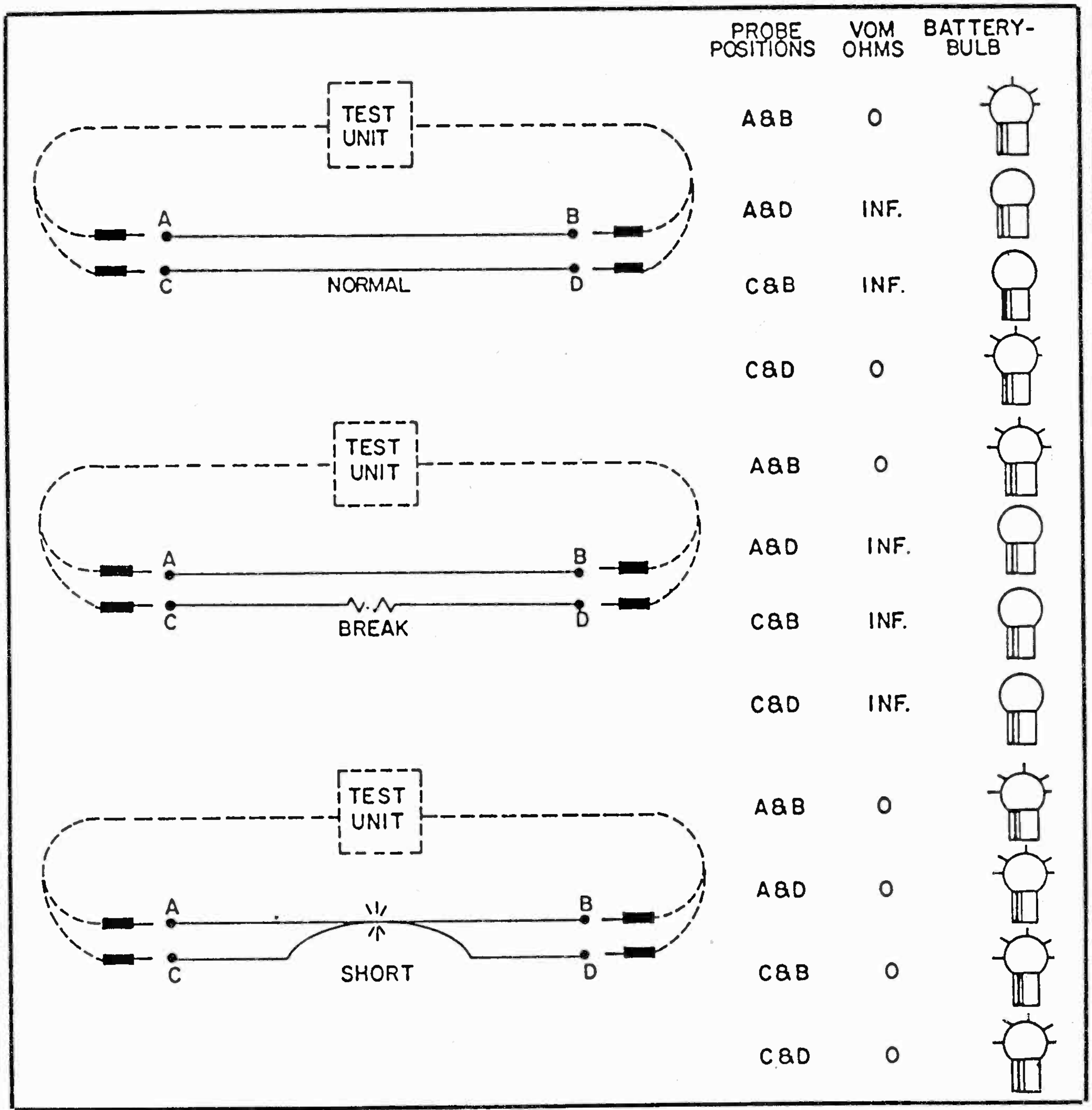
Though it looks complicated, a modern variable speed power drill is easier to troubleshoot than you might imagine. Things you can do: clean commutator, change brushes, replace power cord. If you make voltage checks on a variable speed drill, remember that the current is AC where the power cord is attached, but DC on the other side of the trigger.

a three-conductor grounding cord that terminates in a plug with three prongs, be extra careful to reconnect the ground conductor to its proper place inside the appliance. Otherwise you may feed lethal current to the outer body of the appliance.

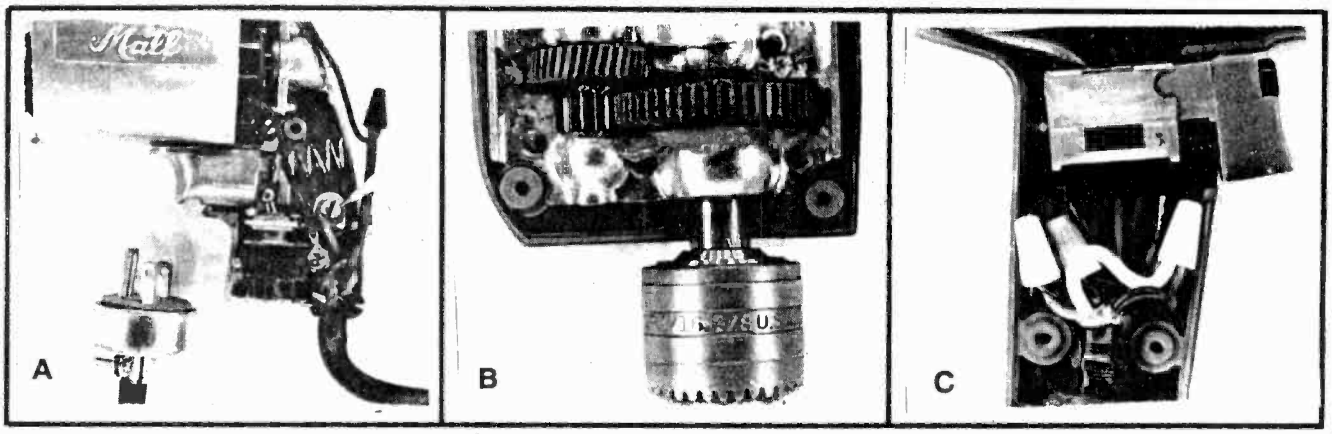
Safety Checks

Before a repaired appliance is plugged in for a final performance test, you should make some sort of safety check to be certain that there isn't a short to the outer body or other metal part of the appliance or tool. The VOM can be used by touching one probe to the metal housing of the appliance and the other alternately to each of the prongs of the power cord plug. If you get anything other than an infinity reading on the meter as you dial through the various multiplier settings of the ohmmeter portion of the VOM, repair the indicated short before you apply 110 volts to the appliance.

The VOM safety check is better than none at all, but not as reliable as the test you can perform with the simple tester shown in the drawing, because the higher, 110-volt test voltage can "punch through" a poorly insulated place to reveal a potential hazard that the very minute voltage generated by the VOM cannot do. Before using the tester, be certain that the



Appliance power cord tests, using either a VOM to read resistance or a simple battery-bulb continuity tester, yield the indicated results when the test instrument probes are applied in the four possible combinations. Note that a conducting condition that causes the bulb to light is observed as zero ohms resistance, and a nonconducting condition indicated by an unlit bulb is observed as infinite ohms resistance.



A Old style power tools that do not have insulating plastic housings should be fitted with three-conductor grounding cords. Here the ground wire is attached to a bolt used to hold the switch in place. Worn grommet where power cord emerges from the tool should be replaced.

B Cause of malfunction of a tool or appliance can sometimes be mechanical rather than electrical. For example, drill gearing systems may reveal damaged gear teeth, or grease may have dried out or become dirty. Replacement of damaged gears would be a factory or service job, but you can easily clean out old grease and pack with fresh lubricant.

C Trigger of a variable speed power drill contains a silicon-controlled rectifier (SRC) to convert incoming AC current to DC current, and a slide resistor to vary the voltage and thus vary the speed of the drill motor. If malfunction is traced to this component, replace with a new trigger unit.

bulb is good. Then attach one alligator clip to the metal housing of the appliance (in an unpainted area) and the other clip to one of the prongs of the power cord plug. *Momentarily* insert the tester plug into a wall socket while you keep clear of the appliance and tester. If the bulb glows you have a hazardous short. Perform this test with the appliance switch in both on and off positions. *Caution:* Do not leave the tester plug in the wall socket even for a moment; withdraw it as you take your hand away so that you won't accidentally get a shock from the alligator clips. The tester can also be used as a continuity tester for power cords. Observe the same safety rules; make the proper clip connections, stand clear, then plug the tester into a wall outlet momentarily.

Power Tools

Troubleshooting a single speed portable power drill is quite simple. First check the power cord in the manner already described. If the cord is good, make resistance or continuity tests from the power cord terminals to the brush terminals. If there's no indication of current flow, look for a break between the power cord and brushes. Unloosen and retighten any connecting screws, bolts or nuts; the scrapping action can cut through corrosion that may be impeding current flow.

If the brushes look worn, replace them with new ones you can obtain from an appliance repair shop or hardware store. Accumulated dirt on the commutator, which could impede current flow from the brushes, should be cleaned off carefully with a piece of rough cloth. Avoid the use of sandpaper, steel wool, or other harsh abrasives that could scratch the commutator or leave gritty or gummy particles in the works.

If your old-fashinoned drill with a metal housing does not have three-conductor grounding cord, it would be wise to add one. Connect the current-carrying conductors of the new cord in the same manner as were those of the old cord. Attach the ground lead to the metal body of the drill. Usually you can find a hold-down screw or bolt (*not* used to connect a wire) to which the ground conductor can be added. Use your VOM or continuity tester to make sure that the body of the drill is in fact connected to the third, odd-shaped prong on the power cord plug.

Troubleshooting a modern, variable speed drill is somewhat different. Such drills do not need a three conductor power cord because the plastic housing provides virtually foolproof protection.

To test or replace the power cord, open the drill casing *slowly* while you peer in through the crack to make certain you know where all the inner parts fit.

Resistance measurements made at the prongs of the power cord will vary, depending on how the speed control is set; expect a reading of about 12 to 25 ohms at the higher speed settings, and a seeming infinity reading at very low speed settings.

To make voltage checks, lay the opened drill on a pad of towels (to keep it from sliding around), preset the speed control to a low level, lock the trigger into the "on" position, and then carefully plug the tool to the power source. *Caution:* Do not attempt to run the open drill at any speed but a low to medium.

You should find 110 to 120 volts AC at the power cord terminals. But on the other side of the trigger switch you will be measuring variable DC voltage, so reset your VOM to the DC section, beginning with a high voltage setting and working down until the meter needle provides a reading somewhat away from the end of the scale. If you get no measurable voltage on the DC side, the SCR (silicon-controlled rectifier) or the slide resistance built into the trigger unit is probably defective. The only solution is to obtain a replacement trigger.

A convenient place to make DC voltage checks is at the terminals of the double-pole-double-throw reversing switch (if your drill is reversible). At very low speeds you might find only about 4 volts DC at these

(Continued on page 96)

ANTIQUE LOOP ANTENNA

Pulling in DX broadcasts on AM with old-time loop antennas is easy. Here's how.

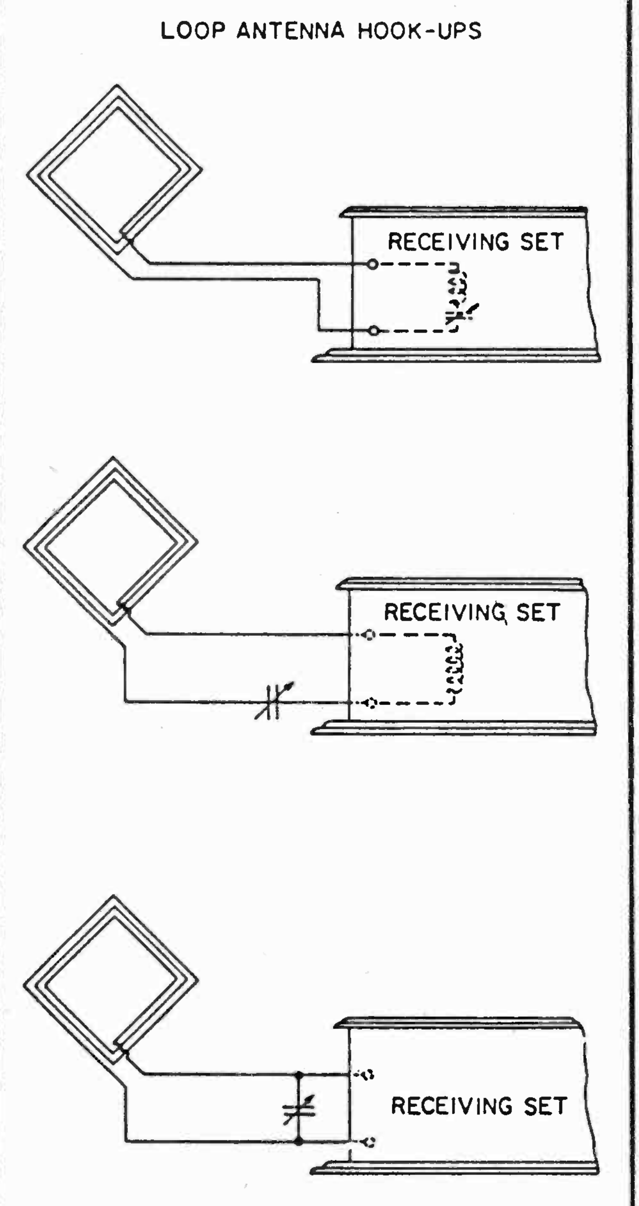


Figure 1. The diagrams shown here detail three different ways of connecting a loop antenna to a T RF AM receiver (or even a modern superhet). In each case the internal antenna tuning circuit determines what method should be used.

Many readers have asked me how to make an antenna that is similar to the old long-line antennas our grandparents used to string between the house and a nearby tree, but without taking up all that room outdoors. Those antennas were up to a hundred feet long, and they were great for pulling in distant (DX) AM broadcast stations, especially at night.

The answer in most cases is a Loop antenna, shown in the drawings accompanying this article. These antennas were widely used in the middle Twenties, when lots of people were putting together radio sets from plans published in newspapers and magazines. This was before the days of built-in loopstick antennas which are common in AM sets today. Actually, those old-time loops were much more efficient than the smaller, modern loopsticks. They were also highly directional. That is, they could discriminate in favor of a station coming from one direction as opposed to another station coming to the receiver from another direction.

The main drawback to reception in those days was often found to be the absence of outdoor space in which to hang the long-wire antenna. In fact, Atwater Kent, whose name was on his thousands of early sets, published plans for outdoor antennas in his instruction manuals which were supplied with his receivers.

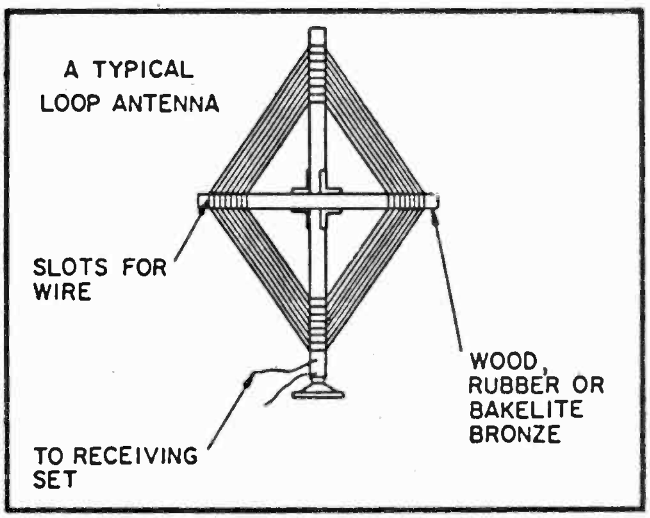


Figure 2. This is a typical loop antenna. Its small (relative) size made it effective when a long-line antenna outdoors was practical. Works fine today too.

In large cities where there were many broadcasting stations only 10 to 30 miles from the listeners a loop antenna became a successful substitute for an

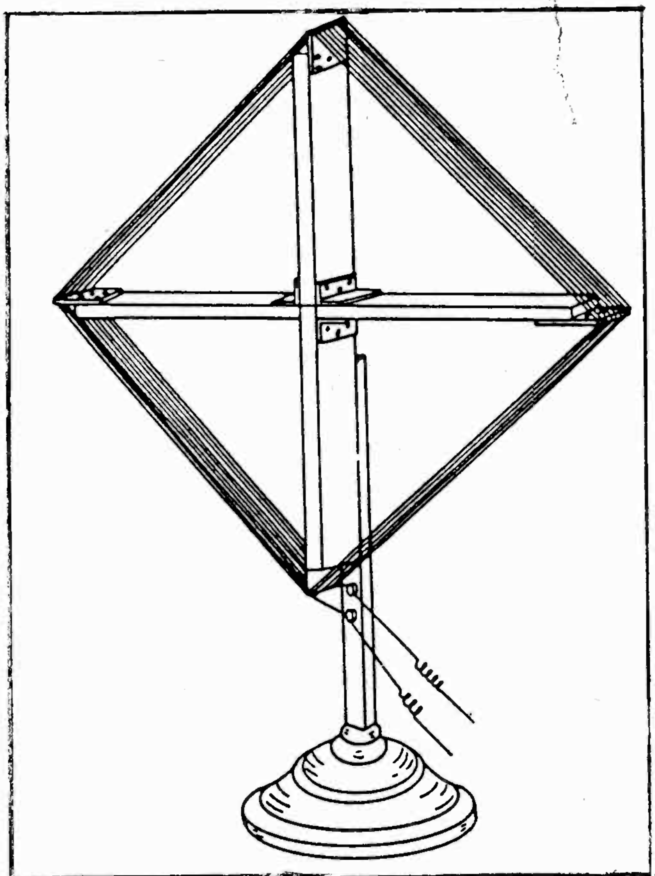


Figure 3. This shows details of a build-it-yourself loop antenna. Use the dimensions shown in the table in Figure 4 to get the spacing and number of turns you need for the broadcast band (AM).

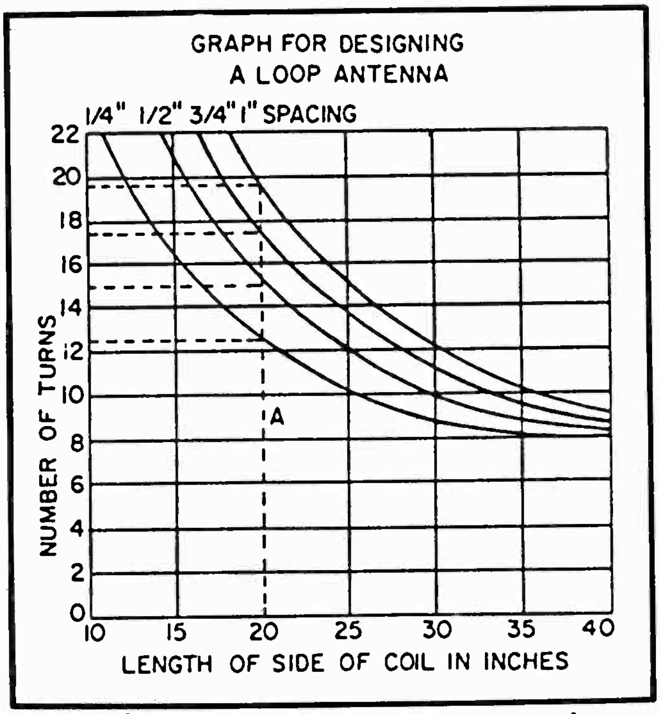


Figure 4. Loop antenna dimensions, for AM band.

outdoor antenna. The loop antenna consisted of several turns of wire wound on a wooden form varying in size from a square one-foot on a side to a square four feet on a side. In spite of its small size it would receive almost as many stations as an outdoor antenna. In addition to its compactness another advantage to the loop antenna was that a ground wasn't necessary with the loop. One big advantage to a loop antenna is its directivity. In most cities there is much electrical interference and man made noise. The loop antenna picks up the loudest signal when the loop is turned so its flat side faces in the direction of the station. If the plane of the loop is at right angles to the station very weak signals are heard. Thus by rotating the loop unwanted signals may be attenuated or nulled out leaving the desired station to come in free of interference.

The method for making a loop may vary mechanically, but the following information can be used if you want to build a loop for a radio that never had one or if you want to replace a loop if the original is lost or broken. For most purposes the wire used for a loop can be number 20 or 22 bare copper wire. If you can find some cotton covered stranded (Litz) wire it will make the loop look very much like an original. The strands of wire can be spaced from ¼ to ½ inch apart. A loop made on a four-foot square wound with six to eight turns of wire and tuned with a .001 mfd. capacitor will cover the whole broadcast band. If the size of the loop is smaller, the number of turns of wire must be increased. Thus for a 20-inch square there should be about 16 turns of wire. In general about 100 feet of wire will be needed for a loop. It is evident that as the loop gets smaller in size it begins to resemble the conventional tuning coil.

More Details

Using the table it is a simple task to make a loop which will work with most of the three-dial tuning battery receivers. The first thing to do when building a loop is to decide how big to build it. Then you can find the numbers of turns of wire and the spacing from the chart. Let's assume that you want to build a loop 20

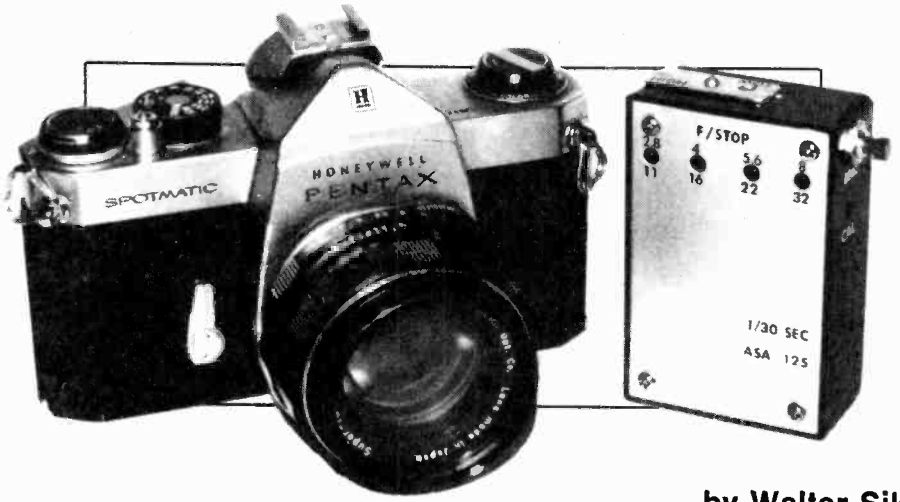
(Continued on page 93)

Turns of wire (20-22 size)	Spacing, in inches	Cross-arm length, inches	Length of wire, feet
11	1 1/4	66	135
12	1.0	52	117
13	3/4	43	105
14	9/16	35	92
15	29/64	30	81
16	3/8	26 13/16	77
17	9/32	21 1/2	67

Wiring for AM band loop antenna. Larger loops will pick up more distant stations.

Build this low-cost light meter now.

LIGHT MASTER PHOTO METER



by Walter Sikonowiz

Light Master is a photographic light measuring instrument without the usual (needle-and-scale) mechanical meter. Instead, it uses light-emitting diodes (LEDs for short) to tell you what lens opening to use. In addition to cutting the cost by more than 50 percent, eliminating the meter has other advantages. The chance of damage from dropping is much less. People with no knowledge of photography can easily use this exposure indicator once taught the significance of the displays.

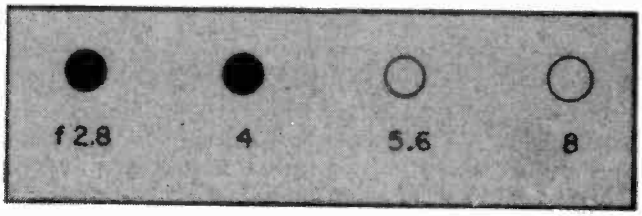
Finally, because the readout is on LEDs, it's always easy to see, even in low light where an ordinary meter's needle might be hard to read accurately.

This comparator-LED light meter is ideal for the serious beginning or intermediate photographer because most people shoot with the same speed film most of the time. And if you do use two or three different speed films, it's easy to apply a conversion factor to the lens-opening scale.

It's a one-speed-range photographic light meter which tells you at what f-stop diaphragm opening to set your 35 mm or other precision camera lens. It provides readings for setting your camera lens opening between f-stops as large as 2.8 and as small as 32. These are based on the most popular black-and-white film for 35 mm use, Plus-X, a widely available fine-grain film.

Photo Basics

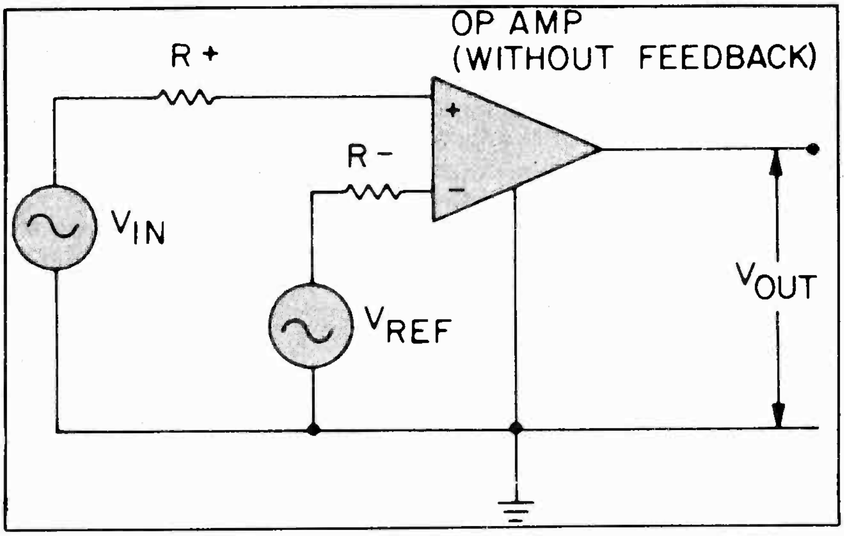
Before we discuss how the meter works let's review some basic photography. The photograher is concerned with three numbers when making an exposure: 1) the ASA rating (the speed) of his film, 2) the f-stop of the lens aperture, and 3) the speed of the shutter. Let's see how these factors interrelate. Suppose you take a correctly-exposed picture under light of intensity **I**, with f-stop **n** and exposure time



This is the way the LED readout of the light meter looks when the amount of light measured is just right for a lens opening of f. 5.6 The two LEDs at the left are dark, the two at right are lit up.

equal to **T**. If the intensity suddenly jumps to **2** times **I**, we compensate by either reducing the aperture (multiplying the f-stop by 1.4) or by reducing the exposure time by half—**T/2**. And if the light intensity is reduced by half you would compensate either by making the f-stop 1.4 times larger, or by increasing the exposure time to **2T**. This assumes, naturally, that the film's speed (ASA) remains constant.

Now suppose that a correctly-exposed photograph is made under light of intensity **I**, with f-stop = **n**, and exposure time = **T**. To take the same picture with a film whose ASA rating is twice that of the original, you'd compensate by making the f-stop = **1.4 n** or by making the exposure time = **T/2**. To take the same picture with



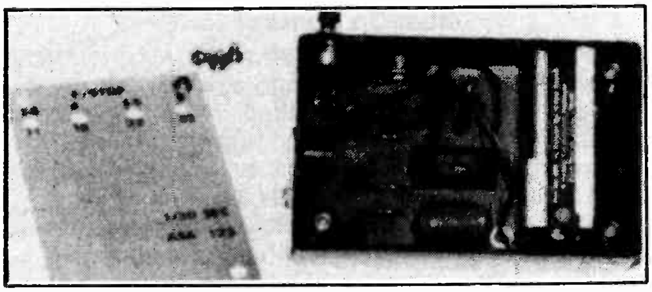
An Op Amp without feedback has extremely high gain. It can be used to compare an input signal voltage (unknown) with a known (reference) voltage. It will indicate clearly, by the output going to saturation, or by staying at its initial (very low) voltage that the unknown voltage is either below or above the reference voltage. This make it a comparator.

a film whose ASA rating is half that of the original film, make the f-stop = **n/1.4** or make exposure time = **2T**.

Use a High-Gain Amplifier

Suppose we take a high-gain differential amp and place a known voltage on one input, an unknown on the other. Since we're using the amp open-loop (without the usual feedback), only a small voltage difference at the two inputs is required to send the output either to saturation or to cut-off. Specifically, if the voltage at the non-inverting (+) input is a few millivolts greater than that on the inverting (-) input, the output will go high. Likewise, if the voltage on the inverting input is the greater, the output will go low.

There are limitations to the size of the voltages which may be compared. For the LM339, a comparator, input voltages should be less than



Here's how the author's light meter looks inside. To keep it small, make a printed circuit board as shown. Perf board is OK, too, but will require a bigger box.

supply voltage (V)-1.5V. Furthermore, these input voltages should be much greater in magnitude than a few millivolts, to swamp out measurement errors due to the inherently imperfect nature of the comparator itself. Between these extremes a comparator can give a very accurate answer to the question, "Is the unknown voltage above or below the reference voltage?"

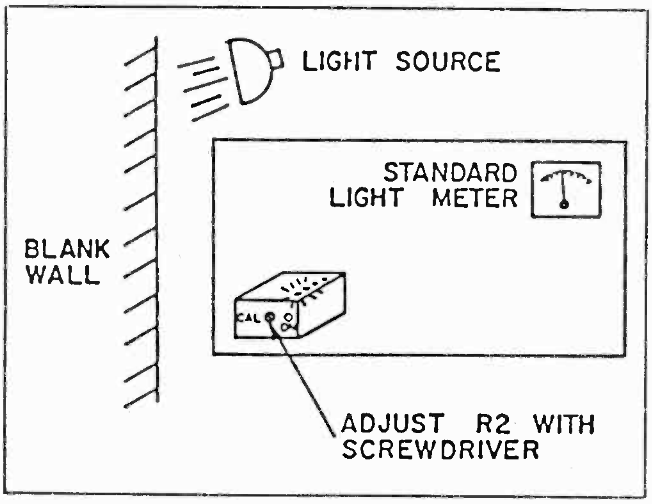
The LM339 incorporates four comparators on a single chip. If one input of each comparator reads some common, unknown, voltage, while the other four inputs connect to different reference levels, then the size of the unknown voltage can be estimated by observing the output states of the comparators.

Figure 1 shows the LM339 as the heart of a light meter. All the inverting inputs to go the junction of PC1 and R1, and thus sense a voltage whose magnitude increases as the intensity of the light measured increases. C2 bypasses any interference caused by fluorescent lighting in the vicinity. The non-inverting input of each comparator goes to a reference voltage, with section A connected to the lowest reference voltage and section D to the highest. Consequently, in very dim light all four comparator outputs will be at cutoff, hence all four LEDs will be estinguished.

As the light intensity increases, section A will be the first to change state (rise toward saturation) and thus cause LED1 to light. At higher intensities LED1 and LED2 will both be turned *On*. The reference voltages I used were chosen to correspond to differences in lens aperture of one f/stop. Thus, a display like the one shown here would indicate that the correct photographic exposure is between f/4 and f/5.6

Notice that in contrast to the continuous readout of an analog meter, this comparator system of voltage measurement indicates proper exposure as being between two levels. In order to get better resolution (more detailed information as to lens opening) we would need more comparators. We would also need more comparators if a larger measurement range is desired. To accomplish such a range expansion we could add another LM339—inputs 4, 6, 8 and 10 would go to the junction of PC1 and R1, while pins 5, 7, 9, and 11 would go to new (added) reference voltages. However, there is a cheaper method of range expansion. We simply install a variable aperture in front of the photocell. In this way the measurement range of he photometer is doubled to 8 stops by using two apertures whose areas are in the ratio of 16:1. This is the scheme I adopted for this meter.

The total measuring range of this instrument thus spans from f/2.8 to f/32 with ASA 125 film (such as Plus X) at a shutter speed of 1/30th second. Later on we'll discuss the simple mathematical conversion

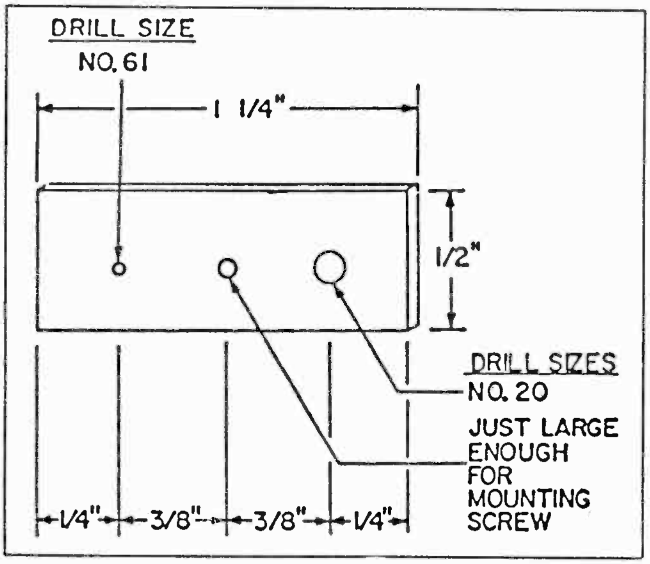


Use this setup to calibrate the light meter. You'll need to borrow an old-fashioned (analog) light meter that's in good working order to follow this calibration procedure.

necessary to allow use of the light meter with different film speeds and different exposure times.

Actual construction is non-critical, but will require some care because of its small size. A printed circuit board was used in my prototype, and although it is not necessary that you use the printed circuit, it would be wise to copy the same general layout as the prototype. It's housed in a 3-1/4×2-1/8×1-1/8-inch plastic minibox. If you use the same box, note that the mounting post in the upper-right-hand corner must be removed to make room for S1. A soldering gun with a cutting tip was used to slice out the mounting post, leaving three posts to hold down the metal cover of the box. If you are inexperienced in small-scale construction, by all means use a larger box. Regardless of the box size used, however, the following construction details given will still apply.

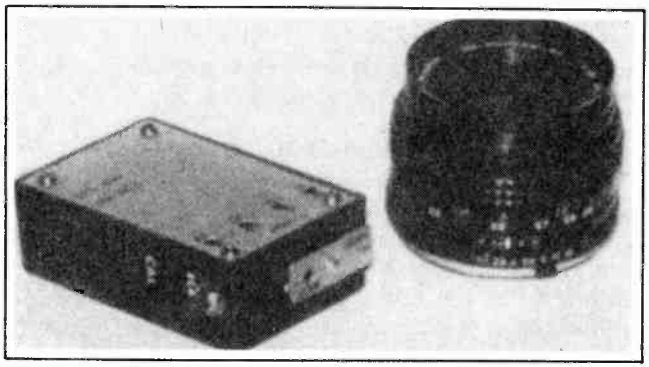
When the board has been completed, mount the IC socket, trimmer R2, and all resistors and capacitors.



The dimensions of the range-extender for the light meter are shown above. It's a simple piece of aluminum with two different holes. The middle hole is for mounting the strip to the front of the meter.

Next, solder the negative lead from the battery clip to its hole near pin 12 of the IC socket. Solder a 2-in. length of flexible wire to the hole indicated in the upper-right-hand corner of the board. This wire will later be connected to S1. Now mount the photocell so that its light-sensitive face is perpendicular to the board and facing toward its upper border. Finally, mount the four LEDs into the circuit board, but be sure to observe proper orientation. The tops of the LEDs should all extend the same distance above the board—about 7/8-in if you have a cabinet of the same depth. Now plug IC1 into its socket and set the board aside temporarily.

The range selector is just a simple aluminum plate (about 18 gauge) with the dimensions shown in the diagram. Note that two holes, one #20 and one #61, must be *carefully* drilled, Further note that the plate must be absolutely flat. Don't cut it out with tin snips. Use a nibbling tool or hacksaw, which will cut the



The light meter is about the size of a good lens, as shown here (Pentax Rokkor f = 7.7, 50 mm.).

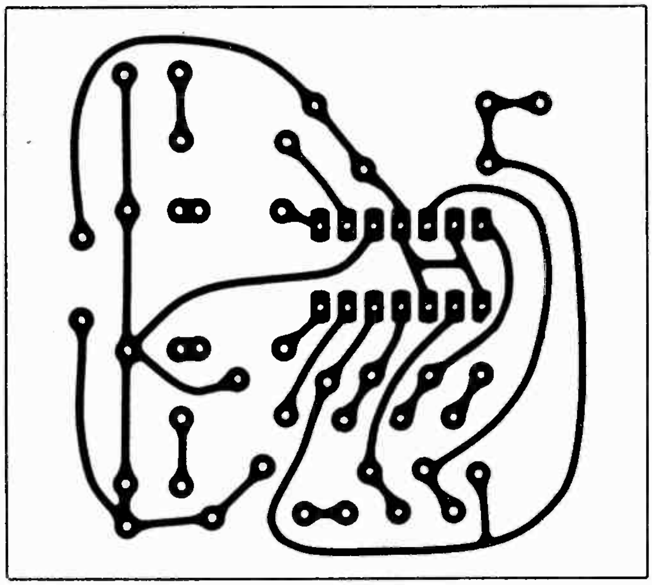
aluminum without distorting it. Now use a file to round off all the edges, and then buff it with steel wool. This will make the range selector rotate readily when you're out shooting.

More On Construction

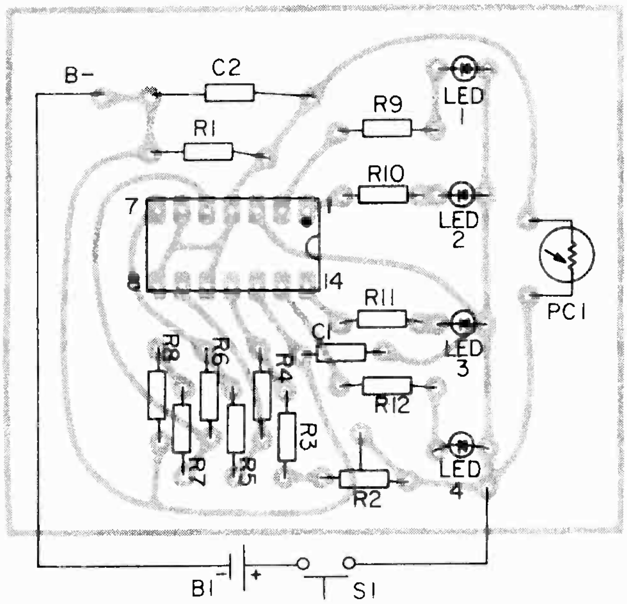
The drawing of the cabinet shows how to mount the photocell relative to the range selector. When the proper holes have been drilled, mount the range selector with #2 hardware and tighten until the fit is just snug. Use a drop of epoxy to lock the nut to the shaft of the bolt, and let the cement dry.

S1 may be placed wherever it is convenient. Be sure to drill a hole to allow calibration-adjustment of trimmer R2 from the outside. Now locate and drill four holes in the cover to allow the LEDs to be visible. The exact location of these holes will depend upon the dimensions of your case and the dimensions of your board. Simply insert the board into the bottom of the box and measure how far from the sides each LEDs center is located. Transfer these dimensions to the cover and drill four #22 holes.

Mount the board in the cabinet so that the photocell lies directly behind and flush against its mounting hole. If you used the same size box as I did the 1/4-in. spacers will be needed between the board and the bottom of the case to allow the LEDs to protrude slightly through the thin metal cover. After the board has been securely mounted, take a 1/4-in. wide, 1-1/2-in. long strip of black electrical tape and wrap it around the perimeter of the photocell.



This is an oversize template for the printed circuit board, if you want to make yours like the prototype. See the text for suggestions on making printed circuit boards if this is your first one.



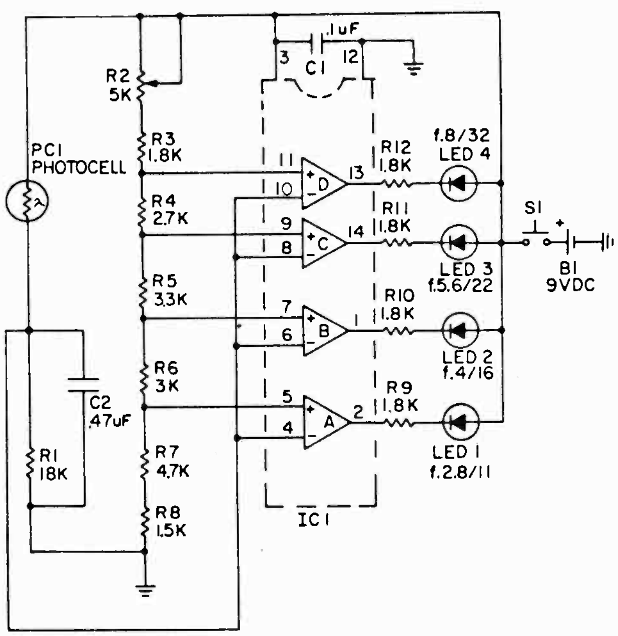
Here's the parts placement layout on the printed circuit board for the light meter. If you use perf board, you can put the parts wherever it's convenient.

This will keep stray light from hitting the face of the photecell. Solder the positive lead from the battery clip to one side of S1. To the other terminal of S1 solder the short lead from the circuit board. Finish off by mounting the cover and applying press-on decal labels as desire.

Set the range selector to the low-light measurement position (the larger hole), then point the meter towards a bright light bulb and depress S1. One or more LEDs should light, depending upon the brightness of the source. If not, go back and check whether any components have been improperly oriented. When all is working well, only the calibration of the meter remains. Borrow a good light meter for this task. Choose a large, preferably blank wall and evenly illuminate it (avoid using fluorescent light sources, however). Adjust, the light source and the distance until your reference meter indicates f/8 at ASA 125 and 1/30 sec. When you have obtained the correct reading on your reference meter, hold your meter in the same spot and point it in exactly the same direction that the reference meter had been facing. Press S1 and adjust R2 so that LED4 (the one farthest)

(Continued on page 94)

PARTS LIST FOR LOW-COST LIGHT METER



C1—0.1 uF capacitor (Radio Shack 275-135)
C2—0.47 uF capacitor (Radio Shack 272-1071)
IC1—Quad comparator IC LM 339 (Radio Shack 276-1712)
LED 1, 2, 3, 4—Light-emitting diodes
PC1—Cadmium sulfide photocell (Radio Shack 276-116)
R1—18,000-ohm resistor (Radio Shack 271-000)
R2—5,000-ohm potentiometer, PC-board type (Radio Shack 271-217)
R3, 9, 10, 11, 12—1800-ohm resistors (Radio Shack 271-000)
R4—2700-ohm resistor (Radio Shack 271-000)
R5—3300-ohm resistor (Radio Shack 271-000)
R6—3000-ohm resistor (Radio Shack 271-000)
R7—4700-ohm resistor (Radio Shack 271-000)
R8—1500-ohm resistor (Radio Shack 271-000)
S1—SPST momentary-On switch (Radio Shack 275-609)
Miscellaneous: Minibox 3 1/4-in. x 2 1/8-in. x 1 5/8-in. or larger (Radio Shack 270-230), socket for IC1 (Radio Shack 276-1999), 9-VDC battery, clip for battery (Radio Shack 270-325), wire, solder, PC board, etc.

Note: All resistors are ½-watt, 20% carbon types, except R2.

New Franklin ACE computers run most of the software programs available for both the Apple IIc and Apple IIe micros.

BEST-BUY FRANKLIN ACE 2000 COMPUTER

Up-To-Date Apple Clone Adds Features, Runs Apple II Software, at Lower Price

by Jon Graham

For several years Apple microcomputers led the pack, along with Tandy/Radio Shack's TRS micros. Then IBM brought out its widely-imitated PC (personal computer) to set a new standard. But Apple brought out newer models besides its II, II+, Lisa and McIntosh. *The Apple IIe* became the most widely-sold home, school and small business microcomputer, not counting the IBM-alikes. Apple then developed a similar model, the *IIc,* which also was sold by the hundreds of thousands. It too was also highly successful in the home, educational and small-business markets.

Now Franklin Computer, a mid-sized firm headquartered in Pennsauken, New Jersey, has brought out its latest counter to Apple's widely sold micros, and they have a real winner in the Franklin ACE 2000 series.

The Franklin has a more grown-up, up-to-date, what-a microcomputer-should-look-like appearance than the two Apples it emulates, the Apple IIe and IIc. Where they have many keys combined on a small keyboard, the Franklin provides more keys on a full-size keyboard, 30 per cent larger than the Apple keyboards.

Further improving on the Apples, Franklin's keyboard is totally separate from the rest of the micro,

TABLE I. COMPARISON OF FRANKLIN SYSTEM WITH APPLE IIe AND IIc

LIST PRICE*	FRANKLIN $999	APPLE IIe $2039	APPLE IIc $1424
128K RAM	Std.	Opt.	Std.
80-column display	Std.	Opt.	Std.
Parallel printer card	Std.	Opt.	N/A
Serial interface	Opt.	Opt.	Std.
Graphics screen dump	Std.	N/A	N/A
Expansion slots	Std.	Std.	N/A
Detachable keyboard	Std.	N/A	N/A
Numeric keypad	Std.	Opt.	N/A
Function keys	Std.	N/A	N/A
Dedicated editing keys	Std.	N/A	N/A

*These prices do not include cost of Monitor, Software, or printer. N/A means Not Available on this system. Opt. means Optional at added cost.

connected only by a flexible coil-cord, just like other up-to-date micros. In addition, where the Apples display only 40 rows of text (80 is an additional-cost option), the Franklin is supplied with an 80-column display as standard.

The price of the Franklin includes everything needed for a complete system except the monitor (in case you already have one). And their monitor is a highly-attractive, position-adjustable unit.

Put these features together with a system which runs over 90 per cent of all software programs available for the Apples, and package it at a price one-third or more below comparable Apple systems, and you've got a winner. Many dealers around the country are carrying and servicing the Franklin line, and Sears, Roebuck has recently added the Franklin to its home computers (along with IBM PCs) putting its many years of satisfying American families behind the Franklin name.

The photograph at the head of this page, along with the others in this article show how Franklin has gone all out to pass Apple. Like many pioneers, Apple's ground-breaking earlier models are now giving way to later designs, in this case the Franklin.

Apple's keyboard unit includes the main computer parts, except the disc drives, which are entirely separate. Franklin, like IBM and its many clones, has the disc drives right in with the main unit, where they belong.

Like Apple's IIe (and the IBM) Franklin has space inside its main unit for adding extra cards for color, for a modem, and/or other features (the Apple IIc can't do this). But unlike the Apples, Franklin includes all circuits needed for the 80-column display, the monitor connection, printer connection, and the disc controller. Apples require that some or all of those be added (and paid for extra).

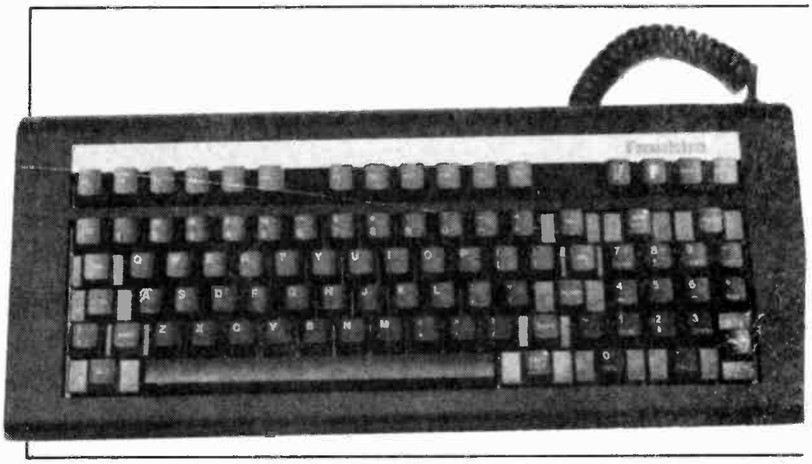
Table I lists the features of the Franklin ACE 2000 micros comparing them with the Apple IIe and Apple IIc. Price and features shown are for a complete system (excluding a monochrome monitor) but with two disc drives, and parallel printer interface (what good is a micro without a way to hook up a printer?.

The Franklin does its most useful work, word processing, with any of several programs developed for Apple micros, including the widely-available Appleworks.

I used it with an inexpensive program developed specifically for Apple called Trio. It took me less than half an hour to learn enough about Trio to start writing letters and reports with it. And the Franklin hooked up directly to my two printers, an Epson and a low-cost SCM printer, functioning perfectly with both of them with no adjustments of any kind. This was a distinct improvement over most of the micros I've tested, which usually require lots of fiddling and studying of the computer and printer manuals (often both) to get printed output from the work done on the micro.

A Doctor's View

Because Apple microcomputers are so widely known and used,we decided to have our Franklin microcomputer checked out by a typical potential Apple customer, one of neighbors. Dr, James Melvin. Here is Dr. Melvin's report, unexpurgated.



Here's the separate 90-key keyboard Franklin supplies which contrasts with Apple's smaller, non-detachable keyboards.

"The Franklin is substantially less expensive to purchase, and has a number of distinct advantages over a similarly-equipped Apple IIe. Here's how they stack up:

1. The Franklin claims to be 2 to 3 times faster than the Apple at accessing data from the disc. In practice it is faster though I did not actually measure it. For $90 you can purchase the Swyftcard for the Apple to accelerate ProDOS to a less frustrating level.

Figure 2.
Franklin microcomputer system has two floppy disc drives in main (CPU) unit, Monitor (shown here atop CPU) can be tilted or rotated for maximum viewing comfort on its own base.

2. The 384K of the Franklin (vs 256 for Apple) would be a very small advantage and only for business applications. If Franklin had offered 512K or better it would have made a more powerful argument.

3. The numeric keypad is a benefit for anyone working with lots of numbers. Apple's numeric pad $100 extra. I liked the basic command functions on the keypad. They could be real time savers.

4. The 12 special-functions keys above the Franklin Keyboard are meant to consolidated multiple keystroke commands once you have programmed them. They seemed superfluous to me and perhaps a double-edged sword, i.e. the time saving could also allow sudden catastrophes.

5. Though I could not figure out how to use it, the Franklin's graphic screen dump feature would seem to be a real plus. The Apple can be made to do this but a special program must be inserted and you must have a knowledge of BASIC language to do it.

6. Although the Franklin has an extensive list of compatible software there is no such thing as 100% compatibility.

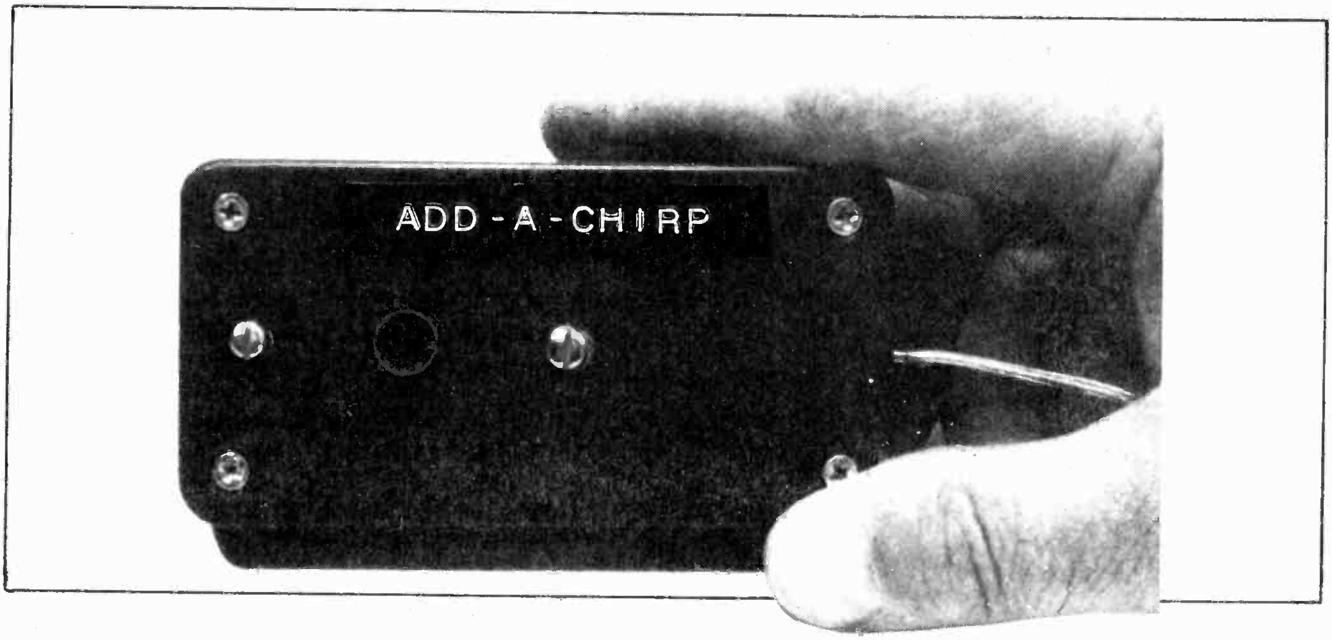
7. The most overriding advantage is the Apple name and image. Apple is a well-known name in the industry. They pioneered the home computer market for the serious user and have weathered the highly competitive marketplace for years. They also have a history of allowing you upgrade your unit as technology advances. It's not easy to put a price tag on this.

8. The fan on the Franklin is too noisy. The Apple has no fan and only recommends one if high energy cards are added to the motherboard. The readily-available Kensington System Saver fan is very quiet

(Continued on page 93)

SOFTWARE TITLE	APPLE SYSTEM	PUBLISHER
Algebra, Vols. 1-4	II, II+, IIe	State of Art
Alice Wonderland	II+, IIc, IIe	Windham
Appleworks 1.1, 1.2	IIc, IIe	Apple Corp.
Bankstreet Writer	IIc, IIe	Broderbund
Bankstreet Speller	IIc, IIe	Broderbund
Barron's SAT Verbal 1,2	II, II+, IIe	Barron's
Barron's SAT Math	II, II+, IIe	Barron's
Beagle's Graphics	all, IIs	Beagle Bros.
Castle Wolfenstein	II, IIc, IIe	Muse Software
Blazing Paddles	II, II+, IIc	Baudville
Charlie Brown's ABC	II+, IIc, IIe	Random House
dBase II	IIc, IIe	Ashton Tate
Delta Drawing	II+, IIe	Spinnaker
Dollars & Sense	II, IIe	Monogram
Dr. Suess Fixup Mixup	II+, IIc, IIe	CBS
Early Games	II+, IIc, IIe	Springboard
Easy Reader	IIc, IIe	American
Flite Simulator	II, II+, IIe	Sublogic
Ghostbusters	IIc, IIe	Activision
Gladiator	II+, IIc	Electro Arts
Math Busters	IIc, IIe	Spinnaker
Homeword Math	II+, IIc, IIe	Spinnaker
Homeword Speller	IIc, IIe	Sierra
Laser Bounce	II+, IIe	Hayden

Table II. Here is a small sampling of the hundreds of software programs developed for various Apple II series home computers which run on Franklin ACE micros. Available at Apple computer dealers as well as Franklin dealers and Sears Roebuck Computer Departments. Most programs list for $40 to $90.



ADD-A-PHONE CHIRPER

Simple extension ringer increases the range of your telephone

If you have only one or two telephones in your home, and need to hear ringing in other areas such as the bedroom, an extra ringer is always a good idea. However, using a clanging alarm bell that wakes up the dead (all over the house) may not be your idea of how to do it. In this case, here's a soothing way to announce phone calls anywhere in your home, without the additional expense of another phone extension or a Bell system ringer (another regular monthly charge added to your phone bill). This device, called Add-a-Chirp, produces a low level chirp (or warble) instead of a clang or, bong.

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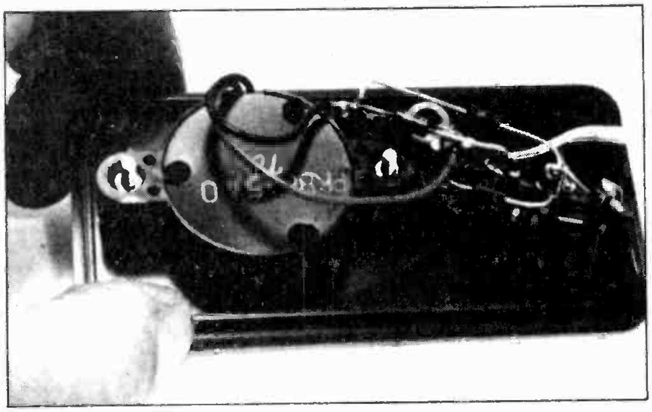
Easy to Build

Add-a-chirp is a simple device requiring few components and is easy to piece together. It is powered by the ringing signal of your telephone.

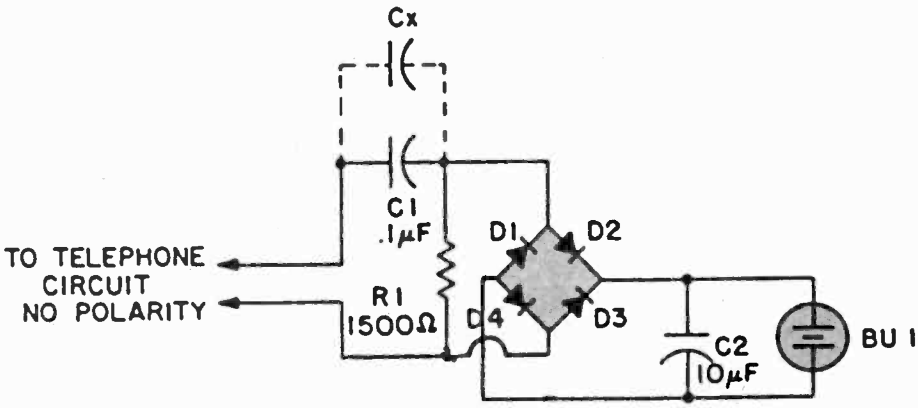
Electronic buzzer BU1 will produce a high frequency whistle (approximately 5 kHz) when 2-12 volts DC is applied to its wires. Normally, the output of the buzzer is a continuous tone because the applied voltage is continuous (DC). As used in the Add-a-chirp, however, the buzzer chirps in step with the 20 Hz ringing current.

The 20 Hz ringing current passes through capacitor C1 to the diode bridge consisting of D1-D4. Partial filtering of the bridge's output is provided by C2. The resultant pulsating DC is applied to the buzzer, producing a high frequency chirp each time the phone rings.

All components values are critical. Any changes in values produces improper operation. Make only those changes or substitutions we specify. A silicon rectifier or full-wave bridge rated 200 PIV or higher can be substituted for D1-D4.



Add-a-Chirp doesn't require many parts or even an assembly board. Just hook up the few parts (nine) on a little terminal strip and it's ready to chirp. Take care when connecting the diodes in the rectifier bridge. Make sure each one is aimed the right way to prevent damage.



PARTS LIST FOR ADD A CHIRP

BU1—solid state buzzer, Radio Shack 273-060
C1—0.1-uF, 500 VDC mylar capacitor
C2—10-uF, 25-VDC electrolytic capacitor
Cx—see text
D1-D4—silicon diodes or small silicon rectifier rated 200 PIV
R1—1500-ohm, ½-watt, 10% resistor
Misc.—cabinet, terminal strip, wire, solder, hardware, etc.

While the PIV can be lower, 200 PIV provides a good safety margin. For most applications C1 should be a .1 uF Mylar capacitor rated 500 VDC. (Again, a lower rated capacitor of 100 VDC could be used but 500 VDC provides greater protection.)

If C1 is made larger, say 0.47 uF, the output of the buzzer will be louder but you will also get kickback, meaning the buzzer will pulse in step with the telephone dial's pulses. If your phone has Touch-Tone dialing, kickback is not a problem, but line static might cause the buzzer to tick.

Capacitor C2 is also critical. If made larger than 10 uF, it will produce a smooth, non pulsating, DC and the output of the buzzer will be a continuous high frequency tone, which is not an attention-getter. If C2 is smaller than 10 mF there will be too much AC and the buzzer will tick instead of chirp; a nice sound but not loud enough for general use.

Add-a-chirp can be connected to your telephone circuit with ordinary zip-cord or speaker wire.

Telephone circuits do vary. Keep in mind that Add-a-chirp is intended for a quiet location, but if the chirp produced by your telephone's ringing signal is too low, connect capacitor Cx, 0.05 uF disc, across C1.

Add-a-chirp can be used as a quiet warning that someone is dialing out on the phone circuit. If capacitor Cx is raised to 0.1 or 0.2 mF, the device will produce chirps in step with the dial pulsations each time someone dials out. (It works with rotary dial telephones.) The total value of capacitors C1 and Cx should never exceed 0.47 mF, nor should the value of R1 be changed by more than 10%. ■

HOW RADIO TRANSMITTERS WORK

Here's the Lowdown on AM Radio Transmission; How Music and Talk Get Out on the Air Waves

"One if by land, two if by sea..." says the famous poem by Longfellow commemorating the midnight ride of Paul Revere in April of 1775. Revere's fellow patriot, who hung the two (if by sea) lanterns in the Steeple of the Old North Church of Boston 200 years ago, was engaged in communicating by modulation, just as surely as today's CBer who presses the PTT switch on his microphone. For modulation simply means variation, or change—and it's modulation, whether you're changing the number of lanterns hanging in a church steeple, or using electronic circuitry to change the radio wave emitted by an antenna in accordance with your voice.

All communication is by modulation. For centuries, the American Indians sent messages by "modulating" a smoke stream with a wet blanket, and primitive tribes have long communicated by modulating the beat of their jungle drums. Later, semaphore flags were used to send messages by modulating their position. Even these words you are reading can be considered modulation of the surface of a piece of paper with spots of ink.

But almost all of today's long-distance instantaneous communication is carried out by modulating radio waves. In fact, this means of communicating is now so commonplace that even the Man in the Street unknowingly refers to modulation when he speaks of "AM" and "FM". These familiar abbreviations stand for Amplitude Modulation and Frequency Modulation, respectively, and refer to the two common methods of changing a radio wave to make it broadcast words or music from one place to another.

Unchanged Waves

A radio wave broadcast from the antenna of a transmitter is, in the absence of modulation by speech or music, an unchanging, constant sine wave, as shown in Fig. 1. It is constant and as unchanging as the steeple of the Old North Church, and conveys no more information than a steeple. It simply gives you something to monitor for the possible later appearance of a signal.

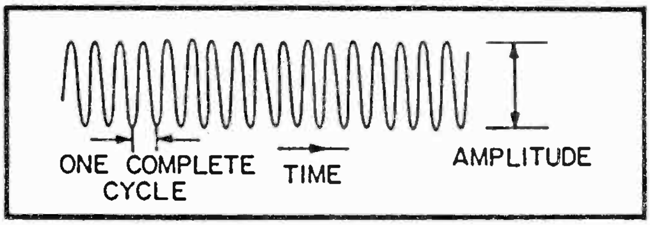


Figure 1. Unmodulated carrier (RF) wave.

Just as the steeple was a support or carrier on which to hang the information-giving lanterns, so the radio wave becomes the carrier upon which the speech or music is "hung". In fact, the unmodulated wave is usually referred to as the carrier.

The carrier may be shown as a simple sine wave, as in Fig. 1.

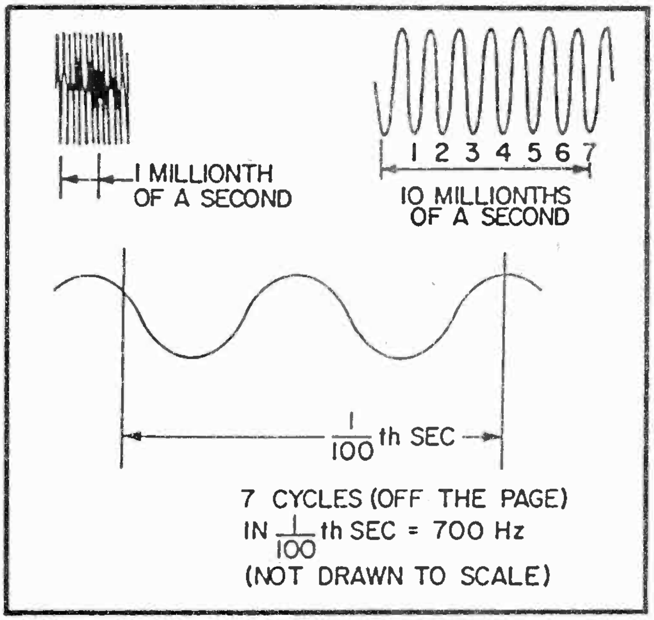


Figure 2. Three different frequency waves. 700 Hz (bottom) is partial, not drawn to same scale as the two higher frequencies.

The height, or amplitude of the wave, indicates the strength of the signal, while the time it takes the wave to complete a certain number of cycles determines the spot on the radio dial where the signal will be received. For example, as shown in Fig. 2a if it takes only a millionth of a second for the carrier to complete seven cycles, then it will complete 7,000,000 cycles in one second, and the signal will appear on a receiver's dial at the 7,000,000-cycle-per-second (7-megahertz) point, which is on the edge of the 40-meter ham band. Such a carrier has a frequency of seven MHz.

On the other hand, a carrier taking longer to complete the same number of cycles—say, seven cycles in 10 millionths of a second (upper right, Fig. 2)—would complete only 700,000 cycles in one second, and would be found on the dial at 700 kHz (700 thousand Hertz), which is in the standard broadcast band.

As can be seen from the above numbers, carrier frequencies are normally very high—much higher than the speech or music (audio) frequencies which we will cause the carrier to carry. For example, when a flutist plays the note F above middle C, he produces vibrations in the air which can be visualized at the bottom of Fig. 2. Here, the time for 7 vibrations is only one fiftieth of a second, which is a frequency of only 350 cycles per second (350 Hertz).

But a constant (unchanging) carrier wave conveys no information. Something about the wave must be varied (modulated) to convey information to the listener. What can be changed, so that the listener can recognize that a signal has been sent to him?

AM and FM. Looking again at Fig. 1, you can see that a carrier has two obvious characteristics—its height, or amplitude, and its frequency. Changing either of these can cause a receiver to recognize that a message has been sent. If the amplitude is changed, we call it amplitude modulation, or AM.

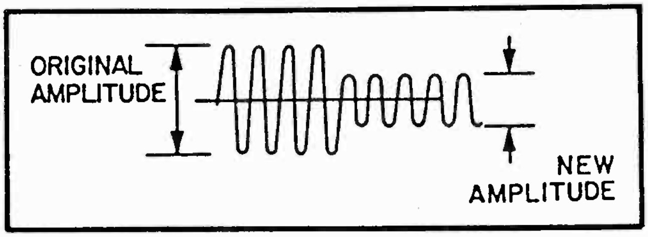


Figure 3. Simplified amplitude modulation of the RF carrier.

A very simple type of AM is shown in Fig. 3. Here the amplitude of the carrier wave has been changed suddenly to half of its former value.

This change in amplitude is a simple form of AM, and can convey simple messages. If Paul Revere had been a CBer, he could just as easily have prearranged a code signal which said "...one drop in carrier amplitude if by land; two drops in carrier amplitude if by sea..." and served the American cause just as well

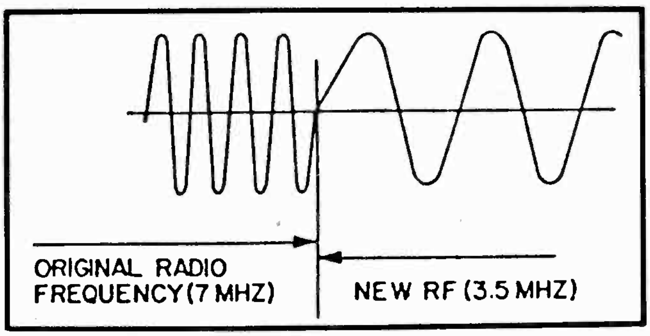


Figure 4. Simplified frequency modulation of the RF carrier wave.

(though Longfellow's poetry might have suffered).

The other obvious characteristic of the carrier wave of Fig. 1 is its frequency. We can also modulate this characteristic, as shown in Fig. 4. Here, instead of a sudden change in amplitude, there is a sudden change in frequency, from 7 MHz to 3.5 MHz. This is a very simple form of FM, and can also be used to convey simple messages. Since the drop in frequency represents a shift in the carrier's location on the dial, as shown in Fig. 5, two receivers, one tuned to 7 MHz and the other to 3.5 MHz, could detect this shift in frequency, and the listener could interpret it as a signal, according to a prearranged code.

Also PM?

While the Man in the Street has made AM and FM household phrases, these modulation methods are

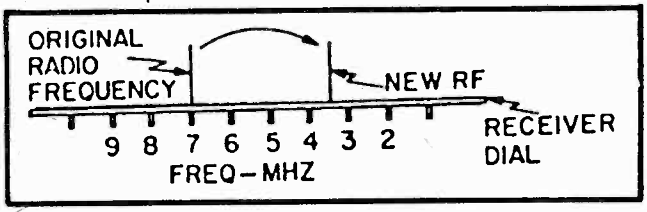


Figure 5. If the frequency modulation were a simple change from one RF carrier frequency to another, an AM receiver could receive it if retuned.

only two of the three ways a radio frequency carrier wave may be modulated. The third method, Phase Modulation, or PM, although virtually unknown to most people, is nonetheless extremely important in such fields as data transmission and color television.

Phase modulating can be visualized as in Fig. 6.

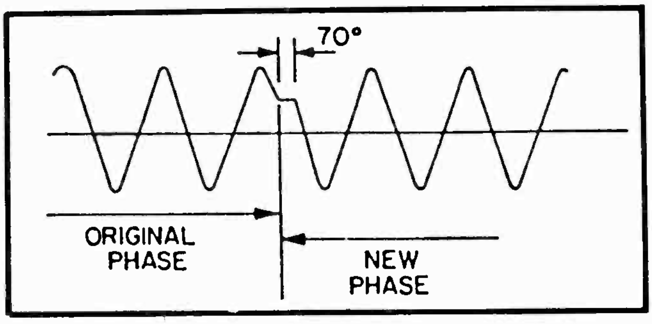


Figure 6. Simplified phase modulation of the RF carrier wave.

Here, neither the amplitude nor the frequency is varied, but the carrier is made to pause for a moment, and then to continue as a sine wave slightly delayed from the original. This delay is called a phase shift. Phase shift is usually measured in degrees. A phase shift equal to the time needed for an entire cycle is 360 degrees. In the sketch, a sudden phase shift of about 70 degrees (less that a quarter cycle) is indicated. By suitable receiver circuitry (found in every color TV receiver), this sudden change in phase can be interpreted as a signal. In color TV, it might represent a shift in hue from green to yellow.

More on AM

The sudden drop in amplitude shown in Fig. 3 is a good way to show the general scheme of AM, but it fails to tell us very much about how AM is used, every

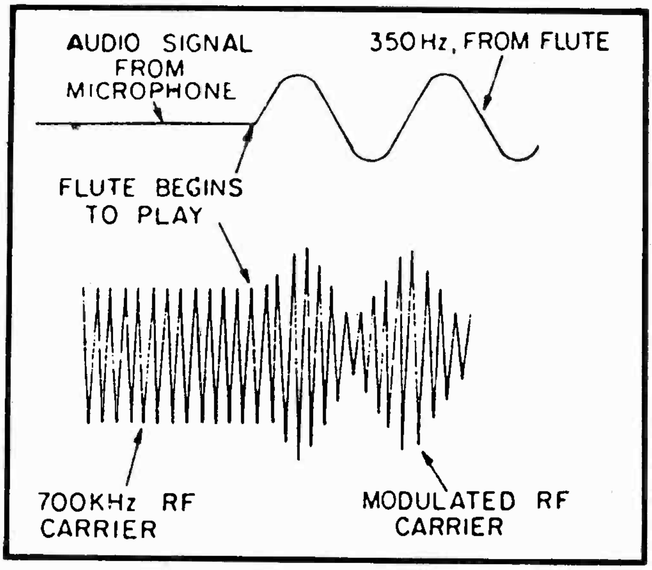


Figure 7. The audio signal (sound) modulates the RF carrier wave.

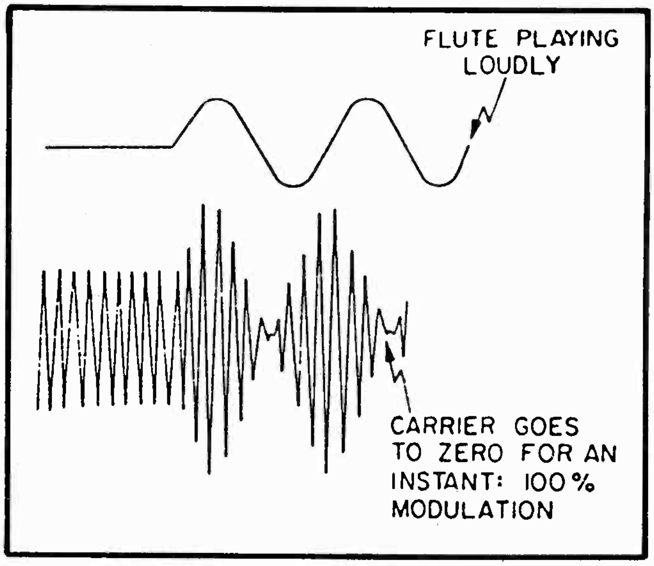


Figure 9. Louder audio signal (sound) modulates the RF carrier to maximum.

day, in our AM receivers and CB rigs. Here there are (hopefully) no sudden shifts in carrier amplitude, but instead, there is a remarkable recreation of speech and music from a distant transmitter. How is this done?

To explain let us assume that our flutist stands before a microphone in a broadcasting studio, ready to play his 350-Hz F-above-middle-C. Let's also assume that the broadcasting station is assigned a carrier frequency of 700 kHz. Figure 7 shows how the

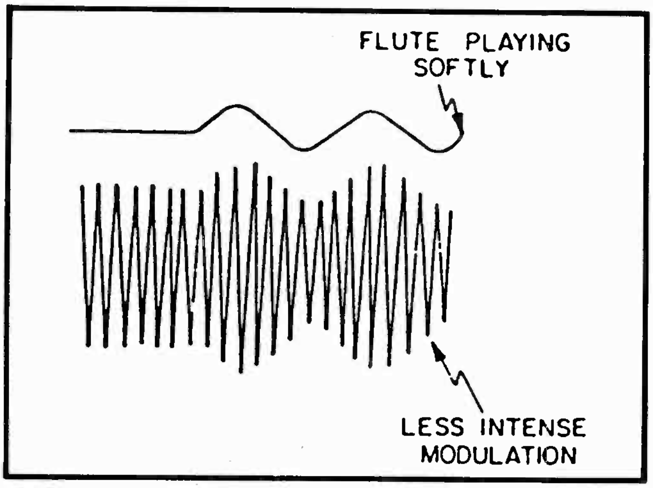


Figure 8. Smaller audio signal modulates the RF carrier wave less.

carrier wave will appear just before the flutist plays, and just after he begins.

As you can see, the 350-Hz audio tone from the flute causes the amplitude of the carrier to rise or fall in accordance with the rise or fall of the flute wave. Note that both the top and bottom of the carrier wave are affected by the flute waveform. It is as though the carrier had been squeezed into a snug-fitting envelope, forcing it to conform to the waveform of the flute sound. The shape thus formed by the tips of the modulated carrier wave is often called the envelope.

The envelope of an amplitude-modulated carrier is therefore a good replica of the audio waveform coming from the studio microphone. Every shading, every change, in the sound striking the microphone will be faithfully traced out by the tips of the carrier wave. For example, if the flutist were to play more softly, the result will be as in Figure 8. If he plays more loudly, Figure 9 is the result. You will note that in Figure 9 the amplitude modulation is intense that, at one point, the carrier's amplitude goes to zero for an instant. This is called 100% modulation, and represents the loudest sound AM can handle. If the flutist plays even more loudly, the result is as shown in Fig. 10. As the figure shows, the envelope is no longer a faithful replica of the original audio waveform, so the listener will receive a distorted sound. This condition is called overmodulation, and is undesirable.

Simple Modulation

One of the most-straightforward methods of producing AM is the method invented by the Canadian Reginald Fessenden, in 1905. In his system,

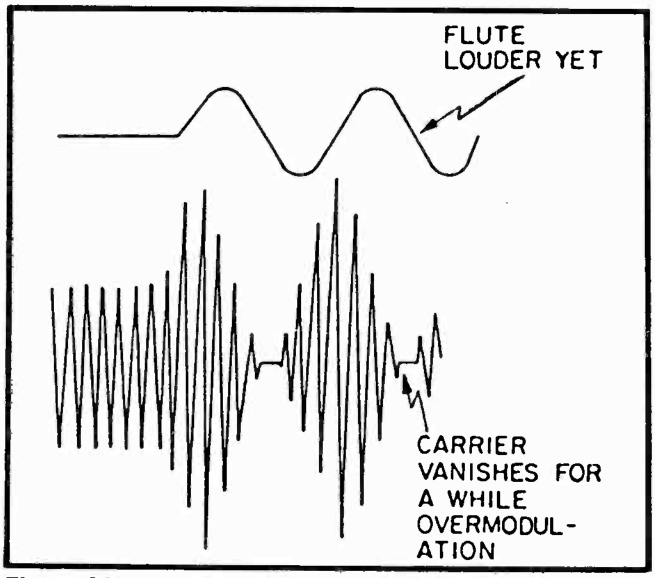


Figure 10. Further increase in amplitude of audio signal causes overmodulation.

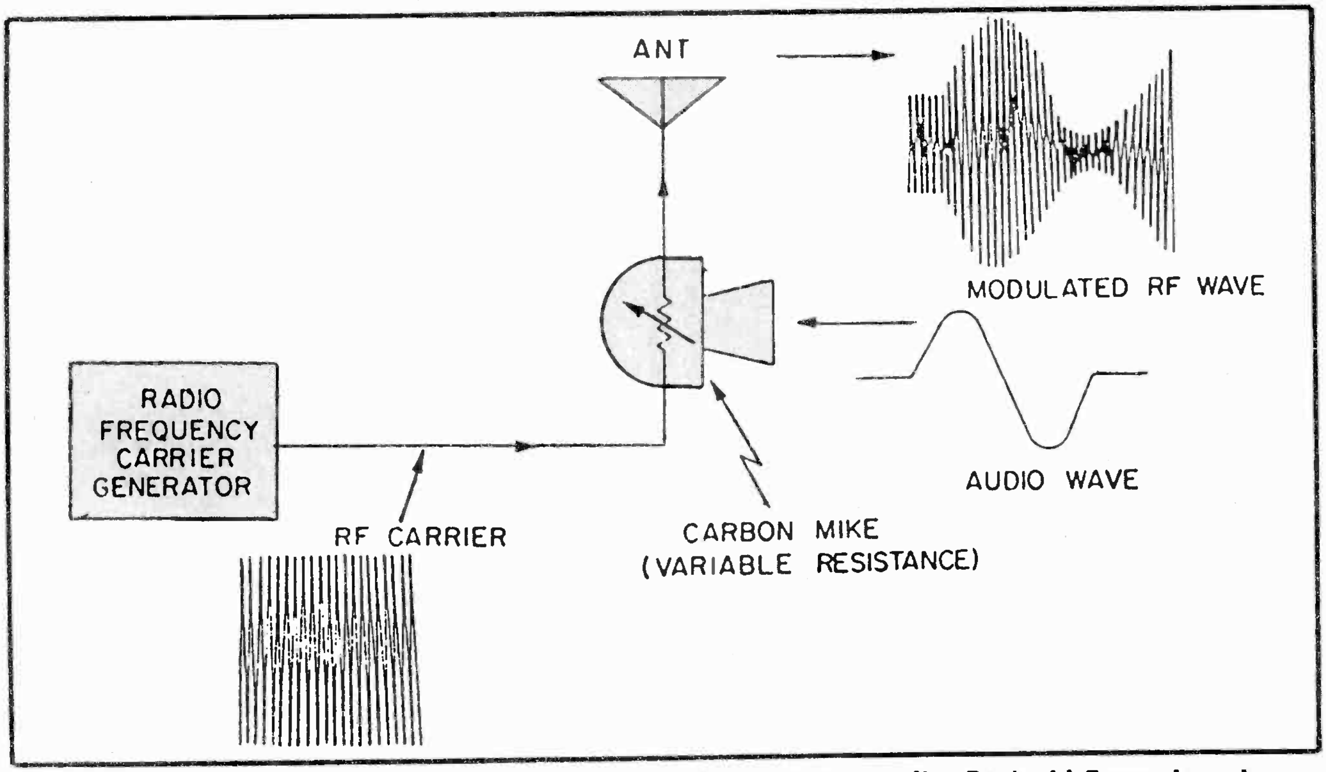


Figure 11. The first radiotelephone broadcast transmitter, invented by Canadian Reginald Fessenden, who broadcast voice and music to a few ships at sea on Christmas Eve, 1905. It worked but was very noisy.

a radio frequency generator produced the carrier wave, which was fed to the antenna through a carbon (variable-resistance) microphone. See Fig. 11.

Since a carbon microphone varies its resistance in accordance with the speech or music, the microphone in this primitive system acted as a valve to allow more or less of the RF carrier wave to pass to the antenna. In this way the carrier wave broadcast by the antenna was amplitude modulated by the sound waves striking the microphone.

Modern Modulation

Although nobody puts carbon microphones in series with antennas any more, the more modern modulation methods, such as those found in AM broadcast transmitters or CB transmitters are still rather similar to the primitive carbon-mike method. The typical modern AM system (Fig. 12), still employs an oscillator (which is crystal controlled, to ensure that the carrier frequency is constant, and thus is found at a known spot on the dial), and a power amplifier to strengthen the carrier before feeding it to the antenna. The amount of "strengthening" is controlled by the audio signal, and the power delivered to the antenna is in this way amplitude-modulated and the radiated carrier will convey the

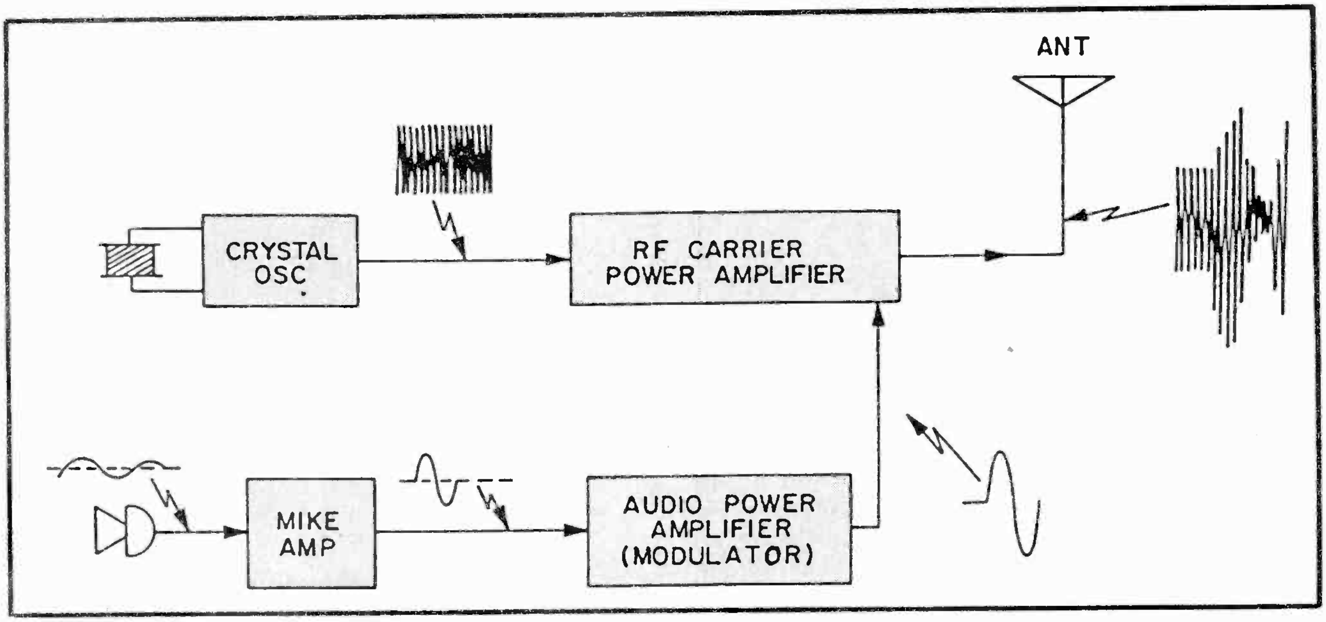


Figure 12. Typical amplitude-modulated RF (Radio Frequency) transmitter.

speech or music to a distant point.

AM Receiving

At that distant point, we all know that the carrier wave may be intercepted by a suitable antenna and applied to a receiver. A simple receiver is shown in block diagram form in Fig. 13. Here, the weak signal from the antenna is first amplified in a carrier-wave amplifier, an RF (radio frequency) amplifier and

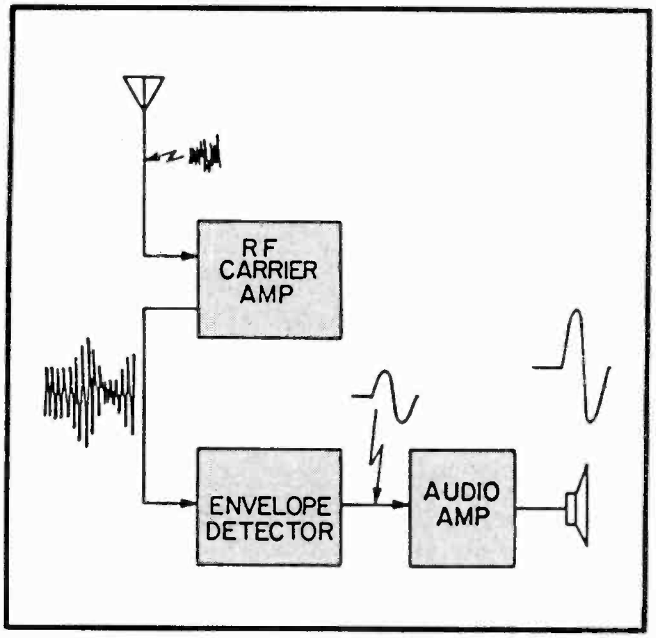


Figure 13. Block diagram of receiver for amplitude-modulated radio frequency (RF) signals.

applied to a detector which can extract the original audio signal from the amplitude-modulated RF carrier. This audio wave is further amplified and then fed to a loudspeaker, which re-creates the original speech or music. By looking at Fig. 13, you can see the detector is the heart of the AM receiver which

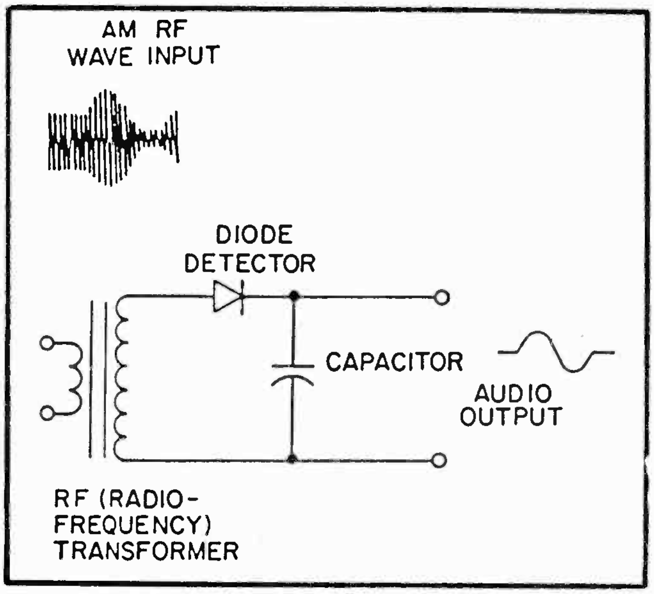


Figure 14. Simple receiver of amplitude-modulated radio frequency (RF) signals.

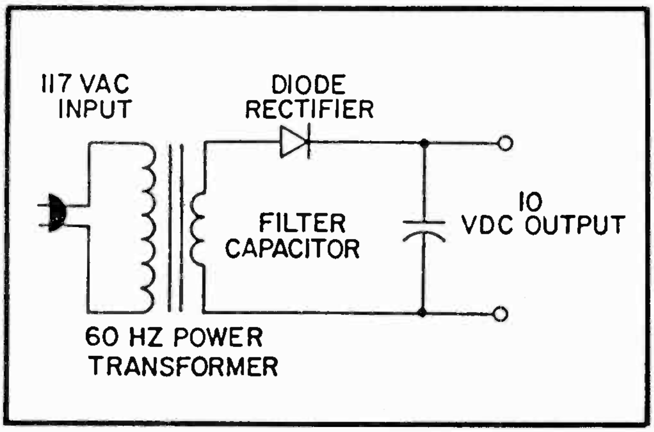


Figure 15. DC power supply from AC house current has circuit similar to that of the simple AM receiver.

extracts the original signal from the amplitude-modulated carrier. The circuit that does this job is surprisingly simple. It resembles very closely the circuit of a typical power supply. In an AC power supply, when 117-volts AC is applied at the input plug, a DC voltage appears at the output. If, because of a black-out or for some other reason, the 117 volts at the input drops to, say, 105 volts, the DC output will

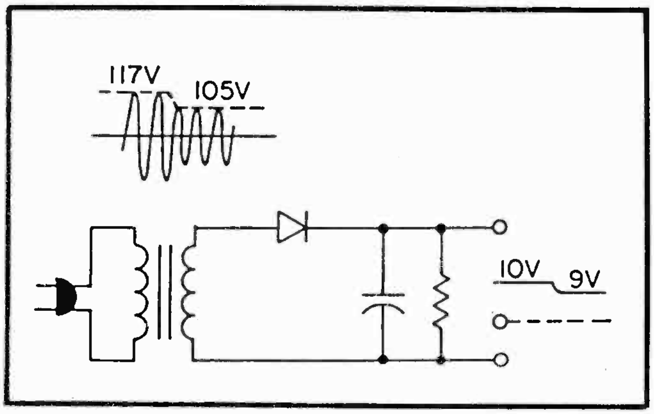


Figure 16. Changing amplitude of voltage input to power supply provides changed (modulated) output.

drop correspondingly. In a power supply, this output drop is undesirable—we want the DC output to remain constant even though the input AC varies. Notice that the drop in voltage of the 60-Hz power line input from 117 volts to 105 volts is actually amplitude modulation, of the 60-Hz input sine wave, and the drop in the output DC has "detected" the AM that occurred at the input! This is shown in Fig. 16.

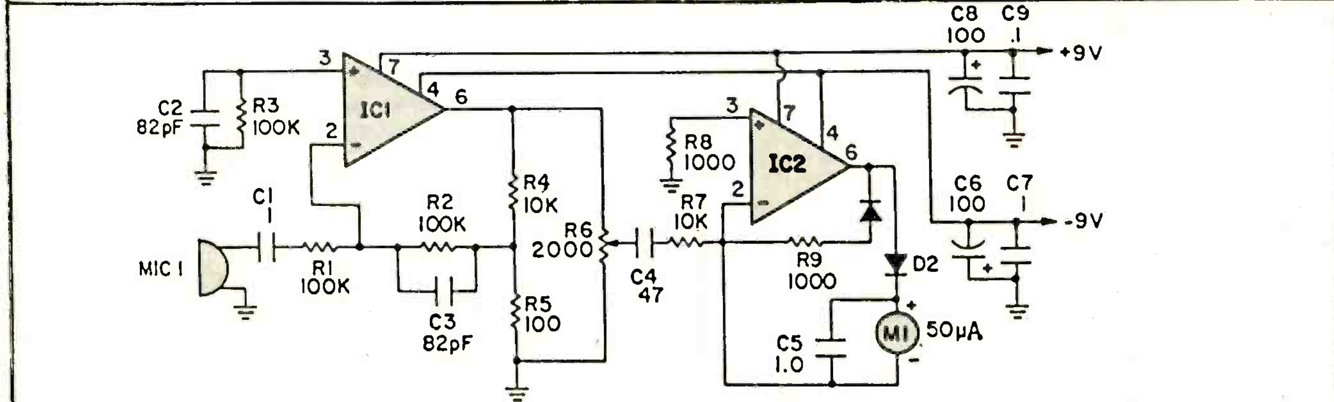
So a simple AM detector may be thought of as a power supply arranged to change its output very quickly in accordance with the amplitude changes in the AC (carrier) at its input. And, since these fluctuations in amplitude of carrier represent the original audio signals, the "power supply" (detector) output will be the same as the original audio. It's interesting to note the power supply's undesirable trait, unsteadiness in output when the input is unsteady, is the useful operating characteristic of the same circuit when used as a detector! ■

WORKBENCH PROJECTS

Every project in this section uses one or more ICs along with a multitude of resistors, capacitors and so on. They're intended for people who have already built at least two or three simpler projects and are ready to tackle something more challenging. Because these projects are more advanced you must be especially careful. As with all work using integrated circuits, be sure to observe the basic rules for handling ICs. (1) Don't handle the IC any more than necessary, to keep from damaging it with static electricity This can run into thousands of volts, even though the currents are very small, and can't hurt people, they can spell death to an IC. Keep the IC in the little piece of anti-static foam it's plugged into when packed for shipment. (2) Use IC sockets instead of soldering the IC directly into the project. (3) Keep it there until time to plug it into its socket and keep the soldering iron heat away from it by letting the connections to the socket cool before plugging in the IC. Finally, (4) use a small soldering iron or soldering pencil—25 or 30 watts is about the right size.

SOUND-LEVEL METER

With this sound-level meter you can easily measure the relative loudness of sounds in the range from 20 to 20,000 Hz. Although your readings will not be calibrated in terms of—or even be linearly proportional to—true sound power, this circuit should very adequately fill the bill.



Amplifier IC1 multiplies the signals from micropohone MIC1 by a factor of 100. This amplified signal is then applied to IC2, which functions here as a precision rectifier. Meter M1 is tucked into one of IC2's feedback loops, where it measures a rectified and filtered direct current proportional to the sound level. Potentiometer R6 allows you to adjust the instrument's sensitivity to match the application—anything from audience-applause measurement to sound-system installation.

PARTS LIST FOR SOUND-LEVEL METER

C1, C7, C9— 1 uF capacitor
C2, C3—82 pF capacitor
C4—.47 uF capacitor
C5—1.0 uF capacitor
C6, C8—100 uF 25V capacitor
D1, D2—IN914 diode
IC1—RCA 3140 FET-input op amp
IC2—741 op amp
M1—0-50 microamp DC meter
MIC1—microphone (Hi-Z)
R1, R2, R3—100,000-ohm, resistor
R4, R7—10,000-ohm resistor
R5—100-ohm, resistor
R6—2,000-ohm linear potentiometer
R8, R9—1,000-ohm resistor

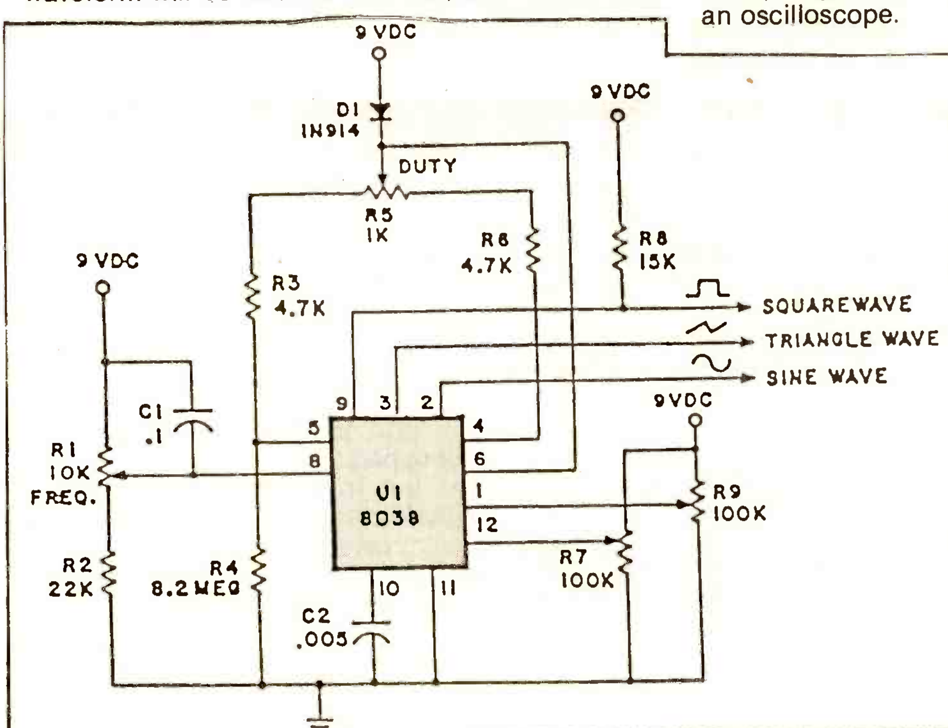
FUNCTION GENERATOR

There's nothing very clever here, because most of the information is taken from the spec sheet for the 8038 waveform generator integrated circuit. This particular chip puts out three waveforms at the same frequency. The waveforms are: squarewave, sinewave, and triangle wave. We used a 9-volt DC transistor-radio battery to power the chip, however, you can use anything from 9- to 30-volts DC. If you have a dual supply available, consult the spec sheet for application.

The parameters selected from the spec sheet are for an audio frequency range from 20 to 20,000 Hz. Immediately you can see the many possible audio applications available to you as a synthesizer circuit or signal generator. Potentiometer R1 selects the frequency output of the circuit. Potentiometer R5 determines the duty cycle of the output waveforms. By that we mean the wiper will select an output square waveform at mid-point of its travel so that the waveform will be half the time low, and half the time high. The slopes of the triangle waveform will be equal. The duty cycle range selectable by the potentiometer is extensive covering approximately 95%.

The best way to adjust the distortion potentiometers, R7 and R9, is to place the output sinewave on an oscilloscope and use the scopes sinewave sweep. An elipse will form. Adjust the sync so that a circle is obtained. It will drift a bit making your adjustment procedure longer than it should be. However, adjust R9 and R7 until a perfect circle is formed. Adjust the gain of both the vertical and horizontal sweeps to fill the scope's face with the circle—the bigger, the better adjustment is possible.

The waveform outputs from the chip, U1, are not equal in amplitude. Should that be required, place the sinewave and triangle inputs into an adjustable-gain op-amp circuit and the triangle wave through a unity-gain op-amp (it has the largest amplitude of the three). Adjust the output to equal peaks with the aid of an oscilloscope.



PARTS LIST

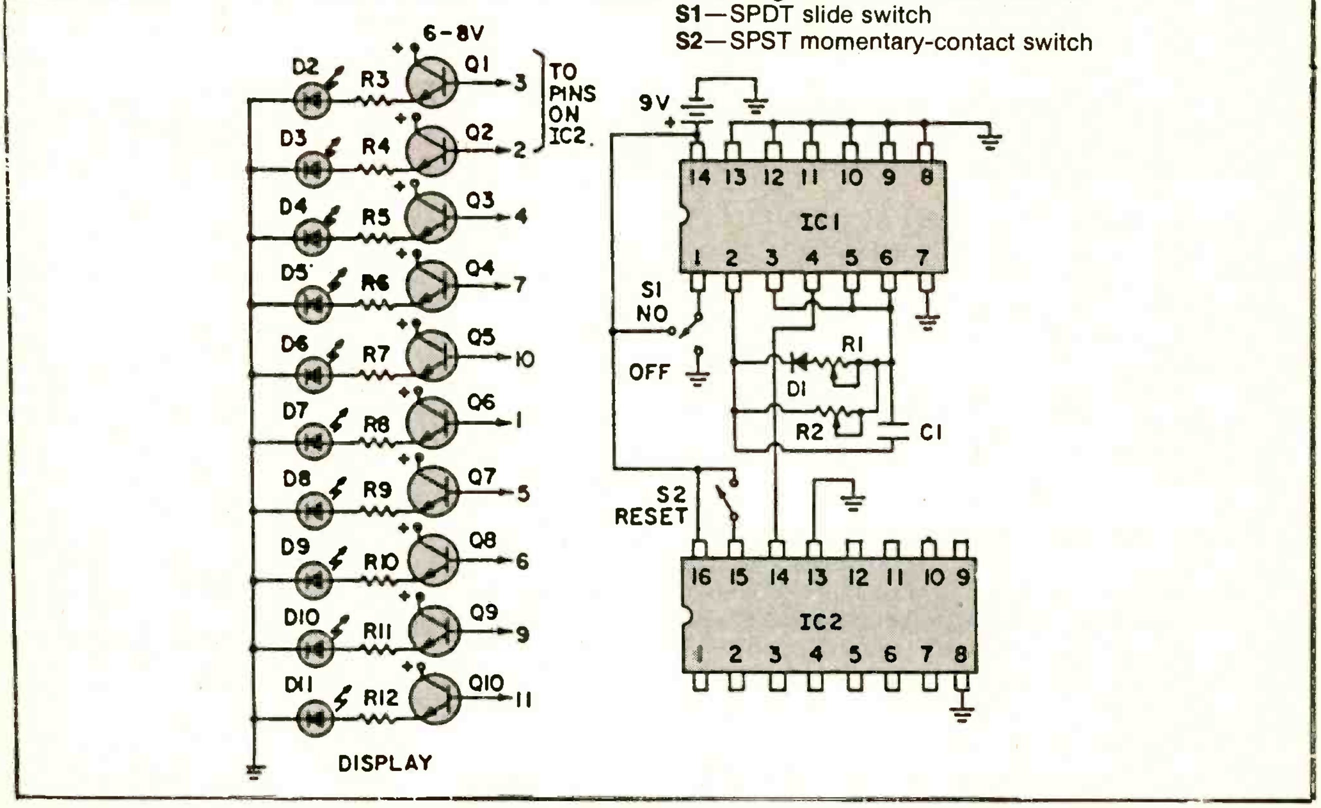
C1—.1-uF capacitor
C2—005-uF, ceramic-disc capacitor
D1—1N914 silicon diode
R1—10,000-ohm linear-taper potentiometer
R2—22,000-ohm, ¼-watt, 5% resistor
R3, R6—4700-ohm, ¼-watt, 5% resistor
R4—8200-ohm, ¼-watt, 5% resistor
R5—1000-ohm, linear-taper potentiometer
R7, R9—100,000-ohm, linear-taper potentiometer
R8—15,000-ohm, ¼-watt, 5% resistor
U1—8038 Intersil waveform-generator integrated circuit

TRAVELING LIGHTS

The rippling effect on the ten LEDs is a beautiful and interesting sight, especially, if they are mounted atop a nice wooden case and placed in the living room. A nice conversation piece. The speed of the ripple is controllable via R1 and R2, where a smaller R1 and R2 makes the ripple go faster. The "on" of each LED overlaps perfectly with a momentary "off," so the ripple travels very smoothly.

PARTS LIST FOR TRAVELING LIGHTS

C1—0.01-uF capacitor, 15 VDC
D1—1N4401 diode
D2 through D11—small LED
IC1—4011 quad NAND gate
IC2—4017 decade counter
R1—10,000,000-ohm linear potentiometer
R2—500,000-ohm linear potentiometer
R3 through R12—1,000-ohm resistor
S1—SPDT slide switch
S2—SPST momentary-contact switch



PRECISION VOM CALIBRATOR

Until now most calibrator circuits could not be considered as primary reference standards. Instead, they were *transfer standards,* since the builder would be instructed to align his calibrator using a voltage reference of known accuracy. The obvious reaction of most readers was: "If I had access to an accurate voltage reference to begin with, why would I want to build this calibrator?"

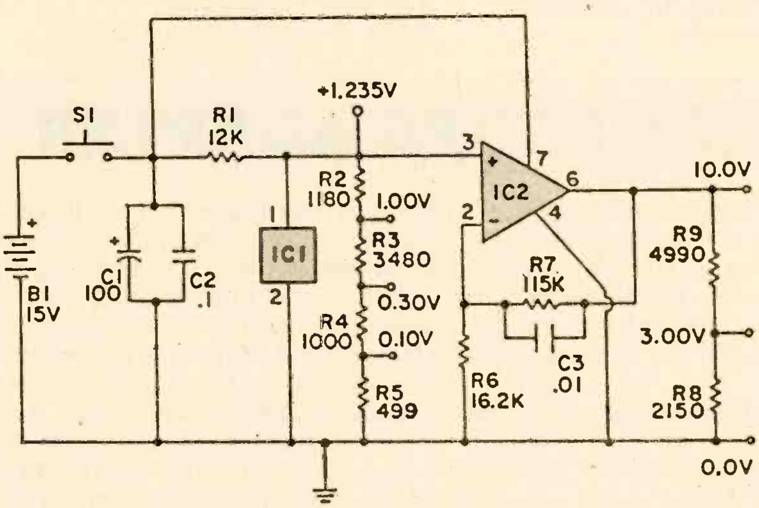
Our sentiments exactly. Now National Semiconductor comes to the rescue with a voltage-reference IC, the LM185, having an output of 1.235 volts ±1%. What's more, this voltage remains stable in the face of changing ambient temperature and supply current.

The circuit diagrammed here produces six useful reference voltages from .100 V to 10.0 V. As noted above, the 1.235-volt output is accurate to within 1%. All of the other outputs are accurate to within 2% except for the 3-volt output, which has a tolerance of ±4%. Reduced accuracy on all derived outputs is the result of errors introduced by the 1% resistor tolerances. Bear in mind, however, that worst-case accuracies are quoted here.

Be certain that the input resistance of the instrument being calibrated greatly exceeds the resistance at the point being read. Most who worry about calibration have high-impedance (10-meg-ohm) FET voltmeters, the loading effects of which are negligible here.

PARTS LIST FOR PRECISION VOM CALIBRATOR

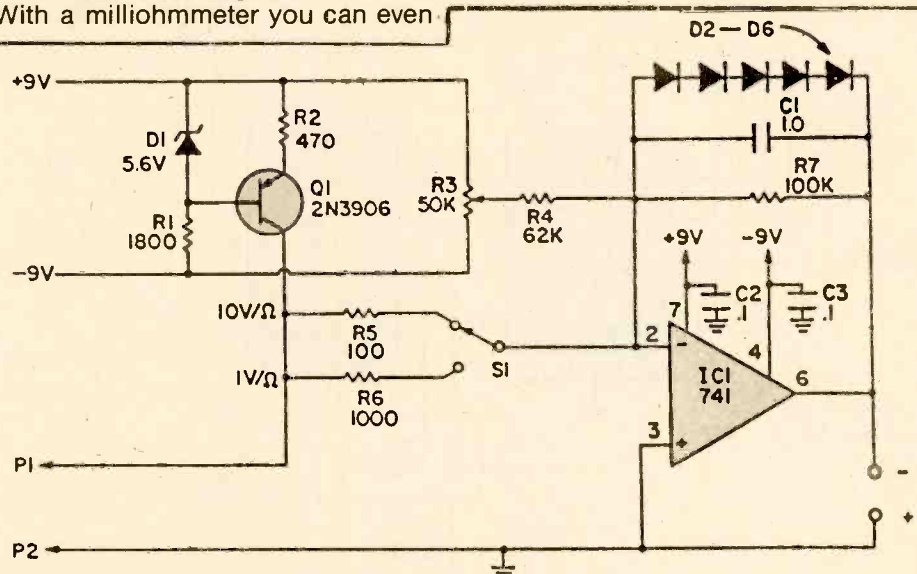
B1—ten AA cells in series
C1—100 uF, 25V capacitor
C2—.1 uF capacitor
C3—0.1 uF capacitor
IC1—LM185 1.235-volt reference IC (National Semiconductor)
IC2—3140A FET-input op amp (RCA)
All resistor ½w, 1% precision unless noted otherwise
R1—12,000-ohm. 10% resistor
R2—1,180-ohm resistor
R3—3,480-ohm resistor
R4—1,000-ohm resistor
R5—499-ohm resistor
R6—162,000-ohm, resistor
R7—115,000-ohm resistor
R8—2,150-ohm resistor
R9—4,990-ohm resistor
S1—SPST normally open pushbutton switch



FRACTIONAL OHMS METER

Few experimenters have the equipment to measure resistances of less than one ohm. But the ability to measure resistance in the milliohm range can be very handy. For instance, motor manufacturers routinely check their coils with milliohmmeter. Since the net resistance is proportional to the length of wire on the coil form, measuring the resistance provides a simple, non-destructive method for checking the number of turns on a coil. With a milliohmmeter you can even check the relative quality of switch contacts and solder joints.

Current source Q1 drives a constant 10-milliamp current through whatever resistance is between probes P1 and P2. U1 amplifies the voltage generated across the resistance by the current flowing through it. You read the voltage at U1's output on your VOM and multiply by the appropriate scale



factor—10V/ohm with S1 up, 1V/ohm with S1 down—to get the resistance. Before reading, short the probes together, and adjust R4 for zero output. Use needle-type probes, since they can easily pierce surface oxide films (which can introduce significant resistance of their own.) Keep the output voltage below one volt; in other words, the *maximum* resistance you can measure is one ohm. When using your VOM be sure to set it for one-volt full-scale (or less) if available.

PARTS LIST FOR FRACTIONAL OHMS METER

C1—1.0-uF capacitor
C2, C3—0.1-uF capacitor
D1—5.6-VDC ½-watt zener diode
D2-D6—1N914 silicon diode
IC1—741 op amp
P1, P2— test probes
Q1—2N3906 PNP transistor
R1—1,800-ohm
R2—470-ohm resistor
R3—50,000-ohm linear potentiometer
R4—62,000-ohm resistor
R5—100-ohm resistor
R6—1,000-ohm resistor
R7—100,000-ohm resistor
S1—SPDT toggle switch
NOTE: all resistors should be 5%.

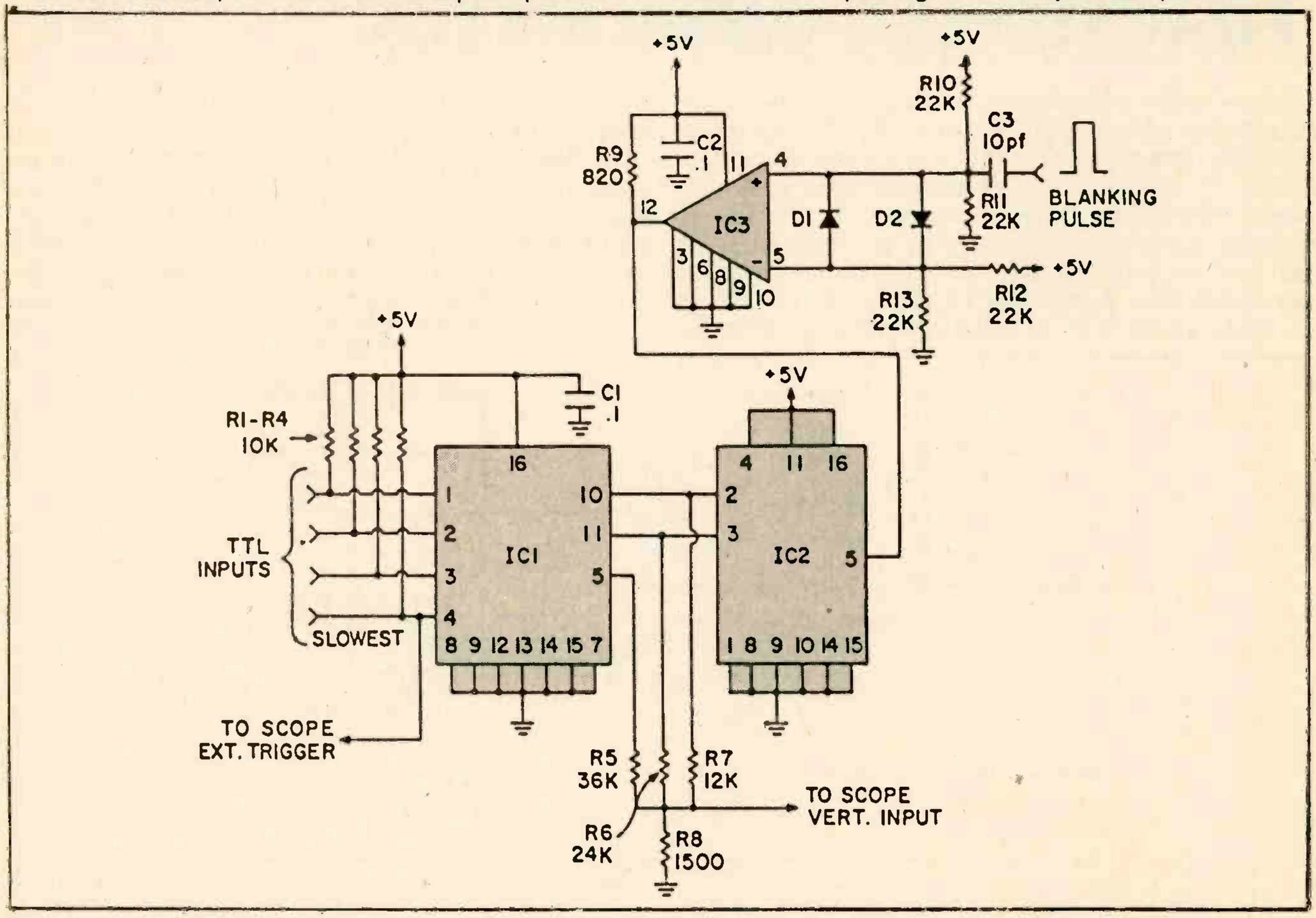
MULTI-TRACE SCOPE ADAPTER

If you experiment with digital circuits, then you will recognize at once the usefulness of this device. Our multitrace adapter allows you to view four digital (TTL) waveforms simultaneously on the screen of your triggered-sweep oscilloscope. The four images are not traced out simultaneously, however, but alternately.

Up to four separate channels of information can be fed into the inputs of multiplexer IC1. If all channels do not have the same frequency, make sure that the channel whose frequency is lowest is the one fed back to your oscilloscope's EXT. TRIG. input.

As noted above, this multi-trace adapter operates in the alternate mode; hence, it will be necessary to locate your oscilloscope's *blanking pulse* and feed it to comparator IC3. The blanking pulse prevents any visible image from forming as the CRT's electron beam returns from the right side of the screen to its starting point on the left. Try to find a positive pulse of TTL magnitude (5 volts). If all you have is a negative pulse, exchange leads 4 and 5 of IC3.

Each time the screen is blanked, IC3's output pulses *HIGH* and clocks counter IC2, the outputs of which drive the address inputs of multiplexer IC1. Therefore, a different channel is selected after each trace. The output signal fed to your scope's vertical



input consists of the multiplexer output (pin 5 of IC1) summed with a voltage proportional to the count in IC2. The latter is necessary to provide vertical displacement between the four separate traces. Use a vertical sensitivity of about 100mV/cm, and connect the adapter to your scope's input with a short length of coax.

PARTS LIST FOR MULTI-TRACE SCOPE ADAPTER

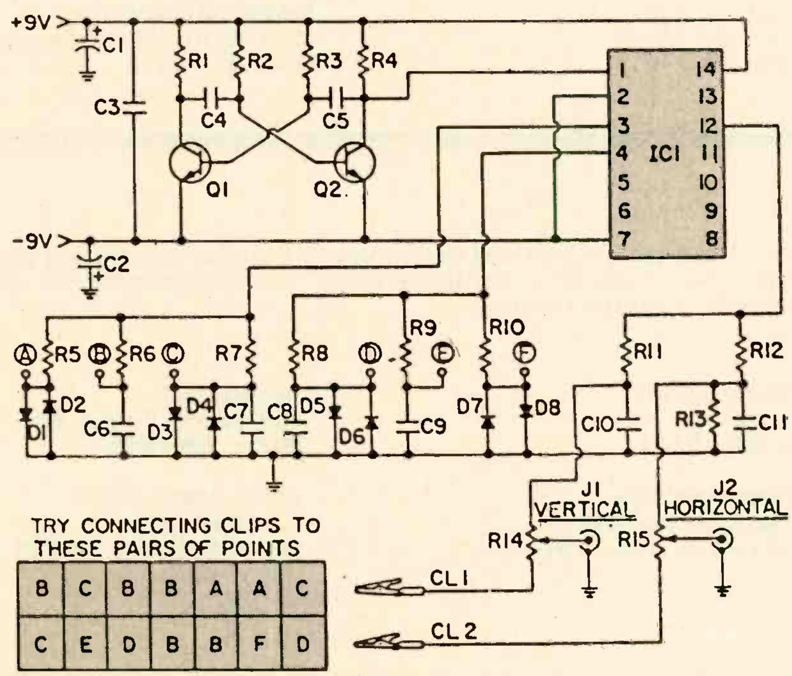
C1, C2—.1 uF capacitor
C3—10 pF, capacitor
D1, D2—IN914 diode
IC1—74151 mulitplexer
IC2—74193 binary counter
IC3—LM319 comparator
R1 thru R4—10,000-ohm, 5% resistors
R5—36,000-ohm 5% resistor
R6—24,000-ohm 5% resistor
R7—12,000-ohm, 5% resistor
R8—1,500-ohm 5% resistor
R9—820-ohm, 5% resistor
R10 thru R13—22,000-ohm, 5%, ½-watt resistors

CRAZY VIDEO GENERATOR

If you have an oscilloscope you will enjoy breadboarding this pattern generator. Feed the signal at J1 to your scope's vertical input, and connect the horizontal input to J2. Attach the clips to the selected pairs of test points, then adjust potentiometers R14 and R15 to create a variety of complex video images. Output signals are about 1-volt, peak-to-peak.

PARTS LIST FOR CRAZY VIDEO GENERATOR

C1, C2—250-uF capacitor, 25 VDC
C3—0.1-uF capacitor, 35 VDC
C4, C5—100pF capacitor, 35 VDC
C6, C7—1.0-uF capacitor (non-polarized), 35 VDC
C8, C9—0.5-uF capacitor, 35 VDC
C10—0.022-uF capacitor, 35 VDC
C11—0.001-uF capacitor, 35 VDC
CL1, CL2—alligator clip
D1 through D8—1N914 diode
IC1—4024BE CMOS ripple divider
J1, J2—phono jack
Q1, Q2—2N3904 NPN transistor
R1, R4, R5, R10—100K-ohm resistor
R2, R3—1.5-Megohm resistor
R6, R9—68K-ohm resistor
R7, R8—33K-ohm resistor
R11, R12—47K-ohm resistor
R13—3300-ohm resistor
R14, R15—250K linear potentiometer



TRY CONNECTING CLIPS TO THESE PAIRS OF POINTS

B	C	B	B	A	A	C
C	E	D	B	B	F	D

BUYING ELECTRONIC PARTS

It has come to our attention that the list of "Addresses Of Parts Suppliers" at the end of the "Buying Electronics Parts" (page 66 Spring 1987 issue) is erroneous. Some of these suppliers are no longer in business. Somehow, we inadvertently printed an old list. Following is an updated Parts Supplier list, that should have been included with this story:

McGee Radio & Electronics Corp.
1901 McGee Street
Kansas City, MO 64108

Delta Surplus Electronics
7 Oakland Street
Amesbury, MA 01913

JDR Microdevices
1224 South Bascom Avenue
San Jose, CA 95128

Dick Smith Electronics
P.O. Box #8021
Redwood City, CA 94603

Jameco Electronics
1355 Shoreway Road
Belmont, CA 94002

DoKay Computer Products
2100 De La Cruz Blvd.
Santa Clara, CA 95050

Priority One Electronics
21622 Plummer Street
Chatsworth, CA 91311

Budget Electronics
P.O. Box #1477
Moreno, CA 92388

All Electronics Corp.
P.O. Box #20406
Los Angeles, CA 90006

Mouser Electronics
11433 Woodside Avenue
Santee, CA 92071

Digi-Key Corporation
P.O. Box #677
Thief River Falls, MN 56701

Electronics Parts Outlet
2515 North Scottsdale Road
Scottsdale, AZ 85257

Advanced Computer Products
P.O. Box #17329
Irvine, CA 92713

Joseph Electronics
8830 North Milwaukee Avenue
Niles, IL 60648

The following firms sell electromechanical components, stepper motors, DC permanent-magnet motors, gears, clutches, robot grippers, tactile sensors, infrared transducers, sonar transducers, etc. of interest to robotics experimenters:

Alpha Robotics Inc.
P.O. Box #21091
St. Paul, MN 55121

Stock Drive Products
2101-B Jericho Turnpike
New Hyde Park, N.Y. 11040

Intrep, Inc.
735 Fourth Street, Box #5381
Napa, CA 94581

AMSI Corporation
P.O. Box #651
Smithtown, N.Y. 11787

THAT BLINKING TUBE

By Homer L. Davidson

You can build the Blinking Tube project using a surplus or defective transmitting or TV tube. Not only is the Blinking Tube attractive and unusual to look at, it is functional and may bring back a few memories of the good old days in broadcasting. Just dig out one of those old tubes (it doesn't have to be a good or working tube), and put it back to work. The Blinking Tube will keep blinking off and on until you remove it from the light.

That Blinking Tube project is constructed around an old vacuum tube, integrated circuit and light-emitting diode. The flashing circuit consists of a LM3909 IC with only five other components. The project runs on solar power so batteries are not required. Four solar-cell pieces wired in series keeps the Blinking Tube doing its thing for years under the sun or an ordinary reading light. The circuit is shown in Fig. 1.

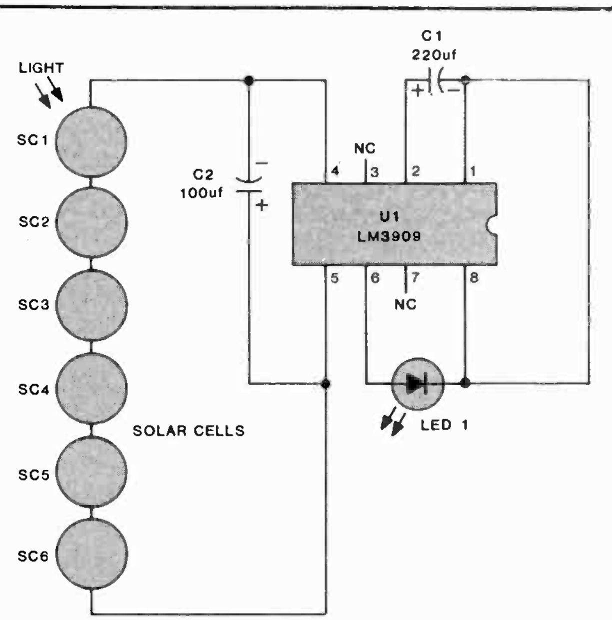
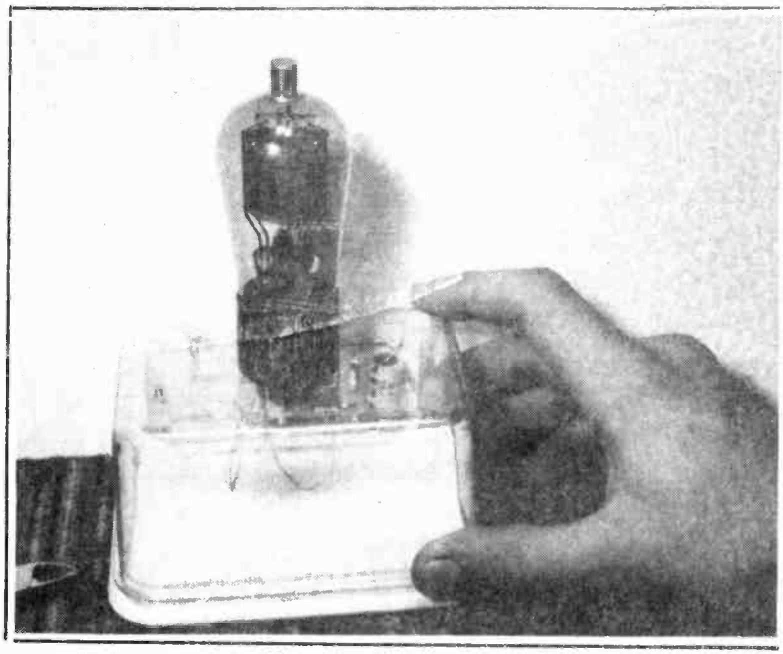


Fig. 1. Here is the simple schematic diagram of the Blinking Tube. Six solar cells (SC1-SC6) are wired in series and placed in a strong light or the sunlight to power the unit.



The parts are inexpensive, including the solar-cell pieces. Actually, these five solar-cell pieces were purchased at $1.00 each. Look around the junk box, you may find a few of the parts that can cut down the total cost.

Circuit Construction. The small light-emitting diode (LED) flashing unit is built upon a small piece of printed-circuit board. Actually, it is easier to use a piece of perfboard. Cut the board from a piece of scrap material or a larger piece. A 4-inch by 1¾-inch piece will fit nicely against the back side of a clear plastic container used to house the unit. All components are mounted upon the small board. The photos show the author's PC board construction; however, we suggest the perfboard construction, because it is easier.

Any container that will pass light and house the unit will do. The author used a clear plastic refrigerator container to mount the tube and chassis board. The plastic container is made up of strong thick plastic sides with a plastic sealing lid which serves as attractive feet. The plastic container is found at most K-Mart or shopping center stores under the trade name of Superseal.

Mounting the Parts. Mount capacitors C1 and C2 into position. Connect two 6-inch wire leads to terminals. These two leads connect to the bottom tube pins for the light-emitting diode LEDI inside the tube socket. Now solder the IC socket in place. Make sure excessive solder does not bridge terminal pins.

Solar Cell Construction. The solar cells are wired in series to acquire the correct working voltage (Fig. 2). Use either a piece of stranded hookup or #30 wrapping wire to connect the cells together. Attach a 2-inch piece of wire to the top and bottom side of each cell. Keep the soldered connection on the bottom side (+) as flat as possible for easy mounting. The top side wire (-) should be soldered to a large cross bar area. Clean off the cell area with the blade of a pocket knife. Be real careful not to break the cell in pieces. Pull each wire upward on each cell.

Each cell is laid out upon the small perfboard for clearance. After determining where the wires will connect, place a dab of silicone rubber cement on the back side of each cell. Press the cell down in place. Be careful not to break the cell. Wait a few hours for the cement to set. The cells may be wired above or below the perfboard. Wires connected below make a neater job.

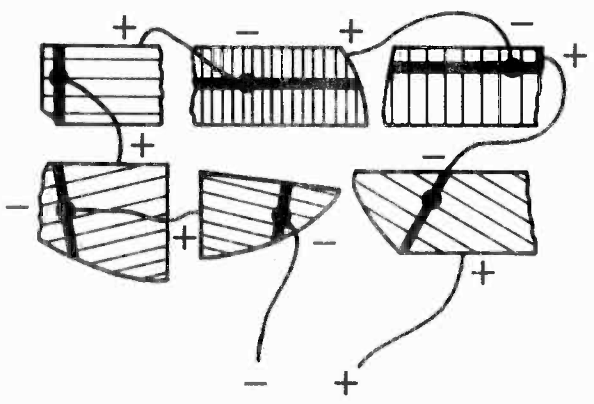
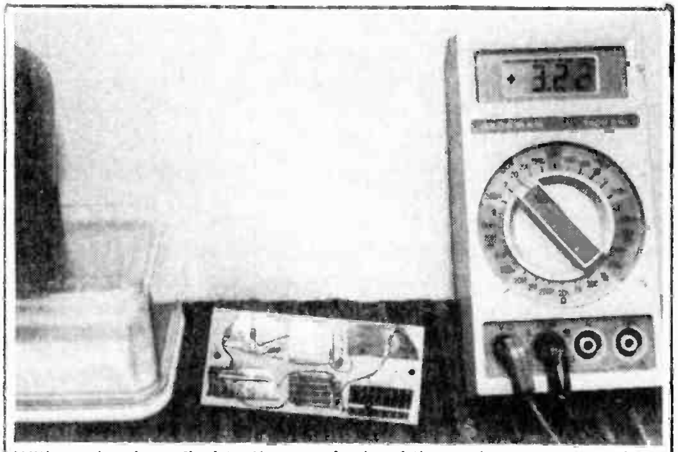


Fig. 2. Connect all the solar cells in series. The stranded wire may be connected from cell to cell (watch polarity carefully) by soldering directly to the cells. Do not use too much heat. Keep wire size down for flexibility.

Now push the terminal wires through the small holes which tie each cell to the next one. Tie the positive terminal (bottom wire) to the negative terminal (top) wire. Proceed with each cell until they are connected in series. If you use a perfboard to mount the solar cells, you will not need to drill holes. Solder the starting and final connecting wires to the negative and positive terminals of the perfboard.

Testing. It's best to test the project before connecting to the tube assembly. Temporarily solder light-emitting diode LED1 leads to the perfboard. If the red jumbo LED's are used, the positive (+) terminal is the anode or long lead. Simply reverse the two leads of the LED if the light does not blink.



With no load applied to the terminals of the series-connect solar cells, measure the voltage output. The meter should register approximately 3.2-volts DC.

Turn the solar cells towards a 100-watt bulb or under the sun. Right away the LED should blink off and on. If not, check the voltage output and correct polarity of the solar cells. The correct voltage should be around 3 volts. Total current consumption should be less than .5 mills of current. Low or improper voltage may be caused with a poor soldered connection of each cell or the cells may be wired up backwards. Take a voltage check across each cell to determine the voltage loss. Check the circuit components when correct voltage is found at pins 4 and 5 of IC1.

Tube Preparation. After selecting the tube you wish to mount upon the plastic base, the outside glass envelope must be removed so the LED can be placed inside. First remove the plastic center piece if one is found at the tube base. Break off the glass tip end of the sealed tube. This will let air enter the tube so it will not implode when the glass envelope is removed. The glass bulb may be removed with a sharp glass cutter or hot soldering iron.

Sometimes with older tubes, the glass envelope is already loose in the plastic base and is very easily removed. Apply the soldering iron to each tube pin and melt out the solder. Quickly flip the tube base downward throwing out excess solder. After all solder is removed the glass-envelope will pull right out of the tube base.

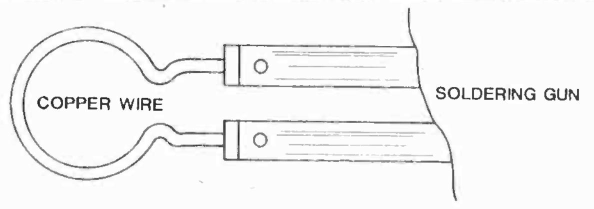


Fig. 3. A piece of solid copper wire (AWG 12 05 14) is placed around the tube's glass at its base. The wire ends are inserted into the terminals of soldering gun. When heat is applied, quickly unplug the gun, and dip the entire heated glass area under cool water. The glass will break cleanly at the heated area.

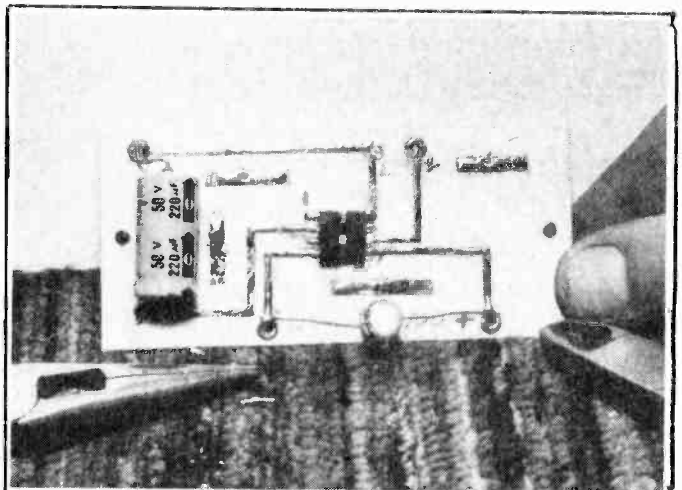
Break off the small tip end at the base of the tube to let air in. Grasp the glass tube with a piece of cloth for protection. Enlarge the glass hole with a small screwdriver. Be real careful no to break the glass envelope. Keep twisting out glass pieces until the hole is large enough to insert the LED. Remove all small pieces of glass out of the broken section. The extended leads from the LED may be inserted through two different tube pins. Apply cement to the old tube envelope before inserting wires through the tube pins. Solder the wires inside the tube pins.

With more difficult tubes, select a piece of number 12 or 14 copper wire and wrap around the outside glass of the tube at the base area. Leave the ends long enough to go into the soldering gun assembly. The copper ends can be brought together around the tube base with a piece of long nose pliers (Fig. 3). Now turn the soldering gun on for a few minutes until the copper wire is red hot. Dip the whole assembly under a water faucet. The outside glass bulb will snap in 2 right where heat was applied with the soldering gun.

If the glass does not break, apply more heat from the soldering gun. Some older tubes have a thicker glass then others. Do not pry or push down on the glass of the tube. You may shatter the whole glass bulb. With the hot copper ring the glass bulb will snap in 2 when running water is applied upon it.

Pull the tube assembly from the glass envelope. The LED may be mounted about halfway up the tube assembly. Bend the LED terminals at right angles so when it blinks the light is more visible. A dab of clear silicone rubber cement will hold it in place. Solder two small wires to the LED terminals. These wires may be insulated and fed behind the tube elements so they are not visible from the front side. Use #26 or #28 enamel wire. Feed the wires through the bottom glass envelope.

Before the tube base is glued to the glass envelope take a continuity test of the LED connection and wiring with the ohmmeter. Use the low-ohm scale for continuity measurements. Now mix up a batch of 5-minute epoxy and cement the glass envelope the plastic tube base. Make sure the plate assembly is straight up and down inside the tube base.

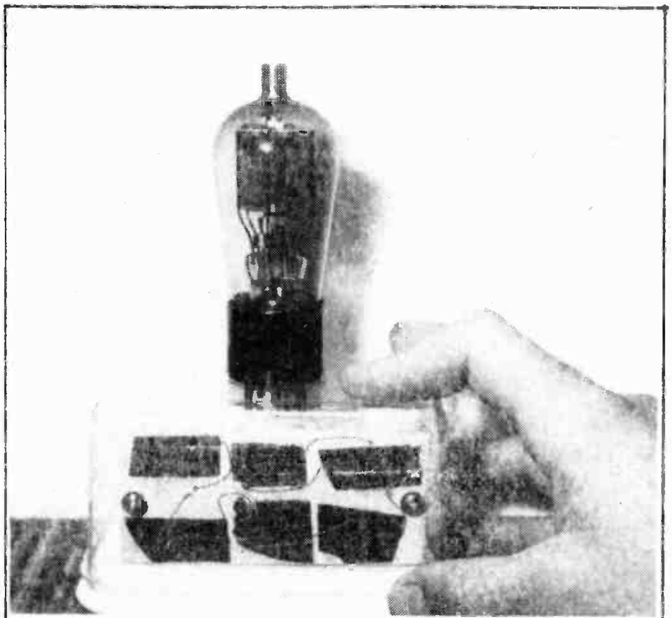


The author's printed-circuit board layout is simple and illustrates the editor's view that a perfboard layout is better. Should you decide to make several units, you may want to make several printed-circuit boards if you use a photo-copying method.

Tube and Chassis Mounting. Although, the plastic container is quite heavy in construction, place a piece of stock 2 +multi 4 wood inside the container before drilling out the hole for the tube socket. Also, the plastic hole may be cut out with the soldering iron tip. Ream out the hole with a round pigtail file. Drill two small holes for the tube socket mounting holes. Bolt the tube socket in place.

The old tube may be mounted directly upon the plastic base instead of in a tube socket. Simply drill the holes large enough to take all the pins of the tube base. Cement the bottom side of the tube base with epoxy or rubber silicone cement to the plastic top. Let the cement set up for a couple of hours. Make sure the LED is pointing towards the front of the plastic container. The two leads from the flashing LED may be soldered directly to the correct tube pins and perfboard circuit.

The perfboard may be bolted to the rear side of the plastic container with a hole in each end. Use plastic spacers to hold the chassis away from the plastic container to prevent damage to the solar cells. Connect two hookup wires from the perfboard to the LED wires of the tube socket.



Here is the completed Blinking Light project viewed from the sunny side, that is, where the light should stick the solar cells to get the light-emitting diode blinking.

Operation. Place a 100-watt bulb towards the rear of the plastic container letting light strike the solar cells. The LED should start to blink. If not, reverse the leads to the tube socket pins. Check the voltage across C2 if LED1 does not blink. LED1 should start to blink with a 2-volt power source. Double check all wiring connections. Check the polarity of C2.

That blinking tube will keep on blinking as long as light is applied to the solar cells. Just set it in a window and let it blink away. A faster blinking rate may be changed by substituting C1 with a 100-uF capacitor or increasing the voltage source with another solar cell. Increase the value of capacitor C1 to slow down the blinking rate. When used under a reading lamp the rate of blinking decreases as the unit is pulled away from the light. ■

PARTS LIST FOR BLINKING TUBE

C1—220-uF, 16-WVDC, electrolytic capacitor
C2—100-uF, 16-WVDC, electrolytic capacitor
SC1-6—solar cell pieces, 6 required for a current of 40 mA or more
LED1—Light-emitting diode, red
U1—LM3909 integrated circuit
MISC.—Perfboard or printed circuit materials (your choice), wire, hardware, old vacuum tube, tube socket, solder, etc.

Solar-cell pieces are available from:

Chaney Electronics, Inc.
P.O. Box 27038
Denver, CO 80227

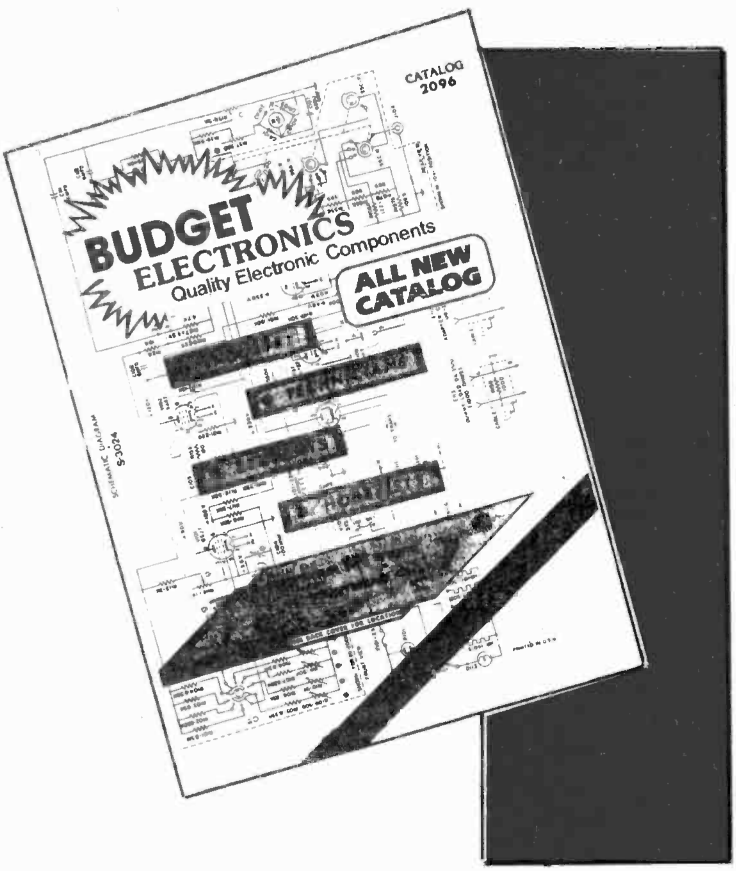
John Meshma, Jr., Inc.
P.O. Box 62
East Lynn, MA 01940

Edmund Scientific
Edscorp Building
Barrington, NJ 08007

THE CATALOG CORNER

If you live in a relatively remote area that doesn't have ready sources for electronic parts, you can send away to numerous supply houses, who have good catalogs of electronic parts and assemblies...many of them real bargains.

Following are several catalogs that we have recently received in the mail, with brief descriptions and comments. Most of these suppliers send out new catalogs every four to six months, with many of the items repeated and new ones added, plus some new "specials"...usually on the first couple pages and the last few pages of each issue.



BUDGET ELECTRONICS

As the name implies, BUDGET ELECTRONICS has an impressive list of quality components, kits, books and other goodies at budget prices. They offer lots of components: passive as well as active, including transformers, project kits, enclosures, LEDs, connectors, transistors and a wide assortment of TAB books. All are a must for hobbyists and technicians.

For beginners in the electronics hobby and the bargain hunters, we suggest they check the front end of the BUDGET ELECTRONICS catalog (available on request) for "Electronics Parts Assortments". These "Budget Assortments" (up to 115 pieces of hand selected, every day, usable parts, including capacitors, resistors, LM324, 7812 TO-220, T1 3/4 Red LEDs, 1N4148, 2N3904 and more, should let the beginning electronics hobbyist jump into the electronics hobby with both feet.

The supplier (BUDGET ELECTRONICS) directs its emphasis to customer service with neatly organized, careful packaging and satisfied customers. In addition to their free catalog, their mailing list members receive frequent fliers with current specials that are available. Request their free catalog and get on their mailing list, **BUDGET ELECTRONICS, P.O. Box #1477, Moreno Valley, CA 92337.**

SEMICONDUCTOR REFERENCE GUIDE

272 pages, $3.95 at all Radio Shack stores. Everyone who uses transistors, diodes, or ICs (integrated circuits) should have this invaluable reference book. It has 272 pages packed with detailed specs and diagrams showing how to use 80,000 of these devices.

Interchangeability tables tell how to substitute Radio Shack's Archer parts for most other transistors and/or ICs. Since there are 8,000 Radio Shack stores nationwide, the transistor or IC you need is only as far away as your nearest store.

Although this Guide is most useful for experienced technicians and experimenters, it can be used by absolute beginners. It includes instructions on the care, handling and soldering of transistors as well as ICs. It even describes out-of-circuit testing.

It's revised and brought up-to-date every year. An absolute **Must** for all serious electronics hobbyists.

SURPLUS SAIL (SALE)

Published "more or less six times a year" with a nominal cover price of fifty cents, this 48-page flyer is number 34 of a series listing military and industrial surplus aimed at teachers, labs, tinkerers...do-it-yourselfers, etc.

Two pages of switches and controls, more on optics and lenses such as a big copy lens-8-inch focal length (f. 4.5), $12.50, plus prisms, mirrors, and so on. More pages on AC and DC motors, lots of magnets, and plenty of surplus electronics parts. Fans, blowers, air plumbing parts, unusual audio components and unique tools are also listed, along with science novelties. Every item is real surplus. Some are terrible, many terrific. Get the catalog by sending a stamped, addressed envelope to **Jerryco, Inc., 601 Linden Place, Evanston, IL 60202.**

RARE OLD RADIO SCHEMATICS & BOOKS

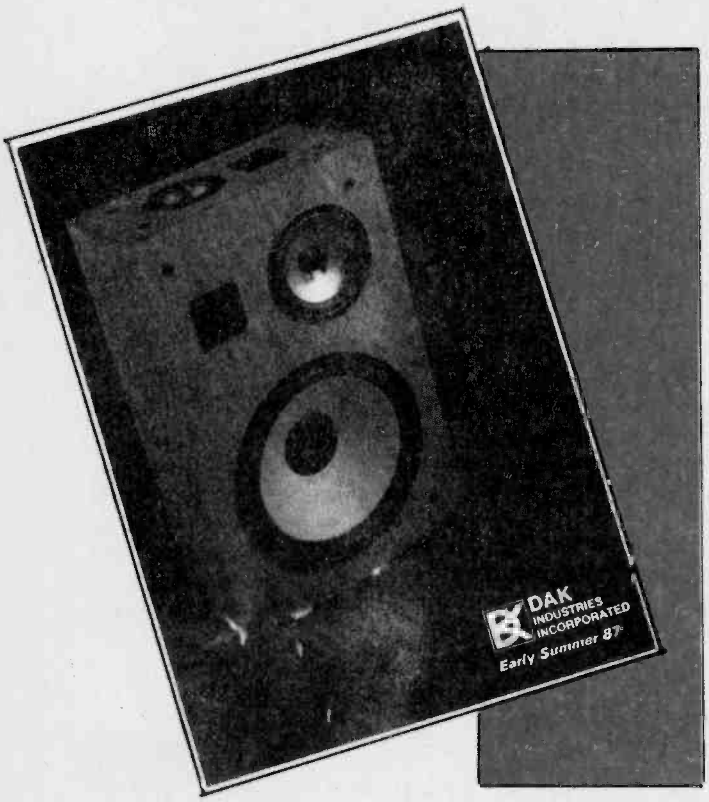
This is a valuable and fascinating catalog listing about 75 historical books and collections of schematics dealing with (mostly) radios of the Twenties, Thirties and Forties. Prices range from under $5.00 to about $20.00 for typical titles such as 1921-1932 Radio Collectors Guide, RCA Radiolas, Vintage Radio, Westinghouse Apparatus, 70 Years of Radio Tubes and Valves, Atwater Kent Radios, How to Repair Old Radios, and reprints of thousands of antique radio repair data—including Morris Beitman's Supreme information.

Many of these books are available only through this catalog; some may be sold elsewhere. The listing above is only the tip of the iceberg. For example, Juke Boxes, Edison Phonographs, Carousels, etc. are among the numerous other non-radio areas which are covered in books offered here. The catalog is available on request (include a stamped, addressed envelope) from **J. Earl Scaramella, Box One, Woonsocket, RI 02895.**

NUTS AND VOLTS

By simply requesting it you can get this publication titled "A National Publication for Buying and Selling Electronics Equipment." This issue has 64 pages, and includes hundreds of classified ads for everything you could imagine, The first I saw that interested me was an IBM printer (list about $400 today) for $150, including cables. Batteries, ham gear, CB equipment, computers, cable and satellite TV stuff, from private parties as well as from dealers are here in profusion.

If you place and ad (40 words for $10.00) you get the monthly magazine for a year. Send your name and address for a free copy to **Nuts and Volts, Box 1111 Placentia, CA 92670.**



DAK INDUSTRIES

This company issues a new catalog several times a year. It's hard to describe their offerings completely because they offer so many different, unusual, and sometime a little off-the-wall things. These are mostly consumer electronic items priced from $25 up through a couple of hundred. Sometimes they're just off-brand models, and other times discontinued models from well-known manufacturers.

And sometimes they're just plain screwy. A good example is on page one of their current catalog. It's The Bearoid Phone, and it's a telephone answering device made to look like a pink cuddly bear. What does it do that regular answering machines don't do? You may not believe this, but I swear it's true. When a call comes in, the bear's lips move, more-or-less in synchronism with the voice at the other end of the line. And it costs only $150.

Some of their other items can be good buys, if it's something you really want, from stereo and tape gear through video and satellite receivers. The catalog is very attractive, and the writing will make your mouth water sometimes. To get a catalog, write to **DAK, 8200 Remmet Ave., Canoga, CA 91304, or call toll-free 1-800-423-2866.**

FORDHAM RADIO

This company sells expensive electronic tools and parts. You can get a good idea from the cover of their current catalog, which shows three items. One is a $299.90 tool case (it does include the tools), a second being a precision oscilloscope (same price). The third item is a good-looking hand-held digital multimeter they'll give you if you order either of the other two items.

If you like to dream, you can enter their Dreamland by getting this catalog from the address or free phone listed here. If you don't want to waste time dreaming, go to your local Radio Shack store. You can get most things you need there, at lower prices. It's **Fordham Radio, 260 Motor Highway, Happauge, NY 11788, or toll-free 1-800-645-9518.**

CORDLESS PHONES

but only a small, non-visible antenna inside. If you plan to separate the two units by more than 20 or 30 feet, it might be wise to have the store agree, in writing on the sales order, to let you return the set within a few days for a stronger set with its own extendable antenna. such an antenna sometimes wears out or breaks loose, so you should be certain you can get it replaced easily.

There are also separate base station antennas which sell for between 40 and 70 dollars. These are intended to extend the range of your set, and can certainly help you get a stronger signal between the two stations. Before purchasing one, make certain it is fully returnable if it doesn't do the job you want it to do.

What Frequencies?

Cordless telephones use one of ten fixed radio frequencies. Since there may be dozens, even hundreds, of cordless phones in use in one area, that can sometimes lead to interference or even make communication impossible. If you use a cordless at the same time a close neighbor does, and he happens to be on the same channel, there could be a problem. In small towns or rural areas there is less likelihood of such interference, but in crowded city locations it'll get worse as time goes on.

The base station transmits on a low (46 megahertz) frequency, while the handset transmits to the base station on a higher frequency (49 megahertz).

There are a few, older sets around which work on much lower frequencies around 1.7 megahertz. These sets are obsolete because they are much more likely to have bad interference. Be sure your set operates on newer, 46 to 49 megahertz frequencies.

Budget-priced cordless from Radio Shack has portable handset. Includes last-number redial. Works on rotary or Touch-tone lines. Nicads recharge automatically. Model ET-390 from Radio Shack $100.

Ma Bell

Just as you should inform the phone company when you install a wired telephone to replace the one(s) you've been renting, you should tell your phone company when you add a new cordless system to your home setup.

They need this information so they can have your line set at their end (the telephone switching exchange) to send the correct ringing power to your line. They will need two pieces of information: first, your FCC Type Registration number, and also the Ringer Equivalent number. Both of these numbers are printed on a label on the outside of all new telephones.

FRANKLIN-ACE

and also has an antisurge device to protect the whole system.

After we got Dr. Melvin's report, we asked him if he planned to buy a Franklin, since he seemed unequivocal as to its superiority.

To our surprise he said, "No, I'm going to buy an Apple, even though it costs more. The main reason is that the Sears, Roebuck store where I went several times to ask questions about the Franklin had salespeople who were either ignorant, uninterested, impatient, or all of the above. I couldn't believe that they were actually Sears employees. They seemed to have absolutely no interest in selling Franklin (or any other) computers, and very little knowledge of any of the several computers they had on sale.

By contrast, the salespeople in the two Apple computer stores I visited were pleasant, helpful, and very knowledgeable. I'd be afraid to buy a computer from people like those in the Sears Computer Department.

ANTIQUE LOOP ANTENNA

inches on a side. On the graph on this page follow the line up through 20 inches to the one inch spacing curve and from that point to the left. This shows about 20 turns are needed; 18 turns are needed for ¾ inch spacing; 15 turns for ½ inch spacing; and 12 turns for ¼ inch spacing. The table shown will give exact dimensions and length of wire needed for various size loops. The inside turn of the loop should be connected to the antenna binding post of the radio.

Now that you have designed and build a loop antenna how do you connect it to your radio? The method of connecting a loop to your radio depends upon the wiring inside your radio. If the set has an antenna coil and tuning capacitor connected in series then the loop is connected in series with them. If the receiving set has a coil only then a tuning capacitor must be placed so that one end of its terminals is attached to the loop and the other to the ground connection of the set. Then the inside turn of the loop is connected to the antenna connection of the set. A loop and tuning capacitor may be used to replace the tuning circuit of the RF amplifier stage in the radio. In this case the tuning capacitor is connected across the grid and filament connection where the original tuning coil was connected. With a loop antenna you needn't worry about a lighting arrestor as you would with an outside antenna. ■

ANTIQUE RADIOS

pin comes out. If you have a lathe you can make the new pins that you need or you can purchase them from the source named at the end of this article. Now that you have removed the pins you are ready to reassemble the tube. Insert the large pin into its hole in the base, and using a puch with a 90-degree point carefully flare the pin until it fits tightly. Do the same with the smaller pin. Be sure you stake them tightly into the proper holes. The drawing shows the base with the pins up. Run a bead of cement around the glass bulb and insert the previously-tinned leads into the proper pins. Remember the plate pin is the large pin, across from it is the grid pin. The other two pins are for the filament. Use masking tape to hold the bulb and base together for 24 hours while the cement dries. Solder the ends of the tube pins, being sure to heat the pins hot enough that the solder will flow down into the pins. Do not use excessive solder, for it may run down inside the base and short the wires together. Use a small file to dress the ends of the pins to a round surface so the pins will go into a socket easily.

Now We Test It.

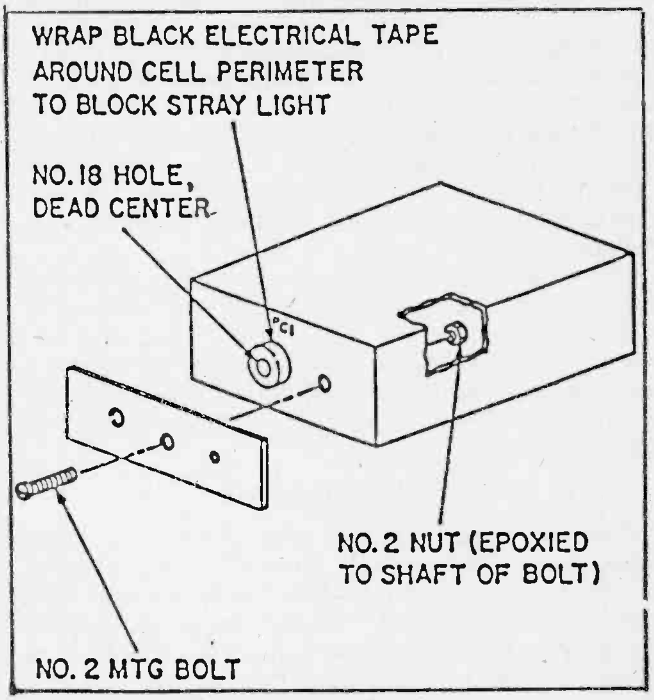
To test the converted 864/WD11 in a regular four-pin tube socket you must make an adapter. The easiest way to do this is to remove a four-pin base from an old tube. Solder pieces of flexible wire about 6-inches long into the tube pins. Solder clips with insulators to the opposite ends of the wires. Identify each clip as to grid, plate, and filaments, Connect the clips to the proper pins, set the tube tester filament selector switch to 1.1 volts, and set the other knobs just the same as you would for a 30, and test in the usual manner. If the lowest filament voltage on your tube tester is 1.5 volts solder a 1.5 ohm, ½-watt or larger in series with one filament lead. This will reduce the voltage to 1.1 volts.

If you decide to convert a 30 or 1H4G to a WD11 replacement follow the same general directions, only use correct wiring and filament voltage for the tube you are converting.

If You Need Help

For those of you who are "all thumbs" or do not have the proper tools you can buy the pins already made or buy a tube base with the pins already staked into the proper holes. Write to Antique Radio Parts, P.O. Box 42, Rossville, IN 46065 for a brochure showing the necessary parts with prices. If you need 30s or a 864/VT24 tube write to George Haymans, Box 468, Gainesville, GA 30501 for his list of tubes and parts. Be sure and send an SASE or you may not get a reply. ■

LIGHMASTER PHOTOMETER



Here are the details for mounting the range extender to the front of the case, and for taping around the photocell to keep it from receiving light which could cause misreading.

extinguishes. Now turn R2 back the other way until LED4 just comes back ON. The meter is now calibrated. To use the meter with different film and shutter speeds, consult the Table below.

Film Speed ASA	Exposure Correction
400	+2
250	+1
125	0
65	-1
Shutter Time	**Exposure Correction**
1/125	-2
1/60	-1
1/30	0
1/15	+1
1/8	+2

ASA = 125
+ - *go to higher f-stop*
- - *go to lower f-stop*

Additional Circuit Uses

You may have noticed that the comparator circuit presented here has great potential. A thermistor might be submitted for photocell PC1 and the circuit becomes an electronic thermometer. Or mount a potentiometer so that its control shaft spins as another shaft rotates. The LED display would then indicate angular position, perhaps for antenna rotor. The information here plus your own imagination should produce many new devices. ■

screen can be used instead. With this, all the on screen characters will have their voices and sounds coming from in front of the viewer, making a much more realistic effect.

Shown in Figure 7 is the circuit required to do this. the other channel of the amplifier used in the rear channel matrix above, and drive the center speaker. Note here, that this center speaker must be hooked out-of-phase with the other front speakers, since the center channel circuit inverts the signals phase. And further, when the center channel system is in operation, carefully adjust its volume so that it blends with the other two front channels; sounds should not be too obvious until the appropriate screen action calls for them to be heard.

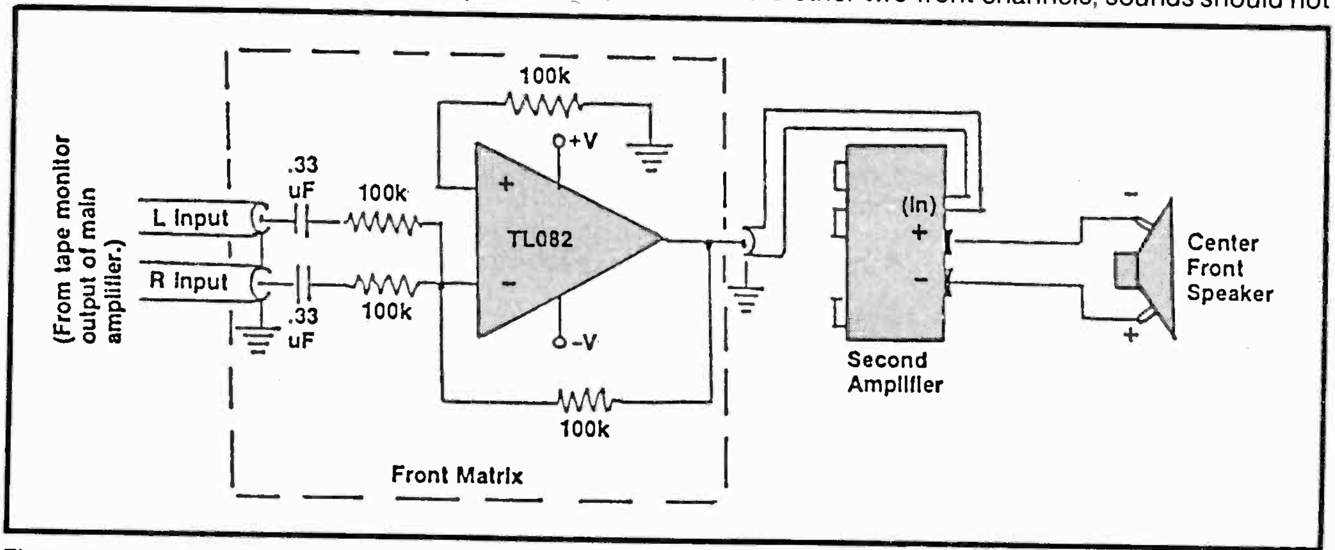


Figure 7. Complete schematic of center front matrix circuit. All resistors, capacitors, and input/output cables are as in Fig. 5.

Notice it also uses a single op-amp like the circuit above, with only a few resistors and capacitors. Also, the power supply in Figure 6 can power it as well as the rear channel ambience circuit. As indicated, it will take the two stereo soundtrack channels, from a tape monitor output of the main amplifier, and provide a summed output, with the center information enhanced, to another second amplifier, which can be

Well, there you have it. Once the system is set up, you can sit back and really enjoy the effects from your favorite science fiction or adventure film, along with the whole family, All you will need to complete the effect is some popcorn, and your favorite beverage. Now sit back, relax and enjoy. ■

BUILD A COKE-BOTTLE ANTENNA

reading is being taken. If not, his body will add capacitance to the antenna and will cause a false SWR reading.

The capacitance hat wires should be trimmed only ¼-inch at a time. Trim ¼ inch from each of the four ends of the capacitance hat on both ends of the antenna. Take an SWR reading between each trimming. Also, it's important to recalibrate the SWR meter after each trimming.

Repeat this procedure until the SWR falls to 1.1 A simple test to make sure you are going in the right direction can be made by placing your hand near the capacitance hat (about one quarter to one half inch away) while taking an SWR reading. If the SWR goes up as your hand approaches, the hat stubs are still too long. If the SWR goes down as your hand approaches, you have trimmed too much. Simply make new capacitance hats and start over.

Once tuned, the antenna should remain at or near a 1.1 SWR from Channel 1 through Channel 40. If you use the antenna vertically, some re-tuning may be required. Keep the shield side of the antenna down, and the center conductor side of the antenna up.

If you are on a ground floor, the proximity to the earth ground or metal and concrete floor may make a low SWR in the vertical mode very difficult to achieve.

Performance

You can see that this antenna isn't the best looking one around. We didn't say it would look good, only that it works well. Our first contact was 12 miles to a mobile with an S meter report of 10. (10 lbs.) Base stations at 20 miles gave good, readable, reports with some S readings of 3 to 6.

Why the 2-litter Coke bottles? On the average we were given 2 to 3 S unit better readings using a larger diameter coil. The 2 liter bottle proved to be the cheap way to get there.

Although our installation wasn't in the attic, I am sure reports would be even better with a second or third floor or attic location.

The PVC and plastic used in this project are biodegradable and not recommended for outdoor use. For outside installation, a coating of black epoxy paint or similar material should be used. All connections should be sealed with RTV rubber sealant. ■

microamps flows in the load connected to the battery, 735 microamps flows through the battery, keeping it charged. It is necessary to fully charge the Nicad cells before installing them in this circuit as it is doubtful that the 735 microamps could fully charge a flat Nicad—at least it might take a while!

Construction

Because of the small number of components, construction is quick and relatively simple. Layout is not critical. All of the components can be mounted on a 1-1/8"× 1" piece of perfboard; the smaller it is, the easier it will be to install inside the telephone housings as shown in Figures #1 and #2. A suggested layout for the perfboard is shown in Figure #5.

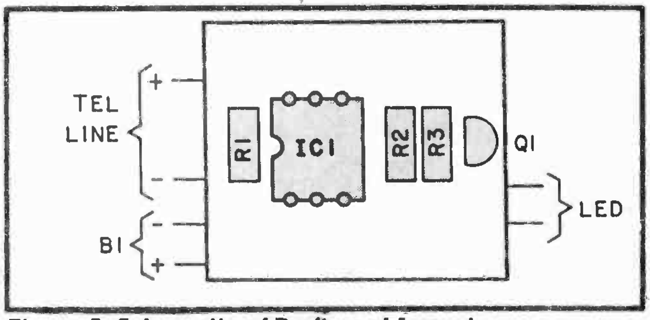


Figure 5. Schematic of Perfboard Layout.

PARTS LIST

B1—Nickel Cdmium Battery, 2 each AAA cells (Radio Shack 23-127) or 2 each N cells (Radio Shack 23-121)
IC1—Optoisolator, MCT2F or TIL 116
LED1—Small light emitting diode
R1—47000 ohm ¼ watt resistor, 5%
R2—100000 ohm ¼ watt resistor, 5%
R3—10000 ohm ¼ watt resistor, 5%
Q1—Transistor, 2N3704 NPN
Cell Holder for 2 AAA cells (Radio Shack 270-398)
Cell Holder for 2 N cells (Radio Shack 270-406)
Optional:
Box, Ponoma Model 2417, 2¼" L × 1-⅜" W × 1-⅛" H, or similar.

The author used hot glue to fasten the perfboard and the batteries in the telephone base. The bottom of the perfboard circuit was covered with hot glue and allowed to harden before gluing to the telephone base (See Figure #2). The layer of hot glue is a very good insulator; using it eliminates the need to drill holes and standoffs. One unit was constructed in a small box to use where it was not feasible to install inside the telephone housing. The author used the Ponoma Box shown as "optional" in the parts list.

It should be noted that the LED lights when *any* telephone on the line is off the hook and that includes the LED on the phone you are using. This should help considerably if you are on a party line! Also remember that disconnecting the telephone from the line will cause the LED to light also. So if you disconnect a phone and plan to store it or otherwise leave it disconnected for more than a few hours, you should disconnect the battery or it will eventually run down. ■

terminals. The voltage increases gradually as you cautiously increase the speed of the drill. You should also be able to read DC voltage across the brush connections. If the voltage is lower than at the reversing switch, look for poor contacts, bad brushes or dirty commutator. When the power is on, jiggle suspected parts only with a non-conducting tool such as a plastic swizzle stick or a length of dry wood dowel.

Basically the same troubleshooting methods would be used to find defects in any other powered shop tools. Single speed tools will surely have AC motors. Look for DC currents in tools that feature variable speeds that are electrically rather than mechanically speed-controlled.

Household Appliances

Motorized household appliances, and the motorized sections of other appliances (the fan circuit of a space heater, for example), would be tested in like manner. But many appliances also have heater circuits requiring different troubleshooting methods.

If the appliance is completely dead, you first check the power cord. If that is good, take the appliance apart far enough to get a good look at the inner components. Trace each circuit carefully, looking for breaks or bad contacts.

If you discover a break in a heating element, it usually means that you will have to obtain a replacement part. Remove the old element from, say the steam iron or toaster, and take it to your appliance repair shop to aid in the selection of the proper replacement. Also take along the model number of the appliance. If the appliance is quite old and an exact replacement is not available, the professional repairman may be able to make a simple wattage test of your defective element and suggest an alternative replacement (assuming that it will physically fit into your appliance).

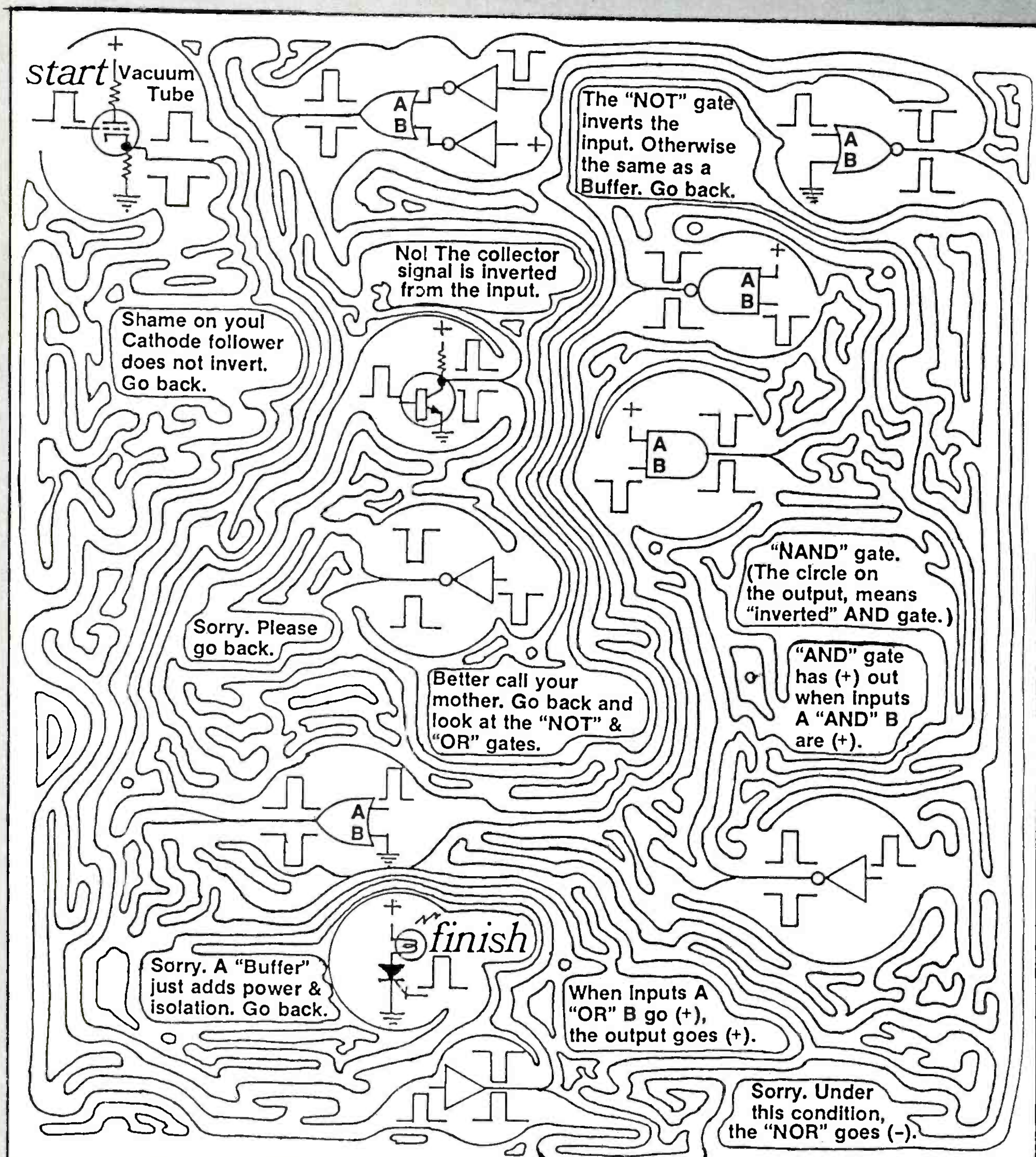
If the appliance uses a coil-type heating element a break can be repaired if the broken ends can be formed into small loops. (Sometimes the heater coil is so brittle that it keeps on breaking as you try to form the loops, in which case replacement of the entire coil is the only answer). If you do succeed in forming loops, bolt them together as shown in the photo. Obviously the connection must be mechanical (bolt or rivet) because solder and cements wouldn't last even a few seconds when the coil heats up again. ■

"I can't help it . . . it draws more power than I thought it would . . ."

PICK A PULSE

by Glenn M. Rawlings

Begin at "START", and with the input shown, see if you can select the proper output pulse from each circuit. If you do, you will be able to light the bulb at the "FINISH". Who knows, this may help you to trace PC boards as well!



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