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ELECTRONICS HANDBOOK

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ELECTRONICS HANDBOOK

CONTENTS

OBJECTIVE WILL BE VARIETY

Welcome......to our second issue of the ELECTRONICS HANDBOOK! For those of you who missed our first (October) issue (the publisher has a few copies in his "shelf stock"), let me explain that it will be our objective in each issue of the ELECTRONICS HANDBOOK to present the kind of variety that we had previously published in our C&E Hobby Handbooks "series".

We will have a multitude of "projects", both simple and not-so-simple. They will involve all of the various components used in "transistor" circuits and "Integrated" circuits. Some will have practical applications, others will be for amusement and still others, will be left to the imagination and creativity of the reader. All will help to improve the skill and technique of the reader in working with electronics and will increase his understanding of the relationship of electronics to the fields of communications, robotics and computers.

Each issue will include articles that explain the theories as well as the mechanics involved in electronics. There will be articles on what is current in the world of electronics, how the reader can get more enjoyment from his electronics hobby, how he can build electronic devices for his home and car that will save him money and how he can profit from his hobby by applying his knowledge and experience to a career in the rapidly expanding world of electronics.

We think that we will have enough variety on electronic subjects in each issue to satisfy any reader interested in electronics and the fun of building electronic projects. Try some of the projects in the following pages and find out for yourself.

Don Gabree

Don Gabree, *—Publisher*

WANTED: PROJECTS

How would you like to find your home-brew project in the next issue of the ELECTRONICS HANDBOOK? It's up to you! Build your project for yourself....It should have a real purpose. Then, if you think it is good enough to appear in the ELECTRONICS HANDBOOK, letusknow about it.

Write us a short letter describing your project. Tell us what the project does. Provide us with a legible schematic diagram and a few black-and-white photographs of the project...photos are important. After we have read your letter, we'll let you know, one way or the other, whether we would like to purchase your article describing the project. Send your letter to:

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Only NRI teaches you to service and repair all computers as you build your own 16-bit IBM-compatible micro

Now that computers are firmly established in offices—and in homes, too—the demand for trained computer service technicians surges forward. The Department of Labor estimates that computer service jobs will actually *double* in the next ten years—a faster growth rate than any other occupation.

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FROM THE EDITOR'S DESK

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

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C&E HOBBY HANDBOOKS INC.
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AM STEREO, THE NEW KID REVISITED

In an earlier article, I discussed a fairly recent change in AM broadcasting, the transmission of stereo. Since I wrote that item, there have been some very remarkable changes that are noteworthy and should be passed along.

The biggest news is that a formal complaint has been filed with the FCC charging that the Motorola C—Quam system of AM stereo transmission causes the signal to exceed the permissible bandwidth for AM stations (20 Khz) when modulation levels are near normal operating levels. At the time of this writing, the FCC is conducting an investigation of its own to determine the validity of the charge.

The formal complaint was filled by Kahn Communications and that complaint has been followed by letters to the FCC by many broadcast engineers calling for a full and complete investigation. Indeed, the rules are very definite in the matter of bandwidth and are also a matter of international treaty. If there is a violation, it would seem to me that the FCC will have to see that changes are made.

Just a few years ago, another manufacturer of AM stereo broadcast systems was forced to remove all of its equipment from the air because of a relatively minor violation concerning distortion. On the other hand, bandwidth is not a minor item and if there is a problem in that area, immediate action is called for.

In other news, Sony has been marketing the XR-A33 AM stereo/FM stereo/cassette receiver for sometime now. I have one of the these in my van and it is a terrific piece of gear with all of the whistles and bells. Most important, it can receive all of the AM stereo systems that are on the air. In addition, Sony has announced a new "boom box", the model CFS-6000 and Sanyo is introducing the MW250. All of these units are "all system" AM stereo. That is, they will receive all of the AM stereo stations on the air.

That brings up another point. There are very few radios being sold on the market today that will hear all of the systems even though they are marked "AM stereo". I have yet to find a salesman that could tell me if the radio that I was inquiring about was limited in its capability. It was necessary to get out the owners manual and read it. Don't get stuck with a receiver that will not hear all systems. At the time of this writing. I can not find an "all mode" receiver at any of the car dealers that I checked and that included every manufacturer of US autos and most of the imports.

If you would like to tune in an AM stereo station in your area, you can do so by using two radios that have log type tuning. Digital wont work because they wont tune "between the cracks". To use this method, you will have to tune a station using the Kahn (or independent sideband) system. Since the right channel is on the upper sideband and the left is on the lower, tune one receiver slightly high in frequency and the other slighty low. There will be some fidelity degrading but the stereo effect will be apparent.

If the radios that you are using are not of good quality with at least 5Khz passband, then don't expect much from this experiment.

If you are unsure of the system that a station uses, a call to them will get you the information.
Good listening.

—Jim Keightley
Chief Engineer
KAPA

FM/TV Boosters?

I need to improve the TV reception of distant stations on our TV sets at home, and I also want to get better FM reception on the FM receiver in our car. My brother, who is studying for his degree in Electrical Engineering in college, says we won't get any noticeable improvement from an FM booster in our car, nor from a TV antenna amplifier in our house.

If he's right, how come the makers are allowed to sell gadgets that won't work? Or is my brother wrong?

Arthur Jameson, Sioux Falls, SD

Your brother is right, almost. An antenna booster can't improve the signal-to-noise ratio (less snow, more TV signal) at your TV sets unless it's mounted right up on the antenna, and unless it's in good working order. Installing such a booster at the set itself will only amplify the noise(s) picked up on the lead-in along with the signals coming from the antenna.

The same thing applies even more to car FM boosters, unless they're very narrow-band (and specially-tuned) amplifiers. In both cases, the best answer is a better antenna.

As for firms who make such units, maybe they believe their own advertising?

Better Crystal Radios?

I've built two crystal radios from articles in your magazine, but I can only get local stations. They both used modern diode (semiconductor) rectifiers instead of the original cats-whiskers. My Dad says crystal sets in the old days used to get great reception, at much greater distances than I do with my crystal sets. What gives?

Could I get better results using the old galena crystals (cat's whiskers)? Where can I get one? Why aren't they sold in Radio Shack, for example?

Roger Englander, Memphis, TN

It's fun to use the old-time parts, but this is one case where older is not better. Any modern diode rectifier (small-signal type) will do as well or better than the old, expensive, and difficult-to-adjust cat's whiskers.

In the old days there were only a few stations on the air, hence much less interference. Also we used long-wire antennas outdoors, 25 to 100 feet long. These superior aerials pulled in much stronger signals. You can't get superior reception without a good antenna. You **can** *get some stations, but not at much distance, with a small indoor wire for your antenna.*

Keep On Truckin!

I share my electronics magazines with a friend who's also 15 years old. He likes only the electronic projects, which I find interesting, but I also want to learn what's going on with computers, which are still growing, in spite of the cutback in strictly "home" computers. He says it's waste of space to write about computers. Who's right?

E.L. Harris, Greenville, SC

Your friend is wrong, but that's his prerogative. Computers are a large and constantly-growing part of the electronic world. If he ignores digital technology (see the article on digital vs analog in this issue) he'll be out in the cold so far as a career in electronics goes.

Electronics Handbook *will continue to publish mostly articles on small parts projects. But we'll also keep you informed of important developments in computers and digital electronics, the electronics of today and increasingly of tomorrow.*

What's Desoldering?

Here I'm just learning how to solder small parts *together* in electronics projects and I begin to see the word *de*soldering. Does that mean what I think? To unsolder? And how in the world can it be done just in case anyone is crazy enough to want to try.

Jane Loring, Elizabeth, NJ

You're right, desoldering is just a way of saying Unsoldering parts. It's sometimes necessary, and there are ways of doing it that aren't at all difficult. Radio Shack and other stores have a wick-like copper braid which sucks up solder, and there are also vacuum bulbs and desoldering guns for people who do lots of construction.

Where to Find Parts

I live in small town almost in the middle of the desert, far from the nearest Radio Shack store, and I have to get everything by mail order. In addition, Radio Shack doesn't always have things I want, though I admit that's a bit unusual.

Can you tell me about catalogues I can order for stuff RS doesn't sell?

Samuel H. Ordway, Roswell, NM

I'm glad you asked that question, Senator. In this issue you'll find a list of parts houses and surplus firms and dealers who specialize in hard-to-find (as well as not-hard-to-find-but-best-buys) parts and electronics. Check 'em out; there are plenty of bargains out there if you look for them.

Pyramid Magic?

I see ads in magazines for little pyramids you can buy that claim to have magical powers; making you healthier, or stronger, or wiser. I can't believe these really work. Some also imply they have special magnetic properties. What's the story?

Frank Hutton, Sausalito, CA

You're right. Barnum said there's one born every minute. And there must be people out there lots more ready to believe fairy tales than you are, because somebody makes it worth while for those firms to keep on advertising those "magical" items.

Some people also believe that getting surrounded by special kinds of magnetic fields can extend one's life, or give one other magical powers.

In fact, many years ago a physician who had some success with hypnosis (his name was Mesmer, from which the word "mesmerize" comes; look it up) claimed magnetism could cure certain ills. He got some cures, but they were the result of the patient's belief, not the magnetism.

It's possible that birds (and other animal life) do respond to the earth's magnetism in navigating, finding their way home. There's still much to be learned about this phenomenon.

But people who look for magical cures should ponder this truth: "If an offer sounds too good to be true, it probably is."

Monitor is TV set

We're buying a new monitor for our home TV entertainment center, probably one 25 inches in diameter or even larger. Can it be used with our computer system as well as with our VCR tape setup? And why do monitors cost more than TV sets.

Ray Mosher, Evanston, Illinois.

Your monitor can be used with any input device, such as a VCR, video disc player, or computer, which puts out a video signal, as compared to a radio-frequency signal.

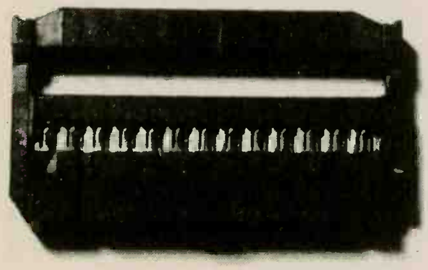
A monitor is a TV set without the RF and IF stages (radio frequency tuner and intermediate frequency amplifiers). It should logically, therefore cost less than a TV set of the same size. However, the economics of mass production and distribution are such that only a few thousand monitors are sold each year compared to several million TV sets. Thus a maker can sell a TV set for much less than a comparable monitor.

NEW PRODUCTS PARADE

FLAT CABLE CONNECTOR SYSTEM

MOUSER ELECTRONICS Announces a new line of high quality flat cable connectors with strain reliefs.

The ME164-9000 series flat cable connectors are a 3 piece system with strain relief which



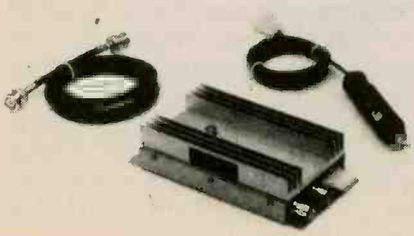
ensures long life. This system allows for lateral-cable insertion which speeds termination. These high quality connectors feature the new "POSI-LOK" locking clips which quarantee positive retention. These connectors are designed to permit tight cable folds and are available in all pin configurations.

A 20 pin connectors with strain relief may be purchased for as little as $1.49 in quantities of 500

Call or write for *FREE* full-line catalog! MOUSER ELECTRONICS, 11433 Woodside Ave., Santee, CA 92071 (619) 449-2222.

POWER AMPLIFIER FOR AIR-BAND TRANSCEIVER

Communications specialists has a 10-watt power amplifier, the CS10, that increases the transmitter power of the TR-720 Handheld Transciever from 1 watt to 10 watts (30 watts PEP). The CS-10 Power Amplifier is designed to be connected in series between the TR-720 Transceiver and an outside quarter-wave antenna on aircraft or ground vehicles.



Field tests have resulted in 5×5 communications over 150 miles at 10,000 feet using a stock TR-720 into an outside antenna through a CS-10 amplifier. The CS-10 requires a 11-15 volt DC power source and draws only 2.2 Amps. In case of a DC power failure, the TR720 will function normally "Straight through" for emergency back-up. The amplifier is furnished complete with a 5-foot power cord and fused cigarette plug. A 5-foot RG58 A/U coaxial cable with two BNC connectors is supplied for connecting the TR-720 antenna jack to the antenna output on the amplifier.

The CS-10 measures only 5.9-×3.0-×1.5 in. and weighs 12 ounces. Complete hook-up and maintenance instructions are included. The CS-10 Power Amplifier is priced at $199.95 and is avialable fof immediate shipment from factory stock. For more information or to place orders contact: Communications Specialists, Inc. 426 West Taft Avenue, Orange, California 922665. Toll free phone: (800) 854-0547. Local phone: (714) 998-3021.

COMPACT DISC PLAYER

Magnavox has added a super-compact portable unit (CD-9510) to its line of compact disc players. Measuring only 4.96-inches wide by 1.57-inches high by 7.46-inches deep, the unit is about the size of an average paperback book. Despite its small size, the Magnavox CD-9510 "personal" compact disc player offers many features and performance functions. A 10-track music memory and repeat are included, as well as forward-reverse track skip, forward-reverse music search, play-pause and a nine-function display.

The disc player can be used as an AC-driven home player, or as a portable player with optional shoulder strap, digital headphones, battery pack and carrying case. The player can be connected directly to a home Hi-Fi system (connecting cord included). Additional features include stop-clear, open door key, power key and mode key. Ther is also a REM (REMAIN) key which selects the display of either elapsed or remaining time and a PRG (PROGRAM) key which stores or cancels tracks in the 10-track music memory. Suggested retail is $300 for the main unit including AC adaptor and connecting cord. The accessory pack, including battery pack, carrying case, shoulder strap and digital headset has a suggested retail of $60. Look for it at your neighborhood audio outlet.

RAIN GAUGE

A new, economical rain gauge kit, the ID-1795, has been introduced by the Heath Company. The ID-1795 Rain Gauge consists of an outdoor mounted measuring device and an indoor LED readout display unit. The outdoor unit uses twin buckets to magnetically actuate a reed switch. The number of switch closings are registered on the readout. This unit may be mounted on a roof, fence post or antenna tower. The indoor unit is housed in an attractive cabinet with walnut trim.

Rainfall is recorded in 1/100th's of an inch up to 9.99 or in 1/10th's of an inch up to 99.9 inches. The Rain Gauge can also be set to display in centimeters rather than in inches. A 9-volt backup battery powers the display during a power outage. In this situation the display will continue to count and record the rainfall readind but will not display the reading until regular power is restored. The ID-1795 operates on 115-volts AC.

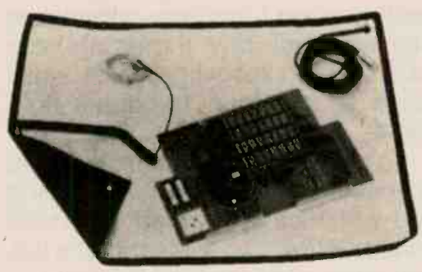
To receive the Heath Company colorful catalog free of charge, write Heath Company, Dept. C&E, Benton Harbor, MI 49022. In Canada write Heath Company, 1020 Islington Avenue, Dept. C&E, Toronto, Ontario, M8Z3. Free catalogs are also available at over 70 Heath/-Zenith Computers & Electronics Centers in the U.S. and Canada. Consult telephone directory white pages for the nearest store.

ANTI-STATIC WORK STATION

An anti-static work station that enables hobbyist to protect newest semiconductor products from static electricity is available from Wescorp. The WS-9001 home hobbyist work station includes an 18×24-inch workbench cover, adjustable wrist strap and grounding strap.

The benchtop cover is electrically conductive on both sides. One side (black) meets MIL specs for "conductive" materials required for protecting products sensitive to electrostatic voltage of 1000 or less. The other side (green) meets MIL specs for "static dissipative" materials for products in the 1000-4000-volt sensitivity range.

The mat is fabricated of conductive and static-dissipative fabric, exclusive to Wescorp, enabling it to be folded for storage in a drawer or toolbox. The adjustable wrist strap is of elastic polyester material for comfortable, secure contact with the wearer's wrist. Insulation on the outside of the wrist attachment protects the user against electrical shock from accidental contact with equipment. Stainless steel threads woven into the fabric on the inside surface assure positive, low-resistance conductivity, corrosion resistance and cleanliness.



A buckle permit adjusment to any size without leaving a loose "tail". This eliminates the problem of non-adjustable elastic straps losing full contact when they stretch from long use. A 10-foot retractable conductive plastic cord is included. A banana plug is at the end mates with a plug built into the mat, conducting static electricity from the user to the mat and then to ground. A 10-foot conductive plastic grounding cord with an alligator clip connects to the opposite corner of the bench cover.

The wrist strap and ground strap have built-in 1-megohm resistors to protect the wearer and the circuit from contact with line currents. The resistors are molded into the cords parallel to the cord to prevent the resistor breakage that is common with previous wrist straps. Price of the WS-9001 anti-static work station is $39.95 and is available from Wescorp, 144 So. Whisman Road, Mountain View, CA 94041.

MOBILE ANTENNA MATCHER

MFJ Enterprises, Inc. announces the introduction of the MFJ-910, a mobile antenna matcher. This device lowers SWR by capacitive matching mobile antenna to 50 ohms. This results in more power out of the transmitter and into the antenna, especially if a solid-state rig is being used. The MFJ-910 matches mobile antennas 10 through 80 meters.

One of the best features of this mobile antenna matcher is that its base measures only 2½×2½ inches, so it can be tucked in a corner of a car trunk or mounted inconspiscuously with the mounting holes provided. Installation of the MFJ-910 is easy. Connect the antenna to the SO-239 connector labeled "out" and the transmitter to the SO-239 connector labeled "in".

This mobile antenna matcher retails for $19.95 each, and can be ordered directly form MFJ. Call toll free (800) 647-1800 to use your Visa or Mastercard, or send check or money order for $19.95 plus $5.00 shipping and handling to MFJ Enterprises, Inc., P.O. Box 494, Miss. State, MS 39762.

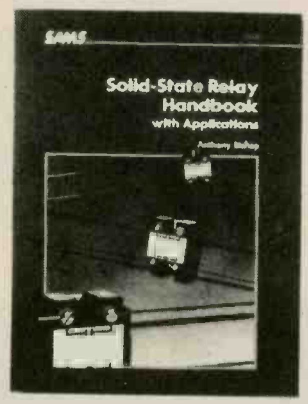
All MFJ products carry a 1-year full warranty, and items ordered directly from MFJ have an additional 30-day money back guarantee. If not completely satisfied, return the product within 30 days for a full refund (minus shipping).

NEW BOOK REVIEWS

ABOUT SOLID-STATE RELAYS

Here's a whole new subject area packed into an exciting volume—Solid-State Relay Handbook With Applications. This comprehensive, state-of-the-art handbook gives the reader an insight into solid-state relays—what they are, how they work, and how to select, specify, test and generally apply them. Suggested drive and protective methods are included with helpful application notes too stimulate design ideas.

Author Anthony Bishop introduces readers to solid state relays through a historical profile for an increased understanding of the technological developments and functions. Mr. Bishop is currently the Manager of Applications Engineering for the Crydon Division of International Rectifier, a leading supplier of solid-state relays. He is considered an authority in his field and has promoted the general application of the device.



This softbound handbook contains 250 pages of invaluable information for the engineer, technician or hobbyist who is now, or will be working with solid-state relays. Solid-State Relay Handbook retails for $19.95. The book is available through bookstores, computer retailers, electronic distributors, or directly from Sams by calling 1-800-428-SAMS, or by writing to Howard W. Sams and Co., Inc, 4300 West 62nd Street, Indianapolis, IN 46268.

ELECTRONIC PROTOTYPE CONSTRUCTION (WIRE-WRAPPING)

by Stephen D. Kasten. 398 pages, Paper.
$17.95 Howard W. Sams & Co. Indianapolis, IN 46268

This book is written for the hobbyist and experimenter who wants to learn the latest in converting schematic diagrams into practical circuitry and PCB (printed circuit boards) which may eventually lead to military and industrial production. However, the early Chapters, especially Chapter 1 (53 pages) are an essential introduction and exposition of the techniques of wire wrapping and similar methods of putting together boards using Integrated Circuits (ICs).

Most electronic devices include several (usually many) ICs, those marvels of miniaturization which each contain hundreds, sometimes thousands of tiny transistors, capacitors and resistors inside small chips less than a ¼ square inch each.

To pack these into small, practical spaces requires special assembling and connecting techniques which involve little or no soldering of wires and other parts. Instead they rely on wrapping wires around small *connecting posts* with a small hand-operated wire-wrapping tool. The tool can be either hand twisted or motor driven. Each has its advantages, though beginners should always learn by first using the simple, inexpensive hand-driven tool.

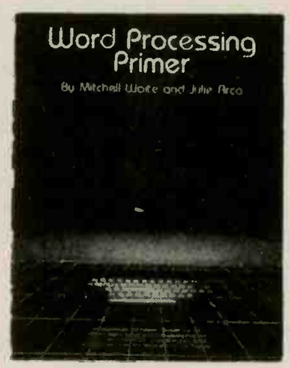
Wire wrap techniques are well suited for one-of-a-kind construction projects using integrated circuits because they are fast (no soldering), compact, and they can readily be rewired (changed) for redesign or correcting mistakes. This is done by *Unwrapping* one or more wires from the connecting posts. For anyone going beyond the one-IC-per project stage, wire-wrapping tools and practice are essential.

The book is a virtual encyclopedia of information (beyond Chapter 1) for converting designs into prototypes (one-of-a-kind or a few-of-a-kind) packaged boards which always go before production boards. It includes details of everything required from the simplest wire-wrapping methods (and unwrapping) through making PCB (printed circuits boards), and photographic methods for creating production-quantity boards.

If you haven't started doing wire-wrap yet, it's probably in your future. This book includes a *through* introduction and explanation of this *essential* skill.

Word Processing Primer
Waite and Arca
188 pages, paper, $14.95
Byte/McGraw-Hill,

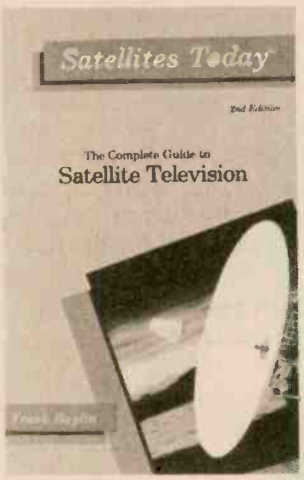
This was one of the first books (1982) written to explain word processing and to examine the microcomputer programs then available (some of them). It is thorough and exhaustive. Highly recommended as a background tutorial for serious students.



Note that it does not include many of the better programs (and worse) marketed since its publication. Nevertheless it's extremely useful in (a) learning a great deal about WP details, and (b) examining early versions of Worstar and other leading WP programs. The book also includes good suggestions on shopping.

UPDATING SATELLITES

Universal Electronics' second edition of Frank Baylin's popular book, Satellites Today, has been enlarged and contains the latest updated satellite information. The text is written for the non-technically



minded reader. The book reviews the history of satellites and explains in a clear and readable fashion the technology of transmitting to and from satellites.

Each chapter deals with specific topics, such as uplinking, footprints, programming, how the latest home satellite TV systems work, and much more. Satellites Today is necessary reading for anyone wanting to learn more about satellite systems and the satellite television industry.

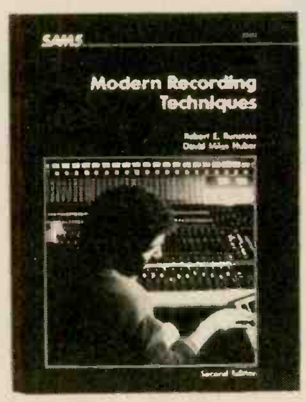
The text retails for $12.95, delivered. It can be ordered from your new book dealer or the publisher, Universal Electronics, Inc., 4555 Groves Road, Suite 13, Columbus OH 43232; or telephone 614/866-4605.

INSIDE RECORDING TECHNIQUES

Here's an excellent introduction to the field of professional recording! It's a new publication by Howard W. Sams & Co.—the second edition of Modern Recording Techniques.

A decade ago, Modern Recording Techniques was introduced to bridge the information gap between sound engineers, record producers and recording artists. Today, new technologies—including digital recording and processing techniques—have revolutionized this industry. The book provides an excellent introduction to equipment and controls found in a recording studio as well as the techniques used and their role in creating a finished product.

Modern Recording Techniques has been used as a teaching and reference manual by thousands of professionals in the increasingly popular music industry. This revised edition updates readers on the



numerous advances in professional recording.

This 384-page, softbound book retails for $18.95. The timely material is presented by two of the industry's most respected professionals, Robert E. Runstein and David Miles Huber—representing an extensive background as: performers, technicians, producers, and educators. The book is available through bookstores, electronic distributors, or directly from Sams by calling 1-800-428-SAMS, or writing to Howard W. Sams, and Co., Inc., 4300 West 62nd Street, Indianapolis, IN 46268.

ALL ABOUT CRYSTAL SETS

58 Pages, $7.75 (including Postage)
All-About, Books, Inc.
Box 4155, Freemont, CA 95439

This little book is a marvel of its kind. In less than 60 pages it not only tells you how crystal sets operate, but includes detailed plans for putting together seven different receivers, starting with the very simplest, and progressing through the best we've ever seen.

If you've wondered how those little wonders of yesteryear worked, without AC power or even a DC battery, this book will give you a complete education. It makes an excellent guide for Science Fair projects for grades five through high school.

Highly recommended.

PROTECTING YOUR MICROCOMPUTER SYSTEM

Harold Highland
Wiley Press, Inc.
New York, 1984
144 pages, Softcover, $14.95

A famous hippie (Abbie Hoffman) once published a book entitled, "Steal This Book!" This review will be brief. It could be summarized, "Don't buy this book." That would be the end of this review, but for the fact that you might fall into the trap thinking it can help you keep your *system* from being ripped off.

The book starts by telling about various software disasters, kid "hackers" who get into government files, and finally gets into keeping the system physically secure. Mostly it deals with software protection.

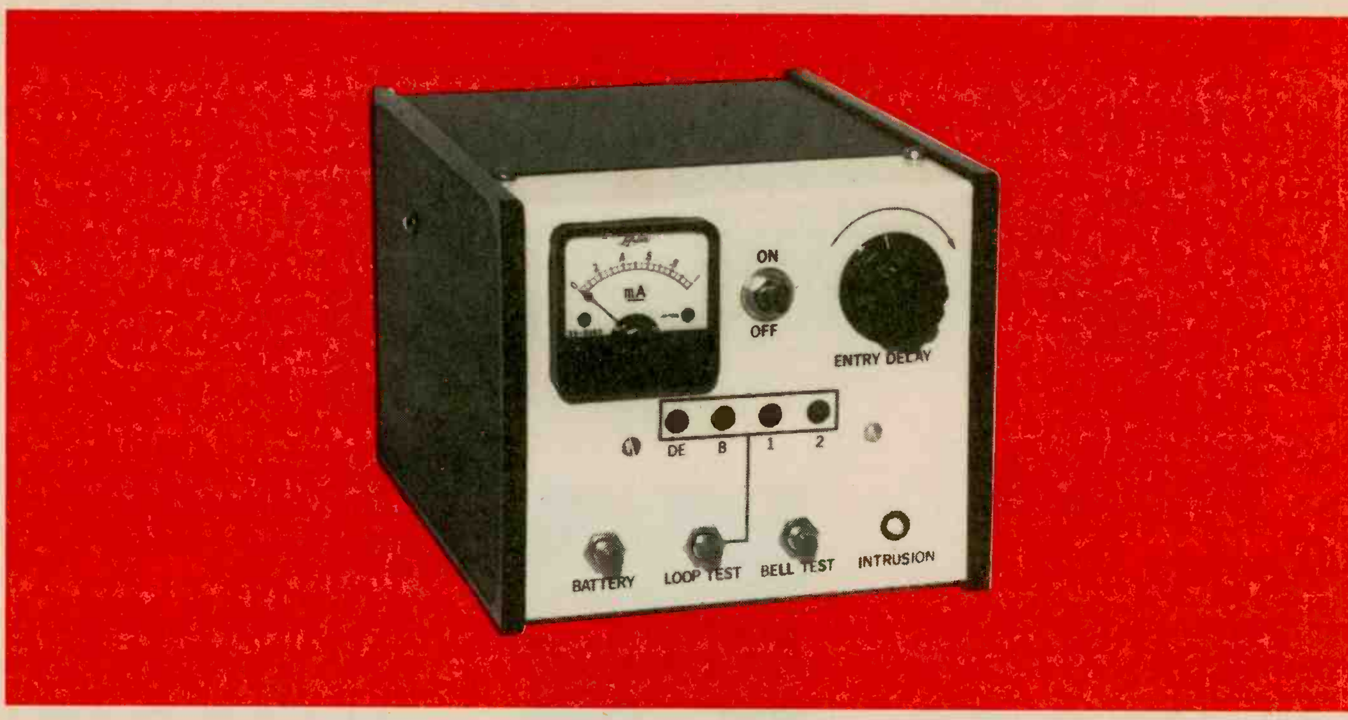
This brings me to a point I hope to make frequently to beginners and intermediate micro buyers and users: When you consider buying a book, read the Table of Contents. If it's *full* of strange words, it's too complicated for you. If you understand at least some of the chapter titles, look further.

To keep your computer system secure, insure it, as I have. My $5,000 system is covered against practically everything for $50 a year.

DELUXE HOME BURGLAR ALARM

Here is a home burglar alarm with optional features for your convenience, at a cost you can afford

by Walter Sikonowiz



There are plenty of burglar alarms available, including plenty you can install yourself. Here, the author, an engineer and designer of numerous projects for the home builder, presents a high-quality alarm system you can customize for you own particular installation.

As you'll see when you read on, you can set this system up for AC operation, or battery-only operation, or (even better) for AC operation with a high-reliability battery backup in case your area sometimes has blackouts, brownouts, or other power problems which could adversely affect the security of your alarm system.

It can be as simple as a one-loop system (just a door and one or two windows) or up to any number of separate areas. You can set it to give you a few seconds to leave (or enter) your home before the system is armed against intruders, or you can give yourself as much time as desired before the circuit is set to sound off.

Provision has been made for two other optional features. One, a Panic Button. It can be placed anywhere inside, and several can be included to make it easy to set the system off yourself should you encounter someone undesired inside the house. The other option permits over-riding one or more window (or door) sensors, for example, in the summertime when you may wish to exclude one or more windows for ventilation.

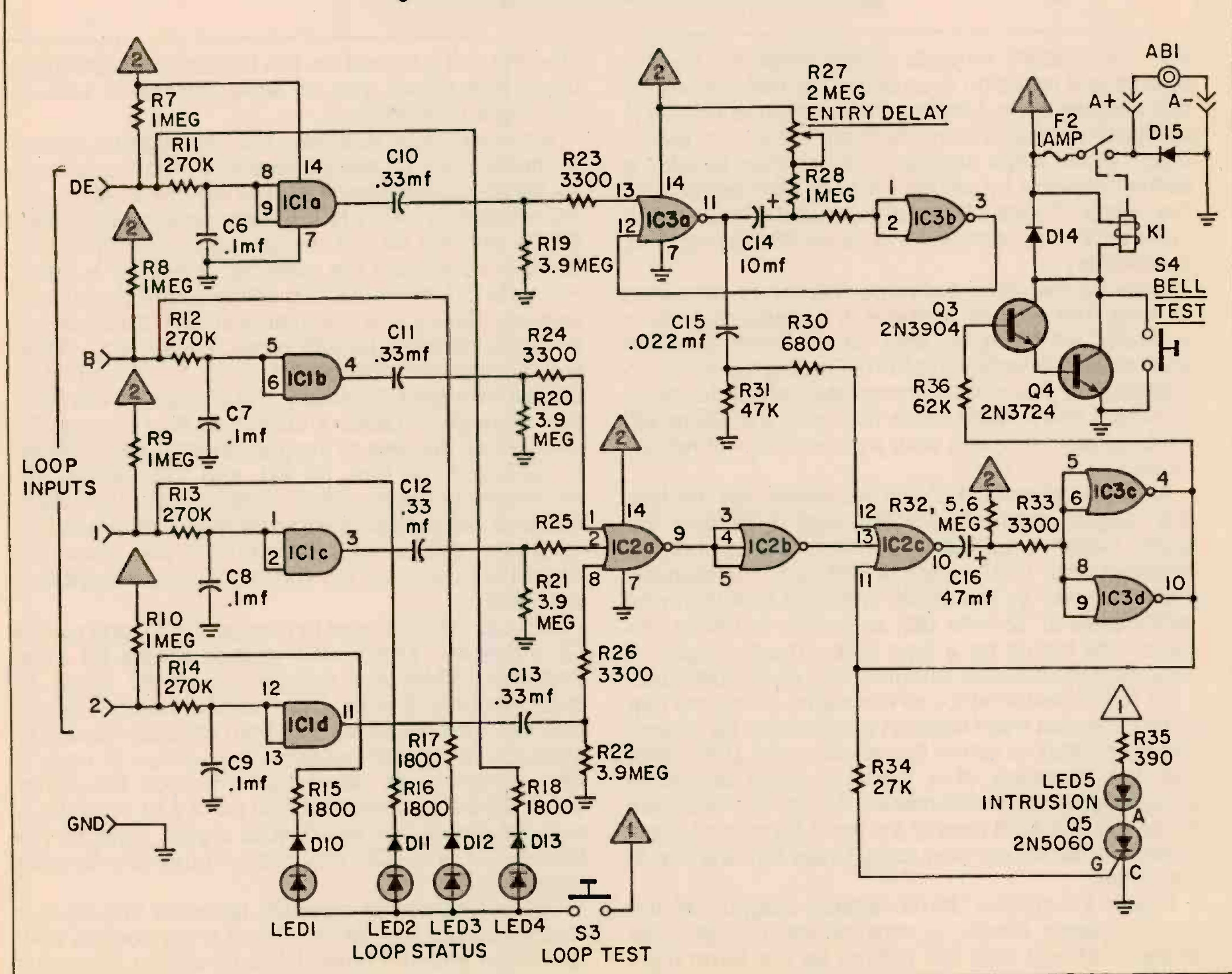
You can build it yourself on a perfboard, wire-wrap board, or use the printed circuit board layout provided here by the author. His parts layout, if followed will provide a truly professional-looking instrument, or you can throw the unit together in about an hour, not counting the optional power supply. What you do is entirely up to you. Whatever you do, when you've finished the Deluxe Burglar Alarm system, you'll have a setup which fits your own requirements perfectly.

The alarm presented here monitors four separate sensor loops, which allow a building to be divided into independent zones of protection. For example, the basement, first floor, and second floor can each be protected by separate loops. Note that one of the loops differs from the other three in that it provides a delayed response to entry, whereas the rest sound an alarm immediately after entry occurs. As you may have guessed, the delayed response-loop is usually wired to a door. When you return home, you enter through the door protected by the delayed-response loop, and turn off the system before the alarm bell rings. If you forget to turn the system off—and you will, at least once—pandemonium breaks loose several seconds later.

Not only is there a delay to let you enter the house, there is also a delay to let you leave without fanfare. Leaving is accomplished thus: First, turn the system on; then, with the aid of an LED display, check the status of the protection loops. Assuming that the loops are secure, exit the premises through any door, close that door behind you, and lock it. As long as you leave the house within one minute of turning on the system, no alarm will sound. After one minute, however, the system becomes fully armed, and any passage—whether incoming or outgoing—through a protected entryway will sound the alarm bell.

If an intruder triggers the system in your absence, the alarm bell clangs for two minutes and then shuts

Figure 1. Schematic diagram of burglar alarm



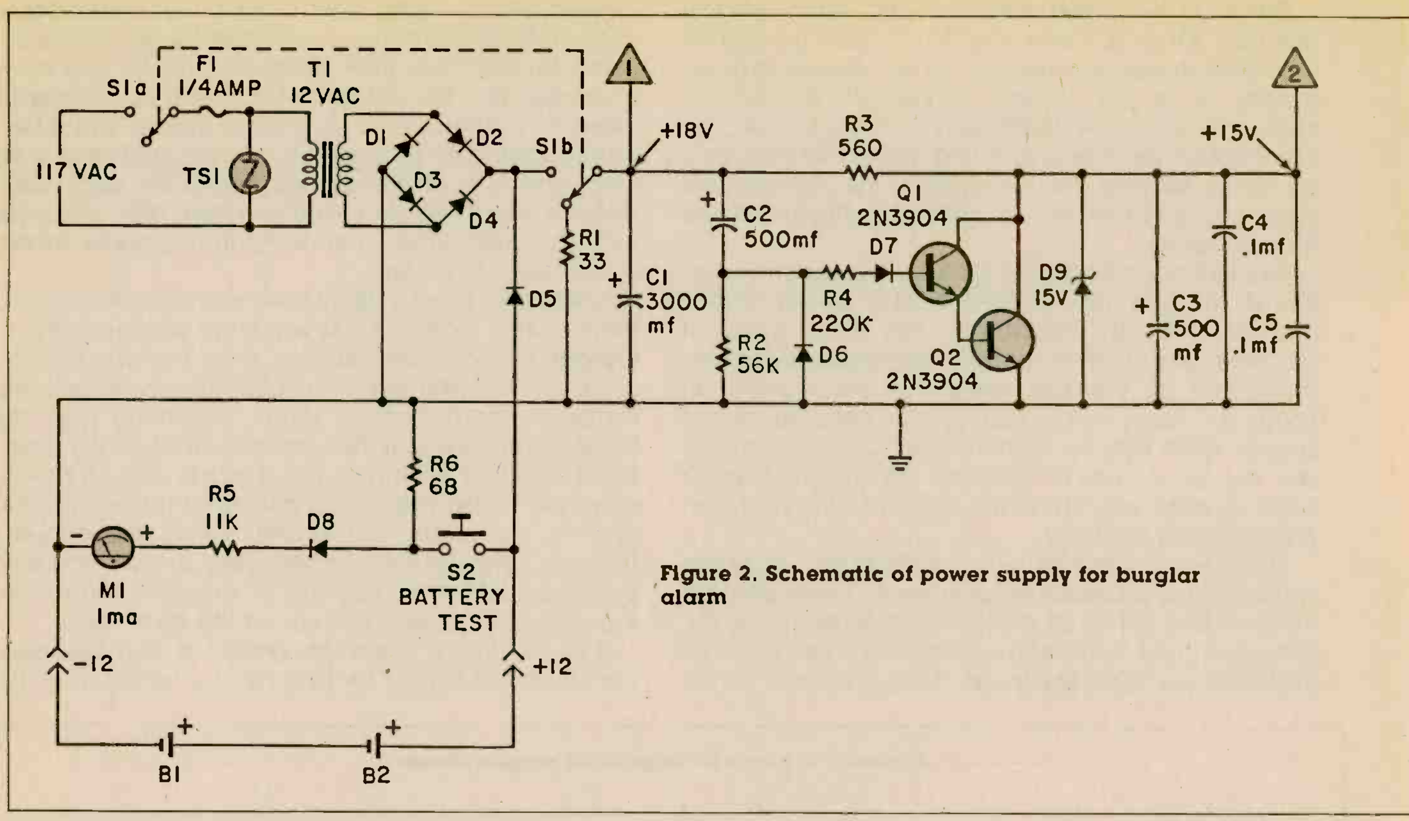


Figure 2. Schematic of power supply for burglar alarm

off. The system remains active, however, so if a subsequent intrusion does occur, the bell will ring for two minutes more. Limiting the duration of ringing is done primarily as a courtesy to our neighbors. By the time the bell stops ringing, your common burglar, a skittish creature by nature, will have scurried far from the scene. Those of you afflicted with hardier and more persistent vermin can increase the ringing time, if necessary.

Because the alarm bell rings only for a brief period of time, the system includes a separate intrusion indicator, which lights after an attempted break-in and remains lit until you return. Finding the intrusion indicator lit, you should immediately check for signs of forced entry. More often than not, the alarm will have done its job, and your possessions will remain intact.

An interruption of 117-volt AC power will not faze this burglar alarm. At the first sign of trouble, the alarm switches to battery power and remains so powered until line voltage is restored. The standby current drawn by the entire system is less than one milliampere at 12 volts DC; so lantern batteries can power the circuit for a long time—much longer, in fact, than the average duration of a power blackout.

As to the performance of this alarm, let me say that the system has been used on a daily basis for several years, and that no failure has yet occurred. Better still, just the presence of a working alarm seems to discourage most troublemakers. (A pair of Doberman pinschers will take care of the rest.) So much for the preliminaries; we are now ready to see how the circuit operates.

Figure 2 contains the schematic diagram of the alarm's power supply, a conventional design in all respects except one: DC voltage for the alarm does not become available until approximately one minute after the unit is turned on. It is this one-minute startup delay that allows you to leave the house without causing a commotion.

When switch S1 is closed, AC line voltage is applied to transformer T1, the primary of which is protected by transient supressor TS1. Current from the 12-volt AC secondary of T1 is full-wave rectified by diodes D1-D4 and fed via S1b to filter capacitor C1. Under no-load conditions the potential at point 1 is about +18 volts DC. Note that this voltage comes up almost instantaneously; it is the voltage at point 2 that will not be available for a minute or so. Here's why: When voltage appears abruptly at point 1, C2 begins to charge through R2. Initially, the voltage across R2 is high enough to cause a current to flow through R4 and D7 into the base of the transistor Q1. This current is sufficient to turn on Q1 and Q2 (which are connected in the so-called Darlington configuration, and thus behave like a single high-gain transistor). In response to base drive, the Q1-Q2 pair goes into saturation, clamping the voltage at point 2 to ground potential.

Now, as C2 continues to charge, the voltage across C2 increases, and so the voltage across R2 must decrease. When the voltage across R2 drops to approximately 2 volts, base current can no longer flow into the Q1-Q2 pair, and both transistors cease to conduct. Once that happens, the voltage at point 2 rises smoothly as C3 changes through R3. Zener diode D9 clamps the voltage at point 2 to +15 volts, a safe maximum for the CMOS digital logic of the alarm. C4 and C5 are high-frequency-bypass capacitors.

Take a look now at diode D5. Normally this diode is reverse-biased (i.e., its cathode is more positive than its anode) and no current flows through it. But let us suppose that the 117-volt AC line goes dead. Very

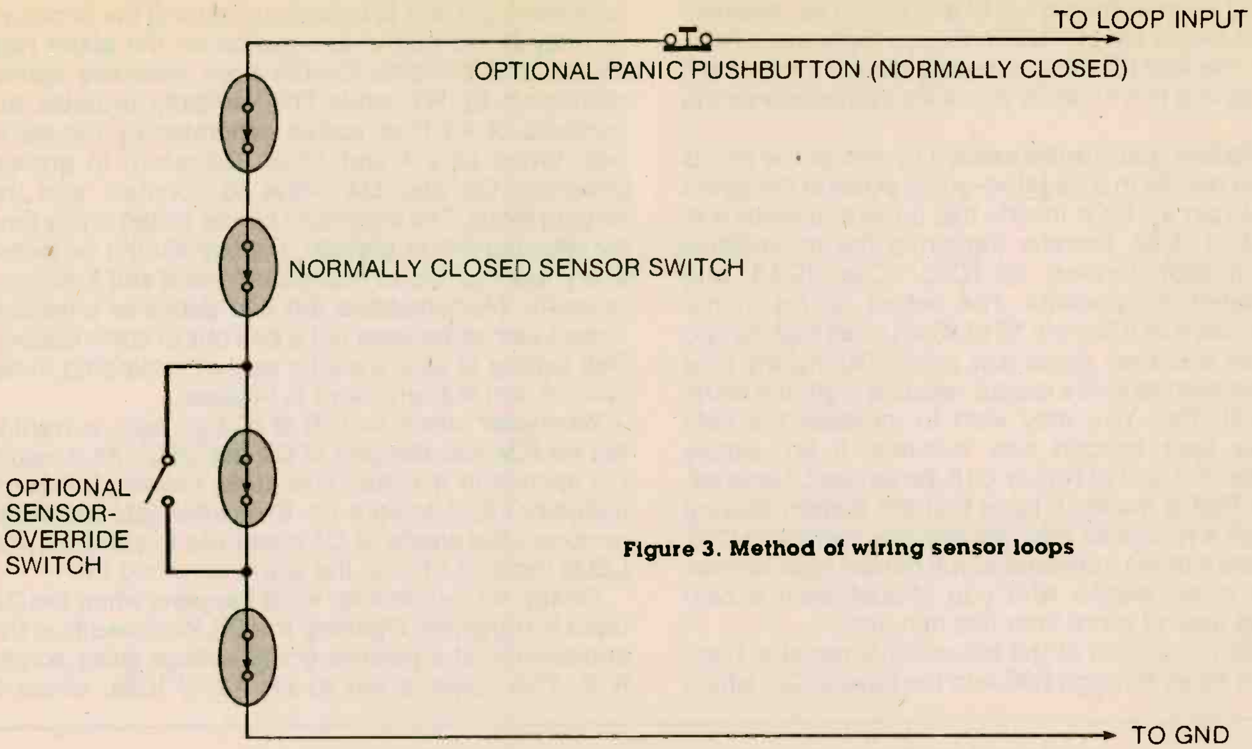


Figure 3. Method of wiring sensor loops

gradually the voltage on C1 will drop to a level about half a volt less than the potential of batteries B1 and B2. At that point D5 becomes forward-biased, allowing current to flow from the batteries and replenish the charges on C1. Running on battery power, the supply delivers approximately +12 volts at point 1 and point 2. Note that the batteries need not be used just to supplement AC power. If you were to disconnect the AC line, the alarm would work perfectly with batteries alone. In particular, the startup delay would occur exactly as described above, although the delay itself would be a bit shorter because of the reduced voltage.

The condition of the backup batteries can be tested at any time by pressing S2; this sends battery current through meter M1 (via R5 and D8) and through R6, which acts as a dummy load during testing. If the deflection of M1 drops below approximately 80% of full scale, it is time to replace the batteries. Testing should be done at regular intervals; once a month will probably be sufficient. Note that D8 protects M1 should you inadvertently connect the batteries in reverse (it happens).

One final comment in regard to the power supply: When the alarm is switched off, S1b contacts R1, which serves to rapidly discharge C1 and C2 (the latter through D6). Normal operation of the alarm requires that C1 and C2 be uncharged at startup. Without R1 to discharge the capacitors, anomalous behavior would result from turning the alarm on immediately after turning it off.

Let's turn now to the schematic diagram of the alarm, Fig. 1. The circuit shown has four intrusion-detecting inputs; each one of these must be wired to ground through a serially connected set of normally closed sensor switches. In the name of brevity, we call each set of sensor switches a *loop*, and each terminal to which a loop connects a *loop input*.

The various loop inputs are labeled as follows: DE (Delay after Entry), B (Basement), 1 (first floor), and 2 (second floor). The last three designations are purely arbitrary; as will be shown later, each input can be connected to any convenient set of sensors. Note that the DE input provides a delayed response to intrusion, whereas all the rest respond immediately. Be sure that you enter the house only through a door wired to the DE input.

Each time that the alarm is turned on, you should press S3 to test the loops for continuity. A loop becomes discontinuous when you fail to close a window or door, causing one of the sensor switches in the loop to open up. Not only does an open switch disable the loop, it also results in automatic triggering of the alarm once the circuit is armed (i.e., one minute after turn-on). So testing for continuity is important. If all of the loops are continuous, all four loop inputs will be grounded, and so LED1-LED4 will light up when S3 is pressed. Should one of the LEDs fail to light, turn off the alarm; find the open door or window and close it; then try the test again. Note that loop testing can take place immediately after the alarm is turned on; there is no need to wait one minute.

Let us now examine the response of the alarm when one of the immediate-action loops is broken. Since loop inputs B, 1, and 2 are identical, we need to consider only one of them. Normally, loop input 2 is held at ground potential by the loop it monitors. Any noise picked up by the loop, which can act as an antenna, is filtered out by R14 and C9, thus preventing false triggering of the alarm. (Typical sources of noise include large electric motors, lightning, and radio transmitters.)

When loop 2 is broken by an intruder, resistor R10 pulls the inputs of IC1d high. As a result, the output of

IC1d (pin 11) also goes high, sending a positive-going spike of current through C13 and R22. This positive-going spike is fed via R26 to IC2a, a triple-input NOR gate. Note that IC2a is connected in such a way that it will respond to a break in any of the immediate-action loops.

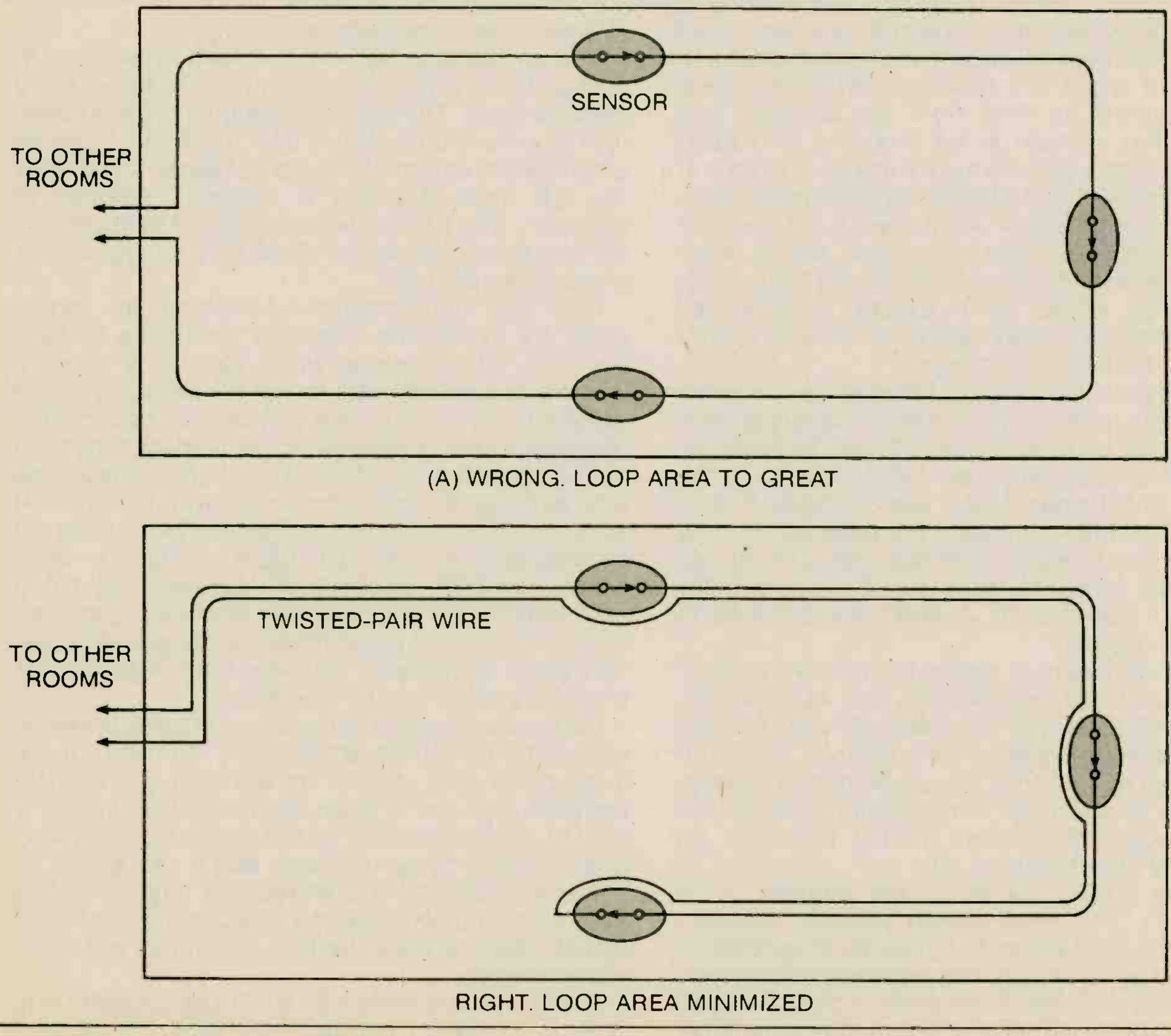
A positive-going spike sensed by one of the inputs of IC2a results in a negative-going pulse at the gate's output (pin 9). IC2b inverts this pulse and feeds it to pin 13 of IC2c, thereby triggering the monostable multivibrator formed by IC2c, IC3c, IC3d, and associated components. The output of this monostable (pin 4 of IC3c; pin 10 of IC3d) goes high for two minutes and then drops low again. During the time that the monostable's output remains high, the alarm bell will ring. You may wish to increase the bell-ringing time beyond two minutes; if so, simply increase the size of R32 or C16. Be advised, however, that if R32 is made so large that the current flowing through it is smaller than the leakage current of C16, the output of the monostable will remain high forever. There is no reason why you should want a bell-ringing time of more than five minutes.

While the output of the monostable remains high, current flows through R36 into the base of Q3, which forms a Darlington pair with Q4. As long as base drive is present, Q3 and Q4 conduct, causing the armature of relay K1 to pull in and switch on the alarm bell. Diode D14 protects Q3-Q4 from inductive spikes generated by K1, while D15 similarly protects the contacts of K1 from spikes generated by the alarm bell. When pins 4 and 10 of IC3 return to ground potential, Q3 and Q4 cease to conduct, and the ringing stops. The alarm bell can be tested at any time by pressing S4. In general, the bell should be tested every few months to make sure that it still functions properly. (Accumulated dirt and debris or a nesting rodent can sometimes put a bell out of commission.) Bell testing is also a subtle way of reminding those around you that an alarm is in place.

Whenever pins 4 and 10 of IC3 go high, current is fed via R34 into the gate of Q5 (an SRC). As a result, Q5 latches in a conductive state, causing intrusion indicator LED5 to light up. Even after gate current is removed, the anode of Q5 continues to conduct, and LED5 remains lit until the alarm is turned off.

Finally, let us consider what happens when the DE input is triggered. Opening the DE loop results in the appearance of a positive-going voltage spike across R19. This spike is fed to pin 13 of IC3a, where it

Figure 4. Method of room wiring to minimize noise pickup by sensor loop



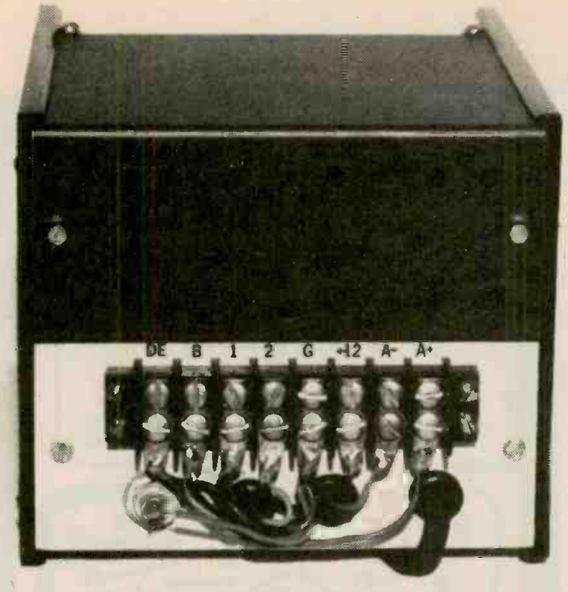


Figure 5. Rear Panel of Alarm Control

triggers the monostable consisting of IC3a, IC3b, and associated components. After a time interval determined by C14, R27, and R28, this monostable generates a positive-going spike that is fed via R30 to pin 12 of IC2c, thereby causing the bell to ring and LED5 to light in exactly the manner described previously. Note that the time lag between an intrusion and the ringing of the alarm bell can be st by means of R27; the delay varies between 5 and 15 seconds, approximately. If you feel the need for more time, increase C14 to 22 mf., which will yield an entry delay of 10-30 seconds. Bear in mind, however, that it is always best to use the shortest practical time delay. If an intruder forces his way in through a door connected to the DE loop, you certainly do not want him wandering around for 30 seconds before the alarm goes off. Mounting the alarm cabinet in a spot that is inconspicuous, yet still fairly close to the door guarded by the DE loop, will make short entry delays practical.

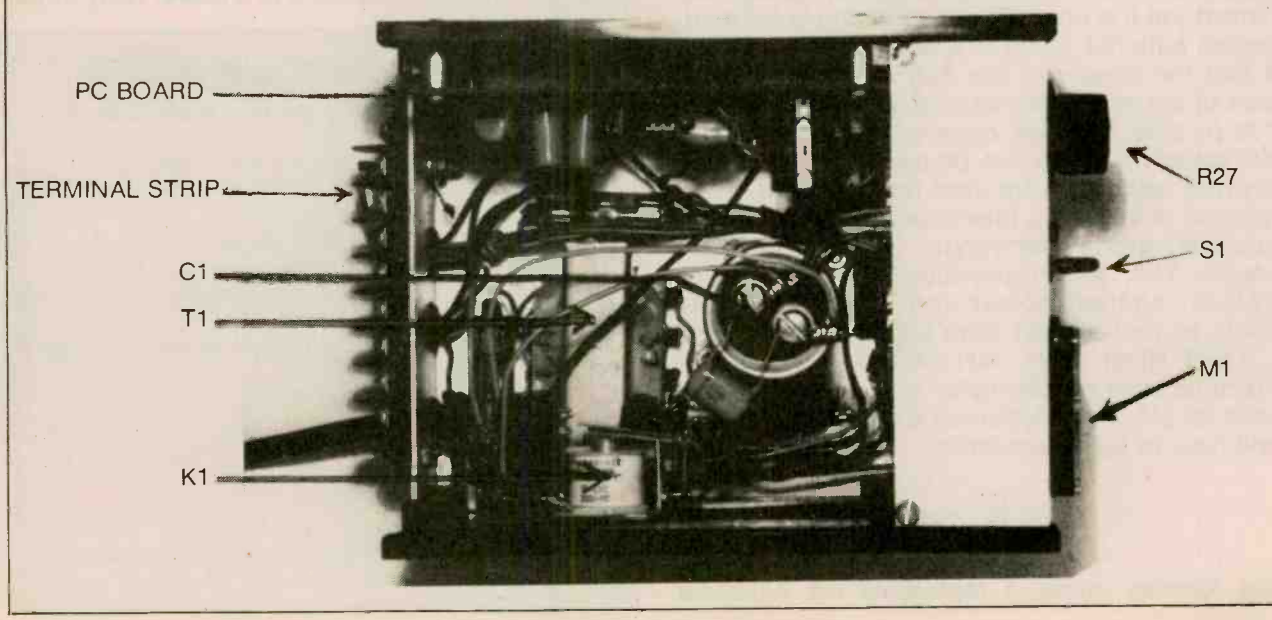
Figure 3 shows how the sensor loops should be wired. Any number of switches can be connected serially in each loop. Be sure that your switches are installed in such a manner that they close whenever the door or window they protect is closed.

Sensors come in a variety of styles, but the cheapest, most versatile, and more easily installed sensor is the familiar magnetically activated switch. Magnetic switches are of two kinds: those that close when a magnet is brought near, and those that open. For this project you will need the former type. Mount the magnet on a door or window; attach the switch to the framework in such a way that the magnet and the switch are in close proximity when the door or window is closed. That's all there is to it. Common lever-action microswitches also make good sensors, but you may have to fashion brackets to mount them.

Some windows in your home may require special attention—for example, basement windows or large picture windows that would be smashed, rather than pried open, by an intruder. Basement windows can be protected by means of self-adhesive conductive-foil tape, which is applied to the glass in a zigzag pattern. Breaking the window breaks the conductive tape and opens up the loop. Tape is reliable and cheap but far too ugly to use on a picture window. For that purpose you need a vibration detector: a small, inconspicuous device that attaches directly to the windowpane. If the window is hit hard or shattered, the shock causes the vibration detector's contacts to open momentarily. Vibration detectors, as well as all of the other sensors described in this section, are readily available items. Radio Shack carries them, and so do many mailorder dealers.

Returning to Fig. 3, note that one or more panic switches (normally closed pushbuttons) can be incorporated into a loop. If used, panic switches

Figure 6. Inside View, Alarm Control



should be distributed throughout the house and hidden behind drapes or furniture. The purpose of the panic switch is to allow the alarm to be tripped intentionally. For example, you might hit the panic button if you saw a prowler lurking outside (no sense waiting for him to break in).

Another optional feature shown in Fig. 3 is the sensor-override switch, which is wired in parallel with one of the sensors. When the override switch is open, normal sensor operation is obtained. But when the override switch is closed, the system will no longer respond to the affected sensor. For example, overriding a window's sensor would allow you to leave that window open for ventilation. Use override switches sparingly because they diminish, rather than enhance, a home's security.

When wiring the sensors in a loop, do so in such a way that the area of the loop is minimized (see Fig. 4). The smaller the cross-sectional area of a loop, the less prone that loop will be to pick up inductively coupled noise. The best advice here is to use twisted-pair alarm wire for all loops. The twisting of the two conductors keeps the loop area to an absolute minimum.

Sensors can be assigned to loops in any way that seems convenient. One possibility is to have all the sensors on a particular floor tied together in one loop. Another possibility is to put all the windows in one loop, all the doors in another. Remember that the DE loop is special: ideally, it should connect to just one door.

This is not a finicky circuit, and there should be little difficulty in getting it to work. To minimize noise pickup, mount the alarm in a metal cabinet, and connect the cabinet to circuit ground. Either printed-circuit or wire-wrapping techniques will give good results. If you copy the printed-circuit layout featured here, note that the board requires one jumper wire (marked with a "J"). Note also that the PCB was laid out for radial-lead electrolytic capacitors; axial-lead types will not fit. Use a small soldering iron rated at 15-25 watts and, of course, rosin-core solder. Since the circuit uses CMOS digital logic, which can be destroyed by static electricity, be sure to use sockets and insert the ICs only after all soldering is finished.

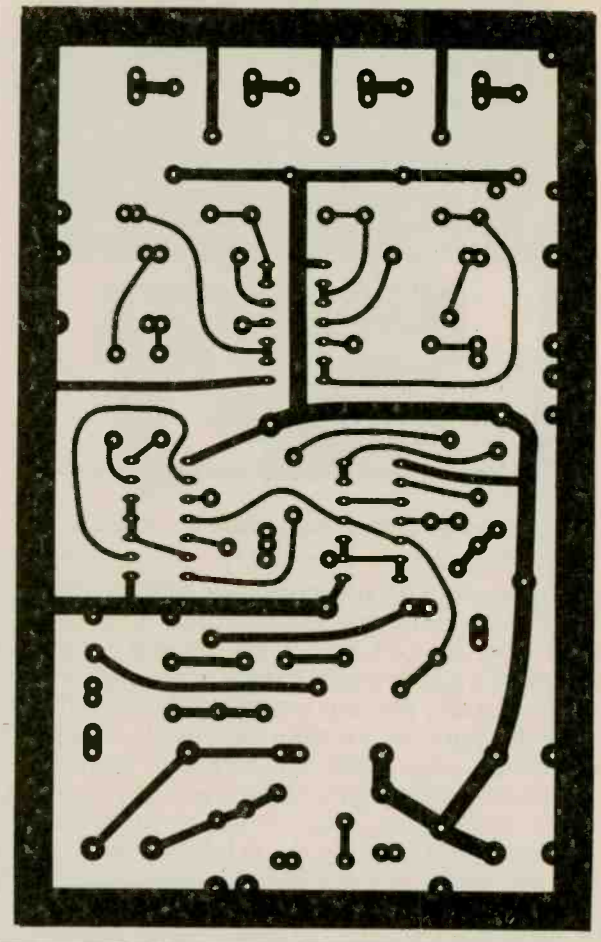
Lantern batteries come in a variety of sizes. Make sure that the ones you use can readily handle an ampere of current. Batteries should last a long time. Just to be safe, however, replace them once a year, regardless of how they test. Be certain that tantalum electrolytic capacitors are used for C14 and C16. In the interest of longevity, filter capacitor C1 should be a computer-grade electrolytic device. Transient supressor TS1, which provides some degree of protection against power-line disturbances, is available as part #P7064 from Digi-Key Corp. (Box 677, Thief River Falls, MN 56701). Almost any microammeter or milliammeter in your junkbox can be used for M1. If a substitution is made, the value of R5 will have to be recalculated:

$$R5 = \frac{12}{I} - Rm$$

In the formula above, I represents the full-scale deflection of the meter in amperes, and Rm is the internal resistance of the meter in ohms. Use the nearest 5% resistor value for R5.

Almost any 12-VDC relay can be used for K1 as long as its contacts are rated at more than one amp DC. Generally, the coil resistance of a power relay of this

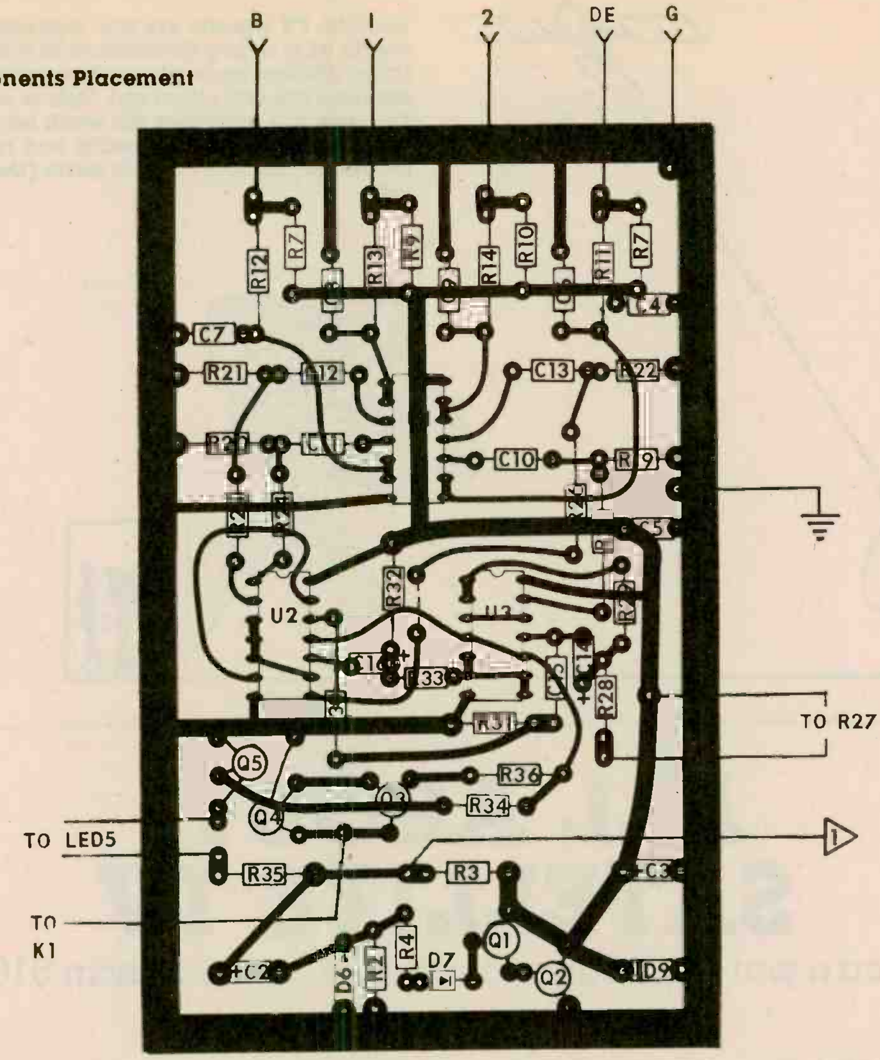
Figure 7. Main Circuit Board, (top view)



PARTS LIST FOR POWER SUPPLY

B1, B2—6-volt heavy duty lantern battery, Eveready type 706
C1—3000 Mfd 25V computer grade capacitor
C2, C3—500 Mfd 25V
C4, C5—0.1 Mfd ceramic
D1-D6—1N4003 200V, 1-amp silicon rectifier
D7, D8—1N4148 silicon diode
D9—1N4744 15-volt 1-watt zener diode
F1—¼-ampere slow-blow fuse
M1—1-milliampere, 1000-ohm, DC panel meter (see text)
Q1, Q2—2N3904 NPN silicon
R1—33-ohm
R2—56K-ohm, 5%
R3—560-ohm
R4—220K-ohm
R5—11K-ohm, ½-watt, 5% resistor
R6—68-ohm, 5-watt, 10% wirewound power resistor
R34—27K-ohm

Figure 8. Components Placement (top view)



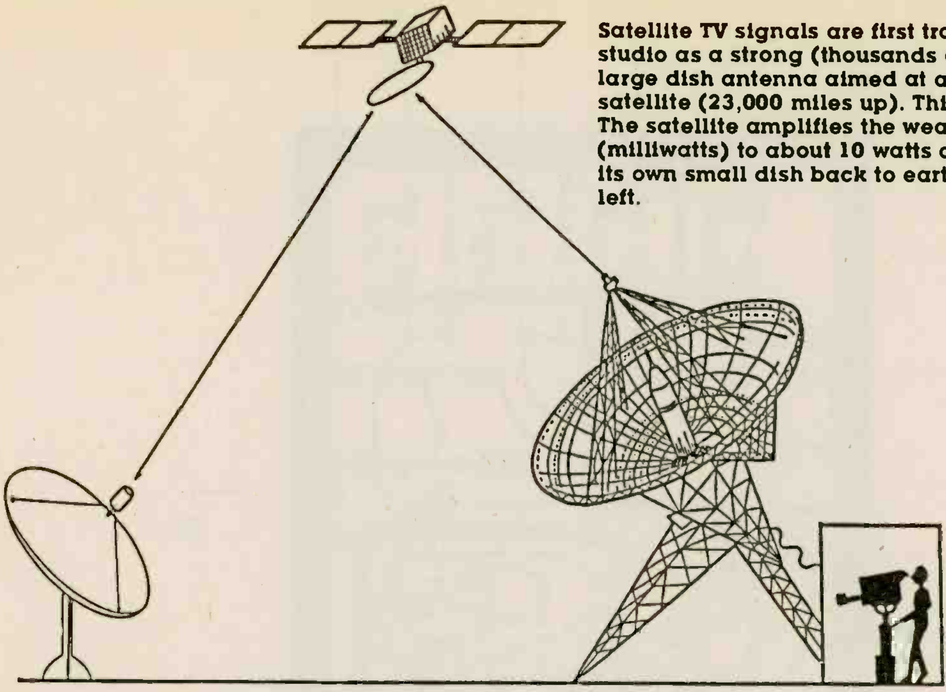
type will fall in the range of 100-200 ohms. The relay in the prototype has 13-amp contacts and is available as stock #TM21K628 from H&R Corporation (401 E. Erie Ave., Philadelphia, PA 19134). If this relay is used, its sensitivity will have to be adjusted. (The relay as shipped will not pull in at 12 volts, although it will hold at that potential. This is typical relay behavior.) Examining the relay, you will see that its armature flops up and down between two stationary contacts. With the relay upright, take the needle-nose pliers and bend the upper stationary contact downward a bit so

(Continued on page 96)

R35—390-ohm
R36—62K-ohm
S1—DPDT toggle switch
S2—normally open pushbutton switch
S3, S4—normally open pushbutton switch
T1—12 VAC, 1-ampere transformer
TS1—130 VAC transient supressor, Panasonic type ERZ-C20DK201 (see text)
Miscellaneous: cabinet, knob, terminal strip, line cord, hookup wire, fuse holders, magnetic switches, twisted-pair wire, IC sockets, press-on decals.
Note: Resistors are ½-watt, 10% except where otherwise specified.

PARTS LIST FOR BURGLAR ALARM

AB1—12-volt DC alarm bell (see text)
C6-C9—0.1 Mfd ceramic capacitor
C10-C13—0.33 Mfd mylar capacitor
C14—10 Mfd 20V tantalum electrolytic
C15—0.022 Mfd mylar capacitor
C16—47 Mfd 20V tantalum electrolytic
D10-D15—1N4003 200 PIV, 1-ampere silicon rectifier diode
F2—1-ampere slow-blow fuse
IC1—CD4081B CMOS quad AND gate
IC2—CD4025B CMOS triple 3-input NOR
IC3—CD4001B CMOS quad NOR gate
K1—SPST 12-volt DC, 120-ohm relay (see text)
LED1-LED5—red LEDs
Q3—2N3904 NPN silicon
Q4—2N3724 NPN silicon
Q5—2N5060 sensitive-gate SCR
R7-R10, R28—1-megohm
R11-R14—270K-ohm
R15-R18—1800-ohm
R19-R22—3.9-megohm
R23-R26, R33—3300-ohm
R27—2-megohm linear potentiometer
R29—15K-ohm
R30—6800-ohm
R31—47K-ohm
R32—5.6-megohm



Satellite TV signals are first transmitted from the studio as a strong (thousands of watts) signals to a large dish antenna aimed at a geostationary satellite (23,000 miles up). This is called the Uplink. The satellite amplifies the weak received signal (milliwatts) to about 10 watts and retransmits it via its own small dish back to earth (the Downlink) at left.

ALL ABOUT SATELLITE TV

You can put up your own station for less than $1000.

Satellite TV reception—using a big circular dish in your backyard to grab TV signals out of the sky directly from satellites 22 thousand miles up in the sky—is here, and thousands of people are using TVRO (television *receive-only*) stations to pick up the dozens of otherwise unavailable programs now broadcast 24 hours a day all over the US and abroad, including foreign TV.

Even though Russia began using a satellite (Sputnik) in 1957 to relay radio signals from the sky, followed the next year by the US with the Air Force's Score satellite, it's only been since the late 1970s that ordinary citizens have been able to set up their own TVRO stations.

Recent advances in high-gain, low-noise amplifiers (LNAs) and down converters for signals in the "C" band radio frequencies (3.7 to 6.8 gigahertz) have made it feasible to assemble a TVRO system using off-the-shelf components so anyone can receive the many available satellite-relayed TV signals.

How It Works

Regular TV reception only works over direct line-of-sight distances. That is, the transmitting station's antenna and the receiving set's antenna must be within sight of each other. That limits standard TV (and FM radio) reception to just over the horizon, depending on how high the two antennas are. That's why New York City's TV stations are atop the 104-story World Trade Center. (They used to be on the Empire State Building.) And that's why people 40 or 50 miles from TV stations have their antennas mounted atop poles and towers from 30 to 50 feet high.

Now we have satellites that were shot into the sky on rockets and placed into *geosynchronous* orbits. The satellite is revolving around the earth at the same speed as the earth turns, thus being synchronized with it and staying put over the same spot on earth all the time. It happens that the distance above the earth needed for an object to neither fall to earth nor fly free of the earth's gravity is 22,300 miles. So geosynchronous satellites are all placed into orbits at that height. Once up there, with electricity from solar cells to power the electronics which receive TV signals from earth and retransmit them back down to the ground, most satellite stations are good for 7 to 10 years of service.

Power and Frequencies

Most satellite *transponders* (transceivers) work at microwave frequencies between 3.5 and 6 gigahertz (a gigahertz is a thousand Megahertz). Some are at higher frequencies, between 12 and 14 GHz. These two groups of frequencies are designated the "C" band (3.5-6 GHz) and the "K" band (12-14 GHz). The original TV program is transmitted from an Earth station using a large dish—up to 30 feet in diameter—at about 500 watts. By the time the signal has traveled 22,300 miles up to the satellite its power is enormously diminished. Only a few microwatts of power actually reach the satellite's receiving antenna which is also a dish. The satellite's transponder amplifies the TV signal and aims it back down to earth with a power of about five watts. This signal is again weakened a great deal, but the receiving antenna (dish) at one's TVRO station amplifies it. (It acts like a lens.) Special electronics at the TVRO further amplify the signal. Finally, that signal is sent to a special satellite receiver in your home which, in turn, feeds the TV set.

TV satellites cover most of the US, much of Mexico, and Canada. There are over 20 satellites presently sending TV programming down with more being added every few months. Each satellite carries 12 or 24 separate transponders. And each transponder can relay one TV program. This mean that 20 satellites have a capacity of well over 200 separate TV channels, since most (and all future) satellites have 24 instead of only 12, as the early ones did.

System Components

There are four main parts in a satellite TV receiving system. These are the dish, or antenna, the electronics at the dish, the electronics inside the house, and the TV set or TV monitor.

The part most people are familiar with is the big round dish, usually on the ground in one's backyard, but sometimes up on top of the house. These dishes are usually between eight and 10 feet in diameter, though some are even larger. The larger the dish, the more it amplifies the weak signals from the satellite, and the less snow and interference comes through on the TV screen. With a good dish and reasonably good electronics one can get TV pictures as good as the very best direct cable reception.

The dish is only part of the antenna it's a reflector, which gathers the weak satellite signals and concentrates them on the real antenna itself, which is at the focal point of the reflecting dish. The system requires two or more components, both electronic. After the signal has been received it is fed to a special Low-Noise Amplifier, or LNA. This is located right at the antenna dish. Putting it anywhere else would cause loss of signal strength, because of the high frequencies (C-band gigahertz) involved.

After amplification by the LNA, the strengthened C-band radio frequency is further amplified and its frequency down-shifted by a *down converter*. This does what the IF (intermediate frequency) section of a regular FM or AM radio does. It makes the signal stronger and changes its frequency from the station's frequency to a lower frequency which can be handled by the receiver more readily. In FM sets the IF is 10.7 Megahertz and in AM sets it's 455 Kilohertz. In TVRO systems this frequency, the output of the down converter is 70 Megahertz.

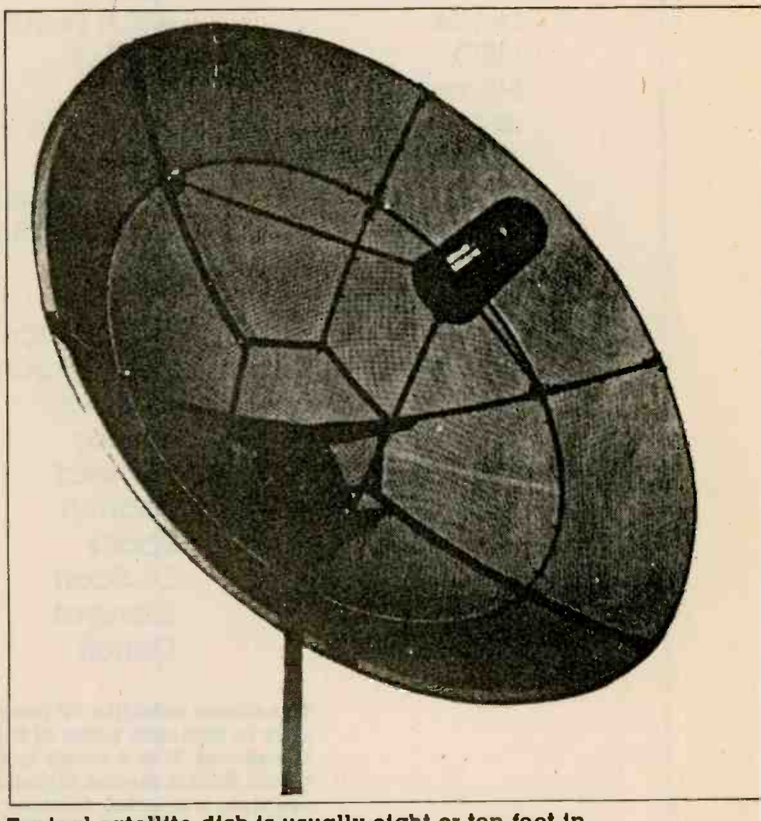
The 70-MHz signals is transmitted with less loss by standard coaxial (shielded) cable than are gigahertz signals. The 70-MHz output of the down converter is fed through a coaxial cable 20 to 100 feet long, to the TVRO receiver in the home.

Here the TV signals from the satellite (remember, there maybe up to 24 programs coming from any one satellite) are separated (tuned), amplified and sent to the TV set. For superior reception it's recommended that one use a TV monitor, which provides a better display than an ordinary TV set. Monitors cost the same as or more than top-grade TV sets. In the future, more and more people will be using monitor screens since they are also good for computer, videotape, and video disc viewing.

The Dish Antenna

Although the antenna dish looks as though it's a slice off a sphere, most satellite TV receiving dishes are actually parabolic-shaped. This is similar to, but differently shaped than, part of a sphere. This shape, which is used in the reflective mirrors in car headlights, takes radio waves coming in parallel to each other and reflects (focuses) them on a point very close to the surface of the dish, It is at this position, the focal point of the parabolic dish, that the actual antenna is located. This is a tiny length of metal, usually under an inch long.

The dish is made of stainless steel, aluminum, or metalized (covered) fiberglass, and its surface may be solid, or it may be wire mesh, to cut down on wind resistance. Using wire mesh also reduces the weight considerably.



Typical satellite dish is usually eight or ten feet in diameter. It serves as a high-gain antenna, gathering weak signals and reflecting (concentrating) them at the focal point just over center of dish. Concentrated, strengthened signal feeds a low-noise amplifier (LNA) which is then further amplified by downconverter, then goes via cable to receiver, indoors.

SERVICE	PROGRAMMING	SATELLITE	TRANSPONDER NO.
ABC (Central)	Network	Satcom 3	10
ABC (LA & NY)	Network	Satcom 3	12
Action (Can.)	Canada Sports	Anik D	2
Christian	Religious	Westar 5	4
Arm Forces	General	Satcom 1	20
Black Ent.	General	Galaxy 1	17
Cable News Net.	News	Galaxy 1	7
		Westar 3	5
Canada	French	Anik B	11
Canada	English	Anik D	24
CBS (Central)	Network	Satcom 3	2
CBS (LA & NY)	Network	Satcom 3	17
Cinemax	Movies	Galaxy 1	19
Christ. Net.	Religious	Galaxy 1	11
College Net.	Sports	Westar 4	20
Country Music	Country Music	Westar 3	18
Disney	Family	Galaxy 1	4, 24
ESPN	Sports	Galaxy 1	9
Galavision	Spanish	Galaxy 1	20
Hi Life	Adult (scram.)	Galaxy 1	21
HBO	Movies	Galaxy 1	23
Home Sports	Sports	Westar 4	4
JISO	Japanese	Westar 5	5
Movie Channel	Movies	Galaxy 1	10, 14
Music Network	Rock Video	Anik D	6
Nashville	Country Music	Westar 5	17
NBC	Network	Satcom 1	8
Nickelodeon	Children	Westar 3	1
On TV	Movies (scram.)	Westar 2	8, 22
Pleasure	Adult (scram.)	Westar 5	22
PBS	General	Westar 4	15, 17, 21, 23
Showtime	Movies	Galaxy 1	5
Silent (Deaf)	General	Westar 4	9
Spanish Net.	Spanish	Galaxy 1	6
Sportsvue	Sports	Westar 5	8
Univ. Network	Dr. Scott	Westar 5	2
WOR-TV	General	Westar 5	3
WXYZ-TV	Detroit	Anik D	10

The above satellite TV program listings are shown only to indicate some of the wide variety being broadcast. It is a small sampling, and changes often. Scram means signals are scrambled, and requires a special decoder to be viewed.

In addition to the (small) LNA which amplifies the weak signals, the dish focuses on the antenna at its focal point, the down converter is usually located behind or near the dish. The antenna may be either fixed or movable. If it's fixed it can receive signals from only one satellite, though that satellite will have several transponders sending signals (different programs). Better systems have the ability to be aimed at any of several satellites. And thus they can bring in more different programs.

Before you install or purchase a TVRO system you must decide what programs you want. Then the satellites offering those programs are selected, and their position in the sky is noted. After that it's necessary to make an on-the-spot check of your backyard house and so on, to be sure you have an unobstructed (by trees, etc.) view of that satellite. Of course you can't actually see the satellite but the position(s) in the sky of the satellite are well know and are on charts readily available.

Table I shows a few of the more popular satellites and their positions in the sky. All present satellites are located around the earth in a straight line over the equator called the equatorial plane. Thus it is only necessary to know the longitude above which satellite is positioned, to know where in the sky it appears. All TV satellites are now positioned between 75 and 145 degrees west longitude. In addition to the position of the satellite, we must consider the location of the TVRO relative to the equator and directly (longitudinally) under the satellite, one's dish would be aimed directly overhead (90 degrees). Since the entire US is well north of the equator, we have to aim the dish below 90 degrees (elevation, it's called). In the US this works out to an elevation of between five and 70 degrees.

In addition to having a clear view of the satellite(s) one wants to receive, there must be no overhead power lines in the line of sight, as they will usually cause severe interference with the tiny satellite signals. Since the dish not only weighs from two hundred pounds up, including its rigid steel mount, but it must be strong enough to withstand severe winds, rain and snow, the location, ground of rooftop, must be carefully considered.

Do It Yourself?

As you'll see from the TVRO system components discussed below, you can put together a system for as little as $2000, and you can go way up beyond that. In addition, installation can cost anywhere from a few hundred to a couple of thousand dollars. If you're very handy, and prepared to spend considerable time and effort, you can save most of the expense of installation. To do so, however, you'll have to read up a lot, and still get expert advice and help.

The following briefly describes the parts of a home TVRO system. There are actually four separate parts at the dish/antenna. One is a small *feedhorn*, which further concentrates the weak signals at the focal point of the dish. The feedhorn is directly connected to the *wave-guide*, which is a short rectangular piece of metal, and the waveguide feeds the signal to the very small (under an inch) metal *antenna probe*. This probe is the actual antenna.

Generally the feedhorn, wave-guide and antenna probe are supplied as a single assembly. Further, most manufacturers supply the antenna assembly along with the dish. However, these can be made up specially for higher sensitivity, at a higher price of course. If purchased separately from the dish, the parts of this assembly can cost from $200 up to over $500.

The biggest expenditure for any part of the TVRO station is for the antenna dish itself and its heavy steel support. Dish prices vary widely from as little as $500 for a six-or seven-foot diameter dish to $1500 or more for a 10-foot or larger one. The steel support is often sold separately and can can cost as little as $200 or so for a small, fixed support, up to $1000 for a larger support which can be moved, by its own motor, to change satellites.

The Low-Noise Amplifier (LNA), usually mounted immediately behind the antenna probe, can cost from under $200 to a great deal over $500. Again, more money buys a better LNA. This is usually purchased separately from the dish/antenna assembly.

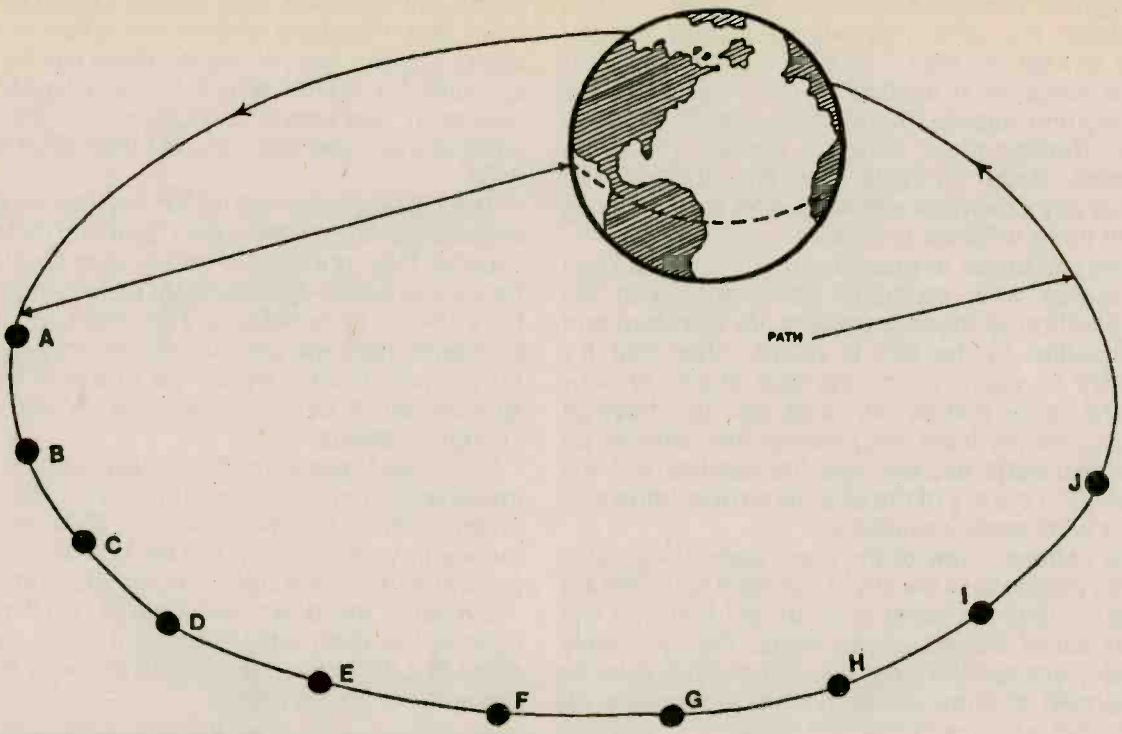
Similarly, the down converter is usually mounted right at the dish, either behind it or on the ground close to it. Down converters are priced in the general range of, or above LNAs.

NTSC	PAL	SECAM
Bahamas	Argentina	France
Canada	Australia	Greece
Japan	Austria	Iraq
Mexico	Belgium	Lebanon
USA	Denmark	United Arab Rep.
	Hong Kong	USSR
	Ireland	Zimbabwe
	Israel	
	Italy	
	Netherlands	
	New Zealand	
	Norway	
	Pakistan	
	Portugal	
	South Africa	
	Spain	
	Switzerland	
	United Kingdom	

There are three different TV standards being used in various countries. To view a different standard such as PAL or SECAM, different receivers are required.

Finally we come to the actual receiver itself. This receives the 70-MHz IF signal provided by the down converter. The 70 MHz signal travels from the down converter (at the dish) over standard coaxial cable into the house. Receivers have many special features, most of them providing better reception when used properly. These receivers come in a wide variety of prices from about $500 up to $1000. More money buys greater convenience, as well as better pictures (sharper, with less interference).

Choosing the parts of the TVRO system, as you can see, requires plenty of study and effort. But whether you do it yourself, and save most of the installation cost ($100 to $1500, generally), or buy an installed system for $3500 and up, a good satellite-TV system, a TVRO, can give you a wide variety of programs 24 hours a day, and with less interference than any other



Symbol	Long-West	Series	No.
A	143°	Satcom	F5
B	139°	Satcom	F1R
C	123°	Westar	5
D	119°	Satcom	F1/F2
E	116°	Anik	C2
F	109°	Anik	B
G	99°	Westar	4
H	91°	Westar	3
I	87°	Comstar	D3
J	79°	Westar	1/2

A few of the 20 satellites now in orbit and transmitting TV programs to earth.

reception. Table II lists a few representative programs and some of the satellites which provide them, free of charge, once you've got your TVRO station set up and working.

There are many books available which can be helpful in getting one's own TVRO system components, as well as in selecting the site for the dish, and installing the dish with its support, and the other parts of the system. One fine introduction to the subject is included in the book *The Complete Guide to Satellite TV* by Martin Clifford, published by TAB Books (250 pages), $11.50 at most bookstores or from the publisher at Blue Ridge Summit, PA.

Scrambling The Satellites

Few people who live near a major metropolitan area really need a TVRO (Television Receive-Only) station just to get the major TV signals. Satellite broadcasting came about because some areas of the US and Canada were getting only one or two major signals, and the cable systems which had sprung up found they could get better, less-expensive program feeds via satellites than previously.

It's important to know that there are between one and two million TVRO systems in use today. People who put up TVRO systems either were too far away from cables, or didn't want to pay their local cable companies. They went ahead and put up their systems which cost up to $5,000 a few years ago, but now go for under a thousand or two. In addition to that category of viewers there are also people who want to get the dozens of channels not broadcast by the major programmers. They fall into the classification of experimenters, not unlike DX (long-distance) or ham radio enthusiasts.

Since there are only between 1.5 and 1.8 million TVRO systems operating today, there's plenty of room for growth. Most of the signals picked up by these systems are on the C Band, between 4.0 and 5.0 Gigahertz (billion Hertz). In the future more new channels will be received on the higher, Ku Band, which is at 12 GHz.

As a result of these factors, there's some confusion in the minds of potential TVRO viewers. They are understandably confused by the recent scrambling of some pay-TV signals. *Scrambling*, the transmission of television signals by the broadcaster so that only receivers using a *descrambler* can get useful pictures, has recently been started by some pay-TV channels broadcasting over some satellites.

(Continued on page 95)

WORKBENCH PROJECTS

One of the best ways to begin your mastery of electronic circuitry construction is to work with discrete components before diving headlong into integrated circuit construction. After all, integrated circuits are nothing more than these individual components and circuits in a more compact package. The only problem is that they don't come in see-through packages to help you identify the individual working areas.

A project which requires 6 individual electronic components, could be purchased as a single integrated circuit, less than the cost of the individual components. Not only that, but it would require only one-tenth the physical space of the discrete components setup.

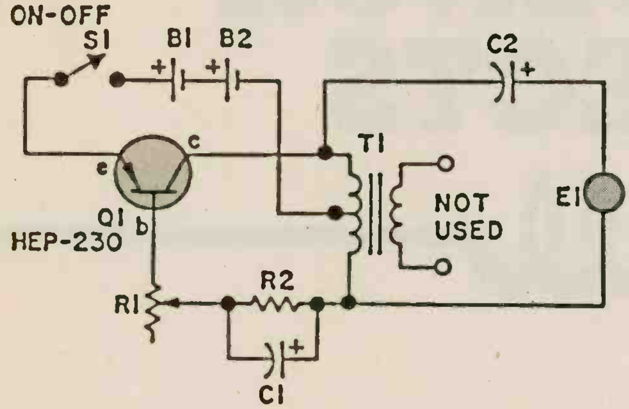
We don't feel that it's of much value to simply "plug in" black boxes without the understanding of what actually goes on inside them. This then is the purpose of the Project Workbench section. If you can learn what the circuitry of an integrated circuit is supposed to do, then it frees you to come up with your **own** innovations, and to accurately troubleshoot your creations when you run into the inevitable bugs or "glitches."

This brings up another point. While some ICs are relatively sensitive to miswiring and are easily destroyed, these discrete components, as a rule, are not. It's a lot better to make your mistakes here than on an integrated circuit project, where ruining an IC due to a reversed diode polarity might set you back two or three dollars. So have fun, but learn!

ANGLER'S FISHING LURE

Click-click might not sound like much to you but to a fish it's the dinner bell. That's the lure of this electronic circuit. Shove the whole works in a watertight container, lower it over the side, and wait for the fish to hit the hooks.

For proper operation T1 must be subminiature type about half as large as your thumb. E1 must be a crystal headphone.



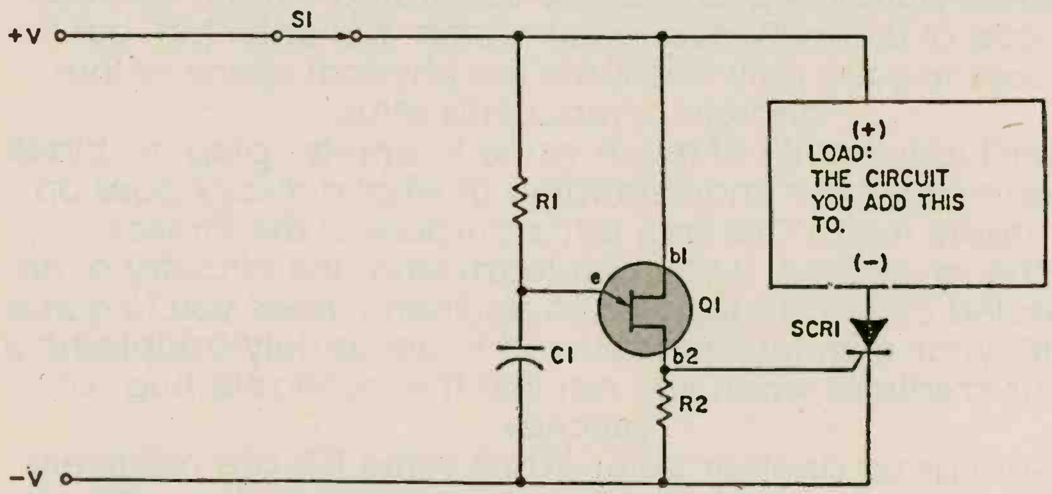
PARTS LIST FOR ANGLER'S FISHING LURE

B1, B2—1.5-V AAA battery
C1, C2—50-uF, 12-VDC electrolytic capacitor
E1—crystal earphone
Q1—Motorola HEP-230 pnp transistor
R1—5000-ohm pot
R2—27,000-ohm, ¼-watt resistor
S1—Spst switch, part of R1
T1—standard size or miniature size output transformer: 500 ohms center-tapped primary to 8-ohm secondary

SWITCH-ON DELAY

Turn the switch on and the circuit you're controlling (LOAD) won't turn on until 10 seconds later with this UJT delay. The SCR is the "switch" that eventually permits current to flow through the load. But the SCR won't turn on until the UJT timer circuit delivers a pulse to its gate. This happens after a time delay determined by the product.

Choose a value for SCR1 that can easily handle the maximum current the load will draw, plus a margin for safety, and the voltage of the power supply, plus a margin for safety. For a 9-12 Volt circuit drawing up to ½ amp or so, a 20 Volt 1 Amp SCR should do nicely. Since S1, when turned off, interrupts the flow of current through the SCR, turn-off for the load happens immediately.



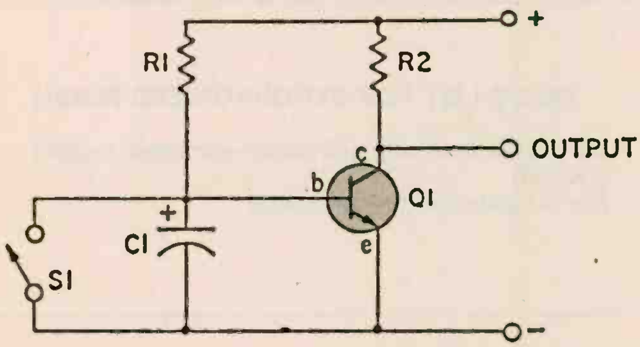
PARTS LIST FOR SWITCH ON DELAY

C1—220-uF capacitor
Q1—UJT (Unijunction Transistor), 2N2646
R1—47,000-ohm resistor, ½-watt
R2—22-ohm resistor, ½-watt
SCR1—See text
S1—SPST

SWITCH DEBOUNCER

Today's logic circuits are so quick that even the fast, tiny bouncing of switch contacts can be counted as separate switching events. This simple circuit adds a tiny delay to the switching to keep those bounces from reaching your logic. It gets its power right from the logic circuit you're using it with. Most logic requires switching between some input and ground. For those uses, use the circuit the way it's shown. It goes in the lead from the ungrounded side of the switch to the logic input (which is then connected to the Output shown)

Should your application require switching to the positive supply (assuming ground is negative above), simply swap the + and – leads and make Q1 a PNP transistor (2N3906, for example). Also, if the capacitor you're using for C1 is polarized, an electrolytic, for example, reverse its polarity as well.



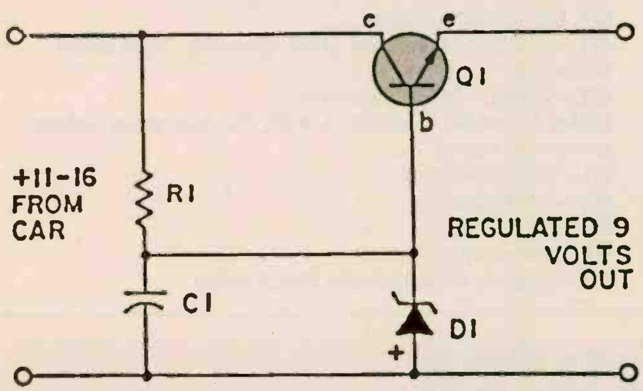
PARTS LIST FOR SWITCH BEBOUNCER

C1—.5-2.2-uF capacitor, electrolytic (VDC greater than your power supply)
R1—10,000-56,000-ohm resistor, ½-watt
R2—270-1000-ohm resistor, ½-watt
S1—SPST (switch to be debounced)
Q1—NPN transistor (2N2222, 2N3904)

CIGARETTE LIGHTER POWER

When you want to run your radio or some other low-power 9 volt device in your car, here's a way you can do it and save on batteries. This is a simple shunt regulator using a 2N2222 and 9.1 Volt Zener. With a 2N2222, you can power devices requiring as much as 800 ma; to drive devices requiring more current, use a 2N3055. With either device, unless the equipment you are driving is very low power, use a heat sink.

There are two easy ways to determine how much current your transistor radio or whatever draws (more to the point, whether or not the amount of current it draws will necessitate heat sinking). One is to connect your VOM in series between one of the battery posts and its associated clip connector. You will want to check the *maximum* amount of current drawn. Another way is to connect this circuit for only a few seconds and touch Q1 with your finger. If it gets too hot to hold your finger on, use a heat sink. You may want to use a heat sink in any case. You may also want to include a small fuse (try ½ amp).



PARTS LIST FOR CIGARETTE LIGHTER POWER

C1—100-uF 25 VDC capacitor
D1—Zener diode, 9.1 V at ¼ watt
Q1—NPN transistor, 2N2222
R1—560-ohm resistor, ½ watt

SYNCHRONIZE THAT FLASH

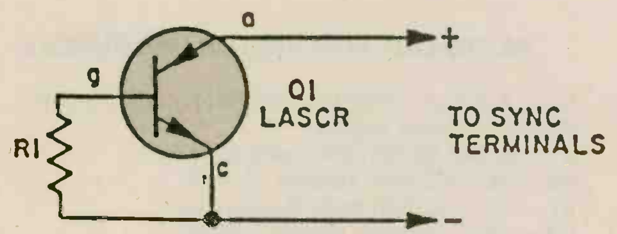
Even if you spend $25 or 30 for super-duper professional remote flash tripper you'll get little more than this two-component circuit. Price is important if the results are equal.

Transistor Q1 is a light-activated silicon-controlled rectifier (LASCR). The gate is tripped by light entering a small lens built into the top cap.

To operate, provide a 6-in. length of stiff wire for the anode and cathode connections and terminate the wires in a polarized power plug that matches the sync terminals on your electronic flashgun (strobelight). Make certain the anode lead connects to the *positive* sync terminal.

When using the device, bend the connecting wires so the LASCR lens faces the main flash. This will fire the remote unit.

No reset switch is needed. Voltage at the flash's sync terminals falls below the LASCR's holding voltage when then flash is fired, thereby turning *off* the LASCR.



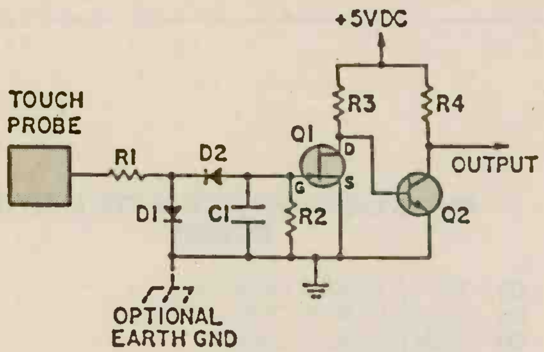
PARTS LIST FOR SYNCHRONIZED FLASH

Q1—200-V light-activated silicon-controlled rectifier (LASCR)
R1—47,000-ohm, ½-watt resistor

PROXIMITY SWITCH

Looking for a way to add a touch of class to your digital projects? Try this touch switch. Not only does it add a note of distinction to a project, but it's bounce-free as well. Whenever a finger touches the contact plate, stray 60 Hz powerline interference is coupled into the circuit due to the antenna effect of your body. The 60 Hz pickup is rectified and filtered to provide a negative bias on Q1's gate, thus causing Q1 to turn off and Q2 to turn on. As a result, Q2's collector drops to ground potential. When the touch plate is released, the potential at Q2's collector terminal once again jumps high. You can use the output to drive either CMOS or TTL with ease.

Note that if you do your experimenting in a place devoid of 60 Hz power-line radiation—in the middle of a field of wheat, for example—the circuit will not work. The average home is full of 60 Hz radiation, however, so the switch should function well. If you have some difficulty, connect your system's electrical ground to an earth ground (the screw on your AC outlet's cover plate) This will boost the signal pickup.



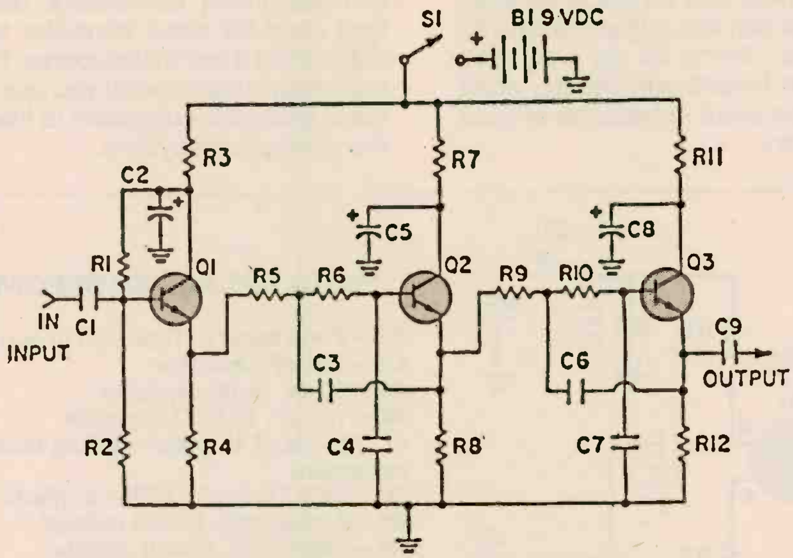
PARTS LIST FOR PROXIMITY SWITCH

C1—0.1-uF 50-VDC ceramic capacitor
D1, D2—1N914 diode
Q1—2N5953 n-channel JFET (junction field effect transistor)
Q2—2N3904 NPN transistor
Note: All resistors rated ½-watt, 5% tolerance unless otherwise noted.
R1—100,000-ohms
R2—1.0 Megohm
R3—22 Kohms
R4—100-ohms
TP—copper or aluminum touch plate

NOISE (LOW-PASS) FILTER

If you own an old inexpensive receiver, chances are it could use a little extra selectivity. In that case, you should consider adding a filter. You could add an IF filter, but it's probably easier, and certainly less expensive to tack on the simple low-pass audio filter diagrammed here. With the constants shown, it has a corner frequency of 1000 Hz-perfect for CW (code) reception. For voice, reduce the values of R5, R6, R9 and R10 to 1200-ohms. The filter's voltage gain is unity (1) so it won't upset things no matter where you insert it. Input impedance is about 30K-ohms—high enough to cause negligible loading.

To install the filter, break into the receiver's audio chain at some convenient point—preferably at a point where the audio voltage is small, say, 1-volt peak-to-peak or less. You may wish to include a bypass switch, too. This will allow you to shunt the signal around the filter and restore the original performance of the receiver.



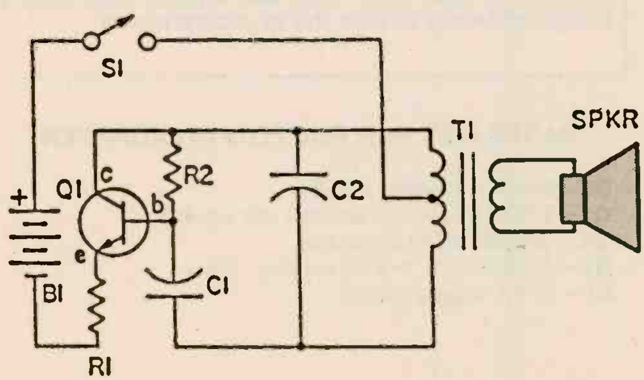
PARTS LIST FOR NOISE (LOW-PASS) FILTER

B1—6 To 12-volt battery
C1, C3, C6—0.1-uF, 25 VDC mylar capacitor
C2, C5, C8—22uF, 20-VDC tantalum capacitor
C4, C7—0.02-uF, 25-VDC mylar capacitor
C9—1.0-uF, 25-VDC non-polarized mylar capacitor
Q1, Q2, Q3—2N3391 NPN transistor
Note: All resistors rated ½-watt, 5% tolerance unless otherwise noted.
R1—56,000-ohms
R2—100,000-ohms
R3, R7, R11—100-ohms
R4 R8, R12—1,800-ohms
R5, R6, R9, R10—3,000-ohms
S1—SPST toggle switch

WAILING SOUND GENERATOR

Once you hear the nifty sound effect this tiny circuit puts out, you'll be dreaming up places to use it. The combination of C1 and C2 causes this oscillator to work at two widely separated frequencies at once. One, determined mostly by C2, determines the basic tone the oscillator will produce. The other, determined mostly by C1, governs the number of times per second the basic tone will be interrupted.

The output sounds very much like a pumping whistle—it's a sound effect associated with toy ray guns, tv and the movies. If you wish to build this as a toy, try using a momentary switch or microswitch for S1.



PARTS LIST FOR WAILING SOUND GENERATOR

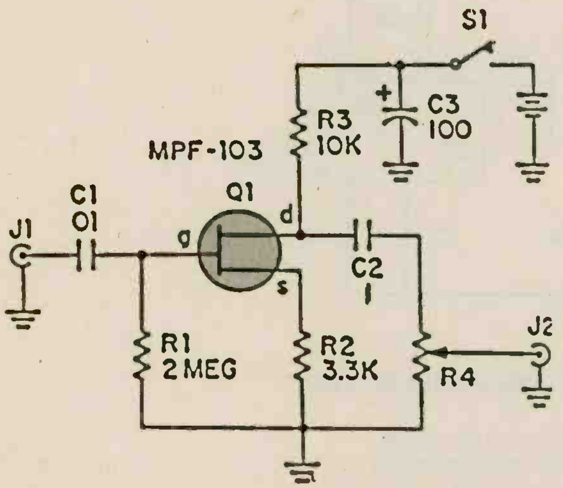
B1—6 to 15 VDC
C1—100-500-uF capacitor
C2—.1-.5-uF capacitor
Q1—NPN transistor (2N2222, 2N3904 or equiv.)
R1—15-27-ohm resistor, ½-watt
R2—8200-15,000-ohm resistor, ½-watt
S1—SPST switch (see text)
T1—250-1000-ohm primary, center tapped; 4-16 ohm secondary

TRANSMITTER POWER BOOSTER

If your CB or Ham rig is a little shy on talk power, this 10 dB talk power booster will give your signal that extra edge through the QRM (noise). The input impedance is high enough to handle anything from a low impedance dynamic mike to a crystal or ceramic model, You can run the booster into just about any rig; chances are it will work. Since it's so easy and inexpensive to try out a breadboard model, don't bother worrying about the input impedance of your rig; it's faster to give it a try.

Potentiometer R4 serves as the volume control into your rig; it is adjusted for optimum modulation, as indicated on a modulation meter or oscilloscope.

Jacks J1 and J2 match your existing microphone and transmitter connectors. Battery B1 can be the type used for small transistor radios as the current drain is but a few milliamperes. Capacitor C3 must be used regardless of what you use for a power supply. A metal cabinet is suggested to keep hum and RF out of the microphone system.



PARTS LIST FOR XMTR POWER BOOSTER

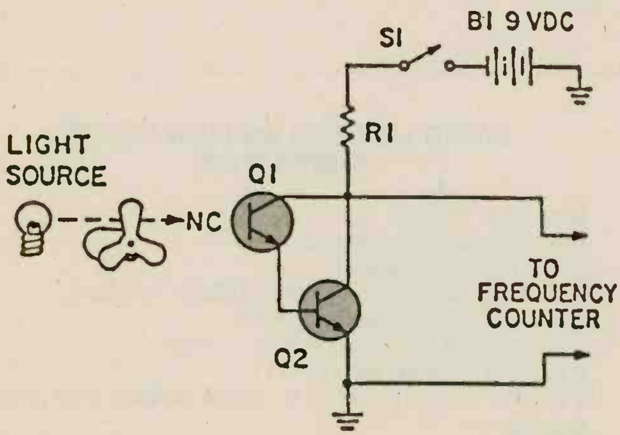
B1—9-volt battery (Type 2U6 or equiv.)
C1—0.01-uF capacitor
C2—0.1-uF Mylar capacitor
C3—100-uF, 10 VDC capacitor
J1, J2—Jacks to match existing microphone equipment
Q1—FET, Motorola, MFP-103 (Radio Shack 276-2028)
R1—2-megohms, ½-watt resistor
R2—3300-ohms, ½-watt resistor
R3—10,000-ohms, ½-watt resistor
R4—50k or 100k audio-taper potentiometer
S1—Spst switch

PHOTOTACH ADAPTER

If you own a frequency counter, you can use this nifty little circuit to measure the rate of rotation of motors, fans and anything else that revolves and can break a beam of light. In the accompanying schematic, you can see that light from the bulb is chopped by the rotating fan blades. This chopped light beam then falls on the light-sensitive face of phototransistor Q1. Transistor Q2 amplifies the photo-current from Q1's emitter to yield a rectangular waveform approximately 9-volt in amplitude at the output. Naturally, the frequency of the output is related to the fan's speed of rotation.

$$\text{RPM} = \frac{\text{Freq. (Hz)} \times 60}{\text{\# of beam interruptions per second}}$$

Suppose we obtain a frequency reading of 100 Hz with the 3-bladed fan illustrated here. Obviously, there are 3 interruptions per revolution. The actual speed is therefore 2000 RPM. For best results, mount Q1 in a small, hollow tube (an old oil barrel, for example) with its light-sensitive face recessed with respect to one end. This will ensure that only the chopped beam strikes the phototransistor.



PARTS LIST FOR PHOTOTACH ADAPTER

B1—9-volt transistor battery
Q1—FTP-100 phototransistor (or equiv.)
Q2—2N3904 NPN transistor
R1—10,000-ohm ½-watt resistor, 5%
S1—SPST toggle switch

THE BASICS OF SCHEMATIC DIAGRAMS

Electronics Road Maps Use Easy Symbols For Parts. Soon You Can Draw Your Own.

by Jon Graham

Electronics is a branch of electricity, so if you're familiar with electrical parts you already have a good start in learning electronics. Even if electricity and electrical wiring are new to you, learning about them will give you a good beginning in electronics. When you finish this article and the easy symbols it shows, you will be able to read most electronic diagrams and tell what's happening in them. In fact, you'll be able to draw simple diagrams right away. Soon after that you'll be able to understand even the most complicated diagrams showing how electronic circuits and devices work.

The Complete Circuit

The first important thing to learn about electrical and electronic circuits is the *complete circuit*. You can think of it as a *complete circle*. That is, two or more parts (components) connect in *series* with each other, in an unbroken circle (circuit). If the series is broken, as for example by a switch, the circuit is not complete, and no current will flow; the circuit won't work. When the circuit (circle) is completed by closing the switch, current flows; the circuit will work.

Four Basic Parts

All electronic devices, even the simplest working circuits, are made up of four (or more) separate parts. These are:

(a) A *source* of electrical *energy* (force); two common sources are batteries, and electrical generators powering the home AC electrical sockets,

(b) A *device* to do the *work* you want, such as a light bulb or an electrical motor,

(c) *Wires*, or other electrical conductors to connect the parts of the circuit, and...

(d) Something to *control* the flow of energy. This can be as simple as an On/Off switch, but it also usually includes some resistance, to *limit* the amount of *current* flowing in the circuit. The control resistance is frequently part of the device itself, as in an electric light bulb.

Wiring Symbols

The simplest component is a wire, and wires are needed to carry current from one part of the circuit to the others. In the diagram in Figure 1, at the left is seen one way of diagramming wiring. A dot is placed wherever wires or other parts are connected. If wires cross in a diagram with no dot, they are not connected.

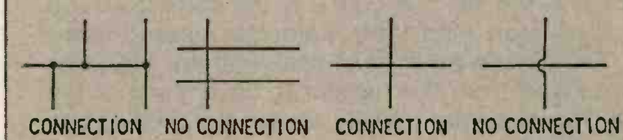


Figure 1. The two symbols at the right show drawing methods not used much today. The preferred method is shown at the left.

At the right is shown an alternate way of drawing wiring. This method is older, and is not generally used in modern schematic diagrams.

Basic Components

The most common components are *resistors, capacitors, diodes, transistors, inductors,* and *transformers.* In addition there are Power Sources such as *generators* and *batteries.* Also much used are various kinds of *transducers*; devices which change one kind of energy into another (electrical to mechanical, or vice-versa).

The best known transducers are *motors, loudspeakers* and electrical *lamps* which change electrical energy into motion, sound, or light. Two other common tranducers are *microphones* and electrical *generators*, which change motion into electricity.

Figures 2, 3, 4, 5, 6, and 7 show symbols for different kinds of resistors, capacitors (in the old days they were also called condensers), diodes (rectifiers), transistors, inductors, and transformers. Figure 8 shows common symbols for AC generators, and

Figure 10 displays the symbols for DC batteries.

Additional Components

There are many kinds of transistors and other solid-state devices, though they are less-often encountered than are basic transistors. The best-known are shown in Figure 6. Indicator lamps, both incandescent and neon are seen in Figure 15, and fuses are usually drawn as in Figure 16. There are many kinds of antennas, and the most often-employed symbols for antennas are shown in Figure 19.

Resistors (Figure 2)

The symbol for resistance suggest that it supplies *opposition* (resistance) to the flow of current so that it is more difficult for current to flow through it than it is through a simple wire (conductor). Hence the sharp-pointed triangular wavy line.

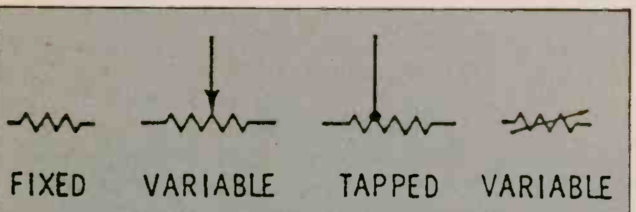


Figure 2. Resistors are usually drawn horizontally, as they are here. The symbol at the right is a Rheostat, not often found today. The symbol next to left is a Potentiometer, widely used in today's circuits.

Shown at the left in Figure 2 is the correct way to draw a resistor, with three complete up-and-down lines. The horizontal lines at each end are the wires which extend from the resistor to other parts of the circuit. Resistors are usually shown horizontally, as they are here.

The *variable* resistors (next to the left in Figure 2) is most often used to show a volume control, bass or treble control, or some other components for tapping part of a signal source which changes in size from time to time. The variable tap is connected, along with one end of the resistor, to the device which uses the varying amount of signal, while the signal *source* is connected to the two ends of resistor.

Next to the variable resistor is a *tapped* resistor. This is a fixed (non-variable) resistor which allows tapping off less than the full amount of the power source. Resistors with two or more taps are sometimes used.

The resistor with an arrow drawn through it (at the right) is another way to show a variable resistor, one with a moveable tap, except that it has only two connections to the rest of the circuit. The technical name for this kind of (variable, two-terminal) resistors is a *Rheostat*. The variable three-terminal resistor (shown next to the basic resistor at the left) is a *Potentiometer*. Rheostats aren't used nearly as much today as they were in the early days of radio. Potentiometers are widely used, in many electronic devices.

Capacitors (Figure 3)

Along with resistors, capacitors are used in most electronic circuits. The basic symbol for a capacitor is two short horizontal lines (not shown here), plus two (vertical) connecting wires. Often one is a straight line with one curved line, as shown at the left in Figure 3.

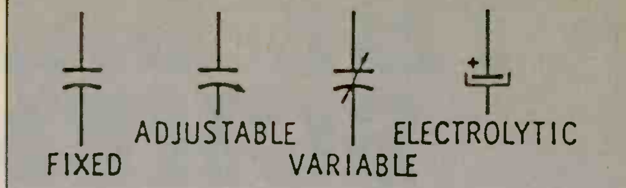


Figure 3. Capacitors are most often fixed, shown at the left, or electrolytic (right) used in power supplies and elsewhere to smooth out varying direct current. Variable and adjustable capacitors are used mostly in radio frequency (RF) circuits.

The curved line, when used, shows the outside element of the capacitor, which is usually connected to ground, or to the negative side of the power supply. The straight line is generally connected to the input signal or to the antenna, or to the high (positive) side of the power supply or source of energy.

A *fixed* capacitor, which can be as large as hundreds or thousands of *microfarads*, as in power supplies, or as small as a few *picofarads* (a millionth of a microfarad) is drawn as shown at the left.

Next to the fixed capacitor (sometimes abbreviated to "cap") is an adjustable capacitor (the bottom plate is a curved arrow). These were first used widely as the station selector in radios, right up into the Fifties. These were a set of several fixed flat metal plates, with another similar set of moveable plates interspersed between them. By rotating the moveable set the amount of capacity was changed as desired, to change the station being selected.

The symbol of two capacitor plates with an arrow through them is another way of showing a variable capacitor. Sometimes the right-hand symbol is used to show a *variable* (frequently-changed) capacitor, while the one with the curved arrow (left) is used to show one which is usually changed only once, such as an antenna trimmer.

At the right of Figure 3 is seen an electrolytic capacitor. A special kind of electrolytic is called Tantalum, because that's what they are made of. These capacitors are used in power supplies and other places to smooth out varying voltages. The bottom plate is usually connected to the negative

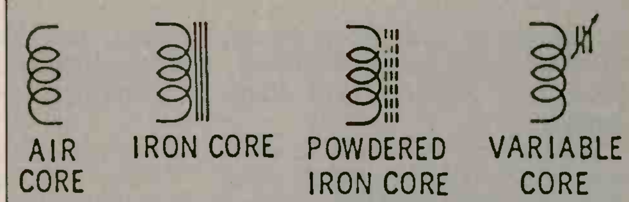


Figure 4. Inductors oppose the flow of Alternating Current (AC), and pass Direct Current (DC) easily. The material used in the core, either iron, powdered iron, or air, is determined by the frequencies the inductor works at. Audio and AC power frequencies (60 to 20,000 Hertz) use iron core inductors. Powdered iron and air cores are used at radio frequencies.

voltage source. The positive side can be indicated with the plus sign, but that's often left out.

Inductors and Transformers

An *Inductor* is a coil of wire, either a coil wound around a core (usually iron) or no core (air core). Just as a capacitor *prevents* passage of Direct Current but *passes* Alternating Current, an inductor passes DC, but impedes AC. One of the simplest inductors is the electromagnet, in which a few turns of wire around an iron core (even an iron nail) can make the core attract iron (when DC is applied to the coil of wire). When the current is turned off the iron core losses (most of) its magnetism.

(Figure 5)

Inductors are used widely in radio frequency circuits, as well as in power supplies (to smooth varying DC into smoother DC).

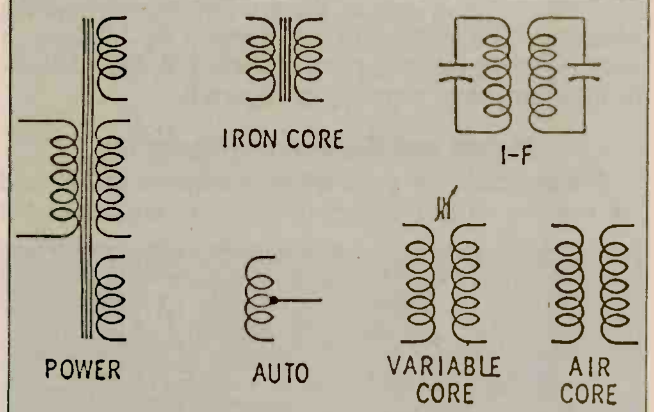


Figure 5. Transformers are specialized inductors which have two or more coils wound around a single core. As with simpler inductors (one coil of wire) the core material depends on the frequencies for which the transformer is intended.

A transformer is an inductor with two (or more) coils of wire wound around a common core. By adjusting the number of turns of wire in each coil, we can make the transformer raise a given voltage up to a higher voltage, or step it down to a lower voltage.

One very common transformer is the power transformer in the power supply of a radio or TV set. 115 VAC from the house AC power is applied to the primary coil of the transformer. The primary will have, typically, 30 to 100 turns of wire. The high voltage secondary will have more turns of wire, perhaps 300 to 500, and this *step up* ratio causes the voltage delivered by the secondary to be higher than the basic 115 VAC, usually a few hundred volts. There may also be one or more additional secondary coils on the power transformer. These generally are just a few turns of wire, and supply lower voltage, most often five or 12 volts.

Transformers without iron cores are used in radio frequency circuits, including the Intermediate Frequency (IF) stages of radio and TV sets. The autotransformer is a special kind of transformer, in which there is only one coil of wire, but it is tapped. By using entire coil as the primary we get a step down transformer (lower output voltage than input voltage). Conversely, by applying a specific input voltage across the tap and one end of coil, we can provide a higher output voltage at the "secondary", the entire coil's output terminals.

Diodes and Rectifiers (Figure 6)

The symbol for the simple *diode* as well as the basic *rectifier* is shown at the left in Figure 6. There is no

Figure 6. Diodes (rectifiers) are shown by an arrow and a straight line. The symbol suggests that current can go in one direction, but not in the other. Diode rectifiers (either word may be used) change alternating current (AC) into direct current (DC).

technical difference between a rectifier and a diode. Both permit Direct Current (DC) to flow in only one direction, and both prevent AC from passing. Diode is preferred term for low-current and signal applications, while rectifiers are more often referred to in power supplies, where heavy currents are involved.

Tunnel diodes and Zener diodes are special-purpose diodes. The diodes shown here are solid-state diodes. The first diodes after crystal (radio) diodes were vacuum tubes. A filament gave off electrons and they went through the vacuum to the plate. AC signals applied to the diode came out as varying Direct Current signals. Vacuum-tube diodes are almost entirely obsolete.

After Edison developed the vacuum tube diode (but couldn't find a practical use for it) the Englishman Fleming used it to *detect* (rectify) radio waves. Later DeForest invented the triode vacuum tube by adding a *control grid* to the diode. This let it *amplify*. Even later the triode was used as an *oscillator*. The amplifier, together with the oscillator provided the foundation for today's radios and most other electronics.

Transistors (Figure 7)

The modern transistor was invented in the late Forties. In the Fifties it was developed for military applications, and in the Sixties it began to replace

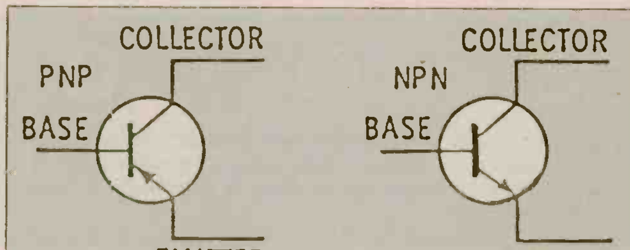


Figure 7. The two most common transistors are NPN (negative, positive, negative) and PNP (positive, negative, positive). In the NPN type (right) current flows into the emitter, and out at the collector. The current flowing between the base and emitter controls the amount of collector current, thus the transistor acts as an amplifier.

vacuum tubes in radios, TV sets and tape recorders. Like early radio tubes, the first transistors had three elements. They worked like the vacuum tube, as a valve (the English still call tubes "valves"). That is, a flow of current between two elements, the *cathode* (emitter) and the *plate*, was controlled by applying a (varying) signal between the cathode and the *grid*.

The first transistors were very much like the vacuum tube in that they had only three elements, and the signal between two of these elements controlled the flow of (larger) current between two (other) elements. The three elements of transistors are the *base* (grid), the *emitter* (cathode), and the *collector* (plate). There are two main kinds of transistors, divided according to whether current flows from collector to emitter, or vice-versa. Both types are shown in Figure 7.

There are many ways to connect transistors in circuits to do their work. The most often-employed functions they do are those of *amplifying*, *oscillating*, or *switching*. All three jobs can be done by transistors of either of the two main types. These two types are NPN (Negative, Positive, Negative) and PNP (Positive, Negative, Positive). These terms refer to the layers of semiconductors material used in the two kinds of transistors.

An easy way to tell by looking at them which type a particular circuit uses is this: If the arrow (emitter) points *down* (out of the circle) you can call it "normal", or NPN. If it points up (into the circle) it is the other type, PNP.

While we're discussing these two configurations there's another simple but immensely useful thing to learn about transistors. It concerns how to connect them to their power supplies. The three elements of an NPN transistor (*emitter, base,* and *collector*, respectively) are connected to Negative, Positive, and More Positive voltages at the power supply.

Conversely, the elements of PNP transistor are connected to voltages which are Positive, Negative, and More Negative. That is, the *emitter* (arrow) of PNP is connected to the Positive side of the power supply, while the *base* is connected to a (more) Negative potential, and the *collector* to the (most) Negative potential of the power supply.

AC Sources and Generators (Figure 8)

The most-often used symbol for a source of AC power or signals is the middle one in Figure 8. It looks

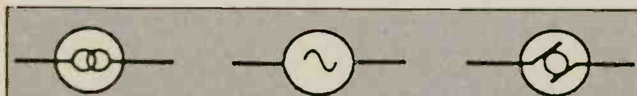


Figure 8. These symbols all indicate AC generators. The middle one is most often used in electronics. The other two appear more often in electrical power drawings.

like an AC (sine wave) waveshape on an oscilloscope. This frequently indicates a source of 115 VAC (volts alternating current) but may also show any other source of AC power or signal. The right hand symbol in Figure 8 suggests an AC generator, and the left-hand symbol is rarely used in electronics, thought it often appears in electrical diagrams.

DC Power Sources (Figure 9)

Batteries are the most common source of Direct Current, apart from power supplies. One "battery" is actually just a "cell," as show on the left in Figure 9.

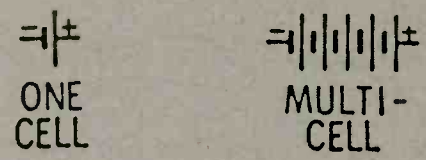


Figure 9. A single-cell (battery) is shown at the left. A "battery" consists of two or more individual cells. Current practice is to show only two sets of parallel vertical lines, regardless of the voltage or number of cells.

Two or more cells (a "battery") may be drawn as shown on the right. It is sufficient to show just two sets of short and long vertical lines, with a number telling what the DC output of the battery is, instead of drawing three or more pairs of vertical lines as shown in the right-hand drawing of Figure 9.

Motors and Generators (Figure 10)

The symbols for *generators* of electric power and for electric motors shown in figure 10 are borrowed

Figure 10. These generator and motor symbols may indicate either alternating current (AC) or direct current (DC) devices.

from electrical drawings, but they are also used both for AC generators and DC generators, and also for AC and DC motors in electronic wiring diagrams.

Measuring and Indicating Meters (Figure 11)

There are many acceptable symbols for meters in

Figure 11. Voltmeters and ammeters are shown above.

electronics. The two shown indicate (at left) Voltage, and (right) Amperes of current.

Ground Symbols (Figure 12)

The most-often used symbol for ground in electronics is the one at the right in Figure 12. It is often drawn, incorrectly, with only three short lines instead of the four shown here. This can indicate either the Negative (minus voltage) of the power

Figure 12. Symbols for ground (right), earth (left), and chassis or case (middle) are sometimes interchanged. Most common is the one at right, which can indicate power supply ground, signal ground, or both.

supply, which is usually Zero volts, or Signal Negative, as in the ground potential for the signal input to a radio or TV receiver. In the latter case it is often ommitted since no special ground connection is made.

The symbol shown at the left in Figure 12 is called "earth", and usually indicates the chassis or case of a device. In the middle is shown an alternate earth (case). These last two symbols are sometimes used to indicate true Ground (the surface of the Earth) when an actual, physical Ground connection is made, apart from the power supply or signal input circuit. This can be useful particularly in long distance communications, or for safety in some high-power situations.

Switches (Figure 13)

The simplest switch, like the On/Off switch for a radio set or a house lamp is shown at the left in Figure 13. This is also a Single-Pole, Single-Throw switch. Next to the left is a similar one, except that it is normally Closed, while the left-hand one is normally Open. Sometimes these switches are labeled NC or NO.

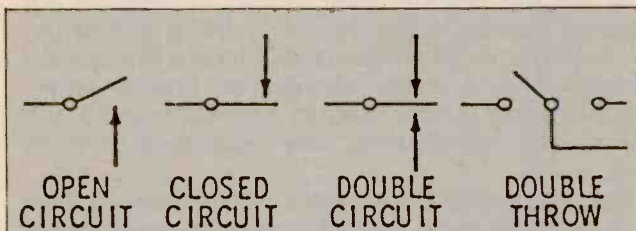


Figure 13. Common switches are shown above. Open circuit means the switch is normally open, and must be closed to produce a (desired) action. Normal closed is usually closed, and the action occurs when it is opened. "Double circuit" nomenclature is infrequently used today. Usually it's "double throw," whether shown as the symbol at right, or the one next to the right.

The right-hand switch in Figure 13 can connect one part of the circuit to either of two other parts, hence it is called Double-Throw. A more complete name for this is Single-Pole, Double-Throw. The diagram to its left performs a similar job. This diagram is not usually used. Instead, the one at the right is generally employed.

Relays (Figure 14)

Relays are used to control the action of one circuit from another circuit, with no electrical connection between the two circuits. Two examples are shown in

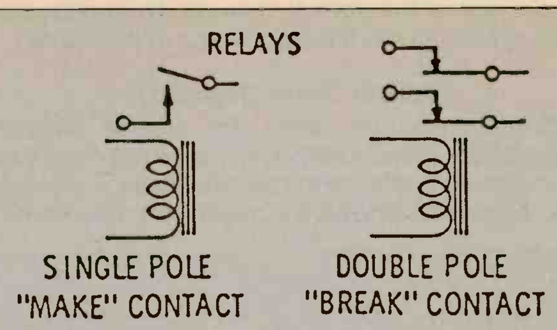


Figure 14. Relays let one circuit control a switch without being electrically connected to that circuit. In addition to single-pole and double-pole switches, many switches control up to 10 or more separate circuits.

Figure 14. In the one at the left single relay closes a single (separate) switch in another circuit. In addition, the relay shown makes the switch *close* (it's a "make" relay) when the relay is actuated. The relay on the right is different in two respects from the one on the left. First, it is a double-pole relay; it controls two separate circuits instead of just one (it could control almost any number at the same time—multiple relays with up to 10 or more sets of contacts are common). Secondly, the relay shown *breaks* the controlled circuits when it is actuated instead of "making" the contacts.

Indicators and Lamp (Figure 15)

The simplest indicator lamp is the incandescent lamp such as is used in a flashlight, house or automobile lamp. It has a tungsten filament. Any of the three left-hand symbols in Figure 15 may be used

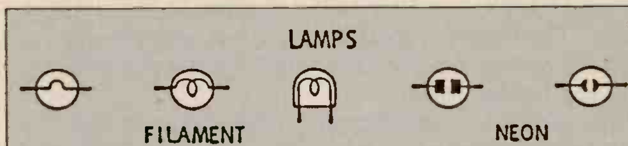


Figure 15. Common indicator lamps are shown. Incandescent (tungsten) filament type may be any of the three at left. Neon indicators are not used as often today as are LEDs (light emitting diodes).

to show this kind of lamp, which in the old days were also used behind radio station tuning dials and to show that radios or instruments had their power On.

Neon bulbs, not widely used these days, were shown by the symbols (two) at the right in Figure 15. More common today are LED (Light-emitting diode) lamps. These are usually labeled just that way "LED".

Fuses (Figure 16)

The symbol at the left in Figure 16 is more usual

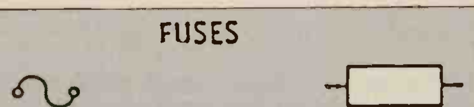


Figure 16. The fuse symbol most used is at left. It often is enclosed in a circle, much like the indicator lamps in Figure 15.

than the one at the right. It may also be enclosed in a circle, similar to the filament lamps in Figure 15.

Vacuum Tubes (Figure 17)

Although vacuum tubes are almost obsolete, except for the cathode ray (CRT) tube used in TV sets and computers, it's instructive to know a bit about them. Figure 17 shows the most common vacuum

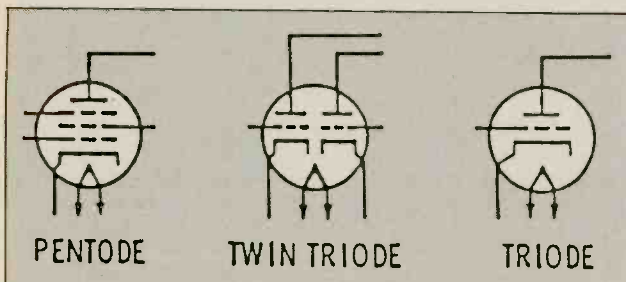


Figure 17. Common vacuum tubes of yesteryear are shown here. The three tube elements in the triode at right are, from the bottom, the cathode (and its associated heater), the control grid, and the plate. Pentode has two added grids; the screen grid (middle) and the suppressor grid (top).

tubes. The first really useful such tube was the triode, which included at first only the filament, the grid and the plate.

The filament was the *emitter*, which gave off electrons when it was heated by a battery. The flow of electroncs to the *plate* (top) was controlled by a signal applied between the *emitter* and the *grid*. This allowed a small signal input, such as that from a radio antenna, to control a much stronger, local current in a radio. This was the triode tube used as an amplifier. After a few years a separate *cathode* was put into the vacuum tube to function as the emitter, in place of the heater. The filament was still used, but only to heat the cathode, which was a much better source of electrons than the heater itself.

After a while an additional *grid* was placed into the tube, between the control grid and the plate. This was called the *screen* grid, and it improved the action of the amplifier in some applications. This four-element tube was called a tetrode. Finally a fifth element, the *suppressor* grid was added in some cases, making a *pentode* vacuum tube. Many vacuum tubes were actually two tubes in one glass envelope. A common one was the twin triode, shown in the middle of Figure 17.

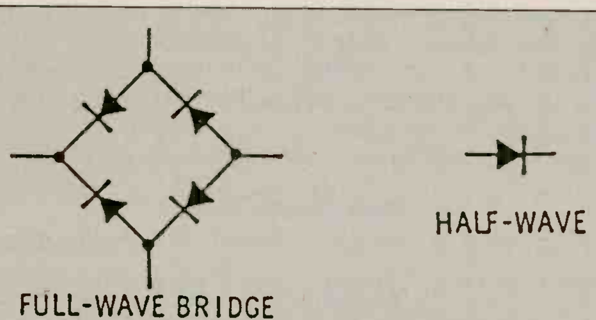


Figure 18. Common configuration of power supply rectifiers shows simplest, half-wave, at right. The full-wave bridge rectifier at the left yields more DC voltage (and current) from the same AC power source than the half-wave rectifier.

Rectifiers (Figure 18)

Diode rectifiers are used in power supplies to provide direct current from AC power. They may be connected in many ways. The most common and simplest is shown at the right in Figure 18. Four rectifiers are often connected together as a full-wave bridge rectifier to supply twice as much voltage as a half-wave rectifier circuit.

Antennas (Figure 19)

Five different types of common antennas are shown in Figure 19. The symbol at the left is the one most often used. It's a general symbol, and can stand for any antenna. Next to it is a more specialized one, not often employed today outside of communications equipment. Actually a dipole antenna looks very

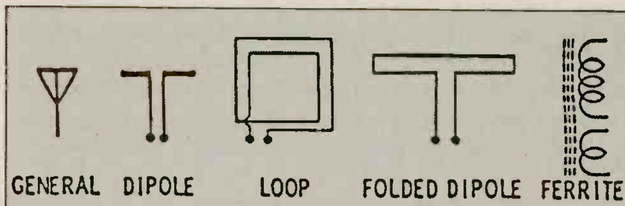


Figure 19. The antenna symbol shown at the left is most often used. The one at the right is usually found in AM radio sets, while the three in the middle are rarely used today. Each of the three looks like its real-life counterpart.

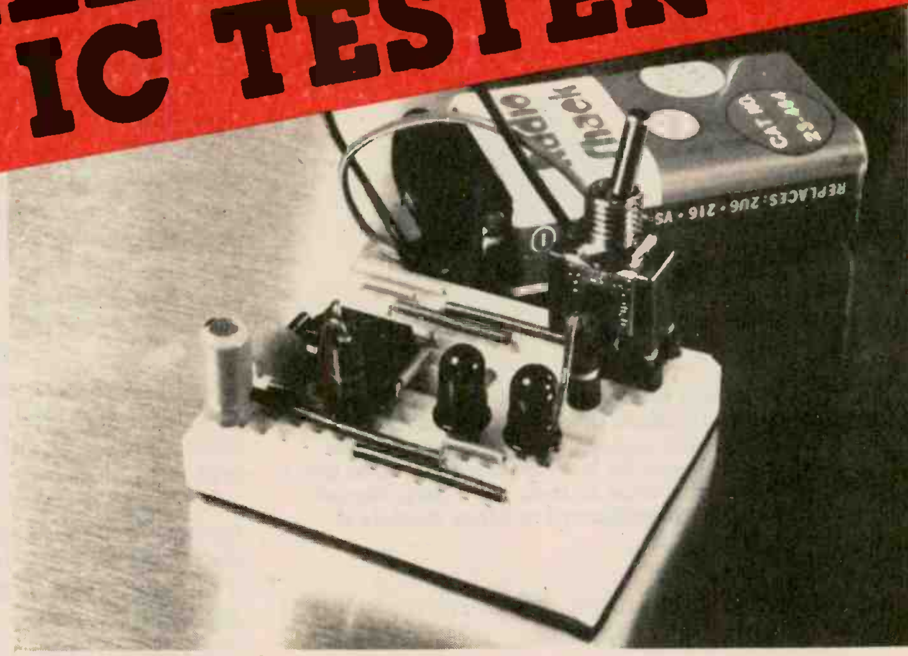
much like the symbol shown here. The two horizontal lines are the antenna itself, whose dimensions are critically related to the frequency being picked up. For example, in TV antennas lengths of a few feet are common, while lower frequencies (longer wavelengths) such as are used in long-wave radio and commercial broadcasting may be dozens of yards long.

The loop antenna was widely used in the early days of commercial radio, and it looked very much like its symbol, the center one in Figure 19. Next to the right is a folded dipole. It works much like the simple dipole, but is stronger; can pick up weaker signals. The right-hand symbol shows a ferrite "stick" antenna, used mostly in portable and table model AM radios. It is actually a transformer with a ferrite stick core.

Practice Makes Perfect

Now that you've seen how simple most symbols for electronic parts and wiring diagrams are you should cut out the figures (or better, this entire article) and paste it up somewhere over your workbench. That way you can refer to it whenever you come across a symbol in a schematic diagram which you're not familiar with. If you always check each part in every diagram you're studying, until you understand exactly what that part does to the flow of electricity (electrons) in the circuit, pretty soon you'll be able to draw your own diagrams of your own circuits. You'll be on way to being your own design engineer. ■

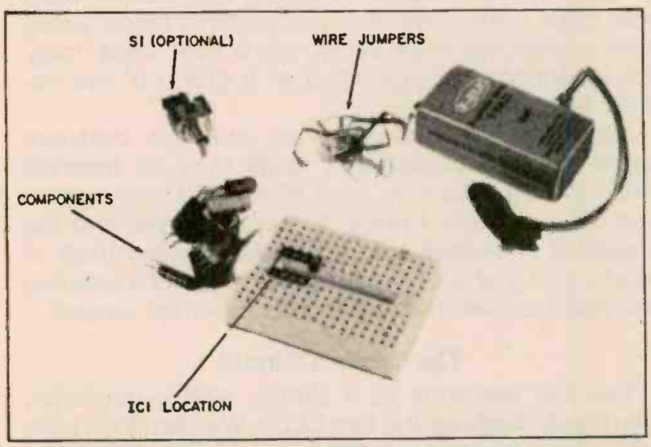
BUILD A 555 IC TESTER



You can test surplus 555 integrated circuit chips in one second with this easy-to-build, simple, project.

One of the most frequently-used integrated circuits today is the 555 timer chip. It's an 8-pin IC, most often found in the Mini-DIP package (rectangular, with the pins in two rows or four each of the long sides). It's also seen in the less-common round transistor-like shape, the TO-5 or TO-99 packages.

It's an IC which can produce a time-delay from a few microseconds to about an hour, with five percent accuracy. It can also run free as an oscillator, at frequencies as high as a megahertz (1MHz) or as low as one pulse per hour! The only external parts are one or two resistors and a capacitor. It can also be used as a comparator, a Schmitt trigger, a controlled switch, and much much more. And today, even though the prices of new integrated circuits are still coming down, you can find untested 555s on the surplus market at great bargains.



Handful of parts includes two LEDs three resistors, two capacitors, two inches of #22 solid wire for jumpers, optional AP Products, solderless breadboard, switch.

This project shows a ready way to test widely-used, widely-available ICs.

Inside, the 555 has many transistors and other components arranged to make up the following circuits: two comparators, one flip-flop (which is a bistable multivibrator), and an output stage. Connections are brought out to several terminals (up to 8) which hobbyists call "pins."

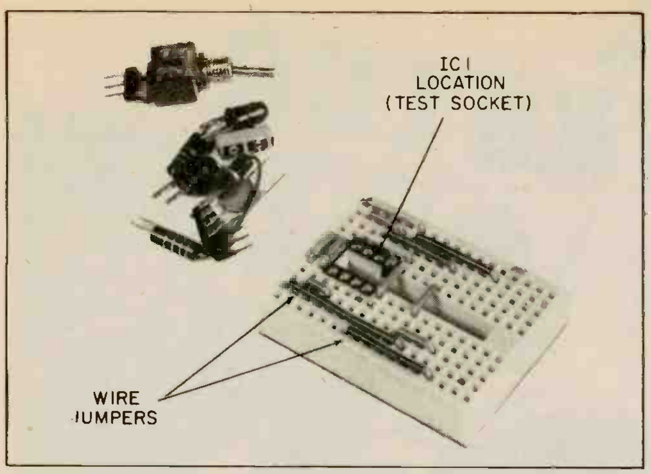
Inside the Chip

Refer to the schematic diagram of the integrated circuit. First we have a comparator, a kind of balancing beam. It looks at two inputs and compares them. Some comparators supply an output when the voltage at one of its inputs is *larger* than the other. Other comparators, like this one, provide an output when both inputs are *equal*.

Now look at the two inputs this comparator is connected to. One input is a voltage divider inside the 555. This consists of a string of three identical resistors connected between Vcc (B+) and ground (—). Since this leg of the comparator is connected 2/3 of the way up the resistor string, it always measures a voltage equal to two-thirds of the supply voltage.

The other input leg of the comparator is connected to the external timing chip capacitor you use in your particular 555 IC timer circuit. The timing capacitor is charged through a timing resistor (two, actually, series-connected and tapped by a connection to pin 7 in most applications). Together, the timing resistor and timing capacitor determine how fast the 555 will oscillate (or how long an output pulse it will deliver). Here's how.

When the charge on the timing capacitor at pin 6, the *threshold* input, reaches a value equal to the voltage at the on-chip voltage divider (2/3 Vcc), the comparator turns *on*. When the comparator turns on, it toggles the flip-flop that switches the 555 output.



#22 solid wire cut to length for 14 short jumpers has been bent and inserted into breadboard. Eight holes used for test socket are outlined with fine-tip felt pen for convenience. Be sure to place dot near pin 1 to ensure plugging 555s in their right way. Circuit may be built up on perfboard or other chassis if desired.

The flip-flop also turns on a transistor that discharges the timing capacitor.

How It Works

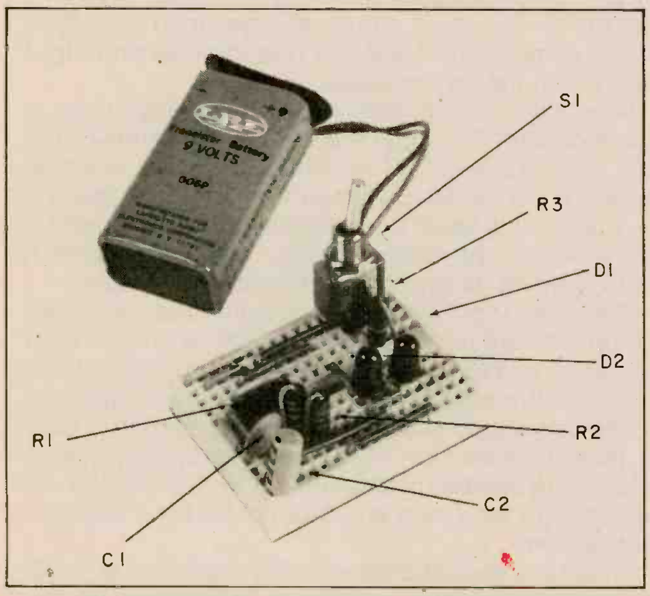
To start the 555 working, a trigger pulse at pin 2 initially sets the flip-flop to turn the 555 *on*. It does this by comparing the input pulse to 1/3 Vcc at a second comparator. This turns off the transistor across the timing capacitor and allows the timing capacitor to begin to charge. The 555 stays *on* until the timing cycle turns it *off* again by resetting the control plip-flop.

The timing cycle can be made to start over again by applying a pulse to the *reset*, pin 4. This turns on the transistor that discharges the timing capacitor, thereby delaying the charge from reaching 2/3 vcc.

In some applications, the reset (pin 4) is connected to the *trigger* input (pin 2) so that each new input trigger signal restarts the timing cycle.

When the *threshold* voltage at pin 2 drops, at the end of a timing cycle, that voltage drop can be used to start a new timing cycle immediately by connecting pin 6 to pin 2, the trigger input. This is how the 555 works when it is used as an astable (free-running) oscillator.

The 555 output circuit includes two high current transistors, each capable of handling 200 ma. One transistor is connected between the *output* pin 3 and vcc, the other between pin 3 and *ground*. Thus, so you can use pin 3 to either supply Vcc to your load (*source*) or provide a ground four your load (*sink*).

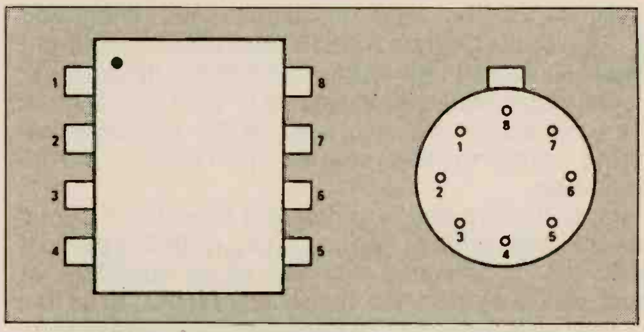


Circuit assembled on solderless breadboard, a 555 plugged in, and optional switch S1 in place. Use of different-colored wires makes it easy to trace circuit. Polarity of diodes is important.

Testing Is Easy

I once asked applications engineer friend of mine how he could tell if a particular gadget of his would work. "Make sure it isn't between you and the door, and then plug it in and turn it on!" he said.

This 555 tester borrows on his advice. Instead of trying to measure specific conditions at each pin (the way most tube and transistor testers make their tests), it plugs the 555 under test right into a simple circuit and puts it to work. A good 555 will flash the LEDs alternately. A bad 555 will cause either or both of the LEDs to light and remain lit, but without flashing.



Most 555s come in rectangular mini-DIP (dual in-line package), but they're also found in round "TO-" package.

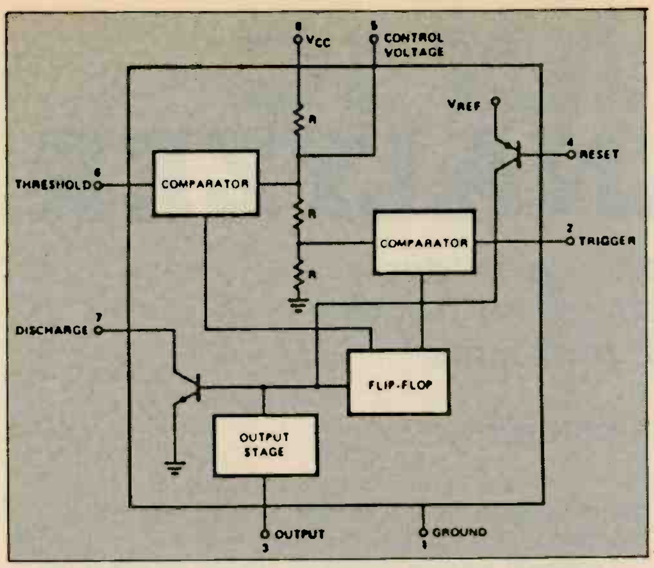
Building Is Fast

The prototype circuit you see here is built on a modern solderless breadboard, this one an A P Products terminal strip. A spring clip behind each hole grips both wires and components leads. Since each conductive metal spring clip is five "holes" long, the breadboard is organized as a group of five-tie-point terminals.

Jumper wires are used to connect between terminals, and component leads may be inserted directly. Any solid wire from #30 to #20 slips right in and hold securely. I prefer to use #22 solid, and I've bought it in several colors to help me keep track of what's going where. A quarter inch or so of insulation stripped from each end provides a perfect jumper.

The Tester's Circuit

The 555 performs as a simple astable oscillator, alternately flashing the two LEDs. We can drive both LEDs from the single output (pin 3) because of the way the 555 is designed. It is made to either *source* (provide a positive voltage, and thereby current, to its load) or *sink* (provide a minus voltage—ground



Block diagram shows major components of timer.

connection, for the load current) its output. So by connecting one LED from B+ to pin 3 (sinking output) and the other between pin 3 and GND (sourcing output), we can take advantage of both capabilities.

You will notice that I've not included the usual current-limiting resistor in series with each LED. What actually happens is that a single resistor, R1, limits current through the entire circuit. In addition to protecting the LEDs from too much current, it does the same for the 555 under test, and it also prolongs battery life. Finally, it also protects the tester's circuitry in case the 555 under test has a dead short between any combination of pins, as often happens when ICs are removed from surplus printed circuit boards, leaving solder bridges.

The circuit's time constant, which governs the flashing rate, was chosen to make the flash easily discernible. Too quick a flash rate could appear to be a steady *on*. Too slow a flash might look like just one LED lighting. You can alter the flashing rate by changing the value of C2.

R2 and R3 also affect the flash rate, and the ratio of their values determines the *duty cycle* (how long one LED is illuminated versus how long the other is on, in this case). While other values for R2 and R3 could have been chosen, the values shown here were used for several reasons. For one, they're standard and easy to find. Second, they yield a very readable flash rate. And most important, they fit within the ratio-of-resistances required by the internal workings of the 555.

Building It

If this is your first experience with solderless breadboards, it's only fair to warn you that they can be habit-forming.

You'll have the circuit together in less time than it takes to lay out a printed circuit board or solder up a haywire circuit. You won't need any hardware at all. You can even leave out the switch if you like, and plug and unplug the leads to the battery.

One of the reasons theses solderless breadboards are so fast and easy is that they're designed with a .1-in. x .1-in. hole spacing. Modern DIP (dual in-line package). ICs are designed with leads spaced in multiples of .1-in. So everything we use can plug right into the breadboard. An IC socket here would only be redundant.

This standard .1-in. spacing appears in another handy device that AP Products makes called a *header*. The header is a plastic strip with small contact posts every .1-in. You can break off as many of these as you need, with 36 of them being supplied on each strip. I soldered a piece of header to the back of a small toggle switch so it could plug right in, too. Another small piece soldered to the battery connector makes the entire project plug-in easy.

Follow the diagram and illustrations as you place each part in position in the breadboard. Mark the breadboard with a felt-tipped pen to show where the 555 under test plugs in, and be sure to index pin 1. Also mark the positive and negative battery connection points.

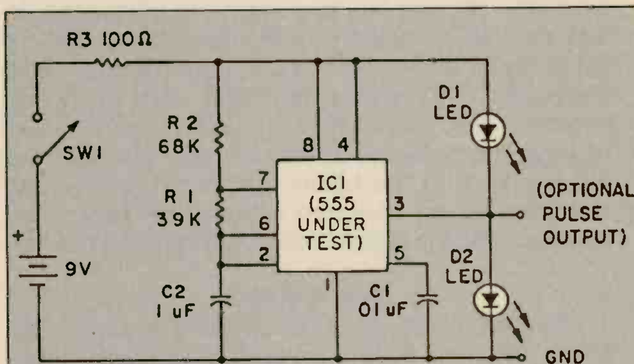
Jumper Wires

Use #22 solid wire. Cut about ½-inch longer than jump (connection) needed. Strip ¼-inch of each end bare and bend at right angles.

You will need one .1-in. jumper, one .2-in., six .3-in., one .4-in., one .5-in., one .6-in., two .7-in. and one .1-in. long.

Be very careful removing 555s from the tester to avoid bending their pins. Use and IC removal tool if

(Continued on page 96)



PARTS LIST FOR 555 TESTER

C1—.01-uF capacitor
C2—1.uF, 16-volts or better electrolytic capacitor
D1, D2—LED red indicators
R1—100-ohm, ½-watt resistor
R2—68,000-ohm, ½-watt resistor
R3—39,000-ohm, ½-watt resistor
S1—SPST subminiature switch (optional—see text)
Misc.—Jumper wire, #22 solid, insulated, various colors. Solderless breadboard and header strip—AP Products 217L terminal strip. Available at dealers, or order AP 923273. Headers are 929834-01.

Solderless breadboard from Radio Shack (#276-175) for less than $7.00. Other firms make similar boards, both smaller and larger. One which specializes in these boards is AP Products, Inc. Box 540, Mentor, Ohio 44060. Their model #109 costs under $20.00 and includes binding posts for power supply voltages as well as other experimenter's conveniences.

BUILD AN IC STEREO ANALYZER

This weekend project provides a versatile test instrument for tracing audio and RF problems

by Homer L. Davidson

Troubleshooting a weak or intermittent stereo receiver system or phono amplifier is made easy with the IC Stereo Analyzer. The stereo Analyzer will quickly spot any loss of gain in a given stage or when one stereo channel can not be balanced. You can locate a dead or distorting stage in either stereo channel, and go directly to the defective component. You can find the defective component by going from stage to stage and comparing the normal circuit with the defective one.

Not only will the stereo analyzer completely check out the entire stereo set, but it can test the condition of tape heads and phono cartridges. In fact, you may connect a stereo turntable directly to the analyzer and diagnose an intermittent or weak cartridge. This instrument will also show up improper tape head balance or alignment. Besides hearing the defective stereo channel you can see the results with the balance meter. If desired the analyzer can be operated without the meter. You can even use the tester as an extra stereo amplifier.

How it Works

The stereo analyzer is constructed around a dual audio amplifier IC circuit. A dual volume control circuit is located in the input stage of each amplifier and is useful when checking gain in a defective amplifier. You can hear the defective stage in the corresponding speaker when the suspected component is located. Sometimes it's easy for your ears to overlook a slight loss in volume or distortion, but your eyes will never deceive you when watching a balance meter. A dual balance meter located in the output circuits will quickly indicate any unbalanced signal.

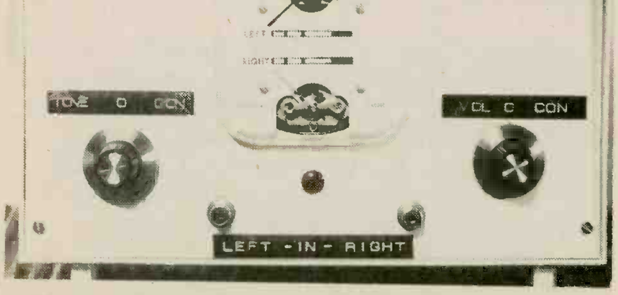


Figure 1. Front view of the finished stereo analyzer.

To signal trace a defective system connect the input cables from the IC analyzer to the input of the amplifier. Start here and work towards the output stages. If you are trying to locate a weak stage in the stereo channels of a tape player, connect the test cables to the volume controls of the stereo amplifier. Now notice if one stage is weaker than the other. If either channel is weak at this point, connect the input cables directly to the tape head. If both channels are normal, go from transistor to transistor towards the volume control. By breaking the audio circuits into individual stages you can quickly determine where the amplifier is defective.

You will use only one channel of the tester for signal tracing a dead or very weak channel. When trying to locate weak or distorted stage, it's best to use both stereo tester inputs and go from stage to stage, comparing the two channels. Since most distortion problems are found in the audio output stages, start at the volume control and work towards the speakers. When testing for weak or distorted conditions always keep the volume control of the analyzer low, but with sufficient working signal. With a separate demodulator probe, plugged into the side of the tester, you can check the radio signal of any AM-FM receiver or tuner from start to finish.

The Amp Circuit

The IC dual amplifier circuit is constructed with a commercial Radio Shack PC board (277-105). You may want to secure one of these or make one of your own. The small amplifier circuit is very simple and can be wired in one evening (Fig. 2). Two separate volume and tone controls are in the input of the audio circuits. A shielded cable input jack is located in each stereo channel for easy testing.

You will notice there are no output transformers in the speaker circuits. Instead, a large electrolytic capacitor (250 uf) couples each speaker to the IC output terminals. Each speaker circuit has a balance meter diode and variable resistor added. Both balance meters are located in one meter case. The balance meter is adjusted and calibrated with a test tape or audio signal generator. A four-inch speaker is located in each end of the metal cabinet. Any thing from 3.2 to 8 ohms will do.

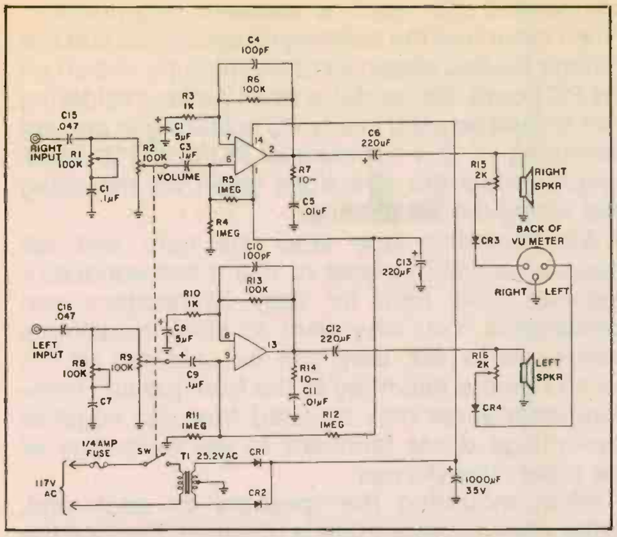


Figure 2. Schematic diagram of the stereo analyzer.

The stereo analyzer is shock-proof and can be safely connected to any unit for testing. A step-down transformer is used in the low voltage power supply. Since the tester may be left on for several hours, choose a 2.5 or 3-amp power transformer for adequate power capability. Two silicon diode rectifiers with a large electrolytic capacitor (1000 uF) form the full-wave low-voltage power supply. A small neon dial light indicates the analyzer is operating. A ¼-amp fuse protects the power supply and amplifier.

Cabinet Construction

The cabinet enclosure is supplied knocked down. This cabinet is a honey, as it makes the finished test instrument look like a commercial project.

You must be careful when putting the sides together so as not to scratch the metal surfaces, the knock-down feature is fine for drilling holes. In fact, the back, sides and front panel must be drilled before putting the cabinet together.

First drill the rear hole for the power cord entrance in the rear panel. A small rubber grommet is inserted in the hole to prevent damage to the electrical cord. Then line up the side panels by placing the four-inch speakers at each end. Two of the pre-drilled speaker holes will line up, but you must mark and drill two additional speaker mounting holes. Ream out the other two holes with a ⅛-inch bit. The speakers may be mounted before the sides are assembled.

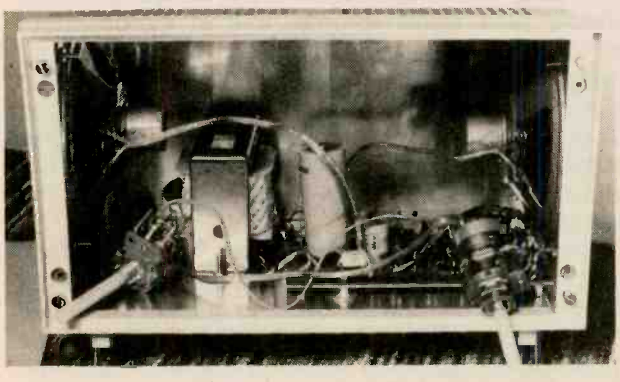


Figure 3. After all holes are drilled, assemble the cabinet.

Drill two power transformer mounting holes in the bottom panel 3 ⅛ inches apart. To hold the small PC board in place, drill four ⅛-inch mounting holes, and use small metal or plastic insulators to hold the board up from the bottom metal panel. Next, mount the plastic feet in the bottom panel.

After drilling, the cabinet panels are fastened together (Fig. 3). First, fasten the rear panel to the speaker panels with four of the smallest cabinet metal screws. The top and bottom pieces are then pushed into the slotted areas. When the plastic front piece is slipped over all four ends it binds the panels securely into position. If the front piece will not fit over the top and bottom ends, (this is a very tight fit) simply bend the curved corners in with a pair of pliers. This will let the plastic piece start over the panels and with a fair amount of pressure, slide into position. When the front panel is fastened into place, the four metal front screws not only hold the front piece but all four panels in position. Before drilling the front cover, you may want to simply tack the front panel into place to see how everything lines up.

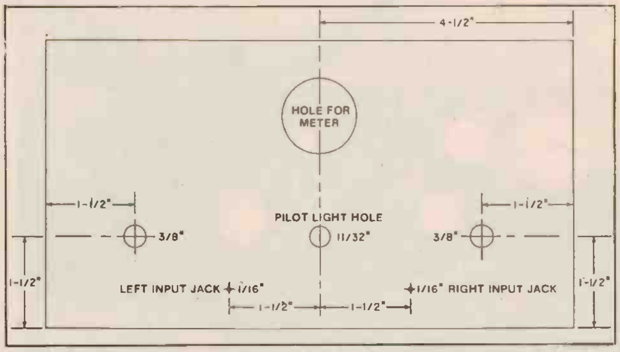


Figure 4. The front cover layout for drilling.

The front panel should be drilled as shown in Fig. 4. Before drilling the front panel, lay out the holes to be drilled on a piece of paper and fasten it on top with masking tape. If real wide masking tape is handy, cover the entire front panel with it. This will prevent any small metal particles from getting inside the paper template and scratching the surface. Use a small ⅛-inch bit to start all the holes, then enlarge the tone and volume control holes with a larger bit.

Use a metal circle cutter to cut out the large meter opening. If you don't have one, you may use the ⅛-inch bit and drill many holes around the outside edge. Shape the opening with a rat-tail file, being very careful to make the hole just large enough for the balance meter to slide into. Extreme care should be used when drilling all the front panel holes so not to damage the professional looking appearance of the cabinet.

Mounting and Wiring Components

First, mount all of the small components such as resistors and capacitors, the prepared PC board, then mount the larger capacitors (Fig. 6). Connect the volume control cables and power transformer

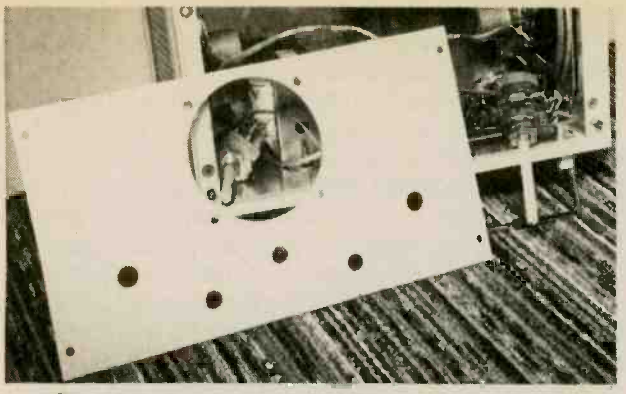


Figure 5. Front panel drilled, ready to assemble.

wires. Use shielded cable for volume and tone controls. Use about 8 inches for the control wires and 12 inches for the speaker cable connections. To make the connections of the volume controls to the PC board wiring easier to follow, use black wire for the ground, green for the center and control terminals and yellow for the high side of the controls or even better, use shielded cable. The connecting wires from volume controls to tone

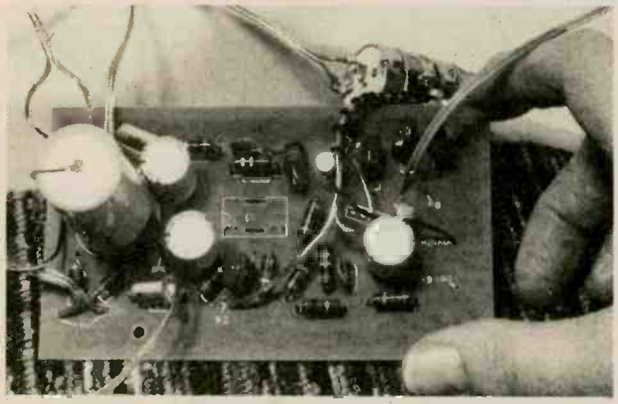


Figure 6. First mount all of the small components and then the larger ones. Leave the IC mounting until last.

control can be made after the controls are mounted on the front panel. After all components and wires are connected to the board, mount the small IC. Use a low wattage iron with a small tip so as not to damage the IC with excessive heat (Fig. 7).

Be sure to clip off the excess wire leads of each

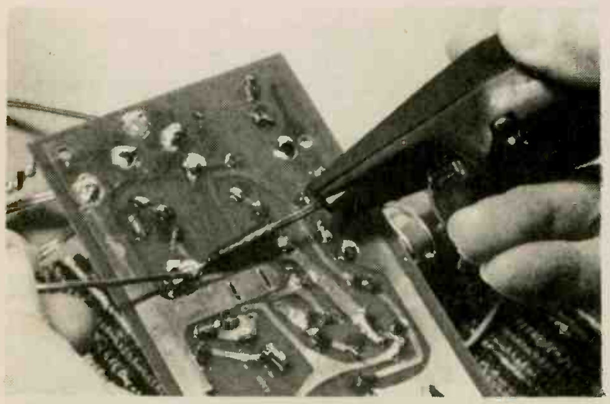


Figure 7. Use a low-voltage soldering iron in wiring up the small PC board.

component after each is soldered into position. When mounting the electrolytic capacitors and low voltage diodes, observe correct polarity shown on the PC board. Be careful, a small wattage soldering iron should be used in any PC soldering to prevent damaging it. If a commercial PC board is used, simply follow the directions given for mounting and wiring the small parts.

With masking tape label the right and left speaker cables. It's best to use a two-conductor speaker cable here for easy connections and appearance. You may want to label the volume control wires but they can be soldered to the control before mounting to the front panel. Three-conductor wires may be used from the negative low-voltage diode terminals to the secondary of the power transformer.

When mounting the speakers on each end, better channel separation is obtained. Position the speaker connections towards the front panel for making easy speaker hookup. Wire the speakers toward the end of the project and cut off the wires so they are just long enough. With the front panel held real close, tape the speaker wires up so they will not lie against the metal cabinet and vibrate.

Since the power transformer has no connecting wires, run a pair of wires from the transformer primary winding to the switch terminals. Connect the pilot light across the primary winding. Now, after all power transformer connections are made, dab black silicone rubber cement over these connections. This prevents possible shocks while working with the tester, or if some metal wire or component slips down from the top side of the cabinet. After all wiring has been completed fasten the front panel to the cabinet. Go over the entire wiring once more. The stereo analyzer is ready for testing.

Testing the Unit

Plug in the AC cord and turn the volume control half on. Leave the tone control at mid-range. Pick up the ungrounded input aligator clip of each channel and you should hear a loud hum. If not, shut the unit off and double check the wiring. In the event both channels are dead, check the power supply circuits. If one side is weak or dead and the other normal, check for trouble in that channel.

When both channels are functioning properly, connect the input test cables to a phonograph turntable or a tape deck. The stereo analyzer should have good volume right at the cartridge wire connections. In fact, if you happen to be testing or servicing several phono turntables select a pair of shielded cables with male ends. You can plug the tester input cables right into the phono output jacks. When testing a tape deck connect the input cables to the pre-amp output, or to the volume controls.

After the stereo tester seems to be normal, calibrate the balance meter. The front panel must be removed or pulled back to get at the small balance controls. These two controls should be mounted on top of the meter for easy accessability. Now, connect a 1 kHz signal from the audio signal generator to each channel and to ground. Rotate the volume control half way and adjust each rheostat until both meters are at center scale.

If an audio signal generator is not handy, you may calibrate the balance meters with a signal from a stereo test tape and tape player. The tape player may be an auto or compact stereo unit with the tape head in correct balance. Connect the stereo analyzer to the tape output or volume controls of both channels. Insert a stereo test tape and rotate the volume control to mid-range. Adjust both rheostats until the balance meter of both channels are at mid-range. The stereo analyzer is now ready to use, to check out and repair those defective parts.

Checking Out a Turntable

To check the condition of your stereo turntable, clip the stereo input test leads to the cartridge output cables. Most stereo changers use the RCA jacks and may be connected to the stereo analyzer with male test cables. If your turntable plugs into an external amplifier, simply insert the phono cables into the input test jacks (Fig. 8). Now plug the

Figure 8. Where to connect the cables from analyzer to the turntable.

changer motor into the power line and load the table with a record. In the event the motor has a plug-in connector, use a power cord with test clips and connect directly to the phono motor leads. The motor will run continuously with this type hookup, and will let you test the phono cartridge under actual playing conditions.

Most problems found with phono cartridges are dead, weak or intermittent conditions. If the volume goes up and down or is intermittent in either channel, suspect the cartridge or a broken lead. Visually inspect the cartridge cable and ground for possible poor connections. If the intermittent condition does not act up, apply a little pressure with your fingers and move the pick up arm sideways. Do not move it enough so the stylus pulls out of the groove. Notice if the sound goes up and down in either channel. The test analyzer is worth it's weight in gold here, for mot only can your hear the sound go up and down but you can actually see the meter needle move. The good channel will be indicated at the center of the scale while the intermittent channel will bounce the needle up and down.

A weak or damaged cartridge will give a lower reading than the normal channel. Sometimes weak conditions are caused by age or by too much heat or sunshine. If the changer sits in the sun or is played constantly with the lid closed you may damage a ceramic cartridge. A dead stereo channel may be caused by a cracked cartridge or a defective phono cable. The stereo tester actually checks out the cartridge under normal playing conditions.

Testing an Amplifier

Whether a defective amplifier is in an AM-FM receiver, a phonograph or tape player, the circuits are serviced in the same manner. You may have a weak, dead, intermittent or distorted channel in the amplifier section. Sometimes you may find a combination of the problems in both channels. To isolate the defective stage, cut the amplifier in half by connecting the stereo analyzer test leads at the volume controls. Now, determine, if the symptoms are in the input or the output stages of the amplifier. If the trouble lies in the front end of an FM stereo section, start at the input and work towards the volume control circuits. For instance, if the left channel is weak, connect the left channel of the analyzer to the defective left channel. Start at the base terminal of the first transistor of the left audio amplifier. Go from base to connector of each stage until you have located the weak stage. Now compare this same stage with the normal right channel.

A slightly weak or distorted condition is more difficult to locate. However, with the stereo analyzer connected to both channels, you can uncover the slightest defect in the bad channel by comparing the good channel with the defective one. Since your ears may not be able to detect a very small loss of signal, the balance meter is better. Always keep the volume control low enough for workable readings on the balance meter. After isolating the weak stage, the suspected component can be located with voltage, resistance and in-circuit transistor tests. All weak, distorted and dead conditions can be located in the same manner.

Testing a Tape Player

You can check the condition of a stereo cassette player from the tape head to the speakers (Fig. 9). An intermittent or dead tape head can be tested right where the tape head cable connections enter the amplifier section. Also, you can check the tape head height and azimuth adjustment at this point. To locate a weak or dead channel, simply signal

Figure 9. Checking out the amp in a stereo tape player.

Figure 10. Locating the defective channel in a tape player.

trace the defective channel.

To locate the bad component of a defective channel, start at the output transistor and work to the volume control. With this test insert a recorded a tape backward.

Since most audio problems are found in output stages this is a good place to start. You can start at the speaker connection and work back from the output stages. Keep working towards the volume control until you hear the music. Now compare this stage with the good one at the very same location in the circuit but in the other stereo channel.

When servicing or trying to locate a defective channel in a tape player, this tester is valuable in sorting out the correct channel (Fig. 10). The tape player may have up to eight power output transistors in a row and a bad one is sometimes difficult to locate. Insert a tape and make correct volume and tone adjustments. Start at the pairs of output transistors and see which side is weak or dead. Then work towards the front end to find the defective channel. Always keep the volume control of the analyzer low enough for a just-adequate working signal. ■

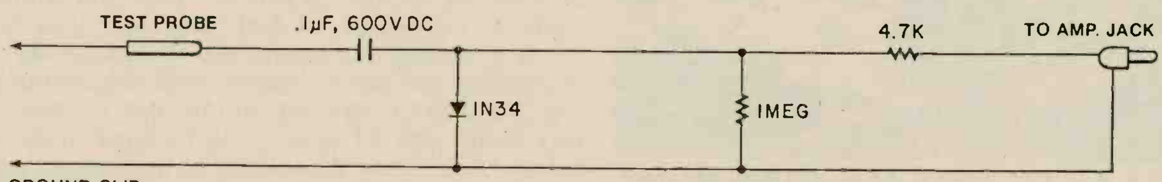
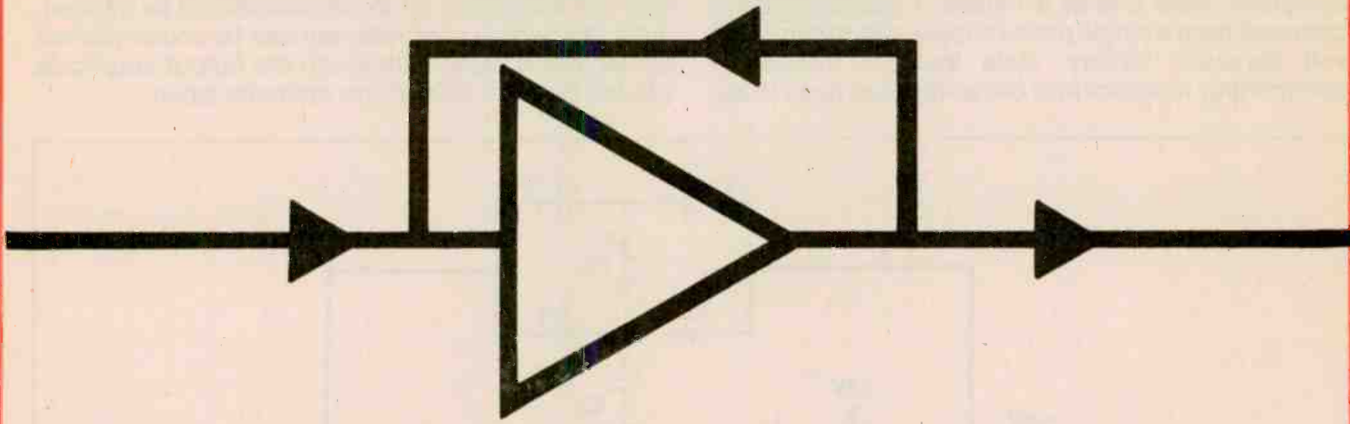


Figure 11. A demodulator probe for signal tracing radio frequency (RF) circuits.

PARTS LIST
(Part Numbers are Radio Shack)

Project board—(277-106) or make your own.
IC—RS2277 Dual audio IC (276-630) or equivalent.
C1, C3, C7, C9—.1 uF pc capacitor (272-1069) or equivalent.
C2, C8—5uF 16 volt electrolytic capacitor (272-1001) or equivalent.
C4, C10—100pF capacitor (272-123) or equivalent.
C5, C11—.01 uF capacitor (372-1065)
C6, C12, C13—220 uF, 16-volt electrolytic capacitor (272-956).
C14—1000 uF electrolytic capacitor (272-1032).
C15 & C16—.047 uF, 600-volt capacitor
CR1, CR2—3-amp, 50-volt diodes (276-1141) or 2.5 amp diodes.
CR3, CR4—1-amp, 50-volt diodes.
R1 & R8—100K dual linear taper controls
R2 &R9—100K dual audio taper controls (with switch)
R3, R10—1K, ½-watt resistors
R4, R5, R11, R12—1 meg, ½-watt resistors
R6, R13—100K ½-watt resistors
R7, R14—10-ohm, ½-watt resistors
F1—¼-amp slo-blow fuse (270-1288).
T1—25.2 volt C.T. transformer (270-1288).
D1—Dial light assembly 1174 type (272-702).
Jacks—two shielded chassis phono type (274-346).
Cabinet—5½×9×4½-inch box (270-281)
Meter—Balance meter (18A13664) $5.95 from Gravious Merchandisers, 715 Armour Rd., North Kansas City, Mo. 64106
R15, R16—variable screw driver controls, 2K ohms
Misc.—power cord, fuse holder, No. 22 hookup wire, shielded cable, nuts, bolts.

IC TESTBENCH



Integrated circuits (ICs) have carried electronics light years ahead in just the few short years (since the Sixties) that they've been around, and they make it possible to pack many complicated circuits and electronic functions into a tiny space, with very few additional (external) components. That's why ICs are so important, and that's why we present a special section just working with ICs (IC Testbench).

By putting together a few of these IC Testbench projects 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.

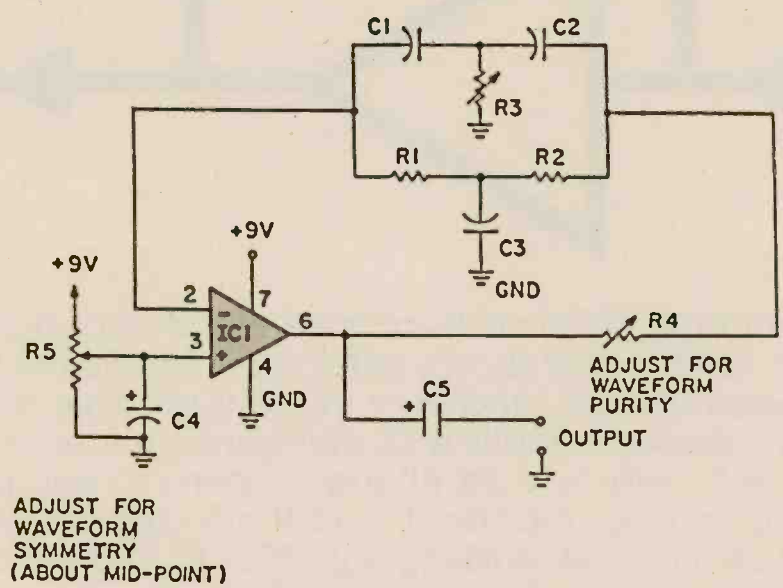
If you've never worked with ICs before you should observe a few simple rules. Don't mount the IC directly into a circuit or solder its terminals into the circuit. Instead, do what experienced experimenters do—solder and IC socket into the circuit (unless you're using a quick-assembly experimenter's board, in which case you'll just plug the socket into the board's holes). Also, don't handle the IC any more than is 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).

Finally, put together as many of these projects as you can. Each of them will teach you something different and important about how to use ICs in modern electronics.

If you're not entirely up on what ICs are, and how important and useful they are in modern electronics practice, you should read the article in this issue titled "All About Integrated Circuits"

AUDIO SIGNAL GENERATOR

The 741 op amp has become a classic for IC designers. Here it is as a Parallel-T audio oscillator operated from a single power supply, which can be a 9 volt transistor battery. Note that the frequency-determining resistors and capacitors are fixed in the ratio of C1=C2, C3=2×C1 and R1=R2, R3=R1×0.1. To vary the frequency, all three pots should be ganged, but a fair degree of adjustment can be accomplished by varying R3 alone, although the output amplitude will fall on each side of the optimum value.



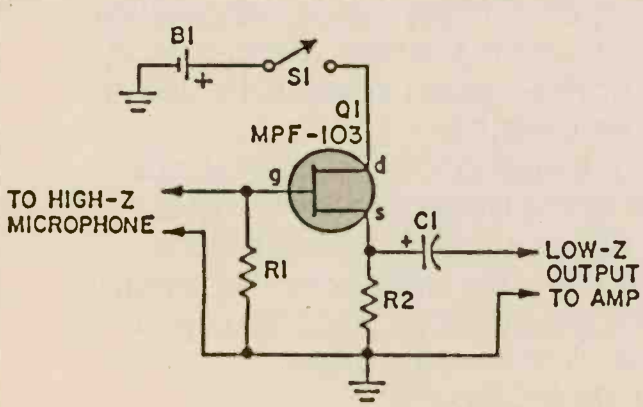
PARTS LIST FOR AUDIO SIGNAL GENERATOR

C1, C2—0.022-uF, 10 VDC ceramic capacitor
C3—0.047-uF 10 VDC ceramic capacitor
C4—100-uF, 15 VDC electrolytic capacitor
C5—10 to 20-uF, 15 VDC electrolytic capacitor
IC1—741 op amp
R1, R2—47,000 to 56,000-ohm, ½-watt resistor
R3, R5—5,000-ohm linear taper potentiometer
R4—100,000-ohm linear taper potentiometer

HIGH IMPEDANCE TO LOW MIKE

Try to run a high impedance mike line for more than 25 feet and you're sure to get high frequency losses and hum pickup. But this simple junk-box project mounted in a small metal enclosure on the mike stand will convert the mike's output to a low impedance that can run for hundreds of feet without hum pickup or losses.

The output can be run into any microphone input-



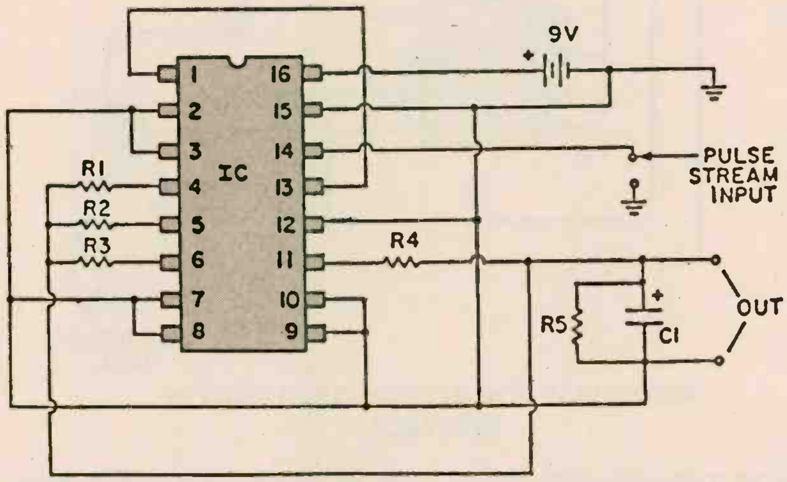
PARTS LIST FOR HIGH IMPEDANCE TO LOW MIKE

B1—1.5-volt AA battery
C1—10-uF, 12 VDC electrolytic capacitor
Q1—Field effect transistor, (NPN) Motorola MPF-103 (Radio Shack 276-2028)
R1—2-megohm, ½-watt resistor
R2—150-ohm, ½-watt resistor
S1—Spst switch

rated from 150-ohms up to high impedance. The circuit serves only to convert high to low impedance; it provide no amplification. A metal enclosure must be used. The Field Effect Transistor, Q1, can be just about any surplus N-channel type.

SINE WAVE CONVERTER

Think it is possible to have a pulse stream turned into a nice smooth sine-wave? This circuit will do it! In fact, you can have the lowest sine-wave frequency you can imagine by slowly pressing a button to generate your own manual pulse stream, if you like. The IC is a counter that has been made to divide the input pulse rate by ten. The outputs feed through resistors R1, R2, R3, and R4 to build up a sine wave.

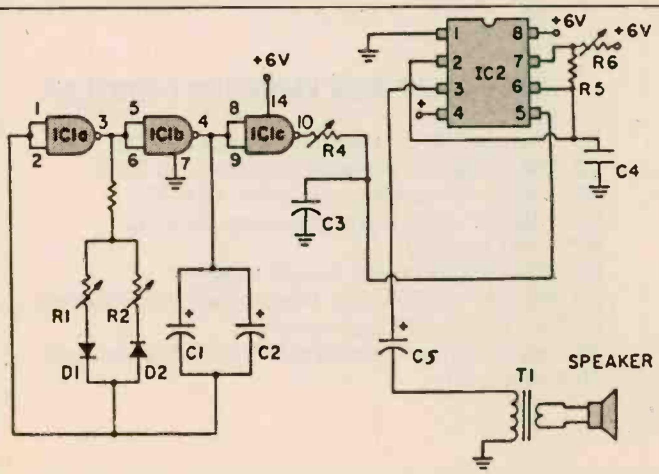


PARTS LIST FOR SINE WAVE CONVERTER

C1—10-uF electrolytic capacitor, 15 VDC
IC1—4018 dividing counter
R1, R2, R3, R4—20,000-ohm, ½-watt resistor
R5—47,000-ohm, ½-watt resistor

FIRE SIREN

When switched on, this little screamer sounds like its official counterpart, with authentic-sounding rise and fall in pitch. Since the siren-sound is subjective to a large extent, plenty of variable components have been included in order to obtain the "perfect pitch." The circuit consists of a 555-type timer in astable mode, modulated by a varying DC, which is developed from a long-term multi-vibrator or clock. The high-low action of the clock causes capacitor C3 to charge and discharge through a resistance R4, the potential on the capacitor being applied to the "modulation input" (pin 5) of the 555. The long-period clock may be derived from another 555, or from the circuit shown.

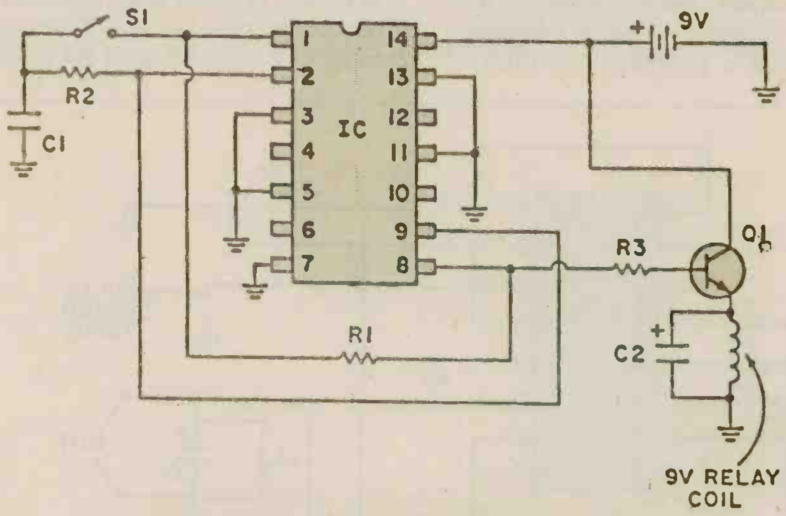


PARTS LIST FOR FIRE SIREN

C1, C2—4.7-uF tantalum capacitor, 25 VDC
C3—500 to 1,000-uF electrolytic capacitor, 25 VDC
C4—100-uF electrolytic capacitor, 25 VDC
C5—0.1-uF ceramic capacitor, 15 VDC
IC1—4011A quad NAND gate
IC2—555 timer
R1—500,000-ohm, ½-watt resistor
R2—500,000-ohm linear-taper potentiometer
R3—47,000-ohm, ½-watt resistor
R4—10,000-ohm linear-taper potentiometer
R5—4,700-ohm, ½-watt resistor
R6—25,000-ohm linear-taper potentiometer
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

ALTERNATING OFF-ON CONTROL

The pushbutton at "A" will cause the relay of this circuit to go off one time it is pressed, and cause the relay to go on the next time the button is pressed. In other words, the pushbutton has alternate action. First, it makes an "off", and later, an "on". This type of circuit is very handy for projects around the house. All unused pins should be grounded.

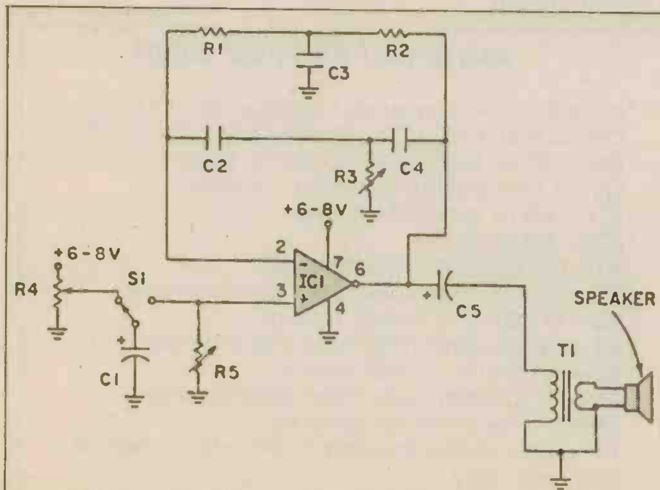


PARTS LIST FOR ALTERNATING OFF-ON CONTROL

C1—0.1-uF ceramic disc capacitor, 15 VDC
C2—1-uF electrolytic capacitor, 15 VDC
IC1—4069 hex inverter
Q1—2N4401
R1, R3—10,000-ohm, ½-watt resistor
R2—100 Kohm ½ watt resistor
S1—SPST momentary-contact pushbutton switch

VARIABLE WHISTLER

At the push of a button, this circuit lets forth with an attention-getting whistle, which can be tailored to meet a variety of formats. The circuitry is built around a Twin-T oscillator, which is triggered into action by a varying positive potential placed on the non-inverting op amp input. Resistors R1, R2, and R3, together with capacitors C1, C2, and C3 determine the fundamental pitch with R3 providing a useful variation. When S1 is pushed, the potential stored in C4 is placed on the non-inverting input, causing the oscillator to function. The duration is determined by R5. The format of the whistle is modified by the setting of R4. At full potential, the effect is a sharply rising tone, followed by a more gradual decline. At about half setting, the effect is more bell-like.

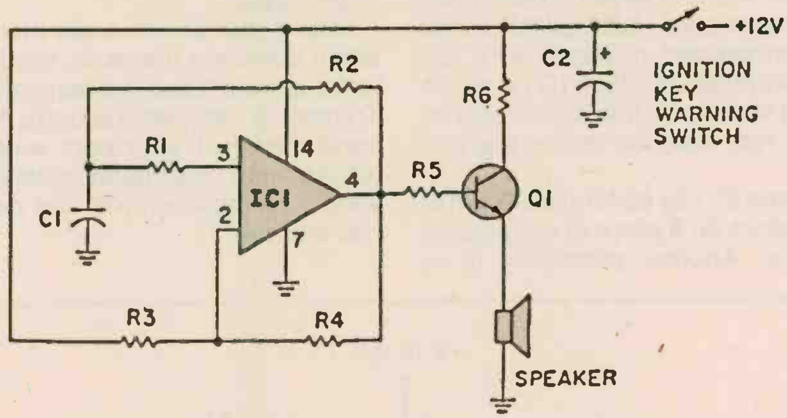


PARTS LIST FOR VARIABLE WHISTLER

C1—100 to 200-uF electrolytic capacitor, 15 VDC
C2, C4—0.001-uF ceramic capacitor, 15 VDC
C3—0.002-uF ceramic capacitor, 15 VDC
C5—100-uF electrolytic capacitor, 15 VDC
IC1—741 op amp
R1, R2—100,000-ohm, ½-watt resistor
R3, R4, R5—10,000-ohm linear-taper potentiometer
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

SOOTHING CAR KEY ALARM

This ignition key tone generator replaces the loud, annoying buzzer in your car with a pleasing tone of about 2000 Hertz. One section of an LM3900 quad operational amplifier is connected as a square wave generator, which is rich in harmonics and produces a pleasant sound. Current amplification to drive the speaker is provided by Q1. The frequency of oscillation is determined by C1 and R2. Total current drawn by the circuit is about 75 milliamperes at 12 volts.

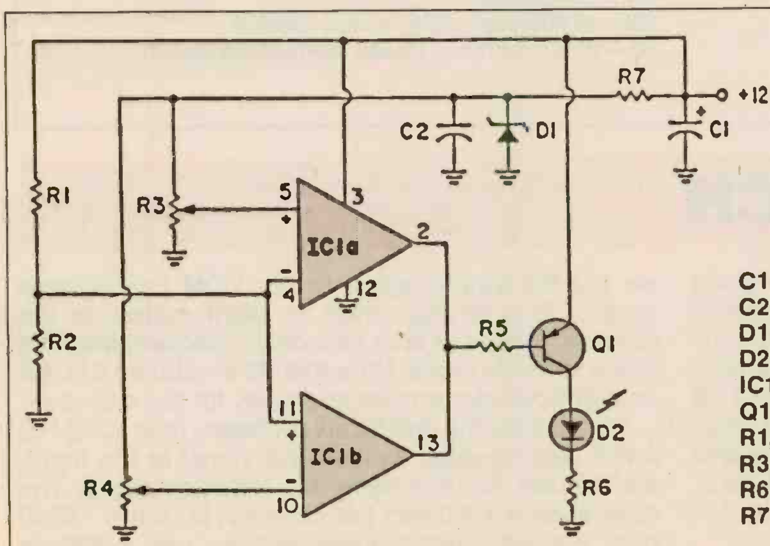


PARTS LIST FOR SOOTHING CAR KEY ALARM

C1—0.01-uF ceramic capacitor 15 VDC
C2—10-uF electrolytic capacitor, 20 VDC
IC1—LM 3900 quad amplifier
Q1—2N4401
R1—2.7 to 3.0 Megohm resistor
R2—33,000-ohm, ½-watt resistor
R3, R4—10 Megohm resistor
R5—10,000-ohm, ½-watt resistor
R6—100,000-ohm, ½-watt resistor
SPKR—8-ohm PM type speaker

CAR ALTERNATOR MONITOR

This circuit will monitor the output of the alternator of any car with a 12 volt electrical system and indicate if the charging system is either undercharging or overcharging. This is accomplish by using 2 sections of a quad voltage comparator IC and connecting the outputs in an "OR" configuration so that the LED will become lit if section A or section B of the comparator detects an improper voltage level. The circuit is connected into any circuit which is active when the car is in operation, such as the ignition or radio circuit. This prevents drain on the battery when the car is not is use. To calibrate the circuit, connect an adjustable



PARTS LIST FOR CAR ALTERNATOR MONITOR

C1—10-uF electrolytic capacitor, 15 VDC
C2—0.1-uF ceramic capacitor, 15 VDC
D1—9 VDC zener diode
D2—large LED
IC1—339 quad comparator
Q1—2N4403
R1, R2, R5—10,000-ohm, ½-watt resistor
R3, R4—50,000-ohm linear-taper potentiometer
R6—470-ohm, ½-watt resistor
R7—220-ohm, ½-watt resistor

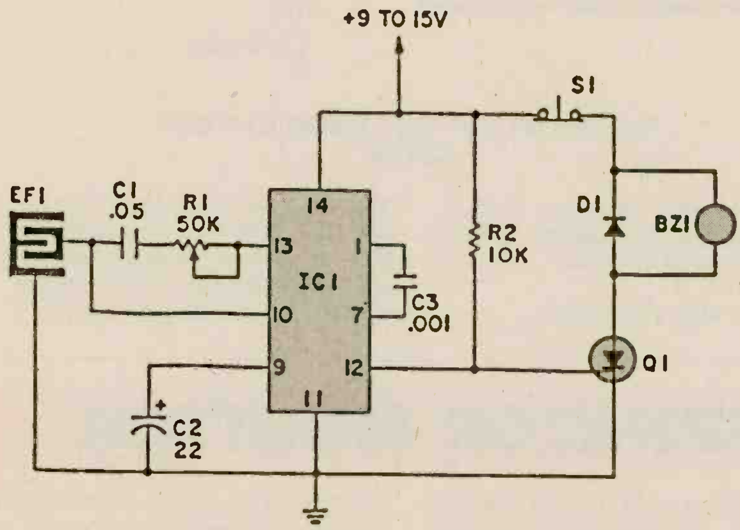
DC power supply to the + and – inputs of the circuit. Set the power supply to 13.4 volts and adjust R3 so that the voltage at pin 5 of IC1A is maximum. Then adjust R4 so that the LED just goes out. Set the power supply to 15.1 volts and adjust R3 so that the LED just goes out. The LED will now become lit if the voltage is outside the permissible range of 13.5 to 15.0 volts when the engine is running.

ALERT POOL GUARD

Want to keep freeloaders out of your swimming pool in the hot summer months ahead? Then build this pool sentry. Whenever pool water splashes into the gap between the conductors of sensor EF1, IC1 triggers the silicon-controlled rectifier (Q1), which latches in a conducting state and turns on the buzzer. To turn the buzzer off, first wipe the sensor dry, and then press S1.

You can easily fabricate EF1 by etching a pattern of two interleaved conductors on a piece of copperclad printed-circuit laminate. Another possibility is to attach a series of copper or aluminum strips to a piece of plexiglass.

Mount your sensor a few inches above water level. When someone jumps in, the crest of the wave that forms should touch the sensor and trigger the alarm. Trimmer R1 adjusts the unit's sensivity to match the conductivity of your pool water. Greatest sensivity occurs with maximum resistance. Incidentally, it should be apparent that the pool sentry could be a real lifesaver.



PARTS LIST FOR ALERT POOL GUARD

BZ1—12 VDC buzzer (Radio Shack 273-051)
C1—.05 uF mylar capacitor
C2—22 uF, 25V electrolytic capacitor
C3—.001 uF mylar capacitor
D1—IN4002 1-amp rectifier diode
EF1—etched-foil sensor (see text)
IC1—LM1830 fluid detector (National Semiconductor)
Q1—2M5060 sensitive-gate silicon controlled rectifier
R1—50K trimpot
R2—10,000-ohm, 10%, ½-watt resistor
S1—SPST normally closed pushbutton switch

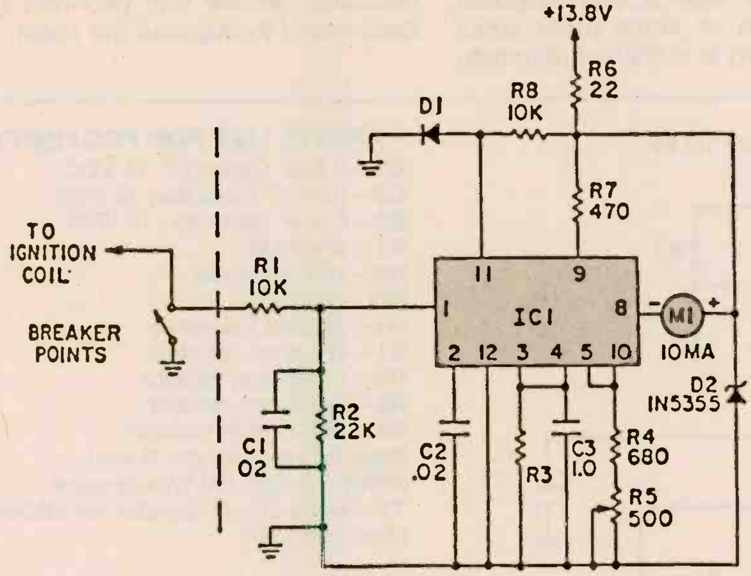
CAR TUNEUP TACH

Four tune-up and maintenance of your car's engine, an accurate tachometer is a must. The one-IC tach featured here is powered by your car's "12-volt" electrical system. (Actually, the potential of a fully charged lead-acid storage battery is equal to 13.8 volts.) Input signals for the tach come from your ignition system's breaker points, which make and break the circuit on the primary (low-voltage) side of your ignition coil. Readout is provided on a 10-milliamp DC meter.

Although you could purchase a meter for this unit, we fed the output signal to our VOM (10-milliamp range), thus saving seven or eight dollars in the process. Since our tach gets only infrequent use, this was a sensible move. Note that R3 should be 91K for an eight-cylinder engine and 120K for six cylinders.

To calibrate the unit for six cylinders, feed a 300-Hz, 2-volt peak-to-peak squarewave signal to the input, and adjusts R5 until meter M1 reads exactly 6. The calibration is 1000 rpm per milliamp; ie.: 6 mA = 6000 rpm. For an eight-cylinder engine, use a 400-Hz signal, and proceed exactly as above.

A note to hot-rodders: A dashboard-mounted tach should be equipped with a large, rugged, easy-to-read meter that swings through 300° of arc. Unfortunately, such special meters are not generally available to the experimenter, except by coincidence as surplus. We recommend, therefore, that you buy rather than build a tach for racing, and use the unit presented here for its intended purpose: tune-ups.

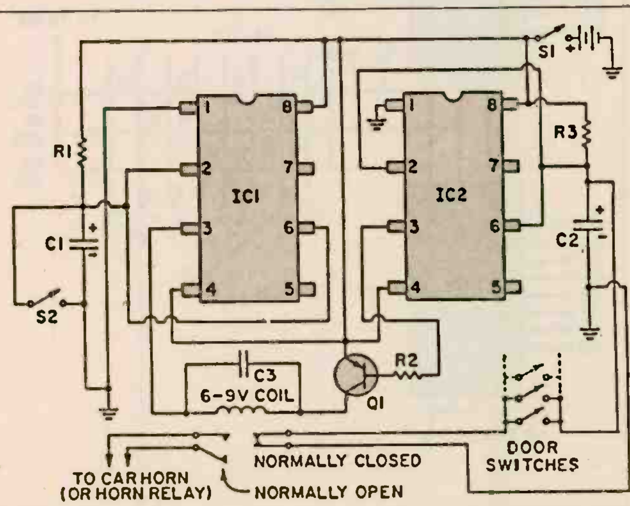


PARTS LIST FOR CAR TUNEUP TACH

C1—C2-.02 uF capacitor
C3—1.0 uF capacitor
D1—IN4002 rectifier diode
D2—IN5355 18V, 5W zener diode
IC1—LM2917 frequency to voltage converter
M1—0-10 mA DC meter
R1—10,000-ohm, ½-watt resistor
R2—22,000-ohm, ½-watt resistor
R3—91,000 (8 cyl) or 120,000 (6 cyl), 5%, ½-watt resistor
R4—680-ohm, ½-watt resistor
R5—500-ohm trimpot
R6—22-ohm ½-watt resistor
R7—470-ohm, ½-watt resistor
R8—10,000-ohm, ½-watt resistor

AUTO BURGLAR ALARM

This burglar alarm will sound your car horn it anyone opens your car door. The timers allow you to leave and enter the car without the horn sounding. To set, or arm, the alarm circuit, open S2. This will give you five seconds (R1, C1) to get out and shut the door behind you. If anyone opens a door for two seconds (R3, C2), the horn will sound and will stay locked on until S1 is opened. If you open the door to enter, you have two seconds to close S2, which is plenty of time if S2 is conveniently located.

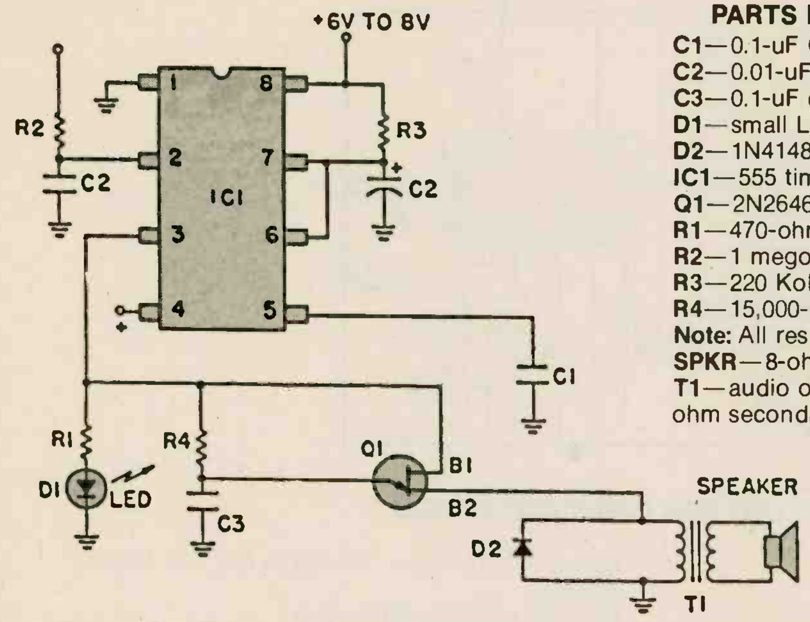


PARTS LIST FOR AUTO BURGLAR ALARM

C1—10-uF electrolytic capacitor, 15 VDC
C2—1-uF electrolytic capacitor, 15 VDC
C3—0.1-uF ceramic disc capacitor, 15 VDC
IC1, IC2—555 timer
Q1—2N4403
R1—500,000-ohm, ½-watt resistor
R2—270-ohm, ½-watt resistor
R3—2,000,000-ohm, ½-watt resistor
RELAY—6 to 9 VDC coil with switch contacts rated at 15 VDC/30 amps; 1 set SPST normally open, 1 set SPST normally closed

PROXIMITY SWITCH NO. 2

This circuit finds the 555 timer as 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 PROXIMITY SWITCH #2

C1—0.1-uF Capacitor, 15 VDC
C2—0.01-uF capacitor, 15 VDC
C3—0.1-uF capacitor, 15 VDC
D1—small LED
D2—1N4148 diode
IC1—555 timer
Q1—2N2646 transistor
R1—470-ohm, resistor
R2—1 megohm resistor
R3—220 Kohm resistor
R4—15,000-ohm resistor
Note: All resistors are ½-watt
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

MULTI-POLE SWITCH

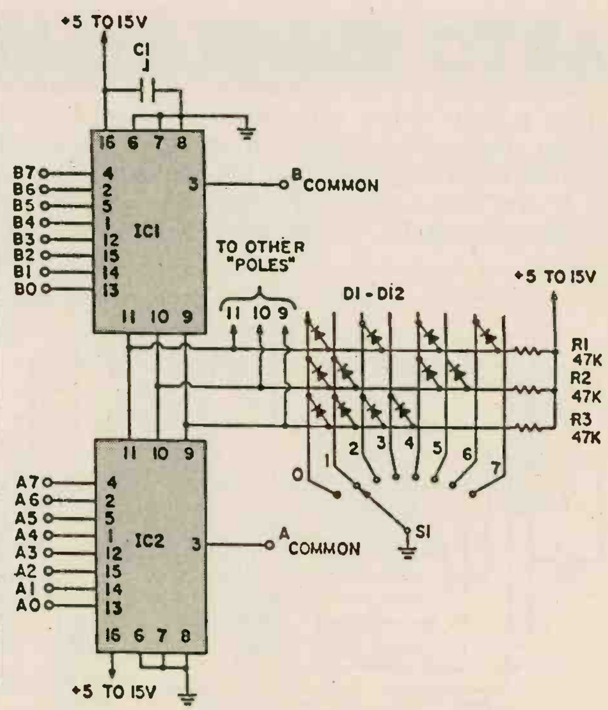
Suppose that you happens to be working in electronic music, and that 30 poles of switching are needed to change voices. Even if you could locate a mechanical switch to do the job, it would be prohibitely expensive. Fortunately, there is a method to switch an arbitrarily large set of analog or digital signals electronically. You can add on as many poles as you like at very little additional cost.

When S1 is in position 3, input A3 is connected to A-common, and input B3 is connected to B-common. As you change S1's position, the input connected to common on each IC changes likewise. Multiplexers IC1 and IC2 are bidirectional (which means, for example, that A0-A7 can be inputs, and A-common can be the output; or that A-common can be the input, and A0-A7 can be outputs).

Supply voltages between +5 and +15 VDC can be used, and input/output signals should fall somewhere in the range between ground potential and the supply voltage. Extra poles can be added by connecting pins 9, 10 and 11 of the additional 4051 multiplexers as indicated in the schematic.

PARTS LIST FOR MULTI-POLE SWITCH

C1—.1 uF ceramic disc capacitor
D1 thru D12—1N914 silicon diode
IC1, IC2—4051 CMOS 8:1 multiplexer/demultiplexer
R1, R2, R3—47,000-ohm ½-watt resistor
S1—3-pole, 8-position, rotary switch



DIGITAL Vs ANALOG

Until a few years ago most electronic devices worked using *linear* amplifiers, more accurately called ANALOG electronics. That is, the output of such circuits was as close a copy of the input (though usually larger) as possible. Today the shift is heavily toward DIGITAL electronics. This is due to many factors, the biggest being that digital circuitry is generally much more readily miniaturized into integrated circuits (ICs).

However, analog electronics are still important, and in some cases, are better suited to specific applications. In this article we look at some of the differences between these two major, separate ways of *processing information* using electronics. As a preamble, it's helpful to briefly describe these two separate ways of handling electrons.

The main difference, then, between digital and analog systems is in the signal that is used to transmit and handle information (data). In an analog system, an electrical signal is used to represent (or make a model of) a physical (real world) quantity. Figure 1 is a simplified block diagram of most analog systems.

Linear and Analog: Equivalents

Linear does not mean that the signal varies in a straight-line way. Instead, it means that the signal varies in a smooth, continuous wave-like manner, not in On or Off levels, as in digital.

In an electrical analog system, we use some *controllable property of electricity*, such as current or voltage, as an *analog* to represent the information we're handling. (Think of the word "analogy.") That is, the electricity is closely and carefully *controlled* so as to be a *more* or *less exact copy* or *representation* (model) of the information. *Figure 2* shows an example.

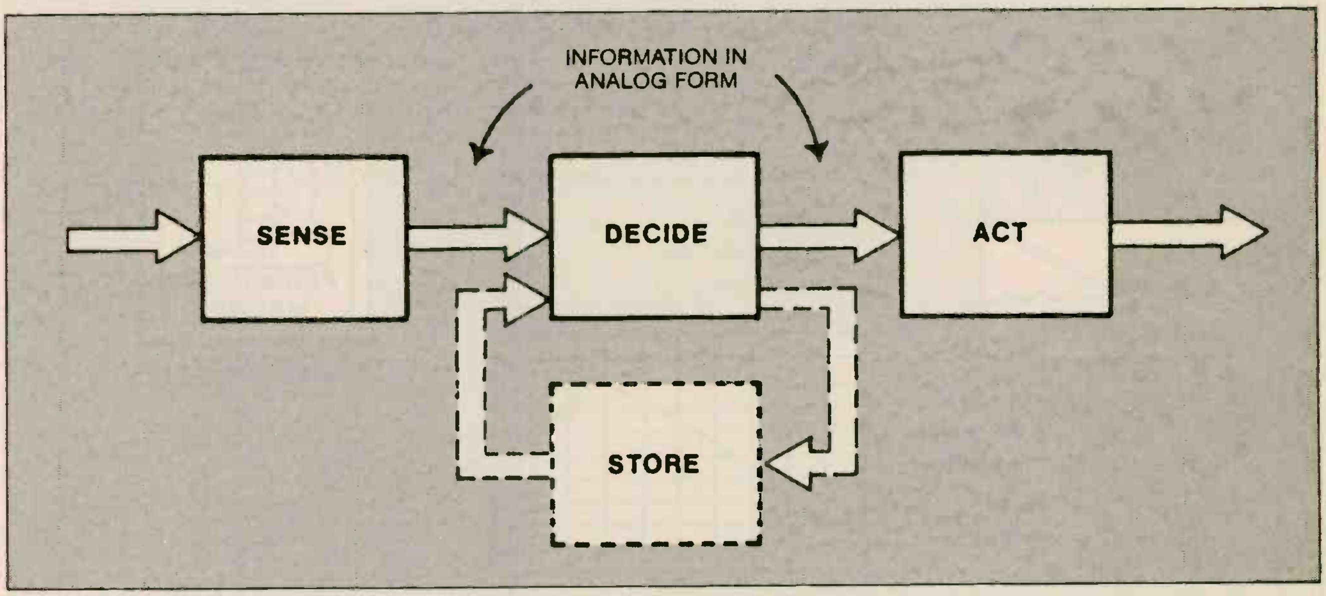


Figure 1. Analog Systems Use Linear (Continuous) Circuits

Analog & Digital Defined

Digital processing requires that everything be a choice of two possible signals. These are usually called On or Off, One or Zero, or True, or False. Electrically, they are either of two signal states, most often Zero volts or about 4.0 volts, sometimes higher or lower, but near 4.0 is most common. In some systems it may be Zero or a negative voltage.

Analog processing has either voltage or current changing according to a more-or-less continuous flow of signal information. The electrical signal is *analogous* (similar) to the actual physical (real world) information being processed.

How Does This System Work?

Let's look at a very familiar analog system, the gasoline gauge system of an automobile. The current in this system is an *analog* of the amount of gas in the tank. If the gas goes down, the current is reduced. If it goes up, there is more current flow in this analog circuit.

The variable resistor would typically be a curved piece of carbon touched by a moveable contact. Sliding this contact along the carbon shortens or lengthens the path travelled by the electricity through

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This article is adapted from *Understanding Digital Electronics* published by Howard W. Sams & Co., Inc. a subsidiary of ITT, Indianapolis, Indiana 46268.

the carbon. Another resistor (next to the first), holds the current down to the range the meter can handle. The ground symbols at the battery and meter indicate that these two points are connected through a common path, such as the frame of the car, which is considered to be at zero volts. (As you probably already know, a *complete circuit* must be provided before current will flow.) A switch turns off the current when the ignition key is off.

The current meter acts as a little electric motor whose rotor is kept from turning very far by a spring. The greater the current, the stronger the magnetic field produced in the little rotating coil, and the more strongly the north and south poles of the coil and the permanent magnet interact with each other. (Remember, unlike poles attract and like poles repel each other.) As the coil turns against the force of the spring, it moves the pointer to indicate current through the coil.

Figure 2 shows a system indicating the fuel level in an automobile gasoline tank in an analog fashion. The float on a swinging arm in the tank adjust a variable resistor according to the gasoline level. (Think of a lever turning the volume-control knob on a radio.) This *varies the current* in a wire running to the instrument panel. For example, as shown in the figure, 1 milliampere of current might mean empty, 9 milliamperes might mean full, and each current in between would represent a certain tank level. At the instrument panel, the pointer needle in a current meter indicates level as it moves between the two extremes of measured current.

Note that the current is *not switched On and Off* as in a digital system. Instead, current flows at all times and is *varied* over a certain range. Thus, the pointer in the meter duplicates the movement of the float over its full range, more or less accurately. What's important to notice is that *current* has carried information from one place to another in an *analog* fashion, by being *varied* over a range.

This smoothly varying feature of analog systems is illustrated in the graph in *Figure 2*, which also shows us where we get the name "linear" for circuits that handle analog information. This graph shows generally how the circuit *output* (pointer position or milliamps) changes when the *input* (gallons—litres—or level) changes. Since the current is *varied* rather than being switched, the graph is a *smooth line*, with no sudden jumps. That's why we call the circuit *linear*.

Unfortunately, the word *linear* can have different meanings in different circumstances. Sometimes it's used to mean that a graph is not only smooth but perfectly *straight*. You need this word but we will not be using it very much. We will mainly refer to *analog* circuitry.

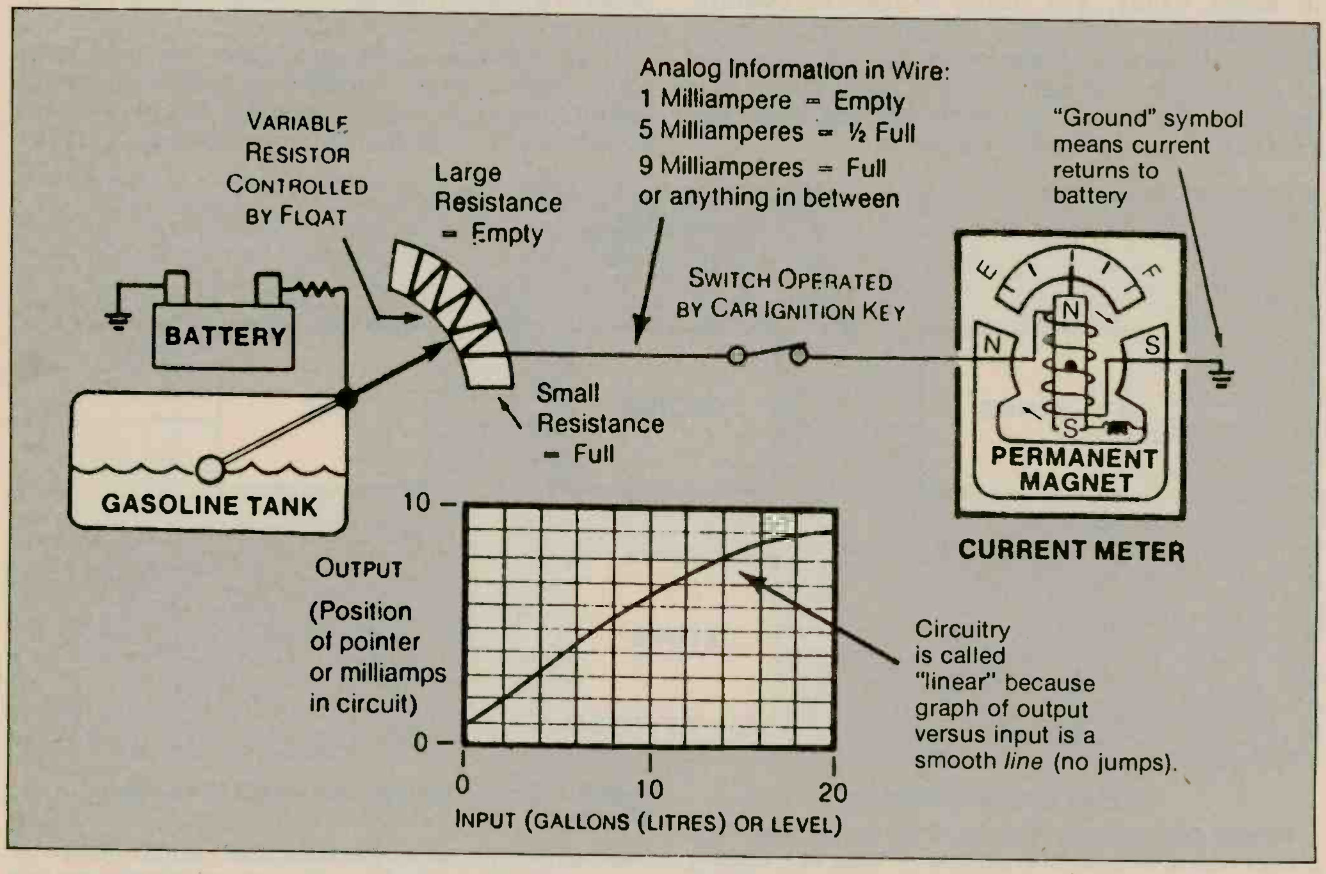


Figure 2. Car's Gas Indicator System Uses Analog Signals

What Has The Fuel Gage Shown?

This, then, is an example of how one controllable property of electricity—namely, current—can be used as an analog (a direct representation) of the information we want to transmit. It's a very simple, idea, actually. It's the natural way anyone would think of to handle information by means of electricity.

This example may have led you to realize that many of the common everyday electrical systems you can think of use some form of analog information, either throughout the system or in part of it. To learn more, let's look at a couple more analog systems.

Telephone is Analog System

In a telephone circuit, the current flowing is an *analog* (physically similar model) of the sound striking the microphone. And when the current gets to the receiver, it reproduces the sound waves.

Although a telephone system may seen pretty far removed from the current-analog fuel-gage system, it works essentially the same way, only much *faster*. *Figure 3* shows the idea of a simplified telephone system, consisting of one mouthpiece and one earpiece. Current flows through the complete circuit, from the direct-current power supply, through the mouthpiece and earpiece, and back to the power supply through the ground connections. As in the fuel-gage system, the amount of current is determined by the resistance in the circuit.

The microphone element in the mouthpiece is a capsule full of powdered carbon that acts as a *variable resistor*. It allows more current to pass when it is squeezed by air pressure. When we speak, we vary the air pressure in front of our mouths. Fluctuations in air pressure occurring from about 20 times a second (a frequency of 20 hertz) to about 10,000 times a second (a frequency of 10 kilohertz) are what our ears hear as *sound*.

So the microphone element creates rapidly surging waves of electricity in its output wire, as an analog representation of waves of varying air pressure—that is, sound waves. (The current increases and decreases very quickly, over and over again, due to the varying resistance.) At the earpiece, this current passes through the coil of a fixed electromagnet, creating surges of magnetic force that match the surges of current. The magnetic force, in turn, attracts a springy metal diaphragm in proportion to the current waves. Finally, the diaphragm, by rapidly pushing and pulling the air, reconstructs a more or less accurate copy of the original sound waves, which have been transmitted in analog form by surges of electricity. Our ears detect the varying air pressure and hear the sound. Simple, isn't it?

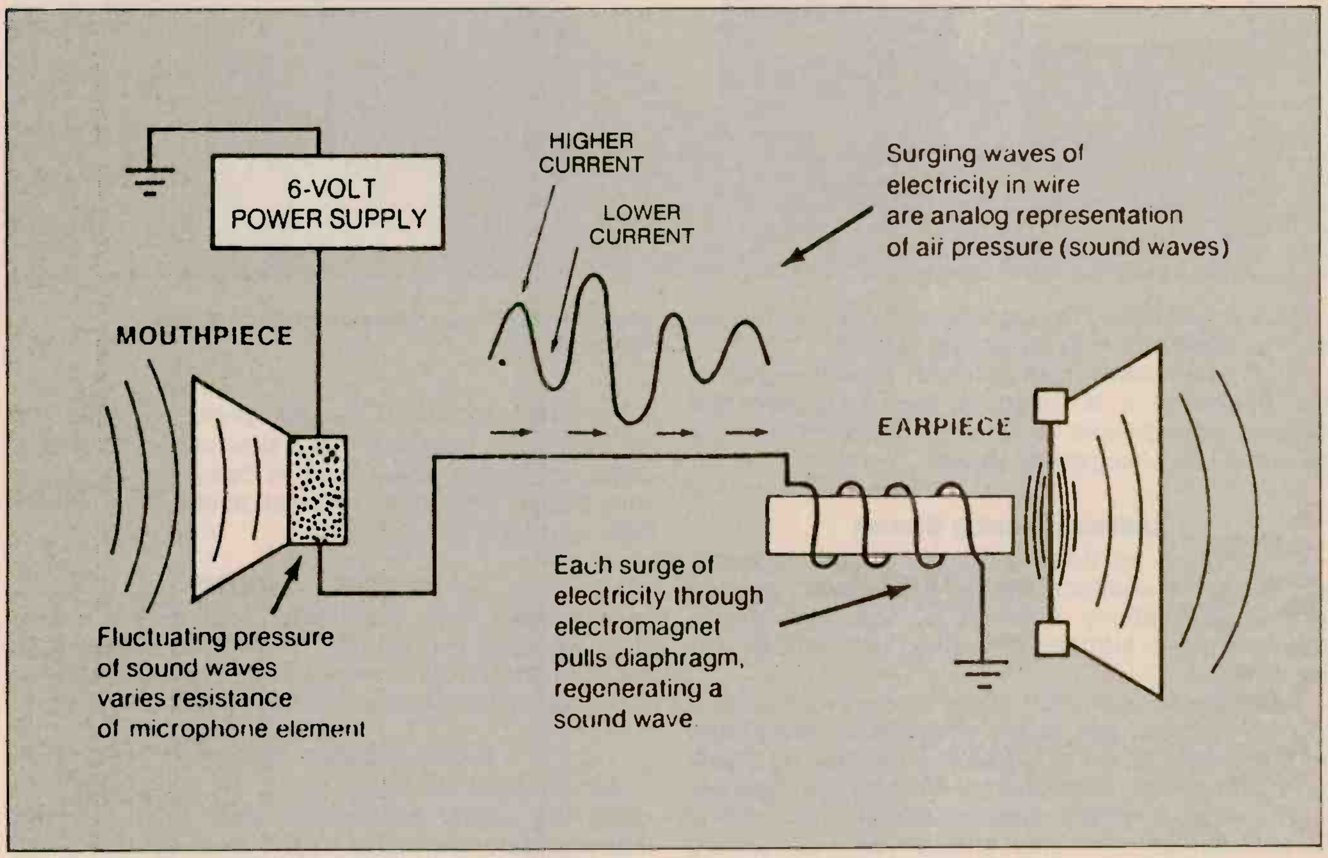


Figure 3. Analog Signals in Phone Transmitter and Receiver

AM Radio Is An Analog System

In AM (amplitude modulation) radio the sound waves change the strength (amplitude) of the radio wave(s) in a pattern which matches the sound waves.

To perform this trick, as shown in *Figure 4*, the system uses an *oscillator* to generate 1-megahertz electrical waves of *constant* amplitude. (The voltage is just going up and down smoothly a million times a second, the *same amount* each time.) A special amplifier circuit called a *modulator* then amplifies these waves. That is, it *multiplies* its input voltage by a certain factor, producing taller and stronger waves at its output.

Now the *gain* of the amplifier—the factor it multiplies the input by—is controlled by the voltage signal from a microphone. This signal is a voltage *analog* of the *sound waves* striking the microphone. The voltage waves, in effect, rapidly turn the volume control knob on the amplifier up and down, thus modulating the amplitude of the 1-megahertz output waves as we desire.

On reaching the antenna, each electric wave generates a radio wave. The radio waves, in turn, are of the same frequency and amplitude (relative to one another) as the amplitude-modulated electric waves.

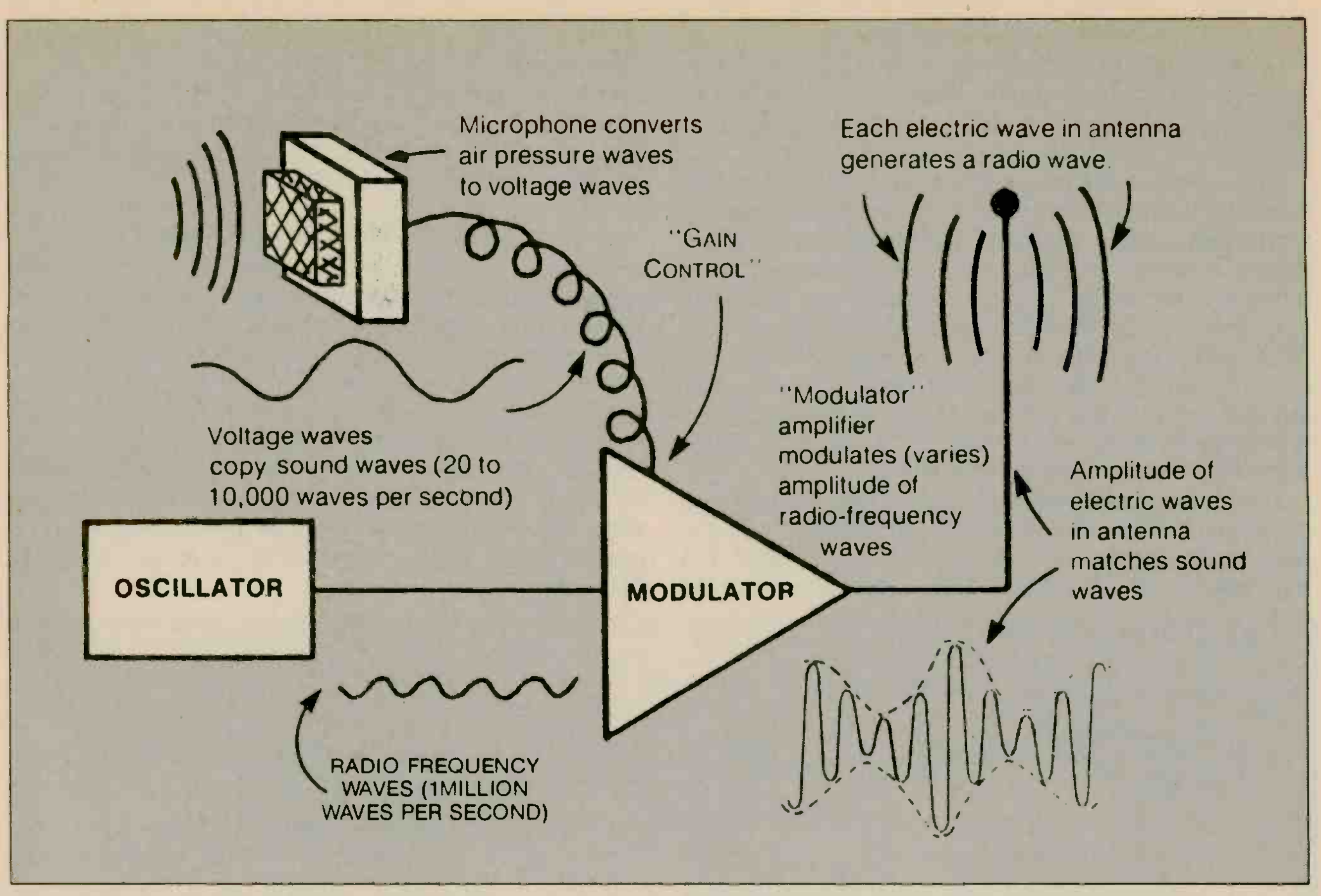


Figure 4. AM Radio Transmitter Uses Analog Modulation

Thus by modulating the amplitude of radio waves, we can transmit sound in an *analog* fashion.

The radio *receiver* responds only to radio waves of the frequency it is tuned to, and it recovers the original sound-wave pattern by following just the *peaks* of the 1-megahertz waves.

Universal Analog System

Sensors in analog systems convert physical quantities into electrical signals; this is called *sensing* (the *sense* function). At the output, *actuators* convert the electrical signals into physical actions (or indicators).

As a reminder of what we've learned so far about analog systems, and to see where to go from here, let's consider how the systems we've studied fit the universal system organization, as shown in *Figure 5*.

The variable resistor, mouthpiece, and microphone *sense* external information and convert it into analog form by varying current or voltage, And the meter, earpiece, and antenna *act* to convert varying electricity into meter indications, sound waves, and radio waves.

But what about the *decide* and *storage* functions in analog systems?

How do analog circuits store information?

Let's consider storage. Analog signals can be stored for a very short, fixed length of time by *delaying* the signal. This method involves sending the signal on a detour through a special path in which the signal travels much more *slowly* than it would through a wire. (In a wire, changes in signal level travel at nearly the speed of light.) Thus, the analog information is stored for the period of time the information is travelling in the slow path. These slow paths are called delay lines. A delay line can store only a small amount of information at a time, and for only a fraction of a second.

Advantages of Digital

Remember now, that digital systems are *binary*; they use only two signals, or electrical levels. As a result, digital circuits are much simpler and have less strict specifications than analog circuits.

Digital Is Easier To Design

As we have already noted, in analyzing and designing *digital* systems our only direct concern with electricity is whether it's On or Off. We don't have to worry about *exactly* what voltage or current is in a wire. All we care about is that it's not *in between* the two permitted states. Consequently, the circuits we work with — *switching* circuits — can be much *simpler* than analog circuits, and the devices in the circuits don't have to fit such close specifications.

Furthermore, digital systems are all built up out of a small handful of basic building-block circuits — *gates* and *flip flops* — and larger building-blocks made from them (*decoders, counters,* etc.) Within a given system or subsystem, all the gates and flip-flops are usually members of the same family or digital circuits, such as TTL, MOS, and others. This means the circuits resemble one another closely. Consequently, the building-blocks are all perfectly *compatible* with one another, provided the designer observes a few simple rules. He can, in effect, put together a digital system like assembling tinkertoys.

Digital Is More Accurate

Figuratively speaking, every analog system has to grab hold of electricity, wrestle and grapple with it, and bend and twist it to make it match the information that must be transmitted. The result is never a *perfect* analog copy. There's always some *error*, which is expensive and troublesome to reduce. However, with digital it's easy to make exact copies because everything is either One or Zero, True or False,This or That!

We have *already* seen analog decisions being made in our examples, without taking note of it. Let's look back at some of the example figures.

In *Figure -2*, the float and variable resistor in the fuel-gage determine what current to transmit in response to a certain fuel level. This process can be considered a sort of *decision*. The meter, in turn, decides what level to indicate for a certain current. Similar decisions are made by the microphone element and the earpiece in the telephone system in *Figure 3*.

In the AM radio transmitter in *Figure 4*, the modulator-amplifier actually performs a *voltage multiplication* decision. At each and every moment of time, it multiplies the input voltage by a factor controlled by the gain signal provided by the microphone. When you stop and think about it, multiplication is a pretty respectable decision for anyone or anything to make!

Of course, you can see what we're driving at. Whenever electricity is modified in some fashion in an analog circuit, *information is being processed*. Existing information is being employed to create new information, or new forms of information. This is the action we have been calling *deciding*, to emphasize its importance with regard to information.

It's important for you to note that this analog deciding process is not made up of separate steps as in a digital system but is a *continuous process*. When electronic devices such as transistors are involved (as in amplifiers), the devices do not switch On and Off. Instead, they *vary* the flow of current *in between* the *On* and *Off* states, in a smooth fashion we called *linear*.

When a transistor is operated in this in-between range, its acts as an electrically-controlled *variable resistor*. When used this way in an electric circuit, a transistor is an *amplifying* element. A *small* change in the control signal varies the effective resistance of the transistor, producing a larger (amplified) change in output current. Transistor amplifiers of various kinds are the main building-blocks in electronic analog systems.

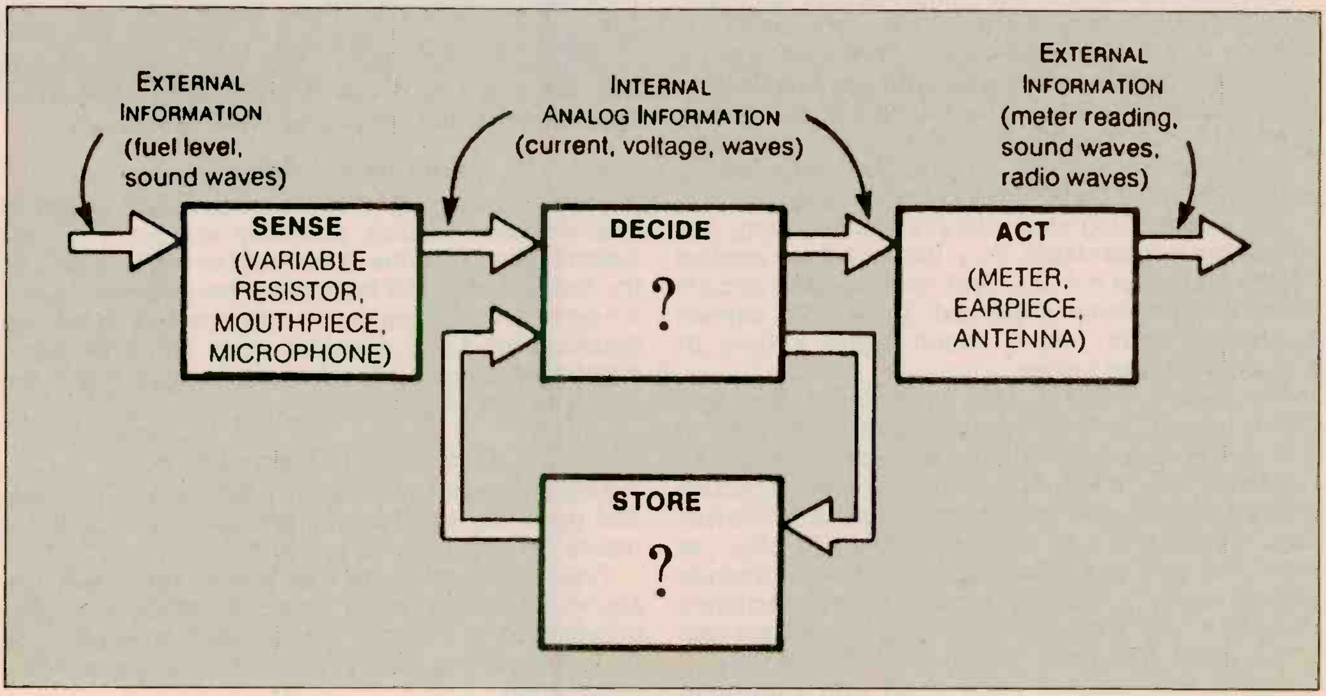
Digital Storage Is Easy

To store digital information we just need a lot of storage circuits, which are easy to get and inexpensive in today's ICs. Analog storage (in delay lines, or in capacitous) methods cannot be at all precise. They can only store *approximative* values.

Such inaccuracies are permissible in some applications but would be out of the question in others. For example, when you multiply two times two with an analog multiplier (analog computers do it all the time, using an amplifier as we have discussed with regard to the AM transmitter), you aren't likely to get *exactly* four. You may instead get 3.976, or 4.028, depending on how *accurate* (and how expensive) the amplifier is. Consequently, people don't use analog methods for handling extremely *precise* information.

On the other hand, digital methods can handle numbers as large and as precise as you need. Our calculator handles decimal numbers with eight digits, so we can multiply 2.0000000 times 2.0000000 and get 4.0000000 without any trouble at all. Big computers

Figure 5. Analog Systems Store Information or Make Decisions



routinely handle decimal numbers that are much longer, and consequently can be carried to more "decimal places" of precision. Such precision can be handled with much less cost than with analog methods because the same simple digital circuits are used—just more of them, for more bits.

On the other hand, we can make a switching circuit store a piece of *digital* information and hold it with perfect accuracy for as long as we need. And we can store numbers as large and as precise as we like by simply using as many storage circuits as we need. If an *analog* system needs long-term, accurate storage, it is best to convert the analog information into *digital* form, and use digital storage techniques.

Digital Can Be Faster

When we consider the *speed* with which circuits handle information, we sometimes run into problems with analog methods. Once again, the trouble is that analog circuits have to manhandle the electricity and whip it into shape. This can take *time* to do, especially when for some reason we have to use large capacitors (as in analog storage) or another class of electric components called *inductors*. An inductor is any device that makes the electricity interact with a magnetic field. Any device with a *coil* of wire is an inductor, such as the fuel meter in *Figure 2* or the telephone earpiece in *Figure 3*.

For example, it may take the better part of *a second of time* to flow enough charge into an *analog* storage capacitor to make its voltage close enough to that of the voltage source. By *digital* comparison, we can easily make a flip-flop that will store an input signal in a few *nanoseconds* (billionths of a second).

Digital Can Be Fully Integrated

By far the most important advantage of digital methods is that digital information-processing circuitry can be *entirely fabricated in integrated-circuit chips*.

The first four advantages (simple design, accuracy, storage, speed) were in effect for many years before integrated circuits came along. Those advantages propelled digital techniques into applications in digital computers and a few nooks and crannies in predominantly analog systems (such as for storage, as we have mentioned, and for *switching* analog signals as in telephone dialing and routing).

But when integrated circuits came along, the tremendous advantages they brought were applied mainly to *digital* circuits. And as integrated circuits have progressively improved, they have carried digital methods into a much wider variety of applications than before.

The reason analog circuitry has not been integrated nearly so fully as digital circuitry goes back again to the fact analog circuits have to force electricity to match outside information. To do this, analog circuits typically need to use several kinds of *devices that just can't be made out of the silicon of an IC chip*—at least, not very economically. Such devices include inductors (coil and transformers), high-capacitance capacitors, and high-precision resistors. A great deal of progress has been made in designing analog circuitry that *doesn't need* such non-integrable devices. But the integration has not been on the grand scale that's much more economically feasible for digital circuits.

To keep the picture in balance, we should point out some important types of linear circuits that *have* been very successful in integrated form. There are only very few analog systems or subsystems that don't contain a number of linear integrated circuits.

By the far the most common type of linear IC is the operational amplifier, or op-amp. An op-amp is a general-purpose building-block to which you can add a few resistors and capacitors, to make nearly any kind of amplifier you want—as long as the frequencies are below about 1 megahertz. And if you want output signals greater than about 10 volts and 0.1 amp, you can add discrete transistors to the output section. Op-amps are differential amplifiers—meaning that they amplify the *difference* between the voltages at two different inputs. The output voltage is around 100,000 times this difference, which for practical purposes is assumed to be an *infinity amount*. This gain factor is reduced to the desired value by *feeding back* part of the output signal to the inverting (subtracting) input.

ADVANTAGES OF DIGITAL

1. **Systems can be easier to design.**
2. **Information can be more precise.**
3. **Storage is no problem.**
4. **Information is sometimes processed faster.**
5. **Circuits can be fully integrated.**

LIMITATIONS OF DIGITAL

1. **The real world is mainly analog.**
2. **Analog processing can be simpler.**
3. **Information can usually be transmitted faster in analog form.**

Figure 6. Comparing Digital and Analog Methods

What's Wrong With Digital?

From considering the big advantages of digital methods over analog, you may wonder why they haven't taken over the entire field of electronics. But the fact is that digital techniques have some *inherent limitations* that keep such methods out of certain applications. Let's consider what some of these disadvantages are. They're listed along with the advantages, in *Figure 6*.

Real World Is Mainly Analog

First and possibly most important, the information that goes into and out of most systems is *analog* in nature (or linear, if you prefer).

Typical examples are fuel levels, meter readings, sound waves, and radio waves. All of this is *analog* information, in that it *varies* anywhere within a range rather than being limited to definite states like digital information.

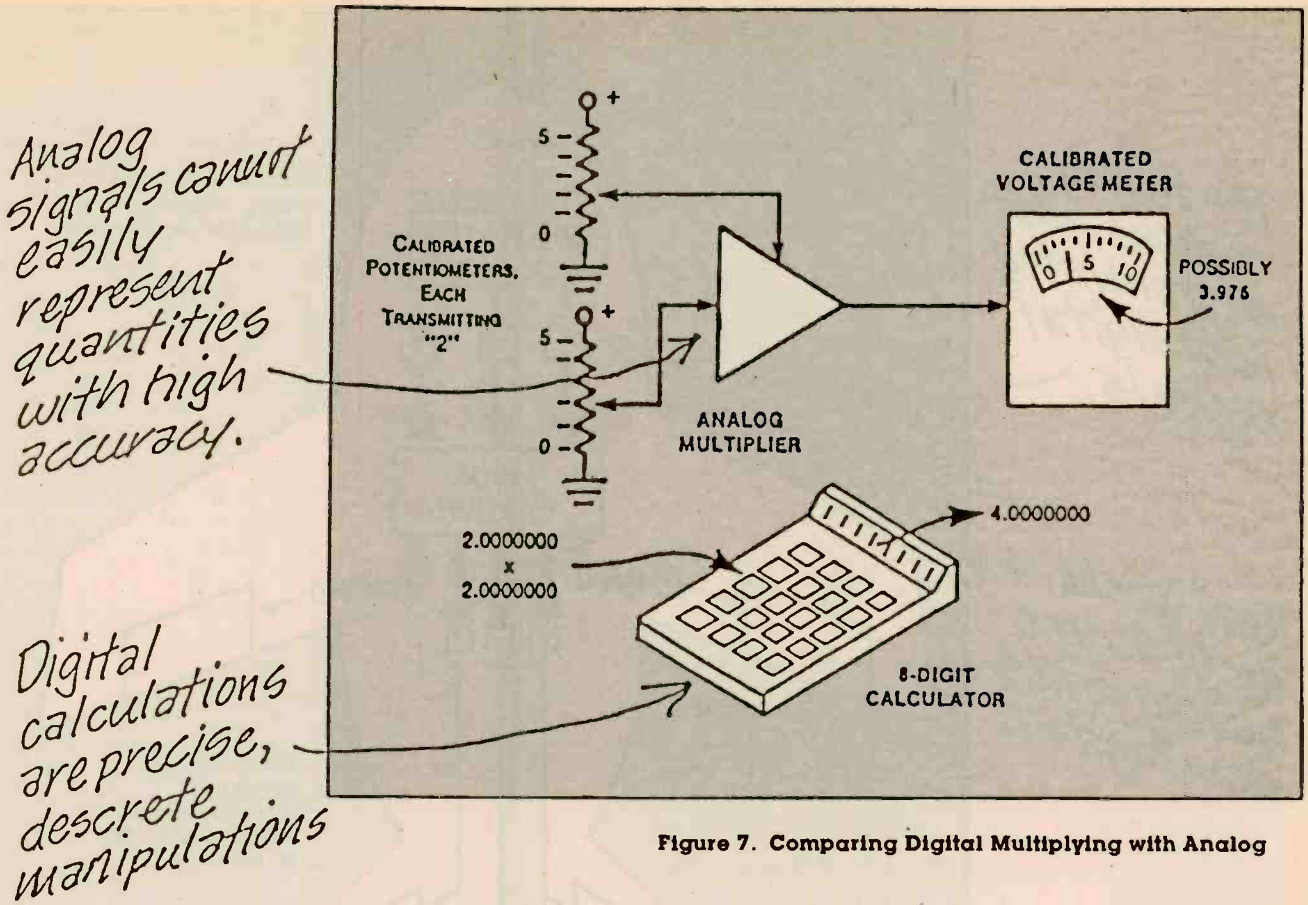


Figure 7. Comparing Digital Multiplying with Analog

The same applies to almost any kind of *natural* information you can think of—temperatures, pressures, weights, intensities, positions, speeds, time, and so forth. You may be accustomed to *expressing* such information in digital form. For example, you may say that you weigh 165 pounds, or maybe 165.3799 pounds if you wanted to be more accurate. But in doing so, you're only giving a *digital approximation* for an *inherently analog* quantity.

If a digital system is to deal with real-world information, taking in and putting out analog information, it has to *convert* the input information to digital form before working on it, and then *convert* the digital results back to analog again. Many digital systems do just that. For example, a computerized autopilot on an airplane *takes in analog information* on compass heading and how the airplane is tilted, and *puts out analog information* controlling the rudder and ailerons and elevators to keep the plane flying straight and level. All these inputs have to be converted to and from digital form.

However, converting information between analog and digital forms can be *cumbersome and expensive*. Furthermore, the conversion process always introduces *inaccuracies* and takes a certain amount of *time*. (Time can be a critical factor in some systems.) Furthermore, it may allow too much random, unwanted information we call *noise* to leak into the system. In the case of the autopilot, the advantages of digital processing are so desirable that we're *willing to pay the price* for the analog conversions. But in a moment, we'll look at another system where it's obviously better to stick with *analog* processing.

On the other hand, digital processing is a shoo-in for situations where both the inputs and the output are *digital* information. The prime example, of course, is systems that handle *numbers* (which are digital of their very essence), such as calculators and computers.

However, the same would go for systems handling *letters* or any other sort of symbols, because such things are also inherently digital. After all, our alphabet can be considered a sort of *number system*—one with 26 numerals rather than ten or two. Likewise, digital outputs are involved in any system that *sequences* events in time, such as the controller for a washing machine. (They used to have a motor-driven analog cam that flipped switches in sequence. But the newer ones are a hundred percent digital).

Analog Is Often Simpler

Okay, suppose we're designing a system that handles analog inputs and outputs as we just discussed. How do we decide whether to process the information by analog or digital methods? In many cases, the answer may be obvious, because we may find that analog processing is sometimes *simpler*.

Let's look at an example—the phonograph amplifier shown in *Figure 9*. We've got weak *analog* signals carrying sound information from the needle and cartridge (which are *sensing* the information from the surface of the plastic record where it is *stored*). The system's main task is simply to *multiply* the height of these electric waves by a factor depending on the loudness we desire, producing

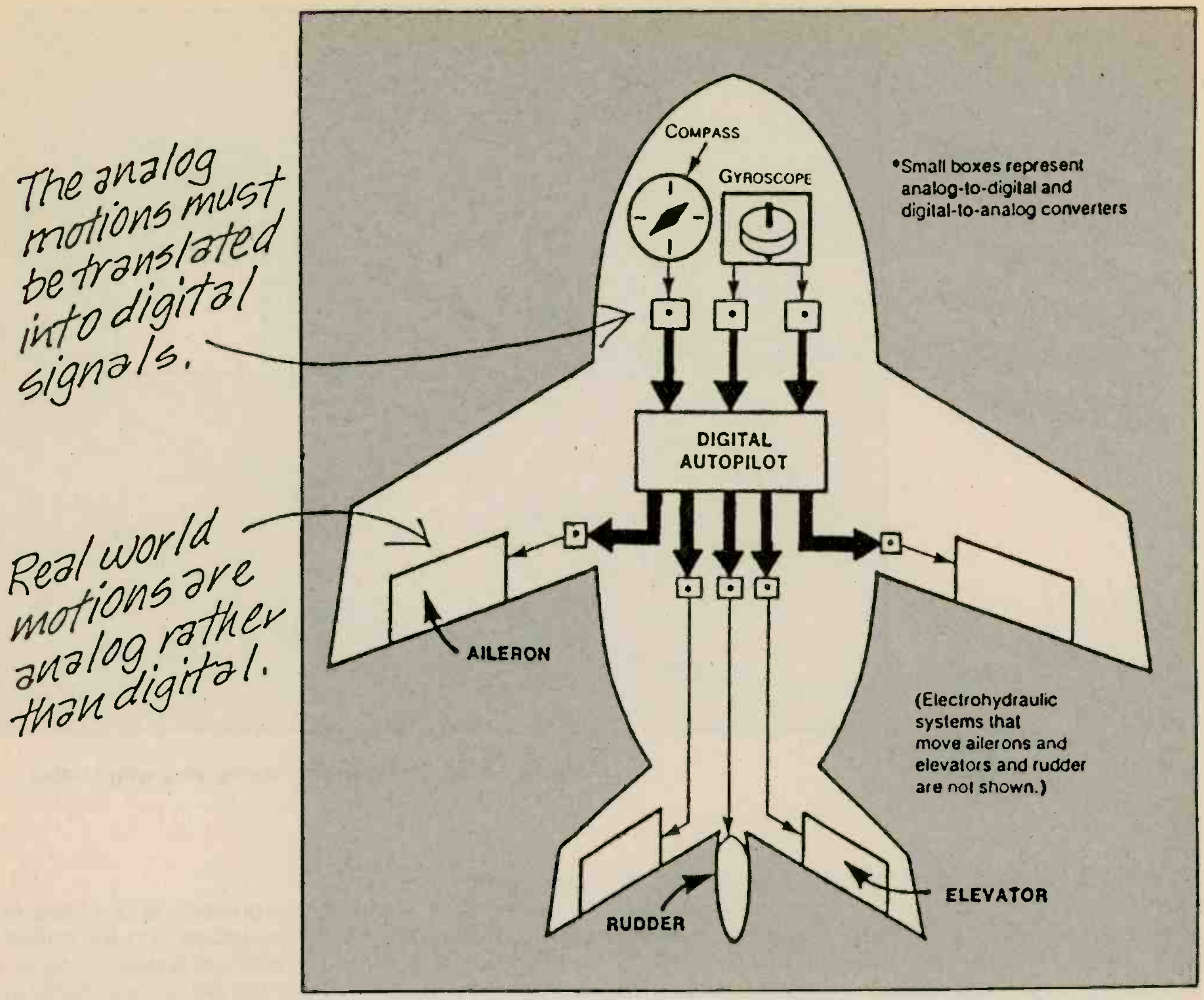


Figure 8. Autopilot Processes Analog Input and Output Digitally

proportionately larger copies of the same waves to drive the loudspeaker.

As we have already discussed, multiplication can be handled with pretty fair accuracy by an analog *amplifier* circuit as shown in *Figure 9.* We can make a rather crude but workable amplifier using just *one* transistor, with a few resistors and maybe a capacitor or two. Or an IC power amplifier could be used here very economically.

Even a very high-fidelity amplifier would be simpler than a *digital* system to do the same job. This would check the input voltage regularly every 100 microseconds or so, convert the voltage to a digital number in several wires, multiply the number by a digital volume-control factor (probably from a keyboard as shown, to avoid having to convert an analog signal from a variable resistor), and finally convert the resulting digital product back into an analog output voltage. A new output voltage would appear every 100 microseconds, giving a fair approximation of the larger waves we desire.

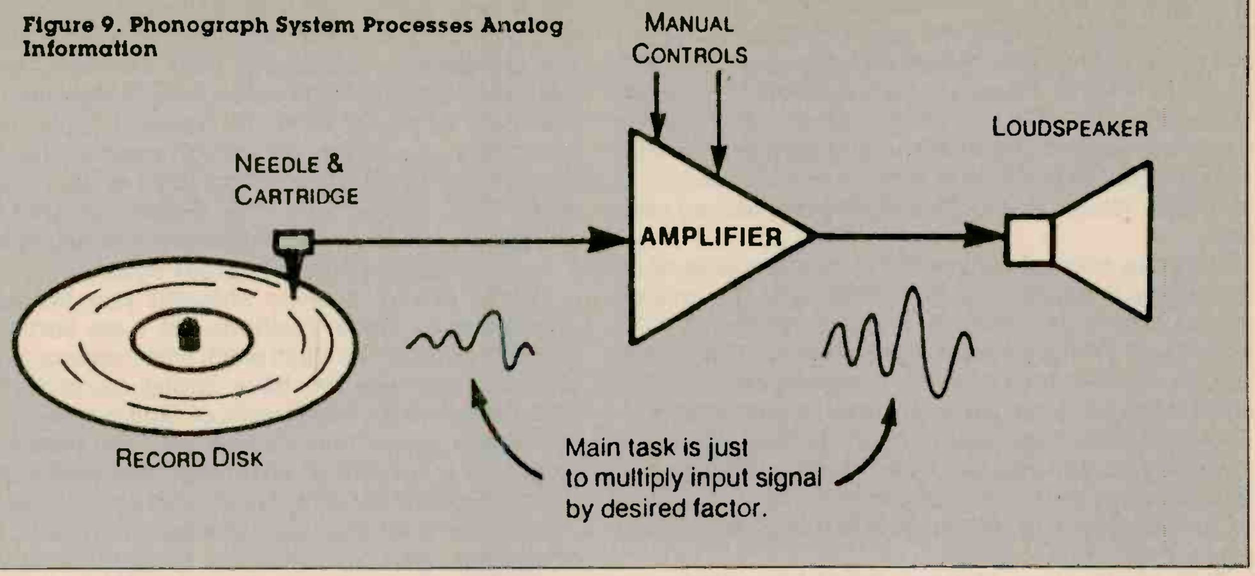
Analog Sometimes Faster

There's one more limitation of digital methods, one that crops up in digital *communications* systems. And that's the fact that when you've got a particular transmission system (counting amplifiers, antennas, wires, or whatever), you can actually transmit information *faster* in the form of analog signals than with digital signals. (You can transmit more information per second.) This limitation only comes into play when you're pushing the capabilities of the transmissions system to the utmost, when you're trying to cram as much information as possible through it in the shortest time possible.

To begin seeing why analog transmission is faster, look at the example in *Figure 10.* Here, we're transmitting voltage-analog television (video) signals from a remote surveillance camera to a monitor. For the sake of simplicity, we're assuming that the information-handling capabilities of the system are limited only by the wire between the units. Let's say that the wire can't carry variations in voltage occurring any more often than five million analog waves (or digital pulses) per second. That is, the *frequency limitation* of the system is five "megahertz." Furthermore, because the wire is long and not perfectly shielded from outside interference, the voltage signals may be *inaccurate* by as much as 1/128 of the full range of voltage.

Well, we have to figure out how many bits per

Figure 9. Phonograph System Processes Analog Information



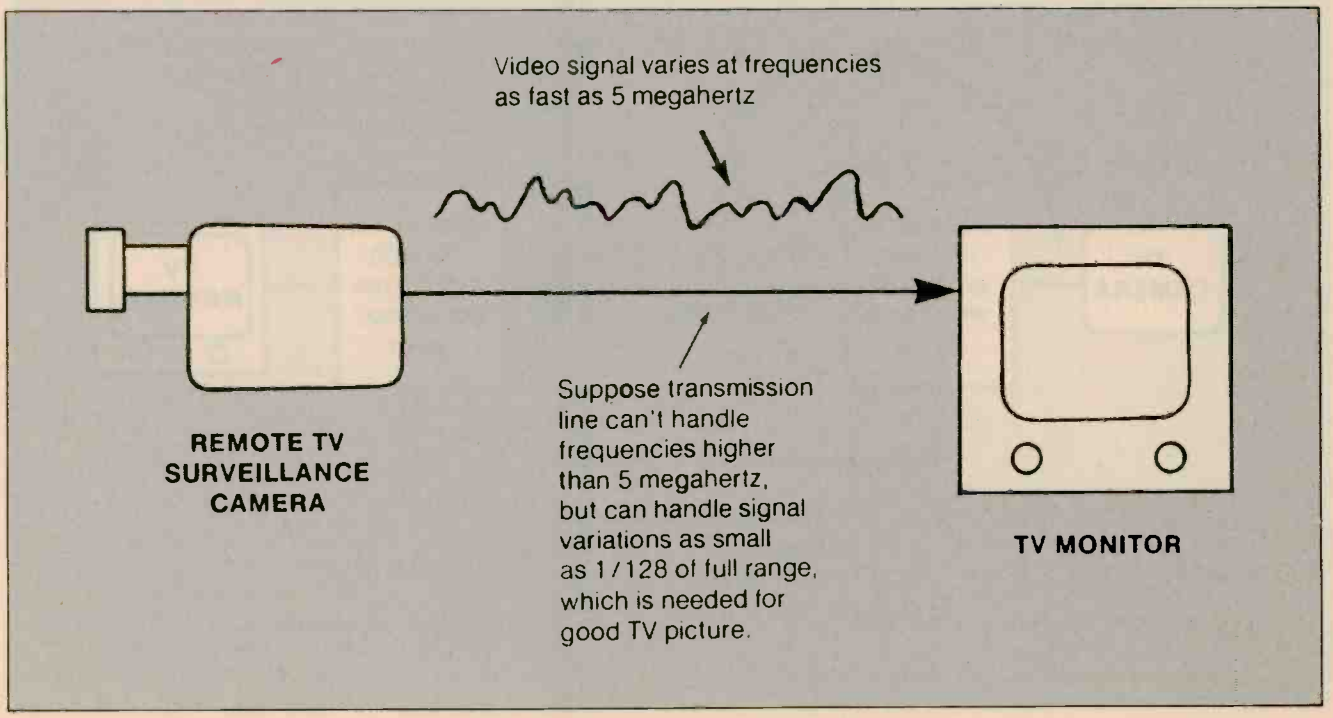
second *would* be required, *if* we were to transmit the very *same* information in the most efficient *digital code*, which is binary numbers. To do this, we have to imagine a system as shown in *Figure 11*.

Here, the analog signal from the TV camera goes to a unit we're calling an "analog-to-digital converter with serial output." Without looking inside this unit, we'll just say that it *measures* the input voltage *ten million times* each second, and converts it into a *seven-bit* binary number. These bits are fed through the transmission line in *series*, as *digital* pulses with a frequency of *70 megahertz*. At the other end of the line, a *digital-to-analog* converter with serial input puts out a continuous analog voltage signal to the TV monitor. This voltage is proportional to the seven-bit binary number that the converter last received. The broken line below the transmission line in the figure is to remind us that if we actually *built* a system like this, we couldn't depend on the two converters to stay synchronized with each other in handling the serial groups. We would need some sort of *common clock pulses* supplied to both systems.

Millions of Bits Per Second

The main point here is that it would require digital signals at *70 million bits per second* to reproduce the same signals with the same accuracy as for the 5 megahertz analog signal. The waveform shown in the transmission line in *Figure 11* illustrates *why* this is so—*why we need ten million 7-bit numbers per second* to carry the information from a 5-megahertz analog signal with accuracy of one part out of 128. Ten million numbers per second will give us a good chance of measuring not only the *peak* of each 5-

Figure 10. Closed-circuit TV Is Analog System



megahertz voltage wave, but also the *valley* next to it. We need to have *both* measurements in order to reconstruct the signal at the receiving end. And seven bits per number gives us a range from zero (0000000) to 127 (1111111). So each measurements is accurate to within 1/128 of the voltage range, which is the accuracy we said was involved in the original analog signal. Therefore, a 7-bit number every 10 millionth of a second results in our 70-megabit-per-second data rate.

Now the original transmission line, because of its frequency limitation, could handle only *five million digital pulses per second. It could not handle the equivalent 70-megahertz digital signal.* The signal would lose its amplitude as it passed through the cable and could not be recognized at the other end. Therefore, the information would be lost. With a 5 megahertz bandwidth, the highest frequency information that could be digitized and transmitted is 0.357 megahertz or *14 times slower* than the analog signal capability.

This explanation of why digital transmission is slower is highly simplified. But the general principles you've seen apply to *any channel* that can carry either digital or analog information. This includes telephone wires, radio broadcasts, and microwave radio beams to and from satellites and space vehicles. As we said earlier, this speed or bandwidth problem of digital transmission only comes into the picture when we're pushing a transmission system *to its limits*. But in those cases, it can knock digital methods right out of consideration, as it did in the case of our television system.

However, there is an advantage of digital transmission hidden in this situation. Suppose you've got a very *noisy* transmission medium (think of a single wire, as we have been doing), but no limit on the bandwidth (frequency). You can send analog signals as *accurate and noise-free as you like* if you put them in *digital* form. To transmit digital pulses accurately, you only need enough accuracy (freedom from noise) to tell One from a Zero at the receiving end. This shows you the digital advantage of *precision* applied to the field of *communications*.

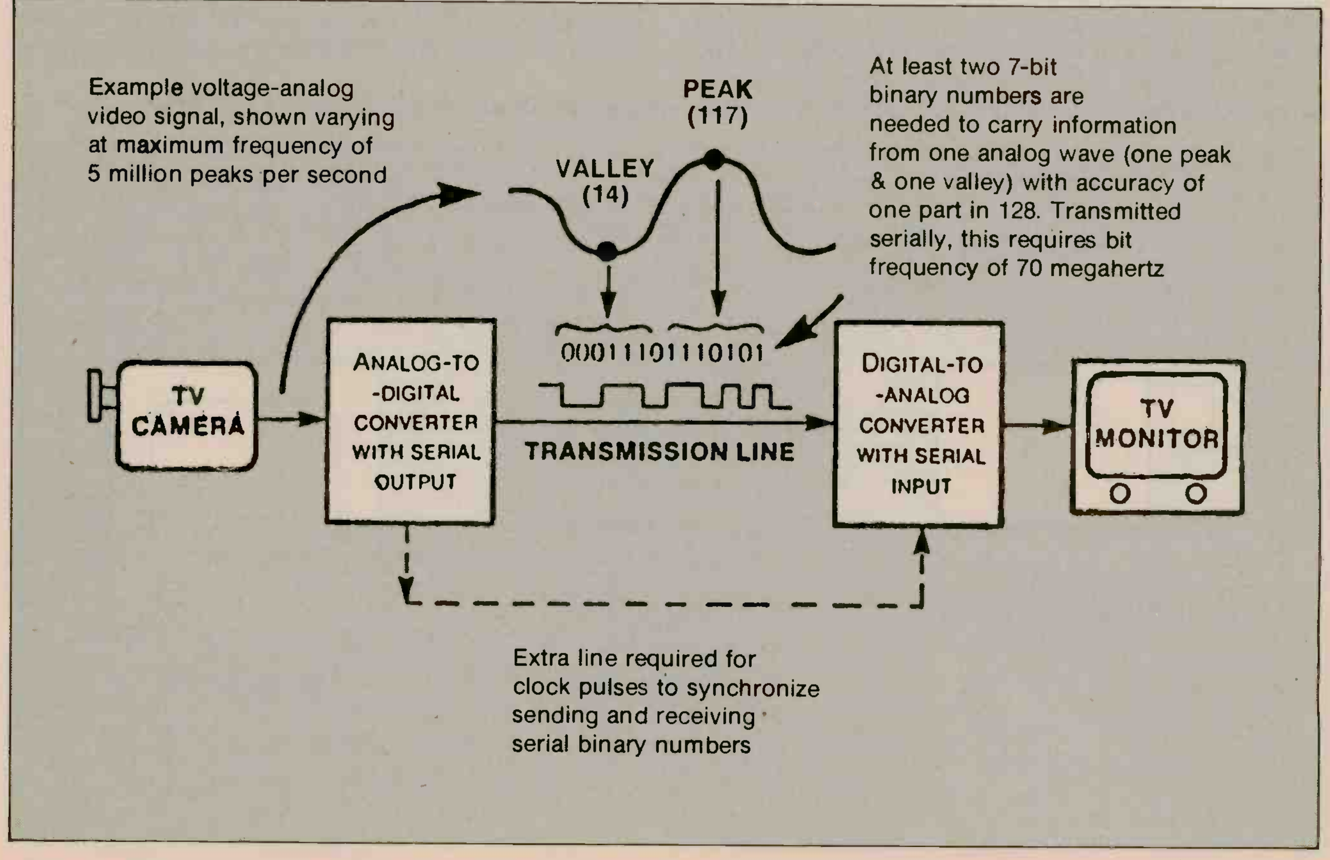
Mixed (Digital Analog) Systems

In this article, besides showing you the analog alternative to digital methods, we have surveyed a range of different kinds of electronic systems. So now you can see why we have digital computers and calculators—and other sorts of digital system—but not digital radios and TV sets yet. The reasons are based on a handful of advantage and limitations of digital methods by comparison with analog methods.

But more than that, you have seen that many kinds of systems use *both* digital and analog techniques in various parts of the systems. Indeed, the most important issue that must be settled early in the design of most systems is which parts will use digital methods and which parts will use analog. In some cases the answer may be so obvious as to be a foregone conclusion. But in many cases the answer may depend on careful economic analysis of the trade-offs.

However—as time goes on, the economic benefits of integrated circuits are being applied more and more strongly to *digital* circuitry, So the balance in the choice between digital and analog is shifting further and further toward the digital side. ■

Figure 11. Digital TV System More Complicated



CIRCUIT FRAGMENTS

Nearly all electronic systems are made up of just a few basic circuits: Amplifiers, Oscillators, Gates, Adders, Comparators, etc. Add Tuners, Power Supplies, and a few others and you can build just about anything.

While increasing your knowledge and gaining experience with these circuits you should be careful not to put anything together unless you understand exactly what you're doing, and why. Study each part of the circuit carefully before you assemble it. Be sure you know the function of every component—why it's included and what it does to the electrons flowing in the circuit—before you go on to the next component. If you follow this plan carefully and slowly you'll increase your electronics know-how to the point where you can combine these basic circuits in various ways to put together any electronic device desired.

If you've been involved with electronics for a while you've probably been saving parts in Ye Olde Junk Box. If not, you should start now. Save every old capacitor, resistor, and other component from junked radios, TV sets or tape players. Before long you'll find you can use many of these "old" parts, and save yourself money as well as extra trips to your local Radio Shack.

Assemble each project onto a small perfboard, or better still, a quick-assembly project board. With these, you just bend the component leads or connecting wires at right angles, clip 'em off close and stick them into the quick-assembly board. The connecting lines in the board (underneath the holes) make the necessary (quick) connections. That way you can work much faster, make changes as needed, and when the project is finished and you've learned all about how it works, use the parts and the assembly board all over again next time.

CURRENT INDICATOR

Here's a "current" tip! When there is a need to know that current is flowing in a circuit to an appliance, you may consider this idea. Place a resistor of a low value in the circuit so that when the current is flowing through that appliance, a voltage drop across the resistor will turn on either light-emitting diode (LED1, LED2) or both when alternating current is present. You will need about two volts across a light-emitting diode to cause it to light when the polarity is correct.

Assume that you want to monitor a fan that draws ½-watt and is located in another room, and the power line passes where you are. Since it would be a big hassle to run leads from one room to another, and since the leads always have voltage across them, only a current indicator will do the job. So, insert a resistor that will drop two volts AC when ½ ampere of current flows. The calculation is simple:

$$\text{Resistor (in Ohms)} = 2 \text{ (Volts)} \div .5 \text{ (Ampere)}$$
$$R1 = 4 \text{ Ohms}$$

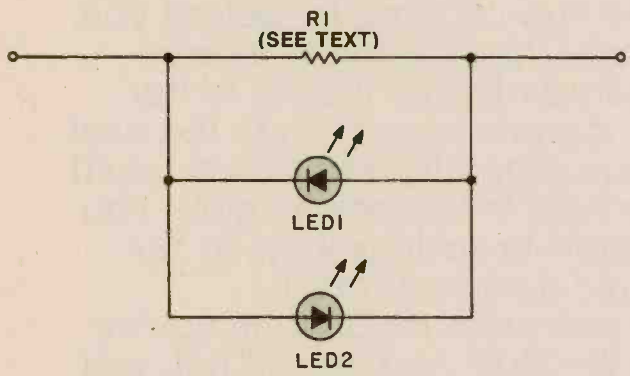
Next, compute the required wattage:

$$P \text{ (Watts)} = I^2 \times R = 0.5 \times 0.5 \times 4 = 1 \text{ Watt}$$

As an added safety measure, a two-watt resistor was used to improve the heat dissipation and keep the temperature of the resistor down.

Since the circuit is non-inductive and non-capacitive, Ohm's law applies for both AC and DC circuits. Light-emitting diodes do not switch on and switch off at an exact voltage level, but come on just before two volts are reached, and the diodes' get brigther as the voltage reaches its normal operating level. Thus, when the fan comes on, the light-emitting diodes will light brightly and drop to a lower illumination level after the fan's current starting surge has passed. Study the characteristics of the diodes' brightness during transient conditions; that will give you an indication of normal operation. Any variation of the diodes' light level pattern will be a trouble indication.

The circuit has the possibility of being a two-way Morse-code indicator. You can see what you are sending and what another person is sending at the same time. Can you figure out the simple circuit configuration that includes rectifier diodes, keys, and a filament transformer?



PARTS LIST FOR CURRENT INDICATOR

R1—2 watt resistor (for resistance value, see text)
LED1, LED2—light-emitting diodes (Radio Shack)

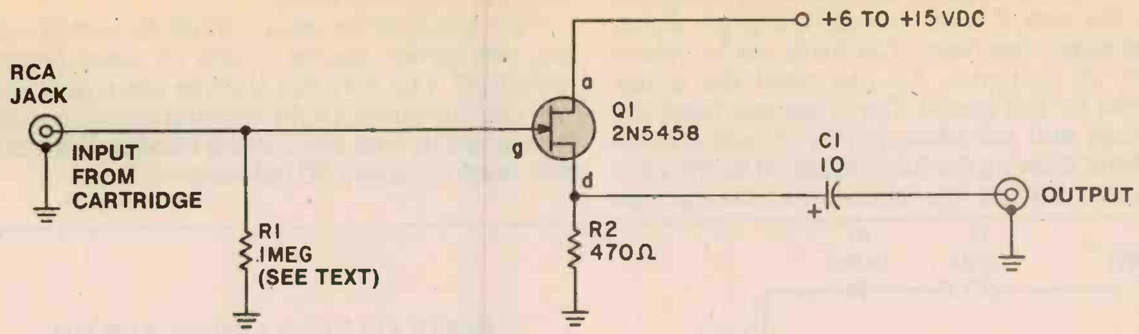
CERAMIC PHONO PREAMP

Every time we turn around we bump into a kiddie's phono amplifier that needs repair. Replacing the phono cartridge is easy enough when you can get the replacement, but when the electronic guts are gone, it's easier to replace them with a new module amplifier. You can either make it or buy it, but in either case the chances are the amplifier will need a preamplifier to match the high-impedance cartridge.

The input's high-impedance is obtained by using a junction-field-effect transistor (Q1). This circuit matches the high impedance of the phono cartridge and provides a low-impedance output to a solid-state amplifier. Resistor R1 is usually a 1-Megohm resistor, but check the spec-sheet for the cartridge. If that is not available, insert a potentiometer into the circuit that will give you a 10-Megohm sweep. You can then select the best resistance and replace the potentiometer with a fixed resistor.

Resistor R2 should also be selected for best results. You could either insert a 470-ohm resistor or a 1000-ohm potentiometer and sweep the pot from 150-to 1000-ohms. Replace the potentiometer with a ½-watt resistor that works best. The value of R2 is not critical; however, do not let the resistance drop below 150 ohms.

Electrolytic capacitor C1's value is not critical, however its WVDC rating should be larger than the voltage applied to the circuit. The N-channel JFET 2N5458 can be replaced with equivalent types. The power supply can be any voltage between 6 and 15 volts that you can tap from the following amplifier section. If you wish, a 9-volt transistor battery can be used to power the circuit—the circuit draws little current.



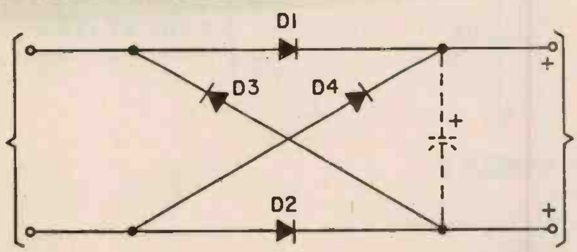
PARTS LIST FOR PHONO PREAMP

R1—1 Megohm resistor
R2—470 ohms resistor
C1—10 ufd, 15-20 VDC electrolytic capacitor
Q1—2N5458 field-effect transistor

GET-IT-RIGHT BATTERY CONNECTOR

It happened once to often: I connected the battery backwards to the circuit and zap—a few transistors went silently and expensively. A diode in the power lead works fine, but when you are breadboarding and no power is passed due to a wrong connection, you waste time seeking the trouble. So, when I came upon this simple diode circuit that lets you connect a battery to a circuit with abandon—I started using it. I connect the diodes at the power input of any circuit I breadboard. Then, when the battery is connected backwards, the diode circuit gets it right.

Use 1N914 diodes for most applications where current is not critical. There is a small drop across the diodes, and should that voltage drop be important to the operation of the circuit being constructed, the diodes can't be used. You may have to decouple after the diodes with an electrolytic capacitor across each output leg. Go for a 100-uF rating and watch the capacitors polarity.



PARTS LIST FOR GET—IT—RIGHT BATTERY CONNECTOR

D1-D4—1N914 diodes or similar (see text)
C—100 ufd (see text)

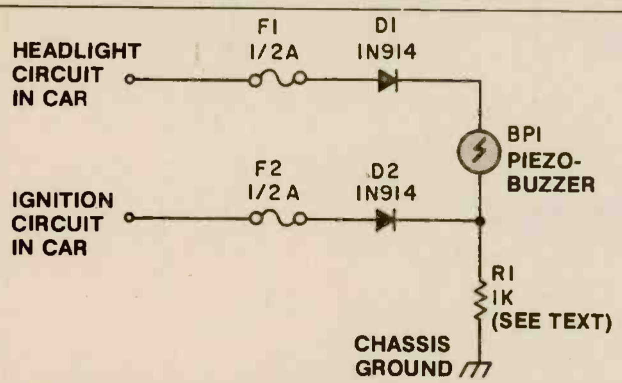
LIGHTS ARE ON.

There is a whole fraternity of car drivers who are noted for leaving their headlights on over night. Well, not exactly over night, for the better part of the night, because the car battery runs down and the bright lights dim to a golden yellow and eventually go out completely. In the morning either the AAA gets a call or your battery jumpers come out of the trunk and a friend provides a much needed boost. Drop out of the society by installing a simple headlight-on warning device.

Here we show a piezoelectric device and a resistor. When the healight circuit (running lights) are on and the ignition circuit is on, battery voltage is applied to both sides of the piezobeeper PB1 with a net voltage drop of zero volts across the device. Thus, the beeper will not sound. Resistor R1 draws approximately 12 milliamperes. When the ignition circuit is off, the battery voltage drops across the series combination of BP1 and R1, causing BP1 to sound. Should the sound be sufficiently loud, fine; otherwise, reduce the value of R1 in 10% steps until its sound is loud. Likewise, increase the resistance to lower the sound. Physically locate the piezobeeper near the left side of the driver so that he will turn into the sound as he leaves the car.

The role the two diodes play is to isolate the ignition circuit from the headlight circuit, otherwise you would be able to start you car when the ignition key is removed. A note of caution, two additional fuses are added to the circuit even though the circuits that supply the power are fused. Car fuses are anywhere from 9 to 20 amperes. All you need are a few milliamperes for this circuit. The ½-ampere fuses are large enough and will blow quickly should a short occur without blowing the fuses supplied by the car's manufacturer. Should the circuit fail, the car will continue to run normally.

This circuit can be used in other devices to indicate that one power source is still on when another is turned off. You may not want to use a piezobuzzer. You can substitute a light-emitting diode provided R1 is selected to limit the current through the LED at a safe value—usually 20 milliamperes.



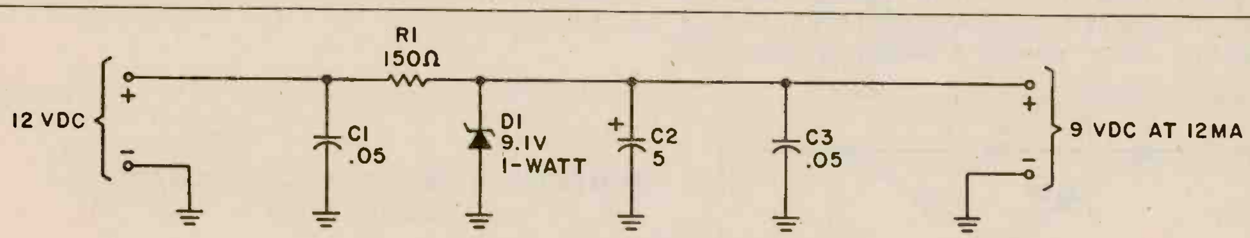
PARTS LIST FOR LIGHTS ARE ON

R1—1000 ohms resistor
D1, D2—1N914 diodes
F1, F2—½ amp fuses
BP1—piezoelectric beeper (Radio Shack)

CHEAP 9

The circuit shown has been used in cigar-lighter, plug-in units for the longest time, but few experimenters apply it to on-board project design. The problem solved is converting from 12-volts DC to 9-volts DC (or less) for special purposes without using a variable or fixed voltage-regulator chip. The diagram is simple, however, you may need some computation for other output voltages.

The value for R1 is selected for the Zener diode shown and permits up to 12 milliamperes of current. Usually, for one-transistor applications, this low current is sufficient. The electrolytic capacitor, C2, provides increased regulation and C3 offers noise elimination should the following circuit be sensitive to some noise on the power line.



PARTS LIST FOR CHEAP 9

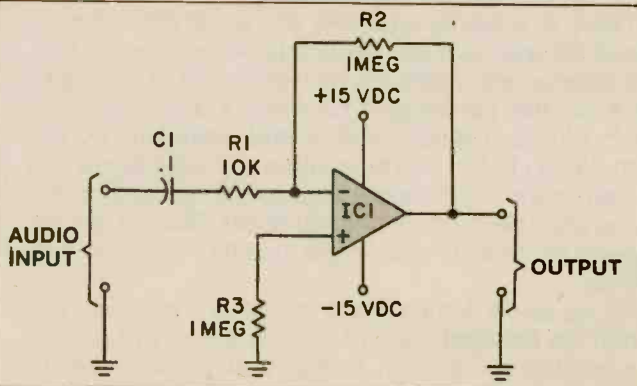
R1—150 ohms resistor (see text)
C1, C3—.05 ufd, 15 VDC or higher capacitors
C2—5.0 ufd 15 VDC or higher capacitor

20-dB AMPLIFIER

How simple is simple? You have a circuit with a gain of 100 (20 dB) with a flat response out to 10,000 Hertz with a gradual roll-off to 20,000 kHz. The overall gain can be reduced to 10 dB by increasing the value of R1 to 100,000 ohms. The amplifier can be made to non-invert the signal by reversing the + and − input connections—but the feedback connection always goes to the negative terminal. If the low frequencies are attenuated too much, increase the size of C1.

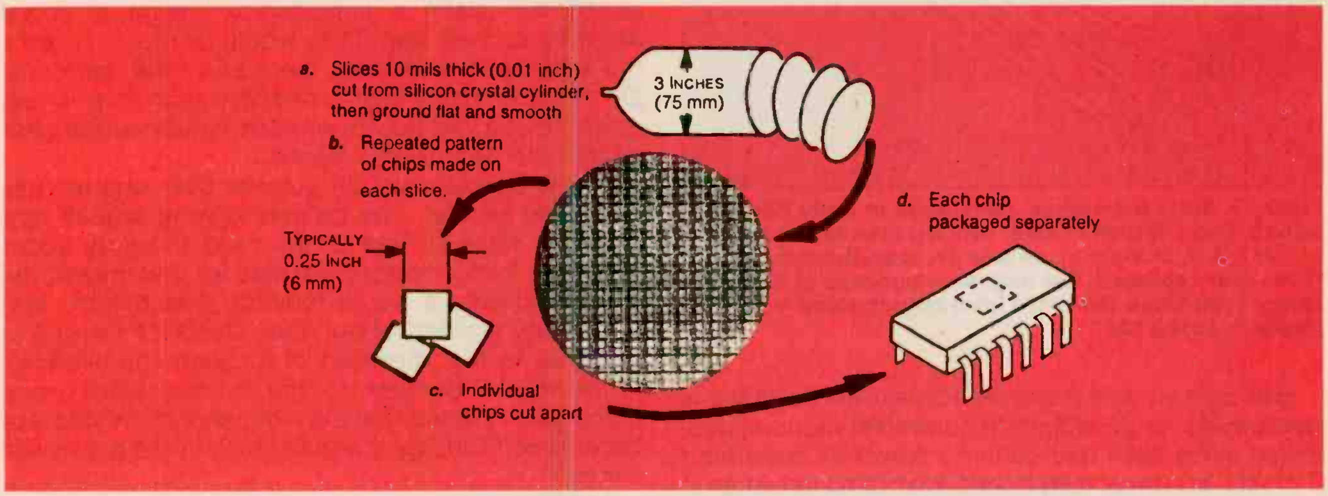
PARTS LIST FOR 20-dB AMPLIFIER

R1—10,000 ohms resistor
R2, R3—1 megohm resistors
C1—0.1 ufd, 20 VDC or higher (see text)
IC1—741 op-amp (Radio Shack)



THE ORIGIN OF INTEGRATED CIRCUITS

Here's How Integrated Circuits, The Brains of Today's Electronics, Originated



Four major steps in the creation of an Integrated Circuit chip. In (a) the silicon, made of carefully-controlled impurities (using chemical dopants) is grown as a cylinder which is typically about three inches in diameter. The cylinder is then sliced into thin slices (about 10 mils). This material is etched photographically in (b), into microscopic pattern(s). Typical slice has between 150 and 200 identical chips. These chips are then separated into individual chips. about a quarter of an inch square (c). After cutting apart each chip is wired and sealed into its own flat plastic IC package (d) along with the tiny wires which connect it to the two rows of terminals on the sides. (Courtesy of Radio Shack)

What Integrated Circuits Are

You are undoubtedly aware that ICs (integrated circuits) are tiny, less than a quarter-of-an inch square, and contain hundreds, often thousands, of tiny transistors, resistors, capacitors and other parts in that small space. But how do they pack so much into so little space?

It's done by making each little transistor, capacitor, etc., out of microscopic little bits of silicon and other materials which are fabricated using photographically-etched *masks*. These masks are laid out by an engineer-draftsman, often using CAD (Computer-Aided Design) with hundreds or more of the microscopic parts carefully placed to pack them very tightly.

After the design has been drawn, several hundred times larger than the final mask(s), it is photographically reduced, and then used to *etch* the same design, now microscopic in size, into the silicon.

The tiny chips are assembled (using robot tools) inside small plastic packages with very small wires connecting them to the outside world using 16, 20, and up to 80 or more small terminals.

These ICs, the building blocks of most modern electronic devices—TV sets, video machines, CD players, nearly all todays electronics—are called "chips" because they are so small. They are miracles of miniaturization, and how they came to be developed from the much-larger individual transistors of the Fifties and Sixties is an absorbing and important story.

Up From Transistors

Bell Laboratories announced the invention of the transistor in 1950. I know, because I was at the press conference when it was first announced and demonstrated. They explained briefly how the tiny new device worked, how with no filament (heater) and no vacuum, it could replace the much larger, hot, and fragile glass vacuum tube, which consumed a hundredfold more power. Bell's spokesman then made an amazing demonstration.

He created a rudimentary little battery by moistening a one-inch square of paper towel with his saliva and sandwiching it between a copper penny and a silver quarter to which he'd soldered wire leads. This minuscule DC power source was then hooked up to a demonstration transistor in an audio oscillator circuit, with a pushbutton switch and a small loudspeaker. The large auditorium was filed with an audio tone each time he closed the switch!

The little transistor, hooked up as an oscillator, had created audible sound all through the large hall from a few milliwatts of power! We were extremely impressed with the incredible efficiency of the new device, as well as its tiny size, resistance to vibration, and absence of heat, all major drawbacks of the vacuum tube.

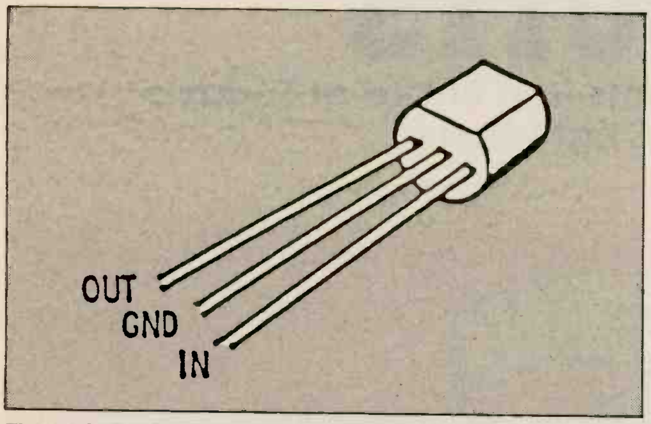


Figure 1. Early transistors, developed in early Fifties, were 1/8 to 1/4-inch in size, with wire leads another 1/5 to 1/4-inch long, much smaller than the vacuum tubes they replaced. But they were hundred of times larger than those that were later miniaturized to fit inside todays's ICs.

Bell claimed, and it seemed to make sense, that this new device would replace the universal vacuum tube, which since 1920 had come to power all radio (and TV) sets, and most telephones. We had no idea than in less than 15 years the vacuum tube would be, except for a few specialized applications, obsolete. Nor could even Bell Labs have predicted that out of the transistor, which was one-fiftieth or less the size of the tube(s) it replaced, would come (in the Sixties) the integrated circuit (IC) which would put a hundred or more transistors and other components in a tiny microchip, less than one-quarter inch square.

How could *we* have guessed the IC would grow (smaller, much smaller) until today we have ICs with many thousands of components on the same tiny chip? We have almost an entire computer on one chip today and it's called a microprocessor. This started in the early Seventies. Today's microprocessors (Z-80 6502, 8088 and so on) determine the computing speed, maximum power, and other capabilities of our Apples, IBM PCs, Color Computers and so on.

Every real robot (industrial robots, not toys) has a computer controlling it. Read on to learn about the evolution of large scale ICs (LSIs) and microprocessors, the very heart of every microcomputer and robot, as well as TV set, microwave oven, automobile, banking machine, video game, and much, much more. You're reading about the single most important component controlling the action of all of these and scores of other devices we use today, and will increasingly depend on tomorrow and all the years ahead, the microprocessor.

A Revolution

When computers first appeared everybody was enormously impressed. Clearly some revolutionary change was in store. Social philosophers and commentators craned their necks upward like a crowd on a sidewalk watching a distant skywriter spell out a blurred and fragmentary message. Most agreed that we were passing into a new kind of society—the "cybernetic society"—in which computers will claim a considerable range of social activities as their own. They would do most, if not all, the work and make most, if not all, of the decisions. On the other hand, as if in compensation, they would return to us a vast flow of whealth, which would usher us into the Age of Abundance.

Where the futurists fell out was over whether this was good or bad. The optimistic wing argued that once we were all free of the need to worry about earning a living, or anything else for that matter, the human adventure would move to new heights and pessimists worried about the effects of living like parasites in the intestines of a cybernetic overlord. What would happen to the human spirit once computers started calling the shots? Would we become self-indulgent and flabby? Would our minds shrivel?

And even if some members of society had the right stuff to live in the coming "age of abundance," did that mean we all did? "I am not sure whether good pay in idleness would be a very healthy thing just for the least intelligent, who are least able to make good use of their leisure," Margaret Mead observed at a conference called to deal with the incipient crisis.

Everyone had a different idea as to how we ought to behave in this new age. George Meany of the AFL-CIO campaigned for the thirty-four hour week. Professor Mead proposed protecting certain jobs by law, such as the "dustman, the nightwatchman, and the postman." And Professor John Wilkinson of the University of California called for the founding of human sanctuaries "as we establish refuges for condors and whooping cranes."

These quotes and comments could be extended to any length. Reading them now, twenty years later, from the vantage point of knowing what did happen, it is clear that the technoprophets were wildly off the mark. But to be fair to the futurists, we must admit that it was impossible for them to foresee the role of

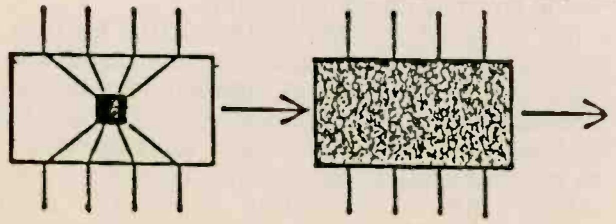


Figure 2. X-ray view (left) shows an early IC with the chip inside, eight wire leads to outside for connecting to other components. Sealed IC is at right. (Texas Instruments)

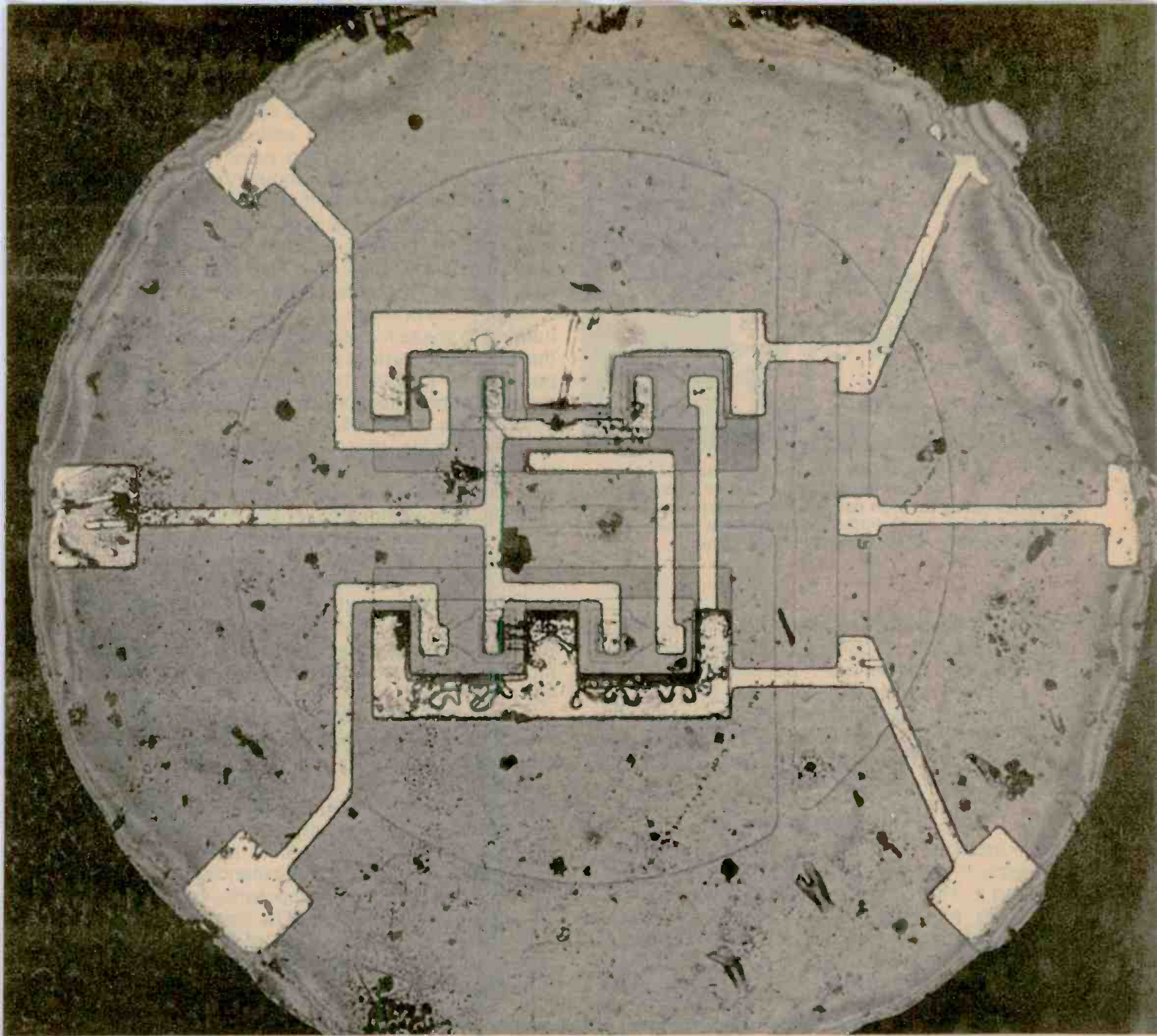


Figure 3. One of the first ICs made, enlarged about 800 times. It had only six lead wired to the outside world. Inside were four tiny transistors. (Fairchild Semiconductor)

computers in society. To have done so in the late 1950s would have required that they somehow realize that the future was not being settled in any Artificial Intelligence Research Center or Palo Alto conference hall, but in an obscure branch of an industry marginally connected to computers.

The First Transistors

This industry was the semi-conductor (transistor) business. Transistors are tiny successors to the vacuum tube that began to crop up in hearing aids and portable radios during the fifties. The technology behind them was based on the discovery in the late 1940s, that certain chemical elements when treated properly, possess a spectacularly flexible set of electrical behaviors.

Depending on what other chemicals were added to them and how, these elements, germanium at first, later silicon, could take an incoming current and step it up, step it down, pass it along unchanged, or store it. While the technology was fairly glamorous—transistors had emerged as another sign that what popular magazines often called "The Wonderful World of Tomorrow" would soon be on us—in fact the market for the product had proved disappointing.

The problem was that for a number of reasons, having to do both with market forces (two of the industry's major customers, NASA and the Defense Department, wanted circuits light enough to be sent into space) and the basic technology, transistors were built small. Often they were the size of a grain of rice. And American materials handling and assembly techniques just were not adapted to dealing with such tiny objects. It proved very difficult to build a machine that could wire these tiny parts together, and that meant depending on platoons of technicians working with tweezers under microscopes.

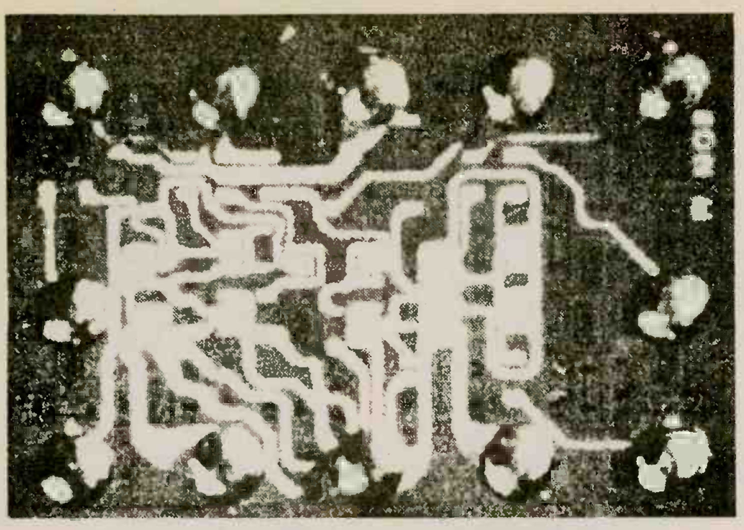


Figure 4. 14 tiny terminals surround microscopic transistors in this Fairchild IC of the Sixties. Size is about 1/20th of an inch across. Modern Ics carry miniaturization much farther, and contain hundred, even thousands of transistors, resistors and capacitors.

All this hand-labor was very expensive, introduced difficult reliability problems, and imposed severe limits on production levels. It put an upper boundary on the level of complexity and degree of miniaturization that could be designed into a circuit and a lower boundary on its price. In every way it limited the range of functions transistors could perform, and therefore the size of the potential market.

First Integrated Circuit

This assembly problem was deeply frustrating to the semi-conductor manufacturers and they bore down on it. The critical breakthrough came in 1959, when two engineers, Robert Noyce of Fairchild Instruments and Jack Kilby at Texas Instruments, discovered how to build circuits that in effect had no parts, and therefore did not need to pass through a conventional assembly stage at all. What those engineers had done was realize the ancient fantasy of bringing pictures to life. They had figured out a way of drawing the circuit design right on a silicon "page" so that when one was through, it was possible to simply plug it in and watch it run.

Of course this is over-simplified. Drawing on a silicon page is a complex affair that combines techniques that resemble both etching and photography. Some steps in the process demand temperatures almost a high as those found on the surface of the sun. Nonetheless, the analogy to simply putting marks on paper was sufficiently strong that these circuits were often called "printed circuits" though their most common name was "integrated circuits," or ICs. From the industry's point of view it was the integrated aspect that was important. With an integrated circuit all the parts and their connections are designed together from the beginning and then fabricated simultaneously. The assembly problem had vanished. Circuits could now be made much smaller, more complex, and more reliable (there was nothing to shake loose). And, a point which no one in the business overlooked for a second, it was now possible to imagine huge production runs, extraordinary price reductions, and a triumphant entry into innumerable new markets.

That was the theory; unfortunately for the IC manufacturers they found themselves faced with two new problems. One was inherent in developing a radically new technology whose major selling point (price) could be achieved only with large production. Any manufacturer thinking about starting to use ICs in his own products would not be interested in buying a million; he would first want to see how a few small-scale experiments went. But small production runs of ICs were very expensive. Thus a manufacturer had no more reason to place a small order than a large one. In 1963, for instance, IBM, a company with a tradition of exploiting new technologies, introduced a whole new line of computers, all of which used hand-soldered components.

Second, it was not easy to think of circuits that could in fact be produced in volume. Circuits tended to be designed for specific products. Even the best salesmen would find it hard to persuade a stereo equipment manufacturer, for instance, to redesign his amplifiers in order to make it possible to use the same circuits as his competitors. The result was that for a long time the major promise of integrated circuits remained fulfilled mostly in calculators and digital watches.

In 1970 there was a new development. A Japanese calculator company approached an IC manufacturer named Intel and asked if it could make a single "master" circuit that could be used in each model they made. The engineer to whom this assignment fell, a gentleman named Ted Hoff, found an elegant solution to the problem. He built a flexible circuit: one that could be programmed to execute any specified set of a wide range of different arithmetic and logical sequences. This answered the Japanese company's

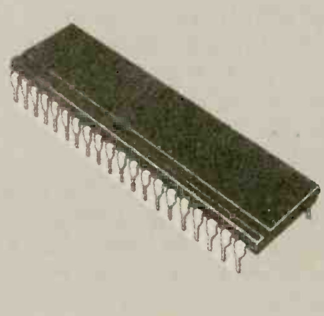


Figure 5. Modern ICs have from 8 to 80 or more terminals for connecting them to outside components. This one has 40 (20 on each side) and is typical of modern microminiaturization. (Radio Shack)

request, since it could modify the same circuit to do the work of any in its family of calculators.

The Intel, whose president was the same Robert Noyce who had been one of the inventors of the IC, began to think about what they had made. A general purpose logic and arithmetic handler: a universal processor. Hmmm. Later Hoff himself was to say, in an interview in Dirk Hanson's history of Silicon Valley called *The New Alchemists*, that the conceptual breakthrough that counted here was not the engineering but the revelation of the market implications. Noyce and Hoff, among other Intel executives, saw that this was the product that the integrated circuit industry had been looking for ten years: a circuit with an enormous number of potential functions, and therefore a huge market, that could be built exactly the same way every time.

First Microprocessors

In 1971 Intel announced the first microprocessor. They called it the "computer on a chip" and the title was apt. By one common definition, a computer is nothing but a machine that can store and execute any of a wide range of possible sets of instructions, and this was just what the microprocessor did. Intel (and the integrated circuit industry in general) suddenly found itself in the computer business. Indeed, in some respects they were not just in the business but at the cutting edge, as manufacturers of the "third generation" of computer technology.

Compared with other computers, the microprocessor, which then sold for about $350, represented a fabulous collapse in price. New markets stood in line. Microprocessors began to show up in cameras, traffic lights, musical instruments, automatic bank tellers, telephones, postage meters, sixty zillion video games microwave ovens, cash registers, taxi meters, automobile engines, home computers, television...and with each expansion of the marker the production runs were larger, prices dropped further, and the market expanded again.

What happened was that, as Robert Noyce has written, the computer went from something that was made out of components to being a component itself. It vanished into the tools and procedures of our society. It stopped looming over the landscape; rather it spread into and merged with it.

This is our present, and, as near we can tell, our future. The scientists working in this area report that more and more flexibility promises to be packed into tinier and tinier packages. The first Intel chip held the equivalent of a single good paragraph of programming; by the time this article is in the hands of the reader either IBM, Japan, Inc., or both will have announced a chip that can store and execute more than a hundred pages of instructions. Work is well advanced on designs that will hold four times that. Of course this density exacts a price in ingenuity: chip crystals are now grown in powerful magnetic fields, and soon the whole process may have to move off-planet entirely, into orbit. But, as Robert Keyes of IBM's Thomas J. Watson Research Center says, "We're not running into a stone wall anywhere."

Perhaps the most significant new automated chip-

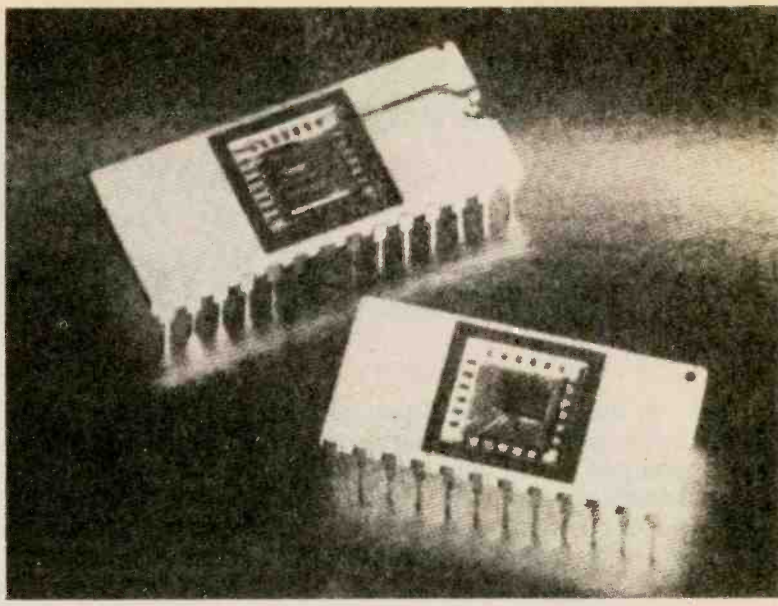


Figure 6. Two modern chips with top plastic covers removed. Tiny chips in middle, each less than ¼-inch square, are surrounded by microscopic leads connecting chip to outside terminals.

fabrication technologies may allow designers to combine the best of both worlds: custom design with large production runs. One of these is called the "multi-project" chip: large numbers of low-volume designs are accumulated and then combined on a single, highly complex chip face. (The result look like a high-tech mosaic.) A second is "gate array" chip design. In this methodology most of the chip design is standard; however, design room is left for a few customized "personality layers" that are deposited at the end of manufacture. There are other ideas working to the same end.

How could the futurists have been expected to foresee any detail of this extraordinary story? Consider the way computers looked to them, and to us all, in the early sixties. First, they were big and expensive. No ordinary person could use one because, for one thing, they did not speak English. They had their own languages, and refused to cooperate with anyone who failed to address them in their own tongue. "...There will be a small, almost separate society of people in rapport with the advanced computers. These cyberneticians will have established a relationship with their machines that cannot be shared by the average man. Those with the talent for the work probably will have to develop it from childhood and will be trained as extensively as classical ballerinas."

The story of the last two decades has been exactly the opposite of what the futurist anticipated: it turned out to be the traditional routines and activities that "took over" the computer rather than the other way around. The net effect was that computers did no one large thing but a universe of small ones. They replaced tools less than they brought flexibility and animation to the ones we had. Who among us could have guessed it? Not I. And certainly if one of the technoprophets had been so careless of his reputation as to express such an idea in 1960 he would have been laughed into silence. ■

INSTALL YOUR OWN PHONES AND SAVE BIG BUCKS!

In the first place, if you can use a screwdriver for basic jobs and follow simple mechanical instructions, you can install your own telephones. Secondly, the telephone company is very helpful and cooperative about providing parts and instructions for it. And they are happy to sell telephones and accessories, though their phones cost more than those of most other companies.

Bell System companies have gracefully accepted the loss of rental income on your telephone unit as an inevitable part of progress. Their people are invariably courteous when you return your telephone(s) to them. In New York, they even give you a $5 credit for bringing it in. Many people putting in their own instruments simply buy them from the phone company, transferring ownership from the phone company to themselves. This is the easy way, of course. And even though it's more expensive than purchasing new phones from other sources, it does save plenty of money in the long run compared to permanent rental.

You can save money starting as soon as you disconnect your present Bell phones and replace them with phones you buy, either from the phone company or from various department stores, **Radio Shack**, or other electronics or telephone dealers. I recently bought five phones, the smaller one-piece kind, from a department store in Wayne, New Jersey. They cost me less than $11 apiece, and I used them to replace five Bell System telephones that we've been renting at $3 monthly each, for the past 15 years. Total cost: $1,650!

The phone company even paid me for bringing in the instruments. In other words, by spending less than $60, and a little time and work, I have started saving us over $15 a month, or $180 a year. If we had been using Touch-Tone phones, or Princess or Trimline instruments, our future savings would be even greater. That's because those instruments' rental costs are greater than the standard dial phones we had. Instead of renting for the $3 a month, they cost from $5 monthly for a Touch-Tone instrument, up to $9 a month for a Trimline unit with Touch-Tone. A phone like that, of which some people have two or three in one house, rents for over a hundred dollars each, yearly. Multiplied by two or three, you can see it will pay you very well indeed to get rid of your rented telephones and put in your own instruments.

What Do They Cost?

Good-quality standard dial telephones are widely sold for from $20 to $30, in various colors. If you want Touch-Tone, you must be sure it will work with your particular local telephone exchange. If you are replacing a pushbutton Bell phone, of course there's no problem. If not, you must check with neighbors or with your local phone company business office.

There are also phones with push-buttons which will work even if your local phone exchange isn't set up for Touch-Tone. These instruments have pushbuttons which convert your button-pushing into separate dialing pulses so that the phone exchange gets the same pulsed signals it would get if you were using a regular dial telephone. If you want a new phone of your own with other special features, you may have to pay more, though the cost to you will still be much less than the cost of renting a similar instrument from the phone company.

Replacing the Phone

To put in your own phone, you first go to a phone store, department store, or **Radio Shack** and pick out your new instruments. Even if you've only had one telephone in your home, you can now hook up three or four more. The phone line can usually handle up to five new telephones. To be safe, you should check with your local business office before you install more than three.

After you've bought the new units and possibly new jacks and/or plugs, take them home and get set to disconnect the old telephones. You will find that the telephones are connected to the phone company's outside line by a small junction box on the wall,

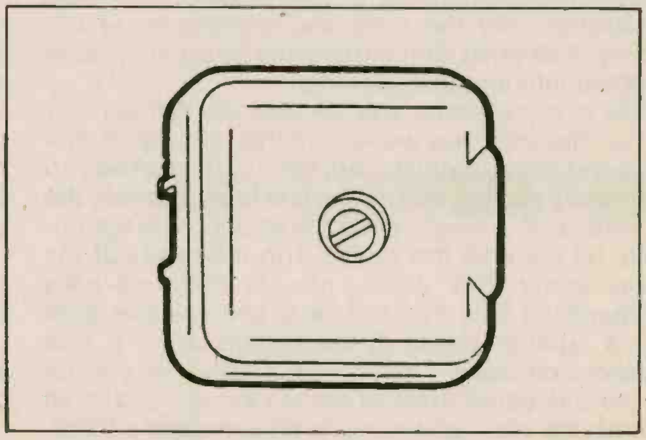


Fig. 1. Many older telephone installations have this kind of junction box. To remove the cover just use a screwdriver on the single screw in the middle. Inside are four color-coded wires. Red and (usually) yellow are the ones used.

Everyone knows today that you can save money by taking out the phone company's telephones and installing your own. But many people are afraid that it's too complicated, or that the telephone company may get annoyed and somehow retaliate. Fortunately, these are both groundless fears.

by Jon Graham

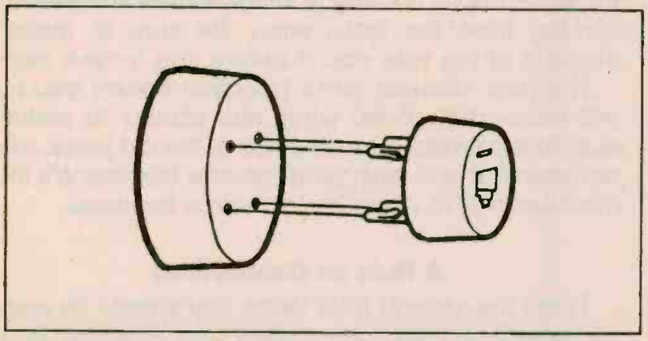


Fig. 2. This plug-in unit permanently converts an old four-prong (obsolete) jack so that it can take the newer, modern, Modular plug.

usually near the baseboard. This box will be one of two types most of the time. It may be the new kind which has been installed only in the past ten or so years by the phone company, called a "modular" jack. These connect to a tiny little modular plug from the telephone, made of clear plastic, and are smaller than a sewing thimble. The other kind of connecting box and plug is the old four-prong type, which is much larger than the modular plug.

No matter which kind of plugs and jacks your old telephones have, your new phones will come equipped with the newer modular plugs. This means you will have to install an adapter plug or a new modular jack, if that's what you have.

You can buy adapter plugs or modular outlet boxes wherever you get your new phone(s) or even at many hardware stores now. Most of the plugs and jack boxes sell for between $2.50 and $7. You can also buy extra-length extension cords in varying lengths up to 25 feet. They all plug together and the only tool you'll need in most cases is a screwdriver. A staple gun will also be useful if you plan to add extra phone extensions in other rooms that don't already have wiring for them installed by the phone company.

Your local phone company has available an excellent booklet free, called *Do-It-Yourself-and-Save*. This 23-page manual goes into more detail than there is room for here on how to install your own telephones. It has many excellent illustrations and is full of hints and suggestions for people who've never before installed anything electrical.

Talk to the Phone Co.

While turning in three separate sets of telephone, I've found the telephone company business offices invariably courteous and helpful. They just want to know where and what day the old telephones were turned in, and also the type number (FCC Registration number) and the "ringer equivalent" number of your new telephone(s). These two numbers are stamped on all new telephones you buy.

They will, in most areas, tell you that you can get a credit of $5 for bringing in the phones, and also how much you'll now be saving each month by supplying your own telephones. Of course they'll probably try to sell you on the idea of using genuine Bell telephones, unless you've already bought your own. They may even tell you that if you have any trouble and call their service department, they'll charge you (plenty—$45 and up per service call) if they have to come out to your house and find a problem with *your* equipment. However, if they come out and there's no problem with your telephones but with their line, of course they can't charge you.

If you should have trouble, simply borrow a phone you know is working OK from a neighbor (or swap them, if you have two or more). Plug the phone known

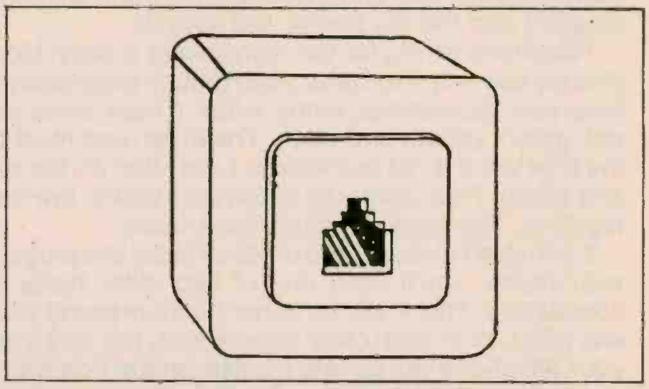


Fig. 3. This is the newer Modular jack now in common use. All phones today have modular plugs that fit this kind of jack.

to be working in place of the one with a problem. If it works, obviously you have a faulty phone. If not, there's a problem with the wiring. It may be a lot cheaper to simply buy a new telephone than to try to get your phone repaired by the manufacturer. The phone company will not repair any phone that is not rented from them. If a phone you have bought from them needs servicing, you have to disconnect it and bring it in.

Basics Of Installing

There are only a few simple basics you must know to install your own telephones. First of all, it's

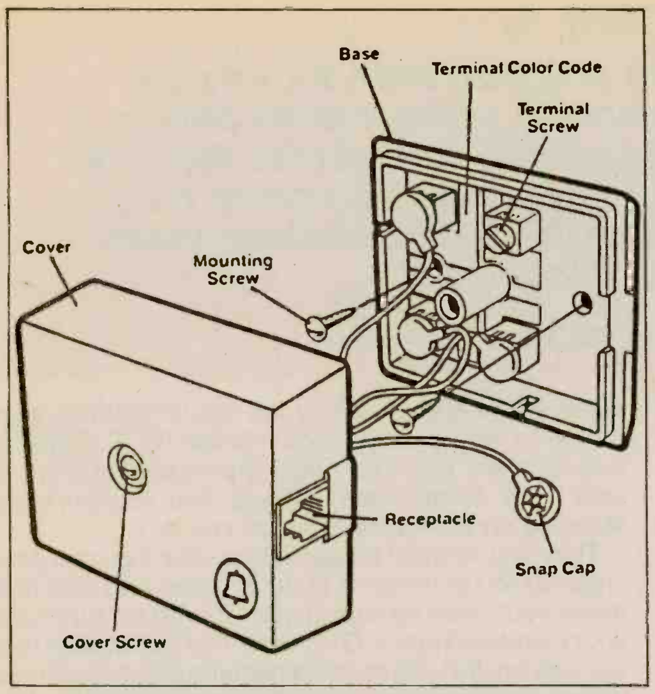


Fig. 4. Some Modular conversion jacks require stripping the connecting wires to put them under color-coded screws. This Bell unit has snap-on terminals. Costs under $8.00.

important to know that you can't get hurt by electricity while working on your telephones—provided you don't get it mixed up with your regular house AC power. The telephone works on an entirely separate power supply supplied by the phone company. Just keep the phone wires (and your hands and tools) well away from the alternating house current and anything plugged into the AC power wall sockets.

Telephone wiring for the homeowner is easy. Most phones use only two wires, even though most phones have four (sometimes more) wires. These wires are red, green, yellow, and black. The wires used most of the time are the red and yellow. Less often it's the red and green. Frequently the green and yellow are tied together. The black is almost never used.

If you don't already have modular jacks and plugs in your home, you'll have one of two older types of connectors. These will be either the four-prong plug and jacks, or in even older installations, the wire from your telephone will go into a small square box with a single screw in the middle of it. This screw holds the cover of the box on, and the cover protects four screws and wires under it. If this is the case, remove the cover and note carefully which screws (what color) the wires from your telephone are secured to. Then unscrew those screws and remove *only* the wires coming from the telephone. You'll see that there are also two, three, or four wires coming from the outside of your house to the srews. These are the wires the phone company uses to connect to your instrument. They must remain in place. You now connect the same colored wires from your new telephone to those wires as were connected before. Replace the cover and you're in business.

Four-Prong Jacks

If your old phone(s) are connected to the outside phone line through a four-prong plug and jack (usually on the wall or down on the baseboard), you can adapt your new, modular-equipped phones with a simple plug-in adapter which the telephone company will sell you for under $5, also available at Radio Shack or other stores. Or you can replace the four-prong junction box with a similar jack box which has its own modular jack instead. This takes a little bit more work, but makes a neater job and is less likely to give you trouble in the future. Just loosen the single screw holding the junction box cover in place and you'll see four screws, just as described in the paragraph above. Unscrew the screws and remove *all* the wires (those coming from the wall as well as those coming from the jacks pins). Be sure to make a diagram of the wire colors before you loosen them.

The new modular jacks (junction boxes) you buy will have color-coded wires and screws to make it easy to reconnect them in place of the old jacks. After replacement you just plug the new telephone's little modular jack in place and you're in business.

A Note on Connections

There are several brief items you should be aware of regarding telephone cables and modular jacks. First of all, the new modular jacks have six tiny slots for possible connections. But there are only four little metal springs in the middle four of these six slots. Further, only the two middle springs are actually used for home telephones.

Thus, if you need to internally wire up a modular jack, you will connect only to the wires coming from the two middle slots.

The wires used for connecting phones are, as noted above, red, green, yellow and black, However, cables supplied by the phone company, and multi-wire cables you may buy if you want to run extension phones into one or more extra rooms, may have some different colors.

You should only use wire intended for telephone use, except in an emergency. These cables have four or six wires, and they are usually color-coded blue, orange, green, brown, gray, and/or white. Don't worry. Just keep track, on a piece of paper, which colors to go which other colors for the phones.

Bell System telephones companies have extension cable for sale to homeowners, in addition to the excellent 23-page installation manual mentioned earlier, and various modular plugs, adapters, jacks, and modular phone cords. They also have an excellent little tool for stripping the ends of extension wires. It costs $3.95 in New York, and it is well worth buying if you plan to run extension phones to other rooms.

Adding Extension Phones

Most telephone company lines will handle up to four or five extension instruments without special measures. That's one reason you have to tell them the "ringer equivalent" numbers on your new phones. If you're going to have only two or three instruments you will have no problem.

To run one or two extra phones into other rooms your simply install a small junction box which has a

(Continued on page 95)

OLD PARTS FOR NEW

How To Choose The Right Resistors For Your Project

by Barry Sheer

Most experiments and technicians gradually build up a supply of spare electronic and mechanical components, which are kept in Ye Old Junk Box. These parts aren't new, but in most cases they can be used again in new circuits with just as good results as if you'd gone out and bought them brand new yesterday.

This is true of resistors, transformers, chokes, transistors, diodes, and even most capacitors. The one case in which old parts sometimes aren't as good as new is when you need an electrolytic capacitor in a power supply. Electrolytics can age through drying out, and can lose some or all of their capacitance, or even become shorted, which is worse. It's easy to test electrolytics with a meter, however, and you can save them too when you junk an old set and want to cannibalize its parts for future possible use.

So don't become discouraged when you want to start a new project. You can save on buying new parts by using old but perfectly good parts from what you often already have on hand. It's just a matter of knowing how to make intelligent substitutions of parts you happen to already have on hand for parts you need for a new project. In this article we'll consider what you need to watch out for in substituting resistors in a new project. Next time we'll discuss substitutions of another basic category of components.

What's In A Name?

When we describe an electronic circuit we often identify its components with names which tell us about the function of each part in the particular circuit at hand. For example, in tuner and receiver circuits we might label a capacitor a "tuning" capacitor if its use is to help select a specific frequency (transmitting station). Or if it's a "coupling" capacitor, we know that it blocks DC (direct current) and passes an AC signal—from one stage to the next. Other common uses/names include "filter" capacitors, "decoupling" resistors, "load" resistors, and so on.

These functional names help tell us what a part does, though not completely. To identify a component totally we need to know its electrical specifications. In the case of a resistor, it will be *fixed*, *variable* or *adjustable*, as well as *linear* or *audio taper*. In addition we need to know if the resistor must get rid of (dissipate) much heat (power), and if it must be an exact value, usually to match another resistor somewhere else in the circuit.

Thus its construction is often also specified. If we know all these qualities of a resistor, we can intelligently substitute a resistor we happen to have on hand for one slightly different which is called for in a new project.

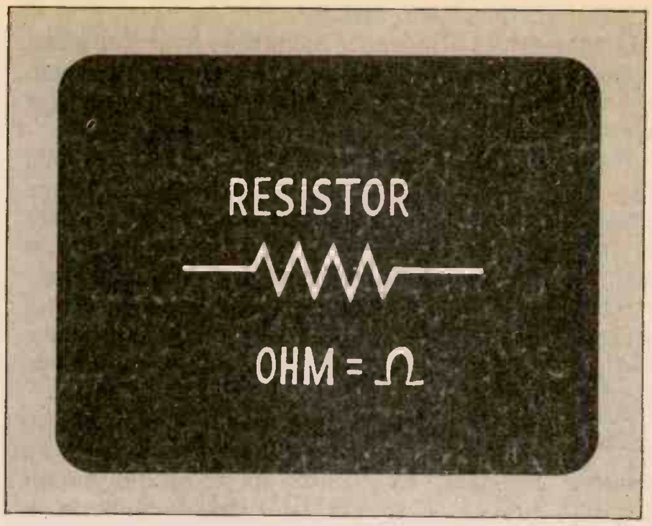


Figure 1. Here is the symbol for a simple resistor, one which is neither variable nor tapped. The OHM is the unit of resistance, and it's abbreviated by the Greek letter shown here.

Three Specifications

There are three specs which apply to all kinds of resistors. The first spec is (of course!) *resistance*.

Resistance is the opposition a resistor offers to the flow of current. Low ohms, say from one ohm or less (a steel bar, or even a piece of copper wire) up to a few thousand ohms are most often written out in numbers; 3, 10, 150, or up to five digits, say 25,000. Resistors of five and six digits in ohms are easier to specify as so many Kohms, either 25K, or say, 250K. By the way, from 10K to 99K may be spelled out either way, as 10,000 or 10 K, or as 100,000 or 100 K.

From a million ohms up we use the term megohms, or megs, thus; 2 megohms, or 2.0 M.

Tolerance Ranges

In most circuits there's a fairly wide range in the actual difference between the real value of a resistor and the ideal value assigned to it by the design engineer. In other words, in most circuits you can use an actual resistor whose value is somewhat off from the perfect design value. The amount of permissible variation is called its *tolerance*. It's usually 10 or 20 per cent in most circuits, although much tighter tolerances are often specified, as little as five percent, or some times even one percent. The more critical the work the resistor is doing in a circuit, the smaller will be its tolerance (and the more expensive it may be).

Wattage Ratings

The power-handling capacity of a resistor is called its *wattage*, and typical values are ½-watt, one-watt, five and ten watters. The lowest ratings cost the least of course. The wattage rating has no particular relationship to its resistance value, by the way. Both are important. The most common resistors, which are the lowest-wattage types, are made of *composition* or *carbon* (usually carbon plus other materials ground up and pressed into small cylinders). Less common, usually higher-wattage types are called *wire-wound* which describes them exactly.

Most resistors are *fixed*. That is they have one value of resistance, and that's it. Unless you put it in a circuit where it's overloaded (draws too much current) and burns up, its resistance value won't change.

There are also *variable* resistors which are what most tone controls and volume controls are. These types also come in two separate varieties. They may be *continuously* variable, in which case they can be set manually to any value between zero and their maximum. In the other case they are *semi-fixed*, which means they have a number of selectable *taps*. The particular value is selected and it usually stays fixed so long as it's in that circuit.

Continuously-variable resistors also have another specification. This is called its *taper*, and it refers to whether it's used as control in an audio circuit (usually) or not. Taper is the relative variation in resistance as the control is turned throughout its range, and it is independent of the unit's total resistance. For example, if one has a potentiometer with a value of half megohm (500 K), and it's set at 10 per cent of the total value, that section will measure 50 K. At 20 per cent it would measure 100K, and at 50 per cent it would measure 250 K. That would be a *linear taper* pot. The other kind of pot taper is called *audio* taper. Its resistance changes according to a logarithmic scheme. This is much better in audio (and some other) circuits. Use of a *linear* taper in such circuits often would require that the action (settings) be crowded into a very small amount of the controls, rotation, all near one end of the control.

If a linear taper pot were used as an audio volume control there would be very little audible effect through most of the control's rotation, and then it would suddenly go from very low volume to very high all at once near the end of its rotation. Using an audio (logarithmic) taper smooths the controls action out throughout its rotation. This is because the apparent loudness increase or decrease is not a direct function of the voltage tapped off by the control. It is approximately logarithmic. Bass and treble controls are not usually audio tape; they are linear.

How To Make Substitutions

First of all, in most circuits you can use either wire-wound or carbon resistors interchangeably. The exceptions to this are in very critical circuits, such as RF (radio frequency) amplifiers and oscillators. This applies only to fixed-value resistors, however.

Let's suppose you need a 10 K resistor, its wattage rating is low (½-watt) and all you have on hand is a wire-wound unit. Its wattage rating is certain to be much higher than you need (and it's certain it would cost (new) a lot more than a simple carbon unit would). But it can certainly do the job in most circuits, provided it doesn't take up too much precious space on the board.

Conversely, if you need a precise value of a wire-wound resistor, say 100 ohms, but its wattage requirement is less than five watts, you can very possibly use a composition resistor provided its tolerance is close enough, say five percent or less. It depends on the resistor's use in the circuit. You can always put it in and if the circuit works OK (as it usually will) no problem. If the value is critical, and the circuit works but not quite the way it should (its timing, say, is slightly off) you can always adjust the value by adding another resistor, or by changing the value of an associated timing capacitor.

You can always use a higher-wattage resistor of the same resistance value in place of a lower-wattage unit. Suppose your circuit calls for a 47,000-ohm, ½-watt resistor, and you have several 47 Kohm units on hand, but no ½-watt jobs. You can certainly use the higher-wattage units, even two-or 5-watters if you happen to have only those.

Series, Parallel

A series, parallel, or series-parallel combination of resistors can replace a single resistor so long as the net resistance is the right value, and the wattage rating is at least met (higher is always OK; lower wattage is no good—it may well burn up).

Suppose you needed a 100 K, 1-watt resistor, but you had only 50 K and 200 K units on hand. You would have a choice. You might use two 50 K resistors in series to get the 100 K, so long as each was rated at least ½ watt or larger. Or you could use two 200 K resistors connected in parallel (again, so long as each was rated at least ½ watts. Or you could even use five 500 K units in parallel!

Frequently a resistor with a higher or lower resistance can be used if it has tighter (smaller) tolerance value. For example, suppose that your circuit calls for a 220 Kohm resistor at 20 per cent tolerance. This means that you could use one whose actual resistance was really anywhere between 176 K and 264 K. You could then use either a 240 K or a 200 K resistor, provided it had a tolerance of 10 per cent (or five, or two). Similarly a 47 K unit could be substituted for a 50 K one, and so on.

Potentiometers

In the case of potentiometers you can substitute a unit which has the same total resistance, but with a different taper, provided you're prepared to live with somewhat different "feel" of the new unit. In addition, you can often substitute smaller or larger value of pot (by a factor of two, generally) with little or no adverse effect on the action of the circuit. This is particularly

BLACK	0	BAD
BROWN	1	BEER
RED	2	ROTS
ORANGE	3	OUR
YELLOW	4	YOUNG
GREEN	5	GUTS
BLUE	6	BUT
VIOLET	7	VODKA
GRAY	8	GOES
WHITE	9	WELL

Figure 2. The table of ten colors above lists the colors and the numbers for which they stand in color-coded resistors. The column at right is an easy-to remember (acronym) expression for the color code, courtesy of Texas Instruments Learning Center.

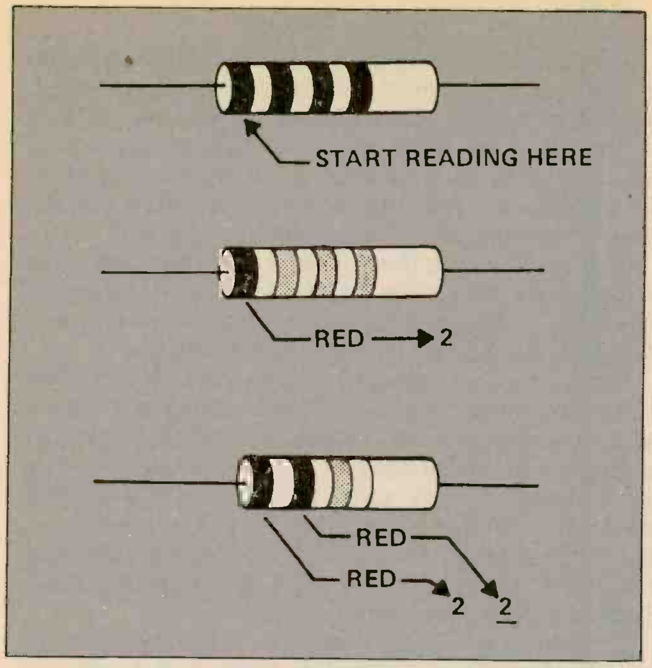


Figure 3. These three resistors show how to read the colored bands on a resistor. This illustrates a value of 220 ohms, assuming the third band were brown (one zero).

true if the pot doesn't draw any direct current in the circuit, but is merely to divide up a signal voltage. In most cases here, as elsewhere, you just go ahead and try the substitution. If the circuit works, fine. If it doesn't work quite right, try adding a fixed resistor (if a smaller pot has been tried) in series just to see if the circuit now works OK. If it doesn't you know you have to go out and buy the exact component brand new, for a change.

Here, as elsewhere in electronics, experiment. If you're not dealing with high voltage or (current) you can often get away with substitutions quite successfully. Try it, it might work. And if not, then you can spring for the extra money for the exact part specified.

Reading Resistor Color Codes

Most readers know that resistors are marked with little bands of color painted on them which tell us the resistance (in ohms), and the tolerance. The resistance goes according to the color code listed below, which you should memorize if you don't already know it. If you're learning it, cut out the chart and paste it up somewhere where you'll see it whenever you have nothing else to read.

BLACK	ZERO
BROWN	ONE
RED	TWO
ORANGE	THREE
YELLOW	FOUR
GREEN	FIVE
BLUE	SIX
VIOLET	SEVEN
GRAY	EIGHT
WHITE	NINE

The FIRST band indicates the number. The SECOND band indicates the second number. The THIRD tells how many zeros follow the numbers.

As an example suppose a resistor is marked Red, Red, Red. This would indicate 2, 2, and two zeros, or two thousand and two hundred ohms (2200). Red, Red, Brown, would be 220 ohms. And so on.

In addition to the resistance, the resistor may have its tolerance marked. If there is a gold band, that tells us it's a 5% unit. If it's marked with a silver band, it's a 10% resistor. And if there's no gold or silver band, it's a 20% unit. Most low-cost units are 20% which is good enough for most common applications.

The size of the resistor almost tells you whether it's a ½-watt unit, which is what the smallest common ones from Radio Shack are. Slightly larger are the one-watters. And larger than that are the five and ten-watters. To learn those sizes you'll just have to look at units of each size. Since you'll be using ½-watters most of the time, it's pretty easy to get used to the different sizes.

Potentiometers often have their resistance value stamped on them.

The Most Common Part

Virtually all electronic circuits and devices contain at least one resistor. It is the most common electronic component, and does several important jobs. The

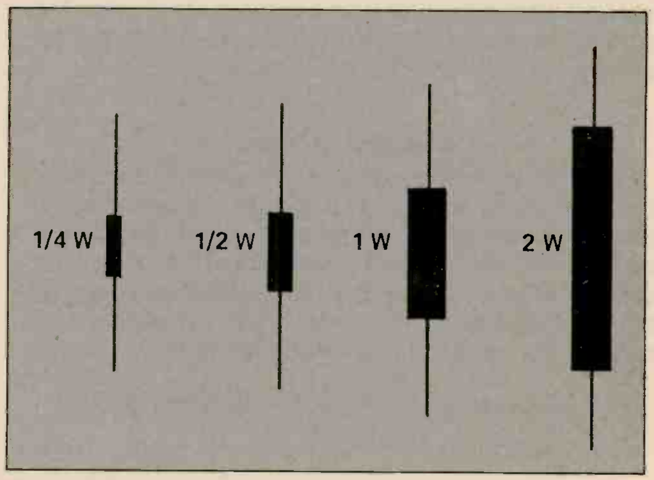


Figure 4. The most common resistor size is one-half watt. The drawings here are typical carbon resistors, shown full size. Values larger than two watts often have the wattage stamped on them along with the actual value. They are most often wire-wound resistors or deposited-film types.

most obvious of these is to limit the amount of current in a circuit to the correct value. That is, it keeps too much current from flowing in a circuit. If it did not, excessive current would flow through the other parts of the circuit, burning some of them up, to say nothing of wasting current which would otherwise be saved.

The most common other components resistors preserve by limiting current to safe amounts are transistors and light-emitting diodes (LEDs). Resistors also can be used to divide power supply voltages up into smaller voltages, since various parts of the circuit often need different power supplies.

Resistors can be fixed in value (most frequently this is the case), or they may be changeable (adjustable or

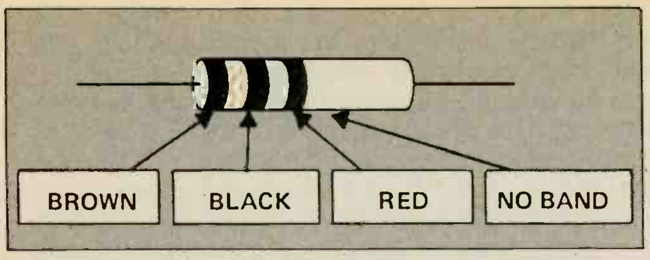


Figure 5. The resistor shown above has an ohmic (resistance) value of 1000 ohms (one, zero, two zeros), Since no tolerance band is shown the tolerance is 20%.

variable) in value. Fixed resistors are usually made from a mixture of powered carbon, contained in a binder of plastic or other inert material.

This mixture is usually in a case with a wire lead extending from each end. Fixed resistors may also have wirewound bodies, or may use chemical film evapored onto insulated bodies of ceramic, glass, or other non-conductors. Wirewound resistors are most often used in power supply circuits because they can handle heat better than other types can. They are more expensive than carbon types, and are usually very precise in value, where carbon types may vary (have tolerance) from their *nominal* value.

Variable resistors, usually called potentiometers, are used wherever it may be necessary to change the value(s) of resistance from time to time, as for example, in a volume control circuit.

Specified in Ohms

The resistance of each resistor is specified in *ohms*. One ohm is the amount of (pressure) of one *volt* will maintain a flow of one *ampere* of *current* through. If you're not yet familiar with these terms, just hang onto the resistance measure, the *ohm*; it'll all fall together for you after awhile. For now, try to remember this formula, the basis of all else in electricity:

R = E/I, or *resistance* equals *voltage* divided by *current*.

The value of a resistor is most often coded right on its body. The illustration shows how this is done with three (or four) color bands. The fourth band (after color-coded resistance) may show the tolerance (possible ohms variation) of a resistor. Less commonly it shows a fractional multiplier for small values. Most small, inexpensive (usually ½-watt) resistors have no tolerance specified, so it's 20%.

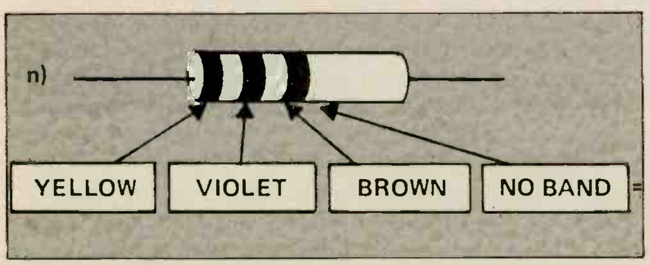


Figure 6. In this example, the resistors value is 470 ohms (four, seven, one zero), and 20% tolerance.

Wattage Ratings

The power-handling capacity of a resistor is called its *wattage*, and typical values are ½-watt, one-watt, five and ten watters. The lowest ratings cost the least of course. The wattage rating has no particular relationship to its resistance value, by the way. Both are important. The most common resistors are the lowest-wattage types, *composition* or *carbon*.

Most resistors are *fixed*. That is they have one value of resistance, and that's it. Unless you put it in a circuit where it's overloaded (draws too much current) and burns up, its resistance value won't change.

There are also *variable* resistors which are what most tone controls and volume controls are. These types also come in two separate varieties. They may be *continuously* variable, in which case they can be set manually to any value between zero and their maximum. In the other case they are *semi-fixed*, which means they have a number of selectable *taps*. The particular value is selected and it usually stays fixed so long as it's in that circuit.

Continuously-variable resistors also have another specification. This is called its *taper*, and it refers to whether it's used as control in an audio circuit

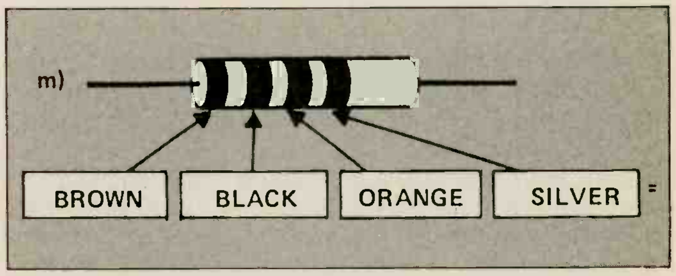


Figure 7. This resistor is 100,000 ohms; one, zero, four zeros. It has a silver tolerance ban which indicates (10%).

(usually) or not. Taper is the relative variation in resistance as the control is turned throughout its range, and it is independent of the unit's total resistance. For example, if one has potentiometer with a value of half a megohm (500 K), and it's set at 10 per cent of the total value, that section will measure 50 K. At 20 per cent it would measure 100 K, and at 50 per cent it would measure 250 K. That would be a *linear taper* pot. The other kind of pot taper is called *audio* taper. Its resistance changes according to a logarithmic scheme. This is much better in audio (and some other) circuits. Use of a *linear* taper in such circuits often would require that the action (settings) be crowded into a very small amount of the controls rotation, all near one end of the control.

If a linear taper pot were used as an audio volume control there would be very little audible effect through most of the control's rotation, and then it would suddenly go from very low volume to very high all at once near the end of its rotation. Using an audio (logarithmic) taper smooths the controls action out throughout its rotation. This is because the apparent loudness increase or decrease is not a direct function of the voltage tapped off by the control. It is approximately logarithmic. Bass and treble controls are not usually audio tape; they are linear.

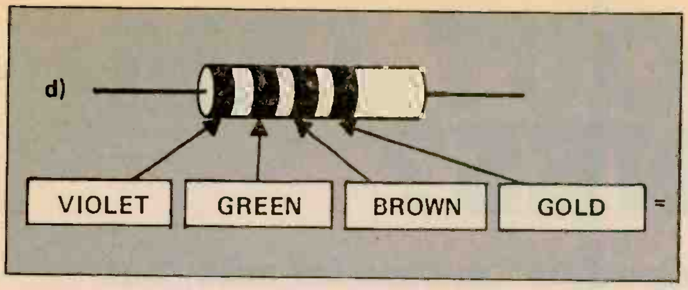


Figure 8. This resistor is marked 750 ohms; seven, five, one zero.

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Let's suppose you need a 10K resistor, its wattage rating is low (½-watt) and all you have on had is a wire-wound unit. Its wattage rating is certain to be much higher than you need (and it's certain it would cost (new) a lot more than a simple carbon unit would. But it can certainly do the job in most circuits, provided it doesn't take up too much precious space on the board.

Conversely, if you need a precise value of a wire-wound resistor, say 100 ohms, but its wattage requirement is less than five watts, you can very possibly use a composition resistor provided its tolerance is close enough, say five percent or less. It depends on the resistor's use in the circuit. You can always put it in and if the circuit works OK (as it usually will) no problem. If the value is critical, and the circuit works but not quite the way it should (its timing, say, is slightly off) you can always adjust the value by adding another resistor, or by changing the value of an associated timing capacitor.

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Series, Parallel, and All That

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Suppose you needed a 100 K, 1-watt resistor, but you had only 50 K and 200 K units on hand. You would have a choice. You might use two 50 K resistors in series to get the 100 K, so long as each was rated at least ½ watt or larger. Or you could use two 200 K resistors connected in parallel (again, so long as each was rated at least ½ watts). Or you could even use five 500 K units in parallel!

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Potentiometers

In the case of potentiometers you can substitute a unit which has the same total resistance, but with a different taper, provided you're prepared to live with the somewhat different "feel" of the new unit. In addition, you can often substitute smaller or larger value of pot (by a factor of two, generally) with little or no adverse effect on the action of the circuit. This is particularly true if the pot doesn't draw any direct current in the circuit, but is merely used to divide up a signal voltage. In most cases here, as elsewhere, you just go ahead and try the substitution. If the circuit works, fine. If it doesn't work quite right, try adding a fixed resistor (if a smaller pot has been tried) in series just to see if the circuit now works OK. If it doesn't, you know you have to go out and buy the exact component brand new, for a change.

Here, as elsewhere in electronics, experiment. If you're not dealing with high voltage or (current) you can often get away with substitutions quite successfully. Try it, it might work. And if not, then you can spring for the extra money for the *exact* component, brand new. ■

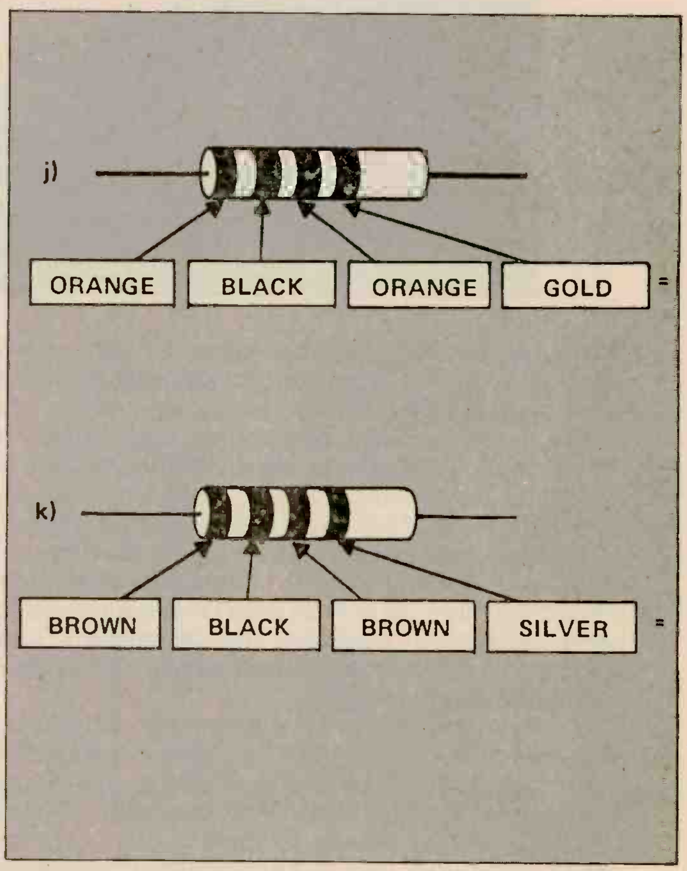


Figure 9. These two resistors are marked (top) 30,000 ohms; (three, zero, one zero), and (bottom) 100 ohms; one, zero, one zero.

HOW ABOUT IBM CLONES?

There are loads of "IBM-Compatible" micros for sale, but is it safe to buy one? Here are the pros and cons.

IBM wasn't the first company to sell microcomputers (micros, from here on) for use in the home, to students, small business people, and others who need one to do word processing, play games, or handle small business-like tasks that they're good at. Apple and Tandy (Radio Shack) along with Atari and Commodore were there well before IBM brought out its popular Personal Computer (PC from here on), along with several others companies who aren't around anymore, or at least aren't making micros for home and small business use anymore (Texas Instruments, Sinclair, and others whose names aren't so familiar, come to mind).

IBM was later than Apple and Radio Shack, but after they brought out their PC, things changed. At first they just sold more than most others, due in large part to their massive advertising campaign (Charlie Chaplin), and of course to their strong corporate image. Then they sold more than almost everybody else put together. Several companies went out of the home computer business, while others took losses on their home computers but stayed in business.

Finally, IBM began competing with itself, bringing out the PC Jr., which made a false start, and finally flopped, after much work and lots of sales and price reductions (it's still a very good value today, if you can find one, despite some minor deficiencies). The PC forged right on, though price reductions have been made. Lots of other companies have brought out micros which are more or less copies (not quite) of the IBM PC. These are called IBM-Compatibles, or *clones*, because they run some or most software intended for the IBM PC.

The Most Successful

The most successful clone (which is what we call the compatibles from here on) was Compaq, which first brought out a *portable* clone, actually before IBM did. In fact some people called the IBM *portable*, when it finally came out, a clone of the Compaq! Compaq did a great job, and has prospered, often adding features that IBM only got to later. It's had considerable acceptance in the business market along with IBM and is a leader in the market for PC clones in various versions. These versions include the PC AT (Advanced Technology) and the PC-XT (Extra Technology). In fact the PC-AT has just about replaced the PC itself in sales to the corporate market, where extra features make a difference. In the market we're concerned with, which the basic PC handles quite well, the PC has more than enough memory and other features.

In addition to Compaq, several other companies are selling lots of clones quite successfully. Leading them, and selling more than all others combined, is of course Tandy Radio Shack. Their model 1000 was priced, including everything except the second disk drive at under $1000 last year, and was often available on sale.

In fact, Tandy (Radio Shack) has had such success with its clone, the model 1000, that it is now offering two new clones, at even lower prices, as well as very good value on clones for the IBM-PC AT and XT, also at lower-than-IBM prices.

The clones of the basic PC, at lower prices than the earlier model 1000, are Tandy's new 1000 SX, which has extra RAM memory, extra slots (for more boards) and includes some good software, all for only $1,200. The even-better-buy model 1000 EX goes for only $799. It looks as though Tandy is intent on knocking lots of the other low-priced clone makers out of the box. Of course, like lots of them, these prices require add-ons, as noted above. However, they're very good buys, particularly since, like all Radio Shack equipment, they're backed by and serviceable by any of the nearly 8000 Radio Shack stores and Computer Centers scattered all over the United States.

We used a model 1000 for several months in our office and it ran all the software we tried on it perfectly, including the revolutionary PC-Write, which is an excellent word-processing program selling for only $75. Epson, the world's leading maker of printers, has a fine series of PC clones at good prices, and Leading Edge, of Canton, Massachusetts, has sold more than most other clone makers.

The best buy PC clone today, if you can find it, Sanyo's 555, is used by our Editor as his own backup word processor. His main one is a professional word processing system, the Digital Equipment Corp. DEC Mate II, which costs about twice as much as most PC clones. There are dozens of other manufacturers offering systems at even lower prices, as will be discussed below.

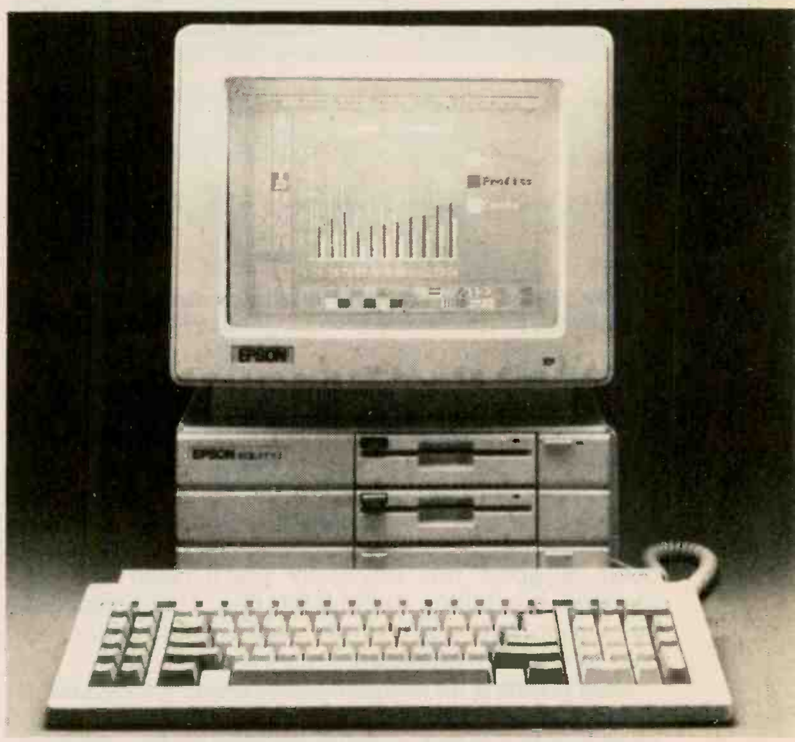
What Does a Complete PC Include?

The basic PC (not the more-elaborate PC-AT or the XT) which is what is meant when most people talk about prices, to compare with the cost of a (real IBM) PC, includes the *main system* unit, with one *floppy* (5 ¼-inch) *drive*, the *keyboard*, a black-and -white *monitor*, plus (bet you) wouldn't have guessed it) a monitor *board*, a *printer* board (either serial or parallel) a *second* disc drive and, guess again, a *controller* board for the disc drive(s). Oh yes, there's also the *software* (word processing, or whatever else you want to do with the system) and in the case of IBM itself, the *Operating System*, which is also software.

Most other companies throw in the Operating System, and frequently the other software (programs to do the work, like word processing). Each of the above costs $50 or more. Software from IBM, if you have to pay for it, costs from $150 to $400 or so, while most other companies charge a lot less. Thus you can see the cost of software runs to a sizeable sum.

Most companies, when they quote a very low price, include just one disc drive, no software, and frequently no monitor or boards, so you have to add those in when comparing prices. You also have to add the cost of a printer.

Let's look at the prices of these various add-ons, to get some real what-would-it-cost-me numbers. Apple, by the way, is sold the same way. The basic computer costs so much, the monitor (how can you see without it?) is extra, plus various other add-ons. Atari, Amiga, and many other popular systems, are also listed in the newspaper ads this way. It's not just IBM and its' clone makers who mislead you in the advertisements in this fashion.



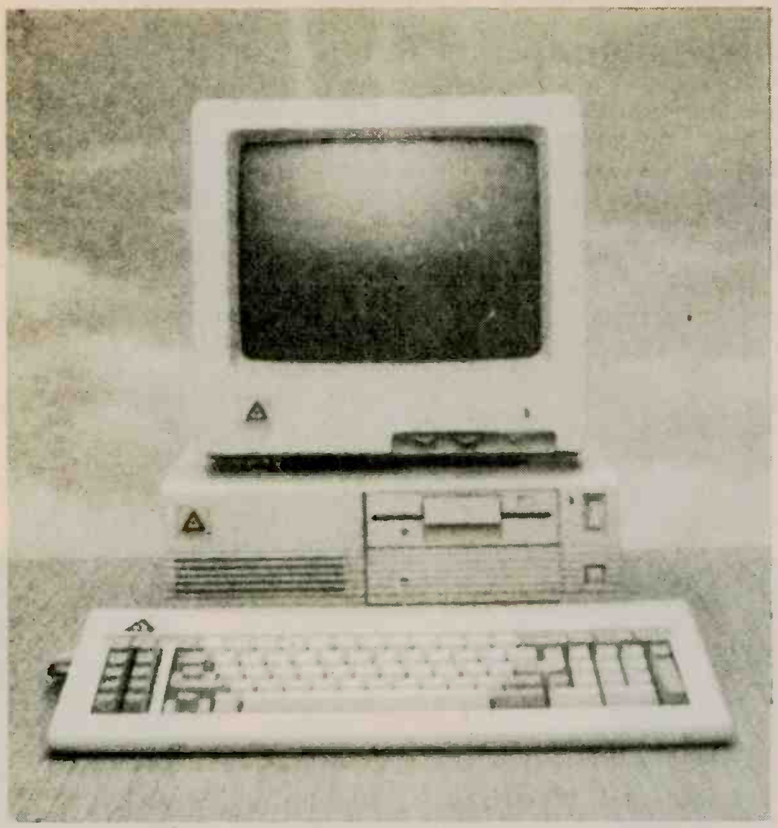
Epson Equity 1 IBM PC-alike comes in three versions. With one disk drive it's $995 plus monitor. Two-drive version lists for $1295. Hard disk also available.

What Are the Add-Ons?

Since there are a great many different add-ons for PC's, let's start out by dividing them into (a) add-ons that *fit into* the *main unit*, and (b) add-ons *apart* from the *main unit* and (c) *software*. We'll deal with the first category (a) parts that go into the main unit, first.

Main Unit Add-Ons

The main, or System unit is a low, rectangular box which almost always has the monitor screen sitting atop it. In addition to internal electronics, it has one or two disk drives (which handle the disks carrying the software). Low-priced systems usually have only one disk drive, but you really need two. Although you *can work with only one, it's very cumbersome to do so.*



Leading Edge micro model D includes own word-processing program and monitor for $1495 list.

Add one disk drive, if the system priced has only one.

You also need a monitor, which frequently isn't included in the base price. This can be a black-and-white monitor, which you must have if you're going to do serious work like word processing or financial stuff. If you're going to do games, charts, Computer-Aided-Design or other complicated stuff in which color is good for, obviously you'll need a color monitor, in addition to the B&W one. That's because color monitors don't show numbers and letters as clearly as B&W monitors.

Now it gets a bit complicated. Low-priced systems frequently don't include a monitor board. You'll often need to add a monitor board, whether it's for a B&W or for a color monitor. Some firms will sell you a combination board, which costs less than two separate boards, usually.

These boards, by the way, plug into the main, or *motherboard* inside the main unit. Most PCs have space for four or more add-on boards, even though some of these spaces are taken up by boards you really must have. Many systems also need another board added. It's a disk *drive controller* board, and without it the system can't run the disk drives.

Most PCs also need a board to handle the output to the *printer* (and/or to a *modem*, which you use to talk to other computers over telephone lines). These are called input/output boards. Regardless of whether or not you want to use a modem (which can also be an internal board) you'll need either a *serial* output board or a *parallel* output board, to drive your printer.

Most PCs already have a parallel output board for the most common type of (parallel) printer. You'll need a serial board if you want to use a serial printer.

If you want to have lots of memory you must also get boards for that, which is a whole separate story. You can also add a *hard disk drive*, which stores much more information than the usual 5¼-in. floppy drives. The hard disk can be on a board, or can be separate, external to the main unit.

There are other less-frequent add-ons, but you get the idea. Let's look now at add-ons separate from the main unit.

External Add-Ons

You may not think of a *monitor* as an add-on, but most low system prices either include a black-and-white monitor, or no monitor at all! If you need color, that's extra (plus, of course, the color monitor board, in most cases). Another add-on is sometimes a better keyboard. The original IBM PC came with a keyboard that had some of the keys in funny places, *unlike* the famous IBM Selectric typewriter keyboard, the industry standard. Most newer keyboards conform to the Selectric keyboard standard, but you may have to pay extra for it.

The next, and almost-always extra item is the printer. There are many different types and grade of printers, so it's not possible to go into this subject here, except to remind you that the printer, as noted above, sometimes needs its own special card in the main unit.

Software You'll Need

The computer is *hardware*. It needs *software* to do any work. It's like a stereo system, where the hardware—the tuner, amplifiers, speakers and tape player—needs records (software) to do any good. In addition to say, a word-processing program on a disk,

IBM Personal Computer (PC) showing business graphics. Good, but costs plenty; the standard of the industry, thanks to excellent corporate image as well as heaviest advertising campaign in the history of computers.

MAKE/MODEL	LIST PRICE	TYPICAL PRICE	PROGRAMS INCL?	KB RAM	COMMENTS
IBM PC	2420	2150	NO	256+	Industry standard. Widely discounted. Price includes entire IBM system, except printer. Widely imitated by clone-makers at much lower prices.
Compaq	2300	2100	NO	256+	Many versions available.
Epson Equity	1250	1100	NO	256	Available with hard disk drive (20 MB); $2000 (list).
Kaypro PC	1595	1300	YES	256	
Leading Edge	1495	1350	YES	256	Software is Leading Edge WP. Additional business software $100-$500 additional.
Tandy 1000-EX	799	799	YES	128+	Highly expandable. Word processing included is minimal. Good WP costs $100 add. Model 1000-SX includes additional features at $1100.
Sanyo 555	1300	1100	YES	128	Available with only one disk drive for $100 less (not recommended). Software package included is very extensive.
Bondwell 1134*	800	800	YES	640	Includes two drives, monitor, with parallel and serial outputs. *Best Buy.

Notes: Discounts are widely available and vary considerably. Prices shown include monochrome monitor. Color monitor add $200-300. Printer adds $200 to $500 to system

you usually need an operating program on a disk to make the thing work. The IBM PC and its clones use an operating system called MS-DOS (DOS means disc operating system). If you bought your micro from IBM, the Operating System (on a disk) would cost extra. So there's some more software costs. Many non-clones, like the Kaypro, included the operating system and several programs (they called it bundling) with the price of the system. But not IBM. Not Apple, Atari, or Amiga either, unless otherwise stated.

What Do They Cost?

You may see system prices for clones of PCs advertised for under $500, but of course you have to add on at least a *second disk drive*, a *monitor* usually, a *printer, software*, and often other items too.

Batteries Included?

A prominent manufacturer of computers accessories calls itself *Batteries Included* in an obvious reference to the practice of some toy makers who increased the price of their products by charging extra for the necessary batteries. So the question is, what's needed to make a micro run but isn't included in the price advertised (usually low) to get our attention? In the auto sales business it's called "low-balling."

Before looking at PC systems price and parts needed you should fix firmly in your mind the difference PC versions (there are at least three) being advertised and sold widely. There's the basic PC, the PC AT (Advanced Technology) which costs more than the basic PC, and the PC XT (Extra Technology). Be sure the prices you're looking at are for the basic PC, not the AT or XT; those will be higher, because they include features (more memory and higher speed) which are of little value to most.

The system priced should include 256 K of RAM (Random Access Memory), two floppy disk drives (with controller, of course) and a black-and-white monitor (with monitor card included). If you're interested in color (remember that displaying numbers and words is best on a B&W monitor) you'll have to add that in. If you need a special printer which is "serial," an adapter board for serial output must be included.

Many ads include the words "AT-style keyboard." That's fine, but it's not worth more than, say maybe $50. What is important is that you don't have to include another $150 to $500 for software such as a word-processing program, maybe $100 or more for the Operating System (MS-DOS, usually) software, and so on. Printers can cost from $150 at the low end to $500 or more. A color monitor (including required adapter board will run at least $350 or so, unless you leave out the black-and-white monitor. Don't omit the B&W one if you're hoping to do any serious work.

More Important Than Price?

And now here comes a question probably more important than the actual price itself. What's the warranty? And maybe even more important than that is: Who will handle any warranty repairs? After you figure the total price, pay attention to the matter of how do you get service?

Buying by mail order, or visiting a city to buy from a discount house may seem like a great way to save money. But if the time ever comes when you need service, you may pay lots more than you saved in the beginning. Most mail order outfits offer a one year limited warranty, though some even advertise two years. Some have only 30 or 90 days. It's very important to know that you have a place to go that'll be in business if and when you ever need service. ■

Here's a real checkbook-breaker! It is one of the very first sets completely assembled at the Atwater Kent factory. Earlier Atwater Kent radios were sold as kits to experimenters. Completely restored, this radio looks good enough to play—and it does!

ANTIQUE RADIOS

Step back into the Time Machine. You can make money at the same time, or just enjoy The Nostalgia!

Have your ever looked at an old Majestic or Stewart-Warner's radio set of the Twenties and imagined what it would be like if you could suddenly, magically, plug it in, turn it on, and tune in one of the old-time late-night broadcasts of a real big band? Are there maybe still floating around in the stratosphere the magnetic waves of those old broadcasts, waiting to be picked up by the right combination of tuning capacitor and coils that once picked them up every single night?

If you can work with your hands as well as your head, and if you've thought about turning old, discarded radios into good-looking units, you can restore them as decorator items at the same time you appeal to people's nostalgic feelings. Lots of people will pay good money to help satisfy those pleasant memories.

Many interior decorators, young people, and older people are clamoring for the Philco cathedral radios, Majestic consoles, Scott, Silver-Marshall, and other radios of the 1930's. The period from 1928 to 1942 will provide you with the opportunity to find what is left of the millions built during that era. We are going to tell you where and how to buy radios, how to cosmetically restore them, where to buy tubes and parts, and finally where and how to sell them to make those needed dollars for yourself.

Where To Find 'Em

There are many sources for old radios and we shall explore them one by one. Flea markets are very good places to find old radios. Some flea markets are permanent affairs located inside large buildings. I find the best flea markets for bargains are the temporary one-to three-day kind that set up once a year in the smaller towns. The sellers usually are nonprofessionals who like to sell at flea markets because they like to meet new people and like to make a quick buck.

A variation on the flea market is the tag sale or the garage sale. This sale may be conducted by an individual or a group of people. Usually the sale is held in the garage, yard, or basement. You will find

This Philco cathedral radio came from a landfill. The veneer and finish have peeled, making it difficult to restore. Perhaps it will end up as a parts radio instead.

everything from radios to horse collars. Usually prices are extremely low and by dealing with the owner you can sometimes bargain prices down even more.

Auction sales are good places to buy radios. Auction sales are especially numerous during the period from April to October. The best kind of auction is one held on a farm that hasn't been widely advertised. There will be fewer dealers there to run up the prices.

Another type of auction is one that is held in an auction house. The auctioneer usually owns the building and has a truck to move estates into the building for weekly sales. Individuals may also consign merchandise to these sales.

Other places to find radios are antique stores, junk shops, and second hand stores. Avoid the high rent, high styled antique stores. The dirtier the windows the more likely you are to get a bargain.

The last but not least place to look is in the local sanitary landfill. It used to be called the city dump. A friend I know picked up several car radios for $2.00 each, house radios $2.00 to $5.00 each, and nearly 100 tubes and several speakers free. The first thing to do is to make friends with landfill operators. They are usually happy to save out items that people want. I know another fellow who got a Philco cathedral radio, 3 plastic cabinet table radios, and two car radios for $15.00 at a landfill.

What to Spend

The difficult thing to tell you is how much to pay for a radio. First, pay as little as possible. Perhaps the first few radios you buy you may pay too much for, but after a week or two you will get the feel of it. At a flea market, shopping center antique show, junk shop, or second hand store look the merchandise over carefully and make up your mind what you are willing to pay before talking to the owner of the items you are interested in. When he tells you his price consider it carefully, comparing it to the price you are willing to pay. Most sellers expect a counter-offer one-third to one-half less than they ask initially. In fact some like to haggle over the price so well that they will be disappointed if you pay their asking price. Sometimes making a lower offer will not work. This is when you walk away with a polite "Thank you."

You have probably heard of bidders at auction sales who bid by a raised eyebrow, a crook of a finger, or a wink of the eye. Don't try to imitate them. Chances are you have never seen the auctioneer before and he won't recognize these signs from you. Shout loud and clear, wave your arm and hand at him, get his attention, because he will not sell to you unless he sees you and hears you bid. After you attend a number of sales the auctioneers will begin to remember you. They will know you are looking for bargains in used radios.

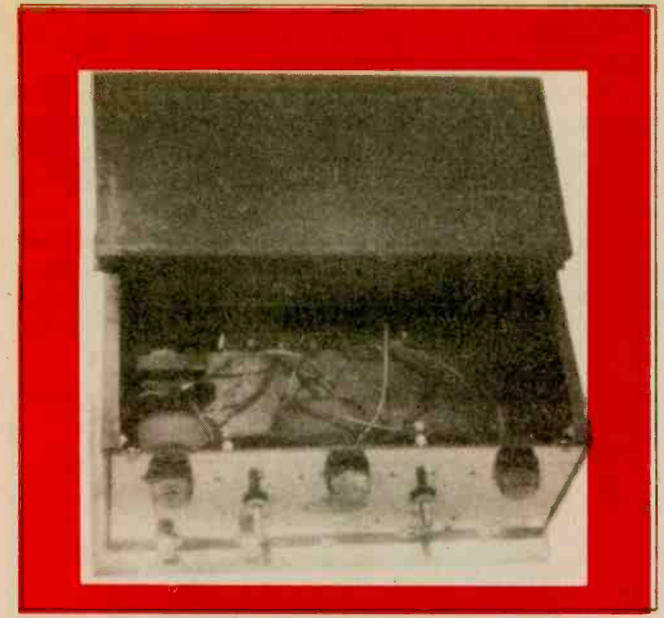
Fixing 'Em Up

Since most of you readers will not be technicians or retired repairmen, we will stick to tube, fuse, and line cord replacements and to cosmetic face-lifts to the cabinets. In the "Where-to Buy" table you will find names and addresses of people with thousands of old radio tubes to sell, sources for cabinet repair materials, books to help you in restoring radios, and companies who offer needed repair services on speakers and transformers.

Let's say you have just bought your first radio. What do you do next? First inspect the electric cord and plug. Nothing is so embarrassing as to plug in a radio and put out all the lights in the house. To prevent this, make the following device: Buy an extension cord with a cube tap on one end, a porcelain lamp socket, and a 100-watt light bulb. Mount the socket on a piece of wood about six inches square. Separate the two wires in the lamp cord without damaging the insulation. Next, cut one wire in two about a foot from the cube tap. Clean the insulation off the two cut ends and fasten the ends under the screws of the electric lamp socket and screw in the bulb. Plug the cord into the wall outlet and the radio into the cube tap. Turn on the radio. If the bulb glows dimly the radio may be okay, and it will be safe to plug it directly into the wall outlet. If the lamp lights to full brightness you probably have a short in the radio. If the line cord is okay, there is probably a short in the transformer or filter capacitors. Take it to your nearest old-time radio repairman for an expert's opinion. Unless you are an experienced radio troubleshooter don't try to work on the set yourself.

This Atwater Kent cathedral radio needs cabinet work, matching knobs, several tubes, and the chassis is in bad shape. It looks like there was a component on fire there.

If the lamp bulb lit dimly plug the radio line cord into the wall outlet. Turn on the set and look at the tubes to see if the filaments are lighted. Any tube that does not light must be replaced. A metal tube will show no light, so wait several minutes and feel it; it should be warm or hot. You will not be able to take the tubes to to your parts distributor to test because their tube tester will not have your tubes listed. So you will have to consult your old-time radio repairman. If you need new tubes, write to the tube sellers listed at the end of



This was a 2-tube radio before someone removed the tubes and sockets. The Kodel radio was purchased at an auction. Of course, it would be necessary to replace the sockets and tubes before the set would play.

this article.

If you're serious about old radios you should buy an inexpensive voltohmeter (VOM) from Radio Shack. They go for as little as $10.00. This meter will enable you to check tube filaments, line cords, pilot light bulbs, speakers, and headphones.

Good Wood

In order to get a good price for your radio it must look good as well as play. Look the cabinet over carefully. Is the wood veneer coming loose? Is any of the veneer missing? The table gives the names and addresses of mail order sellers of wood veneers, finishing materials, and other supplies necessary for repairing cabinets. Are there deep cuts, scratches, gouged places, etc? Perhaps the cabinet needs to be stripped and refinished. Is the grille cloth clean and in good condition? Can the numbers on the dial be read, or have they been rubbed off? Nothing will remove the dirt and grime accumulated over the years like soap and warm water. Be sparing though, with water on wood veneered cabinets because too much water will loosen the old glue.

First re-glue any loose veneer and replace missing pieces with new veneer. Select matching wood for patching. If you do a careful job the patch will go unnoticed by most buyers. Carefully sand and fill the wood with wood filler after the glue is dry. Use a small camel hair brush and the proper colored stain to color-match the patch to the rest of the cabinet. Scratches, nicks, and cuts may be filled with stick shellac. See table for sources. A good coat of paste wax followed by rubbing with a soft cloth will do wonders for an aging cabinet.

You will note that we have not mentioned stripping and refinishing the cabinet. We believe that cabinets should be stripped and refinished only as a last resort. The expense and hard work just won't be repaid when selling most radios. One exception would be if you had a Scott or Silver-Marshall radio. Most radios you will buy and sell will not bring more than $125 to $200, so refinishing them just wouldn't pay. You can do wonders to most cabinets with the suggestions given above.

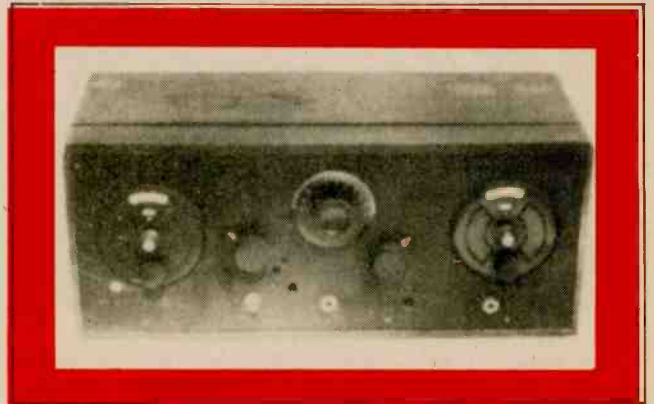
Grille Cloth

Once the cabinet is spick and span take a look at the grille cloth. Is it torn, does it sag, is it dirty or soiled? The replacement grille cloth must have an open weave to let the sound come through. Synthetic fabrics like nylon, dacron, etc. just won't do. Monk's cloth, drapery material, and upholstery cloth are best. Visit a fabric shop in a shopping center, or a Wards, Sears, or Penneys store. As a last resort consult the mail order catalogs.

The best grille cloth adhesive I've found is white shellac. Remove the speaker mounting board and the speaker. Remove the old grille cloth and sand the board to remove glue and remnants of the old cloth. Apply a coat of white shellac and let it dry completely. This will seal the wood. Now brush on another coat of shellac. Let it dry until it is tacky to the touch. *Do not* put grille cloth over wet shellac as it will soak through and make a dark spot. When the shellac is tacky carefully place and stretch the grille cloth over the speaker opening. Press it down and let it dry. Remount the board and/or the speaker back in the cabinet.

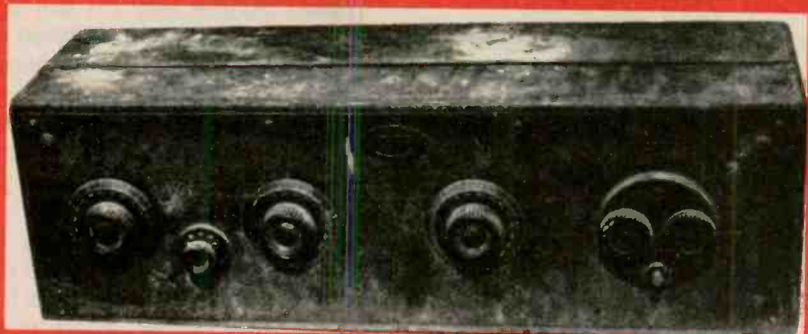
Finishing Touches

You are almost finished and are ready to sell your radio. How are the knobs and dials? The older radios



It is very obvious that this is a homemade radio that was originally something else. To restore this radio you would need a new front panel, and you would have to refinish the cabinet.

will have engraved and white-filled numbered and lettered knobs and dials. Carefully wash them with warm water and soap, and use an old toothbrush to remove dirt and grime from the printing. If the white filling is in bad shape use a sharp tool to remove all the white filling. Now fill in the recessed lettering with a white lacquer stick. See the table for a source for the lacquer stick. How about the plastic dial scale with the frequencies printed there? Either the printing may be gone or you may wash it off while cleaning the dial. To do a complete restoration you will have to reletter the



This is an Atwater Kent Model 20. It too came from a landfill and needs just about everything: It has no tubes, it's dirty inside, and the cabinet and front panel both need refinishing. Fortunately it didn't cost much!

dial either freehand or by using press-on letters. Spray the dial with a clear spray that won't attack the plastic.

Now your radio looks like new, or maybe even better than new. If you haven't fallen in love with the radio and decided to keep it, you are now ready to sell it and make some of that money I told you about at the beginning of this story.

This Radiola Model 17 was not in terribly good condition when purchased at an auction. The dial needed repairing and the tubes needed to be replaced. It is an early AC model.

How to Sell a Radio

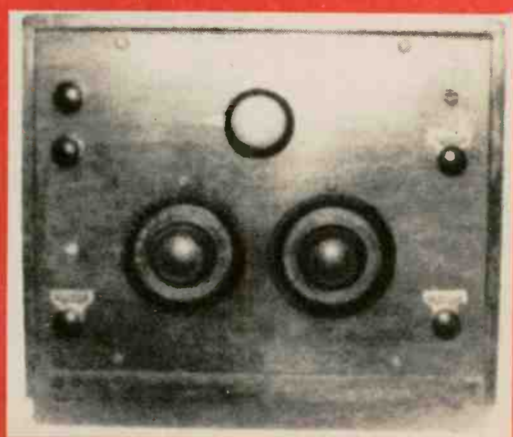
Now I'll tell you how to find a buyer for those radios you have just restored. There are many ways to atract attention to your radios. The obvious ways we will mention, but not explain, because we talked about them when we told you where to find radios. These ways are: garage or tag sales, flea markets, antique shows and sales, and newspaper advertising.

If you can find an empty store window in a cigar store, laundromat, beauty shop, dry cleaner or similar store the owner will probably let you put radios and speakers in the window with prices. If you keep the windows washed and the window area clean he many not charge you a cent for using the window. Be sure to include your telephone number so buyers may call you.

In many parts of the country there are Shoppers Guides, and publications that are full of *For Sale* advertisements. One I know of has 32 pages each week solidly filled with items for sale. This publication will advertise your merchandise for four weeks at no charge. If you sell the item advertised you pay a commission of $2.50 and up depending on the selling price and the paper's policy. I have sold several items this way.

On the west coast there are open air "swap meets" every weekend. Here the sellers sell from their car, truck, or station wagon. Sellers are usually admitted free while buyers pay fees of 50 cents and up to get in. I have heard that thousands attend swap meets every weekend.

There are also bulletin boards in many places where you may put *For Sale* notices at no charge. I have seen them in barber shops, drug stores, supermarkets, grain elevators, and factories. Here again you can reach many people at no cost to you.



This fine example of a one-tube homemade radio might be found at an auction or a flea market. The unit was assembled from mail-ordered parts in the early 1920s.

Perhaps the most profitable market of all is an interior decorator. This surprises you, doesn't it? You are about to ask, "What do interior decorators want with antique radios?"

If you read the expensive women's magazines or Sunday newspaper supplements you may have noticed antique or old radios in the rooms pictured. As you know, nostalgia is a marketable commodity. Everyone remembers the good old days. Older citizens remember that their parents had certain kinds of radios that the whole family would gather around every evening to listen to. The young people remember visiting grandfather and grandmother and seeing an old radio in their homes. Many people are looking for the old radios they remember so well. Other people are building bars in their basements or recreation rooms. I have heard of one man who has purchased two cathedral radios because they fit in with the decor of his room. Previously we covered the places medium-income people might buy your reconditioned radios; we must now try to reach the more affluent people.

These people rely on the advice given them by interior decorators. In addition most decorators have contracts with all the suppliers they work with that pay them a commission on their purchases for clients. You many have to pay an interior decorator a fee for each radio he sells for you. Your profit will be so much greater selling this way that you won't really lose anything.

Well, I must bring this story to an end. I have told you of the profits to be made dealing in old radios, I have told you where and how to buy radios, how and where to buy parts needed for the radios, and finally how and where to sell them. Properly used this information could add $100 to $150 additional to your family's income for each radio. So what are you waiting for? ■

WHERE CAN YOU GET HELP?

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

CIRCUIT DIAGRAMS AND/OR LITERATURE

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

TUBES AND OTHER PARTS

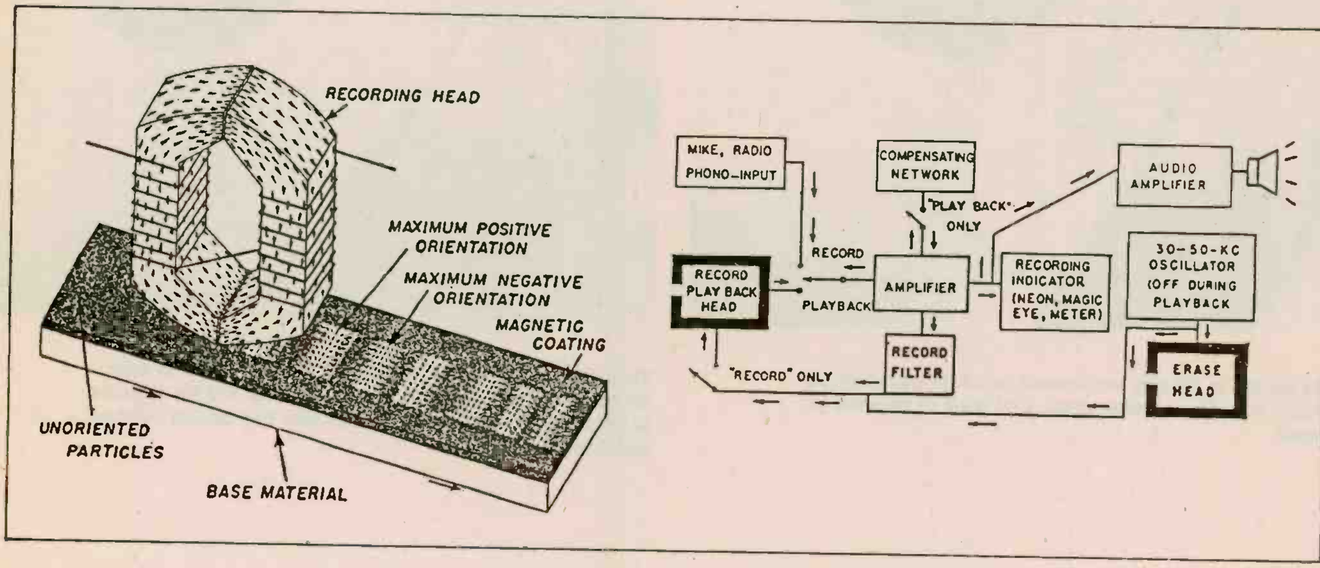
Antique Radio Parts, Box 42, Rossville, IN 46065
Antique Radio Tube Company, 1725 University St., Tempe, AR 85281
Barry Electronics, 512 Broadway, New York, NY 10013
Maurer Television, 29 South Fourth St., Lebanon , PA 17042
Steinmetz ELectronics, 7519 Maplewood Ave., Hammond, IN 46324
Richardson Electronics,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

SPEAKERS AND/OR TRANSFORMERS

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

THE PRINCIPLES OF RECORDING

How Magnetic Recording Works



Have your ever wondered how sound signals, video and other information (we usually call it data) are recorded? How does the sound, or video or data get onto the tape or disk, and how does it stay there? It's really a fairly simple process, although making recordings into high fidelity takes careful engineering and execution.

In the early Fifties sound recording had progressed from using tiny steel wires to using flat paper tapes with iron oxide coated on it in a thin film. It was easy to record on the tape (oxide) and it could be erased (by recording right over the old recording) or it could be kept indefinitely. In fact, I have a reel of paper tape made in 1952 on paper tape and I can still hear the speech and music on it.

Just Like a Magnet

If you take a permanent magnet and put a small iron nail or a sewing needle on it, it will itself become magnetized. You also know that an *electro-magnet* can be made by winding coils of wire around a piece of iron and then passing direct current though the coil. That's exactly what's done in recording onto tape (and disks). The iron oxide coated on the tape or disk is passed under the recording head (soft iron laminations with tiny coils(s) of wire around the core (laminations). Now signals (sound or video) are amplified to make strong recording signals—electrical signals—which are passed through the recording head (coil).

The strong recording current(s) in the recording head coil magnetize the iron oxide on the tape as the tape (or disk) goes past the recording head. The iron (oxide) is magnetized in accordance with the recording currents. The recorded signals are now on the tape or disk.

Playing Signals Back

Passing the recorded tape or disk (at the same speed as the recording) back past the recording head later, the recorded signals in the tape or disk oxide induce small electrical signals in the coil of wire of the recording head. These small signals are now amplified electronically and then converted back into sound or video, then fed to a loudspeaker or a video tube (Cathode Ray Tube).

Iron oxide was the magnetic medium used in the first sound recording tapes. Since then cobalt and other materials have been developed to make higher fidelity recordings. The art of engineering recording heads and other devices for improving the fidelity of sound recordings has been carried on. Video and data recordings are made with high precision video heads which whirl rapidly past the video tape. Disk recordings on magnetic disks 8-inches in diameter and smaller (in microcomputers) use the same principles as sound recorders of the Fifties. Only the details have changed. ■

This photo a poorly soldered joint. It can break almost any time, whenever the wire is moved or flexed.

This picture shows a good soldered joint. It has enough solder to hold securely and make a good electrical connection. It has not too much solder, not too little.

THE SOLDERING TECHNIQUE

by James Dunnigan

One of the most important skills every electronics technician and experimenter must have is a solid knowledge of basic soldering.

This requires (a) the right tools (easy), and (b) understanding of simple heat-transfer.

The most important thing to understand in learning to solder well is the process of *Heat Transfer:* melting the solder, and cooling down the solder joints (parts).

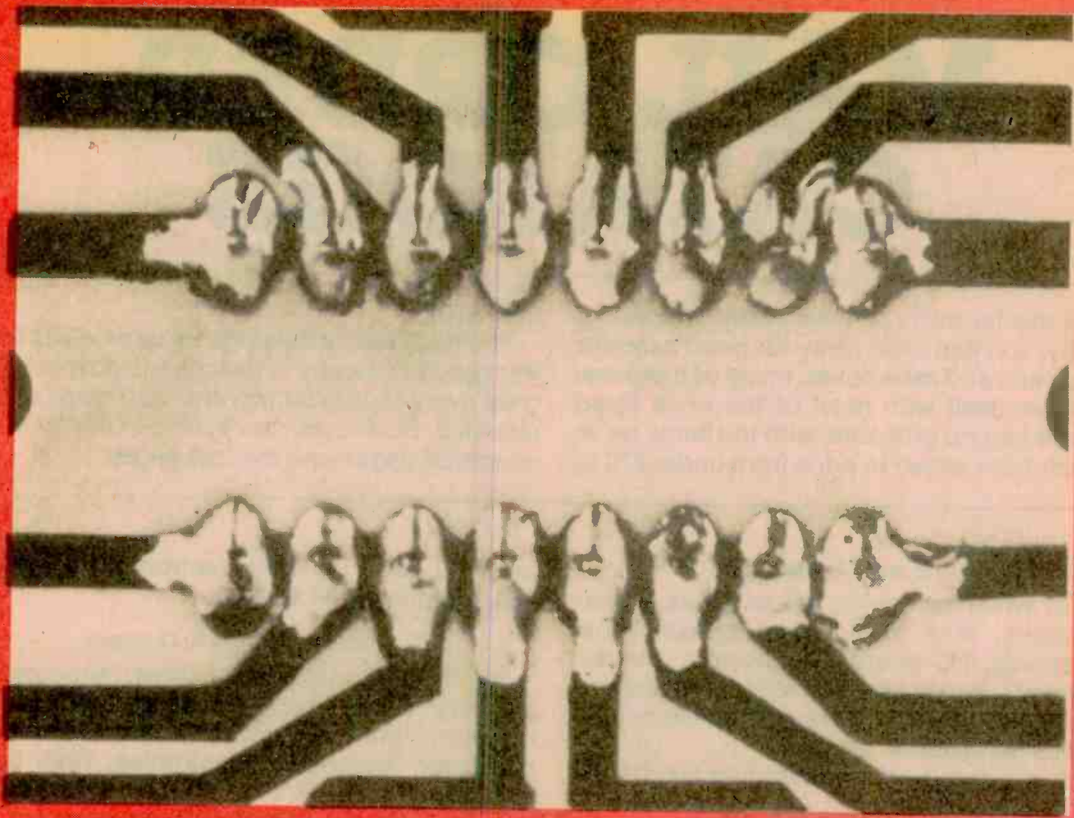
Heat Transfer

Soldering is the process of using heat to *melt* solder which is connected only to itself (a thin wire-like shape) so it can then *flow* onto the meeting of two (or more) wires or wire leads of small parts. Once that's done the solder cools and makes a very tight, solid, permanent connection between the two (or more) parts.

To melt the solder easily you must have a very good heat-transfering connection between the wires and the solder. Once a tiny bit of solder melts it conducts the heat from the parts *to more solder.* After some solder is melted *that solder* transfers *more heat* to the wires where they've been pressed (or twisted) together.

The moment some solder is deposited around the two wires, you can take the iron away. The solder now rapidly cools and solidifies, leaving a solid, permanent connection.

This describes what happens in melting and cooling solder to connect two (or more) wires and/or parts. The following seven steps describe exactly what you must do in soldering, step-by-step.



ICs have their terminals very close to each other, hence great care must be taken not to let the solder from one leak over to another. It takes a bit of practice to solder such closely-spaced terminals.

(a) Use a small iron (called a soldering *pencil.* Best size is 25 to 35-watt (40-watt maximum) for most work. Most pencils have replaceable tips.

(b) if the iron is new, its *tip* must be *tinned;* that is, cleaned and covered with a small amount of solder.

(c) Rosin must be used, unless the solder has a core of rosin. It's labeled if it has rosin in the core. Rosin cleans the surfaces, making the solder flow easily. Soldering without rosin is difficult.

(d) The wires (or parts) must be very clean. If paint or grease or oxidation is on any part to be soldered it must be cleaned off with sandpaper, steel wool, or a file, then further prepared with a small amount of rosin. If you're not using rosin-core solder, the rosin is available separately in small cans.

(e) Heat the connection with the tinned iron, then press the solder onto the heated connection to make it melt. *Don't heat the solder* itself. The iron already has a small bit of melted solder on it. If not, go back to step (b), above.

(f) Let the solder *flow into and around* the wires (parts) as it melts. Use as *little solder as you can,* provided you get some into most crevices or parts very near another wire or part. *Less is better.* You can always go back and put more on, but taking solder off is much harder (it's called DEsoldering).

(g) Clean off the tip of the iron if it's got any excess solder left on it after the connection has been made. Keep an old rag nearby for this purpose.

Finer Points

To prepare wires and small parts for soldering, twist the wires together *just enough* to hold them in place until you can apply the solder. Don't twist two three turns together. If you do, you'll have lots of trouble if you have to separate them. Even a full turn is too much. Twist together the least amount that'll keep 'em in place temporarily.

Avoid Overheating

Be especially careful soldering heat-sensitive parts, particularly small diodes or transistors, which are prone to fail if they get too much heat. You can protect transistors and diodes during soldering by holding the wire(s) being soldered with long-noise pliers. This conducts most of the heat to the pliers. Hang onto the heated wire for a few seconds after the solder has cooled, just to be sure.

Same thing with integrated circuits. Better still, don't solder IC leads at all; instead, solder IC sockets and transistor sockets in place. After their leads cool down the transistor or IC is just plugged in. There's no way you can overheat a transistor or IC if you always use a socket.

The most important thing is to practice, Practice, PRACTICE, if soldering is new to you. A half-an hour's practice with some solder, your soldering pencil, some wire and old parts will make you an experienced solderer! Just PRACTICE! ■

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 electronic 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.

Surplus Parts and Assemblies

40 pages of switches, cables, relays, filters, power supplies, lenses, lens assemblies, blower fans, motors, solenoids, PC boards, connectors, diodes, rectifiers (power), transistors, capacitors, cables and wire, microphones (complete, as well as elements), and UHF/BNC connectors.

Many items are surplus sub-assemblies taken from military and commercial devices. A typical example; A CB Radio (no case) made by Panasonic for Chrysler, working OK including schematic. Power supplies at 1/3 to 1/5 regular commercial (new) prices. Copying and TV camera lenses from $4.50 to $39.00. Electric motors and pumps at all prices. A five-inch rectangular (green) cathode-ray tube (new surplus from Osborne Computer) $15.00. All kinds of capacitors from 10 for $1.25 up. Plenty of other stuff, if you know what you need, a real bonanza.

Marlin P. Jones Co., Box 12685, Lake Park, FL 33403.

Audio Video, Computer, Mechanical

71 pages include video monitors (no cases on some) from $20 up; CCTV cameras and systems; all sorts of loudspeaker drivers and kits (many from well known high fidelity makers); battery chargers (complete) for $12,88; all kinds of security alarm systems and parts, telephone accessories (prices like Radio Shack and lower); cable parts and components (many super bargains); computer disc drives and computer cables, many ¼ or less than comparable prices elsewhere; optical parts and lenses (a huge Bausch & Lomb copy lens for $6.33); tiny motors for robotics; various magnets from 10 for a dollar up; robot kits and parts.

Hi Tek Sales, 119 Foster Street, Peabody, MA 01961.

Similar stuff; different catalog, with lots of different items from another firm with the same address as Hi Tek Sales, **BNF Enterprises** (address above). And a similar company (again), with some different items, (but with lots of duplication) from another company whose catalog is clo e to BNF's in appearance and contents. Another interesting item; a word processing IBM Selectric Typewriter (as is) for $99.95, plus shipping $10; laser tubes from $80 up, power supplies for same, $50 & up, from **Electronic Supermarket, Box 988, Lynnfield, MA 01940.**

For TI 99/4A Owners

24 pages of printers, disc drives, expansion boxes, memory cards, monitors and software for the marvelous but discontinued Texas Instrument home computer. **Unisource Electronics, 7006 University, Lubbock, TX 79464. Free phone 1-800-858-4580.**

More 99/4A Stuff

Similar to above, but much more software, with hardware. **Triton Products, Box 8123 San Francisco, CA 94128 Free phone 1-800-227-6900.**

Surplus Computer Printers, Monitors, Etc.

This outfit doesn't have a big catalog, but they send out flyers often with a few dozens super buys on high-quality printers, disc drives, printers and IBM Selectric-derived printers plus other incredible bargains for people who are hardware-knowledgeable.

I bought an early (1979-80 vintage) word-processing system from them five years ago for $700. I could never get it working (it used cassettes) but I got an IBM Selectric typewriter with it which would have cost me $475 to $550 at that time (used). Trying to get that system working taught me plenty about microcomputers and word-processing systems.

Most items they sell are used; either "as is" and so stated, or "tested", guaranteed operational. Some are brand new in makers' cartons. Most have schematics; if not, that's stated. Prices range from $150 for Epson printers (list $350 and up) and $130 for IBM Selectrics (used, power supply; schematic supplied). Many other items. Minimum order $50, shipping & handling additional, credit cards OK. Get on their mailing list! **CPU, Inc (Computers, & Peripherals Unlimited, Box 204, Newton, NH 03858. 617-372-8637.**

Heath Kits and other Great Stuff

104 pagers 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 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 if 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**

Radio Shack (Everything but Computers)

You can get a free 180-page catalog from your local Radio Shack store (more than 8000) if they have one, though they usually give 'em all out within a few weeks after they're printed (August). However, if you buy anything your name is taken by the clerk and you get one automatically in the mail once a year.

RS really is a supermarket of electronics, stereo, video, satellite stuff, and plenty more. Always good values, and since the demise of most parts distributors as well as the big catalog houses, (who sell mostly only to local TV repair people and technicians) almost the only easy place you can readily find most parts.

For stuff RS doesn't have, you can try your local electronic parts distributor, but you'll have to know more than most average customers. If you're a bit knowledgeable, you can often get terrific buys from the mail-order companies listed above. If your store is "sold out" write to **Marketing Dept.,Tandy Radio Shack, One Tandy Center, Ft. Worth, TX 76102.**

Radio Shack (Computers too)

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 tubers 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 that 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, or many other superior machines, Computer Centers and other Radio Shack stores usually have catalogs in stock. Otherwise, write to **Radio Shack address above.**

What Is It? Miscellaneous

This firm (See below) sent us a 24-page catalog of (unusual) great buys. For example, they offer a Vending Machine Slug Rejector and associated switch assembly which accepts nickels, quarters, dimes, and even Susan B. Anthony dollar coins, but rejects all others, including all slugs. The switch assembly tells your system what's been inserted (of the four acceptable coins). Both for $17.00.

Another juicy item: a three-chip (100-watts-per-channel Sanyo power amplifier kit (you supply the power supply) for $19.00!

Lots of other power supplies, special transistor buys, switches, cables (I found my multi-wire rotator cable here; 9 wires, 100 feet for under $40), all kinds of motors and switches and transformers. An experimenter's paradise! **R & D Electronics, 1202H Pine Island Road, Cape Coral, FL 33909.**

Electronic Parts, Including Breadboards, Connectors, ICs, Transistors, Switches, Transformers, Meters, Opto-couplers, Wire-Wrap Stuff, and More.

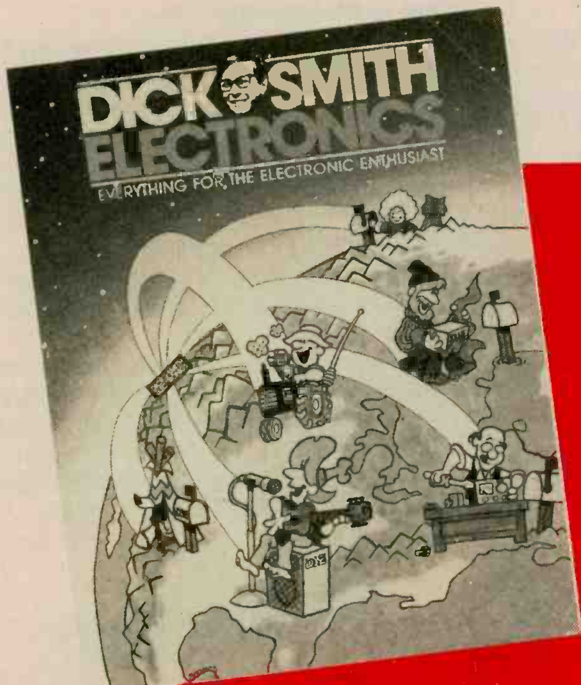
Usually 75 pages, from a mail-order distributor for parts from major manufacturers, with a direct free (800) telephone line. Mostly for the serious amateur and technician, with a wealth of really useful components.

Circuit Specialists, Inc. Box 3047, Scottsdale, AZ 85257 or call toll-free 1-800-528-1417.

Ditto, but different. Get 'em both, this one is from: **DC Electronics, Box 3203, Scottsdale, AZ 85257, or call toll free 1-800-423-0070.**

Everything for the Electronic Enthusiast

We're quoting their motto. This is a slick looking, big (almost 150 pages) catalog. It leads off with low-cost satellite receivers (starting at $99) and goes up through better systems at $500 to $1500; also dozens of satellite system components. Plenty of kits for ham transmitters and transceivers ($160 & up); antennas, CB sets, lots of communications receivers, antennas and scanners; kits for a wide variety of test instruments from $15 up, alarms, test gear (assembled), jacks, cables, radar, sets, a real bonanza for the enthusiast.

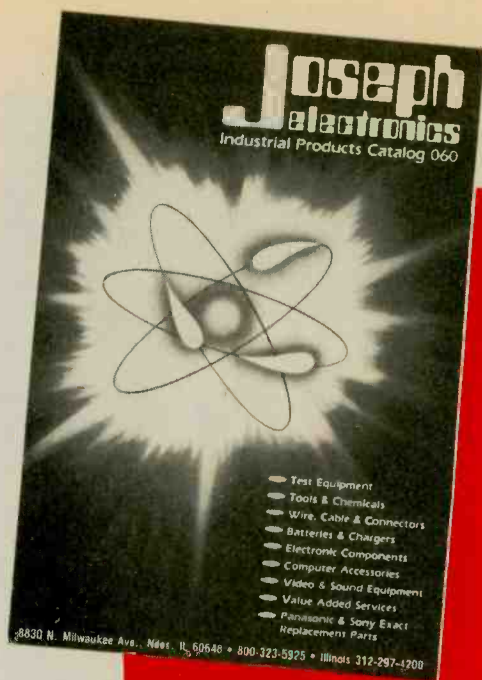


Write Dick Smith Electronics, Box 8021, Redwood City, CA 94063, or call toll-free 1-800-332-5373.

Closeouts, Specials, Lots of ads from smaller dealers, and specialists.

This catalog is issued several times a year and lists a great variety of unusual items including untested IBM-compatible disk drives for $23 (tested, $46), satellite and descrambler specials, plus listings of Ham fests, computerfests, and so on in local areas.

Nuts and Volts, 100 E. Orangethorpe Ave. Anaheaim, CA 92801, or telephone 714-773-0240.



Joseph Electronics, An Encyclopedia

This massive Industrial Products Catalog is 480 pages comprising an encyclopedia of electronics equipment and components.

Intended primarily for professional technicians, engineers and purchasing agents of manufacturers, it could be the second most valuable catalog in most experimenters' hands, after Radio Shack's current catalog. It includes a big section (over 120 pages) on test equipment; Wire, cable and connectors (127 pages on Belden's wire and cables alone!); Batteries and chargers (almost 20 pages); Video and PA (public address) equipment; Computer accessories; and expensive listings of Sony and Panasonic exact replacement parts.

Many manufacturers' resistors, capacitors and other components not readily locatable from most dealers are listed in profusion and in exhaustive detail, all indexed, both by manufacturer and by category, in four pages. **Joseph Electronics, 8830 North Milwaukee Ave., Niles, IL 60648. Or call Toll-free 1-800-323-5952. Credit cards accepted.**

Printers, Monitors, Closeout Computers.

Issued in tabloid newspaper format several times a year, and includes private-label, IBM-compatible micros from under $1000 including monitor & 2 drives. Kaypros, IBMs (the real thing at excellent discounts), Epsons and Toshibas. Examples: Canon portable printer for IBM-compatible, $98! Apple IIc disk drives, $120. Plotters, mouse systems very inexpensive.

Jade Computer, 4901 Rosencrans, Ave., Hawthorne, CA 90251. Toll-free 1-800-421-5500.

Everything in Car Stereo

More than a hundred pages of car stereo gear, all new, with telephones and home stereo stuff thrown in. Prices are about what you'd pay at a local discount store, if you had one nearby. They include installation kits to customize your dashboard installation, as well as toll-free telephone customer support for installation advice. This catalog includes good tips on installing car speakers as well as dashboard installations. They also have a list of several hundred car installation specialists all over the US which you can consult for your area. Very good if you live away from metro centers.

Crutchfield Car Stereo, 1 Crutchfield Park, Charlottesville, VA 22906. Toll-free call 1-800-344-9955.

Surplus Components

This 48-page catalog is packed with capacitors, ICs, fasteners, indicator lights, jacks, cables, plugs, and everything electronic you can imagine. Prices are very good, and the experimenter who knows what he wants will find almost everything he might need. An example is the transformers page. It lists all sizes from a tiny 6-VAC, .250 A one at $1.25 per, up to a 2000 (yes, Virginia, two thousand watts) 120/220 step down (or up) job for only $90. (or a 100-watter for $15.50).

Nicads, charging kits, battery holders, knobs, fans, power supplies of all kinds, relays, hundreds of connectors and adapters.

ALL Electronics Corp., 905 S. Vermont Ave., Box 20406, Los Angeles, CA 90006 Toll free 1-800-826-5432.

Mouser Has It All

Purchasing Manual for Almost All Components. If your local Radio Shack doesn't have what you want, Mouser Electronics, whose 175-plus page catalog is free, probably does.

No funny surplus (but plenty of surplus prices) paired with almost every possible component, be it resistors (including precision types and all wattages) or capacitors, transformers or anything else not locally available. A terrific bonus is their listing of technical catalogs from manufacturers of most of the components listed, (catalogs cost from 50 cents up to a couple of dollars). A real bonanza which should be on the bench of every experimenter and hobbyist.

Mouser Electronics, Box 9003, Lakeside CA 92040, or call 'em at 619-449-2222.

Digi-Key In a Class by Itself

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.

Digi-Key Corporation, Box 677, Thief River Falls, MN 56701, or call Toll-free 1-800-DIGI-KEY.

SATELLITE TELEVISION

These broadcasters now require people who want to watch their programs transmitted via satellite to pay a monthly fee (usually $7.00 to $14.00) as well as to buy a *descrambler* costing about $300. Thus, before investing a thousand or so dollars in a satellite system you may want to resolve questions about the possibility of more channels going to scrambled transmission.

Who's Scrambling?

In January 1986 two major systems (HBO—Home Box Office—and Cinemax) which broadcast signals via satellites, began scrambling the signals they send to cable operators all over the US. This immediately upset private satellite system operators, who had been picking up these signals free. Later (in March) two or more systems, Showtime and Movie Channel, announced scrambling. Since these companies all broadcast to cable operators who paid for their programs, nobody should have been surprised.

In fact, many TVRO viewers have already bought descramblers and are paying monthly for the privilege of getting unscrambled signals. Lots of other satellite signals viewers are getting up to 100 non-scrambled signals free, and most will continue to do so.

Showtime and The Movie Channel set their fees at $11.00 monthly, and HBO/Cinema charged $10 and $15 per month, respectively. Some cable operators made arrangements to set private TVRO owners up for descrambling for even less.

Future Is Rosy

Despite talk in Congress of regulation of scrambling, it's unlikely anything much will happen in the next year or two. Several bills have been introduced, but even the gloomiest predictions are that it'll be a long road before anything is enacted into actual law. Meanwhile there are hundred of signals available now, and if you want programs which are being scrambled, or which may be scrambled later, the prices charged will be within the budget of most serious satellite viewers. ■

INSTALL YOUR OWN PHONES

cover protecting four terminal screws. Extension cable wires are run from one junction box to the next, with the individual telephone instrument wires connected to the same colored wires and each room. Electricians call this *parallel* wiring.

To connect five or more instruments, consult a dealer who sells telephones and then talk to your local phone company also. If you don't do this, some or all your instruments may fail to ring properly.

For running extension wires from one room to another, between new jack boxes, it's best to use special rounded staples. Ordinary flat staples such as are used for stapling papers together won't be secure. The proper staples are quarter-inch round ones, made just for securing wires to wood. Arrow model T25 or its equivalent is what you need.

DELUXE BURGLAR ALARM

that the armature is moved closer to the relay coil. Bend the contacts no more than a few millimeters. Now check to see if the relay will pull in at 10 volts. If not, repeat the adjustment until it does. The necessary 10 volts can be obtained from an adjustable power supply or seven 1.5-V D-cells in series. (The 10-volt potential is typical of an aging backup battery.) You will find that only a slight adjustment of the relay is really needed. Note that if your application is such that battery backup is not required, there is no need to adjust the relay's sensitivity at all.

The typical 12-volt alarm bell draws about half an amp. One bell will suffice in most instances, but if your home is large, you can use two bells in parallel and mount them on opposite sides of the house. Under load the voltage at point 1 drops to about 13.5 volts, which is perfectly acceptable to a 12-volt bell.

When construction is complete, it is time to test the circuit. Before doing so, however, strap each of the loop inputs to ground with a jumper wire, and connect a 14-volt pilot light (#52) to the terminals that normally drive the alarm bell. Turn the alarm on and measure the potential across C1. It should be about 18 volts. Pressing S3 should cause LED1-LED4 to light up, and pressing S4 should cause the relay to pull in and turn on the pilot light.

Now, turn the unit off and connect your voltmeter across zener diode D9. Turn the alarm back on and observe how much time elapses before your voltmeter reading begins to rise. You should experience a time delay on the order of one minute; the prototype exhibits a delay of 1 minute and 15 seconds. Turn the alarm off for at least one second (giving C1 and C2 time to discharge); then turn it back on and repeat the measurement. Record the startup delay time for your own reference.

You should now check the response of the immediate-action inputs (B, 1, and 2). Turn the alarm on, and disconnect the jumper wire from loop input 2; then refasten it. Nothing should happen. Wait about a minute until the circuit becomes fully armed. Now when you remove the jumper wire from input 2 and refasten it, intrusion indicator LED5 should light up, as should the pilot lamp. Observe how long the pilot lamp remains lit and record the result (about 2 minutes). Check inputs B and 1 in a similar manner.

To check the DE input, proceed as described above. Note, however, that there will be a delay between the breaking of the DE loop and the lighting of the pilot lamp. Trip the DE input with R27 set first to one extreme, and then the other, and record the delay between tripping and the illumination of the pilot lamp. A range of 5-15 seconds is typical.

Installing the alarm is a relatively straightforward task, the hardest part of which probably consists of running wires through walls and behind baseboards. Even that job is bearable, however, if you think of the peace of mind your new alarm will bring. Next summer when you're vacationing in St. Tropez or St. Paul, you'll rest easier knowing that some stranger is not vacationing in your house. ■

BUILD A 555 IC TESTER

you have one. If you don't a small screwdriver used as a lever in the deep depression in the center of the IC will let you ease it out safely.

It won't burn up, if you've been careful. There aren't very many ways to do this circuit wrong. But just to be on the safe side, double check your wiring before you connect the battery.

Then, with no 555 in the circuit, connect the battery and turn the switch (if you've included it) *on*.

If you've wired everything correctly, both LEDs will light. The most likely cause of a LED not lighting, assuming your wiring is correct, is that it has been plugged into the board backwards.

Now go ahead and plug in a 555. Choose one you know is good. The LEDs should start flashing. Play with the value of C2 to alter the rate.

Using the Tester

Since the solderless breadboard is its own chassis, you're ready to go.

I have yet to find a surplus 555 that isn't in a DIP package, but even those 555s that come in transistor-style TO-5 or TO-99 cases usually follow the same lead arrangement. So identify pin 1, plug your 555 in and turn it on.

If both LEDs come on, your 555 is open. If only one comes on, or if neither comes on, your 555 is either open or shorted. If there are no visible solder bridges between pins and no pins are missing, the open or short must be internal. Perhaps you could use a 555 that tests bad as an ornament; you sure can't use it for electronics.

A good 555 will always flash both LEDs. It's that simple.

Your handy tester even provides a bonus. With a good 555 in place, you can use the pin 3 output as a clock pulse to drive TTL circuitry. You can use the pulse directly, but a small resistor or capacitor will help keep things safe. Remember to use pin 1 for *ground*.

By the way, it probably took you longer just to read this article than it will take you to build your tester. ■

"BET YOU WEREN'T EXPECTING TO SEE A SCHEMATIC CENTER-FOLD OF THE MARK 12 AMPLIFIER."