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All about the bounces and the skips

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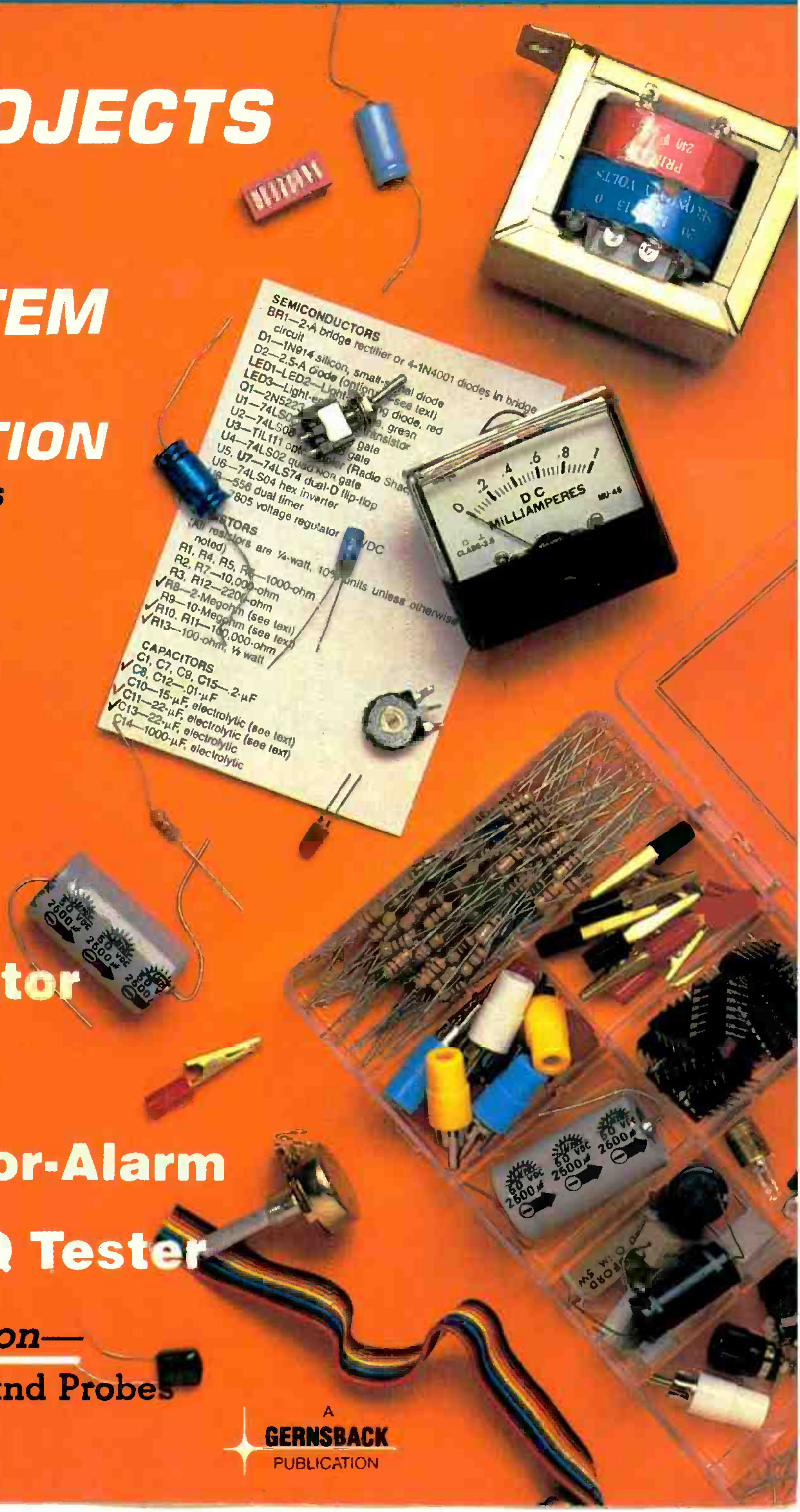

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Hands-on Electronics
Volume 2, No. 6 November/December 1985

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PROJECTS YOU CAN BUILD

SPECIAL COLUMNS

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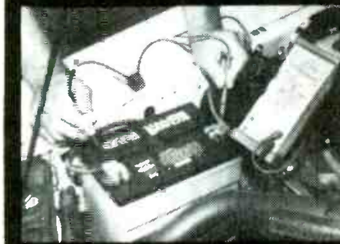

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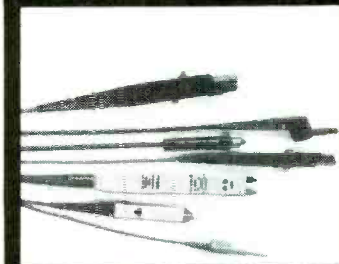

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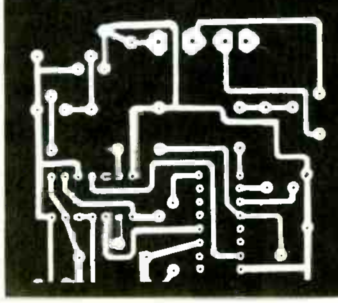

Hands-on Electronics
The Magazine for the Electronics Activist!

EDITORIAL PAGE

#6
NOVEMBER/
DECEMBER 1985

The Editor Unwinds

Here we are again, and one month sooner! Our new bi-monthly schedule has played havoc with the staff, but we adjusted quickly. This issue of **Hands-on Electronics** is chock full of projects, theory, and informative articles that you, our readers, have asked for.

Some time ago we ran an article on a Jacob's Ladder project. The mail came back asking for a Van de Graaff generator. *You got it!* It took a little doing, but we found an author who put one together. That's our job. Also, some readers have become first-time authors by submitting projects for publication. In case you didn't know, all of our articles (except this editorial) are purchased from readers like you. If you are the project-building type, the home experimenter, or appliance fixer-upper, maybe you should be writing for **Hands-on Electronics.**

A reader wrote telling us of a $1500 repair bill on his car that included a computer module and a battery cable. While driving home a poorer man, he thought that the battery cable may have been the trouble all along. Since the cable-repair cost was under $50, he rationalized that had he fixed the cable himself, he might have saved over $1450.

We are inclined to agree with that reader. In this issue we have included an article on how to troubleshoot your car's electrical system by using a digital multimeter. No, we don't tell you how to fix *every* fault, but we do tell you how to detect those common faults that you can fix quickly and keep your family buggy out of the grasp of the auto mechanic.

There's much, much more between the covers, so please read on, and write us if you have a mind to!

Julian Martin

Julian S. Martin, KA2GUN
Editor

Composition and interior design by Mates Graphics

Cover photography by Robert Lewis

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Gernsback Publications, Inc.
200 Park Ave. S., New York, NY 10003
212-777-6400
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NATIONAL ADVERTISING SALES

Joe Shere
1507 Bonnie Doone Terrace
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Hands-on Electronics, (ISSN 0743-2968) Published quarterly by Gernsback Publications, Inc., 200 Park Avenue South, New York, NY 10003. Second-Class postage pending at New York, NY and at additional mailing offices. One-year, six issues, subscription rate U.S.A. and possessions $14.00, Canada $17.00, all other countries $21.00. Subscription orders payable in U.S. funds only, international postal money order or check drawn on a U.S.A. bank. U.S. single copy price $2.50.

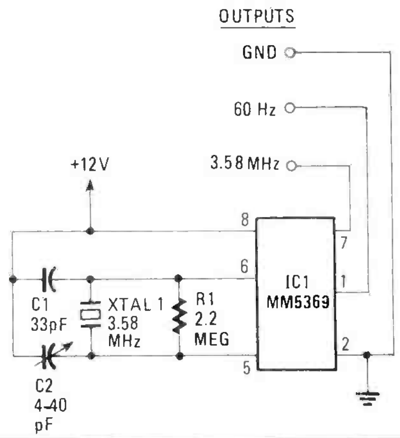
Postmaster: Please send address changes to **Hands-On Electronics**, Subscription Dept., P.O. Box 338, Mount Morris, IL 61054.

LETTER BOX

60Hz Clock Pulses

I need a schematic diagram for a 60-Hz clock pulse for a project I'm working on. Can you help?
R.F., Highpoint, NC

You didn't give us a whole lot to go on, but we found something that should help. The circuit in the drawing will provide a clean, stable squarewave and it's the kind of thing you find in auto dashboard clocks. This one calls for a 12-volt supply, but it will operate on anywhere from 6 to 15 volts. You'll find that the IC and color-burst crystal are the kind used in TV receivers. Both are relatively easy to locate and are inexpensive. Parts and parts placement aren't critical either. As a bonus, you get a 3.58-MHz output that makes a handy marker signal for shortwave bands. Hope that this helps.



Finding Parts

In building many electronics projects, it's often hard to find the exact part specified by the Parts List. Because of that, many of the most interesting projects go untried. What I'd like to know is if there is another source that can be relied upon for direct replacements, so that modification to the circuit board or component substitution is unnecessary? And if so, how can I get in contact with that source or its authorized representative?
J.C., Ridgway, IL

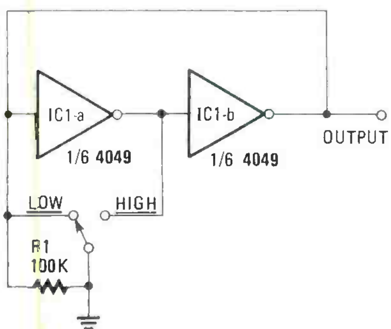
First, when building any electronics project, check the Parts List for for a supplier of kits and parts. If there is no supplier listed or the supplier does not offer specific components separately from the kits, I usually head for the mail-order parts catalogs (which can be had, in most cases, by simply filling out a Free Information Card in this and other electronics publications). I try to get catalogs from all the suppliers that I can, so that if I have to find a special anything, I can always go directly to those publications and find exactly what I want. Usually, after thumbing through two or three of them, I can find the specified part at a reasonable price.

Failing that, I turn to either RCA's SK or Philips/Sylvania's ECG replacement guides. Those manuals list thousands of pin for pin replacements along with some of their most important param-

eters. And finally, if all else fails, I go the the IC Master, which has a substitution guide in the back pages. Perhaps now you can build some of those untried projects.

Debouncing De Bounce

Okay, it seems that the last circuit I built is a bit too sensitive. When I operate the control switch, the LED's flicker on and off, and it's just about anybody's guess as to whether the thing will be in the operate or non-operate mode. My question is, how do I go about de-sensitizing that circuit?
A.G., Clawson, MI



The trouble is not in your circuit—you've got a common malady called "switch bounce!" To eliminate that problem, try the simple latch shown in the diagram. Throwing switch S1 one way or the other changes the state of the output. Since there's always a time period when no connection is made, resistor R1 keeps the circuit from glitching when the switch is thrown. Even the noisiest SPDT switch can be used, for the resistor acts as a temporary storage device when the switch is being operated.

How Do I Get Started In Electronics

Recently, while visiting a friend, I had the chance to skim through several back issues of your magazine, and I found some of the construction articles to be fascinating. I would like to build several of the circuits presented: but because I know absolutely nothing about the subject and don't know where to begin, I must admit that I'm a bit afraid to try. Is there some book that I can get that will put me on the right track?
C.B., Shamrock, TX

First, you can check with Radio Shack, provided that there's one near you, for a book called (oddly enough) Getting Started in Electronics. Other suppliers of similar publications include the Electronics Book Club (PO Box 10, Blue Ridge Summit, PA). McGraw-Hill Book Club (PO Box 582, Hightstown, New Jersey).

Of course, the easiest way is to read each issues of Hand-On Electronics, since the intention of this magazine is not only to entertain, but to also teach. In addition, you get a chance to pick up some basic electronics principals while you build the project—making the operation of future projects easier to understand.

Are Heat Sinks Really Necessary?

When building the power supply for many electronics projects, I've noticed that it is usually recommended that the three-terminal voltage regulators in those circuits are heat sinked, even though the current drawn by the circuit is nowhere near the operating capacity of the regulator. Why?
R.W., Silver Lake, WI

While it's obvious that is not an absolute must in many cases, heat sinking does provide an extra margin of safety. Instantaneous peaks in the line voltage of sufficient magnitude can destroy the regulator. So for the most trouble-free operation of the circuit, if the author says use a heat sink, use it. It's cheaper and easier than unsoldering and replacing the regulator.

Unstable Astable

I wired up this two-transistor astable multivibrator using a pair of bipolar transistors, and learned that if the supply

(Continued on page 102)

BOOKSHELF

Halley's Comet—A Mysterious Visitor from Outer Space
By Terence Dickinson

Prepare yourself for the arrival of Halley's Comet, a solar-system spectacle that is a once-in-a-lifetime astronomer's treat. Terence Dickinson, one of North America's leading astronomy authorities and science journalists, details the comet's projected swing past the Earth in 1985 and 1986 and the best ways of viewing that once-in-every-76 years event. Using clear, concise layman's terms, Dickinson presents a well-researched history of that most famous of comets, a flying mountain of ice that has decorated the sky dating at least as far back as 240 BC.

Learn what scientists and astronomers from across the United States and Canada expect to see as Halley's Comet makes its latest contact with Earth. Compare those projections to the information gathered when the comet last swung past the Earth in 1910.

The text includes chapters on other notable comets of the past, how to discover a comet yourself, and the curious aspects that a comet presents. It includes charts—so you can track your own experiences

CIRCLE 641
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with Halley's Comet as it passes us—and photographs of the comet's last contact with Earth.

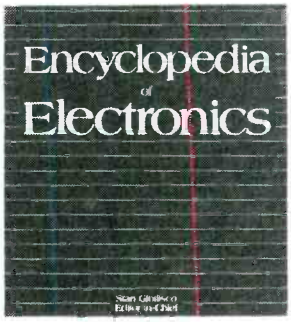
The author, Terence Dickinson, has been a professional science writer for 8 years. His published works include four books and more than 800 articles that have appeared in newspapers and in magazines such as *Omni*, *Popular Mechanics* and *Reader's Digest*. Before turning to full-time freelance writing, he was editor of *Astronomy* magazine. He has also worked as staff astronomer at planetariums in Toronto and Rochester, NY. Fascinated by the stars since childhood, he regularly scans the night sky with several telescopes from his home near the Thousand Islands section of St. Lawrence. Published by Edmund Scientific Co., 101 E. Gloucester Pike, Barrington, NJ 08007. Hard cover, 125 pages, $8.95 plus $2.95 for handling and UPS shipping.

Encyclopedia of Electronics
By Stan Gibilisco, Editor in Chief

This new reference work sets a new standard for excellence in the electronics and communications field. The most complete and comprehensive electronics information source available, this is an essential reference for anyone involved in any aspect of electronics, electricity, or communications for professionals, students, hobbyists, and experimenters!

Over four years in preparation, this text has been meticulously researched, checked and double-checked for accuracy, timeliness, and fullness of detail. Upon completion it was carefully reviewed and approved by a special editorial board composed of 20 distinguished authorities in the electronics field. The result: An encyclopedia of electronics terms and topics that can be depended on to give the most authoritative, accurate, and up-to-date information available anywhere!

Here are more than 3,000 complete articles covering many more thousands of electronics terms and applications. Each article is fully illustrated and



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includes relevant formulas, charts, and tables. Not simply a dictionary of electronics terms, this is the first true *encyclopedia of electronics*! It provides extensive information on each topic—what it is, what it does, how it does it, and, most important, its relationship to other electrical and electronics operations and applications.

Both qualitative and quantitative data has been given in language that is not only simple and easy-to-follow, but also precise and complete. With extensive cross-referencing provided for each entry, it's a simple matter to find exactly the information needed on any topic. Those not sure just which topics will include the specific data being sought, have only to check the front of the *Encyclopedia* for a complete alphabetical listing of all subject categories.

A must-have resource for anyone involved in any area of electronics or communications practice, The *Encyclopedia of Electronics* is the most complete and comprehensive reference available. From basic electronics terms to state-of-the-art digital electronics theory and applications...from microcomputers and laser technology to amateur radio and satellite TV: it's all here!

Stan Gibilisco is an experienced technical writer and editor. An associate engineer and consultant with Electronics Systems, Inc., he is co-author of Tab's *Illustrated Dictionary of Electronics—3rd Edition* as well as bestselling TAB titles as *Black Holes, Quasars and Other Mysteries of the Universe*, and *Understanding Einstein's Theories of Relativity: Man's New Perspective on the Cosmos*.

Published by TAB Professional and Reference Books, Division of TAB Books, Inc., Blue Ridge Summit, PA 17214., Tel: 717/794-2191. The text contains 1024 pages and 1300 illustrations. It's hardbound and sells for $58.00. ■

By Don Jensen

JENSEN ON DX'ING

The Dark Continent is bright with listening spots!

FOR SHORTWAVE LISTENERS, AFRICA offers a wealth of tuning opportunities. Between Cairo and Capetown, and on the islands of the Indian Ocean and the South Atlantic, there are about 50 different countries with shortwave broadcasters. Those stations range from the powerful international broadcasters to the lower-powered domestic stations.

Africa is a continent of contrasts. The lush, leafy umbrella of the equatorial rainforest gives way, north and south, to the thirsty, treeless Sahara and Kalahari deserts. Its people include the nomads of the north and cattle herders of the eastern plains, descendants of pharaohs and European colonizers, brown skins, black, and white.

It is a place of many tongues: Arabic, Afrikaans and Amharic; Swahili; Zhosa and Zulu; the leftovers of the colonial era, French, Portuguese, Spanish, English and the many languages and dialects of West Africa.

And sometime, somewhere on the shortwave dial, you'll hear them all.

Let's focus on the shortwave voices of Africa, where and when to listen.

Starting off with the "A's," there is Angola; *Radio Nacional* in the capital of Luanda can be heard on 9,535 kHz. Programming in Portuguese and English is aired around 2100 Universal Coordinated Time (abbreviated UTC, which is equivalent to the older term, Greenwich Mean Time or GMT).

You might also try for the all-night domestic service at various times from about 0100 to 0400 UTC on around 5,366 kHz. That frequency can wander as much as 30 kHz, though.

Burkina-Faso is the rather strange new name for the West African country formerly called Upper Volta. The *National Radio of Burkina* in Ouagadougou operates on 4,815 kHz, signing on at 0530 UTC.

La Voix de la Revolution—in English,

the Voice of the Revolution—is the National Radio of the Republic of Burundi in East Africa. Its home service from Bujumbura can be heard on the 90-meter band frequency of 3,300 kHz, when conditions and interference permit, about 0330 UTC, in the local language, Kiurundi and French.

Throughout World War II, while France itself was Nazi-occupied, Gen. Charles DeGaulle kept the *Voice of Free France* speaking to the world from *Radio Brazzaville*, then one of the strongest and most commonly heard stations in West Africa.

Much has happened there in the intervening years, not the least of which was independence for France's portion of the Congo. But it is still possible to hear shortwave from Brazzaville, *Radiodifusion TV Congolaise*, on 15,190 kHz, in French from 2100 UTC.

Egypt's *Radio Cairo* has to rank as one of the more important international broadcasters in Africa. It is one of a small handful that have English broadcasts directed specifically to North America, using transmitters of 100 and 250 kilowatts.

That station should be received without difficulty throughout North America between 0200 and 0330 UTC on 9,475 or 9,675 kHz., has what is nominally called an English International Service. In fact, a California radio broker has sold air time to a variety of U.S. religious organizations, whose recorded Gospel programs, in English, are heard over that African outlet during the period from about 1930 to 2200 UTC.

The Voice of Revolutionary Ethiopia has English-language programming to Africa at 1500 UTC on 9,560 kHz.

Continuing alphabetically, through Africa, there is Gabon, where a French-owned commercial station, called *Africa Number 1*, puts out a potent shortwave signal from Libreville on frequencies such as 17,820, 15,200 and 11,815 kHz.

Interestingly, the previously mentioned Ethiopian station, pre-revolution, belonged to a religious organization, Lutheran World Federation. Today, LWF's *Voice of the Gospel* program airs at 1725 UTC on *Africa No. 1*.

As that list may suggest, missionary groups make considerable use of shortwave radio to reach African audiences. Liberia's ELWA is another of those religious stations. It can be heard in English with its "Good Morning, Liberia" program from 0600 UTC on 4,760 kHz.

Harder to hear is another Liberian shortwave operation, the commercial ELBC, also in the capital of Monrovia, on 3,255 kHz. The times to try are around 0530 UTC, or again during the late afternoon in North America.

Libya's *Radio Jamahiriya* has English to North America on 11,815 kHz, from 2200 to 2250 UTC. Try also from 1900 to 2000 UTC on 15,450 kHz.

Major international broadcasters elsewhere in the world make use of relay stations in Africa to augment their worldwide shortwave services. *The Voice of America*, for instance, has shortwave transmitters in Liberia and Morocco; Germany's Deutsche Welle in Rwanda in East Africa, and Netherlands on the large island of Madagascar.

The British Broadcasting Corp. has one of its shortwave relay operations in Lesotho in southern Africa. English programs from the BBC are aired from that relay station from 0400 to 0915 UTC on 9,515 kHz, and 1800 to 2015 UTC on 6,190 kHz.

United Nations Radio, using the relay facilities of the *Voice of America* in Tangier, Morocco, broadcasts to Europe and Africa on 15,245 and 17,815 kHz at 0710 UTC. The VOA's own English programs from the Tangier station are aired from 0600 UTC on 6,095, 11,840 and 15,195 kHz.

The Voice of Nigeria, in Lagos, has English transmissions on 15,120 kHz at 1800 and at 2100 UTC. Or try 7,225 kHz at 0500 UTC.

(Continued on next page)

JENSEN ON DX'ING

(Continued from previous page)

Madagascar, in addition to the *Radio Nederland* relay mentioned above, has its own governmental shortwave outlet. *Radio TV Malagasy* at Antananariva in recent months has been easier to hear than it has been in years. North American DX listeners logged that one with some regularity on 5,010 kHz, signing on at 0259 UTC with a vocal anthem and announcements in both French and the Malagasy language.

Call it Namibia if you prefer, but the shortwave station is called *Radio South West Africa* and it operates from the town of Windhoek on 3,295 kHz. You may find that one with popular music around 0300 UTC. It uses English, German, and the Dutch-based Afrikaans languages.

South Africa, controversial and often in the news, operates one of Africa's major international shortwave stations, *Radio RSA*. You will have no trouble in hearing its English-language foreign service, directed to North America, from 0200 to 0300 UTC. Frequencies to try are 5,980, 6,010 and 9,615 kHz.

You may find the South African home services more interesting. There is the "all night" musical feature of *Radio Orion* from 0000 to 0400 UTC on 3,250 kHz. Later, from 0400 UTC, there is the *Radio Five* service on the same frequency.

Radio Tanzania, from Dar es Salaam, broadcasts in English to Africa on 5,985 and 6,105 kHz, from 0330 UTC.

And, nearing the end of the African alphabet, how about *Radio Uganda* on 5,026 kHz? You may find that one around 2030 to 2100 UTC somewhat later in the year, or around 0400 UTC now.

Z is for Zaire, once upon a time, the Belgian Congo. The regional station at Lubumbashi, far up the Congo River, has been heard rather widely in North American in recent months. Look for that one around 0400 or 0430 UTC on either 4,750 or 7,205 kHz, with programs in French and African languages.

While there's only a handful of the African stations that you can hear on shortwave, it is a starter, and a reasonable mix of easy and more difficult loggings.

Next time I'll continue our worldwide tour of SW stations with a look at another part of the the globe.

SWL Call Letters

"Many, many years ago," writes reader Jerry Kelly of Bardstown, KY, "I had a SWL call, with letters similar to the amateur radio call signs. I've not done any SWL'ing for about 15 years, but I am anxious to start again. Do you know where I can get another call sign?"

JENSEN ON DX'ING

Some years ago, as you know, Jerry, many—perhaps most—shortwave listeners had those call signs. Ham radio operators, of course, were officially licensed and had their government-assigned call letters. Since SWL's are not licensed, listeners clubs and various magazines issued their own unofficial "calls." It was common then for SWL's to have printed cards with their call signs to trade with other listeners. Card swapping was a popular sidelight to the listening hobby.

Yes, Jerry, the same outfit that issued the most widely known of the SWL call letters, Monitor and DX Headquarters, P.O. box 3333, Cherry Hill, NJ 08034, is still in operation.

Originally those were called WPE-calls, since they were sponsored by the now-departed *Popular Electronics* magazine. Later they were taken over by Monitor and DX Headquarters, operated by former columnist, Hank Bennett.

Currently, Hank is issuing calls beginning with the prefixes WDX and KDX. Since 1970, I've held a certificate for WDX9EZ.

There is a $2 fee for a call and certificate. If you prefer a specific three-letter combination, following the numeral, which designates your geographical zone, the fee is $3. A two-letter or one-letter call, if available, will cost $5.

There are also award certificates available for various listening feats, such as tuning a certain number of countries, states, Canadian provinces, or world zones.

A bit of trivia in the form of a question. Who was the first director of the WPE certificate program? Where is he today? Better still, who was the second director of that program and what is he doing today? Both men are well known and are active in hobby electronics.

Well tell you next issue.

Here's the multi-colored DX certificate you will receive from Hank Bennett, WDX2FT for only $2.00. The text gives all the details.

HANDS-ON ELECTRONICS

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An elapsed time meter from Simpson satisfies many low-priced applications. The Model 109ET counts to 99,999.9 hours and can be operated on from 10 to 80-volts DC, or on 100 to 265-volts AC (50–1000 Hz) with an optional plug-in AC converter module. This compact meter uses only a 48-mm (1.894-inches) square panel space and only 46-mm (1.811-inches) behind the panel. And is compatible with both consumer and industrial needs. Its applications include measuring running time on generators; gasoline, diesel, and electric motors; and also computers, copy machines, telephone equipment, etc.

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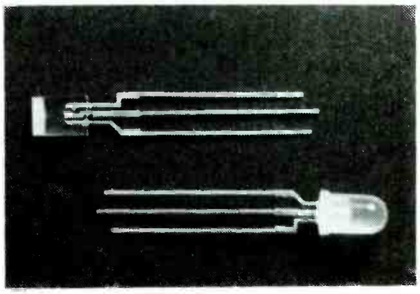
The Simpson Model 109ET uses a quartz oscillator, special CMOS IC circuitry and time-proven stepping motor design to achieve high accuracy and reliability. The meter is also protected against voltage surges to 300-volts peak, negative spikes up to 1000-volts; also, the input is protected against damage from improper connection. Its operating temperature range is −40° F to +150° F.

The Model 109ET elapsed time meter (Catalog No. 03616), complete with mounting hardware, is priced at $15.00. The optional AC converter module (Catalog No. 03617) is only $5.00. Both are available from authorized Simpson distributors worldwide. For the latest copy of Simpson's panel meter catalog, 5500-PM or test equipment catalog 5500-TE, write to Simpson Electrical Equipment and Products Group, 853 Dundee Ave., Elgin, Il 60120-3090.

Dual Color LED's

Dual color LED indicators, from Mouser Electronics, offer two colors, red and green, by simply reversing the polarity of the voltage on the leads. Its compatibility with most DTL and TTL circuits, as well as its low-power consumption rate, makes it ideal for digital applications. The indicator operates at a forward voltage of 2 volts for the red and 2.1 volts for the green. Operating at 5 volts, it has a reverse current rating of 100μA and dissipates only 105 milliwatts. These dual-color LED's are available from stock for as low as 39 cent in quantities of 1000. A free 176 page catalog containing LED and other electronics components is available upon request from Mouser Electronics, 11433 Woodside Ave., Santee, CA 92071.



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Free Catalog

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(Continued on page 16)

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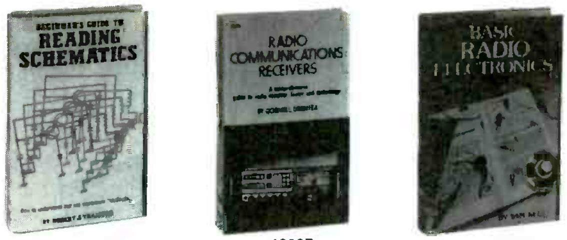

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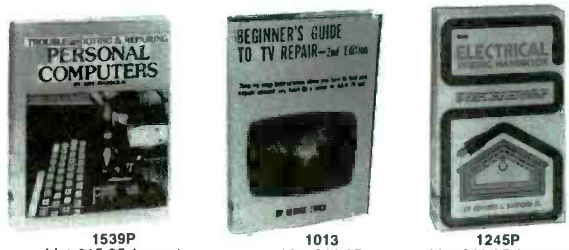

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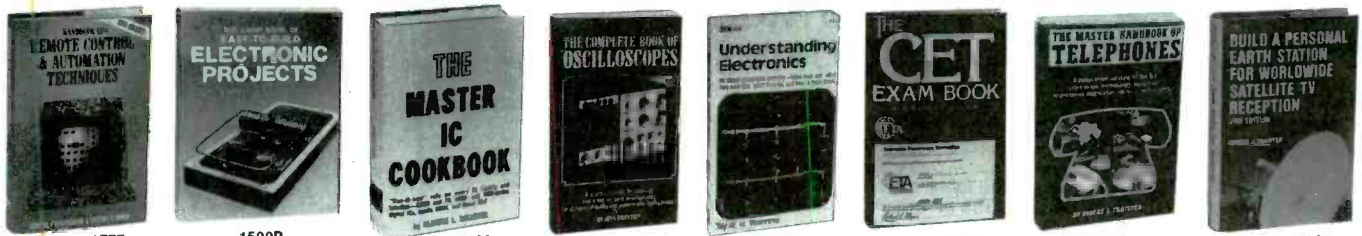

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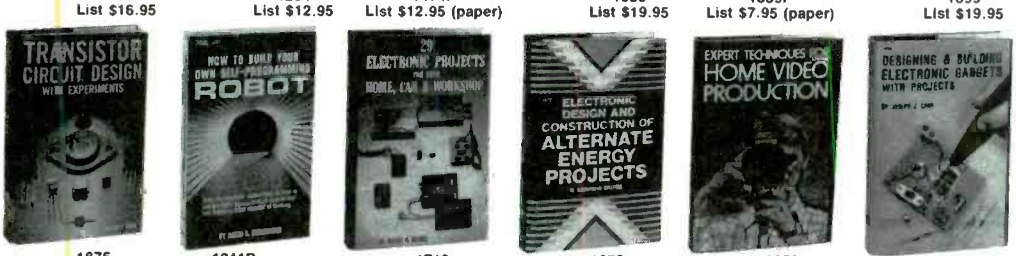

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FREE guide to mail order sources for electronic parts and components

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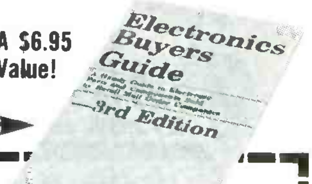

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RESP-1185

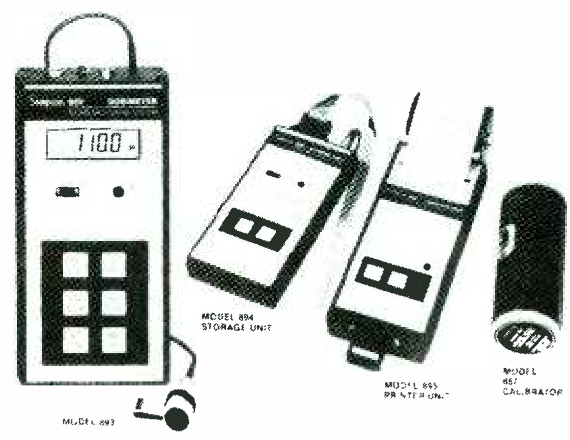
NEW PRODUCTS

(Continued from page 14)

pairing electronic equipment. This is an excellent buying guide for engineers, technicians, hobbyists and researchers.

Products include precision hand tools, test instruments, tool kits, soldering supplies; plus, a full selection of telecommunication tools and instruments, and a complete range of static protection products. All products are fully illustrated with photographs, detailed descriptions, and pricing to allow for easy ordering by phone or mail. Most orders are shipped within 24 hours and carry a 100% satisfaction guarantee.

The 1985 catalog is available free from Contact East, 7 Cypress Drive, PO Box 160, Burlington, MA 01803; or phone (617) 272-5051.



A Personal Noise Dosimeter and Integrating Sound Level Meter

CIRCLE 647 ON FREE INFORMATION CARD

Noise Dosimeter/Sound Level Measuring System

Simpson Electric Company has introduced a combination noise dosimeter and integrating sound level meter with data storage and printing units. The system, designed for industrial (OSHA) noise measurement, analysis and record keeping, is easier to use and lower in price than comparable systems. Everything is included: No extras are needed.

The Model 893 Noise Dosimeter/Sound Level Meter is a pocket-size, portable instrument that computes noise dose and projected 8-hour TWA (time weighted average). It measures continuous, intermittent, and impulsive noise from 80 dBA to 130 dBA according to present OSHA and DOD requirements. The unit has switch-selectable threshold levels of 80 dBA, 85 dBA and 90 dBA. It features microprocessor electronics with touch membrane switching and a large, easy-to-read 4-digit LCD readout, 140-dB peak detector and security lock.

Together with the 893, the companion Model 894 Data Storage unit and Model 895 Data Printer unit provide storage and printout of pertinent OSHA heading and noise summary information, a noise-profile histogram, and 60-second integrated, time-weighted averages.

The Simpson Model 887 Sound Level Calibrator provides for quick, accurate field calibration of the dosimeter. The Simpson Sound Measuring components meet all applicable OSHA requirements, including 140 dB impact noise detection. The complete system, Model SMS-1, in a fitted attache case, is priced at $1,695.00, and the stand-alone noise dosimeter/sound level meter is priced at $590.00. Both are available from authorized Simpson distributors worldwide.

(Continued on page 20)

Train for the Fastest Growing Job Skill in America

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

As computers move into offices and homes by the millions, 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 than any other occupation.

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As an NRI student, you'll get total hands-on training as you actually build your own Sanyo MBC-550 series computer from the keyboard up. Only a person who knows *all* the underlying fundamentals can cope with *all* the significant brands of computers. And as an NRI graduate, you'll possess the up-to-the-minute combination of theory and practical experience that will lead you to success on the job.

You learn at your own convenience, in your own home, at your own comfortable pace. Without classroom pressures, without rigid night-school schedules, without wasted time. Your own personal NRI instructor and NRI's complete technical staff will answer your questions, give you guidance and special help whenever you may need it.

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Critics hail the new Sanyo as the "most intriguing" of all the IBM-PC compatible computers. It uses the same 8088 microprocessor as the IBM-PC and the MS/DOS operating system. So, you'll be able to choose thousands of off-the-shelf software programs to run on your completed Sanyo.

As you build the Sanyo from the keyboard up, you'll perform demonstrations and experiments that will give you a total mastery of computer operations and servicing techniques. You'll do programming in BASIC language. You'll prepare interfaces for peripherals such as printers and joysticks. Using utility programs, you'll check out 8088 functioning. NRI's easy step-by-step directions will guide you all the way right into one of today's fastest growing fields as a computer service technician. And the entire system, including all the bundled software and extensive data manuals, is yours to keep as part of your training.

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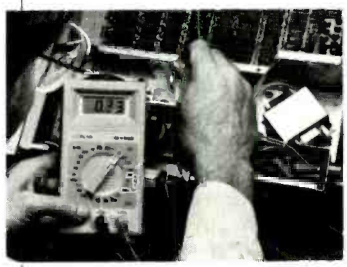
Send the postage-paid reply card today for NRI's big 100-page color catalog, which gives you all the facts about NRI training in Microcomputers, Robotics, Data Communications, TV/Video/Audio Servicing, and other growing high-tech career fields. If the card is missing write to NRI at the address below.

NRI is the only home study school that trains you as you assemble a top-brand microcomputer. After building your own logic probe, you'll assemble the "intelligent" keyboard . . .



. . . then install the computer power supply, checking all the circuits and connections with NRI's Digital Multimeter. From there you'll move on to install the disk drive and monitor.

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NEW PRODUCTS
(Continued from page 16)

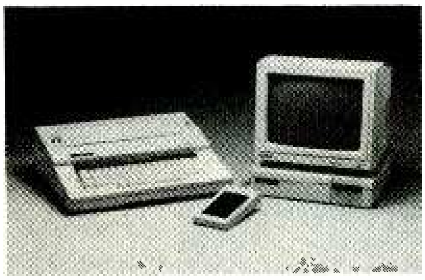
Simpson Electric Company, a member of the Katy Industries,Inc. Electrical Equipment and Products Group, is headquartered at 853 Dundee Ave., Elgin, Il 60120-3090; (312) 697-2260.

Personal Word Processor

Personal Word Processor (PWP), from Smith Corona, is a dedicated accessory unit with 64,000 characters of memory or approximately 32 pages of text offering complete editing capability including the ability to insert and delete text, move paragraphs, search and/or replace text for the low suggested retail price of $499.99.

Designed for use with Smith Corona's Messenger electronic typewriters and newer models with the Spell-Right spelling checker, the PWP components include keypad, an 80 character by 24 line, 12 inch monitor, word processing module with built-in software, connecting cable, and micro-wafer cassette drive.

Smith Corona's computer-compatible electronic typewriters act as both keyboard and printer for the Personal Word Processor. All of the advanced electronic features of the typewriters also work with the word processor. If attached to Smith Corona's Spell-Right typewriters, PWP actually detects spelling errors and alerts the typist with an audible beep.

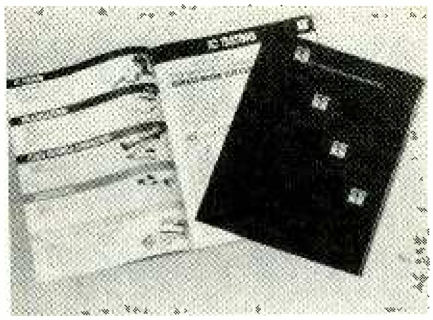


CIRCLE 654 ON FREE INFORMATION CARD

The Smith Corona Personal Word Processor is available at Smith Corona office product dealers. For additional information contact Smith Corona, 65 Locust Ave., New Canaan, CT 06840.

Catalog of Entire Product Line

A comprehensive catalog featuring A P Products Inc.'s entire line of quality breadboarding, interconnection, and testing devices in one handy volume is now available. In the past, A P has published two separate catalogs; one for its breadboarding and testing devices, and another for its interconnection products. This 30-page manual provides a single source for engineers, technicians, hobbyist, educators, and students seeking the latest in IC testing products.



CIRCLE 660 ON FREE INFORMATION CARD

The 8½ by 11-inch glossy publication has been organized by product category, allowing the reader to zero in on areas of interest. With its large photographs, easy-to-read specifications, and concise product descriptions, A P's catalog is truly a hands-on reference manual, covering the company's most recent advances in IC technology: the Surface Mount Test Clip, the Low Profile Logical Connection TM and the ACE Board TM 100 series. A P Products makes its product line available through its national representatives and distribution network.

Multimixer Series

Best known for rugged, reliable EQ's and disco products, Numark Electronics Corp. has introduced another generation of entertainment products aimed directly at the disco-video and audio/video production market. The MMX 1000/2000 mixers are rack-ready, fully stereo, and boast balanced, low-impedance operation at the +4 dBm pro output level. And super low-noise semiconductors throughout mean impressive noise specs.

Twelve stereo inputs on the rear are routed to six mixer channels using the source-select switches. That eliminates messy repatching. Each unit feature full prefade cue, LED output meters, output EQ, and a processor loop on the output bus. Level faders control house, booth,

CIRCLE 667 ON FREE INFORMATION CARD

and headphone monitor volume.

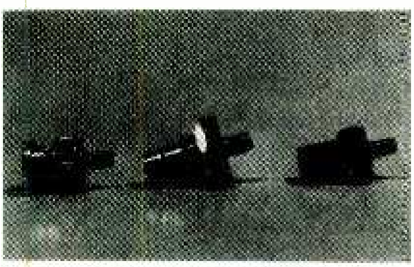
Five stereo inputs, three phono inputs with RIAA preamp, and four balanced mike inputs (with phase reversal switches) accept any modern audio source. A fader on the phono 1 and 2 channels means smooth transitions for DJ's. In addition to a balanced house output, you get unbalanced house, booth and tape 1 and 2 jacks.

All those features are standard on the three-rack-space MMX 1000. The 2000 is five spaces tall because of the additional three-band per channel EQ. You also get processor loop, front-panel switching. Audio/video sound dubbing and channel patch points on the seven input preamps. Both models are attractive satin black and white. The MMX 1000 lists at $1,095.00 and the 2000 at $1,495.00. Both are unsurpassed professional audio workhorses for club, studio, or location.

For more information on the Multimixer Series, contact Paul Freidman at Professional Products (a division of Numark Electronics Corp.) 503 Raritan Center, Edison, NJ 08837 or phone: (201) 225-3222.

BNC Series Connectors

Mouser Electronics has introduced an extensive line of BNC connectors specifically designed to withstand rough handling. With features like quick disconnect bayonet lock, design-based on U.S. military specifications, the ME174 and ME164 series connectors can be used in a wide range of working and environmental conditions. In operating temperatures of $-55°$ C to $200°$ C, these connectors perform quite well with silicone rubber gaskets and teflon insulation.



CIRCLE 637 ON FREE INFORMATION CARD

The ME174 and ME164 BNC connectors consist of 14 connectors, all have a working voltage of 500 volts and a frequency range reaching up to 10 GHz. The captive and crimping type jacks and plugs have silver-plated center contacts that are argalin dipped to inhibit oxidation. With all the features and variations, a BNC connector from this line can be found to fit any need.

The captive plug can be purchased for as little as $1.71 in quantities of 250, while a captive socket cost as little as 59 cents in quantities of 250. Mouser's full-line catalog is available free of charge by writing to Mouser Electronics 11433 Woodside Ave., Santee, CA 92071 or call (619) 449-2222.

Dial with Your Voice!

You can dial with your voice. Imagine picking up the phone, saying a word or two into the receiver, you hear the telephone dialing the party you want—automatically! This is made possible by the Command Dialer II, Model VRT-1150 by Audec.

Designed for the home as well as for the business and professional user, the new phone offers unique capabilities that will make your day more productive. The phone recognizes spoken words, and matches them with pre-programmed words and numbers. You store into its memory as many as 16 frequently-called phone numbers of up to 30 digits each. With your own voice you assign each of

(turn page)

CIRCLE 607 ON FREE INFORMATION CARD

CIRCLE 613 ON FREE INFORMATION CARD

NEW PRODUCTS

(Continued from previous page)

the 16 phone numbers. Once programmed, they become part of the voice-recognition memory of the Command Dialer II.

It takes just minutes to program the phone. So the next time you want to place a call, all you do is lift the receiver (which

CIRCLE 652 ON FREE INFORMATION CARD

contains the memory-activating pushbutton), speak the code word "John," for instance. The Command Dialer II then puts the call through to John, without you doing any dialing. While the phone is trained to respond to your voice, it will adapt to the same name spoken by others—members of your family, your secretary and other office associates, etc.

The Model VRT-1150 functions automatically (switchless) in pulse or tone-dial modes. Other capabilities include a quick visual feedback for checking pre-programmed numbers. And, if a vital line is busy, you can hang up the phone, and the Command Dialer II will re-dial the number fifteen times, pause for ten minutes, then repeat the cycle for one hour. It calls you back when the number is free. One of several imporant features is the unit's capability for programming a secret code to prevent unauthorized long-distance calls. An alarm sounds when an attempt is made to place such a call.

Available through major retail outlets, the Model VRT-1150 carries a suggest retail price of $199.95. For additional information write to Audec Corporation, 299 Market Street, Saddle Brook, NJ 07662.

Head-worn Microphone

Designed for hands-free vocal delivery, the Telex PH20 Head-Worn Microphone utilizes a close-talking, wide response, electret microphone, with an excellent frequency response curve for a variety of applications, including music, computer speech-recognition, auction, bingo parlors, public address systems, and audio-visual applications.

The PH20 has a stable, split-piece headband that mounts securely on the head for a comfortable, dependable fit. Slip-proof foam temple cushions provide long-lasting comfort while averting fatigue. A reversible swivel-mount and 180° adjustable boom provide a custom fit for proper mouth-to-microphone distance and the option of wearing the mike on the right or the left side of the head.

Included with the PH20 microphone is the PS10 power supply. The small, rugged PS10 supplies in-line power to the PH20 through a 1.4-volt calculator-type battery, or can be switched to phantom power from an external source.

The PS10 is unobtrusive, lightweight and includes a handy belt/clothing clip. The matte black finish and slender design of the PH20 give it a subtle appearance, allowing professionals on stage and in front of the camera to look their very best at all times.

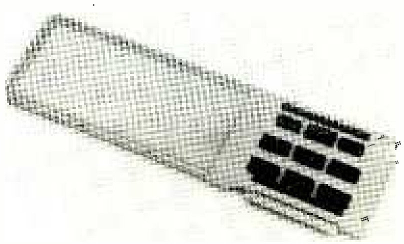
Also available are the PH21 Head-Worn microphone, without the PS10 power sup-

CIRCLE 663 ON FREE INFORMATION CARD

ply, and the PH22 Head-Worn Mike that connects directly to Telex Wireless Microphone Systems, without the PS10. For more detailed information, write to Telex Communications, Telex Professional Audio Department, 9600 Aldrich Aveue South, Minneapolis, MN 55420. Telephone: 612/884-4051.

Prototyping Board

The eZ card is a blank circuit board for computer hobbyists or engineers who wish to build a prototype board according



CIRCLE 671 ON FREE INFORMATION CARD

to specific design. The board provides the means to interface prototype circuitry for the IBM-PC. The board has several features. A switch-selectable address decoder frees the user to concentrate on design. Selector switches permit up to

(Continued on page 102)

SAXON ON SCANNERS

By Mark Saxon

☐YOU MAY NOT BE AWARE OF HOW EASY it is to eavesdrop legally on private conversations of your neighbors, or how simple it is for them to listen to conversations you are having in the supposed privacy of your own home. Nevertheless, it is easier than you might have thought (until now, that is).

A recent story in *The Arizona Republic* newspaper told how a scanner owner was searching through the 49-MHz range of frequencies when he stumbled upon a rather personal conversation between a man and a woman. After spending a little time tuned in on this transmission (which was on the air continuously) he learned the name of their baby, that they had a dog, and many other details of their chatter that made the scanner owner decide to try to seek out the talkative family and warn them that some of the more personal details of their life were being transmitted throughout the area.

A mobile monitor and a little detective work zeroed in on the home from which the transmissions were being sent. When the people who lived there were approached they couldn't imagine how their conversations were "getting out." That was just before they remembered that they had left in operation, on a continual basis, a transmitter unit placed in the child's room combined with a battery-operated portable receiver. And you guessed it, it turned out that the transmitter operated on 49.89 MHz!

The owners of this unit were horrified to learn that their conversations could be monitored over a wide area and immediately contacted the manufacturer of the device. The manufacturer didn't deny that the problem could have happened, but said it was the first time that anybody had complained. In the meantime they modified the instruction booklet for the equipment to state that the equipment should not be left on continuously. And the scanner owner who made the original discovery has turned up several other owners using similar equipment who didn't realize that their household conversations were self-bugged for all to share.

If you want to check out those frequencies in your own area, set up your scanner

(Continued on next page)

SAXON ON SCANNERS

(Continued from previous page)

to monitor the following frequencies: 49.67, 49.77, 49.83, 49.845, 49.86, 49.875, 49.89, 49.93, 49.97 and 49.99 MHz. You might also hear the handsets used with newer cordless telephones as they also use these frequencies. However, if you've got a wireless babysitter radio, better turn it off when it's not needed!

Reader Tony L. Davila, APO Miami, asks if we can offer a list of frequencies used by itinerant communications systems. They are popular with convoys, construction companies, or any service that takes companies from place to place. The Goodyear Blimps use some of those channels (especially 151.625 MHz) and that frequency is also popular with hot-air balloons. The complete list of frequencies available for itinerant users is: 27.49, 35.04, 43.04 151.505, 151.625, 158.40, 464.50, 464.55, 469.50 and 469.55 MHz.

Elmer Richardson of Toledo poses a reasonable question. He notes that Air Force 1 uses HF radio for telephone "patches" (calls) while flying outside the USA, but he wonders if VHF might be used when the aircraft is flying within the continental USA. Our information on this, Elmer, is that a duplex system is in use with the aircraft transmitting on 415.70 MHz while it is in contact with ground transmitters operating on 407.85 MHz. If you happen to live near one of the many ground tranmitters and have two scanners (one for frequency) you will be able to monitor both sides of the plane's telephone calls; otherwise you'll only hear those from the aircraft itself on 415.70 MHz.And remember that the Vice President's aircraft, Air Force 2, also uses this air/ground system.

Geoff Wilkinson of Ottowa, Ontario, wonders if we can unravel one of life's major mysteries, that being the frequencies used by the Senate of Canada and the House of Commons. Those frequencies, Geoff reports, are closely guarded. No problem! The Senate operates on 172.35 and 172.47 MHz, while the House of Commons can be monitored on 172.17, 172.68 and 172.86Mhz.

Regency's interesting new Z-45 scanner even brings in the VHF aero band along with your local police and fire channels.

Regency Electronics Inc., 7707 Records St., Indianapolis, IN 46226-9989 (That's a nine-digit ZIP), advises that they've brought out their new Model Z45 scanner. It is a 7-band 45-channel programmable unit covering the six public service bands plus the popular 118 to 136 MHz aero band.

No crystals are required, and the set's internal memory is programmed with (what Regency feels are) 45 of the most popular frequencies. A special feature of the Z45 is its digital clock with programmable alarm.

Additional features include nifty woodgrain styling, a permanent memory system, priority control, search, dual-level display with prompting messages, channel lockout, scan delay, squelch, slide controls, and a telescoping antenna for local station reception.

The Regency Z45 sells in the $330 price range. The company will be happy to send you additional information on that exciting new scanner.

Before we sign off for this issue, here's a reminder that we'd very much like to hear from our readers with suggestions, comments, frequencies, questions, and photos. Address your letters to *Saxon on Scanners*, **Hands-On Electronics**, 200 Park Avenue South, New York, NY 10003. See you next issue!

The Goodyear Blimp can be monitored on your scanner using frequencies in the broadcast auxiliary and aero radio services. It might be interesting to hear their comments on some of the sporting events they fly over.

SOLAR ENERGY

Pollution-free Power

Researchers look to the heavens for the worlds future energy needs. Get a preview of what some analysts believe will be the power source of tomorrow!

By Alan Concannon

FINDING A VIABLE SUBstitute for fossil fuels has required a great deal of research and development effort during the last decade. That research has lead to the development of the new photovoltaic cells, which just may turn out to be the bright light on the horizon. Solar-cell efficiencies have improved to the point where, for many applications, photovoltaic panels are now a competitive energy source for consumers in areas remote from an electricity grid. Some optimistic researchers now predict that by the turn of the century photovoltaics will be a cheaper energy source than oil. The last three years have seen American manufacturers making serious commitments to photovoltaic cell production. Annual commercial production of photovoltaic cells in

SOLAR ENERGY

the United States has increased 500% over the last three years. Today, most alternative energy technologies throughout the world would falter if governmental support for research and development were dropped. But even without the support of research and development, according to leading industrialists, the photovoltaic industry would hardly collapse.

Members of the Solar Energy Research Institute (SERI), the US Department of Energy, and many other leading researchers and industrial developers, all agreed at SERI's last annual meeting that photovoltaic technology is ready for commercialization. Since the first cells were made for the US space program in 1958, they have been credited as being a silent, inexhaustible, and pollution-free source of electricity—but expensive.

Now that's all changing. Solar cells have progressively become a keen competitive energy source where commercial power supplies are not available, especially in remote locations and in underdeveloped countries. Due to raw materials such as silicon and others being manufactured at a lower price with a higher purity rate, the efficiency of the units has risen considerably.

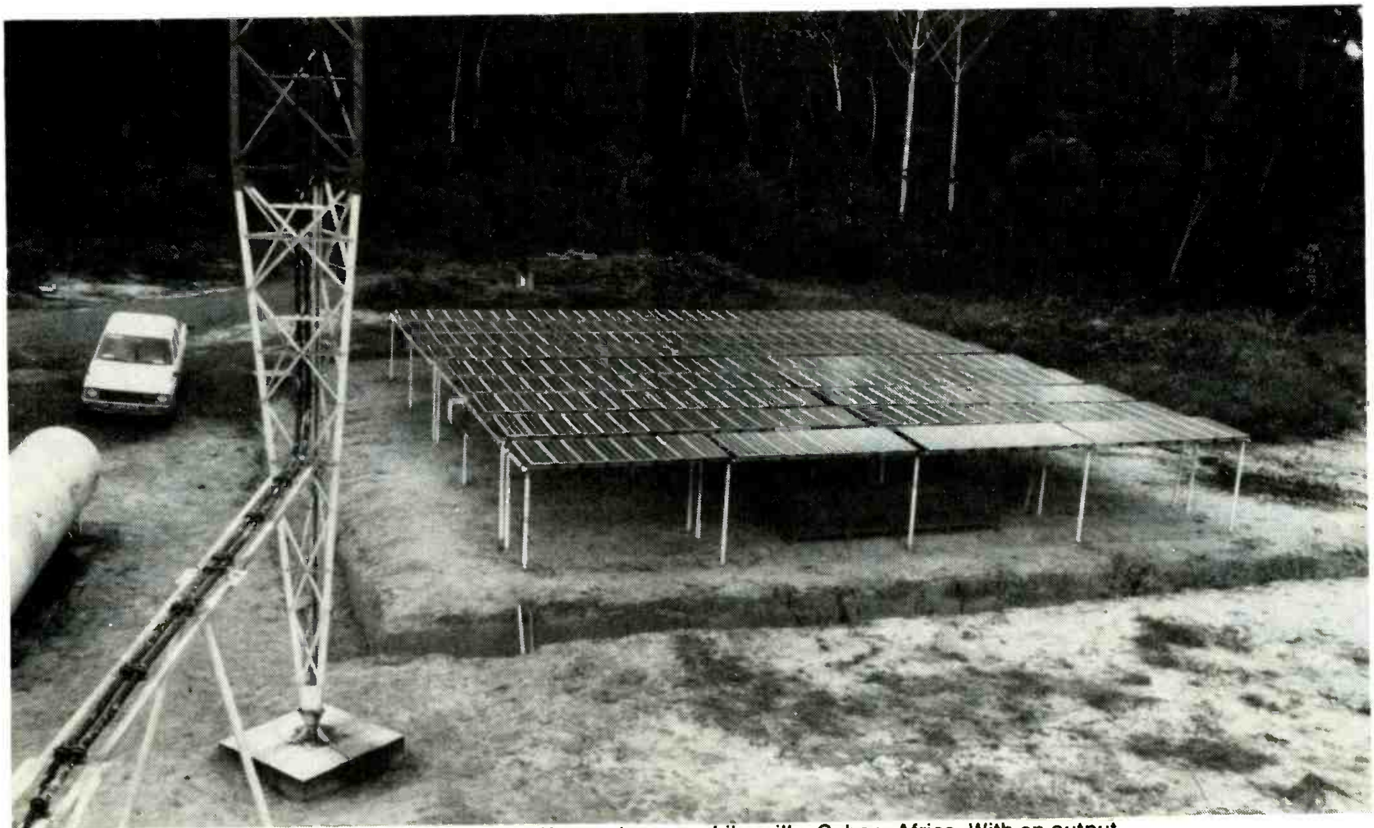
"Some oil companies have even made a commitment," says Roger Taylor, manager of photovoltaic research at the Electric Power Research Institute in the US, "because they have envisioned and can see a viable and growing market. Other alternative energy technologies, such as wind turbines, just don't have that backing."

Working Solar-cell Systems

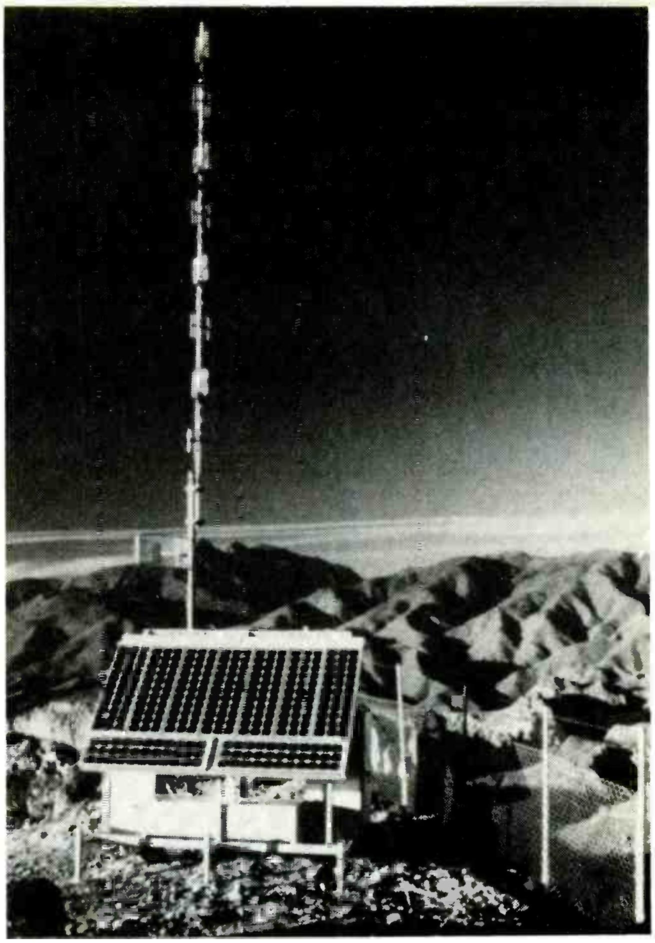
From irrigation pumps to village power systems, solar-cell installations are now economically producing electricity. One of the largest such installations in the world is a 100-kilowatt (kW) unit at the National Bridges, National Monument in Utah. Since June 1980, that system has supplied energy for all of the park's electrical needs, including water pumping, maintenance shops, a visitor's center, power for campers or motor-homes, and service mains to several park-ranger's homes. And lead acid batteries have not discharged below 40 percent of their capacity.

The park's 2054.4 square-yard, solar-cell layout contains 250,000 silicon cells in 4762 modules. Together those units provide 210 amperes of peak output current. The system also has diesel generators for backup, but they're rarely needed to compensate for lack of sunlight. Instead, they are mainly pressed into service to equalize the charge between banks of batteries. A self-sufficient, billion-dollar-a-year industry is forecast for the US by 1986, and user acceptance in America is predicted to follow: Remote communities and houses; sunbelt residences already connected to the mains, remote water pumps for irrigation, houses in less sunny areas, etc., will be among the first to be served.

A 3.5-kW photocell system at the Papago Indian Reservation Village in Arizona is the first stand-alone unit designed specifically to supply power to a small community. The unit can send over 1040 gallons of water an hour to the 10,816 gallon storage tank. It also provides lights for 15 houses and keeps domestic appliances going. The system is certainly a success story! But success hasn't come without its negative side: One of the major drawbacks with such a system is the need for "load-management." The residents of the Papago



Microwave repeater site at Kougouleu, near Libreville, Gabon, Africa. With an output capacity of 16-kilowatts, to power a microwave link for the Gabon Post and Telecommunications Authority, it is the largest solar energy system installed outside the United States.



Located at Bronco Butte near Apache Lake, Arizona, Solarvolt's 300-watt peak array is used to power a radio repeater for the Arizona Department of Pubic Safety. That installation contains three radios and two 20-watt repeaters. Two of the radios and one repeater are used by the Highway Patrol, while the other repeater and the third radio provides communications for the Emergency Medical Services. The installation also contains a multiplex microwave control.

Reservation have already developed such an appetite for electricity that the system may soon have to be upgraded, because the available power must be used effectively and that requires careful load management.

Battery storage is invariably necessary and the size of the storage bank must be limited in terms of minimizing costs. Therefore, the solar-energy system has controlled, independent circuits and a central-control unit that delegates power according to specific priorities and conditions. For instance, functions such as water pumping and crop-grinding might be permitted only during periods of high solar gain. And battery backup for those functions may not be available. The available pumping time at the Arizona installation varies from three hours per day in winter to over five hours in summer. Additional restrictions are needed to protect the batteries from damage and to prolong their life: Circuits to washing and sewing machines are disconnected at 50 percent *depth of discharge*—for example, when a battery bank having a 100 ampere/hour (ah) rating has dropped to 40-ah or below—lights at 60%, the water-pump motor at 70%, and refrigerators at 80%.

Types Of Cells

Photovoltaic cells can be fabricated from a variety of materials in several ways. The materials are generally grouped into four categories: single-crystal silicon, polycrystalline compounds, semiconductors such as gallium arsenide, and amorphous (non-crystalline) silicon. Single-crystal cells are approximately 19% efficency. The best commercial modules have efficiencies ratings of between 11 and 12 percent. Most of those cells (grown using the Czochralski process, which was originally developed to form semiconductors) are cut from round silicon ingots and then polished.

Polycrystalline cells are made of semiconductor compounds with small crystal-grain sizes and are easily and reliably produced using thin-film techniques. The highest cell efficiency to date is 11%. Their greatest attribute is that they can be mass-produced economically. Gallium arsenide (GaAs) cells are the undisputed champions, where efficiency is concerned. Those laboratory cells of gallium arsenide, measuring one square centimeter, have reached an efficiency of 20.34%. Though no one has yet made GaAs cells on a production-line basis, one California company is developing a mass-production process to produce GaAs cells for space applications. Much of the interest in GaAs is attributed to the potential for its use in tandem cells—a GaAs layer deposited on a layer of silicon. Such cells have the potential to reach a 30% efficiency rating.

Amorphous silicon photovoltaic are the latest of the commercial cells, the first version being fabricated in 1974. By 1982, RCA had developed a one-square-centimeter cell with an efficiency of 10 percent. Because amorphous silicon absorbs light energy more readily than does single-crystal silicon, thick wafers are not needed. Of all the photovoltaic cells produced in 1983, 25% were amorphous silicon cells.

Increasing Cell Efficiency

Until 1970, the highest efficiency rating of any photovoltaic cell was about 14 percent. Today, however, efficiency ratings of up to 22% are being achieved, while tandem photovoltaic systems—groups of cells selected to use the wavelengths in sunlight more effectively—have produced efficiencies of over 28%.

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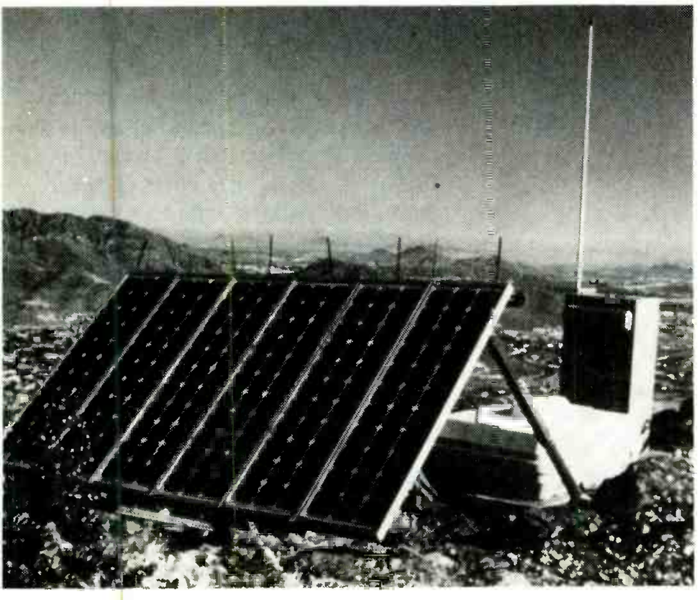


Solarvolt's 240-watt peak array, consisting of six 40-watt photovoltic modules mounted atop Mummy Mountain in Paradise Valley, Arizona, supplies power to the Paradise Valley Police Department's radio repeater.

Selecting the best VOLTAGE PROBE for your measurement applications

By Ken Carlson
Project Engineer, Tektronix, Inc.

THE OSCILLOSCOPE (SCOPE) PROBE may be the most critical component in the scope-measurement system because it interacts *intimately* with the signal source. The probe's characteristics should be matched to both the scope and the circuit under test. Probes are to oscilloscopes very much as interchangeable lenses are to 35-mm camera bodies. The lens must mount exactly on the camera body and be suitable for the subject it must view. Any failing will produce a distorted, partial, or out-of-focus image that will be useless. Similarly, it is necessary to choose the correct probe-scope system to be able to get the best view of the signal we want to focus on.

Scope users need to take several major considerations into account when determining the best probe for an application based on the specifications of the probe, scope, the circuit to be tested, and the characteristics of the signal being measured.

While a wide variety of probes have been designed to assure maximum scope performance, the most used, yet least understood, are *passive* and *active* voltage probes. Those probes are used to measure signal voltages—the most often made scope measurement.

Passive Probes

Passive voltage probes are the most common, because they are inexpensive and easy to use. Those probes use an RLC network to present a high impedance to the circuit under test, which minimizes probe loading. Passive probes are rugged and can stand more mechanical and electrical abuse than other probes. Because of their simplicity, passive probes are easy to calibrate.

Passive probes have some disadvantages. Because of the internal capacitance, the input impedance of passive probes decreases as the signal frequency increases. To obtain a high enough input impedance, the

The voltage probe is only one part of a testing system that includes the oscilloscope and the system under test. Understanding the test conditions and the characteristics of the voltage probe is of importance to the hobbyist.

attenuation of the probe must be increased; but that may make the signal amplitude too small to be seen on the scope display.

Active Probes

Active probes typically incorporate a FET input-buffer with a 50-ohm output-driver to provide the best-obtainable combination of high input-resistance and low input-capacitance, without signal attenuation. Therefore, active probes can be generally considered one of the best for general-purpose measurement.

The advantages of active probes include:

1–Full bandwidth with no signal attenuation using the 1X (no attenuation) configuration.

2–High input-resistance and low input-capacitance while working into 50-ohm scope input terminals. Those features yield fast risetime and minimum pulse-amplitude error.

3–Output impedance selection for use into 1-Megohm or 50-ohm scope input terminals.

4—The capability of extending the probe length through the use of 50-ohm cable without increasing probe loading.

Probes Are Not Created Equal

The purpose of a probe is to deliver the selected test signal to the oscilloscope input terminals without affecting the signal or the source in any way. While that may be ideal, it is difficult to design a single probe to meet the requirements for all circuit applications. It is necessary to know how to select the best type of probe for use in a particular application. Proper probe selection will assure maximum measurement system performance while minimizing the probe's loading effects.

Circuit Loading

A typical scope input can be represented by a 1-Megohm resistance shunted by 20 pF of capacitance (Fig. 1). When that input impedance is applied to the circuit under test, it loads the circuit, causing the signal to be altered. In the worse case, the operation of the circuit itself is affected. By using an attenuating probe, the loading effects can be reduced since the combined impedance of the probe and scope input is higher than the scope alone (Fig. 2). The resulting probe-scope equivalent circuit applied to the circuit under test is shown in Fig. 3. Notice that the probe specification indicates the resulting impedance of the probe-scope input combination (10 Megohm, 9.5 pF, at 10× attenuation).

The source impedance of the circuit under test is an important consideration. That can vary from a fraction of an ohm to more than 10 Megohms and from 1 pF to greater than 100 μF. In order to minimize probe loading effects, the lowest impedance point available for a particular signal should be selected.

Bandwidth

The frequency bandwidth specification of a probe is closely related to risetime response. Bandwidth (BW) can be approximated by:

$$BW = 0.35/t_r$$

where t_r is risetime in seconds. The bandwidth of a probe is affected by the resistance and capacitance of the probe head as well as the transmission characteristics of the probe cable and connector. Insufficient bandwidth will cause attenuation of higher-frequency sinewaves and rounded edges when measuring squarewaves and other pulses (Fig. 4a). That leads to an inaccurate representation of the waveform of the circuit under test.

Aberrations

Aberrations are the percentages of allowable deviations from optimum pulse response (Fig. 4b). Typical specifica-

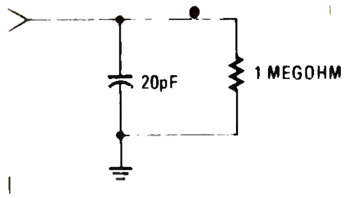


Fig. 1—Simplified oscilloscope input circuit.

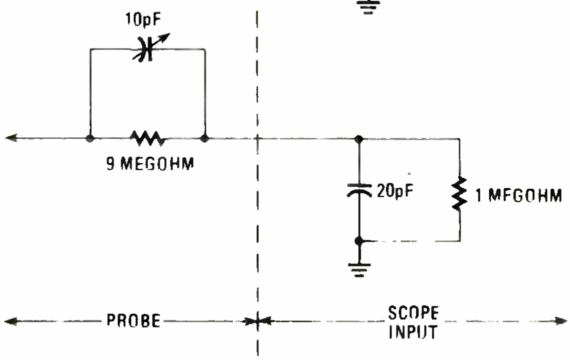


Fig. 2—Simplified oscilloscope input circuit with matching voltage probe connected.

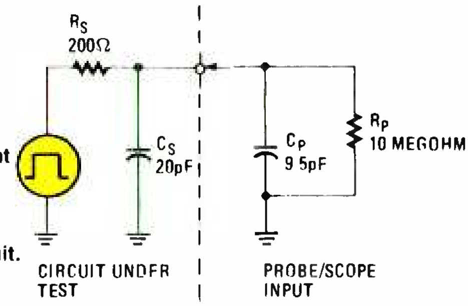


Fig. 3—Equivalent circuit for the circuit under test and the probe/scope input circuit.

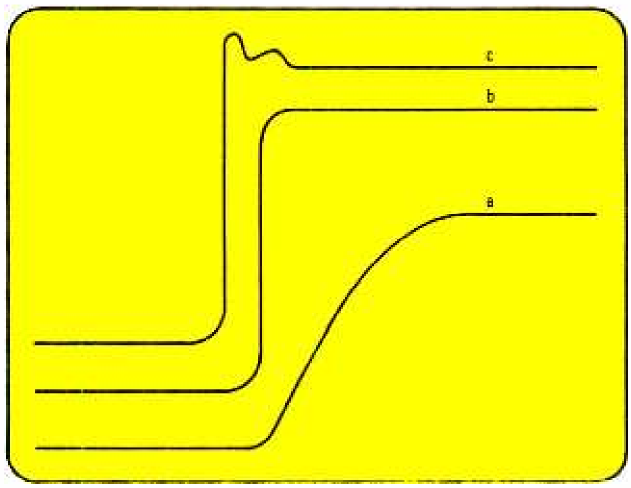
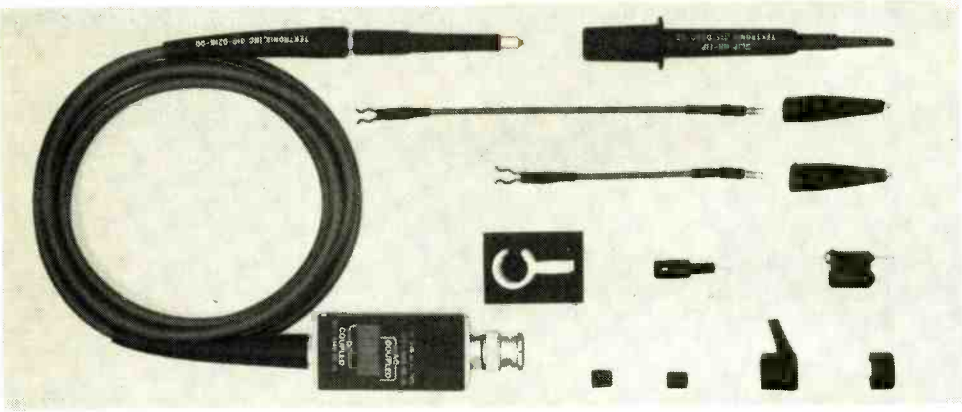


Fig. 4—Views of the leading edge of a squarewave where: a–there is insufficient bandwidth pulse response, b–optimum pulse response, and c–poorly matched probe that causes ringing.

Based on an article that appeared in *Electronic Products Magazine*



Probes come in all sizes and shapes. Shown here is the Tektronix P6048 DC-to-200-MHz, 10X probe with a minimum loading of 1 pF to 1000 ohms. The probe comes complete with accessories to make measurement taking easier.

tions are ±4% and 5% p-p. Those two values define not only the absolute limit (±4%), but also the total magnitude of the deviation (5% peak-to-peak). Some probes use peaking circuits (resonant circuits tuned to the high end of their frequency range) to extend bandwidth. However, without careful design practices that may cause aberrations (ringing) in the displayed waveform (Fig. 4c).

Probe Dimensions

Shrinking integrated-circuit packages and increasing pinouts are making it more difficult to attach a probe to the measurement point, especially if several probes must be attached in close proximity. Probe manufacturers have responded by decreasing the probe dimensions that make probes easier to handle and attach. An assortment of probe tips that are specially designed for various types of attachments (dual in-line integrated circuits, printed-circuit boards, discrete component leads) makes probing easier and faster.

Ground Path Effects

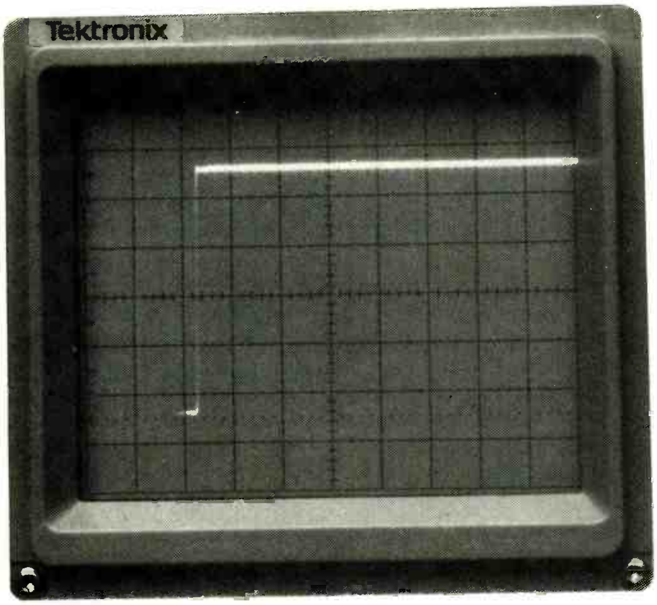
When measuring high-frequency signals, the ground return path (ground lead) to the probe can have a major impact on the fidelity of the displayed signal. The ground lead introduces an inductance into the measurement path that will cause ringing (a damped oscillation due to inductance and capacitance of the circuit) in the displayed signal if the inductance becomes too high. That appears as a small oscillation superimposed on pulse signals: To cure it, the user must ensure that the return-wire length (ground lead) is as short as possible to prevent ringing at the LC resonant frequency. Therefore, it is important to have an assortment of different-length ground leads and special fittings on hand when making measurements at very high frequencies.

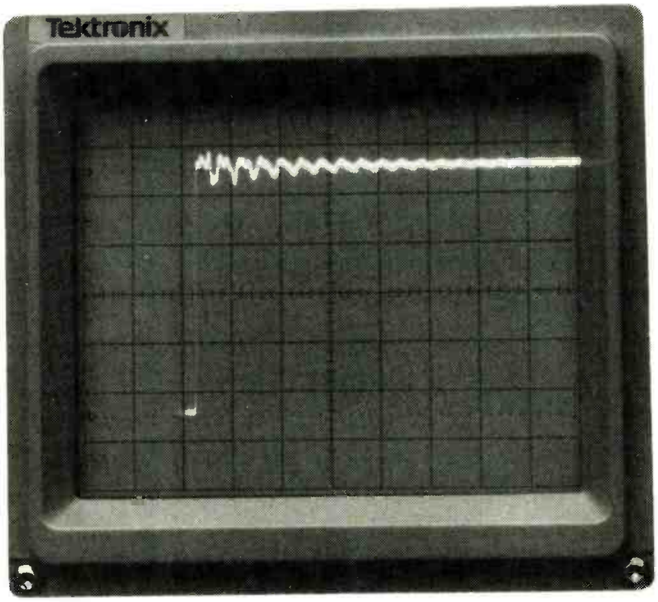
For example, Figs. 5a and 5b show the improvement that the proper grounding arrangement can make. In Fig. 5a, a 100-MHz signal is measured with a 25-cm long ground lead. Fig. 5b shows the same signal measured with a similar setup except that the ground lead has been replaced by an in-circuit probe tip connector. In that case the ringing due to the ground lead has been completely eliminated.

Amplitude Measurements

In making amplitude measurements we must consider two types of signals: sinewave (CW) and pulse. For CW signals, the accuracy of an amplitude measurement is a function of the probe-loading impedance.

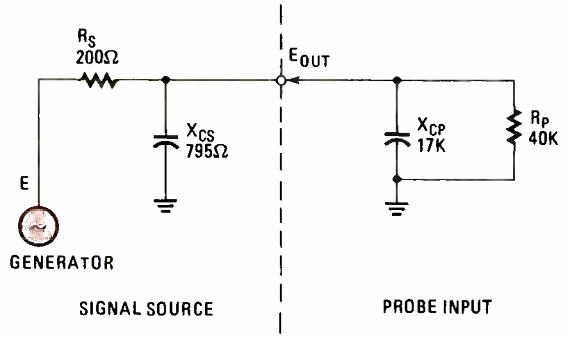
That would imply that the highest division-ratio probe (highest resistance) available would be the best choice. However, as the signal frequency increases, the probe impedance is affected more by the probe's input capacitance, until the capacitance is the dominant parameter. Then the probe impedance may be drastically less than the division ratio would imply. In that case, it might be better to opt for a lower resistance, lower capacitance probe to reduce loading (such as a 500-ohm divider probe whose input capacitance may be only 1-2 pF).





Estimating Amplitude Error

Amplitude errors for sinewave signals can be calculated by considering the equivalent circuit of the signal source and probe input (Fig. 6). Using the values in Fig. 3 at a signal frequency of 10 MHz, R_P is 40,000 ohms and X_{CP} is 1700 ohms. The output voltage, E_{OUT}, of the source without probe loading is about 97% of the generator voltage. However, when the circuit is loaded by the probe, the output voltage drops to 94% of the generator voltage, a change of 3%.



WITHOUT PROBE

$$Z = \sqrt{R_S^2 + X_{CS}^2} = 820\Omega$$

$$\%\ E_{OUT} = \frac{1}{Z}\ X_{CS}\ 100$$

$$\%\ E_{OUT} = 97\%$$

WITH PROBE

$$X_{CEQ} = \frac{X_{CS}\ X_{CP}}{X_{CS} + X_{CP}} = 542\Omega$$

$$Z = \sqrt{R_S^2 + X_{CEQ}^2} = 577\Omega$$

$$\%\ E_{OUT} = \frac{1}{Z}\ X_{CEQ}\ (100) = 94\%$$

Fig. 6—This illustration presents the circuits and equations that are used to determine the loading affect between the probe-input circuit and the circuit under test. Refer to the text.

For pulse amplitude measurements, the probe resistance is the overriding factor and should be large relative to the source impedance. An accurate amplitude measurement can be made with no concern for the input capacitance, if the RC time-constant of the probe-scope input is greater than 1/5 of the pulse width.

Risetime Measurements

When measuring the risetime of pulses, the input probe and scope capacitance becomes much more important. Since the risetime of the signal is affected by the probe resistance and capacitance, it is desirable to minimize both, giving the shortest probe time-constant. But the resistance can not be decreased too much, because the loading effects will be too great. It becomes very important to make C_{IN} as small as possible.

The probe/scope input system adds resistance and capacitance to the circuit under test, affecting the measured risetime. If the resistance of the probe is high compared to the circuit-source resistance, then the measured risetime will be:

$$T_R = 2.2\ R_S\ (C_S + C_P)$$

Fig. 5—Failing to provide a proper ground return for the probe can introduce unknown inductances, resistances and capacitances into the input circuit. In most instances, the added inductance will cause ringing in high-frequency waveforms. In (a) we see the effect of an improperly grounded probe, and in (b) we see the resulting waveform when the ground return is proper. The photos shown were taken from the screen of a Tektronix 2235 100-MHz oscilloscope.

where R_S is the source resistance, C_S is the source capacitance and C_P is the probe capacitance. From that formula you can see that minimizing the probe capacitance reduces the risetime error.

For example, consider a typical signal source loaded by a 10X probe (Fig. 7). Since R_P is much larger than R_S, it may be disregarded. The change in risetime caused by the capacitive loading of the probe is given by:

$$C_P/C_S \times 100 = 9.5\text{ pF}/20\text{ pF} = 48\%.$$

From that example, you can see that minimizing the probe capacitance reduces the risetime error.

Summary

No probe is perfect for all measurement applications; scope users need to consider their probe, scope, and circuit as a system before making a measurement. Knowing the characteristics of the signal source, and choosing the proper probe for the application, will assure accurate scope voltage measurements.

Here are some general rules that give a starting place for selecting the right probe for a particular measurement situation:

1. Always check probe compensation on the scope being used before making measurements. Compensation matches the capacitance of the probe to that of the scope input to ensure accurate attenuation at all signal frequencies. If you change scopes, or even channels on the scope, you should recheck the probe compensation.

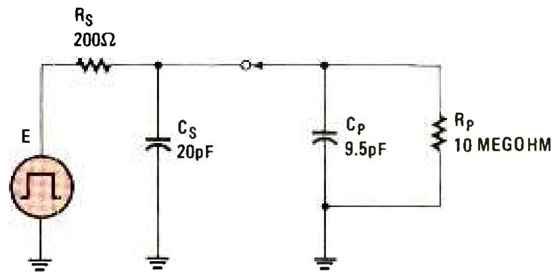
2. Choose the lowest-impedance test point possible to view the signal.

3. Always use the shortest ground-return path (ground lead) possible to minimize ringing.

4. When making amplitude measurements:

a. For sinewave measurements, choose a probe with the highest input impedance at the frequency of interest. Remember, loading error changes with frequency.

b. For pulse measurements, choose a probe with a large input resistance relative to the source impedance. Input C is of little concern if pulse duration is about five times longer than the input RC time constant.



$$\Delta t_R = \frac{C_P}{C_S}\ (100) = 48\%$$

Fig. 7—Effect of capacitor loading on rise-time measurements.

5. When making risetime measurements:

a. Choose a probe with R and C as low as possible.

b. Scope and probe risetime should be short relative to the signal risetime.

c. The observed risetime should be approximately equal to the square root of the sum of the squares of all risetimes in the system. Those risetimes include the risetime of the signal source, and the specified probe/scope system risetime.

RADIO WAVE PROPAGATION

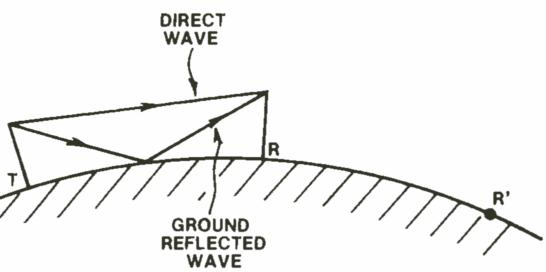
THERE ARE FIVE BASIC WAYS BY WHICH A RADIO WAVE CAN travel from a transmitter to a receiver. The five *propagation modes* are space wave, surface wave, sky or ionospheric wave, scatter, and satellite transmission. The best mode for a particular communications link depends on the carrier frequency of the transmission and the distance involved.

Methods of Propagation

When the transmitter and receiver are located in *line-of-sight* of each other, with no obstruction between them, radio waves can propagate in a straight line, although a radio wave (or wave) reflected from the ground is also possible (Fig. 1).

The direct line-of-sight wave and the ground-reflected wave are known collectively as the *space wave*. Those are obviously not the only two paths of travel possible, otherwise no radio signal would reach a point such as R^1, over the optical horizon of the transmitter. One mode of over-the-horizon propagation is the *surface wave*, which travels in close proximity to the Earth's surface and follows the curvature of the Earth (Fig. 2).

Fig. 1



Radio waves may also reach a receiver by being reflected from the ionosphere, a region of charged particles in the upper atmosphere. The radio wave, in this case, is referred to as the *sky wave*, and follows the path shown in Fig.3.

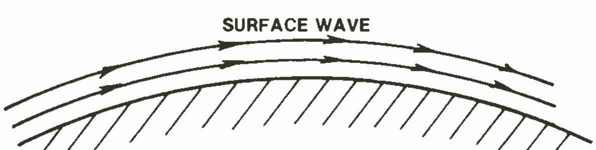


Fig. 2

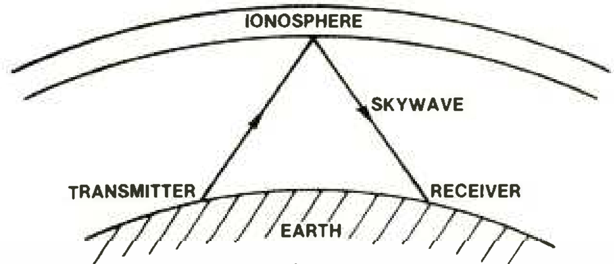


Fig. 3

In addition, radio waves can be transmitted far beyond the optical horizon by *scatter propagation*. Although not a reliable method of propagation, because of variations in the scattering properties of the atmosphere, it is used when other methods are not available.

Finally, the newest method of radio propagation involves Earth satellites. An artificial satellite placed in orbit at an appropriate height above the Earth picks up the transmitted signal, amplifies it, and then retransmits it back to Earth (Fig. 4).

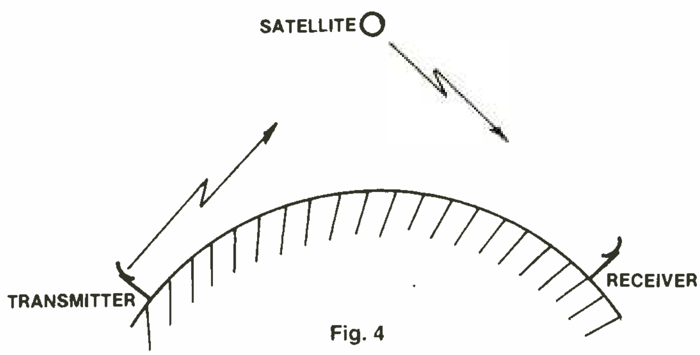


Fig. 4

Surface Waves

At frequencies below about 500 kHz, practical vertical antennas are very small compared to a wavelength. The wavelength (λ) of an electromagnetic signal is given by:

$$\lambda = 300 \div f$$

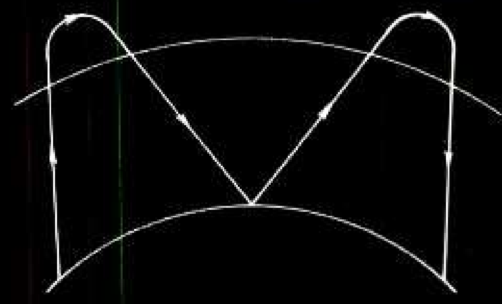
where λ is the wavelength in meters when the frequency (f) is given in MHz. At 500 kHz, that works out to be 600 meters. A full-wave vertical antenna would have to be 1,968.5 feet tall, and they are practical at selected transmitting sites only.

Practical antennas are smaller than that and, under those conditions, the wave reflected from the ground and the direct wave cancel each other out, leaving only the surface wave. A

*Original article appeared in *Electronics Australia*, December 1984 edition, and appears here by permission.

Radio propagation is considered by many to be a complex and difficult to understand subject. We unveil the simple facts and discuss the various modes by which radio signals are transmitted.

By Elmo Jansz, VK7CJ



radio wave consists of an electric field and a magnetic field. The electric field is perpendicular to the surface of the Earth and antennas used for surface wave propagation are generally vertical metal towers.

As the surface wave moves away from the transmitter, the magnetic field is cut by the surface of the Earth, and that leads to induced current being generated in the Earth's surface, which amounts to a power loss. The power is lost to the ground as the surface wave moves forward and the resultant effect is that the surface wave tilts over as it moves forward and could eventually be totally absorbed (Fig. 5).

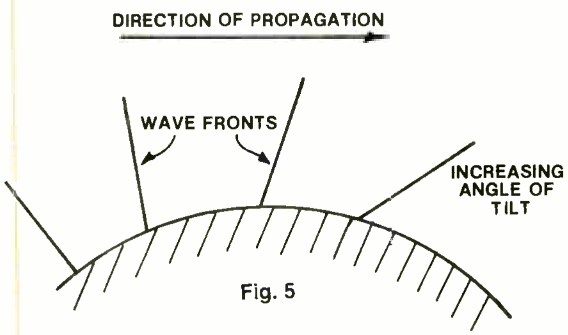


Fig. 5

The extent to which the surface wave is attenuated depends on the type of surface it passes over. When propagation takes place over sea water, which is a good conductor, and the frequency is below about 100 kHz, the surface absorption and attenuation due to the atmosphere is very small, and the angle of tilt is the only limiting factor!

The angle of tilt is directly proportional to the frequency. At the low-frequency end of the spectrum, waves are able to travel very large distances, even right around the Earth, if the transmission conditions are correct.

Frequencies in that band are, thus, particularly useful for maritime communications and worldwide time and frequency standards. Ships use about 10 to 100 kHz for navigation and communications, and shore-based time and frequency standard stations use fairly high transmitter powers—generally about 1-million watts—to reach ships at sea.

The Omega navigation system uses VLF radio waves to communicate with submarines at depths of up to 500 meters. (The submarine's towed antenna is at a lesser depth than that, however). Omega stations operate on carrier frequencies between 10 and 14 kHz. By measuring the phase differences between signals from several Omega stations, a mobile receiving station can establish its position quite accurately.

Similar considerations apply to the medium wavelengths. In such cases, the physical length of the antenna is made proportional to the wavelength, and practical quarter- and half-wavelength antennas are feasible. The amplitude-modulated broadcast bands used for domestic radio transmission are in that frequency range.

Ionospheric Propagation

The ionosphere plays a major role in transmission in the frequency range of 500 kHz to 30 MHz. The ionosphere is the upper region of the Earth's atmosphere in which gases are ionized by radiation from outer space, principally solar radiation. The region extends from about 30 km above the surface of the Earth.

The ionosphere itself is divided into several layers in which the maximum intensity of the ionization varies. These layers are designated D, E and F in order of height. During the daytime, the F layer splits into two separate layers called F1 and F2. At times, a peak electron density has been observed in the D layer, indicating that the region from 50 to 70 km above the Earth's surface could be considered as a distinct layer, the C region. Figure 6 shows a graph of electron density against height above the Earth.

Remember that Fig. 6 shows an average situation. The actual propagation conditions depend on many variables, some of the more common being time of day, seasonal influences, the latitude, and the 11-year sunspot cycle. Day-

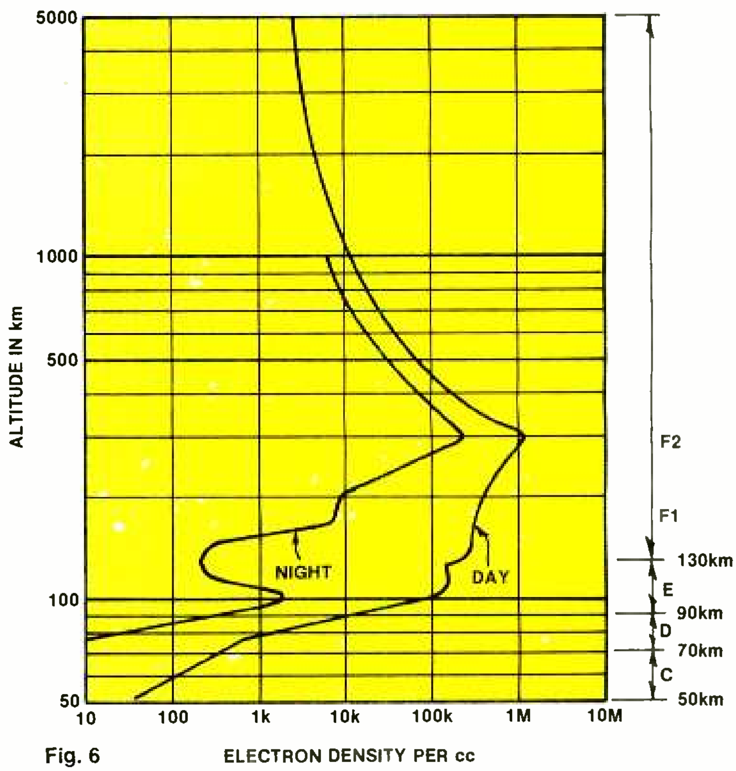


Fig. 6

to-day variations in the ionosphere are referred to as *diurnal variations*.

Let us briefly examine the mechanism that gives rise to these layers. At great heights above the Earth, the ionizing radiation is quite intense, but the atmosphere is rarified. Consequently, the few gas molecules present cannot create a significant ionization density.

As the height decreases, the atmospheric pressure and the ionization density increases until a height is reached where ionization is at a maximum. As the height is further decreased, atmospheric pressure increases but the ionization density decreases, because the ionizing radiation is absorbed in the process of ionizing the upper atmosphere.

The existence of several layers is explained by the fact that the atmosphere is made up of a mixture of gases, each of which behave in a different manner when exposed to ionizing radiation. Fig. 7 shows the relative positions of the various layers.

The D layer is the lowest of the recognized regions, lying between 70 and 90 km above the Earth. The atmosphere in that region is comparatively dense and ions rapidly recombine to form uncharged molecules. Maximum ionization is at noon, diminishing as the sun sets and vanishing completely at night.

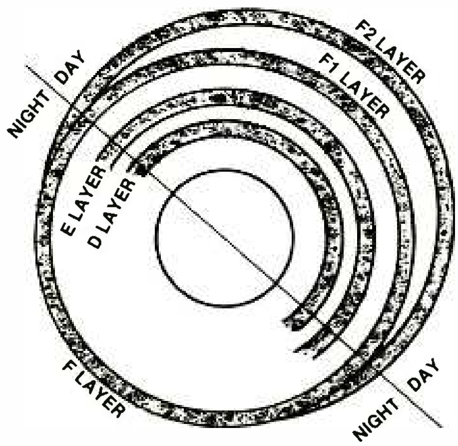


Fig. 7

The D layer completely absorbs frequencies below 2 MHz, so broadcast band transmissions are not reflected during the day. At night, the D layer disappears and medium waves are reflected off the next layer above, the E layer. Thus, the range of medium-wave stations is considerably increased, allowing interstate broadcast-band stations to be heard during the night.

The E-layer lies between 90 and 130 km above the Earth. Its ionization increases from sunrise to noon, reaching a maximum at noon. The E-layer also remains weakly ionized at night.

The F-layer is the region of the atmosphere between about 130 km and about 500 km. At night, a single layer occupies that region but, during the day, the F-layer splits into two layers called the F1 and F2 layers. The F2 layer has the highest level of ionization.

Maximum Usable Frequency

The highest frequency that is reflected from a given layer when the transmission is perpendicular to the layer is called the critical frequency, given by the formula:

$$f_{CRIT} = 9\sqrt{N}$$

where N is the electron density of the region under consideration.

The *Maximum Usable Frequency* (MUF) is the maximum frequency that can be reflected off a particular ionospheric layer. The actual frequency of transmission is generally chosen to be about 15% less than the MUF. Whether or not a wave will be reflected off a particular layer depends also on the angle of incidence. The Fig. 8-a diagram shows what happens when the angle of incidence remains fixed but the frequency is changed. In Fig. 8-b, the diagram shows the situation when the frequency is kept fixed and angle of incidence is varied.

The MUF and the critical frequency are related by the equation: $\text{MUF} \times \cos i = f_{CRIT}$

where i is the angle at which the wave enters the ionized layer.

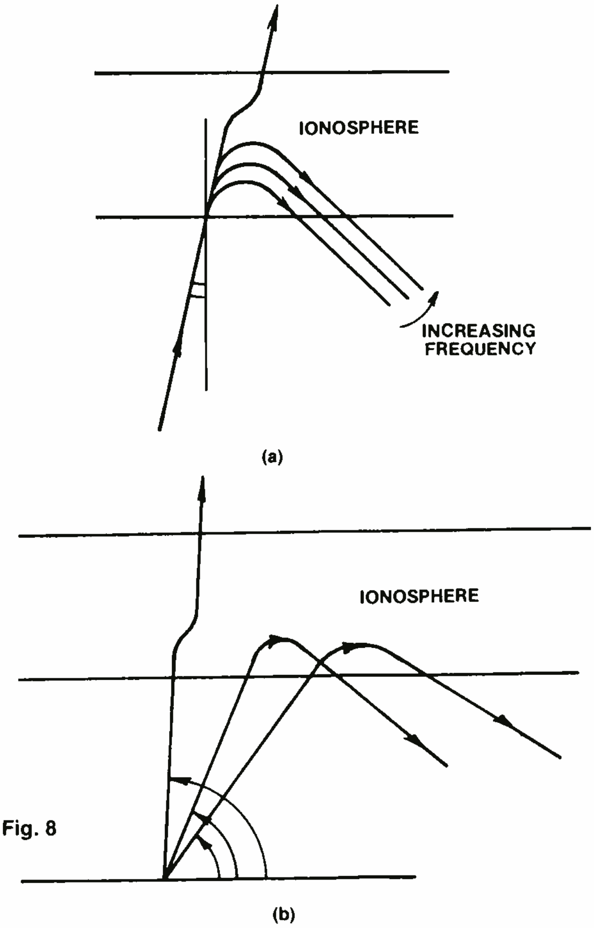


Fig. 8

Virtual Height

Virtual height is the height from which the radio wave would appear to be reflected if it had undergone a perfect (mirror-type) reflection (Fig. 9). However, the wave does not undergo a perfect reflection, but allows a curved path such as A-B-C-D-E. The actual height from point C to ground is, therefore, *less* than the *virtual* height, *h*. *(See page 38)*

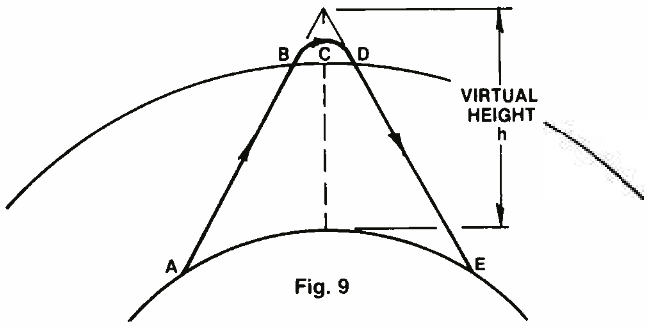
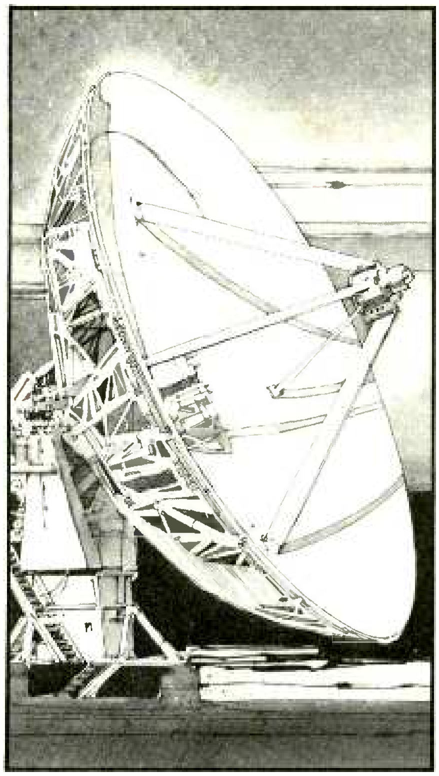
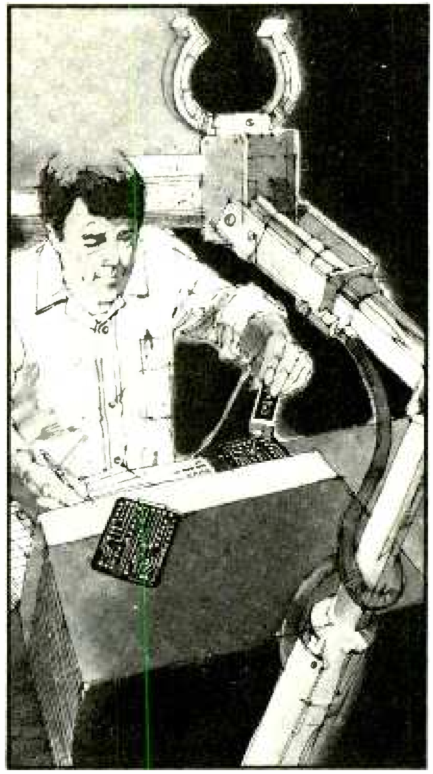


Fig. 9





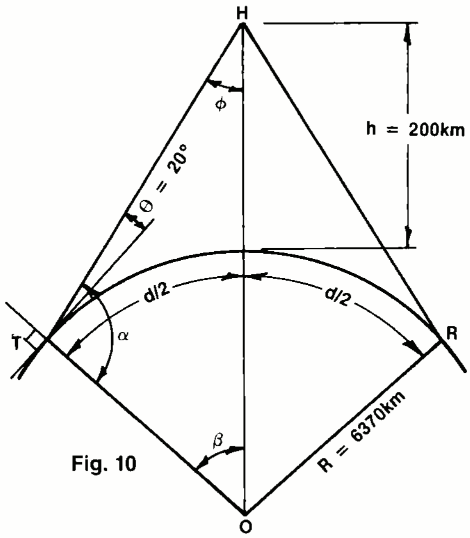


Fig. 10

The virtual height is, however, used in calculating the transmission path between two stations. In Fig. 10, the transmission path between transmitter (T) and receiver (R), as measured along the surface of the Earth, is shown as d. θ is the angle made by the antenna main beam at point T, h is the virtual height, and R the radius of the Earth.

The transmission path (TR) can be calculated as follows:

$$\text{angle } \alpha = 90° + 20° = 110°$$

$$\text{and side OT} = R = 6370 \text{ km}.$$

The angle ϕ can be found from the sine theorem:

$$6570/\text{Sin } 110 = 6370/\text{Sin } \phi$$

which gives $\phi = 65.65°$. Thus, β is equal to:

$$180 - (110 + 65.65) = 4.34°,$$

or .0758 radians. TR can now be found from the equation:

$$\text{Angle in radians} = \text{Arc/radius}.$$

Thus, $.0758 = (d/2)/6370$, ie. $d = 965.9$ km, which is the path TR.

Measurement of virtual height is usually carried out by an instrument called an *ionosonde*. A pulse of about 150 μs is transmitted vertically upwards. The reflected wave is received very close to the transmission point and the time required for the round trip is measured. The virtual height is given by:

$$h = Ct/2$$

where C is the speed of light and t is the time in seconds.

The *ionosonde* can sweep over a frequency range, for example 1 MHz to 20 MHz, in about three minutes and has facilities for plotting virtual height against frequency, resulting in a plot that's called an *ionogram*.

There is a minimum distance over which communication at a given frequency can be established by means of the sky wave. Usually the MUF is used for the link. If an attempt is made to shorten that distance by using a smaller angle of incidence, the radio wave will not be returned from the ionosphere, but will pass through it and into space. That minimum distance is called the *skip distance* (Fig. 11). For a certain transmission frequency, each ionospheric layer has a different skip distance.

For communication between two points separated by more than about 4000 km, two or more hops are required as shown in Fig.12. The number of hops possible depends on the transmitter power and the losses at each ionospheric reflection and surface bounce.

Ionospheric Disturbances

The ionospheric variations described above are not regular or smooth as assumed, and calculations based on those assumptions yield only approximate results. Some irregularities travel through the ionosphere at speeds greater than 1 km/s and are referred to as *Travelling Ionospheric Disturbances*, which have not been fully determined, although some contribution is assumed to be made by gravity, electric currents, plasma instabilities, and solar activity.

Complete loss of signal has been observed to accompany solar flares. Those fade outs occur very suddenly and are known as *Sudden Ionospheric Disturbances* (SID's). They are also referred to as Dellinger fade outs and Mogul-Dellinger fade outs, after Dellinger and Mogul who observed them in the U.S. and Germany respectively.

During solar flares, protons are also emitted by the Sun, and reach the Earth about 30 hours after the flare, affecting the Earth's magnetic field, which results in what is termed a *magnetic storm*. Magnetic storms affect radio waves, especially at higher latitudes.

Another form of ionospheric irregularity is called *Sporadic-E*. Thin, highly-ionized regions are formed in the E-layer that can reflect very high frequency signals, which would normally pass through the ionosphere. Those irregularities are formed with no periodicity; hence, the name, *sporadic*. Due to those *freak* conditions, distant VHF TV stations can sometimes be received.

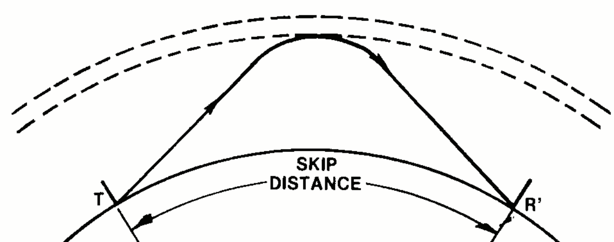


Fig. 11

Ionospheric or sky-wave propagation has been used since the early days of radio, when large distances had to be covered. Recent applications of satellites have overshadowed some of them but, because of its low cost and simplicity, sky-wave propagation continues to be used. Radio amateurs use sky-wave propagation to achieve world-wide communication with very modest transmitter powers.

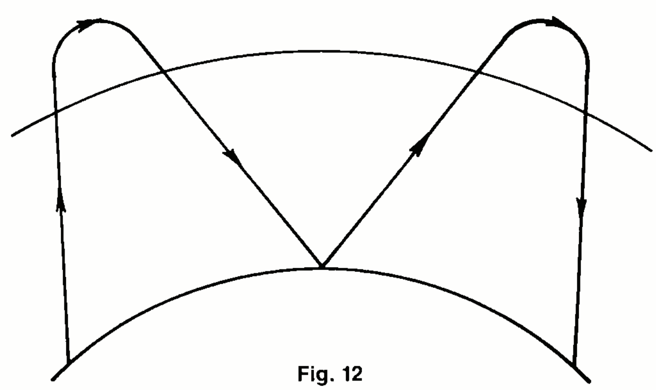


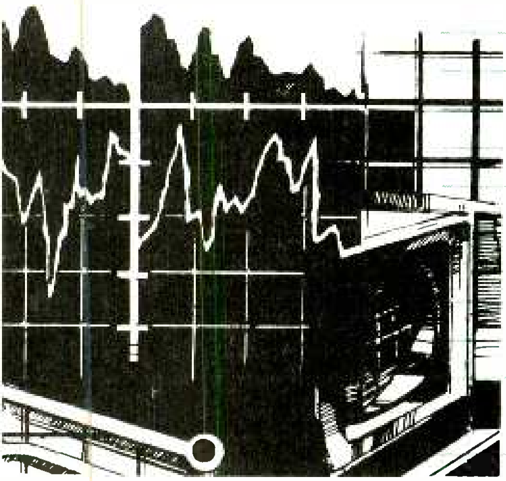
Fig. 12

Probably the major application, and the one that will continue for many years, is that of marine communication.

The Space Wave

Sky-wave or ionospheric propagation is not possible at

(Continued on page 104)



INSIDE THE OSCILLOSCOPE

The difference between oscilloscopes can be found in their specifications and features. This article tells you about those characteristics that affect performance.

By Marge Gustafson*, Larry Johnson*, and Carl Laron

EXAMINE THE CATALOGS OF ANY TEST-EQUIPMENT MANufacturer or distributor and you will find a multitude of different oscilloscopes. The reason for that, of course, is that each oscilloscope is better for some particular application than others. At one end of the scale, you'll find the inexpensive "hobbyist" models that are suitable for occasional workbench use. At the other end, you will find the multi-thousand dollar laboratory models. The differences between them are features and specifications. But what are those features and specifications, and which ones are most important in determining which scope is right for you? We will answer those questions for you in this article.

Bandwidth

The most basic oscilloscope specification is vertical bandwidth. When deciding between scopes, that specification is your best indication of whether or not a particular scope is suitable for your application.

The vertical amplifier of an oscilloscope is designed so that its frequency response remains more or less the same until it reaches some point, known as the 3-dB, or half-power, point. At that point, the displayed vertical signal is down 3 dB (or at −3 dB) with respect to a low-frequency reference voltage (see Fig. 9). At frequencies higher than the 3-dB point, the oscilloscope's response will roll off at a rate of approximately 6-dB-per-octave. Oscilloscopes that have a roll-off that is considerably higher than 6-dB-per-octave will have trouble reproducing the high-frequency components of complex waveforms. Those with a roll-off rate that is considerably lower than 6-dB-per-octave will suffer from overshoot on pulse signals.

It is obvious that the wider the bandwidth the more versatile the oscilloscope. Also, it is obvious that the wider the bandwidth, the more expensive the oscilloscope. That is so because it is expensive to produce a vertical amplifier that has nearly flat response across a wide bandwidth. Thus, unless you have money to spare, it pays to consider carefully how much bandwidth you really need. For general experimentation, or occasional TV or audio equipment troubleshooting, a bandwidth of 15 MHz or so should suffice. If you regularly service video equipment, or work with digital equipment, a higher bandwidth will probably be needed.

*Tektronix, Inc.

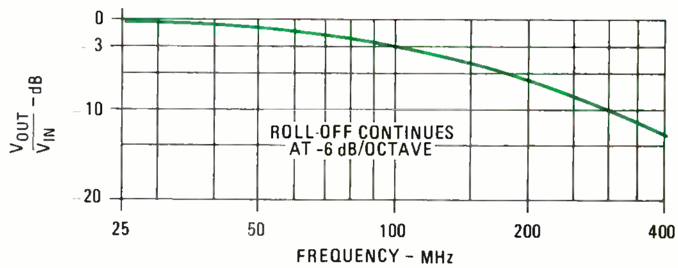


Fig. 9—The vertical amplifier of an oscilloscope is designed so that its response is reasonably flat to a point know as the 3-dB point. That point defines the oscilloscope's bandwidth.

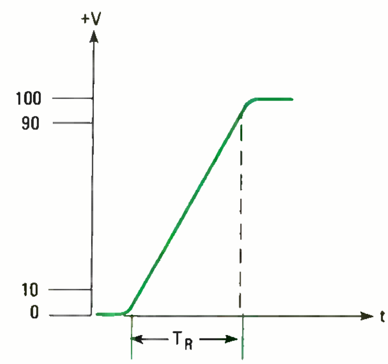
Comparing oscilloscope bandwidth ratings is not always as simple as it should be. That's because all manufacturers do not quote the specification in the same manner. While most use the 3-dB point as the upper bandwidth limit, some use 3.5, 4, and even 6 dB. While the specification might be accurate, a bandwidth that is specified as being 4-dB down at 50 MHz is not the same as one specified as 3-dB down at 50 MHz. Use of non-standard specifications can stretch the bandwidth by 50%, or even more.

When working with computers, or other digital equipment, a second specification, closely related to bandwidth, becomes important. That specification is *risetime*. Risetime is defined as the period required for the leading edge of a pulse to rise from 10% to 90% of its ultimate level (see Fig. 10). It is related to bandwidth through the relationship:

$$T_R = 0.35/f + rt1$$

where T_R is the risetime in seconds, and f is the bandwidth in MHz.

Fig. 10—Risetime is defined as the time it takes for a pulse to go from 10% of its ultimate value to 90% of that value.



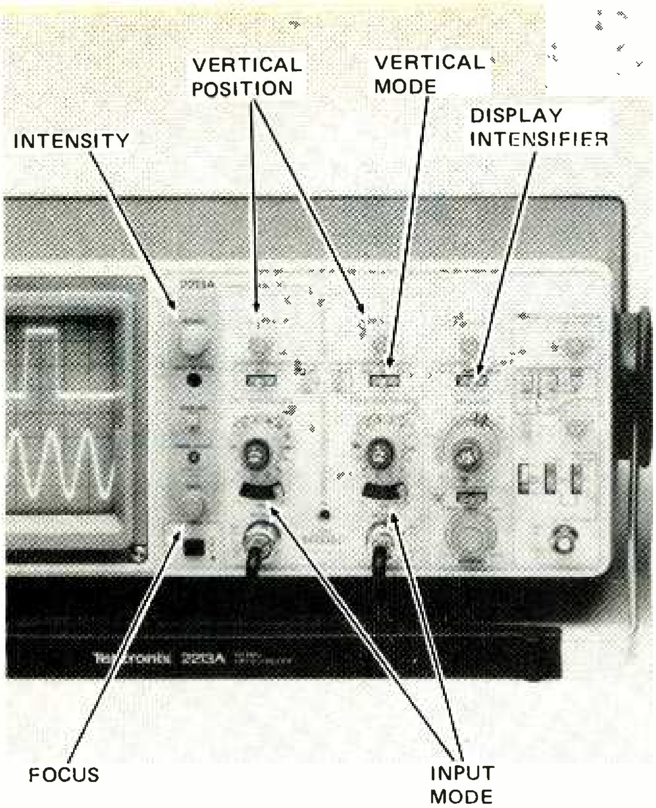


Fig. 11—The Tektronix *2213A*. Note the input mode selector switches, as well as the other key features.

To examine short-duration pulses, such as the rapidly changing digital logic-levels within a computer, you need a scope with a wide-enough bandwidth to display those pulses without distortion. For example, to see pulses with a 5-nanosecond (ns) risetime, an oscilloscope with a 70 MHz bandwidth is required ($.0000005 = 0.35/f$; $f = 0.35/0.0000005 = 70$).

Oscilloscopes come with vertical amplifiers that are AC coupled, via a coupling capacitor, or both AC and DC coupled (no coupling capacitor). The chief difference between the two is that the DC component is filtered out when the scope is used in the AC mode. Generally, all but low-cost units offer both coupling modes.

When operated in the AC-coupled mode, the oscilloscope will have an upper 3-dB point determined by the vertical-amplifier's frequency response, and a lower 3-dB point that is determined by the low-frequency reactance of the coupling capacitor. That lower 3-dB point is generally between 2–10 Hz. In addition, in the AC coupling mode, the peak input must be specified. That peak input is typically 400–600 volts AC plus DC.

Oscilloscopes that offer both AC and DC coupling have an input mode selector switch (see Fig. 11). That switch will usually have a third position labeled "ground." That position disconnects the vertical amplifier from the input connector and simultaneously grounds the input to that amplifier. That setting allows the 0-volt position of the trace to be noted.

Sensitivity

Almost as important as bandwidth is the specification known as *input sensitivity*, or *deflection*. That specification refers to the minimum signal voltage required to produce a useable deflection on the scope's CRT display. Generally, that deflection is defined as one graticle division (usually one cm).

As should be obvious, a scope with a sensitivity specification of 2-mV/cm is more sensitive than one with a sensitivity of 5-mV/cm. But sensitivity specifications are given in both peak-to-peak (p-p) and root-mean-square (rms) voltages. There is a significant difference. To make a meaningful comparison, you can convert rms to p-p by multiplying the rms rating by 2.8. For example, a scope rated at 2-volts rms would be rated at 5.6-volts p-p (2.8×2). Thus, a scope rated at 2-volts rms is not as sensitive as one rated at 5-volts p-p (5.6- vs. 5-volts).

Bear in mind that it is difficult to do any meaningful analysis of signals that are only one division high. Usually, you will want the signals to be at least two divisions in height; four divisions of height will allow you to see most signal details. On the other hand, the higher the sensitivity, the more expensive the scope.

You can determine the sensitivity of the scope by looking at the vertical amplifier control. The lowest setting on that control is the vertical sensitivity of the oscilloscope. If the scope has a vertical magnifier, divide that lowest setting by the magnification factor. Thus, an oscilloscope that has a minimum setting of 5-mV/cm, and a 5× magnifier, has a minimum sensitivity of 1-mV/cm.

Input impedance

For almost all applications, an oscilloscope with a high input impedance is desirable. That prevents the oscilloscope from affecting the circuit that it is being used to test. These days, almost all oscilloscopes have an input impedance of one Megohm (one-million ohms).

Triggering

Most sophisticated oscilloscopes provide several trigger options to make the unit more versatile. Those options include positive- or negative-slope triggering, triggering level, trigger signal source (external, internal, power-line, etc.), and more.

As with the vertical amplifier, sensitivity and bandwidth are used to describe trigger circuitry performance. Generally speaking, sensitivity should be sufficient to allow a stable trace of one division or less to be displayed. Trigger bandwidth defines the highest frequency that can be displayed with any degree of stability at the oscilloscope's minimum deflection. That specification determines the ability of an oscilloscope to trigger on complex waveforms, and the stability of the display of such waveforms. Generally, the trigger bandwidth should be at least as wide as the vertical bandwidth. Anything less than that will provide unacceptable results when viewing complex waveforms. On the other hand, a trigger bandwidth of twice the vertical bandwidth will provide outstanding results.

Features

As important as specifications are, it is often the features that make an oscilloscope either suitable or unsuitable for a particular application. Let's briefly go over some of those features and their use.

Last time, we looked at the two methods oscilloscopes use to display two simultaneous traces—alternate and chopped. In addition, all dual-trace scopes are capable of displaying only one channel at a time.

More sophisticated oscilloscopes offer yet another option, called *add*. In that mode, the two signals are added algebraically, and displayed as a single trace. Most often, oscilloscopes equipped with that option also provide a control that allows you to invert the polarity of one of the traces.

When that is done, and the signals are added, the parts of the signal that are common to both inputs are not displayed—only the parts of the signal that are different are seen (see Fig. 12). That allows for easy comparison of the inputs.

Voltage calibrators are found on many oscilloscopes. They provide the user with an easy way to check the accuracy of the oscilloscope's vertical amplifier and permit compensation of the probes. (If probes were ideal, no such compensation would be needed. However, real probes have some capacitance that can cause distortion of the displayed waveform. As a result, most oscilloscopes use probes that have a compensation adjustment to counteract that effect.)

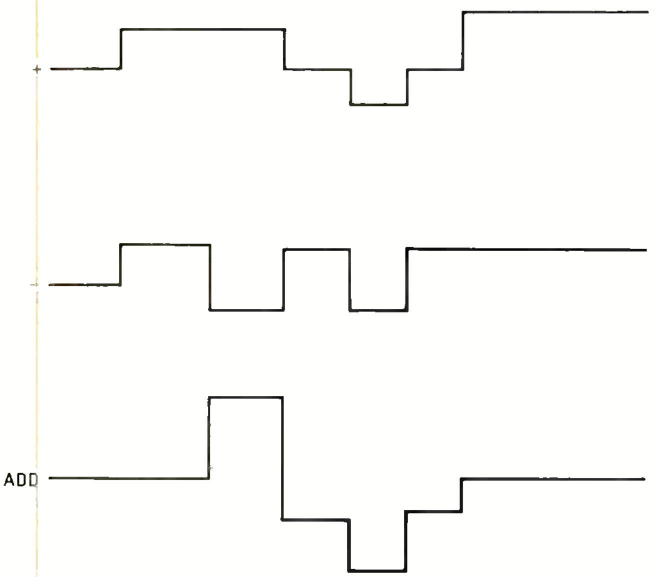


Fig. 12—In the add mode, the two channels are added together algebraically. If one of those channels is inverted, that mode is useful in comparing the two input signals.

If you expect to see the fine details of a display, you need a trace that is as sharp as possible. A trace that is unacceptably thick can hide such things as ringing and overshoot. Most scopes have adjustments that are used to control the characteristics of the trace. Those are focus, intensity, and astigmatism. The purpose of the first two of those is self explanatory. The astigmatism control is used to shape the beam into a perfectly round dot.

Most oscilloscopes have controls that allow you to adjust the horizontal and vertical position of the traces. Units without such controls have limited versatility. You should also be sure that those controls allow you to position either trace anywhere on the screen.

Most dual-trace oscilloscopes offer an X-Y mode. In that mode, one channel serves as the horizontal channel. That mode allows you to use a triggered scope in the same manner as an older recurrent-sweep oscilloscope with separate horizontal and vertical inputs. That mode can be used to examine Lissajous figures, phase differences, vectorscope displays, etc.

As we saw last time, the graticle is the grid that is placed on the face of the CRT. But how that grid is placed there can sometimes affect the accuracy of the oscilloscope. If there is any space at all between the graticle and the face of the CRT, a considerable parallax error can be introduced. Because of that, the graticle must be placed as close to the face of the CRT as possible. In addition, a parallax error can even be caused when the graticle is placed directly on the face of the

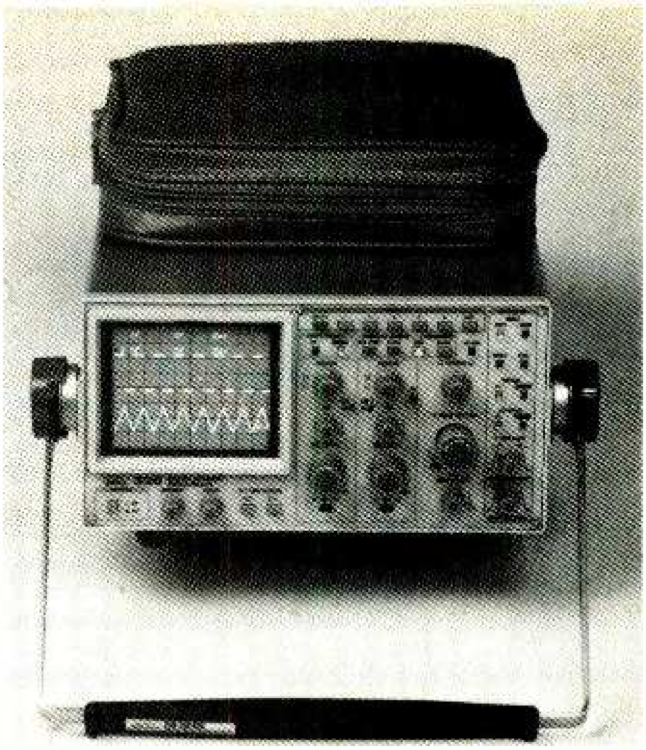


Fig. 14—The Tektronix/Sony 1336. This scope features an on-screen alphanumeric display and digital trace storage.

CRT. That error is caused by the thickness of the glass itself. (Remember, the display is generated by exciting phosphors that are located on the inside surface of the glass.) Thus, the most accurate displays are obtained on oscilloscopes that have their graticle etched on the inside surface of the glass. However, such tubes are expensive.

To make the lines of the graticle stand out, some more expensive oscilloscopes offer an illuminated graticle. There are many methods through which that can be achieved. One is simply to flood the graticle with light. A better method is to ground the edge of the graticle and light that ground edge. On graticles where the lines have been etched rather than painted, that method will result in a very uniform display.

Delayed triggering, or gating, allows you to observe, in a horizontally expanded format, only the portion of a waveform that is of interest. It does so by delaying the triggering of the scope until a particular point in the waveform is reached. Thanks to the inclusion of a display intensifier, or marker, use of delayed triggering is fairly easy on most scopes. The latter is used to mark the portion of the waveform that is of interest. Once that is done, the delay time, which is actually the timebase you wish to use to view the selected portion of the waveform, is chosen. You then activate the delayed triggering option and the display opens up and shows the selected portion of the waveform in detail.

The above are some of the more basic oscilloscope features; there are, of course, many more. Some oscilloscopes include built-in DMM's. Others offer on-screen alphanumeric readouts (see Fig. 13), color displays, the capability to store traces in memory, multiple-trace (4, 8, or even more) displays, and just about anything else you can think of. Some of the newest oscilloscopes are even using digital signal-processing techniques. In such a scope, a measured trace can be manipulated and displayed in an almost unlimited number of ways. Unfortunately, those oscilloscopes are prohibitively expensive at present for most applications.

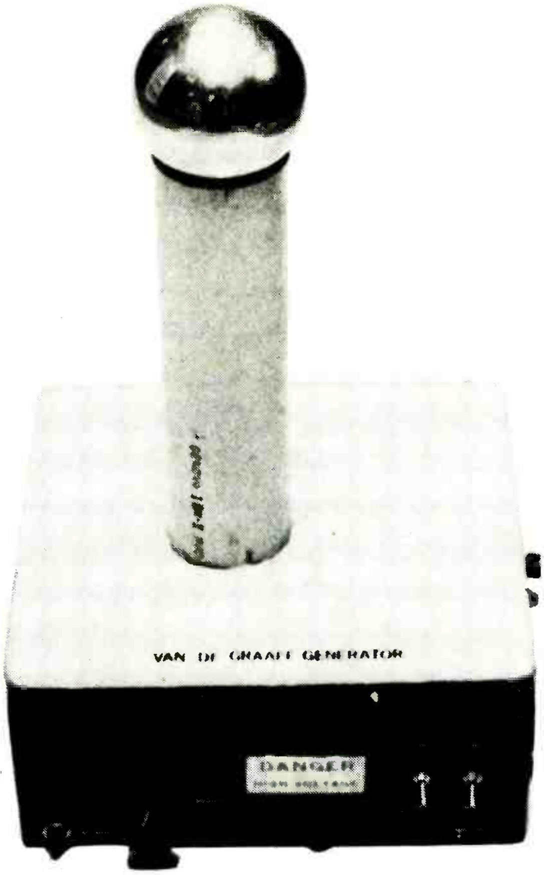
Now that we know how an oscilloscope works, and what its various specifications and features mean, it's time to learn how to use one to its best advantage.

BUILD THIS

VAN DE GRAAFF GENERATOR

This amazingly simple device produces electrostatic effects beyond your wildest imagination, as static charges seem to fill the air

By D. E. Patrick



ANYONE WHO'S INTO ELECTRONICS FROM A HANDS-ON point of view (no pun intended) enjoys almost any unusual gadget that's apt to cross his path, whether it has some practical application or it is strictly a conversation piece. And if you're familiar with, or are curious about, the Telsa Coil (or have built one), then you'll probably find pleasure in building your own, working Van de Graaff Generator. Pound for pound, it develops even higher voltages than the Telsa Coil and is considerably safer to operate.

What It Does

A Van de Graaff Generator (see Fig. 1) is a high-voltage electrostatic generator in which electrical charges are carried to a metal sphere or collector by a rubber charging belt. The rubber belt is positively charged at the base of the generator by a high-voltage power supply that is connected to a wiper that rubs against the belt. The belt, which is wrapped around a motor-driven pulley in the base of the generator and an idler pulley at the top, carries the positive charges to the metal sphere where a second wiper removes the charges, causing the sphere to become highly charged.

The charges collected by the sphere are prevented from returning to ground by the insulating qualities of the charging belt, which passes through an insulating column or cylinder supporting the sphere. The voltage rise at the sphere is directly proportional to its diameter, but will be limited by leakage or sparkover through the air and down insulators to ground under no-load conditions. The power supply used can be anything capable of providing around 10,000-volts DC or more.

Other units similar in basic design to Fig. 1 can generate over 1,000,000 volts at standard atmospheric pressure. Also, generators, not too different from that unit, operating in pressurized gas mixtures with special insulating cylinders and other refinements, can produce voltages in excess of 10,000,000 volts. Even a mini, desk-top unit (see Photo) is capable of producing voltages in the 100,000-volt range. The upper limit is dictated by the diameter of the metal sphere collector, more than anything else. However, by simply scaling the basic parts shown in Fig. 3, you can build the monster of your choice.

Electromechanical Operation

Figure 2 shows a schematic of the power supply for the Generator. In the author's first working prototype, the high voltage required was provided by a 10,000-volt, 30mA sign transformer (the type used for neon lighting fixtures). Other high-voltage transformers suitable for our purpose include converted flybacks, auto spark coils, cannibalized supplies from copy machines, TV's, etc.

If desired, the sign transformer's primary voltage may be optionally adjusted using a variable transformer as Fig. 2 shows, or it may be connected directly to line voltage through a suitable fuse and/or switch. The author opted for the former. The variable transformer allows adjustment of the sign transformer's secondary voltage from around 0 to 10,000 volts. The sign transformer's output can be rectified and used directly, or passed through a voltage doubler or tripler from an old color-TV set. As shown in Fig. 2, that arrangement provides an adjustable output from around 0 to 30,000 volts.

In any case, a high positive potential (voltage) is applied to a charging belt (which can be an oversized rubber band) by a metal wiper in the the base of the Van de Graaff generator (see Fig. 1). Those positive charges are carried up to the metal sphere and removed by a second wiper, which is also the idler pulley.

If the idler pulley is metal and has metal-sleeve type bearings, the top side wiper can be eliminated as long as there is good electrical contact between the idler pulley and the sphere. There's nothing critical about the sphere; in fact, two copper bowls soldered together, or stainless steel bowls welded together, etc., will all suffice. We'll elaborate on that a little later, but for now let's take a closer look at the mechanical part of the unit.

The Mechanical Operation

Figure 3 is a sketch showing the insulating column and

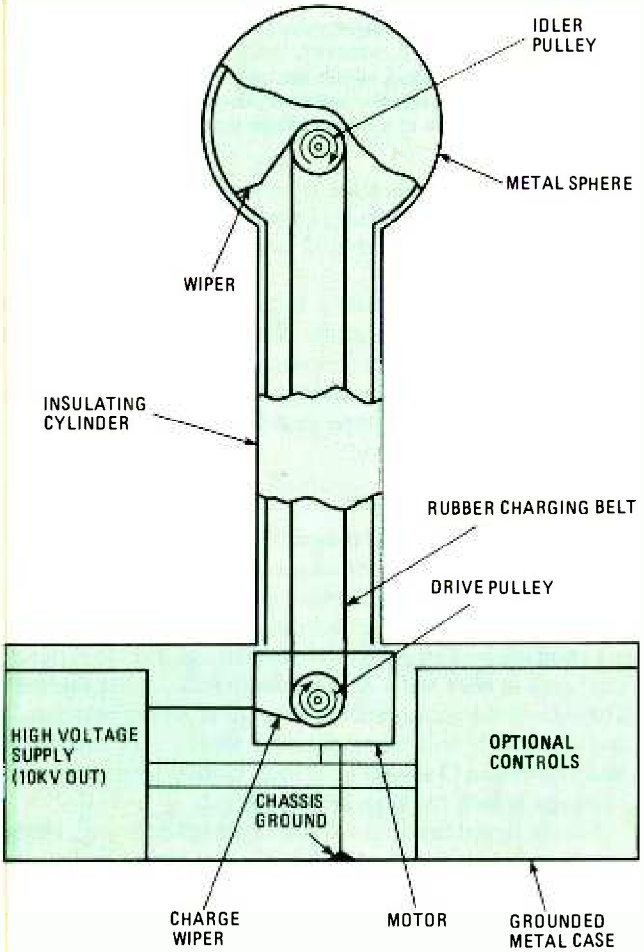


Fig. 1—Sketch showing the basic makeup of the Van de Graaff Generator. All the parts used to make the unit can be salvaged from old equipment that you may have laying around your shop.

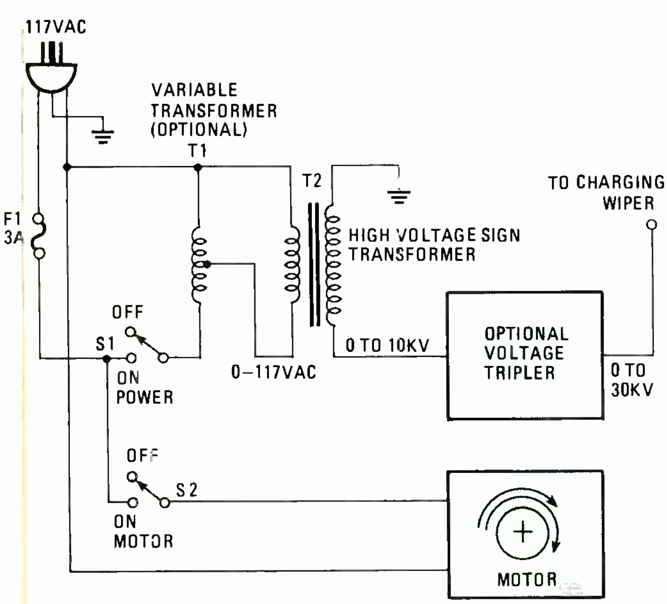


Fig. 2—Schematic of the power supply used in the Van de Graaff Generator. As can be seen, there is very little needed in the way of parts. The variable transformer, T1, is optional. T2, the sign transformer, is the type used in neon signs such as you might see in store windows; however, other high-voltage types may be used (see text).

spherical portions of the Van de Graaff Generator. Note that each element in the sketch is designated by a letter, which we'll use to call your attention to the topic area. As shown, power is applied to motor A, which drives a rubber charging belt (I) via pulley C, drive belt D, pulley E, a metal shaft (F), and pulley K. The motor is isolated from the high voltage supplied to wiper L at point M by a series of plastic or nylon pulleys—C, E, and K—along with drive belt D.

When the motor is energized, pulley C rotates, driving belt D, which then causes pulley E to rotate. Pulleys E and K are mounted on a common shaft (F), so that as E rotates so does pulley K, which sets charging belt I into motion. Shaft I, supporting pulleys E and K, goes through the insulating column (J) and is allowed to turn freely via sleeve bushings N and O on either side of the column. Charging belt I moves up through the insulating column to the metal idler pulley (P), which also acts as the second wiper. The idler pulley, attached to shaft Q, turns freely via another set of sleeve bushings, R and S.

Those bushings are part of a metal subassembly (T), which makes good electrical contact to the sphere (U). That subassembly (i.e., P, Q, R, and S) can be replaced by a fixed pulley and sleeve-bearing set. However, if the unit holding the pulley and sleeve bearings is made just large enough to slide sidewise into the sphere so that it catches the lips when turned around; the downward pressure of the charging belt will hold sphere and pulley assembly in place on the column. That method provides for easy belt replacement, while leaving the sphere seamless.

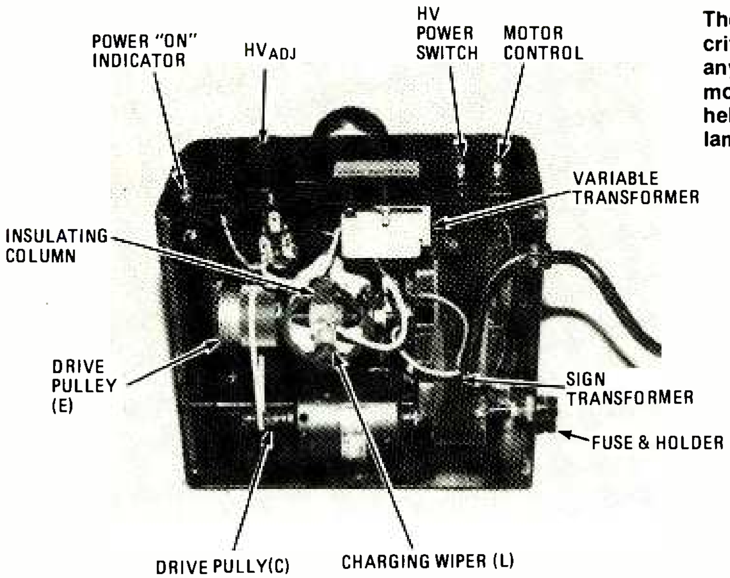
On the other hand, a much simpler approach would be to simply run the shaft through the sphere, albeit such an approach might not be esthetically appealing. In any case, the net effect of using several plastic pulleys allows the motor to be at ground potential, while keeping the high-voltage supply isolated. Of course, there are other ways of accomplishing that. A series of plastic gears, for example, might be

PARTS LIST FOR THE VAN DE GRAAFF GENERATOR

Metal sphere—float, bowls welded or soldered together, world globe (see text)
Insulating cylinder—OK to use PVC, ABS tubing,or Plexi-pipe
Pulleys—3 required, plastic or nylon, idler pulley located in the sphere metal
Wipers—2 required, spring steel, copper, beryllium, or brass.
Rubber belt—2 required, tape-machine belts or oversized rubber bands.
Charging belt should be as wide as feasible
Sign transformer—10,000-VAC secondary winding, Gateway Electronics (see text for substitutes)
Case—should be metal and grounded; size is not critical.
Fuse and holder, knobs, pilot light, line cord, hookup wire, hardware, etc.

OPTIONAL
3-ampere variable transformer
Voltage doubler—30,000 to 35,000-VAC, TV-type, doubler or tripler (see text)

A kit of parts is available from Electronic Technical Consultants: All parts needed to build a desk-top Van de Graaff Generator $75.00, postpaid.



The minimum parts count of the unit, along with its non-critical construction, allow the electronics to be built into any suitable housing available. Note that there are some panel-mounted components included, which are optional, but will also help to avoid accidental injury. For instance, the power-on lamp warns of the presence of a high-voltage potential.

used instead of pulleys and belts. Either system allows for motor-speed reduction if the pulley or gear on the motor drive shaft (C) is made small in comparison to pulley E. There's nothing critical about construction; any one of a number of possibilities can be used to achieve the same thing.

Where to get the parts

The simplest approach to getting the parts to build the Van de Graaff Generator is to order them. But you can usually save a few shekels by a little judicious shopping. Most of the mechanical parts can be found at your local hobby shop, with the exception of the sphere and insulating column. However, you can generally find a world globe at most stationery stores and the PVC (polyvinyl chloride) or ABS tubing at any hardware store.

On the other hand, the local *bone yard* is an even cheaper and sometimes better way to go, especially if you can find an old cash register, adding machine, copier, etc. Mechanical clunkers like those, recalled from a scrap heap, offer many possibilities as they are full of gears, belts, sleeve bearings, plastic pulleys, and the rest, if you don't mind getting your hands dirty.

The parts for the author's prototype came right out of surplus stores and scrap heaps. While the unit is not exceptionally fancy, it wasn't expensive either. The cheapest source of high voltage is an old neon-sign transformer or similar unit cannibalized from tube-type junk like a transmitter, TV receiver, etc.

Construction

Once you've found all the parts and pieces, assembly is a snap—especially when you take a few short cuts. And though the layout in Fig. 3 might look simple, it takes a little trial and error to work it out. Begin building the Generator by preparing insulating column J. Drill holes through the tube, punching holes in both walls and running parallel to its diameter. The size of the holes depends the size of sleeve bearings, N and O, which will support metal shaft F. The holes for bearings N and O should be drilled slightly smaller than the bearings, which can then be force-fitted.

Mount sleeve bearings, N and O; install pulley K, charge belt I, metal shaft F, and pulley E. You can either be very meticulous about mounting bearings N and O and pulleys K and E with hardware, or you can simply epoxy both bearings in place with a little plastic steel (as the author did). Install wiper L with screws, or you can slap on a little plastic steel to stick it in place.

With that done, set the column to the side and prepare the housing in which the motor and the electronics will be located. (Refer to photos). The housing will also support column J. First, drill an appropriate sized hole in what will be the top of the housing, through which column J is to be fitted and secured. Also make holes in the front panel to accommodate the controls: on/off switch for the power supply and another for the motor. If you've included a variable transformer in your design, its control should also be mounted on that panel.

On the rear panel, drill holes for the line cord, and panel mount the fuse holder. After which, mount the electronics—motor A, the sign transformer, variable transformer (optional), fuse and holder, voltage doubler or tripler (optional), etc.—in the chassis. Be sure to use a strain relief where the line cord enters the housing. Then connect the wires between the various elements.

Install pulley C on the shaft of motor A if you haven't already done so. Then

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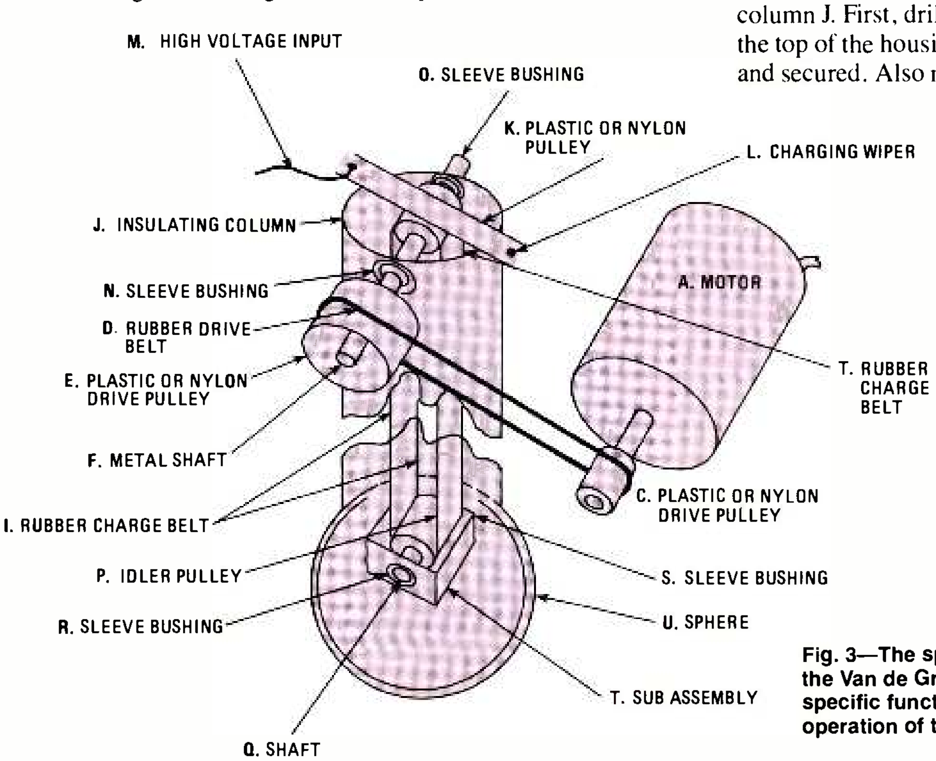


Fig. 3—The spherical and cylindrical sections of the Van de Graaff Generator; each element has a specific function that is vital to the safe operation of the generator.

Let's talk about...

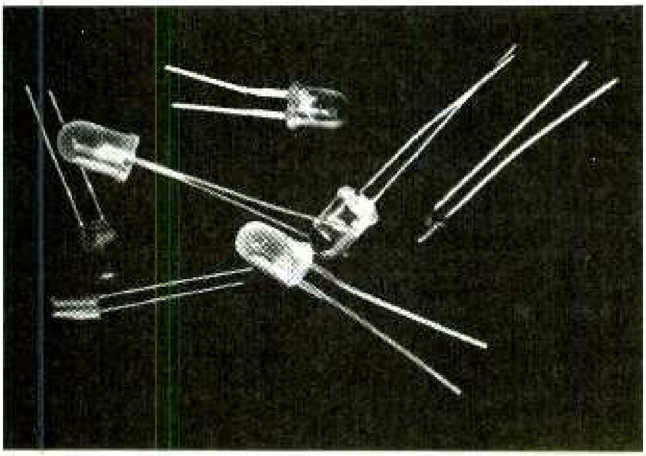
GETTING PARTS for HOMEBREW PROJECTS

By Herb Friedman

Getting the most for your hard-earned dollar, when it comes to electronics parts, isn't as straightforward as it may seem. Know what you're doing before you put your money on the line!

BECAUSE OF THE LARGE VARIETY OF COMPONENTS USED IN hobbyist projects and the manner in which they are usually sold, it's often difficult to assemble a project without making substitutions or running up the cost beyond what the device is worth. In the so-called "Golden Age of Projects" (which in this era of high prices is difficult to believe ever existed), essentially *all* the components that might be used in consumer, commercial, and hobbyist equipment and devices filled a catalog of about 175 pages. It listed every conceivable kind of resistor, capacitor, coil, tube, transistor, hardware, fitting, cabinet, panel and power-supply component. And better still, it was often possible to purchase many of those parts from your local radio-and-TV repair shop.

Today, just the catalog of available integrated circuits fills more than 1000 pages; and even if you had the catalog, it's an odds-on bet that it would be next to impossible to find anyone to sell a single unit of anything. That's because the electronics marketplace is oriented primarily toward the large-volume commercial user: Most parts distributors have a minimum order of 100 pieces, and when there's no minimum-quantity restriction the distributor might require a minimum order of $25, $100, or even $200. In practical terms, the marketplace has given the hobbyist the short end of the stick. But even when faced with quantity and price restrictions, there are ways for the hobbyist to get parts easily and at a reasonable price or, at worst, substitute an equivalent for a device that's generally only available to commercial users.



To start with, whether you're primarily interested in saving on the overall cost, or don't care about cost but just want the project to work when you've made the last solder joint, the first thing to do is to build a project the way the author said to build it. What many hobbyists don't realize is that to be reasonably certain a magazine project or circuit will deliver the performance claimed by the author, most editors require a working model before a construction article is published. In that way, the editor can be certain the project will work and deliver the performance claimed for it.

It is only when a hobbyist makes unauthorized substitutions in order to use parts he can easily obtain locally, or tries to force a substitution in order to use parts from the junkbox that a project won't work, or gives marginal performance. For example, over the years this author has written hundreds of projects; and with rare exceptions (usually caused by typographical errors), problems have been traced to unauthorized substitutions.

These seven LED's are from a 10-for-$1 assortment. All are defective. Active components from a "bulk budget package" or kit should be checked before you use them in a project, because many often prove to be defective, and they are often difficult to locate once soldered into a circuit.

A Case in Point

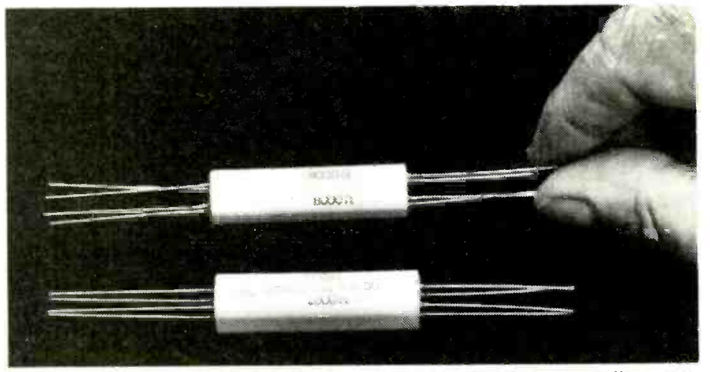
In particular, I remember a short-wave booster project that used three transistors, two RF coils, three resistors, and two capacitors. The project should have been absolutely trouble-free; yet, we got the usual assortment of requests for aid. One letter, especially struck the editor's interest because the builder enclosed two "letters of commendation," one from a local TV repair shop certifying that the project was assembled correctly as per the article; the other from the reader's High School science teacher, an ex-engineer (according to his letter) certifying to the excellence of his student's assembly.

Essentially, the hobbyist wanted us to service his project (at no charge) because he believed there had been an error in the article. Now, no magazine nor author is in the service business; we don't check or repair projects either for free or for a fee. But since we knew that hundreds of other readers had built the project successfully, we couldn't resist seeing a defective project to which a service technician and an engineer had affixed their stamp of approval. We told the reader to send in the project and we would take a look at it.

First off, instead of the *Do Not Substitute For...* printed-circuit assembly that was specifically recommended, the builder had hard-wired the components as a mobile: There was no chassis or support of any kind—we could have suspended it on a string for use as a wind chime. Also, totally incompatible substitutes had been used for the three transistors; not one resistor value was within 10% of the value specified in the parts list, and the the coils were only "heaven knows what." The only parts that matched the published Parts List were the capacitors. We never did understand how the builder got two testimonials to his technical ability.

Making Substitutions

One of the first problems you'll run across in building many projects is getting solid-state devices: Unless the project uses digital devices or components available from Radio Shack, you might have a hard time getting the exact part. Digital devices aren't usually a problem because the marketplace is literally drowning in a sea of surplus digital hardware:



When you need a wirewound power resistor having a generally unavailable value, you can use a special kind of multivalue resistor to create the desired value. That IRC resistor actually contains four individual 10-watt wirewound resistors, any of which can be wired in series, parallel, or series-parallel to obtain standard values in the 10% tolerance ranges.

Everything from UART's (Universal Asynchronous Receiver/Transmitter) to memory chips are available at bargain prices. Just turn to advertisements in the back pages of **Hands-on Electronics** or **Radio-Electronics** magazines when you need digital devices. The biggest problem you're likely to have will probably be caused by a minimum-order limitation, which we'll get to later.

Analog components such as transistors, many diodes, SCR's, and thyristors are a whole 'nother ball game. If it's a popular device, like the 1N914 or 1N4004 diodes, or a 40673 FET, or a 2N2222 bipolar transistor, or a 555 timer, it will most likely be listed by the same distributors who advertise digital devices. The less well-known components, or digital devices used primarily in a single commercial instrument, often prove next to impossible to locate or obtain because it simply doesn't pay for a distributor to tie up his money stocking parts for which there will be, at best, only a slight demand. That's where many hobbyists pull out something from the junkbox and assume it's a substitute because it (what a laugh!) has the same lead arrangement as the required component.

There Really Is Great Similarity

While there are presently thousands upon thousands of solid-state devices, many differ so slightly in characteristics

The solid-state substitutes in the Sylvania and RCA replacement series are identified either by their Sylvania *ECG* or RCA *SK* number. The RCA line also provides the ECG identification. Since both are intended for professional service technicians the packaging provides important data as well as all possible lead configurations for the substitutes you can use.

that for many applications they *are* direct substitutes. Although it's true that the operating characteristics between apparently similar solid-state devices can be significant, they rarely have any affect on circuits not specifically tweaked for their characteristics. For *general use*, the thousands upon thousands of solid-state devices can be represented by a small selection of general replacements. Unfortunately, "general replacement" is a much abused term: For example, there is no way a general replacement transistor with a gain, expressed as *beta* (β), of 50 could be a substitute for a transistor with a beta of 500, but that's what's being sold by some well-known distributors.

When you *must* substitute for a solid-state device, you'll probably wind up with the correct part if the substitute comes from the RCA or Sylvania replacement line. Both RCA's SK and and Sylvania's ECG replacements are *prime* stock—not rejects or overruns—because they're intended for service technicians who cannot fuss or gamble with parts that might not work. The replacements must be close enough to the original component to work in both consumer and commercial equipment; therefore, you are almost guaranteed a quality part. In fact, often the replacement is the original component marked with the general-replacement part number, the actual difference being the price. The advantage to using RCA or Sylvania general replacements is that you can be reasonably certain you are actually using the same or an acceptable substitute for the components specified for a project.

Replacement IC's

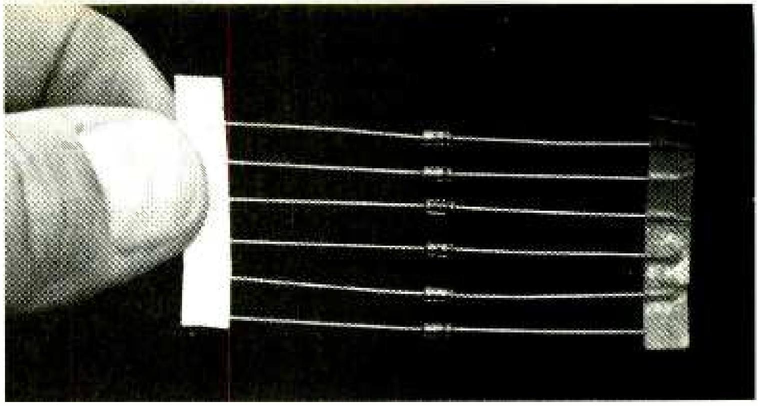
While thumbing through an RCA or Sylvania replacement guide, you're sure to notice that there are substitutes for certain integrated circuits and wonder "How can that be?" Many IC's, particularly analog types, are manufactured under different identities, or are marked with a manufacturer's proprietary identification. Also, the same component with a different lead configuration will have a different part number.

The RCA and Sylvania replacement guides list or cross-reference both the industry standard and some of the more common proprietary identities, so if you can't locate the exact IC specified for a project, check for a "universal replacement." If there is some variation in an electrical parameter that might influence performance, both the RCA and Sylvania guides will call attention to the discrepancy (which isn't true of most most general-replacement guidebooks).

Watch Out for the Electrolyte

Capacitors are also a troublesome and often expensive component. As a general rule of thumb, except for high-frequency RF circuits, almost any kind of small, non-polarized capacitor can be used: ceramic, disc, Mylar, *poly*, it doesn't matter. On the other hand, circuits often are very fussy when it comes to electrolytic capacitors: low-cost substitutes can often result in an inoperative project. While, we normally use conventional electrolytic capacitors for bypassing, most digital circuits call for the relatively expensive Tantalum capacitor.

For the hobbyist, the major differences between the Tantalum and the electrolytic capacitor is that Tantalum's more



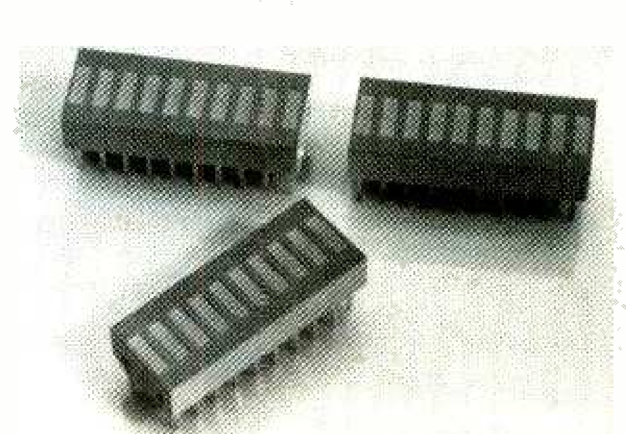
When you're offered a jumbo package of parts at a cheap price, you can usually be certain the parts are OK if they are secured on both ends to a strip of tape. The strip means that the parts came from a standard "ribbon" that's used when parts are inserted into PC boards by automated machine.

effectively bypass the higher frequencies (it is almost 10 times more efficient) and it's of higher density (meaning small size). Value for value, a Tantalum is considerably smaller than an electrolytic. While you can usually substitute a Tantalum for an electrolytic, it doesn't work the other way round. If you substitute an electrolytic for a Tantalum in a digital circuit, you can have unwanted glitches floating in every power and signal wire. That's because glitches are generally caused by high-frequency components that haven't been safely bypassed. (It takes a 10-μF electrolytic to provide the high-frequency, bypass efficiency of a 1-μF Tantalum capacitor.)

Resistors Are No Problem

If you browse through an industrial parts catalog, it might appear that there are more kinds of small resistors than there are stars in the heavens, but rarely is anything other than a conventional carbon or wirewound resistor used in a hobbyist project. At most, all you have to worry about is the power rating (1/10, 1/4, 1/2 or 1 watt) and the tolerance, usually 10% or 5%. Sometimes, a project will call for 1% resistors, which isn't among the most easy of items to locate. A more serious problem is wirewound power resistors with 5, 10, and 25-watt ratings: they're simply no longer all that common.

Very few parts distributors stock anything more than a handful of the most common values, and it's likely that you'll have extreme difficulty locating the specific value needed for a project. In such instances, your best bet is a distributor specifically catering to the TV service technician. TV's use many different kinds of power resistors, and TV parts distributors are sure to have a wide selection of values and ratings. They'll also have a somewhat unusual universal



Sometimes it pays to spend a bit more to get what you need. These surplus bar-graph LED displays cost slightly more than the separate standard LED's. But consider that the final project will look better, and it will be easier to assemble.

replacement wirewound resistor that really consists of four individual wirewound resistors of different resistances that the user can combine in series and parallel to create a broad range of values. A kit of five of those units can synthesize almost any conventional value from 1 ohm to 1 megohm, so if you're stuck for a wirewound, think in terms of a universal replacement.

The TV parts distributor is also the place to go when you need resistor values of less than 1 ohm, such as used in the emitters of audio power-amplifiers. Those values are also not the easiest to locate in power ratings greater than 1-watt, but they are commonly used in TV sets. Hence, your local parts distributor catering to the TV service technician probably stocks less-than-1-ohm resistors in a broad range of powei ratings.

It Gets Expensive

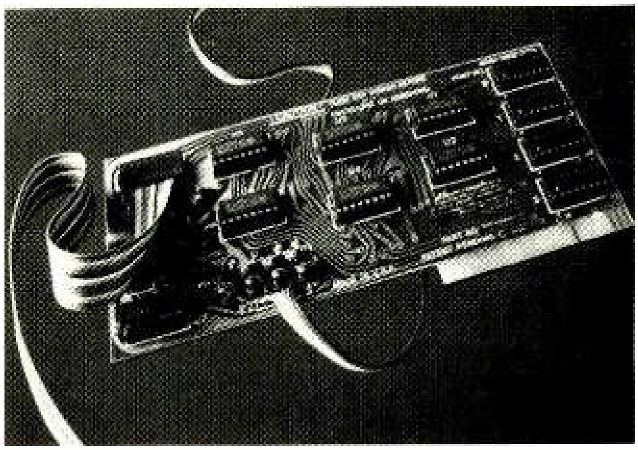
One of the problems with using only the parts specified in the parts list, or a direct substitute, is that for other than commonly used transistors and digital IC's, the devices tend to be relatively expensive; thus, the final cost of a home-brew project can exceed that of an equivalent commercial device. About the only way to make many projects cost-effective is to save on the non-critical components and to avoid repetitive shipping/insurance charges and minimum-order limits.

In addition, shipping/handling/insurance charges are now approaching $4–$5 even for small orders; often, they are 10% of the total order regardless of shipping weight or the actual insurance cost to the distributor. It would be nice to be able to say that you should order from a single source to avoid repetitive shipping charges. But, as we all know, it's almost impossible to find everything that we need at one distributor. It is often necessary to order from two or three sources. Also, many commercial-type components are available only from conventional parts distributors who have relatively high minimum-order requirements. ($25 is a large amount if all you want to purchase is less than $2 worth of transistors.)

In the "Good Old Days" of hobbyist construction projects, we used to suggest that hobbyists use minimum-order limits to stock up on commonly used parts, meaning just about anything. Today, however, the state of the art changes so rapidly that few active components—particularly integrated circuits—can be described as common. But there are devices that are easily substituted for specified components that can be stocked with some assurance that they won't soon become obsolete, since their tolerance limits are rarely critical.

That includes 5-volt three-terminal voltage regulators, the 1N4000 family of miniature silicon rectifiers, the 1N914 silicon signal diode, the 40673, MPF-102 and MPF-103 field effect transistors; any kind of 10K, 50K and 100K potentiometer, almost any value miniature electrolytic capacitor, almost any kind of low-cost SPST or DPDT subminiature toggle switch (with or without printed-circuit terminals), and any kind of ¼ or ½-watt assortment of resistors having the conventional 10% tolerance rating in resistance values like 470 ohms, 4.7K, 47K, 2.2K, 22K, 10K, 15K, etc. (Unusual resistor values such as 6580, 35,700 and 165,000 ohms are rarely convenient or useful.) If you must make up a minimum order, concentrate on the most commonly-used components. Avoid esoteric parts that might be great buys, but stand little chance of ever being used.

The RCA SK Series Semiconductor Replacement Guide lists more than 178,000 solid-state components, with cross references to devices produced by other manufacturers; even a cross reference to Philips ECG replacement products can be found between its covers.



There are many good buys in the surplus market of fully assembled printed-circuit boards packed with valuable IC's. Manufacturers can not afford the time to remove them, sort them, and go through a repackaging process, including testing, in order to put the chips back on the shelf for future use. As a bonus, you can obtain valuable connectors, headers, and other PC-mount parts which you would normally purchase.

Is Surplus Worth the Trouble

We used to suggest purchasing surplus printed-circuit boards and removing the parts. In the good old days, we could usually "prove" a 2-for-$1 printed circuit assembly could yield $25 or more in parts. Well, the good old days are long gone. The assemblies that you are likely to run across are often rejects or culls, and you can easily end up with an assembly whose active devices—which you can't easily test—are defective. (Do you have any idea what's it's like troubleshooting a homebrew project that contains several IC's when one or more of those units are shot before you fire up the circuit? You start out wondering, "is the trouble caused by a defective component, a wiring error, or a crack in a printed-circuit foil?")

Then there's the physical act of removing the parts from the board. The cost of the solder-wick or other device used for extracting components may be greater than the worth of salvaged parts, not to mention the problem of short leads. You might salvage a handful of resistors and capacitors only to find that their leads were clipped off so short as to render them useless, or that the parts are so old that the electrolytic capacitors are "dried out."

Most certainly, we all know several persons who have salvaged a king's ransom in parts from old printed-circuit

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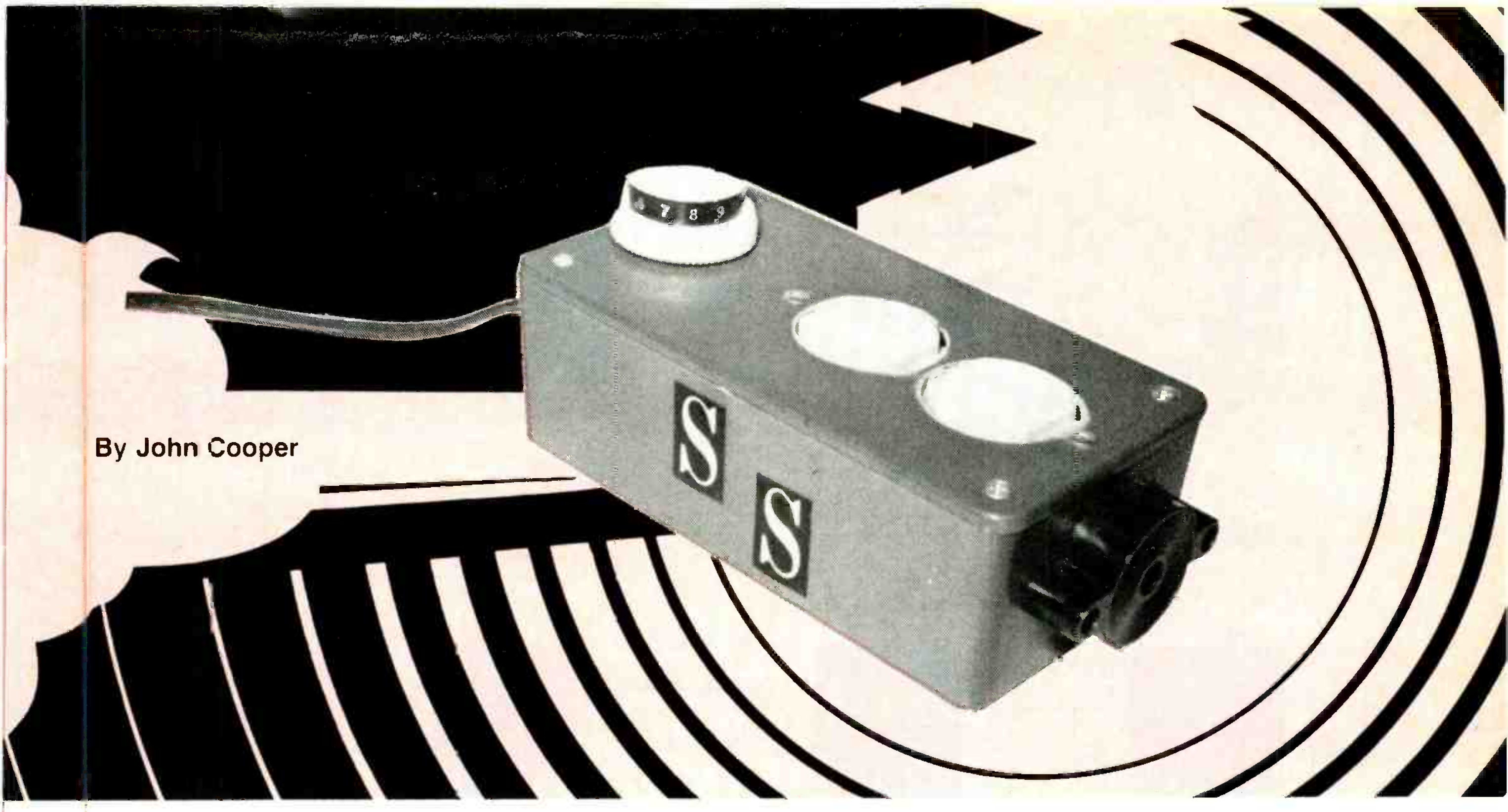

By John Cooper

BUILD THE SOUND SENTRY

This little device senses the creaks from the crunches and sounds an alarm when the noise is from an intruder!

ONE NIGHT WHILE YOU AND THE FAMILY ARE AWAY FROM home a shadowy figure slips quietly up to your back door. He hesitates for a moment as the bark from a distant dog bristles the hair on his neck. Then he goes to work with a small crowbar on the door latch. Suddenly, from within the house the lights come on. Voices are heard! Startled, the sinister intruder dashes away. You find out about the event when you return. A call to the police increased the patrol in your area. Damage to the door—a piece of molding and some scarred paint. That's a cheap price to pay considering the loss you could have suffered.

Your Sound Sentry is on the job—listening for noises that should not be there when you are away. Once the Sound Sentry is activated, it can switch on interior and exterior lights and activate the audio system. The Sound Sentry is an electronic, sound-activated, sound-selective AC outlet. At the sound of a knock at the door, window breaking, or other sounds not normally heard in an empty house, Sound Sentry turns on a lamp, TV set, a hi-fi in the den, and just about anything else you'd want to be energized to scare away an unwelcome visitor.

Building the Sound Sentry takes an evening or two and requires only a few readily available parts.

How It Works

Figure 1 diagrams the circuit for the Sound Sentry. Sound (noise) is picked up by the sensor element, PE1. A piezoelectric element is shown in the Fig. 1; however, a small crystal microphone or PM loudspeaker will work also.

The output of PE1 drives the inverted input (pin 2) of op-amp U1. A fixed positive voltage is applied to the positive input (pin 3) for the purpose of cancelling input signals caused by ambient noise and induced hum. Network R3-R4-C2 provides approximately 6-volts DC of bias for that purpose. Potentiometer R2 is used to adjust the gain of the U1 amplifier stage and thereby selects the sensitivity of the circuit to noises.

Noise signals from U1 are amplified to cutoff so that a random array of pulses are supplied to the 4017 counter/divider clock input (U4 pin 14) and a clear-counter circuit consisting of a ½-4013 flip-flop, U2-a, and, 555 timer trigger input (U3 pin 2).

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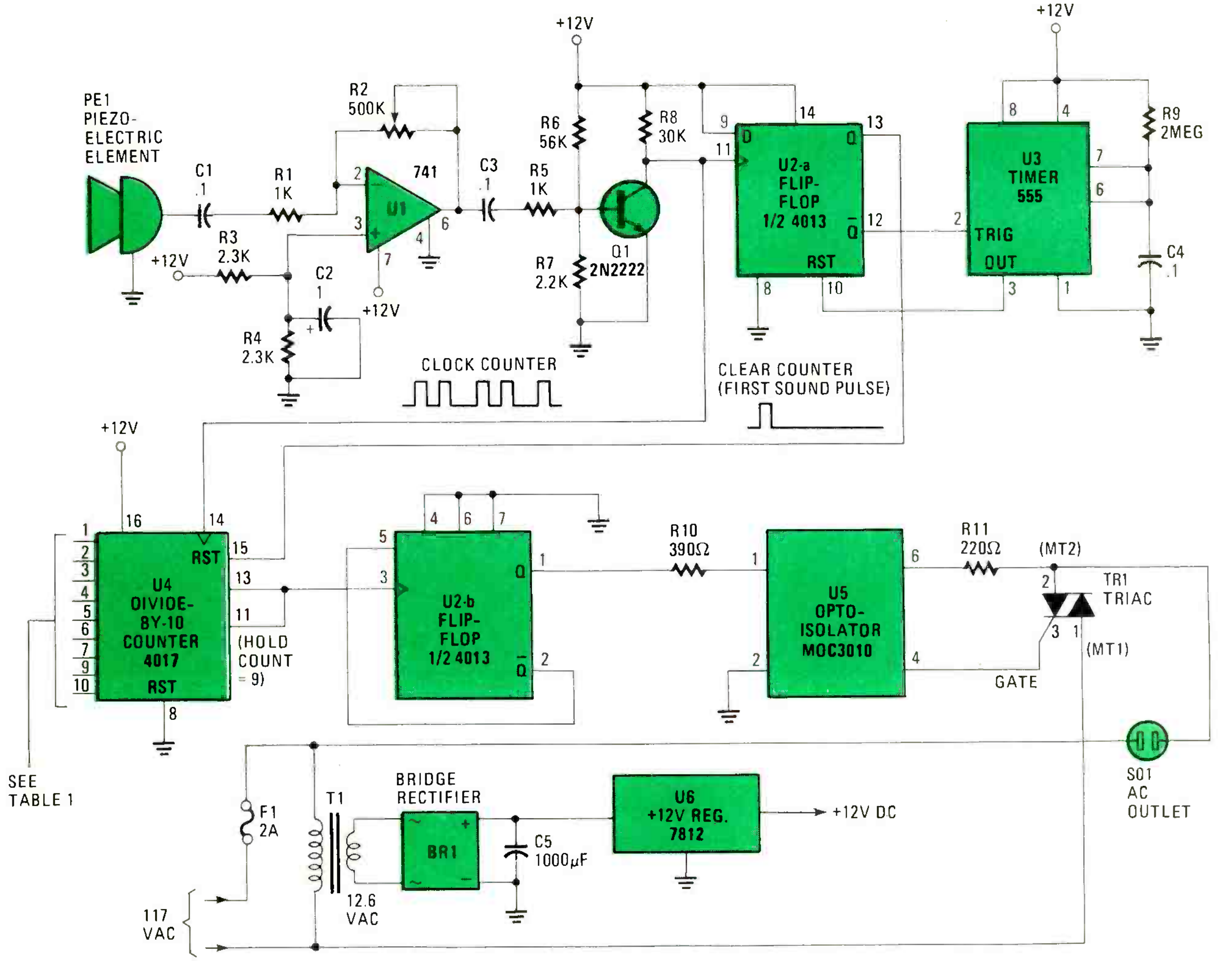
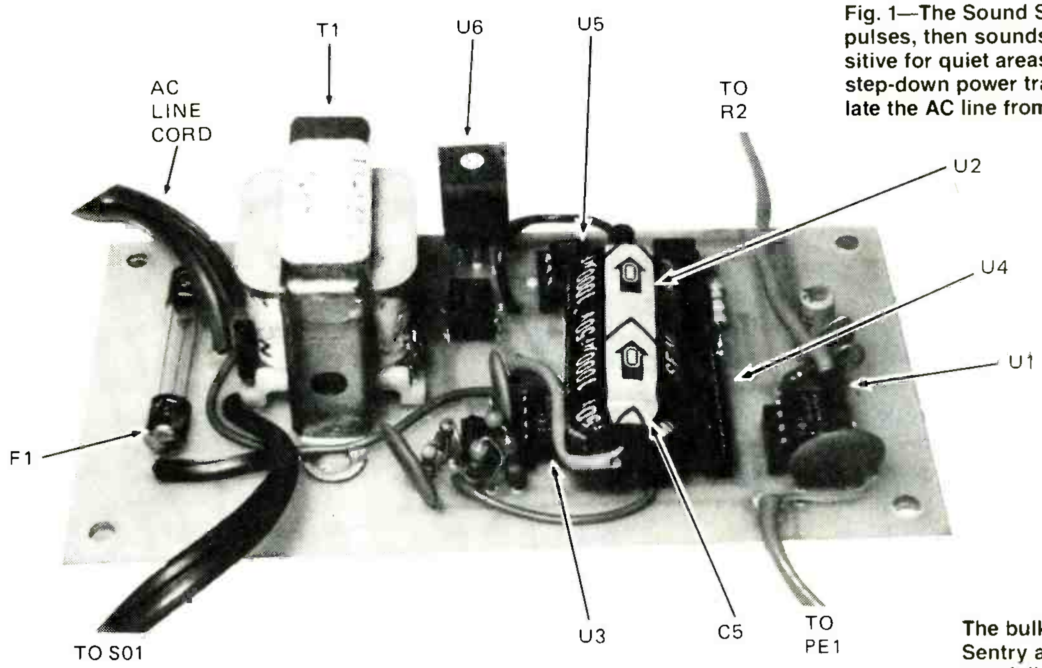


Fig. 1—The Sound Sentry detects and counts noise pulses, then sounds an alarm. You can make it sensitive for quiet areas. The optoisolator (U5) and step-down power transformer (T1) electrically isolate the AC line from the unit's internal circuitry.



The bulk of the parts for the Sound Sentry are soldered or secured to the non-foil side of the printed-circuit board. AC power from the line cord and to the socket (SO1) are on the left side of the board. Be careful here when soldering the stranded leads. The triac (D1) is not visible; it is mounted on the foil side of the board under the transformer (T1).

TABLE 1—U4 PULSE COUNT CONNECTION*

Pin	3	2	4	7	10	1	5	6	9	11
Count	0	1	2	3	4	5	6	7	8	9

*Connect pin 13 (ENABLE) to a pin above to obtain desired count.

PARTS LIST FOR SOUND SENTRY

SEMICONDUCTORS

DB1—Diode bridge rectifier (Radio Shack 276-1161, or equivalent)
PE1—Piezoelectric buzzer used as an audio sensor (Radio Shack 273-064, or equivalent)
Q1—2N2222 OR 2N2222A silicon NPN transistor
TR1—Triac rated at 6-A and 117-volts AC (Radio Shack 276-1001, or equivalent)
U1—741 operational amplifier integrated circuit
U2—4013 dual D flip-flop, integrated circuit
U3—555 timer, integrated circuit
U4—4017 divide-by-10 counter (with 1-of-10 outputs), integrated circuit
U5—MOC3010 opto-isolator (Radio Shack 276-134, or equivalent)
U6—7812 +12-volt regulator integrated circuit, 1 = A

RESISTORS

(All fixed resistors are ¼-watt, 5%, unless otherwise noted)
R1, R5—1000-ohm
R2—500,000-ohm, linear-taper potentiometer
R3, R4, R7—2200-ohm
R6—56,000-ohm
R8—30,000-ohm
R9—2000-ohm
R10—390-ohm
R11—220-ohm, ½-watt

CAPACITORS

C1, C3, C4—0.1-µF ceramic
C2—1-µF, 16-WVDC, electrolytic
C5—1000-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

F1—Fuse, 2A, type 3AG
T1—Miniature, step-down power transformer: 117-volts AC to 12-volts, 300-mA (Radio Shack 273-1385, or equivalent)
Plastic case (Radio Shack 270-223), line cord with molded plug, line-cord strain relief, fuse holder, dual AC outlet, knob, 2-conductor shielded cable, wire, solder, hardware, printed-circuit board material, etc.

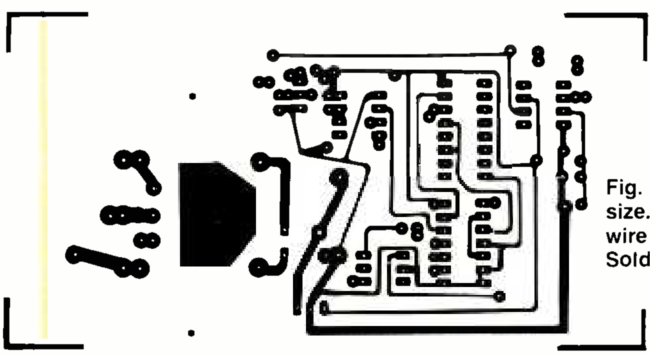
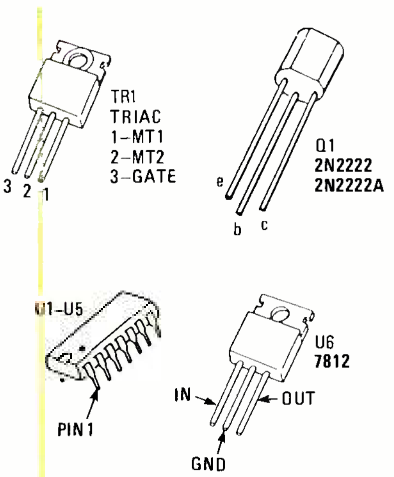
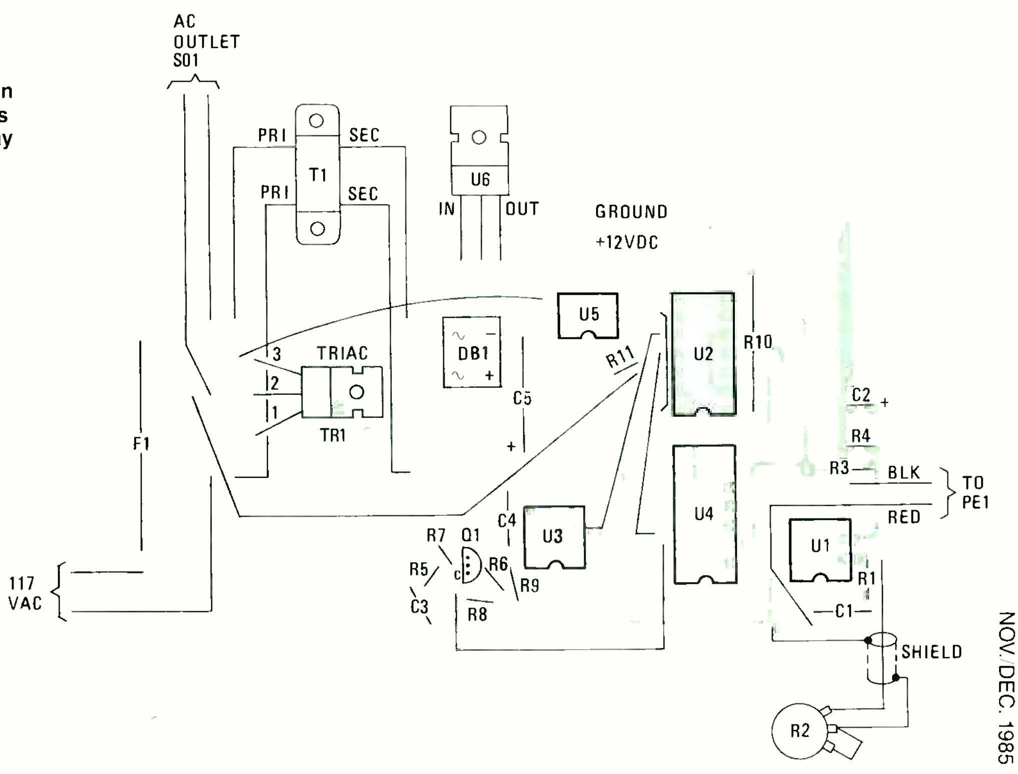
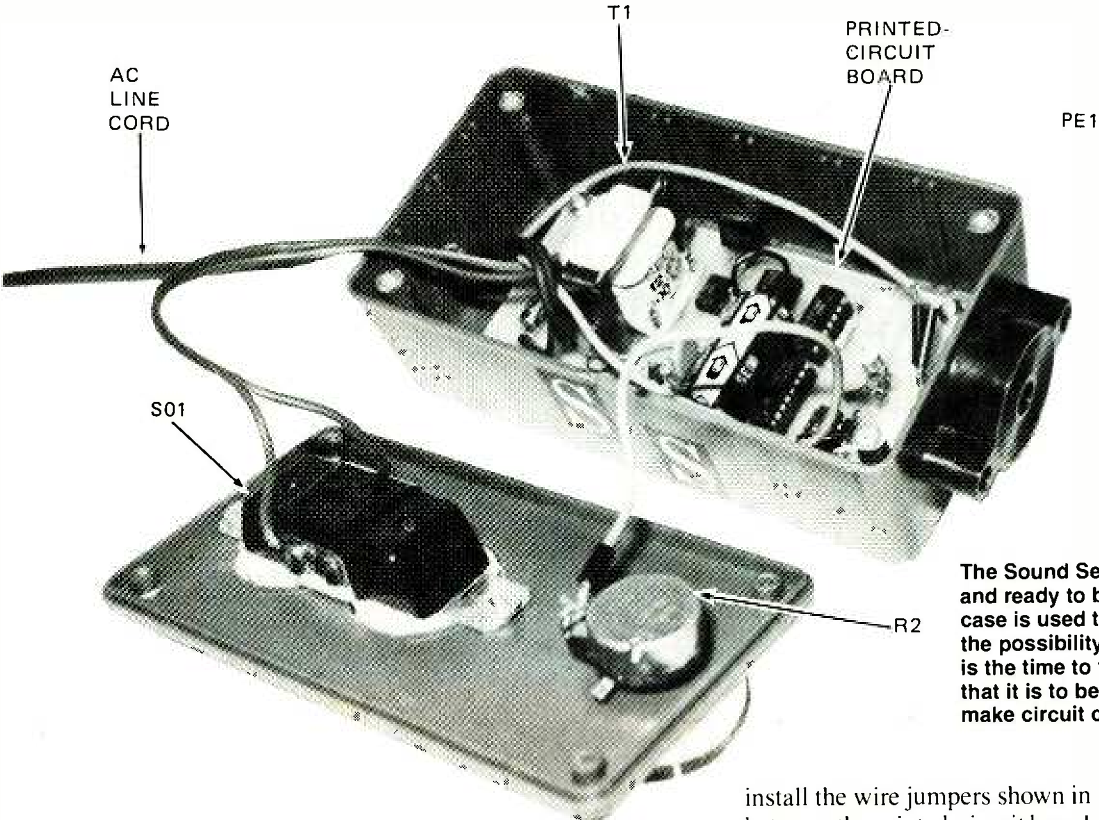


Fig. 2—The foil pattern for the printed-circuit board is supplied same size. Layout of parts is not critical so that should you decide to hard-wire or wire-wrap connections, you should experience no undue difficulties. Solder DIP components directly to the board; there is no need for sockets.

Fig. 3—An x-ray view of the printed circuit board with the foil side down is provided with the components shown in position. The polarized circuit elements are diagrammed for the novice who may experience some difficulty during the assembly of the unit. The large foil area with no connection holes (on the left side of the board as shown) serves as a heat sink for the triac.







The Sound Sentry is shown here all wired and ready to be buttoned up! A plastic case is used to house the unit and reduce the possibility of electric shock. Now is the time to test the unit in the area that it is to be installed. You may want to make circuit changes; see text and Table 1.

The output of Q1 fires single-shot circuit U2-a, and U3 on the first pulse of the noise train of pulses. The single-shot circuit sends a clear counter-pulse (from pin 13 of U2-a) to decade counter U4, pin 15. The pulse-counter stage is now ready to count pulses from the detected sound at PE1. Wired as shown in Fig. 1, pulse-counter U4 will count to nine and hold. The pulses that follow the noise burst will not generate additional clear-counter pulses until a delay determined by R9-C4 provides an output to U2-a to clear the U2-a flip for more flopping.

Smaller noise-pulse counts (clock counter pulses from Q1) can be used to activate U4 by breaking the connection at U4, pin 11, and connecting U4, pin 13, to the desired pin on U4 that will provide the count you desire. Refer to Table 1. For example: Connect pin 13 to pin 2 to hold on a count of 1. When 9 counts are used the lower number of stray noise pulses won't clock U2-b.

The output from U4, pin 11, toggles U2-b. Depending on the flip-flop state of U2-b, that action either turns electronic AC switch combination U5-TR1 on or off. U5 is a MOC3010 opto-coupler, and TR1 is a 6-ampere triac.

A 12-volt DC regulated power supply is added to the Sound Sentry board. That supply is permanently connected across the AC line. When the Sound Sentry is connected to an AC outlet, the total power used overnight is about one watt-hour. The Sound Sentry was designed to operate small non-inductive loads such as a lamp or TV and should not be used to control heavy-duty appliances. If you want to control inductive motors and high currents, use the switched AC from the Sound Sentry to the coil of a power-switching relay.

Putting It Together

The foil pattern shown in Fig. 2 is used to etch a 4¾- × 2½-inch printed-circuit board. The parts layout for the printed-circuit board is shown in Fig. 3. Don't forget to install the wire jumpers shown in Fig. 3. Use ⅜-inch spacers between the printed-circuit board and case, because triac TR1 is mounted on the bottom.

It is recommended that two-conductor shielded cables be used to interconnect both the piezoelectric element, PE1, and potentiometer R2 with the board. Solder the shield to the board's electrical ground. Use IC sockets and do not plug in the IC's until after the unit has been completed. Install U6 first and check the 12-volt DC output, to be on the safe side. Triac TR1 mounts on the foil side with its case soldered to the foil heat sink. Finally, mount all the IC's in their respective sockets.

Final Steps

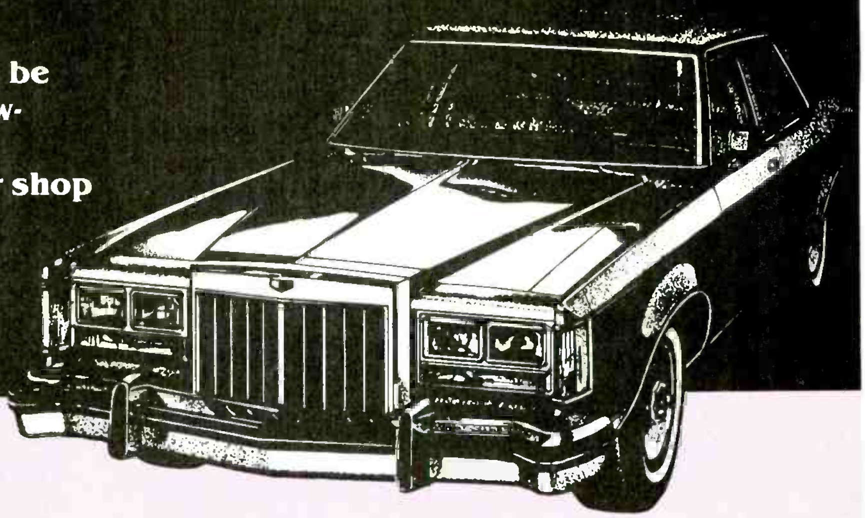
Use a 1⅜-inch chassis punch to make holes for the dual AC outlet, SO1. If you don't have that size chassis punch, use the largest drill bit available to make a starter hole and finish it off with a saber saw, going slow to avoid melting the plastic. Then use a file to smooth the edges. Should you do a sloppy job, fabricate a cover plate either from a brass, outlet, cover plate or piece of colorful plastic to fit over outlet SO1. Mount this cover plate using a screw to mate the threaded hole in the outlet.

For ultrasonic applications, a suitable transducer is needed in place of PE1 that will work at those frequencies. There are a number of ultrasonic transducers on the market, one of which is item No. J4-815 that sells for $9.50, plus $1.50 shipping, from Circuit Specialists, P.O. Box 3047, Scottsdale, AZ, 85257. Check their latest catalog. Circuit Specialists includes a simple one-transistor transmitter circuit diagram.

When you are testing the Sound Sentry, in or out of the case, remember that 117-volts AC is present. Take care! The life that you save may be your own! Check the sensitivity of Sound Sentry! The prototype detected hand-claps from 30-feet distance, making the unit suitable for senior citizens who can't get around too well, and for the bedridden.

The cost of automotive repairs can be astronomical, but with a little know-how, you can forego some of the all-too-frequent visits to the repair shop

By Herb Friedman



Use a DMM to Troubleshoot Your Car

THERE WAS A TIME WHEN A SIMPLE PUSH WAS ALL IT TOOK to start a car with a dead battery; when a squirt of "hot shot" (ether) starting fluid would kick the engine on a bitter cold morning; when almost any problem could be diagnosed by holding your ear against a screwdriver that was pressed against the engine. Today, you can't start a vehicle with an automatic transmission other than by the starter. You often can't "hot shot" start a car because computer sensors mounted above the carburetor aren't programmed for anything but gasoline; and a screwdriver pressed against the engine will tell you next to nothing because many modern-day car problems are electric and electronic rather than mechanical.

From the starting motor to the electronically-regulated battery charger; to the on-board computer that runs the fuel and engine systems; to electronic speed control, radiator fans, electronic radios, digital clocks, security systems; to power seats, windows, and even side-view mirrors, so much of the modern-day auto depends on electric and electronic systems that the ordinary service-grade multimeter is one of the most important troubleshooting tools.

While automotive electric/electronic circuits are usually so reliable that they are rarely given a second thought, they are extremely difficult and time-consuming for the average automobile mechanic to troubleshoot. Often they require the services of a specially trained and very expensive auto-electric specialist. Except for certain kinds of problems with an automotive computer system, most auto-electric problems can be easily resolved by the average electronics hobbyist using nothing more than a multimeter, and a few optional meter accessories. (That's if you want to get into the nitty-gritty of some of the obscure problems that can drive an auto mechanic to distraction.)

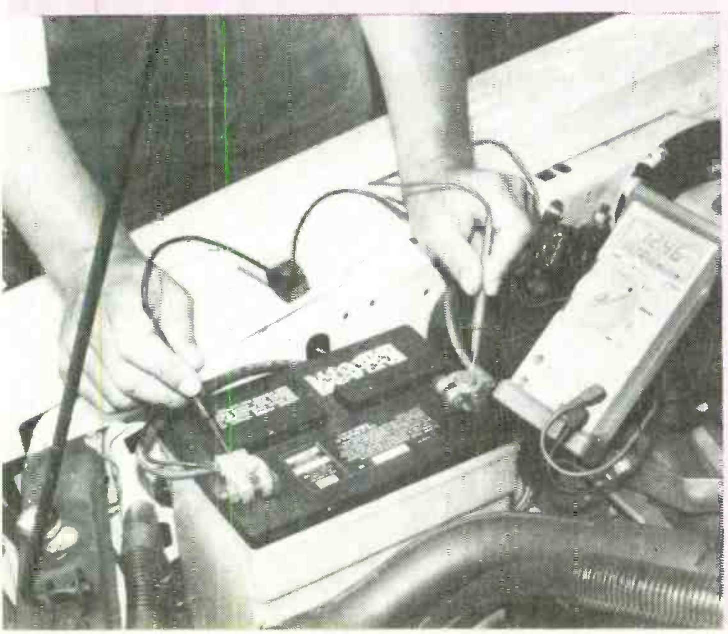
What Kind of Meter?

Any kind of multimeter can be used to troubleshoot auto-electric problems, but because many of the new autos are sensitive to small variations in operating current and voltages, the use of a digital meter is specifically recommended—particularly one also having an analog meter scale, so that you can see transient variations that might be concealed by a digital meter's sampling time.

To illustrate how to troubleshoot an auto-electric system we're going to use a Fluke model 23 digital meter, because it also has an analog indicator. And rather than use separate automotive-type, high-current sensors to test the charging system, and boiling pots of water to test thermostats, we'll use a temperature probe and an electronic current sensor that's specifically designed for use with a digital multimeter—the kind of equipment that might be found in a typical electronics hobbyist's shop.

Three Measurements

Electronics and electrical troubleshooting involves three measurements: voltage, current, resistance—and for some vehicles, temperature. The presence of voltage tells you that, at the very least, a component is receiving voltage. A current value tells you if a component is working properly. A resistance value primarily tells you if the wiring or a component is defective. Temperature combined with a resistance or current



When checking the voltage of a battery, turn on a heavy load such as the bright lights and measure the voltage across the battery clamps, not the terminals. Corrosion between a battery terminal and its clamp can often serve as an insulator.

Having electrical problems with lights, fans, etc.? Often the problem is a high resistance between the battery's negative terminal, and the chassis and engine block. Don't make resistance tests; they are worthless in this instance. Instead, turn on the maximum current load and measure the voltage drop between the battery's negative terminal and the chassis/body. It should be well under 1 volt—usually in the millivolts range.

measurement tells you if a thermostat—such as the one that controls a fan—is working properly.

Creating Heavy-duty Battery Loads

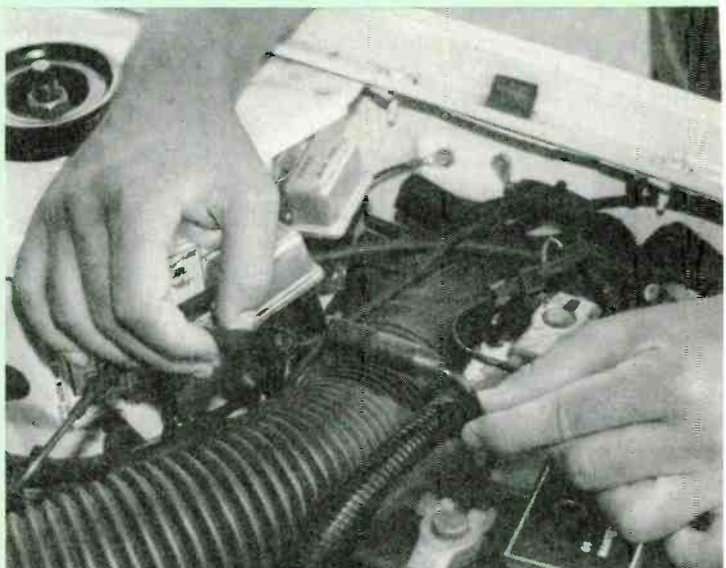
Many auto-electric tests (at least those covered in service manuals) require the use of a "carbon pile" to apply a load to the battery, charging system, or whatever. A carbon pile is essentially a high wattage variable resistor that's adjusted for a desired test-current load. Since few, if any, hobbyists own or have access to a carbon pile, we're going to use a convenient substitute: the headlamps. In vehicles that have separate lamps for the low and high beams, the low-beam lamps average about 10 amperes; turning on the high beams (the "brights") increases the average load to 20 amperes.

For vehicles that have a single lamp providing both the low and high beams, the low beam is nominally 10 amperes; turning on the high beam increases the load to 15 amperes. In our tests, we're going to use the low and high beams as a carbon pile. It won't be as accurate, but it sure beats using nothing at all. And for extra heavy-current tests, you can add nominally 20 amperes from the air conditioner with the fan on high, and another 10 amperes for the rear window-defroster elements; the heating strips applied directly to the glass.

First Things First.

The first step in auto-electric troubleshooting is to test the battery, because nothing is going to work without electric power. Usually, a hydrometer (a device that measures the specific gravity of the acid) is recommended. Unfortunately, not too many people own hydrometers, and even fewer want to handle sulphuric acid. And even if you wanted to, you can't use a hydrometer on the new sealed batteries. So, the most convenient battery test is simply to measure the voltage across its terminals. However, even a battery that's stone cold dead can indicate nominally 12.6 volts when not delivering current. For reliable measurements, the battery must be tested while delivering substantial current. We'll use the headlamp high beam to provide the current load.

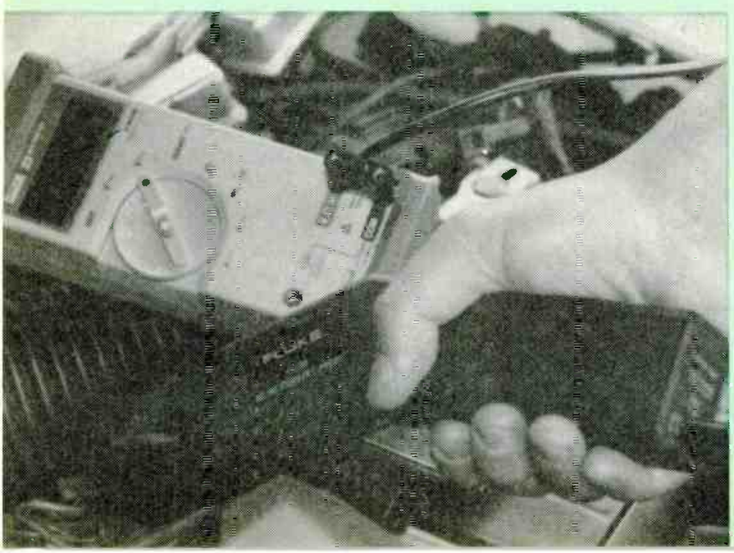
Connect your meter's test probes across the clamps that secure the wires to the battery terminals, not to the terminals themselves, because corrosion can develop an insulating



Modern cars use connectors for just about every current path. So if you want to disconnect some equipment when taking current readings, it might be easier simply to open the appropriate battery connector than to start disconnecting wires at the particular device you want to disable.

surface between the battery and its clamp. When the battery is delivering substantial current, the drop across the insulation can be substantial—enough to disable the starting system and also prevent charging. If the battery voltage at the terminals is low with the lights on, dig the test probes into the battery terminals. If the voltage reading varies by any amount, the terminals should be cleaned.

If the readings are the same on both the clamps and battery terminals, and the voltage is low, check the charging system.



Current divides among the various wires going to the battery terminal, so if you use a current probe, make certain that you encircle all the wires going to the battery terminal. The current probe has been clamped around the thin wire that connects the negative battery terminal to the car body only, causing an incorrect reading because the main part of the current is going through the battery cable, which has not been clamped.

Start the car—using a jumper cable if necessary—and then check for battery charging. One way is to measure the voltage across the battery: It should be in the range of 13.2 to 14.4 volts, depending on the particular car manufacturer.

Unfortunately, the presence of a charging voltage doesn't mean that the battery is accepting the charge. A more accurate check of the battery's ability to accept a charge, as well as a check on the charging system, can be made with a *current probe*, an accessory for the digital multimeter that clamps around a wire and indicates the actual current flowing in the wire. If you can measure the specified charging voltage across the battery, but little or no charging current flows *into* the battery, then you know that it's time to replace the battery.

Battery Leakage

Be careful not to be confused or fooled by normal leakage current when testing the battery circuit. Before Detroit starting putting computers, digital clocks, and radios in cars, there was no current flow when the ignition was off. At most, there might be a minute current flow if the car was equipped with a clock. But digital computers, clocks, and radios in modern cars require a substantial amount of continuous current to keep their memories "alive."

It's not unusual for a computerized mid-size car to pull anywhere from 0.2 to 0.5 amperes with the ignition off. Looking at it another way, the drain is enough to run down a weak battery in a few days. Nevertheless, if you measure a substantial leakage current, don't be too quick to blame a defective diode in the alternator or a short in the wiring; the drain might be perfectly normal.

Checking the Charging System

As long as you have the current probe clamped around the battery cable, assuming that the battery is good, now is a good time to check out the charging system—the alternator and regulator. First, run the battery down by turning on the bright lights for about 15 minutes. Then start the car and bring up the engine to about 2000 rpm. If you don't have a tachometer, feed enough gas for a moderate, not fast, race. Turn on all electrical equipment: the air conditioner, the window wipers, the rear defogger, and the bright lights. (Do it fast, before the battery gets a chance to fully recharge.) Note the charging current into the battery. It might be small, perhaps just a couple of amperes; but there should be *some* amount of charging current, even if you have turned on the maximum electric load. If the maximum electric load results in current flowing out of the battery, the charging system is "weak."

Connect the current probe around the alternator's output wire. If you can't reach it, or it's in a dangerous location, clamp the current probe around one of the battery wires. But take care: If more than one wire comes off a battery terminal, they must all be encircled by the probe. Next, disconnect the connector at the voltage regulator, and—depending on the kind of car you have—get set with an alligator clip to jump the connector's terminals. With the engine at a very low race (slightly above curb idle), jump the regulator connector so that the alternator is energized.

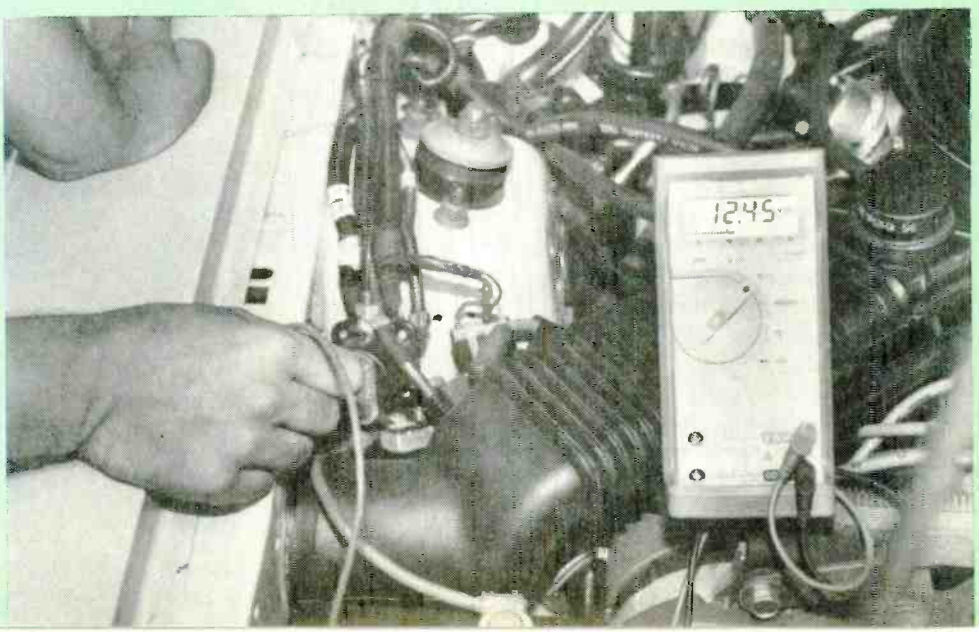
If the charging current surges to 20 amperes or more, and then almost instantly falls off, the charging problem is more than likely caused by a loose or worn drive belt. If the charging current surges to a high value and remains there, the problem is probably in the regulator—a relatively inexpensive item to replace. If the charging current is low, the problem is a "weak" alternator. Disconnect the wires from the alternator (of course, turn off the motor) and use the digital multimeter's resistance functions to test the alternator's internal rectifier diodes and the field winding's brush connections. (Take note that many of the new cars don't require removal of the alternator or its wiring, because they are connected into the vehicle's wiring through connectors. Simply opening the connectors, which are located in convenient locations near the battery, provide easy access to the alternator's connections. Check the service manual for your particular vehicle.)

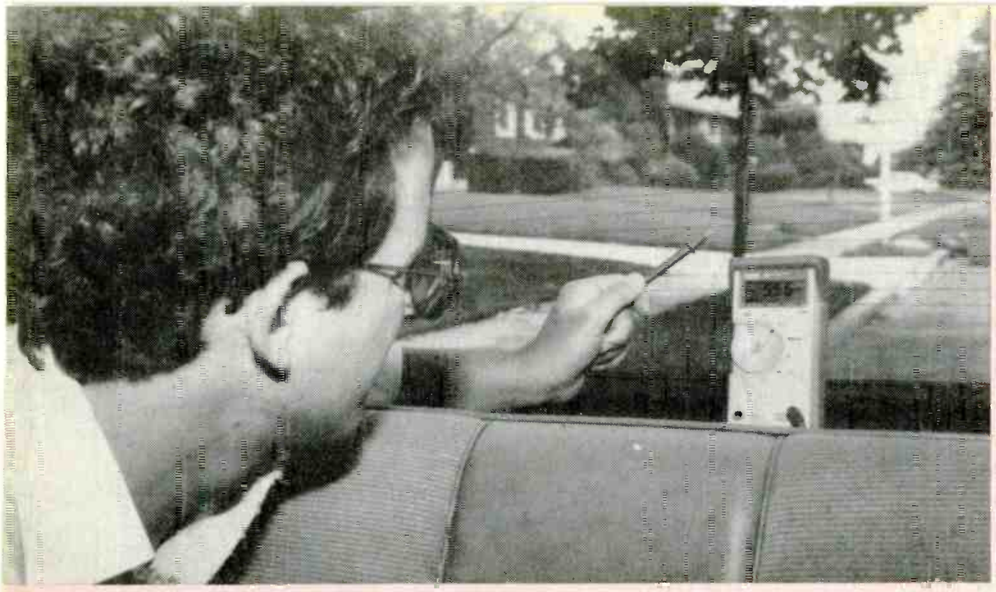
High Resistance

The term "high resistance" is relative. In automobiles, as little as 0.06-ohm (that's right 6/100) can interfere with the starting or operation of the auto. The resistance of auto connections increase as the car ages; and it may, in fact, be caused by concealed battery-acid vapor dissolving wires in the battery cable under the insulation, or corrosion at terminal screws caused by road salts. The easiest way to locate bad or poor connections is to measure voltage drop, rather than resistance. That's because, in the final analysis, it is low voltage that affects the car.

With the engine running and all electric accessories turned on, the recommended limits for voltage drops from any point

If you have starter motor problems, use the voltmeter to check for DC voltage up to and through the starter relay to the starter itself, while turning over the starter motor. Be careful to keep away from all moving parts in case the engine starts.





The individual wires in the rear window defogger can be tested by connecting one probe of a voltmeter to the power connector on one side of the defogger and then sliding the other along each "ceramic wire." The voltage reading will decrease as the probe is moved along the wire. If the reading suddenly drops out, the probe has passed over a break in the "wire."

to any other point is 0.2 volt for wires and cables: 0.3 volt for switches (such as the starter switch when the starter is actually turning the engine over); and 0.1 volt between any two grounds (such as a fender and the engine block, or the engine block and the chassis, or the fender and the battery's negative terminal). Connections should have zero voltage drop; that is, there should be no voltage drop between the terminal itself and, say, the lug from a connecting wire.

Ignition

If the car coughs and sputters after it warms up, the problem could be within the ignition coil—possibly a winding opening. Check and compare both the hot and cold resistance value of both the primary and secondary connections with the values specified in the vehicle's service manual. If the resistance values don't match both the hot and cold specifications, a new coil is probably what's needed.

Condensers

Condensers (automotive shop-talk for capacitors) didn't vanish when electronic ignitions were substituted for the old distributor breaker points. Even the new cars have condensers; they're used as "radio noise" filters. A leaky condenser can either create hash in the radio or tape player, or actually disable an electric circuit by blowing the associated fuses. Use the multimeter's ohmmeter function to check condensers.

Usually, the meter will indicate a low resistance at the instant it's connected across the condenser's terminals. That value increases to infinity as the capacitor charges up. If the measurement settles at some moderate resistance value, it's best to replace the condenser. If the meter reading doesn't kick when the meter is first connected the condenser is probably open.

When The Snow Won't Melt

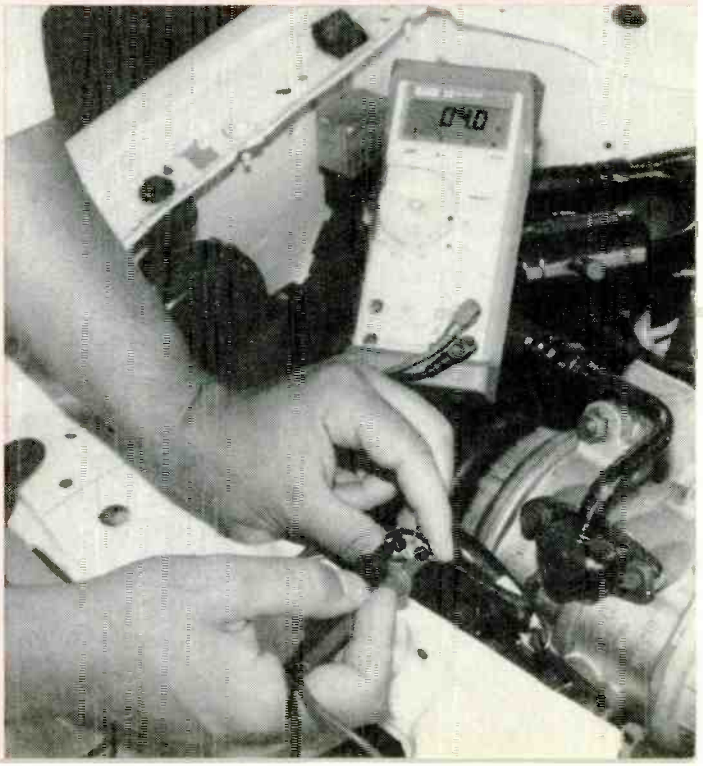
Rear window defrosters/defoggers depend on the heat produced by ceramic resistor elements (strips) applied to the window. If an element breaks, no heat is developed for the full length of the element. Fortunately, repair kits are available from both dealers and auto-supply stores. But the kits can only repair a length of an inch or so, and it's often most difficult to locate the break visually; a multitimeter can isolate the break within seconds.

Simply clip one meter probe to either of the defogger's battery connectors, turn on the defogger, place the other test probe gently on the opposite side of the element and then slide the probe toward the other probe. When both probes are on opposite sides of an element the meter indicates 12.6 volts. As the probe is moved, the indicated voltage will drop—6 volts will be measured when the probe is in the center of the element. Suddenly, the voltage reading will fall to zero; that's where the probe passes over the break in the resistance element; the place where you apply the repair kit.

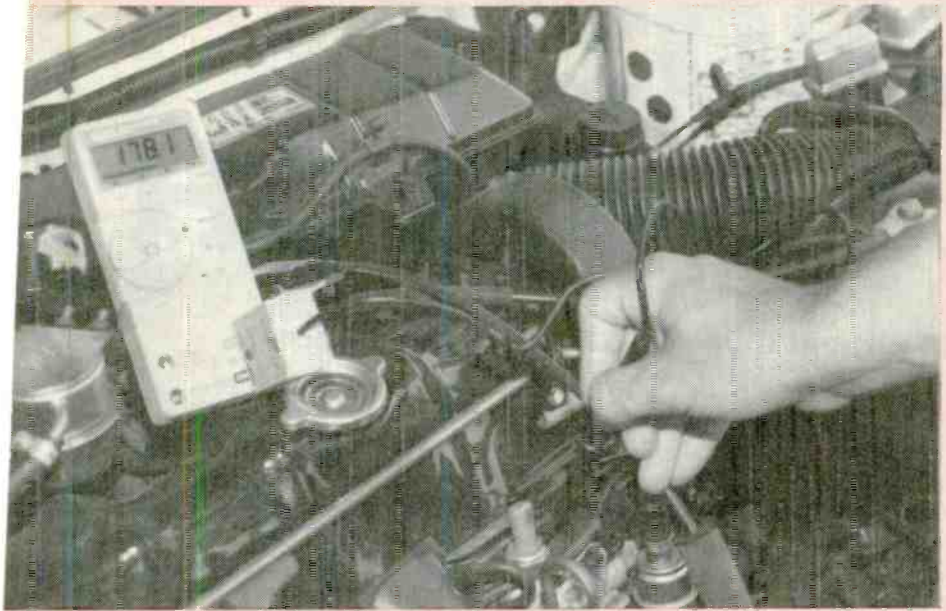
Is It Hot

Has the air conditioner pooped out? Is the compressor running? Is it the control switch that's defective? The compressor won't turn if the electric clutch is burned out or not receiving voltage. To check the clutch, just turn off the motor, disconnect the connector at the clutch, and measure the resistance across the terminals.

If you get an infinity reading, the clutch is open; if you get zero resistance, the clutch is shorted; if you get any value in



The ohmmeter function can be used for a quick test on the air conditioner clutch. If the resistance reading is very low (about 4 ohms), the clutch's coil is probably OK. And if there's no smoke or squealing when the A/C is on, the clutch is definitely OK; any A/C problems are someplace else.



Having heat problems with the engine, the radiator, the heater? You can track them down with a thermistor temperature probe (a device that converts temperature to a DC voltage that can be read on a DC voltmeter in terms of temperature). Here the probe shows that the engine temperature is too low, possibly indicating that a thermostat is stuck open.

between the clutch is probably OK. Next, insert the voltmeter's probes in the connector and turn on the ignition and the air-conditioner switch. If the meter doesn't indicate 12.6 to 14.2 volts, either the fuse is blown or the switch is defective. Either way, you've got a good idea of where the problem is.

How's The Fan?

In many vehicles, the fan is controlled by a heat-sensing switch that's built into the radiator. If the fan doesn't work, disconnect it first so that it doesn't start suddenly while your fingers are in reach of the blades. In some cars, the fans operate even when the ignition switch is set at OFF. Then bring the car up to temperature and check the switch. Since all modern radiators are meant to run sealed, you can't stick a thermometer in the coolant. But what you *can* do is the next best thing: Measure the temperature of the heat switch.

To do so, connect a temperature-sensing probe to your digital multimeter, place the tip of the probe on the sensor, and run the engine until the probe indicates that the sensor has reached the temperature where the fan should start. Quickly switch the meter function and measure the resistance across the sensor's terminals. If the sensor is working properly, you should read a short, which would start the fan (if the fan were connected). If the sensor is open, you have isolated the problem.

Resistance Checks

Naturally, resistance measurements can be made on any switch or wire; just be careful that you're not working on a "live" circuit. If necessary, disconnect the battery. Some of the latest cars use a quick-connector on the main battery wires—the ones that don't connect to the starting motor. Simply open the connector(s) and the battery is disconnected from everything except the starting motor. You can also locate certain radio-reception problems with resistance checks. Road salts often corrode or actually short-circuit the antenna.

To check the antenna installation, measure the resistance from the antenna mount to the fender itself: It should be less than 5 ohms. If the value is higher, look for corrosion inside the fender and under the antenna's mounting hardware. If you can, unplug the antenna lead from the radio and then measure the resistance from the antenna itself to the fender. It should be infinite (read as an open circuit). If it isn't, either replace the antenna or remove the corrosion, which is functioning like a partial short-circuit.

Dim Headlights

Are the headlights dim, or do they flicker? Check for any resistance between the lamp's ground terminal and the battery's negative terminal by measuring the voltage drop between the lamp and the battery when the lamp is on. If it's more than 0.2 volts, the wiring has excessive resistance; work the test probe back from the battery until you locate the wire or connector that's causing the excess resistance.

Summing Up

We've shown some of the most common practical examples of electric and electronic troubleshooting. You can extend the general principles we've covered to all the other electrical gear in the car. If you use a digital multimeter, most of the tests and checks are quick and easy. That's because a digital meter can detect minute variations that often point to

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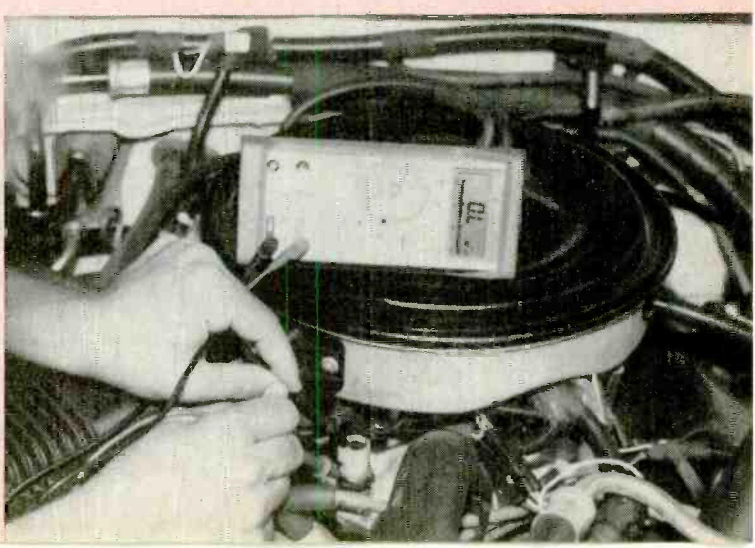
The ohmmeter can also be used to check out defective heat sensors used to control the radiator fan, computer, engine warning lights, etc. The car's service manual gives the sensor's resistance value for various operating conditions.



ROBOTIC LIGHT SWITCH

Flip on room lights without flipping your wig in the process

By Mike Gannon

IT IS OFTEN NEXT TO IMPOSSIBLE TO FLIP ON A LIGHT switch as you enter your apartment; for instance, imagine your arms are filled with packages when you've just returned home from a shopping spree. And just as often, many of us forget to turn out the lights as we exit a room (even though the local electric company sends us a gentle reminder of the high cost of energy each month!). But, before you start screaming about the high cost of energy, why not try this little gizmo, the Robotic Light Switch.

If there's a light in your home or perhaps at work that's turned on and off several times a day, this light-control switch can help make life a bit simpler. It will automatically turn a light on as you enter a room and turn it off as you leave. That means, no more having to juggle or drop packages as you attempt to turn on the lights. And when you leave a room, unlike us mortals, the Robotic Light Switch never forgets to turn them off!

How the system works

The operation, as you'll see in Fig. 1, is inordinately simple. A beam of light from small 12-volt lamp, LMP1, is focused on two side-by-side mounted light-dependent resistors, LDR1 and LDR2 (set and reset, respectively). The two LDR's feed a flip-flop that controls a relay through a transistor switch. The relay supplies 117 volts AC to the room light—a lamp, perhaps— through a socket, SO1.

The heart of the circuit, a 4011 quad 2-input NAND IC (U1) configured as an R-S (reset-set) flip-flop, is shown in Fig. 2 along with its truth table. Any input of about 5.4 volts or less is seen as a low by the circuit, and anything above that value is high. The LDR's, each in series with both fixed and variable resistors, provide the trigger voltage for the flip-flop. The 5000-ohm "compensation" resistors, R3 and R4, make up for a weaker illumination level that may exist across either LDR.

With no light striking the LDR's, each has a resistance of about 1 Megohm. Under strong light that resistive value drops to about 100 ohms. The 12-volt supply voltage is divided across each LDR and its associated series connected 270-ohm resistor, R1 or R2, to yield about 3.5 volts, an amount on the low side of the 5.4-volt threshold.

The LDR's are positioned in the doorjamb so that some one entering the room passes the set LDR first and then the reset LDR (with the opposite sequence occurring as the person exits). That's important to the operation of the circuit as we'll soon see.

Light striking the LDR's cause each to drop in resistance, reducing the voltage drop across them and resulting in dual

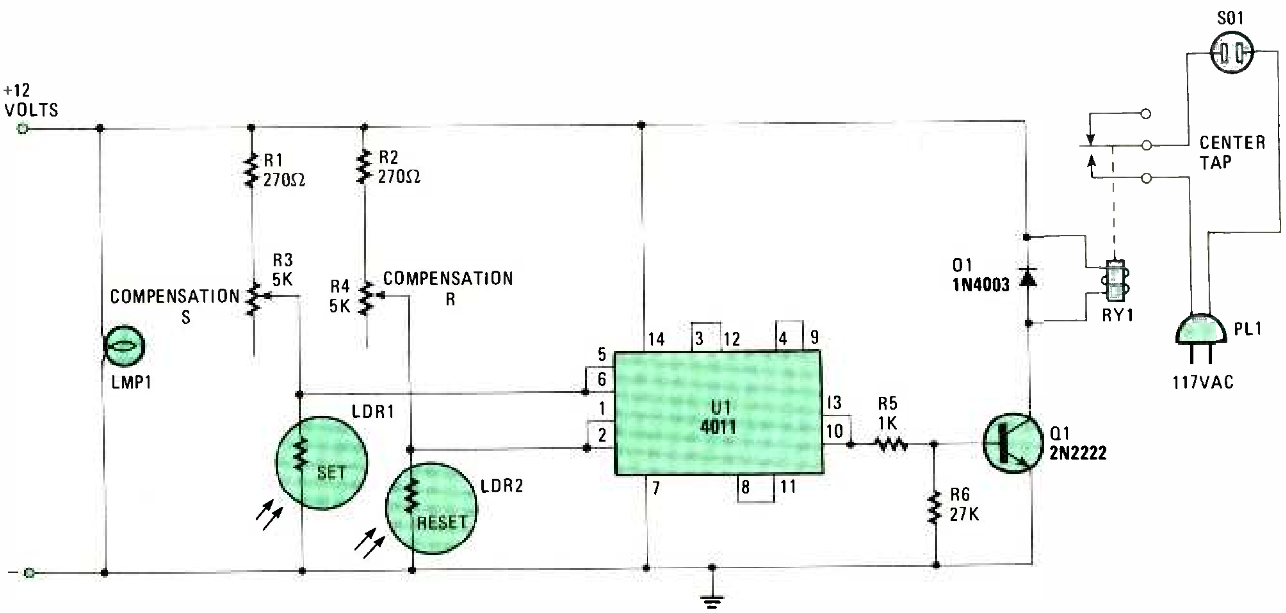


Fig. 1—Schematic diagram of the basic circuit. Note that the order in which shadow falls on LDR1 and LDR2 will determine whether the relay latches to apply voltage to SO1, or unlatches to remove it.

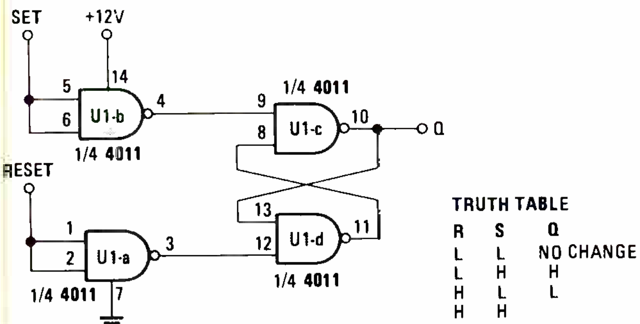


Fig. 2—The workings of the 4011 quad 2-input NAND gate integrated-circuit chip. The 4011 is configured to function as a set-reset latch (flip-flop).

low-level inputs being presented to the flip-flop. With both inputs low (as the Truth Table in Fig. 2 shows) the output remains unchanged.

When the light beam striking of the set and reset LDR's is initially blocked by somebody entering the room, both LDR's increase in ohmic value sending highs to both the set and reset inputs of the flip-flop. That invalid combination causes the output of U1 to remain unchanged. No harm is done, though, the Q output is problematic.

A fraction of a second later, illumination is restored first to LDR1 (set). And for a short period, the set input is high, while reset is low. That combination causes the output of the flip-flop to go high, energizing relay RY1 through current step-up transistor, Q1.

As the person exits the room, the opposite sequence occurs; that is, light from LMP1 strikes LDR2 first, placing a high on the reset input of the flip-flop. That causes the flip-flop to reset, pulling its output low. That low turns Q1 off and de-energizes the relay, removing power from the light.

Resistor R5 limits excessive drive current to Q1. And R6, connected in shunt across its base, ensures that the transistor remains off when the Q output is low. Diode D1 dampens or suppresses voltage spikes generated as the relay is de-energized. Without the protection of that diode, transistor Q1 would have a short life.

PARTS LIST FOR ROBOTIC LIGHT SWITCH

SEMICONDUCTORS

BR1—4 A., 50 PIV full-wave bridge rectifier (Radio Shack 276-1146, or similar)
D1, D2—1N4003 rectifier diode
Q1—2N2222 NPN general purpose silicon transistor
U1—4011 quad 2-input NAND gate integrated circuit
U2—7812 12-volt regulator

RESISTORS

(Fixed resistors are 1/4-watt, 5% unless otherwise specified)
R1, R2—270-ohm, 1/2-watt
R3, R4—5000-ohm, linear-taper potentiometer
R5—1000-ohm
R6—27,000-ohm
LDR1, LDR2—light-dependent resistor (Radio Shack 276-116, or similar)

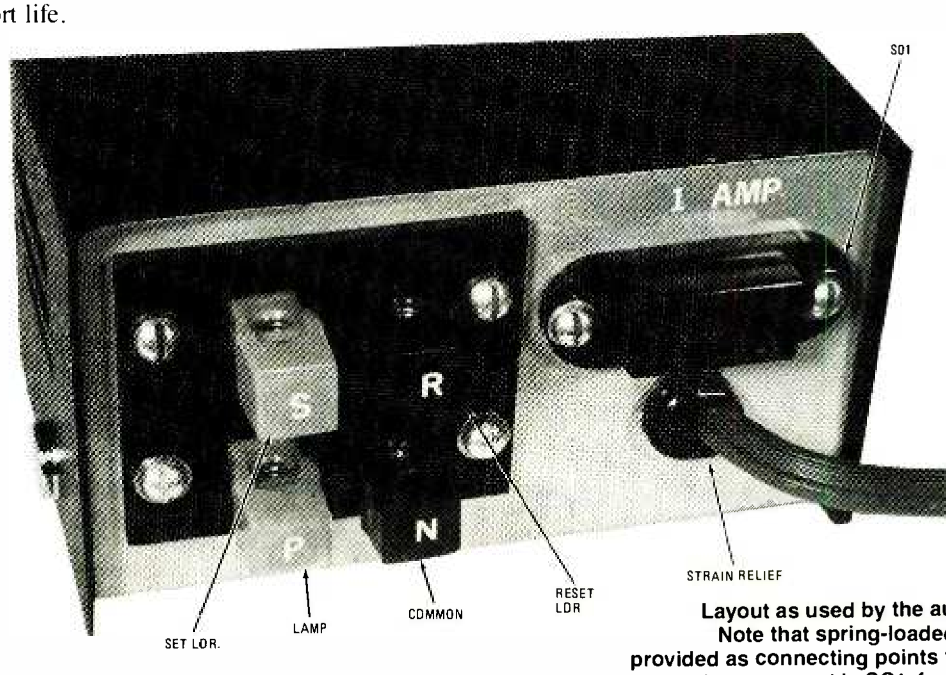
CAPACITORS

C1—3000-μF, 25-WVDC, electrolytic
C2—10-μF, 25-WVDC, electrolytic

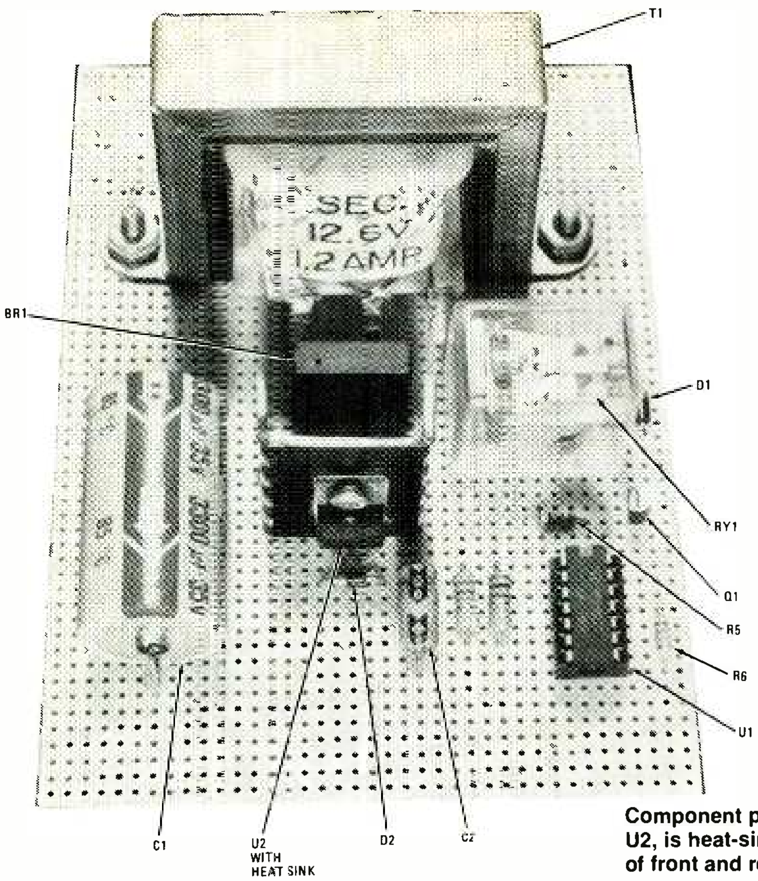
ADDITIONAL PARTS AND MATERIALS

LMP1—12-volt lamp
RY1—12-volt relay with contacts rated for connected device.
S1—SPST switch
T1—Power transformer: 117-volt primary, 12.6V, 1.2A secondary
Heat sink for TO-220 package, lamp reflector, wire, perfboard, stand offs, solder, hardware, etc.

Relay RY1 can be installed in a wall box to control a prewired lighting fixture. (Check local wiring codes before making any such modification.) By using two separate lamps to trigger the LDR's, the circuit can be made to function as an industrial control, responding to objects moving along a conveyor belt.



Layout as used by the author for his rear panel. Note that spring-loaded speaker terminals are provided as connecting points for the LDR's and lamp. Included on the rear panel is SO1, for room light connection.



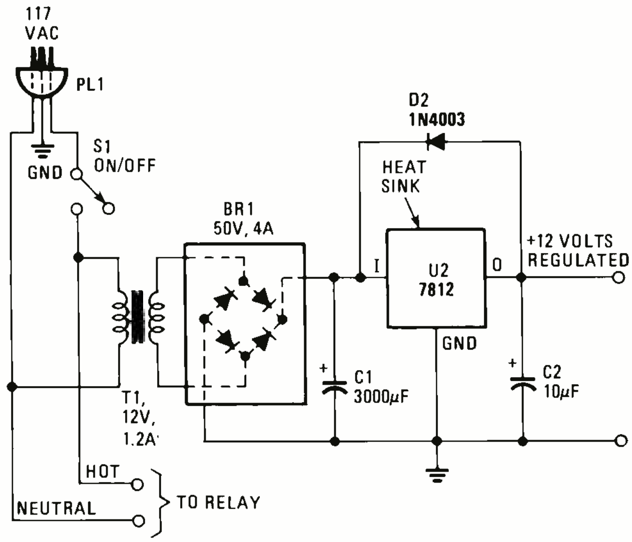
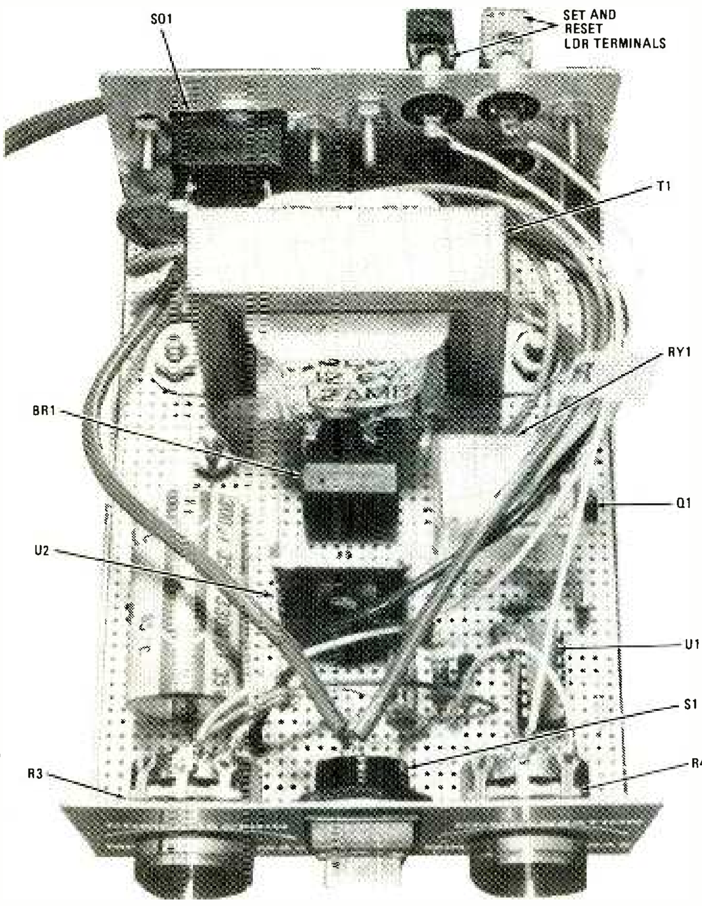


Fig. 3—Recommended power supply features current limiting, so no fusing is required. A tap from the transformer's primary is routed to relay RY1 to power room lights.

Component placement on the perfboard. Note that the regulator, U2, is heat-sinked. Ample room is allowed for clearance of front and rear panel-mounted components.



With all circuitry in place, you can see how wires are placed from front to rear panel components. Note that the compensation potentiometers, R3 and R4, each have one end-terminal left floating.

You can also place the lamps and LDR's sufficiently high on the doorjamb leading to your home workshop. In that way, only "big people" can trigger the circuit. That way, little tykes are protected from injury by power tools, like saws and drills, which they may attracted to.

A suitable power supply for the circuit is shown in Fig. 3. That circuit can provide up to .8 A—an ample amount for handling additional lamps, plus a heavy-duty relay. The circuit, without the lamp and relay, draws only about 100 mA. Because the 7812 regulator has a current-limiting feature incorporated into it, a fuse is usually not needed, but feel free to include one if desired.

Construction

The circuit may be built using the construction method most convenient for you. The author's prototype was built on a piece of perfboard about 4 × 5-7/8 inches. (Refer to the photos.) Perfboard with suitable spacing for IC sockets should be used. Be sure to allow sufficient clearance for the panel-mounted components when laying out the board. The power switch (S1) as well as LMP1, R3, R4, the AC socket (SO1), and the set and reset LDR's are, of course, off-board components.

Wire the circuit-board components according to Fig. 1. Next connect the AC source to the circuit using a 3-wire line cord with the ground lead going to both the transformer case and the circuit box. (The usual precautions apply.) In any event, observe the hot and neutral wiring even if a two-wire line cord is used. And use a strain relief where the line cord enters the circuit box.

Next prepare the chassis by drilling holes for the components that are located on the front and rear panels. One of the photos shows the layout of the rear panel. Push-button speaker terminals (labeled S, R, P, and N) allow easy connection of the LDR's and lamp. To the right of the terminal block is

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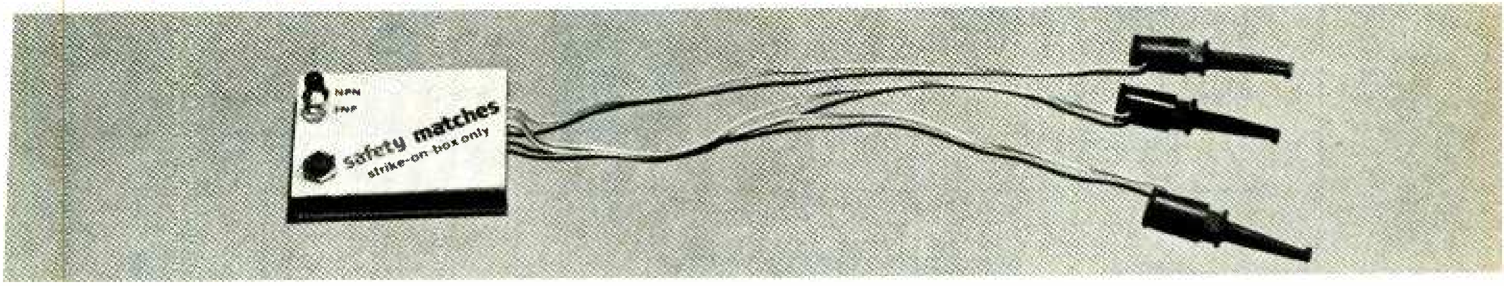
Matchbox In-Circuit



Transistor Checker

This little transistor tester, with features like the commercial models, can save time, money, and otherwise wasted energy!

By D.E. Patrick

IF YOU'VE EVER BUILT OR TESTED ANY TYPE OF EQUIPment containing transistors, then you probably know what a blessing a good transistor checker can be. While some low-priced models sell for \$6 or \$7 or so, you can just as easily build your own for about a buck, depending on how well your junkbox is stocked. In order for our junkbox transistor checker to be worth while, however, certain guidelines must be met.

First, we want the tester to check transistors both in and out of circuit, so that you don't have to extract the suspected faulty unit from its circuit. That eliminates the possibility of wiping out printed-circuit foil patterns; or damaging the transistor if it's not defective, or damaging other components with excessive heat. Second, the tester should have provisions for determining transistor type, either NPN or PNP. And finally, its parts count should also be low; it should be made as small as possible so as not to lend additional clutter to your work bench or area.

Well, the circuit that we'll show you meets those criteria, and if so desired, it can be modified to include a couple of "bells and whistles." Things like an audio indicator may be added to tell you (without a glance) that the transistor is good. Or you may want to add various sockets so that transistors with different package outlines may be plugged into the circuit for testing.

General Description

The Matchbox In-Circuit Transistor Checker is a 15-minute project that can be built from parts that are probably in your junkbox. The Checker's schematic diagram is shown in Fig. 1. That circuit uses two light-emitting diodes (LED's) to indicate the the condition of the unit-under-test (UUT); for instance, the PNP indicator, LED2, flashes when a good PNP unit is connected, and the NPN indicator, LED1, flashes for a good NPN. On the other hand, if both LED's flash or both LED's are extinguished, you know the transistor is "shot."

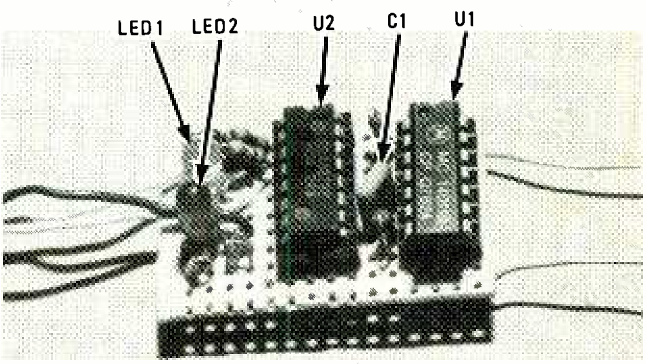
Circuit Operation

The schematic in Fig. 1 shows an astable multivibrator (oscillator) formed by two CMOS (Complementary Metal-Oxide Semiconductor) NAND gates, U1-a and U1-b. Although the author used a 4011 quad NAND gate, any inverting CMOS logic device can be substituted. The approximate output frequency of the multivibrator is calculated:

$$f \approx (R2C1)/2.2$$

where $10R2 \geq R1 \geq 5R2$. Resistor R2 can be a fixed 100,000-ohm unit for an output frequency of about 10 Hz or adjustable (using a 100,000-ohm potentiometer as shown) from about 10 Hz to 20 Hz; however, that frequency is not critical. The multivibrator's output is fed to U2, half of a 4027 dual J-K, master-salve flip-flop. That unit, like the inverting logic used, can be any number of CMOS flip-flops, not just the one shown. All that's needed are complementary outputs, Q and $\overline{Q}$, which drive the base (B), collector (C), and emitter (E) of the unit-under-test (UUT) and the light-emitting diodes, LED1 and LED2.

With no transistor connected to points B, C, and E, the Q output at a logic 0 and the $\overline{Q}$ output at logic 1, LED1 lights thru current limiting resistor R5. When Q is at logic 1 and $\overline{Q}$ at logic 0, LED2 will light. Thus, as U2 toggles back and forth



The author's prototype of the Transistor Checker is shown laid out on perfboard. Note that the resistors and diodes are vertically mounted to reduce the size of the board. Its small size allows it to easily fit into a matchbox.

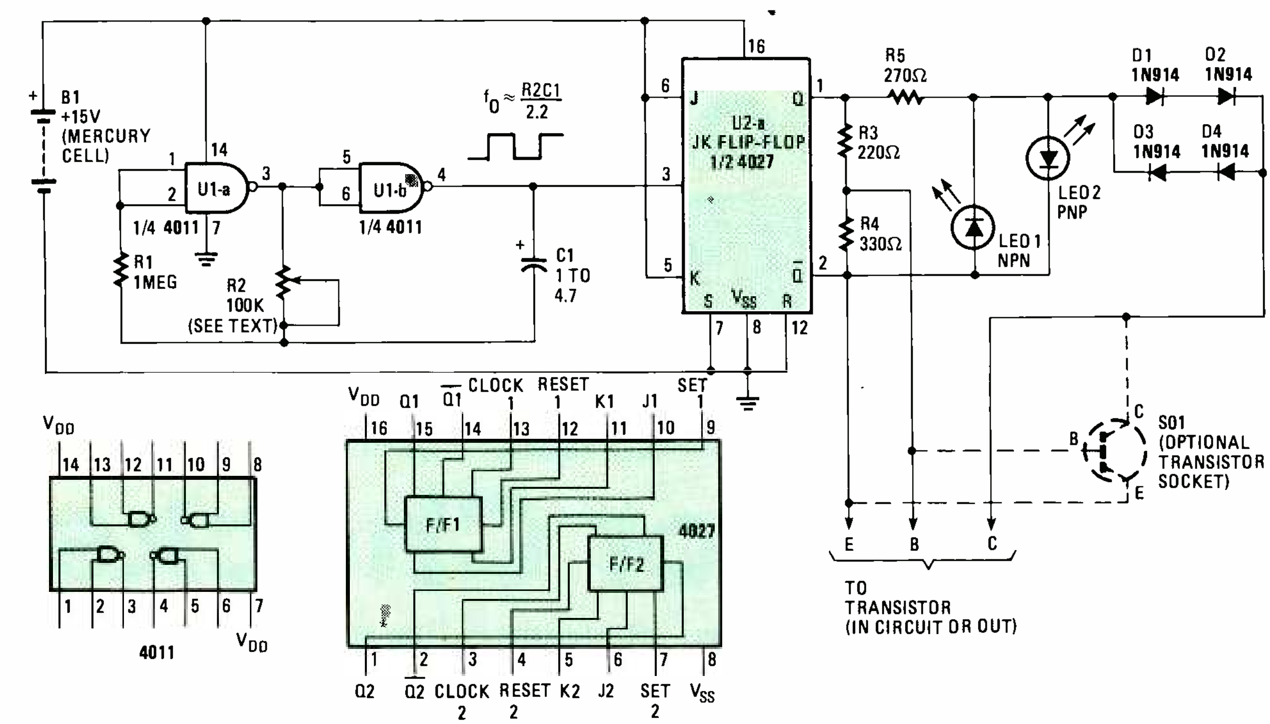


Fig. 1—The MatchBox In-circuit Transistor Checker circuit is made from a handful of readily available parts and there's nothing critical about them. U1 may be replaced by any inverting logic integrated circuit, and most any flip-flop can be substituted for U2. Note that both the J and K input are tied to +V. As always, when dealing with any CMOS components, all unused inputs should be tied to ground. Resistor R1 can be a 100,000-ohm fixed or variable unit and C1 can vary anywhere between 1–4.7-µF.

PARTS LIST FOR THE MATCHBOX IN-CIRCUIT TRANSISTOR CHECKER

SEMICONDUCTORS

D1–D4—1N914 general-purpose, silicon, switching diode
LED1, LED2—Jumbo light-emitting diodes (see text)
U1—4011 quad two-input NAND gate, integrated circuit
U2—4027 J-K master/slave flip-flop (or any J-K flip-flop) integrated circuit

RESISTORS

(All resistors are 1/4-watt, 5% units unless otherwise noted.)
R1—1-Megohm
R2—100,000-ohm (fixed or adjustable, see text)
R3—220-ohm
R4—330-ohm
R5—270-ohm

ADDITIONAL PARTS AND MATERIALS

C1—1-µF–4.7-µF electrolytic capacitor
S1—SPST, momentary, normally-open, push-button switch
B1—Small 15-volt, mercury-cell battery (or equivalent see text).
Matchbox (or project box), hookup wire, perfboard, test clips or alligator clips, integrated and transistor sockets (optional), hardware, epoxy, solder, etc.

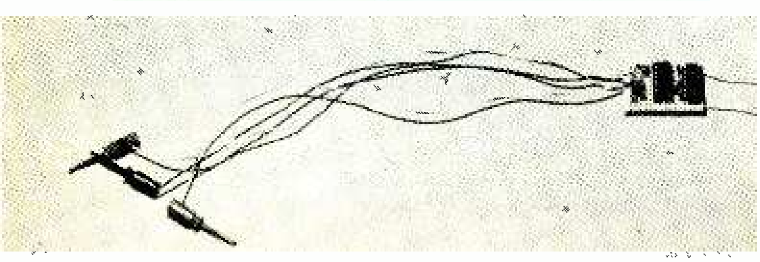
repeatedly. LED1 and LED2 alternately cycle on and off under a no-load condition. But when the B, C, and E leads are connected to a good transistor, bias is provided to the base of the unit via R3 and R4.

The transistor will be turned on or off depending on the polarity of voltages established at the Q and $\overline{Q}$ outputs. And the light-emitting diodes are either short circuited, or one or the other will be turned on, but not both at once. That is, when a good PNP transistor is properly connected and Q is at logic 0 (low) while $\overline{Q}$ is a logic 1 (high), the transistor turns on shorting LED1 and reverse biasing LED2, holding both light-emitting diodes off for the first half of the cycle.

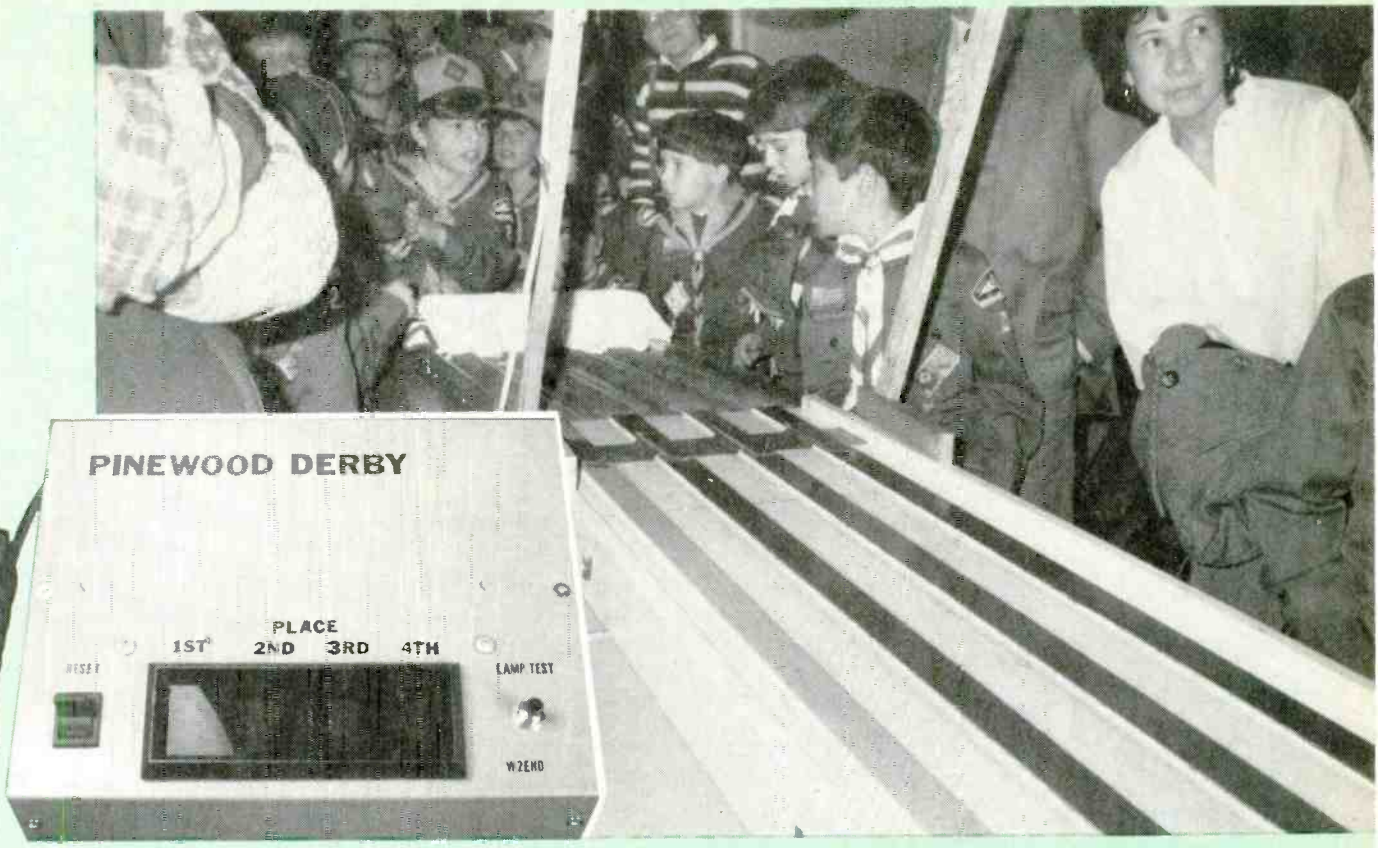
When Q goes to logic 1 and $\overline{Q}$ to a logic 0 on the other half of the cycle, LED1 will be reverse biased. But, the PNP transistor is now in cut off and LED2 will light. Therefore, with a good PNP in circuit, LED2 will flash at the rate ½*f*, while LED1 is held off. It may be shown that the reverse happens for an NPN transistor—i.e., LED1 flashes at the rate of ½*f*, while LED2 is held off.

In the case of bad transistors, a collector-to-emitter short turns both LED1 and LED2 off, while an open transistor causes them to flash on and off alternately. If the transistor has a base-to-emitter or base-to-collector short, both LED1 and LED2 turn on alternately, because half the transistor is acting like a diode and would be indicated as a good transistor. However, diodes D1 through D4 in series with the collector (C) prevents that from happening. The voltage drop across the forward-biased pair, D1/D2 or D3/D4, establishes a 1.2 volt drop. That voltage drop adds to the voltage drop across the transistor being tested. For a good transistor, the total voltage

(Continued on page 98)



◀ Connections from the circuit to the transistor can be nothing more than three lengths of wire terminating in test clips as shown; or, if you prefer, alligator clips may be used.



PINEWOOD DERBY SCOREBOARD

A goof-proof position indicator takes the guessing out of judging!

By John B. Meagher, W2EHD/Ex-W8JGN

THE PINEWOOD DERBY IS AN ANNUAL COMPETITION CONducted by many Cub Scout Packs around the country. The Cubs are given a rough-cut block of pine, four round-head nails, four wheels, and good wishes. With those, they can carve their own race cars, assemble the wheels in place, paint them to their taste, and let them whiz down a gravity race track.

Parents are usually pressed into service as finish-line judges; it is not always an easy job! The little racers zip across the finish line at velocities of three to five feet-per-second.

Pity the poor judges who must try to remember the lane numbers for first, second, third, and fourth place! Some honest difference of opinion frequently occurs!

Having been pressed into service on the judging team several times, the author concluded that some method could be devised that will call even the closest of races.

The device shown here will determine the order of finish among as many as four lanes even if the racers are milliseconds apart!

How It Works

Basically, the Pinewood Derby Scoreboard (refer to the schematic diagram in Fig. 1.) simply waits until the finishing race cars darken the phototransistors (Q1–Q4) that are mounted just below the finish line in each lane.

Before the race starts, the Scoreboard operator hits the RESET switch S2, which zeros all the displays and enables U8, the 4511 decoder-driver that will show the first place winning lane number. As each car crosses the finish line, the number of the lane is flashed in BCD code onto the common input bus to the decoder-drivers (U8–U11). Note that only the A, B, and C input lines are used; since the Scoreboard is required only to count up to four, the D input line (8 in BCD) is grounded. Only one of the 4511 chips (U8–U11) can be enabled at a time. The chip that happens to be enabled gets a 47-microsecond "peek" at the lane number on the input lines, displays it and is locked, preventing any change, until the RESET switch S2 is pressed.

In addition to pulsing the lane numbers onto the BCD input

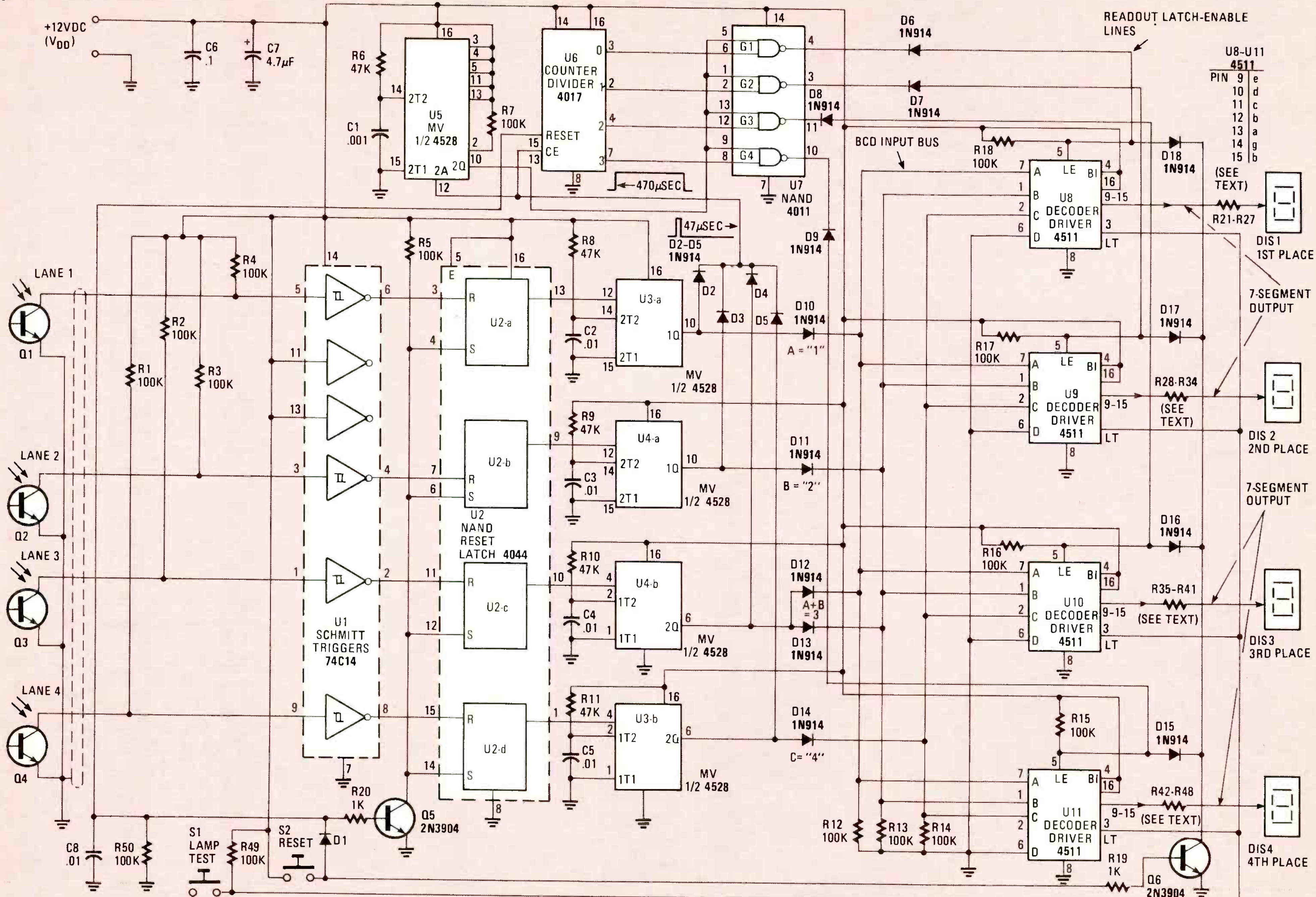


Fig. 1—Schematic diagram of the scoreboard is less complicated than it may appear at first glance. Much flexibility is permitted in non-critical components.

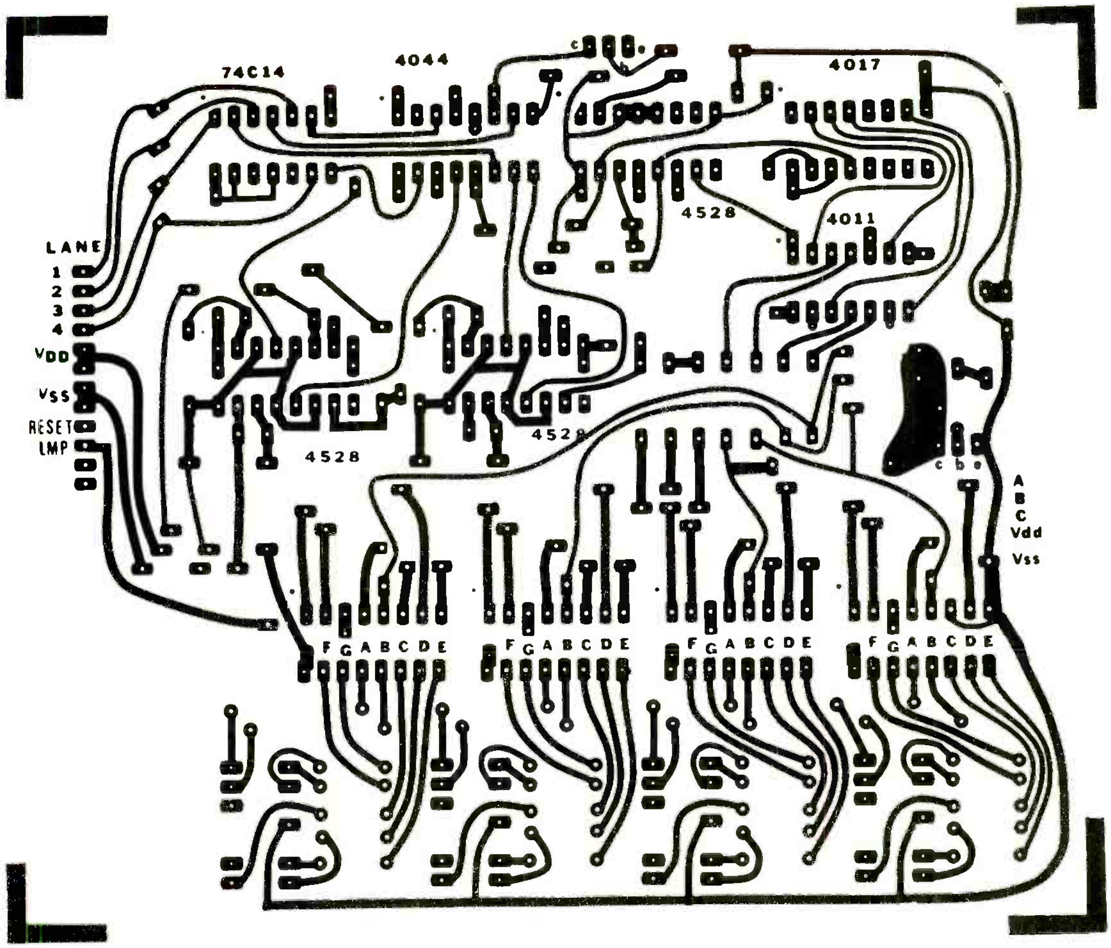
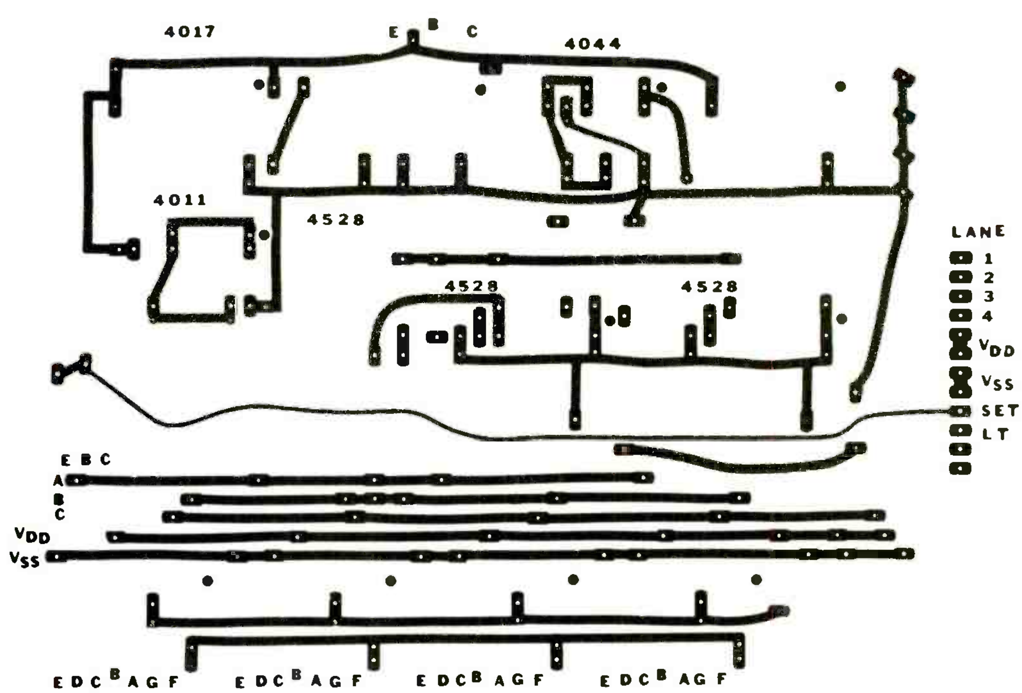
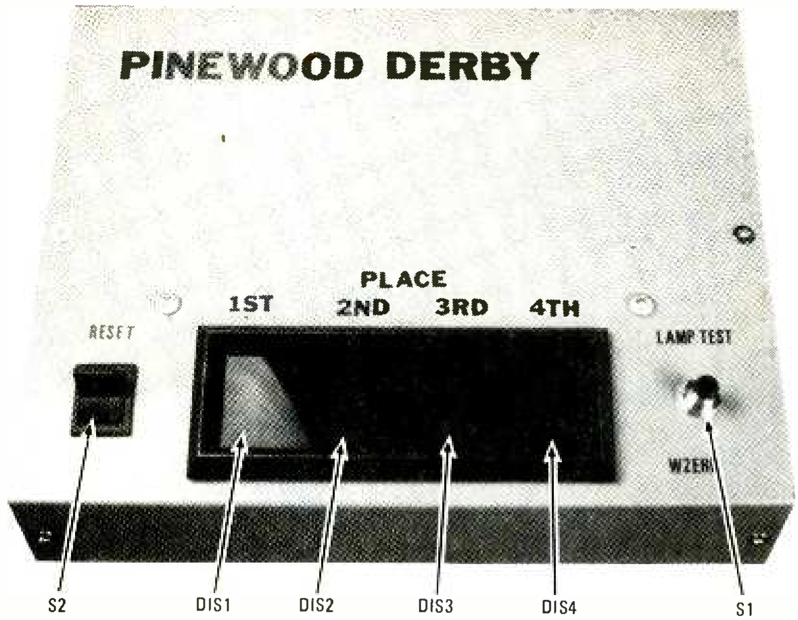


Fig. 2—Printed-circuit board templates are provided here for the Scoreboard's main circuit board. Foil side is shown above, component side below. Note that both sides must be etched, and some holes require soldering through.





Completed unit, attractively mounted in its cabinet. Press-on lettering and a lacquer spray completes the job quite nicely. The display LED's are hidden behind the bezel; only their lit segments can be seen during operation.

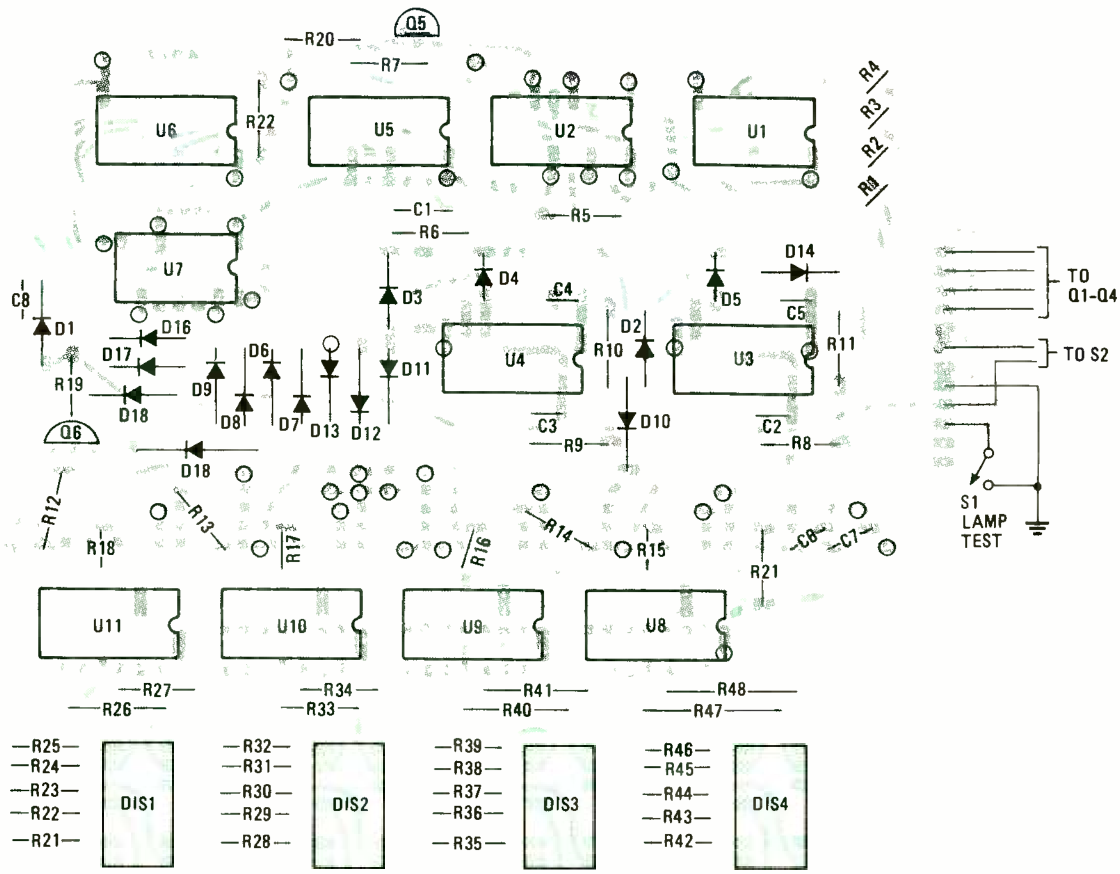


Fig. 3—Parts placement for the main printed-circuit board. Note that some solder pads are marked with circles. Those are the ones that must be soldered through from upper foil to lower foil.

bus, U3 and U4 (see Fig. 1) also trigger the 4528 one-shot multivibrator (U5) and advances the 4017 counter (U6) which, through the 4011 gate (U7) enables the decoder-drivers in turn.

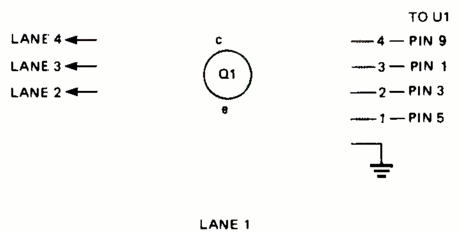
The purpose of the Schmitt trigger (U1) is to clean up the relatively ragged rising voltages from the phototransistors and make them clean, sharp squarewaves before they are applied to the four IC latches (dual sections in U3 and U4).

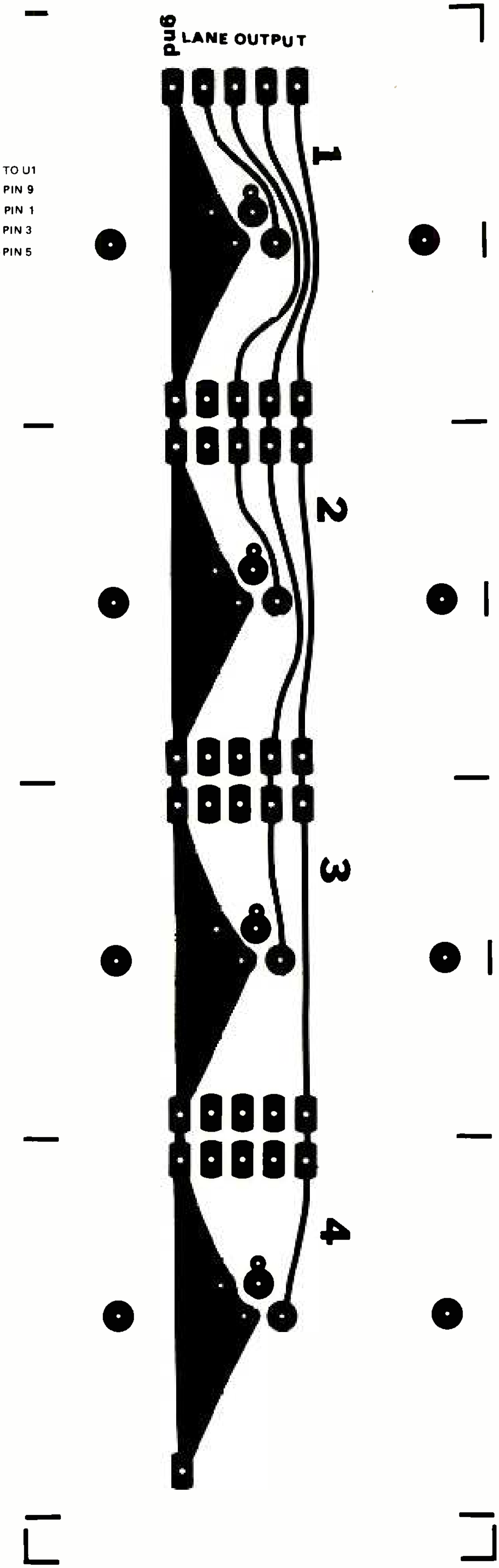
The Pinewood Derby Scoreboard transitions from one "place" to the next on the order of 470 microseconds. Therefore, the Scoreboard is able to differentiate between two rival racecars easily, even if they are a small fraction of an inch apart.

Construction

The printed-circuit board used by the author may seem more complicated than it is. (See Fig. 2.) The board is of double-foil construction; circuit traces are on both sides. The

Fig. 4—Foil side of phototransistor printed-circuit board layout is presented fullsize. Note that for spacing the phototransistors under pinewood car tracks, the sections can be sawed apart and connected by jumpers. The inset shows one section of the foil with connections made to it for lane one. Be sure to position the phototransistors in the center of the lane that they are judging.





PARTS LIST FOR PINEWOOD DERBY SCOREBOARD

SEMICONDUCTORS

U1—74C14 hex Scmitt trigger integrated circuit
U2—4044 quad NAND reset latch integrated circuit
U3, U4, U5—4528 dual monostable multivibrator integrated circuit
U6—4017 decade counter/divider integrated circuit
U7—4011 quad 2-input NAND gate integrated circuit
U8–U11—4511 BCD-to-7-segment latch/decoder/driver integrated circuit
Q1–Q4—NPN silicon phototransistor (Radio Shack 276-130)
Q5, Q6—2N3904 NPN transistor
D1–D18—1N914 silicon diode
DIS1–DIS4—Seven-segment, light-emitting diode display (Radio Shack 276-067)

RESISTORS

(All resistors 1/4-watt, 10% fixed units)
R1–R5, R7, R12–R14, R21, R22—100,000-ohm
R6, R8–R11, R15–R18—47,000-ohm
R19, R20—1000-ohm
R21–R48—820-ohm

CAPACITORS

C1—.001-µF. C2–C5, C8 .01-µF, ceramic
C6—.1-µF, ceramic
C7—4.7-µF, 16-WVDC, tantalum

ADDITIONAL PARTS AND MATERIALS

S1, S2—SPST, momentary-contact, pushbutton switch
Cabinet: 7-7/8 × 5-7/8 × 2-3/4 (Radio Shack 270-265); bezel/lens 3-9/16 × 1 (Radio Shack 270-301); (Note: The bezel comes with a polarized red filter. For use with yellow readouts, author found and used amber filter), printed-circuit materials and/or perfboard, power line cord, decals, wire, solder, hardware, etc.

PARTS LIST FOR POWER SUPPLY

BR51—Bridge rectifier; 1.4-A, 100-PIV (Radio Shack 276-1152)
C51—1000-µF, 18-WVDC, electrolytic capacitor
C52—4.7-µF, 25-WVDC tantalum capacitor
F51—1/2-A fuse
S51—SPST, toggle switch
T51—Power transformer; 12-V CT, 1.3-A (Radio Shack 273-1505) Note: Since this project draws only 200 milliamperes, the transformer is well-overated.)
U51—7812 voltage regulator, 12-VDC, 1-A (Radio Shack 276-1771)

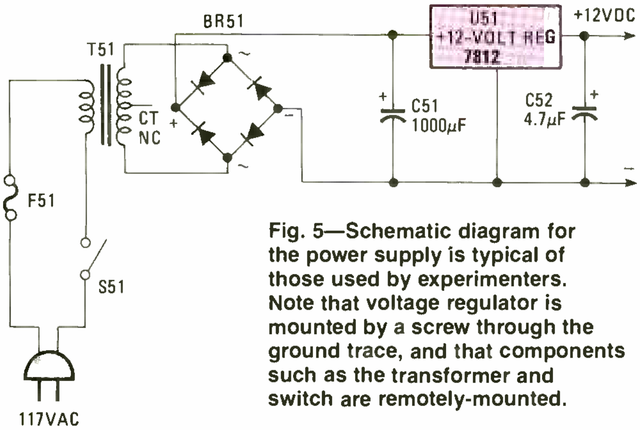


Fig. 5—Schematic diagram for the power supply is typical of those used by experimenters. Note that voltage regulator is mounted by a screw through the ground trace, and that components such as the transformer and switch are remotely-mounted.

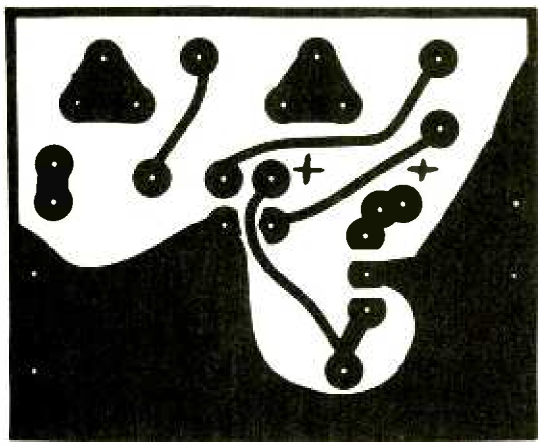


Fig. 6—Power supply board foil layout is shown. Note that the power transformer is wall-mounted to the cabinet. Diagram above illustrates parts placement on component side of the board.

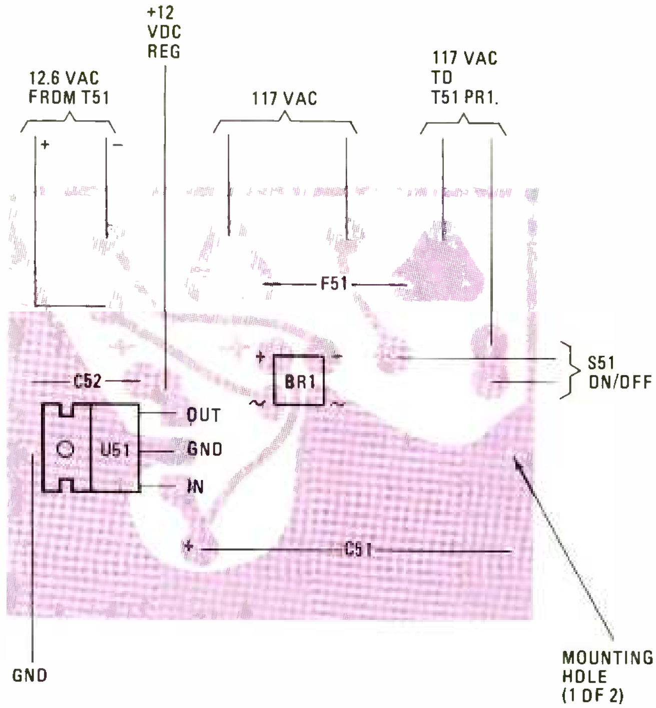
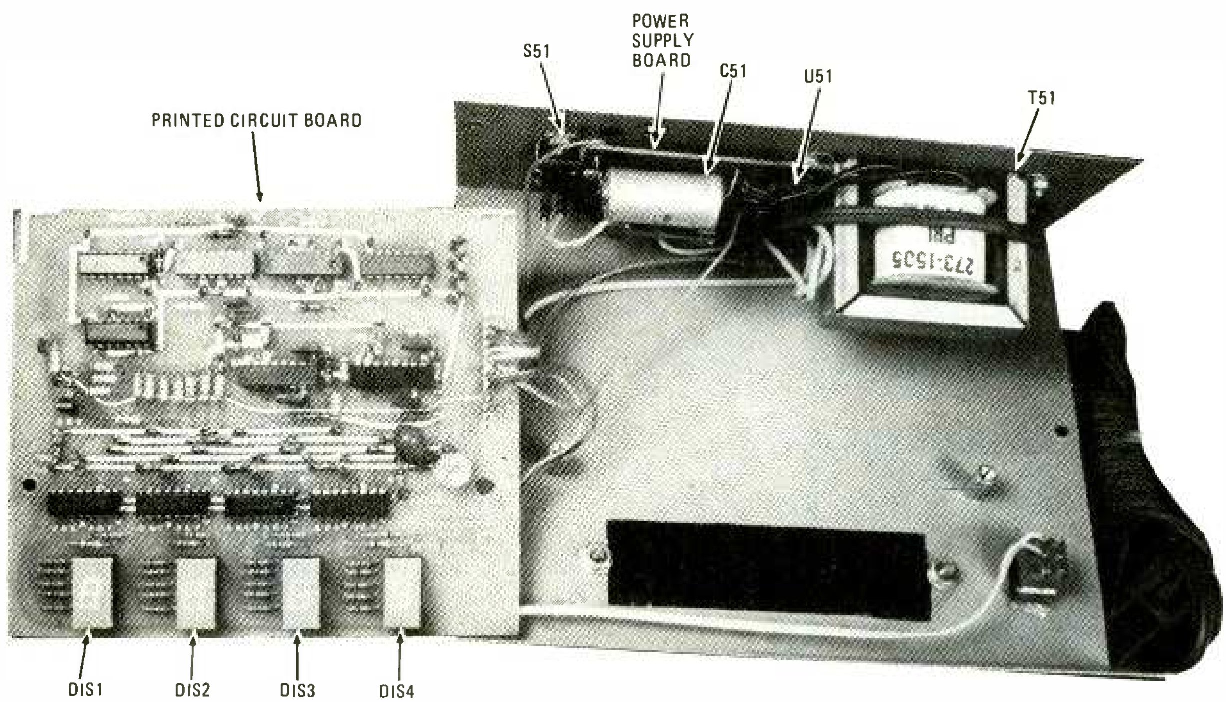
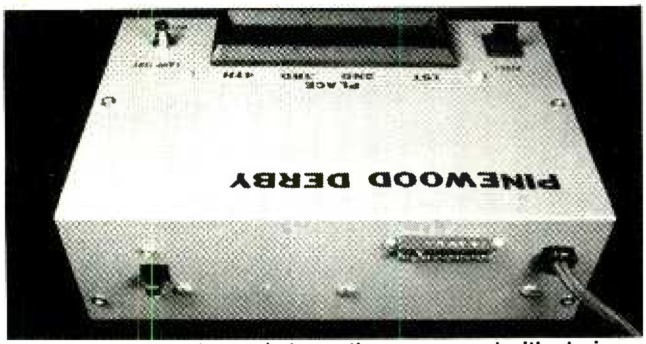


Fig. 7—Here is an x-ray view, foil-side down, of the board shown in Fig. 6 of parts location shown.
If you have the 1N4000 series of diodes, you can construct your own BR1 (diode bridge) circuit.



With the base removed the neat package is revealed. Note placement of power-supply transformer and power supply PC board on back wall of cabinet. Main printed-circuit board mounts on stand-offs and is careful positioned beneath the window cut in the chassis cover.

Put it all together it spells "love!" At the extreme left volunteers and scouters work to assemble the Derby gravity track as Cub Scouts look on. In the center, excited Cubs wait at the finish line just before the cars are released. Why is the Pinewood Derby Scoreboard needed? In the right photo, we see the Cubs get excited as the cars go by. The action was so quick that the photographer missed the cars crossing the finishing line. That's why the human judge is not as reliable as the electronic eyes and circuitry of the Pinewood Derby Scoreboard.



The view of the back panel shows the power cord with strain-relief, the power supply on/off switch (S51) and a ribbon cable connector that the author used. That connector interconnects the external photocell transistors on their printed-circuit board with the internal circuitry of the Scoreboard. Any connector will do, or you may elect to hard wire the ribbon cable directly to the Scoreboard eliminating the need for a connector. Exactly how you do it is up to you!

ideal technique would be to use plated-through holes. Should you not have that technology in your shop to so assemble a double-sided board, a number of soldered jumpers will be necessary to make through-the-board connections. Whenever possible, use component leads (refer to Fig. 3) to make the connections. At some spots that interconnection is not possible so those locations are marked with circles to denote feed-through jumpers.

If you choose to solder the IC's to the board, then many jumpers can be avoided by using the IC pins, soldered top and bottom, to make the connections. (Caution: Be sure to use either a battery-powered or a well-grounded soldering iron before you do that.) In any case, those who fabricate their own printed-circuit board must give careful attention to the registration of the holes to make sure that they are within a few thousandths-of-an-inch of each other, front to back on the board.

The original Pinewood Derby Scoreboard used Hewlett-Packard yellow LED displays that were obtained from a mail-order surplus house. This version of the Scoreboard is designed to use Radio Shack yellow LED displays that are difficult to find. Almost any yellow LED display may be used,or even change color!The author chose 1000-ohm resistors (R21–R48) for the segment's current limiting resistors, because the device is fed from a 12-volt DC supply. An amber filter was cut to fit the bezel over the display LED's.

Figure 4 shows the printed-circuit board for the phototransistor layout. That board is optional, because you may elect to hard-wire the phototransistors (Q1–Q4) under the lanes of the gravity track.

The Power Supply

The power supply is a simple full-wave bridge that feeds a three-legged, 1-ampere regulator. (See Figs. 5, 6, and 7.) The parts in the power supply are identified in the fifty series of part numbers solely for identification purposes.

The connection cable from the cabinet to the phototransistors (Q1–Q4) mounted beneath the Derby's finish line is a 5-conductor, unshielded ribbon cable about 12-feet long. That permits the operator to remain out of the way of the crowd at the finish line. It is not necessary to duplicate the author's version exactly. It is possible, for example, to remotely locate the LED readouts, decoder-drivers, and the RESET switch, S2. The LAMP TEST switch (S1) is not mandatory; however, in case of a problem, it is convenient to verify that all LED segments of the four displays (DIS1–DIS4) are functional. If they don't all light up when the LAMP TEST switch (S2) is pressed it may be a clue to the glitch.

The lighting of the finish-line sensors is not critical. A 60-watt incandescent bulb about 25 to 30 inches over the finish line worked well. The aim of the illumination is to turn on the phototransistors fully. The collector voltage should be close to zero under the illumination; certainly it must be less than half V_{dd} if U1 is to make any logic decision when the sensors are darkened, turning them, off and permitting their collectors to rise to V_{dd}.

Do not use fluorescent lamps for finish line illumination because of the strong AC component in their light output. They'll work; but incandescent lamps are much better.

The Scoreboard had its full-scale trial at the Closter, New Jersey Cub Scout Pinewood Derby and acquitted itself admirably. That year, there were no knots of perplexed judges, no conflicting race calls, no discussions among judges and parents as to which car finished in which place. It made the event go lots faster, too!

There seems to be no problem in using the Scoreboard on a slotcar racetrack. Since slotcars make more than one circuit of the track during a race; however, the officials would have to make sure they zero the display during the final lap. It's also possible to attach other "bells and whistles" such as an elapsed timer. Other modifications can be dealt with as you encounter them.

My thanks to Neil Abitabilo, WA2EZN, for the photographs.

By Edward M. Noll

Inside... HEX BUFFERS

Have you ever wished for a universal circuit that could do anything?

□WE ALL KNOW THAT (UNFORTUNATELY) THERE'S NO SUCH thing as a "universal circuit" that will do whatever you want it to do. If there were such a device, getting an electronics engineering degree wouldn't take more than two weeks! But some integrated circuits are so applicable in so many different uses, that they come awfully close to universal. Such devices are the 4049 and 4050 CMOS chips.

You will often find the 4049 at work as a regular inverter in digital circuits. But its capabilities go beyond simple low-power inverter applications. It has the power capability to drive LED's, solid-state relays, sensitive electromechanical relays, two-TTL inputs, etc., so it is known as an inverting buffer and TTL driver. The 4050 is the same as the 4049, except that it is non-inverting.

Pin-out diagrams are given in Fig. 1. Note that the supply voltage is connected to pin 1 and that pin-outs are the same for the 4049 and 4050. Electrical characteristics are the same, too. At 5- volts DC, each of the six segments will source 2.5 mA and sink 6 mA (Fig. 2). Those values rise to 10 and 40 mA respectively at 15 volts. The sink connection will supply greater current for operating a relay, etc.

A 555 slow clock can be used to demonstrate the operation of the buffers (Fig. 3). Two LED's can serve as a load. A clock-output LED in connection with a bipolar transistor indicates the clock-output logic. One of the hex sections is source-loaded by an LED; the other, sink-loaded.

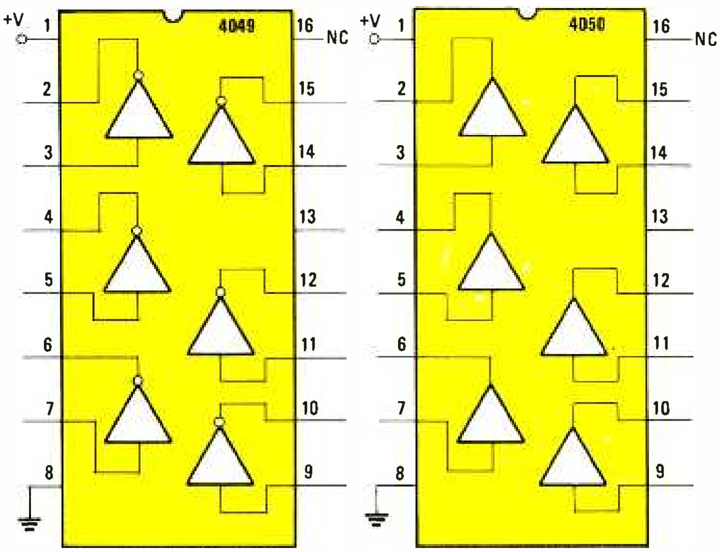


Fig. 1—Pinouts for the hex buffers are shown above. The 4049 is shown at the left, the 4050 on the right. Note that pinouts and electrical characteristics are the same for both the 4049 and 4050. The only difference is that the 4050 is non-inverting.

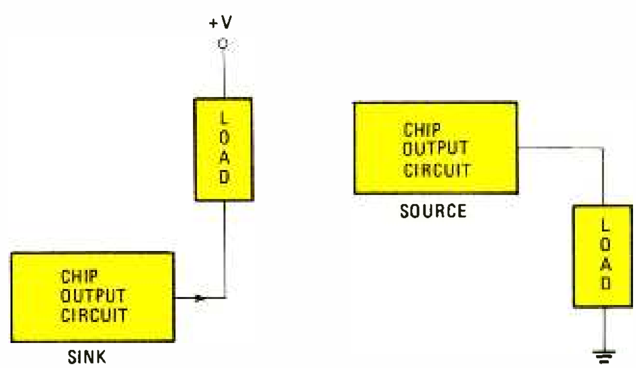


Fig. 2—Sinking and sourcing a load are demonstrated in the block diagrams above. With a 5-volt DC supply, each segment will source 2.5 mA and sink 6 mA. As shown, one segment is source-loaded by an LED, the other is sink-loaded.

Make a Prototype

Build the circuit on a solderless circuit board and apply power. Note that the LED, which is sink-connected, will illuminate when the clock-output logic is 1. Since the 4049 is an inverter, the output at pin 2 will be logic 0 when the clock output is logic 1. The associated LED is connected to the supply voltage. Therefore, it will turn on, because pin 2 is at logic 0. Conversely the second output LED will turn on when the clock output is logic 0. In that case, pin 4 of the 4049 is at logic 1 and source current is present in the LED because of its connection to ground (logic 0). The sink-connected LED will glow brighter than the source-connected LED.

Remove the 4049 and substitute a 4050 in its place. No rewiring is required. The 4050 output is non-inverting. Consequently the source-connected LED will turn on when the clock logic is 1; the sink-connected LED when the clock-output logic is 0. You choose the 4049 or 4050 according to your circuit's needs.

Return the 4049 to the circuit. Connect a sensitive electromechanical relay to the outputs of three paralleled sections of the 4049 as shown in Fig. 4. The 6-volt relay with a relay coil resistance of 500 ohms will be satisfactory. The Radio Shack 275-004 can be used. Required relay current is 12 mA. Three paralleled sections will have a sink-current capability greater than that value, so the relay current can be supplied easily. The relay coil is sink-connected because of its tie-in to the plus supply voltage.

Wire and operate the circuit. Observe that the relay is energized when the clock-output logic is 1. If you would prefer relay energization to match a clock-output logic of 0, you can use the 4050 instead of the 4049. As the relay contacts are SPDT, the contact wiring can be such that the LED will turn on or turn off with the relay energized. The contacts of the relay are capable of handling 1A at 125VAC.

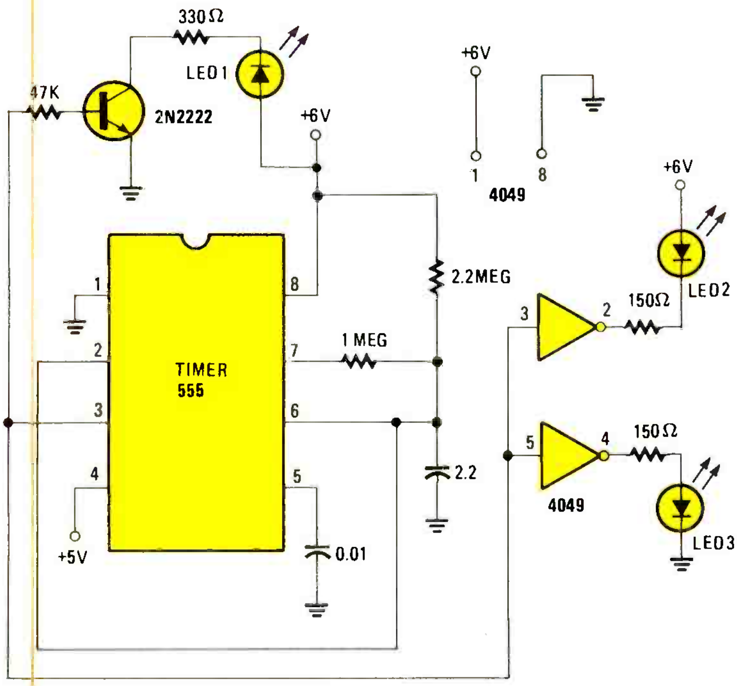


Fig. 3—Slow clock circuit above, shows method of operation of the buffers. Loads are represented by light-emitting diodes. In the schematic diagram shown, one segment is sink-loaded by LED2, the other is source-loaded through LED3. Timer 555 with bipolar transistor indicates clock output logic through output LED1.

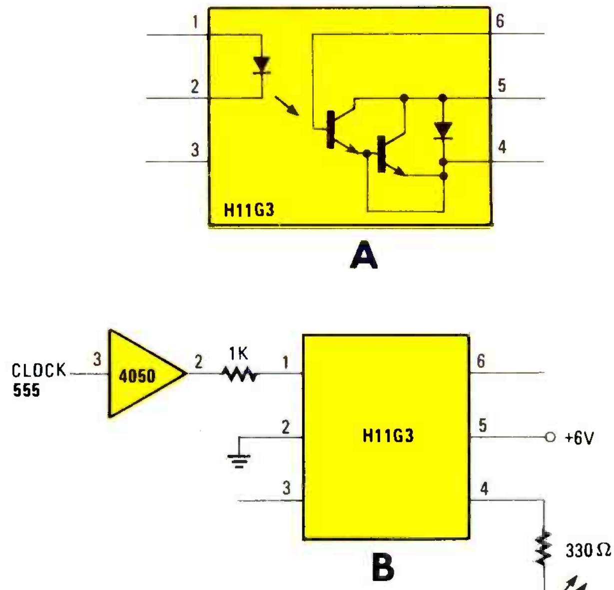


Fig. 5—Schematic diagram (A) above shows how output from 4050 activates the infrared diode, which in turn activates the phototransistor. This and the output transistor, set-up as a Darlington pair, operates the solid state relay to operate the load represented by LED1, which is source-connected.

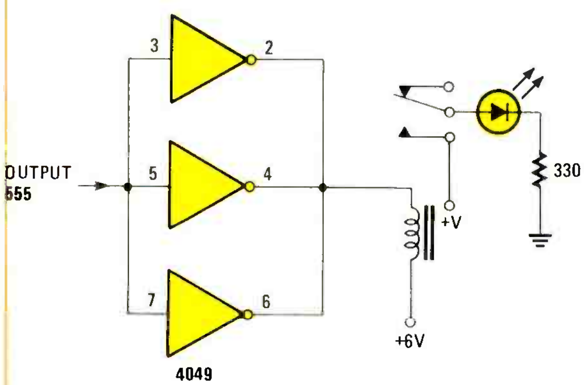


Fig. 4—Circuit shows how to use a clock timer with three segments of the 4049 to control a sensitive electro-mechanical relay. The relay is energized when clock output is at logic 1. You could change that simply by switching to a 4050, but since the relay is a SPDT type, you can accomplish the same thing by simply connecting it to the other relay contact.

Solid-State Relay Operation

An opto solid-state relay can be driven from the output of a hex buffer. Such a relay consists of an input infrared diode that is light-coupled to a photosensitive output circuit and amplifier. The light protons follow a confined light path to the output circuit, and provide a high order of isolation between input and output. Output can be operated from a separate source of supply voltage that needs no connection to the input circuit. That method is ideal when you wish to interface digital circuits with a variety of electrical and electronics devices that are to be controlled.

One such device is the GE H11G1 or H11G3 6-pin, mini-DIP chip (Fig. 5). The IR diode is connected to pins 1 and 2. The infrared light activates a phototransistor and output transistor connected as a Darlington pair. The circuit or device that is to be controlled is connected between pins 5 and 4. Typical output current-capability is 40-50 mA.

More Circuits

Figure 5-b shows how the solid-state relay (SSR) can be connected to the clock and hex buffer circuit. The input-current requirement for the IR diode is so low that it can be driven from the output of a single buffer in series with a 1K resistor. Absolute maximum current for the diode is 60 mA. Be careful not to short it across the supply voltage. It will activate with less than 5 mA.

Place your circuit in operation. When the input clock is at logic 1, the LED will come on. If your project requires output when the input logic is 0, use a 4049 instead of the 4050. Don't forget that a major advantage of the SSR plan is that the supply voltage associated with pins 4 and 5 can be completely isolated from the digital system that supplies drive to the IR diode. That supply voltage can be as high as 55 volts for the G3 and 100 volts for the G1.

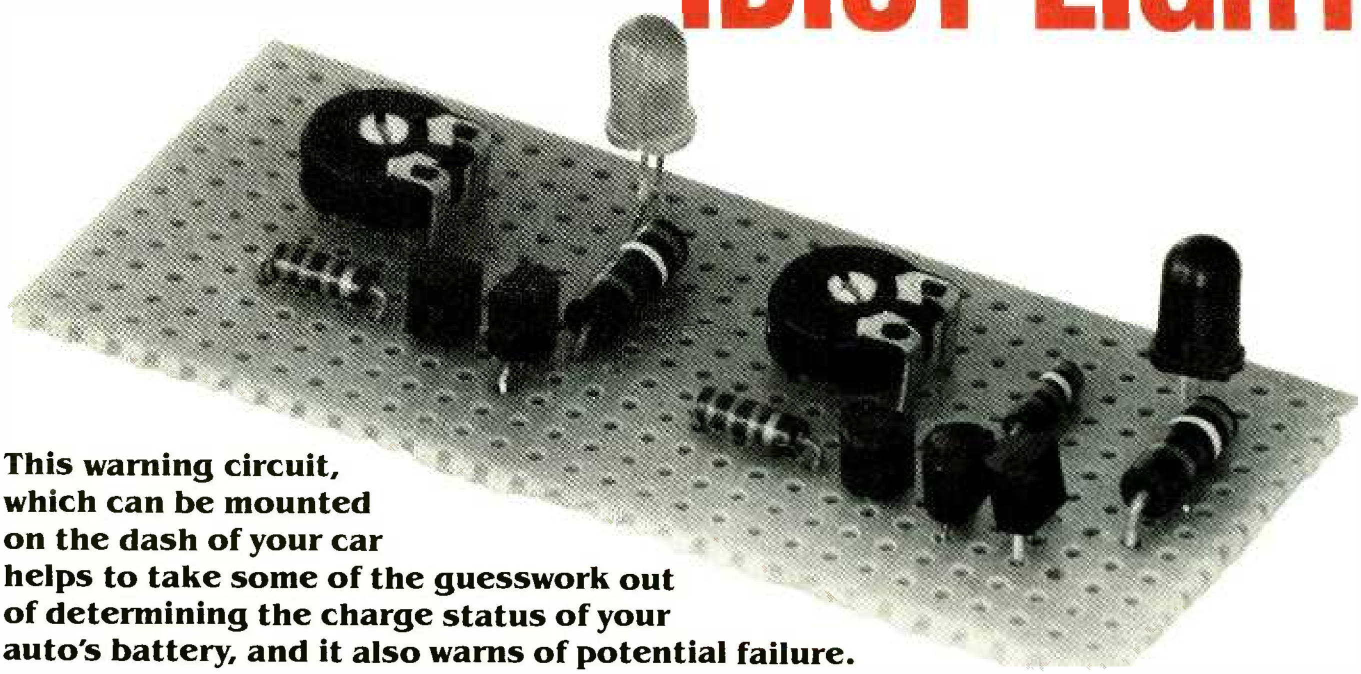
One application for the SSR circuit is to provide drive for a large electromechanical relay. The circuit of Fig. 6 shows the arrangement for driving a mini-DIP relay with output contacts that are rated for 3A at 125VAC. The relay used in the circuit was a Radio Shack 276-246, 5-volt DC SPDT printed-circuit relay. A coil current of 72 mA is required.

The circuit is given in Fig. 6. The pin 4 output of the SSR connects to one side of the relay coil, while the other side goes to ground. The arm of the PC relay connects to the supply voltage by way of a 330-ohm resistor. The normally closed and normally opened contacts of the relay are connected to indicating LED's.

Apply power. Note that when a logic 1 is supplied to the input of 4050 buffer, the normally open LED comes on because the relay is energized. When the input logic is 0, the normally closed LED turns on. Again, if you wish relay

(Continued on page 97)

INTELLIGENT IDIOT LIGHT



This warning circuit, which can be mounted on the dash of your car helps to take some of the guesswork out of determining the charge status of your auto's battery, and it also warns of potential failure.

By Evert Fruitman

☐IF YOU'VE EVER BEEN STRANDED ON A LONG STRETCH OF road out in the middle of nowhere because of a battery failure, then you surely know what a blessing it would be to have your car outfitted with an "early warning system" to alert you to impending danger. I, myself, recently experienced just such an event: While driving down the road, my engine gave off a loud thumping and hissing sound just before the temperature gauge lit, glaring at me from the car's dashboard. A quick check showed that a fan belt had let go without the courtesy of some advance warning. The alternator light didn't glow because it had be left unconnected during a recent repair, in which the regulator had been replaced.

After fixing the problem, I decided that it was time to think about a warning system or perhaps a status indicator that would show whether things where working correctly, as well as giving indications that something had failed. At one time, auto manufacturers equipped their cars with meters. A glance at the instrument panel showed the oil pressure in pound per square inch, water temperature in degrees Fahrenheit, and the battery-charge rate in amperes.

But then someone in Detroit became aware of the fact that the average motorist didn't have a clear understanding of what the gauges meant, and that a bright red light would get attention faster than a wiggling needle. The fact that two bulbs cost less and take up less panel space than meters didn't escape their attention either. And so, the auto makers replaced the gauges with the glowing red lamps that we've all become accustomed to.

New Problems

Regrettably, the lights signal their warning only after something has failed. If the light is off, then the system must be working OK, right?—wrong! Indicators often fail to do their job for one reason or another. And on other occasions, by the time the light turns on, a critical system can be close to a dangerous failure. Case in point: My indicator glowed only after the cooling system was on the brink of a disaster. With those things in mind, and the smell of my steaming engine still in the air, I headed for the workshop and swing my hot soldering iron into action.

Since outboard meters can be hard to read in the dark, I decided to stick with lights, but they would have to be Intelligent Idiot Lights. I wanted a green light to signal when the battery had reached the safe-charge zone, 13.5–14.4 volts, and red to signal when the battery voltage dropped below 12.7 volts. Between those two limits, I would have a good indication that the charging system and the warning system were both working. You could look at the warning system as simple, single-range voltmeters with light-emitting diode (LED) outputs to show when the input voltage is above or below preset limits.

How It Works

Figure 1 shows that only five components make up the basic indicators. The potentiometer, R1, samples the battery voltage and delivers a percentage of that potential (deter-

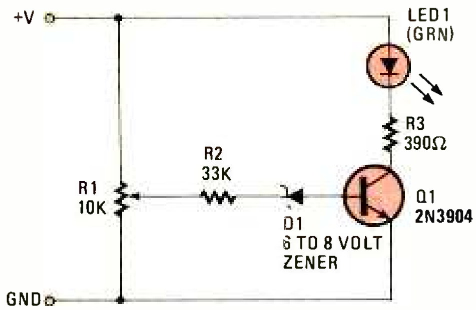


Fig. 1—The basic design of the Intelligent Idiot Light consists of only five components. The transistor (Q1), acting as a switch, turns LED1 on or off. That switching action is determined by the setting of R1 and the voltage presented to the base of Q1.

mined by the setting of R1) to current-limiting resistor R2. When that value exceeds the transistor's emitter-base junction voltage, plus the Zener voltage, the transistor turns on like an on/off switch. That causes current to flow through the LED1, and R3. Resistor R3 limits the current flowing through the LED and the collector circuit to a safe level. Although the circuit would still work without it, the Zener diode provides temperature compensation and a relatively sharp turn-off characteristic.

More gain would give millivolt resolution at the expense of additional parts; but in this application, it's not required. The second LED driver (see Fig. 2) has more gain and switches faster, but only because Q2 is included as a phase inverter, which turns LED2 on when the applied voltage dips below the desired level. Although it is possible to combine the two circuit functions and save a few parts, the final version

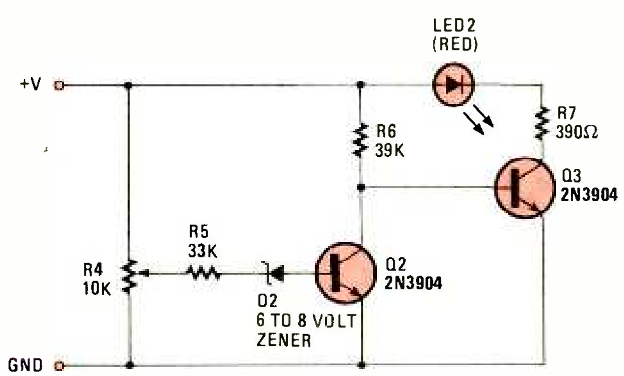


Fig. 2—Although this circuit is basically the same as that shown in Fig. 1, the light-emitting diode, LED2, turns on only when the voltage at the base of Q2 is below the reference voltage determined by potentiometer R4. Note that in addition to the the five components used in Fig. 1, a few others have been added. Transistor Q2, acting as an inverter and whose output drives Q3, provides additional gain for the operation of the circuit.

(shown in Fig. 3) uses separate transistors and diodes for the Normal and Low indicators to simplify construction and give greater reliability.

A Panoramic View

Refer to Fig. 3. With the Intelligent Idiot Light circuit connected across the the battery, as long as its voltage level remains at or above the preset level, Q1 is held on by the potential applied to its base. When Q1 conducts, current flows through the LED1, causing it to light. That shows that the charge-circuit output is at a normal level. At the same time, Q2 is held on by the voltage applied to its base. With Q2 turned on, the base of Q3 is held low; thus it is turned off—no current flows through LED2 so it remains dark.

But when the +V input falls below the preset threshold, Q1 and Q2 turn off. With Q2 off, the level of voltage at the base of Q3 is increased and causes the transistor to turn on. When that transistor turns on, current flows through LED2, which is in the collector circuit of Q3, and the light-emitting diode lights to show that the alternator voltage has dropped below the acceptable level.

Construction

The parts fit comfortably on a 1½-inch by 3-inch piece of perfboard (see photo), which also provides an easy-to-follow layout. Since I used the cheaper light-emitting diodes, which need about 20–30 mA, the resistors in series with them in the collector circuits of Q1 and Q3 had to be ½-watt units. Better grade LED's with lower ratings can cut power-supply requirements by as much as ¾, allowing you to use ¼-watt resistors throughout.

PARTS LIST FOR THE INTELLIGENT IDIOT LIGHT

(Refer to Figure 3)

SEMICONDUCTORS

D1, D2—6- to 8-volt Zener diode, or Zener-connected transistor (see text)
LED1—Jumbo green light-emitting diode
LED2—Jumbo red light-emitting diode
Q1, Q2, Q3—2N3904 or 2N2222 NPN general-purpose, silicon transistor

RESISTORS

(All resistors ¼, 20% or better unless otherwise noted.)
R1, R4—10,000-ohm, miniature potentiometer
R2, R5—33,000-ohm
R3, R7—390-ohm, ½-watt
R6—39,000-ohm (see text)

ADDITIONAL PARTS AND MATERIALS

Prefboard or printed-circuit materials, project box (optional), solder, wire, mounting hardware, etc.

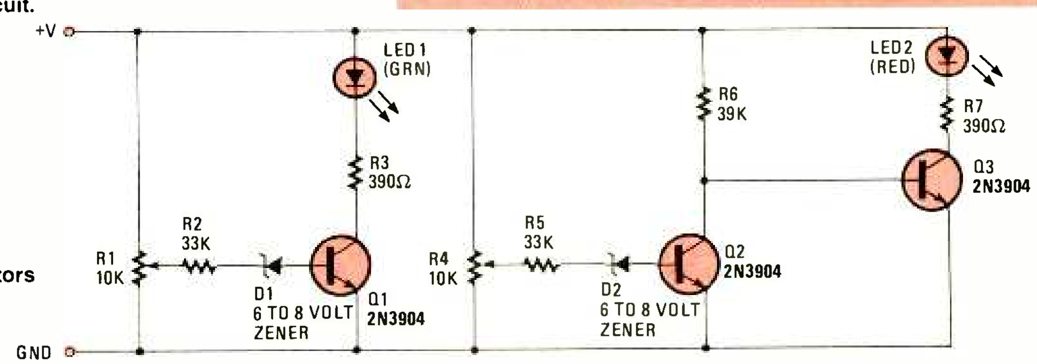
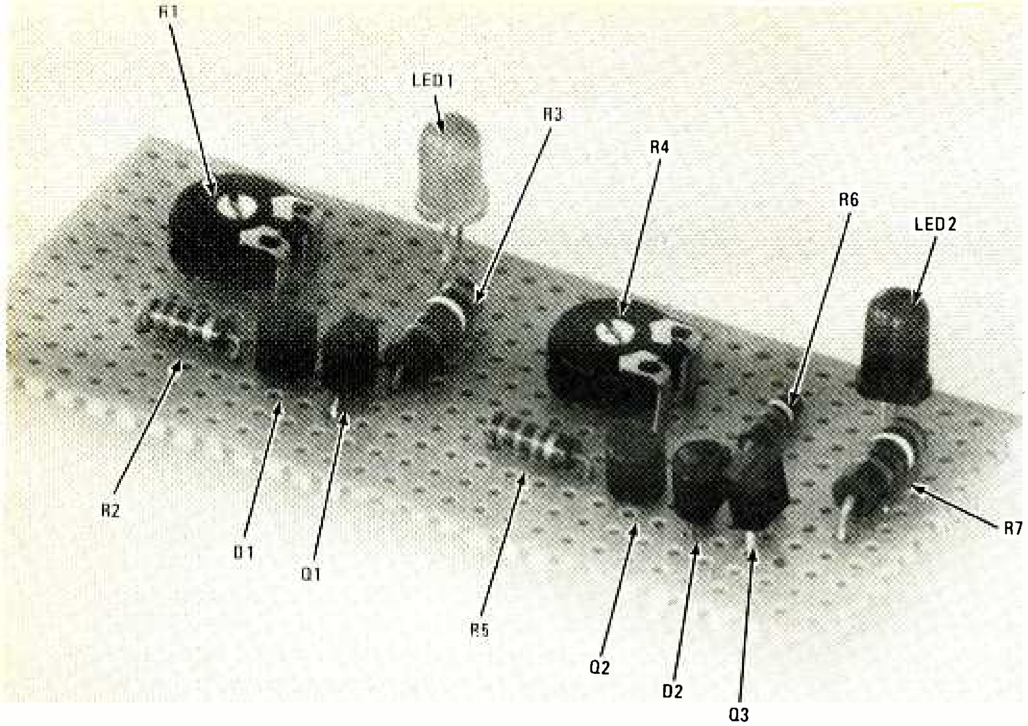


Fig. 3—The circuits of Fig. 1 and Fig. 2 are combined to produce a fully operational Intelligent Idiot Light circuit. Although the schematic diagram calls for 6 to 8-volt Zener diodes, Zener-connected general-purpose silicon transistors may be substituted (that procedure is outlined in Fig.4).



The completely assembled circuit board (with callouts) reveals that in the author's prototype, Zener-connected transistors are used. Using that scheme further reduces the cost of building the circuit, as general-purpose transistors are considerably less costly than Zener diodes.

The Zener diodes, mounted next to the 33,000-ohm resistors are really transistors: A small-signal, silicon transistor with its emitter/base junction reverse-biased makes an excellent Zener diode. Besides that, a Zener diode would cost about a dollar; whereas, transistors like the 2N3904, 2N2222, and other similar devices cost about 15 cents each, and are more likely to be found among your spare parts. Figure 4 gives the proper connections. Note that the base of the Zener-connected transistor (acting as the anode) is connected to the negative bus, while the emitter, which is effectively the cathode, goes to plus.

Whether you use perfboard or decide to make a printed-circuit board on which to mount your components, the circuit may be housed in a small project box. Or, if you want to save space, the board may be mounted directly on or under the dash in an out-of-the-way place and the two light-emitting diodes, LED1 and LED2, on a separate board. Then you can run thin (speaker) wire to the LED's and place them where they'll show without having to hunt for them.

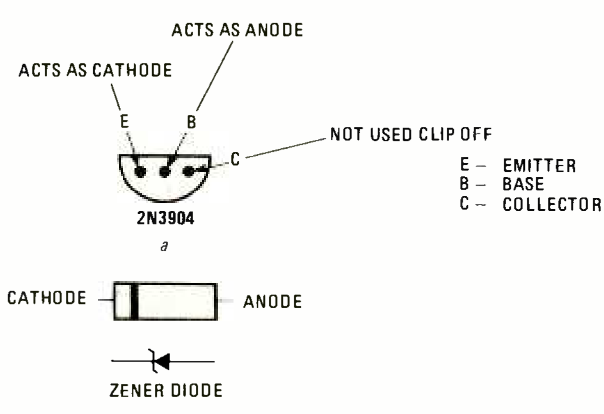


Fig. 4—Pinouts for the 2N3904 transistor and lead designations for the Zener diode are given to aid in the construction of the circuit. Use *a* as a guide if you intend to use transistors in place of the Zener diodes. For Zeners, note that the banded end of the unit outline corresponds to the cathode of the diode symbol. When wiring the Zener into the circuit, be sure that its cathode is connected to the wiper arm of the potentiometer. The Zener-connected transistor should be wired the same way.

Calibration

After completing construction, you can set the controls with the aid of an adjustable power supply and a voltmeter, or with the aid of your car (battery) and a voltmeter. If you use the power-supply method, set it for a 12.5–12.7-volt output and adjust control R4 so that the red LED turns on. Run the voltage up and down while noting the voltage at which the red LED turns on and off. It should turn on very close to the desired point and stay on as long as the voltage is below that value. At about 4–5 volts it will fade out due to a lack of available power.

To set the control for the green LED, turn the voltage up to 13.5 volts, and set control R1 so that the green LED just turns on. Then turn the voltage up to 14–16 volts. The green LED should get brighter. As you turn the voltage down and the green light goes out, there may be a dead spot where neither is lit. You could put in a third (yellow) LED or change the setting for one of the other LED's so that one would be lit all of the time. But that might be over doing it a bit.

If you wish to do the final adjustment with the circuit in your car, connect the minus lead to a good chassis ground, and the plus lead to a point that receives power only when the ignition switch is on; connect a voltmeter across the unit—or for more accurate results, across the battery. If you use long leads to connect to the battery, take care to keep them clear of moving engine parts.

Unless the engine was just turned off, the battery voltage will be close to 12 volts, although it can read as high as 12.7 volts for a few minutes after getting a good charge. Check the battery voltage with the engine off; and if the voltage is high enough, set the red LED control. If it is too low, start the engine and change the alternator load by turning on lights, blowers, etc., to get a suitable voltage around 12.7 volts.

Some cars give a full charge at 13.7 volts. My old Chevy takes close to 14.3 volts to keep the battery charged. So, with the extra load turned off, note the voltage on your battery, then turn on enough lights, etc. to drop the voltage two to four-tenths at a slow idle, it can't keep the alternator up with the extra loads such as the headlights and blowers. At normal road rpm, however, a properly operating charging system will keep the battery well charged. Don't be surprised to see the lights follow the ticking of your turn signals when you are stopped at an intersection with the headlights and heater on. As you gently ease the pedal down and the car quickly rolls forward, you can drive with greater confidence, knowing that your car has Intelligent Idiot Lights.

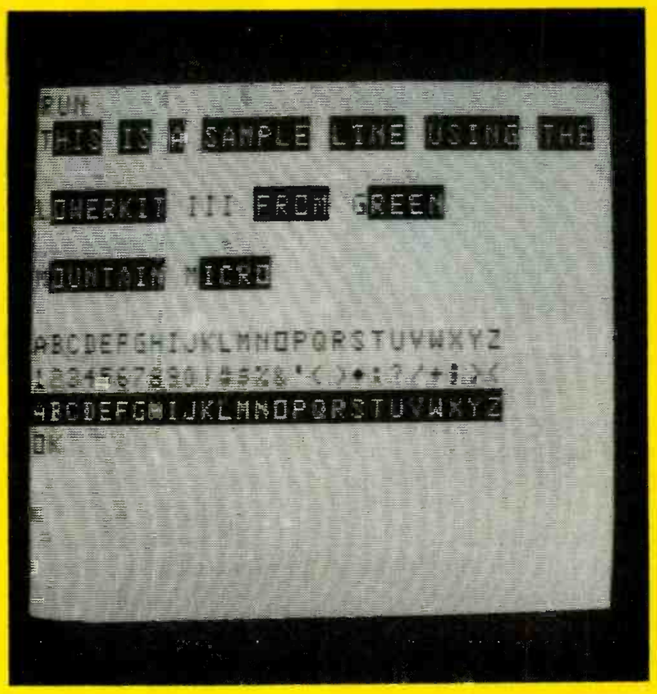
ADD LOWER-CASE CAPABILITY TO YOUR COLOR COMPUTER

By Herb Friedman

Now you can add lower-case character video capability to your Radio Shack Color Computer and get reversed video in the bargain!

☐INDIFFERENT TO WHY IT WAS DONE, THE LACK OF A LOWER-case video display for Radio Shack's Color Computer was a real boo-boo. Although the computer responds to, and will output, lower-case characters to a printer, the screen shows lower-case characters as reversed video; which, as you quickly learn, is a pain in the byte, at best. It often proves confusing and misleading; so much so, that the very best professional-quality word processors (like Telewriter-64 and VIP Writer) generated their own lower-case monitor characters through graphics.

But word processing isn't the only time when lower-case characters are needed. Not by a long shot! Mailing lists, spreadsheets, and database programs benefit from a lower-case display. Unfortunately, that kind of software almost never generates lower-case video characters. But if you know one end of a screwdriver from the other, and can follow instructions without assuming that you know better, you can retrofit your Color Computer with full-time upper and lower-case display capabilities.



In truth, the retrofit not only gives you full-time upper and lower-case, but the option of reversed video—light characters on a dark background, which is the standard display for personal computers. (Because the Color Computer was intended to use a TV set as a monitor, its normal display is dark characters on a light background.)

Lower case and inverted display is obtained through a retrofit accessory called *Lower Kit III*, which is available mail order from Green Mountain Micro (Bathory Rd., Roxbury, VT 05669; 1-802-485-6112). Although there appears to be only two models of the Color Computer—known as version 1 (gray cabinet) and version 2 (white cabinet)—there are really several variations within each model group. Since *Lower Kit III's* are designed for specific versions of the Color Computer, you must specify the model number printed on the computer, or the "board identifier" letter (E, D, etc.) when ordering. In fact, it's a good idea to phone Green Mountain Micro to find out what version of the retrofit you need.

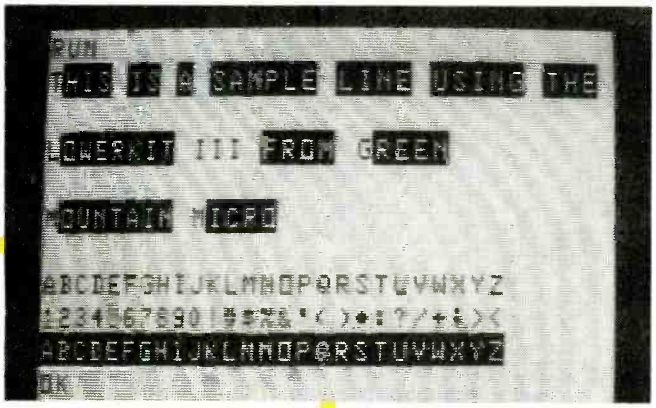
The photographs illustrate a *Lower Kit III* retrofit for the Color Computer I using the full-kit version; meaning that, aside from installing it, the user also assembles the *Lower Kit III*. The kit—also available factory wired—consists of a small printed-circuit board and a handful of parts. No particular assembly skill is needed as long as you use a small soldering iron of about 20 watts, a needle point soldering tip, and #20 or #22 wire gauge solder, which is a fancy way to describe very thin rosin-core solder.

The kit's integrated circuits are sensitive to static electricity, so they are supplied on a piece of conductive foam. Do not remove the IC's from the foam until you are connected to an "earthen" electrical ground through a ground strap. A ground strap is simply a length of wire that is series-connected to a 1-megohm resistor. One end of the wire is connected to an electrical ground such as a cold water pipe or a grounded electric box. The other end of the wire terminates in a small alligator clip which is secured to your metal watchband, or to the metal buckle of a wristwatch strap. The wire will discharge to ground any static electricity that might build in your body when you walk across a carpet, or stroke the family cat, or perform any of your normal duties.

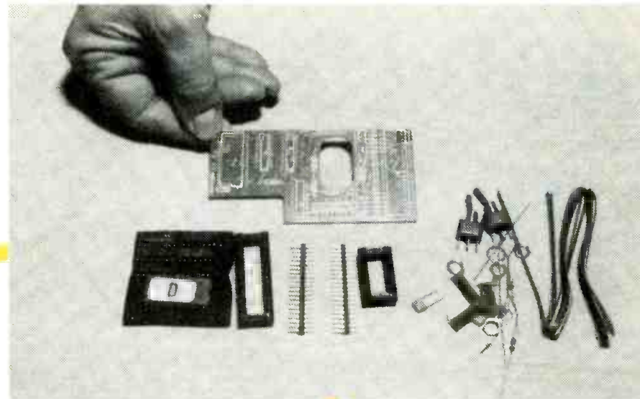
Assemble the retrofit in the order given in the supplied assembly manual. **Do not** jump ahead or rearrange the assembly order. And make certain that you use the ground strap when handling the IC's.

Installing the Retrofit

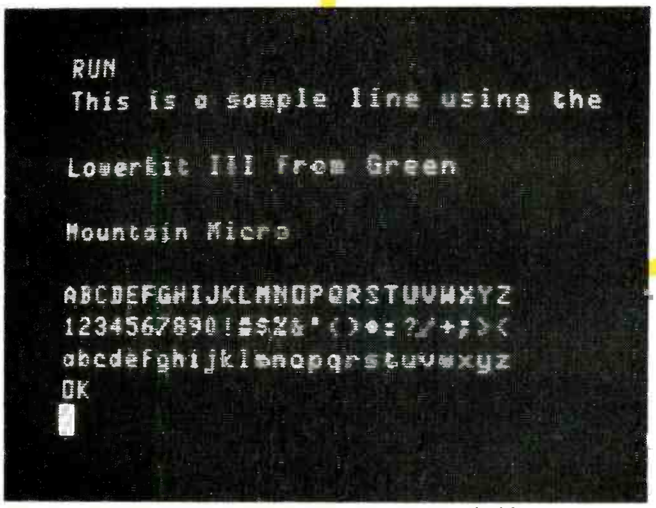
The first step is to open the Color Computer. Flip the computer upside down and remove the seven screws that secure the cabinet. You will probably find only six screws: The seventh is concealed under the "warranty seal:" the label



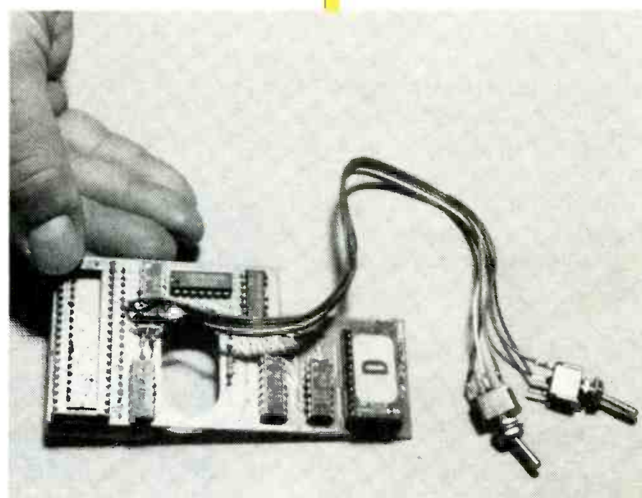
In the conventional Color Computer monitor display, the lower-case characters are indicated by reverse video blocks.



The *Lowercase III* retrofit produces true lower-case characters just as they would appear if printed.



The *Lowercase III* is available factory-wired or in kit form. The kit version is a less than one-evening project.



The completed kit. The switches provide reverse video as well as lower-case characters.

that voids the warranty if broken. To get at the screw simply push your screwdriver through the label. If you're worried about voiding the warranty, simply wait 90 days until the warranty expires.

Hold the cabinet together with your hands and turn the computer right side up; then carefully lift the top off. Now locate the VDG—Video Display Generator—which is the large integrated circuit labeled MC6847. Make certain that your ground strap is in place; then slip a nail file—or a similar tool—under each end of the VDG and carefully (extremely carefully) lift the VDG out of its socket. Don't rush the job: rushing can cause the IC to break in half. Lift one edge a smidgen, then the opposite end. Repeating that back and forth procedure a few times will cause the VDG to pop out of its socket.

Place the *Lower Kit III* retrofit over the empty VDG socket and check for clearance on all sides. Because of variations in the size of original Color Computer components, the retrofit's printed-circuit board might barely hang up on the shield covering the RAM (Random Access Memory) IC's or one of the unshielded IC's. If the printed-circuit board does hang up, very carefully shave the excess off the retrofit board with a sharp pocket knife: Actually, you will scrape, rather than cut the board. Make certain you take extra care because the board has foils very near the edges.

Next, position the assembly over the VDG socket and make certain that it clears the components on the computer's mother board. Do not try to force it into position. Instead, phone or write to Green Mountain Micro for an extension socket, which gives a little "lift" to the retrofit assembly. Position the retrofit assembly over the empty VDG or extension socket, and quadruple check to make sure that all pins or terminals are in exact alignment. Once done, gently seat the retrofit into the VDG socket. Finally, place the VDG itself into the retrofit's empty socket, and using finger pressure on both ends of the IC, gently—but very gently—seat the VDG IC into the socket.

The two switches attached to the retrofit's printed-circuit board provide for upper/lower-case or upper case only characters, and for "normal" (dark characters on light background) or "reversed" (light characters on dark background) display. The documentation suggests that the switches be installed in the rear of the case by cutting notches in the bottom of the cabinet. However, you may prefer having the switches on top of the cabinet where they can be easily reached (as the photograph shows). Bear in mind however, that if you install the switches on the top of the cabinet, they'll have to be removed each time that you want to take off the cover. A rear switch installation permits the cover to be removed independent of the switches.

Checkout Time

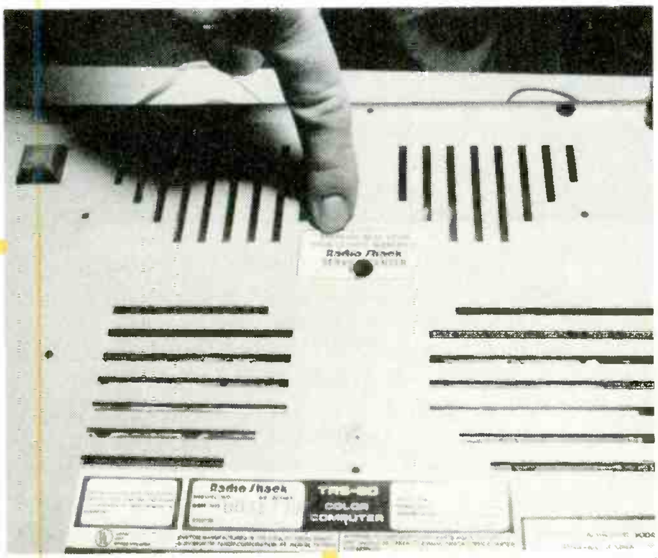
Make certain the retrofit works before you replace the cover. Connect the Color Computer to your monitor, making certain that the switches are lying on an insulated surface, such as a piece of cardboard, and then apply power. Ignoring what appears on the screen, work the switches to see if you can get normal and reverse video. If you can, set the proper switch for a conventional display. Next, type in a line of text using what should be upper and lower-case characters, and then flip the other switch back and forth. The screen display should change from the conventional upper-case-only display (which indicates lower-case in reverse video) to actual upper and lower-case characters.

With the switch set for upper and lower-case characters, flip the screen switch to reverse video. Even with a reversed display the characters should still be in upper and lower-case. If you fail to get any of the described results, check for proper installation of the retrofit in the VDG socket and for proper installation of the IC's on the retrofit's printed-circuit board.

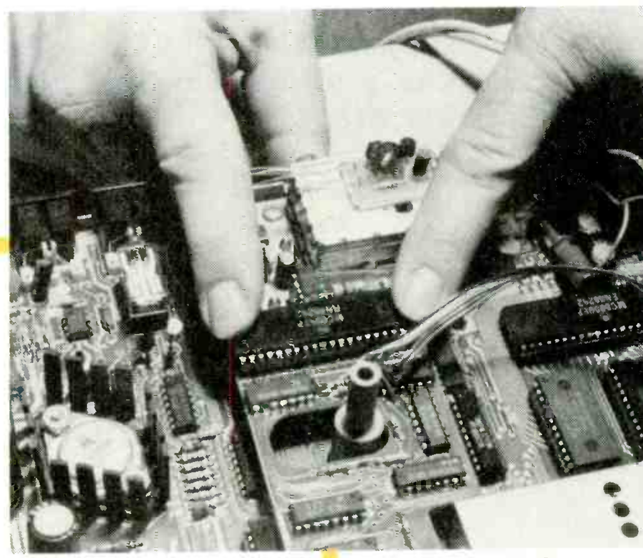
Last—and extremely important—check for solder bridges across the retrofit's solder connections. When you're certain that everything checks out as it should, mount the switches and secure the cover to the computer.

Using Lower Case

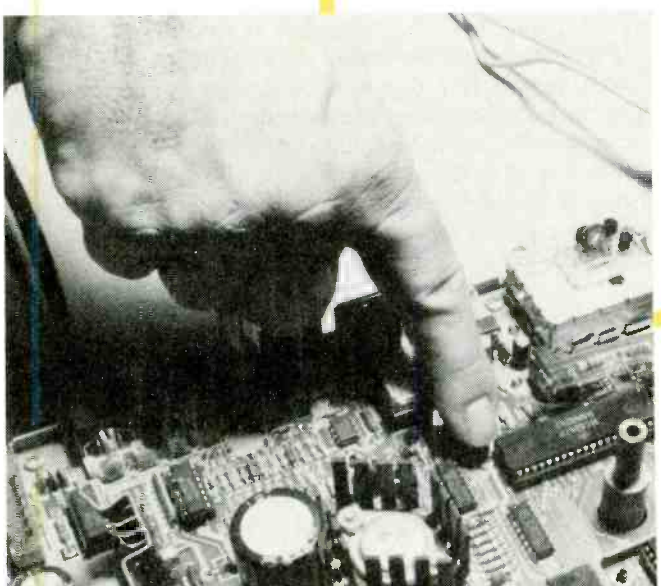
Now, you can reverse video or use upper and lower-case characters whenever you want, or even interrupt entry from the keyboard to make the transition. However, bear in mind that the upper and lower-case mode is inoperative when the software itself generates upper and lower-case characters through graphics. In that instance, flipping the upper/lower-case or the reverse video switches has no effect on the displayed characters. The switches will only work for your own programs, or commercial programs that use the Color Computer's normal character generator—which includes just about everything other than high-performance, word-processing software.



To open the Color Computer, you must break the "warranty seal" to get at the seventh screw. If voiding the warranty worries you, wait until it runs out. Of course, the warranty on the "gray" Color Computer I expired many moons ago.



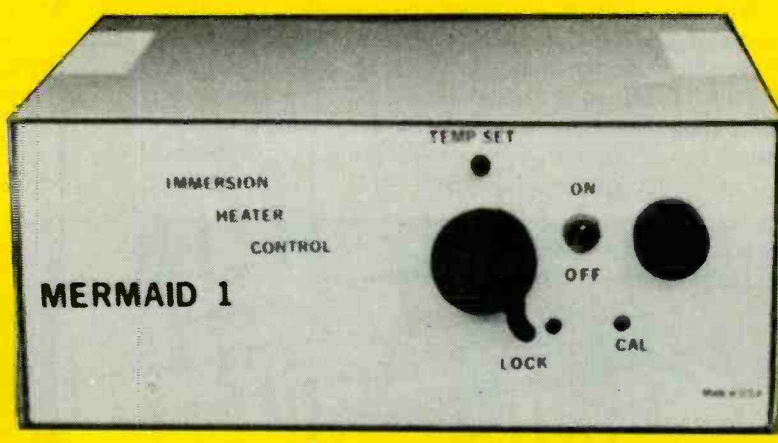
Remove the VDG, and in its place install the retrofit. Then install the VDG in the *Lowercase III* taking extreme care not to damage the IC or its socket. Use fingertip pressure on both ends of the chip when seating the IC.



The finger points to the VDG—the Video Display Generator—whose location depends on the particular model of the Color Computer. Make certain that you locate the VDG, not a large IC.

Mounting the switches on the front panel, rather than the rear, makes them convenient to use. However, if you need to remove the cover in the future, you'll have to remove the switches.

Build the *MERMAID I*



A submersible heater, made out of junkbox ½-watt resistors, for etchant, chemical baths, photoprocessing, fish, mermaids, etc...

By D.E. Patrick

☐WHETHER YOU'RE INTO ETCHING PRINTED-CIRCUIT boards, photography, keeping coffee, fish, mermaids, or anything warm and at an exact temperature, the Mermaid I is a project made to order for you! Using an electronically-controlled submersible heater made from a power resistor or a string of ½-watt parallel-connected resistors, you can hold any liquid at an exact elevated temperature at a very low power cost.

In the case of etching printed-circuit boards, it's well-known that no matter what etchant you use, you can decrease the etching time required by raising the temperature and/or agitating more vigorously. However, when the etchant is cold or at room temperature, it can take a considerable amount of time to get a circuit board done. On the other hand, raising the temperature of the etchant, as the professionals do, will get your circuit boards done faster.

In film processing, holding chemical baths at a constant temperature is necessary. Here, the Mermaid I will hold temperatures constant up to 85 °C. However, as you'll see, you don't have to fork out big bucks for commercial units that don't approach the performance of this low-cost project.

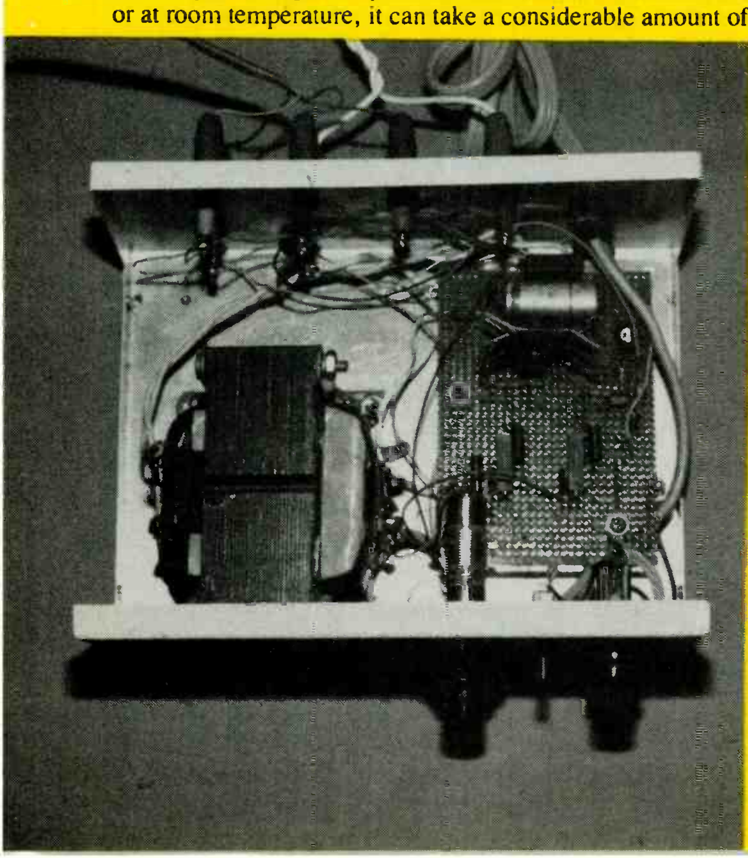
For those of you who aren't into etching printed-circuit boards or into photography, but happen to like their food or coffee at a given temperature: This project will do that, too. I happen to like my coffee at exactly 110 °F, which (while it might be a little odd) requires waiting around for it to cool. But the Mermaid I can keep a cup or even a pot at exactly the right temperature, which is more than you can say for even the most expensive electric coffee pots or food warmers.

Further, when the Mermaid I is used as an aquarium heater, there's no unsightly glass tube hanging down the side of the tank. You can bury its submersible heater under the rocks in the tank out of sight. Also, this unit runs off low voltages, so the chance of frying either you or your fish's fins is limited. And just considering the cost and construction of most commercial aquarium heaters operating off 117-VAC, with their inaccurate bimetal switches, which can stick and stew or break and scald anyone's mermaid, makes this project worth building.

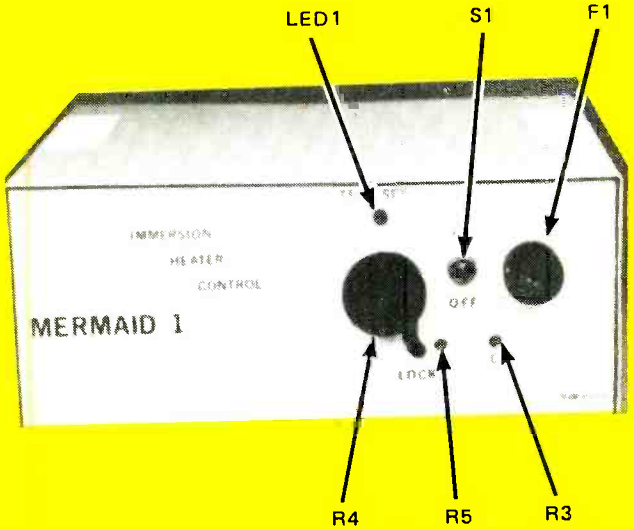
There are probably a thousand applications and I've only mentioned a few. So let your imagination be your guide.

How the Circuit Works

Step-down transformer T1 (Fig. 1) provides power-line isolation and a safe 20-VAC output, which is rectified by diodes D1 through D4 connected in a bridge network. The



With cover of Mermaid I removed, the wired perfboard circuit is revealed, with the power transformer (T1) occupying much of the space. All operating controls are front-panel mounted; interconnecting terminal points are brought to the rear apron.



The Mermaid I was designed as a showpiece by the author, however you need not indulge in so expensive or time consuming a fad.

positive output of the diode bridge drives the resistor heater consisting of R13 through R35, which consists of twenty-two 220-ohm, ½-watt resistors. Other resistive configurations are also possible to obtain a 10-ohm, 11-watt load. The positive output of D1 through D4 also provides power to drive light-emitting diode indicator LED1. That LED serves as a heater-on indicator. Diode D5 feeds filter capacitor C1 and integrated circuit U1, an LM3911N temperature sensor controller, which in turn controls the gate of SCR1, via emitter-follower Q1, applying power to the other side of the heater and LED1.

The LM3911N controller's comparator (U1) performs a balancing act, where the voltage at the plus input (pin 4) produced by its on-board sensor is compared with the reference voltage at the minus input (pin 1). The reference trip or turn-on point is determined by R2 through R6. Resistors R2 and R6 act in conjunction with optional R3 and R5 trimmer potentiometers to set maximum and minimum trip points respectively. Potentiometer R4 is a front-panel, 10-turn adjustable potentiometer with a vernier readout used to set the desired temperature in degrees C for the resistor values shown for R2 through R6.

When U1's output is low, SCR1, LED1, and the heater (resistors R13–R35) are off. If the temperature of the liquid bath in which U1 and the heater was immersed were to drop, the voltage change at the positive input of U1's comparator would be reflected at its output by going high. U1's output going high fires SCR1 via emitter-follower Q1, and the heater (R13–R35) and LED1 turn on. Since pulsating DC is applied to SCR1, when the temperature of the liquid rises so that U1's output goes low again, the heater and indicator will turn off. Hysteresis is provided by D6, R10, C4, and R11. It usually takes some time for the volume of liquid to both heat and cool.

Heating Things Up

The heating element proper could be anything from a commercial submersible heating element to a waterproofed, parallel string of composition resistors. The former can be expensive with most commercial heaters running off 117-VAC. The latter is generally cheaper and allows for a custom low-voltage design. Using a string of parallel resistors allows heat to be dispersed over a wider area for even heating, which may be handy for certain applications. If you prefer to concentrate the heat, a single power resistor could be used.

You can over-build a multi-resistor heater so that it will operate in free air. But the resistor array shown in Fig. 1 will handle approximately 11 watts in free air and four times that (44 watts) when immersed in a suitable volume of water or other low-viscosity liquid. Also, ½-watt resistors can be purchased for under three cents each for a cost-effective heating element under $1.50. Further, the transformer, diodes, and SCR will handle 6 amperes, driving a heater that you could push over 100 watts if the need arises.

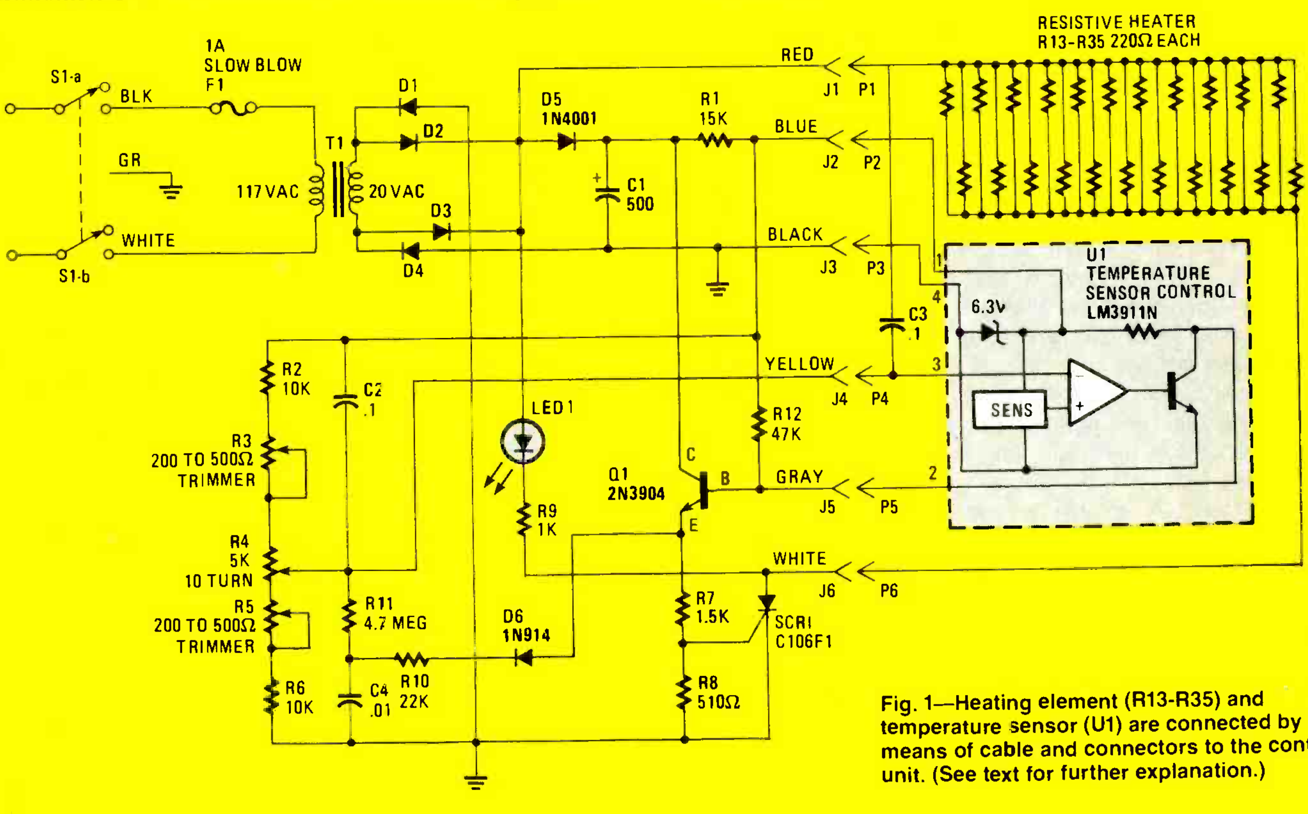
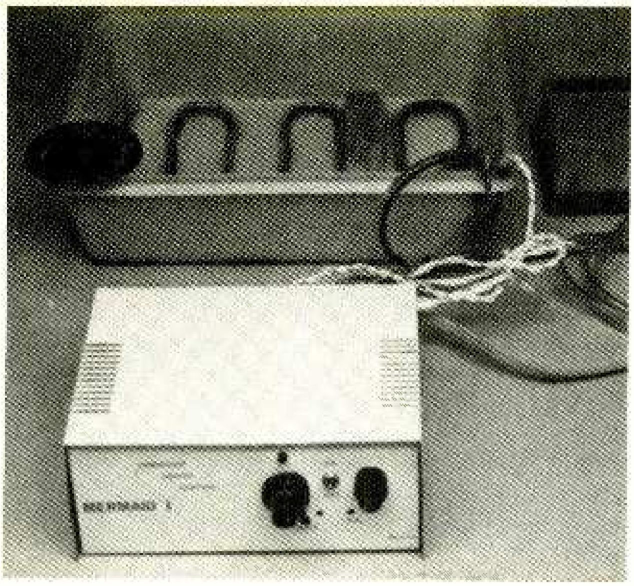


Fig. 1—Heating element (R13-R35) and temperature sensor (U1) are connected by means of cable and connectors to the control unit. (See text for further explanation.)



With the heating network resistors in place on the bottom of the pan, the Mermaid I is now ready to control temperatures for either film processing or etching circuit boards.

PARTS LIST FOR MERMAID I

SEMICONDUCTORS

D1–D4—6-A, rectifying diode
D5—1N4001 diffused-junction silicon rectifier diode
D6—1N914 silicon small-signal diode
LED1—Light-emitting diode, 20-mA, red
SCR1—C106F1, 200-μA gate-current, silicon-controlled rectifier
U1—LM3911 temperature-sensor control integrated circuit

RESISTORS

(All fixed resistors ½ watt, 10% unless otherwise indicated)
R1—15,000-ohm
R2, R6—10,000-ohm, film
R3, R5—200- to 500-ohm, 10-turn trimmer potentiometers
R4—5000-ohm, 10-turn, linear-taper potentiometer
R7—1500-ohm
R8—510-ohm
R9—1000-ohm
R10—22,000-ohm
R11—4.7-Megohm
R12—47,000-ohm
R13–R35—220-ohm (see text)

CAPACITORS

C1—500-μF, 25- to 50-WVDC electrolytic
C2, C3—.1-μF, ceramic disc
C4—.01-μF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

F1—Fuse, 1-A, slow-blow type
J1–J6, P1–P6—Tip jack and tip plug. Flat ribbon cable soldered directly may be used, or any six-connector mating jack and plug.
S1—DPDT, miniature toggle switch
T1—Step-down power transformer: 117-VAC primary winding; 20-VAC, 6-A. secondary winding (See text)
Fuseholder, metal or plastic case, 3-lead power cord with molded plug, cement (see text), hardware, solder, wire, etc.

KIT AVAILABLE

A complete kit of parts is available from E.T.C., 837 Galapago Street, Denver, CO 80204. Price is $50.00 postpaid.

Construction Hints

There is nothing critical about construction. The circuit may easily be breadboarded as shown, with SCR1 mounted to a suitable heat sink, where even the aluminum case might have been used in place of the free-standing heat sink shown. Chip U1 can be connected to the rest of the electronics via flat-ribbon cable. For convenience, the author used pin-plugs and pin-jacks, but any six-terminal plug-and-jack mating combination could as easily have been used. Stranded hookup wire (#18 AWG) should be used to connect the heater. Teflon-coated wire is the best choice for interconnecting U1 and the heating element, where the Teflon properties will give long-life service.

The heating element can be constructed by placing half-watt or bigger resistors across two pieces of #12 solid copper wire used as positive and negative buses. A smaller diameter of wire such as #14 is also all right to use, but #12 is stiff and will probably work a little better. There's nothing critical about this selection.

Once the resistors are soldered in place with hookup wire to the controller installed, they should be given two thin coats of silicon rubber cement. The same process will also waterproof U1, but don't forget to install C3 between pins 3 and 4 before connecting ribbon cable and waterproofing. In both cases, it is not advisable to use epoxies—especially the 5-minute variety—in place of silicon rubber compounds. Many epoxies can leach into certain liquids when immersed without proper curing.

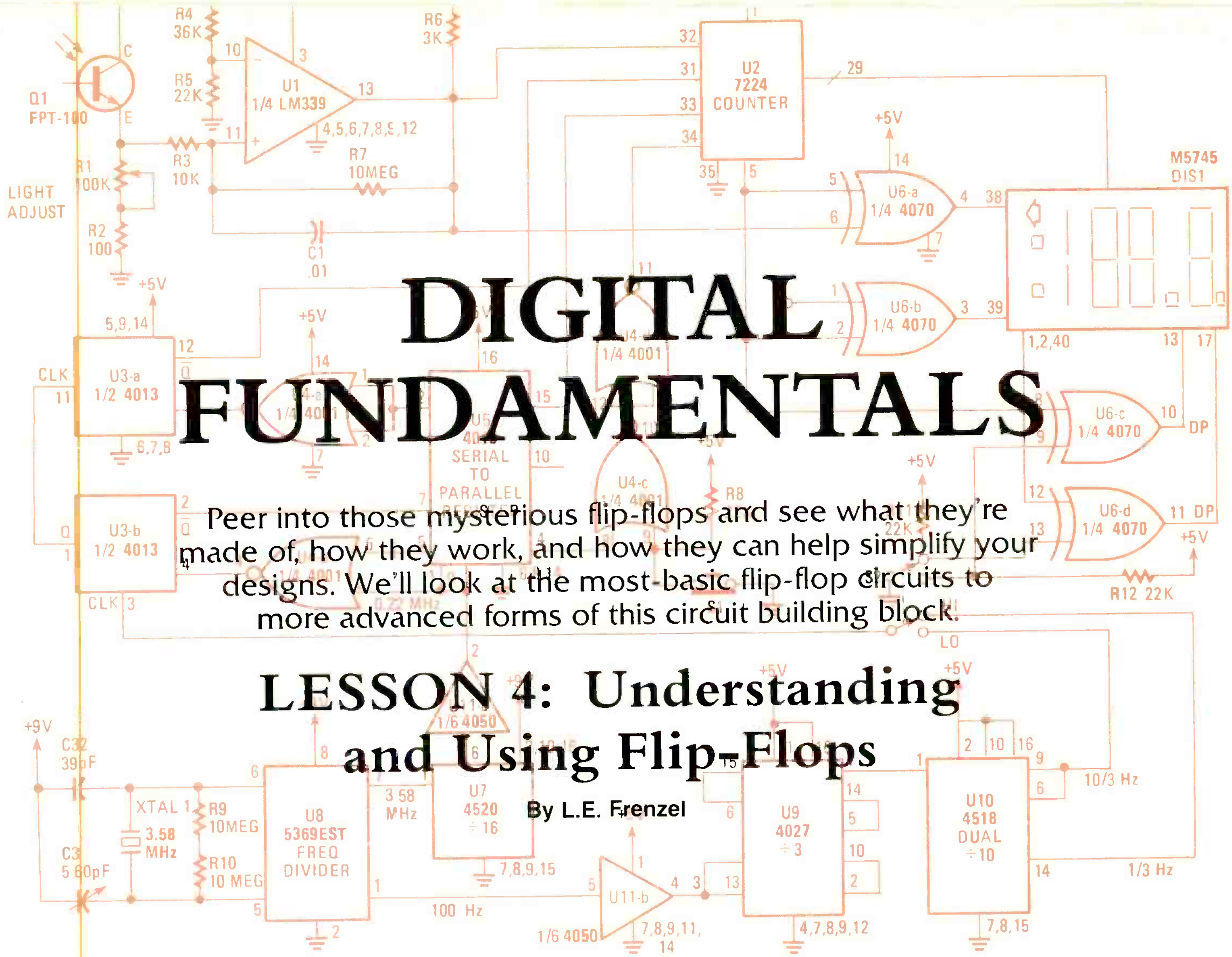
Silicon rubber compounds can take some time to cure. However, that time problem can generally be overcome by placing U1 and the heater unit in an oven to speed up the process.

The two coats of silicon rubber should extend at least 2 to 4 inches up the hookup wire to prevent leaks. Another solution is to coat the units with silicon rubber, place them into a heat-shrink tubing and shrink. The heat shrink will squeeze out excess silicon rubber and provide a double water-barrier in the process.

Some Final Notes

For less than critical applications, the R3 and R5 trimmer potentiometers along with 10-turn potentiometer R4 may be deleted to cut costs. The vernier control may also be replaced with a hand-lettered dial, when a single-turn potentiometer is used.

On the other hand, R3 and R5 trimmer potentiometers can be used to make the vernier control track actual temperature more closely. That can generally be accomplished by using a thermometer of known accuracy while making trimmer adjustments. And the single-point accuracy of both the Mermaid I and reference thermometer can be checked by using a mixture of crushed ice and water in two large styrofoam cups. At sea level on a clear day, both devices should give an approximate indication of 0 °C. You can also check the reference thermometer used at approximately 100 °C, the point at which water boils at sea level just to be sure that everything is copacetic. But remember to add correction factors if you happen to be in mile-high Denver as opposed to sea-level San Francisco.



DIGITAL FUNDAMENTALS

Peer into those mysterious flip-flops and see what they're made of, how they work, and how they can help simplify your designs. We'll look at the most-basic flip-flop circuits to more advanced forms of this circuit building block.

LESSON 4: Understanding and Using Flip-Flops

By L.E. Frenzel

THERE ARE TWO BASIC TYPES OF DIGITAL LOGIC CIRCUITS, *combinational* and *sequential*. Combined circuits are made up of logic gates connected in a variety of configurations. Combinational circuits typically have multiple inputs and multiple outputs. Their outputs are a function of the input states, the types of gates used, and how they are interconnected.

Sequential logic circuits also contain gates, but their main element is a logic circuit we have not yet discussed; it's called the *flip-flop*. A flip-flop is a circuit used for storing one bit of data. Because flip-flops are a kind of memory circuit, they permit a variety of storage and timing operations to be performed. Some of those operations include counting, shifting, sequencing, and delay generation.

In this lesson, you are going to learn about the various types of flip-flops and how they are used. In a future lesson, we will cover more advanced sequential logic circuits, including counters and shift registers.

Note: In the following discussion, we use the expression "high" to refer to a binary-1 logic level of some positive voltage in the +3 to +5 volt range. "Low" is used to designate a binary-0 logic level, which is ground or 0 to +.2 volt.

Data Latches

The simplest form of flip-flop is the latch or RS flip-flop. Like all other flip-flops, this type is capable of storing one bit of data. It has two inputs and two outputs, and is usually represented by the simple logic block shown in Fig. 1. For example: To store a binary 1, you apply a signal momentarily to the set input. To store a binary 0 in the latch, you momentarily apply a logic signal to the reset input. Once the latch is set or reset by the input pulse, it remains in that state. The flip-flop remembers to which state it was set (0 or 1) until the state is changed, or until power to the circuit is removed.

To determine what bit is stored in the latch, you look at the outputs. By examining the normal output with a voltmeter, logic probe, or oscilloscope, you can determine what state the flip-flop is in. If the normal output is a binary 1, then the flip-flop is set and storing a binary 1. If the normal output is binary 0, the flip-flop is reset and a binary 0 is being stored. The complementary output is an inverted version of the normal output and is useful when the latch is used to drive other logic circuits.

Incidentally, you will note that in Fig. 1, the outputs of a

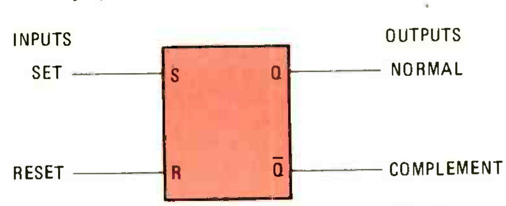


Fig. 1—The logic symbol for a RS (reset-set) flip-flop or latch is given above.

flip-flop are normally labelled with letters of the alphabet. Q is commonly used with flip flops, but other letters of the alphabet or other mutli-letter combinations can be used, too. Also, when a line or a bar appears over a letter as in $\overline{Q}$, that signal is the reverse of its counterpart, Q. That is to say, should Q be at a low, then $\overline{Q}$ will be at a high.

A latch or RS flip-flop is easily constructed with NAND gates as shown in Fig. 2. We say that the gates are connected back to back with the output of one connected to the input of the other, and so on. The operation of a latch is easy to understand if you remember how a NAND gate works. The simple truth table in Fig. 2 will refresh your memory.

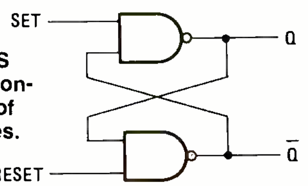


Fig. 2—RS flip-flop constructed of NAND gates.

TRUTH TABLE OF NAND GATE

INPUTS		OUT
A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

When power is first applied to a flip-flop circuit, the latch comes up in one of its two stable states. Because of minor differences between the two gates, the circuit will flip to either the set or reset state immediately upon power-up. You will not be able to predict which state will occur. Let's assume that the flip-flop initially comes up in its set state. That means that the Q output is a binary 1. The binary 1 appears at the input of gate 2 along with the reset input. The reset input is shown open here. Remember, that an open input usually has the same effect as a binary-1 input. With those conditions on gate 2, its output will be a binary 0. The output of gate 2 is applied back to the input of gate 1. The set input is also open at that time and has the effect of a binary 1. However, it has no effect on the circuit, because the binary-0 input to gate 1 causes its output to remain high.

Just to be sure you understand the idea, trace the circuit state by assuming that the flip-flop comes up in the reset condition. Start out with the complement output being binary 1 and repeat the analysis above.

Keep in mind that the set and reset inputs will normally not be open. Instead, they will be held at the binary-1 level. To change the state of the flip-flop, either the set or reset input must be brought momentarily to the binary-0 level.

Assume that the flip-flop is initially set with the Q output being binary 1. If we want to reset the latch, we simply apply a brief pulse that switches from binary 1 to binary 0 and back again. The binary-0 input on gate 2 immediately forces its output high. That high output to the input of gate 1 along with the high set input causes the normal output to go low. The flip-flop changes state from set to reset.

Incidentally if another reset pulse is applied to the reset input, no additional state change will occur. If the flip-flop is already reset, then another reset input pulse will have no effect on the circuit. The same is true for set pulses.

To Tell the Truth

As with logic gates, a truth table can be used to show all possible states of a latch. The truth table in Fig. 3 shows the various combinations of inputs and outputs. There are two special conditions that we should explain. First, when both inputs are binary 1, the state of the latch is not affected. Since we don't know which state the latch is in, we simply designate the output with the letter X—which, of course, can represent 1 or 0.

Another special condition occurs when both inputs are binary 0. At that time both outputs will be forced to the binary-1 level. Looking at the normal output, you will see a binary 1 and, therefore, might suspect that the flip-flop is set. However, that is not the case, because as the complement output is also a binary 1, implying that reset is an ambiguous state that does not represent either the set or reset condition. It should be avoided by eliminating the possibility that both inputs could go to binary 0 simultaneously.

The operation of the latch can also be illustrated with input and output waveforms as shown in Fig. 4. Take a minute to look over those signals to be sure you understand the operation of a flip-flop. The way to do it is simply to observe the Q or normal output to determine the state of the flip-flop. Then note how the set and reset inputs change it. The complement output, of course, is simply an inversion of the normal output except in the ambiguous state.

You can also construct a latch using NOR rather than NAND gates. A NOR latch is shown in Fig. 5. The flip-flop has normal and complement outputs, but note that the positions of the set and reset inputs have been reversed. Because the operation of a NOR is different from that of a NAND, the signals used to change the state of the flip-flop must be binary 1 rather than binary 0, as with NAND gates. Normally both the set and reset inputs will be binary 0. At that time, the flip-flop will be either in its set or reset state. To change the state of the flip-flop, a momentary binary-1 pulse is applied to either the set or reset input. Figure 6 shows the truth table for a NOR latch. The operation of that circuit is further described by the timing waveforms shown in Fig. 7.

INPUTS		OUTPUTS	
S	R	Q	$\overline{Q}$
0	0	1	1*
0	1	0	1
1	0	1	0
1	1	X	X

X = EITHER 0 OR 1
* = AMBIGUOUS STATE

Fig. 3—Truth table for a RS flip-flop.

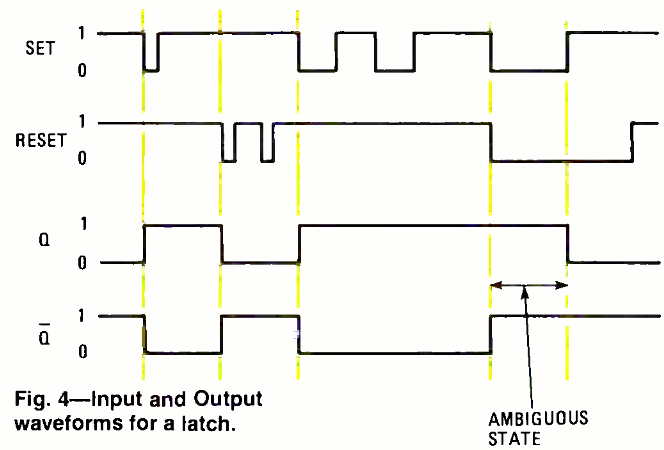


Fig. 4—Input and Output waveforms for a latch.

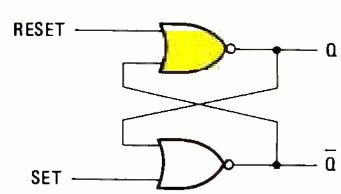


Fig. 5—RS flip-flop constructed of NOR gates.

INPUTS		OUTPUTS	
SET	RESET	Q	$\overline{Q}$
0	0	X	X
0	1	0	1
1	0	1	0
1	1	0	0*

X = EITHER 0 OR 1
* = AMBIGUOUS STATE

Fig. 6—Truth table for the NOR latch.

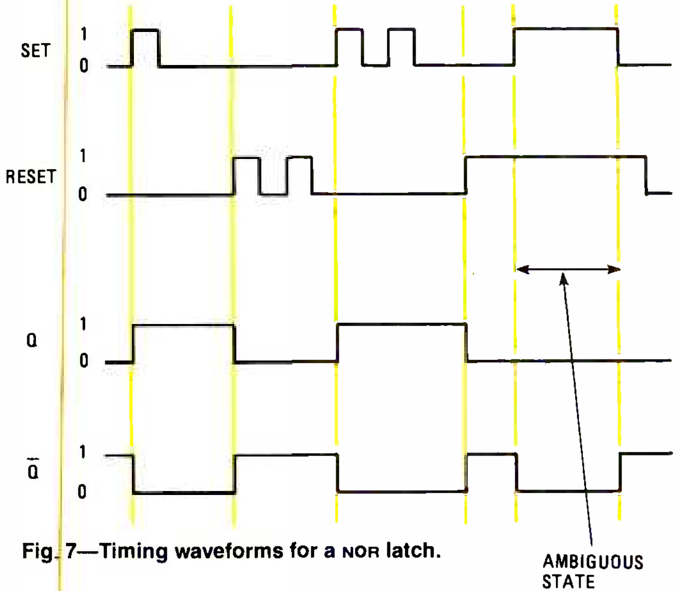


Fig. 7—Timing waveforms for a NOR latch.

Debounce

A popular application for a latch is switch *debouncing*. Switch debouncing is the process of removing the noise (undesired electrical signal) created by most switches when they are opened or closed. Switches of all types are widely used to create binary input signals for logic circuits. A typical arrangement is shown in Fig. 8. With the switch open, the output is a binary-1 level as seen through the resistor. When the switch is closed, the output is brought to ground or binary 0. While clean, clearly defined logic levels are generated by that simple circuit, the problem lies in the garbage generated by the switch for a brief duration when it is opened or closed. The waveforms in Fig. 8 illustrate that effect. Whenever two metal contacts are opened or closed, they will often vibrate or not cleanly make or break contact for a short duration. Any

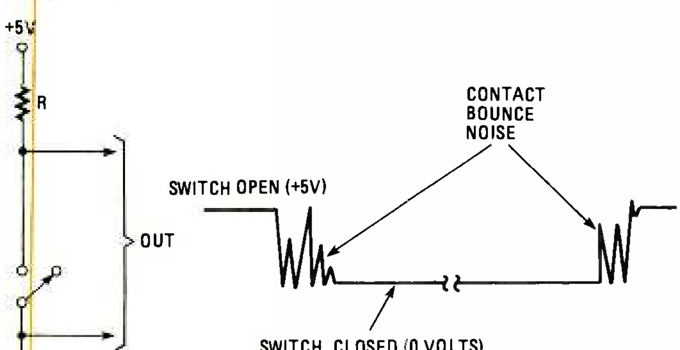


Fig. 8—Waveform for undesired switch-contact bounce.

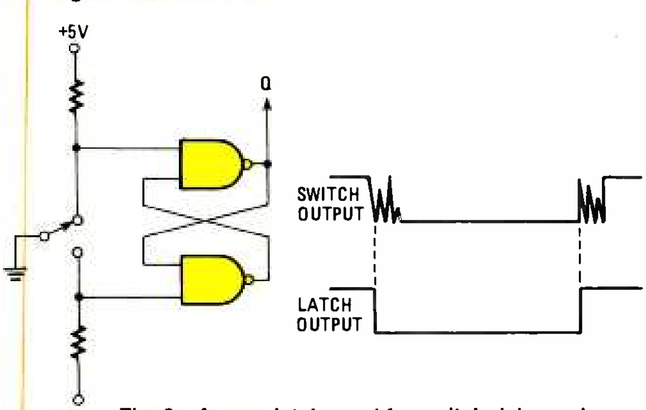


Fig. 9—A NAND latch used for switch debouncing.

dirt or other foreign matter on the contacts will aggravate the problem. The result is multiple pulses or spikes during opening or closing. Such noise can falsely trigger logic circuits. A latch can be used to eliminate the problem.

Fig. 9 shows a latch debounce circuit. A single-pole, double-throw (SPDT) switch must be used in the application. While the contacts still bounce at the inputs to the latch, they effectively have no affect on the output. Recall that if a signal is repeatedly applied to the set or reset input, the flip-flop state will not change. Once it is set, it remains set despite additional inputs. Once it is reset, it remains reset despite erroneous inputs. The result is an output signal that follows the switch conditions, but whose transitions from 0 to 1 and 1 to 0 are *clean*.

A NOR latch can also be used for switch debouncing, as shown in Fig. 10. However, note that the switch input is +5 volts, or a binary-1 level, rather than ground as in the NAND latch. Otherwise the operation of the circuit is similar.

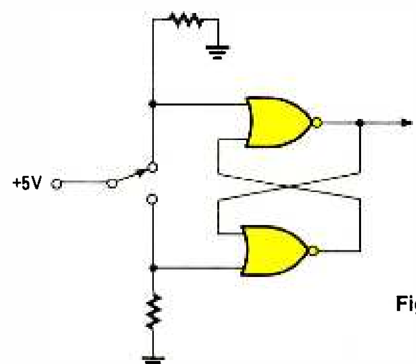


Fig. 10—A NOR latch used for switch debouncing.

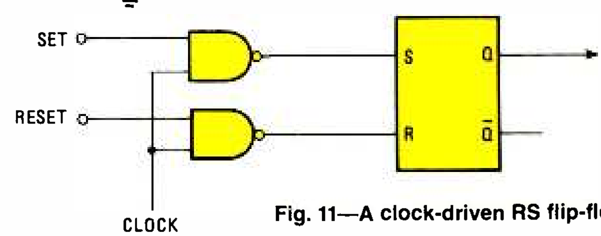


Fig. 11—A clock-driven RS flip-flop.

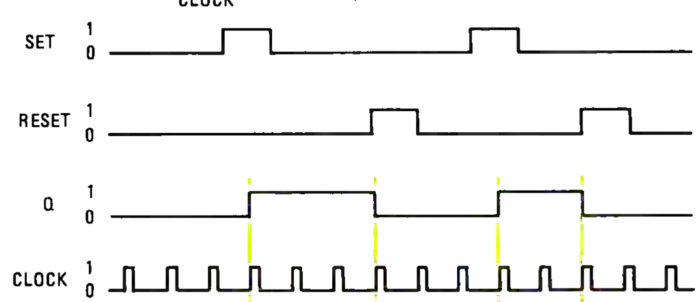


Fig. 12—Timing waveforms for a clocked latch.

Clocked RS Flip-flop

The latch or RS flip-flop is an *asynchronous sequential circuit*. That means that the output changes state immediately upon application of the input signals. On the other hand, some logic circuits act in response to a master timing signal called a *clock*. A clock is an oscillator circuit that generates a fixed-frequency periodic sequence of pulses that are used to control all timing and sequencing operations in a digital cirucit. Logic circuits controlled by a clock are referred to as synchronous because all state changes are intiated and occur in step with the clock signals. Asynchronous circuits, of course, do not use a clock and state changes occur immediately upon applications of inputs. Clocked logic circuits are more predictable and are generally immune to "race" conditions that exist in some asynchronous circuits.

A basic latch can be modified to be used in synchronous operations as shown in Fig. 11. Here the set and reset inputs are buffered by NAND gates. The operation of those NAND gates is controlled by the clock. It is assumed that the latch is a NAND latch whose set and reset inputs must momentarily be switched to the binary-0 condition to cause a state change.

To set the latch, a binary 1 is applied to the set input and a binary 0 is applied to the reset input. With those inputs, the latch does not change state immediately. The reason for that is that the clock is normally in the low position. That inhibits the NAND gates keeping their outputs high and the latch unaffected. When a binary-1 clock pulse occurs, the NAND gates are enabled and the set and reset input signals are applied to the S and R inputs of the latch. The S input goes low while the R input remains high. The result is that the latch is set and the Q output goes to binary 1.

To reset the latch, the reset input is made binary 1 and the set input is made binary 0. When a binary-1 clock pulse occurs, the latch changes states.

That form of synchronous operation is better illustrated with timing diagrams as shown in Fig. 12. Various input and output conditions are illustrated. Note that the actual latch output state change occurs on the positive going or 0 to 1 transition of the first clock pulse following an input-state change.

D-Type Flip Flop

The D-type flip-flop is a variation of the gated latch. The D-type flip-flop is a synchronous circuit in that it uses a clock signal to control the setting and resetting operations. The main difference between the D-type flip-flop and the gated latch is that the D-type circuit has a single input. The symbols shown in Fig. 13 are used to represent a D-type flip-flop. Note that instead of separate set and reset input, a single data input (D) is used. To set the flip-flop, a binary 1 is applied to the data input. When the clock pulse occurs at the C input, the flip-flop is set. To reset the flip-flop, a binary 0 is applied to the data input. The flip-flop assumes the set state when a clock pulse occurs.

Figure 14 shows a way to build a D-type flip-flop with NAND gates. With that arrangement, a D-type flip-flop can be quickly constructed out of a standard quad two-input NAND gate. However, that is not usually necessary as IC's containing 2, 4 or 8 prepackaged D-type flip-flops are available.

The truth table in Fig. 15 illustrates the operation of the D-type flip-flop. Here we are assuming that a positive-going or a binary-1 clock input is required to initiate the change of state. Note that when the clock is 0, the flip-flop simply remains in the state which it was put on a previous clock operation. The output of the flip-flop can be either a binary 1 or binary 0 at that time. That state is represented by an X in the truth table.

When the clock pulse is binary 1, the latch stores the input state. If the input is binary 1 while the clock is high, the latch will set and its output will be binary 1. If the input is binary 0 while the clock is high, the latch will be reset and the normal output will be binary 0. Keep in mind that while the clock input is high, the normal output directly follows the signal applied to the D input. Ordinarily the clock only occurs for a very short interval. Because of the input gating circuits, the ambiguous state cannot occur in a D-type flip-flop.

The waveforms in Fig. 16 summarize the operation of the D-type flip-flop. All possible combinations of inputs and outputs shown in the truth table are repeated in the timing diagrams. Take a look through them to confirm your knowledge of the circuit's operation.

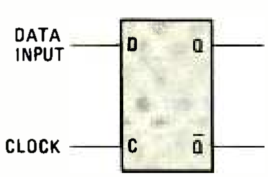


Fig. 13—Logic symbol for a D-type flip-flop.

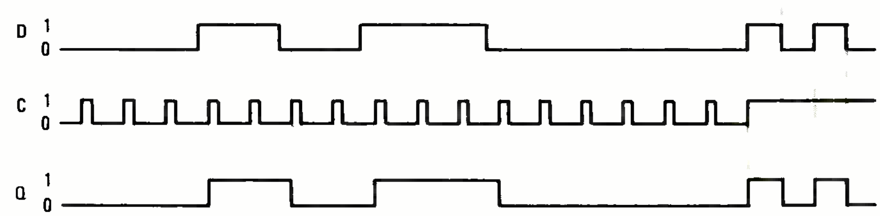


Fig. 16—Timing waveforms for a D-type flip-flop.

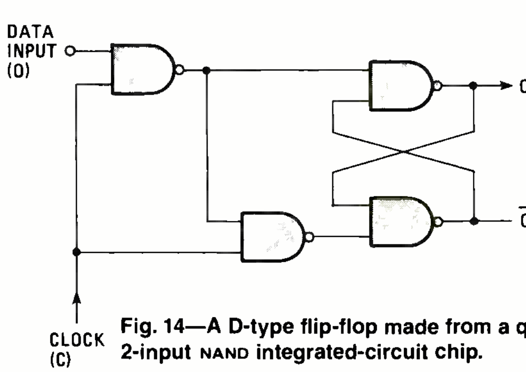


Fig. 14—A D-type flip-flop made from a quad 2-input NAND integrated-circuit chip.

D	C	Q
0	0	X
0	1	0
1	0	X
1	1	1

Fig. 15—Truth table for a D-type flip-flop.

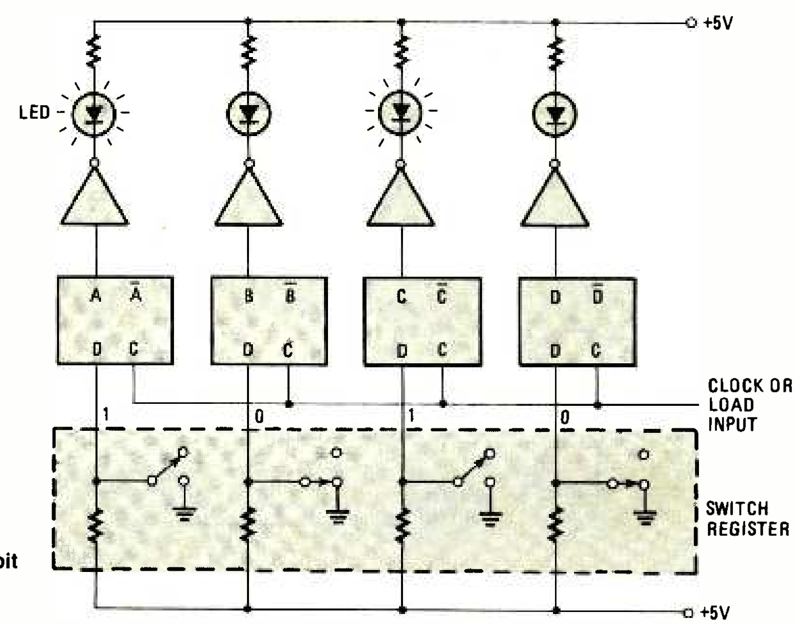


Fig. 17—A four-bit storage register.

Storage Registers

One of the main uses for D-type flip-flops is to form *storage registers*. A storage register is a circuit capable of storing a binary word. One flip-flop is needed for each bit in the word. For example, to store one byte of data, eight types of flip-flops would be needed.

Fig. 17 shows a storage register for a four-bit word. The parallel inputs to the register are supplied by a set of switches referred to as a switch register. The switch register allows you to manually select a binary word to be stored in the register. The output of the register drives light-emitting diode (LED) driver circuits. The LED's indicate the binary flip-flop states.

To store or load a word into the register, the desired word is set manually with the switches. Then a clock pulse is applied to the load input. The word will be stored in the D flip-flops and their state will be shown by the LED indicators. Note that the A flip-flop is designated as the most significant bit (MSB), while flip-flop D is the least significant bit (LSB). Therefore, the word stored is 1010.

JK Flip-flops

The most sophisticated and versatile form of storage circuit is the JK flip-flop. It can perform the functions of both RS and D type flip-flops. But it also has some additional unique features of its own. The JK flip-flop is widely used to form storage registers, but finds its greatest application in implementing sequential logic circuits such as counters and registers. You will learn more about those circuits in a future lesson.

The symbol used to represent a JK flip-flop is shown in Fig. 18. We won't discuss the internal logic circuits of a JK flip-flop, because they are somewhat complex. Besides, you don't really need to know what's inside to understand its operation or to use it.

The JK flip-flop has five inputs and two outputs. The S and C inputs, meaning "set" and "clear," are similar in operation to the set and reset inputs on a basic latch. Clear is the same as reset as it puts the flip-flop in the binary 0 or reset state.

The J and K inputs are synchronous inputs similar to the set and reset inputs on a gated latch. "J" means set while "K" means reset. The T input is for the clock. Finally, standard normal and complement outputs are generally provided.

The S and C inputs are asynchronous in nature. Those inputs are normally held high and in that state have no effect on the operation of the flip-flop. However, to set or reset the flip-flop as you would an ordinary latch, momentary low signals are applied as needed. For example, to reset the flip-flop, a binary-0 pulse would be applied to the C input momentarily. The normal output would go to the binary-0 state.

The truth table in Fig. 19 illustrates the effect that the S and C inputs have on the outputs. The results are identical to those obtained with the NAND latch discussed earlier. It is necessary to avoid the condition where both S and C inputs are low, so that the ambiguous state will be avoided.

The asynchronous S and C inputs override the J, K, and T synchronous inputs. Their effect is immediate and they predominate over synchronous operations.

The main application for the S and C inputs is presetting. To preset a flip-flop means to put it into one state or another prior to another operation taking place. An example is the resetting of a storage register. Resetting or clearing a register means setting all of the flip-flops to the binary-0 state. That would be done by connecting all the C inputs of the flip-flops

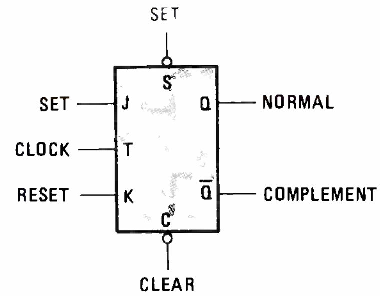


Fig. 18—Logic symbol for a JK flip-Flop.

INPUTS		OUTPUTS	
S	C	Q	$\overline{Q}$
0	0	1	1*
0	1	1	0
1	0	0	1
1	1	X	X

X = EITHER 1 OR 0
* = AMBIGUOUS STATE

Fig. 19—Truth table for the S and C inputs of a JK flip-flop.

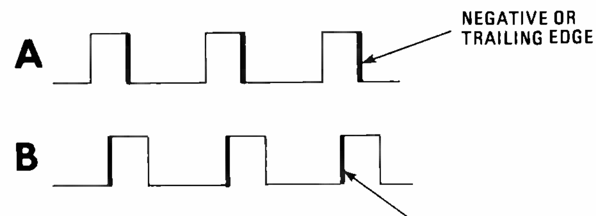


Fig. 20—Clock pulses showing negative (A) and positive (B) edge triggering.

together and applying a low pulse. The register is then said to be cleared.

Presetting can also mean setting the flip-flop. Occasionally it is necessary to load a specific binary number into a register prior to another operation beginning. By the use of external gates connected to the S and C inputs, any binary number can be preloaded into the register.

Now let's consider the synchronous inputs. As in a gated latch, the J and K inputs are used to set and reset the flip-flop but under the control of a clock pulse. If the J input is made binary 1 and the K input binary 0, the flip-flop will be set when the clock pulse occurs. If the J input is a binary 0 and the K input is a binary 1, the flip-flop is reset on the occurance of the clock pulse. In most JK flip-flops, that state change occurs on the trailing or negative edge of the clock signal; it is illustrated in Fig. 20-a. Some kinds of flip-flops initiate a set or reset operation on the positive or leading edge of the clock signal as shown in Fig. 20-b. Negative edge triggering, however, is more common.

When both the J and K inputs are held at binary 0, nothing happens. Even when a clock pulse occurs, no state change occurs. The flip-flop simply remains in the state in which it was previously set.

When both the J and K inputs are binary 1, an unusual action occurs. When a clock pulse appears, the flip-flop will be toggled or complemented. What that means is that on the trailing edge of the clock pulse, the flip-flop will simply change state. If the flip-flop was set on the occurence of the trailing edge of the clock pulse. That unique feature of the JK flip-flop allows it to be used in a variety of counter and frequency divider circuits as you will see. Figure 21 illustrates that toggling or complementing mode of operation.

The synchronous operation of the JK flip-flop is summarized by the truth table in Fig. 22. The four possible combinations of the JK inputs are shown. Note that the output is expressed in two ways. First, the Q_n column is the normal output state of the flip-flop. Note that all of the entries in that column are designated X which means that the flip-flop may be either set or reset. The other output column is designated Q_n+_1. That is also the normal output, but it designates the

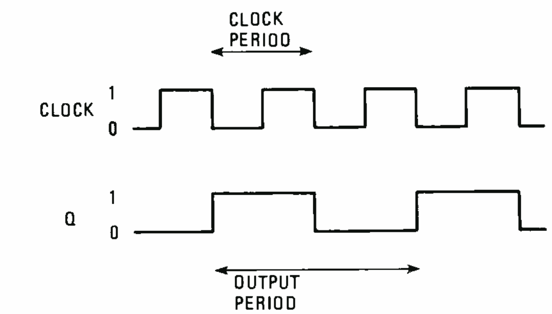


Fig. 21—The toggling or complementing of a JK flip-flop by a clock when the JK inputs equal 1.

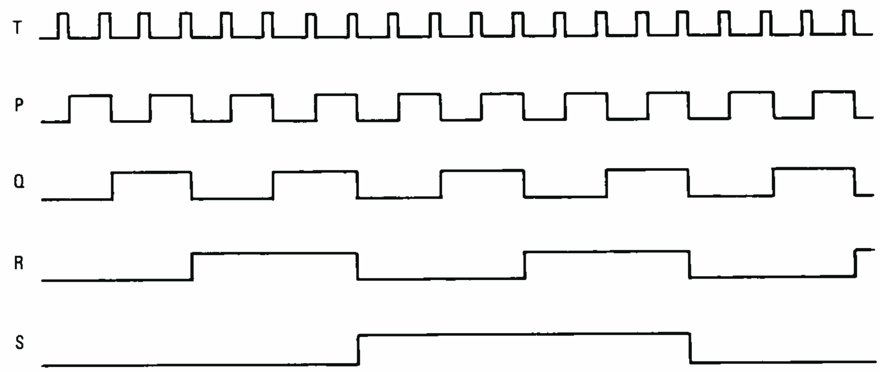


Fig. 25—Output waveforms from a four-stage frequency divider. Negative edge triggering is used.

INPUTS		OUTPUTS	
J	K	Q	Q n+1
0	0	X	X
0	1	X	0
1	0	X	1
1	1	X	$\bar{X}$

X = EITHER 0 OR 1

Fig. 22—Truth table showing synchronous operation of a JK flip-flop.

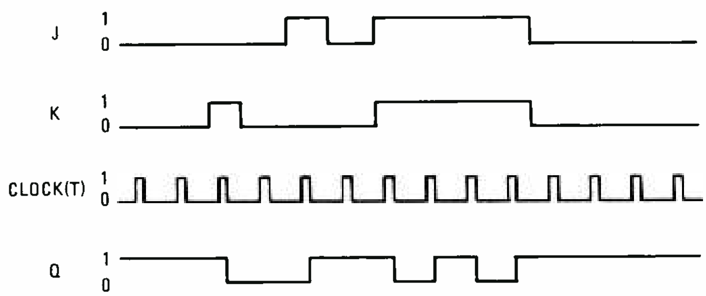
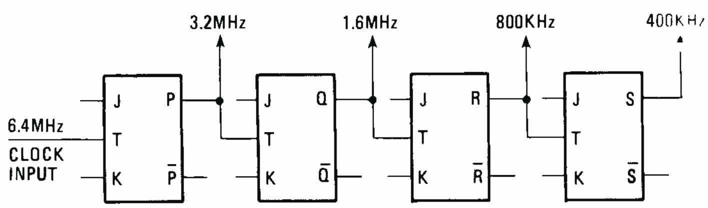


Fig. 23—Synchronous timing waveforms of a JK flip-flop.



NOTE: ALL JK INPUTS = 1

Fig. 24—Cascading JK flip-flops to form a frequency divider.

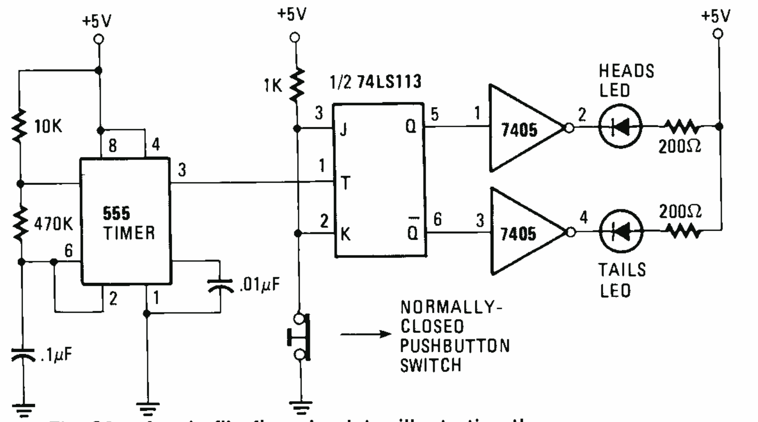


Fig. 26 —A coin flip-flop simulator illustrating the operation of a JK flip-flop.

state of the flip-flop after the occurance of a clock pulse with the designated JK inputs.

Figure 23 shows the timing waveforms of a JK flip-flop. Work your way through those diagrams from left to right to be sure that you understand all conditions—trailing-edge triggering is assumed.

JK Flip-flop Applications

As indicated earlier, the JK flip-flop finds its greatest use in various kinds of registers and counters. We won't discuss those here as a complete lesson is devoted to them later. However, we do want to illustrate several simple applications.

A major application of JK flip-flops is a frequency divider. Refer to the input and output signals of a typical JK flip-flop as shown previously in Fig. 21. Note that each time a negative going transition occurs, the flip-flop will toggle. Because of that, the output of the flip-flop is one-half the frequency of the input. Or the output period is twice the period of the clock. We say that the flip-flop is a divide-by-2 circuit. If a 100-kHz clock is applied to the flip-flop, the output will be a 50-kHz signal.

JK flip-flops can be cascaded to perform frequncy division by greater multiples of 2 (4, 8, 16, 32, etc.). In Fig. 24 we show four JK flip-flops cascaded with the normal output of one connected to the T input of the next. Naturally each flip-flop divides by 2. With the 6.4-MHz input shown, the other flip-flop outputs are 3.2-MHz, 1.6-MHz, 800-kHz and 400-kHz as shown. The waveforms in Fig. 25 show the full operation of the circuit.

An easy way to determine the division factor for a given number of flip-flops is to use the simple relationship shown below. Here F represents the frequency division ratio or factor. It is equal to 2 raised to the n power where n is the number of flip-flops in the chain. With four flip-flops, the frequency division ratio is:

$$F = 2^n = 2^4$$

$$F = 2 \times 2 \times 2 + \times 2$$

Learn By Building

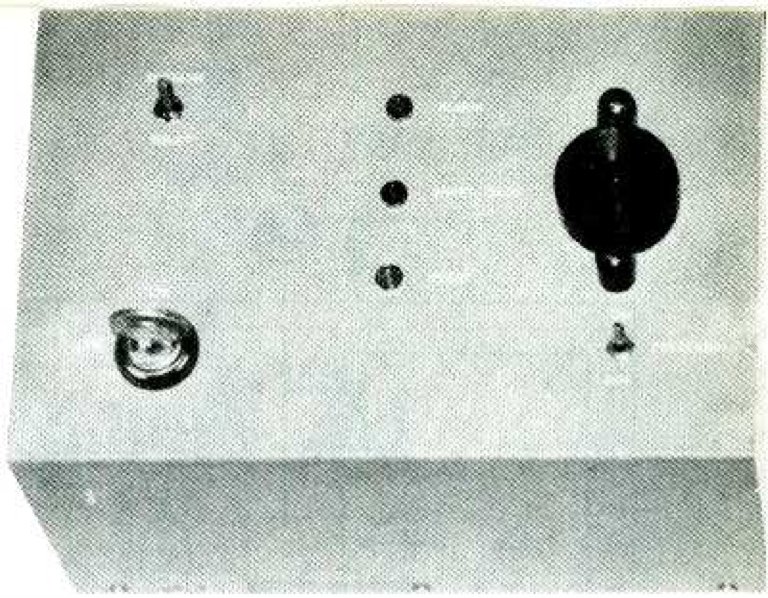
Figure 26 shows a simple circuit you can build to understand the operation of a JK flip-flop. Here a 555 timer IC is connected as a clock. It generates a clock signal that will repeatedly toggle the JK flip-flop whenever the pushbutton switch is depressed. When the switch is released, the JK inputs are held low and the clock has no effect on the flip-flop.

The outputs of the JK flip-flop are connected to LED driver circuits. You will find that the outputs will always be complementary as indicated by one LED being on while the other is off.

That circuit simulates the flipping of a coin. For example, heads might represent set while tails indicates reset. To flip the coin, all you do is press the pushbutton switch. The JK inputs go high. The flip-flop will then toggle repeatedly for a period of time. When you release the pushbutton, the JK inputs go low. The flip-flop will then be set or reset depending

(Continued on page 94)

BUDGET BURGLAR ALARM



This home-protection system does everything the big, fancy, expensive systems do. And it costs a lot less!

By John Cooper

☐I FOUND OUT THAT INSTALLING A BURGLAR-ALARM SYSTEM can save money. How? An added discount on my insurance premium! Deadbolt locks, fire extinguishers, and smoke alarms, all contribute to such savings, so check with your insurance agent. I had long wanted a security system, and that added incentive started me shopping. I made a list of the features I wanted: A key switch to arm/disarm; an instant/delay switch; an alarm memory; entry open and ready LED indicators; a pre-alarm sounder with on/off switch; auxilliary dry contacts for a light; a trickle charge for rechargeable battery backup, and an automatic alarm reset and power-on reset.

I checked the local stores. With the features I wanted, the prices were exorbitant. I decided to design my own.

How the System Works

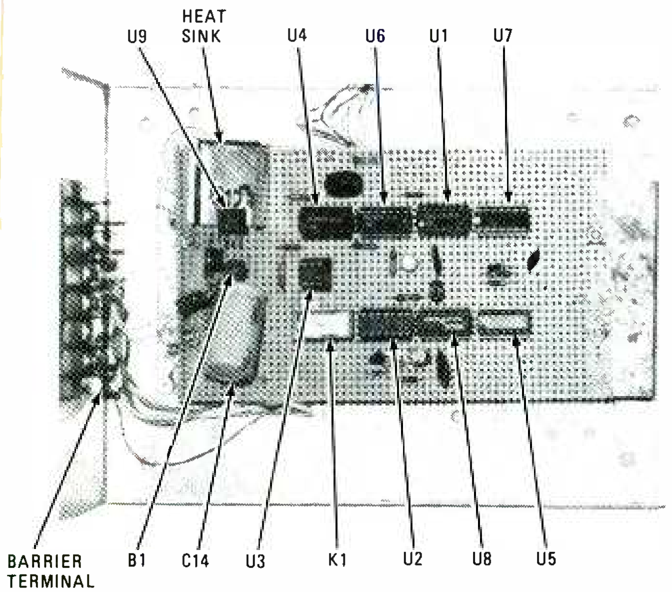
The schematic diagram for the Budget Burglar Alarm (Fig. 1) shows that the closed-loop switches place a ground on optocoupler U3, pin 2. As long as the doors and windows remain closed, U3, pin 5 stays low. That low blocks the clock, U4A and U4B, the NOR gates, through U2A, an AND gate, holds flip-flop U5A clear and turns off LED 2, ENTRY OPEN. That LED comes in handy for setting the alarm.

The system is off and the logic is reset when key switch S1 is in the off (open) position. With S1 on and all entries closed, U2C, an AND gate, pin 8 goes high and turns on READY indicator, LED3.

In the INSTANT mode of operation, as determined by switch S2, INSTANT/DELAY, if an entry is opened, the clock is gated through U1A, a NAND gate, and fires U8B, a dual timer. At that time, relay K1 operates and grounds the siren causing it to sound. U8B is one half the 556 dual timer whose on time is set by R9 and C11. When U8B fires, U5A and U5B both set. U5A blocks the alarm until the entry is closed and U5B turns on ALARM MEMORY indicator LED1. That indicator remains on until the key switch, S1, is operated.

With S2 in the DELAY position, leaving home opens the loop and the clock fires U8A. That sets U7B, a flip-flop, and the system is armed. The next time an entry opens, U8A fires again, turning on the pre-alarm sounder and setting U7A. After a delay (determined by R8 and C10 unless S1 is off) U8B fires and the siren sounds. Note that U7B remains set and U7A is cleared. Therefore, after an attempted break-in, if the entries are closed, the system is reset to respond to the next violation.

Hex inverters U6B and U6C form a power-up reset to condition the logic if the AC power fails and a battery backup is not used. Resistor R13 and diode D2 are optional components to provide a trickle charge to a 12-volt battery and can provide that added security.



Parts placement is not critical to the operation of the circuit, and while author used perfboard and wirewrap techniques, an etched circuit board could just as easily be used.

Building the Unit

The author wired the Budget Burglar Alarm control unit on a 3½ × 6-inch perfboard using wire-wrap sockets for the relay and integrated circuits. The parts layout is not critical, and a Photo shows the layout used by the author. Naturally, should you opt to do so, the circuit could be etched on a printed-circuit board.

There is a wide tolerance on the C10, C11 electrolytic capacitors used in the 556 timing circuits. Use clip leads to test U8A and U8B for the correct on time before wiring those capacitors in place. Many cities have regulations regarding

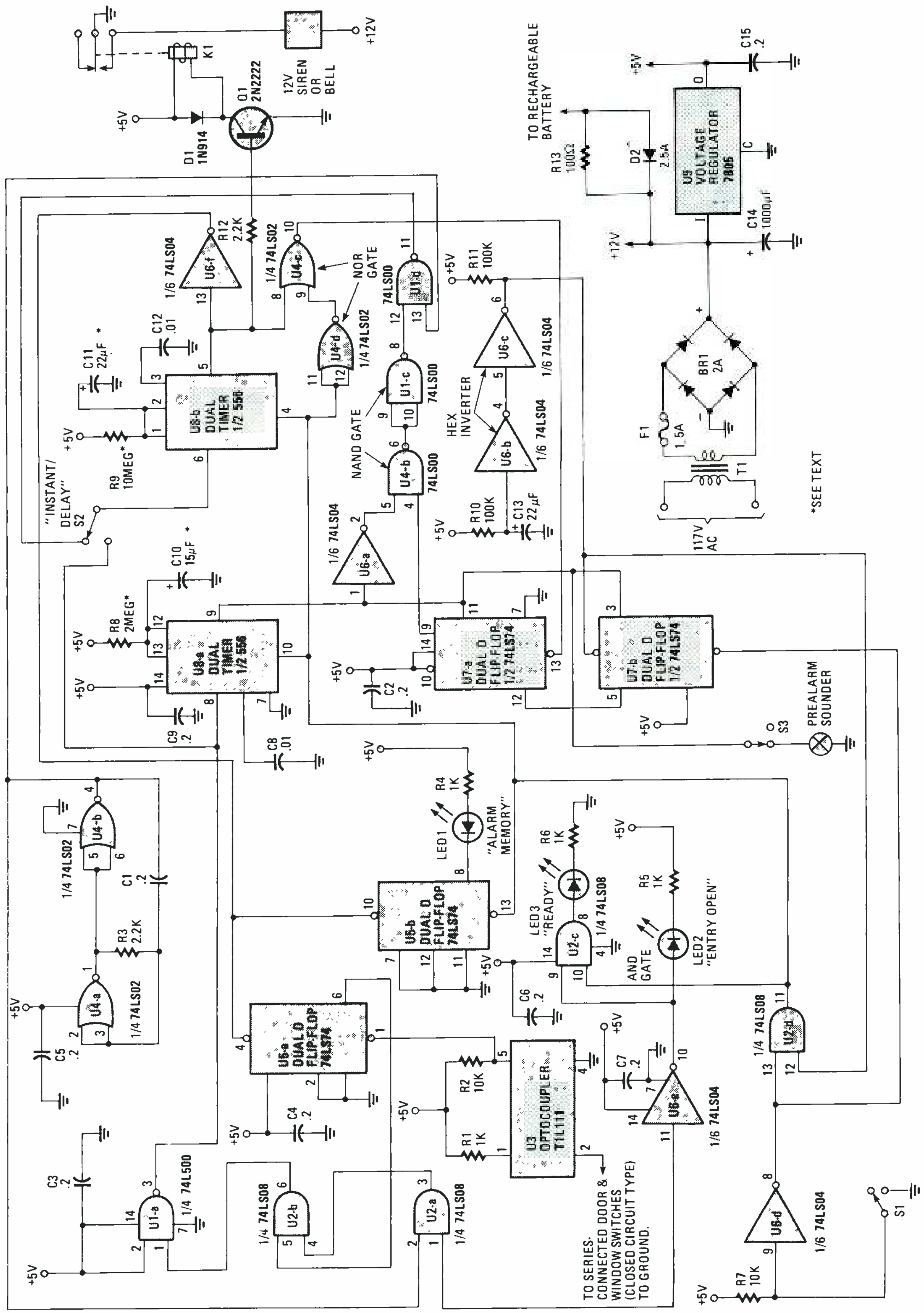


Fig. 1—Schematic diagram for the Budget Burglar Alarm. Resistor R13 and diode D2 are required only if a trickle charge is needed for battery backup, and can be included or not at builder's option.

PARTS LIST FOR THE BUDGET BURGLAR ALARM

SEMICONDUCTORS
BR1—2-A bridge rectifier or 4-1N4001 diodes in bridge circuit
D1—1N914 silicon, small-signal diode
D2—2.5-A diode (optional—see text)
LED1–LED2—Light-emitting diode, red
LED3—Light-emitting diode, green
Q1—2N5223 or 2N2222 transistor
U1—74LS00 quad NAND gate
U2—74LS08 quad AND gate
U3—TIL111 optocoupler (Radio Shack 276-132)
U4—74LS02 quad NOR gate
U5, U7—74LS74 dual-D flip-flop
U6—74LS04 hex inverter
U8—556 dual timer
U9—7805 voltage regulator +5VDC

RESISTORS
(All resistors are ¼-watt, 10% units unless otherwise noted)
R1, R4, R5, R6—1000-ohm
R2, R7—10,000-ohm
R3, R12—2200-ohm
R8—2-Megohm (see text)
R9—10-Megohm (see text)
R10, R11—100,000-ohm
R13—100-ohm, ½ watt

CAPACITORS
C1, C7, C9, C15—.2-µF, mylar or ceramic disc
C8, C12—.01-µF, ceramic disc
C10—15-µF, electrolytic (see text)
C11—22-µF, electrolytic (see text)
C13—22-µF, electrolytic
C14—1000-µF, electrolytic

ADDITIONAL PARTS AND MATERIALS
BZ1—5-volt DC piezoelectric buzzer (Radio Shack 273-060 or equivalent)
F1—1.5-A fuse and holder
K1—DPDT relay: 100-mA, 5-volt DC solenoid; 125-VAC, 1-A contacts (Radio Shack 275-215 or equivalent)
S1—SPST key-operated switch
S2—SPDT miniature toggle switch
S3—SPST miniature toggle switch
T1—Transformer: AC-line, step-down, power; 12.6-volt, 2-A, secondary winding
Cabinet, siren, 12-V, ¾-A, circuit board, wire-wrap IC sockets, barrier strip, hardware, wire, solder, etc.

the maximum time that an alarm may sound.

A six-terminal barrier strip was used to connect the siren, 12-VAC, and protective loop to the control board. A plug-in transformer is used for T1 so that low-voltage AC could be provided for the control unit. The unit draws about 1 ampere with the siren on, so use sufficiently large wire and provide a fuse at the transformer.

The author selected a cabinet measuring 8 inches long, 6 inches wide and 4½ inches deep. While the pre-alarm sounder could have been mounted inside the cabinet, we installed it on the outer surface for better volume. If the siren is connected during testing, take proper precautions. It is very loud.

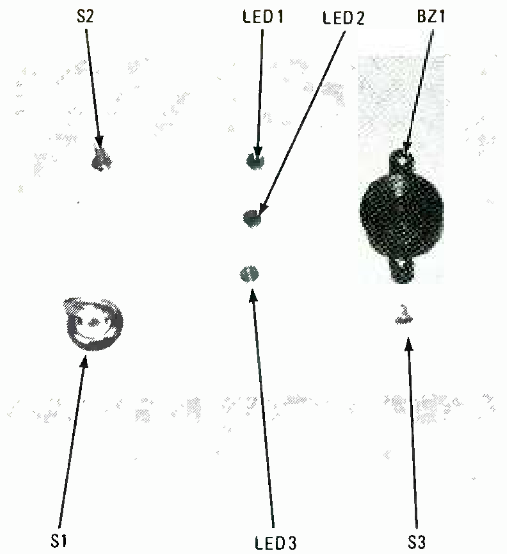
Testing

To test the control unit board, turn S1 off (open), put S2 on INSTANT and close S3. Place a clip lead from U3 pin 2 to ground, which simulates a closed loop. Apply 12 VAC to the board. The three LED indicators should be off. Closing S1 should cause LED3 READY to turn on. Remove the clip lead from U3 and several things should happen: LED1, ALARM MEMORY, and LED2, ENTRY OPEN, should come on, LED3 READY, should go off. Relay K1 should energize until U8B times out, then it should de-energize. Note that the pre-alarm sounds though it is not used in the INSTANT mode. Using the same R/C values as the author should provide about 30 seconds of pre-alarm and about 3½ minutes for the siren. That concludes the INSTANT test.

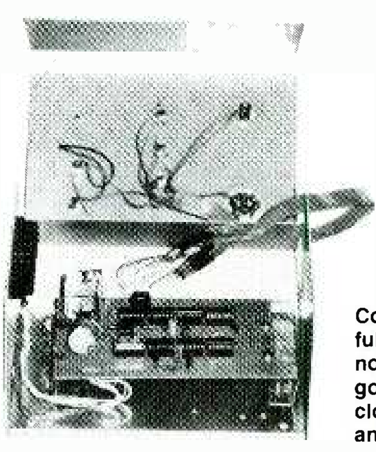
To test DELAY operation, turn off S1 and reconnect the ground jumper to U3. Put S2 on DELAY, turn S1 on and simulate leaving home by breaking the jumper to ground momentarily. Wait until the pre-alarm has timed out, then again remove the ground jumper to simulate an entry. This time, after the pre-alarm times out, relay K1 should energize.

Using the Budget Burglar Alarm system is simple. Turn S1 off. If you're going out, set S2 to DELAY. If the ENTRY OPEN indicator is on, locate and close the open window or door. Turn on S1.

The chances are that, like me, you'll save money with this unit, but even if you don't, you'll surely sleep a lot better.



The unit's front panel is clean and uncluttered with only two toggle switches, a key switch and three LED indicators, in addition to the piezoelectric pre-alarm sounder. The sounder could just as well have been placed inside the aluminum chassis-box, but external mounting provides additional volume.


Completely wired, carefully checked, the unit is now assembled and ready to go. All that remains is to close the protective cover and put in the screws.

DIGITAL FUNDAMENTALS

(Continued from page 90)

upon where the flip-flop was prior to releasing the switch. Because of the high-speed nature of the clock, and the random depressing and releasing of the pushbutton, the circuit accurately simulates the random flipping of a coin. Another way to put it: No matter how hard you try, you can't fix a head or tail setting by holding the switch closed a practiced time interval.

SHORT QUIZ ON DIGITAL FUNDAMENTALS—LESSON 4: UNDERSTANDING AND USING FLIP-FLOPS

1. When a flip-flop is storing a binary 1, it is said to be:

a. reset b. set

2. Another name for a latch is ____________.

3. A common application of a latch is____________.

4. To clear a flip-flop means to:

a. reset it to 0 b. preset it to 1

5. Flip-flops such as the D and JK types whose state changes occur upon the occurrance of a clock pulse are said to be____________.

6. When the JK inputs are 0 and a clock pulse occurs, the flip-flop will:

a. set b. reset
c. toggle d. not change state

7. When the JK inputs are 1 and the clock pulse occurs, the flip will:

a. set b. reset
c. complement d. remain in the same state

8. The clock input to a D flip-flop is high. The D input is low. The complement output will be ____________.

9. A six bit register is made up of D-type flip-flops. The flip-flops are labelled A through F with A being the LSB and F being the MSB. The flip-flop outputs are A = low, B = high, C = high, D = low, E = high, F = high, where high = 1 and low = 0. The decimal equivalent of the binary number stored in the register is ____________.

10. A frequency divider made up of 7 cascaded JK flip-flops is used to generate an output frequency of ____________ kHz with an input of 512 kHz.

ANSWERS TO THE ABOVE QUESTIONS

1. b-set
2. RS flip-flop
3. switch or contact debouncing
4. a-reset it to 0
5. synchronous
6. d-not change state
7. d-complement or toggle
8. high. With the clock input high, the normal output will be the same as the D input. The complement output will be inverted.
9. 54 (FEDCBA = 110110 = 54)
10. 4kHz (7 flip-flops divide by 2. $2^7 = 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 128$. $512 \text{ kHz} \div 128 = 4 \text{ kHz}$.

ROBOTIC LIGHT SWITCH

(Continued from page 62)

socket SO1, below which is the line cord with strain relief.

The circuit board should be mounted in the cabinet on stand-offs to avoid short-circuiting. Now wire the chassis-mounted components to the board. The photo of the top-view of the unit shows the circuit board wired to the chassis-mounted components. Next prepare the lamp and LDR blocks, which are "custom-made" to suit your own application.

The LDR block requires that wells about 3/4-inch deep be drilled to block out stray light, when the LDR's are in place. Two holes can be drill side-by-side into the doorjambs or a block of wood to accommodate the LDR's. Space the holes at least 1-inch apart center-to-center so the LDR's can distinguish shadow edges, but not so far apart that the lamp does not shine on them evenly.

A low-current lamp of about 75 mA provides sufficient illumination for a distance of up to six feet. The reflector from a flashlight can serve to focus the light on the LDR's. The bulb must be carefully positioned in the reflector for best effect.

Installation, Test, and Adjustment

Place the circuit box in a protected area near an electrical outlet and the light it must control. Attach the lamp and LDR block on opposite doorjambs. If possible, try to attach the lamp block to the hinged side of the door. Passing too close to the lamp block can cause shadows on the LDR block to have ill-defined edges.

The set LDR's should be placed so that upon entering the room, it is the first to have its light source interrupted. Using four-conductor cable, connect one lead wire of the two LDR's to the circuit board through terminal S and R (set and reset). Connect the lamp to the circuit board through 2-conductor speaker wire with the positive lead going to the P terminal on the rear panel. The other end of both LDR's and the lamp are connected to the common N terminal.

Once done, close off all windows and doors, making the room as dark as possible. Set each compensation control to minimum and connect a voltmeter across each LDR and measure the voltage. If the LDR's receive an optimum amount of light, your readings should be between 2.5 and 4.5 volts, and no further adjustment will be required. But, if either of the LDR's is above 4.5 volts, adjust the corresponding compensation control until a 4.5 volt reading is obtained.

Finally, with everything in place, pass though the doorway as you normally would. The lights should turn on as you enter the room and extinguish as you exit. Of course, if the circuit doesn't work as expected, it will be necessary to trace back through your wiring to find the problem. Look for solder bridges, mis-wired components, and so on.

If it does work as desired, your Robotic Light Switch is complete and ready to go to work. As an added benefit, the small lamp also serves as a marker or night light for the entryway.

By Herb Friedman

ON COMPUTERS

FRIEDMAN

Reconfiguring the standard RS-232 serial I/O port of your computer so that it can communicate with some peripheral device may be a real headache: But a simple "breakout box" can help to ease the pain!

GENERALLY SPEAKING, SOMETHING that is accepted as a "standard" should always work or perform the same way every time it's used. Unfortunately, almost from the very start of personal computing, hobbyists and users have had to go through wiring and software convolutions in order to use what is known as the "standard" RS-232 serial connection. It's not unusual to find that a serial printer that works perfectly well with one brand of computer won't work with another brand, or that two serially-connected computers can't communicate with each other even though all the equipment is known to be working properly.

The Non-standard RS-232 "Standard"

Serial problems come about because the serial I/O, as we know it, was intended primarily for communications—meaning, some kind of modem. It wasn't meant to be used for connecting two computers to each other, or a computer to a printer. Most early word processors and mainframe computers that used serial printers had a serial I/O and connector that was different from the one we know as RS-232. On the other hand, RS-232 was intended to connect a modem directly to a printer; again, we are using the serial I/O for communications.

The problems with RS-232 serial I/O are due to its being designed to be used for two distinct devices: *D*ata *T*erminal *E*quipment, known as DTE; and *D*ata *C*ommunications *E*quipment (DCE). DTE is any equipment that originates or *displays* data. (We need that distinction because a printer is data terminal equipment—after all, it displays data doesn't it?) DCE is any equipment through which the signals must pass; in other words, "communications." Although the DTE and DCE signals are identical, their actual pin connections on a subminiature D-connector (generally used for RS-232 connections) are different, and it's those differences that cause problems.

TABLE 1—RS-232 PIN ASSIGNMENT

DTE Pin	DCE Pin	SIGNAL	FUNCTION
1	1	NC	Usually equipment ground.
2	3	Transmitted data	To external device.
3	2	Received data	From external device.
4	5	Request to send.	Data terminal ready.
5	4	Clear to send.	Indicates DCE is ready.
6	20	Data set ready.	Indicates DCE is ready.
7	7	Signal ground.	
8	8	Received line detector	Carrier detect.
20	6	Data terminal ready	Indicates DTE is ready.

Commonly used DTE and DCE configuration for RS-232 signals. The computer or terminal should be wired DTE for a DCE-connected modem, and it always is. But check the unit's manual to be sure: The "RS-232 standard" is anything but standard!

An illustration will help you understand the problem. A DCE connection (the modem) outputs data on pin 2 and receives on pin 3. If connected to another DCE device nothing will happen because the other device will also be outputting on pin 2 and receiving on pin 3. Obviously, neither device knows what's going on. What's needed is for one device to have DTE pin wiring reversed, so that the unit receives on pin 2 and transmits on pin 3, allowing the two devices to exchange data. The same applies to the other connections through which control signals are transmitted and received.

Table 1 shows the DCE and DTE serial-data pin connections for commonly used RS-232 signals. Logically, the computer or terminal should be wired DTE if the modem is DCE—which it always is. Unfortunately, serial printers are generally wired DTE. That means that the printer cannot be connected directly to the DTE wiring of a computer. In order to drive a printer, the computer must be wired DCE, but a DCE computer cannot drive the DCE modem. See the problem? Printing was never properly thought out by the folks who created the RS-232 "standard."

In order to make a computer's single serial output work for both a DCE modem and a DTE printer, somewhere along the line an "adapter" cable must be used to reverse the wiring for one of the devices. That's what is done for some Radio Shack, IBM, and IBM-compatible computers as well as others. Both the Radio Shack and IBM computers have serial outputs that are DTE for driving a DCE modem; and to use a printer, a special adapter cable is always necessary. Kaypro, on the other hand, gets around the adapter-cable problem on their latest models by simply providing two RS-232 connectors for a single serial output: One connector, wired DTE, for the modem; and a DCE-wired connector for the printer. That permits the use of "straight across" cables (meaning connectors that are wired identically on both ends).

If you're tangled up in RS-232 connections, try using the wiring schemes outlined in Table 2 and Table 3. Table 2 shows the "reversing cable's pin assignment: A cable wired as indicated will solve most DTE/DCE matching problems. Table 3 gives the pin assignments for a "straight across" cable that's capable of accommodating virtually every DTE/DCE modem hookup. Take note of the

(Continued on page 100)

HEX BUFFERS

(Continued from page 73)

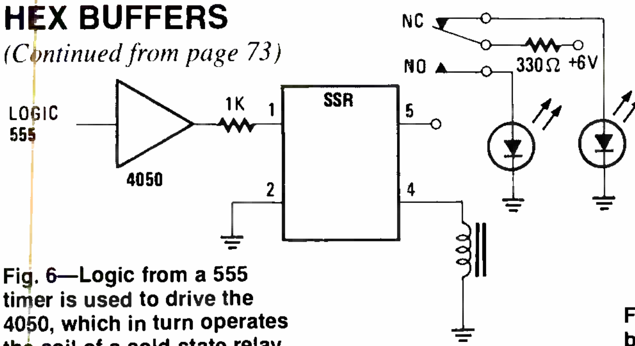


Fig. 6—Logic from a 555 timer is used to drive the 4050, which in turn operates the coil of a sold-state relay. The relay coil is source-connected, and the two LED's represent operating loads. Changing operating mode is as simple as switching from the 4050 to a 4049.

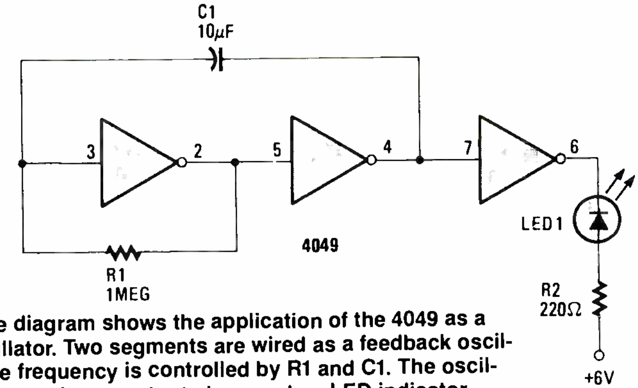


Fig. 8—The diagram shows the application of the 4049 as a buffer oscillator. Two segments are wired as a feedback oscillator whose frequency is controlled by R1 and C1. The oscillator is followed by an output stage and an LED indicator.

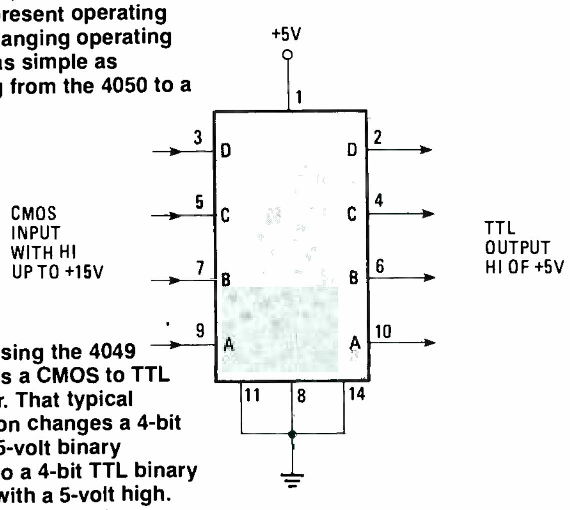


Fig. 7—Using the 4049 or 4050 as a CMOS to TTL converter. That typical application changes a 4-bit CMOS, 15-volt binary number to a 4-bit TTL binary number with a 5-volt high. Output drive is sufficient to supply two 4-bit TTL inputs.

energization when a logic 0 is applied to the input of the buffer, you need only substitute a 4049 in place of the 4050. The relay contacts are capable of switching three amperes, so it is capable of switching more than 350 watts assuming an AC source of 125 volts.

In the circuit of Fig. 7, a 4-bit CMOS 15-volt binary number is being changed over to a 4-bit TTL binary number with a high of 5 volts. The output drive is adequate for supplying this 4-bit TTL binary number to two 4-bit TTL inputs.

Buffer Oscillator

The inverting buffer can be connected into a general-purpose oscillator or clock generator delivering a good output for a variety of applications including the driving of two TTL inputs. In the arrangement of Fig. 8, two sections are connected as a feedback oscillator followed by an output section and an LED indicator.

Frequency of operation is set by the RC time constant and has an approximate value of:

$$f = 1 \div [2.2 \times R(\text{Megohms}) \times C(\mu F)]$$

For values shown frequency is:

$$f = 1 \div [2.2 \times 1 \times 10] = 0.045 \text{ Hz}$$

The 4050 and 4049 are a versatile pair of buffers. Keep them in mind in your project planning.

In summary, the hex buffer is attractive in many digital systems and interfacings. It is helpful to have two similar hex buffers that can be used in inverting or non-inverting applications.

VAN DE GRAAFF

(Continued from page 44)

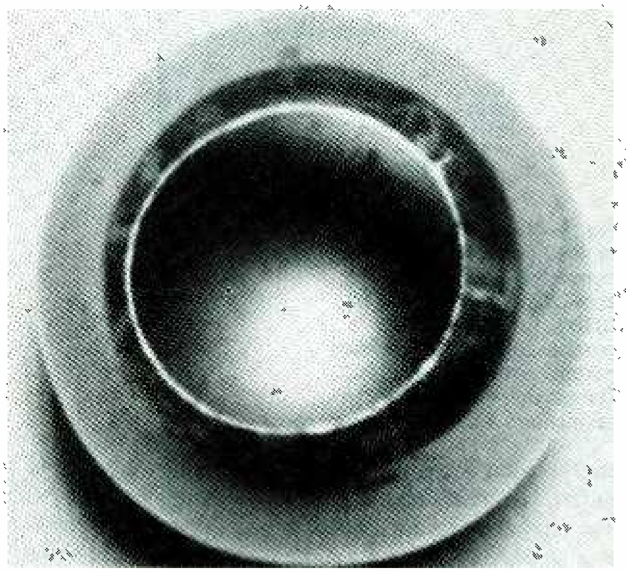
stretch the rubber drive belt from pulley C to pulley E. (Refer to photos.) Once that is done, set the bottom half of your Van de Graaff Generator aside until the sphere is completed.

Assuming that you've picked up a world globe or similar painted sphere, remove the paint using Stripe-Ezz™ or a similar product. Then drill a hole in the globe (refer to photos) through which the charge belt will pass. Begin with a ⅓-inch bit, working your way around in a circle. Enlarge the holes using increasingly larger drill bits until the hole has reached the desired size. That's the same method that might be used when installing panel-mount meters. An easier way is to use the right size hole cutter or, if you have one, a nibbling tool. But no matter how you cut the hole, go back over the edge with a grinding stone to smooth and deburr the opening.

Once the globe has been prepared, install the wiper, charge belt, and metal pulley (which can act as both a wiper and belt support). If you want to be able to get at the pulley so you can change belts, make adjustments, etc, mount the idler pulley (P) on a subassembly, as shown in Fig. 3. That assembly will be mounted in the globe at a right angle.

In doing so, make sure that it cannot fall out once it's turned out by 90 degrees, as described earlier. In other words, make the assembly supporting the pulley act like a lag bolt. If you handle the pulley in the sphere that way, the force of the drawn charging belt pulling down on the sphere will keep it in place. But be sure that the idler pulley can turn freely. Another solution is to simply fix the pulley assembly in place with hardware.

That completes the basic assembly.



In preparing the sphere for use in the Generator, several small holes may be drilled in a circular pattern. Then using increasingly larger bit sizes, the circular pattern is removed. However, a hole-boring attachment (such as the type used in lock mounting) may be used with a drill to accomplish the same thing. But whatever method is used, be sure to deburr the opening before using the sphere in the Generator.

Final notes

As mentioned previously, the potential difference or voltage rise between the sphere and ground is limited by the dielectric qualities of insulating column, insulators, air, etc. Also, maximum potential developed will be directly proportional to the area of the sphere. Thus, increasing the diameter of the collector sphere, cylinder height, and starting potential, will also effect an increase in output potential; but construction will still be basically the same.

Finally, after you've gotten all the hardware rounded up and whipped together, it's a good idea to cover all high-voltage points, which can arc over to ground, with some good quality silicon rubber or RTV sealer. That is especially necessary if you decide to boost a 10,000-volt sign transformer's output to 30,000 volts or more. Remember that, because of the unit's high-voltage output, its case should be grounded to prevent unplanned hair-raising experiences.

GETTING PARTS

(Continued from page 48)

boards. Unfortunately, we never hear of the hours that the same hobbyist spent salvaging handfuls of useless components. If you must salvage parts, get them from your own unused homebrew projects, for they probably contain the type and quality you generally use. In addition, they've probably been assembled with a little extra lead length, and the parts will be easy to install on your latest creation(s).

Nevertheless, do not give up totally on salvaging surplus printed-circuit boards. Don't buy surplus boards on impulse—buy them after full consideration and inspection. The boards that are the most valuable are unused items that have been replaced by newer designs. A lot of people still pan for good parts and come up smiling!

Regardless of how or where you obtain parts, keep in mind that the next best thing to a written guarantee that a project will work as it should is to always build the device the way the author says to build it, using the parts specified in the parts list or direct substitutes. Universal substitutes and/or salvaged or scrounged components should only be used when they cannot possibly affect performance.

MATCHBOX TESTER

(Continued from page 64)

drop will be on the order of 1.3 to 1.4 volts, not enough to turn the LED's on. But, with a base-emitter or base-collector short, total voltage drop will be on the order of 1.8 volts, alternately lighting LED1 and LED2.

Generally, the heavy base drive provided by R3 and R4 is sufficient to overcome low-valued resistors in a in-circuit transistor. Thus, in-circuit resistances across base-emitter or base-collector junctions of as little as 50 ohms can be overcome. On the other hand, even more base current could be garnered using emitter followers at Q and $\bar{Q}$ if desired.

There is nothing critical about construction. The entire circuit and battery can be placed on a small piece of perfboard (see Photo) or pre-etched experimenters board or printed-circuit board and housed in a matchbox, or a mini-project box if desired.

If you decide to use the matchbox case, be sure to go over it first with some 5-minute epoxy to strengthen and waterproof it. Then you can drill or cut out holes for S1, LED1, and LED2, which protrude out the top. Base (B), collector (C) and emitter (E) hookups can be clip leads.

SOLAR ENERGY

(Continued from page 27)

Researchers are optimistic; it is their contention that by increasing the cells in tandem (which effectively increases the light concentration), they should be able to boost efficiency ratings to 60 percent. The goal of the US Department of Energy is to reduce photocell cost to 70 cents per watt by 1986.

Storing Energy

So that electric power can be available at night and on cloudy days, a storage medium is necessary with a photocell installation. Storage batteries can be too expensive for larger solar installations. Therefore, alternative technologies have been proposed for energy storage and are receiving R&D treatment. Such technologies will benefit conventional plants as well as solar plants, because they will permit "load leveling" and improve the load factor of the system. They will allow energy to be stored during off-peak periods and thus reduce the need for new generating capacity to meet increased peak demand.

Proposals include rotating masses that store power as kinetic energy; hydrogen-based systems where water is electrolyzed by the solar-plant output and the hydrogen product is consumed as needed in fuel cells; and hydro-pumping, where water is elevated by solar-powered pumps and then converted into electricity by hydroelectric turbines. Regardless of solar cell advances, large-scale solar power won't really be practical until an economical energy-storage system is developed.

Economics

Today, solar power is too expensive to compete with fossil-fuel and nuclear power. If the cost of solar power could be reduced to around 70 cents per peak watt, then it would be a viable alternative to conventional electric power generation. Impossible, you say? Not really. Today, the price per cell is around $10 per peak watt; whereas, 10 years ago, it was $500 per peak watt. Since sunlight varies in intensity throughout the day, one-hundred 10-megawatt (MW) stations scattered throughout a region will yield more average power than a single 1000MW station.

Also, that scattered arrangement would eliminate some transmission costs. That is because the site area per unit of output power decreases with increased capacity for conventional plants, whereas, the site area for solar plants increases linearly with increased output. A 100-megawatt solar plant would cover nearly 1 square mile of land with solar cells, while a 1000MW solar plant would need 10 square miles.

The economics of solar plants is strongly influenced by the cost of auxiliary equipment. For instance, the cost of mirrors or lenses used in concentrating systems must be taken into account, as must the cost of a tracking system to point the concentrator towards the sun as it moves from east to west. Some experts say that if solar cells were priced in $1 to $2 range per peak watt, solar power would have an economic advantage over the diesel-powered pumps that are presently used in irrigation schemes.

It is also likely that large-scale solar power will be exploited in the developing countries, first; the main reason being the lack of electrical grid and network distribution systems. With localized units (not involved with transmission costs), the higher cost of the solar cells will appear more acceptable. For example, a village located 60 miles from a conventional power station or grid system that provides power at a cost of $2 per peak watt would make the installation of a local solar power station less expensive than extending the grid.

The experts concede that no one is thinking of a total commitment to photovoltaic power at the present time. However, they do foresee a gradual increase in the use of solar power, mainly to relieve the load on diminishing fossil-fuels, and nuclear plants.

(Continued on page 104)

FRIEDMAN ON COMPUTERS

(Continued from page 96)

fact that that cable is the so-called "null modem" needed when directly connecting the serial ports of two computers for what is known as a "direct cable" or "direct wire" connection.

No matter how hard you try, there is always some manufacturer that creates an RS-232 wiring scheme that's totally off the wall—regardless of what you do, you can't quite figure out what the designer had in mind at the time. That's when you need a *breakout box*. A breakout box is a device that has an RS-232 D-connector at either end, but no connecting wire between the two. Instead, there are a series of miniature switches or sockets that allow the user to experiment easily with different connections. As a general rule, the breakout box also has light-emitting diode (LED) indicators on, at least, the most commonly used connectors to indicate if and when a signal appears on a particular circuit. Breakout boxes can range in price from a few dollars to well over $100.

TABLE 2
REVERSING-CABLE PIN ASSIGNMENT
DCE computer to DCE modem

Computer Pin	Modem Pin
1	1 (See Note 1)
3	2
2	3
5	4 (See Note 2)
4	5 (See Note 2)
7	7
20	6
6	20

Note 1: Leave open if specified in equipment manual

Note 2: Often not used

This cable reversing, wiring scheme may help to solve some of the problems encountered when trying to connect DTE and DCE devices to each other.

But, no matter how fancy, they all do essentially the same thing as the Global-Data's *Data router Model 225*. The wiring is done with jumpers using the same kind of connecting block used by hobbyists for experimenting. The eight light-emitting diode indicators aren't prewired to particular circuits; they can be user-connected to any user-selected circuit as necessary.

TABLE 3
STRAIGHT-ACROSS CABLE PIN ASSIGNMENT
DTE computer to DCE modem

Computer Pin	Modem Pin
1	1
2	2
3	3
4	4 (See Note 1)
5	5 (See Note 1)
6	6
7	7
8	8
20	20

NOTE 1: Often not used

This "Straight-across" cable wiring scheme can accommodate almost all DTE/DCE modem hook-ups.

The advantage to using such a device when you're having problems with an RS-232 serial connection is that you can almost instantly rewire or disconnect a circuit and then, using the light-emitting diode indicators, observe its effect. After you untangle the connections with the breakout box you can simply hard-wire a conventional cable using the same connections.

In the next issue of **Hands-on Electronics** Herb Friedman will discuss the details and advantages of a hard-disk upgrade for your personal computer.

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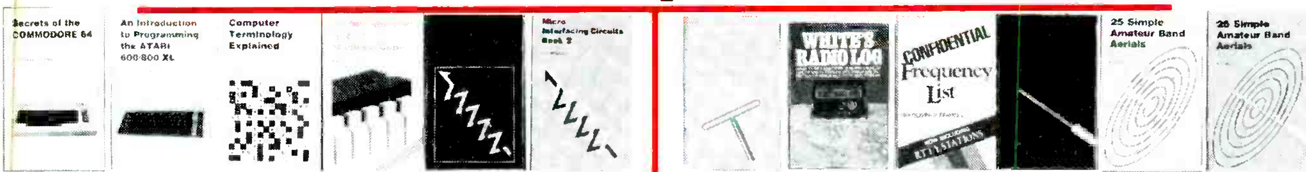

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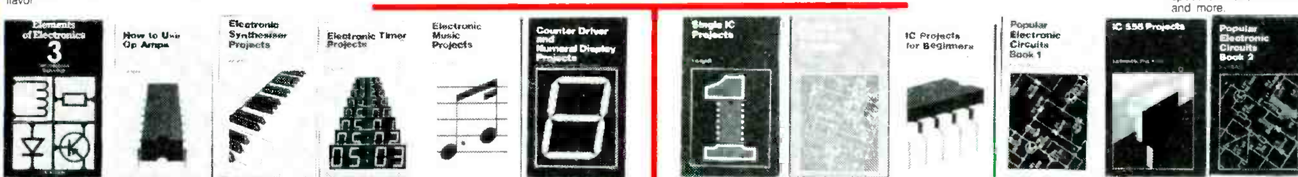

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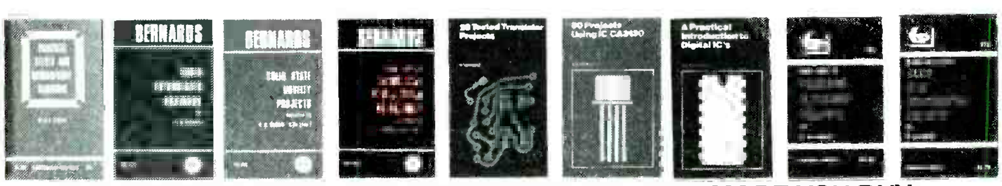

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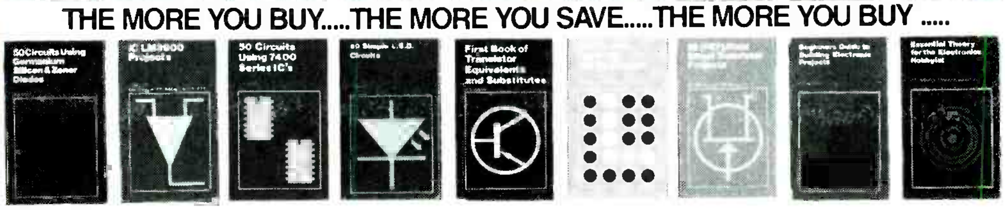

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(Continued from page 22)

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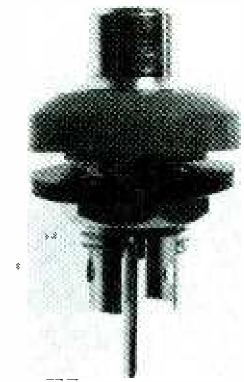

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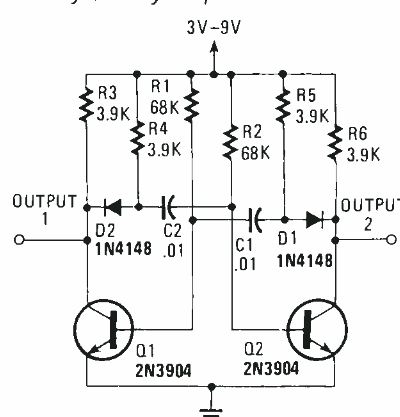
LETTER BOX

(Continued from page 5)

voltage exceeds the reverse base-emitter breakdown voltage of the transistor (roughly 9 volts) the timing voltage of the circuit will be upset. Is there something I can do about this, or is it "back to the drawing board?"
M.P., Hillside, IL

Try adding a 1N4148 diode in series with the base input terminal of each transistor. That effectively raises the reverse base-emitter breakdown voltage of each transistor to about 80 volts. It should handily solve your problem.



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SOLAR ENERGY

(Continued from page 99)

Looking to the Future

In February 1983, a 1-megawatt solar-system using single-crystal silicon panels—at present, the largest photovoltaic central power station in the world—was commissioned in California. The plant, which cost approximately $11 million, covers about 20 acres. Ironically, what started out as just peak watt installations, eventually broke the 100-watt barrier; and now the same has been done for the megawatt barrier. About 36-megawatts worth of single-crystal, silicon modules had been installed worldwide by the end of 1983.

The average selling price at the time was $7 per peak watt. At that price, an American manufacturer says, there is a $100 million (US) a year international market for solar panels. If costs are brought down to $3 per peak watt, according to analysts, then the solar market could explode to $1 billion annually over night. At $1 per peak watt, an estimated $10 billion solar energy market would await manufacturers.

There may not be much gold left in "them thar hills" or much black gold left in the valleys, seas, or deserts, but the sun shines on: It's just a matter of catching the golden rays at the right price.

RADIO WAVE PROPAGATION

(Continued from page 38)

frequencies above about 30 MHz, in what are called the VHF and UHF bands. Those frequencies pass through the ionosphere. Propagation at VHF and above is restricted to the space wave, which travels in the lower region of the atmosphere (called the troposphere).

Slight refraction of radio waves occurs in that region due to the refractive index of the atmosphere, resulting in *radio line-of-sight* that is somewhat longer than the *optical line-of-sight*.

Space-wave propagation is used for FM broadcasting, TV broadcasting, land mobile radiotelephones, and point-to-point microwave links. Normally, one or more base stations are used, mounted on a tall building or hill to increase the effective range of the system.

In scatter propagation, frequencies between 350 MHz to 10 GHz are used. A high-power radio wave is transmitted upwards and a very small fraction of the transmitted energy is forward scattered by the troposphere and directed downward towards the Earth.

The forward scattered energy is received by a high-gain antenna, normally a parabolic type. The distance between the transmitting and receiving stations is about 300 to 500 km and nearly always covers geographically hostile terrain such as mountains, jungle, etc. That mode requires high-power transmitters and high-gain, low-noise receivers, and is normally used when no others are available.

Satellites

Communications satellites can be divided into two basic classes called asynchronous and synchronous satellites. The former continuously change their position with respect to the Earth, which leads to antenna tracking problems. The latter type rotates about the Earth's axis at the same speed and direction as the Earth. Under these conditions, the satellite remains in a fixed position relative to the Earth's surface and can thus be used as a repeater station.

Three such satellites can be located at an angle of 120° to each other to give complete coverage of the Earth. The transmitting and receiving equipment on board a satellite repeater is similar to that used on a ground station, except that miniaturization is used as far as possible and power requirements kept to a minimum. The same antenna is used for transmitting and receiving. Frequencies used are normally 4 to 6 GHz, with transmission and reception on two different frequencies.

At the present time, all overseas TV broadcasts are via satellite and so are a larger number of telephone conversations. The round trip distance for a satellite link is on the order of 70,000 km and that leads to a transmission delay in the link. Echo suppressors are used in telephone links to reduce delayed echo to an acceptable level.

Finally, it is worth mentioning the amateur satellites used by radio amateurs, which are popularly called the *Oscar Series*—Orbiting Satellites Carrying Amateurs Radio. Unlike the type discussed above, these travel across the equator and contact between two stations can be held only for a short time.

You have just completed a very brief, but thorough, description of how radio waves travel from one point on the Earth's surface to another. For most readers, this discussion is sufficient. For those of you who get involved with amateur communications supplementary reading and learning is in the cards.

TROUBLESHOOT YOUR CAR

(Continued from page 59)

serious problems, which are generally masked by the more conventional, analog multimeter.

When it comes to what accountants call "the bottom line," doing your own electric/electronic checks and tests pays off in big dividends because you can avoid paying for what you don't need. For example, replacing a worn alternator belt is a lot cheaper than replacing the alternator, and replacing a radiator's heat sensor yourself can easily save a shop charge of $50 for the diagnosis. The fact is, what you can save on a single electric/electronic repair can easily pay for a quality digital multimeter and its accessories.

ADVERTISING INDEX

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74LS03	14	29	74LS138	16	59	74LS253	16	59
74LS04	14	39	74LS139	16	59	74LS257	16	59
74LS05	14	35	74LS145	16	1.19	74LS258	16	59
74LS06	14	99	74LS147	16	1.95	74LS259	16	1.49
74LS07	14	99	74LS148	16	1.79	74LS260	14	59
74LS08	14	35	74LS151	16	59	74LS266	14	55
74LS09	14	35	74LS153	16	59	74LS273	20	1.49
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74LS11	14	35	74LS155	16	69	74LS280	14	1.95
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74LS20	14	29	74LS157	16	69	74LS293	14	89
74LS21	14	35	74LS158	16	59	74LS298	16	89
74LS26	14	29	74LS160	16	69	74LS299	20	2.95
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74LS32	14	39	74LS164	14	69	74LS353	16	1.29
74LS37	14	35	74LS165	16	89	74LS363	20	1.49
74LS38	14	39	74LS166	16	1.19	74LS365	16	49
74LS42	16	49	74LS169	16	1.49	74LS366	16	49
74LS47	16	89	74LS170	16	1.49	74LS367	16	45
74LS51	14	29	74LS173	16	69	74LS368	16	45
74LS73	14	39	74LS174	16	69	74LS373	20	1.49
74LS74	14	49	74LS175	16	69	74LS374	20	1.49
74LS75	16	45	74LS181	24	2.49	74LS375	16	69
74LS76	16	39	74LS190	16	79	74LS377	20	1.39
74LS85	16	89	74LS191	16	89	74LS386	14	45
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74S05	14	45	74S136	16	1.39	74S251	16	99
74S08	14	45	74S138	16	89	74S253	16	99
74S09	14	45	74S139	16	89	74S257	16	99
74S10	14	35	74S140	14	69	74S258	16	99
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74ALS08	14	59	74ALS112	16	69	74ALS245	20	2.59
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74F08	14	75	74F139	16	1.49	74F257	16	1.79
74F10	14	75	74F157	16	1.69	74F280	14	1.69
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8203	40	64K Dynamic RAM Controller	29.95
8205	16	Hi Speed 1 out of 8 Binary Decoder.	3.95
8212	24	8-Bit Input/Output (74S412)	2.25
8224	16	Clock Generator/Driver	2.19
8228	28	Sys. Cont. Bus Driver (74S428)	3.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	12.95
8238	28	System Controller (74S438)	4.95
8243	24	I/O Expander for 48 Series	3.95
8250A	40	Async. Comm. Element	9.95
8250B	40	ACE (IBM PC or XT Software Compatible)	10.95
8251	28	Prog. Comm. I/O (USART)	3.25
8251A	28	Prog. Comm. Interface (USART)	3.49
8253-5	24	Prog. Interval Timer	6.49
8254	24	Programmable Interval Timer	13.49
8255	40	Prog. Peripheral I/O (PPI)	3.95
8255A-5	40	Prog. Peripheral I/O (PPI) 5MHz	4.25
8257-5	40	Prog. DMA Controller	6.95
8259	28	Prog. Interrupt Control	5.95
8259-5	28	Prog. Interrupt Controller	6.95
8272	40	Sgle/Dble Density Floppy Disk Cont.	16.95
8274	40	Multi-Protocol Serial Cont. (7201)	14.95
8275	40	Prog. CRT Controller	14.95
8279	40	Prog. Keyboard/Display Interface	5.49
8279-5	40	Prog. Keyboard/Display Interface	5.95
8282	20	Octal Latch	6.49
8284	18	Clock Generator/Driver	5.49
8286	20	Octal Bus Transceiver	6.49
8287	20	Octal Bus Transceiver (Inverted).	6.49
8288	20	Bus Controller	13.95
8289	20	Bus Arbiter	24.95
8741	40	8-Bit Univ. Peripheral Interface	19.95
8748	40	HMOS EPROM MPU	19.95
8749	40	MPU 8-Bit (EPROM Version of 8049)	19.95
8751	40	CPU w/4Kx8 EPROM & 128x8 RAM	29.95
8755	40	16K EPROM with I/O	19.95
80186	68	High Integration 16-Bit MPU	19.95
80188	68	High Integra. 16-Bit MPU (8-Bit Data Bus)	49.95
80287	40	Numeric Processor Ext.	195.00
SPECIAL FUNCTION			
MC3470P	18	Floppy Disk Read Amp System	4.95
MM5321N	16	TV Camera Sync. Generator	9.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	8.95
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95
MC146818	24	Real-Time Clock Plus RAM	7.95

DYNAMIC RAMS

Part No.	Pins	Function		Price
1103	18	1024x1	(300ns)	.99
4027	16	4096x1	(250ns)	1.49
4116N-15	16	16,384x1	(150ns)	1.39 — 8/10.95
4116N-20	16	16,384x1	(200ns)	.79 8/6.29
4116N-25	16	16,384x1	(250ns)	.69 8/5.49
4164N-150	16	65,536x1	(150ns)	1.22-9/10.95
4164N-200	16	65,536x1	(200ns)	1.11-9/9.95
MM5261	18	1024x1	(300ns)	.35 — 8/1.95
MM5262	22	2048x1	(365ns).	.35 — 8/1.95
MM5270	18	4096x1	(250ns)	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5298-3	16	8192x1	(200ns)	.59
8118	16	16,384x1	(120ns) (+5V Only Req.)	.99
41256-150	16	262,144x1	(150ns)	6.49
41256-200	16	262,144x1	(200ns)	5.95
4128	16	131,072x1	(250ns)	8.95

STATIC RAMS

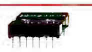
Part No.	Pins	Function		Price
2101	22	256x4	(450ns) 8101	1.95
2102	16	1024x1	(350ns)	.89
2102-2L	16	1024x1	(250ns) L.P. (91L02)	1.49
2111	18	256x4	(450ns) 8111	2.49
2112	16	256x4	(450ns) MOS	2.49
2114N	18	1024x4	(450ns)	1.29 — 8/9.95
2114N-L	18	1024x4	(450ns) L.P.	1.65 — 8/12.95
2114N-2	18	1024x4	(200ns)	1.39 — 8/10.95
2114N-2L	18	1024x4	(200ns) L.P.	1.69 — 8/13.49
2147HN	18	4096x1	(70ns)	4.49
2148HN	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	1.95
5101	22	256x4	(450ns) CMOS	2.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-2	24	2048x8	(120ns) CMOS	4.95
HM6116LP-2	24	2048x8	(120ns) L.P. CMOS	6.49
HM6116P-3	24	2048x8	(150ns) CMOS	3.75
HM6116LP-3	24	2048x8	(150ns) L.P. CMOS	3.95
HM6116P-4	24	2048x8	(200ns) CMOS	3.49
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	3.69
HM6264P-12	28	8192x8	(120ns) CMOS	7.25
HM6264LP-12	28	8192x8	(120ns) L.P. CMOS	7.95
HM6264P-15	28	8192x8	(150ns) CMOS	6.95
HM6264LP-15	28	8192x8	(150ns) L.P. CMOS	7.49
27LS00	16	256x1	(80ns) L.P.	3.95
7489	16	16x4	(50ns) 3101	2.25
74C921	18	256x4	(250ns) CMOS	5.95
74C930	18	1024x1	(250ns) CMOS (6518).	5.95
74S189	16	16x4	(35ns) 93405	2.95
74S289	16	16x4	(35ns) 3101	2.95
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25

PROMS/EPROMS

Part No.	Pins	Function		Price
1702A	24	256x8	(1μs).	3.95
TMS2516	24	2048x8	(450ns)	4.95
TMS2532	24	4096x8	(450ns)	5.49
TMS2564	28	8192x8	(450ns)	10.95
2708	24	1024x8	(450ns)	3.95
TMS2716	24	2048x8	(450ns) 3 voltage.	7.95
2716	24	2048x8	(450ns)	3.95
27C16	24	2048x8	CMOS	9.95
2716-1	24	2048x8	(350ns)	4.95
27160-5	24	2048x8	(550ns)	3.75
2732	24	4096x8	(450ns)	4.25
2732A-20	24	4096x8	(200ns) 21V	9.95
2732A-25	24	4096x8	(250ns) 21V	5.95
2732A-45	24	4096x8	(450ns) 21V	4.49
27C32	24	4096x8	CMOS	11.95
27C32A-30	24	4096x8	(300ns) 21V (CMOS)	22.95
2764-20	28	8192x8	(200ns) 21V	6.95
2764-25	28	8192x8	(250ns) 21V	5.09
2764A-25	28	8192x8	(250ns) 12.5V	5.95
2764-45	28	8192x8	(450ns) 21V	4.95
27C64	28	8192x8	CMOS 21V	11.95
27128-25	28	16,384x8	(250ns) 128K 21V	5.95
27128A-25	28	16,384x8	(250ns) 128K 12.5V	7.95
27256-25	28	32,768x8	(250ns) 256K (14V)	11.95
68764	24	8192x8	(450ns) 21V	12.95
68766	24	8192x8	(350ns) 25V	14.95
74S188	16	32x8	PROM O.C. (6330-1)	1.75
74S287	16	256x4	PROM T.S. (6301-1)	1.79
74S288	16	32x8	PROM T.S. (6331-1)	1.79
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	4.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S476	18	1024x4	PROM T.S.	6.95
74S478	24	1024x8	PROM T.S.	9.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	2.95
82S129	16	256x4	PROM T.S. (27S21)	2.95
82S130	16	512x4	PROM O.C. (27S12)	3.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
82S191	24	2048x8	(80ns)	14.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95

DATA ACQUISITION

Part No.	Pins	Function	Price
DC10		Mostek DC/DC Converter +5V to −9V	2.95
ADC0801	20	8-Bit A/D Converter (1/4LSB).	14.95
ADC0803	20	8-Bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-Bit A/D Converter (1LSB).	3.49
ADC0808	28	8-Bit A/D Conv. w/8 Channel Analog	9.95
ADC0809	28	8-Bit A/D Converter (8-Ch. Multi.)	4.49
ADC0816	40	8-Bit A/D Conv. w/16-Channel Analog	14.95
ADC0817	40	8-Bit A/D Converter (16-Ch. Multi.)	9.49
DAC0806	16	8-Bit D/A Converter (0.78% Lin.)	1.95
DAC0807	16	8-Bit D/A Converter (MC1408-7)	1.49
DAC0808	16	8-Bit D/A Converter (MC1408-8)	2.25
DAC0830	20	8-Bit Up D/A Conv. (.05% Lin.)	5.95
DAC0831	20	8-Bit Up D/A Conv. (.10% Lin.)	4.49
DAC1000	24	10-Bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-Bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1022	16	10-Bit D/A Conv. (0.20% lin.).	5.95
DAC1222	18	12-Bit D/A Conv. (0.20% Lin.).	6.95
DAC1230	20	12-Bit Up D/A Conv. (.05% Lin.).	14.95
DAC1231	20	12-Bit Up D/A Conv. (.10% Lin.)	13.95
AY-3-1015D	40	25K Baud UART	4.25
AY-5-1013A	40	30K Baud UART (TR1602)	3.95



Low Profile (Tin) Sockets

Part No.	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
40 pin LP	.49	.46	.43

Soldertail (Gold) Standard

Part No.	1-9	10-99	100-up
8 pin SG	.39	.35	.29
14 pin SG	.49	.45	.39
16 pin SG	.55	.49	.45
18 pin SG	.65	.59	.51
20 pin SG	.75	.65	.59
22 pin SG	.79	.69	.65
24 pin SG	.79	.69	.65
28 pin SG	.95	.85	.75
36 pin SG	1.25	1.15	.99
40 pin SG	1.39	1.25	1.15

Wire Wrap Sockets (Gold) Level #3

Part No.	1-9	10-99	100-up
8 pin WW	.55	.49	.45
10 pin WW	.69	.65	.59
14 pin WW	.75	.69	.65
16 pin WW	.79	.72	.65
18 pin WW	.95	.85	.75
20 pin WW	1.19	1.09	.95
22 pin WW	1.29	1.19	1.05
24 pin WW	1.35	1.19	1.09
28 pin WW	1.69	1.55	1.39
36 pin WW	1.89	1.79	1.69
40 pin WW	2.29	1.95	1.79

Header Plugs (Gold)

Part No.	1-9	10-99	100-up
14 pin HP	.65	.59	.55
16 pin HP	.69	.65	.59
24 pin HP	1.15	.99	.89

Header Covers

Part No.	1-9	10-99	100-up
14 pin HC	.15	.13	.12
16 pin HC	.19	.17	.15
24 pin HC	.29	.25	.22

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Part No.	Pins	Function	Price
2816A	24	2048x8 16K E²PROM 350ns. . .	12.95

Features: • On-board Address/Data Latches • Auto-Timed Byte Write (on chip timer) • 5V Erase/Write/Read • Optional High Voltage Erase/Program (12V-22V) • Power Up/Down Write Protection • Auto Erase before Write
The 2816A is an ideal nonvolatile memory providing in-system alterability with the same ease and with the same features as 2Kx8 Static RAMs

Digitalker™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc. The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. The DT1050 consists of a Speech Processor Chip MM54104 (40 pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24 pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™. . . . . $29.95 ea.
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DT1057 - Expands the DT1050 vocabulary from 137 to over 260 words. Incl. 2 ROMs and specs
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INTERSIL

Part No.	Pins	Function	Price
FE0202D	40	4 Digit LCD Display for 7211IPL & 7211MIPL	14.95
FE0203D	40	3½ Digit LCD Display for 7106 & 7116	14.95
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit	28	Stopwatch Chip, XTL (Evaluation Kit)	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	10.49
7106EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7107CPL	40	3½ Digit A/D (LED Drive)	10.95
7107EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	10.95
7201IUS		Low Battery Volt. Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	14.95
7205EV/Kit	24	Stopwatch Chip, XTL (Evaluation Kit).	16.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit	16	Tone Generator Chip, XTL (Evaluation Kit)	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit	14	Freq. Counter Chip, XTL (Evaluation Kit)	8.49
7211IPL	40	4 Digit LCD Display Decoder/Driver (TTL compatible)	7.95
7211MIPL	40	4 Digit LCD Display Decoder/Driver (Microproc. compat.)	8.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	16.95
7215EV/Kit	24	4 Func. Stopwatch Chip, XTL (Evaluation Kit).	19.49
7216AIJI	28	8 Digit Univ. Counter C.A.	31.49
7216DIPI	28	8 Digit Freq. Counter C.C.	21.49
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	9.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AEV/Kit	40	5 Function Counter Chip, XTL (Evaluation Kit)	99.95

30009 1983 INTERSIL Data Book (1356 p.) **$9.95**

74HC HIGH SPEED CMOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74HC00	14	59	74HC139	16	1.05	74HC245	20	2.59
74HC02	14	59	74HC147	16	1.29	74HC251	16	99
74HC03	14	89	74HC151	16	99	74HC253	16	1.09
74HC04	14	59	74HC153	16	1.09	74HC257	16	99
74HCU04	14	69	74HC154	24	2.65	74HC259	16	1.69
74HC08	14	59	74HC157	16	99	74HC266	14	89
74HC10	14	59	74HC158	16	99	74HC273	20	2.79
74HC11	14	69	74HC160	16	1.39	74HC280	14	4.59
74HC14	14	89	74HC161	16	1.39	74HC299	20	5.59
74HC20	14	59	74HC162	16	1.39	74HC366	16	2.59
74HC27	14	59	74HC163	16	1.39	74HC367	16	2.59
74HC30	14	69	74HC164	14	1.35	74HC373	20	2.69
74HC32	14	79	74HC165	16	2.15	74HC374	20	2.69
74HC42	16	1.09	74HC166	16	2.49	74HC390	16	1.59
74HC51	14	89	74HC173	16	1.29	74HC393	14	1.59
74HC58	14	89	74HC174	16	1.09	74HC533	20	2.69
74HC73	14	79	74HC175	16	1.09	74HC534	20	2.69
74HC74	14	79	74HC190	16	1.59	74HC595	16	3.19
74HC75	16	99	74HC191	16	1.59	74HC688	20	3.59
74HC76	16	79	74HC192	16	1.49	74HC4024	14	1.75
74HC85	16	1.69	74HC193	16	1.49	74HC4040	16	1.49
74HC86	14	75	74HC194	16	1.19	74HC4049	16	89
74HC107	14	79	74HC195	16	1.19	74HC4050	16	89
74HC109	16	79	74HC221	16	2.95	74HC4060	16	1.49
74HC112	16	79	74HC237	16	1.49	74HC4075	14	59
74HC123	16	2.29	74HC240	20	2.29	74HC4078	14	59
74HC125	14	1.75	74HC241	20	2.29	74HC4511	16	1.95
74HC132	14	1.29	74HC242	14	2.15	74HC4514	24	4.19
74HC137	16	1.59	74HC243	14	2.15	74HC4538	16	2.59
74HC138	16	1.19	74HC244	20	2.29	74HC4543	16	3.75

74HCU04 is unbuffered

74C—C/MOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74C00	14	29	74C107	14	.79	74C240	20	1.95
74C02	14	35	74C151	16	2.19	74C244	20	1.95
74C04	14	35	74C154	24	3.25	74C373	20	2.29
74C08	14	35	74C157	16	1.75	74C374	20	2.29
74C10	14	35	74C160	16	1.19	74C901	14	59
74C14	14	59	74C161	16	1.19	74C902	14	79
74C20	14	35	74C162	16	1.19	74C903	14	59
74C30	14	35	74C163	16	1.19	74C906	14	59
74C32	14	39	74C164	14	1.29	74C907	14	89
74C42	16	1.19	74C165	16	1.29	74C911	28	8.95
74C48	16	1.79	74C173	16	89	74C912	28	8.95
74C73	14	69	74C174	16	1.19	74C915	18	1.19
74C74	14	59	74C175	16	1.19	74C917	28	8.95
74C85	16	1.39	74C192	16	1.39	74C922	18	4.49
74C86	14	29	74C193	16	1.39	74C923	20	4.95
74C89	16	5.95	74C195	16	1.29	74C925	16	5.95
74C90	14	1.09	74C221	16	1.75	74C926	18	5.95
74C93	14	1.09				80C95	16	69
74C95	14	1.19				80C97	16	69

LINEAR

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
DS0026CN	8	1.95	LF355N	8	1.09	LM747N	14	.69
TL071CP	8	79	LF356N	8	1.09	LM748N	8	59
TL072CP	8	1.09	LM358N	8	59	UA760HC		9.95
TL074CN	14	1.95	LM359N	14	1.79	LM1456V	8	1.95
TL081CP	8	59	LM370N	14	4.95	LM1458CN	8	59
TL082CP	8	1.19	LM373N	14	4.95	LM1488N	14	69
TL084CN	14	1.95	LM377N	14	1.95	LM1489N	14	69
LM109K		5.95	LM380CN	8	1.09	LM1496N	14	99
LM301CN	8	.39	LM380N	14	89	LM1605CK		9.95
LM302H		2.49	LM381N	14	1.79	LM1871N	18	2.95
LM304H		1.95	LM382N	14	1.49	LM1872N	18	3.25
LM305H		99	LM384N	14	1.95	LM1877N-9	14	2.95
LM307CN	8	.49	LM386N-3	8	89	LM1889N	18	1.95
LM308CN	8	69	LM387N	8	1.39	LM1896N	14	1.59
LM309K		1.25	LM389N	18	1.19	LM2002T		1.95
LM310CN	8	1.95	LM391N-80	16	1.19	ULN2003A	16	1.49
LM311CN	8	59	LM392N	8	.59	XR2206	16	3.95
LM312H		2.79	LM393N	8	45	XR2207	14	2.49
LM317T		1.19	LF398N	8	3.95	XR2208	16	1.79
LM317K		3.49	LM399H		5.95	XR2211	14	2.95
LM318CN	8	1.59	LF412CN	8	1.95	LM2877P		1.95
LM319N	14	1.49	TL494CN	16	2.79	LM2878P		2.95
LM320K-5		1.35	TL496CP	8	1.59	LM2901N	14	79
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