ELECTRONICS HOBBY-THEORY PROJECTS

C&E HOBBY HANDBOOKS

SPRING 1987

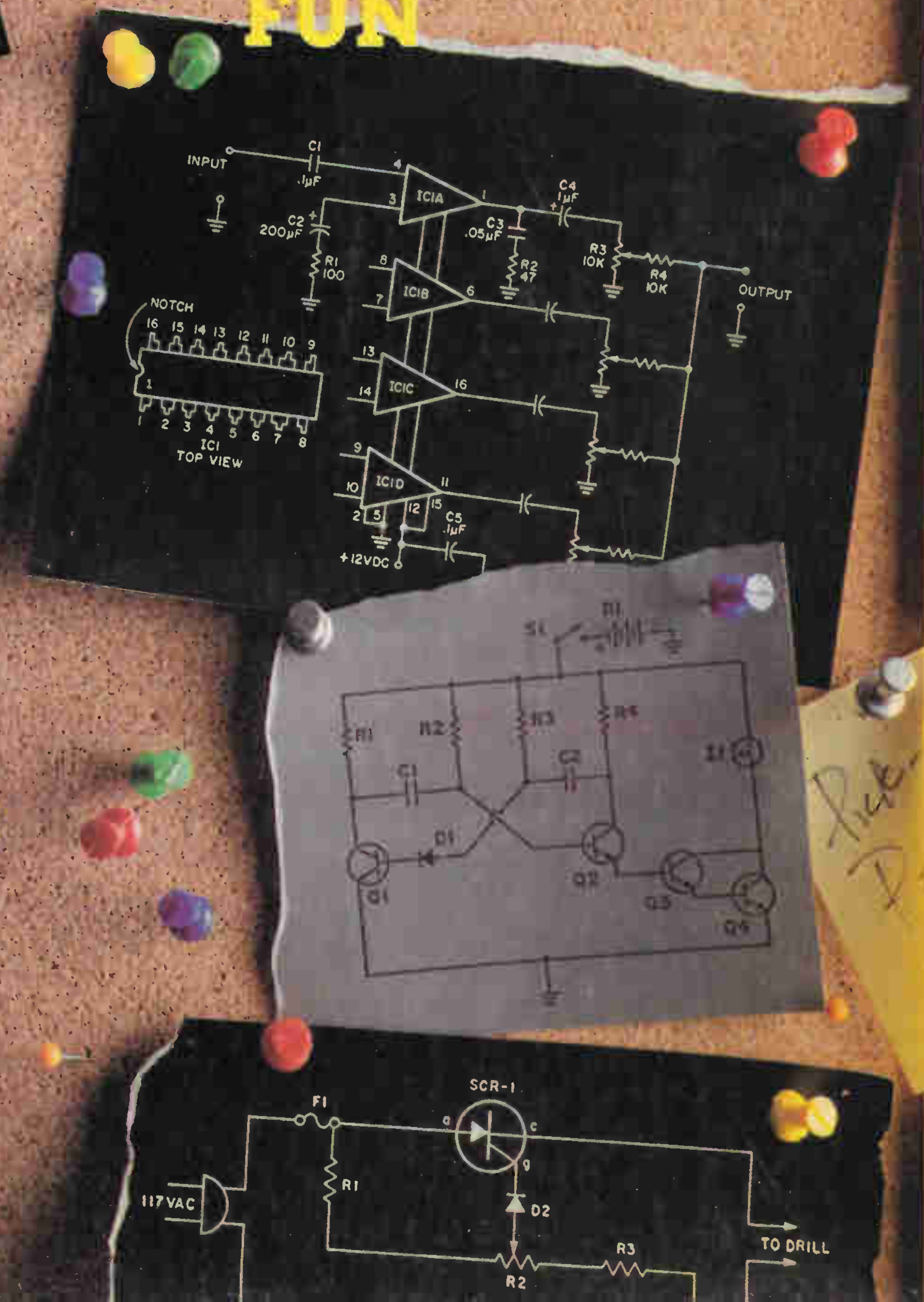
$2.95

ELECTRONICS HANDBOOK

WPS 36286

IN CANADA $3.50

PIN-UP PROJECTS FOR AN EVENING'S FUN



BUILD A GAS ALARM

'SCOPES ARE EASY

TODAYS ROBOTS

CHOOSING A VCR

ALL ABOUT CAPACITORS

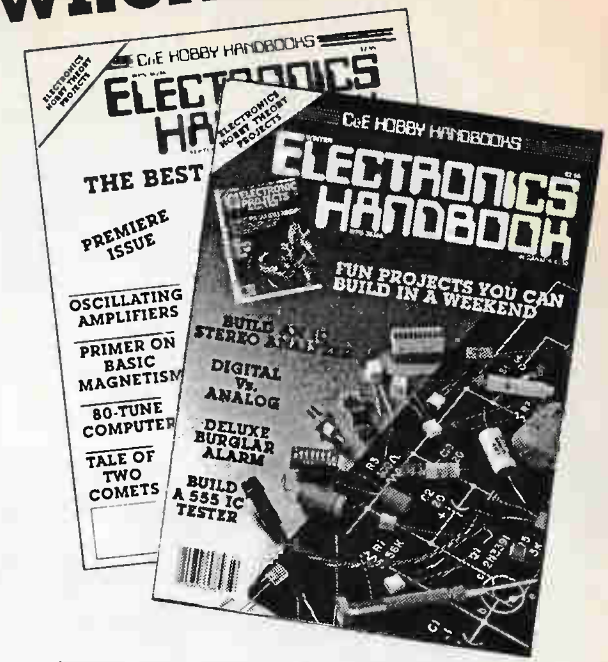
BUILD A TWO IC RADIO

71

70989 36286 4

Lab Test
ELECTRONICS
HANDBOOK
For Yourself

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
Newgraphics, Inc.

ASSOCIATE ART DIRECTOR
Joe DeStefano

COVER ART
George Mattei

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

Published by C&E Hobby Handbooks, Inc. Editorial and Business address, P.O. Box #5148, North Branch, N.J. 08876 (201) 231-1518.

EDITORIAL CONTRIBUTIONS must be accompanied by return postage and will be handled with reasonable care; however, the publisher assumes no responsibility for the return or safety of manuscripts, artwork or photographs. All contributions should be addressed to: PUBLISHER, C&E HOBBY HANDBOOKS, P.O. Box #5148, North Branch, N.J. 08876.

As a service to readers, C&E HOBBY HANDBOOKS publishes available plans and/or information relating to products, techniques of scientific and technological developments. Because of possible variances in the quality and condition of materials and workmanship used by readers, C&E HOBBY HANDBOOKS disclaims any responsibility for the safe and proper functioning of reader-built projects based upon or from plans and/or information published by C&E HOBBY HANDBOOKS.

ELECTRONICS HANDBOOK

CONTENTS

WELCOME ABOARD

Welcome to another issue of the ELECTRONICS HANDBOOK. Whether you are a new reader or have become acquainted with our "Handbook" from previous issues, we have once again endeavored to compile a collection of articles and projects similar to those that we published in **101 ELECTRONIC PROJECTS, ELECTRONICS THEORY HANDBOOK, 99 IC PROJECTS** and the **ELECTRONIC HOBBYIST**.

To bring you more and better articles and projects, ELECTRONICS HANDBOOK welcomes 3 authors to our pages and adds their names to our staff (Page 1).

Ed Noll, who has contributed articles to the C&E Hobby Handbooks in the past, has agreed to author a regular column, "**Chip-By-Chip**", starting in this issue. Ed has written and been published extensively, including "**Applications And Experiments With Oscilloscopes**", "**Handbook For FCC Radio Telephone Licenses**", and "**Microprocessor Circuits**" in hard-back editions for **Howard W. Sams & Co.** In addition, he is an accomplished lecturer and the author of numerous other technical articles and books.

His "**Chip-By-Chip**" column will be an interesting and educational series on the uses of those universally-used little marvels that are at the heart of everything electronic these days...the IC chip.

Walt Sikonowiz has another editorial contribution in this issue, "Buying Electronic Parts", a timely and informative article on the fine art of finding those elusive electronic parts for your projects......at a price you can afford. Walt contributed the popular "**Deluxe Burglar Alarm**" project in the last (Winter) issue. We look forward to more articles and projects from Walt.

Another author, who is no stranger to the ELECTRONICS HANDBOOK readers, is **Homer Davidson**. In this issue, Homer presents an interesting do-it-yourself project on how to build an inexpensive "**Two IC Radio**". Homer has been a regular contributor to the C&E Hobby Handbooks in addition to his numeorous articles and projects that have appeared in many other Electronic magazines and books for many years.

To each of these gentlemen, we extend a hearty welcome! We are certain that their editorial contributions will provide entertainment and just plain fun for the ELECTRONICS HANDBOOK readers. We look forward to adding other distinguished authors to our staff in the months ahead.

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

Get switched on

THE FUN WAY TO LEARN ELECTRONICS

Lab Test ELECTRONICS HANDBOOK For Yourself!

LEARN ABOUT ELECTRONS: Electricity and Magnetism, Inductance and Capacitance

NEWEST SOLID STATE TECHNIQUES: Thermistors, Op Amps, IC Learning Aids

SECRETS OF RADIO: Phase and Frequency Facts, AVC, Superhet Circuitry, Power Supplies, Antennas

ALL ABOUT COMMUNICATIONS: Low Frequencies, Shortwaves, FM, TV, Microwaves, Satellites

"PLUG IN" to the excitement and satisfaction of

ELECTRONICS HANDBOOK

★ **RESERVE YOUR COPIES OF FUTURE ISSUES...**

★ **ORDER COPIES OF BACK ISSUES...**

★ **MAIL THIS COUPON FOR DETAILS...**

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

SP-87

FROM: (Please Print)

Name: ______________________________

Address: ______________________________

City & State: ______________________ **Zip:** __________

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:

The Editor
C&E HOBBY HANDBOOKS INC.
P.O. Box #5148
North Branch, N.J. 08876

Electrical Vs Electronic

I read about "electronics" a lot, and every so often the word "electrical" creeps in. What's the difference? Isn't it all electrons running around inside wires and little parts, anyhow? Please straighten me out—**D.R. Hawkins, Southport, NY**

You're on the right track when you say, "Isn't it all electrons running around inside wires and components?" Electricity is the flow of electrons (through wires and circuit components). Electronics is a special branch of electricity, in which the electrons go through electronic components. ***Electrical,*** *as encountered in everyday life, is a somewhat simpler discipline, involving mostly lights, motors, generators and so on. In electronics we usually put the electrons through more transformations (or changes).*

A fairly simple way to decide whether a circuit is just ***electrical*** *instead of* ***electronic,*** *is whether it involves what we call* ***active*** *components or only* ***passive*** *components. Active components are transistors (or vacuum tubes) for example. Passive components are resistors and capacitors.*

Likes Computer Review

Thanks for your informative article on the Atari ST-520 (as compared to the Apple McIntosh). I was about to buy a Mac when I bumped into an Atari, and then I read your article on the Atari ST-520. I am now seriously considering buying (the Atari), but the stores where I've seen it seem to be run by salespeople who don't know much about it, and nothing at all about word processing programs available for it.

Can you help me find retail outlets in the metro New York area where they might know what the Atari can really do?—**M.C. Stone, New York, NY**

The problems you've run into are common in the merchandising of home microcomputers in many retail outlets. The Mac is sold only through computer stores, whose salespeople know more and are paid more out of the higher price(s) charged for the Apple McIntosh. Since we ran the article you read on the Atari ST there have been many software programs published for it, including Word (for word processing) and Degas (for high-quality graphics), at prices far below competitive programs for the Mac. A list of stores selling the Atari ST and software for it in your area is attached. Thanks for your kind words.

To Socket Or Not to Socket

What's the real story on IC (integrated circuit) sockets? Should I use them in my projects, or shouldn't I? Is it better to solder ICs directly into the project board, or should I go to the extra trouble of first mounting a socket, then plugging the IC into the socket?—**James Winslow, High Point, N.C.**

The way I do it is to rig the project up first on a solderless breadboard and get it working the way it's supposed to. Then I hand wire the project on a perforated board, or a home-made printed circuit board (if I'm going to make up several copies of the finished project). I don't usually use sockets because they can cause trouble when a pin on the IC bends or breaks as the IC is inserted into the socket. The only time I recommend using sockets is when the circuit is still being designed or debugged, even after the hand wiring stage. Then the use of sockets is recommended. (Or when you're going to reuse the circuit components, as in Ed Noll's new column, ***Chip-by-Chip.***

Junky Noise

I often get noise in my car radio (more on AM than on FM) from the windshield wiper when it's working. I have a friend who gets similar noise in his car's CB radio from his car's windshield wiper. How can this be cured?—**Elbert Farouk, Atlanta, Georgia.**

Noises in car and CB radios can come from a number of sources in your car's electrical system. Most common, of course, is the windshield wiper, because that's not on very often and if it is, you'll usually have the car radio off, being too much concerned with seeing what's ahead to have the radio (or CB) on anyhow. Other sources of this kind of impulse (AM) noise are the radiator fan, the gas pump, and the ventilation blower motor. Capacitors to by-pass the electrical (AM) impulse noises to the car's chassis are needed in the DC supply lines of all these devices to reduce the noise. Also, the car's alternator, particularly in the low speeds (first, and second) can make lots of noise. Installing by-pass capacitors (0.1, 600 VDC) at each device will by pass most interfering electrical impulses to ground, clearing the hash from the radio.

Sound Goes Up and Down

I have an SW (short wave) radio that acts strange. The sound keeps going up and down, fading in and out, particularly on stations far away at night. Will a better antenna fix that, or what? —**Lester Goodwin, Albuquerque, NM**

A little research into shortwave and DX (long distance) AM radio will show that AM signals often fade in and out, causing the kind of sound variations you complain about. All sets have an Automatic Gain Control (AGC) that helps minimize fading, but some radio signals come from so far way that the fading, which is normal at great distances, particularly at night, can't be entirely overcome.

Young But Likes Antiques Radios

I am only 13 years old, but I've already got two antique radios, and want to start a real good collection. I have built and repaired several radios already. But I don't know how to find old-time radios. Can you help me locate them? —**Ronnie White, Melvin, South Dakota.**

You should advertise, man, advertise. You can do it for free, too. Tell all your friends, relatives and neighbors, first of all. Put up notices in your local supermarkets. Your parents can put up notices in their plants or offices, And you should visit all possible garage sales, flea markets, tag sales, etc. Start thinking about where people might have old radios, stashed away in closets, garages, and attics. You'll begin to get results. Don't offer much money ($1.50 to 2.00) until you know more about the market values involved. Read our ***Antique Radio*** *articles, and check the list of Antique Radio Sources we ran in the* ***Antique Radio*** *Department in our last issue.*

Reader Loves Us

Where have you been all my life? I just bought the latest issue of *Electronics Handbook*, and it's great. One question, however. I saw an ad in another magazine for a wireless microphone, and they wanted $800 for it? How many parts could there be in it to justify such a high price (most resistors and capacitors only cost a few cents, don't they)? Isn't that just a ripoff? How can they get away with it. —**Thomas Pruit, Newcastle, Delaware**

The ad you saw was for a professional microphone system, probably for use in making movies and TV commercials. It's a super-high fidelity device, and includes not only the microphone, but a radio transmitter, as well as a precision receiver. It also has to be extremely small so that the actor or singer using it can keep it concealed from the camera.

The receiver picks up sound to be recorded along with the pictures. In addition to being extremely high fidelity (and stereo), it has to work with absolutely no fading or static, and sometimes at considerable distance. Put all these requirements together, and also remember that the market for this system is very small, unlike the market for mass-production radios and TV sets. The price is probably not all that much out of line.

As you guessed, you can get wireless mikes that will work OK for only a few dollars. But they will be mono, will have low fidelity, and won't work reliably for much distance.

Go Another Way

Is there a company that will design printed circuit boards from schematic diagrams? I've tried making PC boards, but they seem to be more trouble than they're worth. Where can I get then custom-built? —**Karl Montrose, Durham, NH**

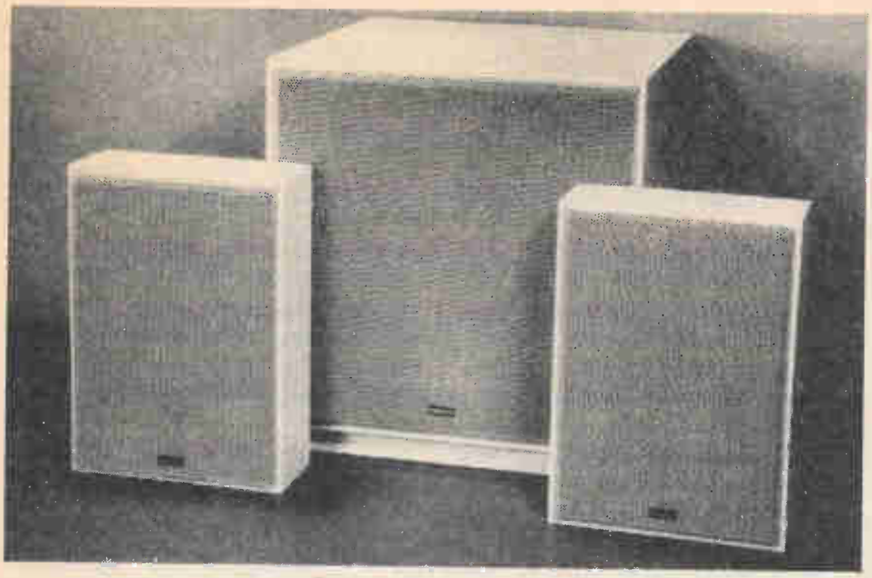
What you need are solderless breadboards. Radio Shack has them in small, medium and large. Solderless breadboards are good because you can build on them, troubleshoot, make design changes, and use the final design. And afterward you can take it all apart quickly to reuse the components and the board(s) all over again. You can often put the PC overlay right on top of the solderless board and trace most of it out there. You can frequently simplify the layout some, but you'll find it much easier to use these boards than PC boards. PC boards were used before solderless board were thought of. They're still good for making several (or many) copies of a project. But for one-shots, go with solderless or perf boards.

Light Bulb Resistance is Wrong

One of the basics of electronics I've learned is that more current flows through a low resistance than through high resistance. But when I measure a light bulb's resistance I get only fraction of an ohm. How come the light bulb doesn't draw hundreds of amperes of current (thousands of watts) when it's plugged into 110 (115 or 120) volts AC power in the wall? What's the story? —**Lee Knowles, Paducah, Kentucky**

When the filament of an incandescent light (tungsten) is cold, its resistance is very, very low, less than an ohm, as you measured. So you're right (almost). If it stayed low, it should as you've stated use hundreds maybe thousands of watts. Much more, obviously than the power line transformer outside your home could supply. What happens, however, is that the filament heats up fast when current starts flowing through it, increasing its resistance to much higher than when it's cold. This resistance then keeps the flow of current down low so that only 60, 75, or maybe a hundred watts of current flow most of the time. When the lamp is first turned on, a great deal of current does flow, briefly, and this called the ***initial surge.*** *With light bulbs, as with most other devices, much more current flow briefly, when the device is turned on, than after it gets going normally.*

NEW PRODUCTS PARADE

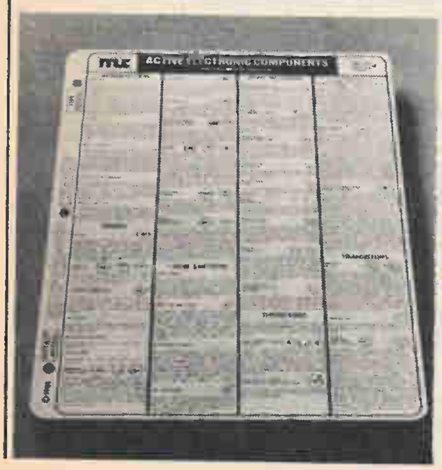


COMPACT REVOX SPEAKERS

Revox of Switzerland, famed for professional tape recorders and other high fidelity equipment, has a new compact loudspeaker system available in two configurations. It consists of a pair of full-range loudspeakers so thin they may be wall-mounted. They can be used alone, for most applications, or with a companion subwoofer speaker floor-mounted anywhere in the room that's convenient This is because extreme bass-frequency sounds are non-directional.

The small speakers each have a 4 3/4-inch midrange driver and a 3/4-inch dome tweeter in a cabinet 8×11×3 3/4-inches deep. Their frequency response is 80 Hz to 25 Khz (±3 dB) and distortion at 91 dB sound pressure level (at 6.6 feet) is under 1.0 per cent. The companion subwoofer can produce audio waves from 48 to 120 Hz (±3 dB) at under 3.0 per cent distortion.

It measures 15×14×14 inches (approx.) and weighs 32 pounds. The smaller satellite speakers weigh five pounds each. Supplied in matte-black or white, the stereo speakers are $300 per pair, and the subwoofer sells for $350. **Revox America, Inc. 1425 Elm Hill Pike, Nashville, TN 3720, and better audio dealers everywhere.**



ELECTRONIC COMPONENT CHART

If you design or repair electronic circuits, you can now get a handy plastic reference card that lets you get right to the basic workings of everything from op-amps to programmable unijunction transistors—without having to go through theory, fabrication methods, or advanced terminology. From Micro Logic Corp. of Hackensack, NJ, MICRO CHART #10 entitled "ACTIVE ELECTRONIC COMPONENTS" is a two-sided two-color 8½ by 11" plastic card that is packed with information. If you reference this card while designing circuits you will end up with circuits that are simpler and less expensive, according to the publisher. If you repair circuits, you will not have to stop and research unfamiliar parts. Non-digital functions readily available in a single monolithic package are covered including 13 diode types, 6 types of transistors, 5 families of thyristors, 4 types of light emitters, 9 types of light receivers, plus the analogue switch, A/D & D/A, comparator, multiplier, one-shot, op-amp, optocoupler, PLL, bridge rectifier, sample and hold, Schmitt trigger, tone decoder, varistor, VCO, voltage follower, voltage regulator, and more. Typical descriptions cover: names of part, signal names, detailed operation, and examples of key specification parameters. Micro Chart #10 and other time-saving cards are available for $5.95 each (plus $1 postage) from **Micro Logic, Dept P, POB 174, Hackensack, NJ 07602. Contact James Lewis (201) 342-6518.**

NEW HAM RADIO COURSE FOR BEGINNERS

You can communicate over the air waves with almost a million other ham radio enthusiasts and hobbyists all over the world once you get your Novice Ham Radio license. You only need to pass a code test of five words per minute and some very easy theory and rules.

Heath's updated course comes from the long-time leader in electronics kits and instruction courses for self-study. The manual comes with two cassette tapes which teach you how to learn Morse code and pass the five-word-a-minute test, all about circuit components, as well as teaching you some basic theory; much more than you need to pass the Novice test easily.

In addition to telling you everything you need to pass the Novice exam you're told how to set up a small station and get your call letters.

It's all described on page 42 of Heath's latest catalog, and costs $44.95

Heath Company, Benton Harbor, MI 49022. Toll-free 1-800-253-0570

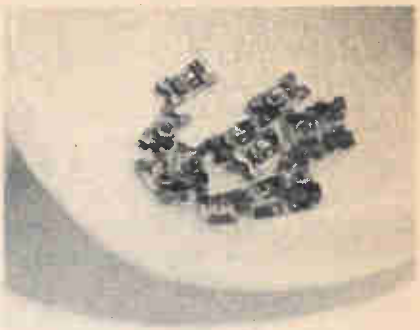
CORDLESS STEREOPHONES

You can now walk around the house and hear whatever is being played on your home stereo receiver, tape or record player. It's done with the Koss Kordless Infrared Stereophone system. This system has two parts. One is a small console (shown in the photo under the phones) which plugs into your receiver. Whatever the receiver is being used for (radio tape, phono, or even TV through the Aux. input) will now be broadcast throughout the house up to about 100 feet over infrared frequencies, and received on your special Koss infra-red phones. The phones weigh less than 10 ounces, and are of the sealed (no outside noise leaks in) type.

The system works from a 9-volt transistor radio battery contained in the little console. Priced at $150 at audio salons everywhere.

CERAMIC CHIP LED'S

Mouser Electronics announces a new "state of the art" Ceramic Chip LED. the ME351-2700 series chipled's are miniaturized LED lamps consisting of a light enitting diode chip bonded by wire on a ceramic chip substrate. The mouser chipled was developed for a more compact, thinner structure compared with conventional LED's. These chips feature leadless type structure and are designed for surface mounting. Because they may be used in almost any automatic mounting machine they are the most economical chippled's on the market today. They may be "fixed" in a number of different ways; they may be glued with conductive epoxy, reflow soldered, vapor phase reflow soldered or flow (wave) soldered with "foot-step" fixing.



When properly installed the mouser chippled can utilize 10 times the current of standard LEDs, this results in brightness 10 times greater than standard LEDs. Available in red, gree, yellow and orange.

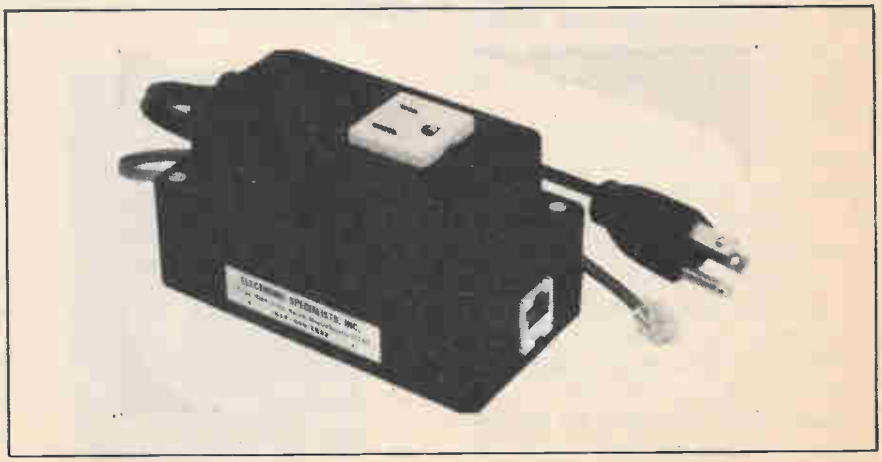
For more information contact **Mouser Electronics, 11433 Woodside Ave., Santee, CA 92071 (619) 449-2222. Ask for free catalog.**

CORDLESS PHONE PROTECTION

ELECTRONIC SPECIALISTS introduces KLEEN LINE Protection for Cordless Phone Base Stations. Intended to suppress damaging telephone and power line spikes caused by lightning, spherics or phone office switch gear, the KLEEN LINE security system uses modern semi—conductor, Gas Discharge Tube and Metal Oxide Varistor suppression techniques.

Model PDS-11/SUP has suppression on red and green phone lines (pins 3 & 4) with yellow and black lines brought straight through. A 6500 Amp Suppressor protects the AC Power Line. Standard modular 4 pin telephone connectors provide simple, trouble-free hook-up. PDS-11/SUP @ $92.95

Electronic Specialists, Inc., 171 South Main Street, P.O. Box 389 Natick, Massachusetts 01760 Phone: 800-225-4876



NEW BOOK REVIEWS

Coming of Age in the Electronic Era. Forest M. Mims, III. McGraw-Hill Book Company 208 pages, Hardcover, $16.95

An absolutely fascinating narrative of high-technology-in-the-basement by a participant in several epochal electronics developments. He was one of four partners in the garage-spawned company (MITS) which later brought out the first successful microcomputer (the Atari 8800).

author photo by Minnie C. Mims

Mims gives us a first-person account of his growth (along with the early microcomputer industry) from a young experimenter through real contributions (fiber optics and diodes to achieve a telephone breakthrough) to his victory over Bell Telephone and his present position as one of the most widely-read (and readable) writers on electronics today.

Included is a behind-the-scenes account of his adventures at a top-secret Air Force laser laboratory, his victorious battle with Bell Telephone Labs over his invention, and an incredible story of the time the National Enquirer hired him to eavesdrop on Howard Hughes by reflecting a laser beam against the billionare's hotel window.

Mims writes regularly for Modern Electronics and has authored many books for Radio Shack and other firms on electronics.

If you like inside, non-technical stuff about the history of the electronics industry by one who was (and is) there, **get this book!**

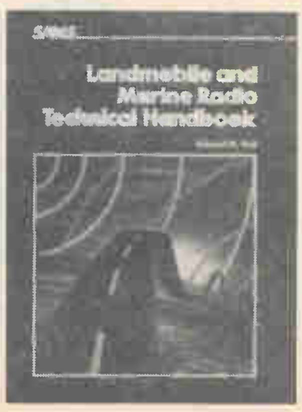
LANDMOBILE AND MARINE RADIO TECHNICAL HANDBOOK

This book is a complete atlas of the commercial two-way radio field. It covers the landmobile (industrial, public safety, and land transportation), marine (ratiotelephone and radiotelegraph), and personal radio services. Approximately two million radio stations are licensed in these services.

This book contains updated material from previous books *General Radiotelephone License Handbook* and *Marine Radiotelegraph License Handbook* as well as all-new material. Here, in this one volume, you will find:

- Two-way radio fundamentals
- Equipment circuit details
- Maintenance and installation data
- Test equipment types and practical usage

Since navigation, radiotelegraphy, and radar remain important facets of a number of radiocommunications systems, these fields are also discussed. In addition, there is coverage of cellular radiotelephones and satellite communications systems.



Landmobile and Marine Radio Technical Handbook has been written for current and prospective two-way radio technicians, operators, and engineers. It can be used as a radiocommunications textbook in community colleges, trade schools, and universities as well as radiomarine and armed forces radio schools. It should be a public library standard and a reference book for all types of two-way radio businesses. Inplant training courses can be organized around its content. A special objective has been to prepare the book as a reference for those electronics persons seeking two-way certification or FCC licensing.

Individual chapters are devoted to:

- Two-way radio services and their frequencies
- Transmissions characteristics and emission and modulation classifications
- Solid-state fundamentals as related to transmission circuits presentation
- Modulation systems used in two-way radio services
- Digital and microprocessor circuits
- Test equipment types and usage
- Antenna systems
- Landmobile two-way radio systems and circuits
- Repeater, trunked, and cellular radio systems
- Marine radiotelephone and radiotelegraph equipment
- Direction finders and loran
- Marine radar
- FCC licensing information

Landmobile and Marine Radio Technical Handbook is a very practical presentation. It provides fundamentals along with a comprehension of advanced practices that can make you a more knowledgeable and capable two-way radio technician.

Published by Howard W. Sams & Co., Inc., 4300 W. 62nd Street, Indianapolis, IN 46268. Signed copy available from author: Edward Noll P.O. Box 75 CHALFONT, PA 18914, $24.95 plus $2.00 Postage & Handling.

THE NEW SOUND OF STEREO

(The Complete Guide to Buying and Using the Latest Hi-Fi Equipment) Berger and Fantel. 265 pages. Paperback. New American Library. $12.95

This book is the nearest thing to a complete guide on the subject yet written. It should be, because its authors are nearest the ultimate experts on the subject. Unlike many mavens they eschew technicana in favor of plain talk, providing practical methods for negotiating one's way through specifications and sales myths.

Anyone planning to upgrade or start an audio system can profit from reading and rereading appropriate chapters. The book is divided into 26, with major subjects spread among several (Loudspeakers get three).

Because models and makes change all the time they've bypassed the difficult task of specific recommendations. But following their guidelines carefully will get neophytes and experienced audiophiles alike closer to the most for their money than any other advice available. Along with many other eminently practical suggestions they include a brief but excellent section on Making Tape Recordings.

One hilarious mistake crops up, so obvious as to be attributable only to imperfect editing, on page 110; "...the CD is an analog medium." And one small technical statement I question: "There are single-play turntables which play both sides of the disc...separate arms to play each side.." If there still are, today, few shoppers will find them.

In sum, an excellent guide, devoid of cant and myths, both of which abound in too much writing on the subject. Highly recommended for everyone planning to spend money on audio gear.

Charles Graham

CRASH COURSE IN MICROCOMPUTERS

Louis Freznel
Howard Sams, Indianapolis, IN
318 pages, paperback, $21.95

This comprehensive self-teaching book uses the programmed instruction way of transmitting information to the reader. That is, it's organized into many small pieces of information, each followed by a drill on that material, and finally, a very brief quiz on that bit of information. This is called programmed instruction, for teaching oneself when no other human teacher is available.

The material included covers all that most people will need, and then some (programming languages and operating systems). For anyone who is more than a casual potential buyer of a micro system, this book is excellent. If you just want to buy a micro and be done with it, this book will require more effort than you need to invest in it.

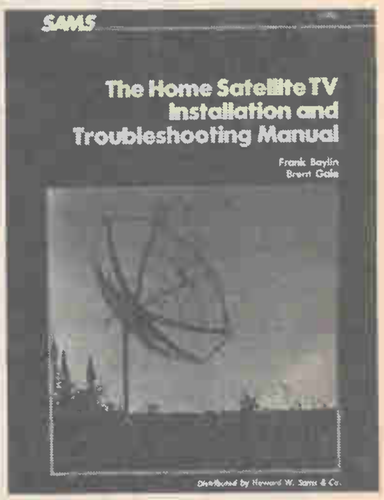
Along the way items like "telephone link" (modem), "Teletext" (similar to Viewdata), "telemetering," and "terminal," are covered briefly but clearly. RAM (Random Access Memory, that part of the micro which remembers what's going on, and what you type in) and ROM (Read-Only Memory, where the micro gets many of its instructions on what to do and in what order to do them) and other words found in the glossaries are explained in much better detail than is possible in brief lists of computer buzz words.

Despite it's early publication (see first paragraph, above) this book should be on the bookshelf of every serious computerist, technician, and interested layman.

SATELLITE TV INSTALLATION & TROUBLESHOOTING

Bailyn & Gale. 325 pages, paper. $16.95
Howard W. Sams & Co. Indianapolis, IN 46268

This comprehensive book details everything one needs to know about installation and maintenance of a home TV satellite system in a straightforward manner. The topics the authors cover include (of course) fundamentals of how satellites for home TV reception often called Television Receive Only (TVRO) stations work, the frequencies used, the major (and other) components, and how they need to be taken care of.



This book is suitable both for service technicians getting into the field as well as for home enthusiasts who want to do their own purchase and installation of a home setup for picking up some of the hundreds of satellite signals now available to those who want to invest the time and effort in this absorbing hobby.

GETTING STARTED WITH ELECTRONIC PROJECTS

Once you've decided to put together the parts that make up a circuit there are several things that you should do before starting actual work. The first is to understand exactly how the circuit works; what each part does in the circuit. Don't just put it together **hoping** it will work. You can be sure you have put it together properly, so that it'll work, only if you know what each component does to the flow of electricity (electrons) going through it, as well as through the rest of the circuit.

If you don't understand the circuit thoroughly, every part as well as its function, read the article again, carefully, until you do. If that's not enough, look up words you're not familiar with in a good electronics dictionary. Read the "teaching" articles that we include in each issue of the ELECTRONICS HANDBOOK, like the one on "Capacitors" in this issue and the ones on "Resistors" and "Understanding Schematic Diagrams" in the issue before this.

Once you understand the circuit and what each of its components does, and after you've got all of the parts together, clear a good workplace. Be sure you've got a good light and that you've got all the right tools, including a small soldering iron or pencil. 25 or 35 watts is usually just right. Also be sure that you can solder properly before you start the project. If you're not comfortable with soldering, it is suggested that you review the brief (2-page) article on "Soldering Technique" by James Dunnigan, in the last issue. A little practice and you can become adept. Good soldering is essential for good working projects.

If you don't have a copy of the last (Winter) issue, the publisher has back issues for sale. Write for more information.

Another caution is in order, even if you've worked with electronic parts before but haven't handled integrated circuits (ICs). Be sure to observe these simple precautions:

Don't mount the IC directly into a circuit or solder its terminals into the circuit. Instead, do what experienced experimenters do—solder an IC socket into the circuit (unless you're using a quick-assembly experimenters board, in which case you'll just plug the socket into the board's holes). Also, don't handle the IC any more than necessary, to keep from damaging it with static electricity. Most ICs are sold mounted temporarily in a little piece of anti-static foam. Keep the IC in its foam mount until you're ready to plug it into a socket. Finally, keep excessive heat away from ICs, particularly when putting them into a circuit with a soldering iron (another good reason to use a socket whenever possible).

'SCOPES ARE EASY

Portable 'scope (3-inches high, 7-inches wide) has a three-inch diagonal cathode-ray tube (CRT). Handle makes it highly portable.

Although 'scopes look complicated, they're easy to learn to use

by Ken Durand

Everybody knows the VOM (voltohmmeter) is the basic instrument of electronics, and it certainly is the first one everybody must learn to use. Most repairs of radio, telephone and other fairly simple devices can be done using a VOM. But today's electronics have many circuits that put out rapidly-changing signals. Such signals can't be checked with a meter, because the meter's needle just can't respond to signals that change many times a second.

Fast-Changing Signals

For fast-changing signals such as waveshapes and digital signals (computer circuitry, especially), we need an instrument that responds to and can show us signals changing anywhere from a few times a second to millions of times each second, (megahertz). That instrument is the oscilloscope, usually abbreviated to "scope".

It's very similar to a black-and-white TV set. In fact the first TV sets were oscilloscopes with some of the circuits changed to display signals moving across the screen 60 times a second and up-and-down vertically about 500 times a second.

Using a scope is not much more difficult than using a VOM (or a vacuum-tube voltmeter; VTVM). If you study the pictures shown in this article, you will be able to set up a standard scope and adjust it to display waveshapes in typical electronic circuits such as radios, TV set and many computer circuits. This will let you analyze what's happening (or not happening, as the case may be) in those circuits. In turn this will help you figure out what's wrong in those circuits, and thus what needs to be done to repair them.

Like a TV Set

Although the controls on the front of most scopes look impressive, even formidable at first, after you examine them carefully you'll find that many, in fact most of the controls you'll use most of the time, are very similar to the controls and adjustments on a black-and-white TV receiver.

The first control on a scope (as well as TV set) is the *On/Off* control. This may be a separate switch, but it's often combined with the *Intensity* control. On a TV set

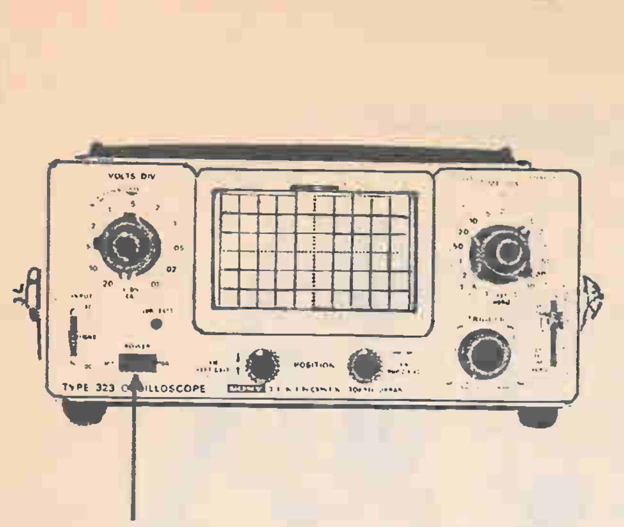


Figure 1. Arrow indicates Power On/Off switch. It's often combined with the Intensity control, but on this scope they're separate.

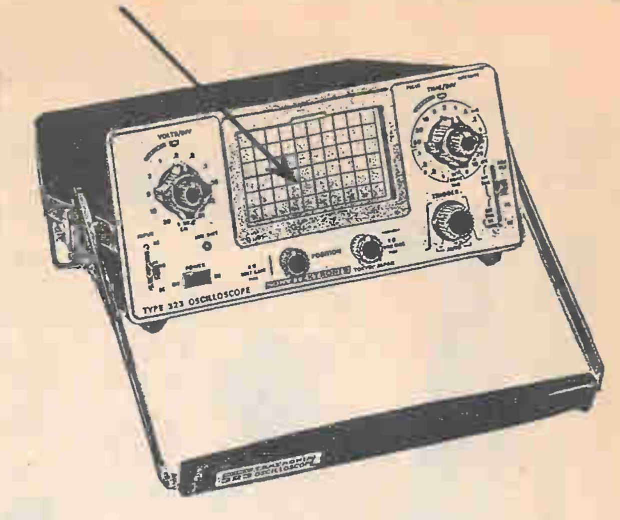


Figure 3. Vertical and horizontal lines are overlaid on Graticule (vertical and horizontal divisions) on the face of the CRT to permit measuring voltages and time periods of waveshapes.

this would be marked *Brightness* usually. And the extreme counter-clockwise of this control, if combined with the *Power* switch, is the *Power Off* position.

When you first turn the scope on, it may take a minute or two for it to warm up. This is true even if it's a modern instrument and uses only transistors and other solid-state devices, instead of the vacuum tubes earlier scopes (and TV sets) used. This time lag is because scopes still use one vacuum tube, the cathode ray tube (CRT) to show the picture. And the CRT, being a vacuum tube, has a filament which takes a finite time to warm up, unlike solid state devices, which are ready to go as soon as the power is turned on.

Some scopes have the On/Off switch combined with a different control which adjusts the intensity of a graph-like overlay in front of the CRT. This overlay glows amber, and is adjustable. It lets you measure the size of waveforms by comparing its graphic lines (vertical and horizontal) with the size and shape of the waveforms. This graphlike overlay is called a *graticule.*

When you first adjust the *Brightness* control you should set it fully clockwise. That's because it's easier to find the scope trace when it's brightest, at first. Once you've got the trace visible on the screen you should turn it down so it's not at full brightness. This is to keep from burning a hole in the phosphor coating which is on the inside of the CRT faceplate.

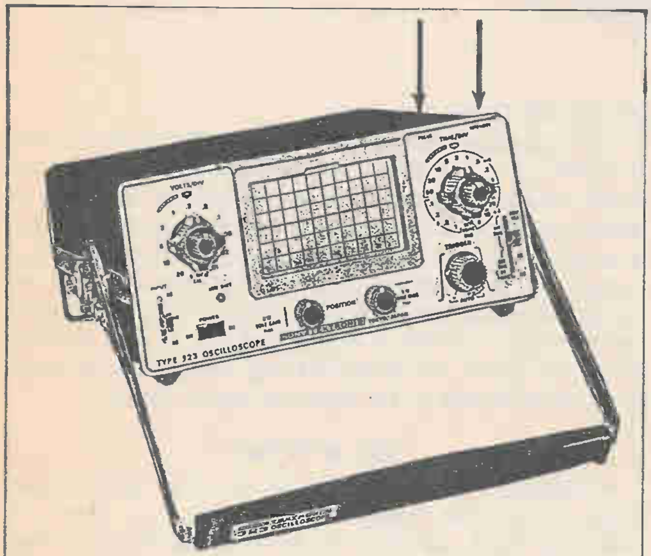


Figure 2. Intensity control is usually grouped with Focus and other display controls right under the cathode ray tube (CRT) face. Because this portable scope has less panel space than most others, Focus and Intensity are (hidden) atop the screen (at right).

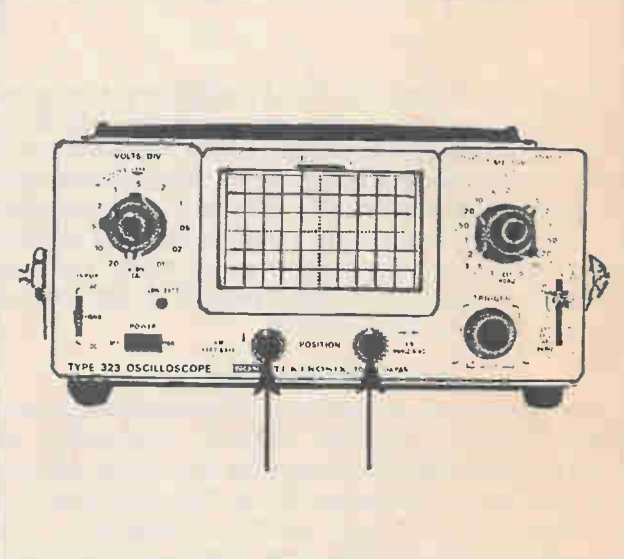


Figure 4. Horizontal and Vertical Position are easy to adjust. Each is a dual control, and normally controls position. When pulled Out they adjust Horiz. or Vert. Gain.

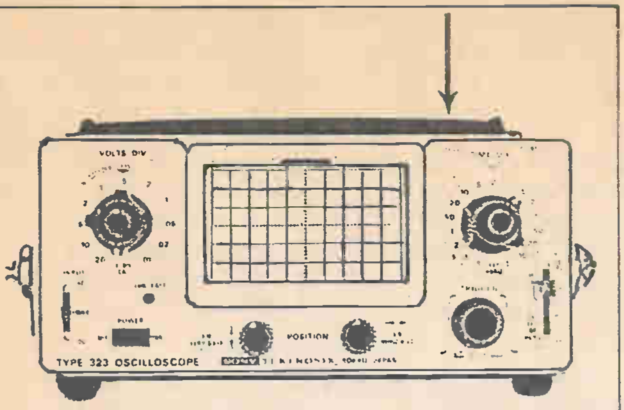


Figure 5. After electron beam has been centered, Intensity control is adjusted to prevent burning a spot in the face of the CRT. Focus and Intensity are adjusted one after the other since they interact.

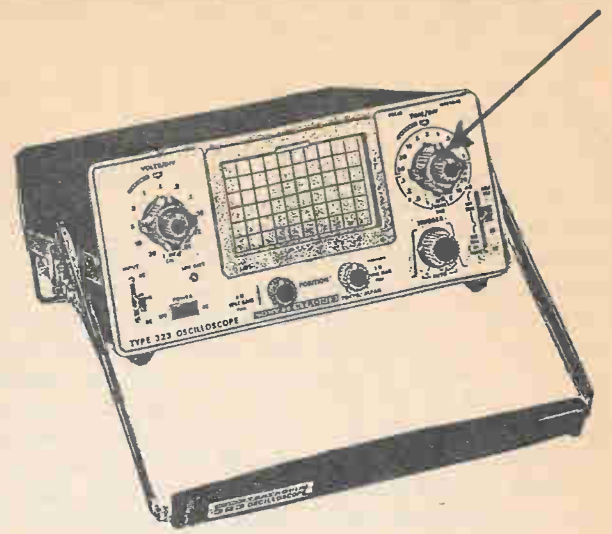


Figure 7. Time/Div. is one name for control which adjusts timing for video (vertical) input signal.

If you don't see a trace on the screen right away, the next step is to adjust the Centering controls. These will usually be labeled *Horizontal Position* and *Vertical Position*, or *Hor Centering* and *Vert Centering.* Rotating the *Vertical* control moves the spot up and down, and the *Horizontal* moves it sideways. Set each of the two controls to its center position, approximately, and then move first one, then the other, back and forth around its center position, meanwhile watching the screen carefully for any hint of light. It many require that you jockey the two controls back and forth a few times to pull the light spot onto the CRT face.

After the beam has been placed near the middle of the screen, adjust the *Intensity* as low as you can set it and still see the spot easily. This is to keep from burning a spot in the middle of the CRT. Now adjust the control marked *Focus.* This is usually right next to the *Intensity* control. You simply rotate the *Focus* control to get the smallest spot. When the *Focus* control is moved in either direction away from correct (smallest) focus, the spot will get larger and at the same time will also get fuzzier.

In most uses of the scope you'll want to get a horizontal line displayed on the CRT before you go further, to apply an input signal to the *Vertical Input* terminals of the instrument. If you have just a dot on the screen instead of a horizontal line, you'll have to adjust at least one more control to make the spot sweep back and forth across the screen. This is done

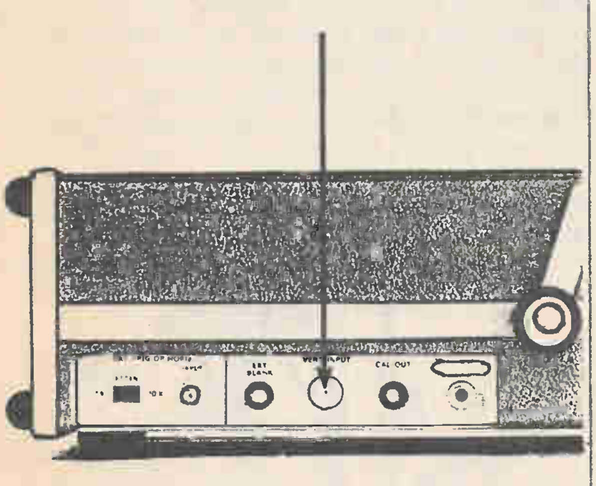


Figure 6. Vertical Input is used for the video signal to be displayed.

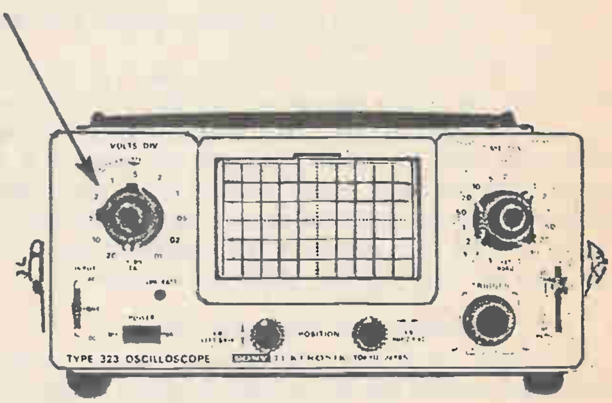


Figure 8. Volts/Div. switch and vernier (fine) adjust vertical size of displayed waveshape. This control also has Calibrate position. This puts signal of known amplitude (from internal generator) on screen to permit accurate voltage measurements.

by setting the switch marked *Horiz Sel* (Horizontal Selector) to one of its positions marked 10, 100, or even 1000.

This number tells us the number of times the electron beam will sweep back and forth across the CRT screen each second, and is called the Horizontal Sweep Frequency. At first it doesn't matter which numerical position of the *Horiz Sel* switch is chosen. What we need is to have some sweep voltage fed into the horizontal system so that a horizontal line appears across the screen. On many scopes the *Horiz Sel* also has a switch position in which the sweep frequency generator is disconnected from the horizontal deflecting input. This position is usually labeled *External Input*, or *Horiz Off*. The switch position labeled *Horiz Input* that would mean the horizontal deflection system is connected to the horizontal input terminals on the front of the scope. In this case an external sweeping signal would be required to be connected to these input terminals in order to sweep the beam back and forth across the CRT screen. *External Sweep* means the same thing.

Additional Controls

There are other horizontal control names which do the same thing as *Horiz Sel*. Some of these are *Sweep Sel*(ector), *Coarse Freq*(uency), and *Sweep*. They all mean Horizontal Selector. This control will usually have several ranges of frequencies indicated by pairs of numbers, such as 10-100 Hz, 100-1KHz, and so on. But sometimes instead of two numbers, there will be just one number. Thus there might be five numbers arranged before, between, and after four switch positions, to indicate the lower and upper ranges of each switch position.

In addition to a range of frequencies for the horizontal sweep, selected by switch position, there is an additional horizontal control. This is a fine tuning control, or Vernier control. This varies the exact horizontal sweep within each range so that the horizontal sweep can be set by you to exactly match (or be an exact multiple of) whatever signal you are looking at (at the Vertical Input).

Thus, if the selector switch is set to, say 10-100, you can make the beam sweep across the CRT at any frequency in this range. This lets the scope show either one, two, or more complete waveforms. It is usually best to have either two or three complete waveforms shown on the screen at a time. Other names for the fine tuning vertical control are *Fine Freq*(uency), *Freq Vernier*, and *Fine Sweep*.

Vertical and Horizontal Gain

All scopes have separate gain controls for the vertical as well as the horizontal channel. These do just what they do on a TV set (except that on a TV set they are called Adjustments, and are usually on the back of the set). They are used to adjust the height and width of the beam sweep on the screen, so that the waveshape more or less fills the screen comfortably, for easiest viewing.

Along with the *Vert Gain* control some scopes include another adjustment called *Vert Atten*(uator). This 3- or 4-position switch permits reducing the amount of signal input on the vertical channel, since some signals which are observed (for example, the modulation of a CB or Ham transmitter) are very large, and would, if not reduced by using the *Vert Atten* control, more than fill the screen, up and down. In other words, this adjustment may be needed to prevent overloading the vertical input channel. The *Vert Gain* then serves as a vernier (fine) adjustment of this channel. *Vert Atten* is usually marked X1, X10, or X100, standing for attenuation ratios of one, 10, or 100, respectively, although sometimes it is instead marked 1, .1, and .01, respectively.

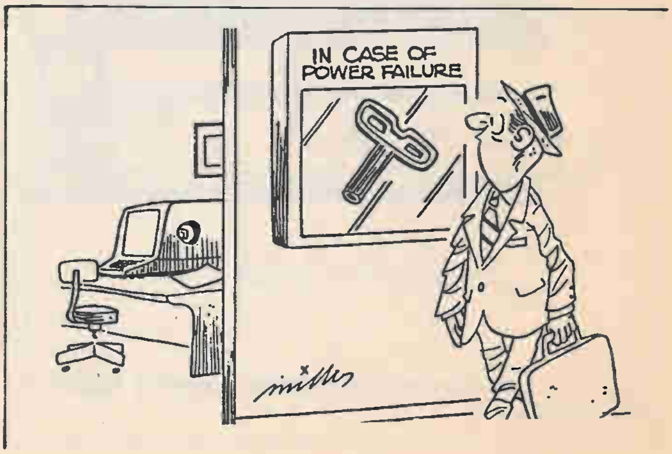
Further Controls

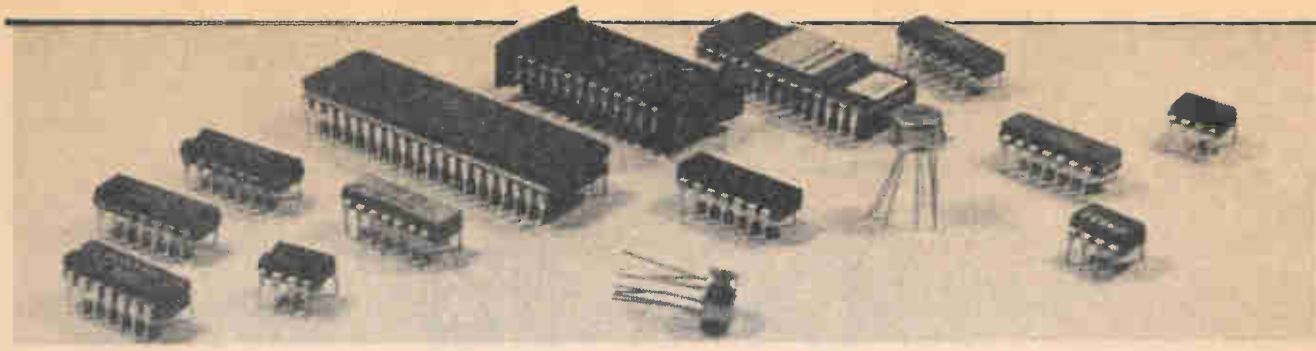
Some scopes include a *Vert* Polarity switch. This has two positions, *Norm*(al) and *Rev*(erse). The most usual application of this switch is in looking at TV receiver patterns, where the waveform might inadvertently be flipped upside down. It's much easier to examine such a (relatively) complex waveform right side up.

Finally, most scoped include a *Sync Amp*(lifier) control (often just marked) *Sync*. This is a gain control which varies the amount of input signal (vertical) tapped off and applied to the vertical channel to aid in synchronizing the signal being examined (vertical) with the sweep (horizontal). This permits one to keep the pattern on the CRT stationary, so it can be examined carefully. Without this synchronization the waveform would roll and change continuously, making it impossible to examine it at all—much like a TV picture which rolls continuously (and fast, usually).

This control is operated just the way the vertical (as well as horizontal) *Hold* controls on a TV receiver are used when there is rolling or tearing of the TV picture. The control is rotated until the rolling (or tearing) stops, then a bit past that point, until it just starts rolling or tearing in the opposite direction. Then the control is backed off just slightly, and the picture (or scope trace) remains rock solid, for careful examination. Other names for this control are *Sync Amp, Sync Lock, Sync Adj*(ust), and plain old *Sync*.

There are other controls on some oscilloscopes, particularly more advanced models used in examining modern, digital circuitry. However, if you learn to operate the controls described above, on your scope, you will be well on your way to using this second-most important electronic instrument. It can help you see what's happening in many circuits where nothing else will do the job.





CHIP-BY-CHIP

by Ed Noll

BASIC IC CLOCK AND INVERTER

Integrated circuits (chips) are the engines of most modern electronics. Chips come in two types, linear and digital. This column will deal with the latter. The digital chip is a complex collection of electronics switches. In groups of a few or many they are the control part of computers, satellite control systems, microprocessors, cameras, watches, and most other modern devices. And, important to **Electronics Handbook**, and to you as readers, is the fact that chips

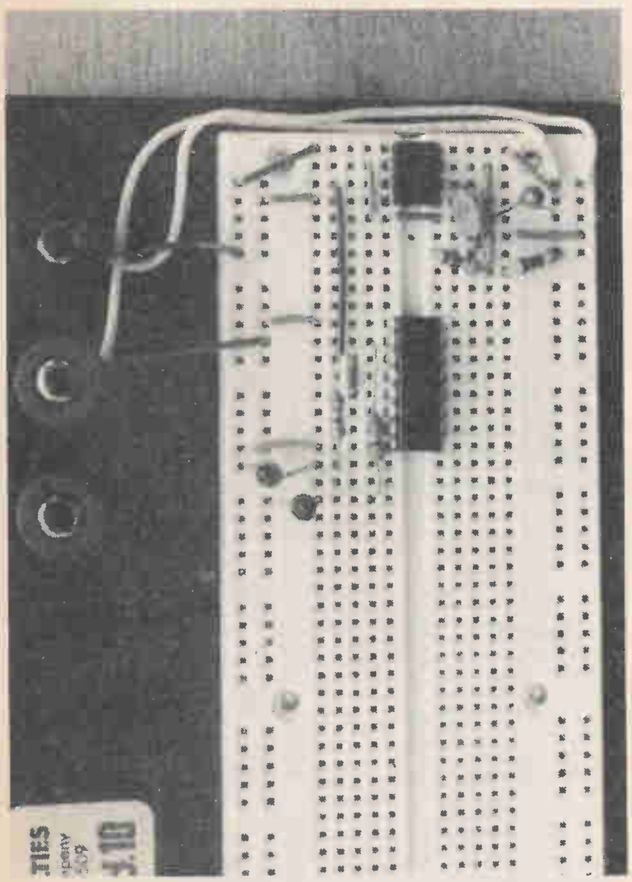


Fig. 1. Clock and inverter ICs mounted into solderless bread board.

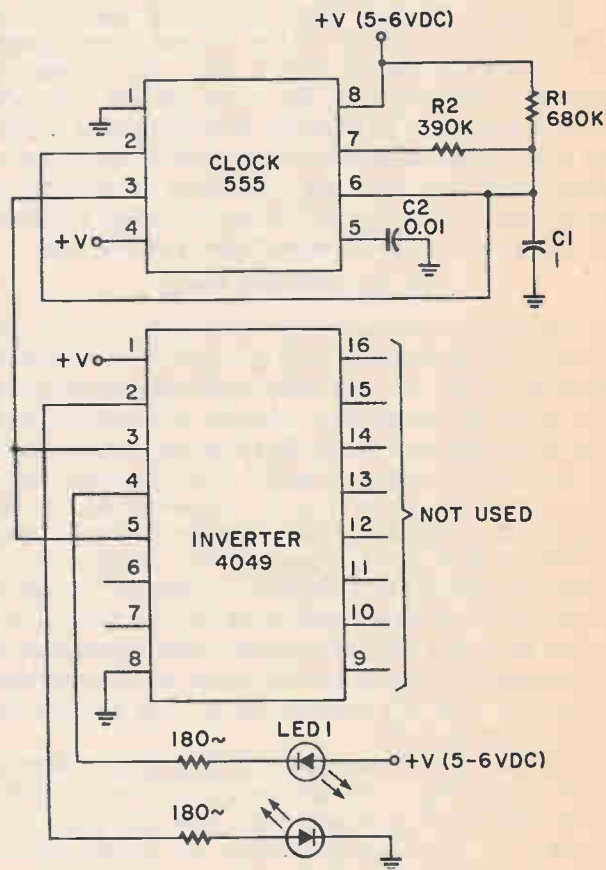
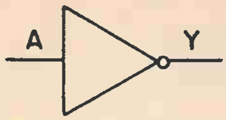


Figure 2. Clock generator and inverter output with LED indicators.

LOGIC I	HI	TRUE	YES	ON	+V
LOGIC O	LO	FALSE	NO	OFF	GND

(A)



A	Y
0	I
I	0

(B)

Fig. 3. Logic designations (A) and inverter and its truth table (B).

are paramount in many of the projects presented in its pages.

In most of the articles in **Electronics Handbook** it is the objective of the project and the contributions of the individual chips to that objective which must be emphasized.

The objective of Chip-by-Chip is to provide details of operation on individual chip types. Not what goes on inside of each chip, but how the chip responds to input and output stimuli and conditions. The emphasis will be on what a chip can do, and how it can be made to do it. Most of this will be demonstrated with experimental circuits built on a small solderless circuit board. Important parts will be a 555 clock, one or several additional chips including the chip of interest in each column, LED's and associated parts, and finally a circuit board with its necessary hardware. Working with the parts, we will take you through a score or so of chips, at very low cost, to give you substantial growth in knowledge of chips. As an extra bonus you will gain a working knowledge of digital electronics and switching. Let's take a look at the basic clock, and an associated inverter chip.

The Versatile 555 Timer

A cheap and versatile chip is the 555 and you can expect it to be the timer chip or clock for almost all of the other chips you will learn about and experiment with in the demonstration circuits of Chip-by-Chip. Thus it is important that in this first column you learn about clock capability. The 555 chip operates from a very low frequency up to frequencies in the megahertz, generating constant-frequency timing waveforms that swing between two voltage levels. These are referred to as **logic 0** and **logic 1**, as well as by several other designations mentioned later. Since we will be using LED's to display what happens with the various chip types, our 555 design will be operated at low and very low frequencies so you can see the LEDs go on and off.

All of the democircuits we will build on a solderless circuit board, Fig. 1. All connections are made on the board with wire jumpers. You can cut your own jumpers or, you can purchase an assortment of jumpers that fit well, and save preparation and wiring time. A third major item is a 6-volt lantern battery or a 5-volt power supply designed for digital circuit use. The above three essential items will be used in each of the Chip-by-Chip columns.

The remainder of the parts are inexpensive. Even most of the chips will be used a number of times as back-up for the individual chip under discussion in each column. The clock is the essential test signal source. The required parts you'll need for the first two columns are given in the parts list. Most columns that follow will require only a few additional, inexpensive parts.

Three parts that will be changed in testing out the clock and in using it in later columns, are capacitor C1 and resistors R1 and R2. They are mounted at the far right in a location where they can be changed readily. If you like you can leave slightly longer leads on these parts which will be helpful when parts of different value are substituted. Again remember to remove

PARTS LIST

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

6-volt lantern battery
- Eveready 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)

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

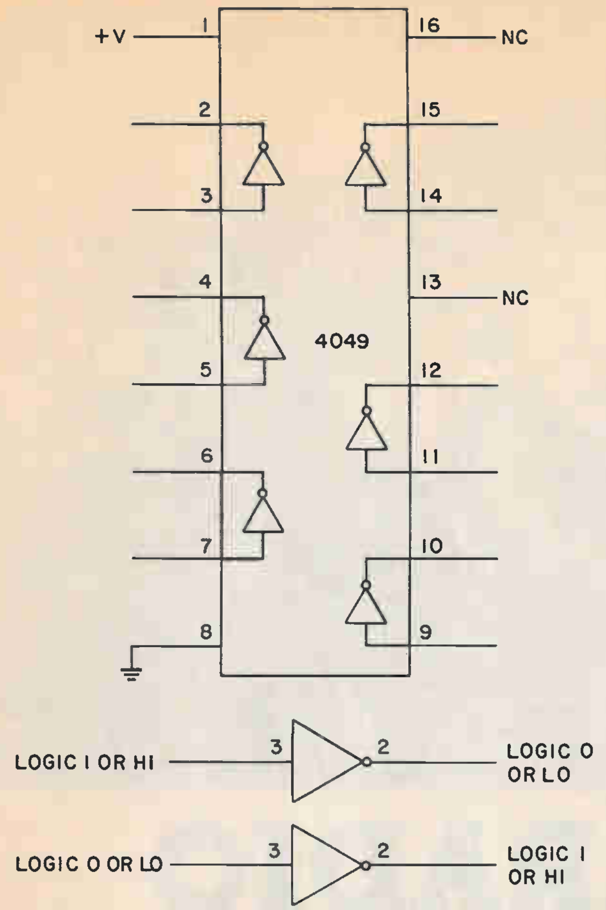


Fig 4. Inverter pin-out (4049) and inverter symbols.

power when making such changes in the circuit. Observe capacitor polarity for the wiring. Positive polarity is marked and usually is associated with longer lead. The longer lead of an LED connects to positive.

In the wiring of the 4049 inverter the top two inverters on the left side, Fig 4, are made active. The output of the clock at pin 3, Fig. 2, is connected to the inverter input at pins 3 and 5. Compare Figs. 2 and 4 to verify these connections. The output of the top left inverter is obtained from pin 2, and is applied to LED 2, at the bottom of Fig 2. When this LED turns on it indicates that the logic at the output of this inverter is 1. Of course when the output logic is 1 it means that the voltage there is +V which is applied to the anode of LED 2. The cathode is connected to ground, and the LED turns on. The 180-ohm resistor limits the LED current to a safe value.

The output wiring is different for LED 1. Notice its polarity has been changed and the anode is connected to +V. In the case of this inverter the LED turns on when the output logic at pin 4 of the second inverter is 0. Of course logic 0 represents ground. Consequently there is a complete path for LED 1 and it will turn on when the output logic is 0. If the output logic at pin 4 is 1 there will be no voltage drop across the LED and it will not glow. Conversely when the output logic at pin 2 of the top inverter is 0 there will also be no voltage drop across LED 2 and it will not glow. In summary, a logic 1 at output pin 2 turns on LED 2 and a logic 0 at the output of pin 4 will turn on LED 1. Consequently as the logic changes at the output of these 555 clock the two LED's will turn *alternately* on and off. Hence you will be able to see the clock at work. You will be able to judge the frequency of the clock as well as the relative duration of the two clock **alternations, 0 and 1.**

Wire you circuit board. Check and double check before applying power. When power is applied you will know the clock is operating when the two LED's turn on an off at a relatively fast rate. The 0 or negative alternation of the clock will be of shorter duration than the positive alternation. Thus LED 2 will turn on for a shorter interval of time than LED1. This is understandable because the logic 0 at pin 3 of the 555 clock timer is applied to pin 3 of the inverter. The inverter changes logic 0 to logic 1 at its output. Consequently it turns on LED 2 for the duration of the logic 0 output of the clock. Conversely, for the logic 1 output of the clock, the output of the second inverter at pin 4 is 0. Under this condition LED 1 will be turned on for the longer duration of the logic 1 output of the clock.

The 555 clock is a part of each chip demonstration circuit. Also the **inverter driver** and its associated LEDs will be needed, as indicators to display the operating characteristics of the chip described in each issue. What you will assemble from this column are the clock and indicators for use with the columns that follow in the moths ahead.

The 555 circuit, Fig. 2, generates a repetitive pulse wave-form that switches between supply voltage and approximately 0 volts (ground) or, in the circuits arrangements used in the column, between **Logic 1** and **Logic 0**, or **Digital 1** and **Digital 0**. These are the only two voltage states in digital circuits. But more on this later. Other ways for expressing logic are listed in Fig. 3A. A bit confusing at first, perhaps, but important to learn and remember. The inverter and LED associated with the 555 are used to indicate circuit logic.

The **inverter** is one of the basic digital chips. Its basic function is to change circuit logic either from 0 to 1, or from 1 to 0, as needed and as shown in Fig. 3B. The symbol for the inverter is shown and also its so-called **truth table**. Note that when the A input is 0, the Y output is 1, and vice versa. The 4049 chip used in the demonstration circuit, Fig. 4, has six inverters housed in a 16-pin single chip as depicted in A. In digital schematics instead of displaying the entire chip the appropriate inverter symbol is used along with the pin numbers of a particular chip (as shown in Fig. 4).

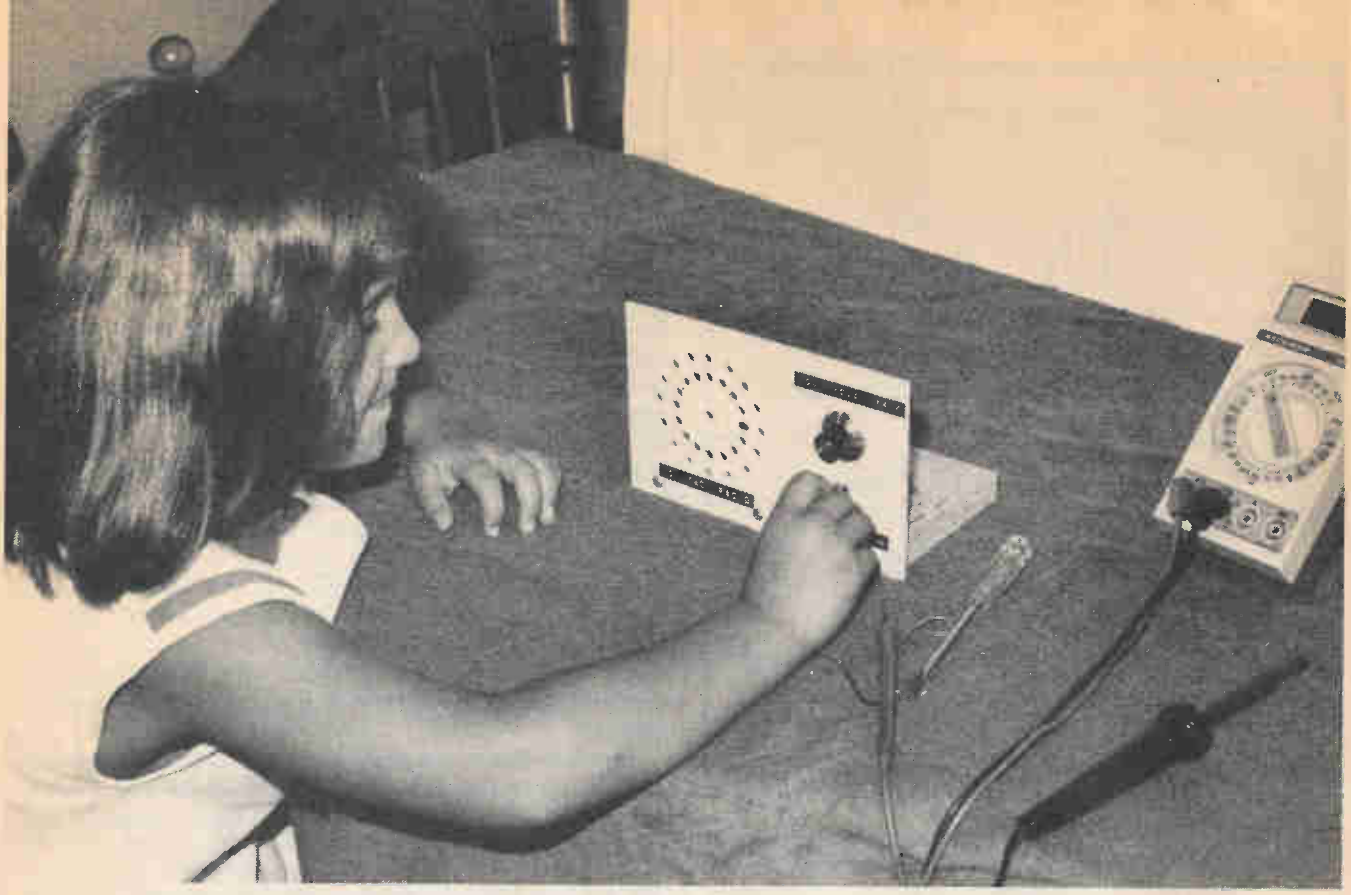
Example B again shows how an inverter reverses the digital logic.

There are a variety of low, and a few higher-powered inverters referred to as **drivers.** The 4049 is one of the latter, and it supplies enough output to illuminate the LED. Hence, it is referred to as **Hex** (hexagonal, meaning six) **Inverter Driver.** The 4049 can be used to drive various other devices and you will work with it again in later columns.

Constructing and Testing the Clock

The schematic of the clock and inverter is shown in

(Continued on page 95)



TWO-IC RADIO

By Homer L. Davidson

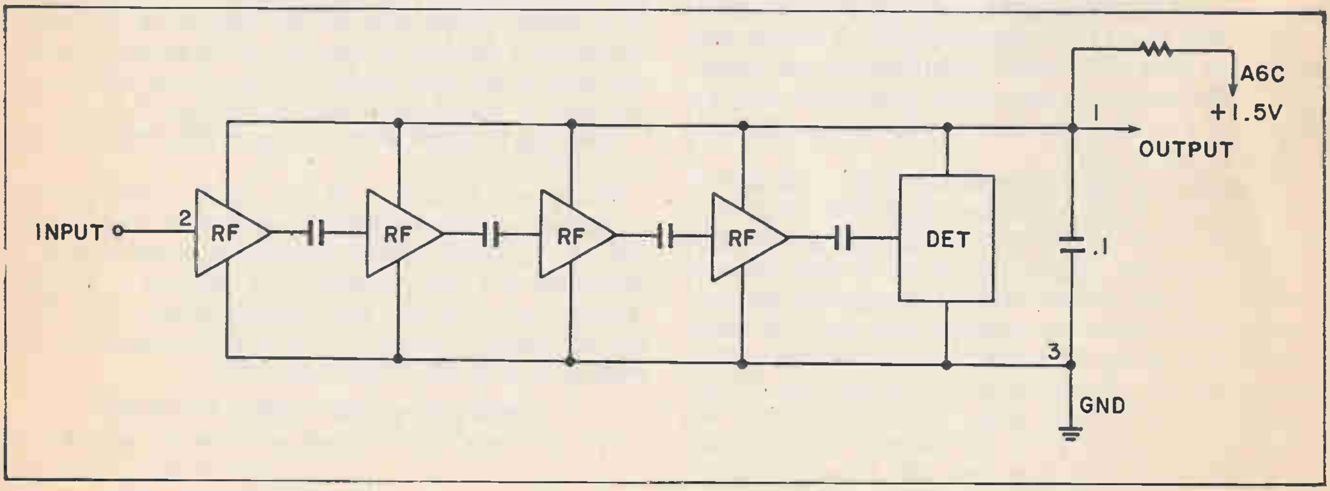
This unique little AM radio is low-cost and simple to build. In fact, you can put it together in a couple of evenings or less. The radio consists of only two inexpensive IC components that operate from two small AA batteries with loud speaker reception plus a handful of other parts. No outside antenna is needed to pick up your favorite stations. IC101 (ZN414) costs $2.00, while IC102 (LM386) costs less then one dollar.

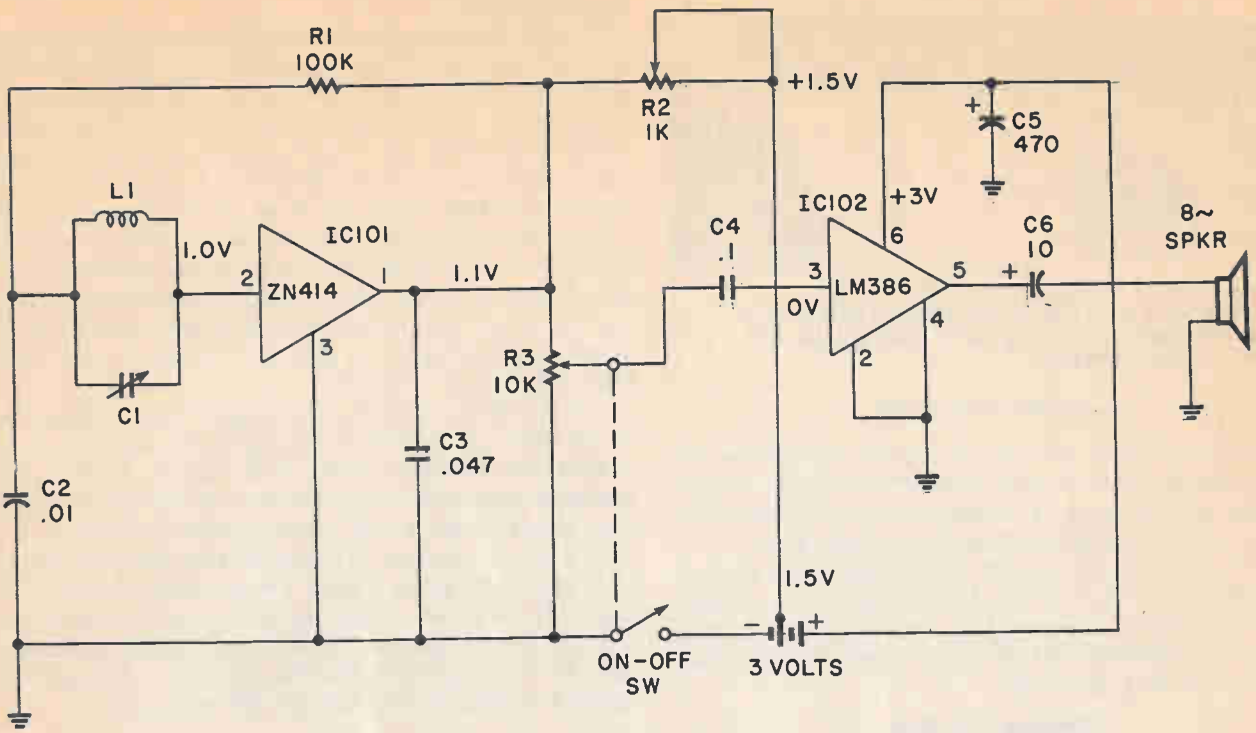
IC101, the ZN414 looks physically like any ordinary transistor. However, inside its case is a 10-transistor, tuned radio frequency (TRF) circuit using Ferrante-developed technology. The circuit includes a complete RF amplifier, a detector and an AGC system (automatic gain control) providing a high-quality AM tuner. No setup or critical alignment is required, except adjustment of R2. IC101 may be wired directly into the circuit without a transistor socket.

Figure 1. The ZN414 IC has the equivalent of a 10-transistor stage, but it looks just like an ordinary transistor.

How It Works

To obtain good selectivity with a TRF (tuned radio frequency) circuit, IC101 must be fed with an efficient antenna coil and tuning capacitor. Select a 5 to 7 inch





PARTS LIST FOR TWO-IC RADIO

L1—72 Turns #24 or #30 enamel or ⅜×5" ferrite rod
C1—365uFD tuning capacitor #AT-232 (Circuit Specialists) or #185-VA (ETCO)
C2—.01 100-VDC capacitor.
C3—.047 100-VDC capacitor.
C4—.1 100-VDC capacitor.
C5—470uFD electrolytic 35-VDC capacitor.
C6—10 uFD electrolytic 35-VDC capacitor.
R1—100 K ½ watt resistor.
R2—Variable 1K thumb type resistor #32JQ301 (Circuit Specialists)
R3—10K miniature vol control with on/off switch, #31×P401 (Circuit Specialists)
IC1—ZN414 IC (Circuit Specialists)
IC2—LM386 IC (Circuit Specialists)
IC sockets—8-terminal type C8408 (Circuit Specialists)
Speaker—3 or 4-inch speaker
Battery holder—#140 (Circuit Specialists)
Battery—2 required 1½V AA penlight cells.
Mics.—Plastic front panel, wood chassis, perfboard chassis, wood screws,solder, etc.

Addresses

Circuit Specialists, Inc.
P.O. Box 3047
Scottsdale, AZ 85257

ETCO Electronics Corp.
North Country Shopping Center
Rt. 9
North Plattsburg, NY 12901

Dick Smith Electronics
P.O. Box 2249
Redwood City, CA 94064-2249
Radio Shack stores, everywhere.

Figure 2. The actual circuit is shown with IC101 and IC102. Volume is sufficient to drive a small speaker.

ferrite rod to wind the antenna coil upon. To pick up weak stations you'll rotate the receiver chassis. No additional antenna is needed for local radio reception.

The tuned-in station is selected with L1 and C1. The RF signal is fed into input terminal 2 of IC101 (Fig 2). Here the tuned RF signal is amplified and detected providing a normal audio signal at output terminal 1. Terminal 3 is at ground potential. The stator (stationary) plates of C1 should be connected to the input terminal number 2 of IC101. Output terminal 1 is wired directly to the top side of the volume control R3.

Potentiometer R2 adjusts the AGC voltage supplied to input terminal 2 of IC101. Adjust R2 so that all stations come in nice and clear. If adjusted poorly you may have gurgling sounds with strong local stations. Improper adjustment of R2 may also cause the weak stations to disappear. So adjust R2 so all stations can be heard.

The audio signal applied to the volume control is controlled by R3. C4 (.1) capacitor couples the audio signal to pin 3 of IC102. R3 must be turned down for strong radio stations and turned full up with weak stations. IC102 amplifies the audio signal to drive a small speaker. Terminal 6 supplies the 3 volts which powers the audio amp. The speaker is coupled to terminal 5 with a 10 uFD electrolytic capacitor. Terminals 2 and 4 of IC102 are grounded. A small 8-prong IC socket is used to plug in output IC LM386. Do not plug in IC102 until the wiring is completed.

This small radio is powered with only two AA penlight batteries. A tap of 1.5 volts is fed to R2, supplying voltage to IC101. Both positive 1.5 and 3 volts are fed to the ICs. The radio is turned off or on with a switch on the back of the volume control R3, in the negative line of the small batteries.

Figure 3. Wind 72 turns of number 24 or 30 enameled wire on a 5-inch (or longer) ferrite rod. L1 is cemented to the top plastic front panel with rubber silicone cement.

Locating The Parts

Any combination of L1 and C1 which covers the AM band may be used. C1 should be of the miniature type to keep the cost down. L1 may be a commercial tuned coil or can be constructed as described later.

IC101 and IC102 may be purchased from Circuit Specialists or Dick Smith Electronics. You should have no problem locating the required parts for this radio. The addresses of electronic mail order houses are given in the parts list.

Winding The Coil

Select a ⅜ diameter ferrite rod at least 5 inches in length. You will see these rods advertised in radio part stores, in grab-bag bargains or it may be purchased individually. If the rod is longer, it will provide better station pickup. L1 is mounted at the top of the plastic front panel with clear silicone cement.

Wind coil L1 close-wound with 72 turns of number 24 enameled wire (Fig. 3) .Place a layer of scotch or masking tape at one end holding the wire tight against the ferrite rod. Let the spool of wire rotate around the leg of a chair or vise to keep the wire tight. Tape down the last few turns to keep the connecting wire from coming loose. You may want to put a drop of airplane silicone, or rubber cement on the end turns to hold them in place; then remove the tape. Leave about 6 inches of extra coil wire to connect to variable capacitor C1. Scrape off the enameled wire and tin with solder before soldering to the capacitor terminals.

The antenna coil is wound with number 24 or 30 wire-wrap wire. Besides winding coil L1 this wire may be used as hookup wire. Since this wrapping wire is covered with a coat of plastic, it may be close wound directly on the ferrite iron core. The plastic covering must be removed from each end for soldering. Scrape off with a pocket knife or burn back the insulation with the soldering iron tip.

Preparing The Chassis

All components except the variable capacitor, volume control, antenna coil, speaker and batteries, are mounted upon a 2×3-inch perfboard chassis. Cut the small chassis from a larger piece of perfboard found at any electronic store. The very small holes allow mounting the IC socket and all parts leads through the perfboard. Solder each small component as it is mounted. Mark terminal 1 of IC 102 on the bottom side of board.

Keep the input and output components connected to IC102 apart.

In other words, keep C4 and C6 on opposite sides of IC102. Place large filter capacitor C5 on the same side as C6 (Fig. 5). The speaker leads from C6 will extend outward from the same side. No shielding of the input wires is needed. By keeping the input and output parts away from each other we prevent feedback (howling noise). Keep all wires as short as possible.

The front panel is made of a white piece of plastic 5×8 inches. The speaker hole is drilled out with small drill holes or with a circle cutter. If the round hole is cut out, place grille cloth or metal screen over the hole speaker protection, or drill out holes in the front panel, as shown in Fig 6.

Cut a piece of white pine board 7½×4 inches. No holes need be drilled in the back chassis except to mount the battery holder. The battery holder and perfboard chassis shown here were cemented to the rear chassis with a dab of clear silicone cement.

The small speaker is cemented to the front panel with silicone cement. Bolt the variable capacitor in place. If the small mounting screws of the capacitor will not mount level on the front panel, drill holes part way so the capacitor lies flat against it. Secure the volume control in the bottom 3/8 inch hole.

Mounting And Wiring Components

Start at C6 and solder its positive terminal to terminal 5 of IC102. Slip the negative wire in through a hole close to the edge of the perfboard for connecting the speaker. Connect an 8-inch piece of hookup wire to pin 6 and the positive terminal of C5. The negative terminal of C5 solders to ground terminals 2 & 4. Now, solder one lead of C4 to terminal 3, opposite the output components. Connect a four-inch piece of

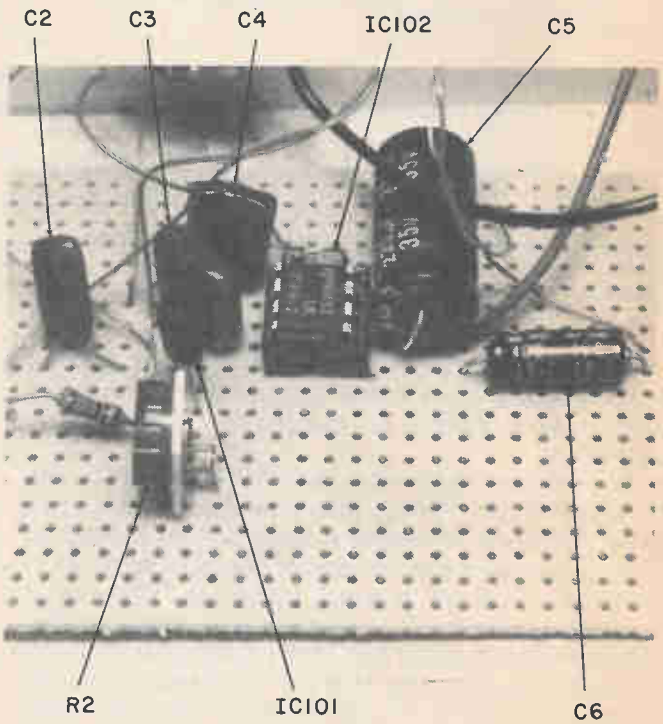


Figure 4. The input and output parts are mounted on separate sides of IC102 to prevent feedback. Mount the parts as they are wired into the circuit.

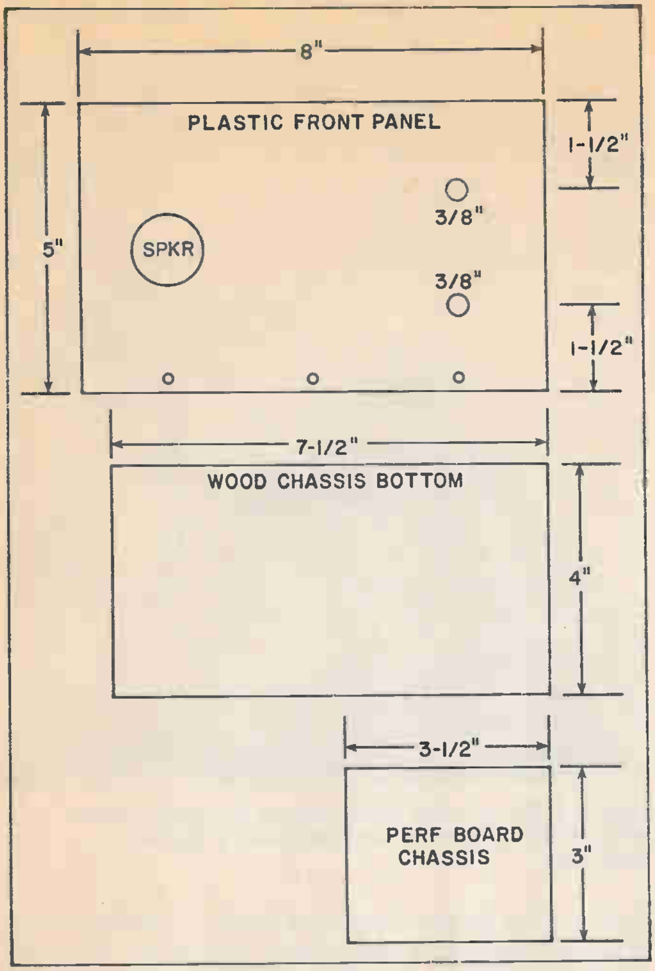


Figure 5. Here are the dimensions of the plastic front panel and rear chassis. Cut a smaller parts chassis from a larger piece of perfboard.

hookup wire to the other terminal of C4, which goes to the center terminal of the volume control (Fig. 6)

Next, mount IC101 through the holes and ground terminal 3. Connect C3 to terminal 1 and ground. Mount R2 and connect it in series with R1. R1 and one end of C2 are tied to the rotor plates of the variable capacitor. There are several hookup wires that must be soldered to other parts and connected to those on the front panel and the wood chassis.

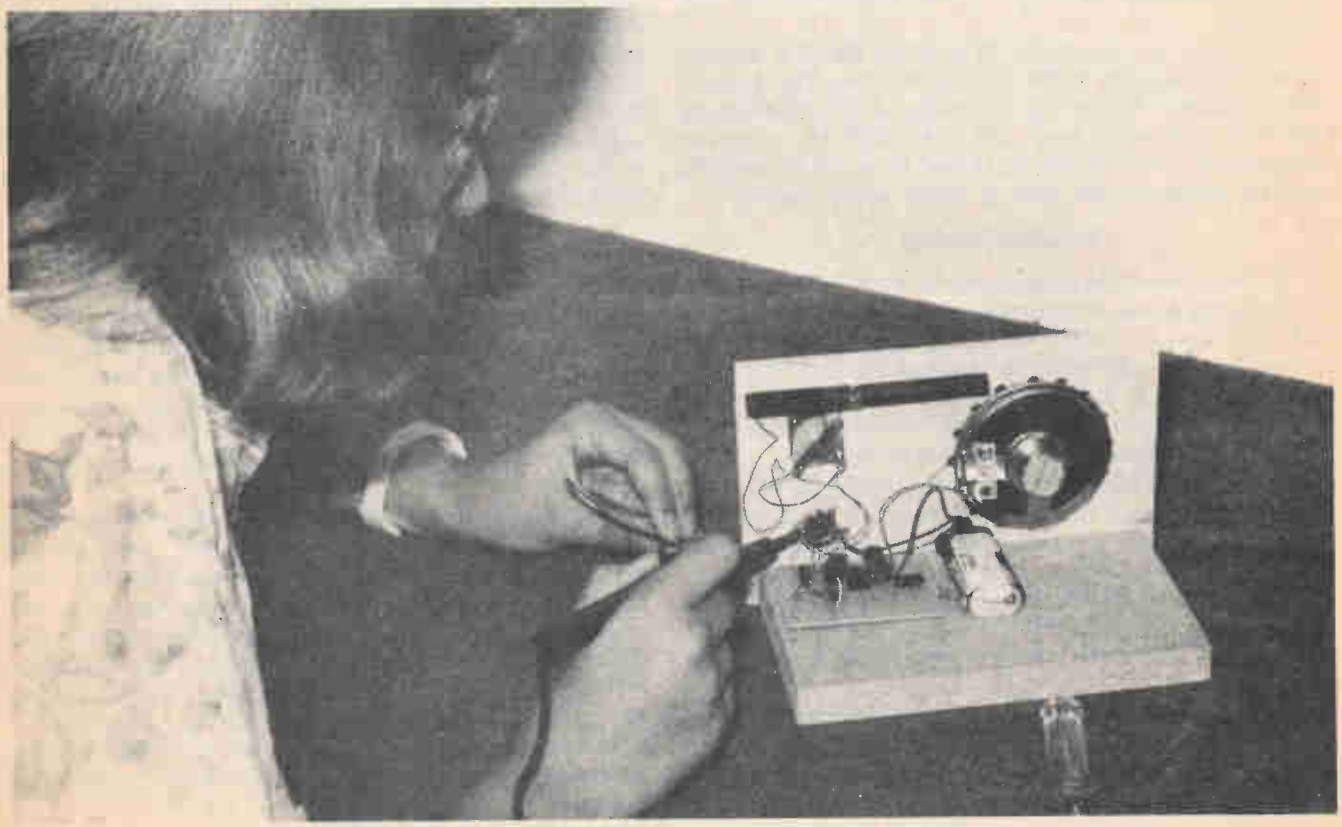
Connect a wire from C4 to the center terminal of the volume control, and the other (outside) terminals after the panel parts are mounted. Solder a piece of hookup wire from R2 to the 1.5 voltage source. Another wire must be soldered from the top of the volume control to pin 1 of IC101. Connect a four-inch hookup wire from pin 2 of IC101 to the tuning capacitor. Solder both leads of L1 across the variable capacitor terminals. Last, but not least, solder the speaker and battery-connecting wires.

Connect a wire from the negative battery terminal to one side of the on/off switch. Solder the other switch terminal to ground. Tap the battery source at 1½ volts and run the wire to one side of R2. This supplies voltage to IC101 through R2. The 3-volt positive battery lead is wired directly to pin 6 of LM386 and C5.

Testing

Before turning on the switch, double check all wiring. Go from each part to each connection and make sure all parts are on the right wires. Check off each part on the schematic. Make sure each connection has a good soldered joint. Extreme care

Figure 6. Solder and connect all wires from the small perfboard chassis to those parts on the front panel. Double check each connecting wire.



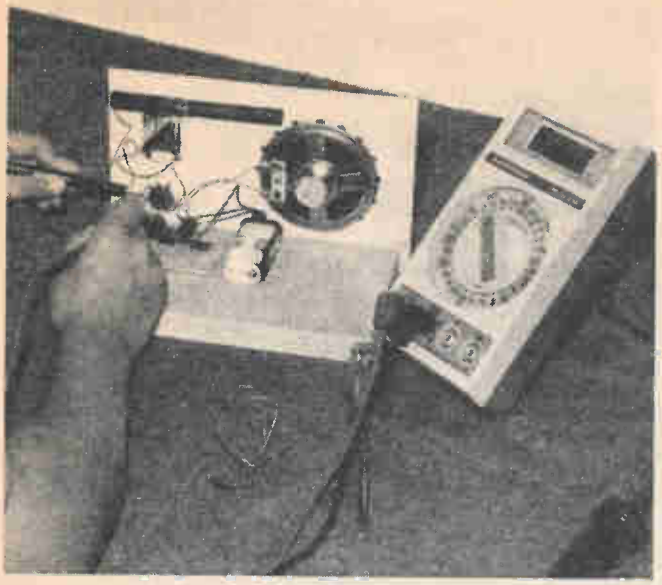


Figure 7. Take critical voltage measurements with a VOM or digital multimeter (DDM). Compare the voltage measurements with the schematic.

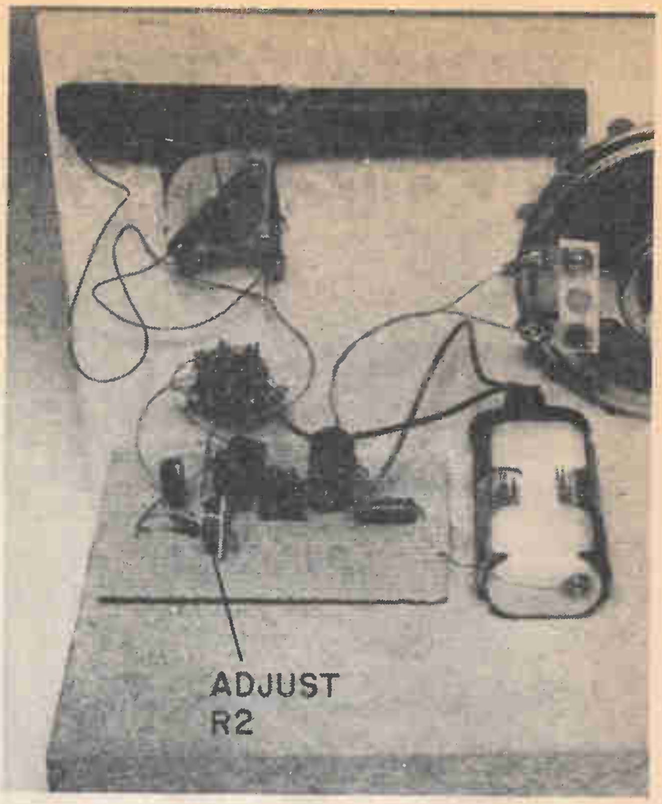


Figure 8. Here is the back view of the radio when completed. Adjust R2 for best overall station response.

should be used when soldering IC101 (ZN414). Do not leave the soldering iron on too long. Use a pair of long nose pliers as a heat sink on each IC terminal. Remember that IC101 has terminals like a transistor and is soldered directly into the circuit. Check all socket contacts of IC102 to be sure they are not shorted.

Now turn on the switch and rotate the dial to your favorite broadcast station. If by chance the radio is dead, recheck the wiring. The volume of local stations will not blast your ears, but is enough for personal enjoyment. You will be surprised how many stations can be received with only a 3-volt power supply.

Troubleshooting

Go over all wiring and check for misplaced or poor connecting wires, if the radio us dead. Shut the radio off and take a meter reading across the switch contacts on the 20 milliamp scale of a VOM. This little receiver pulls a little over 5 mils of current. If the current measurement is above 10 mils, suspect a leaky output IC102, or inproper wiring.

Next, take voltage measurements on IC101 and IC102. Be careful not to short out the IC terminals (Fig.8). It's best to take voltage measurements at connecting parts. Measure the battery total voltage at pin 6 (3V). Pin 5 should be 1.6 volts. Proceed to IC101 if the voltages are normal on the output IC. Pins 1 &2 should be about the same voltage (1.1) if the IC is normal.

Another way to check the output IC is with a click test. Take a test probe or screw driver and touch the center terminal of the volume control. When normal a faint click will be heard in the speaker. If in doubt, remove the center lead and hold it between your fingers. You should hear a hum, indicating the audio section is normal. A loud hum or click indicates the trouble may be in the IC101 circuit.

Sometimes a connecting wire will break off after connecting other components. Take another peek. Advance R2 and when it approaches R1, should hear a squeal or whistling noise if IC101 is normal. With R2 all the way down, you should hear local broadcast stations loud and clear. R2 is adjusted to pick up weak stations (Fig 9.). Besides adjusting R2, turning the radio chassis may help bring in weak stations, since the ferrite antenna coil is directional.

Conclusion

Dress up the front panel with stick-on labels or pressed-on letters. Be careful when soldering IC101 into the circuit. Check each terminal of IC101 from the bottom. Mark terminal 1 on the bottom side of the perfboard with a red or black dot for reference. Double check the batteries for correct polarity. Hooking the batteries up backwards may destroy both ICs.

Go over the wiring at least twice before firing up the radio. Install IC102 in the socket just before connecting the batteries. If you want to feel safe, insert the milliampere meter in series with the negative lead as power is applied. You may assume the output IC is hooked up correctly if the current is around 5 or 6 mils. Remove the meter probe at once if the current is extremely high. You may save the IC, with this current meter test. If the small radio sounds off the first time, pat yourself on the back or give out a loud yell for a job well done.

WORKBENCH PROJECTS

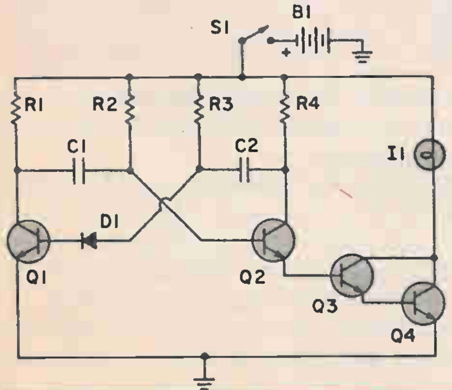
The best way to become proficient at working with electronics is (you guessed it) to use electronic parts (components) in actual working circuits that have useful functions. Most of the projects in this "Workbench Projects" section are relatively simpler or have fewer parts than the other project sections of this magazine, so this is a good place for the beginners to start......

After you've successfully assembled one or two of our Workbench Projects, you are ready to go on to more complex projects, which you will find in the "IC Testbench" and the "Circuit Fragments" sections of this issue. You'll probably find several that you can apply to good advantage after putting them together and you'll have an opportunity to learn more about a rewarding hobby and a favorite subject of ours.....the ever-expanding world of electronics.

If you haven't had much experience building electronic projects, there are a few things that you should know and be sure to keep in mind during your construction. These are detailed earlier in this issue under the title "Getting Started With Electronic Projects". We urge you to read this carefully before you begin any actual assembly....good luck and have fun.

EMERGENCY FLASHER

For camping or highway emergencies, here is a solid-state light flasher that's compact and reliable. Q1, Q2 and the associated resistors and capacitors comprise a conventional 2-transistor multivibrator. Q2's emitter signal drives the Q3-Q4 Darligton pair, which turns on high-current lamp I1. The light flashes



PARTS LIST FOR EMERGENCY FLASHER

B1—6-volt lantern (heavy-duty) battery
C1, C2—1.0-uF 25-VDC non-polarized mylar capacitor
D1—1N4002 diode
I1—#82 lamp rated 6,5 VDC @ 1-amp
Q1, Q2, Q3—2N3904 NPN transistor
Q4—2N3724A NPN transistor
R1, R4—10,000-ohm, ½-watt resistor, 5%
R2, R3—390,000-ohm, ½-watt resistor, 5%
S1—SPST toggle switch

on for about 0.4-second, then darkens for about the same period of time before turning on again. Power for the circuit comes from a standard 6-volt lantern battery. You could probably build the entire flasher circuit inside the housing of your lantern and actuate it only when necessary. If longer battery life is desired, and decreased illumination is acceptable, you could substitute a less power-hungry 6-volt lamp for I1.

CAPACITOR TESTER

Capacitors in the .002 to .007 mf range are not large enough to produce an audible tone from the speaker. But, when R2 is set to maximum and switch S1 is pressed, adding C1 in parallel to the value of the capacitor to be tested, the two combine to form a capacitance that is just large enough to produce a very high audio tone from the speaker.

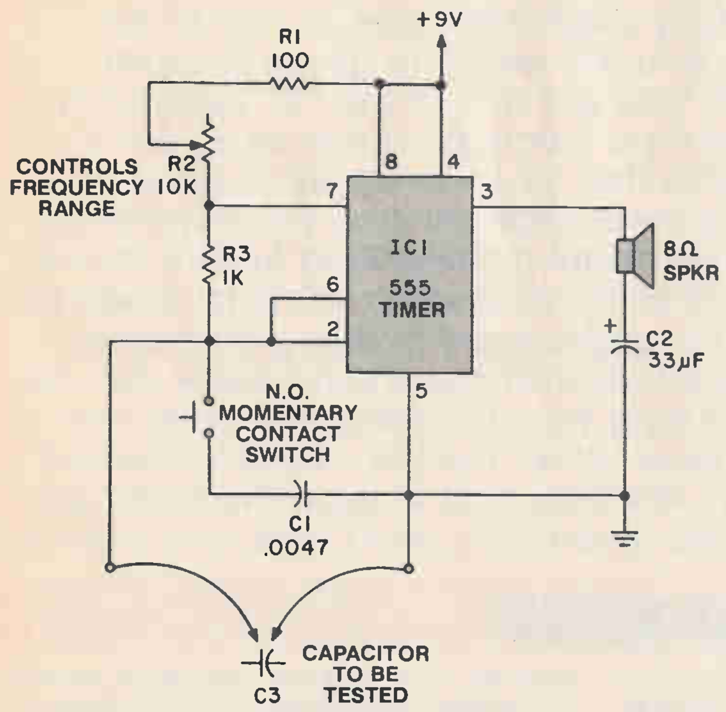
Capacitors above 50mf tend to produce a clicking sound from the speaker when R2 is set to minimum. R1 is placed into the circuit as a safety feature to keep things from shorting out when R2 is set to minimum.

This tester does not show the values of the capacitors being tested. It simply shows if they are good or bad, which is all that is important when you are checking a board for bad components.

The tester is very simple to build. The layout is straightforward and placement is not critical. You can use circuit boards, or use point to point on perf boards. The author used an old circuit board after removing the old components from it. The 9 volts D.C. can come from a battery, or power supply. Here, we have 9 volt battery eliminator that is clipped to the proper circuit board leads and plugged into the wall. No cabinet was used (wasted effort and expense).

Over 200 capacitors in the .002 to several hundred mf range were tested. Of these 12 were thrown away because the tester has shown them to be bad.

For compact size and sturdiness, we have placed the variable resistor R2, the switch S1 and the speaker (small 2 inch size) all on the same board as the 555 timer.



PARTS LIST

R1—100Ω
R2—10KΩ variable
R3—1KΩ
IC1—555 Timer
C1—.0047 mf
C2—33 mf
C3—capacitor to be tested
S1—N.O. momentary contact
MISC.
8 Ω 2-3" speaker
Test leads probe tips or clips.

THIRD DEGREE TESTER

When a person is under mental stress one of the physiological changes includes a lowering of the body's skin resistance and one of the characteristics measured by the modern lie detector is skin resistance.

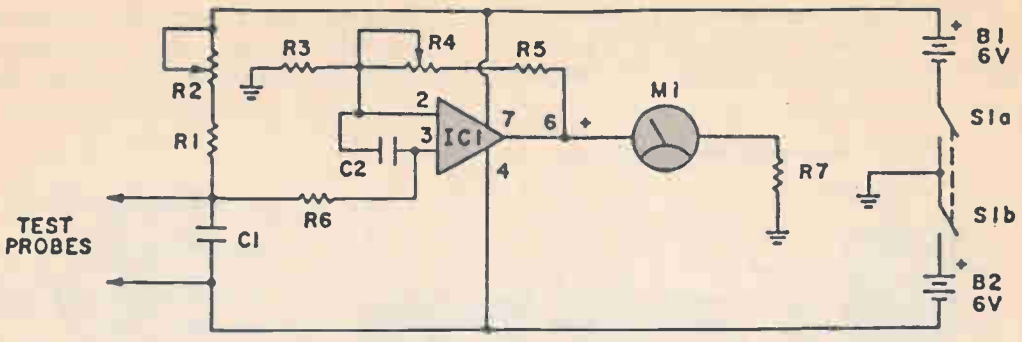
Our lie detector work the same way: it measures the body's skin resistance. In typical use you would connect one test probe, actually a length of non-insulated wire taped to the skin, to each hand, arm, or wrist, adjust control R2 for a meter null (zero meter reading) and then ask your questions. If a question causes the subject mental stress you will usually see this stress indicated by an increase in the meter reading.

Potentiometer R4 serves as a sensitivity control. To avoid pinning the meter start with R4 at about the mid position: increasing the resistance increases the gain, while decreasing the resistance reduces the gain and the meter reading.

To avoid taping the probes to the person under interrogation get a pair of the metal clips used to secure trousers cuffs by bicyclers. They're available at sporting good stores, department stores, if they sell bicycles and at bicycle shops, of course.

Solder the test probe wires to the clips (or wrap well with bare wire, if they're stainless). Then bend the clips to fit the arm(s). Wipe the skin with alcohol to make better skin contact.

If long test probes are used (More than 3-feet long) use shielded wire to cut down hum pickup. Connect each shield to chassis ground (where switches S1a and S1b meet) or use two-conductor shielded wire, then fan conductors out a foot or so at the probe end.

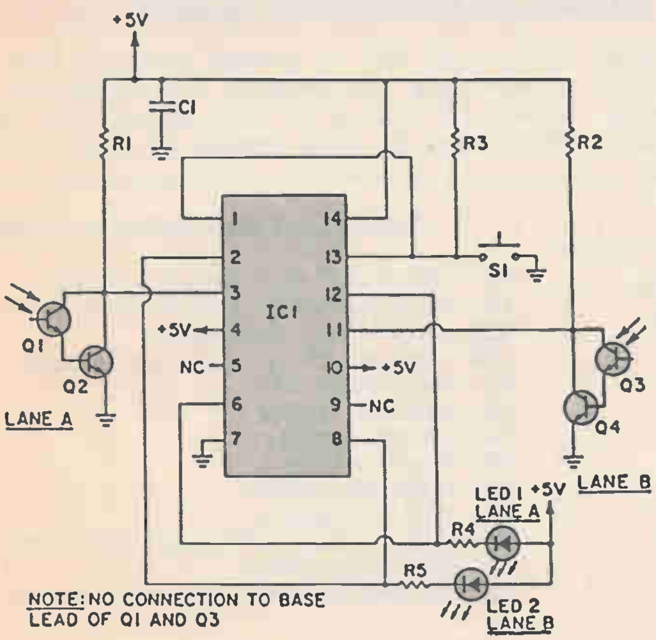


PARTS LIST FOR THIRD DEGREE TESTER

R1, R5—10,000-ohms
R2, R4—1 megohm potentiometer
R3, R6—1,000-ohms
R7—560-ohms
C1, C2—0.01-uF, 25 VDC or higher
IC1—Operational amplifier, type 741
S1—Switch, DPST
B1, B2—6V OR 9V battery, Burgess Z4 or equiv.
M1—Meter, 0-1mA DC

SLOT CAR REFEREE

Build this optoelectric judge and end forever those quarrels over who really won the race. Install phototransistors Q1 and Q3 at the finish line, but in separate lanes of your slot-car track so that the light-sensitive face of each device is facing upwards. The best method would be to cut a small hole into the track for each phototransistor, and mount each unit flush with the track's surface. Arrange for light to fall on both Q1 and Q3; a small desklamp will work well, but ambient room light will usually suffice. Press S1 and both LEDs will go off. The first car to cross the finish line interrupts the light beam and the appropriate LED to light up.

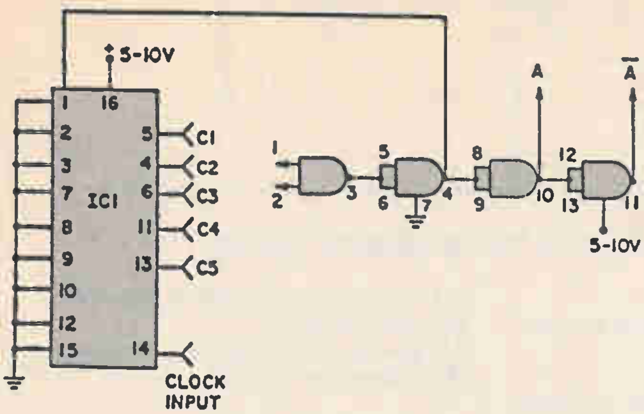


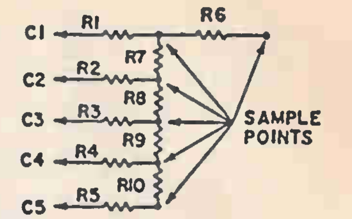
PARTS LIST FOR SLOT CAR REFEREE

C1—0.1-uF capacitor, 35 VDC
IC1—7474 dual D-type flip-flop
LED1, LED2—light-emitting diode
Q1, Q3—FPT-100 NPN phototransistor
Q2, Q4—2N3904 NPN transistor
R1, R2—18K-ohm resistor
R3—3900-ohm resistor, R5—330-ohm resistor
S1—normally open SPST pushbutton switch

CLOCK DIVIDER

The type 4018 programmable counter is a useful digital tool, especially where a basic clock frequency must be divided down for various timing operations. With proper connections, divisors of from 2 through 10 may be configured. The table shown gives the connections. The odd divisors do not give symmetrical outputs, but close ratios, such as four-high, three-low for a divide by-seven setup. Digital-to-Analog Conversion may also be studied by connecting the outputs as shown. Interesting waveforms may be obtained by trying out the various dividing connections, while tying an oscilloscope into the different resistor network junctions. With the circuit set for a divide-by-ten function, a digital sine wave may be discovered at certain points along the network. With clock frequencies above 1 KHz, this output may be heard on an audio amplifier. Computer Music, anyone?





DIGITAL TO ANALOG CONVERSION NETWORK

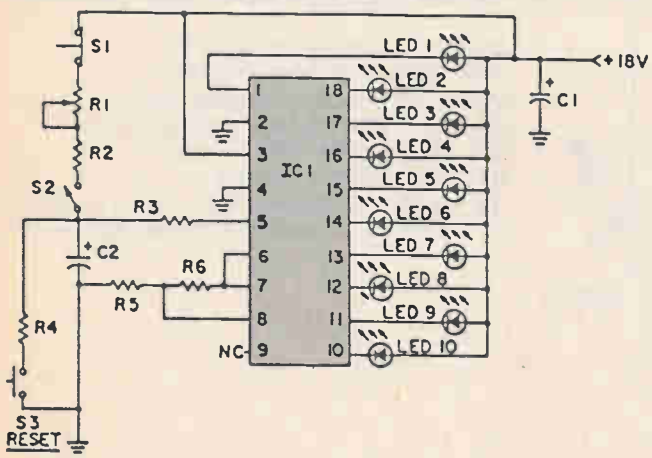
To Divide By	Connect Pins 1 & 2 of IC2 To Pin 1	Pin 2
2	C1	C1
3	C2	C1
4	C2	C2
5	C2	C3
6	C3	C3
7	C3	C4
8	C4	C4
9	C4	C5
10	C5	C5

PARTS LIST FOR CLOCK DIVIDER

IC1—4018 dividing counter
IC2—4011A quad NAND gate
R1 through R6—100,000-ohm resistor
R7 through R10—47,000-ohm resistor

BETTER THAN A BREATHALYZER

It's curious and unfortunate fact, but many people feel that a drink or two will improve their reflexes. Here's your chance to prove them wrong. Imagine for the moment that S1 is depressed (open circuited) S2, is closed and C2 has been completely discharged. On command from someone acting as the tester, the person depressing S1 must remove his hand from that



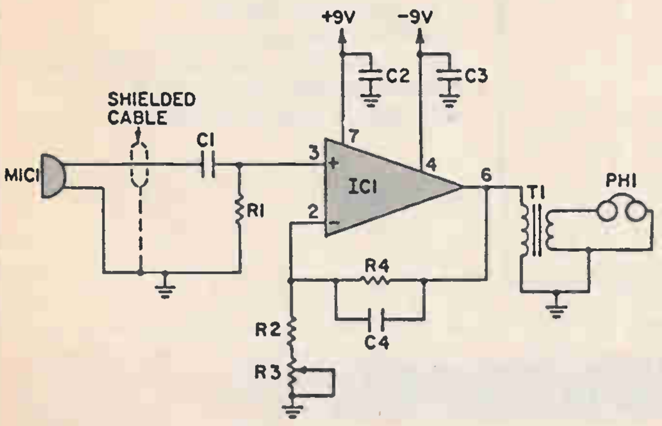
PARTS LIST FOR BREATHALYZER

C1—250-uF electrolytic capacitor, 35 VDC
C2—50-uF electrolytic capacitor, 35 VDC
IC1—LM3914 LED display driver
LED1 through LED 10—light-emitting diode
R1—50K potentiometer
R2—5600-ohm resistor
R3—33K-ohm resistor
R4—47-ohm resistor
R5—18000-ohm resistor
R6—1000-ohm resistor
S1—normally closed SPST pushbutton switch
S2—SPST toggle switch
S3—normally open SPST pushbutton switch

switch and use the same hand to open toggle switch S2. When S1 is released, charging current begins to flow into capacitor C2 through R1 and R2. This current is interrupted, however, as soon as S2 has been opened. C2 will have accumulated a voltage directly proportional to the reaction time, which is the interval between S1's release and the opening of S2. Longer times create higher voltage and cause higher-numbered LEDs to light. For example, a sober person might react quickly enough to light LED 2 or LED 3, while someone truly sloshed will light up LED 10. To run another test, discharge C2 with S3, then press S1 and, finally close S2 once more. R1 should be adjusted so that a sober person lights one of the low-numbered LEDs.

LET'S PLAY DOCTOR

Ausculation is the medical term for the procedure. In simple language, it means having your ribs tickled with an icy cold stethoscope. Should you ever get the urge to play doctor, we prescribe the simple electronic stethoscope diagrammed here. Best results will be obtained using hi-fi or communications-type low impedance headphones designed to isolate the listener from ambient sounds. Be sure to connect the microphone cartridge to the rest of the circuit using shielded audio cable to keep noise pickup to a minimum. Potentiometer R3 adjusts the gain. Use a socket when mounting IC1 since it has delicate FET inputs.

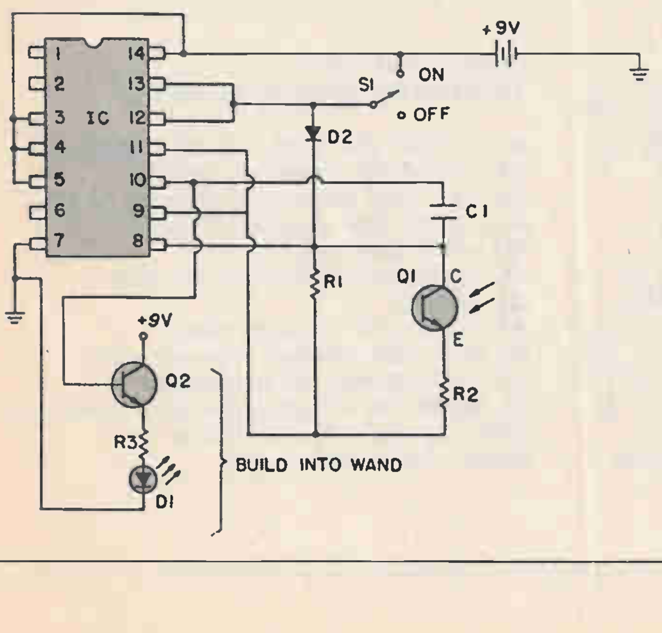


PARTS LIST FOR LET'S PLAY DOCTOR

C1—0.01-uF capacitor, 35 VDC
C2, C3—0.1-uF capacitor, 35 VDC
C4—10-pF capacitor, 35 VDC
IC1—RCA CA3140 op amp
MIC1—ceramic mike cartridge or small ceramic mike
PH1—low impedance (Hi-Fi) Headphones
R1, R4—1 Megohm. ½-watt resistor, 10%
R2—1000 ohm, ½-watt resistor, 10%
R3—10K linear-taper potentiometer
T1—miniature audio output transformer (500 to 1000 ohms primary)

MAGIC BLINKER

Imagine a small black box that you place on a table in front of your friends. Connected to the box with a thin wire is a wand with a small red light (LED) on the end. The light flashes about twice a second, but at your command, it flashes faster and faster. You hand it to your friends, but they cannot do it. The secret? In the box is a small hole with photo transistor Q1 showing through, As D1 gets closer to Q1, it flashes faster and faster but it will take your friends a long while to catch on. It's especially effective when all the room lights are out. Have fun.

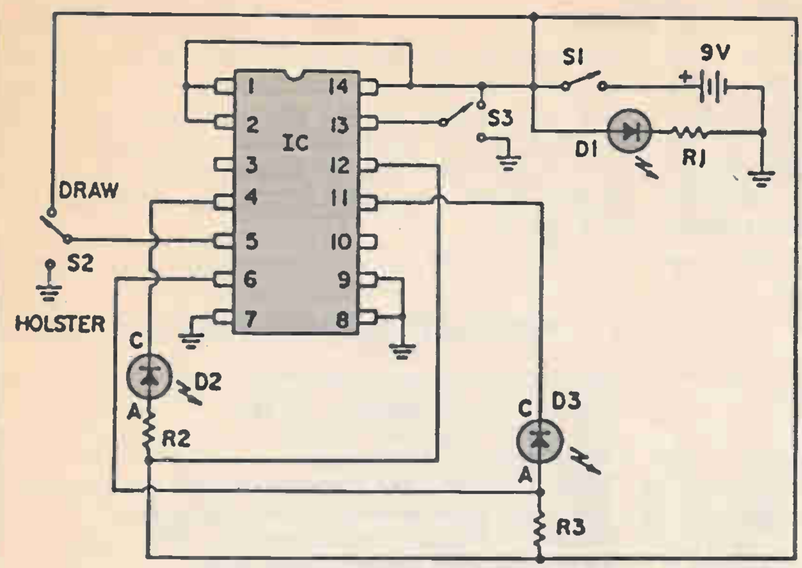


PARTS LIST FOR MAGIC BLINKER

C1—0.01-uF capacitor, 15 VDC
D1—small LED
D2—IN4001 diode
IC1—4000 dual Nor gate w/inverter
Q1—FPT100 phototransistor
Q2—2N4401 transistor
R1—1 megohm resistor
R2—5 megohm resistor
S1—SPST switch

REACTION TIME TESTER

The object of this tester is to test your reaction time against your opponent's. A third person acts as referee and begins the duel by pressing S1, which lights LED D1. Upon seeing D1 lit, you try to outdraw your opponent by moving S2 (or S3) from "holster" to "draw" before he does. If you do, D2)or D3 if you use S3) will light first and will automatically prevent the other LED from lighting. A clear winner every time!



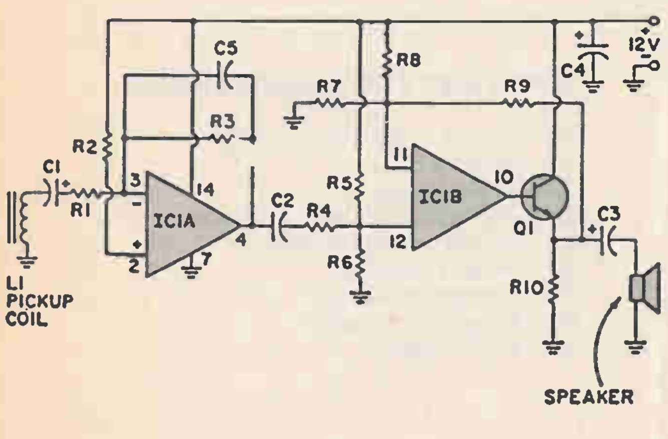
PARTS LIST FOR REACTION TIME TESTER

D1, D2, D3,—large LEDs
IC1—4011 NAND gate
R1—2,000-ohm resistor
R2, R3—1,000-ohm resistor
S1—pushbutton (doorbell) SPST switch
S2--toggle-type SPST switch
S3—toggle-type SPST switch

TELEPHONE EAVESDROPPER

You can pick up and amplify the voice signals from your telephone by using this simple IC circuit and a small pickup coil. The circuit has sufficient output to drive a loudspeaker. One section of a quad op amp is used as a high-gain voltage amplifier. This increases the relatively low output of the pickup coil (a few millivolts) to a sufficient level to drive the loudspeaker. The circuit draws about 60 milliamperes from a 12 volt power source. You can purchase a ready made pickup coil or construct one yourself using about 200 turns of fine enamel wire wound around an iron core. Place the pickup coil near the telephone receiver for best results.

You can also record the phone calls by tapping off the output signals at C3 and feeding it to your tape recorder.



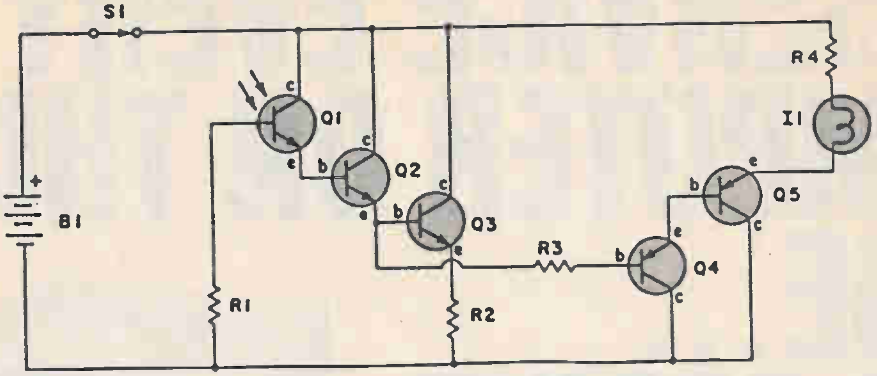
PARTS LIST FOR TELEPHONE EAVESDROPER

0C1—10-uF electrolytic capacitor, 25VDC
C2—.01-uF disc capacitor, 15 VDC
C3, C4—15-uF electrolytic capacitor 15 VDC
C5—.001uF disc capacitor,15 VDC
IC1—3900 quad amplifier
L1—inductance pickup coil (see text)
Q1—2N4401
R1—1,000-ohm, 1/2-watt resistor
R2, R4—1,000,000-ohm, 1/2-watt resistor
R3—470,000-ohm, 1/2-watt resistor
R5, R6, R8, R9—10,000,000-ohm, 1/2-watt resistor
R10—100-ohm, 1/2-watt resistor
SPKR—8-ohm PM speaker

AUTOMATIC NITE—LITE

It's automatic! Let the face of Q1 get dark and L1 turns on. Phototransistor Q1 turns on buffer switch Q2-Q3, which activates Darlington switch pair Q4 and Q5 to turn on I1. I1 is current limited by R4 to deliver long life and reduce the circuit's overall current drain.

Don't make the mistake a brilliant engineering school made years ago. They installed a sophisticated system based on a circuit much like this. It was designed to turn their area lights on at dusk, off at sunrise, and had delays built in to keep the lamps from flickering when a cloud for example, temporarily blocked the sun. The mistake came when they placed the circuit at the bottom of the light poles. The first night the lights came on fine, but after a delay the circuit mistook them for sunlight and turned them off again. Which started the whole process over and had the campus blinking all night.

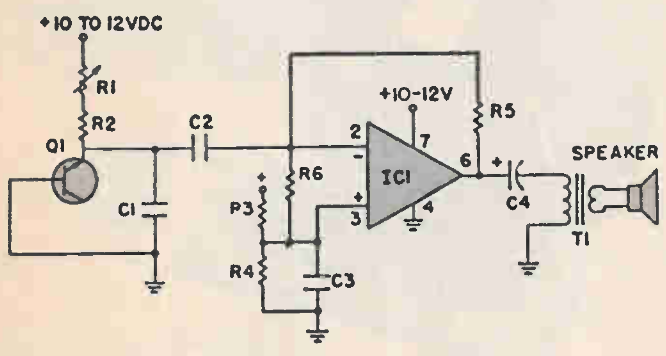


PARTS LIST FOR AUTOMATIC NITE-LITE

B1—9 VDC battery
I1—Bulb, #47—type
Q1—Photoelectric transistor, FPT 100
Q2, Q3—NPN transistor, 2N3904
Q4, Q5—PNP transistor, 2N3906
R1—10-Megohm resistor
R2—1000-ohm resistor
R3—100,000-ohm resistor
R4—27-ohm resistor,
S1—SPST switch

WHITE NOISE GENERATOR

Noise, more or less "pure white" from some source of uncertainty can be filtered and shaped for various purposes, ranging from radio alignment to music or the simulated sounds of rain on the roof. There are various naturally random impulse sources available to the experimenter, including the plasma from gaseous discharges occurring in neon lamps. On the semi-conductor level here are diodes and transistors purposely configured and biased into noisiness. But under certain conditions, many semiconductor junctions develop wide band RF noise. When amplified by a type 741 op amp, which has internal frequency roll-off elements, the result is a continuous hiss in the output speaker, simulating rain. The signal can also be used in the development of "electronic music" and the testing of hi-fi filters and systems.



PARTS LIST FOR GENERATOR

C1—.005-uF capacitor, 15 VDC
C2, C3—10uF electrolytic capacitor, 15 VDC
C4—75-uF electrolytic capacitor, 25 VDC
IC1—741 op amp
Q1—2N4401
R1—100,000-ohm linear taper potentiometer
R2, R6—10,000-ohm
R3, R4—4,700-ohm
R5—1,000,000-ohm
SPKR—(3.2 to 8 ohm) speaker
T1—audio output transformer (500 to 1000 ohm primary)

NRI Trains You At Home—As You Build Your Own IBM PC Compatible Computer

GET THE KNOW-HOW TO SERVICE EVERY COMPUTER ON THIS PAGE... AND MORE!

IBM is a Registered Trademark of IBM Corporation.
Epson is a Registered Trademark of Epson America, Inc.
Apple and the Apple logo are Registered Trademarks of Apple Computer, Inc.
Compaq is a Registered Trademark of COMPAQ Computer Corporation.
©1985 AT&T Technologies, Inc.

Learn the Basics the NRI Way—and Earn Good Money Troubleshooting Any Brand of Computer

The biggest growth in jobs between now and 1995, according to Department of Labor estimates, will occur in the computer service and repair business, where demand for trained technicians will actually *double.*

You can cash in on this opportunity—either as a full-time corporate technician or an independent service-person—once you've learned all the basics of computers the NRI way. NRI's practical combination of "reason-why" theory and "hands-on" building skills starts you with the fundamentals of electronics, then guides you through advanced electronic circuitry and on into computer electronics. You also learn to program in BASIC and machine language, the essential languages for troubleshooting and repair.

Total Computer Systems Training, Only From NRI

No computer stands alone . . . it's part of a total system. To really service computers, you have to understand computer *systems.* And only NRI includes a powerful computer system as part of your training, centered around the new, fully IBM PC compatible Sanyo 880 Series computer.

NEW!
Train with the newest Sanyo 880 Series Computer–it's fully IBM-compatible and runs almost twice as fast as the IBM PC!

You start with the step-by-step assembly of the new, highly-rated, Sanyo computer. You install and trouble-shoot the "intelligent" keyboard. Then you assemble the power supply, install the disk drive, and add extra memory to give you a powerful 256K RAM system. The new 880 computer has two operating speeds: standard IBM speed of 4.77 MHz and a remarkable turbo speed of 8 MHz, making it almost twice as fast as the IBM PC. Next, you'll interface the high-resolution monitor and begin to use the valuable software also included with your complete computer system.

It all adds up to confidence-building, real-world experience that includes training in programming, circuit design, and peripheral maintenance. You'll be learning about, working with, servicing, and troubleshooting an entire computer system—monitor, keyboard, computer, disk drive, power supply—to ensure that you have all the essential skills you need to succeed as a professional computer service technician.

Your NRI total systems training includes: • NRI Discovery Lab® to design and modify circuits • Your four-function, digital multimeter with walk-you-through instructions on audio tape • Digital logic probe for visual examination of keyboard circuits • The newest Sanyo 880 Series Computer with "intelligent" keyboard and 360K double-density, double-sided disk drive • High resolution monochrome monitor • 8K ROM, 256K RAM • Bundled software including GW BASIC, MS-DOS, WordStar, CalcStar • Reference manuals, schematics, and bite-size lessons.

No Experience Needed, NRI Builds It In

This is the kind of practical, hands-on experience that makes you uniquely prepared, with the skills and confidence you need for success. You learn at your own convenience in your own home. No classroom pressures, no night school, no need to quit your present job until you're ready to make your move. Your training is backed by your personal NRI instructor and the NRI technical staff, ready to answer your questions and help you when you need it. You get it all with NRI at-home training.

100-Page Free Catalog Tells More

Send the postage-paid reply card today for NRI's big, 100-page, color catalog on NRI's electronics training, which gives you all the facts about NRI courses in Microcomputers, Robotics, Data Communications, TV/Audio/Video Servicing, and other growing, high-tech career fields. If the reply card is missing, write to the address below.

SEND COUPON TODAY FOR FREE NRI CATALOG!

NRI SCHOOLS
McGraw-Hill Continuing Education Center
3939 Wisconsin Avenue, NW, Washington, DC 20016
We'll give you tomorrow.

For Career courses approved under GI Bill ☐ check for details.

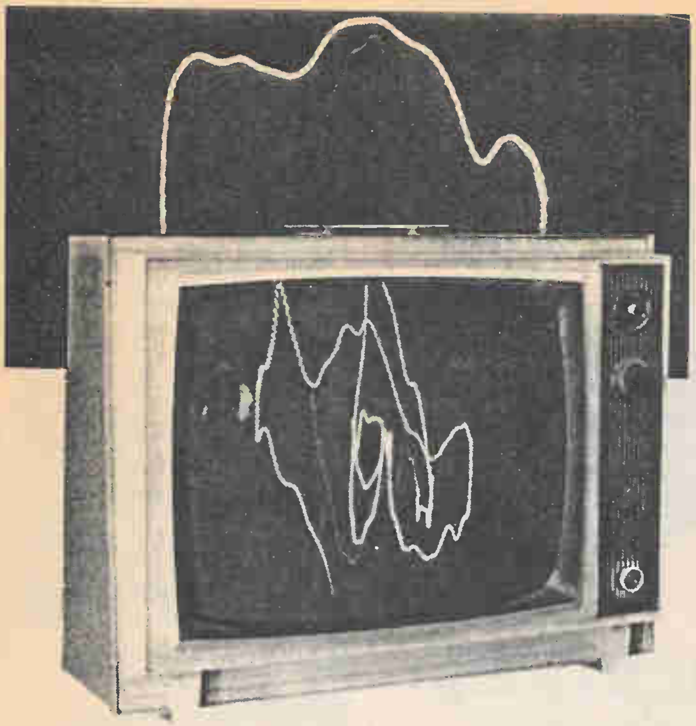
☑ **CHECK ONE FREE CATALOG ONLY**

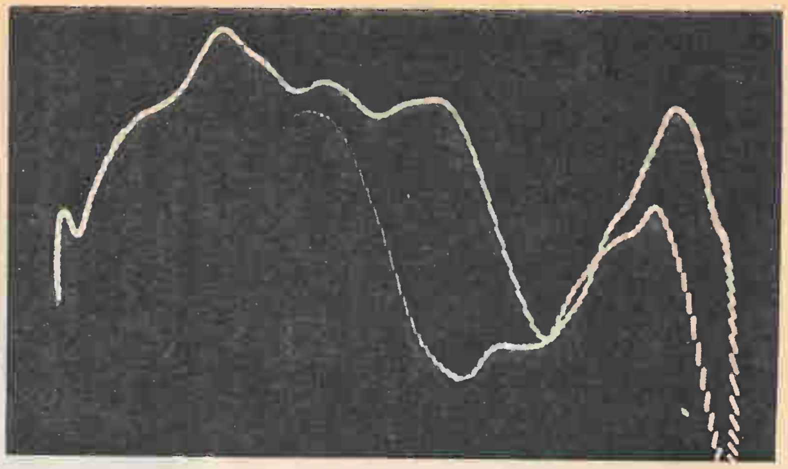
- ☐ Computer Electronics
- ☐ TV/Audio/Video Servicing
- ☐ Satellite Electronics
- ☐ Robotics & Industrial Control
- ☐ Industrial Electronics
- ☐ Telephone Servicing
- ☐ Digital Electronics Servicing
- ☐ Basic Electronics
- ☐ Electricians
- ☐ Small Engine Repair
- ☐ Air Conditioning, Heating, & Ref.
- ☐ Locksmithing & Electronic Security
- ☐ Photography
- ☐ Bookkeeping & Accounting

Name (Please print) ____________ Age ____

Street ____________

City/State/Zip ____________ Accredited by the National Home Study Council 13-027





BUILD TV LITE PEN

Old TV Set Adds Video Excitement to Your Stereo Setup

If you're a dedicated stereo sound listener who likes to experience the ultimate in Sounds; if your home stereo gives you lots of sonic pleasure but you'd like even more, this TV Lite Pen can provide an extra Zing of visual lift every time you turn on your (heavy) Sound System.

It works by displaying dancing, pulsating light patterns on an old TV screen (or a new one) set up so that the changing light rays move and dance across the screen in synchronism with the sounds from both stereo channels.

So-called light organs have been around for a long time, but they just show gently pulsing lights (or two, or at most three or four) colors through translucent (milky) glass or globes. They respond only to changes in audio volume, and rather slowly at that.

Like an Oscilloscope

You may have seen an oscilloscope hooked up to a microphone to display the variations produced by voice signals, or of music. Well, TV Lite Pen is much like an oscilloscope, the workshop of lab instrument which displays changing voltages on its screen. But the 'scope usually shows a single horizontal wavetrace moving in accordance with a changing (or steady) voltage. TV Lite Pen blends both audio channels of stereo signals to give you a visible display of what's going on while you hear the pulsing, throbbing crescendos (as well as the quieter parts) of your favorite music.

TV Lite Pen is an adapter which turns just about and old (or new) TV set into a special oscilloscope for stereo sounds. It shows the myriad sound patterns on the screen of the set. These are called Lissajous patterns.

About Lissajous Patterns

Going back to basics, a Lissajous pattern is an oscilloscope display of *two* signal inputs to the 'scope inputs. The most usual 'scope display is just what ever is fed to the vertical input of the instrument, which is then moved across the screen by an internal sweep signal (usually 60 hertz). But Lissajous patterns need signal inputs to both scope inputs, the *horizontal* as well as the vertical. Lissajous figures are 'scope displays of *two* signal inputs to the display screen-not just the usual *vertical* input signal which we use when we want to measure the amplitude of a voltage or watch how its amplitude changes with respect to time (the most common use of the oscilloscope).

With signals going to both the vertical and the horizontal inputs of an oscilloscope we can measure the relationship with respect to time (it's called phase) between the two signals.

For example, if a known signal is applied to the horizontal input *and* an unknown signal is applied to the vertical input, the resulting Lissajous pattern shows the phase relationship of the two signals.

Lissajous patterns can also be used to measure **frequency.** A known frequency is applied to the horizontal amplifier and an unknown frequency is applied to the vertical. By counting the number of tangency points at the top and at one side, a ratio of unknown-to-known frequency can be obtained. By multiplying the ratio times known frequency, you can determine the frequency of the unknown.

A Simple Light Pattern

The figure at the top of the page shows a lissajous pattern for two sine waves. Numbers have been assigned to corresponding voltage points of the two signals. Extensions of these points are brought to the screen. The intersection of corresponding numbered lines is the position of the electron beam at that instant of time. In this case the two sine waves are **in phase.**

In the figure below, voltage/time relationships are different; corresponding voltage points are 45 degrees apart. Therefore the waveforms are 45 degrees out of phase.

A continually shifting Lissajous pattern results when the phase relationship between the two input signals is constantly changing. The more complex the pattern (resulting from a frequency ratio having large numbers, such as 17/13) the harder it is to interpret. But since were not trying to analyze the pictures, we can just lean back and enjoy.

How it works

By connecting the parts of an old TV set so that the output from one channel of a stereo set (for example, the left) drives the electron beam of TV tube vertically, and the output of the stereo set's right channel drives the beam horizontally, we can use the TV set to

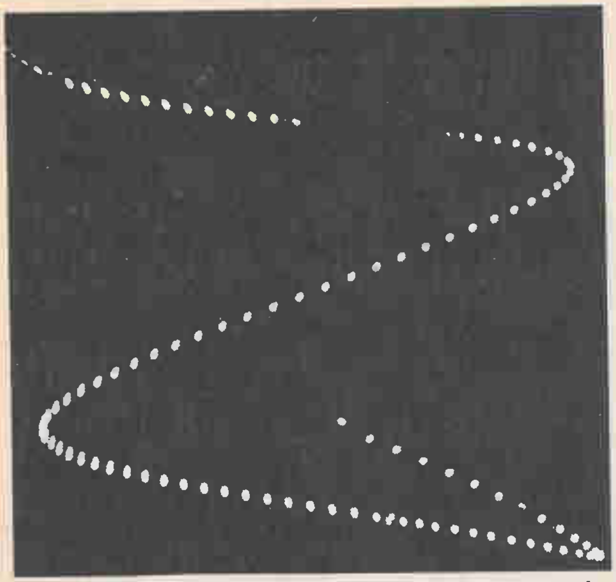


Figure 1. Patterns like these appear from moment to moment on the TV screen when it's being driven by signals from music. Since they don't fade out right away (persistence of screen, as well as persistence of our vision) you'd have to use motion pictures (or TV tape) to break this composite picture down into individual frames.

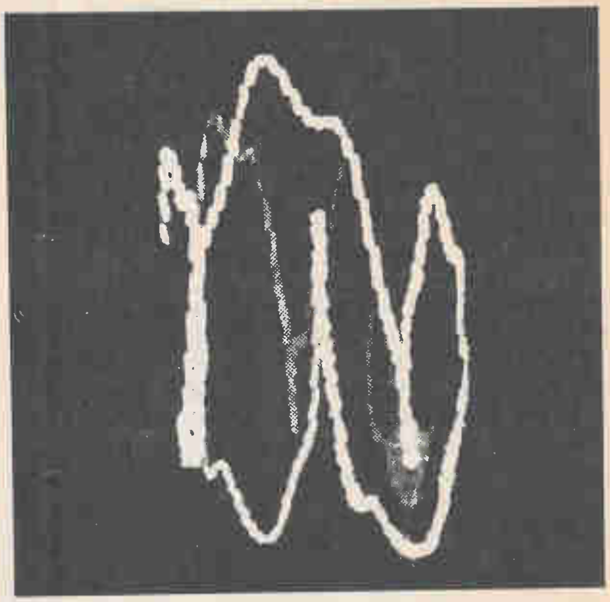


Figure 2. This rather simple light pattern (Lissajous figure) is about as simple a visual display of signal input to TV Lite Pen as you could expect. It shows a very slow, low frequency signal on the horizontal input being modulated (changed) by a slightly faster (higher frequency) sound on the vertical.

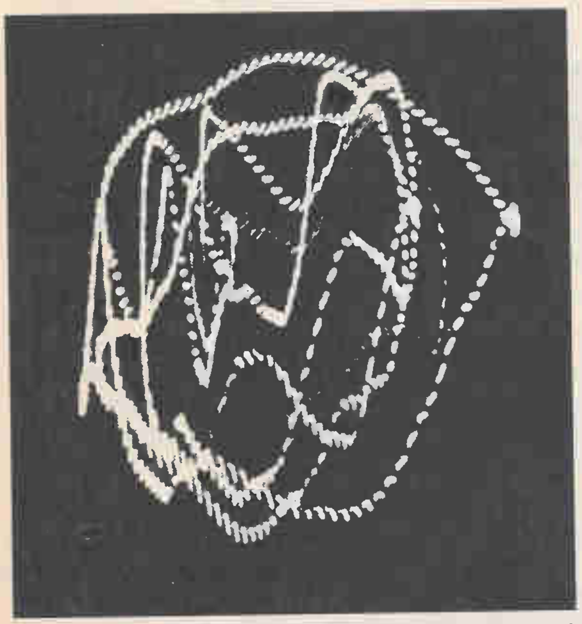


Figure 3. This light pattern would be produced by a slightly more complex (but not much more) pair of sound signals.

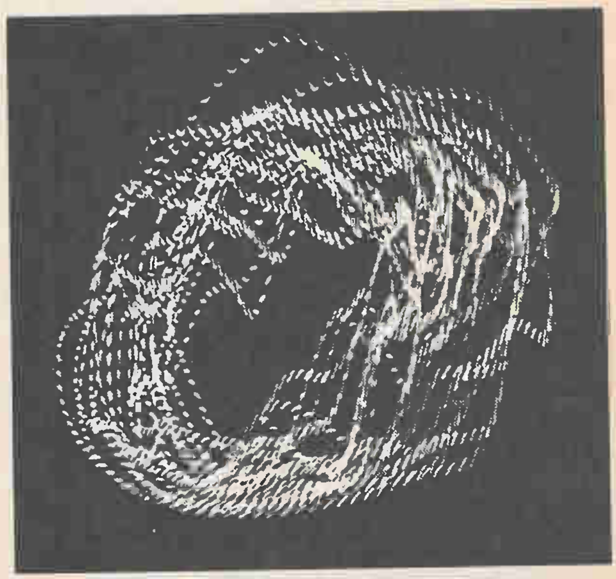


Figure 4. This pattern drawn by TV Lite Pen shows nearly identical but rather simple signals going to both vertical and horizontal inputs. Perfect matching between the two channels would provide a single slanting line, as in Figure 5.

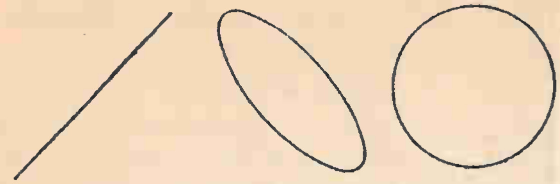


Figure 5. Simple Lissajous figures are produced when the identical signal (left) or almost the same (middle and right) signals are applied to the two (horizontal and vertical) inputs of a scope, or a TV screen.

display Lissajous figures created by the signals from the two stereo channels. What we do is make the old TV set/stereo amplifier combination into an uncalibrated oscilloscope. Then we feed it the two signals without worrying what they mean.

Putting it Together

Begin with an old television set. You can use one in which the tuner, IF, and sound sections do not work since they will not be used. You'll also need an extra deflection yoke from another set. Most of the older tube-type black and white sets have yokes the same size. As long as the extra yoke will fit over the neck of the set's picture tube it can be used. A junked TV is the best place to look. You must also have a stereo set with amplifiers capable of producing 12-15 watts of output power per channel. Even better is a spare (second) stereo set. This will insure better results and will also allow you to adjust the tone, volume and balance controls to the TV set without upsetting your listening pleasure, by changing the volume setting while you listen.

Begin by removing the back from the old TV set. Disconnect the socket from the rear of the picture tube. Loosen the clamps holding the deflection yoke and slide it off the neck of the tube. Do not disconnect any of the wires from the yoke since it is part of the circuit for putting the beam on the screen. Secure the old yoke to the chasis of the TV somewhere out of the way, taking care in seeing that it does not short circuit.

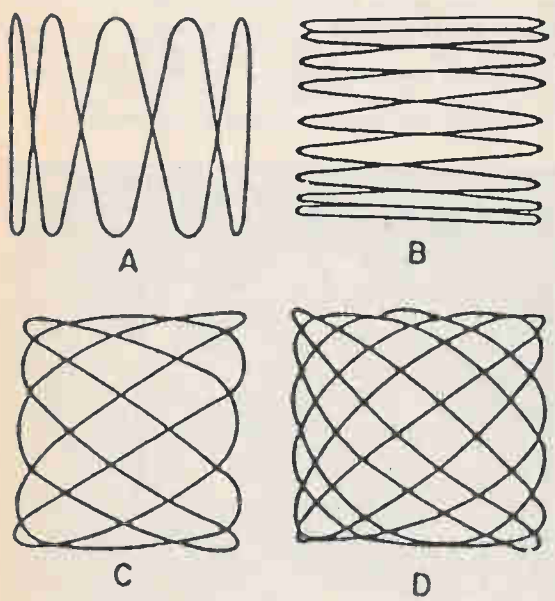


Figure 6. More complex figures (still Lissajousm, however0 result when a simple sine wave is fed to the horizontal (sweep) input of a scope along with exactly-related signals on the vertical (signal) input. (A) shows signals five times the frequency of the sweep; (B) input at vertical is 1/9 the horizontal sweep; (C) shows what happens when signal is 5/3 the sweep; at (D) is shown the result of 6/5 ratio mixing.

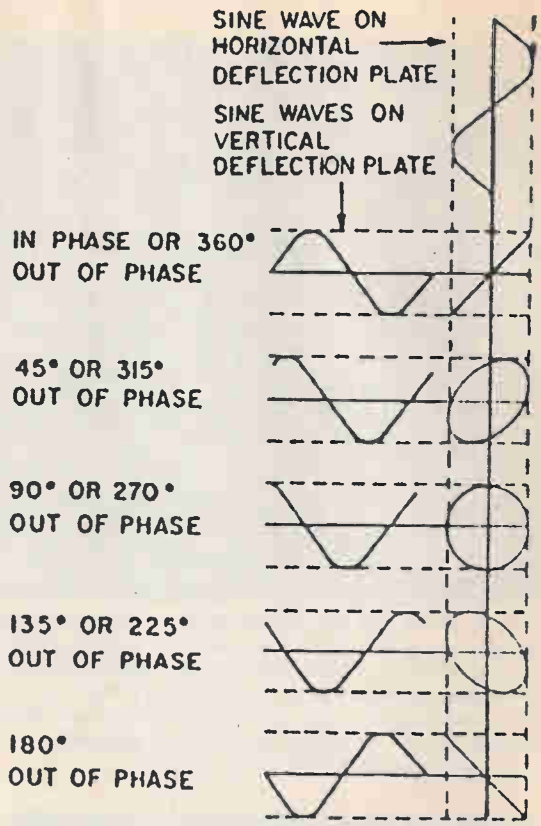


Figure 7. If a mono signal is fed to both channels (of a scope or to TV Lite Pen) the slant line (below top right) results. Adjusting gain of one or both channels is required to get 45% slant. other Lissajous figures will show as gain and phase are varied. These wave forms are very simple compared to the waveforms of music. Simple input signals result in simple pattern. Complex (music) waveforms make complex waveshapes.

Preparing the Deflection Yoke.

There are two coils in the CRT deflection yoke of a TV set. One is called the horizontal and one the vertical.

Each of these two coils is divided into two sections, and we must eliminate any extra parts such as a small resistor or capacitor which are often connected to one or both of the yokes. They are usually connected

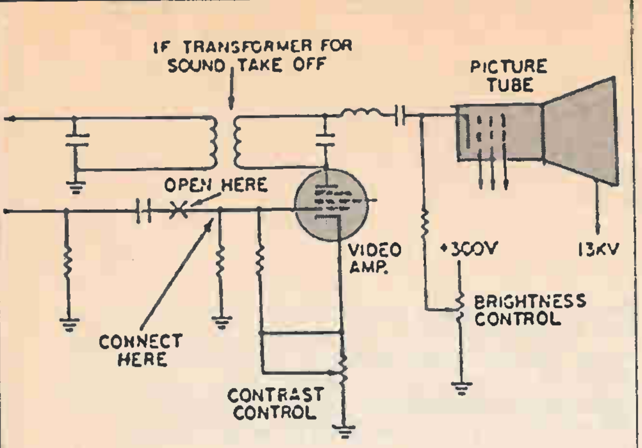


Figure 8. This schematic diagram shown a typical video amplifier stage for a tube set of the Sixties. Similar setup is found in later, transistorized TV sets. The video (picture) input signal to the cathode-ray tube (CRT) is disconnected, and TV Lite Pen's oscillator can be hooked in its place to make TV Lite Pen do extra tricks.

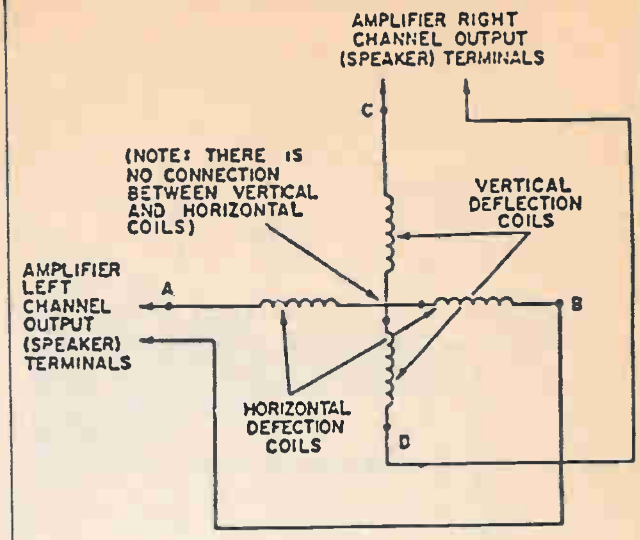


Figure 9. This is the basic hookup for TV Lite Pen. Two CRT deflection yokes can be used.

to the midpoint of the horizontal coil or vertical coil. Simply remove any resistor or capacitor connected to any parts of the yoke, and if this separates the two sectional parts of either the horizontal or vertical coil, put a jumper between the two sections. Check with a voltmeter to be sure which terminals are connected (through the two coils) together. Mark them in some way so that you'll know which two leads of each coil are connected together (through each coil). Solder two three-foot lengths of speaker wire to the terminals of the vertical and horizontal coils.

Assembling Lite Pen

Take the CRT yoke and slide it on to the neck of the

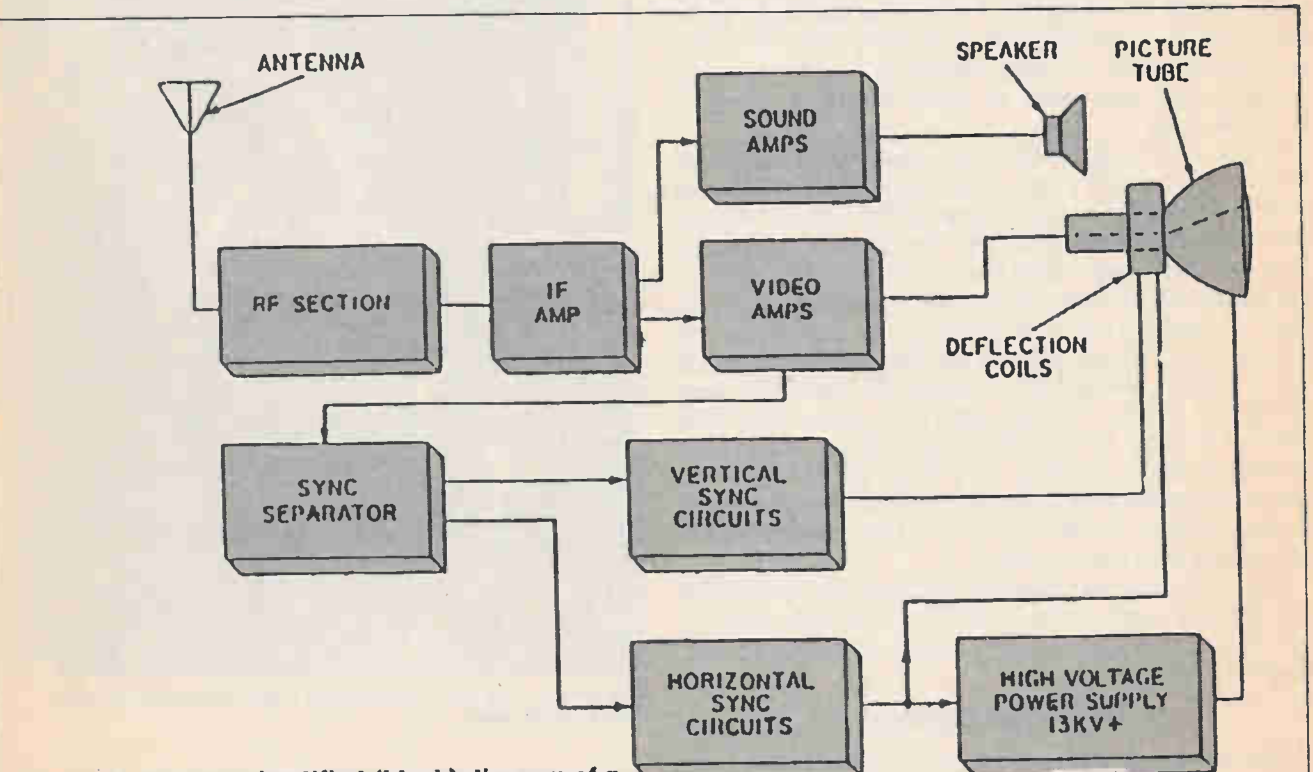


Figure 10. This is a simplified (block) diagram of a typical TV set showing the horizontal and vertical sweep (signals) currents being derived from the *syncronizing signal coming from the TV transmitter. The horizontal and vertical sweep (signals) drive the horizontal and vertical deflection yokes of the receiver.

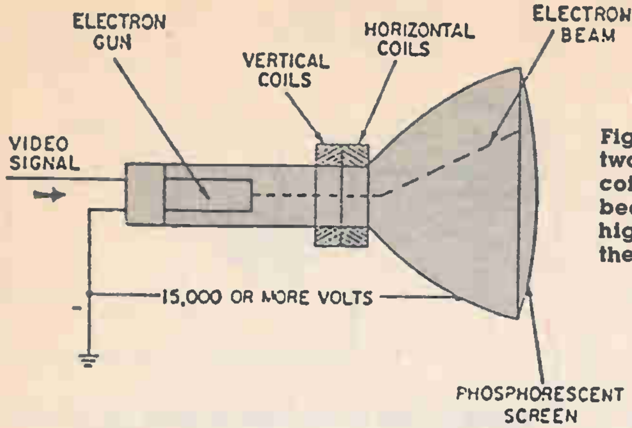


Figure 11. Here's a typical CRT (TV tube) with its two deflection yokes; the horizontal and vertical coils. The old deflection yoke of the TV set is used because it's part of the circuit which produces the high voltage needed to pull the electron rays from the electron gun (rear of CRT) to the screen.

picture tube securing it with a clamp. Return the socket to the back of the tube along with any magnets that may have been removed. Put the magnets back exactly where they were. (Adjust to center beam, later). Route the speaker wire out the back of the TV set as you put the cover back on. Run wires from the speaker outputs on your stereo to the TV set and connect the two sets of wires together using a terminal strip.

You are now ready to test it out. Leave your stereo off and turn on the TV set. After warm up a small dot should be visible in the middle of the screen. Adjust the magnets, if any, to center the beam. If necessary turn the brightness control up or down. Now turn on the stereo set and turn up the volume slowly until you start to notice the dot moving. By adjusting the balance control you should be able to make the dot move about an equal amount horizontally and vertically. It may be necessary to disconnect the speaker in order to move the beam enough. Adjust the brighness for a pleasing light level without burning the screen phosphor. Low bass notes will show up as rotating circles. Each tone has its own pattern which intensifies with the volume.

Now that you are finished sit back and enjoy the added dimension of the music TV in a dark room. It will provide you with many hours of listening and viewing pleasure.

Other Light Displays

Once your Lite Pen is working you may want to add an extra circuit which will strobe the moving pattern on and off, making a more unusual and interesting light display. By connecting the output of an oscillator to the grid of the TV set's video amplifier tube you can turn on and off the electron beam in the picture tube. This will produce dots and dashes as the beam is moved around on the screen. The effect is quite pleasing. A stop-action type of display (called "strobe") is only one interesting improvement you'll see.

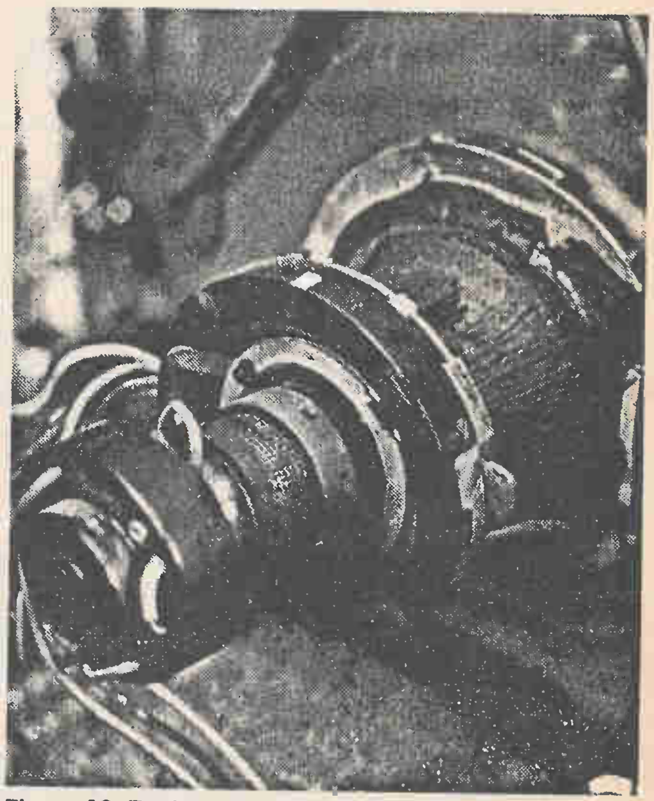
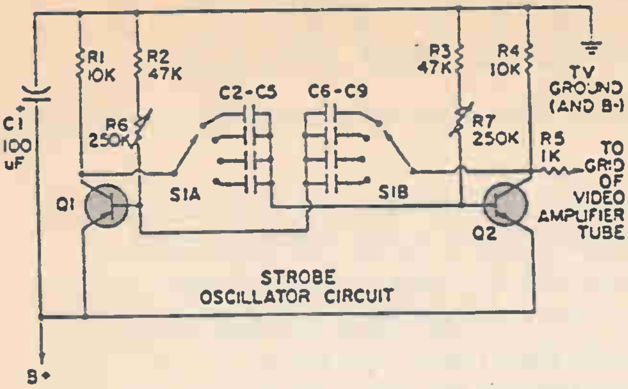
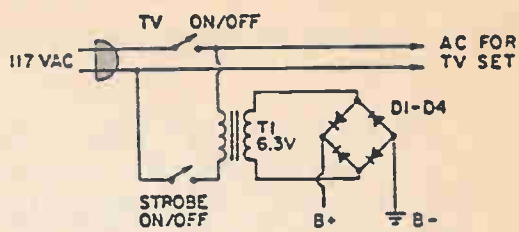


Figure 12. Typical deflection yoke mounted on the neck of TV tube.

Simple Oscillator

The added circuit is a simple two-transistor





PARTS LIST FOR STROBE CIRCUIT FOR LITE PEN

C1—100uF. 16VDC electrolytic capacitor
C2, 6—.02 or .22uF capacitor
C3, 7—.01-uF capacitor
C4, 8—.1-uF capacitor
C5, 9—1-uF capacitor
D1, 2, 3, 4—rectifier diodes, 30 PIV or better any amperage (Radio Shack 276-1626 bridge rectifier will do fine)
R1, 4—10,000-ohm resistor
R2, 3—47,000-uF resistor
R5—1000-ohm resistor
R6, 7—250,000-ohm potentiometer (or 500,000 if 250,000 not available)
Single pole, 4-position or more— rotary switch (Radio Shack 274-1386 or equiv.)
Q1, 2—General-purpose PNP silicon transistors, HEP 242 or similar
T1—Power transformer, 117 VAC primary 6.3 VAC secondary, any amperage (Radio Shack 273-1384 will do fine).

PARTS LIST FOR TV LITE PEN

TV receiver—which has light (raster) on the picture tube. It need not have a working tuner or IF section, nor sound.
Picture tube deflection yoke—in working condition. (Most are—this is a part that rarely fails in TV sets.)
Speaker wire—8-10ft.
Stereo amplifier or receiver—preferably 12-15 watts or more per channel.
Misc.—Solder, wire, switches, etc.

oscillator. The switches and potentiometers allow you to select different dot line lengths and frequencies. By connecting the output of the oscillator to the grid of the video amplifier you force the tube alternately into conduction and cutoff.

The oscillator and power supply are not critical and can be constructed any way that is convenient, as long as safe construction practices are used, The circuit in the prototype was built on a terminal strip using point-to-point wiring and then mounted inside the TV. Almost any general purpose PNP transistors can be used for Q1 and Q2.

If you can't get a schematic of the TV set you are using the best way to locate the video amplifier tube is to look at the tube placement chart (usually on the side or back of the TV) and find the tube which is labeled Video Amp. If the video amp tube also contains other elements in the glass envelope you will have to trace down that part of the tube which has its plate connected to the sound trap transformer (usually a metal can type) and its cathode connected to the contrast control. This may vary slightly in your set.

Once you have found the video amplifier cut one of the leads of the capacitor going to the grid and replace it by connecting the oscillator output to the tube in its place, (see the schematic). Connect the negative lead on the oscillator's power supply to the TV common ground.

Now's the Time

Now you are ready to test the circuit. Look it over for any wiring errors. Set the potentiometers to maximum resistance and set the rotary switches at the .01 uF capacitors. Turn on the TV set and get a music display on the screen. Turn down the brightness control until you can no longer see the raster (white lines). Turn on the strobe oscillator and adjust the brightness control as needed. The display should be chopped up into little line segments. By adjusting the controls you can get different line lengths and frequencies—anything from star-like dots to a pulsating array of stopped action traces.

Now you can lean back and enjoy your TV light organ which will amuse and amaze your friends for many evenings ahead.

ALL ABOUT CAPACITORS

Here's how these basic building blocks of electronics work.

Almost everything in electronics is built of just a few basic building blocks; resistors, capacitors, coils, diodes and transistors. In this article we'll examine capacitors to see what they are and how they control the movement of electrons in electronic circuits and electronic devices.

In the early days of radio, the word "condenser" was used, and it was exactly the same as "capacitor", but today we don't have condensers anymore, just capacitors.

A capacitor consists of just three parts (electrically). It is two plates (metal or other material which conducts electricity) separated by a space which is filled with an insulator. This insulator is called the dielectric. In figure 1-A you can see the symbol for capacitors used in schematic diagrams. It's two parallel lines (representing the two plates) separated by a space.

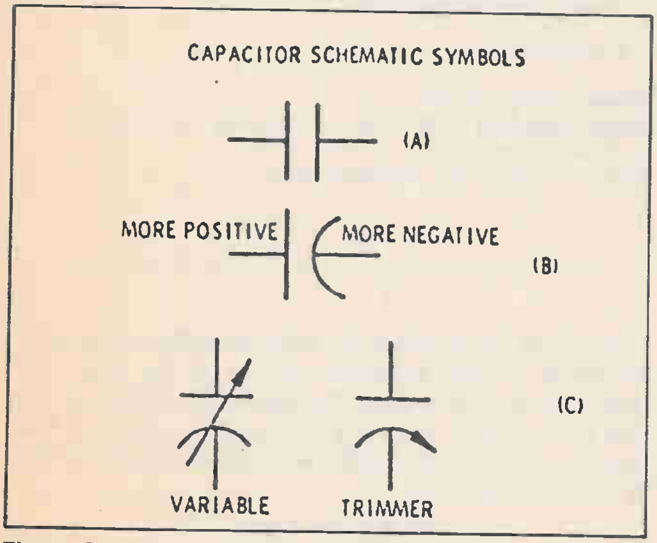


Figure 1. Basic capacitor symbol is (A) above. (B) Shows polarized capacitor, with negative (curved) line connected to ground. (C) Shows symbols for adjustable (variable) capacitors.

The editors of ELECTRONICS HANDBOOKS present here a condensed article on the functions of capacitors and their application in the construction of electronic projects.

Much of the material for this article was taken from the Howard W. Sams Co. title "BASIC ELECTRICITY AND AN INTRODUCTION TO ELECTRONICS" for which we extend our gratitude for granting us permission to reprint this material for our readers.

For those readers who are interested, the entire volume of "BASIC ELECTRICITY AND AN INTRODUCTION TO ELECTRONICS" (3rd Edition) may be purchased from Howard W. Sams Co., Inc., 4300 West 62nd Street, Indianapolis, IN 46268 or at most quality bookstores.

Figure 1-B shows the most commonly accepted symbol for a capacitor. Notice that the major difference between this and the previous symbol is that in this symbol one plate is curved while the other plate is symbolized with a straight line. Generally, the curved line indicates the plate that should be connected to a more *negative voltage* than the other plate. Figure 1-C shows some symbols you may see for *variable* capacitors or trimmer capacitors used in a variety of electronic applications.

Electrolytic Capacitor

One other important capacitor symbol is shown in Figure 2. This symbol has a "plus" sign next to the "flat" plate. This symbol is the most common one used to signify an *electrolytic capacitor*. Electrolytic capacitors should *always* have the plate marked with the "plus sign" connected to a more positive voltage than the other plate. Electrolytic capacitors are designed to be used in dc or pulsating dc applications only.

A variety of other symbols are in use for electrolytic capacitors, and some additional ones are shown in Figure 2. In any of them, however, the polarity of the plates is identified; one of the plates is either labeled positive, or its shape tells you that it is positive. (Certain specially constructed electrolytic capacitors are available that can be used in ac applications, and the symbol used to indicate these "nonpolarized" electrolytic capacitors is also shown in Figure 2.)

If this is your first opportunity to learn about the capacitor, you may be wondering just how the thing works in direct current (DC) circuits. There is no direct conduction path for current flow through the

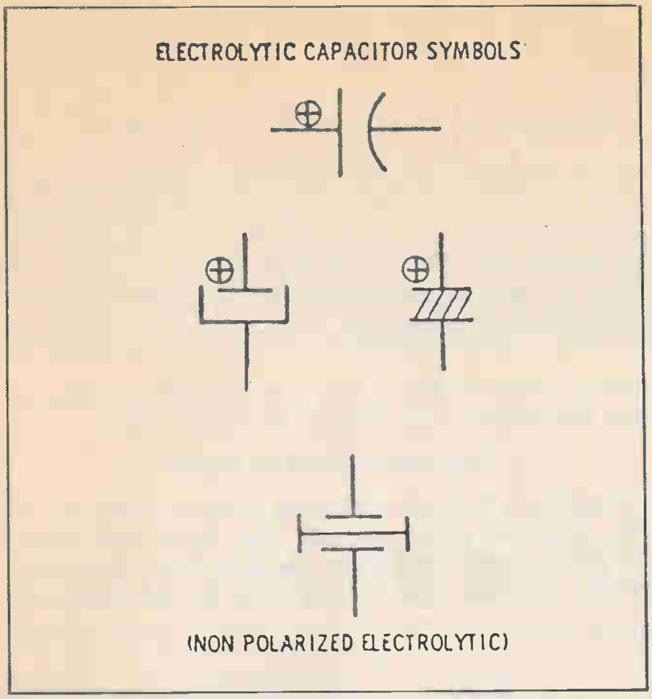


Figure 2. Electrolytic capacitor symbols. One at top is most common. Tantalum capacitors are a special type of electrolytic.

device, so what good is it? Just what does it do? These questions about capacitors will be answered. First, however, a little discussion of the history of capacitors may be interesting. The fact is that the capacitor was discovered by accident in 1746 in Leyden, Holland by a physicist named Pieter Van Musschenbroek.

The Leyden Jar

Pieter was doing some experiments in an attempt to "electrify" water. The water electrification device consisted of a large jar lined inside and out with

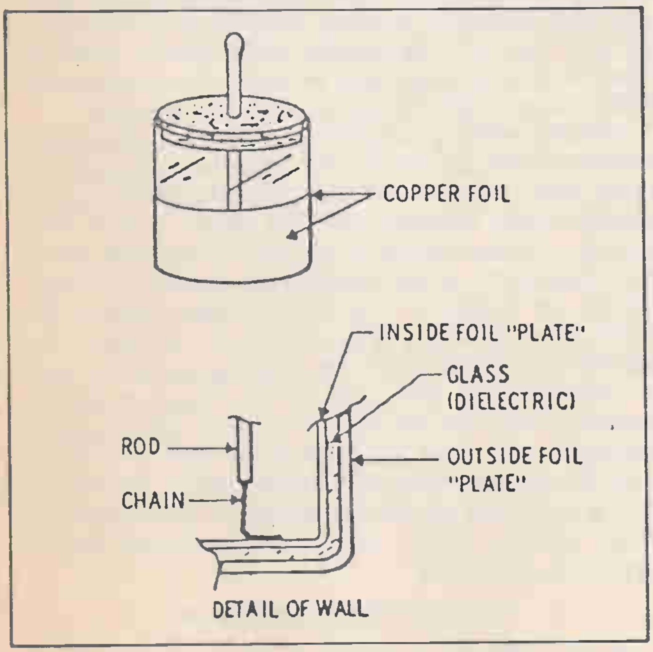


Figure 3. Earliest capacitor was the Leyden jar, consisting of a glass jar with copper foil inside as well as on outside.

copper foil as shown in Figure 3. This Leyden jar as it is called, has all of the elements of a capacitor. As shown in the Figure, the rod sticking through the lid of the jar had a chain on the end that hung down and supplied connection to the inside layer of foil. This formed one plate of the capacitor, the glass wall of the jar served as the dielectric, and the outer foil served as the other plate. Van Musschenbroek connected the Leyden jar to a voltage source for a period of time

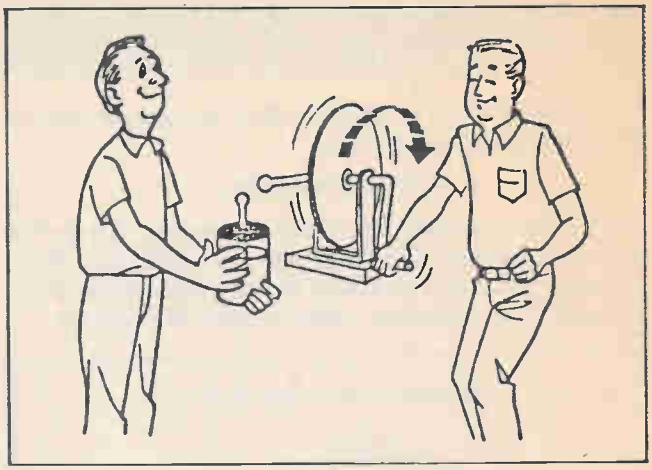


Figure 4. Leyden jar can be charged with electrons by an electrostatic generator (or from any voltage source).

(Figure 4), then the voltage source was disconnected, and the jar removed. At this point Van Musschenbroek's assistant is said to have held the jar with one hand while disconnecting the high-voltage lead with the other hand. The lab assistant received an unexpected shock of considerable intensity (Figure 5). Unfortunately, history didn't record the words spoken by the assistant.

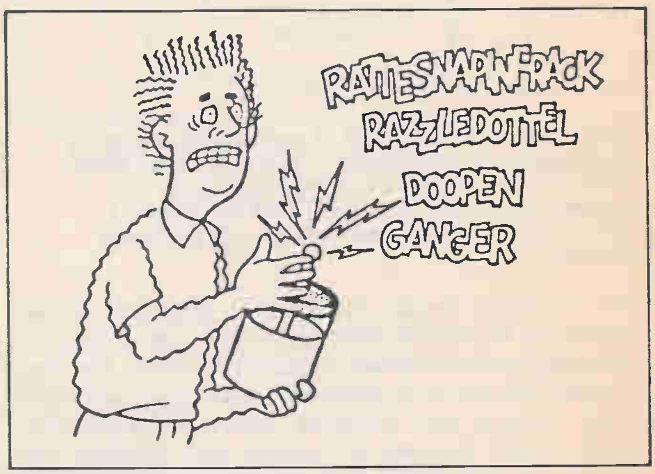


Figure 5. If a Leyden jar (or any other capacitor) is charged to a high voltage—more than, say 60 or 70 volts—it can give you a shocking experience. Some capacitors can hold a charge for hours, or even days!

The shock received by the assistant points up a most important aspect of capacitors: *They are devices that can store an electrical charge.* Electrical energy can be stored or held in a capacitor and then released at a later time. Note that capacitors *must be given* the charge they store. A capacitor cannot

Capacitance is Measured in Farads. So what's a Farad?

The units used to measure capacitance are called *farads*, named after the scientist Michael *Faraday*. Following the equation C=Q/E, a capacitor has 1 farad of capacitance when it can store 1 coulomb of charge with a 1-volt potential difference placed across it.

In reality, 1 farad turns out to be an extremely *large* unit of capacitance , so most capacitor values are written either in microfarads or in picofarads.

Micro means one-millionth. *Pico* stands for one millionth of a millionth, or one *trillionth!* Microfarads are abbreviated as uF, or as uFD, or mF, or mFD. Picofarads are abbreviated as pF, or mmF. The Greek letter "µ" (which is pronounced "Mu") is commonly used to mean "micro."

produce electrical energy by itself, the way a battery does with chemical action.

Capacitor Action

How does a capacitor store an electric charge? It does this through the action of an *electrostatic field.* To see just how this works, focus your attention on the sketch of capacitor plates shown in Figure 6.

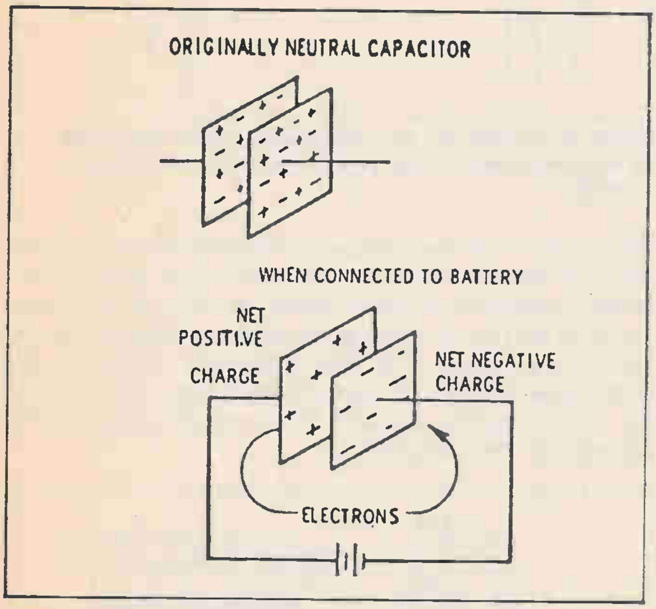


Figure 6. When a capacitor is uncharged it has the same number of electrons (-) on each plate. When connected to a source of energy (voltage), electrons collect on one plate until the voltage between plates equals the voltage of the source (battery).

As you now know, a capacitor consists of two conductors separated from each other by a layer of insulating material called a dielectric, Normally, the two metal conducting plates will have equal amounts of net positive and negative charge. Objects that contain equal amounts of positive and negative net charges are said to be *electrically neutral.* What will happen to these two plates if a potential difference is applied to them, say with a battery? The negative terminal of the battery pushes electrons out onto the negative connected plate, while the positive battery terminal draws electrons from the positive connected plate. As one plate receives a negative charge due to excess electrons building up, the other plate receives a positive charge due to the lack of electrons created. The net charges created on the capacitor's plates are *equal* and *opposite.* This is an important point. The battery takes electrons from one plate of the capacitor and essentially puts them on the other plate.

Electron Buildup on Plates

Negative charges (electrons) cannot build up on the negative plate forever. As more and more electrons move toward the negative plate, they start getting pushed back or repelled by the electrons

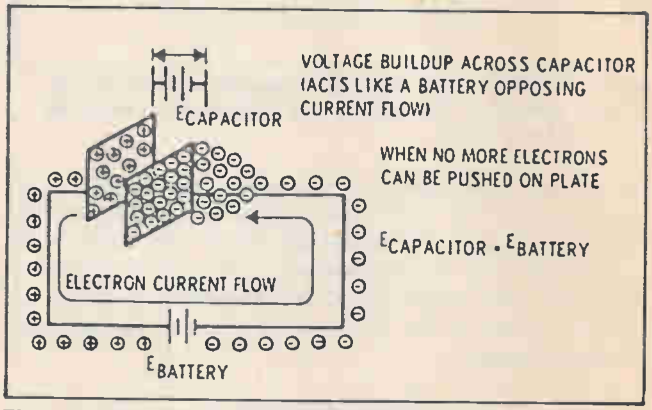


Figure 7. Current flows through connecting wire(s) when a source of electrons is hooked up to a capacitor.

already there. After a while the battery cannot push any more electrons onto the negative plate. The same thing is true with the positive plate. After a while, so many electrons have been removed from the positive plate that the battery cannot pull any more off.

Consequently the capacitor develops a net positive charge on one plate and a net negative charge on the other plate. Because of this, a potential difference or voltage exists between the two plates. At the point where no more charge is flowing the voltage across the capacitor's plates equals the battery's voltage. Notice in Figure 7 that the voltage across the capacitor opposes the battery's voltage. The capacitor's negative plate is pushing electrons back in opposition to the push of the negative battery terminal, and the capacitor's positive plate attracts electrons and thus prevents their further removal from the positive plate. At the point where the voltage on the capacitor equals the voltage of the battery, no more current flows, since these voltages are in opposing directions.

Capacitor Equivalent Circuit

As you can see in Figure 8, once the capacitor's plates have accumulated enough negative and positive charges, the capacitor acts like a battery wired to act *against the original battery* in this circuit.

Review in your mind for a moment the important points about a capacitor which have been discussed. When a capacitor originally having neutral plates is connected to a battery, *charge flows* as a *current exists* in the circuit. Electrons flow out of the battery's negative terminal and build up on the negative connected plate, while electrons are drawn from the positive connected plate. The charge created on each

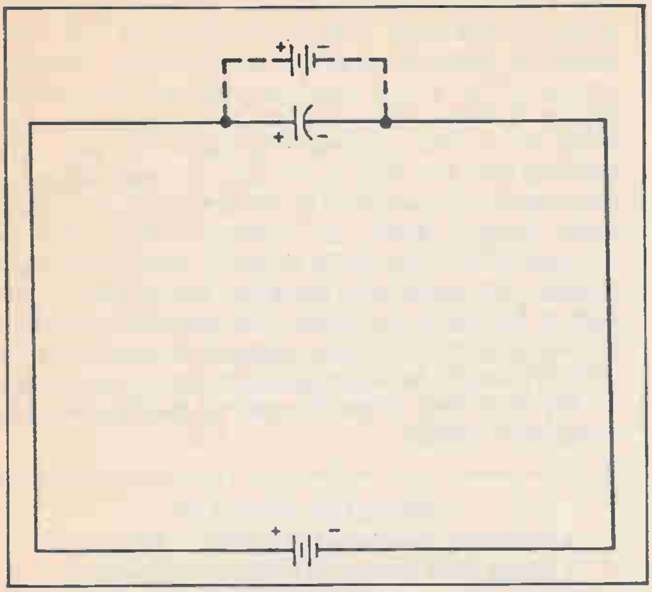


Figure 8. After the capacitor has been charged to the full voltage of the battery or other voltage source, it (the capacitor) acts just like a battery (or other source), opposing the further flow of current. Thus no more current flows in the circuit.

plate causes a potential difference or voltage, to build up on the capacitor. As the charge on the capacitor's plates increases, the voltage across the plates increases, until finally the potential difference of the capacitor equals that of the battery. Since these two voltages are in opposition, when they equal each other there can be no more electron current flow. So notice: Electrons flow in the *circuit,* but none flow *through* the capacitor because of the insulating gap between the two plates. Also, electron flow or *current only goes on for the short time* necessary for the voltage across the capacitor to become equal to the battery voltage.

Charged Capacitor

When a net charge exists on each of the capacitor's plates, a *potential difference* or voltage exists across the capacitor. Likewise, when a voltage is *placed* across a capacitor, "charge" gets stored inside. Here's an important definition for you to remember: whenever a potential difference or voltage exists between the plates of a capacitor, the capacitor is said to be *charged.* A primary function of capacitors is this ability to **store a charge.** Capacitors are rated or measured by how well they perform this function.

The three factors that affect a capacitor's ability to perform the function of charge storage are the *size of its plates,* the *spacing between the plates,* and the *type of insulating material* separating the plates.

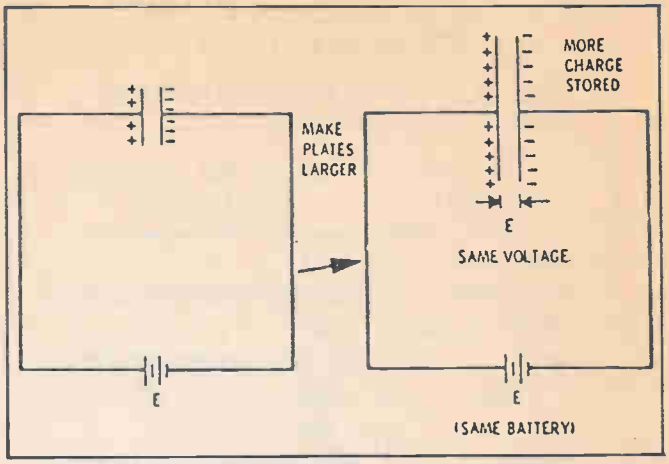


Figure 9. If the plates of a capacitor are made larger (more capacitance) it will take more electrons (more current) to charge the capacitor fully—up to the same voltage as the battery (or other source) That's why larger capacitors store more current.

Plate Area and Capacitance

Each of these factors will be discussed in detail and you will see the first factor, *plate size,* is the most obvious thing about a capacitor that will affect its charge storage ability. As shown in Figure 9, if each of a capacitor's plates is made larger (that is, the plate area is increased), and then connected to a battery, more charge will be stored on the larger plates than on the smaller plates. More charge would have to flow until the potential difference across the capacitor equals that of the battery. When current flow stops, the capacitor would be storing more charge than a capacitor with smaller plates, even though both capacitors were charged to the same voltage.

Capacitance

Since charge storage is really one of the most basic capacitor functions, a quantity is needed to describe how well a capacitor does this. This quantity is called the *capacitance* of the capacitor. You have seen, in Figure 9, that the capacitance of a capacitor depends on the area of its plates, the bigger the plate area, the bigger the capacitance. As has been mentioned, there are two additional factors that affect capacitance. One is the **spacing** between the capacitor's plates. It turns out that if the *plates* are pushed *closer together,* the *capacitance* will be *increased.* The third factor deals with the *type of dielectric* used. If different dielectric materials are placed between the plates, the capacitance will vary. Remember that the capacitance of a device depends on these **three things:** the *spacing* between plates, the *area* of the plates, and the *dielectric* material (specifically, the *dieletetric constant* of the material.)

Dieletric Strength and Dielectric Constant

Notice that the dielectric in a capacitor is actually doing two things. First of all it is the *insulating material* that prevents charges from flowing form one plate to the other. Second, dielectric materials because of their makeup, actually act to help the capacitor store charge. As different dielectrics are

DIELECTRIC STRENGTH ABILITY OF A MATERIAL TO WITH STAND ELECTRICAL BREAKDOWN	
MATERIAL	DIELECTRIC STRENGTH (VOLTS/MIL)
AIR	20
CERAMICS	600-1250 VARIES WITH TYPE
PYREX GLASS	330
MICA	600-1500 VARIES WITH TYPE
TEFLON	1525
OIL	375
PAPER	400-1250 VARIES WITH TYPE

Figure 10. The dielectric strength of materials varies. Air has the lowest dielectric strength (ability to withstand voltage before arcing over). Glass can stand much higher voltages (for the same thickness) and Teflon is able to prevent arcing at very high voltages.

placed between the plates of a capacitor, its capacitance will vary.

Two special quantities are used to describe how well a dielectric performs these *two* functions. One is *dielectric strength.* This describes how *resistant to breakdown* a dielectric is. In capacitors, dielectrics consisting of very thin sheets are often subjected to very high voltages. When the voltage applied across the dielectric becomes high enough the dielectric will "break down," and electrons will "punch their way through" the dielectric. This creates a conducting path from one plate to the other through the dielectric and the capacitor malfunctions. *Dielectric strength* is a measure of how *resistant* a dielectric is to this type of breakdown. The dielectric strength of a material is commonly measured in volts per mil (V/mil); and some common values are listed in Figure 10 (One mil=1/1000th of an inch). These values tell you how many volts a one-mil thickness of dielectric can withstand before breaking down.

For example, the dielectric strength of air is 20 volts/mil. How many volts would be required to break down 1 inch of air and jump a spark through it? As 1 mil is 0.001 inch; so 1 inch is 1000 mils. Air can withstand 20 volts for each mil of thickness so 20 volts/mil times 1000 mils equals 20,000 volts. In a capacitor with 1 inch of air between its plates, 20,000 volts applied would be enough to cause breakdown as shown in Figure 11.

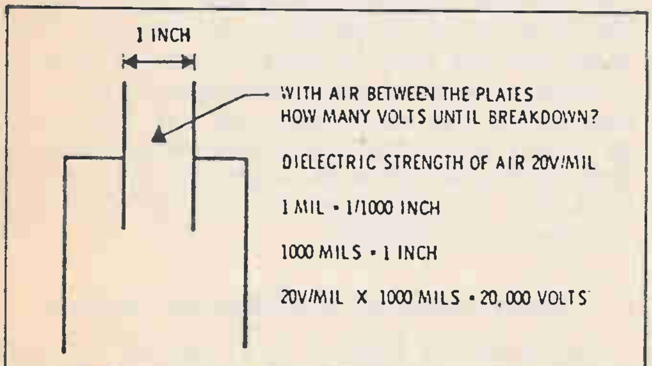


Figure 11. The voltage that a capacitor can withstand before it breaks down (arcs over) depends both on the spacing between the plates and on the dielectric strength (material) of the dielectric between the plates.

Dieletric Constant

The other factor of importance that describes how well a dielectric functions in a capacitor is called its *dielectric constant.* This is a measure of how well a dielectric helps a capacitor store charge. Dielectric constants for some common materials are listed in Figure 12. Notice that the dielectric constant for air is listed as 1. The dielectric constant for any other material tells you how much more (or less) effective a material Is (as compared to air) in helping a capacitor store charge. Glass, for example, has a dielectric constant of 8. If you had a capacitor with air originally between its plates, and replaced the air with a glass slab of the same thickness, the capacitor's ability to store charge would have increased *8 times.* Just how dielectrics work to help capacitors store charge has to do with how they affect the *electric field* between the capacitor's' plates.

DIELECTRIC CONSTANT A MEASURE OF HOW WELL A DIELECTRIC HELPS A CAPACITOR STORE CHARGE (AS COMPARED TO AIR)	
DIELECTRIC MATERIAL	DIELECTRIC CONSTANT
AIR	1
CERAMICS	80-1200 VARIES WITH TYPE
GLASS	8
MICA	3-8 VARIES WITH TYPE
TEFLON	2.1
OIL	2-5 VARIES WITH TYPE
PAPER	2-6 VARIES WITH TYPE

Figure 12. The material used between the plates (the dielectric material) determines how much energy (current) can be stored by a capacitor. An air-dielectric capacitor, such as is used in AM radios, can store the least energy. Other materials store much more energy, for the same area and the same spacing between plates.

Capacitor Charging

As you remember, from the story about the lab assistant who discharged the Leyden jar (Figure 5!), if you want to charge up a capacitor, you must connect it to a supply of DC (direct current) and apply a voltage. After a very short while, current stops flowing and the plates have a potential equal to the supply voltage.

An important point: if the capacitor is *disconnected* from the battery or supply while in its charged condition, *the charge still remains on its plates.* How does the capacitor hold this charge on its plates?

The first law of electrostatics states that *unlike*

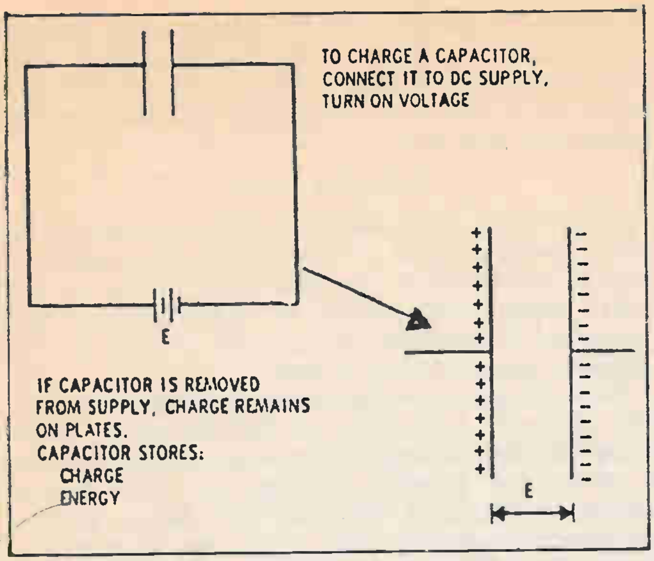


Figure 13. When the voltage (energy) source is removed or disconnected from the capacitor, the energy (electrons) remain stored on the plates of the capacitor until they are reconnected by a wire or other circuit components, as in Figure 14.

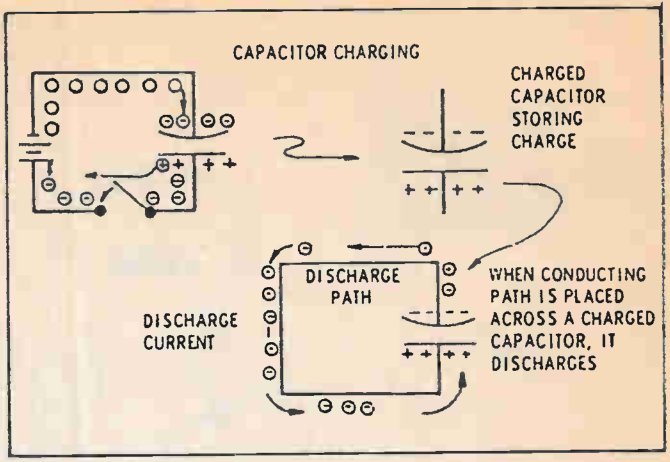


Figure 14. At the left, above, the capacitor is charging while connected to an energy source (battery). At the top right it's been disconnected, but is storing (holding) its charge. At the bottom right, connection through a circuit has been made across the charged capacitor, and the energy (electrons) rush back around through the circuit (wires or components) to equalize the charge on the two plates of the capacitor.

charges attract each other. Look at Figure 13, and you can see that even with the battery disconnected, the positive charges on one plate will attract the negative charges on the other plate and hold them there. Because of these unlike charges on the plates, an *electric field* exists in the dielectric region between them. This field is actually the mechanism that holds the charge on the plates, and also while acting to do that, actually *stores energy*. Since this electric field exists in the dielectric in the absence of current flow, it is called an electro*static* field.

Since the charges on the plates cannot move to reach each other because of the insulating dielectric between the plates, in its charged condition the capacitor can store charge and energy for long periods of time. This means that a charged capacitor can be used to provide a current or do some work for you at some later time.

Disharging a Capacitor

Remembering the Leyden jar and how it was discharged, the electrical energy (charge) which is stored in a capacitor may be *recovered* if a conducting path is provided between the plates. This procedure is called *discharging* the capacitor. The excess electrons on the negative plate will flow to the positive plate, until both plates have no net excess charge, or are neutral. In this condition, the capacitor is said to be *discharged*. The current that flows is called the discharge current and the path taken by the current is called the discharge path. A charged capacitor may be discharged by providing an

CAPACITOR TYPE	RANGE OF CAPACITANCE	RANGE OF WVDC	COMMENTS
Ceramic	1 pF — 2.5 µF	20 — 200	small size low cost
Paper	0.001 — 200 µF	50 — 2000 or more	low cost
Electrolytic and Tantalum	0.5 — 1,000,000 µF	700 10 — 600	very small size very low cost
Mylar	0.001 — 20 µF	50 — 100	small size higher cost
Air	10 — 400 pF	200 volts per 0.01 inch	variable size
Mica	1 pF — 1 µF	50 — 10,000	small size, may be adjustable
Oil Filled	0.001 — 15 µF	100 — 12,000	

Figure 15. This table shows all the common types of capacitors with their widely different characteristics. Air, mica and ceramic types are most often used in radio frequency circuits. The other types are more often used in audio frequency and power circuits.

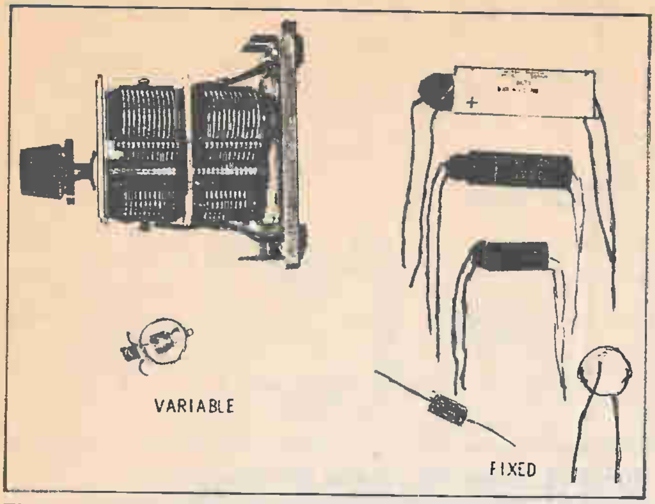


Figure 16. Two types of variable capacitors are shown here. The top is a common tuning capacitor for AM radios. It's actually two (ganged) separate capacitors using air dielectric. Below it is a trimmer capacitor, often used to optimize car radio antennas.

appropriate conducing path between its plates as shown in Figure 14. An important observation for you to make should be emphasized at this point. Even though the power may be shut off to a circuit, every capacitor in the circuit may retain its charge for a long period of time. Therefore, before working on high-voltage electronic circuitry, you should be sure to discharge all capacitors. The stored charge and energy in capacitors can discharge through you *giving you a nasty shock.* Ask Pieter Van Musschenbrock's lab assistant!

Charge Formula

The amount of charge present on the capacitor's plates and the voltage across the plates are related. To restate, the capacitance of a capacitor in farads equals the charge on the capacitor in coulombs divided by the voltage across it. or $C=Q/E$ This equation may now be rearranged to be shown as $Q=CE$, or the charge stored in a capacitor (in coulombs) equals its capacitance (in farads) times the voltage between its plates. Look at this new equation carefully. It states that the amount of charge stored in a capacitor is directly related to the voltage across the plates, the more charge on the plates, and vice versa. For a given voltage, the higher the capacitance, the more charge will be stored on the plates, and vice versa.

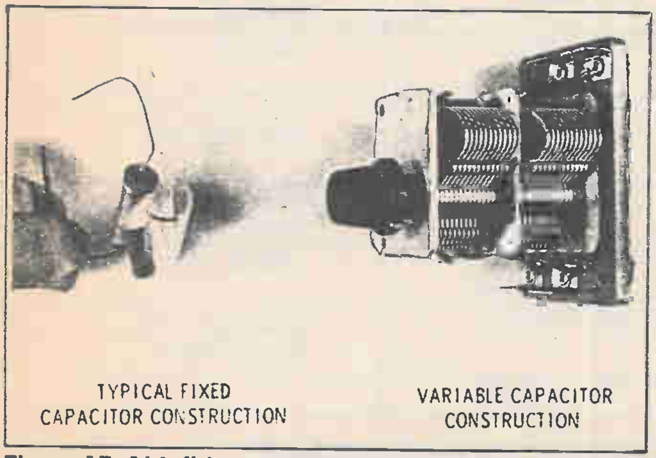


Figure 17. At left is a paper capacitor partly disassembled. At the right a two-section air tuning capacitor is shown partly opened (to less than full capacity).

Capacitor Types

Now that you have seen a bit about how capacitors work, consider some of the actual components you may find available in the laboratory. Figure 15 is a chart listing various types of capacitors that are available. Capacitors are usually *named* by the *dielectric* material used in them.

Because of the many applications of capacitors and the different properties of the dielectric, each capacitor you encounter will probably be labeled with a WVDC or "Working Voltage dc." This is the maximum voltage the capacitor can tolerate without its dielectric breaking down. As you apply capacitors in circuits, the voltage across them must be kept well below this WVDC.

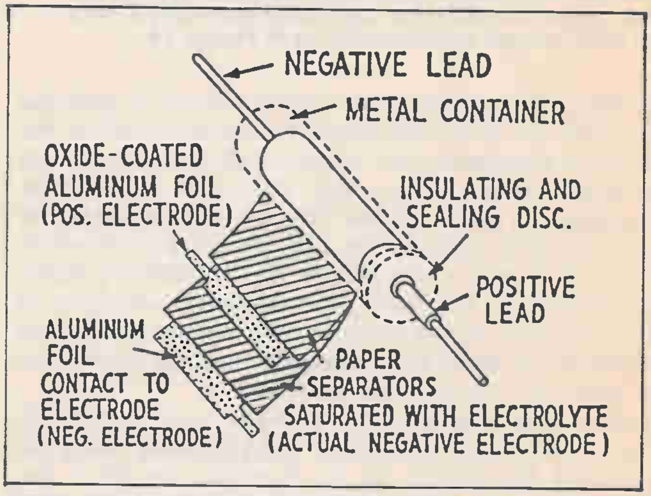


Figure 18. An electrolytic capacitor is shown in this diagram. Tantalum capacitors are similar, with tantalum foil plates instead of aluminum foil.

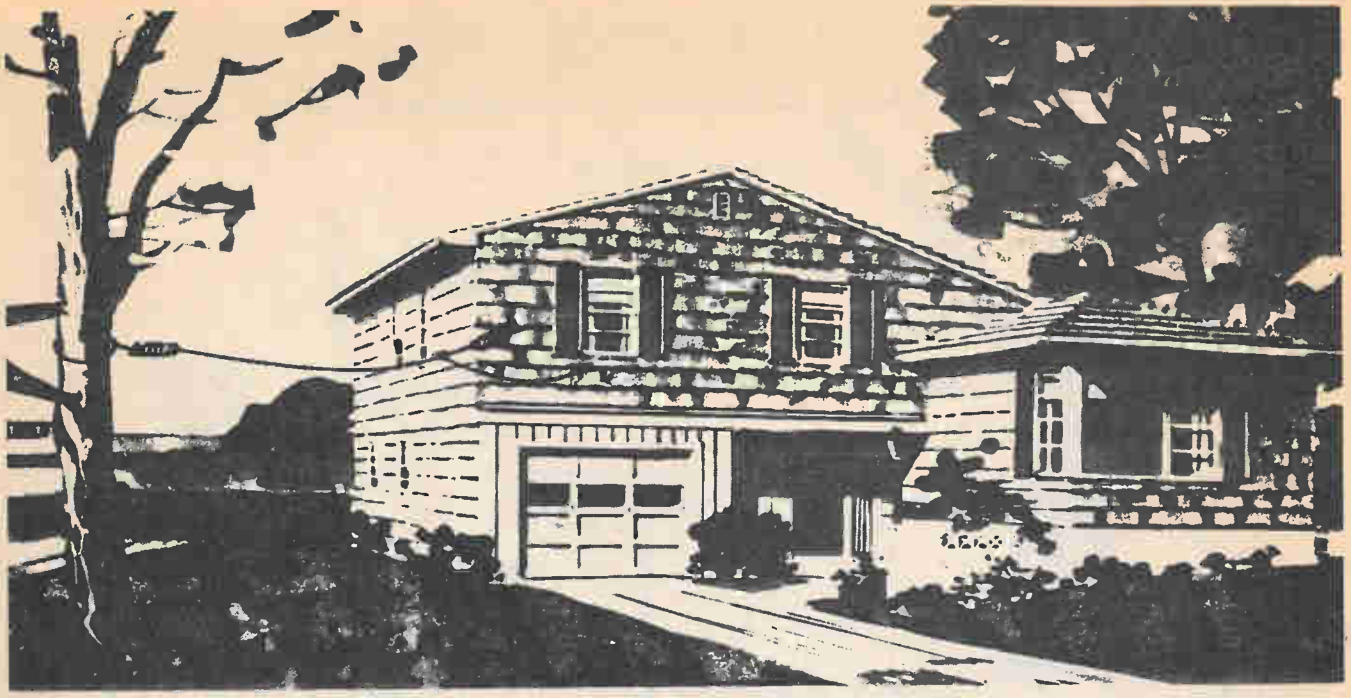
Fixed and Variable

Capacitors are available in both fixed and variable types as shown in Figure 16. Several different common types including paper, mica, and ceramic capacitors are shown in the figure. As mentioned, these are named for the *dielectric material* employed in manufacturing them, and are produced in a set of preferred values, with tolerances similar to those of resistors.

Construction

To keep the size of these devices as small as possible a series of foil plates is usually employed with thin sheets of dielectric rolled up in between them as shown in Figure 17. Also shown in the figure is a typical *variable* capacitor. Variable capacitors are most often constructed so that their effective plate area can be varied by rotating a shaft connected to one set of plates. These plates can be moved between a stationary set of plates changing the capacitance value of the device.

(Continued on page 94)



SHORT-CUTS TO SHORT WAVE ANTENNAS

It's easy to construct a good shortwave antenna. Just follow these simple directions.
Shortwave listening (SWL) beginners have no problem in finding good receivers, either budget-priced units or gold-plated specials, when starting their first listening shack. Putting up antennas maybe their downfall.

Antenna theory is beyond the grasp of most novices. It is very complex at the beginning and rapidly becomes incomprehensible as different antenna types are introduced. So, why not take a shortcut approach to your first antenna installation. Get your new receiver pulling weak signals as you pile up listening hours with exotic DXing. What about antenna theory? It'll come if you work at it by reading theory books, but in the meantime here are three recorded case histories on low-cost antenna shortcuts which you can follow.

Case No. 1—The Dangler

Harry is a youngster I met while giving a talk to the local high school student body during Science Fair Week. Harry was fascinated by the idea of English language newscasts from far-away places, so he bought a Realistic DX-360 receiver and set up a listening corner in his upstairs room in his folks' Colonial-style house. For an antenna, he dangled an odd length of wire out the window, letting it drop to the ground. The BBC and Radio Moscow came in fine except on rainy nights. In fact, it was a rainy evening when he rang my doorbell for help.

Harry's long wire was long and that's all it had going for it. It was vertically polarized (wrong) by hanging down and shorted out to ground (not good either) on damp nights. What Harry needed was a length of wire extended from the window to a distant pole, out-building, garage or tree, In Harry's case, some sturdy trees outlined the house's properly line and he could run a 60-foot antenna with no difficulty. The antenna pointed due North-West and his area of the U.S was able to pull in Europe, North Africa, and the Near East with ease. Here's how we went about licking Harry's problem.

First, I told Harry that a good long-wire antenna should be 30 to 100 feet long for good reception performance on 2 to 30 megaHertz (MHz). As mentioned earlier, a 60-foot run was possible. A sturdy tree was selected because it hardly swayed in strong winds at the 20-foot level where the antenna would be secured. Some slack (one foot of droop) was left in the antenna to compensate for tree sway

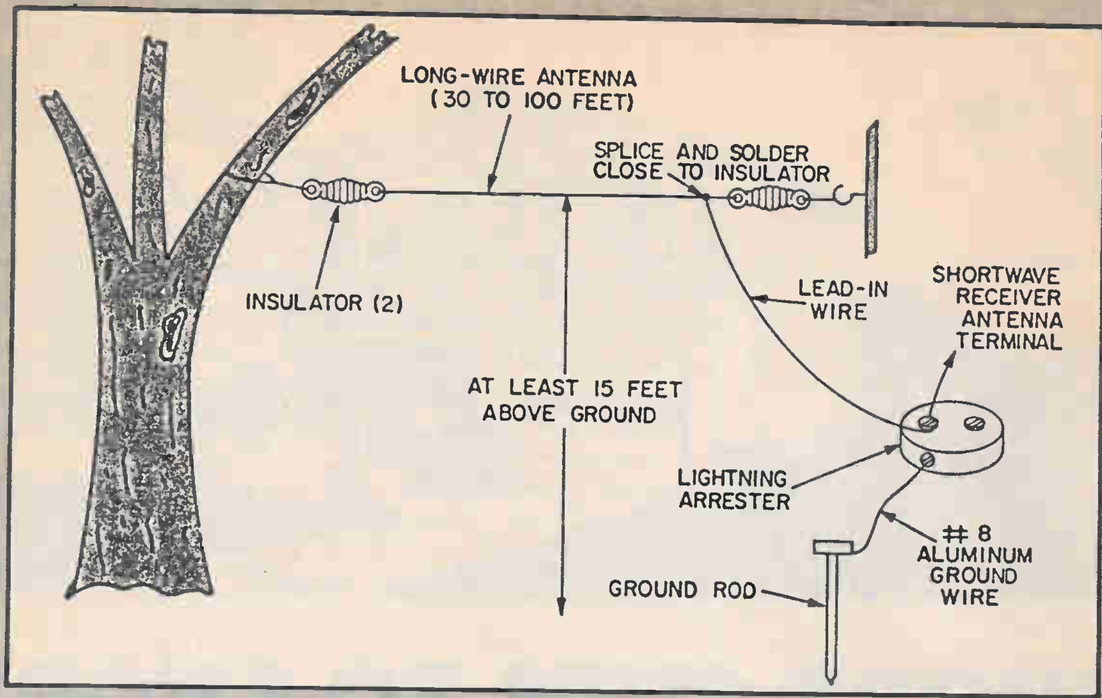


Figure 1. Harry had it made after he put up this simple long-wire antenna.

and strong winds. Harry's antenna details can be seen in Fig. 1.

Antenna wire and antenna long wire kits are available everywhere. Harry actually used 60 feet of bare copper antenna wire, and 50 feet of lead-in wire. Harry had no trouble at all getting the antenna up.

Harry was a little smarter than I was. He remembered to protect against lightning. Since shortwave lightning arrester kits are usually not available locally, Harry made do with lightning arrester parts made for TV. The TV arrester has two screw-tight terminals with star washers for the 300-ohm TV line, however Harry only used one for his antenna and the other was left unused. The whole lightning installation kit came to about $10.00. That's cheap. To bring the antenna lead-in into the house, Harry used a "Wall-Thru" tube (Radio Shack 15-1200).

Now I don't see much of Harry. Maybe once in a while he's at the Pizza joint with a date, but you can be sure Harry's getting a lot of DXing and mail confirmations every week.

Case No. 2—The Specialist

I've known Mort for over 20 years. We knocked about through high school and somehow the paths of our lives are forever crossing. At one such juncture, Mort invited me to his home to see his new shortwave listening shack which sported a brand-new freshly assembled Heath SW-7800. The SW-7800 is a hot receiver. Unfortunately, I couldn't say the same for Mort's antenna. Mort was always inclined to specialize, and he had rigged up a dipole antenna with 300-ohm TV antenna lead-in wire. Mort wanted to log the 41-meter band and found it offered poor reception in his area. Besides, the noise was too high. He was asking, if not pleading, for advice.

First of all, I told Mort that dipole antennas are cut to exact dimensions for specific frequency bands as shown in Fig. 2. The dipole consists of a wire of a specific length which is cut in half. At the mid-point and both ends, each half of the wire is insulated from each other and insulated from ground. The lead-in cable from the antenna is actually two wires, and it's best to use a 72-ohm coaxial cable (coax) because it is inexpensive and commonly available. Without getting into theory, let me say that a 72-ohm coax lead-in cable "matches" a dipole antenna with less signal loss than does a 300-ohm TV twin-lead cable, On the design board, dipoles have a 75-ohm impedance and match pretty well into 72-ohm coaxes. The 300-ohm cable Mort was using was a bust.

The equation for determining the overall length for a dipole antenna at a given frequency is determined by dividing the given frequency in kiloHertz into the number 468,000. Or, as seen in the text books:

$$L = \frac{468{,}000}{f}$$

Where L is the overall length of the dipole in feet and f is the desired reception frequency in kiloHertz (kHz). I computed the overall length for dipole antennas to receive the international shortwave broadcast bands using the mid-frequencies of each and listed them in the Table shown here.

When buying materials for a dipole antenna, the wire and insulators are the same type as required for

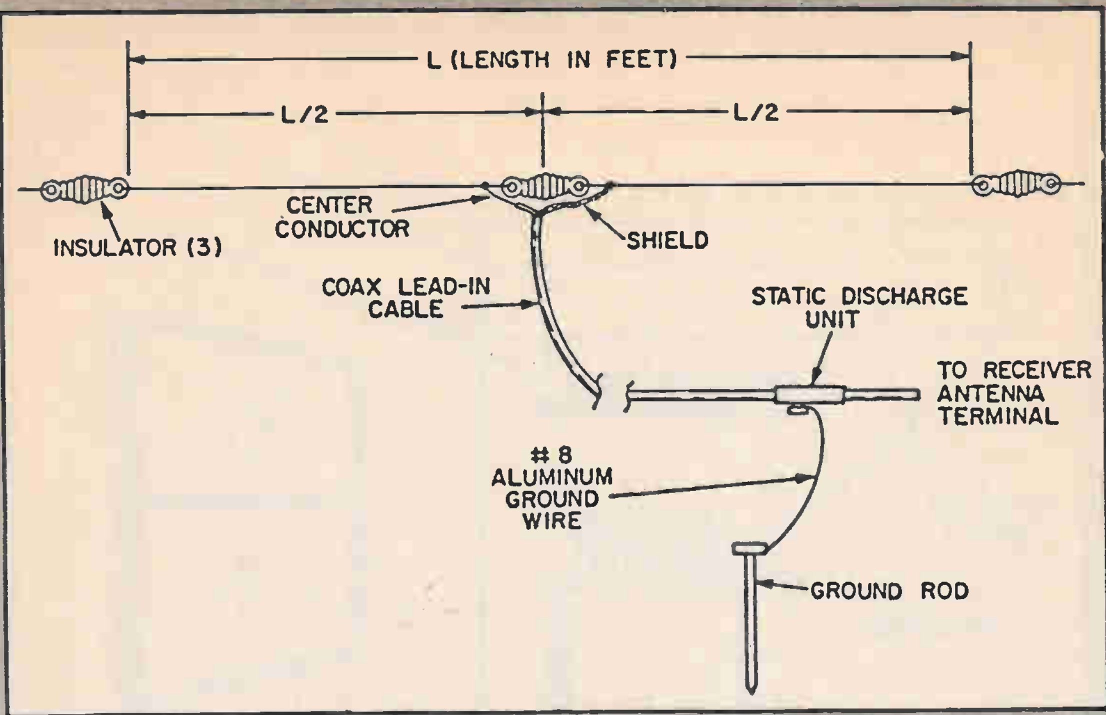


Figure 2. If you want the kind of DX Mort is getting, put up a tuned dipole antenna.

the long wire antenna. The lead-in coaxial cable should be RG-59/U or RG-11/U, each of which exhibits 72-ohms impedance. Stay away from unknown coax types or those with different impedances (ohms). As a guide, the table lists commonly available coax cables and their impedances. Any coax exhibiting an impedance in the 70's is good for the purpose. Let price dictate your selection.

I did not forget the lightning arrester in Mort's antenna. At the window, out of reach of the rain. I installed a Radio Shack coax static discharge unit (21-1049). This gadget requires a PL-259 connector on the coax lead-in cable. It's worth the trouble. A grounding screw on the connector attaches to the grounding wire and ground rod. An ounce of prevention can save your home.

A dipole has some bonuses. For example, a dipole works equally as well on frequencies three times the designed frequencies. Thus, a 41-meter band dipole which will pull in 7100-7300 kHz signals will also receive 21300-21900 kHz which covers the 13-meter band. Or, if there is sufficient space to string a 195-ft. 2-in. antenna for the 120 meter band (2300-2495 kHz),

DIPOLE OVERALL LENGTH FOR THE SHORTWAVE BROADCAST BANDS

Band	Frequencies (kHz)	Mid-Frequencies (kHz)	Length (feet—inches)
120	2300-2495	2397.5	195—2
90	3200-3400	3300	141—10
75	3800-4000	3900	120—0
60	4750-5060	4905	95—5
49	5950-6200	6075	77—0
41	7100-7300	7200	65—0
31	9500-9775	9637.5	48—7
25	11700-11975	11837.5	39—6
19	15100-15450	15275	30—8
16	17700-17900	17800	26—3
13	21450-21750	21600	21—8

Coax Lead-in Cable

Cable Type	Typical Ohms
RG-11/U	75
RG-59/U	72
RG-59A/U	75
RG-59B/U	75
F-11/U	75
F-59/U	72

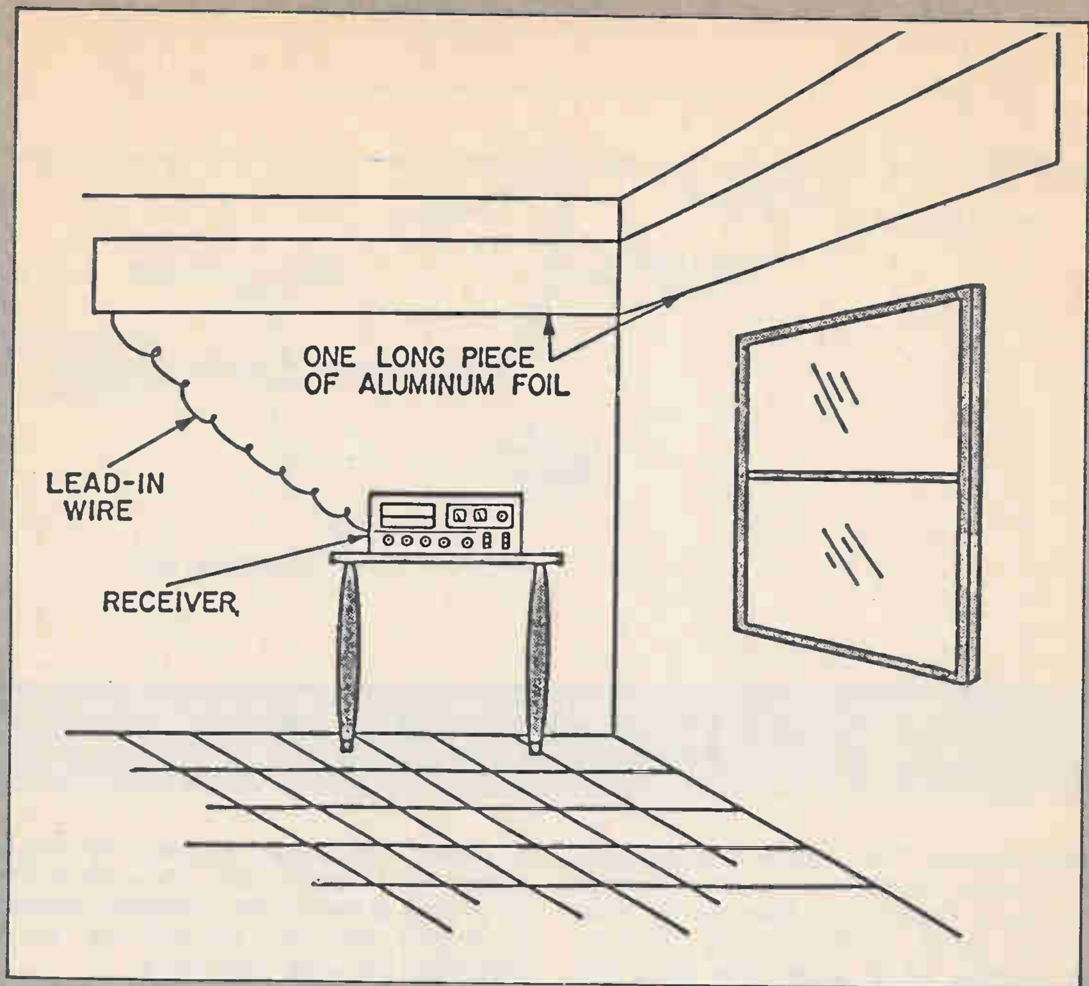


Figure 3. How to install an alumimum foil antenna like the one that set Artie straight.

then you could pull in the 120, 41 and 13 meter bands. Of course, if you want all the shortwave bands, they're your best bet is a commercial dipole antenna with built-in wave traps.

Don't see much of Mort anymore except at the supermarket. Seems he's a "stay-at-home" type lately. Happy DX-ing. Mort.

Case No.3—Indoor Antenna

In the third case a friend's son named Artie had caught the short-wave listening bug from a friend in another city. Artie's family lived in an apartment house, and there was no way Artie could rig an antenna up on the roof of the apartment building.

I went over to his family's apartment after his father told me about Artie's problem. He'd already got hold of a good second-hand all-wave receiver, and was using a piece of wire six feet long hooked to the antenna terminal. This picked up lots of local broadcasts, as well as some up to a couple hundred miles away, at night. How to get real DX (long-distance) broadcasts?

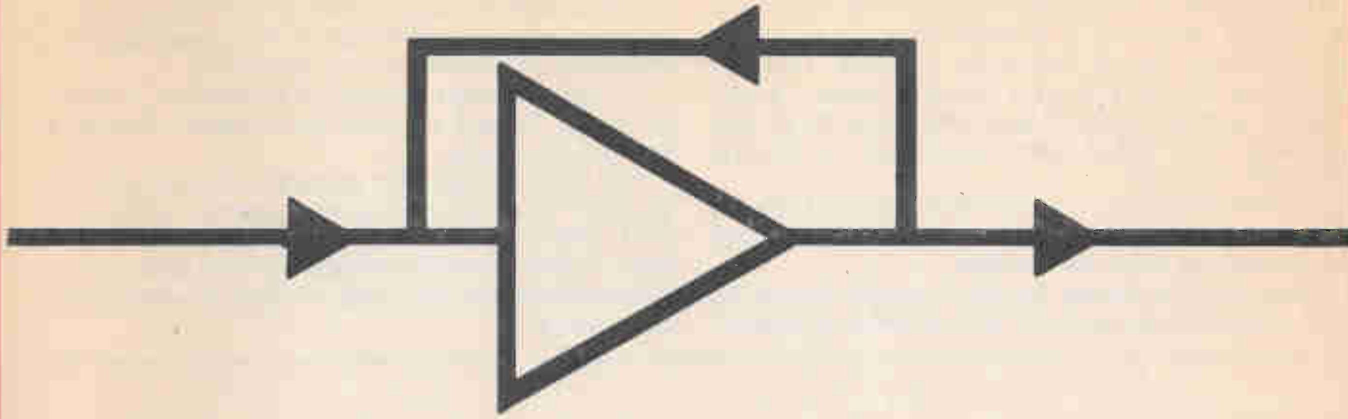
After looking over his situation we borrowed a roll of aluminum foil his mother had in the kitchen, along with some Scotch tape. We ran it all along one wall near the ceiling, starting near the receiver, and also along a second wall, as shown in Figure 3. Artie has been logging overseas stations on most bands on his receiver ever since, and now he's looking at a brand-new, super-sensitive all-wave receiver.

For the lead-in wire we just used the ordinary hookup wire (number 18 to 24 will do) Artie had been using for his antenna before I visited him. Connecting the receiver's ground terminal to a radiator helped bring in more stations, too.

Editor's Note: If you have difficulty locating good antenna wire and lead in, write to Heath Company for their Longwire SWL antenna package. It's 75-feet long with 30 feet of lead in and includes all insulators and hardware. Item GRA 72, $14.95.

Heath is at Benton Harbor, MI 49022. Toll free telephone for credit card ordering is 1-800-253-0570. ■

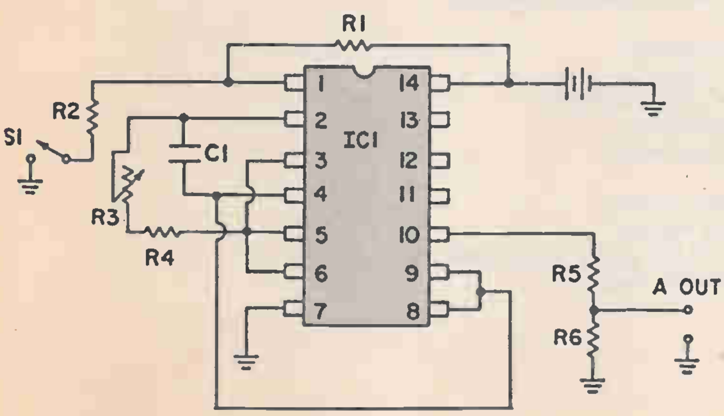
IC TESTBENCH



Integrated Circuits (ICs) are an electronic experimenter's dream come true. They have carried electronics light years ahead in just a few short years (since the Sixties) that they've been around. They make it possible to confine many complicated circuits and electronic functions into a tiny space, with very few additional (external) components. That's why ICs are so important and it is why we present a special "project" section, just working with ICs (IC Testbench). By putting a few of these IC Testbench projects together, you'll learn much about the many varied and complicated jobs ICs can do and how to use them in today's sophisticated electronic devices and systems. The projects in this section are designed to provide some basic features that can be used in larger projects or by themselves as a learning guide.

HAM PRACTICE SET

Are you getting ready to practice CW (Morse Code), also known as Dot-'N Dash, for your Ham (radio amateur) examination? It only takes five (5) words per minute to get you on the air. This one-IC circuit (only six little resistors added) will do the job. You use Pushbutton S1 as your code key. The tone



PARTS LIST FOR HAM PRACTICE SET

C1—01-uF ceramic capacitor, 15 VDC
IC1—4001 quad NOR gate
R1—100 Kohm ½-watt resistor
R2—220-ohm, ½-watt resistor
R3—500,000-ohm, linear-taper potentiometer
R4—50,000-ohm, ½-watt resistor
R5, **R6**—2,200-ohm, ½-watt resistor
S1—SPST momentary-contact pushbutton switch

output at point "A" goes to a pair of high-impedance phones (not low-impedance Stereophones) or to the input of any amplifier, or the Aux input (or Tape) of a stereo set.

4-CHANNEL MIXER

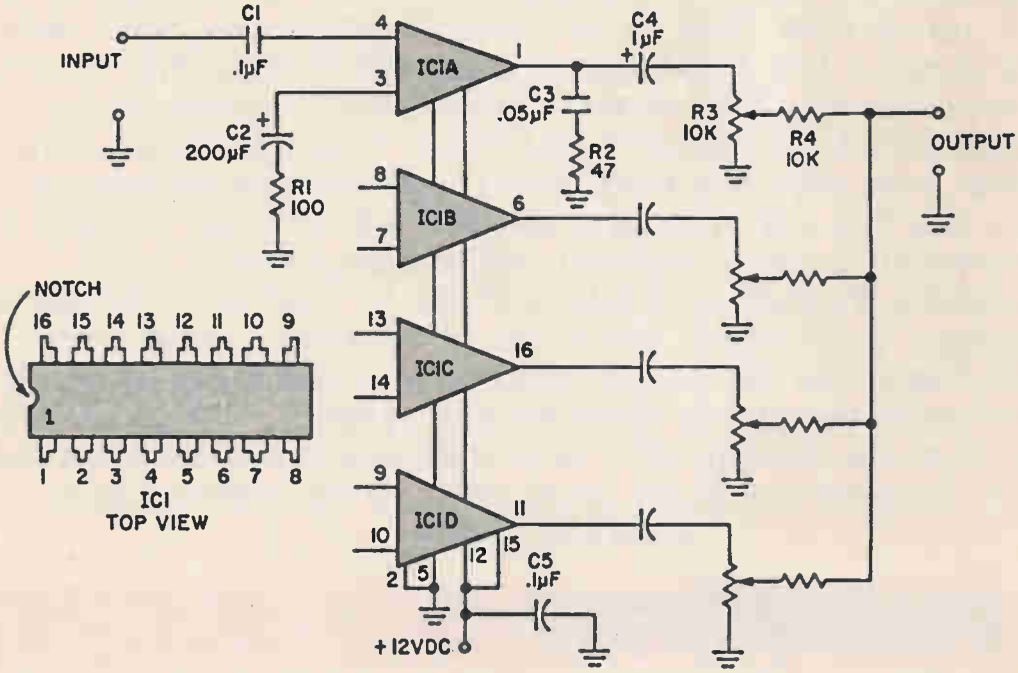
Best signal to noise ratio in a microphone mixer is always obtained if amplification is provided ahead of the loss in the mixer network. You can easily put this idea to work with our mixer—a full-fidelity, professional grade microphone mixer that contains four independent amplifiers within the integrated circuit.

For simplification, our schematic shows only the connections for one of the four amplifiers; the others are identical to the first.

Note that the power supply is single-ended 12 VDC (negative grounded); it must be well filtered, or, use a battery supply. The current requirements are approximately 30 mA total. The power supply is internally connected to the amplifiers.

To prevent high frequency oscillation, components C3, R2 and C5 must be installed directly at the IC's terminals.

Any 50 to 50,000 ohm dynamic microphone can be used. However, crystal and ceramic mikes won't work with Pro-Mix; the medium impedance IC's input impedance will excessively load down a high impedance mike, resulting in sharp, low frequency attenuation.

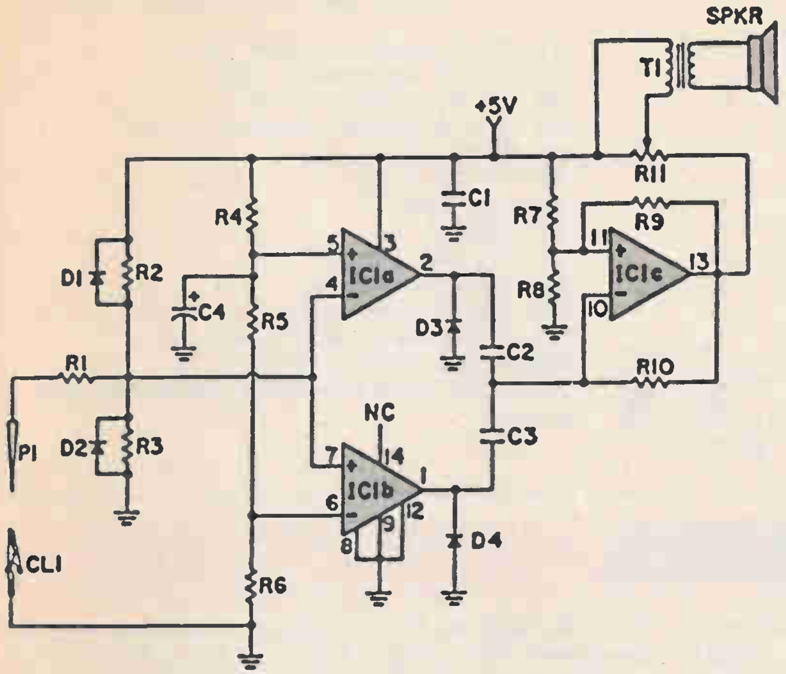


PARTS LIST FOR HI-LEVEL MIXER

C1—0.1-uF, 3 VDC capacitor
C2—200-uF, 3 VDC capacitor
C3—0.05-uF, 75 VDC disc capacitor
C4—1-uF, 15 VDC capacitor
C5—0.1-uF, 15 VDC capacitor
IC1—RCA CA 3052
R1—100-ohms, ½-watt resistor
R2—47-ohms, ½-watt resistor
R3—Potentiometer, 10,000-ohms audio taper
R4—10,000-ohms, ½-watt resistor

IC LOGIC TESTER

Here is the old familiar logic probe but with a new twist. Instead of displaying logic status with LEDs. it does the job aurally. The logic-1 state, 2-volts or greater, is signaled by a high tone. On the other hand, a low tone sounds to indicate the logic-0 state, 0.8-volt or less. Inputs between 0.8 and 2-volts produce no output. (Note that this probe is designed especially for TTL and cannot be used for any other logic family.) The circuit requires a regulated 5-volt supply, which means that it can be powered by the same supply used by the TTL circuitry under test. Output can be taken from a miniature speaker, as shown in the schematic, or you may use a miniature earphone. Potentiometer R11 sets the output volume level.

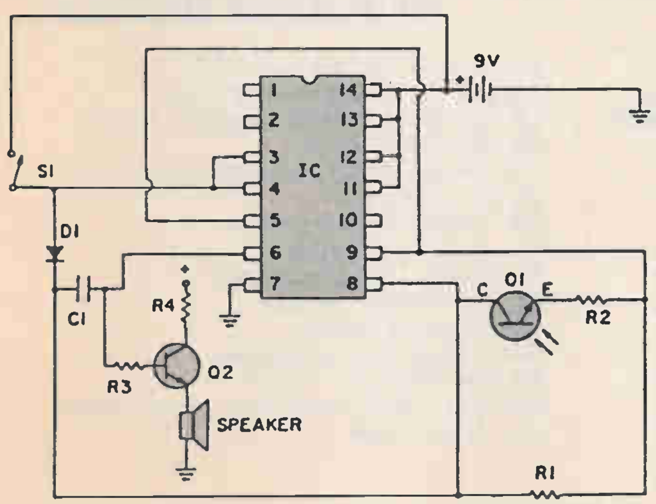


PARTS LIST FOR IC LOGIC TESTER

C1—0.1-uF capacitor, 35 VDC
C2—0.005-uF capacitor, 35 VDC
C3—0.1-uF capacitor, 35 VDC
C4—1.0-uF capacitor, 10 VDC
CL1—alligator clip
D1, D2—IN4001 diode
D3, D4—1N914 diode
IC1—LM339 quad comparator
P1—metal probe tip
R1—10K-ohm resistor
R2, R3—220K-ohm resistor
R4—30K-ohm resistor, 5%
R5—12K-ohm resistor 5%
R6—8200-ohm resistor, 5%
R7, R8, R10—56K-ohm resistor
R9—120K-ohm resistor
R11—1000-ohm audio-taper potentiometer
SPKR—miniature speaker
T1—miniature audio output transformer-(500 to 1000 ohm primary)

HAUNTED HOUSE

An eerie sound comes from a small box in a dark room. As your friends shine a light toward the sound it whines with a higher pitch, but falls again as they drop the light and run. The output at A can also be run into your hi-fi system to cause a very loud witch's squeal. The principle is a NOR-gate



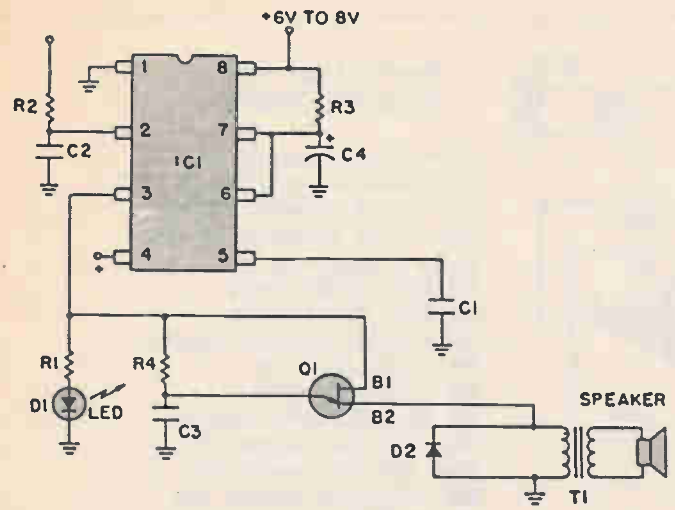
PARTS LIST FOR HAUNTED HOUSE

C1—0.01-uF ceramic capacitor, 15 VDC
D1—1N4001 diode
IC1—4000 dual NOR gate w/inverter
Q1—FPT-100 phototransistor
Q2—2N4401
R1—30,000-ohm resistor
R2—1 Megohm resistor
R3—2,000-ohm resistor
R4—500-ohm resistor
S1—SPDT toggle switch

oscillator with a pitch controllable via the light-sensitive transistor. Q1. Changing R1 to a higher value will give a lower-pitched wail.

JEWEL-CASE ALARM

This circuit finds the 555 timer as a watchdog ready to cry out if an inquisitive finger comes too close. The trigger input is terminated with a one megohm resistor, attached to a coin or some other small metallic object. Hand capacity is sufficient to initiate the timer for about five seconds. The output is fed not only to a warning LED. but to a unijunction type oscillator, whose tiny two-inch speaker can make itself heard throughout the room.

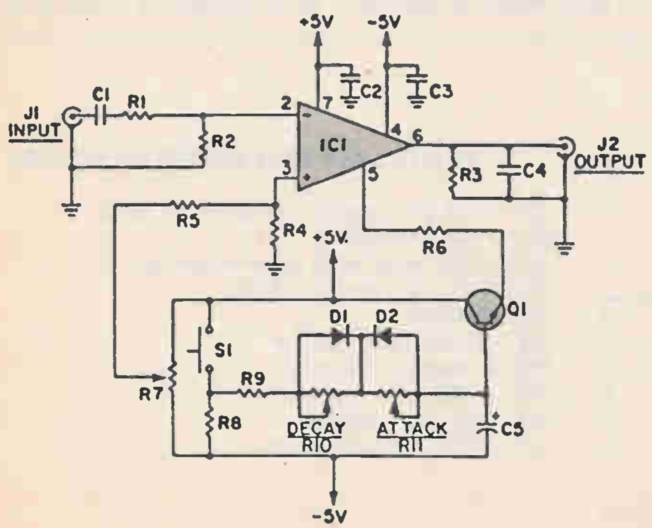


PARTS LIST FOR JEWEL-CASE

C1—0.1uF capacitor, 15 VDC alarm
C2—0.01-uF capacitor, 15 VDC
C3—0.1-uF capacitor, 15 VDC
C4—1-uF electrolytic capacitor, 15 VDC
D1—small LED
D2—1N4148 diode
IC1—555 timer
Q1—2N2646
R1—470-ohm resistor
R2—1 megohm resistor
R3—220,000-ohm resistor
R4—15,000-ohm, ½-watt resistor
SPKR—(3.2 to 8 ohm speaker)
T1—audio output transformer (500 to 1000 ohm primary)

BASIC VARIOTHIZER

Feed this circuit a simple audio tone, and it gives you back a musical note with selectable attack, sustain and decay. Input impedance is 10,000-ohms, output impedance is 1000-ohms, and the gain is unity. Best results will be obtained with signal inputs having amplitudes of 1-volt peak-to-peak or less. When S1 is pressed, the output volume rises at a rate determined by attack control R11. As long as S1 is pressed, the sound will be sustained. Releasing S1 causes the note to decay at a rate determined by decay control R10. Try sine, square or triangular wave inputs for musical notes. With a noise input you can imitate such things as gunshots and explosions, R7 can be adjusted to cancel out any audible "thumping" (noticeable with very rapid attack or decay).

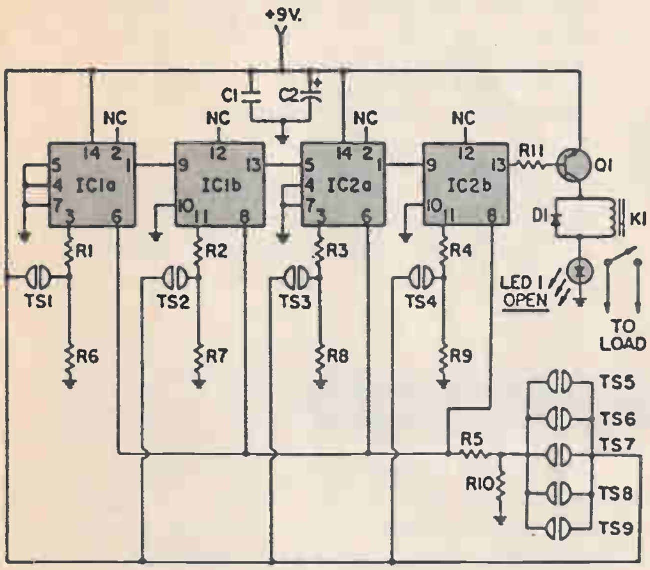


PARTS LIST FOR VARIOTHIZER

C1—0.33-uF capacitor, 35 VDC
C2, C3—0.1-uF capacitor, 35 VDC
C5—2.2-uF electrolytic capacitor, 16 VDC
D1, D2—1N914 diode
IC1—RCA CA3080 transconductance amp
J1, J2—phono jack
Q1—2N3904 NPN transistor
R1—9100-ohm resistor
R2, R3, R4—100-ohm resistor
R5—2.2 Megohm resistor
R6—15K-ohm resistor
R7—1 Megohm potentiometer
R8, R9—5600-ohm resistor
R10, R11—250K linear-taper potentiometer
S1—SPST switch

TOUCH-ACTIVATED COMBINATION LOCK

Here's an electronic combination lock that's tough to crack. To open the lock, thereby causing relay K1 to pull in and LED 1 to light, you must touch TS1, TS2, TS3 and TS4 in sequence. Should one of the dummy switches TS5 through TS9, be touched, the lock immediately resets and the compete 4-digit combination must be reentered to open it. Since there are five dummies, chances of ever opening the lock accidentally are slim indeed. Once you've opened the lock, just touch one of dummies to lock again. The touch switches consist of two small pieces of aluminum or copper separated by a 1/16-inch gap. Bridging the gap with a fingertip closes the switch. If you like, conventional normally open pushbuttons could be substituted for the touch switches.

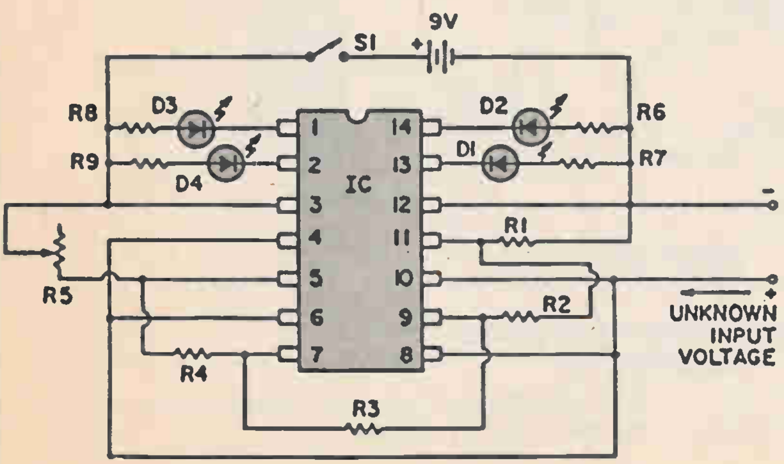


PARTS LIST FOR TOUCH-ACTIVATED COMBINATION LOCK

C1—0.1-uF disc capacitor, 35 VDC
C2—220-uF electrolytic capacitor, 16VDC
D1—1N914 diode
IC1, IC2—4013 CMOS dual D-type flip-flop
K1—6V, 500-ohm relay with SPST contacts
LED1—light-emitting diode
Q1—2N3904 NPN transistor
R1 through R5—100K-ohm resistor
R6 through R10—4.7 Megohm resistor
R11—18K-ohm resistor
TS1 through TS9—touch switches made of 2 pieces metal separated by a 1/16-inch gap.

IC DIGITAL VOLTMETER

This circuit introduces the principle of a digital voltmeter and actually provides a very sensitive, high impedance meter for your workbench. The LM-339 is an IC containing four separate operational amplifiers of special type. These op amps compare the reference voltage set on one input pin with an unknown voltage on the other. If the unknown voltage exceeds the reference, the output goes high and lights an LED. D1 lights first. With a slightly higher input voltage, D2 will light, etc. Variable resistor R5 allows you to set the voltage steps between D1, D2, D3 and D4 from about .02 volts per step to about 0.5 volts per step.



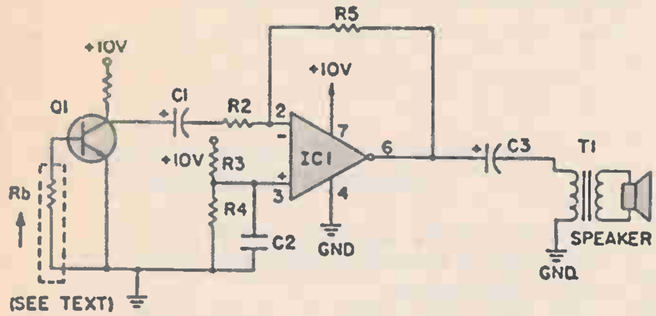
PARTS LIST FOR IC DIGITAL VOLTMETER

D1, D2, D3, D4—large LEDS
IC1—LM339 quad comparator
R1, R2 R3 R4—1,200-ohm resistor
R5—1 Megohm-ohm linear-taper potentiometer
R6, R7, R8, R9—470-ohm resistors
S1—SPST toggle switch

AUDIBLE LITE DETECTOR

When connected this system may be quick-checked with a flashlight, while listening to the speaker and/or observing the op amp output on a scope. Modulating the light source mechanically with a pocket comb produces a buzzing tone, as the teeth of the comb alternately gate the light source.

A modulated LED can be used, with proper optical interfacing, as a communication source. The phototransistor is at its greatest sensitivity with the base lead open, though this may introduce unwanted hum. A 100K to 1 Meg resistor (R6) may be run to ground to check the best compromise.



PARTS LIST FOR AUDIBLE LITE DETECTOR

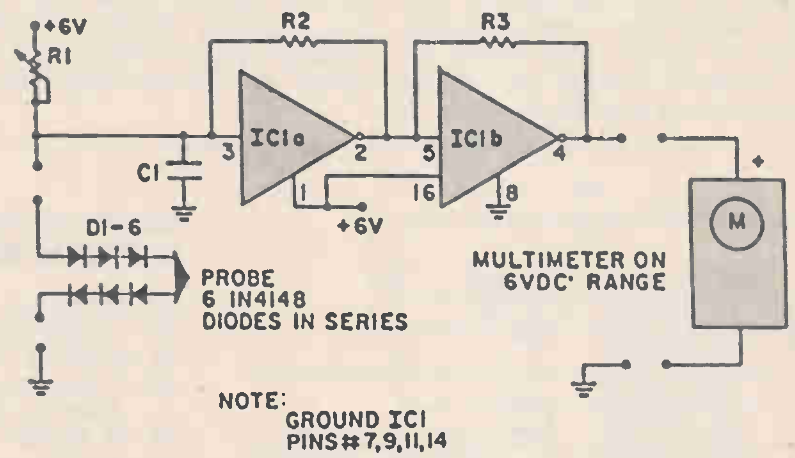
C1 C2—10-uF electrolytic capacitor, 15VDC
C3—50-uF electrolytic capacitor, 25 VDC
IC1—741 op amp
Q1—FPT100 phototransistor
R1—47,000-ohm resistor
R2—1,000 to 10,000-ohm resistor
R3, R4—4,700-ohm resistor
R5—500,000-ohm resistor
R6—100,000 to 1 Megohm resistor (see text)
SPKR—PM speaker
T1—audio output transformer 500 to 1000-ohm primary.

SOLID STATE THERMOMETER

Here's a precision thermometer which uses low-cost diodes. You could interface it with a frequency counter, or it can be read directly with a low-cost (20-thousand ohms-per-volt) voltohmmeter.

The thermometer's precision depends on the accuracy of the thermometer you use to calibrate it. If you're not sure, average several inexpensive units to get the nearest reading, throwing out all readings which are too far off (that's the way the manufacturers of low-cost thermometers do it.

The circuit uses a pair of 4009 inverter sections, biased into the linear region to amplify the temperature effects upon the diode probe. In this application, the adjustment potentiometer, R1, is set to give a mid-scale reading at room temperature on a typical multimeter set on the 6 volts DC scale. If a separate 0-1 DC milliampere meter is available, it could be calibrated directly in degrees F or C, with a suitable resistance in series with the amplifier output.



PARTS LIST FOR SOLID STATE THERMOMETER

C1—0.1-uF capacitor, 15 VDC
D1 through D6—1N4148 diode
IC1—4009A hex buffer
R1—100,000-ohm linear-taper potentiometer
R2, R3—Megohm resistor

CHOOSING A VIDEO TAPE RECORDER

Hundreds of VCRs are available. Here's how to pick the Right One

by Stephen Cody

If your family is one of the nearly half of all American households (over 40 per cent) which already have a video machine you may be one of those thinking about getting a second machine. And if you're still getting ready to choose one, this article can help you make up your mind.

You probably know that there is more than one basic type of machine available. In fact, there are now three competing systems for sale in most video shops. And there are over 100 different models of machines available for you to choose between these three systems. List prices range from under $300 to nearly $2000, with discounts available in all price ranges. With such a wide choice it's easy to feel bewildered.

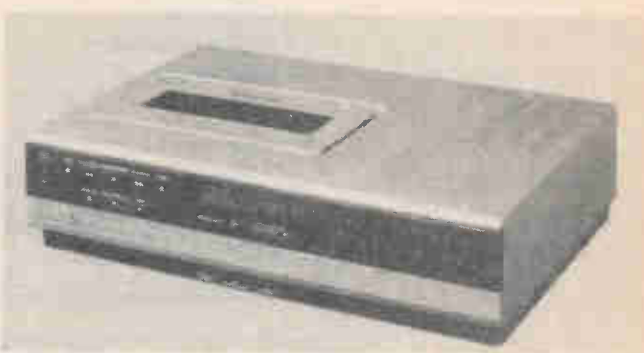
The big reason for the VCR's popularity is the control it gives over home entertainment. By using it as a time shifting device (record while you're away from home, or asleep, or watching something else) you are much more free to control your TV time. And of course if you want to record programs while you watch them, you can do so while you zap out (eliminate) the commercials. More and more families are renting tapes instead of going to the movies. Those tapes rent for as little as under $1.50 a night, although the most popular current hits sometimes cost as much as three or more dollars for overnight rental.

The basics we detail here will give you a good guide to cutting through the technical jungle to end up with a video cassette recorder that meets your needs and also fits into your budget. Here's what's involved in making your choice.

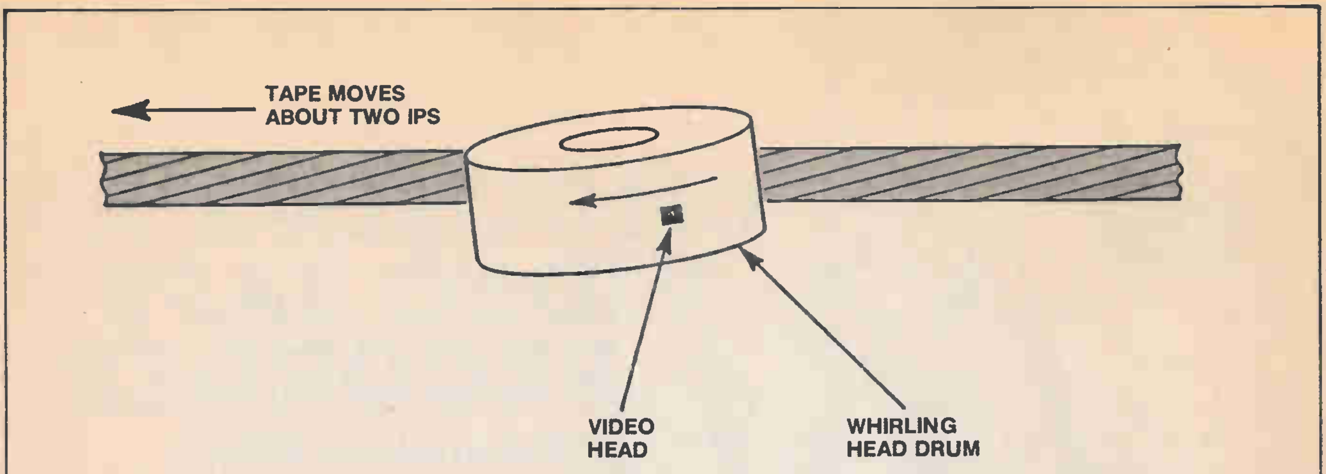
There is the Beta system, which was invented by Sony, who first perfected home video recording on tape in the early 60's, and the VHS system, a similar but slightly different system developed by JVC (Japan Victor Company). In the box near the end of this article you'll find the main features summarized as a checklist to help you when you go shopping.

Both of these systems use tape which is one-half inch wide. The tape they use is actually the same, but it is packed in slightly different cassettes in the Beta and the VHS systems, due to the slightly different way the two systems unwind the tape inside the machine(s).

In addition to Beta and VHS, which have been around for many years, there's a newer system, called 8 Millimeter (8 mm.) which uses (you guessed it) a different-sized tape. It's narrower than the 1/2-inch wide tape of the two older (Beta & VHS) systems, just the width of the 8-mm movie film which was the



This VCR is typical of good buys available on today's market. Because it uses the now-obsolete top-loading system, it is available at savings of $75 to $100 less than similar but newer front-loading machines. With that exception it's as good a value as any today.



Video tape recordings are slanted tracks on the half-inch wide tape. They're made by a recording head across the tape. One slanted track carries the video information for one horizontal line on the picture screen.

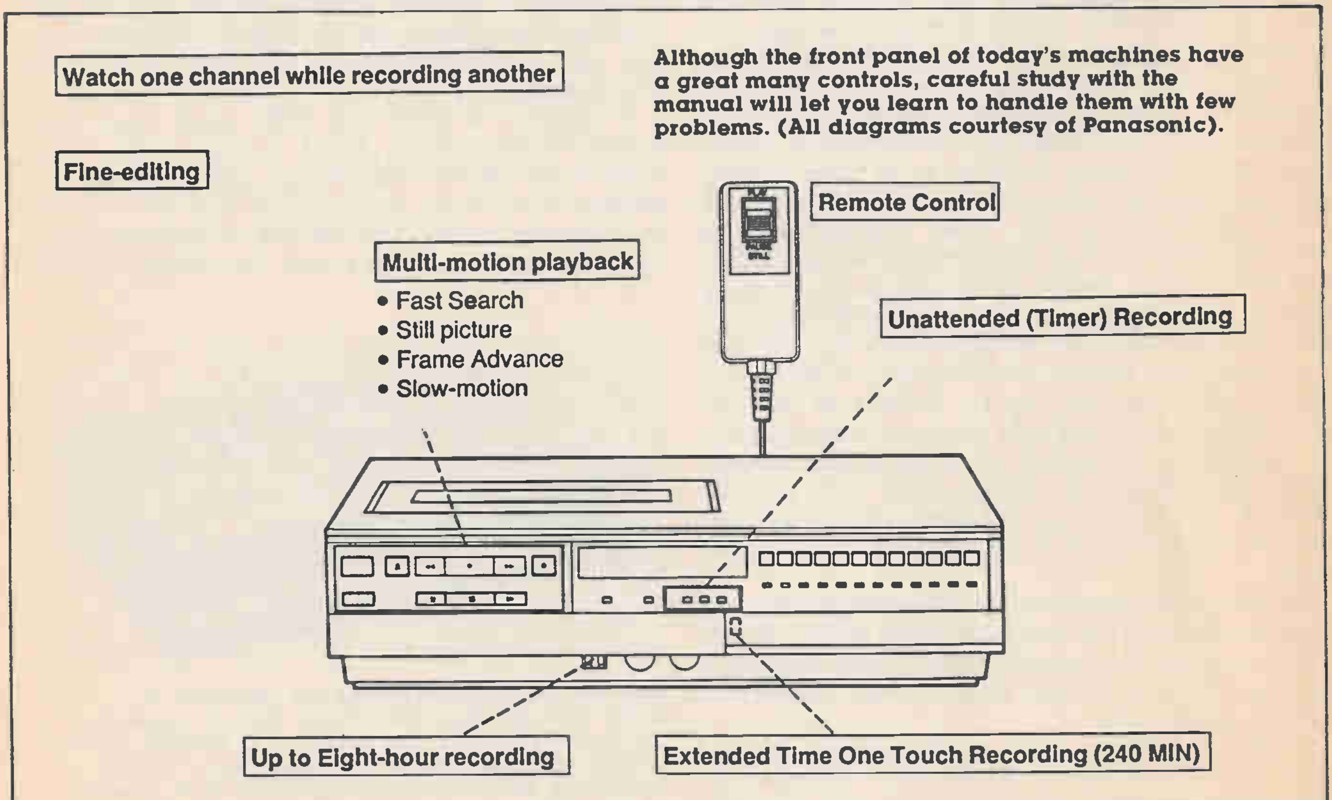
standard for home movies until video machines became popular and knocked home movies on film out. The cassettes for 8 mm. are only a little bit larger than the familiar audio cassettes we all have used for years. There haven't been any 8 mm. movie cameras manufactured for several years now. You can only buy such cameras on the used market now that VCRs have displaced them.

Talk To The Man

The first thing you should do when you go shopping is to make it very clear to the sales clerk in your video store what you plan to do with your VCR. Having studied this article and as much manufacturer's literature as possible beforehand, you should have a good idea what features you want, and also what features are unnecessary for what you want to do with your machine. That way you only get what you really need, not paying for features you can easily do without, that the store wants to sell you.

In addition, bear in mind that most (not all) stores will discount the list prices of most VCR; up to 20 per cent; more on models two or so years old, and those with the fewest features. Your first decision then, has to do with which of the three formats, Beta, VHS, or the newer 8 mm., is the one for you.

Although the front panel of today's machines have a great many controls, careful study with the manual will let you learn to handle them with few problems. (All diagrams courtesy of Panasonic).



Remember, the three systems are incompatible. Tapes made on any of the three cannot be played back on any but its own equipment even though the tape used in Beta and VHS is the same. The cassettes they come in are different.

Beta, The Better Picture

Although Beta and VHS are very close, the Beta system is capable of slightly better video resolution (sharpness). They are so close in quality that only direct comparison of the two machines, both perfectly adjusted, and showing test patterns, will let you see the difference.

Although Sony (Beta) was there first, because of involved marketing practices and corporate rivalries, VHS took the lead away from Beta after a couple of years, and today there are more than three times as many VHS machines being sold as there are Beta machines. There are many more companies selling VHS, and far more models available.

As a matter of fact, most stores that rent and sell prerecorded video tapes carry only VHS today. Using Beta is no problem if you record most of your own tapes, for there's no difficulty getting blank tapes for Beta. At this time there are a few prerecorded tapes you can buy or rent on 8 mm., and there will undoubtedly be more in two or three years when there begin to be enough 8 mm. machines around.

the main advantages of 8 mm. are that the camera (and playback machine) is even smaller and lighter, thus more portable that the two earlier 1/2-inch tape systems. This is a great advantage if you're going to do lots of "home movie" video taping, especially outdoors or elsewhere away from house electric power. In addition to the much smaller cassettes that the 8 mm. system uses (they're not much larger than an audio cassette), that system can supply very high quality sound.

Several companies, including Sony, Canon, Kodak, and Pioneer, have brought out 8 mm. equipment, and others are sure to follow.

Important Questions

If this is your first VCR, you should answer a few basic questions before you go shopping. Most important is the matter of How Will You Use It? The two main uses, as noted above, are (1) Time Shifting, and (2) Playing Prerecorded Tapes.

The more expensive the machine, the more different programs it can record, and the more days it can record over.

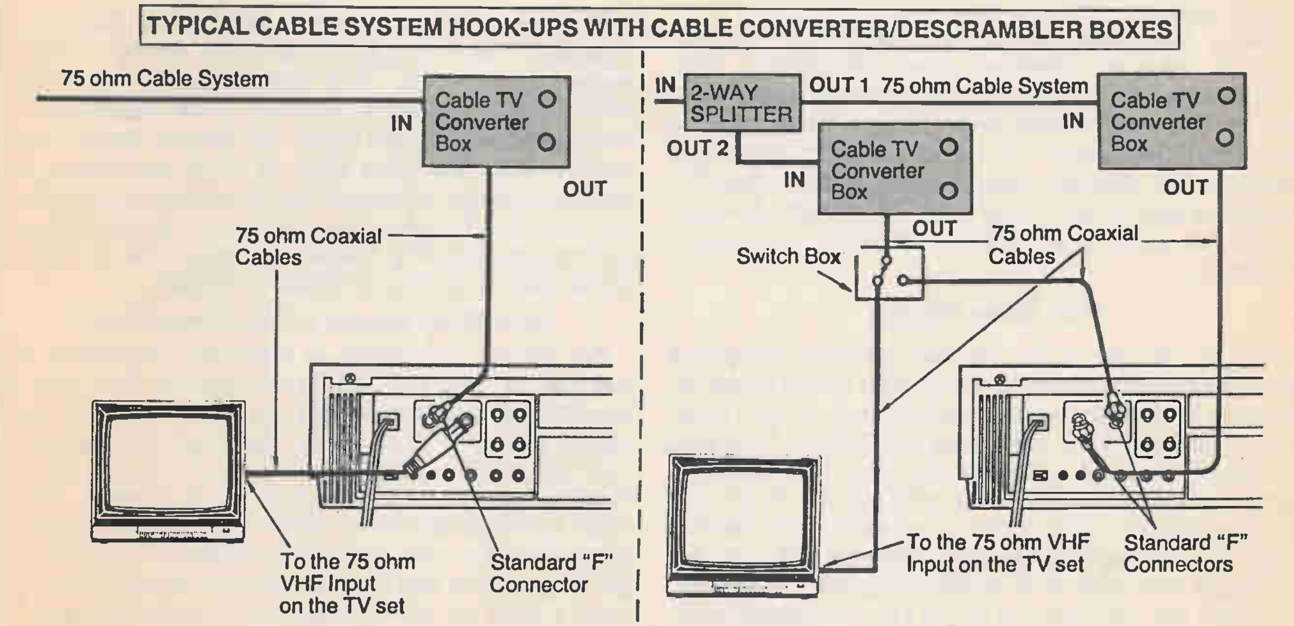
In addition, the tuner in the VCR (all have TV tuners built in) must be able to handle all the stations plus all the cable stations in your area.

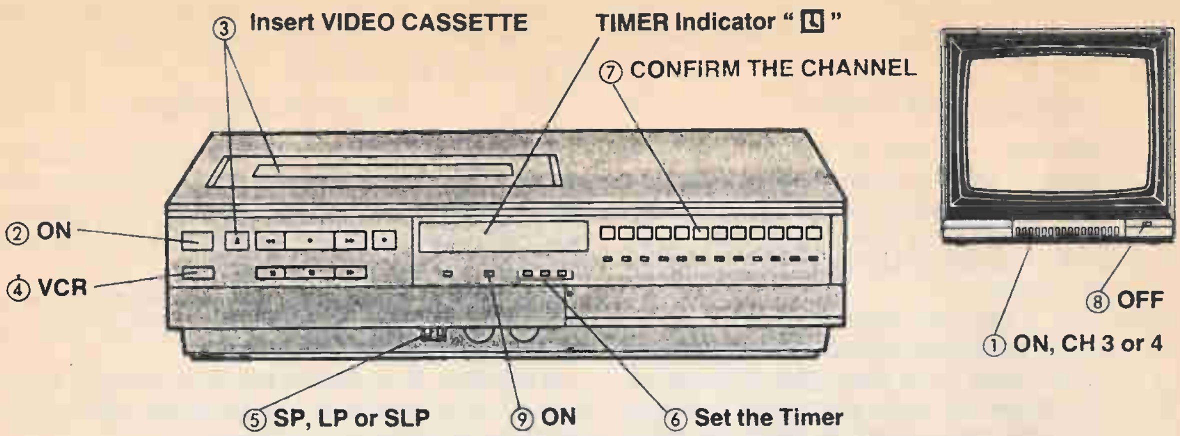
No Time Shifting?

Many people don't care at all about time shifting. They just use the machines to watch prerecorded movies, with occasional recording of programs off the air so they can keep them. It this is your situation you can skip most of what we tell you in the rest of this article and just get the simplest, least expensive basic VCR with a minimum number of features. It'll play back the prerecorded movies you rent just about as well as the most expensive machines which are loaded with all kinds of extra features. Unless you're a sports fan. For people who like to watch sports a lot, certain extra features are very useful, as we detail below.

In fact, there are even basic Playback Only video tape machines which do just that, and they cost only about $150, though you'll not find them widely sold.

First glance at these diagrams for connecting cable converter (or descrambler) boxes may seem complicated. However, the very careful instructions given in today's manuals make it easy, if you just take your time.





Setting up a recorder to make unattended recordings (time shifting) is pretty logical. Of the Nine (count'em, 9) steps listed above, only the sixth one above; Setting the Timer, should make you go to the manual. The best (highest-priced) sets today actually project instructions for doing this right on your TV screen.

For playing video with music you'll get more enjoyment with higher-priced machines that have high-fidelity sound features.

More and more people are making their own home videos, using a Camcorder which is, as you'd imagine, a combination camera and recorder. These cost around a thousand dollars, though some with fewer features, and with the discounts fairly widely found, may be considerably less expensive.

If you're planning to shoot your own movies, in addition to the camcorder you should plan to get a home VCR which has more, rather than fewer features. That's because the more elaborate machines have features useful in editing and dubbing sound onto your movies later.

Basic machines are called Table-top models, because they are intended purely for indoor, non-portable use. They can be used to play back tapes you rent or buy which have been prerecorded, just the way you play back LP or 45 records and tape cassettes. Or you can make your own tapes from TV programs and/or with your own TV camera, either at home or with a portable recorder, outdoors, anywhere.

How Many Heads?

As you can see in the diagram showing simplified tape recording drums, the recording is laid down on the tape in slanted, parallel tracks, next to each other along the tape. This is done by moving the tape past the head drum at between one and two inches a second and at the same time whirling the drum very fast (several hundred times a second). The slanting angle on the tape is accomplished by drawing the tape past the head in a slanted direction. The head drum has two (sometimes more) tiny recording heads in it.

Recording on Tape

Looking at the diagrams of video tape you'll notice the recorded video tracks are very close together, and slanted away from horizontal. Each slanted line represents one recorded track equal to one horizontal line on the TV screen.

Retail store salespeople make a big deal of the number of heads a machine has. In some cases more heads let you get better sound (VHS models). In other cases slow motion is provided by additional tape heads in the drum. But more heads by themselves don't give you a better picture.

Better Pictures?

Today's video machines (the more expensive models) can include a feature called "picture enhancement". On VHS machines the label says "HQ" (high quality?) and on Beta machines it's "Super-Beta". These really do deliver better video quality than standard Beta or VHS machines, and have only been on the market for a short time. In fact, the best machines today deliver very good pictures, but some economy models (without HQ or Super-Beta) deliver barely acceptable images.

How Many Events & How Many Days?

For people interested in time shift recording, the number of different programs (events) that can be recorded one after another while you're away from home, and over how many days, can be important. The simplest machines today can record one, two or three programs in a row, over up to a week. Much more common are those which can handle up to four programs in a row, over a two weeks. And some can go up to once a day for a whole year! But they run out after a total of eight hours on a single cassette, of course.

However, the number of events and days a machine can handle is only part of the story. Setting up a VCR to record while you're out of town can be quite a job. If the machine projects programming instructions on the TV screen, it can make the task of setting your VCR up to time shift fairly easy. Or it can be, without enough easy instructions, a nightmare.

If you're planning to do time shifting, check out the machine carefully to set it up for this work, and see if it has easy-to -understand instructions shown (on the TV screen itself is best) to help you.

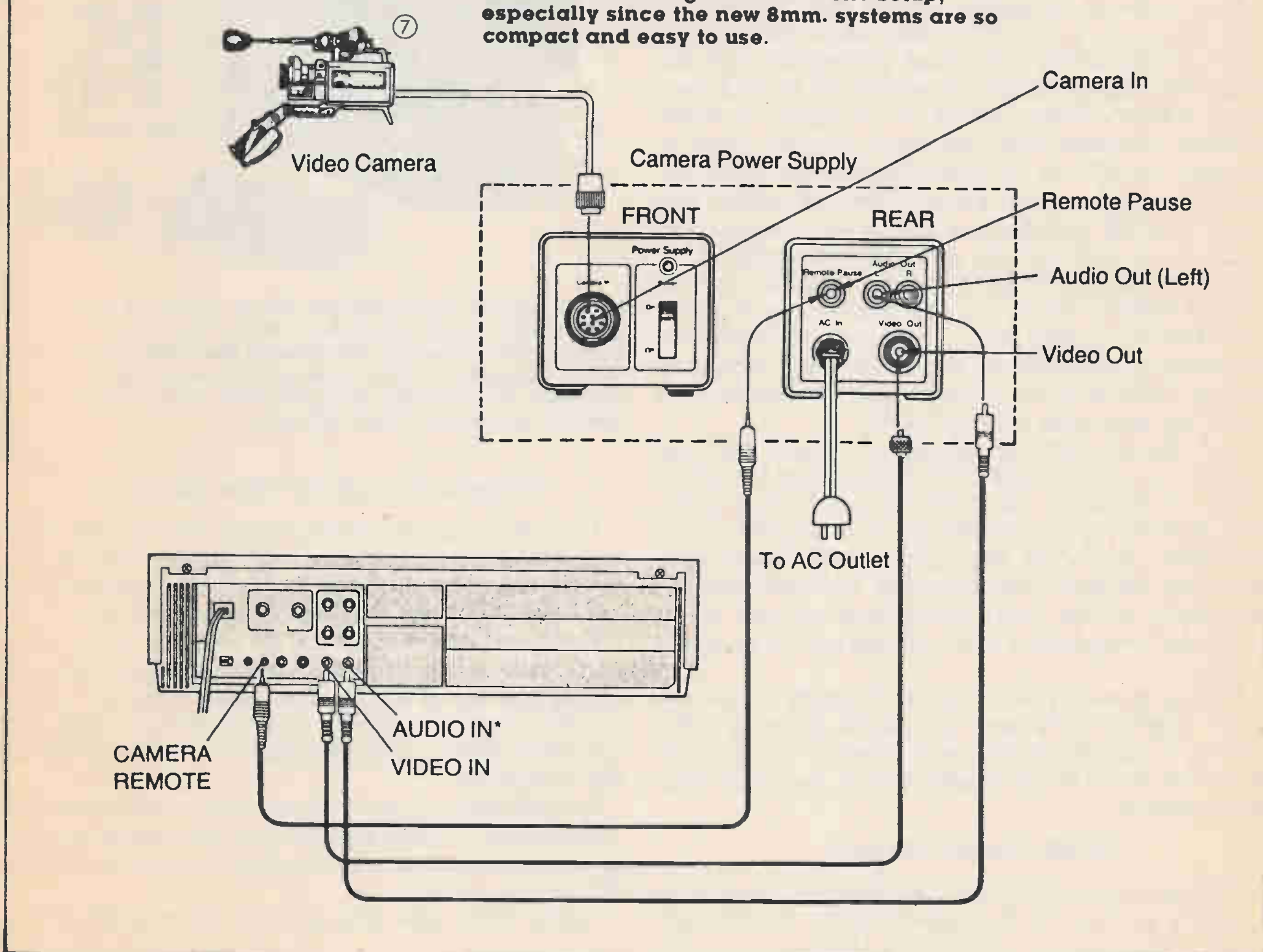
At the very least there must be clear instructions in the manual, and also on the drop-down panel on the machine. Best, of course, are the on-screen "menus" which walk you through the programming task.

All but the least-expensive sets have features like Freeze-Frame, Slow-Speed Forward (and often Slow-Speed Reverse) and Step-by-Step advance. These are all nice features, but most people can live without most of them provided they do have High-Speed Forward (and High-Speed Reverse). Additional features (found only on the more-expensive units) include the ability to see what's happening during High-Speed Forward (and Reverse). In addition to Freeze-Frame, the better models even have Delayed-Action, Stop Frame, and Frame-by-Frame Advance and Reverse, which sport fans find very useful.

The less-expensive video cameras don't let you see what's being taped directly. You look through a viewfinder similar to what you get on a 35-mm. still camera. More expensive video cameras let you see what you're taping on an electronic viewfinder, which is really a tiny TV screen, mounted right on the video camera. This is usually black-and-white, but the most expensive ones have a color viewer. With these electronic viewers (tiny TV sets) you can play back the tape in its entirety in the field if you wish.

Table-top models are less expensive than portables, though they can have even more special features than basic portables. In addition to the added cost for portables, there's the cost of the camera to consider. Tapes made on a portable with its own camera can of course be played back on a table-top unit later at home. You just have to have the same system at home as as outdoors, Beta or VHS (or 8mm).

Here are the connections for hooking up a TV camera to your VCR to make home movies if you use your table-top VCR, instead of an all-in-one Camcorder. Just looking at this diagram will send timid souls out to get an all-in-one setup, especially since the new 8mm. systems are so compact and easy to use.



Digital or Standard?

If you have plenty of money, or if you want the very best possible picture, you should also consider whether the newest improvement in video processing, Digital (yes, here comes that magical word again !) if digital circuitry is for you. Digital adds another couple of hundred dollars to the list price of a VCR providing better pictures in Stop-action, Freeze-Frame, and Slow-Motion viewing modes. This is a very valuable for watching sports or dance action, as compared with those viewing modes on non-digital machines.

You should also consider if the VCR is "cable-ready." Most new models are, but be sure to check if you plan to use it with cable reception.

Hi-Fi Versus Regular Sound?

One more decision will require more money, another $150 or more can be spent for a "Hi-Fi" VCR—one with the ability to record and play back the stereo sound which is becoming available on TV (about 300 stations now broadcast part of the time in stereo sound). And newer video tapes and cable systems also feature stereo sound. Of course stereo sound requires that you hook up your video system to a high-quality stereo audio system.

Incidentally, some VCRs can record and play back two separate sound tracks—stereo—in low-fi sound.

Hooking It All Together

Accomplished videophiles will be able to figure out how to hook up a new VCR to the rest of their viewing and listening systems. But most people will need the instruction manual which comes with all VCRs today. Many different hookup diagrams are shown in these manuals because there are many possible ways to connect the VCR to the television set, the cable, the antenna, and the audio (stereo) listening system. I've run into some complicated setups, and the manual can often be a great help with VCR connections.

Be sure you understand what's needed to connect up your system before you pay your money and take your gear out of the store. That's a good reason for shopping in your friendly local retail store instead of buying a VCR at a low price through the mail or from some big, low-price discount store.

And there's another important reason for not buying just on the basis of the lowest possible price. That's the warranty. All VCRs are guaranteed by the manufacturer for at least 90 days, including both parts and labor. But some also carry further guarantees which say "90 days parts and labor, one year parts" or something similar. Such guarantees are just about worthless, because the labor charge can be so easily padded.

Finally, be sure you understand exactly where the repair agency is in case you need it. Across the country a couple of thousand miles is not a repair place that you'll enjoy dealing with if your VCR ever needs service.

Which Brands Are Best?

VCRs are not particularly trouble-prone, especially in light of the fact that they are extremely complicated electro-mechanical machines, and do a very complicated set of mechanical tasks. In fact it's estimated that less than 10 peer cent of all VCRs in use today have ever needed any kind of repair, including head cleaning. Repairs are not cheap, however, with most repairs averaging out to almost a hundred dollars a shot. That may seem like a lot for a machine you only paid two or three hundred dollars for.

A recent study by a vary reliable study group found that the VCRs which had the best repair record (fewest number of problems, on the average) were (surprisingly, to us) those made by Matsushita, and marketed under the brand names of General Electric, Magnavox, Panasonic, and Quasar. Incredibly, the brand with the worst frequency of repairs record was (hold your hat) Sony. That's right, Sony, who make the best TV sets, and just about anything else electronic you want to name.

However, remember we're talking here about machines which as a group have good records. There is no reason to fear one brand any more than any other so far as likelihood of needing repair (apart from head cleaning) is concerned. They're all pretty good, thanks to the marvelous job the Japanese electronics manufacturers' industry group has done of self-policing and quality control.

Miniature VHS camcorder by JVC is typical of new generation of video recorders. Shown next to a playing card, this JVC Videomovie uses the small VHS-C tape which plays back on standard VHS machine at home; with adapter ($70). Camcorders are still expensive ($900 and up).

Features To Look For When Shopping

In order to check this you might want to take your own Video tape (one you're very familiar with) into the store and have it played on a good video monitor (not a TV set, which can't do nearly as good a job).

Look at the sharpness of vertical lines, and particularly at the amount of graininess (background noise) or snow in the picture. Color rendition isn't a problem from one VCR to another, because that can usually be easily corrected with the controls on the TV set or monitor.

In VHS sets look for the label "HQ", or with Beta, for "Super Beta", These sets can give you higher-quality pictures, at a substantial increase in price of course. Sharpness control

Some VCRs have this control, others don't. It can

(Continued on page 96)

BUYING ELECTRONIC PARTS

By Walter Sikonowiz

With some advance planning and the knowledge of where to start looking, the hobbyist can save a lot of time and a lot of aggravation, not to mention, some cold cash, by following these simple guidelines in pursuit of those hard-to-find electronic parts that are essential to the completion of that challenging electronic project....just waiting to be built.

Ask a group of electronics enthusiasts what the single most difficult part of project building is, and more often than not the reply will be, "Buying the #$%&* parts." Such an attitude is not unwarranted because, try as you may, you will never find one distributor capable of supplying all the parts you need. Even so, there is no reason for the incredible amount of difficulty experienced by some people.

If you're planning to build a particular group of projects at once or in a series, then it may be of help to plan in advance, and only have to make one or two parts orders by mail, or the same number of trips to the local parts stores. Buying in larger groups can also cut costs, because some houses give discounts for purchases of the same part in excess of five pieces. Your savings can really add up if you exercise some prudence in shopping.

The Big Four

You start by collecting catalogs; the more the better. Ten will get you by, but twenty is not too large a figure. Begin with the Big 4: Mouser Electronics (2401 Hwy. 287 N., Mansfield, TX, 76063), McGee Radio (1901 McGee St., Kansas City, MO, 64108), Dick Smith Electronics (P.O. Box 8021, Redwood City, CA, 94063), and Radio Shack (just about everywhere). These are the general practitioners of electronics; they dispense a little of everything.

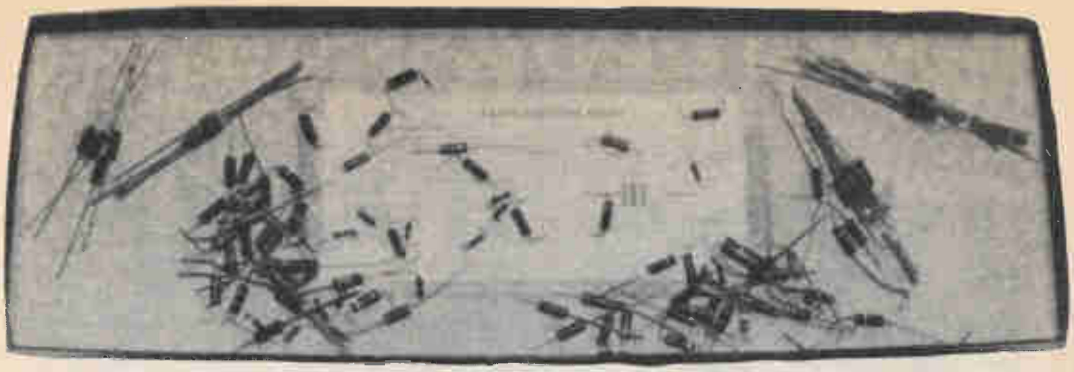
The Specialists

Once Ohm's Syndrome takes hold, however, and your sales resistance rises in the face of inflation (and limited selection), it's time to see a specialist. This might be any one of several firms selling certain products, such as integrated circuits, and little else. Because of specialization, these companies can afford to have very complete inventories of selected merchandise. Futhermore, although you might expect a specialist to slap you with a fat fee, in most cases just the opposite will happen; you'll save money.

Who are these specialists? They are the mail-order businesses that advertise in the back pages of electronics magazines. Some of these companies restrict themselves to new merchandise, which they sell at very agreeable rates because of low overhead. Others sell only surplus, that is, unused components obtained from manufacturers willing to sacrifice some inventory for ready cash. A component's appearance on the surplus market can be caused by a multitude of economic factors which are unfortunate for the manufacturer, but a windfall for you, the buyer.

New or Surplus?

How can you tell whether merchandise is brand new or unused surplus? In many instances, the



Since a great many people have trouble remembering the color code, a useful aid to sorting surplus resistors is an old tie box with the color code marked inside the lid.

catalog will tell you. If not, there is one sure indication: If the merchandise is being sold for a fraction of the retail price you would expect to pay, it's surplus. Two firms that deal exclusively in surplus are Delta Electronics (7 Oakland St., Amesbury, Massachusetts, 01913) and John Meshna Inc. (PO Box 62, E. Lynn, Massachusetts, 01904). Others, like Poly Paks (PO Box 942, South Lynnfield, Mass., 01940), or Herbach & Rademan (401 E. Erie Ave., Philadelphia, Penn., 19134), offer a mixture of surplus and brand new stock. Regardless of whether the merchandise is new or surplus, all firms offer some guarantee of satisfaction.

In order to get better acquainted with the various suppliers, let's survey the market item-by-item. In the following paragraphs, whenever a specific company is mentioned in connection with a component, it is only because that firm is particularly strong in a certain area. Some degree of overlapping does exist among all firms, however, so don't assume that any one supplier is being recommended to the exclusion of all others.

Integrated Circuits

Although human life is based on the chemistry of carbon, it is the chemistry of silicon that now forms the basis for our business and industry, thanks to the integrated circuit. Because of their tremendous importance, integrated circuits are sold by almost every electronics supplier, big or small. You'll find that the Big 4 have quite respectable IC inventories, but their selections are certainly not complete. Jameco Electronics, 1355 Shoreway Road, Belmont, CA 94002 and Ancroma Corp. (PO Box 2208, Culver City, Calif.,90230) feature perhaps the widest selections of ICs; linear, TTL, CMOS, DTL, ECL, LSI and so forth.

Digi-Key (PO Box 677, Thief River Falls, Minn., 56701) also features a wide assortment, including some circuits difficult to find elsewhere. Last, but not least, there is Solid State Sales (PO Box 74A, Somerville, Mass., 02143). Although this company's selection may be a trifle smaller than some, its service is like the fabled "greased lightning."

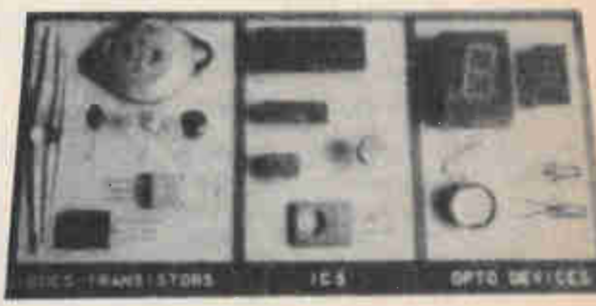
Occasionally you are going to receive a dud. When this happens, it's best not to go berserk. A calm request for a replacement is usually accommodated very quickly. After all, these companies want your continued business in the future. As a precautionary measure, you might consider ordering two of each IC. The chances of getting one dud are so small that the probability of receiving two duds simultaneously is infinitesimal. You can use the extra IC, if it is good, in a future project.

Occasionally, the inevitable happens, and you will find yourself with an inoperative circuit. If you have any reason to suspect the IC as the culprit, either from poor handling technique, or from having eliminated any other possible causes, a spare IC will cure many late-night headaches caused by projects that have no good reason *not* to work. Try the new IC before you burn the schematic!

Discrete Semiconductors

This category is an exceptionally broad one. Included are: bipolar transistor, FETs, SCRs, diodes, UJTs and so on. As in the case of ICs, almost everyone sells some discrete semiconductors, but few vendors stock each part number. Before giving up an elusive part, try either Hanifin Electronics Corp. (P.O. Box 188, Bridgeport, PA 19405), or the Ancrona Corp. These two firms have perhaps the most extensive listings of discretes.

Most suppliers offer special discounts to encourage volume buying of parts. This appeals directly to the squirrelish instincts of the electronics hobbyist, but be careful. Just like that greedy little tree-dweller, you will probably horde more than you can ever use. If you must stockpile parts, do it sensibly. Choose those



Try to build up a supply of transistors, diodes, ICs and electro-optical devices.

discrete components that are most frequently used: 2N3906 PNPs, 2N3904 NPNs, 1N914 switching diodes, 1N4003 rectifiers and so forth. Avoid the high-wattage zener diodes now appearing in surplus. Today integrated circuits have supplanted zeners as regulators at all but the lowest power levels.

Resistors

Buying from one of the larger retailers, you can expect to pay around 10 cents a piece for carbon-composition resistors. Compare that with the typical 4-cent selling price from the specialist firms, and the choice of a supplier is obvious. Resistors are one class of component that can be sensibly stockpiled. Buy half-watters with a 5% tolerance. They cost only a bit more than 10% resistors and save you the trouble of stocking two tolerances.

Most construction projects are designed to utilize resistors with a tolerance of 10%, unless specified otherwise in the parts list.

Power resistors, with ratings from 5 to 100 watts, are available from the surplus dealers at incredible prices. Buy a small assortment. Power supplies and audio amps often need dummy loads during checkout, and for such purposes these high-power resistors are ideal. If you do not have exactly the right resistance at hand, use serial and parallel combinations whose net resistance is the desired value.

Don't forget those high-class resistors, the metal-film precision units with tolerances of 1% or better. You can get these from the larger retailers, but at 60 cents to one dollar a piece (often with a ten-piece minimum order) who needs them? Actually, for certain ultra-stable or low-noise circuits, precision resistors are mandatory. Active filters, accurate voltage dividers, and analog-computer circuits are but a few examples. When you really need precision resistors, Hanifin Electronics can supply them at about 15 cents each. But because Hanifin is an industrial supplier, do not send in a 75¢ order; fifteen dollars worth is a realistic minimum. Since Hanifin offers lots of goodies besides resistors, you should have no trouble putting together a good-sized order.

Capacitors

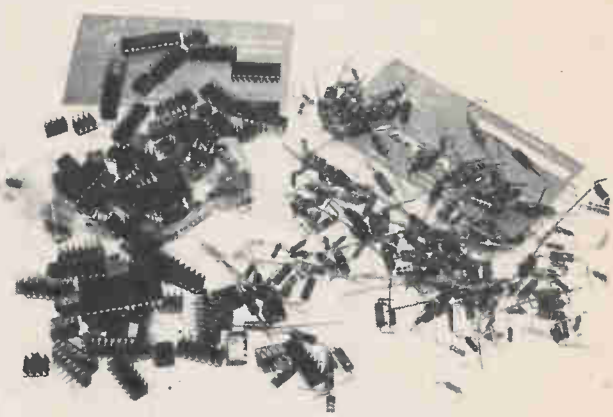
The best all-around capacitor that money can buy is the polystyrene type. It also happens to be one of the cheapest, a fortunate coincidence. Polystyrenes are available in the range from 5 pF to 0.5-uF, but above .01-uF, they begin to get bulky and expensive. Your best and most complete sources for these capacitors are Mouser Electronics and Digi-Key. Standard tolerances are 5% (super for a capacitor), with 2.5% and 1% available at higher prices.

In the range from 0.01-uF to 1-uF, you are best off with mylar (polyester) capacitors. (Mylars are available outside this range, too.) Standard tolerances are 20% and 10%. A great many firms carry mylar capacitors.

Above 1-uF, most capacitors are aluminum electrolytics, which are polarized devices. One of their most important functions is filtering, particularly in AC power supplies. Tolerances tend to be relatively loose since applications rarely call for very precise electrolytic capacitors. Capacitances as high as 40,000-uF and beyond are available.

The aluminum electrolytic has a more sophisticated cousin, the tantalum capacitor, which is commonly available in capacitances as high as several hundred microfarads. Relative to the aluminum electrolytic, the tantalum features tighter tolerances (10% typically), lower leakage, and smaller size for equivalent capacitance. As a result, tantalums are preferred over aluminum electrolytic in timing applications. Both electrolytic types are stocked by many distributors.

Surplus capacitors are available, with perhaps the best source being Poly Paks (see above), at least in terms of variety. If you do buy surplus capacitors, play it safe and check each one on a capacitance meter. Ceramic bypass capacitors for digital logic are available very cheaply as surplus, and so too are mylars. On the other hand, be very cautious when buying surplus aluminum electrolytic capacitors. They have a limited shelf life, and once they dry out, they are useless. Most dealers are scrupulous enough not to do this to you, but you can end up with a relic of the 1950's that looks more like an artillery shell than a capacitor. Choose carefully.



You can buy bulk components at next-to-nothing prices if you buy untested, surplus parts. Poly Paks is a popular bulk supplier and two of their packs are shown here. Most of the parts are useable.

Potentiometers

New pots cost about the same no matter where you buy them. Imported units may sell for less, but cheap materials yield an inferior device, one that is often difficult to turn because of high-friction bearings. While imports are excellent for experimenting, it always pays in the long run to use top-quality pots in your projects.

Surplus pots can save you a lot of money, but read the fine print closely. Pay attention to shaft length. Some units are intended for screwdriver adjustment and have short, slotted shafts which cannot accept a knob. In addition, watch out for strange tapers, such as "reverse logarithmic." Pots specified as having either "linear" or "audio" tapers are the ones most usually called for in projects.

You will find that only linear and audio taper potentiometers are called for in the circuits described in this magazine.

ADDRESSES OF PARTS SUPPLIERS:

Ace Electronics,
5400 Mitchelldale Houston,
TX 77092

Active Electronics Sales Corp.
12 Merser Rd., Natick, MA 01701

Aldelco, 228 E. Babylon Tpk.
Merrick, N.Y. 11566

Ancrona Corp., P.O. Box 2208
Culver City, CA 90230

Bullet Electronics, P.O. Box 1944
Dallas. TX 75219

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

Diamondback Electronics Co.
P.O. Box 194, Spring Valley, IL
61362

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

Electronics Distributors, Inc.
4900 N. Elston
Chicago, IL 60630

Formula International, Inc.
12603 Crenshaw Blvd.
Hawthorne, CA 90250

Fuji-Svea, P.O. Box 3375
Torrance, CA 90510

Hanifin Electronics, P.O. Box 188
Bridgeport, PA 19405

H & R Corp.
401 East Erie Ave.
Philadelphia PA, 19134

HobbyWorld, 19355 Business
Center Dr., Northridge , CA 19324

Integrated Electronics
540 Weddell Dr., Sunnyvale, CA
94086

International Electronics Unlimited
Village Square, P.O. Box 449
Carmel Valley, CA 93924

Jameco Electronics
1355 Shore Way Road
Belmont, CA 94002

John Meshna, Inc., P.O. Box 62
East Lynn, MA 01904

Mouser Electronics
2401 Highway 287 North
Mansfield, TX 76063

New Tone Electronics, P.O. Box
1738
Bloomfield, NJ 07003

Olson Electronics, 260 S. Forge St.
Akron, OH 44327

Optoelectronics
5821 N.E. 14th Avenue
Fort Laudeerdale, FL 33334

Poly Paks, P.O. Box 942
South Lynnfield, MA 01904

Radio Hut, P.O. Box 401247
Dallas, TX 75238

Radio Shack Consult your local
phone book.

Signal Transformer Co.,
500 Bayview Ave.
Inwood, NY 11696

Solid State Sales, P.O. Box 74A
Somerville, MA 02143

Steven Products, P.O. Box 698
Melville, NY 11746

Surplus Electronics Corp.
7294 N.W. 54th St., Miami, FL 33166

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

Delta Surplus Electronics
7 Oakland St.
Amesbury, MA 01913

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

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

JDR Microdevices
1224 S. Bascom Ave.
San Jose, CA 95128

Dick Smith Electronics
P.O. Box 8021
Redwood City, CA 94063

Electronic Parts Outlet
2515 N. Scottsdale Rd.
Scottsdale, AZ 85257

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

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

Priority One Electronics
21622 Plummer St.
Chatsworth, CA 91311

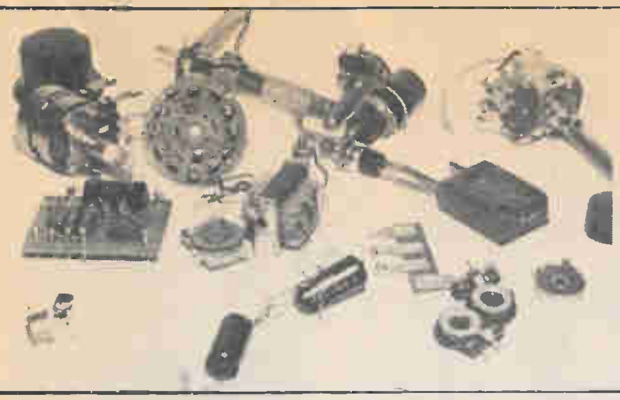
The following firms sell electromechanical components; stepper motors, DC permanent-magnet motors, gears, clutches, robot grippers, tactile sensors, infrared transducers, sonar transducers, etc., of interest to robotics experimenters:

Alpha Robotics Inc.
P.O. Box 21019
St. Paul, MN 55121

Stock Drive Products
2101-B Jericho Turnpike
New Hyde Park, NY 11040

Intrep Inc.
735 Fourth St./Box 5381
Napa, CA 94581

AMSI Corp.
P.O. Box 651
Smithtown, NY 17787



The best way to build up your parts inventory is to salvage useable components from junked pieces of electronics gear. Transformers, switches, potentiometers, crystals and coils are always handy to have.

For some reason, wirewound pots seem to abound in surplus. These are fine for low-frequency work, often at high power. But wirewounds have poor resolution and should never be used in a circuit where very precise adjustments must be made. For the bulk of your experimenting, standard carbon composition pots are your best choice.

Slide pots are a great convenience in audio work, especially if you are building a mixer or music synthesizer. Many outlets carry them, but most units have too short a path of travel (1¼ inches) to be really useful. Slide pots with twice the adjustment range are preferable, and they can be purchased at reasonable cost from Mouser Electronics.

Relays

These may well share the fate of the dodo, thanks to fast and reliable solid-state switchers like triacs, SCRs and transistors. Industrial control systems that once bristled with relays and cam-actuated microswitches now rely on digital logic and thyristors. Even Ma Bell, at one time the patron saint of relay manufactures, now uses electronic switching to route calls. The result of all this phasing-out is a surplus market chock full of relays at bargain prices.

Despite the decline in its commercial popularity, the relay still possesses some admirable qualities, such as excellent driver/load isolation and minimal temperature sensitivity. Furthermore, it happens to be one of the easiest devices for the beginner to understand and use. All things considered, it makes sense to take advantage of the surplus bargains now, while they last.

Power Transformers

Here is another item carried by almost every supplier, but inventories are generally limited in scope. When your application demands just the right transformer, it pays to be able to order directly from the manufacturer. Signal Transformer Co. (500 Bayview Ave., Inwood, N.Y., 11696) offers a wide array of transformers, from tiny, PC-mount devices to mammoth, kilowatt isolation transformers. Other makers also offer diverse selections, but some may not encourage direct mail ordering.

Undoubtedly the most economical way of securing a transformer is through a surplus dealer like Delta. Many kinds of transformers end up as surplus, and with just a little luck you can find one to suit your purposes. Discounts greater than 75% off list are common, so the money you save may be substantial. This is especially true if you are planning to construct something big such as a high-powered audio amplifier. Transformers from some of the best amps ever to shake a loudspeaker end up as surplus, victims of design changes and competition.

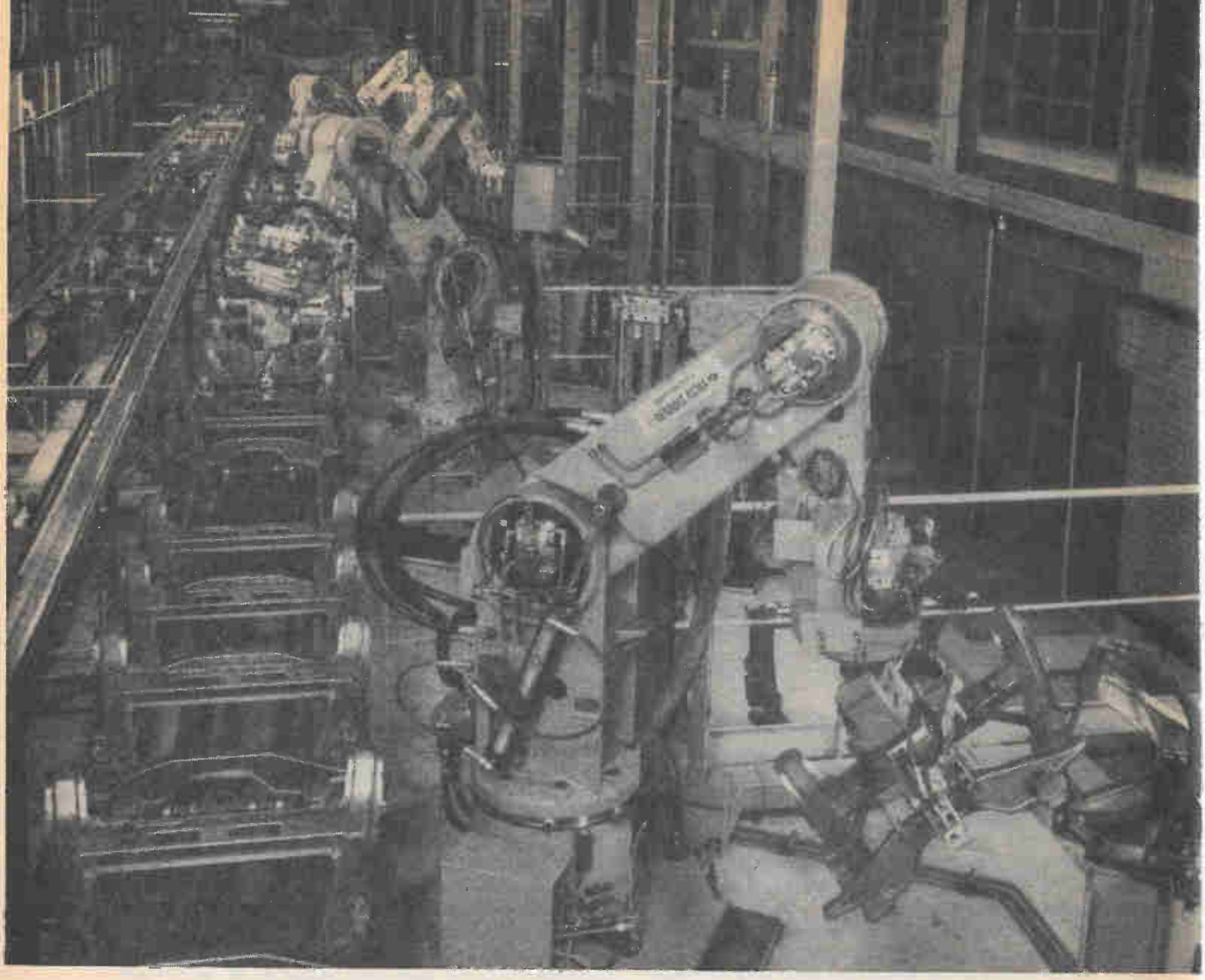
Printed Circuit Stuff.

There is no surplus material worth mentioning in this category, so let's focus on new merchandise. The simplest PC methods involve placement of a pattern directly on copper-clad board. These are fine in the beginning, but for serious experimenters, photographic techniques are a must. Not only do photographic methods yield neater copper traces and a greater density of components on your board, they also allow any number of boards to be produced from a single piece of artwork.

Photographic PC processing can best be learned from one of the kits offered by various manufacturers. You do not need expensive equipment like a camera or enlarger. All necessary materials and instructions come in the kit. These PC kits may employ either negative or positive photographic processes, which differ from one another principally in the method used to prepare a board's artwork. Positive methods are perhaps easier for a beginner to visualize, but negative kits seem to be equally popular. Most suppliers carry at least one brand of PC kit, if not more. Choose one that fits your needs and budget. You'll find the professional-looking results to be well worth the extra effort.

Although only the tip of the iceberg has been exposed here, you should have a pretty good idea of how to find supplies by now. To obtain copies of the catalogs you want, write directly to the companies mentioned in the text. Note that our coverage has been by no means exhaustive. Undoubtedly other worthwhile catalogs are available, so hunt carefully through the back pages, too. Remember, all companies stock much more merchandise than they can economically include in a single magazine advertisement.

Now that you have a pretty fair idea of how to purchase the parts you'll need for the projects you plan to build, sit down and compile a master parts list. As you do this, you'll probably start to see the same parts cropping up time and time again. To avoid unnecessary duplication only buy a part twice (or more) if the project it is being used for is one of a permanent nature. If you're going to tear it down, you can use its parts for another project at a later time.■



ALL ABOUT ROBOTS

What they are and how they work.

The fascination, awe, and sometimes even fear that surround the subject of robots probably center on the idea of creating artificial life. The potentially threatening and uncontrollable consequences of this possibility have been the theme of many books, plays, and horror movies, of which the first well-known example is the man-made horror of Dr. Frankenstein's monster.

Two notable exceptions to this grisly tradition are the fiction of Isaac Asimov, and the recent series of science-fiction movies, beginning with *Star Wars*. In that movie robots are shown as lovable friends and loyal companions. And in Asimov's stories, the robots are programed in accordance with the idealism of Asimov's three Laws of Robotics. These are:

(1) A robot may not injure a human being, nor, through inaction, allow a human being to be harmed.

(2) A robot must obey all orders given by humans, except when they conflict with the First Law.

(3) A robot must protect its own existence unless that conflicts with the First or Second Laws.

In the real world, of course, mankind is in little danger from rebellion by neurotic robots, and that's not likely to change for several centuries. That's because robots we can build won't be smart enough for a long, long time. The reality of modern computer science, as it applies to artificial intelligence and robots, is that machines have very primitive intellectual capacities, as well as very low-level motor (motion) capabilities. Despite recent advances in modern computers and artificial intelligence, the sensory perceptions, the decision making, and the intellectual capacities of robots remain far interior to humans, and will continue to remain so for the forseeable future.

What Is A Robot?

There seems to be some confusion as to the exact definition of robots, so let's clear that up here. This is important, since there are key differences between a true industrial robot (IR) and other mechanical human-like (or semi-human-looking) "robots." The word *robot* is described in the dictionary as coming from the Czech word *robotnik*, which means serf or slave, or from *robata*, which means compulsory service. A robot is thus defined as a machine in the form of a human being, which performs some mechanical motions of a human, but which lacks human thoughts, emotions, etc. It is also defined as an automatic device which performs things ordinarily done by humans, operating with what appears to be semi-human intelligence.

Man's fascination with machines that move under their own power and some kind of internal control is as old as recorded history. The Egyptians are said to have built water clocks and figures which moved their hands, arms or head, as early as 3000 B.C. The ancient Greeks, Ethiopians and Chinese built statues and figures that acted out sequences of human-like motions, powered by falling water. And in the late seventeen hundreds a team of Swiss craftsmen (precursors of Swiss watchmakers) built lifelike *automata* that could write, draw simple pictures, and play musical instruments.

Not Human-Like

Most people know that real, working (useful) robots are not human-like automatons—machines than can walk, talk, think, and do human tasks better than humans. Real robots are machines which do many specialized jobs better than humans can do them, without getting tired, and while making fewer mistakes.

Before the idea of robots was dreamed up, there were *automatons*, which were automatic, people-like (or animal-like) machines. Most were doll-like figures with clockworks which let them turn their heads, bend over (bowing), open and close their eyes and/or mouths. Some could even write words on paper, and Thomas Edison put tiny phonographs in dolls which could then recite, "Many had a little lamb." These were curiosities or toys, of course, and the word "automaton," meaning automatic machine, was apt for them.

But in 1920 the play *R.U.R.* (Rossum's Universal Robots) was produced in which the author had an inventor named Rossum (which means "reason" in Czech) create automatons to do much of the world's daily work. His *Robots* were intended to improve life for humanity by freeing man from drudgery, but they rebelled, killed the humans, and started a new race themselves. The word *robot* replaced *automaton*, and came to represent (in most people's minds) man-like machines.

For years the long-sought goal of machines which could serve as human-like workers has persisted, but until modern electronics especially the *transistor* (in the Fifties) and later the *integrated circuit* arrived, such machines were only fantasy.

With the development of micro-electronics in the Sixties and Seventies we can finally build robots to do much of man's most demanding, boring, and/or dangerous work on production lines in modern factories.

Man-Like Robots

The only robots which resemble humans, at least so far as having a "head", and often also two arms, are recreational robots or personal, toy, or demonstration robots. These are not practical for doing useful work, which is what *industrial robots* do. Industrial robots are hard at work day and night (they never have to sleep) in automobile factories in Japan and the US as well as other countries. There are over 300,000 IRs in factories of all kinds now, with thousands more being installed every month.

Japan leads the world in the number of IRs installed and at work with the US, West Germany, Sweden, France and Italy next.

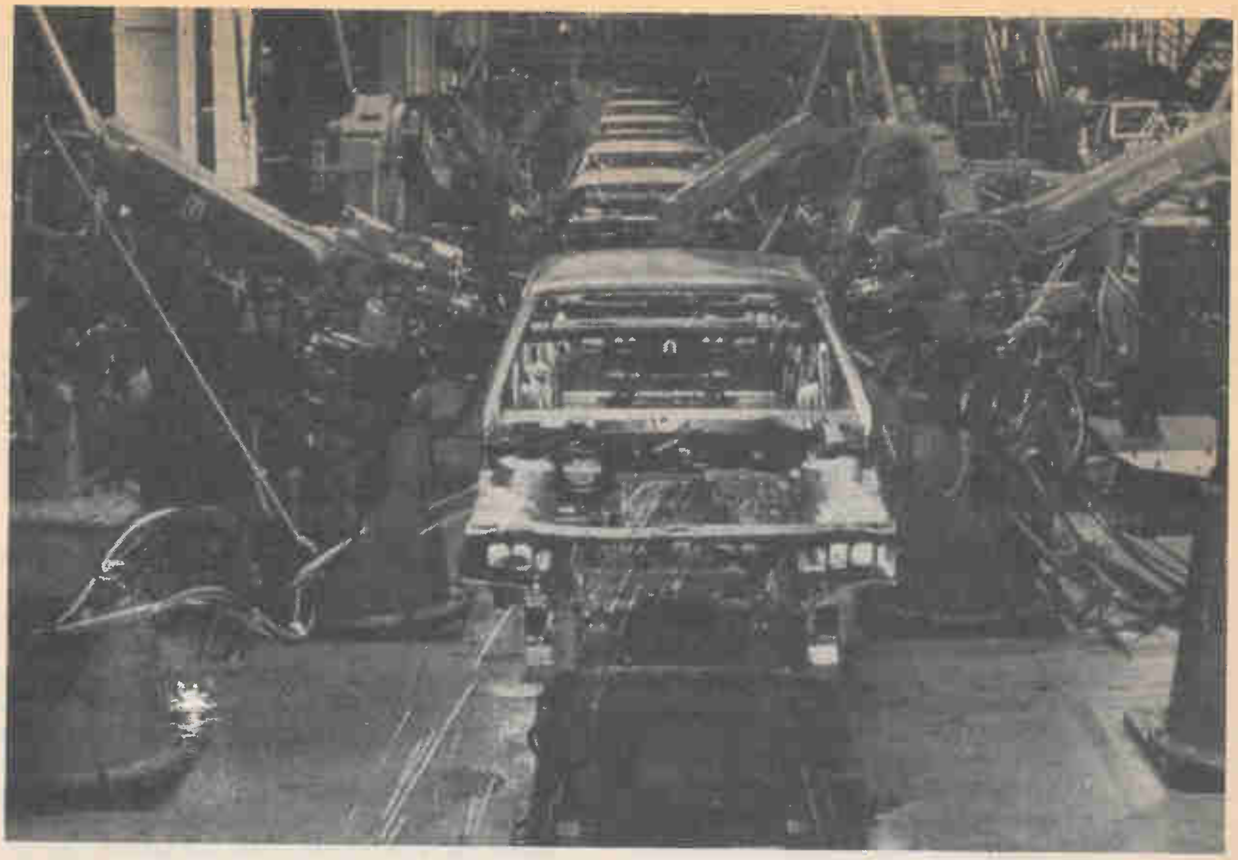
In addition to working (industrial) robots, there are also demonstration "robots," sophisticated toys or learning tools. They will be discussed in this article, but the important robots of the future (which are here today) are *programable* machines which can do jobs formerly done by humans, but now, or soon, are better done by machines.

In the last two years microcomputers and microprocessors, which are the heart of micros and robots, have begun to outnumber human beings. That's right, there are beginning to be *more of them* than there are of *us*! I'm not talking about intelligent electronic *beings*, of course, but about obedient electronic *servants*. Most of them are small *special-purpose* computers, such as are used in automobiles for controlling ignition, microwave ovens and other appliances for controlling their operation, and of course, microcomputers, (micros from here on) which are desktop or smaller *general-purpose* computers, for home, business and entertainment.

By the late Eighties it's estimated that over half of all workers will in some way be involved with computers and robots either using them or working on them or designing them or fixing them. Computers will control most of the machines doing mass production, and even most service-related work. Yet by the beginning of 1984, less than ten per cent of the children in the US had taken any computer-learning classes.

Keeping Ahead

People who are at home with computers and robots (especially how to design and/or fix them) will be in better shape to get ahead and stay ahead in the



Industrial robots work mostly on production lines assembling, welding, painting and finishing cars, refrigerators, and parts for them and other precision machinery

coming world.

In the years ahead people without some familiarity with computers, at least using the keyboard to put data in and get information out, will be in worse shape than an illiterate of the 1950s up to today. You will have to be at least slightly computer-literate in the years ahead, as jobs shift more and more to controlling the machines that do the real work.

It's estimated that there are now over a billion microcomputers world-wide, of which at least 14 million are home/business micros. As time goes on there will continue to be more and more small computers serving us in ever more ways and controlling (under our supervision) the work of production, and of our daily lives.

Industrial Robots

All IRs have *arms* which can be manipulated, and at the end of each arm is a *gripper* (elementary hand). Such robot arms may be pick-and-place machines, moving objects from one place to another. *Assembly* robots place one or more items into another, and *welding* robots and *painting* robots are widely used on assembly lines.

We call them robots if they do jobs humans used to do, or still doing. *Robotlike* means doing a job mechanically, as though a machine were doing it.

Most people know that robots are already used in producing cars in Japan, and here is the US the major car makers are rapidly converting much of their production to include robots in their assembly lines. Industrial robots are taking over much of the drilling, welding and painting, and soon will be doing much more complicated jobs they've been developed for in other manufacturing processes all around the world.

Not only cars and kitchen appliances, but transistor radios, digital watches, and nearly all processes which involve mass production of precision appliances are now being robotized, or will be soon.

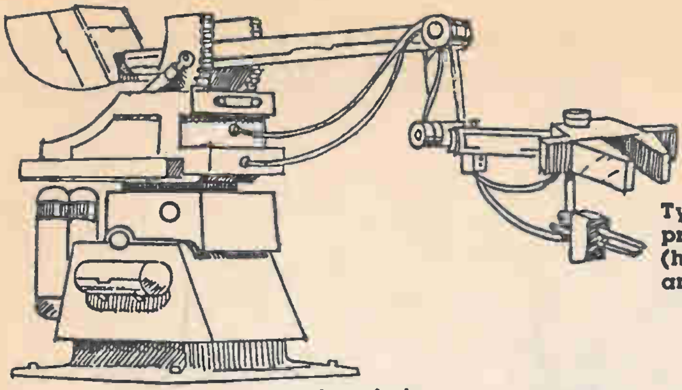
The Robot Brain

All robots have electronic brains. That is they are run by microprocessors, which are the controlling part of microcomputers. Generally, a robot will have a microcomputer for its brain, receiving input signals from its "eyes," its "ears,", and other sensing parts, such as its sonar (distance-measuring sense).

This microprocessor is similar to and, often exactly the same as the CPU (central processing unit) of a microcomputer, which we call simply a micro. Although such a robot "brain" can be extremely sophisticated, taking in continuously-changing information from its "senses" and directing its "feet," usually wheels if it's a mobile robot, or more often its arms (most have only one).

Its brain is still much less complicated than our own brains. It works only by digital switches, millions of On and Off switching, which is *digital counting.* The robot's brain takes in information, either from its senses, or from a preprogrammed tape or other memory. It then does things depending on what the input information tell it to do. These things are most often picking something up, moving it, painting it, welding it, drilling it, and/or replacing it somewhere else.

Small industrial robots are already used widely to sort small objects, to pick them up and place them



Typical industrial robot is fixed in place on a production line and only moves its arm, its gripper (hand) and its trunk. This robot has both a gripper and welding electrodes, below its gripper.

An industrial robot

into larger assemblies, and for dozens of other dull, simple, repeated tasks. Robots can be used for any job which is repeated enough to make it pay by replacing a human's work. Some robots are already doing jobs which are dangerous for humans, and they will continue to do more and more of them.

Intelligent Robots

If a robot is to do a job which depends on varying conditions, it must receive information from the outside world. This is called self-intelligence, and provides a robot of greater complexity.

Although robots can be made to move around, it will be a long time before moving robots will do very complicated tasks. Most moving robots are just for demonstration, or for learning about robots and computers. One such robot is the one sold by the Heath Company (both as a kit and factory-assembled).

Robot Carts

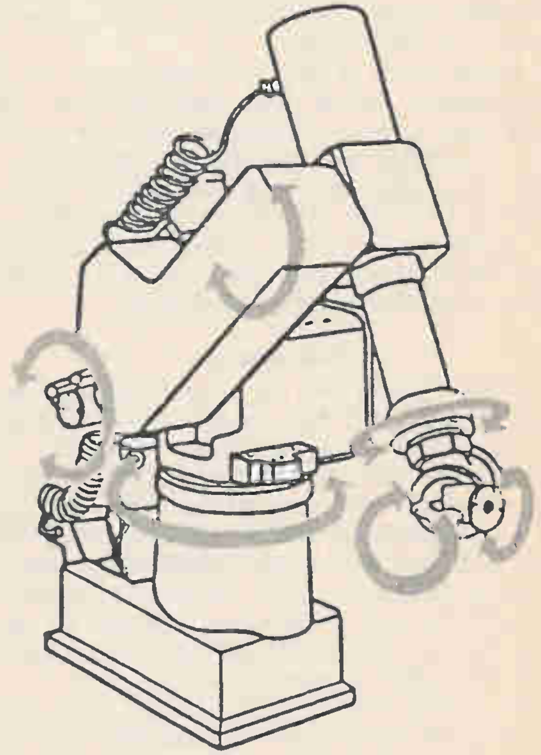
Some police bomb squads have a remote mobile manipulator which can safely examine and transport suspected bombs. Robotlike prison guards have been developed and may be in use in some institutions before long. They're even under discussion for use elsewhere.

Robot exploration machines have been built at enormous cost, and used on the moon and Mars. These are part robot (they can move about independently) and partly under the control of remote humans who observe the robot's surroundings via long-distance TV camera. Underwater robots have explored the ocean floor, including the wreck of the long-lost ocean liner, **The Titanic**, bringing back memorable pictures of its empty (for 72 years!) ballroom on the 2-mile deep ocean floor.

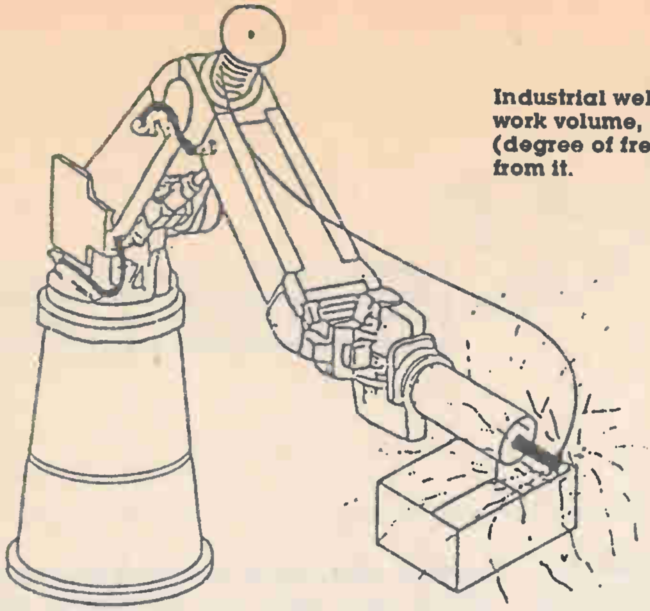
What Machines Are Robots?

Machines such as tethered submersibles, or bomb carts are obviously not real robots. They are extensions of human operators. Other near-robots include remote "manipulator" arms, prosthetic arms and legs, etc. None of these devices can operate on their own. They need direct human control and supervision. It has been suggested that, "A real working robot must be autonomous and independent; at least partly free of external control from a human operator. It must be a general-purpose device that, at different times, can do different jobs. To do these things requires that the robot be controlled by a programmable computer."

In addition a true robot must imitate one or more human senses, most obviously touch, vision, and hearing. It must be able to respond to external sights, sounds, or physical objects, as well as operating under internal (computer-directed) commands.



This heavy-duty industrial robot is a Cincinnati Milacron robot fixed in place on a heavy pedestal. Arrows show the possible motions of the pedestal, the upper arm, the forearm, the wrist, and a mounting plate for the end effectuator.



Industrial welding robot shown here has limited work volume, can only move in a few directions (degree of freedom) toward its work or up, away from it.

As a result of these requirements, a true working robot must interact with its surroundings by receiving information (seeing, hearing, and/or touching). And it must be able to act (react) in this environment. Simple examples are avoiding an object when moving, or picking something up and placing it some (specific) place else.

In other words, a real working robot must be under computer control, and it must have senses. This would appear to rule out robot arms, which are the most widely-used robot machines (in car and other factories), as true robots.

To recap, most of today's "robots" are not true, fully-functional robots. But they do work. Other "robots" (toy, hobby, educational, etc.) are not "real" robots. Robotics and computer intelligence are rapidly advancing, as integrated circuits (ICs) get smaller and smaller (thousands of transistors and other components on tiny chips). Microcomputers will get stronger and stronger, making it possible to do more complicated jobs with robots.

Real Robots

Industrial Robots can be programmed, using the microcomputer each has, to obey complex instructions, and alter their operation to adjust, when needed, to changing circumstances. They do jobs like lifting, moving, or turning things over. They paint, weld, polish, deburr, and otherwise finish rough metal pieces, and load and unload individual pieces to or from bins, pallets, or other containers. Nearly any repetitive work can be done over and over by robots, freeing human production workers form boredom, fatigue, and often dangerous work.

Most of the robots in existence now are an outgrowth of automation (automatic machines) which started in the Fifties, and became established widely in many factories in the Sixties. The programmable robot—as distinguished from a control system built into the machine itself, began to appear in the late Sixties.

Today there are more industrial robots in Japan than anywhere else. It's believed they have well above 70 thousand industrial robots at work now, with many more being added each month. The US is second, with perhaps half or more that number, steadily growing of course. Germany and Sweden are believed to have between10and 15 thousand robots each, on production lines, with other countries also adding them.

The Soviet Union of course has many robots in similar applications, but it's much harder to estimate their numbers, which are believed between those of Japan and the US. These numbers are purely for industrial, useful robots, and do not include toys or learning machines.

Hobby Robots

By far the best-known hobby (educational robots) are the two Heros (Hero 1 and Hero Jr.) available from giant kitbuilder Heath Company, of Benton Harbor, Michigan. In addition to being able to walk (roll, actually) talk, listen, and pick up objects, Hero can move about on flat surfaces. Hero can also be programmed to execute numerous motions, pick things up, and so on. Available as a kit, or assembled, Hero 1 is widely used in advanced science and other educational courses. In several versions, Hero costs from about 800 dollars up.

Many simpler kits are available for building turtle-like robots which can roll about, often being programmable to avoid objects. Robots which can walk, as opposed to just rolling, are too expensive to be anything but research robots.

Educational Robots

In addition to Heath Company's Hero 1 and Hero Jr., several firms are producing educational robots, among them Microbot, of Mountain View, California, Rhino Robots, in Champaign, Ill., and Mitsubishi Electric, in Japan. Microbot also makes and sells a small IR called Alpha. Unlike other teaching robots, Alpha can do truly useful work, handling light materials in factories.

Promotional Robots

We see "robots" at Disneyland, Epcot Center, trade shown, in Hollywood films (R2D2, and Hal, the computer in 2001). These are promotional or entertainment robots. Usually they can speak, and some can understand a few words or phrases, and move around on small wheels. Some can also do simple tasks like giving out flyers or cards, or pour a beverage. This is hardly useful work, which is what "real" robots do. Star Wars (1976) aroused great popular interest in robots, and "robots" which have appeared publicly include look-alikes of Marilyn Monroe, Muhammad Ali, and Robert Redford. These are few in number, but they have raised public expectations about robots to unrealistic heights.

Robot Brains

The robot brain is, you guessed it, a microcomputer. In fact, many educational robots can be operated using a home microcomputer such as the Commodore 64 or Atari 800, or an Apple or IBM.

The robot's computer brain is made up of the same three sections as a home microcomputer: *Memory* (data storage), data processing (CPU or Central Processing Unit) and *input* and *output*—accepting information and sending it out after processing it. The data coming in (from the fingers on the gripper, or the TV camera, or sonar in the case of object-avoidance) is digital information; ones and zeros strung together into groups of eight (or 16 or 32). A group of eight *bits* of data is called a *byte*, and the size of the brain's (microcomputer) memory is specified as so-many-thousand bytes.

The Human Brain

The human brain is divided up into many separate areas. One handles sight, another smell, another touch, and so on. Similarly, a microcomputer for a robot has separate functions. One part may handle reflected light (in a room for object-avoidance), another may report to the Central Processing Unit the weight of an object the gripper has picked up, while another part decodes words or sounds received through the robot's "ear" (microphone).

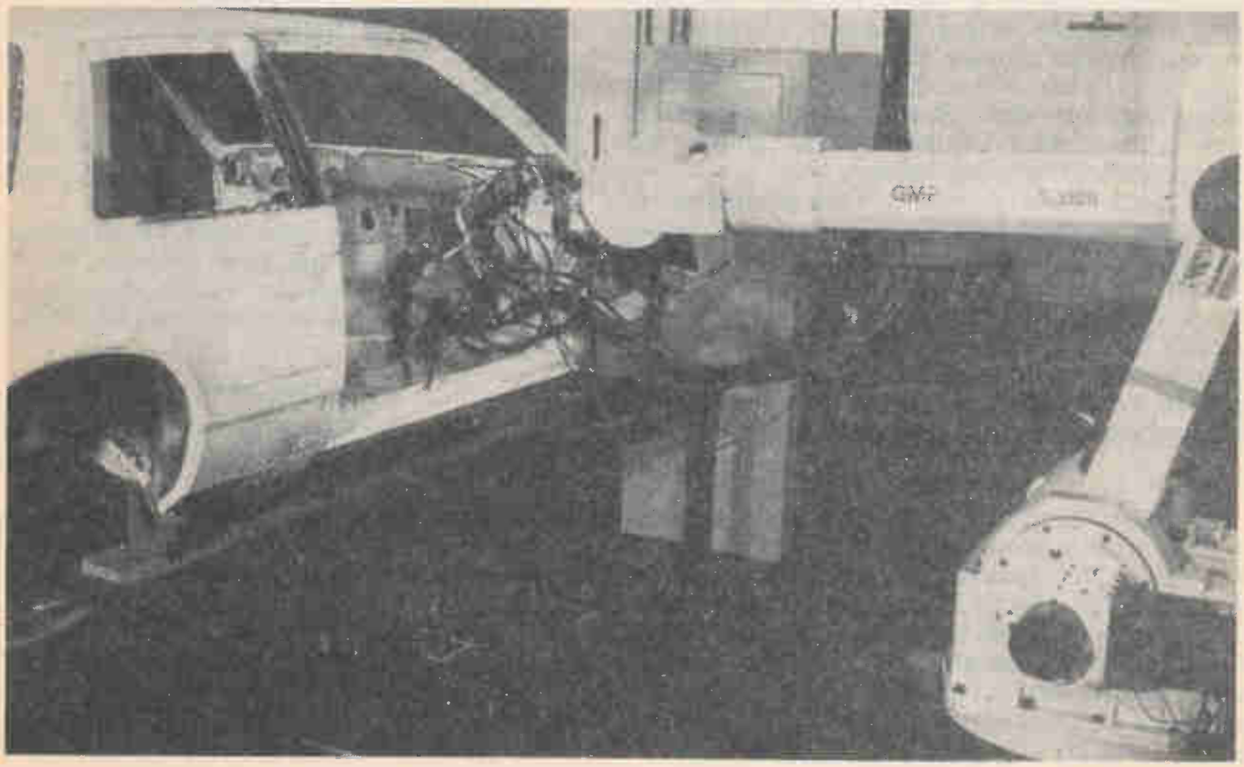
Although robot technology has expanded dramatically in the last hundred years, it has only been in the last 25 years that the long-standing dream of automated factories has become a distinct possibility. Modern robot technology is the final major technological breakthrough needed to turn this exciting possibility into reality.

Robot capabilities have expanded substantially in recent years, but the level of understanding of just how to apply them has not kept pace. Before industrial robots can hope to achieve their full potential, it's essential that engineers and technicians understand what robots are, just where and how they can be used, and how to select the best industrial robots.

Automation and Industrial Robots

In order to gain a better understanding of what an industrial robot is, we will now turn our attention to industrial automation. The general term *automation* covers anything from simple powered tools up to

GMF industrial robot shown here welds the bottom of automobile door opening. The small claw at end of arm are the two welding electrodes.



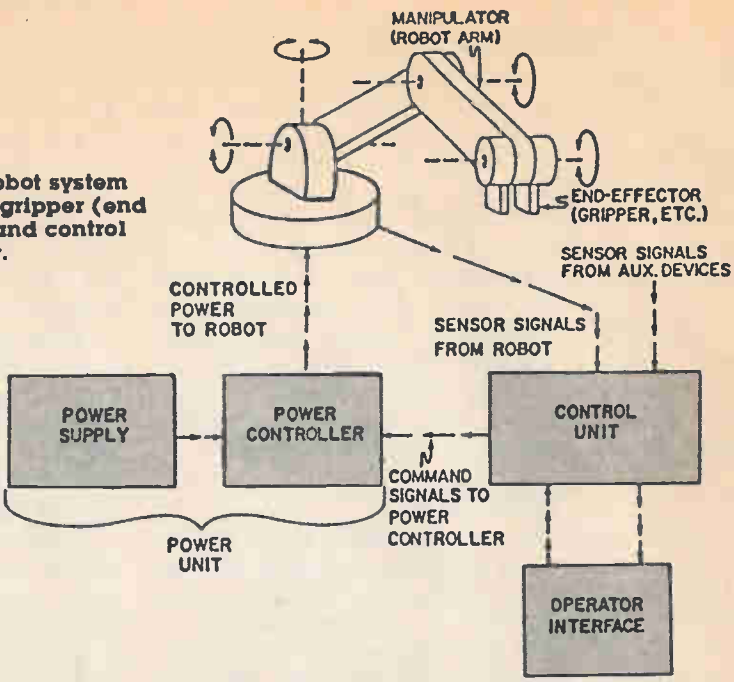


Figure 1. Main parts of an industrial robot system show the robot, consisting of arm with gripper (end effectuator), power supply, controller and control unit. All are controlled by the operator.

entire factories under complete computer control. But two main classifications are recognized: hard automation and flexible automation.

Automation

In *hard automation*, an operation is performed by a tool that has been specifically designed to perform that task. Because of the high initial costs, hard automation is generally used only for long-run manufacturing operations. Hard automation can't be economically justified for use in short-run manufacturing operations where frequent changes are required. The cost of direct labor in such operations is almost always lower than the cost of the special tooling required. Manipulators using mechanical stops with limited adjustment fall within the classifications of hard automation.

Because of the high cost of hard automation in batch (short-run) operations *flexible automation* was developed. Unlike hard automation, flexible automation can be readily adapted to product changes. The change from one job to another can typically be accomplished by simple adjustments or basic reprogramming (rather than reworking or replacing equipment). Industrial robots fall into the general classification of *flexible automation*.

Programmable

The industrial robot is controlled by a form of programmable control that can store a sequence of movements. The controller is programmed to direct the arm and end-effector through a series of motions. Once programmed, the robot will repeat the desired operation until reprogrammed. If the robot is to be used in another location or operation, an entirely new sequence of movements can be created by reprograming the controller.

Multifunction

The industrial robot is capable of performing a wide variety of tasks. Generally, any task within the reach of the robot can be performed during a single cycle. For example, a robot can pick up a workpiece, load the piece into a machine, unload the machine, place the piece into an inspection station, unload the inspection station, and finally place the workpiece on a conveyor belt.

Manipulator

The industrial robot differs from machines employed in hard automation in its ability to move an object through space while at the same time reorienting its position (that is, changing its place and direction relative to its surroundings). This capability allows the robot the perform tasks that previously were performed only by human workers.

Industrial robots can best be described as machines that fill the gap between the highly specialized capabilities associated with hard automation and the extreme flexibility typical of human labor.

Four Robot Types

Robots already in use which can be programmed to perform particular operations fall into four groups:

(1) Fixed-sequence robots
(2) Variable-sequence robots
(3) Numerical control robots
(4) Playback robots

The last category are robots which can be taught a sequence of complicated operations by a worker who "walks" the robot through its paces. Once the operator is satisfied the robot can do the job perfectly, it's on its own; the sequence is stored in its memory

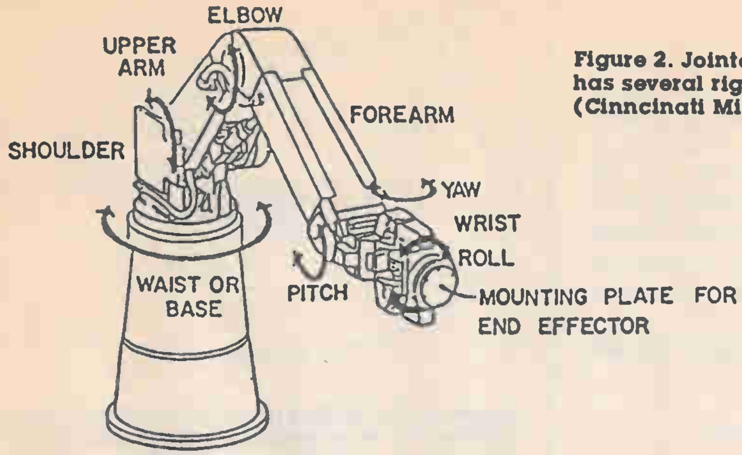


Figure 2. Jointed-arm robot (the most common type) has several rigid parts connected by rotary joints (Cinncinati Milacron).

and thereafter it can keep doing the task(s) as long as desired. That's usually until the robot is needed to do another job, or the job is changed to become even more complex. These are called "second-generation" robots.

More recent (third-generation) robots can be programmed to respond to changes in the situation. These are usually something which it can sense by sight or by feel; visual or tactile sensing (or both). In other words, these more sophisticated robots can detect changes in the world around them and make decisions based that information. These decisions affect the actions of the robot.

Fixed Sequence Robots

These machines perform successive steps in a given order. Preset conditions and information are built into the robot and they are not readily changed. Such machines are barely capable of being called robots because they are designed for a specific, relatively simple operation or series of steps.

Variable Sequence Robots

These robots are similar to the above type, except that the information placed into them can be changed readily to accommodate new and different jobs.

Numerical Control Robots

The first numerical control machines (and still the most numerous) were programmable machine tools in machine shops. In these a skilled machinist teaches the programmable machine (a drill press is a simple example, or a milling machine is a more complex one) how to handle a series of operations on a piece of raw metal. After he's gone through the operation correctly the machine can do it. If it makes any slight mistakes he reprograms the memory of the machine (usually a tape) and the machine can then do it properly.

These numerical control machines are used widely, and the information they use can be on punched cards (IBM cards) as well as magnetic tapes.

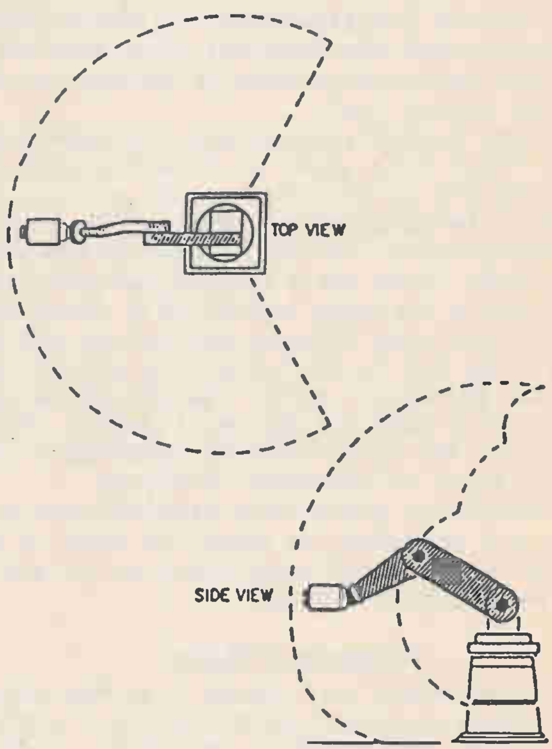


Figure 3. This jointed-arm robot has an irregular (non-symetrical) work volume (area).

Playback Robots

This is an extension of the numerical control system. The word playback suggest the tape *playing back* the sequence of operations *recorded* on it by the human operator, the "teacher".

How They Work

Industrial robots are generally fixed in place, though obviously they may be moved for new tasks. Most often they consist of an *arm* mounted on a base, with the electronics (brain) in the base. The arm is capable of motion in two or more axes, up to maximum of eight. See the diagrams showing left-right arm mobility, and rotation of the "wrist." These are two of the possible axes of motion, which are among those the human arm can make (much more easily).

The possible motions for a robot arm (and a human one) are as follows:

(1) Arm sweep, or left-to-right movement
(2) Shoulder up-and-down movement
(3) Elbow extending (arm goes backward/forward)
(4) Body turning (left/right)
(5) Wrist up/down (pitch)
(6) Wrist left-right (yaw)
(7) Opening of hand (gripper)
(8) Change direction of hand (gripper)

Many robot arms use only five or six of these motions, even so achieving a great deal of movement and complicated tasks.

The robot arm is a combination much like our own arms. It includes a shoulder joint, the arm itself, a wrist, and a hand-like extension. Taken together these can pick something up, carry it, perhaps turn it over or around, and place it down in a desired place. The robot's work area determine where (how far) it can reach, first to pick an object up, and then how far it can go to put it down.

The arm must articulate (move) in at least three ways. These three paths of motion include (1) *extending* and *retracting* the *arm* (in and out), (2) *rotating* or *swinging* (left and right), and (3) *elevating* or *lowering* the arm. The *wrist* must also be able to do three things. These are to *bend*, to *yaw* (spin from either side to the other), and to *roll* or *swivel* (roll down to either side). If the arm and wrist can each do these things, just like the human wrist and arm, the robot can pick up and use any object the gripper can reach. This is called six degrees of freedom, which means that the robot arm-wrist combination can move in any of six independent directions.

In addition, the gripper must be able to open and close, and preferably, to adjust the force of its "fingers" to the object being picked up (to hold it securely, but not to crush it).

Categories of Motion

Although robots vary widely in configuration, mechanically speaking most fall into one or another of four basic motion-defining categories—*jointed*-arm, *spherical*-coordinate, *cylindrical*-coordinate, and *Cartesian*-coordinate. Each of these configurations has its own unique work envelope or volume.

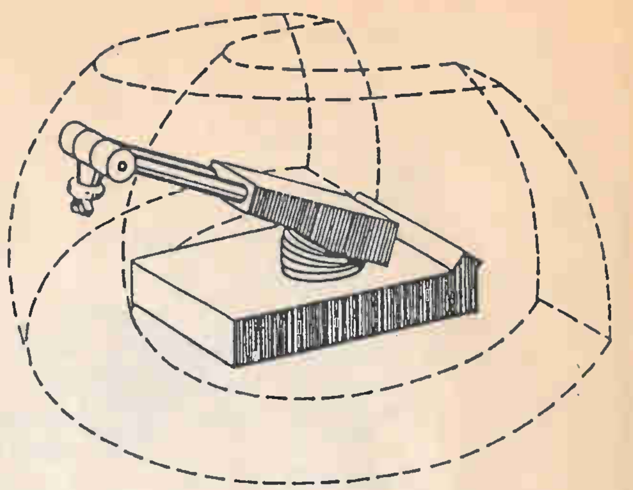


Figure 4. The dotted lines above show the work volume of a spherical-coordinate robot as a sphere whose top and bottom are cut off.

The size and the shape of the work volume is one of the most important characteristics to consider when selecting a robot for a particular application. Robot manufacturers' brochures describe the work volume, envelope, or range, with the aid of one or more scale drawings.

What a given robot manufacturer means by "work envelope" or "work volume" (also called "solid work area") is crucial. Generally speaking, work volume includes each and every location in the vicinity of the robot which can be reached by some point on the wrist of the manipulator-*not* the tip of the end-effector (see Fig. 1). This is because the robot manufacturer can't predict the shape or size of the end-effector that a given user may have in mind. Generally speaking, the robot will be able to reach outside of the work volume specified by the manufacturer because of the added dimension of the end-effector. This extra reach is taken into account when planning for the safety of the people working near the robot, and considering the placement of equipment around it.

It should be noted that the robot, as received from the manufacturer, rarely includes the end-effector. Since every task is unique in the type of workpieces that will be handled, robot manufacturers leave the design and construction of the end-effector to the user.

We'll examine the work-volume shapes (solid areas) of the four basic robot configurations.

Jointed-Arm Robots

Also refered to as the jointed spherical-coordinate robot, it is the jointed-arm robot that most closely resembles the human arm. This robot consists of several rigid members connected together by rotary joints, as shown in Fig 2. These members comprise the major axes, or degrees of freedom, of the robot. Up to three additional degrees of freedom may be provided at the extremity of the forearm. Such an addition is generally refered to as the *wrist*.

The rigid members are analogous to the human

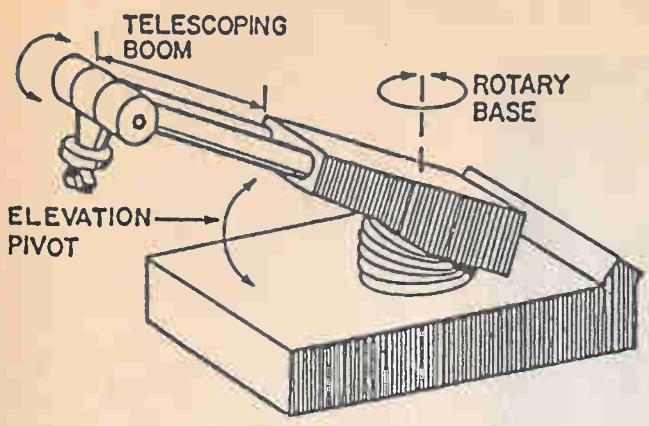


Figure 5. This is a special type of spherical-coordinate robot with limited work volume. It can move around only around its rotary base and up or down. Used mostly for moving parts from one spot or another.

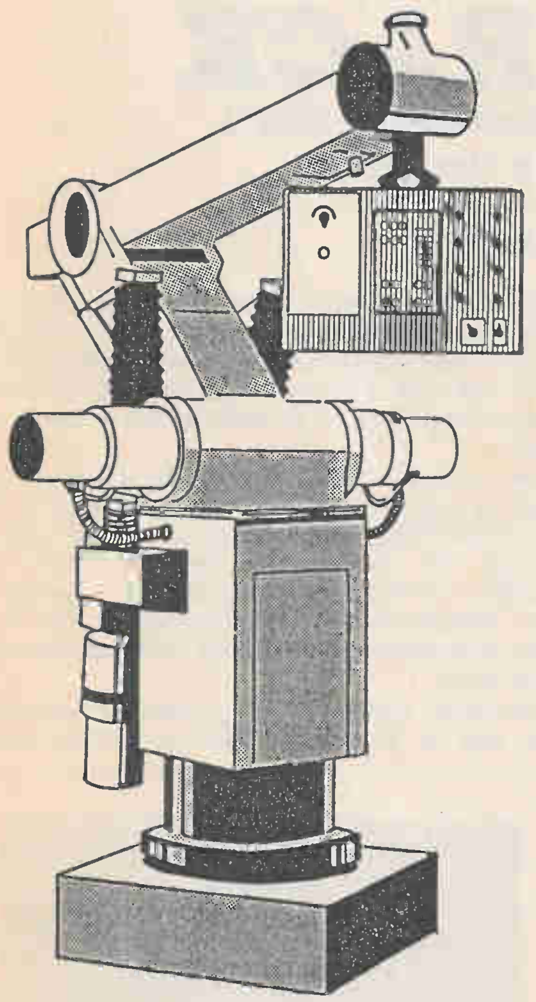


Figure 6. This is one of many point-to-point, limited-motion robots.

upper arm, forearm, and hand; the joints are equivalent to the human shoulder, elbow, and wrist. A robot arm of this type is generally mounted on a rotary joint whose major axis is perpendicular to the robot mounting plate. This axis is known as the *base*, or *waist*. Up to three wrist axes—pitch, yaw, and roll—can be used to control the orientation of the end-effector.

Figure 3 illustrates the irregular work volume of the jointed-arm robot. Note that work-volume information provided by the manufacturers is generally specified for the weight of the robot components only, and does not take into account the load that the robot may have to handle.

The length of the arm, joint arrangement, and range of motions of the joints determine the limits of the work volume. In some cases, these limits will change if the robot is called upon to handle particularly heavy loads. In this case, the end result may be a smaller work volume.

The jointed-arm robot is used where it's necessary to get into difficult areas, such as inside the body of a car.

Spherical-Coordinate Robots

The configuration of a spherical-coordinate robot is similar to that of a turret on top a military tank. It has a *rotary base*, an *elevation pivot*, and a telescoping *extend-retract boom* axis. Three more axes are sometimes used, letting this robot imitate the action of the human wrist, pitch, roll, and yaw.

Figure 4 shows the nearly spherical work volume (solid area) of the spherical-coordinate robot.

The robot in Figure 5 is an example of the spherical-coordinate robot. Because these robots can extend and retract their boom axis, they are used in operations where it's necessary to reach horizontally into the work area. Loading and unloading punch presses and die-casting machines are typical of such operations.

Cylindrical-Coordinate Robots

Cylindrical-coordinate robots are made up of several orthogonal (mutually perpendicular) slides and a rotary base, as shown in Figure 5. Additional rotary axes are often used to allow for end-effector orientation. It is called a cylindrical-coordinate robot because of the shape of the available work volume (solid area). The cylindrical robot is one of the most stable with regard to loading. Since there are no pivot joints in this kind of robot (except for the rotary base, and possibly in the wrist joints) load handling is greatly improved.

This kind of robot consists of several orthogonal slides with a non-rotary base. The end effector is positioned inside a rectangular (Cartesian) coordinate system. These robots may also be called *rectangular motion* robots.

Point-To-Point Robots

The point-to-point (PTP) robot is one subset of the servo-controlled robot class. This is the most common servo-controlled robot, being used in a wide variety of industrial applications for both parts-handling and tool-handling tasks. The robot shown in Fig. 6 is typical. (Continued on page 94)

TANDY'S

RADIO SHACK

It's The Biggest (and One of the Best) Electronics Store in the World

by Charles Graham

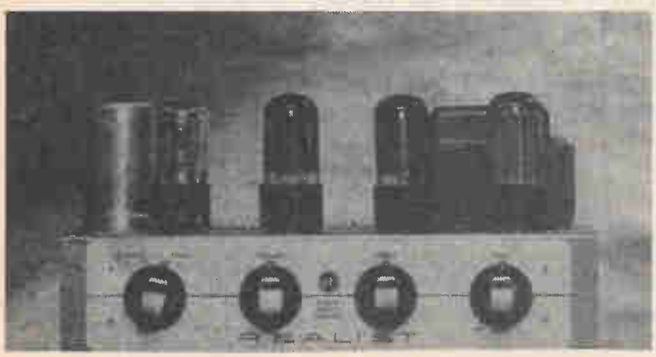
In 1958 magazine publisher Milton Sleeper sent me to Boston to visit some high fidelity manufacturers. "And while you're there," he instructed me, "drop in to a store called Radio Shack. They've been putting out a mail catalog recently, and some of their stuff looks interesting."

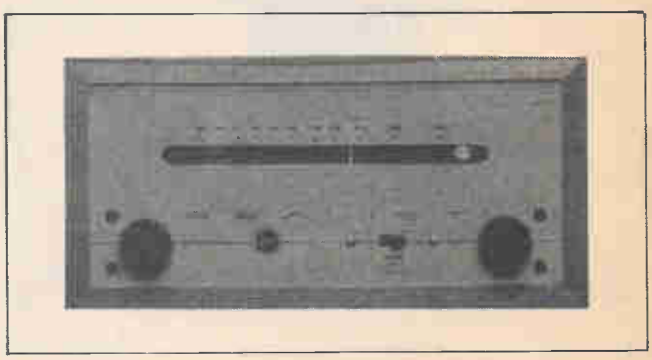
I followed his instructions, and a few a days later I was talking to a young man named Bob Lewis, who was the manager of a retail store in downtown Boston, as well as their main engineer. He'd just finished designing one of the first FM (only) radio tuners and they called it "Realistic." A picture of this tuner, with its companion audio amplifier (both used vacuum tubes, of course) is shown here.

The amplifier had a 6SN7 voltage amplifier/phase inverter to drive the power amplifier tubes, a pair of 6V6s, with a full-wave rectifier completing the lineup. Note that there was no preamp tube for the phono pickup. This indicated that magnetic pickups weren't being used yet. The crystal pickups of the day had enough output (½ to 1.0 volt) to drive the amplifier directly.

You can also see that although the tuner had a metal cabinet, the amplifier was uncovered. In those early days of high fidelity it was not only unnecessary to hide the chassis, but the amplifier's tubes generated so much heat that a cabinet would have been difficult to ventilate adequately. The tuner's tubes generated much less heat, so it had a decorative metal cover.

The store I visited was one of several in the Boston area, and its mail order catalog business was so





This modest building (photographed in the late 1940s) was in Boston. It housed the headquarters as well as the assembly, receiving, shipping, etc. of Radio Shack's modest beginnings. It also included one of their first stores. It contrasts sharply with the nearly 8,000 stores the company has around the world today.

successful after awhile that in the early Sixties a Texas-based firm, Tandy Leather Company, took over Radio Shack and moved the headquarters to Dallas.

They began carrying radio and TV parts and kits for learning about electronics. They also produced low-priced and medium-priced stereo components of excellent quality. Another reason for their success, and for buying Radio Shack stereo that I've often pointed out in print, is that their one-year (on some parts more) parts-and-labor guarantees are good at Radio Shack stores all over the country.

In 1977 Radio Shack began selling personal computers, the TRS-80 line, which early computerniks jocularly called "Trash-80." Meanwhile, Radio Shack was laughing all the way to the bank for it was the first manufacturer to sell personal computers. After Apple came along Radio Shack continued to bring out new models, resisting the industry shift in the early Eighties to copying the IBM PC. They also had the lowest-cost computer for games, educational programs, and inexpensive introduction to computers, their Color Computers. First was the Model 1 in 1980, and then the Model 2. Recently the Model 3 Color Computer was brought out, and it continues to be the most-expandable and lowest-cost entry-level micro system.

In 1984 Tandy stopped fighting the trend to copy IBM's PC and joined the crowd, soon becoming the biggest seller of PC-compatible clones, with their Model 1000. The model 1000 successors and system components (monitors, printers, modems, software and accessories) are the lowest-priced similar equipment in the market. There are lower-priced PC clones sold by mail order. But you can't take them into your local store for help.

Tandy also spearheaded the portable computer market with its highly-successful lap-model 100 four years ago. This has been followed by successor model 102, 200, and now 600, while the earlier models continue to be sold and supported at ever-lower prices.

Watch For Sales

This is another advantage of shopping for computers (and other sizable items) at Radio Shack stores. They often run sales, and you can frequently save substantially on computers, radio, telephones etc. by watching for such sales.

Across the U.S. there are nearly 5,000 Radio Shack stores and over 2,500 Computer Centers. Many combine both at one location. This makes a total of 6,900 stores. There are also 166 Radio Shack Service Centers which serve these thousands of retail stores.

Best Buy Microcomputers

Let's look at Tandy's line of PC clones (IBM-compatibles) which, if you buy them during one of

Here's an early Radio Shack store on the inside. Like many "parts" stores in those days (the Forties and Fifties) it catered both to hobbyists and to service technicians, as evidenced by the many test instruments (including Tube Testers) on display. Like most early electronics supermarkets, it was so cluttered you needed a sign to find the place to pay (Cashier).

Tandy-Radio Shack's frequent computer sales, represents the Best Buys you can make in microcomputers today.

The highly-successful model 1000 micro has recently been replaced by two newer versions which offer new features. The new model 1000EX is the lowest priced MS-DOS personal computer, it is 50 percent faster than the original IBM PC. Targeted to the home and educational user, the 1000 EX has 256K RAM and uses the MS-DOS version 2.11 operating system, which is upgradable to version 3.2 at a reasonable price. Even with version 2.11 there are thousands of popular MS-DOS programs for the EX. It has one external 360K, 5¼-inch floppy disk drive, to which you can add a second 5¼-inch or a 3½-inch 720K external drive. A three-voice circuit provides sound and music generation through a built-in speaker or headphone jack, and can use a "mouse" (like the Apple McIntosh, the Atari STS and the Commodore Amiga) as well as game joy-sticks. The 1000 EX package comes with Tandy *DeskMate* software, which is an electronic desktop, worksheet, and word processing program with a number of other applications, including telecommunications and electronic mail.

The 1000 SX packages two 360K drives internally, operates on MS-DOS version 3.2, and allows for expansion with its five PC-compatibles slots. This permits the addition of memory boards, and an internal modem or 20Mb hard disk card. It gives a little extra RAM as well, 384K, which is expandable to 640K on the main board. It too is 50 percent faster than the IBM PC, and makes use of the *DeskMate*.

Lap-Top Model 100

The most widely-sold lap-top (portable) has been Tandy's Model 100. It cost $1000 three years ago and has been on sale often, today it keeps selling at $400,

(Continued on page 96)

Comparison of 1000SX & EX

	Model 1000SX	**Model 1000EX**
Microprocessor	8088	8088
Operating system	MS-DOS 3.2, GW BASIC	MS-DOS 2.11, GW BASIC
Internal memory	384K, expandable to 640K	256K RAM expandable to 640K
Internal expansion	5 full-length IBM **slots**	2 expansion **boards**
Disk drives	2 double-sided, double-density	1 double sided, double density
Drive expansion		external 360K 5¼ inch or 720K 3½ inch drive
Input/Output	Parallel port, composite video, line level audio output, light pen port, 2 joysticks,	Parallel port, composite video, ⅛-inch headphone jack with volume control, 2 joysticks
Basic price	$1200	$800

CIRCUIT FRAGMENTS

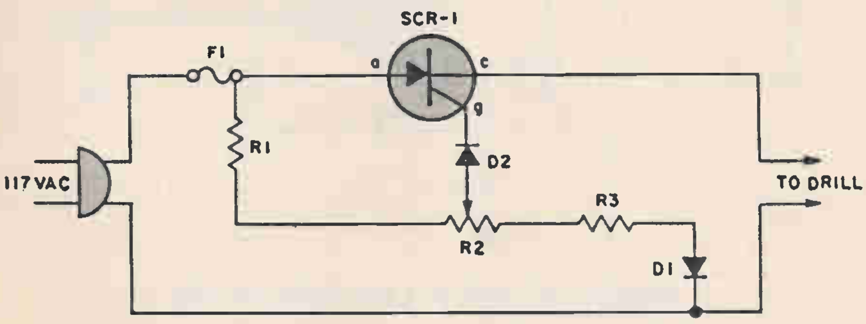
The circuits on the following pages are an assortment, each of which can do useful things while teaching the reader more about the building blocks of electronics. Each contains one or more oscillators or amplifiers or a power supply, etc. Learning about these and similar simple circuits and how to combine them will teach you how to build just about anything electronic. These projects provide an opportunity for you to be creative and combine circuits to make more complicated projects that will have a useful purpose. If you are a beginner at putting circuits together, it is suggested that you first read the article "Getting Started With Electronic Projects" in this issue, before you start any of these projects. Then let your imagination take over and have fun.....

POWER TOOL TORQUE CONTROL

As the speed of an electric drill is decreased by loading its torque also drops. A compensating speed control like this one puts the oomph back into the motor.

When the drill slows down, a back voltage developed across the motor—in series with the SCR cathode and gate—decreases. The SCR gate voltage therefore increases relatively as the back voltage is reduced. The "extra" gate voltage causes the SCR to conduct over a larger angle and more current is driven into the drill, even as speed falls under load.

The only construction precaution is an extra-heavy sink for the SCR. The SCR should be mounted in a ¼-in. thick block of aluminum or copper at least 1-in. square; 2-in. if you drill for extended periods.

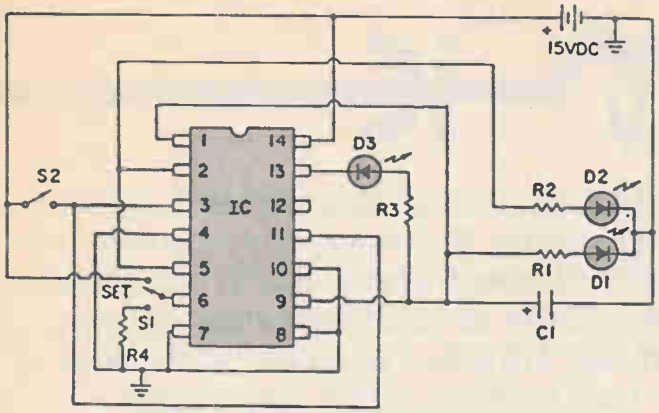


PARTS LIST FOR POWER TOOL TORQUE CONTROL

D1, D2—1A, 400 PIV silicon rectifier (Calectro K4-557 or equiv.)
F1—3-A "Slo-blo" fuse
R1—2500-ohm, 5-watt resistor
R2—250-ohm, 4-watt potentiometer
R3—33-ohm, ½-watt resistor
SCR1—3-A, 200 PIV silicon controlled rectifier (Calectro K4-584)

EYEBALL SPEED TESTER

This circuit uses the two flip-flops of the CD 4013 integrated circuit to test your eyesight. Start by moving S1 from ground to "set" and back to ground. This will light D1 and D3. Now press S2. D1 and D3 will go off and D2 will go on, but D3 must go off slightly later than D3 due to built-in delays in the circuit. Can you see the difference in the two LED's? This makes a great experiment for kids to take to school.

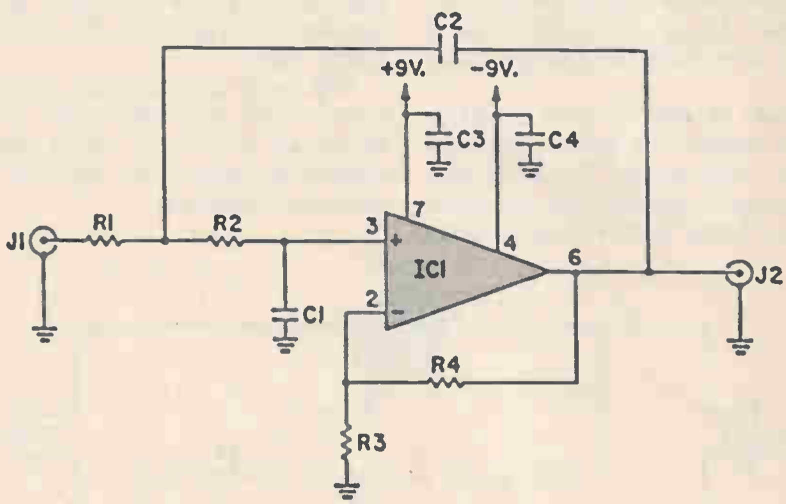


PARTS LIST FOR EYEBALL SPEED TESTER

C1—1-uF electronic capacitor, 15VDC
D1-D2, D3—small LED
IC1—4013 dual flip-flop
R1, R2, R3—2,000-ohm resistor
R4—500.000-ohm resistor
S1—SPDT slide switch
S2—SPST momentary contact pushbutton switch

IC LOW PASS FILTER

As its name suggests, a low-pass filter passes signals with frequencies lower than some specific value, called the cut-off frequency, but blocks passage of frequencies above the cut-off. Illustrated here is an active low-pass filter having a 1000 Hz cut-off frequency. You can shift the cut-off by changing C1 and C2 together. To multiply the cut-off by a factor of N, multiply the capacitances of C1 and C2 by a factor of 1/N. For example, a 2000 Hz cut-off would require 0.005 uF capacitors while a 500 Hz cut-off calls for 0.02 uF capacitors for C1 and C2. Drive the filter directly from the output of a preceding op-amp stage for best results.

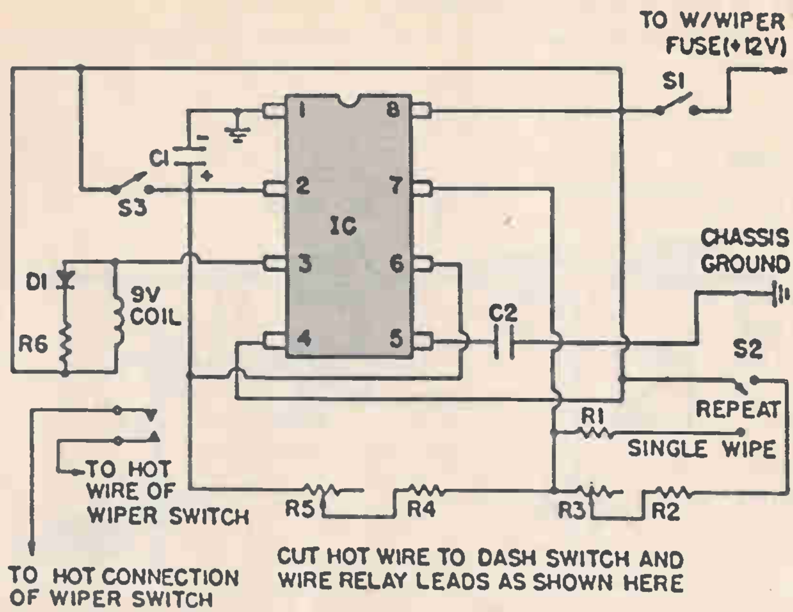


PARTS LIST FOR IC LOW PASS FILTER

C1, C2—0.01uF capacitor, 35 VDC
C3, C4—0.1-uF capacitors, 35 VDC
IC1—741 op amp
J1, J2,—phono jack
R1—12K-ohm resistor, 5%
R2—22K-ohm resistor, 5%
R3, R4—68K-ohm resistor, 5%

WINDSHIELD WIPER CONTROL

Ever have the problem of not being able to make your car wipers go slow enough? And sometimes, would you like to just press a button to make wipers flip one time? This circuit does both. Set S2 to the mode you want. If you pick "repeat", then R3 will determine the time between wipes (up to several minutes), so put R3 on a knob you can turn while sitting in the driver's seat. R5 will control the length of the wipe; you just set it once for your car. If S2 is set to "single wipe" then pressing S3 will kick the wipers up once. A very handy circuit.

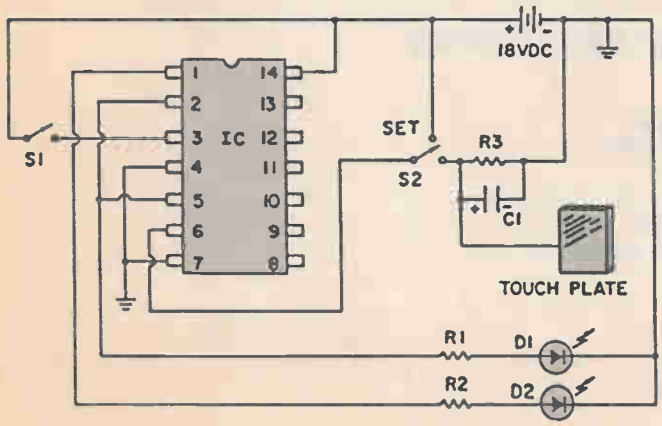


PARTS LIST FOR WINDSHIELD WIPER CONTROL

C1—100-uF electrolytic capacitor, 15 VDC
C2—0.1 uF capacitor, 15 VDC
D1—1N4001 diode
IC1—555 timer
R1—10 Megohm resistor
R2—20,000-ohm resistor
R3—500,000-ohm linear-taper potentiometer
R4—18,000-ohm resistor
R5—50,000-ohm linear taper potentiometer
R6—100-ohm resistor
S1—SPST toggle switch
S2—SPDT toggle switch
S3—SPST momentary-contact pushbutton switch
RELAY—9 VDC coil with normally open SPST switch contacts rated at 15 VDC/25 amps

MAGIC TOUCH CONTROL

Ever wonder how a touch plate, like the kind you see on some elevator buttons, works? This circuit will give you a good feel for how the touch plate works in a circuit and lets you experiment further.



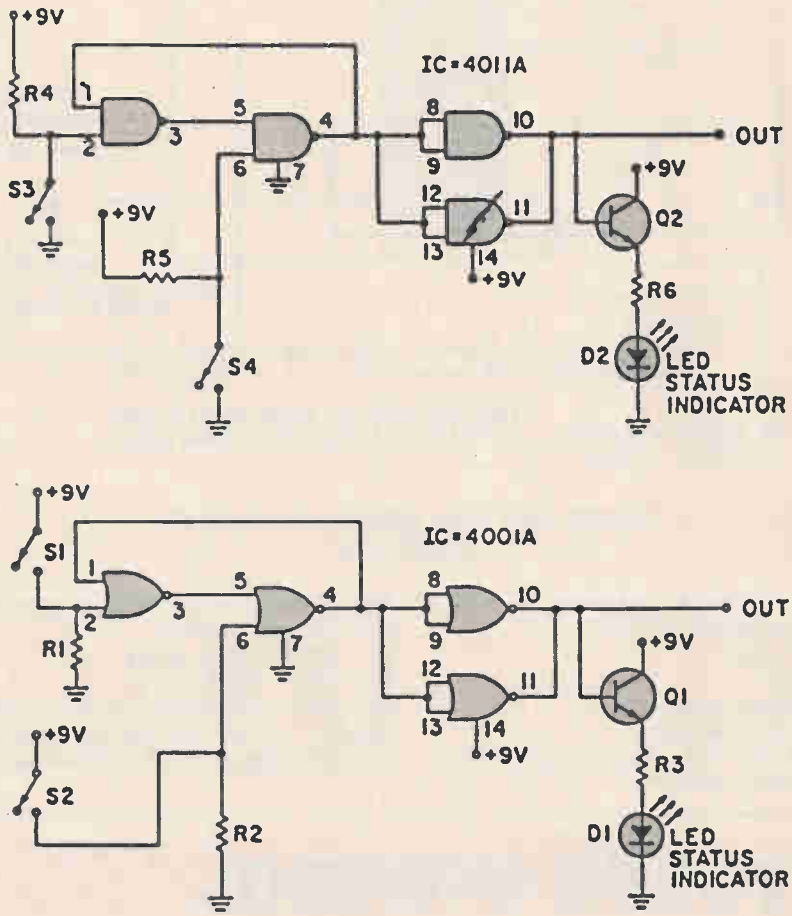
PARTS LIST FOR MAGIC TOUCH CONTROL

C1—4.7-uF electrolytic capacitor, 15 VDC
D1, D2—large LED
IC1—4011 quad NAND gate
R1, R2 R3—2,000-ohm resistor
S1—SPST momentary contact pushbutton switch
S2—SPDT slide switch

The plate can be just a small piece of metal or aluminum foil. Start by sliding S2 to "set" then back to R3. Now press S1. LED's D1 and D2 will flip. Now touch the plate to flip them back. The sensitivity of the touch plate will depend on humidity in the room and on R3 and C1. You can experiment with those in various ways.

TWIN SWITCHES

Two switches and a choice of logic gates make up this "bounceless" package. One switch turns "on;" the other turns "off" Either a 4001A NOR gate, or 4011A NAND gate set can be used, giving the constructor a choice of chips.



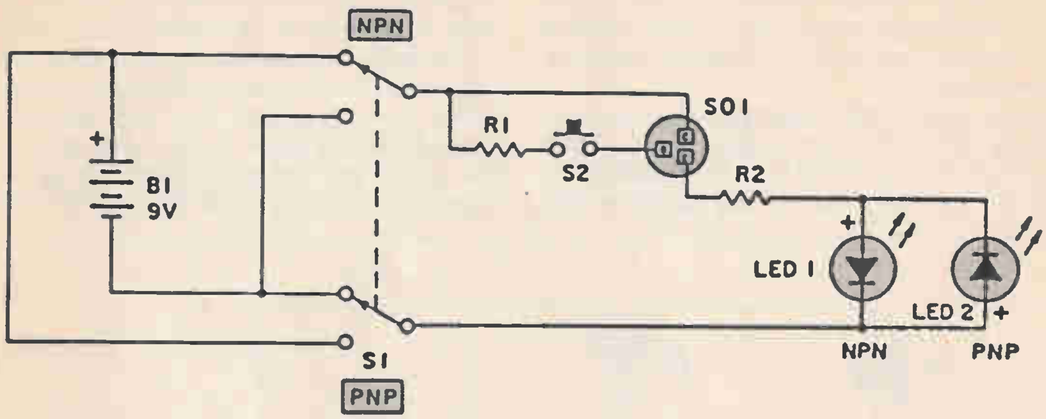
PARTS LIST FOR TWIN SWITCHES

D1, D2—small LED
IC1—4001A quad NOR gate
IC2—4011A quad NAND gate
Q1, Q2—2N4401
R1, R2, R4, R5—1,000 to 4,700-ohm resistor
R3, R6—1,000-ohm resistor
S1, S2, S3, S4—SPST toggle switch

TRANSISTOR CHECKER

It's pushbutton-easy to check transistors with this tiny marvel. Just plug the transistor in and push S2. If it's good and you set the PNP-NPN switch S1 properly, the appropriate LED will light.

Don't know the type? That's okay. Plug it in and try both S1 switch positions while you watch for the appropriate LED to light. You can even test diodes using the collector-emitter leads on the socket. The collector-emitter leads can also be used to check continuity.

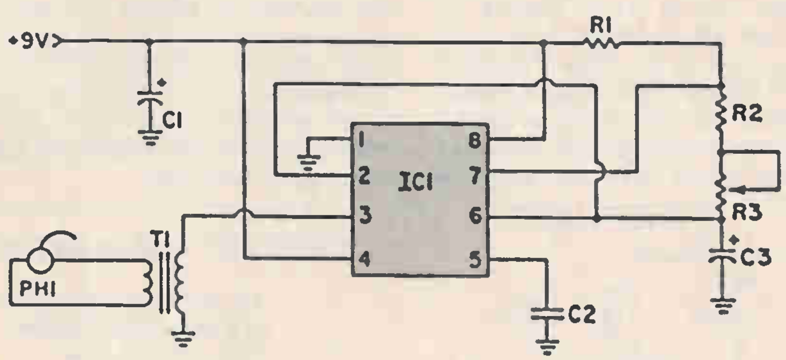


PARTS LIST FOR TRANSISTOR CHECKER

B1—9 VDC battery
LED1, LED2—Light emitting diode
R1—1000-ohm resistor
R2—470-ohm resistor
S1—DPDT switch
S2—Momentary push button switch
S01—Transistor socket

JOGGING PACESETTER

One of the problems faced by the beginning jogger, especially on city streets, is that of maintaining a constant pace. Tractor-trailer trucks, careening cars, and ill mannered dogs can all interrupt your concentration. While there is little that can be done about these nuisances, this little pacesetter may make them less severe. A miniature earphone in your ear driven by a 555 timer produces regularly spaced "ticks" just like a metronome. The pace can be adjusted via R3 from a leisurely one stride-per-second to a sole-blistering six paces per second. The whole circuit complete with a 9-volt transistor radio battery weighs only a few ounces.



PARTS LIST FOR JOGGING PACESETTER

C1—100uF electrolytic capacitor, 16 VDC
C2—0.1-uF ceramic disc capacitor, 35 VDC
C3—1.0-uF tantalum electrolytic capacitor, 20VDC
IC1—555 timer
PH1—8-ohm miniature earphone
R1—10K, resistor
R2—220K, resistor
R3—1-Megohm trimmer potentiometer
T1—miniature audio output transformer—1,000-ohm primary/8-ohm secondary

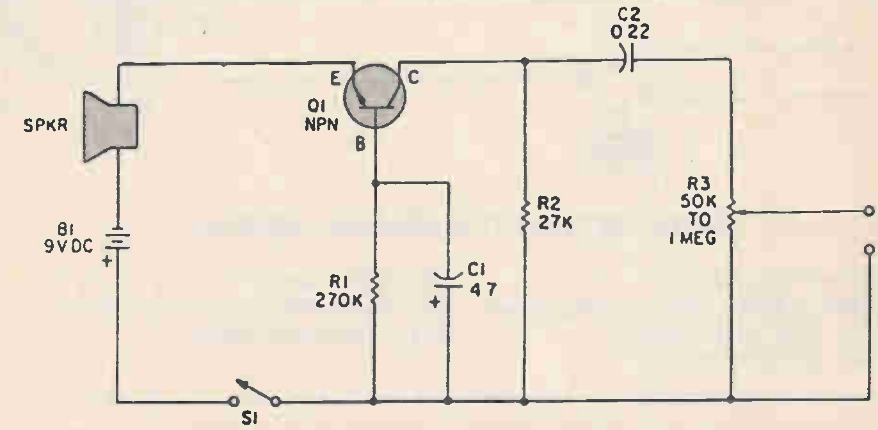
ECONOMY MICROPHONE

You can spend between six to ten dollars or more for a general-purpose microphone, but there's a better way, provided the mike doesn't have to be too small or portable. Pick up a junked (small) loudspeaker, four or five inches diameter is usually best (tiny speakers may have less sensitivity) and use it as a pickup device. Speakers and microphones are both transducers. That is, they convert one form of energy (sound) into another (electricity) or vice-versa).

This speaker, plus a few more general-purpose components is all you'll need to get a high-output microphone substitute, While not hi-fi quality by any stretch of the imagination the Speaker-Mic handles voice frequency signals very well.

Transistor Q1 can be just about any general-purpose NPN with a Beta of about 50 to 150. The speaker can be anything you have lying around of virtually any impedance rating in the range of 3.2 to 16 ohms. If the entire circuit, including battery, is assembled in a small metal enclosure, you'll end up with a hand-sized "amplified microphone."

The volume level is adjusted with potentiometer R3, which can be any audio taper unit from 50,000-ohms to 1-megohm. You can substitute a linear taper potentiometer if you have one lying around, but you'll find the adjustment range is scrunched together on one end of the shaft's rotation.

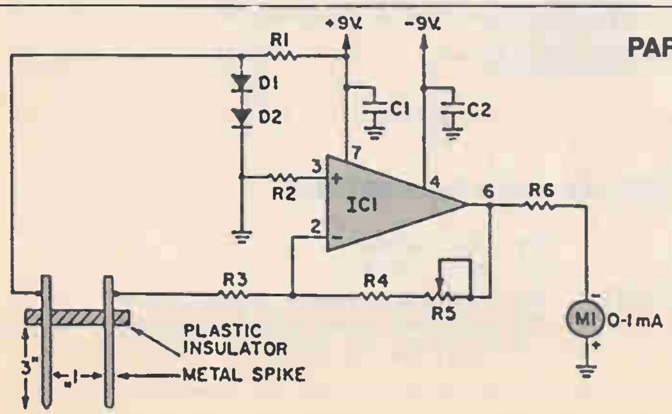


PARTS LIST FOR ECONOMY MICROPHONE

B1—9-volt transistor radio battery
C1—4.7 uF, 10-VDC electrolytic capacitor
C2—0.22-uF, 10 VDC capacitor
Q1—general purpose NPN transistor, see text
R1—270,000-ohm, 1/2-watt resistor
R2—27,000-ohm 1/2-watt resistor
R3—potentiometer
S1—SPST switch

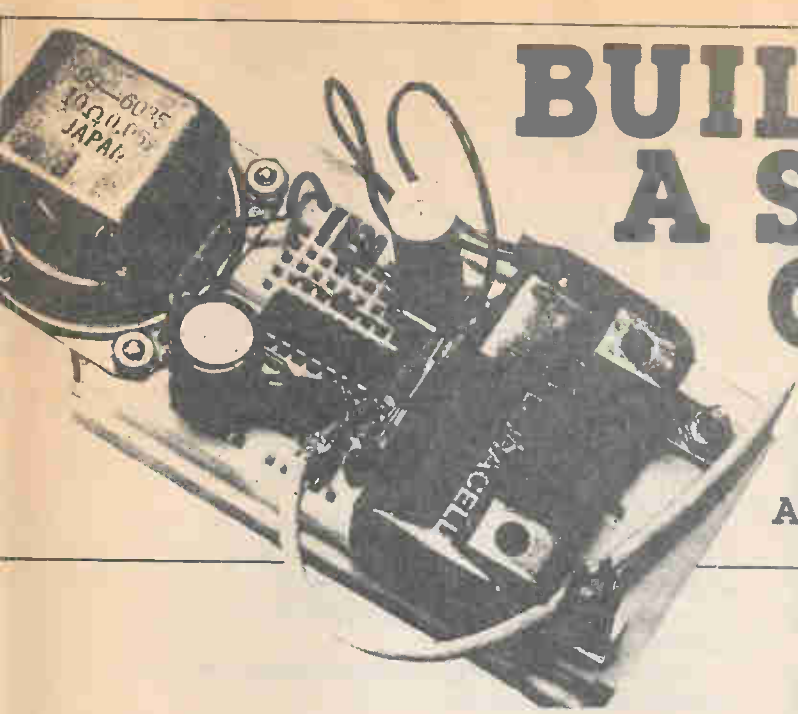
PLANT MOISTURE METER

Talked to your houseplants recently? Well, if they could talk back, you'd hear plenty of complaints—most of them about water. Too much of the wet stuff is just as bad as too little. To assist you with the watering, try this little moisture meter. Note that you will need to construct a probe assembly consisting of two metal spikes mounted in a wooden or plastic block. For the sake of uniformity, use the dimensions supplied. The spike can be nails or pieces of heavy wire (#8). Stick the probe assembly into the soil surrounding a just-watered plant and adjust R5 for a deflection around mid-scale on M1. Thereafter you can use the meter to tell whether your plants are too wet or too dry. Note that different plants are apt to prefer different degrees of wetness.



PARTS LIST FOR PLANT MOISTURE METER

C1, C2—0.01uF capacitor, 35 VDC
D1, D2—1N914 diode
IC1—741 op amp
M1—0-1 mA DC meter
R1—6800-ohm resistor, 10%
R2—15K-ohm resistor
R3—1000-ohm resistor
R4—10K-ohm resistor
R4—100K potentiometer
R6—3300-ohms resistor



BUILD A SIGNAL CHASER

One-evening Project Provides Low-Cost Universal Tool for Finding AM, FM, or TV Troubles

Probably the most sure-fire way to find the problem in any set you're repairing is to start checking in those parts of the circuit where there is no trouble. You then go backward through the circuit until you've reached the point where it isn't working. The same trick can work frontwards, letting you trace a signal through a circuit until you reach the point where it disappears.

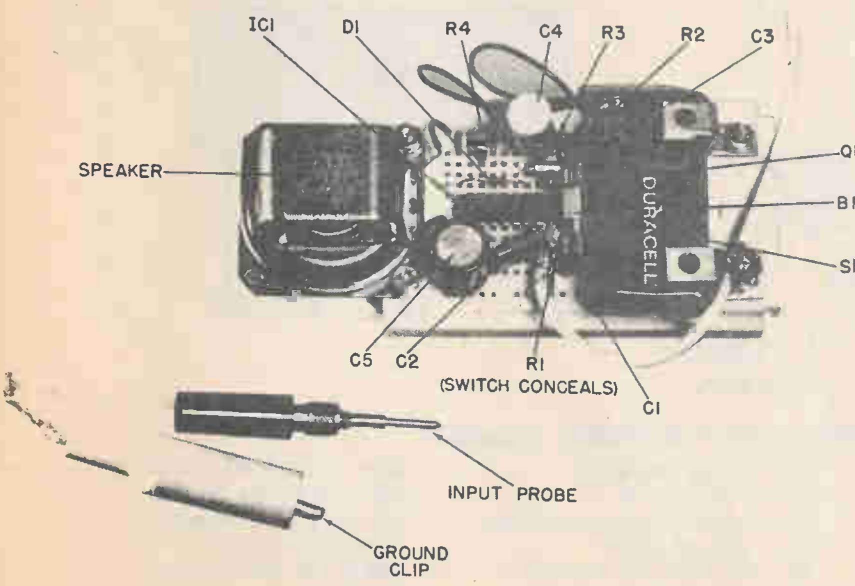
Here's a handy aid for troubleshooting in the frontwards fashion, a signal tracer with a great deal of input sensitivity called Signal Chaser.

Built-In Demodulator

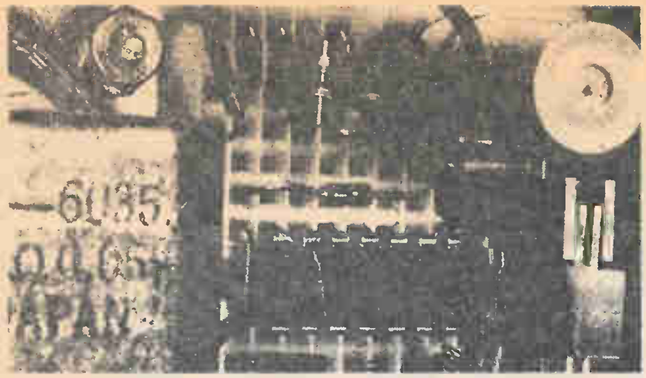
An ordinary amplifier could help you find signals in the AF (audio frequency) range but the Signal Chaser can do more. D1, a IN914 diode, acts as a demodulador, much like the diode in a simple crystal-set-style radio, to demodulate AM (amplitude modulated), RF and IF signals directly to audio (or whatever the carrier is modulated with). On FM and PM (frequency modulated and phase modulated) signals, the diode acts as a slope detector, giving a suitable, if low-fidelity, audio output.

High Impedance Input

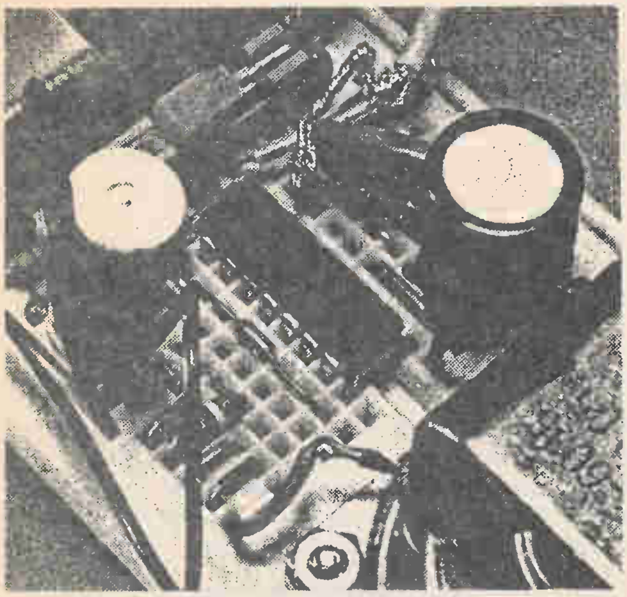
The one feature of this circuit that really makes it shine when compared to most signal tracers is its high impedance input. The input impedance of the Signal Chaser is close to 10-Megohms. This is due to the use of a JFET (Junction Field Effect Transistor) for Q1. Q1, a siliconix 2N5458 or similar P-channel JFET, is



Our Signal Chaser was built using a solderless breadboard and, as you can see, it made for a neat component arrangement. If you follow this photo, be certain you don't forget about R1 which connects to the Gate of Q1 and to C1 — it's really there, it's just hard to make out in the picture! Signal Chaser should go together quite quickly, so if you start it after lunch you should be chasing your first signals before the dinner bell.



Signal Chaser has a high impedance input that is close to 10-Megohms. It will draw very little current and so will not usually load down the circuit under test.



Solderless breadboard material is arranged with the holes about 1/10 inch apart. As you can see, this just fits the spacing of the IC's leads and of most modern components.

configured as a high-to-low impedance converter with an input impedance converter with an input impedance determined mostly by the value of R2, 10-Megohms. Capacitor C1 blocks DC but passes AF, RF and IF signals. Resistor R1 limits the input current to Q1.

A high input impedance means that for a given signal voltage, very little current is drawn by the Signal Chaser. This means that under almost all conditions, the Signals Chaser cannot load down the circuit you are troubleshooting.

Plenty of Output

The output of Q1 alone would be enough to drive a high impedance earphone, but keeping one in your ear while busy probing a suspect circuit can be, to say the least, inconvenient.

Instead, the output of Q1 (after demodulation) is coupled to the input of IC1, an LM38ON audio amplifier. IC1 provides enough drive to power even low-impedance speakers. around 8-ohms, to a good, healthy volume.

Capacitor C5 provides DC decoupling between the speaker and the output of IC1.

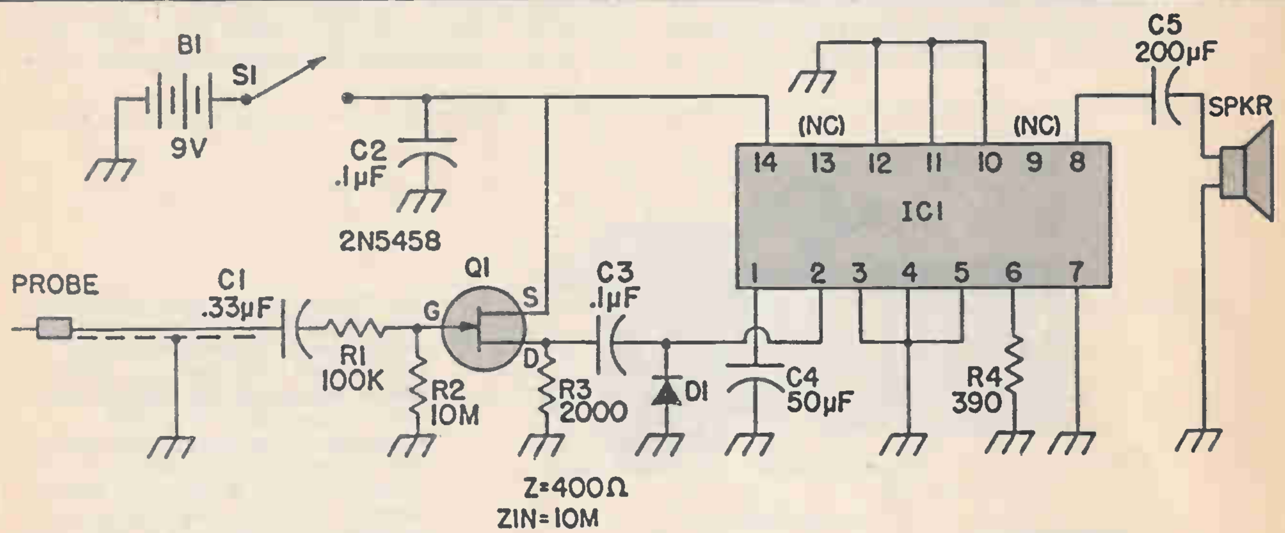
Solderless Construction

The entire circuit can be built up on a small solderless breadboard like the one shown (a Continental Specilities Corporation board) or a similar one from Radio Shack for under $7.00, in almost less time than it takes to tell.

There are three tricks you can use here.

For one, I used a pair of zig-zag mounting brackets (from the local Radio Shack) as battery hold-down clips. The mounting holes in the CSC EXP350 helped make this especially easy. At the far side of the

(Continued on page 95)



PARTS LIST FOR SIGNAL CHASER

B1—9-VDC battery	**C5**—200-uF capacitor	**R2**—10-Megohm resistor
C1—.33-uF capacitor	**D1**—1N914 diode	**R3**—2000-ohm resistor
C2—.1-uF capacitor	**IC1**—LM380N audio amplifier	**R4**—390-ohm resistor
C3—1-uF capacitor	**Q1**—2N5458 JFET	**S1**—SPST switch
C4—50-uF capacitor	**R1**—100,000-ohm resistor	**SPKR**—8 ohm speaker

MISC—Breadboard (Continental Specialties or Radio Shack.)

POISONOUS-GAS ALARM

Build This Alarm for Carbon Monoxide and Noxious Gases

by Cass Lewart

The Gas Alarm project described in this article detects carbon monoxide (CO) and other noxious, flammable and poisonous gases. The alarm is equipped with stand-by rechargeable batteries which take over in case of power failure. When the alarm detects carbon monoxide, natural gas, gasoline fumes or one of many other flammable or "oxygen hungry" gases, it activates a warning buzzer.

The recent series of fatal hotel fires made it obvious that it is not always the hot flame and smoke that kill and main. Many people are killed or incapacitated by odorless, poisonous carbon monoxide, the product of incomplete combustion, which is frequently encountered far away from the source of the fire. For example, several members of a family in the township of Hazlet, NJ, were fatally poisoned when a defective furnace filled their house with carbon monoxide. Early warning signs of headaches and nausea were simply ignored till the disaster struck.

What is even more frightening is that standard smoke detectors will not respond to carbon monoxide. The most popular ionized chamber or photocell type smoke detectors will only respond to hot gases or smoke which may not be present in areas away from the fire, in areas still subject to the danger of carbon monoxide poisoning. Similarly, natural gas leaking from a gas stove, or carbon monoxide escaping from a defective furnace will not trigger a standard smoke detector.

On the other hand, when properly adjusted, this Gas Alarm will sound its warning before carbon monoxide reaches dangerous levels. This Gas Alarm should be considered *complementary* protection only and not as a replacement for standard smoke detectors. For example the Gas Alarm will not respond to ionized gases generated by fire unless the fire is smoldering in an enclosed area which is lacking oxygen. Still, the Gas Alarm described here allows you to carry with you a portable protection both at home and whenever you stay in a hotel or motel.

The Gas Alarm is based on the inexpensive Taguchi Gas Sensor (TGS), shown in Figure 1 which changes its electrical resistance when exposed to oxygen-reducing gases such as carbon monoxide, methane, butane, alcohol vapors and many others. The sensor element is enclosed in a small capsule protected by stainless steel mesh. A low-power, 5-Volt heater activates the sensor element, and also purifies it after exposure to gas.

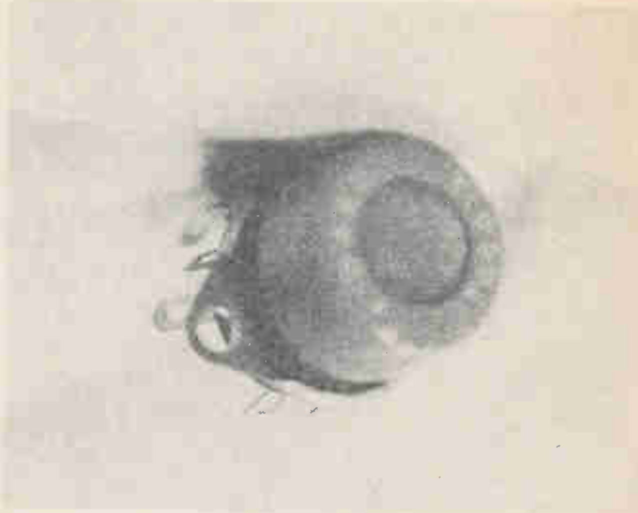


Figure 1. The Taguchi Gas Sensor, shown here, mounts on top of the chassis, as seen in the other photographs. It is available from the address in the parts list.

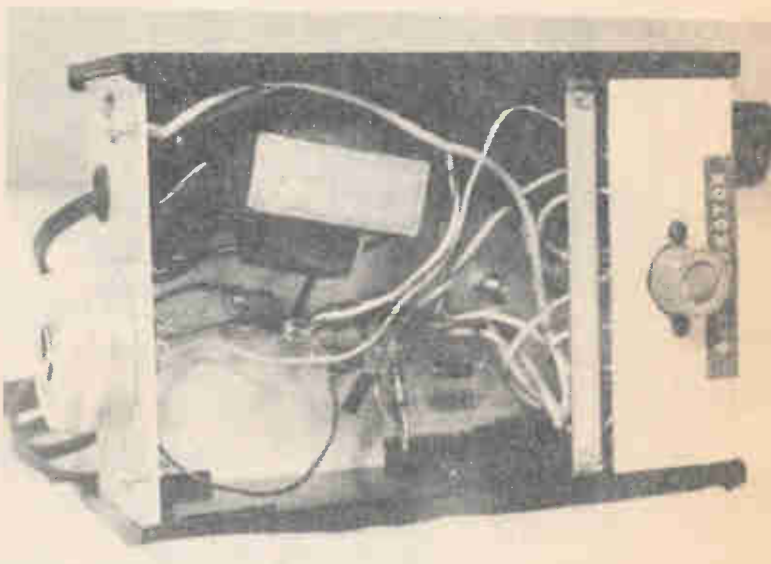


Figure 2. Inside view of Gas Alarm chassis shown here the alarm buzzer (next to AC line cord), the gas sensor (right), and power transformer, middle top.

Circuit Description

The circuit is powered by an AC transformer, and also by stand-by rechargeable NiCad batteries. The 12-Volt transformer provides power for the heater of the sensor, charges the stand-by batteries, and energizes the piezo electric buzzer. The 5-Volt IC regulator controls the heater voltage and assures its uniform sensitivity. A Silicon-Controlled Rectifier

HOW THE GAS SENSOR WORKS

The Taguchi Gas Sensor (TGS) is a sintered N-type semiconductor device composed mainly of SnO_2 (tin dioxide), whose conductivity increases in the presence of combustible gases such as hydrogen, carbon monoxide, methane, ethane propane, or organic solvent vapors belonging to the alcohol, ketone, ester and benzol families etc.

The increased conductivity of the TGS when exposed to even a low concentration of gas can be as high as twenty times that of its conductivity in air. Such a change can be brought about by the presence of 0.1% propane by volume which represents only 1/20th of the lower explosive limit for propane. This large change enables a buzzer or relay to be directly actuated by the TGS. When used with a simple amplifier several hundred ppm of carbon monoxide can be readily detected.

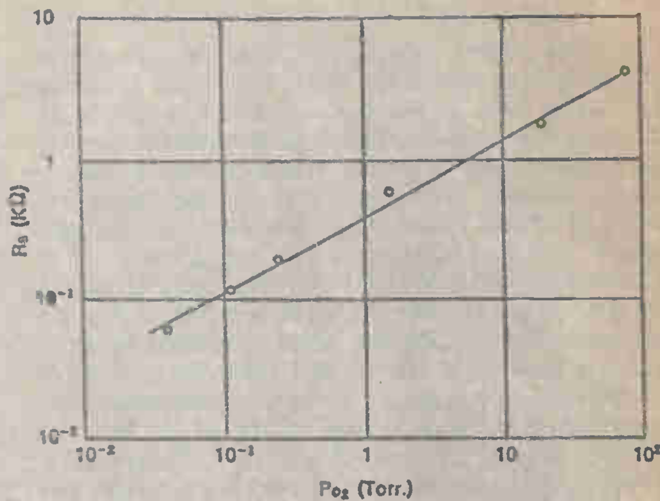
When a gaseous molecule is absorbed on the surface of a semi-conductor, an electric charge transfer occurs between the surface of the semi-conductor and the absorbed molecule, due to the difference of the electron energy between them.

For example, when oxygen in air is adsorbed on the surface of an n-type-se i-conductor device like TGS, electrons move from the device to the absorbed gas, and as a result oxygen is absorbed as a negative charge. Hence the density of conduction electrons in a space-charge layer of the semi-conductor decreases resulting in reduced conductivity.

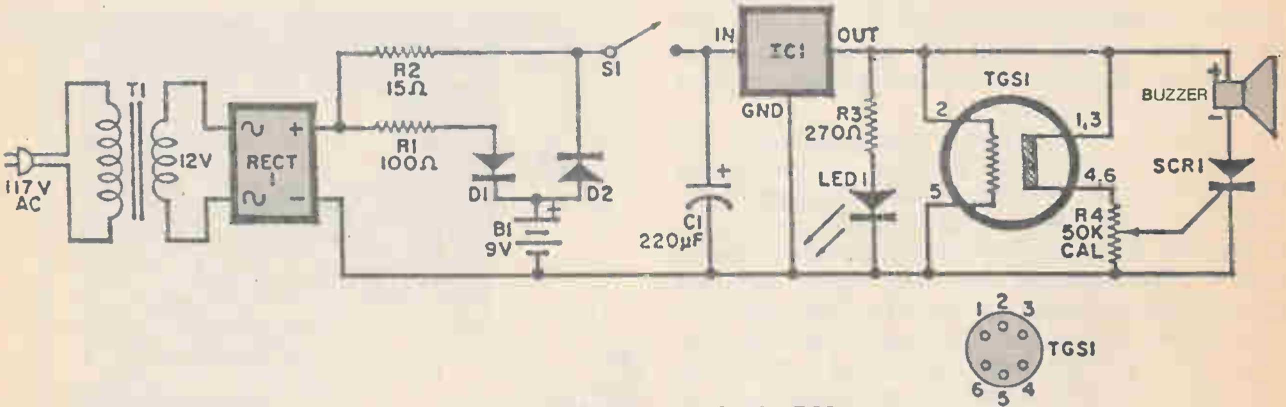
Consequently, the oxygen pressure in the atmosphere and the conductivity of the device are mutually related. When the partial pressure of oxygen is reduced, the value of the electrical resistance of the device decreases. This is shown in the graph here.

Since the pressure of the oxygen which is in the air all around us is nearly always the same, heating the TGS to a fixed (steady) temperature results in a steady (constant) amount of oxygen being absorbed, and in the conductivity of the device (the TGS) remaining constant.

When oxygen-absorbing or combustible gases such as hydrogen, carbon monoxide, or others are present in the air, they are absorbed on the surface of the semiconductor as a positive charge thereby increasing the density of conductive electrons in a space-charge layer. Thus the conductivity of the device increases corresponding to the concentration of the gas present.



Relationship between the resistance of TGS (Rs) and the Pressure of Oxygen (Po_2).



PARTS LIST FOR GAS ALARM

B1— 6 Ni-Cad cells (AA, C, or D)
R1—100-Ohm, ½ W resistor
R2—15-Ohm, 1W resistor
R3—270-Ohm ½ W resistor
R4—50-Kohm, linear potentiometer
C1—220-uF/16V capacitor
D1, D2—1A/200V silicon diodes
S1—SPST miniature switch
RECT—50V/1A full-wave rectifier
LED—Red Light Emitting Diode
IC1—5-Volt regulator, 276-1770
T1—110V/12V 1.2A transformer, 273-1352
BUZZ—Piezo electric buzzer, 273-068
SCR1—200V/O.8A or 200V/6A Silicon-controlled rectifier, 276-1067
TGS1—Taguchi Gas Sensor. The sensor (with socket) is available from C&R Electronics, P.O. Box 217, Holmdel, NJ. 07733 for $14.95 + $1.00 for First Class postage and handling. New Jersey residents add 6% tax.

ICI, TI Buzzer, and SCR numbers are Radio Shack stock numbers

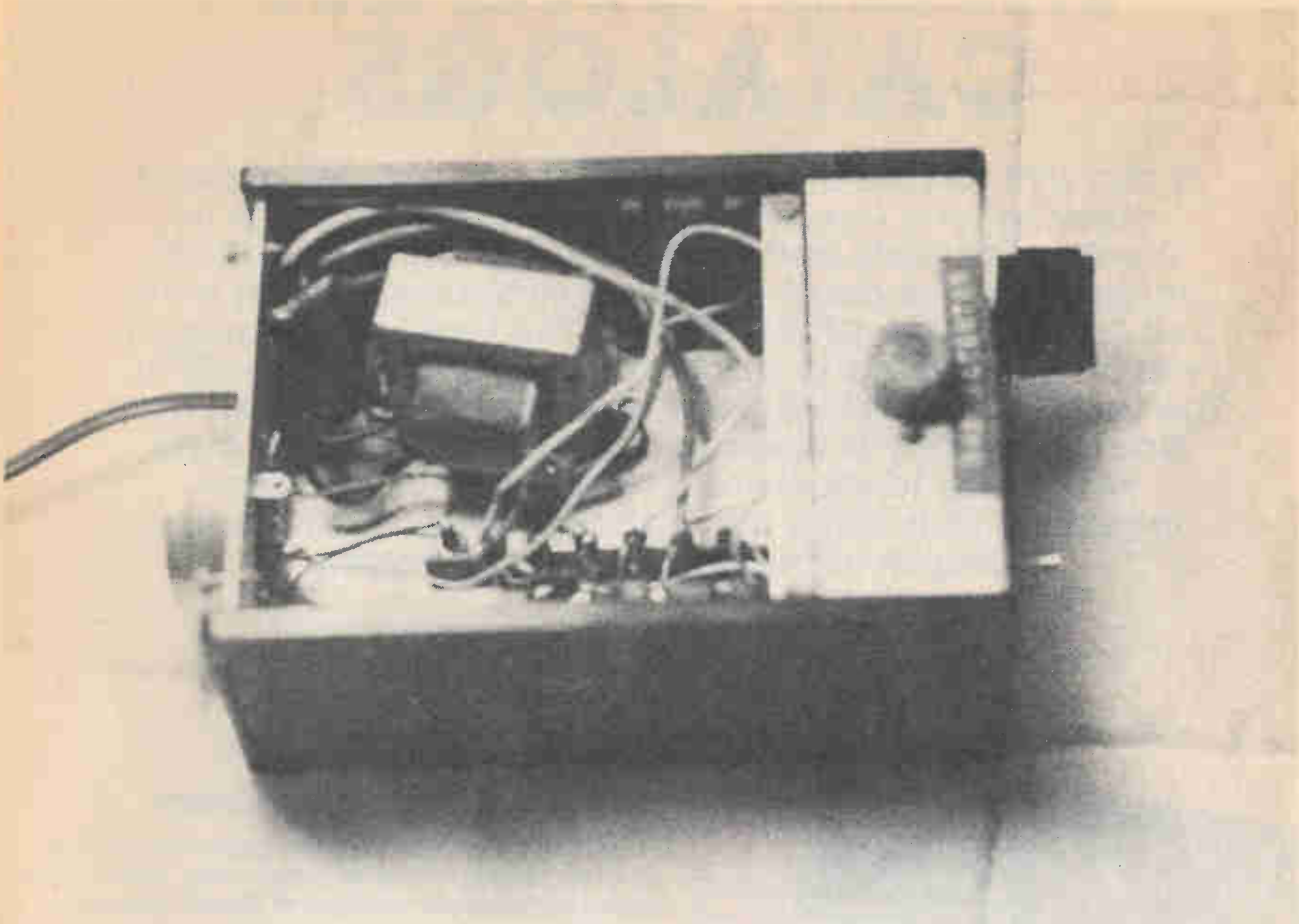


Figure 3. This view of the alarm chassis shows the terminal mounting strip (middle bottom, below the power transformer) on which resistors and small capacitors are mounted. Most of the other connections are made on this strip, too.

(SCR) triggers when the resistance of the gas sensor element is low enough to provide approximately 0.3-Volts at the SCR's Gate terminal. The piezo electric buzzer periodically interrupts the current flow so that the SCR does not latch; the buzzer can be silenced by simply turning down the CAL control. The LED shown whether the AC power or the stand-by power to the circuit is ON, and that the Gas Alarm is operating.

Construction

This Gas Alarm project will easily fit in a 6″×4″×2½″ metal cabinet. All components except for buzzer and sensor element can be mounted on a perf board or on multi-lug terminal strips. The project is easy to assemble, as point-to-point wiring is perfectly acceptable. The schematic of the circuit is shown in Figure 2. Except for the sensor element all components are available from your local electronics store as per the Parts List. Mount the socket for the sensor on top of the cabinet for maximum exposure to surrounding air. Mount the buzzer on the side or back of the cabinet for best sound.

Operation and Setting

1. Plug the Gas Alarm into a 110V AC outlet.
2. Turn the CAL control fully counter-clockwise, for minimum resistance between the SCR Gate and ground.
3. Let the sensor stabilize for 1-2 minutes, then turn the CAL control clockwise, till the buzzer sounds.
4. Turn the CAL control CCW till the buzzer stops. The Gas Alarm is now ready for operation.

Testing it

Test the alarm by rubbing a drop of alcohol between your fingers near the sensor. When the buzzer sounds, repeat steps 2, 3, and 4.

The NiCad batteries are trickle charged when the alarm is plugged into an AC outlet. They will be fully charged after about 24 hours of operation. To test that the batteries are working properly unplug the Gas Alarm from the AC outlet, and then test it after a few minutes with a drop of alcohol as described above. The fully charged AA NiCad batteries should operate the sensor for over an hour in case of a power failure. For longer stand-by operation use C or D-size NiCad batteries. They will operate longer but will also require longer charging time. When the Gas Alarm is not in use, switch S1 OFF to protect the batteries from discharging. Whether S1 is ON or OFF the batteries are being charged if the unit is plugged in. ■

MAIL ORDER CATALOGS

If you live too far away to have ready sources of parts close by, you can send away for good catalogs of electronics parts and assemblies, many of them real bargains. We've dealt with most of the firms listed here, and have had no problems with the items we've bought, which have varied in price from under $10 to over $700. The most recent catalogs we've received in the mail from each company is described. Most send out new ones every four to six months, with many of the items repeated, plus some new specials usually on the first couple of pages and the last pages.

JAMECO ELECTRONICS

Several times a year this firm issues (free) a multi-colored catalog about 40 pages long replete with listing of solderless breadboard (Global Specialties) and other parts for experiments and constructors, lots of the more popular integrated circuits and LEDs, displays and modules, transformers, plugs and cases (many on sale), builders special hand tools, switches (lots of 'em) and more.

Jameco also has a good supply of boards, components and disc drives for Apple and IBM-compatible micros. You can build your own with their components and save plenty. **Jameco Electronics, 1355 Shoreway Road, Belmont, California 94002. Phone 415-592-8097.**

DIGI-KEY

Integrated Circuits, IC Sockets Connectors, Switches, Relays and especially precision stuff not readily available elsewhere. Nearly a hundred pages of components in this industrial supply catalog list parts you may have trouble locating elsewhere. They also have a few pages of current surplus switches, capacitors etc. which apply to limited quantities.

These people are really well-organized. For example, unlike most "parts" firms, they have a helpful Index on the front cover listing over one hundred categories of parts for easy location on the pages inside. For parts you can't find anywhere else, try Digi-key, especially integrated circuits and precision resistors and other components. It's easy because you can call 'em toll free. **Digi-Key Corporation, Box 677, Thief River Falls, MN 56701, or call Toll-free 1-800 DIGI-KEY.**

RADIO SHACK

Along with Apple, Radio Shack was into home computers before anyone else. For years they sold only their own TRS-80 units (Tandy Radio Shack-1980 ?) and they were very good. RS resisted IBM's lure for several years. Even after IBM's much-touted PC Jr. went down the tube they resisted. But a couple of years ago RS gave in and today their Tandy 1000 (an IBM "Clone") is one of the best buys available maybe THE best. Currently it's being sold at less than $700 (minus monitor and software, one disc drive) in RS stores; a great value which even today would cost you nearly twice as much from Big Blue (IBM).

If you have an RS computer store or Computer Center nearby you can't go wrong if you want to get into computers. Their Color Computers are an even cheaper way of getting into computers, though they're not IBM compatible. Neither are Apples, nor many other superior machines, Computer Centers and other Radio Shack stores usually have catalogs in stock. Otherwise, write to **Marketing Dept., Tandy Radio Shack, One Tandy Center, Fort Worth, TX 76102.**

HEATH KITS

104 pages crammed with terrific electronics. You've probably already seen their catalog. If you haven't, you should know they make and sell more kits than everyone else put together. Included are ham radio (everything from starters to the most elaborate), automotive tuneup and test gear, computers (expensive), fishing & boating instruments, robots (Hero) selling from $300 to over $2000, TV sets (the best) and satellite TV systems and parts (tops); lots of 'scopes & other top-drawer test equipment.

This catalog is worth having just to read, even it you're not ready to buy their great stuff yet. You can order their stuff toll-free from 1-800-253-0570 and they have (not free) telephone help on-line if you need any with their kits. I've put together at least 10 of their kits over the years, with never an unsoluble problem. **Heath Company, Benton Harbor, MI 49022.**

MORE GOOD SURPLUS

Surplus power supplies which include box fans for less ($9.50) than the cost of the same fan alone; Jerrold remote TV controls (58 channels) you can add to your non-remote television set, for under $70; automobile windshield washer pumps for $3.99; solar panels and components; factory closeout varactor TV tuner assemblies for $5.95; 1200 foot mylar tape recorder tape on 7-inch reels 69 cents (!); transistor amplifier stereo chassis needing only power supply $3.95; automatic telephone dialer system $9.95; dozens of other small and large surplus (and some new) items at great savings. You must know what to do with 'em once you get 'em. But you can't lose much money because they cost so little, considering what you get. Their newspaper-sized catalog is mailed free, irregularly. **Etco Electronics, North Country Shopping Center, Plattsburgh, NY 12901. Telephone 518-561-8700.**

SUPER SURPLUS...FER SURE!

American Design Components is a highly descriptive name for this New Jersey surplus house. Though they sell many other electronic items at super bargain prices, they specialize in close-outs of power supplies, keyboard, disk drives etc. Currently they are offering most of the components of the ill-fated Adam Computer from Coleco. It sold for $800 new, and was a great buy if the one you bought worked. (If not, the company did stand behind it, by they way). However, their quality control wasn't great, so Coleco sold off thousands of parts and here lots of them are; Adam's printer, $70; the whole system, minus printer and cabinet, $99. Adam cassettes, 13 for $19.95. Nine-inch video monitors $20 (no case), muffin fans for $6.00, and so on. Get their catalog by Calling **Toll free 1-800-524-0890 (or locally in NJ, phone 201-939-2710).**

ALL ABOUT ROBOTS

The point-to-point robot takes its name from the approach used to "teach" the robot a series of points and operations to be repeated on command. The robot's manipulator is moved to the desired point in space by means of manual controls, and the outputs of the position sensors are stored in memory.

Another group of servo-controlled robots is the continuous-path (CP) robot. These are the simplest robots to operate, and require the least knowledge of robotics on the part of the operator. It's far more important that the operator be skilled in the nature of the operation that the robot is to be taught. If the robot is to be used for spray painting, for example, the operator should be a skilled spray painter; if the robot is to be used for welding, the operator must be a skilled welder; and so forth.

The operator leads the robot through the task by moving the end-effector and tooling (a spray gun or welding torch in this example) while the robot control continuously records the position, orientation, and related operations. Since every motion of the operator is recorded any deviation from the desired path is also recorded—which is why it's important that the operator be skilled in the operation the robot is to perform. This method of programming is called *teaching* or *playback programming.*

The program recorded during lead-through can be played back from memory as often as required. An important additional feature is that the program can be replayed at speeds different from those at which it was recorded. Therefore, the cycle time can be varied as required, to compensate for changes in the manufacturing process.

Components of the Robot System

We have seen that IRs are available in a wide range of capabilities and configurations. However, all IRs include four major parts, which are as follows:

(1) The *manipulator*—the mechanical unit that actually performs the work
(2) The *controller*—the brain that stores data and directs the movement of the manipulator
(3) The *sensors*—the sensory system that connects the manipulator functions to the controller
(4) The *power supply*—the unit that supplies energy to the manipulator

The Robot Manipulator

The manipulator is a series of mechanical linkages and joints capable of moving in various directions to perform the work of the robot. These linkages and joints can likened to the limbs and joints of the human body. In the human body, motion is imparted to the limbs by a series of muscle fibers, while the joints allow the limbs to assume a wide variation in attitude and orientation. Not surprisingly, the robot operates a little differently!

In the robot, the linkages and joints receive their muscle power from mechanical actuators. These may be pneumatic or hydraulic cylinders, hydraulic rotary actuators, or electric motors. The actuators may either be coupled directly to the mechanical links or joints; or indirectly coupled through gears, chains, or ball screws. If the manipulator uses pneumatic or hydraulic actuators, the flow and direction of the oil or air are controlled by control valves mounted on the manipulator. Electric motor actuators receive their power from remotely-mounted power-control amplifiers.

The dynamic properties of a given manipulator include its stability, resolution, repeatibility, accuracy, and compliance. These characteristics depend upon the tool at the end effector and its function, the arm geometry, the accuracy of the individual servos, and the quality of the computer programs that perform the position and velocity computations.

What's Ahead

The programmable robot which can respond fully to changes in its environment is the ultimate robot of course. Robots who can understand spoken commands and answer "intelligently" as in the movie 2001, are on the way. But even when they appear to understand, it will only be to a limited number of commands. ■

ALL ABOUT CAPACITORS

Electrolytics

Many electrolytic capacitors are manufactured from two aluminum sheets separated by a satured paper layer (Figure 18). The paper is saturated with a special chemical called an *electrolyte,* and rolled together with the aluminum sheets and packaged in a compact roll. When the capacitor is manufactured, a dc voltage is applied to it causing a thin *oxide layer* to be formed on one sheet. This oxide is *very thin* and acts as the insulating dielectric between the two plates. One of the capacitor's plates is now the aluminum sheet with the oxide deposited on it (positive plate), and the other plate is actually the electrolyte, which is connected to external circuits by the second aluminum sheet. Since the oxide layer is extremely *thin,* very large capacitances are available in electrolytic form. Since the oxide is fairly fragile, only lower voltages can normally be used with electrolytics. But most important, because of the way electrolytic capacitors are constructed, they can never be used in ac applications. They are restricted to only dc or pulsating dc applications, and must *always* be wired into dc circuits in the correct polarity, positive terminal to more positive voltages, negative to more negative voltages. If wired in the opposite direction, the electrolytic behaves as a low-value resistor, and the capacitor may actually explode due to heat generated by large amounts of current flow through it.

A subgroup of electrolytic capacitors are called **tantalum** because they use tantalum instead of aluminum alloy for their plates.

Electrolytic Vs Oil-Filled

Often in electronics, large amounts of capacitance may be needed in a small space. Most standard fixed capacitors are limited to values of about 1 microfarad or less due to cost and size considerations. There are capacitors available, however, that use a special chemical action to cram a large amount of capacitance into a small space. These are called *electrolytic* capacitors. An electrolytic capacitor having a capacitance of 42,000 microfarads may be about the same size as a 10 microfarad standard oil-filled capacitor. A price is paid, however, because the maximum working voltage of electrolytic capacitors is usually much lower than oil-filled or other standard types. As mentioned, the maximum working voltage or WVDC of a capacitor is affected by its plate spacing and dielectric. If voltages on the capacitor's plates are higher than the WVDC, the dielectric will usually break down, allowing charge from one plate to pass through the dielectric to the other plate. When this happens, the capacitor is no longer properly functioning. With severe breakdown, the plates may actually short together, rendering the capacitor useless. A good rule of thumb is to choose capacitorsthat have a working voltage well above the highest voltage with which they will come in contact. ■

BUILD A SIGNAL CHASER

breadboard the mounting holes there happened to match exactly the holes on a small speaker I had on hand, and I was quick to take advantage of it. My third trick was to solder stiff wire (resistor leads I cut off some of the resistors in the circuit) to the breadboard end of the shielded probe cable. You may also want to use "headers," available from several sources and many parts stores for under a dollar a strip.

The rest of the assembly is fairly straighforward. Follow the lead of my layout, as shown in the photograph, when you lay out your own Signal Chaser—whether on a solderless bread-board, a PC board or whatever method you use.

Solderless Breadboards

In case you haven't tried solderless breadboards before, you may not know how easy they are to work with. The holes in the face of the breadboard are arranged on .1" centers (1/10th of an inch apart), which happens to be lead spacing on standard DIP (dual in-line package) integrated circuits and most other modern components.

The center channel (.3" wide) is just right for ICS to straddle. On each side of the center channel are groups of five holes (columns if you view the breadboard as widest on the horizontal , with the center channel running left to right). Behind each group of five holes is a spring clip with slits between the hole positions to allow a lead inserted into any one hole to be grasped firmly and independent, and interconnected with anything grasped at any other position in the group.

Each five-position terminal can be interconnected with any other by simply using hookup-wire jumpers.

The separate rows (at the top and bottom) are connected across their entire lengths and can be used for power or signal busses. I use them to carry the battery plus and minus lines.

Using Signal Chaser

For most run-of-the-mill signal tracing, clip the probe cable shield to a circuit ground near the area you're testing and touch the probe to each side of the signal path near each active or passive device in the signal path. Start at the front end and work your way to the output, if you like—but skipping a few stages on the chance they'll work can also help you localize a problem.

The high impedance of the Signal Chaser input means high sensitivity, which lends it to some useful applications .

You can attach a coil of wire or a magnetic tape head to the input to inductively probe circuits and devices. You can "listen" to the magnetic stripe on the back of your credit cards, amplify a telephone conversation or pick off the signal on your transmitter's modulation transformer.

Or attach a photocell to the input and listen to the sounds of light bulbs, LED readouts. the sun, street lights and then some.

Signal Chaser—not only a good introduction to solderless breadboarding, but once it's built you may find it to be one of the handiest gadgets in your electronic bag of tricks-of-the-trade. Have fun and chase those signals—and those problems—down!

CHIP-BY-CHIP

Fig. 2; the actual wiring in Fig. 1. If you have never worked with such a board before, the chips are inserted across the center groove. For each pin there then remain available four additional push-in wiring positions for that individual pin. Along both sides there are two vertical rows of continuous connections, or one for +V and the other for ground (zero VDC). Usually I use the inside row for +V and the outside for ground. Initially the chips will be mounted on the top half. In some later columns some chips will be mounted on the bottom half. In this case four additional short jumpers are needed to supply power to the bottom outside rows. This will be covered at the appropriate time. For the moment keep your circuit parts on the top half of the board.

Note the wires supplying power between plus and minus binding posts to the outside +**V** and **ground** rows. Connections are made with the battery wires by inserting banana plugs into the top of the red and black binding posts of the board. Do not apply power when making board changes. Always check the wiring twice before you apply power.

I have laid out Figs. #1 and #2 in the same way so that you can follow the schematic, and also observe how I make the same connections on the solderless circuit board. It will not be possible to do this in all cases, but it is a good idea for those who might be wiring their first solderless circuit board.

The frequency of the clock can be varied by changing the value of capacitor C1 or, by changing the values of resistors R1 and/or R2. A decline in resistance value raises frequency while an increase lowers frequency. Also an increase in capacitor value lowers frequency, and a decrease does the opposite.

Substitute a 10 mFD capacitor for C1. Now you must wait longer for the change over time between LED 1 and 2. The frequency in fact is reduced by a factor of approximately 10. Next substitute a 0.1 mFD capacitor. Note the high frequency output of the 555. Finally substitute the 0.01 mFD capacitor. Now the frequency change is so fast that the LED's can no longer follow the rate of change. Nevertheless the 555 is speeding along at a fast repetition rate. Clocks in computers and other digital equipment hurry along at rates in the high megahertz range.

Restore the value of capacitor C1 to 1 mFD. Substitute a 2.2 megohm resistor for resistor R2. What has happened to the output? Of course the frequency has lowered. Also observe the LEDs are on for approximately the same length of time. The 555 clock is now generating an almost square wave. Proper resistor values and a potentiometer will let you generate a true square wave at the output of each inverter, swinging back and forth with equal durations of logic 0 and logic 1.

Join us in the next issue with your clock and inverter, and we'll go to work on the very interesting 4017 divider/counter. The components you need are already included in the parts list of this column. Have a good time! ■

CHOOSING A VCR

help you get an apparently better picture by adjusting the picture to produce softer or harder edges. This control permits adjustment of the picture for the best compromise between sharp images and background noise.

Time-Shift Ability

How many separate programs can be recorded, and over a period of how many days, maximum?

On-Screen Programming Help?

This is a series of menus shown on the screen of your TV set which can walk you through the sometimes-complicated steps you must use to get your VCR set up to record programs when you can't be there. Such on-screen programming help is available only on the most-expensive sets, but if time-shifting is important to you, the added cost may well be worth it.

Slow-Motion.

Very useful if you like to review sports action.

Frame-by-Frame Advance.

Same as above.

Other Viewing Features

Backup Slow-Motion, High-Speed (Advance or Reverse) Viewing, and other features whose names are self-explanatory. ■

TANDY'S RADIO SHACK

but has been followed by later, improved models.

Improved Model 200

The Model 200 carries the same 24K memory, but has the popular MicroSoft *MultiPlan* spreadsheet software built into its permanent memory, and sports a forty-by-sixteen character liquid crystal graphics-capable display. The permanent memory also holds an improved version of the Model 100's resident word processing software, along with several useful organizational and time management programs. It too allows programming in BASIC, but in addition features a parallel printer port, RS-232 interface, and cassette and bar code reader interfaces.

Model 600

The top-of-the-line Model 600 adds a built-in 3½-inch, 360K disk drive to the portable package. The five time and organizational management software programs are there, along with the Microsoft *MultiPlan* spreadsheet, MicroSoft *Word* word processing, and MicroSoft *File* database programs. The direct-connect modem operates at 300 bps. A bevy of options and accessories are available for all three models, including external disk drives, RAM upgrades, carrying cases, acoustic couplers, printer and modem cables, a bar code wand, and an ac adapter. The software, some of which requires a cassette recorder or ROM socket upgrade, ranges in price from $19.95 to $149.95.

"THE DIGIMAZE"

by: Glenn M. Rawlings

It may have been awhile since you played one of these winding maze games, but they have always been popular in the comic books. You can go back to your youth again by going to START. Then find your way through the maze by choosing the correct output for each logic circuit. If you choose the wrong path, you will soon see that you are in deep trouble. If you choose the correct path, you will receive your just reward in knowing that you have great knowledge in basic digital logic. Only the correct combination of a 1 or 0 on the inputs will give you the right output path to reach FINISH.........Good Luck.