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CIRCLE 820 ON FREE INFORMATION CARD

Hands-on Electronics
Volume 3, No. 2 March/April 1986

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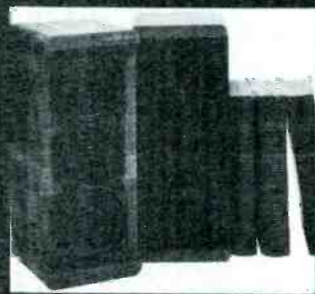

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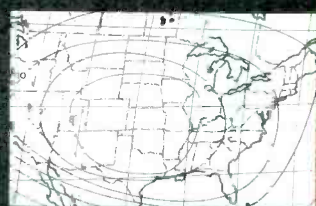

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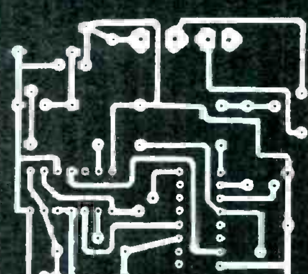

Hands-on Electronics

The Magazine for the Electronics Activist!

EDITORIAL PAGE

Volume 3, No. 2

MARCH/ APRIL 1986

All good things sometimes cause problems!

By now, most of our readers are accustomed to our magazine's bi-monthly appearance on the newsstands across North America. Letters coming from our readers have congratulated us on our extra efforts to bring **Hands-on Electronics** more frequently to them, and, thanks to our new readers, to bring the magazine to many more readers. We are grateful, and we thank those letter writers.

But all is not well in **Hands-on Electronics** land! More magazines each year mean more construction projects, news features, theory articles, and the like that must be published each year. And, do you know where they come from? You, our readers. Without manuscripts coming from our readers, we could not hope to publish **Hands-on Electronics**.

We need your help. Your ideas, projects, and manuscripts are our life's blood. Therefore, the invitation is open to all readers to submit their stories to us. When you get involved in a project based on an original idea, jot down notes of what you are thinking and what is occurring. Take photos of the logical construction steps from the very beginning to the final project in use. A variable-focus 35-mm camera with a strobe is just fine. Then write a letter to me revealing the details of the project. At that time, you will be advised on how to proceed so that your article will be published.

I'm watching my mailbox. Let's hear from you!

Julian S. Martin, KA2GUN
Editor

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LETTER BOX

Pace Maker Alert

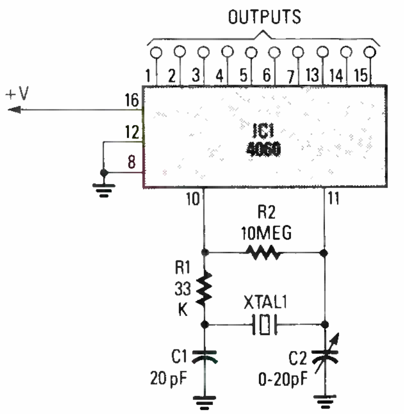
I built the Tesla Coil in your Summer Edition of **Hands-On Electronics** and let me tell you it was worth the effort. Thanks to an old beer company neon sign that broke in a brawl, I picked up a 6000-volt, 30 milliampere transformer at no cost. Also, the 3000-volt capacitor came for only $2.50 at a ham fest. All in all, the Tesla Coil project set me back only $10—what a bargain! Any way, the reason I am writing is to tell you that my Tesla Coil interupts my digital watch at 15 feet distance. Now I don't use a pacemaker device, but if I did, I wouldn't go near that Tesla Coil. Why don't you tell your readers?
J. K., Columbus, OH

The way I see it, anyone who has a pace-maker device connected to himself (and herself) should not rub a glass rod with a cat-skin fur. There is a large question mark in this area. Although no one is known to have been harmed by a consumer-type microwave oven, pacemaker wearers are urged to stay away from them. However, these same people walk freely about airports where many search radars pump out more microwave soup than any microwave oven. Play it safe, fasten your seat belt, and enjoy your Tesla Coil.

TTL Clock

Talk to me about a CMOS TTL clock circuit. I can't tell you more than that I'm working on a secret invention and need the information. When I get my patents, I'll tell you all about it, okay? —L.H., Sioux Falls, SD

Alright, here's your circuit, but we're not going to tell you anything about it until we get it patented! No, we won't do that to you. This 4060 CMOS oscillator/divider has a built-in oscillator that can drive a chain of binary counters. Hope that's what you're looking for. As for keeping the invention a complete secret, it is best to take a friend into your confidence who can testify at a later date confirming the time period you were developing the patent. One solid live witness is worth a bundle of documents.



Doing It My Way

Everyone has their view on how to protect their home with a burglar alarm. Mr. Editor, how would you do your home?
P.C., Eugene, OR

I'll give you a case for a typical home only. First, understand that the prime purpose of a burglar alarm system is to discourage the perpetrator (I watch TV a lot) from even attempting to enter the home. Do this by installing metal foil loops on all windows and glass surfaces throughout the house. Use Radio Shack's foil with self-stick. Before you begin, visit the retail area of your town and see how it's done—neatly, straight lines, square corners, etc. Now you do it, but practice on one or two windows until you are expert. Now do the entire house! Do glass panels in doors and glass or plastic side panels at front entrances. Get the garage door windows, if any—get 'em all. This alone will reduce the chance of break-in by 50 percent. However, since you have gone this far, finish the job—interconnect all windows to a store-bought alarm system.

Purchase an alarm bell box and install it high on the side of your house. Don't bother to place the bell there because that's where the pros would look to disconnect the alarm. Install the bell in the attic near a louvred port. The sound will get out just as well. In fact, I use two bells for front and back—with my luck I'll get a hard-of-hearing burglar.

Make provisions to bypass windows so that they may be opened. However, install magnets and reed switches so that the window can be opened only a few inches, and should someone try to widen the gap, the alarm would go off.

Purchase a BSR-type system to turn the house and yard lights on and off during the night. Anyone watching your house will be spooked away. Remember to change the times and on intervals weekly or every other week so burglars cannot set their watches to your system.

(Continued on page 6)

Letter Box

(Continued from page 4)

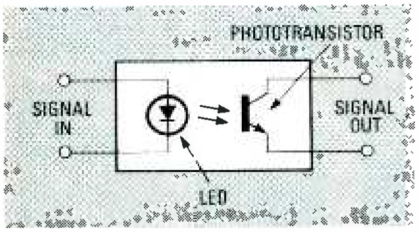
And since you went this far, install an infrared detector in those rooms that are not frequented during sleeping hours. Should someone be clever enough to get past the perimeter alarm, he'd have to be a snowman to remain undetected.

And buy a big, black dog!

Opto-Isolators

More and more, I hear about opto-isolators. Exactly what *is* an opto-isolator? What does it do? —J. P. Wausau, WI

It's a way to actually physically isolate one circuit from another while allowing signal to pass through. It uses a light-emitting diode (LED) and a phototransistor. With no signal at the LED, the LED is dark, so the phototransistor does not conduct. With signal present, the LED illuminates and the phototransistor conducts. As you can see from the schematic diagram, there is no hard-wire path however.



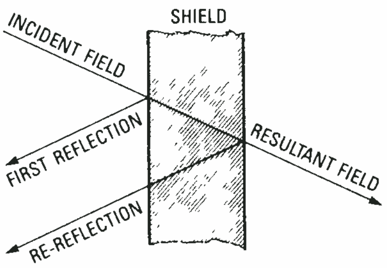
Keep it Simple

My thanks for offering simple and complex construction articles in **Hands-on Electronics**. I prefer the simple projects because their initial cost is low. I say "initial cost" because after the gadget is done, I begin to redesign it , or, as my wife says, "*Complexitize* it." (My wife is a graduate BEE.) That's where I get my kicks, and greatest value from your great magazine. Keep up the good work! G.T. Temple, TX

Thanks for your kind note. The editors are glad that you experiment and modify your projects. That's where the fun and excitement of this fantastic hobby of ours is greatest. All our readers should attempt to make their projects better than that which we offer. Should you be a beginner, it may be a bit more difficult to do so, but though learning and research you'll get the kicks us pros get ten-fold.

How Does a Shield Work?

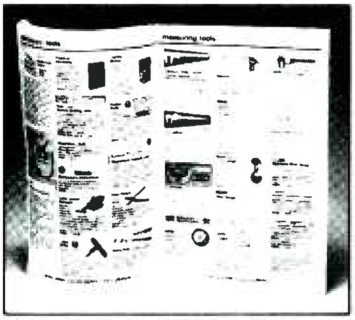
A friend and I were discussing shielding, and we got pretty-deeply into it. But there are still some unresolved questions. Can you shed any light on this matter? —R. M., Sedalia, MO

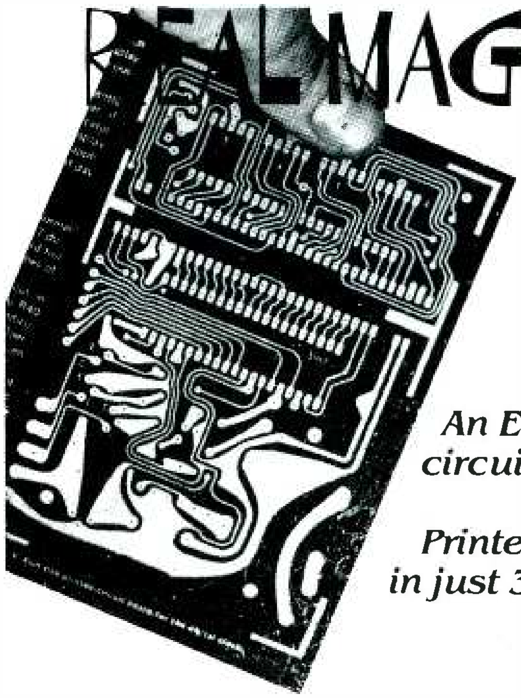


Simple, the shield deflects arrows, spears, stones and small boulders. Then there is the electrical shield. You'll observe from our diagram that electromagnetic energy in the incident field is reflected from both sides of the shield where the shield interfaces with air or medium different from the shield. You'll also note that some of the energy is absorbed by the shielding material itself. Naturally, a lot of this has to do with the material used as a shield and how the shield is connected, usually to ground potential.

Plasma Viewer

Some readers of **Hands-on Electronics** will be delighted to learn that a 117-volt AC, incandescent, house-hold light bulb, preferably one with a large clear globe, can be used as the evacuated display container for the Plasma





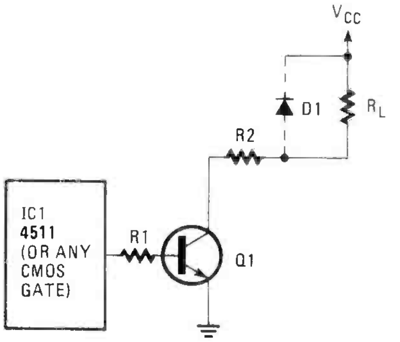
Machine (Summer 1985). Simply solder the transformer's high-voltage output lead to either the base or the pin of the bulb. Even though the bulb is fixed in pressure and atmospheric content, it does provide an economical, yet effective means, of viewing and touching the colorful plasma. P.B, Wailukce, HI

Light bulbs rated at 40-watts and above use nitrogen gas within the bulb to reduce the effect of implosion when the bulb breaks. The bulb is evacuated to some degree, but how many tors of pressure is unknown at this time. Considering how easy it is to obtain a light bulb. Try a 200-watt clear bulb. Be sure that the base and neck of the bulb are insulated so that you accidently cannot get too close to the high voltage. The bulb's internal filament and wires are where the plasma trail will begin (or end).

CMOS Switcher

I'm sure this question has been around the pike a few times but I must have missed it. How can I use a CMOS gate in a switching application? —M.J., Sarasota, FL

You're right. It's an "oldie, but a goodie." You can use a 4511 or any other CMOS gate. The transistor could be a 2N2222. Resistor RL represents the



load to be controlled, and R1 protects the CMOS output. Resistor R2 limits the current through the transistor. Diode D1 is optional, but should be used if you're controlling an inductive load. It protects the coil from inductive spikes. The component values? Simple. Derive R1 and R2 using Ohm's Law. The transistor voltage drop is about 0.6 volts. Make sure the diode's PIV is at least twice the V_{CC} and able to handle at least twice the current drawn by the coil.

Update

Many of our readers became involved with the Electronic Crossover Circuit project designed by Fernando Garcia Viesca that appeared in the last issue of **Hands-on Electronics**. *They followed our suggestion in contacting Gladstone Electronics, Inc. only to discover that we supplied an old address, and for those*

(Continued on page 95)

NEW PRODUCTS SHOWCASE

Digital Multimeter

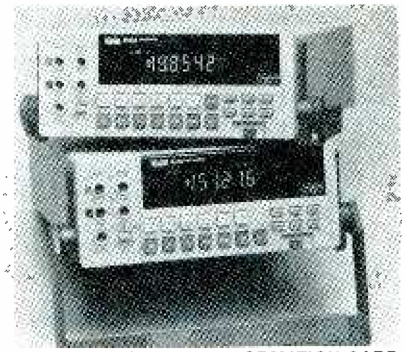
The Fluke 8842A 5½-digit, digital multimeter is the second meter in the highly successful 8840 family of Fluke meters, and provides a natural complement to the widely accepted Fluke 8840A.

The Fluke 8842A offers enhanced measurement capabilities for such applications as production testing or research and development. It features 0.003% basic DC accuracy and 0.08% basic AC accuracy. It also features 100-μV resolution for DC voltage measurements, 1-μA resolution for DC current measurements, and 100-μΩ resolution for resistance measurements. It is hermetically sealed, and thin-film-resistor technology gives the 8842A a two-year calibration cycle and warranty period. The 8842A comes equipped with an adjustable tilt bail/handle for bench use.

The meter features an easy-to-read, high-visibility, vacuum-fluorescent display. The uncluttered front panels have been designed for simple, one-button-per-function and one-button-per-range operation. The 8842A automatically selects the proper range faster than most other 5½-digit DMM's in its price and performance range. Self-prompting software calibration procedures can be performed under front panel or IEEE-488 control, either at the instrument site or in a calibration lab.

The Fluke 8842A is priced at $995, with IEEE-488 and true *rms* AC options available for $150 and $250, respectively.

For more information, contact John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, WA 98206, or call toll free 800/426-0361.

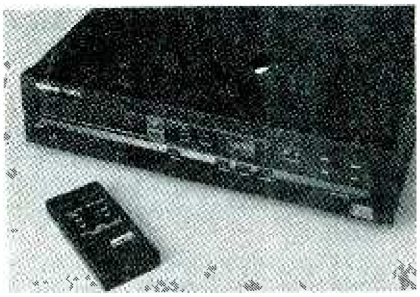


CIRCLE 845 ON FREE INFORMATION CARD

Compact Disc Player

Shure has introduced the D5000 Compact Disc Player. Very few CD players in the D5000's price range offer both analog and digital filtering plus wireless remote control. The D5000 incorporates those features.

The D5000's features include a *Long-life* 3-beam, solid-state laser tracking system and random progammability for 15 tracks, with access up to 99 tracks. The D5000 also incorporates a full 16-bit processor, plus the smoothing effects of oversampling.



CIRCLE 846 ON FREE INFORMATION CARD

The unit's digital filter eliminates phase distortion and graininess while doubling the sampling rate. Additional analog filters enhance the D5000's noise-free performance.

Other convenience features offered with the D5000 include a 2-speed audible scan and various repeat functions, including disc, memory, and phrase. A function for rapid access to the beginning of any track (for disc or memory) is also included.

U.S. suggested retail price for the Shure D5000 is $499.00. For further information, contact Shure Brothers, Inc., Customer Services Department, 222 Hartrey Avenue, Evanston, IL 60202-3696.

Electronic Video Head Cleaner

With the introduction of the first microprocessor-controlled, electronic video head cleaner, the guesswork and *messwork* of cleaning VCR's has been eliminated.

Designed for VHS and VHS Hi-Fi video cassette recorders, the Advanced Video Dynamics head cleaner (Model CJ-58) doesn't require the user to estimate either the length of the cleaning cycle or the amount of fluid to apply. Thanks to its microprocessor-controlled technology, this innovative product automatically calculates the precise amount of fluid needed

(Continued on page 12)

GET THE KNOW-HOW TO REPAIR EVERY COMPUTER ON THIS PAGE.

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

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

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The vital core of your training is the step-by-step building of the 16-bit Sanyo MBC-550-2 computer. Once you've mastered the details of this state-of-the-art machine, you'll be qualified to service and repair virtually every major brand of computer, plus many popular peripheral and accessory devices.

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

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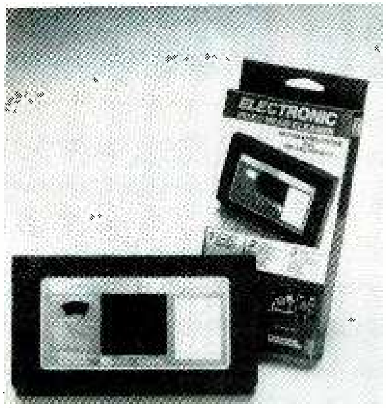
We'll Give You Tomorrow.

NEW PRODUCTS SHOWCASE

(Continued from page 8)

and the exact amount of time required to clean the VCR's entire tape path. As a result, the Advanced Video Dynamics head cleaner is completely safe and highly effective.

The automatic dispensing system in the cartridge also makes this product extremely simple to use. With the Advanced



CIRCLE 847 ON FREE INFORMATION CARD

Video Dynamics head cleaner, there's no spraying, swabbing, or pouring the cleaning fluid. And there are no bottles of solvent or other paraphernalia to keep track of. Just insert the self-contained cartridge in the VCR and press the play button. All it takes is about 15 seconds to clean the audio and video heads and other components thoroughly. When the cycle is complete, the cartridge stops and emits a beep. Then you press the VCR's stop button and remove the tape.

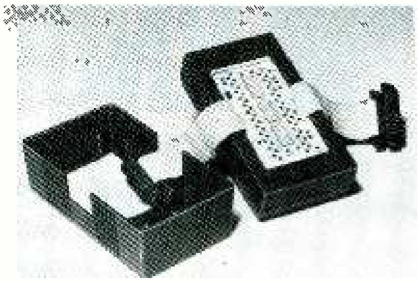
The Advanced Video Dynamics head cleaner lasts for 25 to 30 cleanings, a period of two to three years for most VCR owners. This wet-cartridge cleaning system for VHS and VHS Hi-Fi comes with a 9-volt Eveready Energizer™ alkaline battery and carries a suggested retail price of $18.95. Model CJ-58 is being distributed nationwide in department stores, specialty shops, discount operations, drug chains, catalog showrooms, and mail-order houses.

RS-232 Breakout Box

Heath has a new RS-232 Breakout Box to be used in computer servicing and peripheral design engineering. The device is used to test and modify equipment interconnected by RS-232C standards.

The Heath PMK-130 permits access to all 25 lines of interface circuitry and allows switch disabling of 23 lines to provide isolation or cross-connection of signal lines. Two flat cables with dual male/female 25-pin D connectors allow direct connection of the breakout box between RS-232 devices such as computers, printers, modems, and terminals.

Twelve light-emitting diodes (LED's)



CIRCLE 848 ON FREE INFORMATION CARD

located on the face of the Breakout Box permanently monitor several key signal lines of the interface. Two AA-size batteries are needed to power the unit. The PKM-130 includes a carrying case, which lists common terminology used with interfacing and provides storage for line jumpers.

The Heath PMK-130 is just one of over 400 exciting kits featured in the Heathkit Catalog. For your free copy, write Heath Company, Box 150-594, Benton Harbor, MI 49022. In Canada, write Heath Company, 1020 Islington Avenue, Dept. 3100, Toronto, Ontario, M8Z 5Z3. Free catalogs are also available at over 70 Heath/Zenith Computers & Electronics stores throughout the U.S. and Canada. Consult telephone directory white pages for the nearest store.

Digital Automotive Tune-up Tester

Universal Enterprises' DAT468 solid-state digital automotive tune-up tester performs the tests necessary for maintaining the effective performance of your early or late model car. The DAT468 will check RPM, dwell, battery, starter, distributor, points and condenser, alternator and voltage regulator, spark-plug cable resistance, and all wiring connections, circuits, duty cycle for computers and controlled fuel systems. All of those tests can be performed on 4-, 6-, and 8-cylinder engines.

Pushbutton operation and a front panel

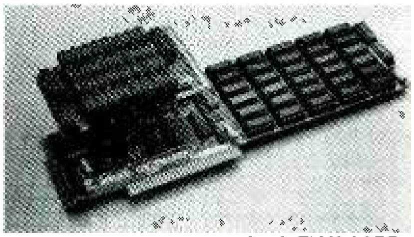
CIRCLE 849 ON FREE INFORMATION CARD

that is color-coded with large, bold, easy-to-read numbers and letters, make range selection fast and easy. The 3½-digit, high-contrast LCD has easy to read 0.5-in. high numerals.

The DAT468 comes with battery-clip test leads, battery, and instructions. A leather carrying case and probe tip-test leads are available. Write to Universal Enterprises, Inc., 5500 SW Arctic Drive, Beaverton, OR 97005; or telephone 503/644-8723.

3 Mbyte RAM Card for IIe

Need more memory for your Apple? You can add three million bytes of additional random access memory (RAM) to your Apple IIe with a Ramworks II board from Applied Engineering of Dallas. A piggyback board, less than half the size of the Ramworks II main board, holds twice the amount of memory. The piggyback



CIRCLE 850 ON FREE INFORMATION CARD

board contains 64 256K-bit dynamic RAM chips in small inline packages. The three-megabyte Ramworks II sells for $1699. A one-megabyte Ramworks II without the piggyback board is $389.

Ramworks II increases the size of Apple IIe memory by 4140%, producing a "desktop" message that reads "2,277K avail." for users of the best-selling Appleworks program. In addition, Ramworks II provides users with a built-in 64K printer buffer that allows use of the Apple while long documents are being printed.

For more information, contact Applied Engineering, P.O. Box 798, Carrollton, TX 75006; or telephone 214/241-6060.

Add-on Hard Disk for Macintosh

Paradise Systems now offers a 10-Mbyte hard-disk subsystem for the Apple Macintosh with system and utility software included. The high-performance hard-disk system is designed to match the Macintosh in appearance, engineered to enhance its performance and priced sensibly. The Paradise MAC-10 10-Mbyte hard-disk subsystem (including software) is available for $999 (all prices suggested U.S. resale) at participating Paradise dealers and authorized Paradise distributors, including Softsel, Micro-D and First Software. The company also recently announced its MAC-20 ($1,399) 20-Mbyte hard-disk subsystem.

NEW PRODUCTS SHOWCASE

(Continued from previous page)

The MAC-10 10-Mbyte hard disk uses the full potential speed of the Macintosh serial port to operate up to six times as fast as a floppy-disk drive. It also offers 25 times as much data storage as a Mac floppy disk. The software supplied with the hard disk includes MAC-10 system software and the latest version of Apple Finder operating system software (licensed from Apple Computer, Inc.).

MAC-10 system software supports the creation and management of volumes (subdivisions of the total disk space). Volumes provide a way around a limitation built into the Macintosh operating system, which would otherwise allow the system to support no more than 250 files. The MAC-10 permits as many as 26 volumes (each of which appears as a separate floppy drive to the computer); that lets it store as many as 6500 files (up to 250 in each of 26 volumes). Utility software included with the hard-disk system supports the creation, naming, mounting, un-

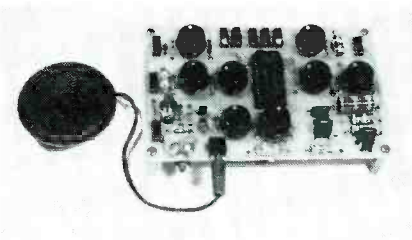
CIRCLE 837 ON FREE INFORMATION CARD

mounting, deleting and erasing of volumes—all "drag-and-click" easy through an on-screen menu.

For further information, contact Paradise Systems, Inc., 217 East Grand Avenue, South San Francisco, CA 94080; or telephone 415/588-6000.

Sound Experimenter Kit

Jameco Electronics has added a sound experimenter kit (JE755) that generates white noise, tone, and low-frequency



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sounds independently or in combination. The JE755 utilizes the 76477-Texas Instruments complex sound-generator chip

(Continued on page 95)

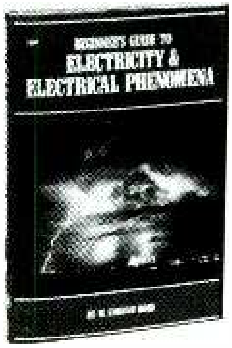
BOOKSHELF

By Barmard de Backus

Beginner's Guide to Electricity & Electrical Phenomena
By W. Edmund Hood

Understand the wonders of electrical phenomena by using the exciting, hands-on projects and experiments outlined in this book. The spread of topics covers everything from static electricity and magnetism to digital logic and microcomputer architecture!

Written for beginners, this guide explores the fundamentals in an entertaining way by combining basic electronics theory with exciting hands-on projects.



CIRCLE 840 ON FREE INFORMATION CARD

It's all here for the taking—from simple experiments to advanced projects like a sound-powered telephone using two crystal microphones.

Find out how home wiring operates, from the fuse box to types of lighting fixtures, how digital logic works, and even what a BASIC program looks like. Exciting projects scattered throughout provide you with hands-on understanding of how an electroscope works, and how you can build one yourself; how a telephone works using a carbon microphone that you put together,and how to build a simple transformer.

This thoroughly up-to-the-minute guide is the ideal reference for students, electronics hobbyists, project builders, do-it-yourselfers, and anyone else who wants a firm understanding of the exciting world of electricity.

Tab Books, Inc., Blue Ridge Summit, PA 17214. Softcover, 250 pages, $10.25.

Handbook of Digital Logic With Practical Applications
By Sam Cowan

Electronics professionals and hobbyists who work with digital circuitry need practical answers to questions on everything from Boolean algebra and logic circuits to microprocessors and memory chips, which The Handbook of Digital Logic provides. The handbook sets forth in a clear and straightforward manner, all the methods, guidelines, and illustrations needed to understand and skillfully apply digital logic to a wide range of circuit design and troubleshooting applications.

This handbook is a one-stop reference source of essential information designed to help solve complicated digital logic problems.

CIRCLE 835 ON FREE INFORMATION CARD

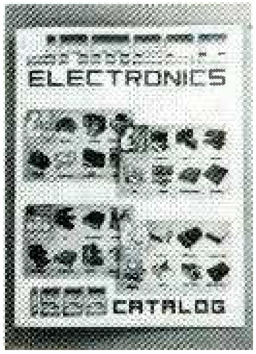
Topics covered include using number systems, definition of logic families, examples of flip-flops and counters, explanation of memory devices, using hamming codes, understanding binary cyclic codes, understanding and applying Boolean algebra; checklist of logic circuits, understanding microprocessors, how to interface with the computer, understanding and applying parity checks, and information on TTL logic circuits.

Written by Sam Cowan, an experienced electronics engineer, and published by Prentice-Hall, Inc. (Business and Professional Books Division, Englewood Cliffs, NJ 07632), this 309-page handbook with its 216 illustration and photographs sells for $29.95.

Tesla Coil Secrets
By R. A. Ford

The Tesla coil, invented by Nikola Tesla in the early 1890's, consists of two coaxial, concentric, single-layer coils wound in the manner of a step-up transformer, each coil having an air core. The coil unit produces high-voltage, high-frequency electricity.

From that scientific invention many legends have sprung clouding the true genius of its inventor, Nikola Tesla.



The Tesla-coil transformers came into being as equipment developed by Nikola Tesla to explore the nature of tuned circuits resonating at high frequency and high voltage. He discovered early in his research that while using a coil of a given wavelength, other coils in the laboratory (tuned either to the same wavelength or one of its harmonics) would respond in sympathy by spouting its own crown of sparks, even though not connected in any physical way to the operating coil. Here, in this text, the science and production details of the Tesla coil is provided in simple terms with ample reference to history.

Tesla Coil Secrets is published by Lindsay Publications, Inc., P.O. Box 12, Bradley, IL 60915; Tel. 815/933-3696. Soft cover, 74 pages, $6.95.

Understanding Computer Science Applications
By Rodger S. Walker

Texas Instruments Information Publishing Center has released the the second volume in a planned set of books explaining the fundamentals of computers in an easy-to-understand language and format. This second volume provides a self-paced course on how computers are used to solve problems and uses examples of computer applications and programs.

The book was written by Dr. Roger S. Walker, a professor in the Computer

(Continued on page 18)

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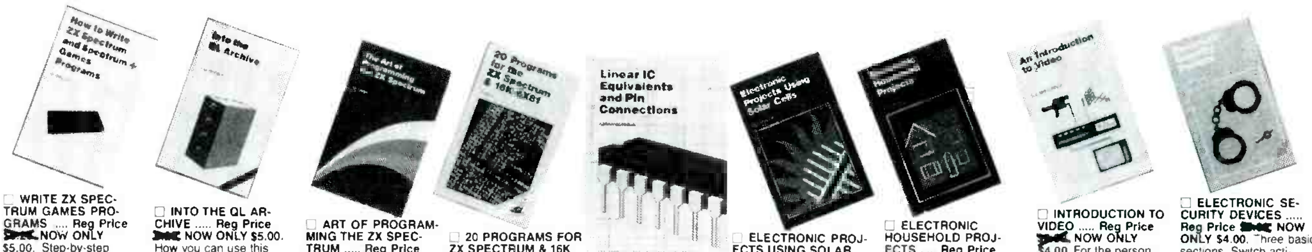

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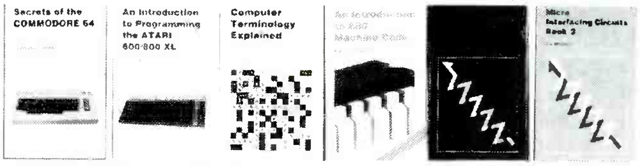

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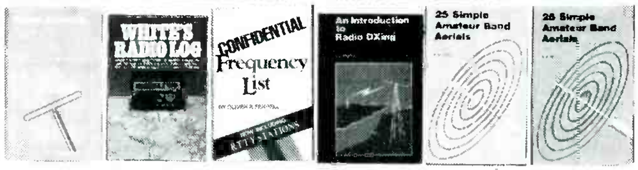

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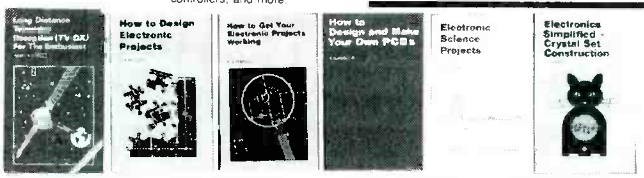

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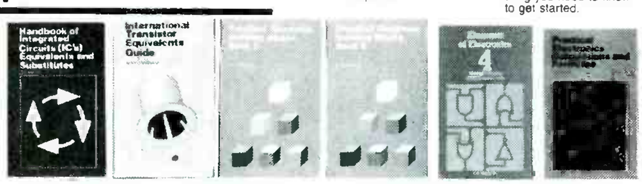

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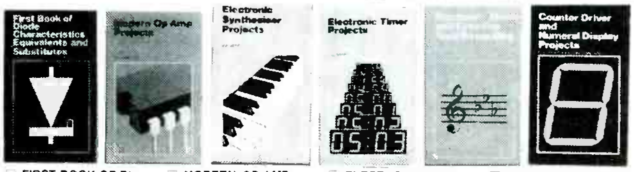

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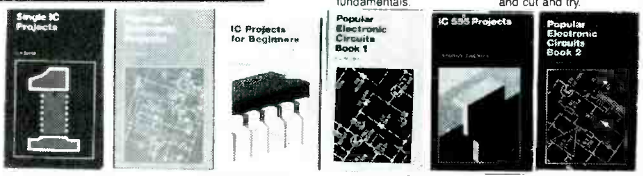

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(Continued from page 16)
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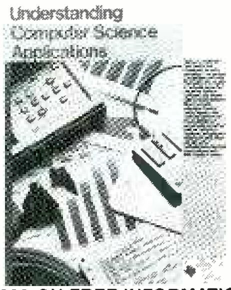


CIRCLE 833 ON FREE INFORMATION CARD

The eight-chapter, 284-page second volume reviews basic-computer concepts and covers serial, parallel, and network communications; distributed processing; modeling and simulation of systems; graphics; and future applications. Each chapter contains a summary and a short quiz that allow readers to gauge their level of comprehension and to progress at their own speed.

The simplicity of the book's language and format in presenting highly technical material make it a useful learning tool with wide applications—from individuals merely curious about computer technology to college courses in introductory computer technology.

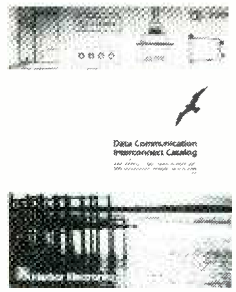
The new computer applications book will be available through bookstores and college stores at a suggested retail price of $14.95.

Data Communication Interconnect Catalog

Harbor Electronics has published a twenty-page catalog for the data communications interconnect market.

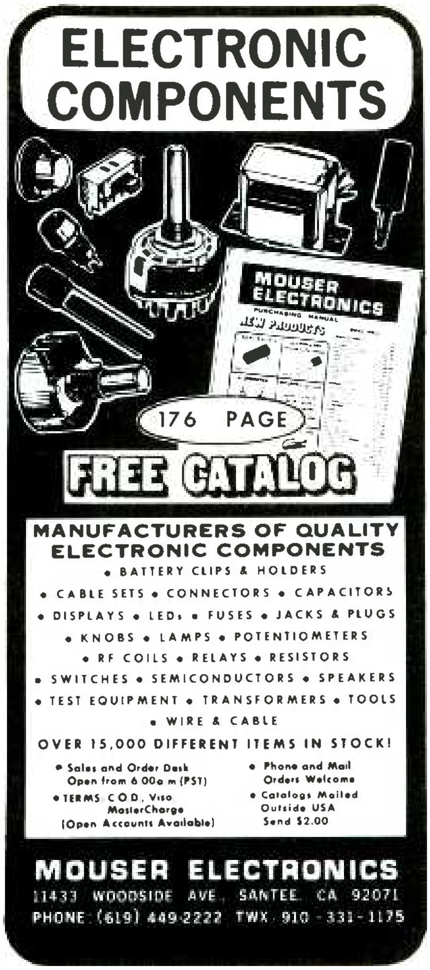
The twenty-page color catalog features sections on cable assemblies, including RS-232, Centronics-type, IEEE, PET-IEEE, D-subminiature, coaxial, twinaxial and dual-coaxial (Wang compatible) connectors, switchboxes for many configurations and connections, modems, fiber-optic products, bulk cable and data-communication accessories including breakout boxes, gender changers, test equipment, surge protectors and others.

Catalogs are available free of charge and may be obtained by writing Harbor Electronics, 650 Danbury Road, Ridgefield, CT 06877; or by calling 1-800-243-4794, in Connecticut 203/438-9625.



1986 Jameco Catalog

Jameco Electronics, established in 1973 as an electronics retailer/wholesaler, has just released a new 80-page illustrate catalog listing over 3,800 items. Product lines include everything from integrated circuits to computer peripherals. Numerous pages are dedicated to Apple, IBM, Commodore, and TRS-80/Tandy computer peripherals/accessories. New feature this year: 8 pages of valuable integrated circuit pin-out data included inside. Jameco's 1986 catalog is an ideal source for the electronics/computer enthusiast. Send $1.00 postage to Jameco Electronics, 1355 Shoreway Rd., Belmont, CA 94002 for your 1986 Catalog today. ■



By Don Jensen

JENSEN ON DX'ING

Shortwave broadcasters this side of the pond

□AMERICA ON SHORTWAVE? *Voice of America*, of course! But there's more to U.S. shortwave broadcasting than the VOA. There always have been private SW stations, albeit a small handful. What is interesting, though, is that their number is growing—particularly in the past five years—just when the so-called experts were writing off SW as an old-fashioned medium in a direct-satellite broadcasting era.

Originally, 50 years and more ago, all U.S. SW stations were privately owned. Some were low-powered experimental transmitters set up by medium-wave broadcasters, which simply duplicated the programming of the parent station, much as early FM'ers, a couple of decades later, simulcast AM programs. They faded from the scene as the domestic radio networks covered the nation from coast to coast.

What remained were the big boys of the day, the SW stations set up by the networks themselves, NBC and CBS, plus major electronics manufacturers, General Electric, Westinghouse, and the Crosley Corp. Advertising income was a lure to private SW stations in the 1930's. Some broadcasters did attract commercial sponsors such as Standard Oil, Firestone tires, Camel cigarettes, and Adams hats. But, for the most part, U.S. commercial shortwave was a disappointment.

When WWII broke out, the U.S. had no official shortwave voice, so the VOA was quickly established out of wartime necessity. Eventually all the prewar SW'ers except two were absorbed into the VOA.

The exceptions were WRUL, operated by the Boston-based World Wide Broadcasting Foundation, and KGEI, the west coast General Electric shortwave station.

WRUL, founded in 1931 as the experimental W1XAL, broadcast from Scituate, Massachusetts. It had a long and fascinating history, complete with wartime and post-war intrigue, but that's another story. Subsequently, it passed through several ownerships, eventually becoming today's WYFR.

WYFR, owned by a Redwood City, California, religious organization, Family Radio, abandoned the old WRUL facilities in Massachusetts. The station now uses new 50- and 100-kW transmitters at Okeechobee, Florida. It also has a swap arrangement with the shortwave *Voice of Free China*, under which the Florida transmitters sometimes broadcast VOFC programs to the U.S., and the Taiwanese stations beam some WYFR programming to the Orient.

Listeners can find WYFR's own transmissions around 2300 UTC on 15,170 and 15,400 kHz; at 1600 UTC on 17,845 kHz.

KGEI was sold, years ago, to another California religious organization, which operates it as *La Voz de Amistad*, the *Voice of Friendship*, broadcasting to Asia and

ABBREVIATIONS

AM	amplitude modulation (modulated)
CST	UTC + 6 hours
EST	UTC + 5 hours
FM	frequency modulation (modulated)
FM'ers	FM broadcasters
kHz	kiloHertz (1000 Hertz or cycles)
kw	kilowatt (1000 watts)
MST	UTC + 7 hours
PSC	UTC + 8 hours
QSL	verification reply from broadcaster
RDI	Radio Database International
SW	shortwave
VOA	*Voice of America*
UTC	Universal Time Code
VOFC	Voice of Free China
WWII	World War II (1939-1945)

Atop Chatsworth Peak, overlooking California's Simi Valley, work progresses on the antenna site for KVOH, a new religious shortwave broadcaster, one of a growing number of private U.S. shortwave stations. The station is expected to be on the air in 1986.

Latin America. The original transmitter site at Belmont, California, was moved to Redwood City, near San Francisco.

KGEI can be heard during its very brief English language program, 2130 to 2200 UTC, on 15,280 kHz.

The third longtime SW religious broadcaster in the U.S. is WINB at Red Lion, Pennsylvania, which went on the air in the early 1960's. Since it uses a single 50-kW. transmitter, it is not as well known as some of the other oldtime U.S. shortwavers.

WINB broadcasts on 17,730 kHz from 1500 to 2000 UTC, continuing on 15,185 kHz until 2245 UTC.

If any one person can be credited with giving U.S. shortwave broadcasting a shot in the arm is Joseph Costello III, a Louisiana entertainment empresario who decided to add a 100-kilowatt commercial shortwave station to his successful stable of motion picture theaters, and AM and FM stations.

WRNO *Worldwide*, the "*Rock of New Orleans*," has some SW-only shows and some simulcasts of AM/FM productions. It also airs some programs for broadcasters who "buy time" from the station. Costello seems to have succeeded—against most predictions—in making his shortwave venture pay.

WRNO is on the air from 1500 to 0500 UTC; on Sundays around the clock. During the evening hours in North American, try 9,852.5 kHz until 0100 UTC; 7,355 kHz from 0100 to 0300 UTC; 6,185 kHz from 0300 to 0500 UTC.

After WRNO went on the air in 1982, others became seriously interested in shortwave broadcasting. Every few months, some group or another—mostly religious organizations, but a few business ventures, too—announced plans to go on SW.

Stations went on the air from American sites outside the U.S. mainland—Alaska, Guam, and Saipan.

Among the new religious SW broadcasters now on the air from within the U.S. are WMLK, Bethel, Pennsylvania, and KCBI, Dallas, Texas.

WMLK was put on air by a small religious organization called the Assemblies of Yaweh. Its small engineering staff rebuilt a used 50-kilowatt medium-wave transmitter and remodeled a vacant gas station for a studio/transmitter building.

WMLK began broadcasting in 1985 on a limited schedule. Try tuning 15,110 kHz between 1700 and 1830 UTC.

A more ambitious operation is KCBI, which went on the air last July. It is owned by the Criswell center for Bible Studies and Criswell Bible Institute.

As WRNO emphasizes its New Orleans location; KCBI stresses its Texas origin and Dallas site. Programs feature

(Continued on page 101)

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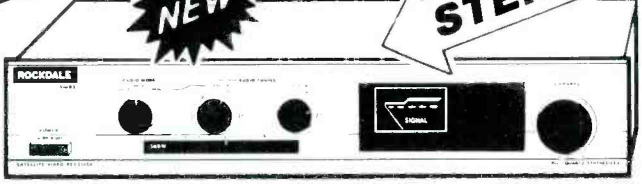

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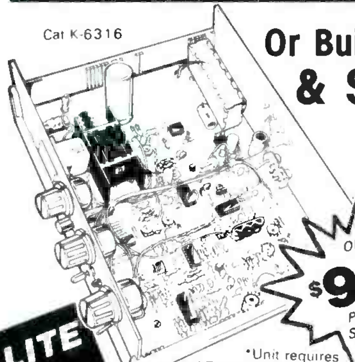

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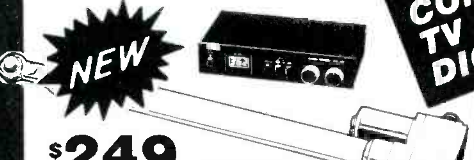

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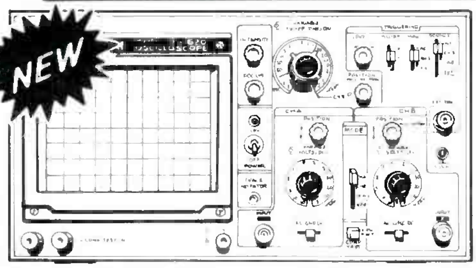

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As always Dick Smith brings you more for less! Our new model dual-trace 20 MHz oscilloscope is packed with features. The high brightness CRT assures easy readability, and a specially designed circuit for component testing allows you to determine component status in or out the circuit board! Other features include: wide bandwidth & high sensitivity, very low power consumption, high sensitivity X-Y mode, 2 axis (intensity modulation) panel electrical trace rotator, & regulated power supply circuit for accuracy. And the best feature of all: our new low price!

20 MHz DUAL-TRACE OSCILLOSCOPE

NEW

IN-LINE VHF AMP

This 10dB video amp has a bandwidth of 50-450 MHz & output capability of 30 dBmV. Noise figure is 4 dB & impedance is 75 ohms.

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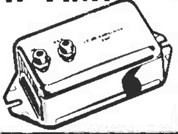

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DIP METER

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Frequency Range:	1.5-250 MHz in 6 plug-in coils
Modulation:	Approximately 2 KHz sinewave
Crystal Oscillator:	1-15 MHz
Power Supply:	9V DC
Semiconductors:	2 transistors & 1 diode

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Hand-Held Convenience!

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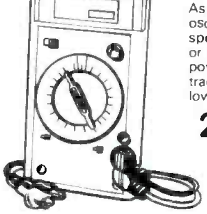
A hand-held oscillator the size of a digital multimeter! 23 ranges of sine & square waves (switchable) between 20 Hz & 1.5kHz, plus a x100 range: 46 settings in all. Many other features: 600 ohms output.



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Make circuit repairs & changes fast & simple! Kit includes spring-loaded clamp & guide, collet knife & blade, 154 asst. copper donuts, 32 sq.in. of foil, & instructions.

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All necessary materials are in this kit! 5"x6" steel print frame, film & processing pack, yellow filter, 4 oz. etch resist, 16 oz. developer, blank copper boards, dry concentrated etch and 1:1 resist patterns & tapes, instructions.

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The ideal professional iron! It's ultra-light weight, so you can use it comfortably for long periods. Superior design ensures that the temperature at the top will be precisely the one selected. This is a lasting iron for the production line or workshop.

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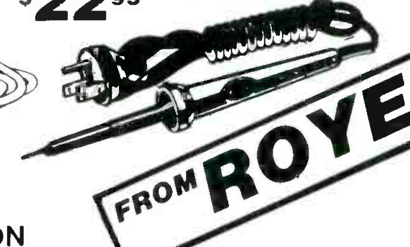
$22.95 Cat T-1830



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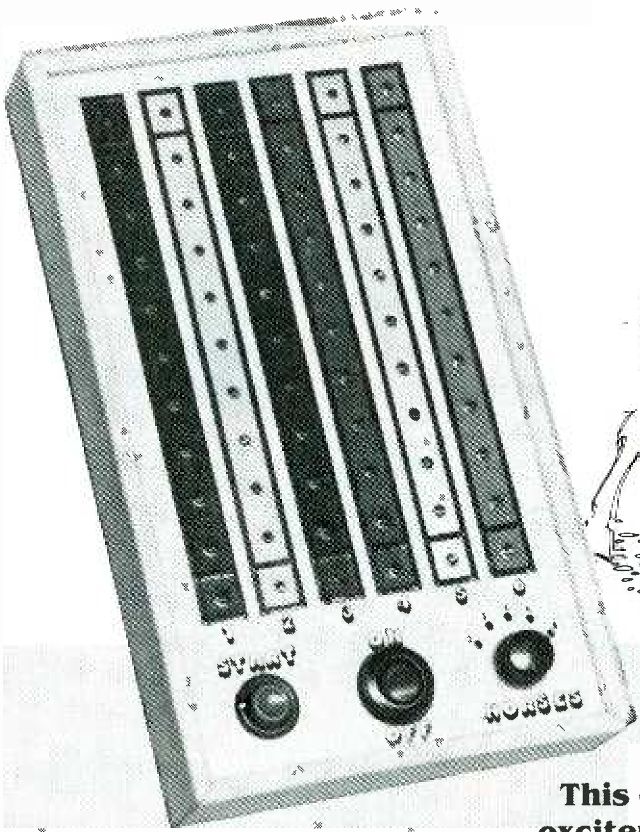
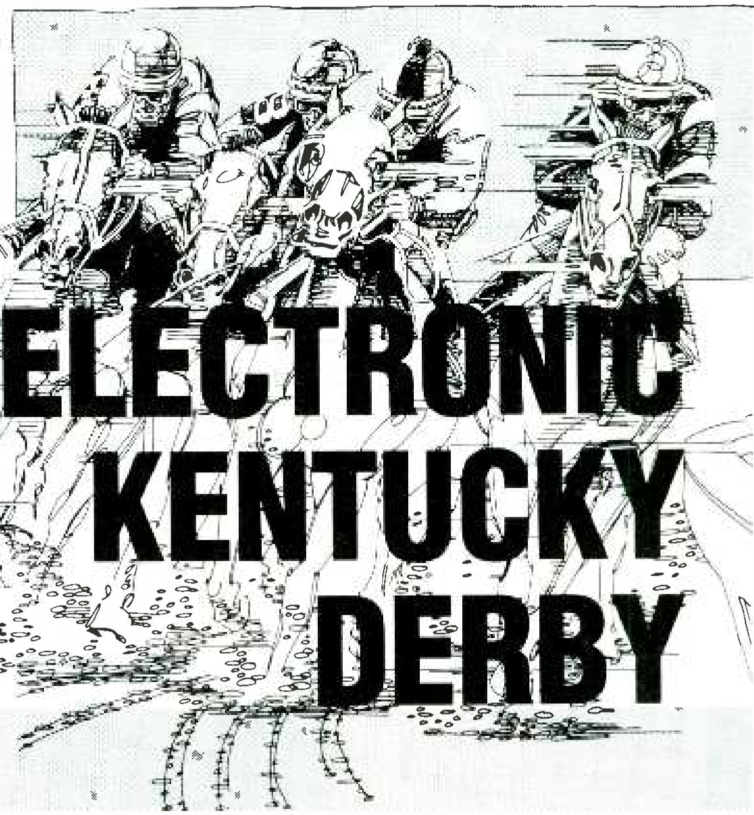




ELECTRONIC KENTUCKY DERBY

This electronic horse-race game has all the fun, excitement, and unpredictability of the real thing!

W. Schopp

□"THEY'RE OFF AND RUNNING!" THAT PHRASE SIGNALS the start for all the fun and excitement of *The Sport of Kings*. Now the thrills of the race and the uncertainty of the winner can be duplicated with a carry-around game. The game has six horses represented by six rows of eleven light-emitting diodes: 10 yellow and 1 red in each row. The position of each horse is indicated by the glowing light-emitting diode in the row.

When the START button is depressed, all the horses line-up at the starting gate, with the first lamp in each row glowing. Once the START button is released, the horses start moving toward the finish line. Each second, a randomly selected horse jumps one step. The first horse to cross the finish line (the tenth light-emitting diode in the row) freezes the action and the race is over. The next race begins when the start button is pushed and released again.

Switch S1, HORSES, allows any number of horses from two to six to be selected to run. Horses not in the race are left at the post to avoid confusion. The circuit is built of a compliment of inexpensive CMOS chips, and can be battery-powered using four "C" cells in series. Or, if desired, a small plug-in wall power-supply, capable of delivering 6–9 volts DC at around 75 milliamperes, may be used. But keep in mind that the current requirement may increase depending on the light-emitting diodes selected.

Sixty yellow light-emitting diodes divided among six lanes are used to indicate the position of the horses during the race. An extra (red) light-emitting diode is wired in parallel with the tenth light-emitting diode so that the winner stands out from the losers.

How It Works

Figure 1 is a schematic diagram of the Electronic Kentucky Derby. Hex-inverting buffer U20 is used to make up two separate signal-generator circuits. The first, comprised of U20-a and U20-b, provides a 5-kHz signal that's fed to the CLOCK input of U19 (a CD4017 counter/divider) at pin 14 through the U20-c buffer stage. The second generator, made up of U20-d and U20-e, feeds a 1-Hz signal to U19's ENABLE input at pin 13. U19 is enabled by a low at pin 13. Thus, every second, 5000 pulses (give or take a few) are fed into U19; after that, the gating signal at pin 13 goes high and the counter is inhibited or cut off. That leaves U19 displaying the last pulse fed into it just prior to its being gated off. The last pulse counted produces a signal on one of the the active outputs of U19.

Circuit subtleties and thermal-drift variations assure that the precise number of pulses between the gating signals will be different each time. Each pulse represents a different output of counter U19. C2, a 0.009-µF capacitor, which is really two 0.0047-µF units wired in parallel, has double the instability of one capacitor, and adds further to the drifting—which, in this application, is a desirable trait.

The gating signal that's fed to U19 at pin 13 is also used as a sort of enable signal for the individual gates of U17 and U18. One leg of each gate is tied to the pin-13 input of U19 and the other leg is tied to one of the outputs of U19. Depending on the logic appearing at the outputs of U19, one of the gates is turned on. During each second that the gate is turned on, a signal is fed to one of six decade counters, U1–U6, which sequentially advance one count for each positive transition of

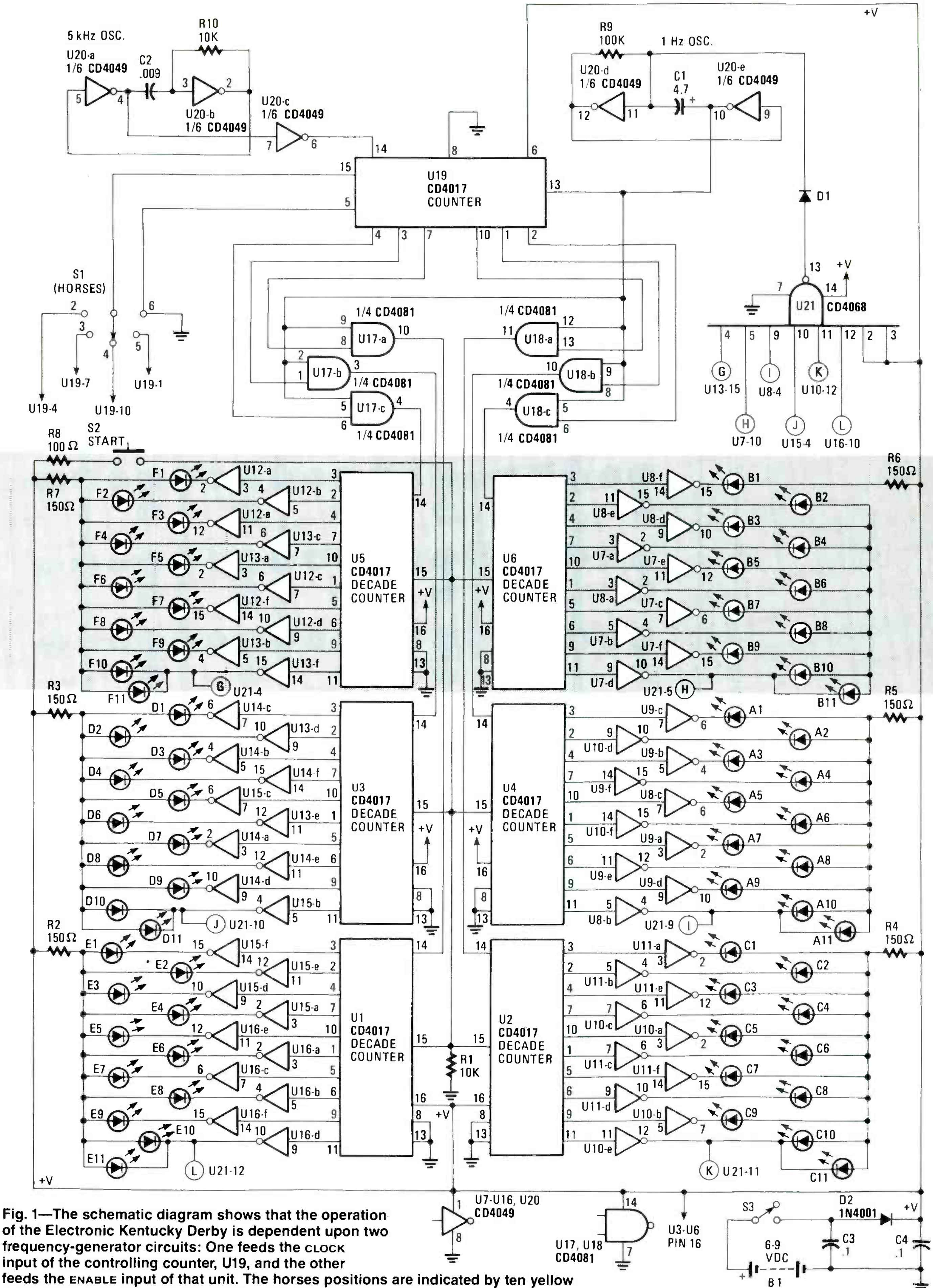


Fig. 1—The schematic diagram shows that the operation of the Electronic Kentucky Derby is dependent upon two frequency-generator circuits: One feeds the CLOCK input of the controlling counter, U19, and the other feeds the ENABLE input of that unit. The horses positions are indicated by ten yellow light-emitting diodes, with the tenth paralleled by a red unit to make the winner more noticeable.

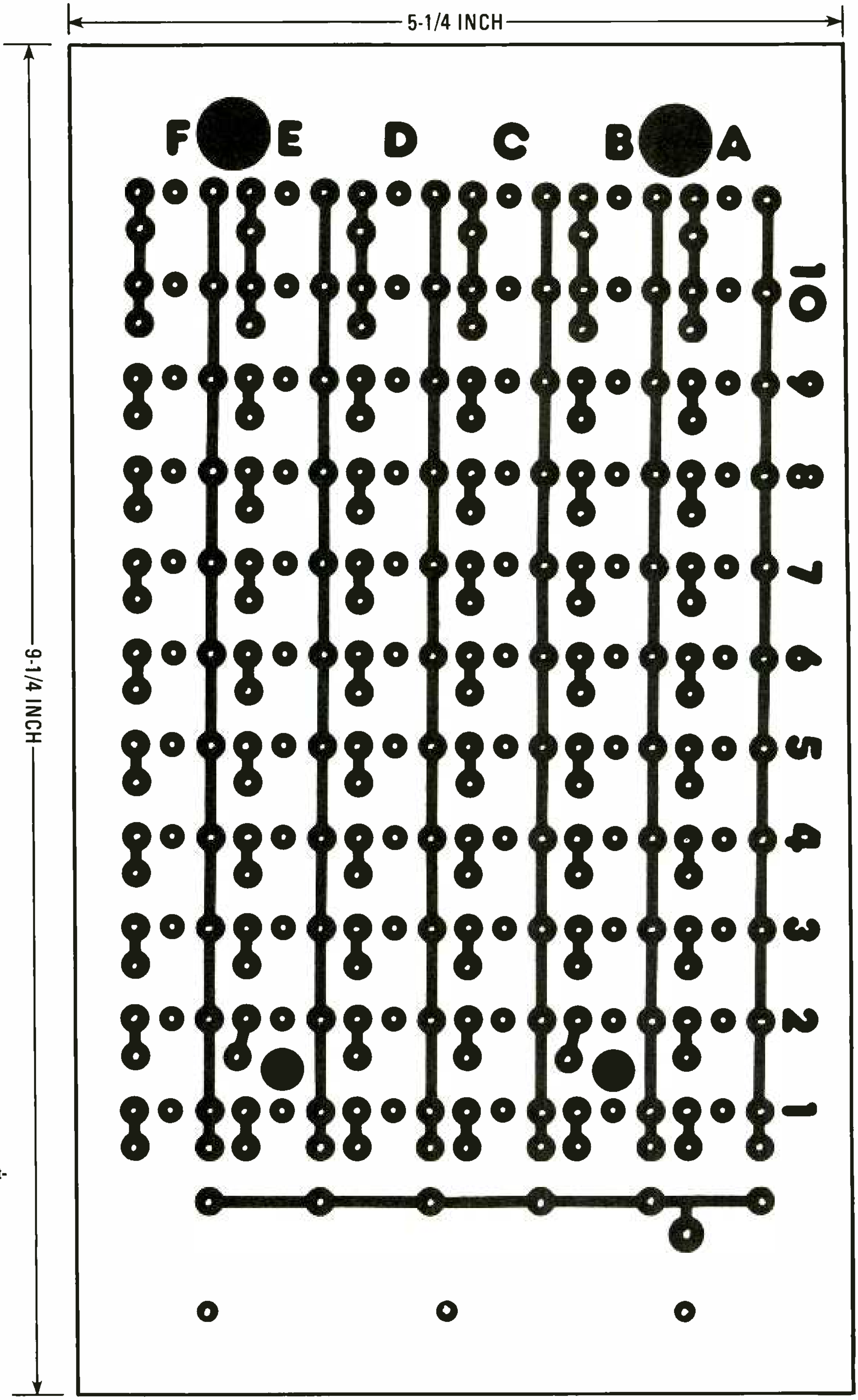


Fig. 2—The front panel of the Electronic Kentucky Derby, on which the indicators and controls are mounted, is made from a single-sided, printed-circuit board with the etching pattern shown. Note that columns are labeled A–F and rows from 1–10. The 11th row, which is not designated, is where the red winner light-emitting diodes are to be located.

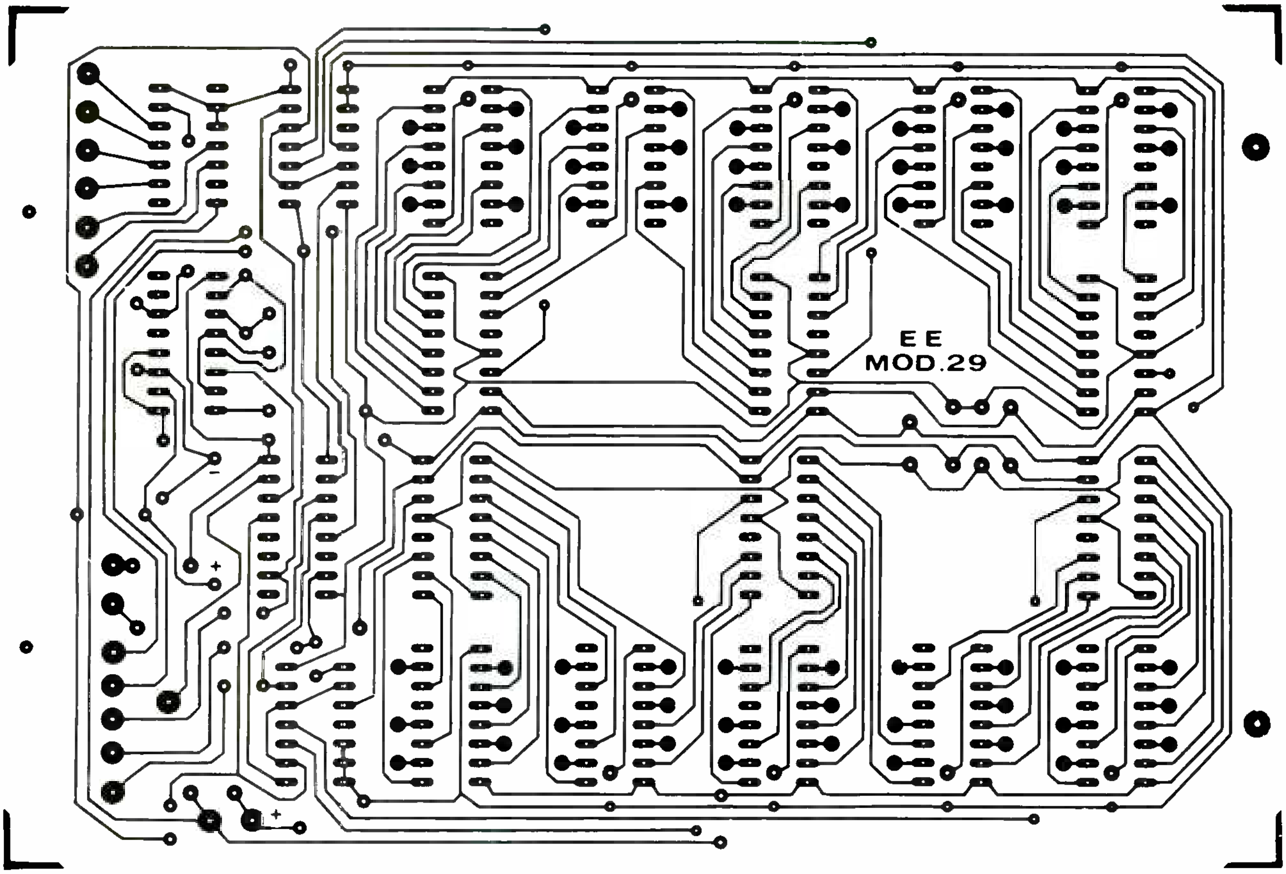
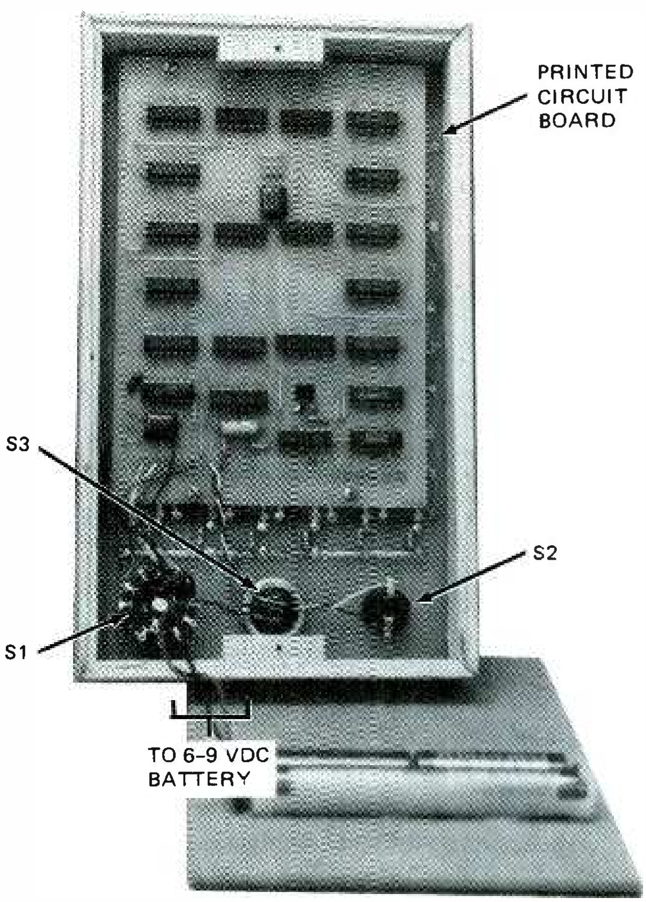


Fig. 3—The main printed-circuit board for the unit may be etched using the foil pattern provided, or ordered from the supplier given in the Parts List. The foil pattern shown here is the same size as that used by the author.



The two printed-circuit boards are mounted back-to-back, hiding the unsightly rats-nest of interconnecting wires.

the received input signal. The counter outputs are fed to the light-emitting diode indicators through the individual buffers of U7 through U16, which provide increased drive current for the light-emitting diodes. Thus, as the count advances, one light-emitting diode of a particular lane extinguishes, and another lights.

When the winning horse crosses the finish line (indicated by the tenth and eleventh light-emitting diode in the lane being lit), a ground signal is fed to one of the active inputs of U21. That produces a high output from U21, which is fed to the gating generator through D1, which, in turn, stops the gating pulses and all further action, eliminating photo finishes and arguments.

Switch S1 selects the appropriate output signal from U19 and feeds it back into the RESET input of U19. That stops horses that are not used from receiving count pulses and allows operation of from two to six horses to accommodate various numbers of players. When only two horses are running, the B and D lanes are used. When the third horse is added, it operates in the F lane. The fourth horse activates the E lane and the fifth uses the C lane. If the horses are numbered on the front panel, use the sequence 6, 1, 5, 2, 4, and 3, from left to right. In that way, the horses are dropped from the race in numerical order by the selector switch, S1.

The pushbutton switch, S2, supplies a positive voltage to the RESET inputs of all the counters, U1 to U6, which causes all the horses to return to the starting gate. Diode D2 is included to protect the circuit in case the power supply is accidentally hooked up wrong.

Construction

The Electronic Kentucky Derby consists of two single-sided PC boards. One of them doubles as the front panel on

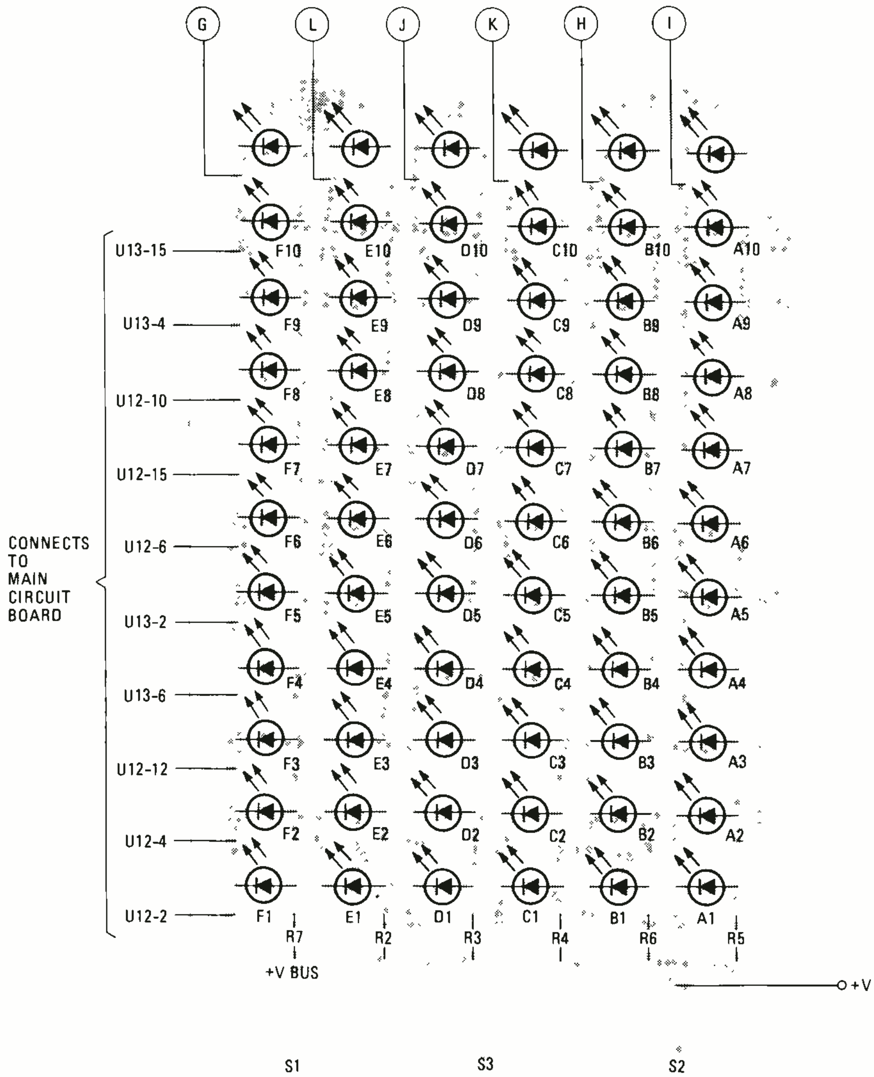


Fig. 4—The layout for the front panel of the Electronic Kentucky Derby shows that the only components mounted on it are the LED indicators, common resistors, and control switches. Wires are run from the panel board to the main circuit board in such a way that, when completely assembled, no wires show on the outside of the unit. The pads designated G–L connect to corresponding positions on the main circuit board.

which the light-emitting diode indicators and controls are mounted. The other, the main circuit board, contains the bulk of the electronics. A foil pattern for the front-panel board is shown in Fig. 2, while the main board is shown in Fig. 3. Dimensions are also provided. Once etched, drill the main board and set it aside until later.

On the front-panel board, it will be necessary to drill ⅛-in. holes (see Fig. 4) where the light-emitting diodes are to be mounted. At the positions labeled S1, S2, and S3, drill holes large enough to accommodate the control switches. After that, flip the board over and lightly sand the unclad side of the board, and spray-paint the front panel to provide a base. The author used white as his base.

Next, hand-paint the lanes using six bright colors. Once dry, dry-transfer lettering may be used to label the lanes and control switches. After that, spray the front panel with a few coats of Verithane until a smooth hard finish is obtained. The various colors allow the horse players to bet on their favorite color as well as their lucky numbers.

After the Verithane is dry, the light-emitting diodes can be pushed through the holes in the front panel from the rear, and the leads soldered to the pads on either side of the holes. The anode goes to the pad connected to the +V bus and the cathode goes to the side that has an extra pad connected to it. The cathode or negative lead is usually the one closest to the flat edge of the lens, or the shorter of the two leads. Sixty yellow light-emitting diodes are mounted in lanes A–F, positions 1–10. Note the each lane (A–F) has an eleventh, unlabeled light-emitting diode position: Those six positions are reserved for the red winner indicator. After checking the polarity and operation of each unit, a small drop of epoxy may be used on each light-emitting diode to secure it in place.

Now Comes the Soldering

The common dropping resistors—R2, R3, R4, R5, R6, and R7—are each connected to a row of light-emitting diodes by tack soldering them to the pads provided on the copper side of the front panel. Four pads on the back of the front panel allow for locating four ¼-inch diameter, ¼-inch long threaded brass standoffs. The standoffs should be soldered directly to the pads, which are properly located to line up with the mounting holes in the main circuit board and provide

(Continued on page 93)

PARTS LIST FOR THE ELECTRONIC KENTUCKY DERBY

SEMICONDUCTORS

A1–A10, B1–B10, C1–C10, D1–10, E1–E10, F1–F10—P310 yellow light-emitting diode (Digi-Key, or equivalent)
A11, B11, C11, D11, E11, F11—P308 red, light-emitting diode (Digi-Key or equivalent)
D1—1N914 (or 1N4148) small signal, silicon-switching diode
D2—1N4001, 1-A, 50-PIV silicon rectifier diode
U1–U6, U19—CD4017, counter/divider, integrated circuit
U7–U16, U20—CD4049, hex inverter/buffer, integrated circuit
U17, U18—CD4081 quad, two-input NAND gate, integrated circuit
U21—CD4068, 8-input NAND/AND gate, integrated circuit

RESISTORS

(All resistors ¼-watt, 5% fixed units)
R1, R10—10,000-ohm
R2–R7—150-ohm
R8—100-ohm
R9—100,000-ohm

Build A Universal Electronic STOPWATCH

More than just a simple timer, this Stopwatch circuit not only displays the seconds as they tick away, but also allows you to time single and multiple events in several ways!

By Warren Baker

☐A FRIEND'S INVOLVEMENT WITH THE BUILDING, MODIFYing, and racing of electric-powered model speedboats brought about the need for an accurate time-measuring device to clock the speed of each model boat. And that need was translated into the simple circuit that we'll describe: the Universal Electronic Stopwatch. The normal method of doing so—where a measured distance is set up on the shoreline and commands are verbally given to someone at the starting line to manually start and stop a stopwatch—led to several inherent errors. However, the Electronic Stopwatch circuit, based on Intersil's ICM7215 6-digit, 4-function stopwatch integrated circuit, overcomes those inaccuracies.

Getting To The Heart Of Things

The ICM7215, housed in a 24-pin DIP package (see Fig. 1), requires only two components (not including the power supply and switches) to form a completely functional Stopwatch circuit. Making use of that integrated circuit keeps construction simple, while, at the same time, provides (probably) more flexibility than most users will find necessary. Its four built-in functions—start/stop/reset, split, taylor, and a time-out mode—makes tailoring the circuit to your specific needs a snap.

The resolution of its internal counter circuits is 59 minutes 59.99 seconds; however, accuracy is determined entirely by your ability to calibrate the on-board crystal oscillator's timebase. The ICM7215 is capable of directly driving a 6-digit, 7-segment, light-emitting diode (LED) common-cathode display.

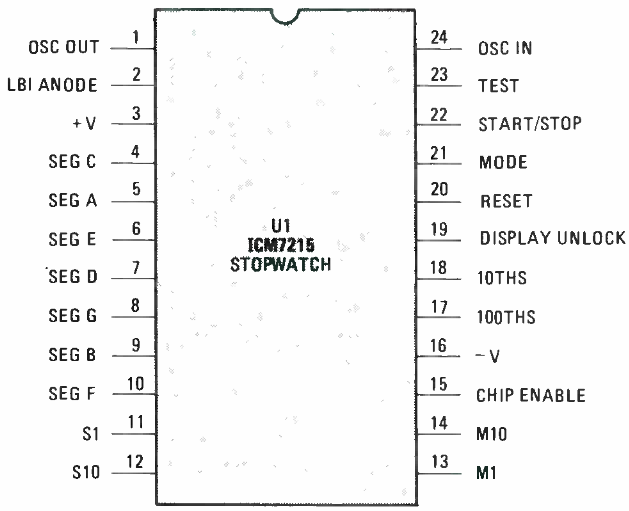


Fig. 1—Block diagram of the ICM7215 integrated Stopwatch circuit. Mode, pin 21, selects the method of timing depending on whether it is tied high, low, or simply left floating. For specifics, refer to Table 1—Switch Truth Table.

Power consumption is held to a minimum by the built-in display multiplexing circuit, which also simplifies the wiring of the display to the counter board. The ICM7215 operates on potentials of 2–5 volts; **Caution:** to exceed those limits is to invite disaster. However, using a well regulated power supply limits the possibility of destroying the chip. Power-supply

TABLE 1—SWITCH TRUTH TABLE

Mode	Switch Position	Mode (21)	Display (19)
Start/Stop/Reset	1	Float	Float
Split	2	V+	Unlock
Taylor	3	V−	Unlock
Time-out	4	Float	V−

requirements are broad, and anything between 6 and 18 volts that's fed to the regulator specified in the Parts List can be used.

How It Works

Figure 2 shows the entire schematic diagram of the Universal Electronic Stopwatch circuit, which, as you can see, has a super-small parts list. Power from whatever source (external battery pack, wall power supply, or internal batteries) is first fed to an LM309H regulator, U2 (which outputs a solid 5-volts with six or more volts applied) through switch S7. The regulated output of U2 is filtered by C1 and fed to the Stopwatch circuit, putting the circuit into a sort of standby mode. At that point (see Fig. 3), the circuit comes up in the reset mode and the display shows "00" on the two fractional-seconds digits (DIS5 and DIS6), indicating that the circuit is ready to go.

When the mode input, pin 21, is left floating and the display unlock input (pin 19) is either floating or connected to the power supply, as would be the case if S8 is set to position 1, the circuit is put into the START/STOP/RESET mode (as Table 1 shows). In that mode, the Stopwatch circuit can be used for single-event timing. To time another event, the circuit must be reset before the new count begins. That's accomplished by pressing S4 a second time to stop the count that is in progress; a third press resets the timer, and a forth begins a new count.

Refer to Table 1 and Fig. 2. The circuit is put into the TAYLOR (or *sequential*) mode by flipping S8 to position 3, which connects pin 21 to ground potential. In that mode, time

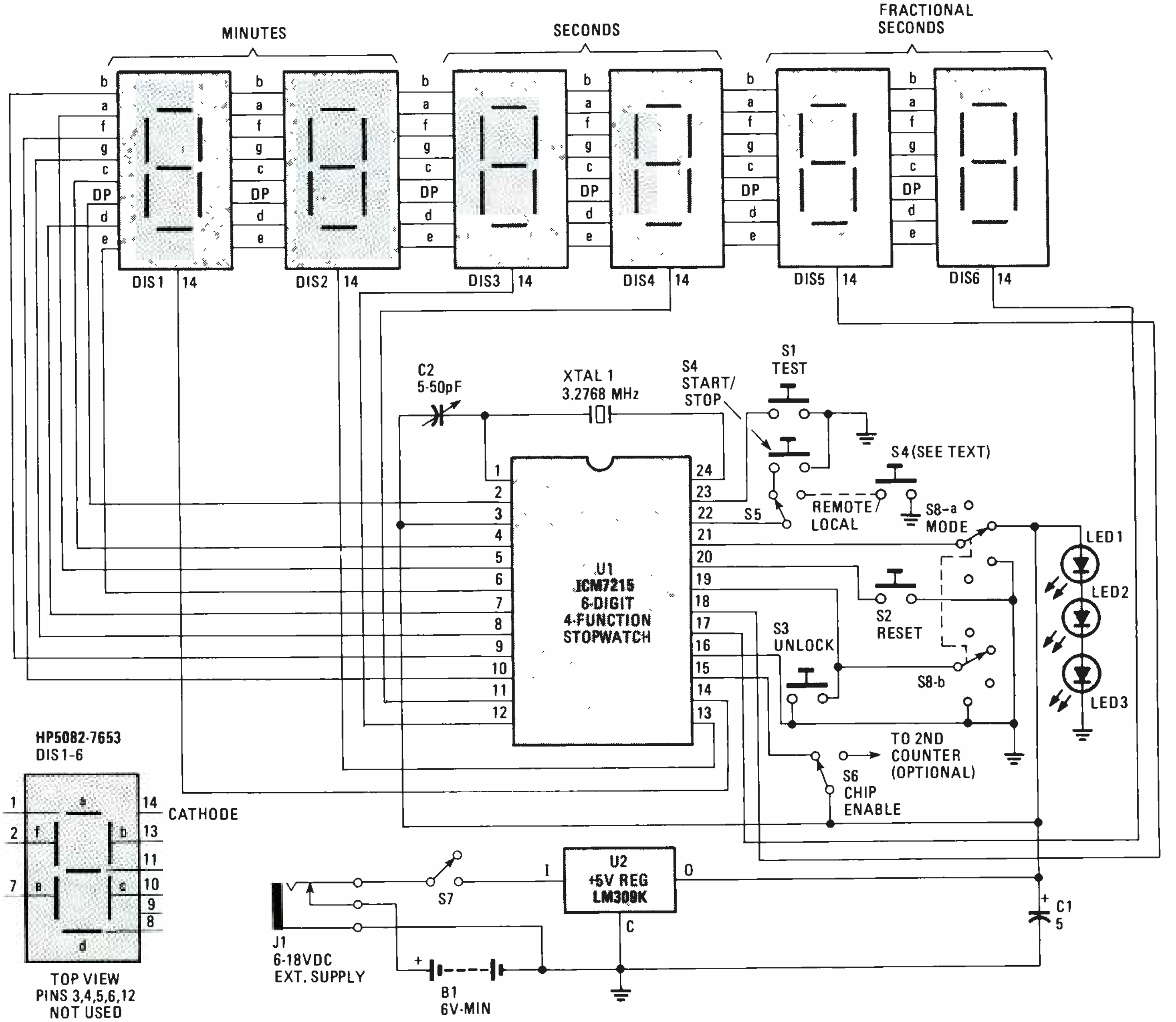


Fig. 2—The schematic diagram of the Stopwatch reveals that the entire circuit consists of two integrated circuits and a few other assorted components. The light-emitting diodes, LED1–LED3—acting as a low-battery indicator when the circuit is powered from dry cells—serve as a colon (between the minutes and second displays) and a decimal point, between the seconds and fractional seconds displays: DIS1/DIS2 and DIS3/DIS4, DIS3/DIS4 and DIS5/DIS6, respectively.

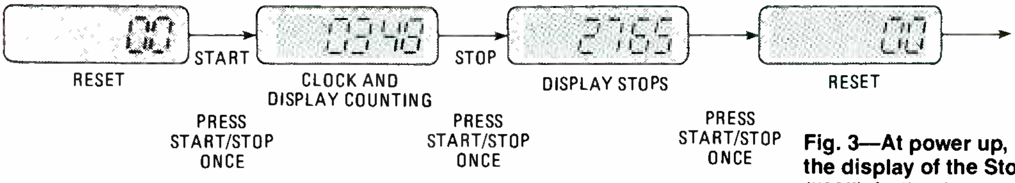


Fig. 3—At power up, in the START/STOP/RESET mode, the display of the Stopwatch circuit shows double zero's ("00"), indicating that the counters have been reset. Event timing is initiated by a single press on the START/STOP switch; a second press freezes the display and the count is discontinued. Pressing the switch for the third time resets the counters and zero's the display.

is measured from zero (see Fig 4); meaning, each time the Stopwatch is stopped, the counters momentarily reset and then start counting the next interval. In other words, each time interval is measured separately without manually resetting the counters. The display is stationary (unchanged) after the first interval unless the display is unlocked by a press on S3, display UNLOCK. And the circuit can be reset at any time by a press on S2; which, when triggered, causes the display to show the same double zeros that were shown at power up.

To put the circuit into the SPLIT mode, as indicated in Table 1, S8 is set to position 2. That mode differs from TAYLOR in that time is measured cumulatively—the counters do not reset or stop after the first start unless RESET, S2, is activated. The value shown is the total amount of time that has elapsed since the first start after RESET. Activating display UNLOCK allows the display to catch up with the counters.

Finally, we come to the TIME OUT mode, which is selected when S8 is in position 4; ie., pin 21 is left floating and pin 19 is connected to ground (see Table 1 and Fig. 2). In the TIME OUT mode both the clock and display are alternately stopped and started with each press on the STOP/START switch, as illustrated in Fig. 6.

Switch S5 (see Fig. 2) is optional and need only be included if you want to be able to trigger the Stopwatch from some remote location, as indicated by the dashed line leading to S9. Another optional control, S6, is necessary only if you intend to add a second ICM7215 to the circuit to provide a split/taylor mode. To do so, follow the block diagram in Fig. 7, wiring the components accordingly. Note that U3, the additional ICM7215, is connected in parallel with the origi-

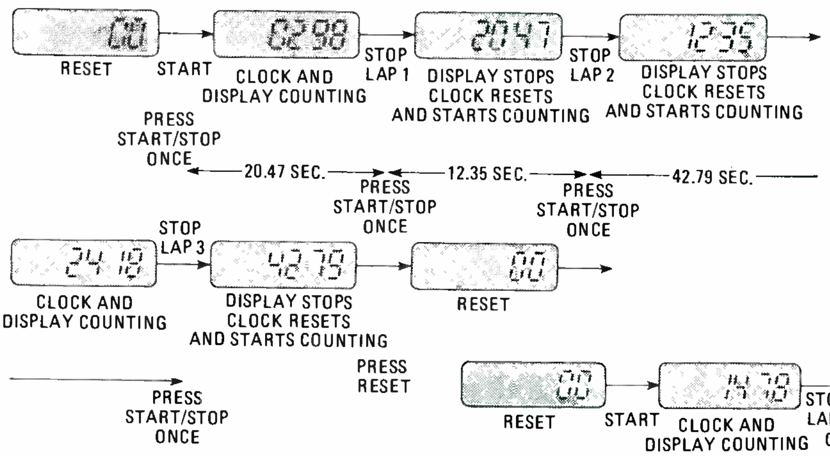


Fig. 4—When the TAYLOR mode is chosen, the Stopwatch is able to count several events, showing the accumulated time for each individual event, without resetting the counters. For instance, the first press on the START/STOP switch begins the count; the second, freezes the display, but the counters begin counting the second event. A third press initiates a third count, but the display remains frozen at the first count unless display UNLOCK is activated.

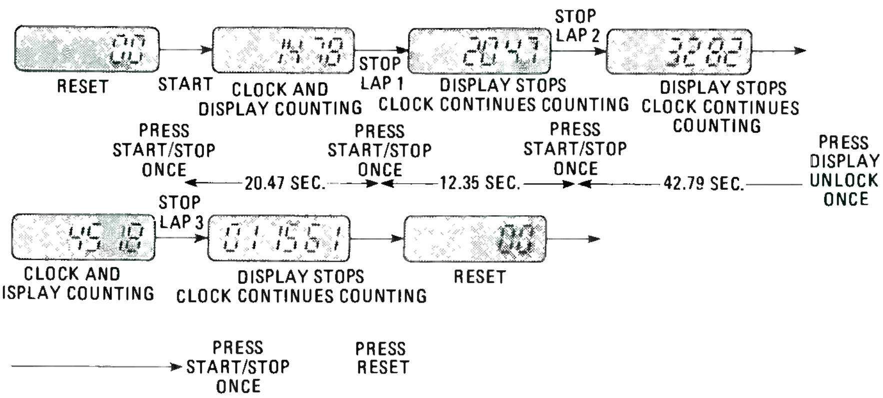


Fig. 5—In the SPLIT mode, multiple events may be timed but the display shows the accumulated time of all events. As shown in the example, once the count has begun, it continues until the START/STOP is pressed. At that point, both the display and the counter are frozen (at 2047 in our example), but not reset. The next press starts a new count, continuing from the point at which it had been frozen.

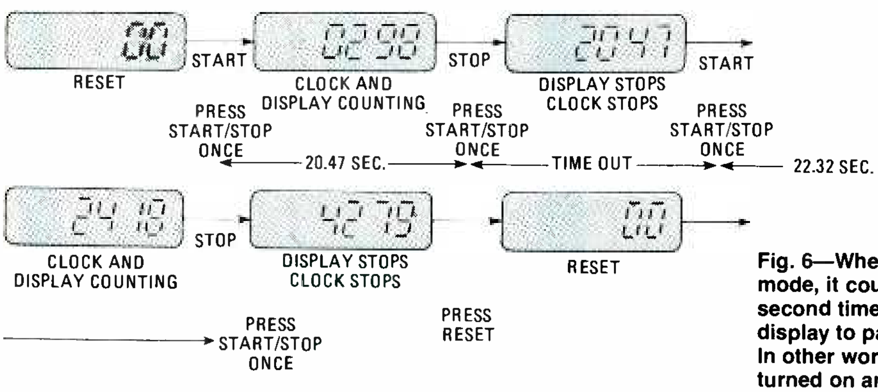


Fig. 6—When the Stopwatch is put into the TIMEOUT mode, it counts until START/STOP is pressed a second time. That causes both the counters and the display to pause, and a third press continues the count. In other words the clock and the display are alternately turned on and off by each press on START/STOP.

nal circuit so that they share the display, the crystal, and the variable capacitor, C2.

The three series-connected light-emitting diodes (LED1–LED3) tied to S8 position 2 (see Fig. 2) are used to provide a colon between the minutes display (DIS1 and DIS2) and the seconds display (DIS3 and DIS4). The third unit provides a decimal point between seconds and fractional-seconds displays (DIS3/DIS4 and DIS5/DIS6, respectively). In addition, the light-emitting diodes serve another function when the unit is operated on battery power. Note that the internal battery supply provides 6 volts. With only 1-volt of headroom, any weakening of the battery-supplied power quickly shows up at the regulator's output terminals. Remember the three individual light-emitting diodes; they are wired in series so they must see between 4.5 and 5.0 volts for proper operation. As the supply voltage drops slightly, the regulator loses regulation. The very first place that that drop becomes noticeable is on the makeshift colon and decimal point. Thus, when they become duller than the displays, it's time to check the batteries.

Taking Control

The frontal view of the author's prototype gives the general layout of the various controls. The arrangement of the switches is flexible and any function that's not needed, may be omitted. On the front panel, immediately to the right of the display, is the 4-position MODE switch (S8) for selection of the manner of timing. Although the author used a 4-position slide switch, any type having four positions or more that's available will do fine.

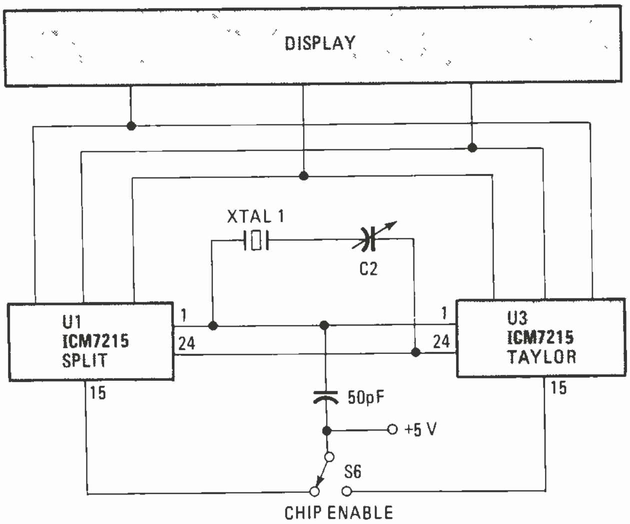


Fig. 7—A second ICM7215 may be added to the circuit so as to allow another mode of operation, SPLIT/TAYLOR. That's easily accomplished by paralleling the additional unit as the block diagram indicates. Note that the crystal and capacitor from the original schematic diagram are common to the two integrated circuits.

Moving to the right, at the top of the next row, we find the START/STOP push button switch, S4. The START/STOP switch is provided to allow for manual operation from the front of the timer, as selected by the LOCAL/REMOTE switch (directly under it), provided that S8 is in the appropriate position. In the remote position, an external trigger source, which connects to a terminal strip on the rear of the cabinet, is selected. Below the LOCAL/REMOTE selector is the chip enable (1 CN 2) switch, which is required only if you plan to add a second timer to the circuit. That control allows both counters to share a common display and other necessary components, by enabling (one at a time) either chip 1 or chip 2 from the front panel.

At the top of the last row is the RESET switch used to zero both the counter and the display simultaneously; UNLOCK (center) is used to release the display so that it can catch up with the counters (recall that in some modes, the counters continue to register, even though the display is frozen); and the ON/OFF switch at the bottom.

The rear panel is outfitted with a set of screw-terminal strips (see Photo) used for connection of the remote sensors. In that case, provision is made for two sensing units. There is also a push-button switch on the rear panel that's used to test the operation of the timer, by speeding up the counting factor by 32 times. (It, too, may be deleted if desired.)

In the author's prototype, provisions were made for battery and/or power line operation; four (4) D-cells are used for portable power (see Photo). Operation of the unit using an external DC supply (like a small wall power-supply or storage battery) has also been provided for through a plug-in connector on the rear panel. Packaging of any electronics project is all-important. The author's timer is housed in a surplus CATV converter cabinet. Although such a cabinet is likely not to be available to you, you can tailor the timer to fit the cabinet available. The author also fabricated a frame-like affair on which to mount the electronics and the batteries, which also allows the assembly to be fastened into the cabinet.

Construction

As pointed out, there are very few external components required. When ordering the ICM7215, you should consider ordering it with the associated 3.2768-MHz crystal, because the cost is reasonable and saves ordering the parts from more than one source. (A look through the back pages of *Hands On Electronics*, *Radio-Electronics*, or some other magazine will reveal several suppliers who offer the ICM7215 and crystal as

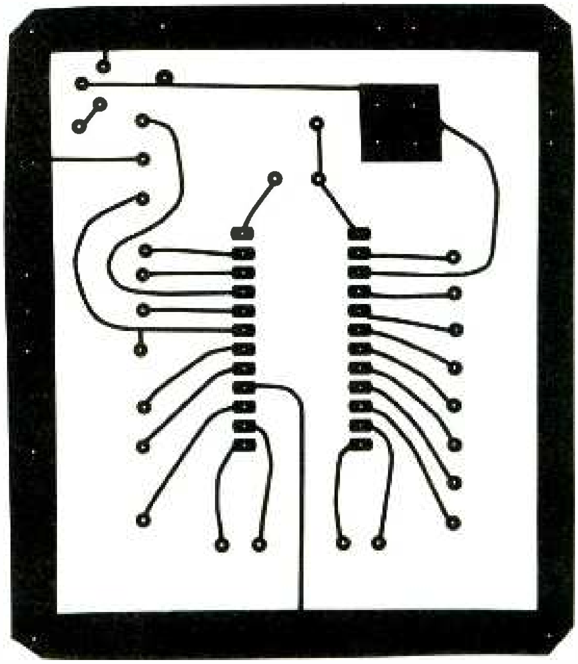
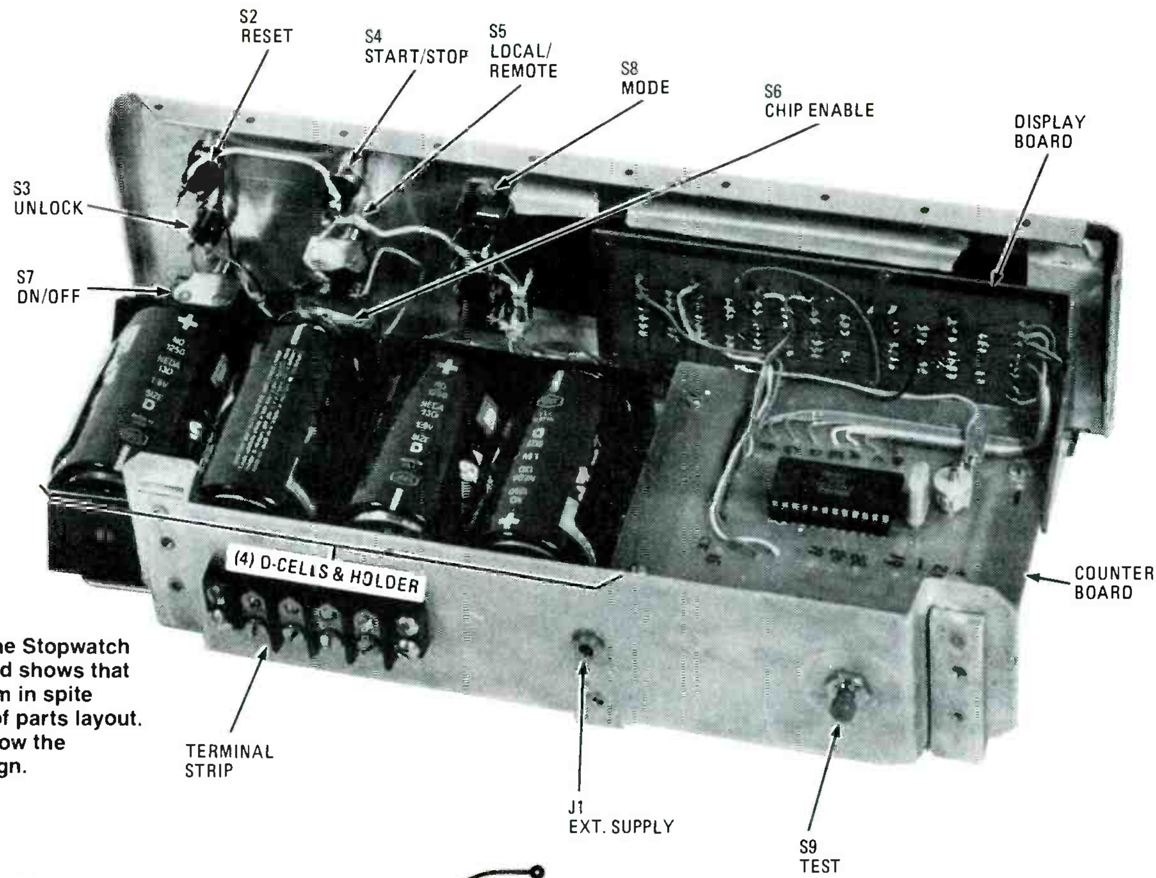


Fig. 8—The counter circuit's foil pattern, shown full scale, may be lifted from the page, or photocopied and lifted from the copy using an adhesive contact sheet (like Lift-it™) and used to etch your own board.



A rear-view peek at the Stopwatch with its cover removed shows that there is plenty of room in spite of the compactness of parts layout. You don't have to follow the original author's design.

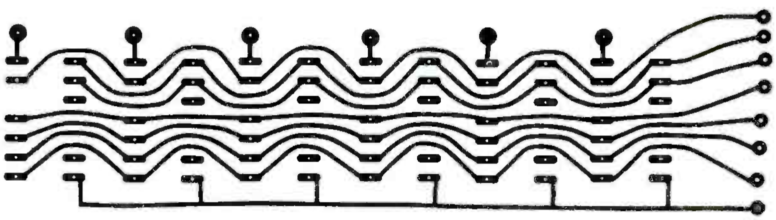


Fig. 9—Foil pattern for the Stopwatch display board is shown full size. Note that the individual modules of that board are of the 14-pin DIP variety. The display board may be eliminated by using a multiple-digit, common-cathode, 7-segment display.

PARTS LIST FOR THE UNIVERSAL STOPWATCH

SEMICONDUCTORS

DIS1–DIS6—7-segment, common cathode, light-emitting diode display (14-pin DIP)
LED1–LED3—Jumbo red, light-emitting diode
U1—ICM7215 6-digit, 4-function Stopwatch, integrated circuit
U2—LM309K +5-volt, 1-A regulator, integrated circuit

SWITCHES

S1–S4, S9—SPST normally-open, momentary, push-button switch
S5–S6—SPDT, toggle switch
S7—SPST, on-off power, toggle switch
S8—DP4T, slide or rotary switch

ADDITIONAL PARTS AND MATERIALS

B1—Four (4) D-cell batteries
C1—5-μF, 10-WVDC, electrolytic capacitor
C2—5–50μF, trimmer capacitor
J1—2-conductor, closed-circuit, audio earphone jack
XTAL1—3.2768-MHz Printed-circuit materials, battery holder (four D-cell type), 1 24-pin IC socket, 6 14-pin IC sockets, wire, solder, etc.

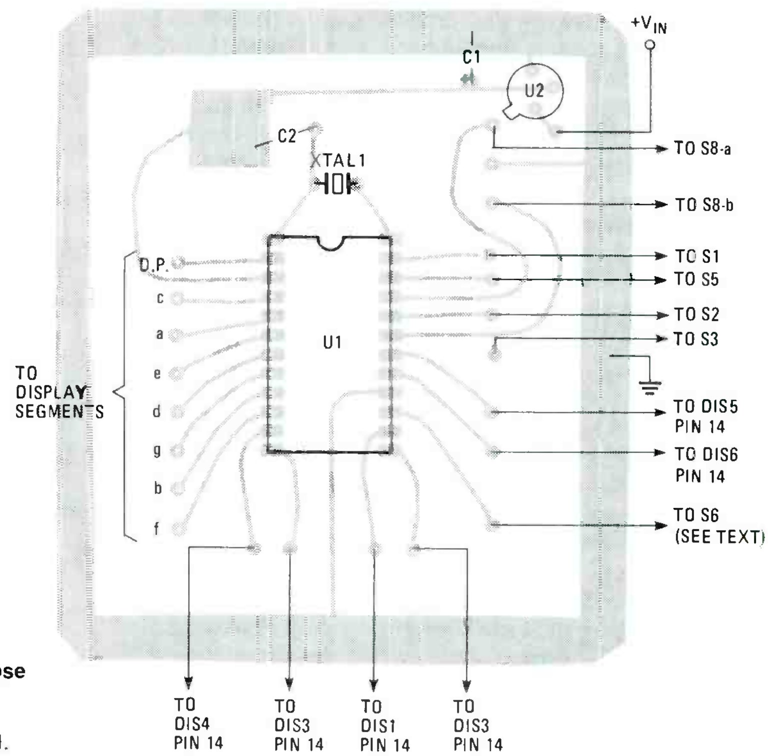


Fig. 10—Several wires must be run between the display and counter circuit boards. Careful attention must be paid to those and all other off-board connections. At the very least, a bad connection can result in weird timing errors; the worst case can result in "silicon meltdown"—the total destruction of U1.

Fig. 11—Again, wire connections are all-important; one slip and the wrong display segment might wind up turning on, or the decimal point flashing when, as we've said, it's not used.

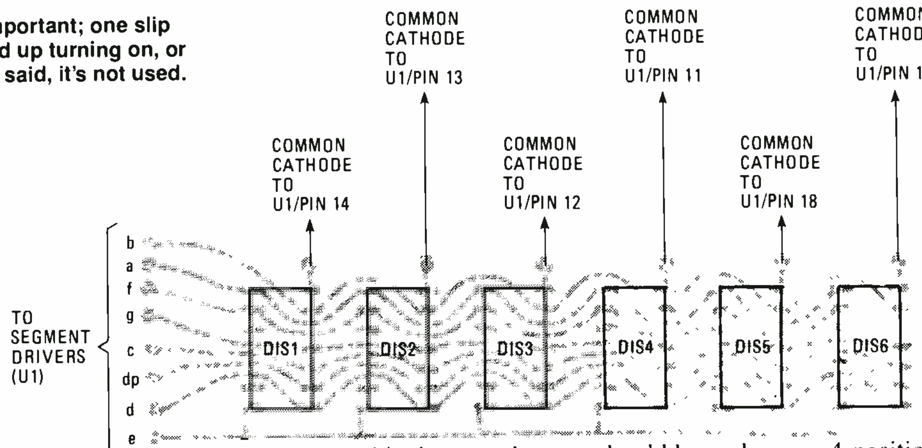
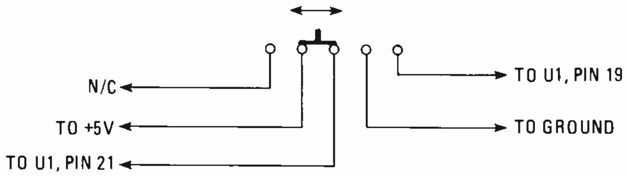


Fig. 12—Although the schematic (Fig. 2) shows S8 as a double-pole, 4-position rotary switch, the author's prototype contained a slide unit in the S8 position. Either type may be used, depending on availability and personal preference.



a package deal; JameCo Electronics, Inc., for one.)

Another external device required will be a small—about 5 to 50pF—trimmer capacitor. The exact value is not too critical and junkbox parts may be used. However, if you are unable to properly set the timebase frequency, substitute another until you are able to get a value that provides the proper level of adjustment. Also required are 6 seven-segment, common-cathode displays. A small electrolytic or tantalum capacitor should be used on the 5-volt line. The value is not critical (see Parts List).

With the simplicity of the circuitry, it is not absolutely necessary to use printed-circuit board construction techniques. But for neatness and wiring ease, the etched board is the way to go. Full-size foil patterns are provided in Fig. 8 and Fig. 9—the counter and display boards, respectively—for those who wish to use the printed-circuit approach. That method greatly reduces the number of wires running between the two boards and also results in a better looking finished product. If printed-circuit techniques are used, populate the board and wire the circuit according to Fig. 10 and Fig. 11; the respective parts-placement diagrams for the counter and display boards.

As Fig. 10 shows, along one edge of the main printed-circuit board there are seven (7) holes labeled "a" to "g," which should be wired to the corresponding terminals on the display board. Note that the decimal points have been wired; but, as outlined, we're using separate light-emitting diodes as a colon and decimal point. Following the diagram, connect pin 14 of U1 to pin 14 of DIS1 on lefthand side of the display board and pin 13 of U1 to pin 14 of DIS2. You have, in doing so, connected the 10-minute and the 1-minute indicators. In a similar fashion, connect pin 12 and pin 11 to the display board's 10-second and 1-second displays (DIS3 and DIS4). The tenths-of-seconds (pin 18) and the hundredth-of-seconds, pin 17, output of U1 should be connected to their respective displays on the display board.

The low-battery indicator signal from pin 2, which is really the decimal-point driver, is not used in our circuit, because (as it was observed) the brightness of the displays—particularly the three individual light-emitting diodes—give a good indication of battery condition. Refer to Fig. 2.

By this time you have or should have chosen a 4-position switch to function as the mode selector, S8. If you are using a slide switch, as in the author's prototype, wire the switch using Fig. 12 as a guide. The four contacts are connected as shown. Turning to the push button switches, wire them according to the placement diagram, Fig 10. Each switch operates with one lead connected to the common (V_{SS}) ground bus (which is also tied to pin 16 of U1). After tying one leg of each push button switch to the common ground, connect the other ends to U1 as follows: S1, the TEST switch, to pin 23; S2, RESET, to pin 20; S3 (UNLOCK) to pin 16, and S4 (START/STOP) to pin 22 through S5, a single-pole double-throw (SPDT) toggle switch that's used to connect an external trigger (S9) to allow remote control of the timer. One clarification is in order at this time. If you have elected not to use the LOCAL/REMOTE switch, S5, then START/STOP switch, S4, should be routed directly to pin 22 and the toggle eliminated.

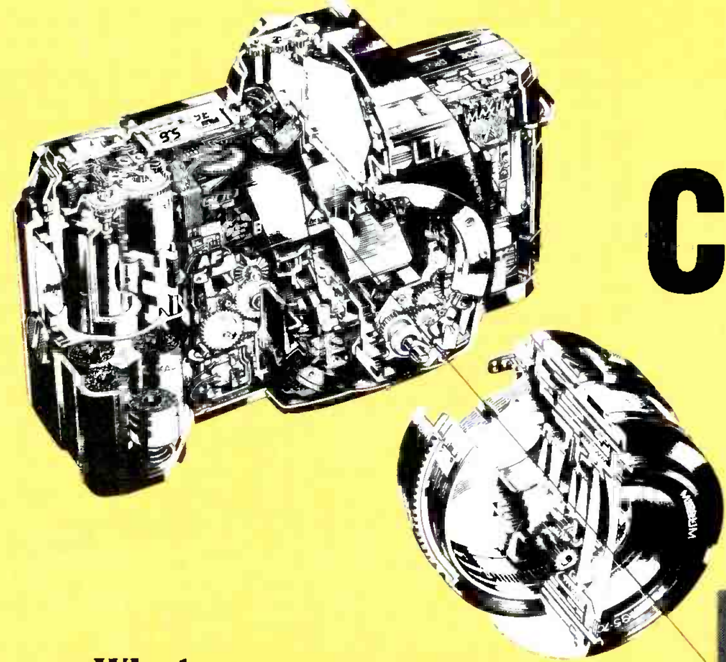
A second SPDT toggle unit is used for S6, the CHIP ENABLE (1 CE 2 on the front panel) selector. That switch, which is used to select either U1 or an optional second counter unit, is wired with one terminal going to pin 15 of U1 and the wiper to the +5-volt supply. When the wiper contacts pin 15, placing +5-volts at that input, the counter is enabled. When thrown to the opposite position, a second ICM7215 would be enabled.

The final toggle switch is merely a simple SPST switch that allows the unit to be turned off when not in use. The layout of the circuit also includes a miniature normally-closed earphone connector, whose contacts were originally used to mute a radio speaker when the phones were plugged into it. That switched jack is used to disconnect the internal batteries when an external power source is being used. You may prefer to use rechargeable batteries and an external "charger." In such a case, be careful not attempt to operate the unit from a higher voltage, as pointed out earlier. You must alter the inputs... Perhaps even to provide individual inputs for the charger and other supply voltages.

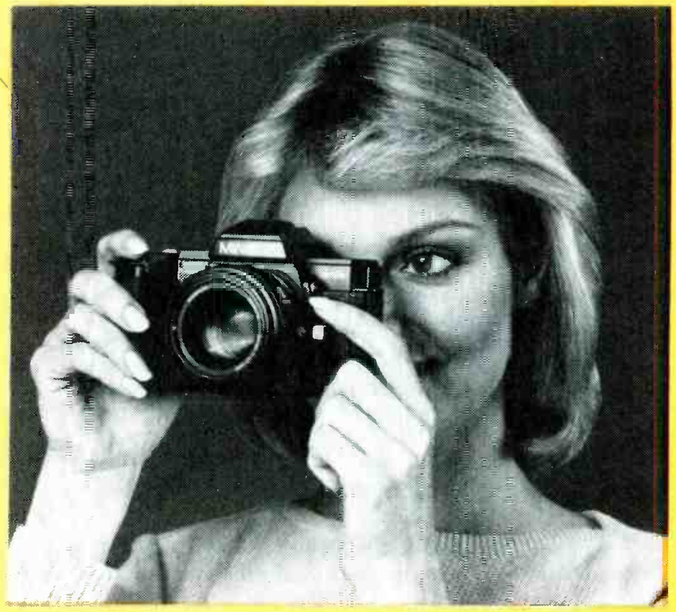
Does It Work?

After the normal checks for wiring errors, loose solder connections, solder bridges, and other potential problems, connect the unit to a power source. Operate the ON/OFF switch and note that the colon, decimal point, and the two rightmost display modules are lit. With the function switch in the normal (1st) position, press the START/STOP button and note the activity of the displays. Let them run a short time to make sure that all six digits are operating.

(Continued on page 99)



Computerized Cameras



What was once a *snap* and a "Maybe I got it!" is now a whirl of motors controlled by a microprocessor and a click—baby, you got it!

By Herb Friedman

☐THE PHOTOGRAPHY PIONEER, GEORGE EASTMAN, ADVERtised his cameras with the slogan "You take the picture, we do the rest." If George were still around, he might logically claim: "Our computer does it all," because in the most recent camera design(s), it's a subminiature computer that actually takes the picture. Except for the user pressing the shutter release, everything from focusing the lens, to the setting of the shutter speed and aperture (*f: stop*), to determining the need for and the amount of external flash (when needed), to winding and rewinding of the film itself, is determined by a computer.

When George Eastman originally claimed "...we do the rest," he was referring to the camera he sold. It had only one operating control: a shutter release. There was no shutter or aperture adjustment, no lens focusing, no nothing. If there was enough light, if the subject didn't move, and if the subject was within the camera's fixed focus range, there was a reasonable possibility that George's employees might be able to develop the film and make reasonably decent prints. More often than not, what came back from George's darkroom was blank or very dark prints, and negatives that were frequently out of focus. Today, because of computerized cameras, if every *shot* isn't *great* it is, at the very least, *good*. Even if you have never used a camera before, every frame of film will be *properly exposed*, and most important of all, in *perfect focus*.

Until the microprocessor was adapted to consumer cameras, the term *computerized* was pure hyperbole because there was, in fact, no computer or microprocessor. More often than not, computerized simply meant some way in which a built-in light meter was coupled to the camera's operating controls—the shutter and aperture adjustments.

In the earliest applications, the light meter was simply built into the camera's body or the viewfinder. The camera was pointed at the subject, the user noted the *reading* indicated by the pointer, and a mechanical slide-rule device interpolated the meter *reading* into shutter speed and aperture values.

Figure 1 shows the typical built-in meter circuit. Photovoltaic cell PC1 generates an electric current proportional to the amount of light falling on the cell. R1 is a sensitivity resistor, whose setting is determined by the film speed, and M1 is a meter movement of some kind that's either built into the camera or the viewfinder. The meter readings were simply relative values or actual illumination levels; either way, they had to be transferred to a mechanical slide rule or scale for conversion to shutter speed and aperture values.

The first of the "computerized" cameras was actually an adaptation of the circuit shown in Fig. 1. Someone decided that, instead of having the meter pointer indicate an arbitrary number that had to be converted by a mechanical calculator of some kind, the meter's sensitivity could be controlled by a second sensitivity control that was connected to the camera's shutter-speed dial, such as in the circuit shown in Fig. 2. By adjusting the overall sensitivity to the shutter speed, the meter

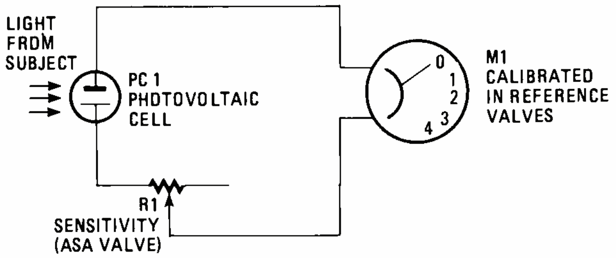


Fig. 1—The first computerized camera contained an adaptation of this circuit. In it, the photovoltaic cell, PC1, generates an electric current that is proportional to the amount of light radiation falling on its sensory area. R1 sets the the degree of sensitivity, with the meter showing relative values or actual illumination levels.

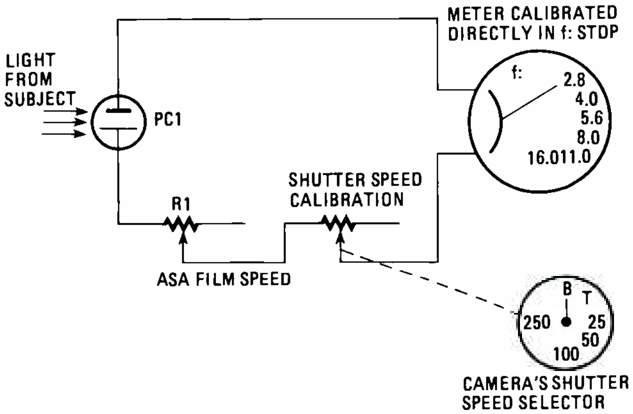


Fig. 2—In the earliest cameras to claim computerized exposure, the aperture control was coupled to the meter's sensitivity control through a mechanical arm. By adjusting the overall sensitivity of the the shutter speed, the meter reading could by calibrated directly in aperture values. That was the true beginning of camera computerization.

reading could be calibrated directly in aperture values. The user had only to set the camera's aperture to the value indicated by the meter. That kind of direct metering is called "shutter priority" because the shutter speed is a preset value.

Naturally, it is just as easy to have the aperture determine the meter's sensitivity; in which case, the meter reading would be calibrated in shutter speed. That's called "aperture priority," because the *f: stop* is the predetermined value. In the earliest cameras that claimed computerized exposure, the aperture setting was originally coupled to the meter's sensitivity control through an external mechanical (arm) linkage—the automatic Nikon lens being the best example of an external linkage. Today, the linkage mechanism is either internal or external depending on the particular manufacturer.

Although automatic control of the meter's sensitivity was convenient, it wasn't truly computerized; however, it *did* lead to automated aperture control, which was the real beginning of the computerized camera. Someone decided that if the blades of the diaphragm, which determined the aperture, were made extremely light, they could actually be driven by the meter. Thus, the light reading would automatically set the aperture to correspond with the selected shutter speed. Since the combined meter/aperture control needed a little more power, cameras switched to the (functional) circuit shown in Fig. 3, in which the series current of the battery is controlled by photoresistor PR1. (The greater the light falling on the photoresistor, the lower its resistance and the greater series current.) Notice that in Fig. 3, the aperture is controlled directly by the meter; the user need only point and shoot, it being no longer necessary to mechanically set the camera controls.

With the development of the electronic shutter, in which the shutter speed is determined magnetically by a current flowing through a coil rather than by a string, it became possible to have the meter circuit control either the aperture, the shutter, or both. In effect, the electric shutter made it possible to have an all-electronic camera.

Once anything is all-electronic, it's easy to interface a microprocessor, which is how Minolta produced the Maxxum 7000, the first of the truly computerized cameras. Other than the the actual pressing of the shutter release, the CPU in the Maxxum 7000 controls or determines every aspect of the photographic process, and displays all pertinent information on an LCD display.

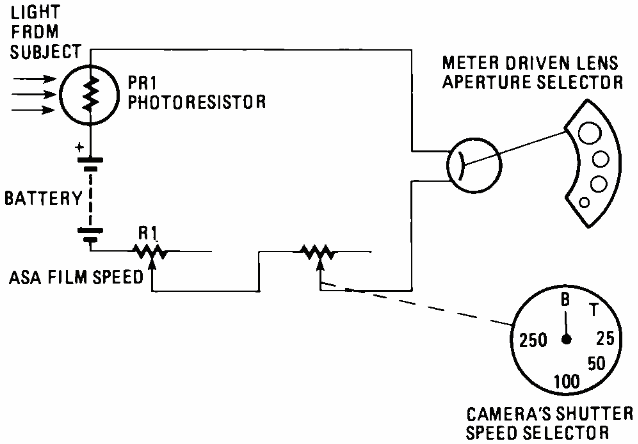


Fig. 3—The combined meter/aperture control required more power so this circuit was substituted, with PR1 controlling battery current and the aperture under direct control of the meter. The development of the electronic shutter allowed its speed to be determined by a current flowing through a coil, which made it possible to produce an all-electric camera.

Figure 4 shows the highlights of the CPU's functional circuit in the Minolta's Maxxum 7000. Notice, in particular, that the computer can sense the type of film and controls the winding motor, so that computer control initially starts with the installation of the film. Most modern 35-mm film now provides data for computerized cameras through what is known as the DX-coded cassette, which simply means that

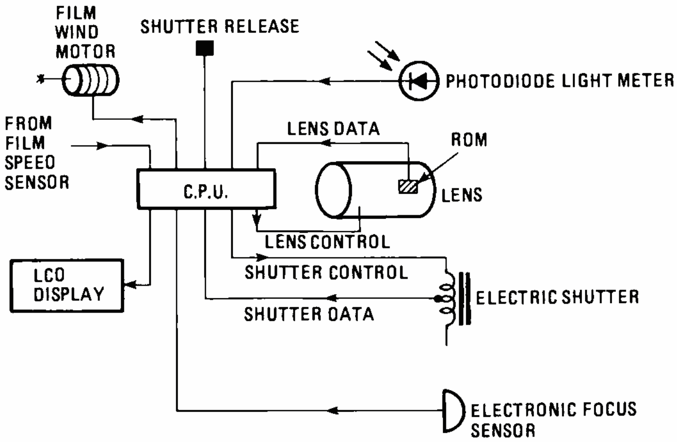


Fig. 4—Highlights of the CPU's functional circuit. The CPU senses the type of film and controls the winding motor; thus computer control begins when the film is installed. The film has what's known as a DX-coded cassette, whose shape specifically represents the film speed and type.

the film's cassette has external metal "foils" whose shape specifically represents the film speed and type. Electric "fingers" inside a computerized camera sense the DX-coding and program the computer accordingly. The computer, in turn, displays the DX information as *film speed* on an LCD readout, automatically winds the film to the first frame, and resets the frame counter, which is also shown in the LCD display. Since the film's length is also programmed by the DX-coding, the microprocessor can keep track of the number of frames used and will *beep* to warn you "...there's no more film."

Like all other computers, the *brain* in the Maxxum 7000 is incorruptable! You can't squeeze out another frame or two at the end of the film.

Moving beyond the simple stuff, we get into the real worth

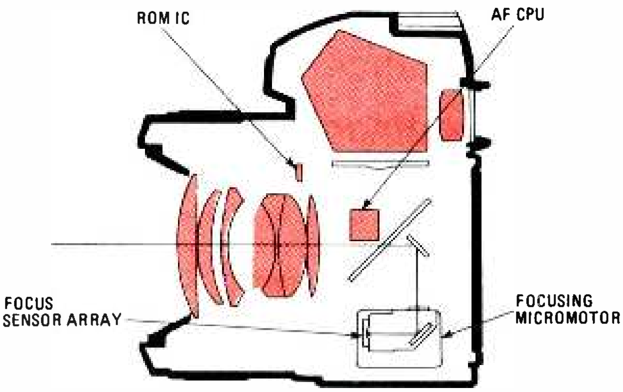


Fig. 5—The Maxxum's auto focusing system solve's problems inherent in motorized lens systems by centralizing all focus operations. The ROM chip supplies vital information for calculating lens adjustments. The focus sensor uses a charge-coupled device to detect minute variations in subject focus, and the focusing micromotor is digitally monitored for precise, high-speed focus adjustments. The CPU pulls it all together by combining data from the focus sensor and ROM to control the micromotor.

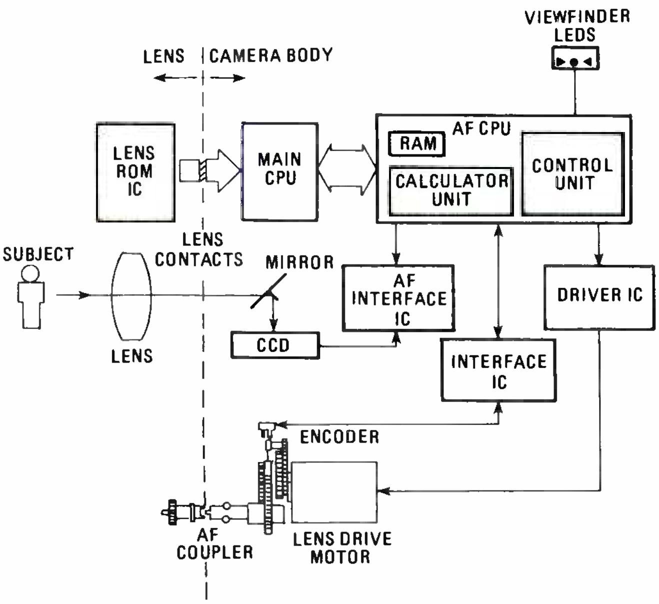


Fig. 6—The distance projected on the CCD sensors varies depending on the focus condition. When the subject is in focus, as illustrated in a, the distance is equal to the reference signal that's preprogrammed into CPU. If the distance is less (as shown in b), the focal point is in front of the subject. But if, as shown in c, the distance is greater, the lens focus is behind the subject.

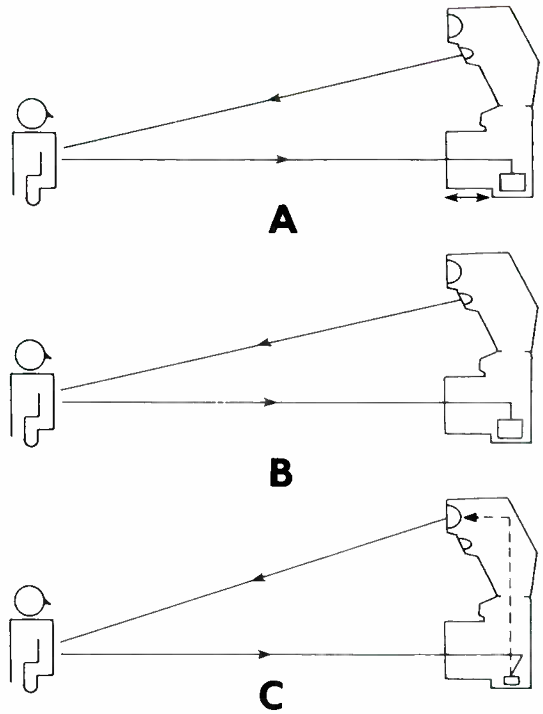


Fig. 7—The Maxxum's autofocus system keeps working even in low light or total darkness. In low light with low contrast subjects, the autofocus illuminator is activated when the operating button is depressed half way. The autofocus system uses near-infrared illumination (as shown in a) to calculate and adjust the focus. Just before the shutter is released, a second burst confirms that the focus is correct (b). If required, further adjustment is made prior to the flash firing. As shown in c, if no further adjustment is needed, the flash fires and direct autoflash metering controls the flash duration for accurate exposure in all modes.

of the microprocessor, the automatic focus and exposure control shown in Figs. 5, 6, and 7. Each lens that's specifically made for the Maxxum 7000 has a built-in ROM that tells the computer the characteristics of the particular lens such as its focal length, maximum and minimum aperture settings, and the minimum focusing distance. The information from the ROM is also used by the computer to optimize the selected shutter speed.

For example, when the ROM informs the computer that the lens is shorter than 35 mm (*Wide*), the computer automatically uses a shutter speed that provides smaller apertures for greater depth of field. On the other hand, when the ROM programs the computer for a lens whose focal length is greater than 105 mm (*Tele*), the computer tries to maintain the highest possible shutter speed to avoid blur caused by camera shake. Focal lengths between 35 and 105 mm are considered *Standard* and the computer automatically optimizes the shutter and aperture for an adequate depth of field. If the camera is equipped with a zoom lens, the computer keeps track of the user-selected focal length and automatically adjusts the shutter/aperture programming for the wide, standard, or tele values.

At the instant the shutter release is partly depressed, the camera checks for proper focus. As shown in Fig. 6, part of the light coming through the lens passes through slots in the mirror and is deflected downwards to a CCD (Charge Coupled Device) whose electrical output is monitored by the computer. The CCD responds to phase comparison of in-focus and out-of-focus illumination. If the phasing doesn't

(Continued on page 94)

Your link from the stars....

SCORES OF COMMUNICATION SATELLITES COURSE through the inky-black void of space, many over 22,300-miles high, orbiting the earth at searing speeds. They perform an array of essential duties for government and private industry: Geologists use them for locating oil and mineral deposits; the U.S. Navy uses them as navigational aids for ships at sea; agriculturists analyze crops and harvest yields through infrared photos taken by the birds (satellites), and cartographers accurately map the world—just to name a few applications.

But perhaps the most exhilarating use of satellites, as they apply to each of us, lies in telecommunications. By installing a satellite-television receiving station in the yard or on the rooftop (see photos), we can literally bring the entire world into our livingrooms. The viewer can tune in live events as they occur around the world. There is an excess of 100 television channels to choose from. Organizations such as Cinemax, Showtime, HBO (Home Box Office), ESPN (Entertainment Sports Programming Network), The Movie Channel, and Playboy feed programming to cable companies across the nation. Those cable affiliates, in turn, beam the programming back to earth via geostationary satellites (stationed directly over the equator at a height of about 22,300 miles) in the form of very weak microwave signals.

A Little Background

In the early 1970's, Western Union launched the first of three domestic communications satellites (WESTAR 1, 2, and 3) to relay telephone conversations and data communication. Each satellite had 12 transponders (a sort of microwave repeater), each capable of carrying one TV channel or 2000 telephone conversations.

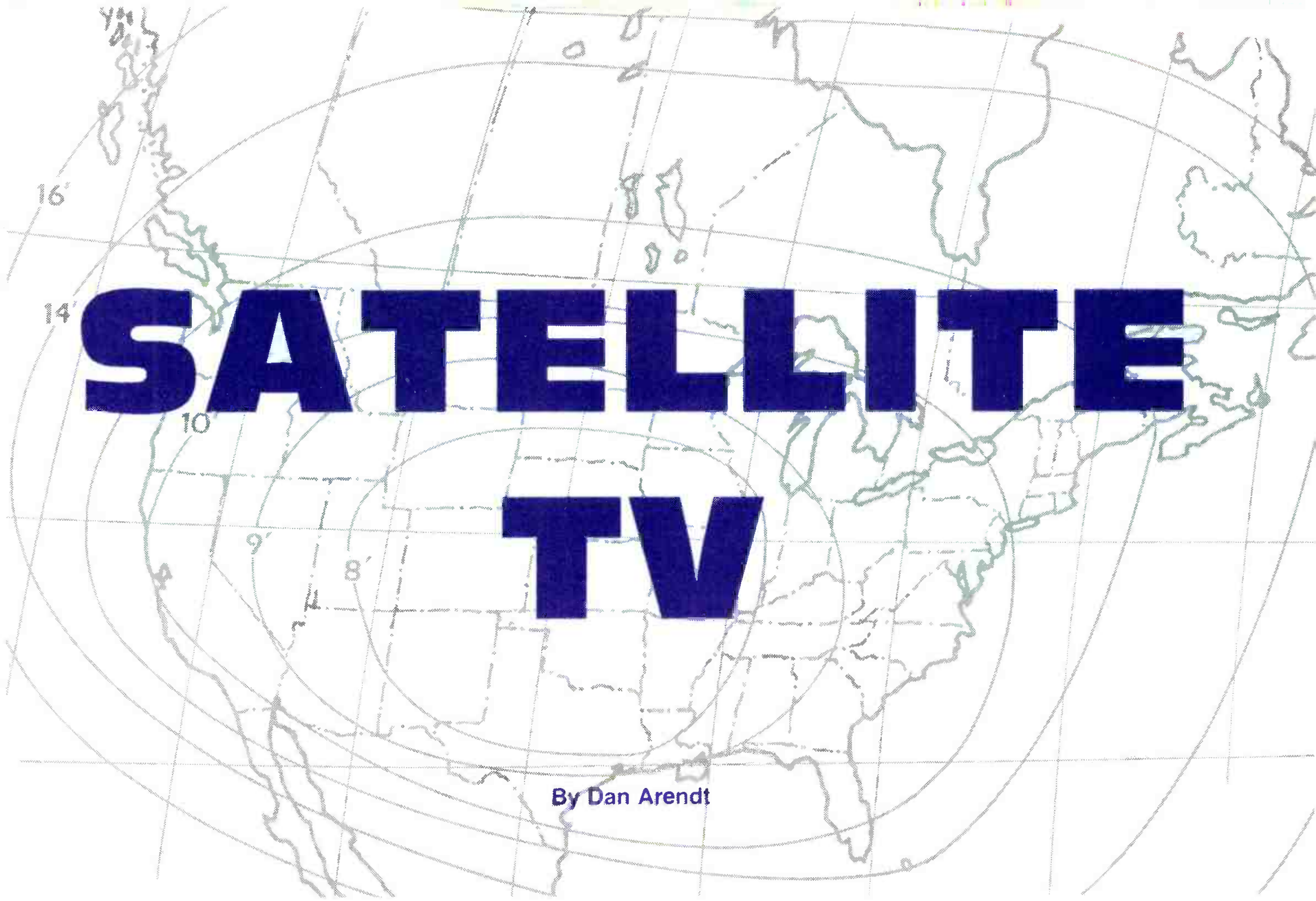
The birth of Satellite Television came in 1976, when Time-Life Films pioneered the industry by using satellites to feed their first-run movies to a network of cable systems from their HBO master-tape facilities in New York. Because of limited production and FCC size requirements for antennas, the first cable-television TVRO (*television receive-only*) earth stations were priced exorbitantly high—$50,000 to $100,000—definitely out of reach for the average American family. As satellite-programming suppliers and networks grew, so did the demand for satellite earth stations, resulting in steadily decreasing prices. Today it is possible to purchase a complete TVRO system for less than $1500. So much for background material.

Speaking The Language

What faces the TVRO neophyte today upon entering the satellite arena is his or her lack of understanding of common terminology and basic science of such systems. After all, who wants to visit a satellite dealer without some basic understanding of the jargon used! So, the remainder of this article will be devoted to familiarizing you with the terminology and technology associated with TVRO satellite systems. A glossary of satellite-TV terms (see Table 1) is given to help further your understanding of TVRO tech-talk. By the end of our discussion, you should be able to go out into the marketplace with the knowledge of how satellite television works; what to expect in system performance; and, foremost, be able to ask the right questions of a dealer, considering the various configurations of satellite earth stations available.

But before we get into choosing a home satellite-terminal,

Thinking about purchasing a satellite-TV system? Well, there are a few things that you should know before you lay your money down!



SATELLITE TV

By Dan Arendt

here is a brief overview of the component parts and their function.

Most of us have seen the prodigious dish-shaped antennas in yards, or perched atop the roofs of homes, office buildings, and apartment complexes. The dish is but one component of an entire TVRO system. Refer to photos. A typical TVRO package is comprised of three major components: The dish, which intercepts and concentrates the satellite signal by reflecting a concentrated beam to the feedhorn; low-noise amplifier or LNA, which intensifies the weak satellite signal; and a receiver, the electronic heart of the TVRO, responsible for converting the amplified satellite signal into VHF for input to an ordinary television set.

Basically you have three alternatives when choosing a TVRO system: Buying a terminal in component form and assembling it yourself; purchasing a dealer-installed turnkey system; or, the do-it-yourself kit, consisting of a parabolic or spherical antenna in kit form and a prebuilt receiver and LNA. Probably the best route to take for a medium-priced system (about $1500 to $2500) would be to buy pre-assembled components through your local satellite-TV dealer and install it yourself. Satellite-TV distributors can be found in TVRO-orientated publications.

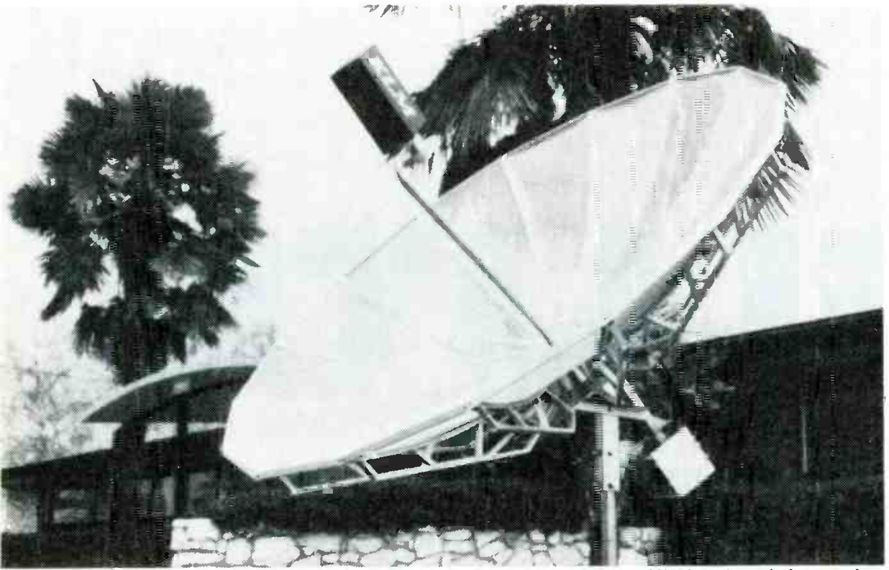
Space-age Elbow Grease

It should take one person approximately 10 hours to assemble a small, 8- to 10-foot petalized, parabolic dish-antenna system the first time, including correct alignment on a specific bird. If money is not a deciding factor in your purchase, then a dealer-installed turnkey system is by far the easiest route to take. The installing dealer will select the antenna—size and location—and receiver combination after a thorough analysis of your location. Dealer-installed turnkey systems can range in price, depending on the dish size, features, etc., from a low of about $2000, all the way up to $15,000 and more. The average price for a dealer-installed, fixed-mount type satellite antenna, with a 24-channel capable receiver and motorized, polarity-rotator control, runs between $3000 and $6000.

Extras, such as block-downconversion receivers, orthomode LNA couplers—a remote-controlled antenna mount for automatic switching between transponder polarizations—will substantially increase the TVRO system's price. If you opt for a satellite-terminal kit, probably the safest way to go would be to purchase a completely built receiver and LNA. The antenna can then be purchased in kit form and assembled by the owner. Antenna kits are offered in both spherical and parabolic form (a detailed explanation of antenna and other components follows) with either fixed or polar mounts.

Installation, such as fabricating the antenna, pouring the concrete for the mount, burying the cables, setting up the polar mount, etc., can be performed by the owner. A do-it-yourself installation should take about 15 hours to complete. The kits that I've reviewed ranged in price from $1200 to $2000. Be sure that the kit includes clear instructions with plenty of illustrations; ask to see the instructions before purchasing.

The following section details the various component parts that make up the satellite earth station. It may appear that I am describing features and alternative systems in greater detail than is necessary, but if you can approach the TVRO market

Satellite-TV dish antennas, such as the KLM unit at left, can be ground-mounted affixed to a heavy concrete slab, or as done with the Satellite Receiver Systems' unit, shown at right, roof-mounted. The roof-top installation, which is becoming a common sight in many communities, must be rigidly secured to a sturdy platform to guard against wind-loading, which could turn an improperly mounted dish into a huge airborne saucer.

place with the knowledge of basic design factors, you'll stand a better chance of choosing a system worthy of your investment.

The Antenna/Reflector

People commonly refer to the big (usually white) parabolic dish perched atop roofs and in backyards as antennas. An antenna, by definition, is "a wire for sending or receiving electric waves." Thus, the dish can be more accurately described as a reflector of microwave signals to increase the power (gain) of the antenna system.

The transmitters (transponders), which send the microwave signals down to earth, operate with a power of just 5 watts (about the same power as a CB radio). Since the signal is traveling over 22,000 miles back to earth, an efficient satellite dish is essential if anything near acceptable reception is to be

TABLE 1 GLOSSARY OF TVRO TERMS

Antenna—A device for collecting and focusing electromagnetic energy, resulting in energy gain, generally proportional to antenna dimension.

Azimuth—Angle in degrees left or right of true north.

Baseband—Information or message signal with a content that extends from a frequency near DC to a finite value. By NTSC standards, the video baseband is from 50 Hz to 4.2 MHz.

Bore Sight—The center of a transponder "footprint," where signal strength is at maximum.

Cassegrain Feed—A radiating system that includes a primary reflector (earth station dish) and a secondary reflector and feedhorn.

Channel—A segment of bandwidth used to establish a communications link. In satellite-TV, sometimes synonymous with transponder.

C/N—Carrier to noise ratio. The ratio of signal power to noise power in a power system, usually expressed as a power ratio in dB.

C/No—Carrier to noise power density ratio.

Decibel (dB)—The ratio of power levels, used as a measurement of gains and loses in a system. Also used to express absolute power levels, such as dBW.

DBS—Direct broadcast system, proposed satellite service to allow transmission from orbital satellite direct to homes.

dBW—Decibels above one watt.

Demodulate—A process whereby information is recovered from a carrier.

Downconvert—To reduce the frequency of a signal, typically from RF to IF.

Downlink—The signal that's transmitted from a satellite to an earth station.

Earth Station—The terrestrial portion of a satellite link consisting of an antenna (dish), amplifiers, and equipment for receiving satellite signals. A TVRO system is referred to as an earth station.

EIRP—Effective isotropic radiated power. Signal strength emitted by a transmitting antenna, expressed in dBW.

Elevation—Direction upwards from the horizon, usually measured in degrees.

Feed—The device on a satellite antenna the transfers signals from the antenna to rest of the equipment in the reception system.

Footprint—The pattern of signal strength of a satellite's transmission as it strikes the earth. The pattern is indiexpected. The dish portion of a satellite antenna requires a reflective surface (as indicated by the Fig. 1 illustration), structural mass, and a surface coating. In all aluminum antennas, the reflective surface and structure are combined. The dish most commonly used for private TVRO reception, however, is made of fiberglas that's sprayed with an aluminum coating. A dull paint or plastic coating tops the aluminum layer to prevent the sun from reflecting into the LNA.

The antenna may be made from a wood structure covered with metal screen, such as the spherical antenna. The reflector is designed as a segment of a sphere. A parabolic antenna can only focus on one geostationary satellite at a time. The spherical antenna, on the other hand, can cover a portion of the band of communications satellites that form an arc over the equator, allowing microwave signals from several satellites to be received simultaneously; from 24 to 50 channels, on 1 to 4 satellites in one fixed position. (For further explanation of spherical antennas, see **Radio-Electronics** reprint on the 8-ball antenna.)

Spherical antennas also have the added advantage of minimizing the problems associated with wind and snow. Because its reflector surface is made of wire mesh screen, it offers less surface to wind-loading (pressure placed on a satellite-TV antenna caused by the wind) and prevents accumulation of snow and ice.

There are two factors detrimental to performance in all antennas. First there's dish size: The larger the surface area of an antenna, the more signal or gain it will deliver. The close tolerance of the dish curvature is another factor. Maintaining close tolerance of the dish curvature assures a tighter focus point and, thus, higher gain. And that results in a clearer picture.

The dish is the one component in the TVRO system most responsible for reception. Your main consideration in choosing a dish is to get as much gain as possible for its size. A 10-foot dish with closer tolerances in its curvature will have more gain than a 14-foot dish that has a less accurate curvature.

The one obvious advantage a parabolic antenna attached to a polar mount (allowing full access to the geostationary satellites), see photos, has over a static or fixed mount is its ability to receive signals from all the satellites. It is the most popular with home-owners. If choosing a solid parabolic dish, it should be sturdily built and heavy. Antennas that can't maintain their curvature or are too small, provide insufficient gain, resulting in specks in the picture.

In addition, the dish should have rigid perimeter framework, coupled with reinforcements that tie back into a rugged central hub (for rotating the antenna) with pivot points between the antenna and mount. The tie points should be widely spaced for added stability in strong winds. When visiting a satellite-TV dealership, grab the edge of a mounted antenna and give it a push. A well built antenna should barely move. To check dish-surface accuracy, stand to one side of the dish, sighting down its side. The profile should appear as one even plane, with no irregular sections of the dish jutting out or back. Irregularities decrease the gain and affect picture quality, which can show up as specks or sparkles (tiny black/white dots) in the picture, indicating insufficient signal input to the receiver. Other causes might be that the antenna is too small, or is inaccurately aimed.

What to Dish Up!

If you're considering a small dish, be sure to check picture quality on the weaker satellites. Choosing a smaller dish may

cated on a map with concentric lines connecting equal levels of EIRP (effect isotropic radiated power).

Gain—The amplification ability of a device, expressed in a ratio of power output to power input, measured in dB.

G/T—The ratio of gain to noise temperature. The primary way of expressing the performance of a satellite-reception system, expressed in dB.

Geostationary (Geosynchronous)—The orbit of a satellite 22,300 miles above the equator. In such an orbit, the satellite circles the earth at a speed relative to its orbit, causing the satellite to remain fixed in relation to a specific point.

GHz—The standard symbol for billions of cycles per second (billions of hertz). The microwave frequency band allocated for satellite-TV in the U.S. is from 3.7 to 4.2 GHz.

Degree Kelvin—A measurement used to express amount of noise generated by a LNA. The lower the noise temperature, in °K, the better the performance of the unit.

LNA—Low-noise amplifier. A preamplifier designed to contribute the least amount of thermal noise to the received signal.

LNB—Low-noise blockconverter. A preamplifier with a built-in mixer that converts the entire 3.7 to 4.2 GHz band down to a lower band of frequencies.

LNC—Low-noise converter. A preamplifier with built-in mixer that takes the signal from one specific transponder can converts it to IF.

Look Angle—The angle at which an antenna must be aimed to "see" (receive the signal from) a particular satellite.

Noise Temperature—The amount of thermal noise present in a device or system, expressed in °K.

Parabolic Dish—A satellite antenna characterized by a round bowl-like shape that concentrates or reflects signals to a single focal point. There are two basic types of parabolic dish: the prime focus and cassegrain.

Prime Focus—The type feed in a parabolic dish antenna that is positioned above the dish as the antennas focal point.

Transponder—A microwave repeater (receiver and transmitter) in a satellite that amplifies and downconverts the received band of signals. Domestic satellites use 12 or 24 transponders, which usually have a 36-MHz bandwidth.

TVRO—Television receive only. An earth station capable of receiving satellite-TV signals, but not capable of transmitting them.

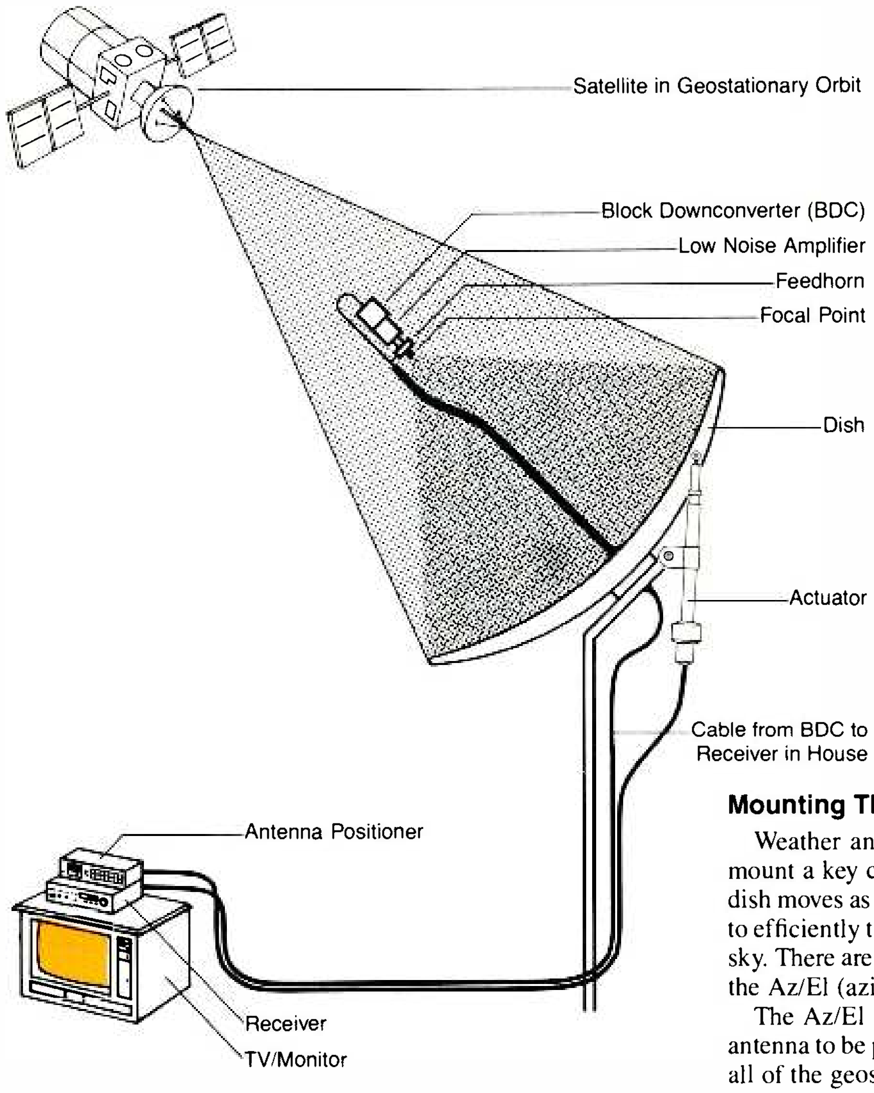


Fig. 1—The dish component of a satellite system can be more accurately described as a reflector of microwave signals to increase the power (gain) of the dish system.

SATELLITE TV PUBLICATIONS

STV (Satellite Television Magazine), P.O. Box 2384, Shelby, N.C. 28151-2384: $19.95 for a one year subscription.

Satellite Orbit, P.O. Box 9999, Dept. Q, Hailey, ID 83399. One year subscription, $48.00.

OnSat (satellite-TV programming guide), P.O. Box 2347, Shelby, N.C. 28151. One year subscription, $39.00.

compromise picture quality! You might consider purchasing a lower-priced receiver and channel the savings into a bigger and better dish. Sometimes bigger is better. A better dish coupled with a low-priced receiver will outperform a low-priced unit paired with a top-of-the-line receiver. As a rule of thumb, 10- to 12-foot dishes are of sufficient size for most of the United States.

A reputable dealer can make a recommendation for a dish of adequate size in your specific area. An eight-foot dish may be large enough in areas of strongest signal, but as you move farther away from the central mid-west regions, the size of the antenna required for clear reception increases. Out in Central and South America, a 16- to 30-foot dish is required.

The do-it-yourself antenna is shipped broken-down in sections. One drawback of the sectionalized antenna is that it seldom goes together with maximum surface accuracy—once again, resulting in loss of the all important gain so essential to a clear picture. Sturdily built, one-piece fiberglas and metal dishes usually offer greater surface accuracy than lightweight, sectionalized units.

Probably the most effective test for dish-surface accuracy is to actually look at the satellite picture. If the picture is less than perfect, the culprit is almost always the dish. "Sparkles" are most often caused by insufficient dish size, improper installation, and inaccurate surface curvature. The LNA and receiver are seldom responsible.

Mounting The Dish

Weather and time are two factors that make the antenna mount a key component in the TVRO ground station. If the dish moves as a result of improper mounting, it won't be able to efficiently track the satellite orbital belt across the southern sky. There are three different types of mounts to choose from: the Az/El (azimuth/elevation), polar, and fixed mounts.

The Az/El mount has two rotational axis' that permit the antenna to be pointed anywhere in the sky so that it may track all of the geostationary satellites. The Az/El mount is easier to install than a polar mount, but is more difficult to use.

A polar mount demands careful installation to ensure proper tracking of the satellites. After it has been properly positioned by adjusting its declination axis angle, simply rotating its hour axis from left to right aims the dish at any satellite in the geosynchronous orbital belt. The polar mount is used in most residential satellite systems because of its ability to easily swing through the orbital arc.

There are also motorized mounts available (see photos) that permit the user to position the antenna by remotely dialing the azimuth and elevation angles for a chosen satellite on a livingroom antenna console. Still, another system uses a home computer: By simply typing the satellite's name into the computer, azimuth and elevation angles are computed. The dish is then directed to aim at a specific point in the heavens.

The fixed-mount is static and does not track the satellites. It is commonly found in the spherical dish where only one section of the satellite belt is used. Several satellites can be received with a fixed-mount, spherical dish by simply repositioning the feedhorn/LNA assembly. The major drawback to a fixed-mount dish is its inability to see the entire satellite orbit belt. For that reason, the spherical type is seldom used as a residential installation with a fixed-mount.

Ground Mounting

Parabolic dishes develop tremendous stresses in high

The 16-foot, parabolic-dish antenna from Birdview on the right, coupled with a block downconverter can feed satellite-TV signals to a multi-unit apartment complex. The dish is the one component in a satellite system most responsible for good or poor reception. As a rule of thumb, however, 10- to 12-foot dishes are generally of sufficient size for most parts of the United States. Although the solid Fiberglas parabolic dish is more commonly used, the open mesh type, constructed of spun aluminum, like the one from Channel Master on the left, offers less wind-loading.

winds and such a dish could cause considerable damage if it became an enormous airborne saucer. Therefore, it is essential to ensure that the dish is properly mounted to the ground or roof. The two basic types of mounts are the single-pole and tripod mounts. A single-pole mount must be set in a large slab or buried bed of concrete, usually eight or more cubic yards, depending on dish size.

The tripod mount, which is used in the majority of higher-priced, commercial-quality dishes, has three legs that attach to the ground. Its wide stance makes it an extremely sturdy mount; thus, it can be attached to either one slab of concrete or three independent footings.

LNA/LNC

An LNA (low-noise amplifier) consists of an extremely sensitive, high-frequency circuit that amplifies the exceedingly weak satellite signals without their being drowned out by the noise generated by the amplifier itself. Since the signal from a satellite's transponder is so weak (about 1 millionth the power of a TV broadcasting station's signal) it must be amplified 100,000 times its original strength to be received as a viewable VHF television signal.

In addition, the sun creates electrical noise by radiating its heat energy into space, which is then bounced off the warming earth. Because of that celestial noise, the LNA's are rated in terms of their noise/temperature equivalence (degrees kelvin or °K).

A 100 to 120°K rating is the current state-of-the-art standard. Lower noise figures mean higher quality LNA's. Conversely, a higher-noise LNA demands a larger antenna than a lower-noise LNA to produce the same quality picture. Your main consideration should lie with the accuracy, quality, and size of the antenna, rather than the LNA rating. Higher priced LNA's with ratings under 100°K are probably not required, unless you are located in areas of weak microwave signal strength.

Some manufacturers mount the LNA and remote downconverter in a single housing to produce an LNC (low-noise converter). See photos. That eliminates running thick, unsightly, and expensive heliax cable from the LNA (mounted outside on the antenna) to the downconverter located in the receiver. Thus, inexpensive coaxial cable can then be used between the antenna and receiver.

Feedhorns

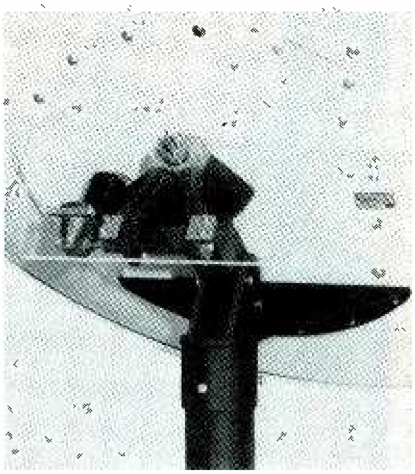
The feedhorn is located at the focal point of the dish to pick up the weak satellite signals. Those signals, downlinked in the 4 gigahertz (GHz) band (3.7 to 4.2 GHz), are focused and reflected by the dish to the feedhorn, which routes the microwave signal (through a metal funnel located on the back of the antenna) to the LNA for preamplification. The two most prevalent feeds used in TVRO antenna are the prime focus and the Cassegrain.

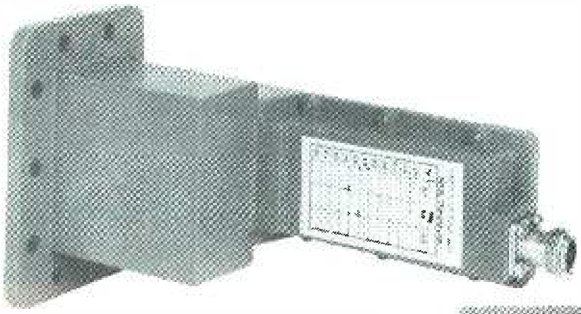
A circular feedhorn, see photos, can produce a quality picture in a lower-priced system. It is one of the most popular feeds available, with the ability to collect stray microwaves, thus eliminating the snow and sparkles prevalent in some lower-priced TVRO systems.

Receivers

A conventional receiver takes the preamplified 4 GHz signal from the LNA and extracts the audio/video signal, similar to a basic hi-fi FM or television tuner. One of your first considerations in selecting a receiver is deciding on a single-

Polar dish-mounts offer greater selectivity for TVRO viewing. The manual-type polar mount (left), from Satellite Receiver Systems, has a crank that allows the operator to aim the dish (adjust the azimuth) to track the desired satellite. But such an installation can be inconvenient during rainstorms or in times of extreme cold. The motorized polar-mount, like that from Birdview shown at the right, offers the greatest convenience. Such mounts often include an elevation adjustment that can be controlled from you living room using a remote dish positioner





In the TVRO system, the LNA (like this one from Avantek) has the job amplifying low-power microwave signals to a suitable level for input to a downconverter, which is usually located within the receiver housing.

Some receivers, like Uniden's UST 7000, include a drive controller that can be used to remotely aim the dish at one satellite or another without leaving the comfort of your home. Some units offer, as this one does, added features like remote control, polarization and channel selection, LED readout showing the satellite at which the dish is aimed, stereo/-mono audio selection, and more.

conversion or dual-conversion model. The conversion technique changes a 4-GHz satellite signal into ordinary baseband video and audio. Single conversion is the least expensive of the two and is the technology used in most intermediate and low-priced home receivers. Go to a local satellite-TV dealership and make a comparison of the picture quality between a higher-priced, single-conversion unit and a dual-conversion receiver. You probably won't notice much difference between the two. In fact, the single-conversion model may even outperform the dual-conversion receiver.

Optional features on the receiver increase the price. Some features are superfluous, while others are worthwhile considerations. Every receiver will be outfitted with a mechanism for audio tuning, channel tuning, and an on-off switch. Other features include video inversion, fine tuning, meters or lights for center tuning and signal strength; pushbutton transponder selection, selectable AFC, LNA polarization control, LED or LCD channel readout, remote control, continuous audio tuning, frequency scan, and more. If cost is a factor, choose a receiver that features only the bare-bone essential controls.

While the optional switches, meters, lights, and frivolous gadgets may be appealing, all a receiver really has to do is produce a quality picture, which can be achieved without the added expense of optional equipment.

The Modulator

The majority of receivers now feature built-in modulators, but lower-priced units may not. However, they are quite inexpensive and can be purchased for under $100. A modulator converts the video and audio signals from the satellite to a normal television transmission frequency for output on channels 3 or 4 of your TV set. The cable from the modulator is connected to the VHF antenna leads.

A standard VCR (video cassette recorder) contains a modulator and can be integrated into your satellite receiver. One obvious drawback here is that if your VCR goes on the blink, your entire satellite earth station is shut down.

After this familiarization with satellite television components and alternatives, what should you purchase if you want to bring the world into your living room? You'll want to best system that falls between the guidelines of your budget—based on reliability, warranties, and ease of operation.

Find a dealer who sells more than one line of equipment and compare the advantages and disadvantages of similar components. Is he the owner? Has he been in business for at least 3 years? Is he a properly licensed dealer in possession of a contractor's license (required by most states)? Those are some of the other things that the buyer should look into. The

(Continued on page 94)

LOUDSPEAKER IMPEDANCE

A HI-FI HASSLE THAT WON'T GO AWAY!

By Neville Williams

ON PAPER, THE IMPEDANCE RATING OF A LOUDSPEAKER system looks all very tidy and official: 4 ohms, 8 ohms, 16 ohms, etc. But don't take those numbers too seriously. At best, they're a rough guide; at worst, they can add up to a variety of hi-fi problems that have been around for the past 50 years.

It's for that reason that engineers generally tend to avoid reference to loudspeaker resistance, preferring the more factual term *impedance* or even *nominal impedance*. By definition, the impedance of a loudspeaker isn't a single, constant figure, but instead varies with frequency. And that's something that loudspeaker (and amplifier) designers are stuck with, no matter how much they might wish it otherwise!

A Step Backwards

Back in the early 1930's, "wireless" technicians were aware, in a vague sort of way, that loudspeaker impedance varied with frequency. It was generally assumed that the impedance of a loudspeaker would always be 20% or so higher, by reason of its inductance, than the measured resistance of the voice coil. In fact, that simple "rule of thumb" was used to classify loudspeakers that had lost their identification marks.

A practical reminder that there might be more to it than that came with the introduction of pentode-output vacuum tubes. Even though they offered considerably more output power with comparable distortion ratings, there were numerous complaints. It was said that they lacked the "sweetness" of the old-fashioned triodes and sounded shrill and harsh by comparison. (Shades of *transistor tone*, 30 years later!) Could it be that with their intrinsically high output-resistance, pentodes performed badly into the typical reactive loudspeaker load? (Published ratings notwithstanding.)

Initially, a quick fix was to wire a 0.02-µF capacitor across the primary of the output transformer as a brute-force restraint on both treble response and distortion. A more salutatory lesson came with the release of RCA's state-of-the-art, all-metal 6L6 beam-power tetrode. When used in conventional circuitry, it showed a marked tendency to self-destruct at high-signal levels by arcing across a glass-bead insulator that separated the plate lead from the metal shell. A crack and a fizz, and another 6L6 ceased to be!

While the problem should, perhaps, have been foreseen by RCA, it did underline the fact that the load impedance presented by a typical loudspeaker was likely to exceed its measured DC resistance; not just by a few percent, but several 100%! Across such a load, a high-power, high-impedance driver—in this case, a 6L6 beam tetrode—could generate a destructively high peak voltage.

In technical terms, a loudspeaker or loudspeaker system can be described as the *load* to which an amplifier delivers audio power ranging, typically, from a few tenths of a watt for a small portable radio, to 100 watts or more for a large hi-fi system. Logically, a loudspeaker should be capable of coping with the drive power put out by the amplifier to which it is connected. But there's a bit more to it than merely ensuring a sensible balance between the power-handling capability of one, and the rated power output of the other. It's also necessary to ensure that a loudspeaker presents to the amplifier that order of load resistance into which the amplifier can most effectively deliver its output power. If, for example, the design of an amplifier calls for an 8-ohm load, complications can arise if it's used instead with, say, a 4-ohm or 16-ohm loudspeaker or system. (More about that later.)

Loudspeaker Design

It is, unfortunately, virtually impossible to design a practical loudspeaker—one that will present to the amplifier a pure resistive load of a desired value. To start with, the ubiquitous "dynamic" loudspeaker depends on a "voice" coil (which exhibits not only DC resistance but inductance and distributed capacitance, as well) for its very operation. Inevitably, inductive and capacitive reactance will be present along with the DC resistance. Also, loudspeakers normally involve moving parts, which exhibit mass momentum, inertia, stiffness, springiness, and a tendency toward mechanical resonance. In the end, all of those properties reflect back into the load (as seen by the amplifier) as electrical analogs, equivalent resistance, inductance, capacitance, which add to the electrical quantities already present.

In April, 1938, the late Fritz Langford-Smith, Editor of the *Radiotron Designer's Handbook*, presented a definitive paper on the general subject to the World Radio Convention in Sydney, which was organized by the IREE. Although that paper—entitled, *The Relationship Between the Power Output Stage and Loudspeaker*—related (at that time) to tube technology, it set out many broad principles that are equally applicable to modern solid-state devices. (I happened to have been his assistant at the time and prepared the original diagrams from which Figs. 1, 2, and 3 have been redrawn.)

Figure 1 shows the impedance curve of a then-current 10-in. loudspeaker with a nominal impedance of 12 ohms. Its impedance conforms to that figure, at most, over the range of 100–700 Hz. Below 100 Hz, the impedance rises to a peak of 80 ohms at 70 Hz, and rises progressively through 80 ohms at 10 kHz—an increment of 6.5 times, or 650%! Is it any wonder that pentodes and tetrodes failed to perform into a reactive load as into a resistive load?

Figure 2 shows that the nature of the loudspeaker's impedance is inductive up to about 70 Hz, changing to capacitive from just above 70 Hz to about 190 Hz and then reverts to inductive for all frequencies above 200 Hz. Only across a narrow band, centered on 200 Hz, could the 10-in. loudspeaker be said to present its rated load: 12 ohms, resistive.

Figure 3 schematically shows the combination of electrical components necessary to duplicate the impedance and phase characteristics, up to 400 Hz, that are shown in Fig. 1 and Fig. 2. Considerable elaboration would be necessary to simulate the curves above that frequency; but, at least, the diagram conveys some idea of how even a simple loudspeaker appears to the amplifier. More important, it emphasizes the fact that loudspeaker *resistance* is a mythical quantity.

Langford-Smith pointed out that, for a given level of drive signal, a low-impedance output stage had a tendency to produce a constant voltage across the load, regardless of variations in load impedance. For that reason, triode output stages tended not to exaggerate the bass resonance (71 Hz in Fig. 2) or the rising treble response above 1 kHz. High-impedance stages (e.g. pentodes and tetrodes) exaggerated both effects, because their output voltage tended to rise and fall with load impedance.

He also drew attention to loudspeaker damping. When a loudspeaker cone tended to *overshoot* by reason of its mass and momentum, or oscillate freely at a natural resonance, its surplus mechanical energy could be damped (absorbed) much more rapidly in a low-impedance output stage than in one with a higher impedance. Those were the facts behind the preference for triodes and the criticism of pentode and tetrode tubes at that time.

Although the behavior of a high-impedance output stage could be modified by the use of a top-cut filter, Langford-Smith maintained that the use of a negative feedback voltage was much to be preferred. He went on to show that with negative feedback on the order of 8–11 dB, a typical receiver-type output pentode or tetrode could offer essentially the same performance as a power triode, but with improved efficiency in terms of the power supply.

In fact, the next generation of domestic receivers and amplifiers followed that general design philosophy: using pentode or tetrode output-stages, with 10–12dB of negative feedback in a modestly configured circuit that had distortion figures hopefully below 3% at the rated output.

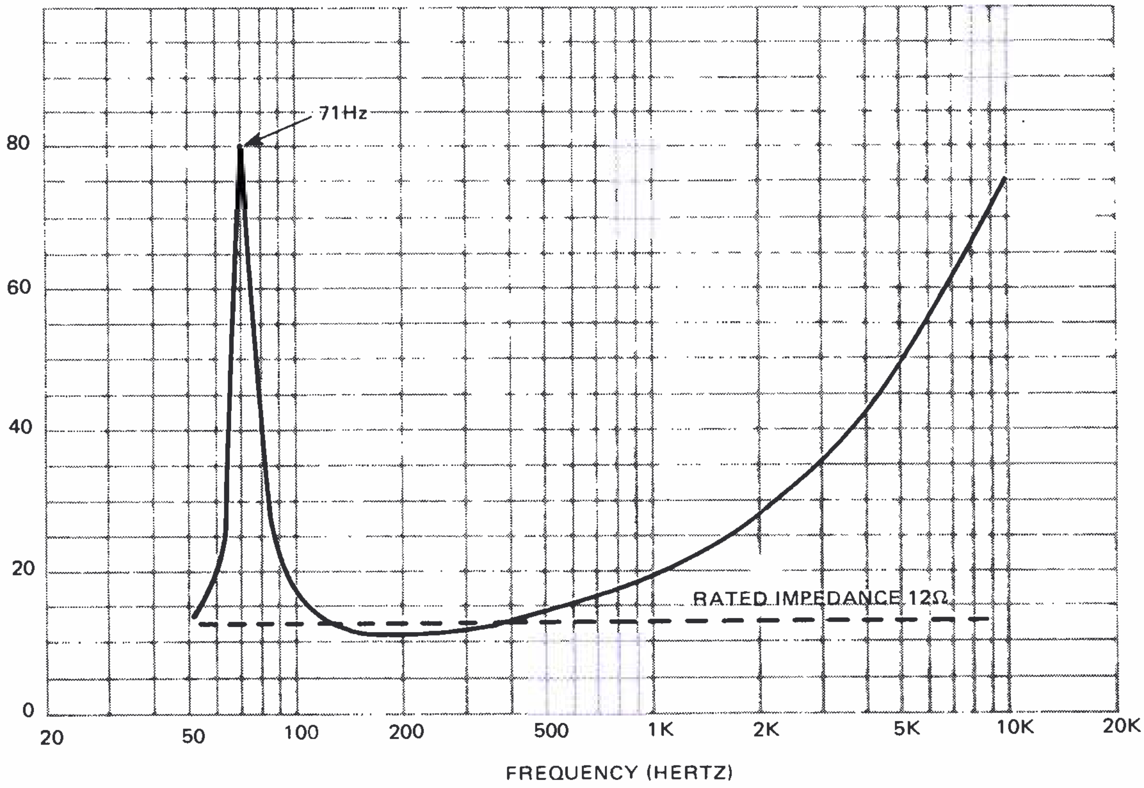


Fig. 1—The impedance curve of a traditional receiver-type 10-inch (25cm) loudspeaker, with a nominal impedance rating of 12 ohms. It was probably mounted on an open baffle.

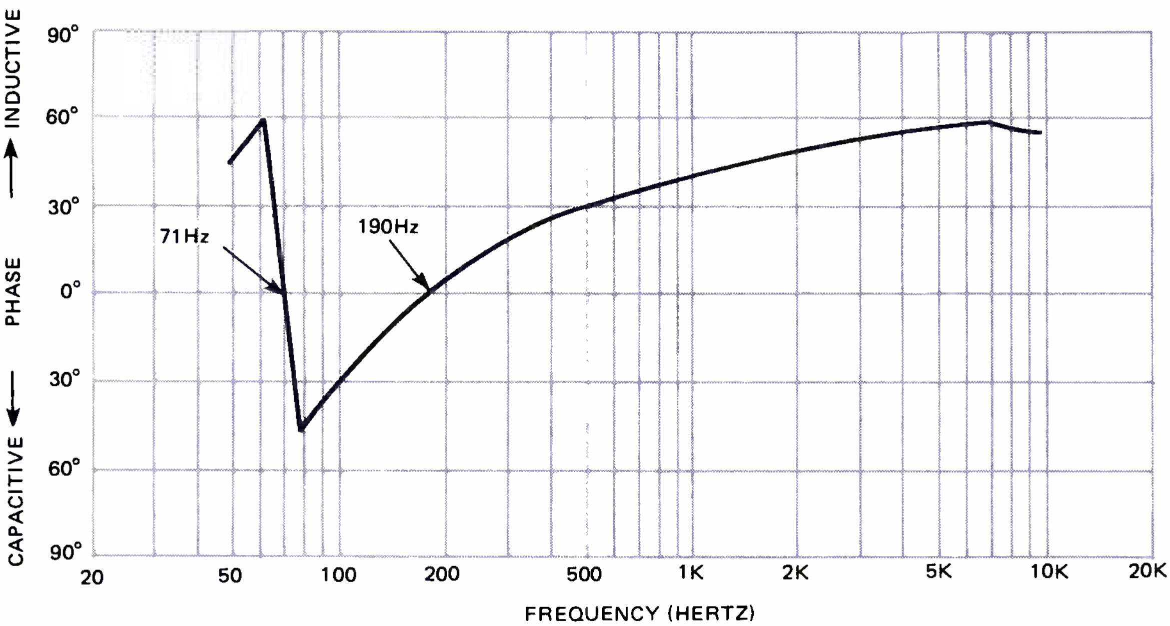


Fig. 2—The phase characteristics of the same loudspeaker as for Fig. 1. The impedance approximates a 12-ohm resistive load only within a narrow band centered on 200 Hz.

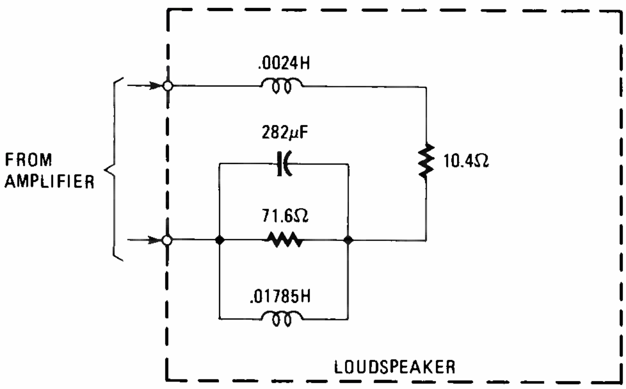


Fig. 3—To an output stage, a loudspeaker appears like a complicated electrical network. This circuit simulates the characteristics that are shown graphically in Fig. 1 and Fig. 2, but only below 400 Hz.

New Problems

With one problem solved, there then came the call for ever lower distortion figures. That, as you might suspect, added up to more complex circuit arrangements that used a greater amount of feedback over more stages. In a roundabout way, that stirred up the problem of loudspeaker impedance all over again. When the amount and the extent of negative feedback is increased in the interests of reduced distortion, lower output impedance, and flatter frequency response, it becomes progressively more important to ensure that the feedback does indeed remain negative—a requirement that applies no less to modern solid-state amplifiers than to classical tube designs such as the "Willamson" circuit and the ultra-linear "Playmasters."

The problem is that reactive effects, which modify phase response in the supersonic (and perhaps subsonic) region, are present in any amplifier. Thus, although the feedback may be strictly negative over the entire audible range, phase rotation effects can still cause the feedback to become positive somewhere within the overall passband, and therefore promote instability. The problem multiplies with greater amounts of feedback, and with the number of stages/components included within the feedback loop.

In an elementary way, Fig. 4 illustrates the problem that faces the designer of a high-gain, high-quality amplifier: whether tube-type or solid-state. The designer can manipulate the amplifier design to ensure that it is stable at all frequencies, when looking into a resistive load of a certain order, or even into an open circuit. But how will it behave when it is terminated into a predominantly capacitive or inductive load, or into a particular combination of inductance, capacitance, and resistance found in a loudspeaker system? Will some unforeseen combination of components at some frequency cause enough phase rotation in the load to promote instability?

In extreme cases, amplifiers have even been known to *take off* when provoked, not so much by a particular loudspeaker system, but by interconnecting wires between the speaker and the amplifier that have an unfortunate order, or combination, of inductance and capacitance.

Fortunately, the matter is well enough understood, these days, for actual or incipient instability not to be a problem for most amplifiers, most loudspeaker systems, and most wire. Indeed, some amplifier manufacturers are sufficiently confident to specify their product as "unconditionally stable."

But enough of phase and stability; let's get back to loudspeaker impedance and the load values specified for typical domestic amplifiers.

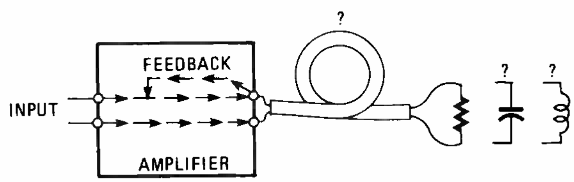


Fig. 4—Amplifiers involving a large order of negative feedback can sometimes prove unstable when used with connecting wires and/or loudspeakers exhibiting unusual reactive properties.

Considerations

In developing a new amplifier, the designer has to nominate a certain order of load, such that the output device can develop across it an appropriate output voltage swing without exceeding device ratings for maximum peak current.

For the sake of commercial convenience, he will probably recommend one or more of the currently popular values (4 or 8 ohms) and list the corresponding power output, distortion

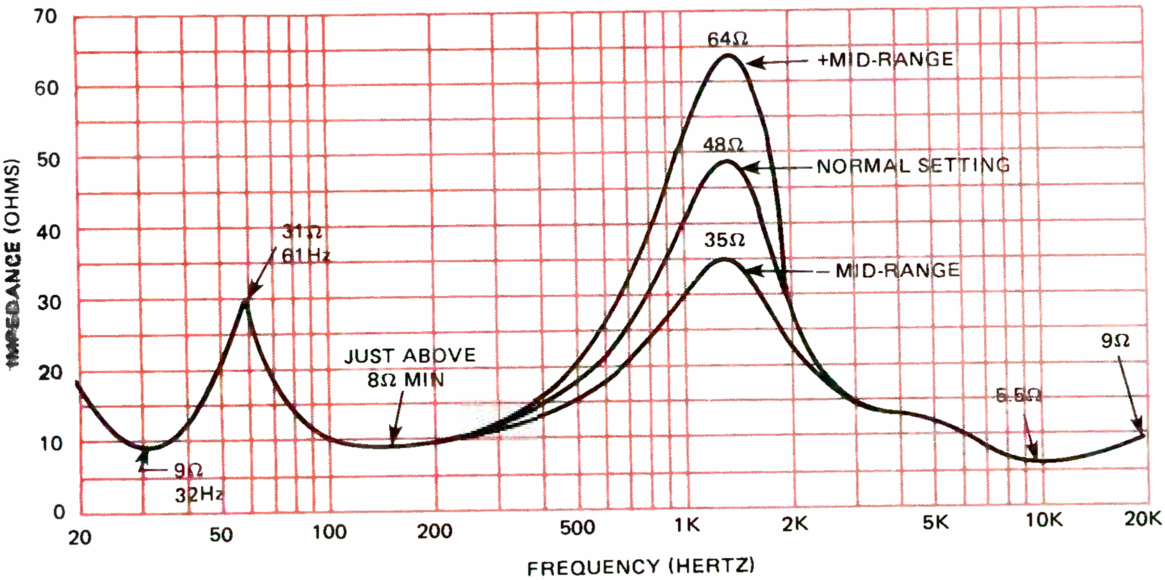


Fig. 5—The impedance curve of a popular medium-priced 8-ohm hi-fi loudspeaker system, using the bass reflex principle and fitted with a 3-position "presence" switch. Note the dip in impedance at 10 kHz.

level, frequency response, and so on. As far as possible, those recommended operating conditions should be observed.

Normally, however, no special difficulty will result if an amplifier is operated into a load higher than that specified; e.g., 8 ohms into 16 ohms. Because of the negative feedback, there'll be little change to the output voltage swing, the distortion level, or the frequency response, but the available power (E^2/R) will be reduced. If there is power to spare, or the speakers are acoustically efficient, it may not matter all that much.

But decreasing the order of load impedance is a different matter (say from 8 ohms to 4 ohms). In such a case, the negative feedback tries to sustain the output level of the signal voltage, and that results in higher output current through the load. Although that may yield a higher power output, it also increases the stress on the output-stage devices to the point of endangering them at peak signal levels.

A tube output stage can generally take such abuse without getting more than a little "hot under the collar" and suffering a possible reduction in overall life span. Solid-state devices, on the other hand, could blow themselves by reason of excessive current or by exceeding their "safe area of operation." By way of explanation, most power transistors have reduced power-handling capabilities at higher voltages within their rated range. Consequently, special design measures are required to ensure that amplifier operation into normal loads do not exceed the transistors' safe operating limits.

To assist users, amplifiers are frequently rated for two orders of load impedance (per channel, in the case of stereo); usually 8 and 4 ohms. It's safe to use an amplifier with a net load impedance equal to between or greater than the specified values—but not substantially less than.

Where an amplifier has provision for multiple loudspeaker systems (main and remote channels), the impedance presented by the two systems operating simultaneously, should not be less than the minimum figure for which the amplifier is rated. Two 8-ohms systems would be the obvious choice for an amplifier with a minimum rating of 4 ohms. In fact, some amplifier designers go so far as to have the main and remote loudspeakers connected in series when both are selected. That ensures that low values of load are unlikely, but does nothing for the damping of each individual loudspeaker system!

And that brings us to the graph shown in Fig. 5, which is based on the published impedance curve for a medium-priced, bass-reflex hi-fi system with a nominal impedance rating of 8 ohms. It is much more typical of present-day systems than Fig. 1.

The impedance is just under 20 ohms at 20 Hz, dipping to 9 ohms between the two bass-reflex peaks. At the upper bass peak, the impedance rises to 31 ohms, falling to just above the rated 8 ohms between 100 and 300 Hz. From there it rises to peaks of 35, 48, or 64 ohms, depending on the setting of the mid-range presence switch. At around 3 kHz, the impedance falls to below 15 ohms and then, with a slight plateau at 5 kHz, passes through a dip to 5.5 ohms at 10 kHz, and back to 9 ohms at 20 kHz.

In looking at Fig. 5, it is important to remember that it is a curve depicting impedance, not frequency response. If such a speaker system were driven by an amplifier with a high output impedance (like non-feedback pentodes or bipolar transistor types), the frequency response might indeed take on a somewhat similar shape. However, when driven normally by a low-impedance (constant-voltage) amplifier, variations in the load have only a very secondary effect. In fact, the base-reflex loudspeaker is credited with a frequency response that's flat within a few decibels over the range of from 50 Hz to 20 kHz.

While, for the most part, the impedance approximates or remains safely above 8 ohms, it does dip to 5.5 ohms at 10 kHz, which raises the question as to whether it would pose any hazard to an 8-ohm amplifier. The answer, in this case, is "probably no" if only because the risk of encountering sustained high-level drive in the 8–15 kHz region is not very likely under ordinary listening conditions. But one could be more concerned with profound dips that occur farther down in the range, as with some loudspeaker systems.

The general answer has to be that although not uncommon, dips in the impedance curve below the nominal rated value are undesirable; especially if they fall below, say, 75% of the nominal value (i.e., below 6 and 3 ohms respectively for 8 and 4 ohms systems). They would certainly add to the risk of using main and remote loudspeakers at less than the appropriate nominal impedance.

The presence of dips in the impedance curve also has a bearing on the choice of cable that connects a speaker system

(Concluded on page 104)

IMPROVING MUSIC RECORDINGS

Copies *can* sound better than the original!

By Raymond M. Fish

IN 1972, I GOT AN EXPENSIVE PAIR OF ELECTROSTATIC headphones for a scientific research project. Of course, the first thing I did with them was to listen to some music. To my surprise, recordings that I'd heard dozens of times in the past seemed to come to life for the first time.

Speakers and headphones are better and less expensive now than they were a decade ago, but the real *sound of music* is still often hidden by less than perfect speakers, headphones, automobile acoustics, radio-reception problems, and magnetic tape formats. Most television and AM radio sound is noisy and of poor fidelity. Tape recordings of one's favorite music made 10 or 20 years ago is likely to have tape noise (hiss) and poor frequency response. To hear the true sound of music, those limitations must be overcome.

You might ask, "Even if I do compensate for my cheap speakers, am I really hearing the music the way it was played? What should music really sound like?" You could also debate about recording methods at length. Suffice it to say that we all have individual tastes that often don't match those of the recording engineer. But, you can undo the damage done to music by outdated or poor recording techniques with relatively inexpensive electronic devices.

Tape Hiss

Hiss, that noise you hear when you're playing audio cassettes, is a relatively new problem. In the 1950's, you didn't encounter tape-hiss problems, even on expensive home tape machines. Of course, all machines then were reel-to-reel types—cassettes had not yet been introduced! And, the speakers and headphones that most of us could afford back then had limited high-frequency audio response. Actually, most of us weren't too concerned about tape hiss, because we believed that hiss *had* to be there—state-of-the-art design couldn't eliminate it. But what really had to be came about, and hiss was eliminated.

Cassette tapes were associated with quite a bit of hiss. When first introduced for voice recording, typical cassette tape hiss-levels were −20 to −30 dB. The high level of noise is due in part to the smaller, thinner tape and other miniature parts of the tape mechanism. Music recorded on cassette tapes was equal to or slightly better than a noisy disk recording.

Actually, the hiss might not bother you if you are listening to a tape in a moving car or other noisy environment, such as in a room where a fan or a dishwasher is going, or a child crying. In such situations, you might even turn up the high-frequency (treble) response, boosting the hiss along with the music. Under noisy conditions, you'd hear the high-frequency notes of your music and not be bothered by the hiss.

If you listen to a high-quality stereo system in a quiet room, however, you're sure to notice tape-hiss, and it's certain to bother you. Even the most inexpensive tape player with headphones will make tape hiss noticeable. One remedy for the hiss problem is to turn down the treble control. However, that cuts out a good part of the music because the high-frequency notes no longer come through.

You have probably noticed that if music is recorded at a relatively high level—the point where the VU meters read near zero dB—tape hiss is not as much of a problem. That's because the input signal becomes relatively strong, while the constant tape-hiss noise remains at the same level. In other words, the signal-to-noise ratio becomes larger, making the tape hiss relatively small when compared to the true audio signal. Unfortunately, after a certain point, playing music into your tape recorder at too loud (high) a level overloads it. On an oscilloscope, that would look like the bottom or top of a sinewave being flattened out, and the sound would be distorted. That happens mostly on the low-frequency bass notes, which tend to be greater in amplitude than others. You can optimize your signal-to-noise ratio by sticking to the proper signal level: The loudest parts of the music will be up near 0 dB, or the tape-machine manufacturer's recommended level, where there is minimal distortion, but a good strong signal.

Some tape recorders have built-in automatic level controls that maintain the optimum recording level. However, quiet music passages become loud and the quiet intervals between songs have the gain boosted quite high. That means that between songs on an album, you'll hear lots of tape hiss (from a tape being copied), turntable rumble, hum, and other noises that are normally too quiet to be heard.

Noise Reduction

Several techniques of reducing tape hiss have been developed, Dolby and *dbx*, for example. Those techniques involve changing the amplitude of all (or just some) frequencies in the sound before it is put on tape, and then making the opposite changes when the tape is played back. Some systems work by boosting quiet (faint) high-frequency sound to a greater extent than louder high-frequency sounds to improve the signal-to-noise ratio.

Other methods of improving signal-to-noise ratio compare the signal, so that when the music is very loud, the gain is turned down. But, when the overall music amplitude is low, the gain is increased. That provides a better signal-to-noise ratio as needed. Some radio stations use that method, which is noticeable when quiet portions of music get loud. You can hear the scratches, surface noise, and rumble on records.

The popular, commercially available noise-reduction systems work well, and they can take care of tape hiss in most situations. However, they do have some disadvantages. For example, you must make and listen to the music as it's being recorded using an encoder/decoder. Therefore, they are of no use with records or tapes that were made without that particular noise-reduction technique. Some of the tapes in my collection that have the most hiss were made on inexpensive tape before I had a tape recorder with a noise-reduction system. Because of that, I cannot reduce the tape hiss using Dolby, without cutting out the high frequency response (high notes of the music).

Most television broadcasts have monophonic sound with noticeable noise (hiss). The video sound processor shown provides DNR (dynamic noise reduction) and synthesized stereo. One's usual stereo amplifier and speakers can be used for listening to the greatly improved sound.

Another disadvantage of commercial noise-reduction systems is that you want to know for sure that a decoder will always be available. If your favorite decoder goes off the market or is *improved*, or if you lose or break the one that you have, you cannot properly decode your recorded music. But, since the more popular noise-reduction systems are being made in extremely large quantities, we can hope that they'll be around for a long time; so that may not be a serious problem—at least not one to be reckoned with in the very near future.

When you are making a new recording, the commercially available noise-reducing systems should be able to make your tapes practically noise free. Most of the tapes and records that you've owned for 10 or 20 years, and most of the music you previously or presently record from the television or AM radio can probably stand some *improvement*.

Equalizers

Until a decade ago, we only had bass and treble controls. Now, the audio spectrum is laid out graphically for us with separate level controls for a number of frequency bands. The simplest of the *graphic equalizers* has three bands. A pocket-sized tape recorder that I recently bought has three slide controls built into its lid. Those controls boost or decrease by as much as 10 dB at frequencies centered around 125 Hz, 1 kHz, and 8 kHz. After using a 10-band equalizer for years, I didn't expect the three controls to be all that useful. However, it turned out that the 3-band equalizer did a fair job of replacing my 10-band equalizer in most of its usual applications. For the most part, my 10-band unit has been used for four different functions: boosting the bass in the music; boosting sound in the 1 kHz region to make speech (lecturer) easier to understand; boosting frequencies above 8 kHz to bring out the high notes in music; and, at other times, attenuating music above 8 kHz to get rid of tape hiss. Of course, in the last application, high notes in the music are also attenuated.

A variety of equalizers are now available with the most wanted features, and in price ranges to fit the tightest budget. Some fit in your pocket, cost under $20, and can be used with portable radios and tape players. Others have variable bandwidths and are quite sophisticated. Equalizers can be used for the four functions listed above, in addition to making up for deficiencies in one's equipment. That can be done in conjunction with a spectrum analyzer.

Spectrum Analyzers

Most stereo equipment have frequency-response limitations. Some tape decks don't work well above 12 kHz, especially if the bias and equalization settings are not adjusted to match the tape being used. Many speakers and earphones have peaks or dips in their frequency response, or simply lack highs or lows. Room acoustics can absorb some frequencies strongly. In most stereo systems, a spectrum analyzer is used to analyze the interaction of the speakers and the acoustic environment.

You can compensate to some extent for equipment and environmental problems with a 10-band graphic equalizer, but how would you know where to set each of those ten (or twenty for stereo) controls? You can set the controls by listening and making the sound seem right. But a better job can be done by using a spectrum analyzer.

The audio spectrum analyzer puts out noise that is of uniform intensity in each frequency band measured (usually each octave). The noise source is connected to the amplifier by audio cables. A microphone, which is an integral part of the spectrum analyzer, picks up sound from the speakers. A bar-graph display shows the sound level in each octave. One compensates for deficiencies in speakers and room acoustics by adjusting the controls on the equalizer so that the bar-graph display shows equal intensities in all bands.

Though I own about half a dozen equalizers, I don't have one spectrum analyzer. Why *not*? I believe that I can tell how music is being distorted by bad speakers and adjust the tone or equalizer controls to compensate for the speakers just as well without a spectrum analyzer as I could with the ones now available at reasonable prices. I've tested that ability in audio showrooms and proven myself to be correct. That trait can be developed by many people who are familiar with live music and frequently dabble in audio equalization either for business or hobby purposes.

The spectrum analyzer can be useful if you're setting up an expensive audio system for someone whose hearing is more acute than yours, or if you want to try out many pieces of equipment quickly, or if you want to see how the sound spectrum varies in different parts of a room.

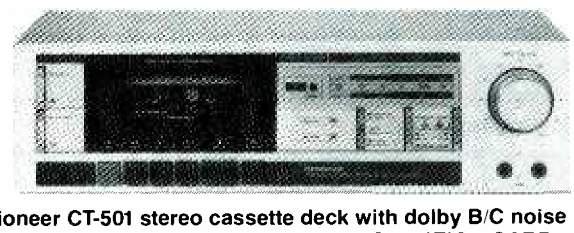
Spectrum analyzers would be more useful if they had finer (closer) bandwidth divisions, especially near the ends of the spectrum. It's far from ideal to have one bargraph display at 8 kHz and the next (and last) at 16 kHz when you know that your tape recorder goes bad around 14 kHz and your speakers poop out somewhere between 12 kHz and 20 kHz. When spectrum analyzers with finer bandwidth divisions become available, I might get one. Then I could turn the controls on the backs of my speakers to get a flat frequency response and adjust the bias of my tape recorders more accurately.

Tape Hiss On Previously Recorded Tapes

I have close to a hundred cassette tapes that were made between 1968 and 1976 using inexpensive tape and monophonic tape recorders. The recordings were off FM radio, but the high-frequency content of the music on many of the recordings is difficult to hear because of tape hiss. I really like a lot of the music, but since the tapes were made on recorders that lacked bass response, the music is noisy, lacks base response, and is in mono. All those problems can be taken care of with readily-available audio equipment.

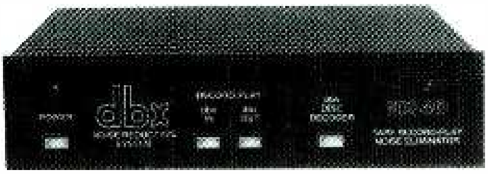
Once a tape has been made, it's difficult to get rid of the hiss without affecting the music. An equalizer can be used to turn down the high-frequency response sharply, giving a better result than the usual treble control, although the music will still be affected. Turning the DOLBY or CHROME settings on for playback (when the tape was recorded without Dolby or chrome tape) reduces tape hiss, as well as the high frequencies of the music that you want to hear.

Still, there is hope for tapes that were recorded without the benefit of a noise-reduction system. One system for reducing noise, which has been built into over five-million audio systems worldwide, is called the DNR, or Dynamic Noise Reduction System. The DNR noise-reduction system, built around an LM1894N integrated circuit, is available from several manufacturers.

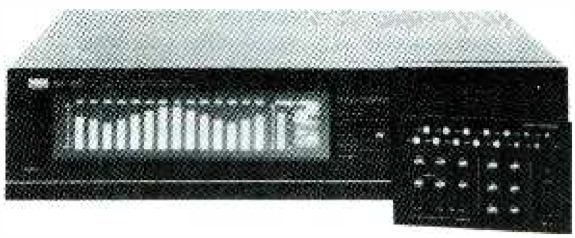


Pioneer CT-501 stereo cassette deck with dolby B/C noise reduction.
CIRCLE 844 ON FREE INFORMATION CARD

Pioneer SG-50M spectrum analyzer/graphic equalizer.
CIRCLE 843 ON FREE INFORMATION CARD



dbx model NX-40 tape record/play noise eliminator.
CIRCLE 841 ON FREE INFORMATION CARD



Sansui SE-88 14-band, graphic equlizer with remote control.
CIRCLE 842 ON FREE INFORMATION CARD

While many stereo components include enhancement circuitry, add-on enhancement devices are available for existing stereo systems.

The author's system for improving noisy monophonic tape recordings which were made years ago. The video sound processor functions as in Figure 1. Bass is added by the bass enhancer on top. Body (full concert hall sound) is added with a small amount of reverberation. A graphic equalizer changes frequency response to fit taste. A second stage of DNR is sometimes used.

The LM1894N senses the highest frequency present, which is a significant amplitude, in the music. The highest frequency sensed becomes the chip's low-pass cutoff frequency. Low-pass filters in the DNR chip are set so that they pass the highest frequency present in the music, but attenuate higher frequencies. Therefore, noise above the highest frequency in the music is attenuated. With high frequencies present in the music, you will hear all of the noise because the frequency of the filter is raised very high. However, the noise is not nearly so bothersome or noticeable as noise that's present during periods of silence, or during periods of time when only lower-frequency musical notes are present. The reason for that is the phenomenon of masking.

Masking means that one sound covers up another. When there are two sounds, one of greater magnitude than the other, you'll tend to just hear the louder sound. If the two sounds are close in frequency, one sound does not need to be very much stronger than the other to completely hide it. The farther one frequency is from another, the greater the magnitude must be for masking to occur. For example, you're jogging along with earphones wrapped securely around your ears, listening to music that contains a lot of low-frequency sounds, when a truck comes rumbling up behind you, and nearly scares you out of ten year's growth. The reason that you hear the roar is the vast difference in frequency of the two sounds. You'd be less likely to hear the truck (with its low-frequency noise) if your music contained just low-frequency sounds. On the other hand, if your high-frequency sounds are loud enough, they might still be able to mask the roar of the truck. Masking can occur even if the earphones are made mostly of foam rubber and let the sounds from the truck reach your ears. Masking does not mean the sound *fails* to reach your ears, but rather that you do not notice the sound that *does* reach your ears.

The DNR system senses the highest frequency present and adjusts the low-pass filter in each channel of the stereo system, which takes about half a millisecond. If the noise is about as strong as the music, the DNR system will not work well. In fact, it works best when the music signal is about 30 dB stronger than the noise signal. When that situation occurs, DNR can add 14 dB to the signal-to-noise ratio, resulting in a significant level of noise reduction. Some new videotape recorders without a *hi-fi rating* have audio channels with signal-to-noise ratios of 40 dB, which gives noticeable hiss, especially when listening through headphones. The DNR system would raise the signal-to-noise ratio to 54 dB in that application. Some stereo/hi-fi video tape-recorders have signal-to-noise ratios of 80 dB; they *need no* any improvement.

Some DNR systems have a bar-graph display that continually shows the frequency at which the low-pass filters are set. That display changes many times a second during the music. It's very handy for assuring that the SENSITIVITY of the frequency-sensing system has been set properly. The SENSITIVITY knob, which is present in systems with or without the bar-graph display, must be adjusted for the amplitude of the incoming signal. If the sensitivity is too low, the higher-frequency music signals will not be detected. Only the low-frequency bass notes, which are of relatively strong amplitude, will be detected. If the SENSITIVITY knob is turned too high, then high-frequency noise will appear as strong as a signal. Thus, the filter will stay open to a very high frequency. That happens even when there's no music present. An automatic level control could conceivably reduce the need for a sensitivity control, but its addition would cause problems.

Without the bar-graph display, a listener has to use his sense of hearing to determine whether or not the SENSITIVITY control is properly set. That can be done by adjusting the SENSITIVITY control to the point where the noise disappears, while retaining the high-frequency sound in the music. By listening carefully, one can tell that high-frequency noise *does* come back during the peaks of music, since it's only when there are no high-frequency peaks that the noise is truly reduced.

If you're going to use your noise-reduction system in a serious manner, or in a noisy environment, you may want a bar-graph display. The display is handy when the music sources aren't all the same amplitude (e.g. from different radio stations or tapes) and if they have different amounts or kinds of noise in them.

You may want to upgrade your tape collection by copying your old recordings onto new tape. The block diagram in Fig. 1 shows the equipment that you'd need to use to make your old tape recordings sound better.

While copying your valuable old tapes, you would first reduce the noise with a DNR system. If your tape was made from a record with scratches on it, or made from a phonograph record to start with, you would put a "click and pop" eliminator in line after the DNR system. Those click eliminators take out much of the impulse noise caused by record scratches. Once the noise was reduced, you could add bass or

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Fig. 1—Here are the components of the basic music improvement system, showing the usual order of making cable interconnections. Details of this system are discussed in the text.

THE COMPULOCK

A Digital Combination Lock for Home and Auto Security.

By J. Daniel Gifford

☐IF YOU'VE EVER SHOPPED FOR A SECURITY SYSTEM FOR your home, then you know that one of the most sought-after features is a digital keypad to arm and disarm the system. Similar devices have been featured in movies like *Brainstorm*, *WarGames*, and several of the James Bond thrillers, where keypads were used to control an electric door lock. However, a keypad lock has only been available on the most expensive security devices, and is not to be had as an add-on for less expensive systems.

Although they've begun to show up as a popular option on many late-model Ford vehicles, allowing doors to be opened without a key, that kind of technology still hasn't been available to the average consumer, at least not at a reasonable price—that is until *Compulock*!

Compulock is a digital keypad combination lock that can be used anywhere that you would use a key-operated switch (including in-home and auto security-systems). The circuit is easy to build and use, and can be put together for about $25. It uses CMOS integrated circuits throughout, permitting it to be used with any supply voltage ranging from 5 to 15 volts, and draws less than 5 microamperes. That ultralow current drain makes the Compulock ideal for applications where battery power is used, like automobiles, because it will not contribute to battery drain, even over extended periods. But don't think that all of that simplicity and low cost makes the Compulock a low-security device; in fact, far from it!

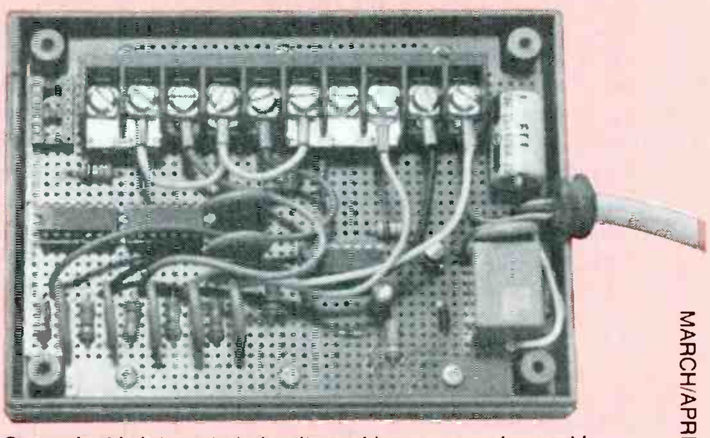
The circuit can be mounted securely inside a car or building, leaving only the keypad (connected via a ribbon cable), exposed. The keypad is nothing more than a set of switches; so even if a thief were to demolish it, he'd be left with a handful of wires that would do him even less good than the buttons! And if he tries to *pick* the lock by guessing at the combination, he's still out of luck. That's because the Compulock's four-digit code has more than 7,200 combinations and can be expanded for even greater security.

How It Works

At the heart of the Compulock are two CMOS 4013B dual D-type flip-flops that are arranged for sequential operation, as shown in Fig. 1. Note: The pushbutton switches represent the keypad that's used to enter the combination. Also the jumper connections between SO1 and SO2 are used to program the combination into the circuit. For the purpose of discussion, we're assuming a combination of 1-2-3-4.

The outputs of each flip-flop, when triggered by pressing its corresponding pushbutton switch, changes states according to the status of its D or data input. Pin 5 of U2-a (its data input) is tied to the supply voltage and acts as a sort of enable for the circuit. When S1, representing the first digit of the combination, is pressed, a positive-going pulse is applied to pin 3 of U2-a. That rising pulse causes U2-a's outputs to change states, driving its Q output high. That high is applied to the D input terminal of U2-b, enabling it.

When S2 (which represents the second digit of the combination and is connected to pin 11 of U2-b) is pressed, U2-b also changes states and its output at pin 13 goes high, enabling the next flip-flop in the chain. When the third and fourth switches (connected in the same manner as the first two) are pressed, their outputs also go high and the lock



Compulock's integrated circuits and jumpers are housed in a small plastic cabinet. A perfboard is used to mount the components. The cable on the right connects to the keyboard.

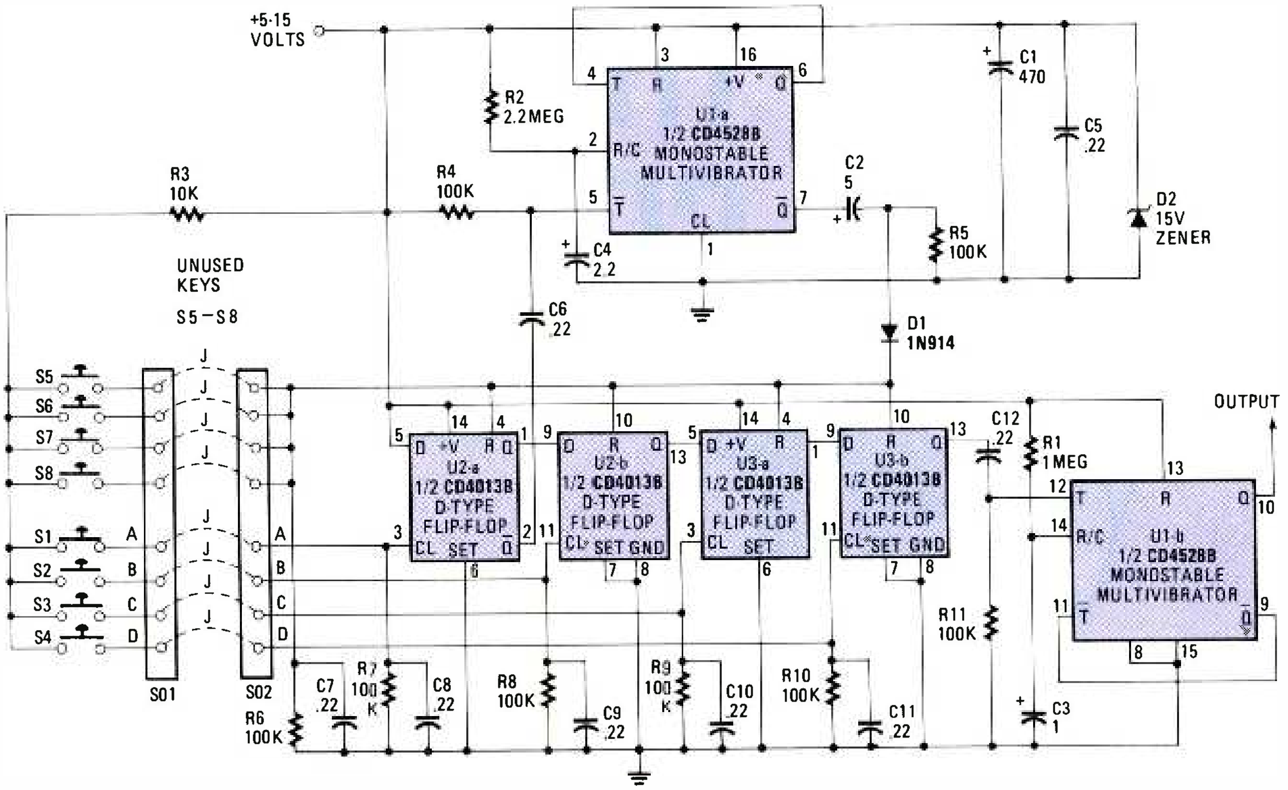


Fig. 1—The basic Compulock circuit. The liberal use of noise-bypassing components, coupled with the inherent noise resistance of CMOS IC's, serves to make to Compulock largely immune to power-supply problems.

opens. Note that if a button is pressed out of sequence, nothing happens because its corresponding flip-flop has not been enabled by the output of the previous one.

To prevent the lock from being left partially "set," increasing the chances of someone cracking the code, the Compulock is equipped with an automatic reset function. When the first digit of the combination is punched in, the $\overline{Q}$ output of U2-a at pin 2 puts out a low that triggers a 4528B monostable timer, U1-a, which resets all the flip-flops after five seconds. So, except for the five-second period allowed for entering the combination, the Compulock is always in its most-secure, fully-reset state. That feature should not interfere with the circuit's normal operation, because it takes a maximum of about two seconds to punch in the combination. But what it does interfere with is unauthorized entry.

The automatic reset does pose one remote problem. Depending upon how fast you are at punching in the combination, the fourth flip-flop's output pulse could range from 1 millisecond to 4 ½ seconds long. To eliminate that variance, and to ensure that the output pulse isn't too short to operate the circuitry that follows, the output of U3-b is fed to the positive trigger input (pin 12) of U1-b. So, no matter how long or short the flip-flop's output pulse, Compulock always outputs a clean 1-second pulse (Fig. 2.). In addition, the unused keys, S5–S8, are tied to the reset (R) inputs of the flip-flops, so that a press on any one of those keys automatically nullifies any previous correctly entered digit. Therefore, anyone who does not know the correct combination is once again denied entry.

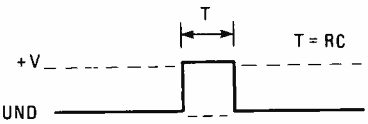


Fig. 2—The output of the Compulock is a single, clean 1-second pulse. The pulse can be lengthened if necessary, using the timing formula shown.

More digits can be added to the Compulock's combination by adding more flip-flops to the chain. With a standard ten-button keypad, a four-code digit Compulock has 7,290 possible combinations. If five flip-flops are used (providing five digits), the number of combinations expands to more than 65,000, and six digits give more than 590,000 possibilities.

Output Circuits

The output of the basic Compulock circuit can be used to directly drive some circuits; but for most applications, one of the two output circuits shown in Fig. 3 and Fig. 4 will be required.

To use Compulock as the arming control for a security system, its output must be used to drive an electronic on/off (toggle) switch like that shown in Fig. 4. A fifth D-type flip-flop, that toggles or changes states every time it receives a clock pulse, is used to drive an NPN transistor (either a 2N2222 or 2N3055), Q1. Q1, when turned on, arms the security system. A 2N2222 transistor can handle current loads of up to about 400 milliamperes. For larger loads (up to 3-amperes with heatsinking), a 2N3055 can be substituted.

Since the 4013B is a dual flip-flop, the second unit can be used as a fifth digit in the Compulock, or used elsewhere in a related application if needed. (Otherwise, all unused inputs of that CMOS IC must be tied to ground.) To trigger the toggle-type output, simply enter the combination once to turn the output on, and enter the combination again to turn it off.

The second type of output (see Fig. 5) is a heavy-duty relay type that can be used to drive any sort of door lock (either AC or DC), or even another type of device altogether. Just be certain that the relay's coil voltage matches the supply voltage that's used power the Compulock. Also, make sure that the relay's contacts can handle the current load of the lock or device it controls.

For most general-purpose applications, a 5- or 12-volt SPDT relay (like Radio Shack's 275-246 and 275-247, respectively) is recommended. Both are rated for 3 amperes at 125-volts AC, and have reasonably low coil-current draw (about 25 mA for the 12-volt device). If the Compulock is to

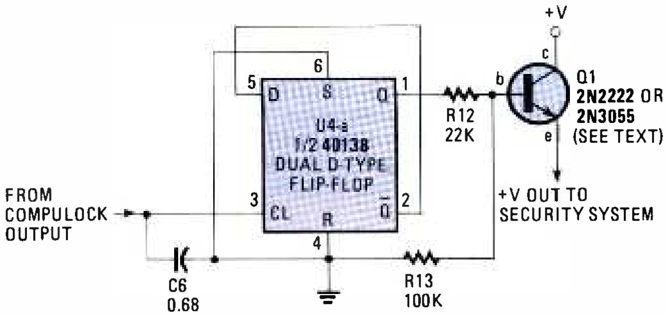


Fig. 3—The toggle-type output allows the Compulock to turn a security system on and off with successive entries of the combination.

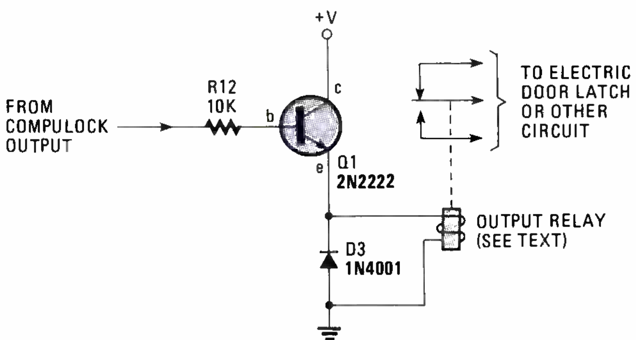
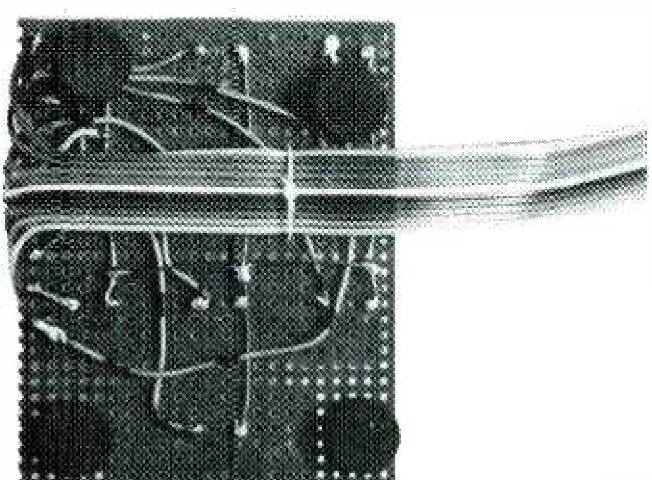
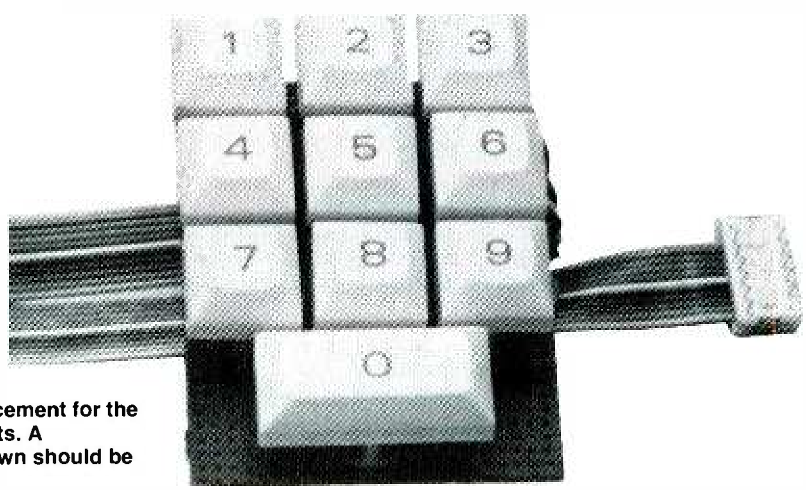


Fig. 4—The relay-type output allows the Compulock to drive an electric door lock, an automobile's door-lock solenoids, or any other type of circuit.



The front and rear views of the keyboard illustrate the simple construction technique used by the author. Point-to-point wiring is used to hold the parts in place as well as provide the electrical connection. The perfboard offers a solution to avoid making a printed-circuit board.



The Compulock is a universal digital replacement for the key-operated switch in security-type circuits. A programming reference sheet like that shown should be mounted inside the Compulock's case.

be used to open car-door locks, be aware that the heavy-duty solenoids used in the auto can draw as much as 5 amperes per device—a 20-ampere load for a four-door vehicle. So, choose the relay accordingly.

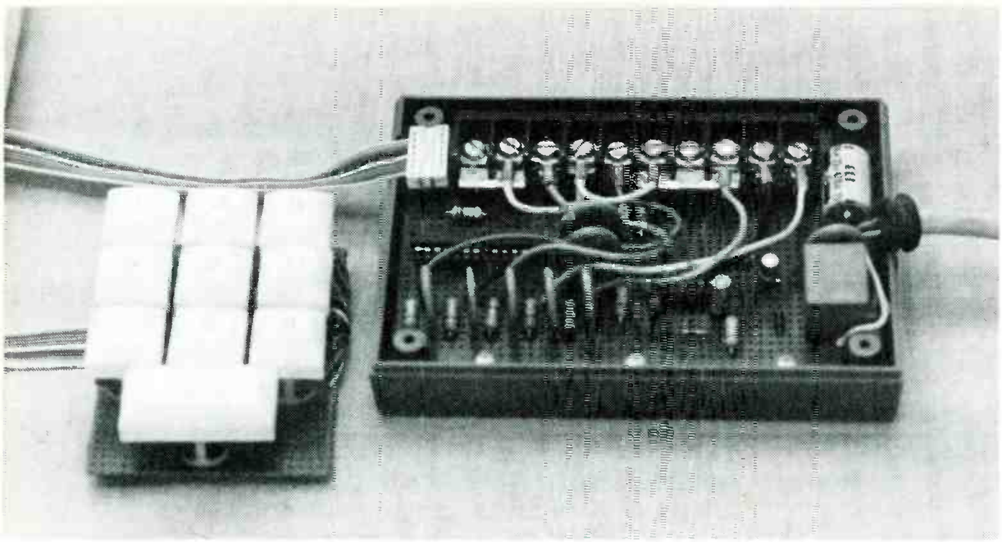
Electronic door latches for building-type use are available from most locksmiths and security suppliers in both AC and DC models. Most are designed to operate with a key-in-knob type door lock as a backup in the event of a power failure. If no such backup is used, it is strongly recommended that the entire circuit—lock and Compulock alike—be powered from a heavy-duty gel cell-type battery that trickle-charges from line current. That prevents a power failure from creating a potentially dangerous situation by disabling the lock. The Compulock's low-current requirement enables it to operate from a gel cell backup for months in the event of a prolonged power failure and still retain enough power to operate the door lock.

The one-second output of the Compulock may have to be lengthened to provide sufficient time to open the protected door after punching in the combination. To increase the "on" time of the relay, replace the 1-megohm resistor (R1 in Fig. 1) with a higher value. With the 1-µF capacitor shown, each megohm of resistance results in one second of "on" time for the relay (e.g., a 2.2 megohm resistor gives about 2 ½ seconds of "on" time). To operate the Compulock with a relay-type output, simply enter the combination and the relay closes for the preset time period.

Construction

There is nothing critical about the construction of the Compulock circuit. Simply choose the type of output you want (toggle or relay) and combine it with the basic circuit shown in Fig. 1. Compulock can be built on a small piece of perfboard (as the author did), or you can devise your own PC-board layout. No special housing is required. The circuit can even be enclosed inside the case of a larger device, such as a security system mainbox. However, there are two things that need to be pointed out about the components: Be certain to use B-series integrated circuits (not the less-reliable A-series); and make sure that dipped tantalum capacitors are used in the timing circuits, not electrolytics. Electrolytic capacitors tend to be "leaky," and their values vary with time and temperature change.

Other possible sources of trouble involve the the keypad and the programming bus. The keypad for the Compulock can be of any physical size or shape, and can have any



Here is Compulock assembled and ready for installation. The ribbon cable terminates in a DIP connector that is optional. Install the keyboard where it is out of sight and reach of kids.

PARTS LIST FOR
FOR THE BASIC COMPULOCK

SEMICONDUCTORS
D1—1N914 or 1N4148 small signal, silicon diode
D2—15-volt, 1-watt, Zener diode
U1—CD4528B dual monostable multivibrator or CD4538B dual precision monostable multivibrator, integrated circuit
U2, U3—CD4013B dual D-type flip-flop, integrated circuit

RESISTORS
(All resistors ½-watt, 5% units)
R1—1-Megohm
R2—2.2-Megohm
R3—10,000-ohm
R4–R11—100,000-ohm

CAPACITORS
C1—470-µF, 25-WVDC, electrolytic
C2—4.7-µF, 25-WVDC, electrolytic
C3—1-µF, 25-WVDC, tantalum
C4—2.2-µF, 25-WVDC, tantalum
C5–C12—0.22-µF, 25-WVDC ceramic disc

PARTS LIST FOR THE TOGGLE-TYPE OUTPUT
C6—0.68-µF, 25-WVDC, mylar capacitor
Q1—2N2222 or 2N3055 NPN silicon transistor (see text)
R12—22,000-ohm, ½-watt resistor
R13—100,000-ohm, ½-watt resistor
U4—CD4013B dual D-type flip-flop, integrated circuit

PARTS LIST FOR THE RELAY-TYPE OUTPUT
D3—1N4001 1-A, 50-PIV, silicon rectifier diode
K1—5-volt coil (Radio Shack No. 275-246) or 12-volt coil (Radio Shack No. 275-247), 3-A at 125-volt AC contact relay (see text)
Q1—2N2222 NPN silicon transistor
R12—10,000-ohm, ½-watt resistor

ADDITIONAL PARTS AND MATERIALS
Keypad, ribbon cable, DIP header, sockets for IC's and DIP header, barrier strip or PC-mount Molex connector, spade lugs or Molex pins, perfboard, case, wire, hardware, solder, etc.

number of keys from six to twenty or more. More keys increases the number of possible combinations; therefore, providing a greater degree of security. However, the standard ten-button keypad is probably the best compromise between security and complexity.

The keypad must be of the non-matrix (one-side-common) type. That means that one side of each normally-open switch must be connected to a common bus, and the other side connected to an individual input line. In the author's prototype, individual key switches taken from a surplus calculator keyboard were used to build up a suitable keypad. Any surplus electronics store should have a large selection of keypads that will either work directly or can be modified to work. The advantage of building up your own keypad is that you can configure the keys into any pattern desired; a single row, two by five, or the standard ten-key pattern.

For external use, such as on automobiles to unlock the doors and disarm a security system, or in an exposed location on the outside of a building, the keypad has to be weatherproof and almost indestructible. Fortunately, such a keypad is available off-the-shelf; the Ford/Mercury "Keyless Entry System." The keypad should be available from any parts department of a Ford dealer, or (for probably much less money) from a wrecking yard. Regardless of the type of keypad selected, a ribbon cable with one conductor for each key and one more for the common bus should be securely attached and soldered to the keypad.

The keypad can be mounted behind a plate or in a box, as the particulars of the application dictate. The ribbon cable, which can be of any length necessary, should be terminated in a DIP plug header for connection to the Compulock circuit.

Programming The Circuit

The programming bus (jumpers between SO1 and SO2 in Fig. 1) allows the Compulock to be programmed and reprogrammed to use any desired combination. There are probably endless ways to set up that portion of the circuit, but the two that we'll describe—the barrier strip and the Molex methods—are probably the easiest and the parts may already be in your junkbox. However, you are not confined to those methods only; use any technique that works.

The author used the barrier-strip method, which has the advantages of being inexpensive and vibration-proof (critical in a moving vehicle). But that technique is somewhat more space-consuming than the Molex method. To use the barrier-strip method, a feedthrough-type barrier strip (with one terminal for each key) and a DIP socket for the ribbon cable to plug into are mounted on the Compulock's circuit board. The two are then interconnected so that each key is connected in an orderly fashion to a terminal of the barrier strip. The terminals should be numbered to make for easy programming. A wire, terminated in a spade lug, should be brought

(Continued on page 96)

THE SILENCER — A GUITAR AMPLIFIER YOU CAN BUILD

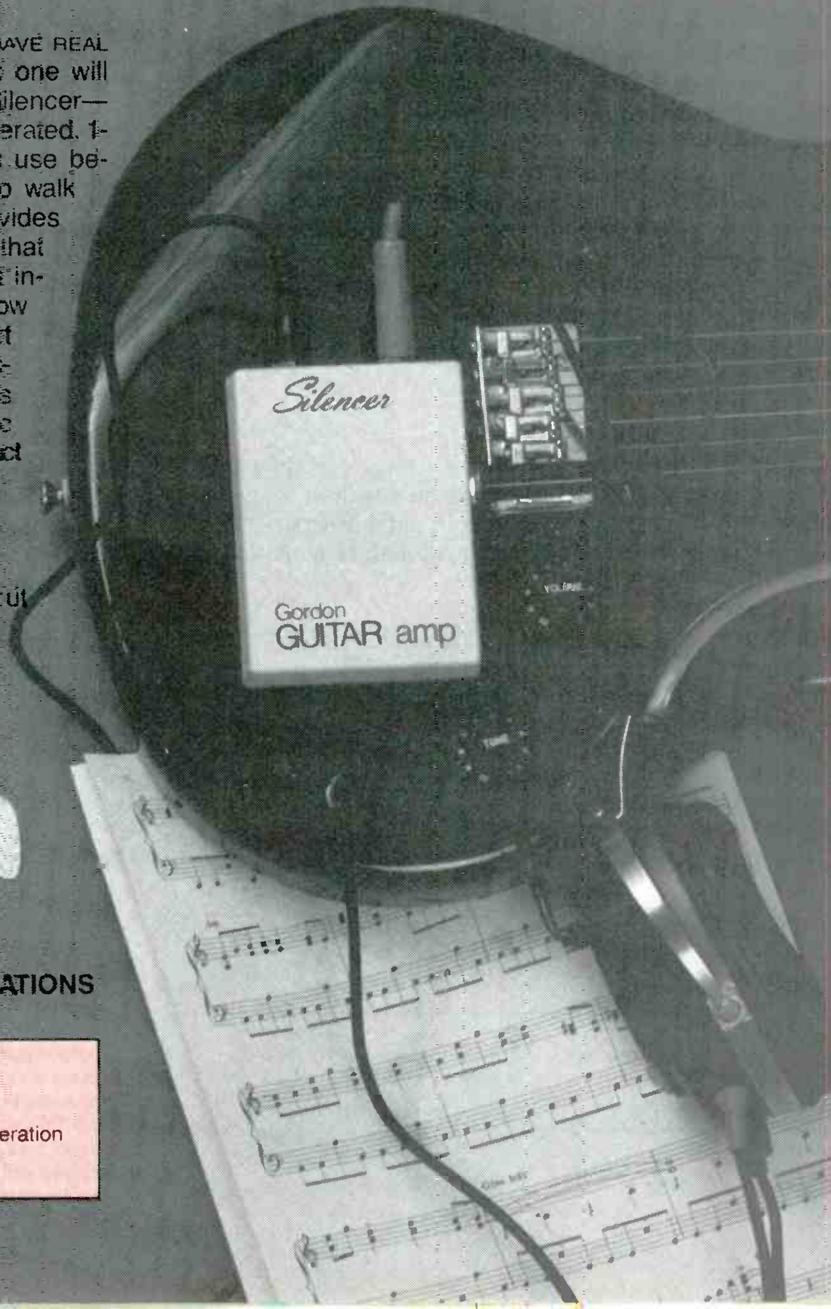
Silence that guitar with a portable, battery-operated 1-watt amplifier for high-fidelity headphone use!

By Jonathan Alan Gordon

IF YOU PLAY AN ELECTRIC GUITAR, YOU CAN HAVE REAL loud sound any time of day or night and no one will mind—that is, provided that you're using the Silencer—a hip-portable guitar amplifier. This battery-operated, 1-watt amplifier for musicians is convenient to use because it clips onto your belt, allowing you to walk about unencumbered. Its full 1-watt output provides the needed headroom, and delivers sounds that are crisp and clean. The amplifier's output is intended for headphone use, so that only you know how awesomely loud it is. Others nearby are not disturbed as would be the case with loud shrieking amplifier speakers. In addition, the circuit is enclosed in an attractive ABS textured-plastic case that's capable of withstanding high-impact abuse.

Design Theory

The amplifier has three main design areas, as shown in the block diagram of Fig. 1: The input circuit parameters; the amplifier parameters



GUITAR SILENCER AMPLIFIER SPECIFICATIONS

Frequency Response	20 Hz–20 kHz
Total harmonic Distortion (THD):	0.01 at 1 kHz
Power Dissipation:	1 watt
Power Supply:	9-volt battery operation
Quiescent Current:	4 mA
Gain:	34 dB

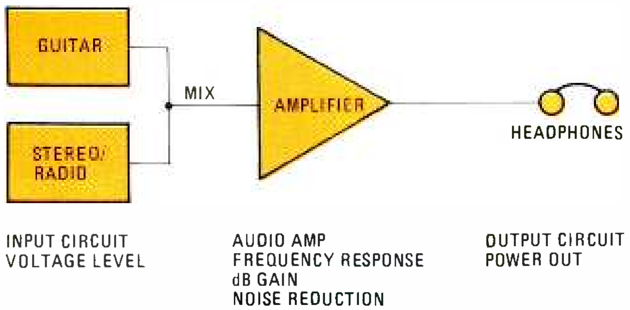


Fig. 1—The block diagram shows the three main areas that must be considered in the design of the Silencer Guitar Amplifier: the input circuit parameters; the amplifier parameters, which includes dB gain, frequency response and noise design; and the output circuit parameters.

such as dB gain, frequency response, and low-noise design; and the output circuit parameters. The amplifier itself is National Semiconductor's LM1895 linear audio power-amplifier. It was chosen primarily because of its high-power output using a 9-volt battery supply and its low-noise specifications.

Input Circuit

The LM1895 is functionally similar to an op-amp in many of its design considerations. For example, the amplifier can be configured for either inverting or noninverting operation. When designed in the inverting configuration (see Fig. 2), the input at pin 5 acts as a virtual ground, which can be used as a summing junction for mixing several signal sources—as is the case in this application. That's especially important for musicians who wish to mix their guitar playing with a recording.

On the other hand, if the amplifier is designed in the noninverting configuration, the mixer advantage is lost, or at best, not as easily achieved.

dB Gain

To the musician, the guitar is a means of expression. However, after all is said and done, to the engineer, the guitar is nothing more than a type of simple audio generator that's rich in harmonics, whose signal output must be amplified to be heard. And like any other signal source, it has both source impedance and an output voltage.

The Silencer's main design criteria (for the LM1895 input circuit) is not impedance matching for maximum power transfer. Instead, what is required is the proper voltage input at pin 5 for the desired amount of amplifier gain. For example, the average guitar input voltage is 0.065 volt and the amplifier's output at pin 1 is 3 volts. Therefore, to reach full output, the necessary voltage gain ($A_v = V_{out}/V_{in}$) must be at least 50; or, in decibels, dB = 20log A_v, a gain of 34dB.

Too much gain, and the output waveform displays signs of distortion, noise, and clipping. Too little gain, and the input signal will not be amplified as much as it could be.

Frequency Response

What does it mean when an amplifier has a bandwidth of 20 Hz to 20 kHz at −3dB down and rolls off at −6dB/octave? Figure 3 illustrates the amplifier's frequency response. The bandwidth (BW) is given by:

$$BW = F1 - F2$$

where F1 is the low-frequency pole and F2 is the high-frequency pole. At those two break frequencies, the output is −3dB down from the input voltage. That is to say, when the input voltage is 1 volt, then the output voltage will be 0.707 volts. According to the decibel formula, dB = 20 log 0.707/1, that is equal to −3dB down.

An octave is a frequency that is double the previous frequency. If the −dB break frequency is 20 kHz, then the next octave is 40 kHz, then 80 kHz, and so on (see Fig. 3). At the 40 kHz point, the output voltage has dropped to 0.354 volts. Therefore, the gain is now 20 log 0.354/1, which equals −9dB—a +6dB drop from the −3dB break frequency. To sum it up, the output voltage rolls off at a rate of −6dB per octave. Or said another way, for each 6dB drop, the output voltage is cut in half.

Noise Reduction Design

Since this is an audio amplifier, low noise and low total-harmonic-distortion (better known as THD) are important. In a good design, audio noise such as hiss, hum, low-frequency oscillations, pops, whistles, and other instabilities are imperceptible to the listener. The following design criteria highlight ways to reduce audio noise.

First, major power-supply ripple hum should be reduced by using a large electrolytic capacitor (C4 in Fig. 2) for supply filtering, and a decoupling capacitor (C5) with short leads

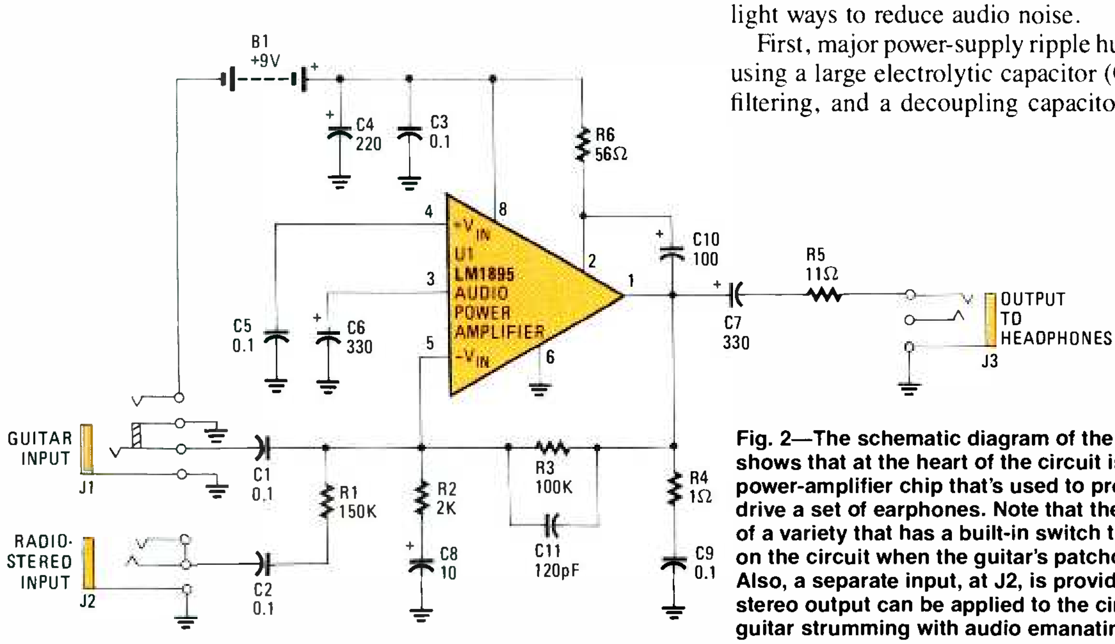
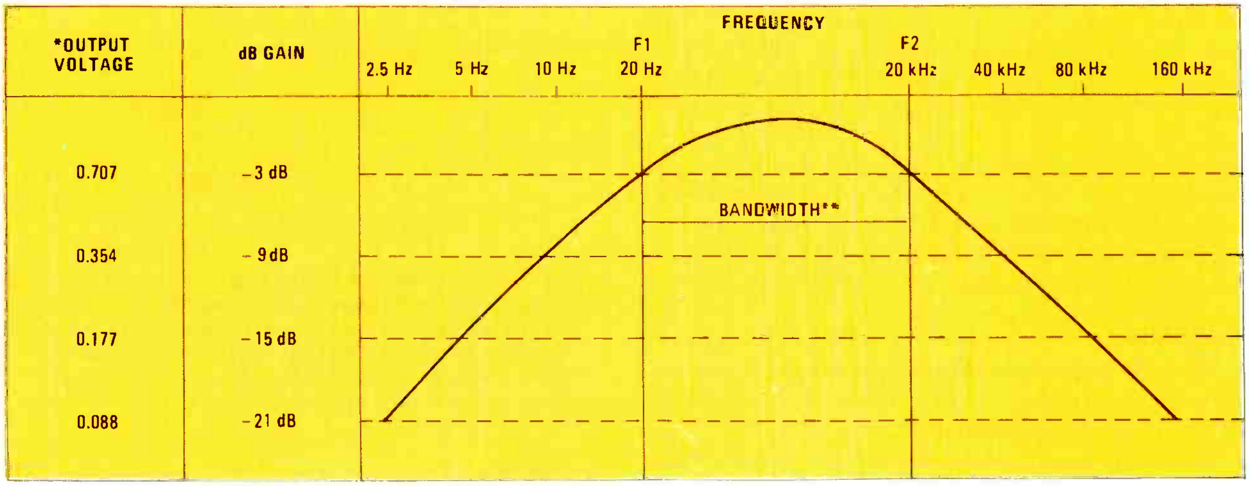


Fig. 2—The schematic diagram of the Silencer Guitar Amplifier shows that at the heart of the circuit is a single integrated power-amplifier chip that's used to provide enough boost to drive a set of earphones. Note that the guitar input jack, J1, is of a variety that has a built-in switch that automatically turns on the circuit when the guitar's patchcord plug is inserted. Also, a separate input, at J2, is provided so that a radio or stereo output can be applied to the circuit, allowing you to mix guitar strumming with audio emanating from another source.



*INPUT VOLTAGE SET AT 1 VOLT
**20 Hz-20 kHz BANDWIDTH at -3 dB DOWN WITH -6 dB ROLL-OFF PER OCTAVE: AMPLIFIER FREQUENCY RESPONSE.

Fig. 3—The Silencer's frequency is graphically shown. Note that as the bandwidth widens, the gain of the circuit drops off. For instance, with a bandwidth of from 20 Hz to 20 kHz, the gain in decibels is −3dB, an output of 0.707-volt rms with the amplifier set for 1-volt peak. But, as the bandwidth broadens, say to about 10 Hz to 40 kHz (which is nearly twice the 20 Hz to 20 kHz bandwidth), the output voltage is cut approximately in half and is said to be 6dB down.

and located close to the chip. Inadequate supply-bypassing manifests itself in low-frequency oscillation, which is also called motorboating, or high-frequency instability.

Second, by using maximum input signal-strength and minimum gain, the noise is amplified less; thus, the noise is less apparent. Stated another way, increase the signal-to-noise ratio as much as possible. Third, since the noise is spread throughout the frequency spectrum, reducing the bandwidth helps to limit high-frequency hiss.

Fourth, using metal-film resistors instead of carbon-film or composite resistors lowers the thermal-generated noise. That noise is created by the movement of electrons within the resistive material itself, which adds to audio noise. Other important criteria for reducing noise are: Separate inputs and outputs by a ground or V_s trace; separate inputs and outputs by as great a distance as possible. Twist battery-supply leads tightly to reduce ripple and voltage spikes; use shielded cable for input leads; and reduce output power by using a resistor in series with the output coupling capacitor (R5 and C7, respectively).

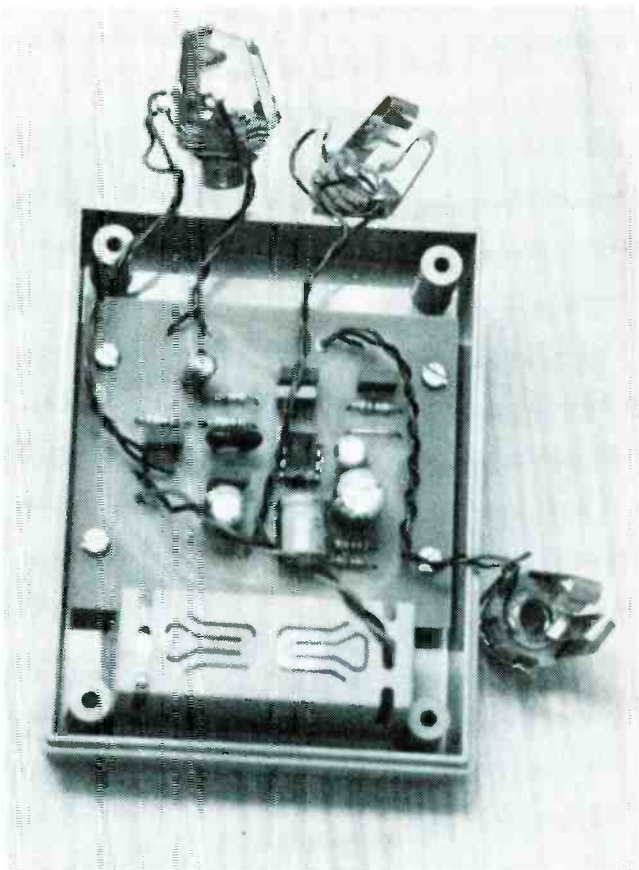
Output Circuit

Most headphones have impedances in the 4–32 ohm range and work well with the Silencer. However, the cheaper super-lightweight headphones, some of which have an impedance of over 200 ohms and poor power-handling capacity, seem to reduce the power output and degrade sound quality.

Circuit Theory

For the following discussion of component function within the circuit, refer to Fig. 2, the schematic diagram of the Silencer.

Resistor R1 attenuates the signal from the radio's headphone output to prevent input overloading at pin 5 of U1. (Its low-frequency pole is set by 1/2π R1C2.) AC coupling capacitors C1 and C2 pass the audio signal, while isolating the signal sources from U1's bias voltages. Resistors R2 and R3 effect feedback-voltage gain along with C8, which is also a



part of the AC voltage-gain adjustment. C11 is for frequency compensation, which stabilizes the amplifier by reducing voltage gain at the higher frequencies. Thus, the bandwidth is given by:

$$BW = 1/2\pi R3C11.$$

Resistor R4 and capacitor C9 work to stabilize the output stage and reduce those bottom-side fuzzies. Although R5 reduces output power slightly, it also aids in reducing noise and hum. C7, the output coupling capacitor, isolates pin 1 from the load, while R6 and C10 form a bootstrap, which sets drive currents for the output stage and allow pin 2 to rise above V_s.

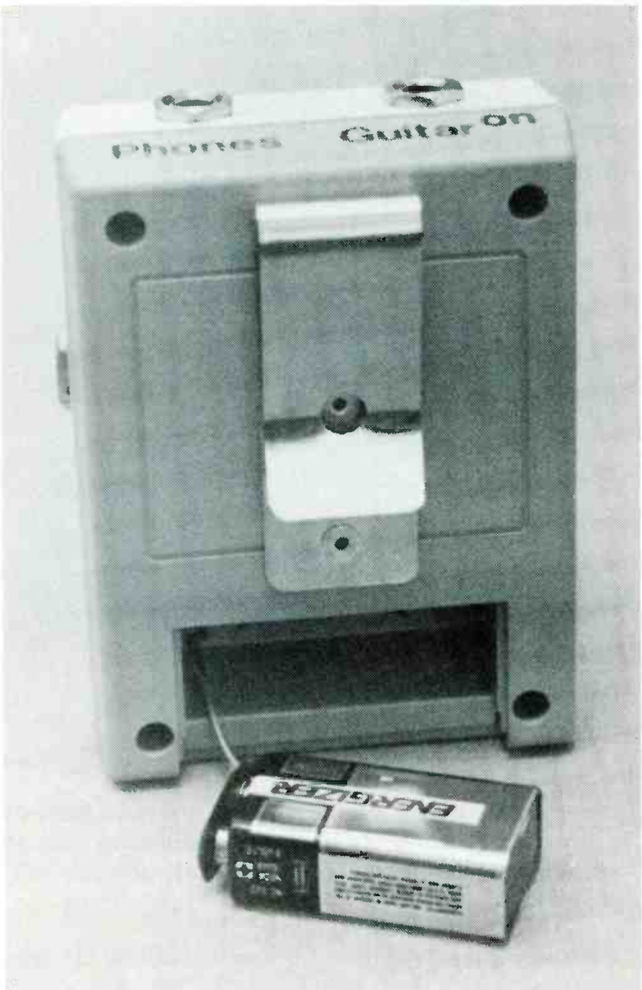
Capacitors C3 and C4 are used for power-supply filtering and decoupling. C6, which is a bypass capacitor, improves the power-supply ripple rejection ratio and prevents turn-on clicks and turn-off pops. C5 maintains pin 4 at a DC potential of $V_s/2$ at the noninverting input.

Modifications

The following describes modifications that can be made to the Silencer such as adding on/off and volume controls, and the addition of auxiliary distortion effects.

The Silencer is unique in that it's turned on by simply inserting the guitar patch cord plug into the input jack, which has an internal SPST switch that works great. As you slide the plug into the jack, the plug hits a piece of plastic that forces two contacts to close. Nevertheless, you can modify the design to use any standard SPST switch, as shown in Fig. 4. The addition of a light-emitting diode (LED) as an indicator is a nice feature, but it also drains the battery. The resistor, R8, in series with the LED is so placed to limit current through the indicator.

A volume control can be added to the Silencer's circuit by replacing R5, the 11-ohm resistor that's connected to the headphone jack, J3, with a 100-ohm potentiometer, R7, as shown in Fig. 5. One popular sound effect is the fuzz box.



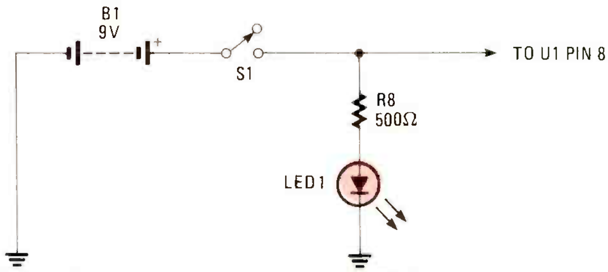


Fig. 4—If so desired, a switch and an LED indicator may be added to the Silencer Guitar Amplifier circuit to allow it to be manually turned on and off, and let you know that circuit is turned on. The LED might also serve as a battery status indicator, as the LED will glow more dimly as the battery begins to die.

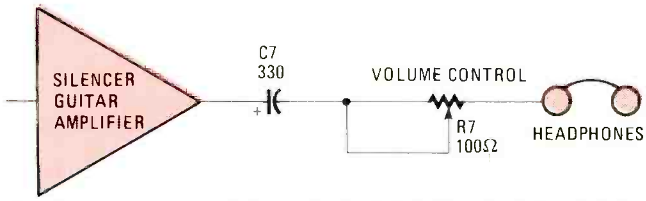


Fig. 5—A volume control can be added to the amplifier circuit by replacing R5, the 11-ohm resistor that's connected to the headphone jack, J3, with a 100-ohm potentiometer.

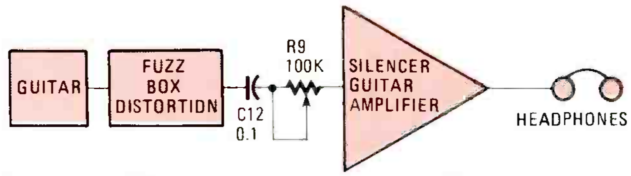


Fig. 6—An additional input may be added to the circuit to allow a fuzz box to be used with the Silencer. Since only two components are used, they may be inserted in the plug of the fuzz box.

PARTS LIST FOR THE SILENCER

SEMICONDUCTORS
LED1—red light-emitting diode
U1—LM1895 audio power-amplifier integrated circuit

RESISTORS
(All resistors are ¼-watt, 5% fixed metal-film units, unless otherwise noted)
R1—150,000-ohm
R2—2000-ohm
R3—100,000-ohm
R4—1-ohm
R5—11-ohm
R6—56-ohm
R7—100-ohm, audio-taper potentiometer
R8—500-ohm
R9—100,000-ohm, audio-taper potentiometer

CAPACITORS
C1, C2, C3, C5, C9, C12—0.1-µF, ceramic disc
C4—220-µF, 10-WVDC, electrolytic
C6, C7—330-µF, 10-WVDC, electrolytic
C8—10-µF, 25-WVDC, electrolytic
C10—100-µF, 10-WVDC electrolytic
C11—120-pF, 5%, silver-dipped mica

ADDITIONAL PARTS AND MATERIALS
J1—Switchcraft model 13 ¼-inch phono jack with isolated make-contact circuit, 2-conductor type
J2, J3—¼ in., 3-conductor phono jack
S1—Single-pole, double-throw (SPDT) switch
B1—9-volt transistor radio-type battery
Printed circuit material, enclosure, rivets, belt clip, hardware, solder, wire, ribbon cable, etc.

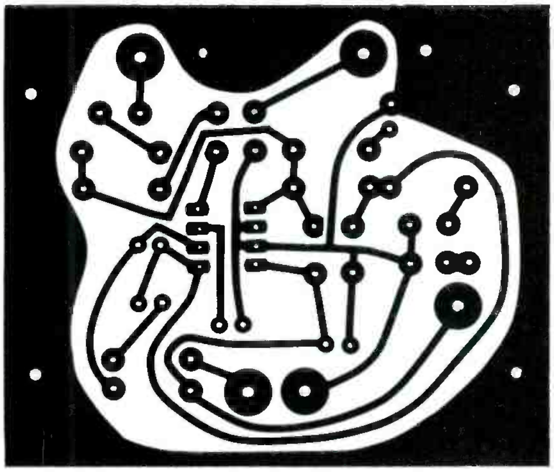
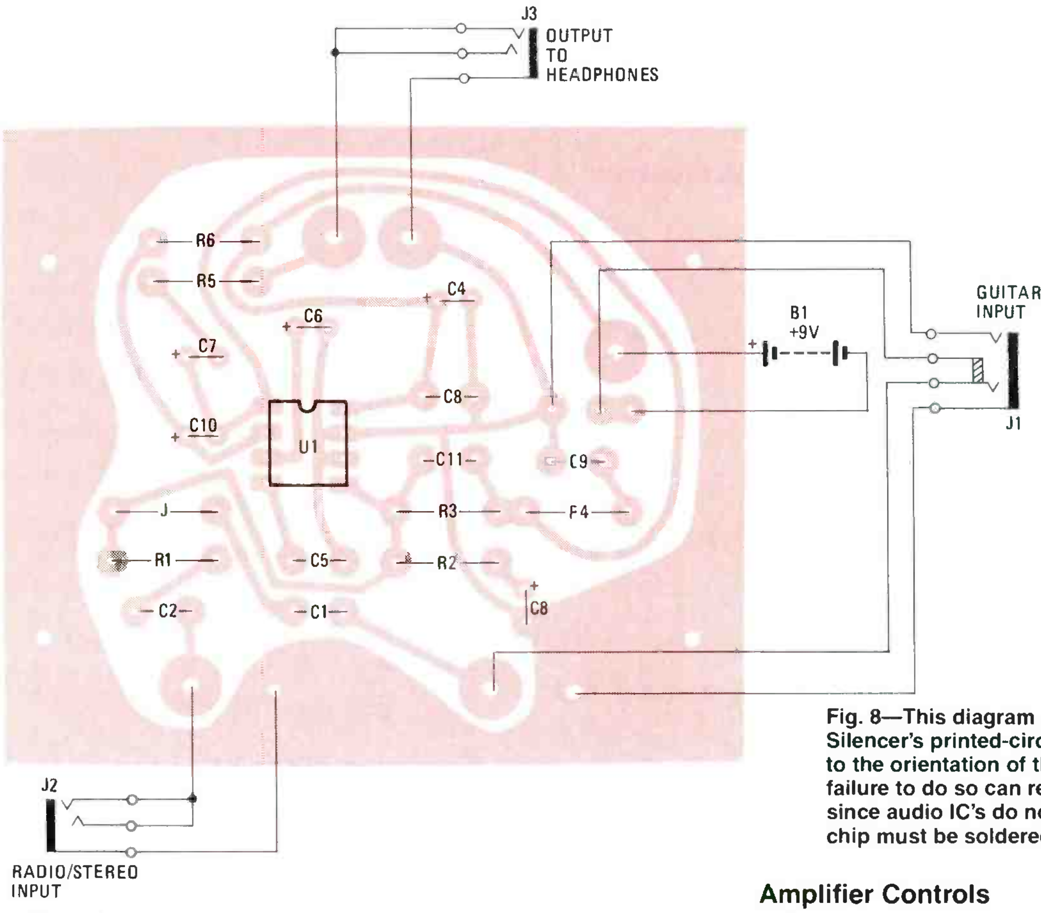


Fig. 7—The foil pattern for the Amplifier's printed-circuit board is shown full size.



They often have an internal amplifier that alters the guitar's sound by clipping the waveform, producing numerous harmonics. Figure 6 shows that only two components, C12 and R9, are needed to interface the fuzz-box output to the Silencer to prevent overloading.

The capacitor isolates the fuzz box DC bias, while coupling the audio output to the Silencer Amplifier, which is represented by the standard amplifier symbol. Potentiometer R9 is used to bring the output voltage of the fuzz box down a point where the amplifier is not overloaded. The guitar is plugged into the fuzz box, and its output is then coupled thru C12 and R9 into the Silencer.

Amplifier Construction

The Silencer can easily be built on perfboard or experimenter's board, however, for those who prefer a PC-type layout, a foil pattern is provided in Fig. 7. When putting the Amplifier circuit together, do not use an IC socket for the LM1895. Audio circuits and IC sockets don't mix well. Also, wire-wrap is fine for digital electronics, but wreaks havoc with audio, so solder all connections. Of course, good grounding and power-supply decoupling are always essential when working with audio. Fig. 8 shows the parts-placement diagram for the PC-board layout. Since the chip does not generate a lot of heat, it requires no special heatsinks.

Figure 9 is a pinout diagram of the LM1895 for those who may need one. By using the pinout diagram in conjunction with the schematic of Fig. 2, you should have no problem in building the circuit on perforated construction or experimenters board. Just remember that the same precautions apply, no matter what construction method is used.

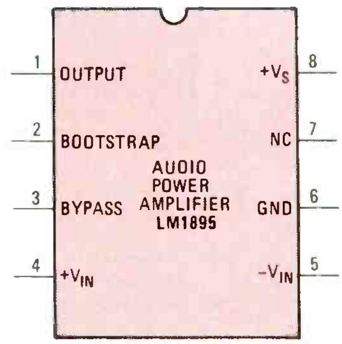


Fig. 9—The pinout diagram for National Semconductor's LM1895, audio-power amplifier is shown here for those who choose to build the Silencer Guitar Amplifier on experimenters or perforated construction board. By using this diagram in conjunction with the schematic in Fig. 2, you should have no problem in getting the circuit to work. The same considerations apply with printed-circuit construction.

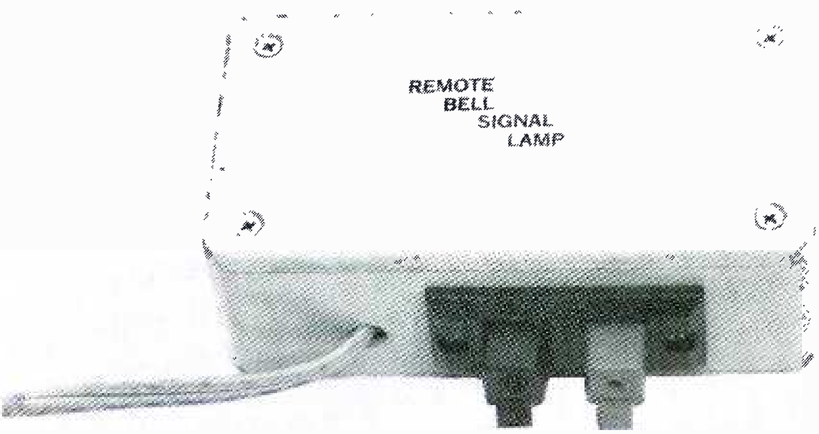
Fig. 8—This diagram shows the parts location on the Silencer's printed-circuit board. Pay particular attention to the orientation of the polarity dependent components; failure to do so can result in burned out parts. Also, since audio IC's do not work well when socketed, the chip must be soldered directly to the PC board.

Amplifier Controls

For the headphone output jack, use a ¼-inch stereo plug only. The guitar input jack has an internal on/off switch that turns on the Amplifier when the guitar's patchcord plug is inserted. When unplugged, the amp turns-off. For the music input jack, use a ¼-inch stereo patchcord. By plugging the Guitar Silencer Amplifier into your radio's headphone output, you are able to mix your strumming with the music.

Amplifier Use

First, securely clip the Silencer onto your belt and plug your stereo headphones into the appropriate output jack. Then insert the guitar's patchcord plug into the GUITAR ON input jack. Adjust the guitar pick-ups, volume, and tone controls. To play along with your favorite record, use the music box. ■



REMOTE DOORBELL SIGNAL LAMP CONTROLLER

This lamp controller will let you see that the doorbell is ringing —even if it's impossible to hear it.

By Herb Friedman

□THE DOORBELL MUST BE HEARD BEFORE IT MAY BE ASKED, "For whom the bell tolls." Unfortunately, in this era of super-power amplifiers, boom boxes, personal sound through headphones, rock, punk, and new-wave music, disco parties, and backyard barbecues, many a visitor has stood outside in the hot sun, high humidity, rain, sleet or snow waiting for someone to hear the doorbell. But, fortunately, we can sometimes substitute one sense for another: If we can't *hear* the doorbell, the next best thing is to *see* it, in the form a flashing bright light.

Whether you're snuggled under headphones listening to a 110-piece orchestra playing *The Great Gate At Kiev* at full volume or Madonna belting out *Material Girl*, you're going to know someone's at the door when a 60-watt lamp starts shining in your eyes. All it takes to make the transition from doorbell to bright light is the Remote Doorbell Signal Lamp Controller—we'll call it Controller for short. Each time the doorbell is pressed the device turns on any kind of conventional 117-volt AC lamp to which it's connected.

How It Works

The heart of the Remote Doorbell Signal Lamp Controller circuit shown in Fig. 1 is an optocoupler-coupler, U1, which provides total isolation between the 16- to 24-volt AC doorbell circuit and the lamp's 117-volt AC power source. The optocoupler, housed in a 6-terminal DIP package (resembling a conventional integrated circuit), is made up of two independent devices: a light-emitting diode (LED) and a light-sensitive *diac* or bi-directional diode. The LED is normally off so the the diac represents a high impedance or open circuit.

When someone rings the doorbell, the same low-voltage AC that causes the doorbell to ring is applied to the optocoupler (at pin 1 and pin 2) through resistor R1 and diode D1, causing the LED to glow inside the package. The two devices are positioned within the package so that radiation emitted by the LED falls on the light-sensitive surface of the diac. That illumination causes the diac to conduct, thereby applying gate current to the triac, TR1. That, in turn, causes the triac to conduct (in effect a short circuit), allowing current to flow through SO1 so that any conventional 117-volt AC lamp screwed into the socket is illuminated.

The triac remains on only as long as a gate current is applied, hence, the lamp connected to SO1 glows only when the doorbell is depressed and turns off when the doorbell is released. Therefore, someone impatiently jiggling the doorbell causes the lamp to blink in step with the doorbell.

Diode D1 is used as a protective or "checkout" device. It isn't really needed, and if desired it can be replaced with a jumper wire. It is shown in the schematic diagram (Fig. 1) only to indicate its location in relationship to the other components. The specified 1N4001 diode is an inexpensive, commonly-available rectifier that protects against accidentally connecting the device to an unusual doorbell circuit. Normally, a doorbell or doorchime operates from a 10 to 24-volt AC source. However, there are some unusual homebrew and commercial "door annunciator" circuits that can use anything up to 40-volts AC. Also, there are some "reject" optocoupler-couplers floating around the marketplace whose peak inverse voltage (PIV) rating is lower than that of the unit specified in the parts list. D1 protects the optocoupler in a doorbell system having an unusually high voltage.

Alternately, if you are certain of the doorbell system's voltage and the quality of the optocoupler, you can replace D1 with a conventional LED that can be observed through a small hole in the front of the cabinet, or you can push the LED through the hole. Then, whenever the doorbell is activated, the LED lights. In this way, you can quickly check out the system if the lamp fails to light. If the LED lights and the lamp doesn't, you have made a wiring error, or the lamp is burned out, or the lamp's own switch is turned off.

Putting It Together

The author assembled the circuit of the Controller on a small printed-circuit board, measuring 4-$\frac{5}{8}$ × 1-$\frac{1}{4}$ inches (see photos), for which we provide a full-scale template in

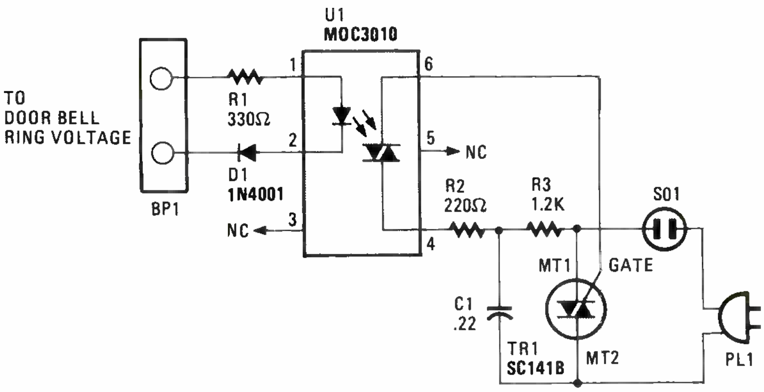


Fig. 1—The schematic diagram of the Remote Doorbell Signal Lamp Controller. The circuit acts as an interface between the doorbell's ring voltage and the 117-volt outlet. When the circuit is tied to the doorbell and PL1 plugged into any AC outlet, an ordinary lamp plugged into SO1 can act as a "visual" doorbell. It is particularly well suited to situations where the conventional doorbells are ineffective—for instance, when you're listening to your favorite music through stereo headphones, or when it's in the homes of persons who have suffered a hearing loss.

Fig. 2. Nothing about the printed-circuit board is critical other than using slightly oversize solder pads for the linecord and SO1 connections, which must be conventional AC wire (zip cord). The reason that the solder pads must be oversize is because zip cord is thicker than the #20 and #22 solid wire generally used for printed-circuit board connections. Refer to Fig. 3. It requires a larger hole, which is almost as large as the small solder pads used for component leads and #22 wire connections. To ensure the pads have sufficient copper remaining for a reliable connection after the oversize holes are drilled for the zip cord, it's necessary to start out with oversize solder pads.

Make certain that you offset TR1's center lead, as shown in the photos; there is a good chance that the connections will short-circuit if you modify the offset connections and make them in-line. A #55 drill bit is suggested for all component wire holes. Use whatever drill bit just clears for the kind of zip cord you're using, and use a #28 bit (#6 screw body size) for TR1's mounting screw. Although a #4 screw is used to secure TR1, the hole in the printed-circuit board is for a #6, because the extra play will probably be required. With a little extra slop in the hole and not-to-tight screw-head binding, the printed-circuit board will not crack.

The indicated TR1 mounting hole in the template is a relative position: its precise location depends on the lead length of the particular triac that you use. Bend the triac's leads first, fit it to the board, then mark the location of the hole in TR1's tab on the printed-circuit board. Solder the leads after it is mounted. Also note that there is a relatively large 1-¼ × 1-¼-inch copper area through which TR1's mounting screw passes. The copper foil serves as a small heat sink for that unit. Normally, it's not needed: It's only there to provide some degree of protection for the triac in the event that someone forgets and connects a lamp to SO1 that is substantially larger than the specified 60 watts.

Because 117-volts AC is involved, the project should be assembled in a plastic cabinet having a plastic rather than a metal cover or panel. In particular, we suggest the all-plastic 4-¾ × 2-½ × 1-⁹⁄₁₆-inch Radio Shack Economy Case (catalog No. 270-222) specified in the Parts List be used, because it has internal slots that are used to position and secure small printed-circuit boards in place. If the printed-circuit board is simply dropped into the set of center, lengthwise slots molded inside the cabinet, it will be secured without the need for mounting screws or brackets when the cabinet's cover is applied.

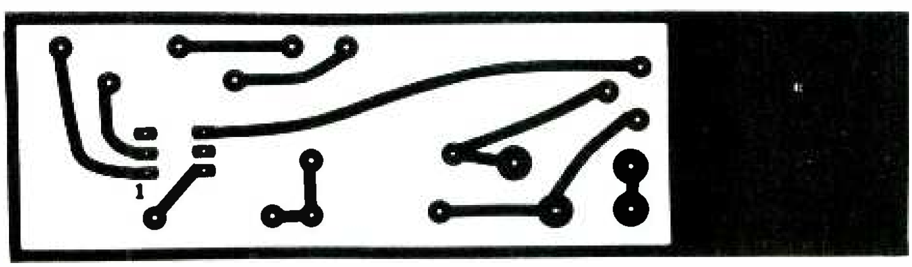


Fig. 2—The foil pattern for the Remote Doorbell Signal Lamp Controller is shown full-scale. The 1-¼ square-inch section of the pattern to the right of the template acts as a small heatsink for the triac when its tab is secured to the board.

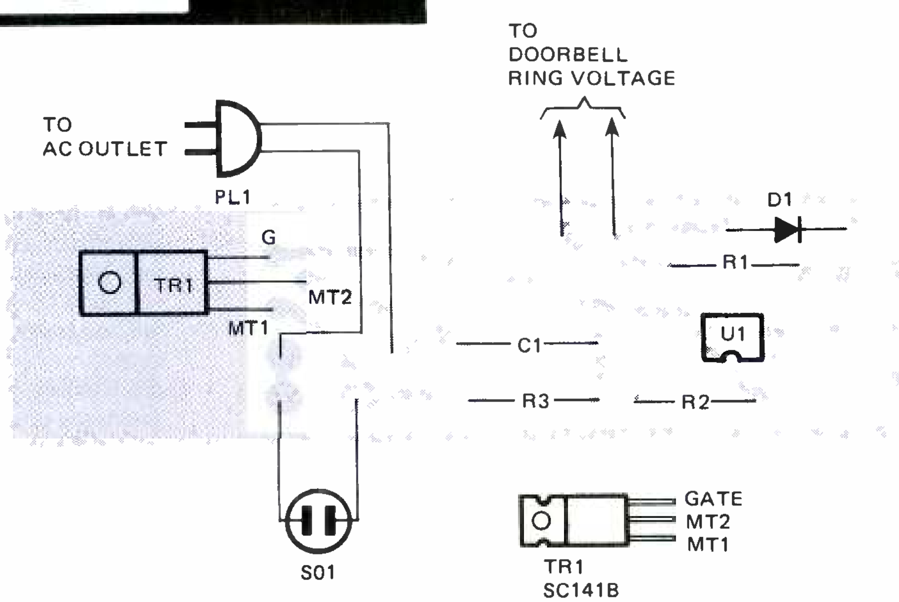
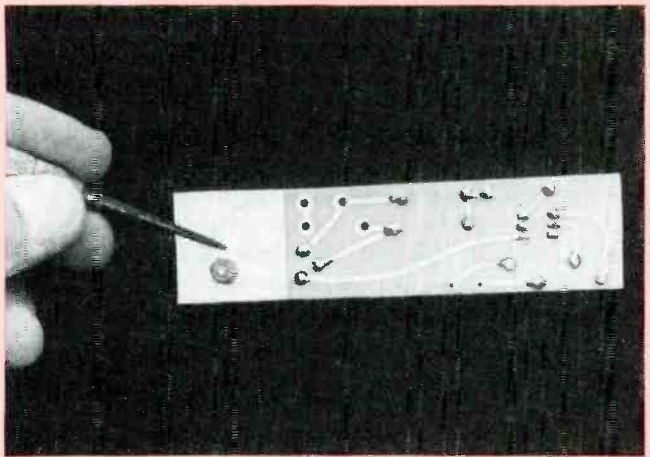
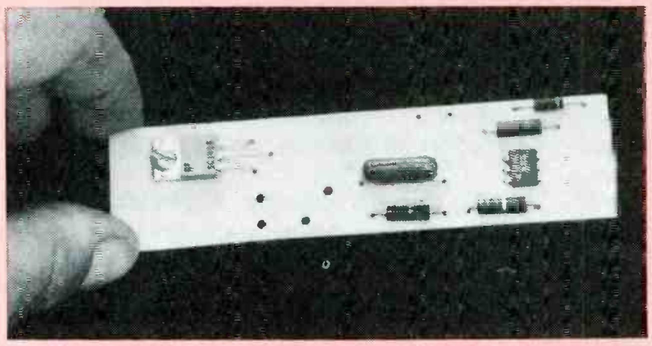


Fig. 3—The layout for the circuit shows that the pads provided for the triac, TR1, are offset so that the possibility of shorting the leads of that unit is greatly reduced.



Oversize pads are provide for the 117-volt AC connections so that once the holes are drilled, there will be enough copper left to make good solder connection with the thick copper wire. The large copper area to the left of the board acts as a heat sink when the triac's metal tab is bolted to the board.



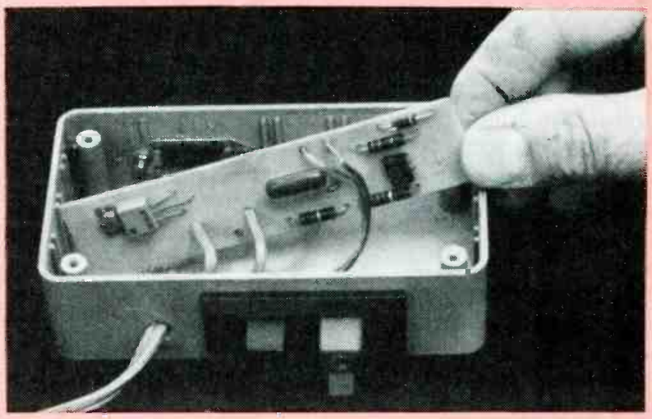
The leads of the triac are offset to prevent shorting the 117-volt AC power source. When installing the triac, first insert its leads in the holes provided and bend so that the metal tab lies flat against the board. Then mark and drill a hole for the mounting hardware. Position and bolt the triac, and then solder the triac leads into position.

PARTS LIST FOR REMOTE DOORBELL SIGNAL LAMP CONTROLLER

C1—0.22-µF, 200-WVDC (or more)
D1—1N4001, 1-A, 50-PIV, silicon rectifier diode (optional, see text)
R1—330-ohm, ½-watt, 10% resistor
R2—220-ohm, ½-watt, 10% resistor
R3—1200-ohm, ½-watt, 10% resistor
TR1—SC141B, 200-volt, 6-A triac (General Electric or similar)
U1—MOC3010 optocoupler (Motorola or similar)

ADDITIONAL PARTS AND MATERIALS

BP1—2-terminal binding posts (see text)
PL1—AC line (zip) cord with molded AC plug
SO1—Chassis-mounted AC socket
Printed-circuit material, enclosure, solder, hookup wire, etc.



Because of tight spacing in the cabinet, it is necessary to make all external connections to the board before it is inserted into the cabinet. Grooves in sides of box hold printed-circuit board in place—cover will lock it in place.

Socket SO1 is a conventional chassis mount type, the kind that's secured with screws. The snap-in kind is not recommended, because the plastic cabinet is too flexible to hold it in place if the lamp is frequently plugged in and out. Binding post BP1—for the low-voltage bell connections—can be just about anything. The connectors having spring-loaded terminals generally used for speaker connections are suggested, because they require the least cutting of the cabinet, and the bell wires can be installed or disconnected at the touch of a button.

Because SO1 connects to the foil side of the printed-circuit board, it should be wired and soldered before the printed-circuit board is installed in the cabinet. Use a 4-inch length of wire to connect SO1 to the board; the slack can be folded inside the cabinet when the printed-circuit board is installed. The wires from SO1's terminals connect to the large solder pads at the bottom of the board. Also pre-solder the linecord connections to the large solder pads in the center of the board, and solder one side of a pair of wires 3 inches in length to the printed circuit board's 16-volt solder pads—the ones that connect to R1 and D1.

Slide the printed-circuit board into the cabinet's lengthwise center supports; then secure socket SO1, and *then* solder the 16-volt input wires to the binding post's terminals.

Checkout And Use

First, make certain that you have an operative lamp—try it out on a conventional AC outlet—and then connect the lamp to SO1. Connect extension wires from your doorbell circuit to binding post BP1. Then plug the controller's power cord to a 117-volt AC convenience outlet. The lamp should turn on when the doorbell is pressed and turn off when the doorbell is released. If the lamp remains on, you either have a defective component or your doorbell's extension wires are connected across the doorbell transformer—which is always "on"—rather than across the doorbell or chime connections, which are always off until the doorbell is pressed.

Check U1 and TR1 by disconnecting the wires from the binding posts. If the lamp remains on, either U1 or TR1 is defective or you have made a wiring error. If the lamp turns off, you have probably connected the binding-post terminals across the doorbell transformer rather than across the terminals of the doorbell or doorchimes. If it all checks out, simply leave the device connected at all times.

No power switch is provided for the Controller, because it's not needed. If you don't want the lamp turning on and off until specifically required, simply turn off the lamp's own power switch. ■

PICK-A-NUMBER COUNTER AND TIMER

Pick a number from 2 to 4096 and divide—it's easy!

By Edward M. Noll

AN INTEGRATED-CIRCUIT COUNTER SUCH AS THE 4040 along with a clock and other accessory chips, can be wired to provide bonus counts and timing intervals in addition to its designed count outputs. For example: The 4040 chip is a 12-stage binary ripple counter, providing the divide-by quantities of 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, and 4096. Additional counts between those limits are possible by combining outputs. For example, by combining the divide-by-2 and divide-by-4 outputs in an appropriate circuit, a count of 3 can be obtained. With an appropriately timed clock the outputs can also represent specific time intervals. If the clock input is exactly 1/60th of a second, the divide-by-3 outputs would be spaced 1/20th of a second apart. Information on the circuitry to obtain many divisions between 2 and 4096 follows.

The basic building blocks of such a system that provides divide-by quantities inclusive from 2 to 4096 are shown in Fig. 1. First there is the clock, which can be one of the low-cost chips that generate a 60-Hz squarewave output from a 3.58-MHz TV crystal. That is followed by the 12-stage ripple counter. The various outputs of the ripple counter are supplied to a gate system that provides the proper combinations to obtain a specific count. It also generates a reset pulse that is conveyed back to the counter, which resets its operation after a specific count has been reached. The gate output is supplied to a one-shot monostable generator that develops the desired output. The time constant of the monostable generator can be regulated to obtain an output of a specific duration.

The binary ripple sequence for the 4040 is given in Fig. 2. Each of the binary outputs is twice the count of the previous one. The A1 count is 2, followed by an A2 count of 4. The A11 count is 2048 followed by the last A12 count or 4096.

The examples shown in Figs. 3 and 4 demonstrate the grouping or "AND'ing" process to obtain intermediate count values. Fig. 3 demonstrates a 4 count. In the 4040 operation, the transition of the input clock logic from 1 to 0 causes a change in logic at the output of the first counter. A change in logic from 1 to 0 at the output of the first counter results in a logic transition at the output of the second counter, etc. Let's follow the sequence. At rest or power-on the logic output at A1 and A2 is zero as shown in the chart of Fig 3. Now the clock makes a 1 to 0 transition. As a result the logic at A1 output changes from 0 to 1. Note that it is a 0 to 1 A1 change and, therefore, there is no logic transition at the output of the second counter and it remains zero.

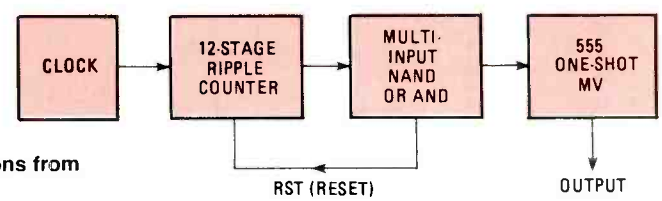


Fig. 1—Basic block diagram for obtaining divisions from 2 to 4096 inclusive from a standard clock input.

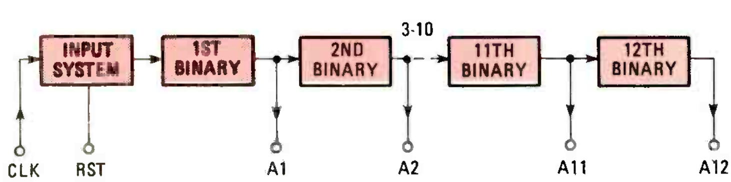
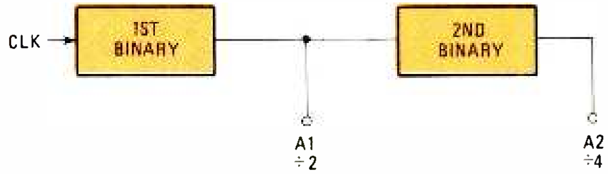


Fig. 2—Binary ripple sequence for the 4040 integrated circuit. Each of the binary outputs is twice the count of the next higher order.



CLK	A1	A2
0	0	0
1	1	0
2	0	1
3	1	1
4	0	0

Fig. 3—The outputs for two successive divisions result in a ÷2 and ÷4. The table highlights the relative output pulses with each other and the clock pulses.

The negative transition of the second clock pulse again changes the logic at the output of A1 back to 0. At that time, however, the A1 output is a 1-to-0 transition and, therefore, the second counter has a logic transition from 0 to 1. Always keep in mind that an output transition for any counter occurs only when the logic at its input changes from 1 to 0. No logic change occurs when the input changes from 0 to 1.

The negative transition of clock pulse 3 changes the A1 output logic to 1. However, that represents an input change to the second counter of 0 to 1 and, therefore, its output logic remains at 1. The fourth clock pulse results in a change of both output logics back to 0 at A1 and A2. The output changes at A2 represent one full cycle of change as compared to the four clock input pulses. There has been a frequency division of 4.

Figure 4 shows how the introduction of a two input AND gate can establish a divide-by-3 output. First recognize that the output of the AND gate will be a logic 1 whenever outputs A1 and A2 are both at logic 1. Stated another way, both counters will be reset to 0 whenever the two inputs to the AND gate are at logic 1 simultaneously.

Let's follow the logic sequence. For the 0, 1, and 2 values of the clock rows associated with example C in Fig. 4, the A1 and A2 logics are the same as they were for example B. Likewise, the negative transition of clock pulse 3 produces a logic 1 at A1 and A2 just as it did in example B. However, note that the same logics are being applied to the two-input AND gate causing both counters to reset immediately to 0 before clock pulse 4 arrives. In other words, the counter has been reset at the end of the third clock pulse. As a result the output is a divide-by-3 count instead of a 4. The arrival of clock pulse 4 causes A1 and A2 to immediately go to the same logic settings of clock pulse 1, beginning a new divide-by-3 sequence.

Observe that the grouping of the two and four outputs resulted in a division-by-3 or (2+4)/2. If one would group outputs 16 and 32 in the same way the division would be 24—(16+32)/2. Table 1 shows how the appropriate grouping of outputs A1 through A4 can result in a choice of any count between 2 and 16. Notice that to obtain a count of 15 it is necessary to "AND" all four outputs and apply them to a four-input gate. That idea is shown in Fig. 5A. If you wanted to obtain an exact count of 201, you would "AND" A8, A7, A5 and A1 outputs to the gate obtaining 201—(256+128+16+2)/2. Fig. 5B shows an AND gate with 8 inputs should you need that many. Those that are not used can be tied to the V_{CC} (high) line.

In the complete circuit of Fig. 6, any four or less outputs can be used. In so doing, the counter will be able to make any count between 2 and 16 and, of course, many more counts in excess of 16. However, not every specific value above 16 is obtainable with that circuit. The use of an eight-input AND gate, as in Fig. 5B, permits every count up to 256 and a host of counts above that value. If you wished all counts from 2

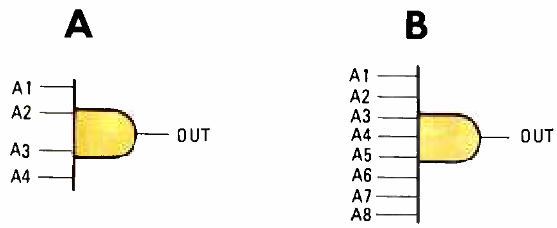
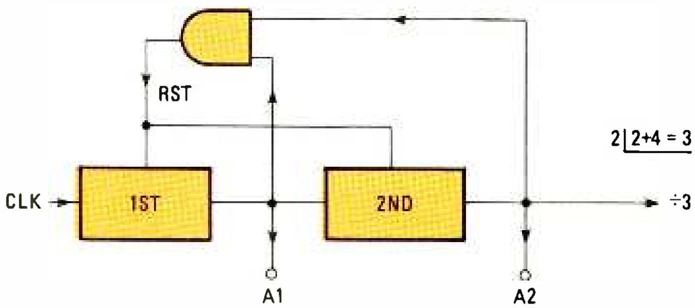


Fig. 5—AND gates with 4 and 8 inputs.

TABLE 1
COMBINING OUTPUTS FOR PROPER COUNT

COUNT	OUTPUT COMBINE(S)
2	2
3	2 |2+4
4	4
5	2 |2+8
6	2 |4+8
7	2 |2+4+8
8	8
9	2 |2+16
10	2 |4+16
11	2 |2+4+16
12	2 |8+16
13	2 |2+8+16
14	2 |4+8+16
15	2 |2+4+8+16
16	16



CLK	A1	A2
0	0	0
1	1	0
2	0	1
3	{1 0	{1 0
4	1	0

Fig. 4—With a slight modification of the previous diagram in Fig. 3, this circuit can divide by 3. Table highlights output relationships. Note what occurs at clock pulse 3.

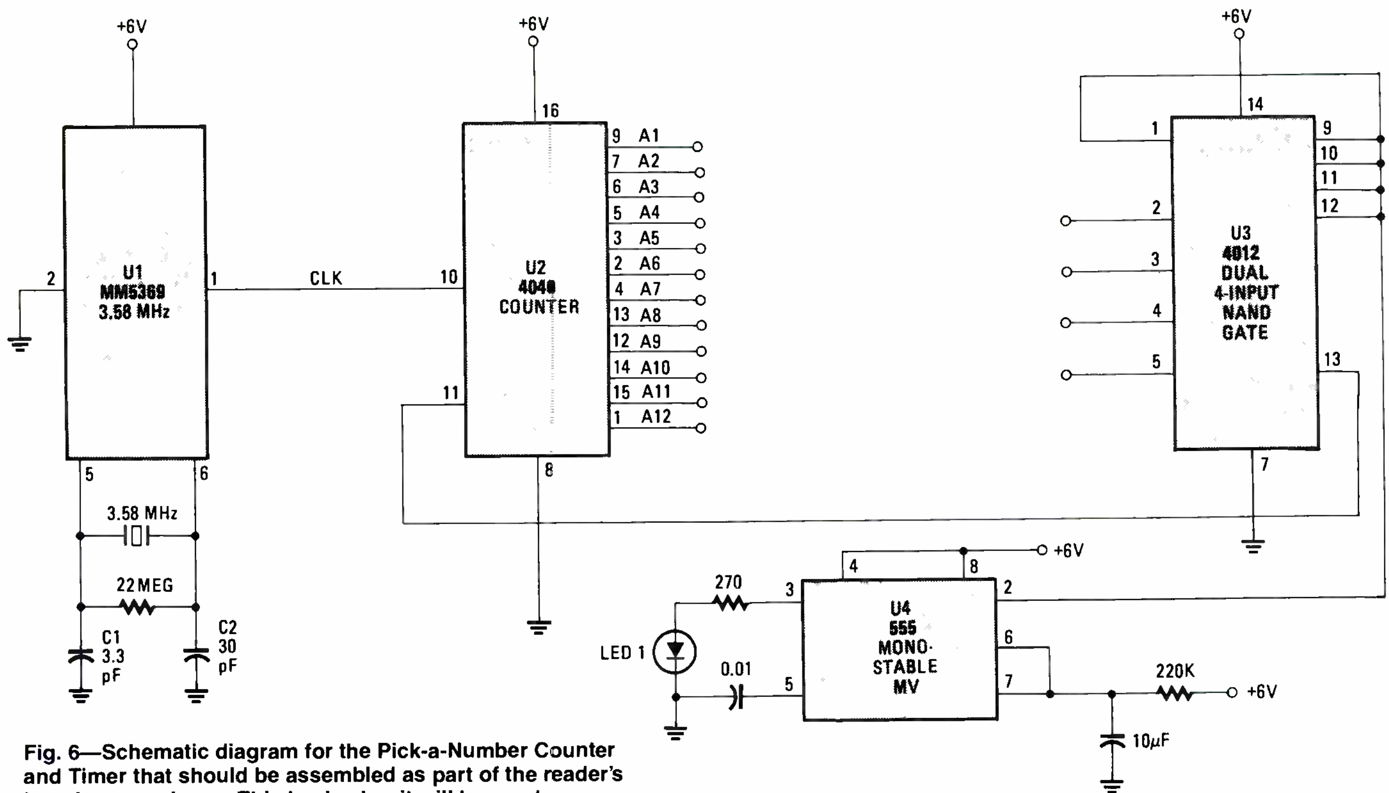


Fig. 6—Schematic diagram for the Pick-a-Number Counter and Timer that should be assembled as part of the reader's learning experience. This basic circuit will be used many times in many projects by active builders.

through 4096, you would need to design the digital equivalent of a twelve-input gate.

Counter/Timer Circuit

The circuit arrangement of Fig. 6 provides many useful counts and time intervals. It can be constructed on a small 2- × 5-inch solderless circuit-board using the low-cost and readily available chips shown. The clock is the popular MM5369 chip. To obtain a precise 60-Hz output, it may be necessary to make some adjustments in the values of capacitors C1 and C2 according to the characteristics of the 3.58-MHz crystal used. That is the popular TV color-burst crystal with a precise frequency of 3.579545 MHz. Capacitor values for our particular color-burst crystal to obtain an exact 60 Hz output are given.

In the circuit of Fig. 6, a dual 4-input NAND gate, U3, was used to obtain the proper positive reset pulse for the 4040 12-stage binary ripple counter, U2, as well as a negative trigger pulse for the 555 monostable multivibrator, U4. According to the count desired, four or less outputs of U2 are connected to the four inputs of the A NAND gate of U3. If less than four outputs are required to obtain a specific count, it is necessary to connect the remaining inputs to the supply voltage. For example, if a count of 6 was needed, the A2 and A3 outputs would be connected to inputs 2 and 3 of the 4012 while inputs 4 and 5 would be connected to a logic 1 (V_{CC}—supply voltage).

The output of the section A NAND gate at pin 1 is connected to the paralleled inputs of section B. That is a negative pulse because a NAND gate is used and it occurs each time the four inputs are simultaneously at logic 1. As a result the same negative-transition pulse can also be used to trigger the 555 monostable, U3. Note the connection to pin 2 of the 555. The output of section B of U3 at pin 13 will see a 0 to 1 transition at the same time. That is the reset bus. Therefore, the positive transition at pin 11 of U2 provides reset for all 12 counters at the end of the chosen count.

The 555, U4, is wired as a basic monostable with a light-emitting diode LED1 to serve as an output indicator. However, the pin-3 output of U4 provides a high-level drive for any circuits and systems you want to hang on to the output of your counter/timer. The time constant is connected to pins 6 and 7 of U4. The values shown provide an output pulse with a duration of approximately 2.4 seconds. Values can be selected for the particular pulse duration you desire. The basic duration-duration equation is:

$$t_D = 1.1RC$$

where t_D is in seconds, R is in megohms, and C is in microfarads.

In selecting a time duration, choose one that has a period less than that of the particular count you selected. If the pulse duration is longer than the period of the count, LED1 will remain on. There may be situations in which you wish to do that, depending upon your particular application. You may wish a continuous output for a particular high count and a pulsed output for a lower count.

After building the project detailed in Fig. 6, you can check out its operation by interconnecting the counter outputs with the NAND gate input circuit for the one-minute timer operation detailed in Fig. 7. Binary outputs A5, A10, A11, and A12 are used. To do so, counter pins 1, 3, 14, and 15 on U2 are connected to the NAND gate inputs 2, 3, 4, and 5 on U3. As shown, the total count is 3600 and, 1/60th of a second period multiplied by 3600 equals a time period of 60 seconds or one minute.

Set up that operating condition and use a watch that's capable of reading in seconds to time the output of the 555, U4. LED1 should come on once each minute for a time duration of approximately 2.5 seconds.

Substitute a 1-megohm resistor in the U4 time-constant

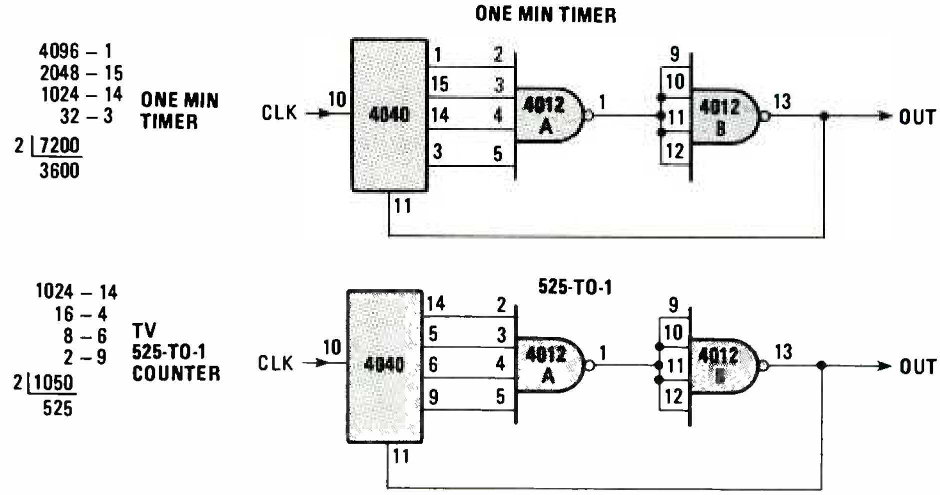
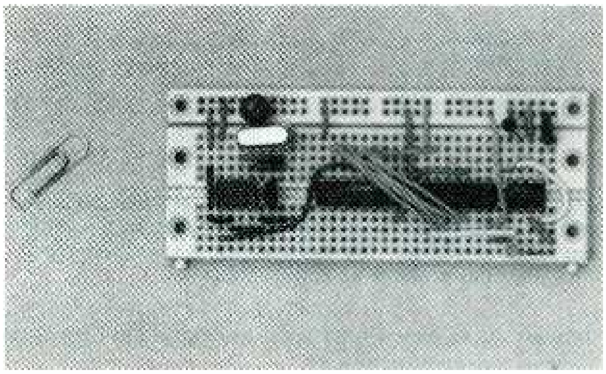


Fig. 7—Here are two count examples that are commonly used. The one-minute timer may be used in a darkroom timer, and the ÷525 counter may be used with a TV raster-marker generator.



The author backs up theory with practice. The circuit was assembled on a solderless circuit-board and powered up. If possible, assemble a test circuit so that you can reinforce your learning with hands-on knowledge.

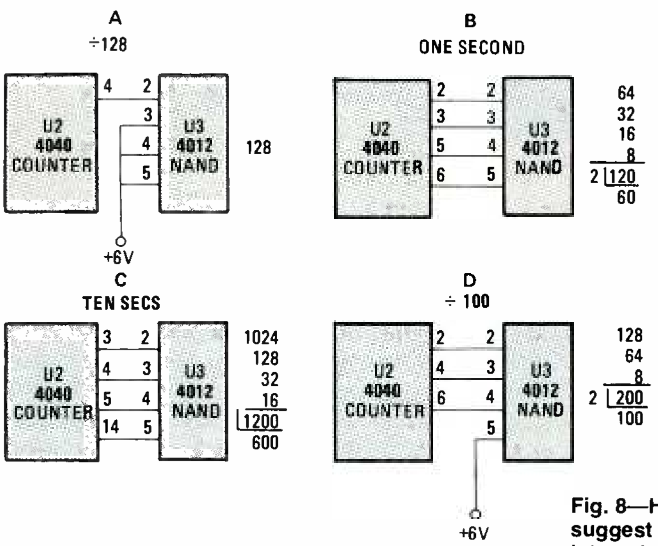


Fig. 8—Here are four count and timing examples that suggest the availability of many other counts and intervals. Understand what is going on here and you will be able to chart other desirable circuits.

circuit. The pulse-output duration should now be approximately 11 seconds. Substitute a time-constant resistor of 2.2 megohms and note the increase in the pulse duration. Go back to the original 220,000-ohm time-constant resistor.

Try 525:1

The second example illustrated in Fig. 7 shows how to interconnect the counter circuit to attain the count of 525 to 1. That is the television system count-down value. A line-rate synchronization pulse, or a double-line rate pulse, applied as the clock frequency will result in a count down to 30 and 60 Hz, respectively. Interconnections and the appropriate grouping are illustrated in Fig. 7.

Procedure for Lower Counts

In making many of the substantially lower counts, three or less of the counter outputs are required. In that case, one or more of the 4012 inputs may need to be connected to a logic 1. Some examples are given in Fig. 8.

When a divide-by-128 count is desired, pin 4 of the counter is connected to one of the inputs of the NAND gate and the other gate inputs are connected to logic 1 (V_{CC}). Refer to the connections in Fig. 8A. Apply power and notice the output pulsing at a slow rate with a long duration interval as compared to the off time. Shorten the pulse duration by substituting a 1μF capacitor in the U4 time constant circuit in Fig. 6.

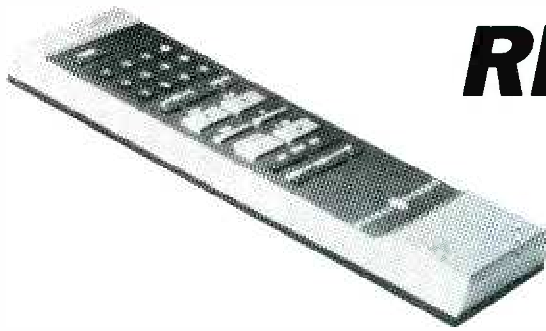
How would you obtain 1 output per second? A division of 60 would be required (1/60th seconds × 60). The interconnections of Fig. 8B would do the job.

One output is desired every ten seconds. What count grouping is needed? Example C of Fig. 8 shows the interconnections. Check it out.

Assume that you wish to count in decades, such as 10, 100 or 1000. A count of 100 requires three outputs as shown in example Fig. 8D. Counter output pins 2, 4, and 6 are connected to the NAND gate input. The fourth NAND gate input is connected to the supply voltage.

For a count of 1000, six counter outputs would be required, A4, A6, A7, A8, A9, and A10. To accommodate six inputs, one could use a standard 8-input 4068 AND gate. Six of the inputs would be used and the remaining two would be connected to supply voltage. However, the simple circuit arrangement of Fig. 6 is very useful and provides most count and timing possibilities. It does so in an efficient and low-cost manner with an extra feature of being able to regulate the duration of the final output pulse. ■

HOW TO CHECK YOUR TV's REMOTE-CONTROL SYSTEM



Eliminating remote-control problems can be a lot easier than you think, if you know what to look for.

By Homer L. Davidson

TODAY, JUST ABOUT EVERYONE HAS A HAND-HELD REMOTE transmitter to allow arm-chair operation of their color TV receiver or VCR. Beside turning the unit on and off, the volume may be raised or lowered, and TV stations may be tuned in with up and down scanning, or each station individually selected with the push of a button. Some remote-control systems have a mute control to shut off the sound while you engage in conversation, or answer the telephone. Still others may have a button to recall a preset channel, or one to place the correct time of day on the TV screen. It is a wonderful device when it is working, but when it fails to function your comfort is disturbed.

When the remote transmitter fails to operate properly, you can perform some inspections and make minor repairs that will restore the remote transmitter to normal operation. This article zeros in on defects found in the remote transmitter. Fig. 1 shows three remote transmitters made by one manufacturer that come in differing shapes and sizes (not to mention functional types) used in remote-control systems.

Basic Transmitters

There are essentially two types of remote transmitters designed for TV set use in the home; the *ultrasonic* variety and the *infrared* type. One distinct advantage that infrared systems have over the ultrasonic system is that they do not interfere with nearby TV sets. You never have to worry about someone living in the same apartment or housing complex setting off your TV. Also, ultrasonic systems have been known to turn on a TV receiver when someone jingles a set of keys. In fact, the big advantage of infrared remote-control systems is that you may have two or three TV's with remote-control systems in the same apartment or house without any interaction between those remote-control units.

The infrared remote transmitter sends out a programmed invisible-light signal that is very accurate and direct. The infrared remote transmitter must be pointed directly at the infrared receiver. That means that anyone standing or walking directly in front of the remote transmitter, so that the infrared light does not reach the sensor on the TV set, prevents triggering from taking place. However, under special circumstances, the infrared device can turn corners and bounce off walls and ceilings. But do not rely on those unusual performances for normal, everyday operation. Other than that, the infrared remote transmitter is very accurate and fast in operation.

The ultrasonic remote transmitter transmits an ultra-high

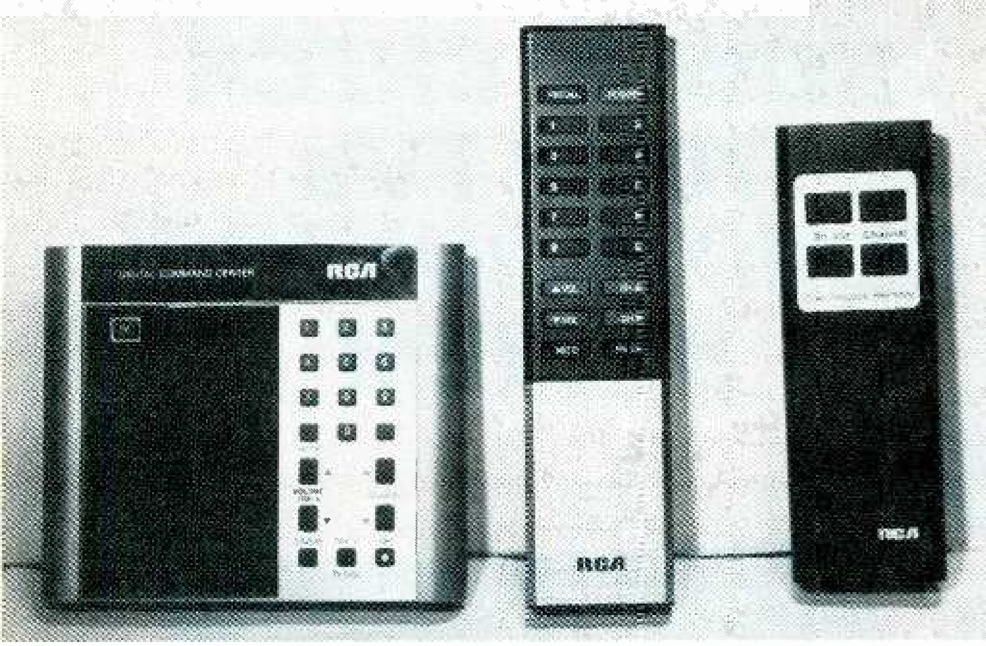


Fig. 1—There are many different types of remote transmitters available on the market. The one to the right is an ultrasonic type with on/off, volume-up/volume-down, and channel-up/channel-down. The other two units are infrared types; the one on the far left is a device that controls a TV set and VCR.

frequency that is picked up by a transducer found within the TV set's remote receiver. In turn, the remote receiver controls all functions within the TV. Supersonic sounds will bounce off walls and other hard surfaces. Persons and furniture between the remote transmitter and the television receiver usually do not hinder normal operation.

Remote-Control Problems

When the TV set cannot be turned-on or controlled by the remote transmitter, is it the remote transmitter that's defective or the TV set? First, check the hand-held remote transmitter. Have you checked the batteries lately? Heavy usage may wear down those small batteries: It may be time to replace them. That should be done at least once a year.

Inspect the hand-held remote transmitter when stations can not be tuned, intermittent operation occurs, or the remote-control system just won't work. Sometimes a defective remote transmitter may scan the stations up, but not scan down, or the TV set may turn on and not turn off. If you have to tap the remote transmitter against the chair or in the palm of your hand to make it operate, suspect problems within the remote transmitter.

The remote transmitter may be damaged if it is dropped on a hard floor. Rough handling or children playing with the remote transmitter can also cause the unit to malfunction.

Battery-Related Problems

When the remote transmitter doesn't work, the fault isn't always in the electronics; instead, the problem is often caused by dead batteries. To replace batteries, remove the screws in the back cover. You may find some models have a sliding plastic cover over the battery compartment. Often the polarity, orientation, or both is embossed in the battery compartment. If not, mark the positive terminal inside the battery compartment before you remove the old one(s). The remote transmitter will not function when the batteries are inserted backward.

Most remote transmitters are powered from a single 9-volt battery, or one or more penlight batteries. Make sure all batteries are replaced with heavy-duty units. (See Fig. 2.) Regular batteries will work, but heavy-duty batteries are sure to last a lot longer. Check the suspected batteries with a suitable battery tester, like that shown in Fig. 3, or simply replace them altogether. Discard all batteries that test weak as indicated by the meter scale.

Batteries can also be checked with a VOM or DMM.

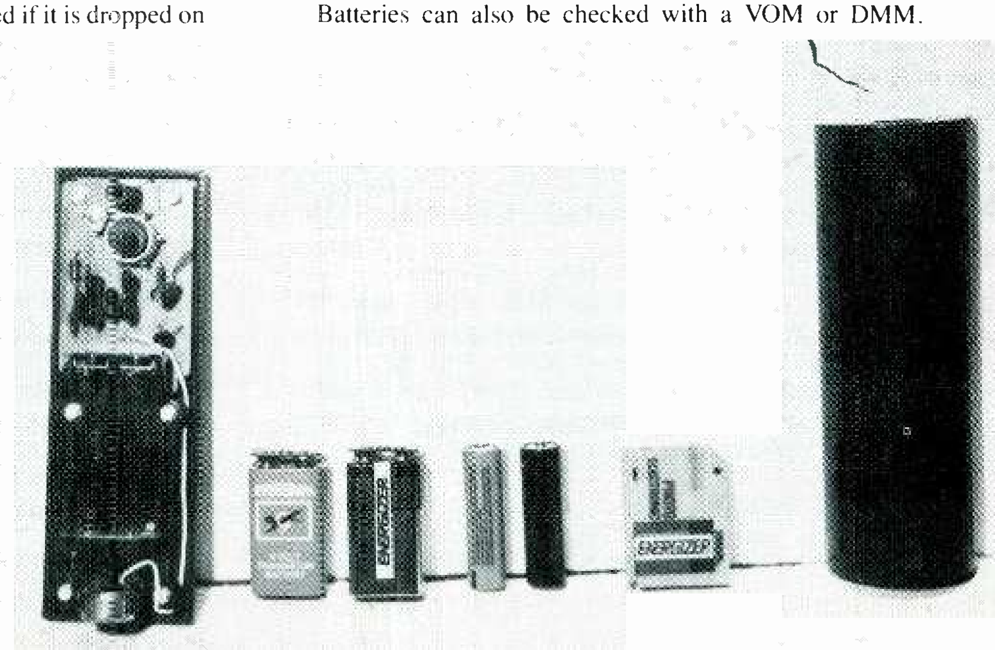


Fig. 2—All batteries within the remote transmitter must be replaced at least once a year. Although ordinary batteries can be used, heavy-duty units are recommended for longer life. The remote transmitter is shown at left and its cover at right. In between are typical battery types you can expect to find inside a remote transmitter. Replace batteries with quality brand names and identical types or with those of a better grade.

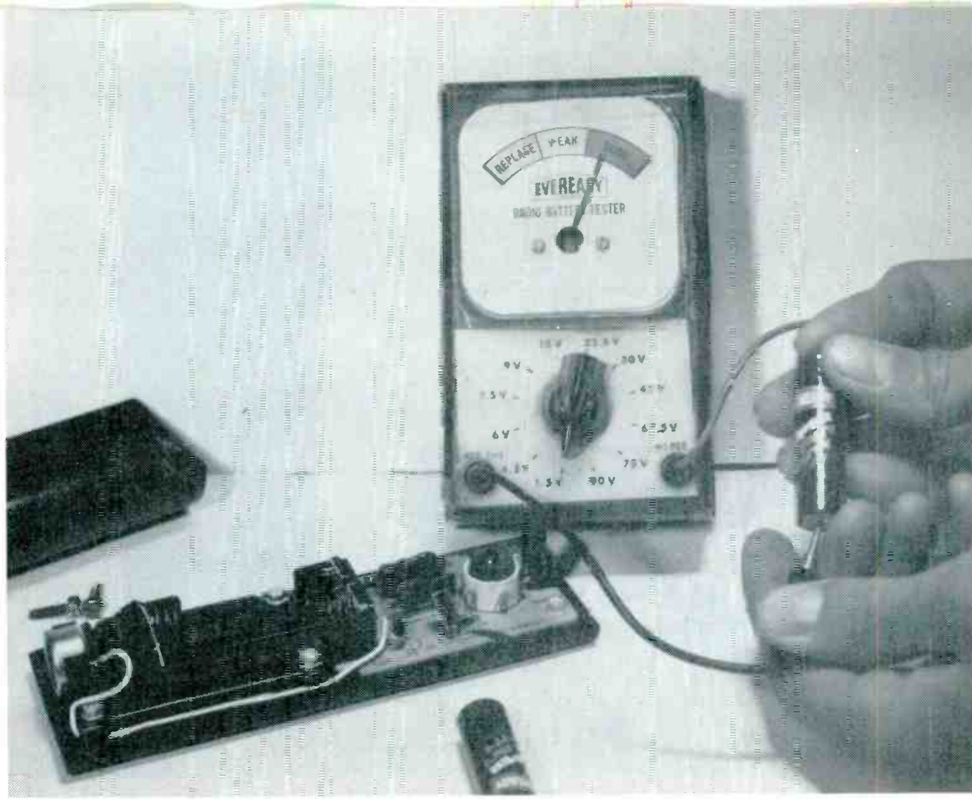


Fig. 3—Check all batteries inside the remote transmitter before installing new ones. Do not use any weak batteries. Just replacing the batteries may put the remote transmitter back into operation in most cases.

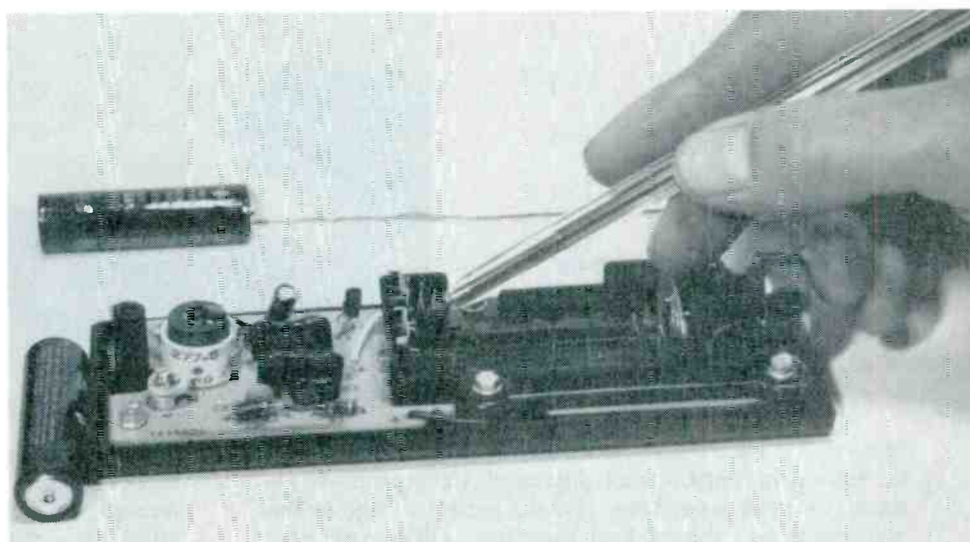


Fig. 4—Check the battery terminals for corroded contacts. Inspect the battery connector terminals for broken wires. Those repairs are obvious upon inspection and should be made immediately. Then retest the remote transmitter immediately.

Fig. 5—The infrared transmitter may be tested by placing it next to a portable radio. Turn the volume of the radio fully on, set tuning dial below 530 kHz (bottom of the dial). Place the end of the remote transmitter close to antenna and press the control buttons. A gurgling or chirping noise indicates that the remote transmitter is functioning normally.

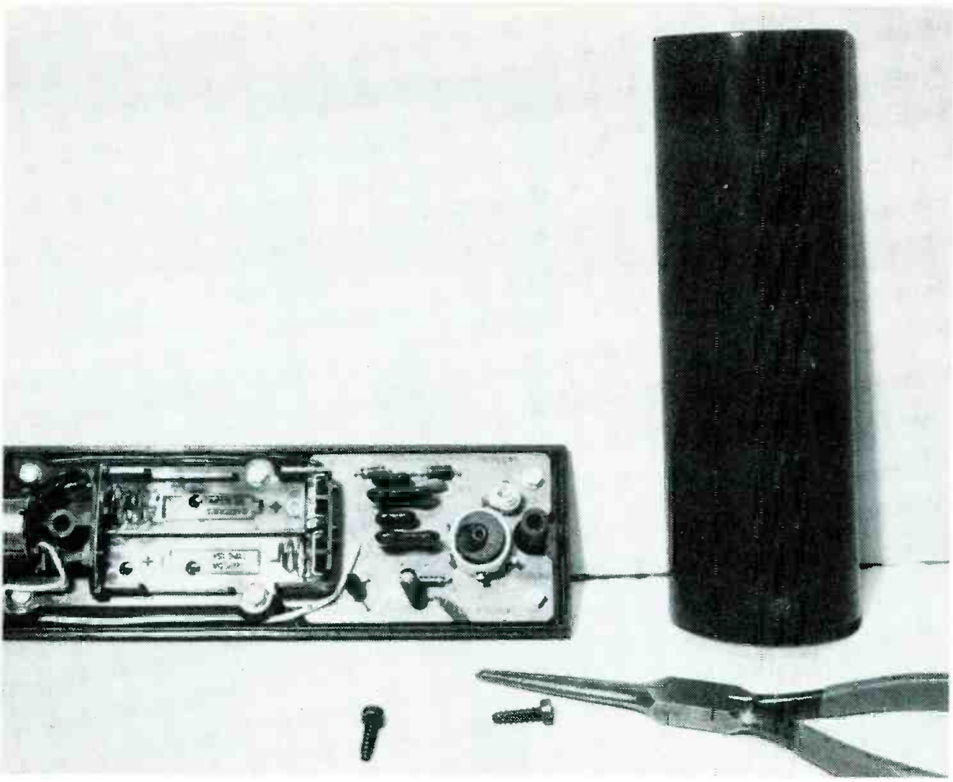


Fig. 6—Some remote-control problems can be eliminated by checking the printed-circuit board for loose components or wires and broken printed-circuit board copper-traces. Loose parts and wires can easily be secured with a hot soldering iron and a bit of solder. Severed traces can be repaired by bridging the gap over cracks with #22 AWG wire.

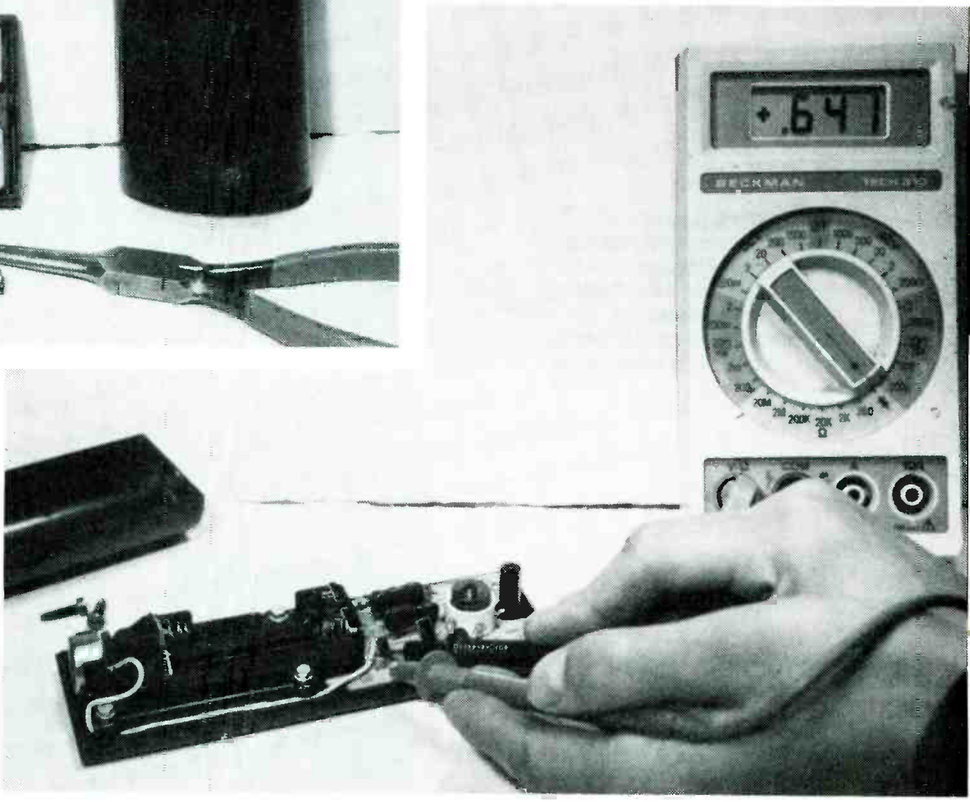


Fig. 7—If a volt-ohmmeter (VOM) or digital multimeter (DMM) is handy, take a low-ohm continuity test. The oscillator transistor may be tested with the transistor-diode scale of a digital multimeter.

Measure the DC voltage across both battery terminals with the remote-transmitter button depressed. Under no load conditions, a weak battery may give the correct voltage on the voltmeter. Under suitable load, the voltage will drop to below a value that is unsuitable for normal operation, indicating that most of the battery's life has been spent.

Replace the battery with a new one if a meter is not handy. If normal operation returns, you've solved the problem.

Intermittent or erratic remote operation may be caused by poor battery contacts. If you must tap the remote transmitter to make it work, suspect dirty or poor solder contacts. Inspect each battery terminal for corroded or dirty contacts. (See Fig. 4.) Clean off the corrosion with the blade of a pocket knife, fingernail file, emery board, or cleaning fluid. Wipe the small pen-light battery terminals against the pant leg or carpet to shine up the terminals for a better connection; actually, any rough cloth will do. Place a layer of foam material inside the bottom cover to hold the batteries more securely in place, providing a more stable contact.

Still No Action

If the remote transmitter still does not function after the batteries have been replaced, determine whether the remote transmitter or the remote receiver in the TV set is at fault. Where possible, check the remote transmitter with another TV that uses the same type of system. If the remote transmitter performs with the other TV, you must have a defective receiver. On the other hand, if the remote transmitter has no effect upon the good TV set, suspect a defective remote transmitter.

If you do not have access to another TV of the same type, the infrared remote transmitter may be checked for signal radiation with a plastic-card infrared indicator. The card may be obtained for a nominal fee from your TV dealer. Hold the white plastic card against the sensor area of the remote transmitter. Push the ON or CHANNEL button, and peek at the plastic indicator. If the remote transmitter is operating, a small area on the card will change color.

Another way to tell if a infrared remote transmitter is working is to place it near the antenna coil of a small portable AM radio. (See Fig. 5.) Place the remote transmitter at the end or back side of the radio where that antenna is located. With the volume fully on, adjust the tuning dial below 530 kHz. Press each button on the remote transmitter. When each button is pushed, a gurgling or chirping noise is heard in the radio speaker, indicating circuits in the infrared remote transmitter is functioning normally.

Remove the back cover and visually inspect the printed-circuit board for loose components or broken wires; pay

(Continued on page 104)

DIGITAL FUNDAMENTALS

We'll discover how gates and inverters are combined to perform unique and specific logic functions!

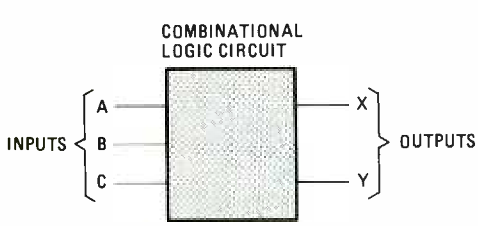
LESSON 6: Understanding Combinational Logic Circuits

By Louis E. Frenzel

A COMBINATIONAL LOGIC CIRCUIT IS A COLLECTION OF gates and inverters that performs some specific logic function. A combinational logic circuit has two or more inputs and one or more outputs. The output is dependent upon the types of logic circuits used and how they are interconnected. The output is also a function of the binary input states. The operation of such a circuit is generally expressed in the form of a truth table where the binary states of the inputs are listed, as well as the corresponding outputs. Figure 1 is a block diagram of a combinational logic circuit, showing its inputs, outputs, and the related truth table.

As you might suspect, there is an enormous number of ways that you can interconnect gates and inverters to form various combinational logic circuits. On the other hand, there are many commonly used combinational logic circuits; so common, in fact, that manufacturers have constructed them in MSI and LSI form, thereby eliminating the need for the user to interconnect individual gates and inverters. Some of the more common logic circuits include decoders, multiplexers, demultiplexers, exclusive OR gates, and many others.

When one of the standard circuits cannot be used, custom logic circuits for special applications can be built with programmable logic arrays (PLA's). PLA's are a type of LSI circuit that permit a designer to interconnect arrays of AND gates, OR gates, and inverters within a single chip to produce a desired special logic function. When you complete this lesson, you will have a working knowledge of all of the most commonly used combinational logic circuits, including PLA's.



COMBINATIONAL LOGIC CIRCUIT TRUTH TABLE

A	B	C	X	Y
0	0	0	0	0
0	0	1	0	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	0	1

Fig. 1—General block diagram of a combinational logic circuit and its related truth table.

New Logic Symbols

Before proceeding to a discussion of combinational logic circuits, we want to introduce some of the newer symbols used to represent logic circuits in schematic and logic diagrams. By now you are already familiar with the symbols for AND, OR, NAND, NOR, and other circuits. Those commonly used circuits are illustrated in Fig. 2. Such logic symbols have been used for many years, but now are gradually being replaced by newer symbols.

The new symbols are shown in Fig. 3. As you can see, each symbol is nothing more than a square block with input lines

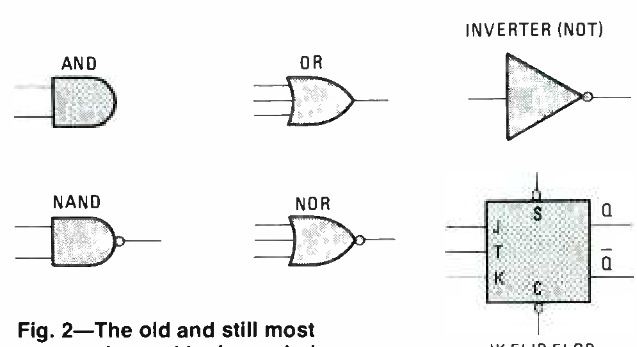


Fig. 2—The old and still most commonly used logic symbols.

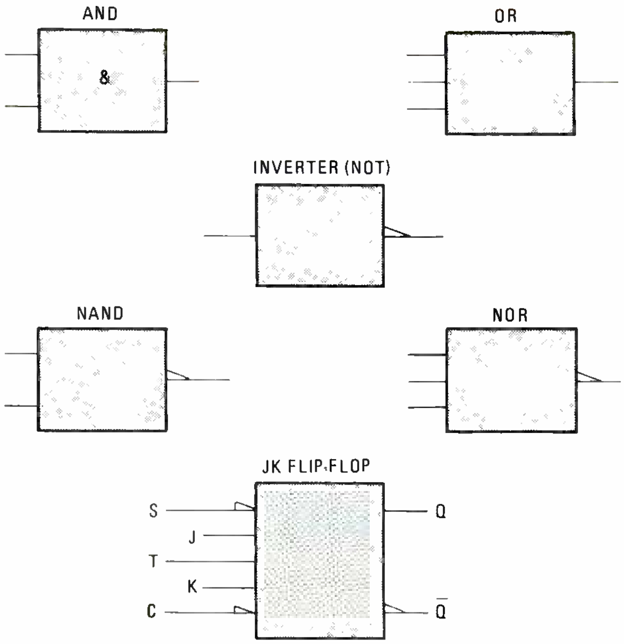


Fig. 3—The new logic symbols—they are easier to draw.

on the left, output lines on the right, and some designation in the block that tells what it does. A triangle at the output means inversion or the complement. A triangle at the input signifies that the input must go low to initiate the operation (active low input). Note the use of *ampersand* for AND and *>1* for OR.

We will be using the new logic symbols, as well as the old ones, in the various circuits to be described in this lesson to help you become familiar with them. In addition, other new logic symbols will be introduced, along with some of the combinational logic circuits as they are discussed.

Decoders

A decoder is a binary number detector. It is a circuit that recognizes the existence of one particular binary number when it appears at its inputs. If the binary number for which the circuit is set up to detect appears at its inputs, the decoder output will be a binary 1. For any other binary-input number, the decoder output will be binary 0.

The primary element in a decoder is an AND gate. Naturally a NAND gate can be used as a decoder if an active low output is satisfactory. For example, suppose that you wish to detect the presence of the two-bit binary number AB where A = 1 and B = 1. All you have to do is apply those two bits to an AND gate as shown in Fig. 4A. When those two bits are present, the output of the AND gate is binary 1, signaling the presence of that input. If any other two-bit combination appears at the input, of course, the output will be binary 0.

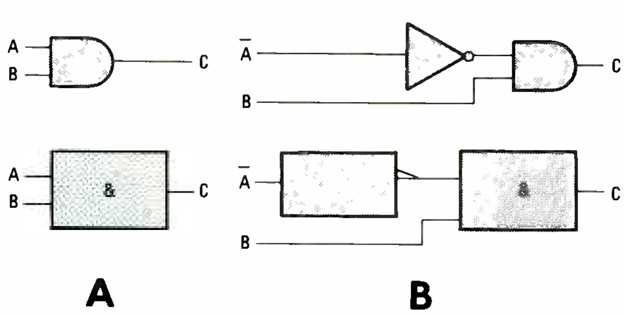


Fig. 4—Simple decoder circuits using old and new symbols.

Now suppose we wish to detect the two-bit binary number AB where A = 0 and B = 1. Again, we use an AND gate for this purpose. But naturally if one input is binary 0, then the output of the AND gate will be zero as well. To eliminate that problem, we simply put an inverter between the desired input signal whose value is binary 0 and the input to the decoder AND gate. That is illustrated in Fig. 4B. Now, when the binary number 01 appears at the decoder input, the inverter makes both inputs binary 1 so that the output is binary 1, indicating the presence of the number.

Figure 5A shows how you would decode the binary number 0110. A four-bit binary number requires a four-input AND gate. Inverters are used on the two input lines whose inputs are 0.

Figure 5B shows an 8-input AND gate used to detect the presence of a specific byte, in this case 00111010. Note the use of the inverters at the appropriate points. Also note that this decoder gate is a NAND gate. Therefore, when the correct number appears at the input, the output of the gate will be a binary 0 instead of a binary 1.

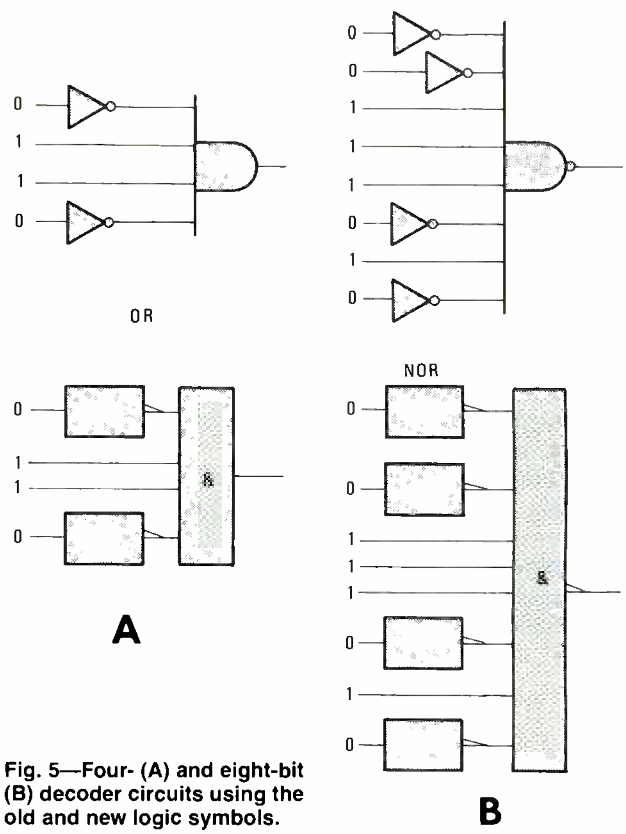
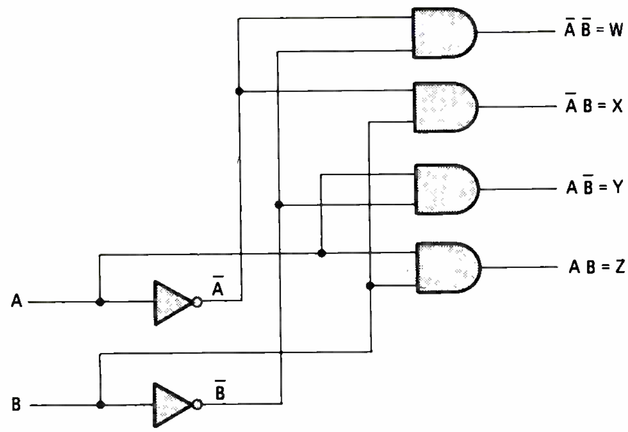


Fig. 5—Four- (A) and eight-bit (B) decoder circuits using the old and new logic symbols.

While decoders are often implemented with individual gates, usually it is desirable to decode all possible states of a given binary word size. For example, a two-bit binary number has four possible states, 00, 01, 10, and 11 or $\overline{A}\overline{B}$, $\overline{A}B$, $A\overline{B}$ and AB. A separate two-input AND gate is used to detect each one.

Inverters are used at the inputs to provide the complement signals where necessary. Figure 6 shows a decoder of that type. The two-input lines are decoded into four possible outputs. As a result, such a circuit is sometimes called a two-line to four-line decoder. Keep in mind, however, that only one output will be binary 1 at any given time. Depending upon the input word applied, only one AND gate will be



DECODER
TRUTH TABLE

A	B	W	X	Y	Z
0	0	1	0	0	0
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	0	0	1

Fig. 6—A two-line to four-line combinational logic circuit, or one-of-four decoder circuit shown as a functional block diagram.

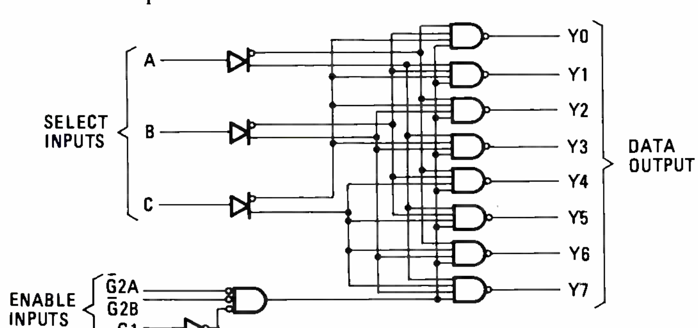
activated and only one output will be high. For that reason, a decoder circuit such as that is often referred to as a 1-of-4 decoder. The inputs and outputs of such a circuit are illustrated in the truth table of Fig. 6.

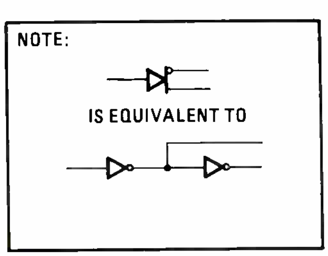
A popular MSI decoder circuit is a three-line to eight-line decoder as illustrated in Fig. 7. The inputs are A, B, and C. The outputs are labeled Y0 through Y7. Such a decoder is often referred to as an octal decoder because it has eight outputs. You will also hear such a decoder referred to as a 1-of-8 decoder. In this circuit, NAND gates are used; therefore, the output of a gate will go low when it recognizes a specific 3-bit input code. In other words, in this circuit all output lines are high except for one, which is at the gate that is decoding the correct input.

Note that this circuit has three control inputs also. Those control inputs are used to enable or disable all of the decoder gates. To enable the circuit, G1 must be high, and G2A and G2B must be low.

The new logic symbol for this circuit is also shown in Fig. 7. Note the designation BIN/OCT which means "binary in and octal out." Also, notice the "&" box, which defines the control inputs.

Other popular decoders include the BCD-to-decimal decoder and the hexadecimal (hex) decoder. The former accepts the standard 4-line BCD input and activates one of the ten outputs, 0 through 9. The circuit is also referred to as a 4-line-to-10-line or 1-of-10 decoder. The hex decoder is a 4-line-to-16-line or 1-of-16 circuit. Both are available as prewired MSI IC's.





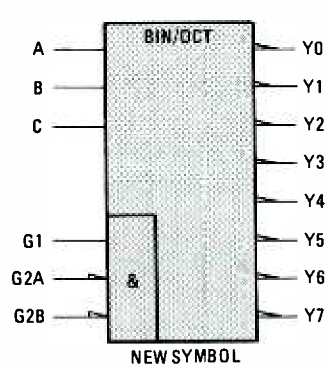


Fig. 7—An octal or 1-of-8 decoder circuit shown in old and new logic symbols.

Multiplexers

Another widely used combinational logic circuit is the multiplexer. A multiplexer is an electronic switch that allows the selection of one of several input signals. Also called a data selector, the multiplexer chooses one of the inputs and passes it through to a single output. The circuit is essentially equivalent to a multi-pole selector switch as shown in Fig. 8.

A digital version of a multiplexer is created with AND and OR gates. The AND gates are used to select one of several inputs, while their outputs are OR'ed together to generate a single output. Such a multiplexer with 4 inputs is illustrated in Fig. 9. Only one of the four AND gates will be enabled at a given time and its output will be passed through the OR gate to form the output. Such a circuit is referred to as a 1-of-4 data selector.

To select the desired input, a 2-line-to-4-line decoder circuit is used. It accepts two control inputs, X and Y that arms an address (0 through 3 or binary 00 through 11). Depending upon which of the four input codes are applied, one of the four inputs will be selected. For example, if the

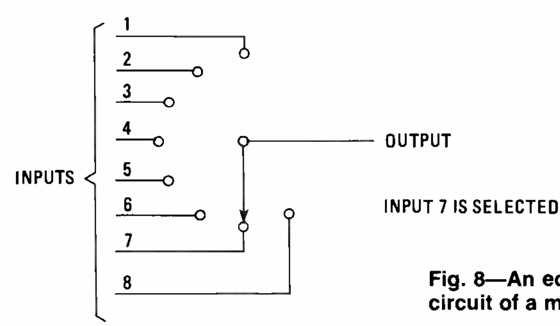


Fig. 8—An equivalent circuit of a multiplexer.

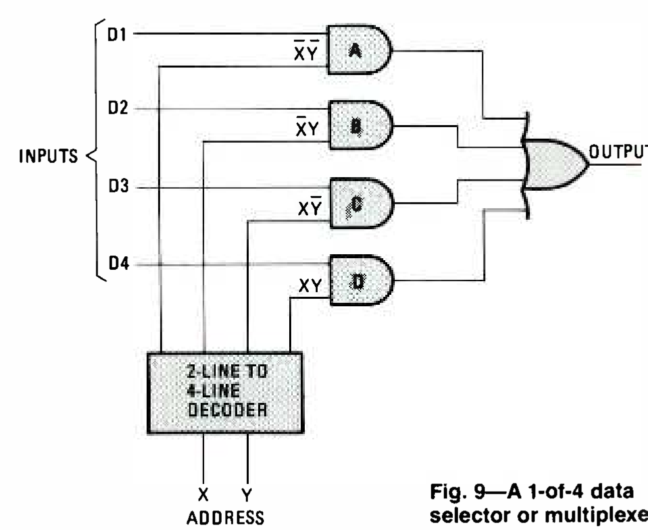


Fig. 9—A 1-of-4 data selector or multiplexer.

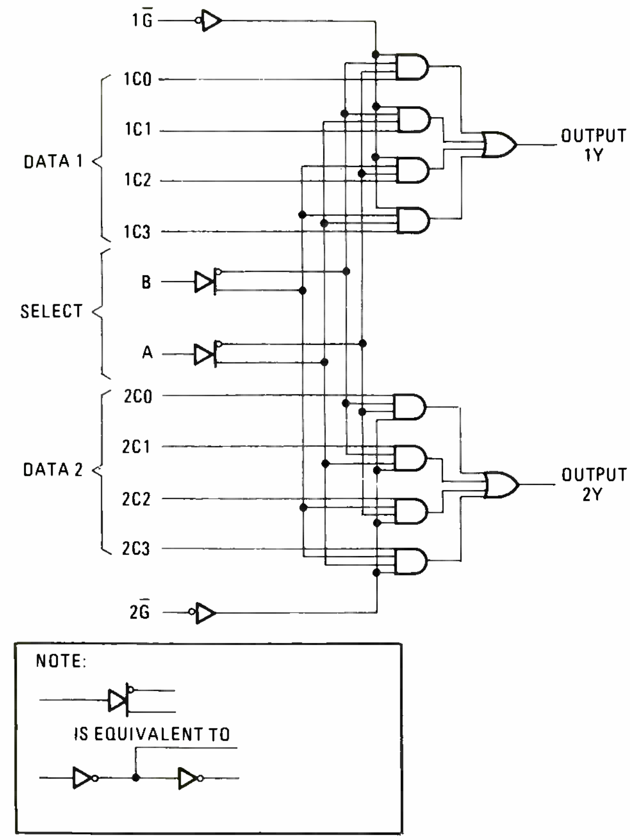


Fig. 10—The 74173 integrated-circuit chip is a dual selector/multiplexer combinational logic circuit.

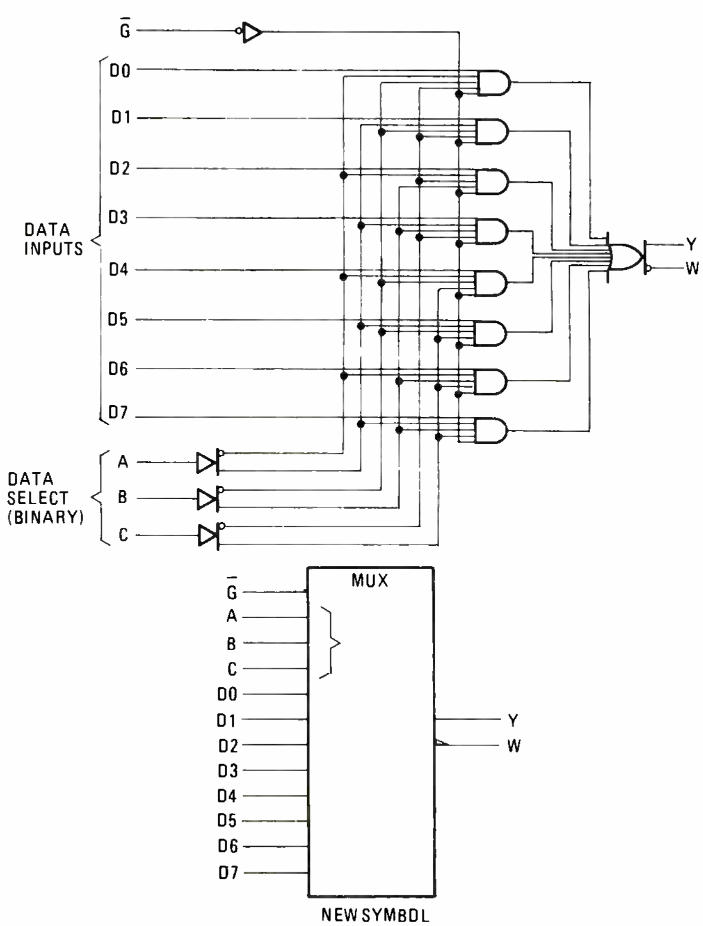


Fig. 11—A 74151 1-of-8 data selector/multiplexer integrated-circuit chip is illustrated using old and new logic symbols.

address is binary 10 or X$\overline{Y}$, gate C will be enabled and D3 will pass through to the output.

In practice, a separate decoder is not required, because the AND gates used for selecting the inputs can also serve double duty as decoders. Figure 10 illustrates how four input AND gates can be used to form a 4-to-1 multiplexer—in this case, a dual 1-of-4 data-selector/multiplexer. The upper and lower multiplexers shown in Fig. 10 are identical. Control lines A and B form the address, which is applied in various combinations to the AND gates. Notice also that inputs to be selected (1C0 through 1C3 and 2C0 through 2C3) are also applied to each gate. Finally, the fourth input of each AND gate is connected to a single common line and an inverter. That line is used for enabling or disabling the entire circuit. When the 1G input is low, the upper multiplexer is enabled. When the 2G input is low, the lower multiplexer is enabled.

Larger multiplexers can also be constructed. An 8-input multiplexer or 1-of-8 data selector is shown in Fig. 11. A 3-bit address (ABC) is used to select one of the inputs D0-D7. A common line $\overline{G}$ enables the circuit. Note also that both normal (Y) and complement ($\overline{W}$) outputs are available. The old and new logic symbols are illustrated.

Demultiplexer

A demultiplexer is simply the opposite of a multiplexer. It has a single input and multiple outputs. It is equivalent to the data selector switch shown in Fig. 12. An electronic 4-output demultiplexer—the 74139 2-line to 4-line demultiplexer, which contains two identical circuits—is illustrated in Fig. 13. A common input line is connected to each of four AND gates through an inverter. The single input is applied here. The additional inputs on each NAND gate are used for decoding purposes. Inputs A and B form an address, which enables one of the four gates. Therefore, the single input will be passed through the AND gate that is enabled.

If you look carefully at Fig. 13, you will see that this circuit is for all purposes a 2-to-4 line decoder. The only difference is that a common input line (enable) is shared by each of the gates. When used as a demultiplexer, the signal to be distributed to one or more of the outputs is applied to that input line. When used as a decoder, the input can simply be ignored or used to enable or disable the circuit.

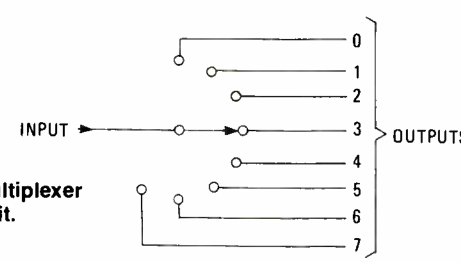


Fig. 12—A demultiplexer equivalent circuit.

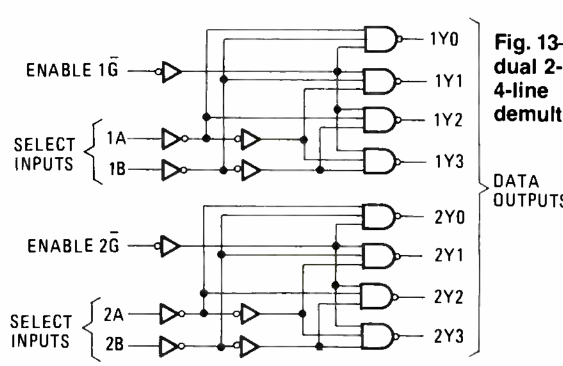
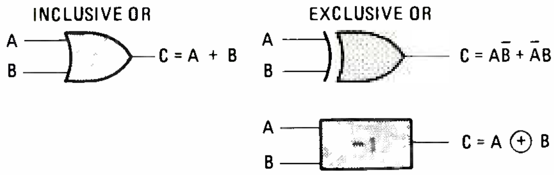


Fig. 13—A 74139 dual 2-line to 4-line demultiplexer.



A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

A	B	C
0	0	0
0	1	1
1	0	1
1	1	0

Fig. 14—Introducing the Exclusive OR gate.

Exclusive OR Gate

The OR gate that we discussed previously is a logic circuit with two or more inputs and a single output. Its output is a binary 1 if any one or both inputs are binary 1. The proper name for such a circuit is *inclusive* OR. However, it is possible to construct an exclusive-OR circuit. An exclusive-OR or XOR gate, as it is referred to, has two inputs and a single output. Its output is binary 1 if one or the other, but not both, of its inputs are binary 1. A truth table for that circuit is shown in Fig. 14 along with the symbols used to represent it. Compare the truth table for the exclusive OR to the truth table for the inclusive OR gate. The designation inside the new logic symbol (-1) designates the XOR function.

In Fig. 14, note the Boolean logic expression for the output of the XOR circuit. That equation of the XOR function can also be written as:

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

or

The exclusive OR function is designated by a positive sign with a circle around it. You will often see the expression for an XOR written in that way.

Using the standard Boolean algebra expression for this circuit, you can easily see a way to implement it with standard AND gates, OR gates, and inverters. A typical circuit is shown in Fig. 15A.

A standard two-input NAND gate can also be used to construct an XOR circuit. Two other approaches are illustrated in Fig. 15B and 15C. Both perform exactly the same function, but in slightly different ways. The circuit in Fig. 15B requires five gates, two connected as inverters. The circuit of Fig. 15C can be made from a single quad 2-input NAND IC such as the 7400.

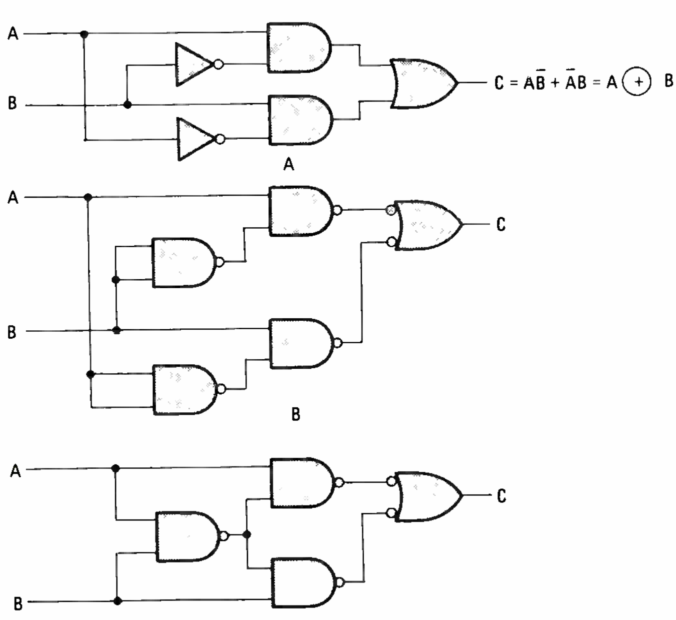


Fig. 15—Three ways to implement an XOR gate.

In practice it is not usually necessary to implement your own XOR circuits with gates like this. Complete, fully-formed XOR circuits are available already prepackaged in several IC forms. The common configuration is four XOR circuits per chip. An example is the 7486 TTL IC.

XOR Applications

True/Complement Circuit—Fig. 16 shows how you can use an XOR gate to construct a true/complement circuit. That circuit accepts a four-bit binary number D0–D3. Each bit is applied to one input of an XOR gate. All of the other XOR gate inputs are connected together to form a common control line.

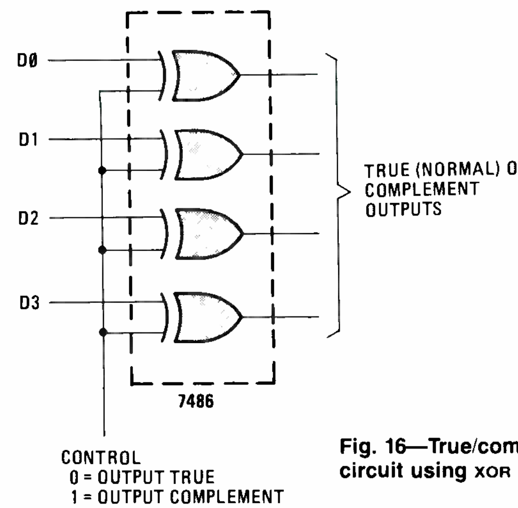
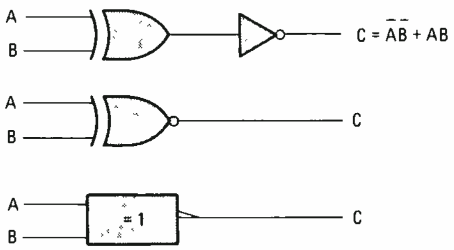


Fig. 16—True/complement circuit using XOR gates.

If the control line is held at binary 0 level, the four-bit binary word will simply pass through the gates and appear at the output unmodified or in "true" form. However, if the control line is made binary 1, the 4-bit word will be inverted by the XOR gates. The complement of the 4-bit input word will appear at the outputs.

Comparators—A comparator is a circuit that compares binary numbers and generates an output signal indicating when they are equal. A simple comparator can be constructed with a variation of the standard exclusive OR gate. Such a circuit is known as the exclusive NOR or XNOR. It is simply an XOR gate with an inverter at its output. Figure 17 illustrates the logic symbols used for this circuit. Also shown is the truth table for the circuit. Note that when two inputs are equal (either both binary 0 or both binary 1), then the output is binary 1 signaling the fact that they are equal. When the two inputs are opposite of one another, circuit output is binary 0. As you can see, the XNOR circuit is a simple 1-bit comparator.

Comparator circuits for multi-bit binary words can be formed by using multiple XNOR gates and AND'ing their outputs together as shown in Fig. 18. That circuit is a 4-bit binary comparator. It compares two 4-bit words. One word is represented by bits X1-X4, while the other word is represented by bits Y1-Y4. The corresponding bits in each word are applied to an XNOR circuit. If all of the bits in the two words are equal, the output from each XNOR circuit will be binary 1. Therefore, the output from the AND gate will be binary 1, signaling equality. If any one or more of the bits in



A	B	C
0	0	1
0	1	0
1	0	0
1	1	1

Fig. 17—Here are three ways to illustrate an Exclusive NOR (XNOR) gate.

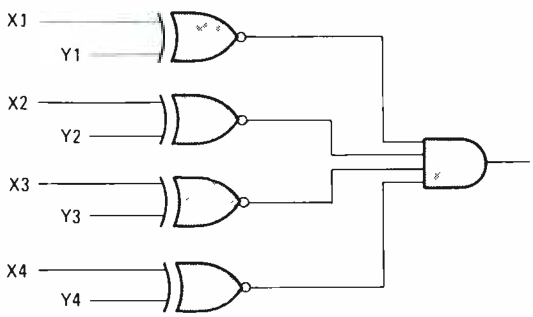


Fig. 18—A 4-bit binary comparator combinational circuit.

the word are different, then one or more of the XNOR outputs will be a binary 0 and the AND gate output will be zero, signaling inequality. To compare larger words, simply add more XNOR circuits, one for each pair of input bits, and additional AND gate inputs.

As with most other types of combinational logic circuits, it is not necessary to build such comparators yourself. Instead, standard MSI comparator IC's are available for that purpose. Both 4- and 8-bit word comparators are available. Such circuits are widely used for address comparison in computer memories and in peripheral interface circuits.

Parity Checker/Generator—XOR circuits are also used in parity generator and checker circuits. Parity is a system of error detection sometimes used in digital circuits. As a binary word is transferred from one circuit to the other or otherwise manipulated, bit errors can occur. One of the bits in a number that should be a binary 1 could be transmitted as a binary 0 or vice versa because of some intermittent circuit fault or noise glitch. The resulting data will, therefore, be incorrect and could cause problems. For example, errors frequently occur when data is stored in or read out of a memory circuit. Parity generator and checker circuits can be used for detecting such errors.

The parity system causes one additional bit to be added to a binary word for the purpose of detecting errors. If the total number of binary 1's in the number plus the parity bit is odd, then we are said to be using odd parity. On the other hand, if the total number of binary 1's in the number plus the parity bit is even, then we are using even parity. Some examples of odd and even parity are illustrated below. Look them over to be sure that you understand the concept.

10110001	1	Odd Parity
10110001	0	Even Parity
11001110	0	Odd Parity
11001110	1	Even Parity

XOR circuits are used in the parity generating process. The circuit in Fig. 19 shows a simple 4-bit parity generator/

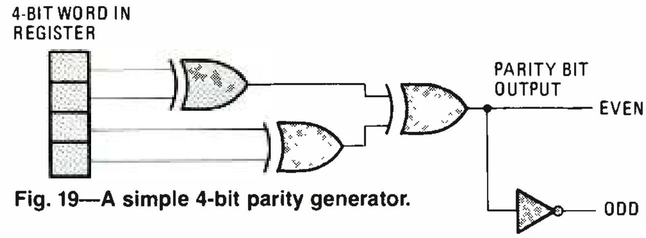


Fig. 19—A simple 4-bit parity generator.

checker circuit. Each XOR circuit looks at a pair of bits and generates a new signal indicating that the bits are the same or different. Those output signals are, in turn, connected to XOR circuits and the process is repeated until a single output is generated. That circuit generates a parity bit, which is added to the binary word from which it was generated. Note that an inverter at the output of the circuit provides either odd or even parity.

Once a parity bit has been generated, it is usually transmitted and/or stored along with the binary word. At the receiving end, another parity generator circuit looks at the received word and a new parity bit is generated. The new parity bit is then compared with the one that was transmitted. That is done in an XNOR circuit. If the two bits are alike, then no transmission error has occurred. However, if the generated and received parity bits are different, an error is indicated. That signal can then be used to indicate an error condition and possibly initiate some corrective action. Parity generator/checker circuits are available in integrated form and need not be separately constructed from XOR gates.

Binary Adder—The main processing circuit in a digital computer or microprocessor is referred to as an arithmetic logic unit (ALU). At the heart of the ALU is a binary adder that permits the computer or microprocessor to perform addition, subtraction and other arithmetic operations. It is the exclusive OR circuit that forms the base for the binary-adder circuit. The addition of binary numbers is a simple process. The rules are illustrated below.

$$\begin{array}{ccccc} 0 & 0 & 1 & 1 & A \\ \underline{+0} & \underline{+1} & \underline{+0} & \underline{+1} & \underline{+B} \\ 0 & 1 & 1 & 10 & C \end{array}$$

Carry Out

A + B = C		
0	0	0
0	1	1
1	0	1
1	1	0

Using those rules, you can easily see how two multibit binary numbers can be added. The examples below show how it is done. Work through the examples yourself to be sure that you understand how carry operations are dealt with.

$$\begin{array}{cccc} 6 & 0110 & 25 & 11001 \\ \underline{+10} & \underline{+1010} & \underline{+26} & \underline{+11010} \\ 16 & 10000 & 51 & 110011 \end{array}$$

To produce binary addition, we need a circuit that carries out the rules illustrated above. If you assume that each of the rules of binary addition shown above represent an entry into a truth table, you will see that an exclusive OR circuit is defined. The carry operation can be performed with a simple

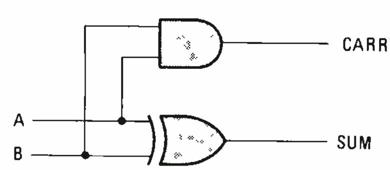


Fig. 20—Did you ever realize that a half-adder circuit would be so simple?

AND gate. Therefore, an XOR circuit and an AND gate together form a simple one-bit binary adder, normally referred to as a half-adder, as shown in Fig. 20. The reason for that being that it only adds two bits and does not take into consideration the need to add in a carry should it be necessary. To accomplish

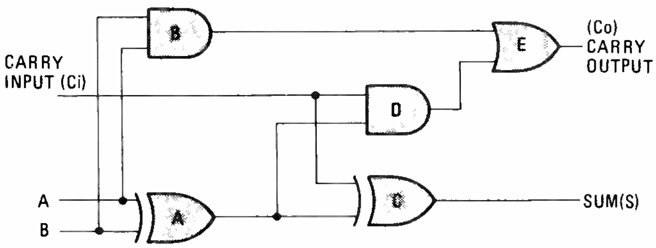


Fig. 21—A full-adder combinational circuit.

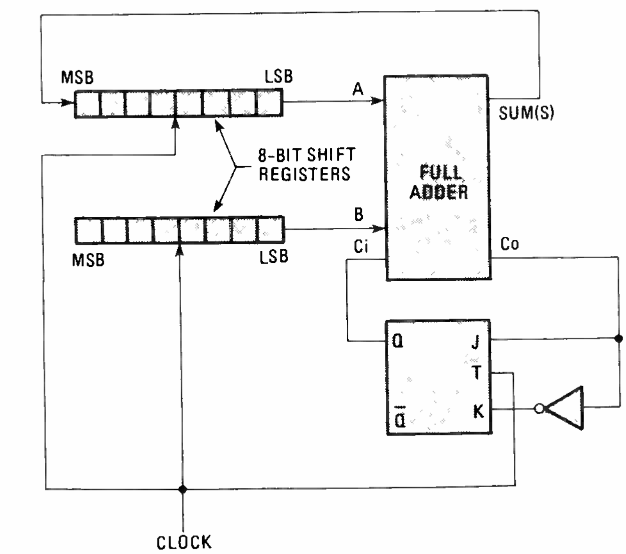


Fig. 22—A serial full-adder for 8-bit words.

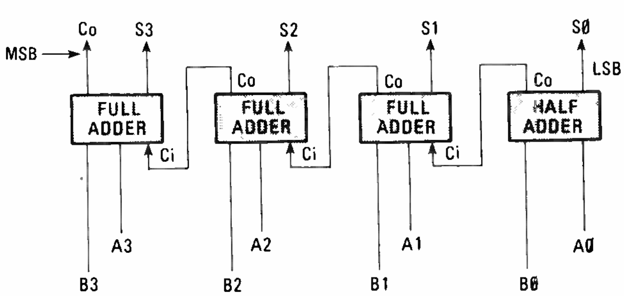


Fig. 23—A parallel full-adder circuit for two 4-bit numbers.

this, two half-adder circuits are combined to form a full-adder circuit as shown in Fig. 21. Here the half-adder made up of gates A and B add the two input bits. The sum is added to any carry input that might be present. That's accomplished with the half adder made up of gates C and D. Gate E is an OR gate that simply creates a carry-out signal to the next stage.

A single bit full adder such as this can be used to add multibit binary numbers. That can be done by storing the numbers in shift registers, then shifting the numbers out a bit at a time in synchronism with a clock, as illustrated in Fig. 22. Here two 8-bit shift registers hold the numbers to be added. The adder generates the sum of the corresponding bits in the shift registers a bit at a time as the clock pulses shifts the words out. The resulting sum is fed back to the input of the upper register for storage. To avoid the loss of the carry signal generated by each bit pair, a flip-flop is connected to the carry output of the adder circuit. The flip-flop is used to store the carry temporarily so that it can be added into the next bit position as needed.

Rarely are serial adders like this used any more. Instead, multiple adder circuits are used so that the addition of parallel binary words can be accomplished. Figure 23 shows a parallel adder for two 4-bit numbers A0-A3 and B0-B3. The corresponding bits in each word are applied to each adder. Note how the carry out of one adder is fed to the carry input of the next adder. Also note that only a half adder is required in the least significant bit position as there is no carry out. Four bit parallel adders like this are available in MSI integrated circuit form. Most of those circuits are extremely sophisticated and perform not only addition, but also subtraction as well as many other logic functions. Such circuits are used as the basis for an arithmetic logic unit (ALU) in digital computers.

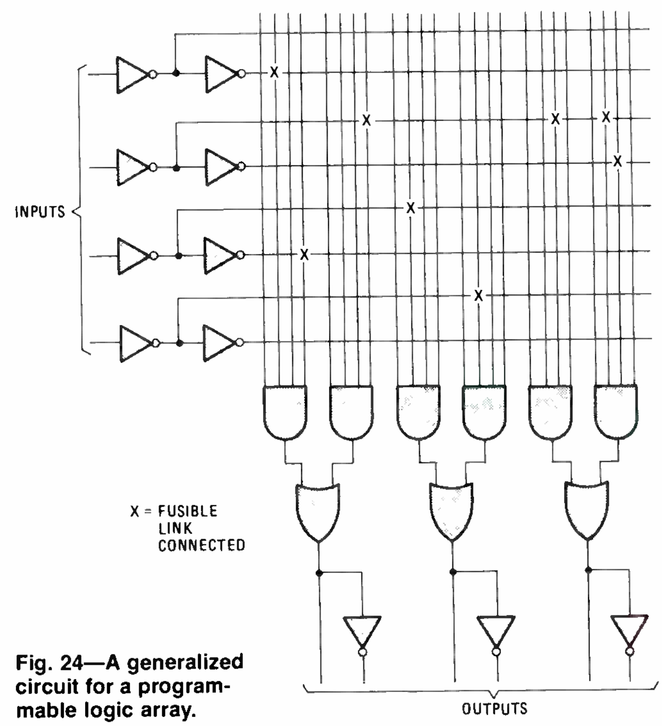


Fig. 24—A generalized circuit for a programmable logic array.

Programmable Logic Arrays

While a high percentage of digital applications can be implemented with the combinational logic circuits just discussed, there are also many applications that require special circuits. Those special circuits can often be made from the available combinational circuits, plus random gates and inverters as required. While the resulting circuit usually performs the desired function, a good number of chips must be used. Those chips take up a lot of space, consume power, require larger circuit boards and occasionally are not fast enough. All those problems can be overcome by using a programmable logic array (PLA). A PLA is an LSI or VLSI circuit consisting of multiple gates and inverters arranged on a chip in such a way that they may be randomly interconnected to perform almost any logic function. Semiconductor technology now permits manufacturers to quickly, easily and inexpensively manufacture custom circuits using PLA's for special designs.

Other PLA's are field programmable. That is, the designer

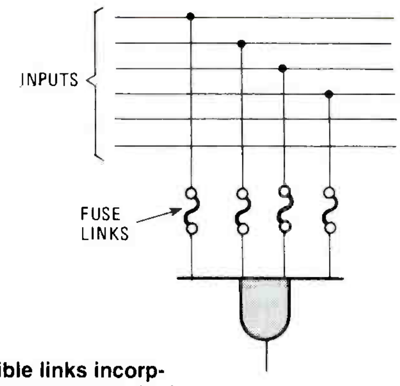


Fig. 25—Fusible links incorporated in a programmable logic array integrated-circuit chip.

may specify his own circuit, then implement it himself with a PLA. Such circuits make it possible to replace MSI functional combinational circuits and all of the random gates and inverters normally required to implement a special function. In some cases, the entire circuit can be reduced to a single PLA chip.

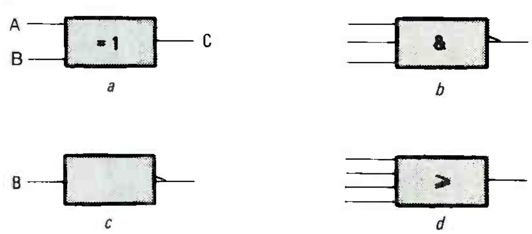
A general block diagram of one type of PLA is shown in Fig. 24. The circuit has multiple inputs with inverters and buffers to supply normal and complement signals. Those lines can be interconnected with any one or more of the inputs to the many AND gates on the chip. The AND gate outputs are, in turn, connected to OR gates as shown. The circuit outputs appear at the OR gates or the associated inverters. Most practical circuits have many more input and output lines than those shown. A typical circuit might have eight inputs and eight outputs.

The interconnection of the various signals on the chip take place in a variety of ways. One common way is to use fusible links as shown in Fig. 25. Each AND gate input is connected to all input lines with a tiny tungsten fuse when the circuit is manufactured. Then the chip can be "programmed" by passing a high current through the appropriate chip pins. The high current will open the fusible links where no connection is desired. In that way, the circuit can be customized to the application. The programming can be done by the user and not the manufacturer. That's another feature that makes PLA's so popular. ■

SHORT QUIZ ON DIGITAL FUNDAMENTALS—LESSON 6: COMBINATIONAL LOGIC CIRCUITS

1. Combinational circuits may contain flip-flops.
a. True ____ b. False ____

2. Identify the logic circuits shown in the Figure below by filling in the correct names:



a. ____________
b. ____________
c. ____________
d. ____________

3. Draw a decoder circuit that outputs a binary 0 when it recognizes the binary number 10111101.

4. A 3-line to 8-line decoder is sometimes called a(n) ____.

5. Another name for the data selector is ____________.

6. Three flip-flops of a binary counter are connected to the A, B, and C inputs of the 1-of-8 multiplexer shown in Fig. 11. A data byte (8-bit word) is applied to the D0-D7 inputs. As the counter is incremented by the clock, the output is observed. Which of the following functions is being carried out
a. Decoding
b. Demultiplexing
c. Binary addition.
d. Parallel-to-serial conversion

7. Parity is a scheme for ____________.

8. Give the parity bit for each word below:
a. 10010010 Odd parity = ____
b. 10111101 Even parity = ____

9. Add the following binary numbers:
a. 1001 + 0111
b. 10011110 + 11110101

10. The following is the truth table of which circuit?

A	B	C
0	0	0
0	1	1
1	1	0

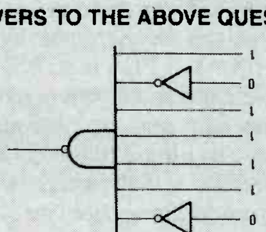
a. OR
b. XNOR
c. OR
d. XOR

11. A single-bit comparator is called a:
a. AND
b. XNOR
c. OR
d. XOR

12. An LSI/VLSI circuit that can be customized to eliminate combinational circuits made with SSI and MSI circuits is called a ____________.

ANSWERS TO THE ABOVE QUESTIONS

1. b. False. Combination circuits use only gates and inverters.
2. a. XOR b. NAND c. Inverter (NOT) d. OR
3. See drawing at right:



4. Octal
5. Multiplexer
6. D. parallel-to-serial conversion. As the counter is incremented, the multiplexer gates are enabled one after another, causing the data input bits to appear sequentially at the output.
7. Error detection
8. a. 10010010. Odd parity = 0.
b. 10111101. Even parity = 0.
9. a. 1001 (9) + 0111 (7) = 10000 (16)
b. 10011110 (158) + 11110101 (245) = 110010011 (403)
10. d. XOR
11. b. XNOR
12. Programmable logic array

The Rabbit Ear

Listen to your favorite music through stereo headphones, without losing contact with the world around you!

By John F. Crooks

☐IMAGINE YOURSELF AFTER A LONG DAY AT WORK AS YOU relax in your favorite chair with your trusty stereo headphones wrapped securely around your ears: You stretch out your legs and your eyes close as the material world fades to a cool black nothingness. Your favorite music bathes you in crisp, clean currents—nothing can spoil this nirvana. A smile creeps over your face. Suddenly, as if to spite you, a heavy hand lands on your shoulder and another lifts one side of your headset. "Dinner!," shouts an irate voice into a cold ear. Your feet hit the floor with a crash. (Sound familiar?)

It's nice to lose yourself in music once in a while, but what about the people that you live with who, for the moment, also seem to be part of another world? It is next to impossible to get the attention of anyone wearing headphones. Dinners go uneaten, phones go unanswered, and tempers flare. But there is a solution: *The Rabbit Ear*.

How It Works

The Rabbit Ear (see photos), when hooked in between your headphones and the stereo, listens to the room for you. When room noise above a preset level is detected, the Rabbit Ear cuts into the music and lets you listen to whatever it's picking up. Then, after a time, if no further noise is detected, the music returns. That means that instead of physically taking hold and shaking you back to reality, all a family member need do is speak, or knock on a wall and then speak (depending on the preset trigger-level), to be heard. It is even possible to carry on a conversation without removing your headphones because any noise (above the threshold) triggers the circuit. Therefore, as long as the conversation continues, the circuit is continually retriggered.

A Look At The Circuit

The schematic diagram in Fig. 1 shows that the Rabbit Ear circuit is a rather simple one, which is actually a combination of four distinct sections: A two-stage amplifier, a trigger/time delay, a headphone relay, and a power supply.

Amplification is accomplished in two stages. In the first stage, an LM386 low-voltage, audio-power amplifier, U1, increases the magnitude of the signal introduced to the circuit through M1. The gain of U1 is set at about 200 by C1. An 8-ohm to 1000-ohm impedance-matching transformer, T1, ensures the proper balance between M1 and U1. The amplified output of U1 follows two paths; the first, through C3 and R2 to K1, and the other through R1 and C2 to U2 (the second amplifier stage).

Potentiometer R2 is connected as a VOLUME control and is used to attenuate only room noise (not the output of the stereo) as it travels to the headphones through K1. Potentiometer R1 is used as a DULL control, meaning that it controls the level of signal presented to the U2 amplifier stage. The higher that control is set, the more the Rabbit Ear is dulled (immune) to noise. U2 is set to the same mode as U1, but with a lower gain. Note that no biasing or feedback resistors are necessary. That's done internally by the integrated circuit.

The output from U2 goes to the trigger/timer (U3), an LM555 timer/oscillator, which outputs a single pulse, whose duration is determined by the values of R8 and C5. The level at which U3 is triggered is internally set to about 1.7 volts with a 5-volt power supply, but can be made variable by applying a control voltage to pin 5 of U3. Thus, R7, THRESHOLD, determines the signal level at which U3 is triggered. The higher that control is set, the higher the signal level must be to trigger the rest of the circuit.

R7 is used in conjunction with DULL control R1 to set the circuit's sensitivity at various levels. The output pulse from U3 instantly charges C4 and turns Q1 on. Transistor Q1 is biased on until C4 has been discharged. If, on the other hand, U3 puts out additional pulses (retriggered by additional noise), C4 is continually recharged and Q1 remains turned on. With Q1 turned on, relay K1 is energized, causing the signal level presented to the headphones to be reduced. Diode D1 prevents capacitor C4 from instantly discharging through U3 pin 3 when its output goes low. Thus, C4, R5, D1, and Q1

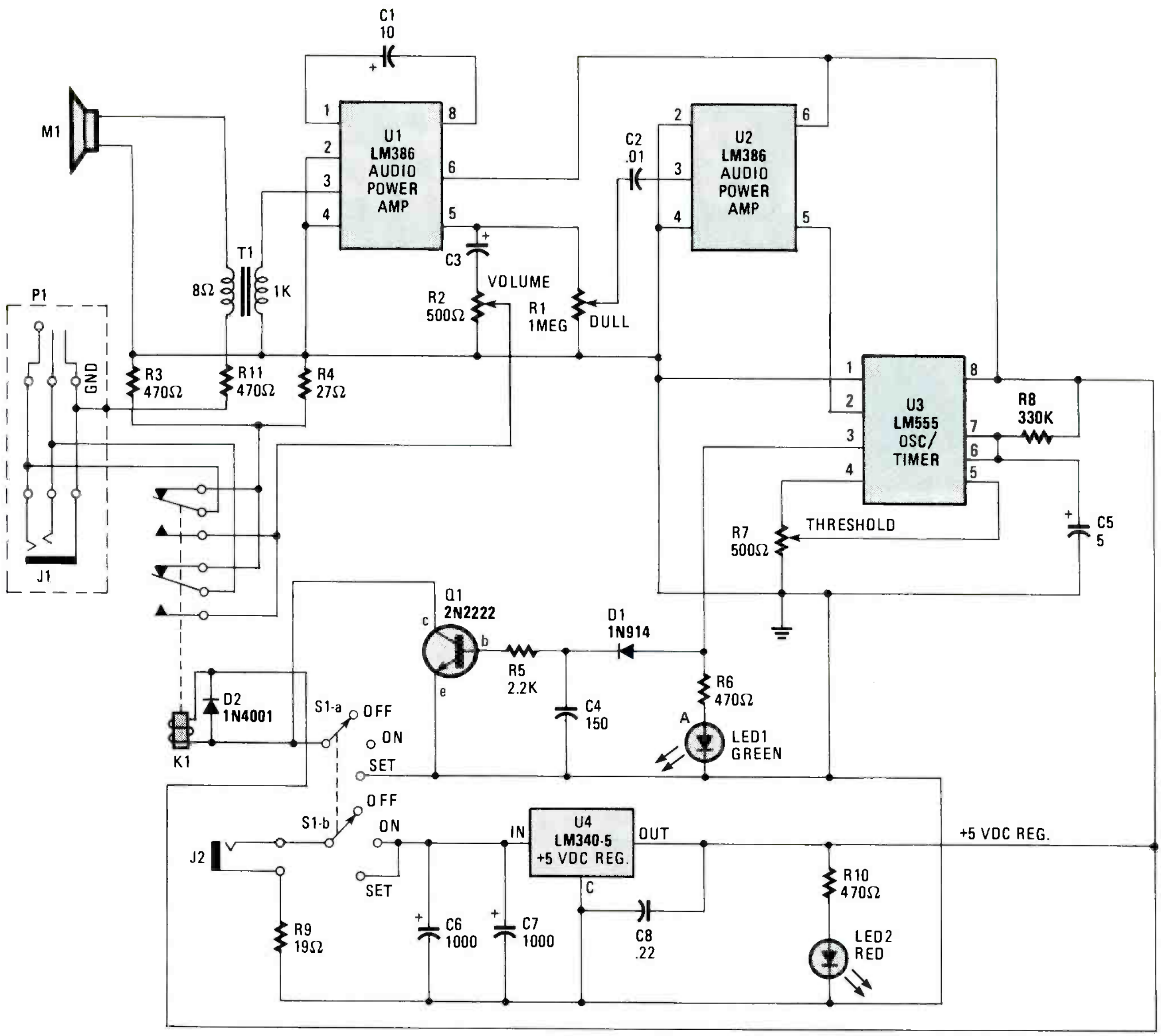


Fig. 1—The schematic diagram of the Rabbit Ear circuit. Note that instead of using a microphone as the pickup device, an 8-ohm speaker is used to detect room noise.

keep K1 on uninterruptedly while U3 resets itself and waits for additional trigger signals. LED1 and R6 are connected across the output of U3 to visually indicate that the timer has been triggered.

When S1-a (half of a 2-pole, 3-position rotary switch) is placed in the SET position, K1 is manually energized so that room noise below the set trigger level can be monitored without removing your headphones or destroying the sensitivity (DULL and THRESHOLD) settings to keep the relay on. It's also convenient for setting VOLUME control R2. Relay K1 switches the headphones between music from your stereo and the room sounds that are detected by M1 and fed to U1.

Relay K1 should be a small, low-voltage relay to keep any mechanical noise that it might generate from retriggering the unit through M1. Diode D4 is included across the coil contacts of the relay to cut down on the inductive kick that occurs when K1 goes off. Resistors R3 and R4 are included to keep the stereo system's headphone output (which is connected to P1) loaded while K1 is on—some stereos do not permit an open at their headphone jacks under those conditions. Resistor R11 is used to cut back on some of the noise picked up in the line between the J1/P1 assembly and the base unit.

A 9-volt, 200-mA wall-mounted power-supply plugs into J2 to provide power for the circuit. The voltage is fed across resistor R9, which helps to decouple the power supply from the Rabbit Ear circuitry. The second half of S1 (S1-b) is used as a power switch. From the switch, the supply voltage is filtered by C6 and C7, regulated to five volts by U4 and fed across C8 to remove any residual ripple. Resistor R10 and LED2 are included in the circuit to act as a "power on" indicator.

Construction

The printed-circuit foil pattern for the author's prototype is shown in Fig. 2. To avoid any possible problems (should you elect not to use the pattern provided), it's strongly recommended that you at least follow the general outline. The circuit is highly susceptible to noise, mostly from an uneven grounding plane and too much noise can make triggering less selective. M1 must be kept away from the rest of the Rabbit Ear's circuit, because mechanical noise that might be generated by K1 during switching can retrigger the circuit.

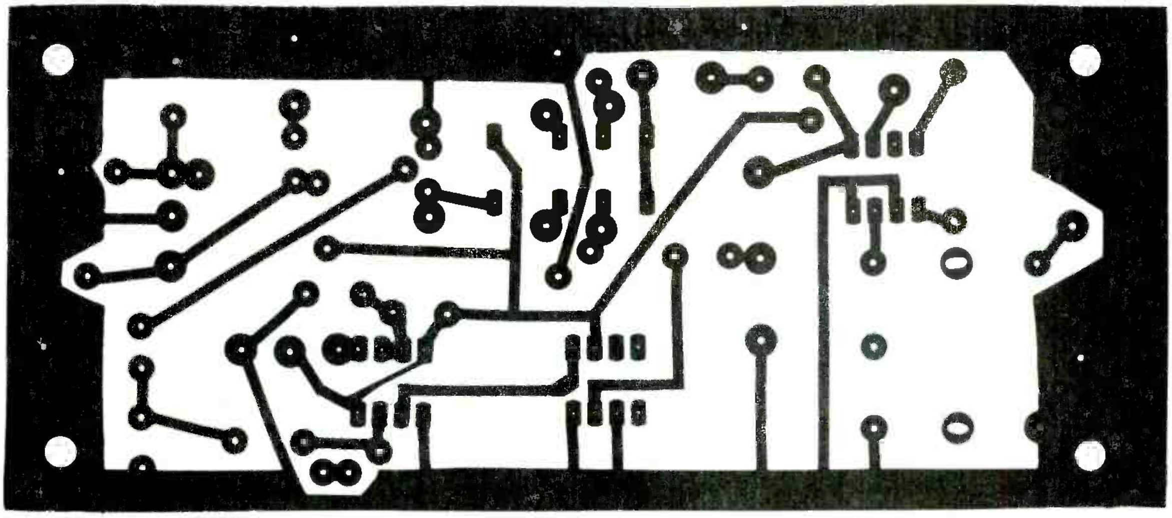


Fig. 2—The foil pattern for the Rabbit Ear circuit PC board is shown full-scale.

PARTS LIST FOR THE RABBIT EAR

SEMICONDUCTORS
D1—1N914, small-signal, switching diode
D2—1N4001, 50-PIV, 1-A rectifier diode
LED1—Jumbo green, light-emitting diode
LED2—Jumbo red, light-emitting diode
Q1—2N2222 or 2N2222A, general-purpose, silicon transistor
U1, U2—LM386, power amplifier, integrated circuit
U3—LM555, oscillator/timer, integrated circuit
U4—LM340, 5-volt, 1.5-A regulator, integrated circuit

RESISTORS
(All resistors ¼-watt, 5% fixed units, unless otherwise noted)
R1—1-Megohm
R2, R7—500-ohm, potentiometer
R3, R4, R6, R10—470-ohm
R5—2200—ohm
R8—330,000-ohm
R9—19-ohm, ½-watt
R11—27-ohm

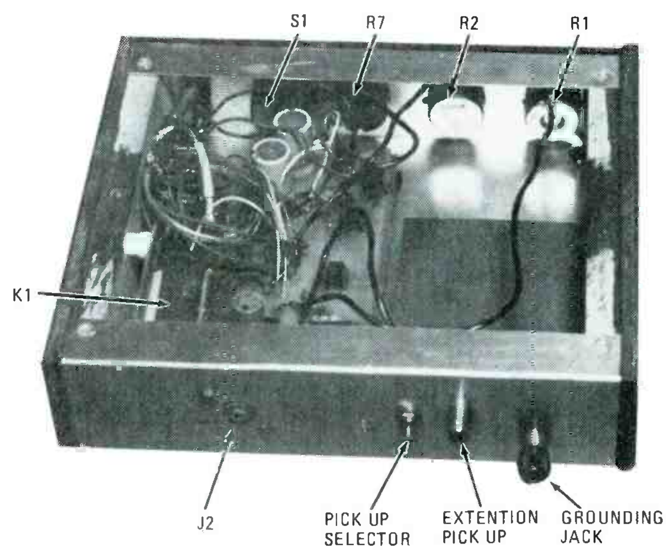
CAPACITORS
C1—10-µF, 15-WVDC, electrolytic
C2—0.01-µF, 16-WVDC, ceramic disc
C3—100-muF, 25-WVDC, electrolytic
C4—150-µF, 150-WVDC, electrolytic
C5—5-µF, 15-WVDC, electrolytic
C6, C7—1000-muF, 35-WVDC, electrolytic
C8—0.22-muF, 25-WVDC, mylar

ADDITIONAL PARTS AND MATERIALS
J1—Normally-closed, stereo earphone jack
J2—Normally-open, phono jack (see text)
K1—DPDT 5-volt coil, 500-mA contact, DIP relay (Digi-Key Z300)
M1—8-ohm speaker or microphone (see text)
P1—Stereo earphone plug
S1—2-pole, 3-position rotary switch
T1—8-ohm/1000-ohm, audio impedance matching transformer
Printed-circuit material, 9-volt DC, 200-mA, wall-mounted power supply, cabinet, wire, solder, mounting hardware, insulating material, etc.

In the author's original prototype unit, a small hand-held microphone was internally mounted, and relay K1 was embedded in a clay-filled box in a futile attempt to eliminate the retriggering problem. However, in the final version, the microphone (which was replaced by a Minus 3 speaker) was externally mounted and connected to the PC board as indicated in Fig. 3.

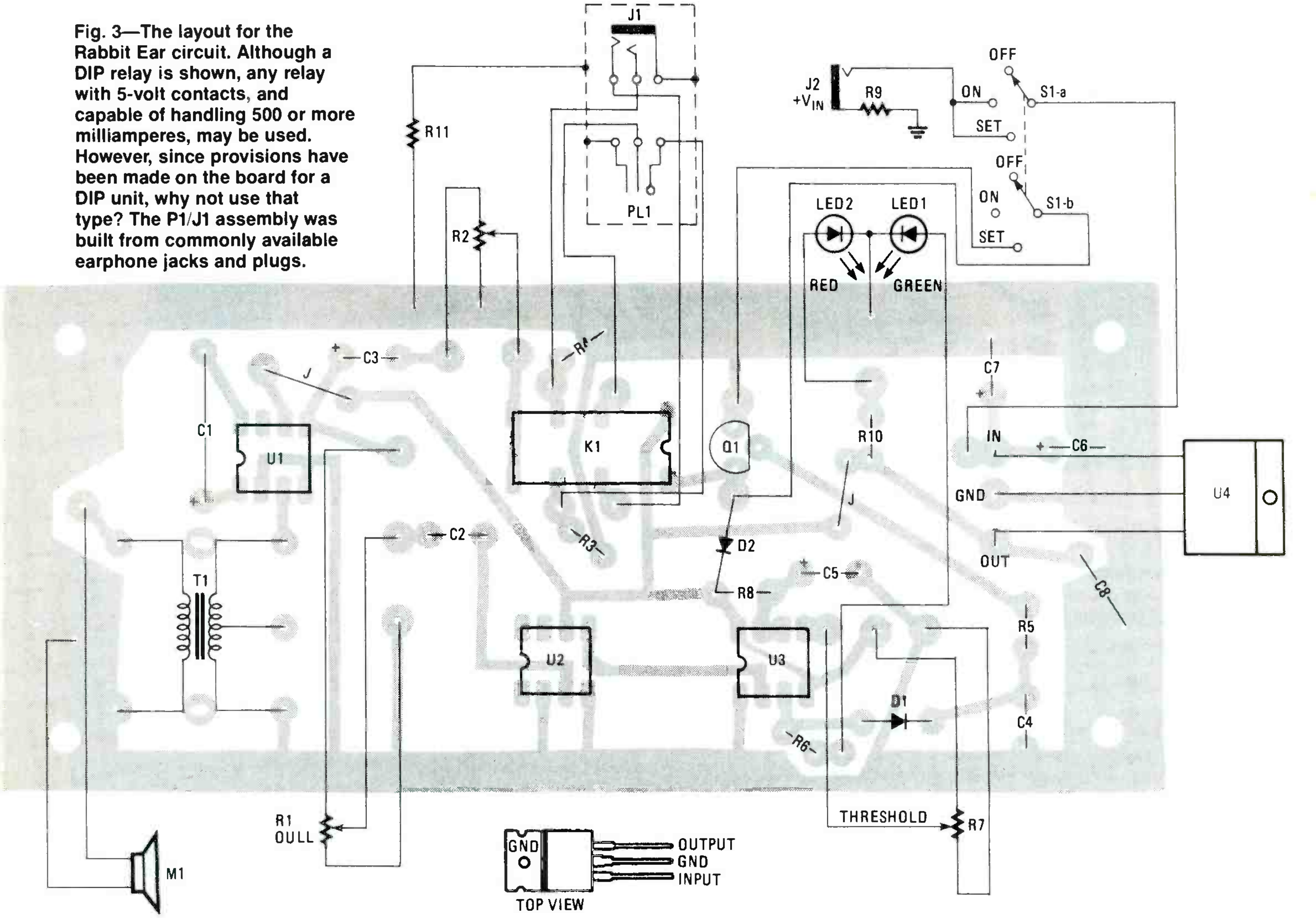
Follow the parts-placement diagram in Fig. 3, mounting the least static-sensitive components first: resistors and capacitors, and then semiconductors. Note that although mounting pads are provided for U4 (the 5-volt regulator), the author chose to to mount it on the chassis (see photos). Mounting the regulator that way serves two purposes: the chassis, while acting as a heatsink for the regulator, is grounded through the regulator tab. Also, note that a DIP relay is shown in the layout, but the photos show a much larger unit mounted to the chassis in the prototype. Either type may be used, but using the DIP type makes installation much easier.

Run wire from the other off-board components to the appropriate pads on the circuit board, leaving enough slack in the wire so as not to restrict mounting. Also, you may have noticed that no provisions have been made on the PC board



Note that the circuit that we've described differs slightly from the author's prototype unit (shown). For instance, in the parts-placement diagram (Fig. 3), a DIP relay is indicated, while shown here is a larger chassis-mounted unit.

Fig. 3—The layout for the Rabbit Ear circuit. Although a DIP relay is shown, any relay with 5-volt contacts, and capable of handling 500 or more milliamperes, may be used. However, since provisions have been made on the board for a DIP unit, why not use that type? The P1/J1 assembly was built from commonly available earphone jacks and plugs.



for R9 and R11: R9 is connected directly to a terminal on J2. R11 is part of the P1/J1 assembly (see P1/J1 Assembly Preparation for details). All interconnections between R1, R2, R7, and the PC board should be made with shielded cable. Once finished, lay the printed circuit aside for the moment, and prepare the cable assembly that will connect the circuit to your stereo system.

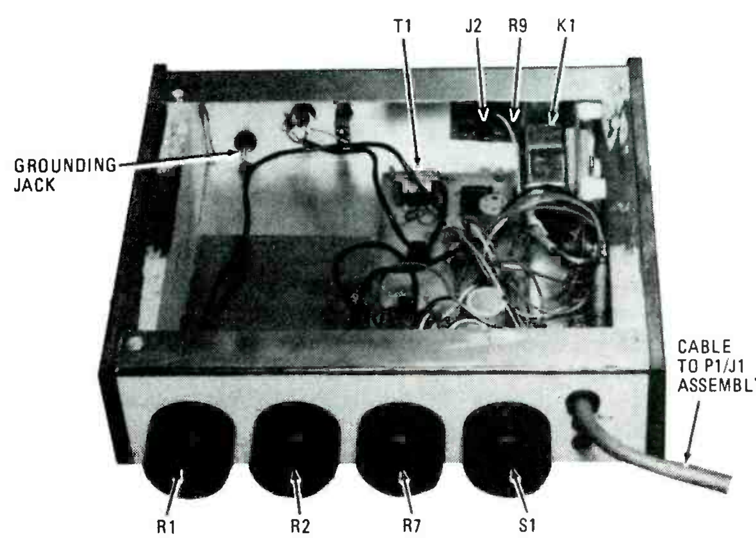
P1/J1 Assembly Preparation

The P1/J1 assembly, which connects the Rabbit Ear circuit to your stereo system, was fabricated by mounting an earphone plug and jack at opposite ends of a small metal box at the end of a 4-conductor shielded cable. Although shielded cable wasn't really necessary, it was useful. When soldered to the inside of the P1/J1 assembly's housing that lead functioned as a strain relief and, by connecting it in that manner, it helped to reduce noise-pickup somewhat. In any event, be sure to use strain reliefs at either end.

The shielding of the P1/J1 assembly's connecting cable was broken, R11 inserted in the line and covered with a piece of spaghetti tubing. Then the shielding was connected to the ground bus on the PC board, as shown in the parts-placement diagram (see Fig. 3), but not before the circuit is mounted in the chassis. That connection serves to cut noise due to an uneven ground plane.

Preparing The Chassis

The author's prototype was housed in a 2 × 7 × 8-inch enclosure that was finished with white formica glued to the



Front view of the author's prototype; note that a grommet is mounted on the chassis to prevent the cable that connects the P1/J1 assembly to the circuit from being shorted out by the sharp edges of the metal chassis. The cable is then clamped to the chassis wall on the inside of the cabinet.

front and top of the cabinet with contact cement. The initial shaping of the formica pieces was done with a fine-toothed saw, taking care so as not to crack the brittle material. Next, the pieces were glued in place and a rasp was used to bring the

(Continued on page 104)

SAXON ON SCANNERS

By Mark Saxon

We dig into the mail bag this issue!

A SCANNER WAS PART OF THE REASON some folks went to jail; really! It happened in Memphis, TN, and points out why law-enforcement agencies are sometimes known to cast a beady eye upon scanner owners.

In this case, homes were being burglarized and police were baffled. The case was broken in a fluke of luck: When a vehicle was *pulled over* because of a minor traffic-rule infraction, the police officer noted a load of apparently stolen goods on the seat. (He reasoned that no one moves TV's, hi-fi's, cameras, silverware, and the like at three AM in a two-door sports coupe.) Also there was a VHF scanner and a beeper (pager) that kept sounding off during the investigation.

When the facts were all assembled, it turned out to have been a pretty slick operation, apparently masterminded by a former police officer who eventually pleaded guilty.

The Assistant DA said, "They were organized to the extent that they would go to the mailboxes of targeted houses and get the names of people they stole from. Then they'd look up the names in the telephone directory, call the people, and if there was no answer, they would drop someone off at the house to burglarize it."

The burglar then took along a beeper while the ring's mastermind remained at home monitoring a scanner tuned to the local police channel. If and when the police were alerted to the break-in, the fellow with the home scanner would quickly *beep* the burglar to alert him to get out of the house. The burglar, in turn, would use a beeper to summon the getaway car driver who was cruising in the neighborhood.

The judge described it as "a sweet operation." (We hope that he was a hanging judge!)

If it hadn't been for the traffic violation, many more homes might have been burglarized by this five-man ring. It's events like that that, unfortunately, reflect badly on scanner owners in general.

They Also Serve

In the last issue we offered some U.S. Army Military Affiliate Radio System (MARS) scanner frequencies. That served to bring in a number of letters from readers who all said, "Hey, why didn't you mention any Navy or Air Force MARS frequencies." Makes sense, no?

Makes sense, yes!

Would you believe that I purposely left them out because I like to hear from my readers? (Some people believe anything.)

I have monitored USAF MARS stations on 142.155, 143.46, and 143.95 MHz. USN MARS networks have been noted on 140.875, 148.375, 148.41 and 148.975 MHz. Is everybody happy? (But don't let that stop you from writing to this column!)

Where Are They?

Here's a logical question from reader Paul Freeman of Pensacola, FL. Paul reports that he's a fan of monitoring the VHF aeronautical bands and he understands that the Jacksonville (FL) FAA Air Route Traffic Control Center operates on a couple of dozen frequencies. The problem is that he can only locate a relatively few on his scanner. *Jacksonville Center* comes in like a powerhouse on 132.15 MHz, with additional operations heard very weakly, and on only a few other channels. Paul wants to know where all the other channels are hidden.

That is a good question and might well have been asked by VHF aero monitors listening to any of the 20 FAA ARTCC's in the U.S., or the 6 ARTCC's in Canada.

Because jetliners travel at such high speeds, and converge upon metropolitan areas from all directions, it was found necessary to establish remotely controlled transmitters for the ARTCC's. Those fan out all around ARTCC's and are located at various distances from the control points (in Paul's case, Jacksonville). Some of the remotely located transmitters are several hundred miles from their announced locations. For instance, the FAA ARTCC in Jacksonville can be heard over transmitters in about 26 different locations, including Valdosta (GA), Dothan (AL), Charleston (SC), Raleigh (NC), Pensacola, (FL), etc.

The closest one to Paul is, of course, in Pensacola. That transmitter operates only on 132.15 MHz, although he's probably in a fringe coverage area of one or more transmitters in other cities. So, while it's true that ARTCC usually uses many fre-

(Continued on page 106)

CAP USAF auxiliaries practice a search/rescue mission, getting ready for the real thing is where time and professionalism pay off with the saving of lives.

By Herb Friedman

ON COMPUTERS

FRIEDMAN

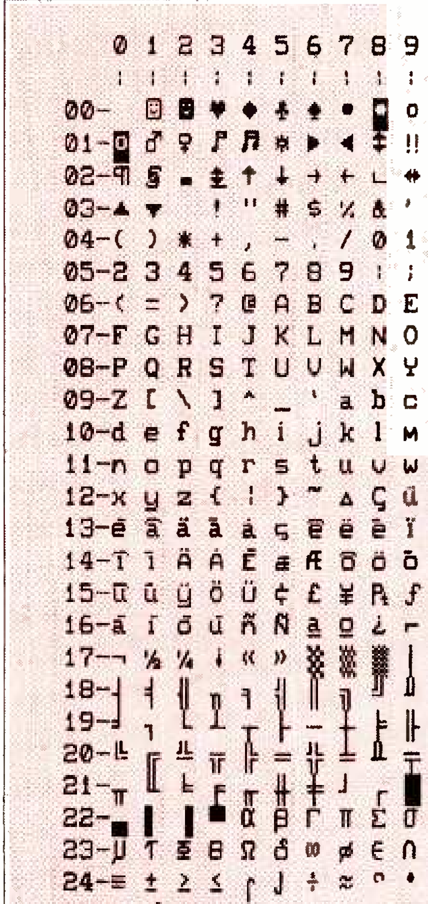
How compatable is that surplus printer?

WHEN IT COMES TO PERSONAL COMPUTERS, the term "compatible" often has little practical meaning. Depending on how much obsolete hardware a manufacturer has clogging the warehouse, "compatible" can mean anything from the *gizmo* will really work with your computer, or might perform only functions having little or no value for you—totally worthless. Through the use of *creative copywriting* even the most worthless junk can be made to appear "compatible;" and, unfortunately, it is two of the most expensive peripherals—printers and disk drives—where a consumer is easily misled by claims of compatibility.

As You Probably Know

The marketplace is literally awash in a sea of "surplus" disk drives and printers, most of which make some claim to compatibility with popular computers. The reason for that is twofold. For printers, it comes about because of the fact that most business computers *must* be IBM-compatible, right down to the printer's character set; and, except for IBM's own printers, none had the IBM graphics—more on that later. The 5-¼-in. disk-drive surplus comes about because of the simultaneous failures of several IBM-compatible computer and disk-drive manufacturers. In fact, there are so many surplus disk drives in the marketplace that 5-¼-in. disk drives that sold for as much as $400 only a year ago are now priced below $80.

Fortunately for the experimenter, an IBM PC-compatible disk drive is also compatible with the Radio Shack and Zenith computers. Also, those drives are downward compatible with earlier models; for example, an IBM-compatible disk drive will work in an old TRS-80 Model 1 computer, or even as a replacement for a Percom add-on disk drive for a SWTP 6800 computer. (How's that for going back in time?) Unfortunately, it doesn't work the other way round; older drives aren't upward compatible. Yet, into a seemingly bottomless supply of IBM-compatible disk drives, many dealers have dropped a supply of older drives that were mouldering in the basement. If you get one of those, you're stuck. It just won't work.



The IBM PC default character set is presented here. If a surplus printer can't generate all of these characters and symbols, it is not truly IBM-PC compatible.

Like Shugart

Most 5-¼-in. disk drives are what is called "Shugart SA-400 compatible," meaning that the electrical and plug connections are the same as those used for the SA-400 drive. But, and this is a big *but*, early drives had track access speeds of 30 msec, and later 20 msec, which was the access time for which early computers were designed. However, the newest computers are designed for disk drives having nominally 6 msec track access. If you install a drive with 20-msec, or even 12-msec track access in a computer expecting the disk drive to have 6-msec track access, the computer either won't see the disk at all, or will produce only I/O errors. In short, although the connections and power requirements are compatible, the drive as a whole isn't.

As a general rule of thumb, just about any Shugart SA-400 compatible drive will work in the early computers: those which predate the IBM-PC, such as Radio Shack's Model 1 and Color Computers, and the Zenith H8 and H89. Newer computers require the faster access of 6-msec drives, and the drive should specifically state that it is compatible with the IBM-PC and not any other IBM computer. (Some surplus dealers use very creative writing to imply that a drive is IBM compatible. It must be clearly stated that the drive can be directly installed in an IBM PC.)

Even more creative writing is used to describe printers. At the beginning of personal computing, the graphics characters of Radio Shack's Model 1 computer were the standard-of-reference. Even Epson, which did not manufacture printers for Radio Shack, provided the Radio Shack graphics in their MX-80 printer. As more computers came into the marketplace, each had its own particular set of graphics (even Radio Shack's own computers employed different graphics) and the graphics capabilities of many printers were specifically designed for a particular computer, or no graphics at all.

As a rule, ASCII codes 0 through 32 were control codes, 33 through 127 were conventional characters, and 128 was DELETE, RUB OUT, or NULL. Printer and computer manufacturers used proprietary graphics for the ASCII codes above 128, although some computers and printers even located a few graphics below ASCII 32.

But then came the IBM-PC and its family of clones and compatibles. With the

(Continued on page 100)

Electric Kentucky Derby

(Continued from page 30)

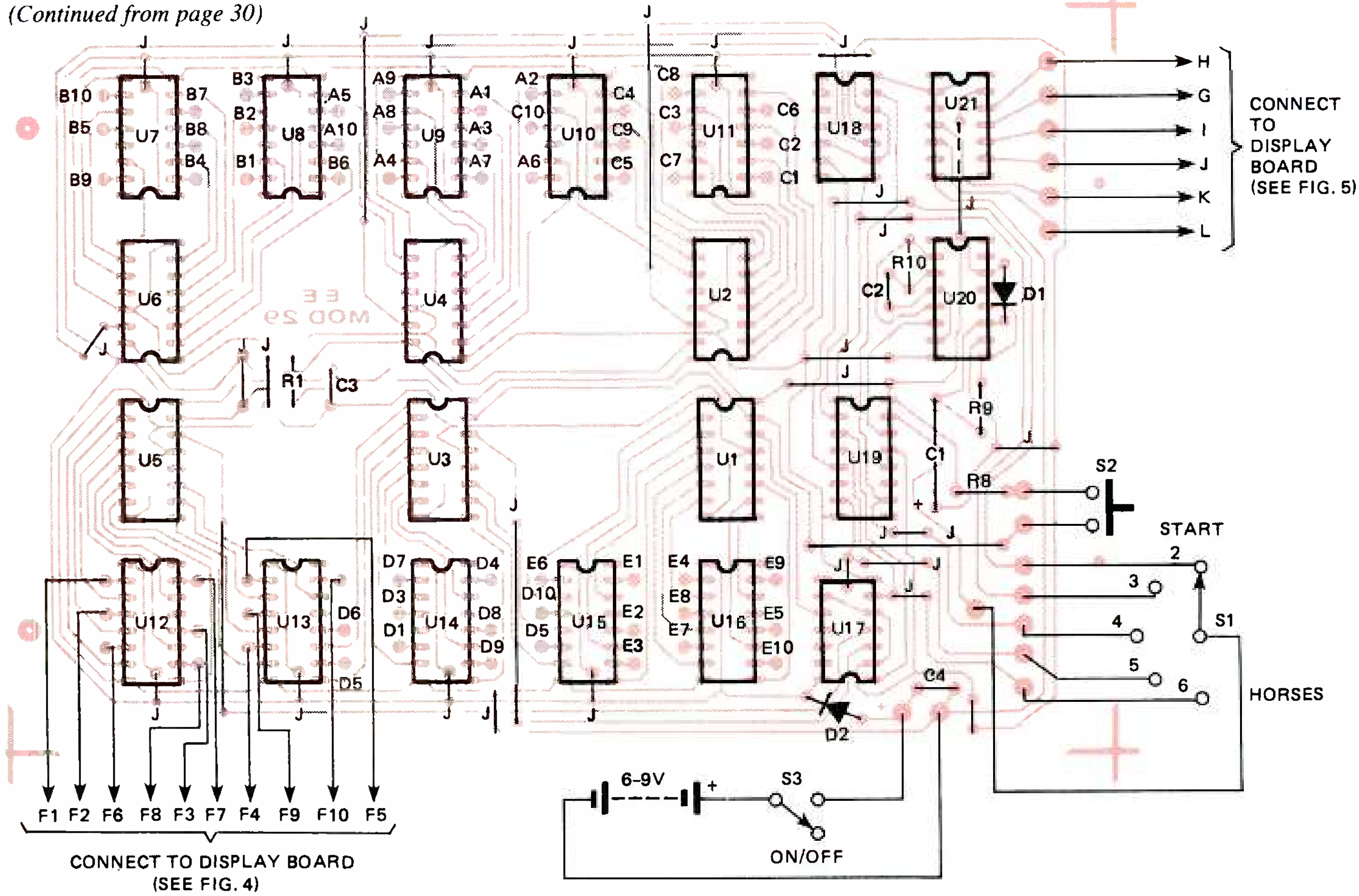


Fig. 5—The main circuit board contains the bulk of the electronics for the Electronic Kentucky Derby. On-board jumper connections should be made prior to mounting the components because several of them must pass underneath the integrated circuits. Pads labeled A1–A10, B1–B10, C1–C10, D1–D10, E1–E10, and F1–F10 connect to pads on the front panel board that have the corresponding designations; e.g., A1 to A1, A2 to A2, A3 to A3, and so on.

mounting for the main board when the wiring is completed.

Turning our attention to Fig. 5, the parts layout for the main circuit board, note that it contains many jumper connections, some of which must pass under components. So install the on-board jumpers first; then the resistors and capacitors, making sure that C1, the only electrolytic in the circuit, is properly oriented. Also, remember that C2, the 0.009-µF capacitor, is really two 0.0047-µF units wired in parallel.

Now install the semiconductors, paying close attention to their orientation. And finally, install the wires at the points indicated in the main circuit's layout pattern. Those wires are used to connect the two boards.

After mounting all the jumpers and components on the main circuit board, lay the two boards end-to-end with their foil sides up and the end with the larger mounting pads against the panel board. Those boards are then temporarily bolted together using the mounting holes and the previously mounted standoffs. Wiring can then be completed between the panel mounted light-emitting diodes and the appropriate solder pads on the main printed-circuit board.

On the panel board, the light-emitting diodes are designated by rows A to F, and position numbers 1 through 10. The corresponding positions are labeled on the layout of the main board. For instance, the wire at position A7 on the main circuit board goes to column A row 7 on the front panel board. Use small-gauge stranded wire to make those connections. The wires should be as short and direct as possible. Be very careful when connecting the wires, because a mistake at this point can result in a horse that doesn't always run in the same direction. *(Continued on page 96)*

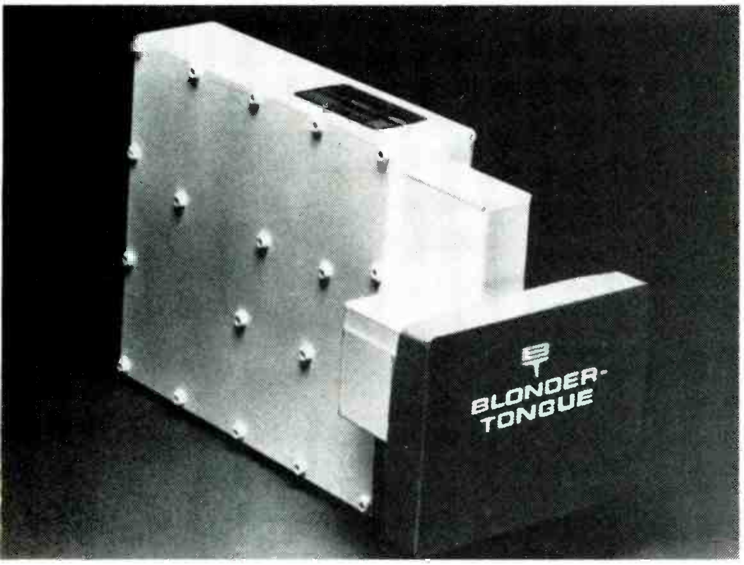
CAPACITORS
C1—4.7-µF, 25-WVDC electrolytic
C2—0.009, 25-WVDC, ceramic (two 0.0047-µF, see text)
C3, C4—0.1-µF, 25-WVDC ceramic disc

SWITCHES
S1—Single-pole, 5-position (SP5T), rotary switch
S2—Single-pole, single-throw (SPST), normally-open, momentary pushbutton
S3—Single-pole, single-throw (SPST), rocker (or toggle) switch

ADDITIONAL PARTS AND MATERIALS
Printed-circuit material, 6–9-volt battery(s) or wall-mounted power supply, enclosure, paint, dry-transfer lettering, solder, stranded hook-up wire, etc.
The main printed-circuit board is available from Electronics Enterprises, 3305 Pestana Way, Livermore, CA 94550: $13.00, including shipping and handling. Please allow 6–8 weeks for delivery

Your Link From The Stars

(Continued from page 48)



A separate LNA and downconverter in a TVRO system, means that expensive heliax cable must be used to connect the two units. But by using a unit like this Blonder-Tounge LNC (a combination LNA and downconverter) long runs of heliax cable can be eliminated, thus allowing ordinary coaxial cable to be used. Also, such units allow more than one TV receiver to be connected to a common dish. However, only one program channel may be selected at a time.

dealer should have a portable receiving system that can be driven to your location to ensure that your TVRO dish will have a clear line of sight to all the domestic satellites and be free from microwave interference.

Ask a lot of questions and compare systems, prices, fea-

The M/A-Com feedhorn pictured here is of the scalar variety, meaning that its entrance features concentric rings to help to gather the reflected microwave energy. The signal is then channeled it to the LNA for amplification.

tures; that way you'll be 99% sure of getting a reliable satellite earth station for many happy years of viewing the world from your backyard. ■

Satellite earth station owners are invited to join SPACE (the Society for Private And Commercial Earth stations), which is a formidable lobbying force in Washington, DC that's dedicated to insuring that all Americans share the benefits of satellite television technology on an equal basis. The yearly membership fee of $35.00, for private earth station owners, entitles you to a monthly magazine, participation in workshops, conferences, and more. For additional information, write SPACE, 709 Pendleton St., Alexandria, VA 22314.

Computerized Cameras

(Continued from page 41)

correspond to that of a reference signal, the computer causes an internal motor to vary the focus of the lens until the phasing of the light through the lens does correspond to that of the reference signal. At the instant the two coincide, the motor stops. If the user presses the shutter release a little bit more, the camera sets the shutter speed and aperture, and snaps the picture.

The actual focusing is much faster than you might think because the microprocessor keeps track of the lens's position and uses up to four motor speeds to adjust the lens. If, for example, the lens is set to its minimum focusing distance, the microprocessor uses the fastest possible motor speed to move the lens about two thirds of the way and then gradually decelerates, eventually easing into focus with the slowest motor speed. If the lens starts out almost in focus, the microprocessor might use the slowest possible speed and simply nudge the lens into focus.

The maximum time it takes to focus depends on how far the lens must be moved from the minimum focusing distance to infinity, which is part of the information provided to the computer by the ROM built into the lens. The longer the lens's focal length, the longer the worst-case condition; for example, a 210 mm lens takes a maximum of .55 seconds to move through the entire range. On the other hand, 24 mm and 50 mm lenses take only 0.15 seconds.

We zeroed in on the Minolta Maxxum Autofocus SLR (single-lens-reflex) camera for the discussion in this text. Our thanks to Minolta for providing the detailed information.

Computerized focusing even works in pitch darkness by substituting an infrared focusing-beam for ambient light. At the moment of exposure, the subject is illuminated by a dedicated electronic flash whose output is controlled by the computer. That works easily enough because the computer measures the reflected light from the subject and extinguishes the flash when the film has received the optimum exposure. Unlike exposure by ambient light, however, the electronic flash is so brief—usually well under 1/1000th of a second—that there's no time to use the light for focusing. The computer gets around that by using a burst of infrared to focus the lens just before the electronic flash is fired.

Figure 7 shows how the infrared focusing works. The infrared burst is automatically triggered when the computer senses that the ambient light isn't sufficient, or the subject contrast is too low, for normal automatic focusing. The computer uses the infrared reflected from the subject to focus the lens. To be certain that the camera is not being fooled by subject motion, the computer causes the flash to fire a second infrared burst just prior to the electronic flash. If necessary, the computer "tweaks" the lens's focus just before the flash goes off.

While we have covered only the major highlights of a computerized camera, bear in mind that once a microprocessor is built into the camera just about any function can be computerized. Other than determining the precise instant you want the shutter to release, a computerized camera can automatically adjust itself to optimize every variable. Judging by the frequency of new developments in both computer and camera technology, it shouldn't be too long before the camera will be able to read our thoughts and automatically trip the shutter at the peak of the action. ■

Letter Box

(Continued from page 7)

letters that got through, the writers discovered that we supplied out-of-date data for the Biamp Power Amplifier. In fact, when Gladstone supplied us with the latest data sheets and prices, they were kind enough to send information on other products. We rediscovered a source for toroidal transformers, preamplifier and mixer modules, MOSFET and Bipolar power amplifier modules, and high-fidelity products that you should know about, too! So, why not drop a line to Gladstone Electronics, Inc., 1585 Kenmore Avenue, Buffalo, NY 14217, or call 716/874-5510. Tell Gladstone that the Editor of **Hands-on Electronics** *sent you!*

Teacher Knows Best

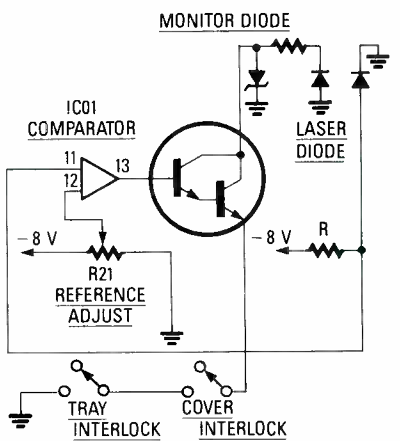
In a final exam I took last semester a question was asked: What is the diameter of the orbit path length of a geosynchronous earth satellite? I have my solution to the problem on the back of this letter, which is correct, and I was marked wrong. Do you agree?
B.B., Fresno, CA

Yes, I agree with your teacher's opinion—you are wrong. You made one mistake that too many of us make continuously throughout our life. You see, we believe the universe revolves around us. It ain't so! *A geosynchronous satellite, when directly overhead, is 22,300 miles above the earth's surface from where you are standing. However, the satellite is 26,300 miles from the center of the earth (assuming an 8000-mile diameter) from which point it rotates. In your solution of the circumference (the orbit path length) you used a radius that was 4000 miles too short! Don't feel bad. Your teacher failed also in that he (or she) failed to use that exam as an instructional tool. Why take a test for a grade only? All tests should include the teaching process. To you, congratulations for seeking the truth.*

Controlling Compact Discs

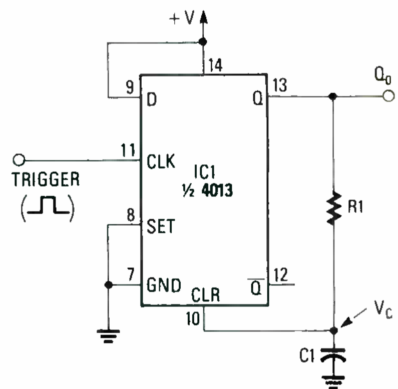
I've been trying to get involved with the circuitry in compact disc players, which is a good step-and-a-half beyond your ordinary phono system. Can you explain in simple terms how they control the amount of light that comes from the laser diode? —P. T., Taos, NM.

Monitor and control circuits are shown in the diagram below. Basically, the output of the monitor diode is applied to the input of a comparator (IC01). The other comparator input gets an adjustable reference voltage. Resistor R21 sets the reference voltage for optimum laser output.



Tough One!

Here's a tough one for you! I know that a monostable multivibrator can be configured as a flip-flop, but can you give me an example of a flip-flop being configured as a monostable multivibrator? I don't mind telling you there's a twenty-dollar bet riding on the answer to this one. —S.K., Camden, NJ



Don't continue reading until you agree that the money goes to a charity! Check the circuit. We've managed to make a 4013 D flip-flop into a monostable multivibrator. Now do we congratulate you, or offer our sympathies?

NEW PRODUCTS SHOWCASE

(Continued from page 13)

that provides unlimited sound capabilities. The JE755 has expansion capability with additional external parts; for example, and external amplifier or stereo system may be added to provide a richer sound.

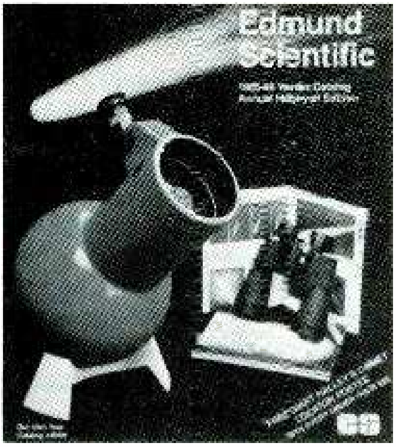
The JE755 comes complete with components and documentation for assembly. The suggested retail is $34.95.

For more information contact Jameco Electronics, 1355 Shoreway Rd. Belmont, CA 94002; or telephone 415/592-8097.

Scientific Hobbyist Catalog

Edmund Scientific's 1985 Fall/Winter Catalog for Hobbyists contains 60 pages in full color and lists over 1,000 unique items in easy-to-read type. This marks the 43rd year that Edmund has mailed its popular catalog not only across America, but to just about every country in the free world. The catalog's Product categories are New Ideas, Astronomy, Binoculars, Weather, Solar, Home Laboratory, Microscopes, Magnifiers, Optics, Photography, Home and Office Products, Auto and Camper Products, and Science Kits. Also listed are Toys, Surplus Items, Magnets, Tools and Motors, Health and Fitness, Security, Outdoors, Electronics and Better Living. Edmund is offering a giant Halley's comet poster at no charge with any order over $25.00.

An interesting section in the catalog is a full page headed "New Ideas." Included are Edmund's new 10000X microscope for $279; a wattmeter that will check the actual rating of an appliance; and the



world's strongest mini-magnets.

Edmund also publishes a 100-page optical and industrial products catalog. Both the catalog for hobbyists and the industrial one can be obtained by writing to Edmund Scientific, 101 East Gloucester Pike, Barrington, NJ 08007; or by telephoning 609/547-3488.

ProLogger Software

Fluke ProLogger, a new software package that links an IBM PC, XT or AT with the Fluke 2280 Series Advanced Data Loggers, turns the IBM PC into a high-accuracy data acquisition system, simplifying control and report generation.

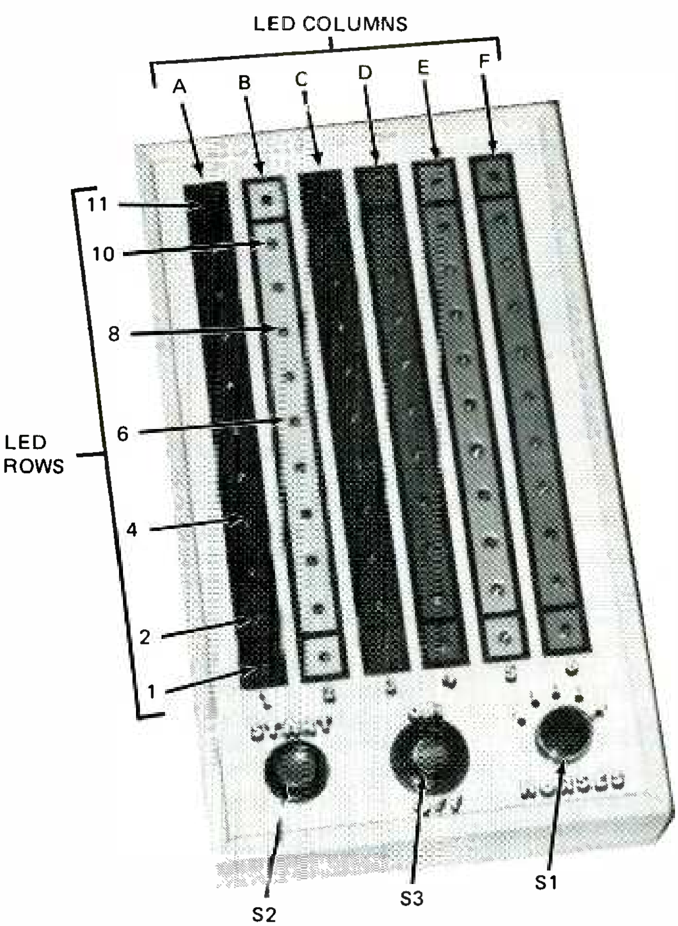
The software package enables Fluke 2280 Series Data Loggers to be operated from an IBM PC. The operator can create and edit application programs on the IBM PC and download them to either the Fluke 2280B or 2285B. The data logger then handles all A/D conversions, linearizations and control functions, freeing the PC for other tasks. Programs can be developed in BASIC, or by responding to the menu-driven prompts of the Fluke 2280 Series. The PC's screen displays a likeness of the 2280 front panel.

The ProLogger software package (diskette and manual) is $295. For more information contact John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, WA 98206; or call toll-free 800/426-0361. ■

Electric Kentucky Derby

(Continued from page 93)

Short leads are then soldered to the pads that connect to S1 and S2. Six wires are soldered to pads G, H, I, J, K, and L on the main board and run to the pads on the front panel board with the same designations (G to G, H to H, and so on). Solder leads to the positive (+) and negative (−) pads on the main board and to the +V bus on the back of the front panel. Now separate the two boards from the temporary end-to-end



The game's front panel is laid out to conform to the separate paths each "horse" will take. The LED's that provide horse advancement information are identified by column and rows.

mounting, fold them together like a book, and then permanently bolt to the standoffs. That leaves a nice compact package with all the messy connecting wires sandwiched between the boards. The loose wire leads are now attached to S1, S2, the ON/OFF and START switches.

The Finishing Touch

The completed game is very compact and easy to adapt to an enclosure. The choice of enclosure depends on whether or not batteries are to be used to power the circuit. You may wish to use an external power supply. For that scheme, mount a small input jack of appropriate size to accommodate the power-supply plug on the case, and connect wires from the jack to the pads on the main circuit board.

When your horse race game is complete, no handicapping is necessary because any horse can win by random choice. One race, your horse may never get out of the starting gate and the next race, the same horse could win by ten lengths. It seems hard to imagine six adults jumping up and down and screaming to make their horse move, but that's just what will happen. All you need to pick a winner is a lot of luck. Come to think about it, that's the way it is at the track too! ■

Compulock

(Continued from page 60)

from each of the Compulock's five inputs (A, B, C, D, and the common bus), and all unused keys. Each wire should be long enough to reach all of the terminals of the barrier strip.

To program the Compulock, connect the wire from the A input on SO2 to the switch terminal (on SO1) of the first desired digit of the combination. (For the 1-2-3-4 combination used as an example in Fig. 1, connections would be made between SO1 pin A and SO2 pin A.) Connect the B input wire to the second desired digit, and the C and D wires to the third and fourth digits, respectively. Connect the wires from the unused keys to any unused terminal and connect them to the point (in Fig. 1) provided for that purpose. By providing separate connections on SO1 and SO2 for each switch (including the unused ones), the circuit is much easier to reprogram.

Regardless of programming technique used, any four-digit code can be programmed into the Compulock, with one exception: No two digits in a row, such as 1-8-3-3 or 1-8-8-3, can be the same. However, 1-8-3-8 or 3-1-3-8 or even combinations like 3-8-3-8 can be used. Any combination, as long as no two digits in sequence are the same, is a valid one. ■

Universal Stopwatch

(Continued from page 36)

You may want to try the TEST pushbutton to check its operation at this time also. Pressing the start/stop button again should cause the display to stop counting and lockup. The same effect will be noted when pressing the reset button. Other positions of the function switch will change the operation of the two push buttons just mentioned.

Check the operation of the other three functions and note that each push button does control the activity. A cursory check can be made by a clock with a secondhand to determine how close the unit may be calibrated. It will be meaningless, however, as you will have to perform the calibration procedure outlined below.

Calibration

To calibrate the Universal Electronic Stopwatch, using a frequency counter of known accuracy, measure the frequency on the cathode of either the 10th or 100th seconds with the device in the reset mode. The counter should indicate a reading of 1066.667 Hz, which is equal to a period of 937.5 microseconds. Do not attempt to measure the frequency directly on the oscillator terminals, because the loading can introduce an error. If care is used in that calibration, the stopwatch should be able to hold its own against a manual stopwatch or other clock.

Way back in the beginning, we explained a little about the ease with which the unit may be triggered. Not really mentioned was the lack of debouncing protection. When the triggering is done it is simply a transition from "hi" to "lo." Once triggered, it is stable so there is no extreme need for conditioning the inputs unless the builder has other reasons to do so.

The Universal Electronic Stopwatch has operated perfectly from simple switch throws, such as push buttons, microswitches, and other leaf-operated units—and even from photocell sensors. No problems were ever experienced.

In timing the model boats, there was an upside down U-shaped bridge-like structure constructed of PVC pipe. The assembly was placed into the water in a manner that allowed the upper section to extend out of the water with enough clearance for the boats to pass under. A reflective type of photocell transmitter and receiver was fastened to one of the uprights and a mirror to the other pipe on the opposite side of the "bridge". Careful alignment allowed anything passing through the beam to be "seen" and counted. A second structure, made exactly like the first one, is used at the other end of the course. All that remains is to measure the distance accurately and run a wire between each sensor and the "stopwatch."

When the boat is up to speed, it passes through the first sensor—which immediately starts the watch. When it breaks the second beam, it stops the watch and displays the elapsed time for the boat to cover the measured distance. Simple math will convert the time into miles-per-hour or to any other distance-time measurement you may desire.

Of course, that is but one method that may be used. It does work very well but may not be usable for every application. As long as the sensing can be converted to a simple switch operation, the stopwatch will make use of that input. A great party game could be fabricated by making use of a unit to indicate the first button pressed by a player when asked a question (similar to the game shows on TV). Thus, beside finding out who knew the trivia answer the most often, you could also determine who could answer the questions the fastest. A prize could be offered for the one with the lowest scored time. Or, how about the one who registered the longest time?

Although the unit pictured is quite large, there is another unit in operation which has been fitted into an enclosure approximately 4-inches square and about 1 1/2-inches high. It can easily be placed into a coat pocket. Operating on nickel-cadmium, AA cells, the Stopwatch has been used often by the owner while attending various races and sporting events. To make it compact, only one of the four functions have been accessed. However, that does not in the least subtract from its usefulness. ■

FRIEDMAN ON COMPUTERS

(Continued from page 92)

IBM-compatible computer fast becoming the computer of choice for business and education, it was necessary for printers to also be IBM-compatible, but there was a catch to that. Although the IBM-PC used conventional parallel and serial electrical connections, the complete IBM character set was totally different from that of all other computers and printers. In particular, it had extensive math, foreign, and graphic symbols. In actual fact, the IBM graphics printer had two sets of characters, the major difference being that Set 1 had almost the conventional control codes below ASCII 32, while Set 2 had the graphics shown in Fig. 1, which are easily accessed through BASIC. For example: ASCII 14 is usually a CTRL-N, but in the IBM Set 2 an ASCII 14 represents the double musical note graphics character.

The IBM Character Set

In Fig. 1, the column of numerals at the left represents the first two numbers of a 3-digit ASCII code. The horizontal row of numerals across the top represents the third digit. The character appears at the intersection of the selected column and row. For example, 012 (ASCII 12) prints the international female symbol, while 234 (ASCII 233) prints the *omega* symbol used to represent resistance.

In order to be truly compatible with IBM computers, a printer must be capable of printing the entire character set shown in Fig. 1. Unfortunately, warehouses were bulging with printers that were only compatible with IBM PC's control codes from ASCII 1 through 32 and the characters from ASCII 33 through 127. Above ASCII 127 a non-compatible printer might produce italic characters or graphics having no relationship to what an IBM PC-compatible computer showed on the screen.

In order to clear the warehouses, many printers were sold as being IBM-compatible as long as the control codes, conventional characters, and serial or parallel I/O connections matched those of an IBM printer.

Eventually, the public got wise and questioned the compatibility of the non-IBM printers. Some were made more compatible through a retrofit accessory that provided most, but not all, of the IBM character set. If the character you needed was missing, then it was tough luck. Other printers were sold with a printer utility that actually created the entire IBM character set from dot-addressable graphics. While that usually works well when printing ASCII text files, the utility can't be used for, among other things, a screen dump because a dump cannot easily be passed through a utility. So again, a "compatible printer" doesn't turn out to be "fully compatible," and what's missing might be precisely what you need.

Commodore, Too!

Printers for IBM-type computers aren't the only ones that can suffer from poor compatibility. Commodore printers have non-conventional electrical connections as well as proprietary graphics symbols that are unavailable on anything other than Commodore printers. While there are several devices in the marketplace, which permit conventional parallel printers to be used with Commodore computers, the adapters don't provide some or all of the Commodore graphics characters.

Summing Up

As you can see, "compatibility" is a relative term when it concerns two somewhat expensive, commonly-used personal-computer peripherals. Before you spend your hard-earned cash for what is advertised as "compatible" hardware, make certain you know exactly what you're getting.

We have been picking our topics from the letters that you have been sending to us. Thanks, and keep those letters coming—it helps us a lot! ■

Jensen on DX'ing

(Continued from page 23)

country music as well as gospel themes.

You can hear KCBI on 11,790 kHz from around 1700 to 2000 UTC.

The next U.S. religious SW station on the air may be KVOH, now under construction by High Adventures Ministries, which already operates the shortwave Voice of Hope and a TV station in southern Lebanon.

KVOH, which hopes to be on the air in 1986, is located in the Simi Valley of California. Among the frequencies it may use are 6,005, 9,755, 11,790, 15,120, 17,775 or 17,830 kHz.

There has been much interest in a proposed station in Opelika, Alabama with the unusual call letters, NDXE. The commercial SW outlet is the dream of broadcaster Harry Dickson Norman Jr., who has talked of plans to operate a mail-order-catalogue-of-the-air, transmit in AM stereo, rebroadcast the audio of TV soap operas and other innovative features. There have been rumors—all denied—of financial problems, however.

The prestigious national newspaper, the *Christian Science Monitor* has announced firm plans to begin a shortwave news station in 1986. The transmitter is to be located in Maine.

Other domestic shortwave projects, which may or may not actually happen, include religious stations in Homewood, Louisiana, and Indianapolis, Indiana; and there are commercial operations in Napa Valley, California (*Radio USA*), Salt Lake city, Utah (KRSP), Louisville, Kentucky, and Presque Isle, Maine.

There *is* a lot more to U.S. shortwave broadcasting than the *Voice of America*.

New Publication

The long awaited *Radio Database International* reference publications are now available.

See what you can hear is the slogan of this Pennsylvania-based publication, which uses innovative computer software design to graphically display station information in an easy-to-understand format. At a glance, you can find which shortwave stations are on the air, their frequencies, transmitter powers, antenna-beam headings, broadcast times, and languages.

RDI comes in two companion volumes; Part I, covering the international broadcasting frequencies from 5,700 to 30,000 kHz, and Part II, spanning the tropical shortwave bands from 2,000 to 5,700 kHz.

The price for both is $12.95, plus $1.95 for shipping and handling from Radio Database International, P.O. Box 300, Penn's Park, PA 18943.

Down The Dial

Let's take a look at what some of our DX reporters are hearing on shortwave. All frequencies are in kHz; times are in UTC (EST +5 hours; CST +6 hours; MST +7 hours, and PST +8 hours):

Antarctica—6,012, *American Forces Antarctic Network*, McMurdo, was heard several times with fairly good signals between 0800 and 0830, with a program of country and western music.

Bangladesh—11,553, *Radio Bangladesh* has been noted with fairly strong signals but difficult readability in the eastern part of the U.S. The station was heard signing on at 1814 and continuing with English language news, commentary, and cultural programs until 1845 tuneout.

Denmark—6,030, *Radio Denmark* noted in this new frequency around 0000, but signals are difficult with plenty of interference.

Djibouti—4780, *Radio diffusion Television de Djibouti* is being heard with reasonably good signals from Africa's northeastern "horn." Reception is possible when the usual interference on this channel, a Venezuelan station, is off. You may hear Islamic religious programming

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Improving Music Recordings

(Continued from page 56)

treble to your liking with an equalizer (or subsonic synthesizer described below). You may not be able to add as much bass as you would like, since the bass notes are already the largest in most music. Adding more than 12 dB causes overloading, which can only be eliminated by cranking down the overall volume and getting your high-frequency signal-to-noise ratio problems back.

I've added 12 dB of bass to many of my recordings. The hiss problem is not bad when I'm using chrome tape and a Dolby system. Equalizers that fit in your pocket and go between your headphones and tape player cost under $20 now, so it is not necessary to put all the bass you want to hear onto the tape itself.

When recording the improved version of your old tapes, you may be surprised that it is necessary to good-quality tapes and Dolby (or dbx or some other noise-reduction system) to maintain the good signal-to-noise ratio you have obtained. You may want to add other special effects to your recordings, such as synthesized stereo, echo, and extended bass. However, you may feel that the recordings shouldn't be modified too much, or you may want to reproduce the recording the way it was originally meant to be. Reverberation and other effects can be added during playback, depending on your mood at the time.

Most of us really don't have the time to monitor the copying of hundreds of hours of tapes. The old tapes have various levels of signal, noise, and other problems, so careful watching and listening is necessary when they are being processed and copied. I've found time to use the noise-reduction equipment and copy a lot of my old tapes by doing it while I do my writing. My word processor is right next to my music and tape copying equipment (see photos). I read and type as the music is playing.

It is difficult to hear how much hiss is present because a good part of the time that I am sitting and typing, I am riding my exercise bike. How's that for efficient and healthy use of one's time? (Actually, the exercise bike keeps me awake, gives me exercise, and helps eliminate some kinds of back pain. It can be used while doing word processing or computer programming. But that is another story.) Things like the audio bandwidth indicator on the Advanced Audio Systems International model DNR 911 make it easier to see that the level settings are correct when the bicycle noise drowns out (masks) the tape hiss, which I am trying to hear. It is necessary to just occasionally glance at the bar-graph display to see that the filter frequency is going up and down...which it does almost continuously.

Frequency Response of the Ear

The human ear's frequency response becomes flat when music is of high intensity (loud). At lower intensities, one does not hear treble and (especially) bass very well. For that reason, music usually sounds better when played loud. Many amplifiers do not have volume controls: They have LOUDNESS controls. The LOUDNESS control boosts lower frequencies more at the low-level settings, compensating for the poor ability of the ears to hear low frequencies when the music is not loud.

Why not just play music loud all the time, possibly using earphones? No one else would hear the music. The answer is that loud music damages your hearing. My electrostatic headphones have an LED (light-emitting diode) built into each side that turns on when the sound level gets to 90 dB. When you get up over 100 dB, you start to get into pain and ear damage. The headphones with warning LED's have taught me what's safe. Most people have never had a safe sound level demonstrated to them. I think that those earphones are responsible for me keeping my hearing despite long years of listening to music. It is too bad that there are so few earphones on the market with indicators built-in that show the sound level going to the ear. Many people would appreciate an LED turning on when the sound level becomes unsafe, but I have not seen many headphones on the market with sound-level detectors.

Boosting Bass

There are other reasons for wanting to boost the bass up on your music besides the necessary boost when playing music at a safe level. Acoustic guitars, like those used back in the 1950's, just did not come through on many recordings. If those same songs were recorded today with the better equipment available and the tastes that people have today, the bass would be louder. A lot of the old songs *do* sound better when the bass is boosted. That can be accomplished by just adding 12 dB on a graphic equalizer at all frequencies below 120 Hz.

The same graphic equalizer settings are used to compensate for the poor frequency response of some speakers. In some cases, boosting the bass by 24 dB using two equalizers makes the music sound really nice. However, there's a device that does an even better job than an equalizer in boosting the bass. The Radio Shack Stereo Bass Enhancer and Subsonic Filter gives one control over the frequency range of 40 to 160 Hz. It's possible to add up to 12 dB gain at frequencies centered at any place between 40 and 160 Hz. The subsonic filter cuts off frequencies below 20 Hz, giving an increased gain of the amount desired (from 0 to 12 dB) at the frequency chosen and at all lower frequencies down to 20 Hz. On many

When improving music, one can also exercise and do computer programming (or word processing). A desk-top computer, securely held at a height that allows comfortable typing, while riding the exercise bicycle. Sound processing equipment is near the computer. The small tape recorder in the picture plays the original noisy, monophonic tape. The large recorder with separate playback and record heads provides monitoring of the final result. Speakers and earphones are available for listening.

types of music, the Radio Shack Bass Enhancer sounded better to me than the result obtained by using an equalizer, which had controls at 32 and 64 Hz. Actually, the Bass Enhancer is meant to be used to compensate for the poor bass response of speakers and earphones, and it does accomplish that task quite well.

There are other devices that can compensate for a tape recorder's poor bass response. Those instruments assume that when there is a sound between 56 and 100 Hz, it is really a second harmonic of a (missing) sound at 28 to 50 Hz. To fill in the missing sound, instruments called *subsonic frequency synthesizers* generate those lower frequencies. Sounds between 56 and 100 Hz are used to guide the synthesis of sounds between 28 and 50 kHz. The synthesized sound blends in with the program material and sound quite natural.

Making Stereo From Mono

With monophonic (one sound) program material, the audio seems to come from one point. If you have headphones on, that point is the center of your head provided that your earphones are properly phased. Otherwise, the sound seems to come from each headphone. With stereophonic (multi sound) speakers, the audio seems to come from in front of you and spread out from left to right. It's as if you were sitting in front of a band. With some good quadraphonic systems, the listener feels as if he or she were sitting with the musical ensemble. With stereo headphones, the sound is distributed throughout one's head, though some people may learn to feel the sound is coming from out in front of them.

Much good, old music was recorded in mono. And, some of us have only mono recordings of some of our favorite music. Also, most television and AM radio is still broadcast in mono. Many of us have wanted to be able to transform our mono television sound, AM radio, and music recordings into stereo sound.

There are several ways to make monophonic sound seem to be stereophonic. One way is to add a little reverberation or echo to one channel of the music....not enough to let you hear an echo. That technique gives a fullness, more than a stereo effect, but it does seem to spread out the sound.

One of the earliest ways to simulate stereo sound was to put most of the bass into one channel and most of the treble into the other. That does not work very well, but good results are obtained by using more frequency bands. An example of a device capable of handling that job is Radio Shacks video-sound-processor, which contains (among other things) a DNR noise-reduction system that's followed by filters. Those filters divide the audio spectrum into five overlapping bands. Two are fed to one ear, and three to the other ear, and the result is quite pleasing. Several switches and knobs allow one to vary the effect. That device, at a cost of about $100, is all one needs to reduce tape hiss in old mono recordings and transform them into stereo!.

AM Radio

I recently spent 5 days on Cape Cod and I tuned to two AM radio stations near Boston that played music from the 1930's and 1940's. The announcer said a little about each song and its performer. I thought that recording a few days of that music would give me some tapes that would be a good introduction to the music of that period. But the reception was weak in that area. There was buzzing at times, and an annoying 10-kHz heterodyne signal caused by adjacent stations. I was forced to use some C-90 cassettes that were the best I could obtain locally and some voice-grade tapes with a terrible frequency response, which I had brought for dictating study notes.

When I got home I started to process and copy over the tapes. The poor frequency response of the tapes (about 8 kHz) completely eliminated the 10-kHz adjacent-station interference. The buzzing was 60 Hz or, at times, a harmonic of it. It could be greatly reduced by putting the 62, 125, or 250 Hz controls of my graphic equalizer all the way down (12 dB). Sometimes two controls (125 and 250, especially) had to be used at once. The equalizer was also used to boost the bass (my personal preference) and the treble (the 4 kHz control). The 8 kHz and 16 kHz controls were kept all the way down because AM radio does not transmit music in those ranges. The DNR system eliminated most of the tape hiss. Body (a fullness quality in a recording) was provided by adding a less-than-noticeable amount of reverberation. The stereo effect was accomplished with the Radio Shack video sound processor. Those AM recordings sounded better than I had ever hoped. I used chrome tape and Dolby noise reduction on the final tapes to maintain the good signal-to-noise ratio that had been achieved.

Now You Do It

It is not difficult to make high-quality recordings of music today. What is difficult is to make your old records, tapes, and other poor-fidelity music sources sound good. However, the variety of commercially available stereo gadgets to help you get good quality sound is growing daily. Expensive music processors, players, equalizers, analyzers, and synthesizers are proliferating the market. You can improve the sound from old records, noisy tapes, television, and AM radio, just keep in mind the basic functions of the gadgets.

A little experimentation with relatively inexpensive equipment, which you many may already own, can bring back the fidelity that was lost in the recording. ■

Jensen on DX'ing

(Continued from page 101)

around 0305, followed by what seemed to be news, probably in Somali.

Greenland—3,999, *Gronlands Radio*, Godthab, tentatively logged in New York State from about 2330 to 0000 with interview program in Danish, then uptempo music from the station at Bafoussam, Cameroon on 4,000, and from the hams.

Kenya—7,220, *Voice of Kenya* has its new 250-kW shortwave transmitter at Koma Rock in operation. During the 0300 to 0630 period, optimum for North American reception, it has been testing on 7,220 kHz. At other times, 4,840, 9,635 or 9,725 kHz have been used.

Mexico—During last September's disastrous earthquakes, several Mexico City stations were monitored with message relays and pleas for help. The official government SW outlet, XERMX, was noted on 9,705 and 15,430 kHz. *Radio Universidad* also was heard, broadcasting on 9,600 kHz.

Cook Islands—*Radio Cook Islands* is another bit of exotica and can be heard on 11,759 kHz in the Maori language from about 0700 UTC, with English news following at 0800 UTC.

Credits—Hohm Herkimer, New York; Jerry Berg, Massachusetts; David Potter, Florida; John Wilkins, Colorado; Finn Krone, Denmark.

That wraps things up until next time. What are you hearing on shortwave? Drop me a line in care of **Hands-on Electronics**, Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735. Also, should you come across any interesting QSL cards, photographs from overseas broadcasters, or even a good-looking shot of your listening shack, send it to us. Remember, one picture is worth a thousand *didadahs*! ■

Loudspeaker Impedance

(Continued from page 52)

to an amplifier. Taken together, the resistance of the contacts and the cable itself should be as small as possible relative to the impedance of the loudspeaker system. Certainly, it should not amount to more than 5% of the load impedance—a maximum resistance of 0.4 ohm for 8-ohm systems, as illustrated in Fig. 5. Ostensibly, that would introduce a loss of less than 0.5 dB and make no discernible difference in the sound as it is heard. Were it a question of signal level, the matter could possibly rest there; but the variation in impedance with respect to frequency introduces another consideration.

In those sections of the curve in Fig. 5, where the impedance is about 8 ohms, cable losses might indeed be just under 0.5 dB, as predicted. However, at 60 Hz, where the system impedance is much higher, the cable loss would be a mere 0.1 dB, and even less in the 1–2-kHz region; the minimum impedance at around 19 kHz would range from around 0.6 to 0.7 dB. From that flows the contention that practical loudspeaker load, contacts, and cable resistance cause not just a loss in level (which might pass unnoticed), but variations in frequency response or a coloration, which might be more apparent.

The counter argument is that the frequency response of a practical loudspeaker system in a practical listening room is already so peaky that it is fantasy to worry about plus-and-minus an extra quarter-decibel! However, human nature being what it is, the impedance *ogre* still has the last laugh when he sees even the counter- arguers doubling and trippling the gauge of their cables "just in case."

But he must really fall about at the sight of ultra-purists hooking-up their loudspeaker systems with lead pipe! ■

Remote-Control System

(Continued from page 78)

special attention to battery wire and transducer connections. Inspect the unit to note if a child has stuck a sharp object into the sensor or transducer area. Check the small oscillator coil for broken coil connections (Fig 6). Take a close look at the printed-circuit board for cracked or broken traces. The traces may be repaired by soldering regular hookup wire across the broken area.

Make resistance and voltage measurements of the various connections and wiring if a VOM or DMM is handy. A digital multimeter (DMM) is the ideal test instrument for accurate resistance and voltage measurements. You can even check the condition of the oscillator transistor with the transistor-diode test of the DMM; that is, provided that your unit, like the one in Fig. 7, is equipped for such test.

The Final Step

After you've made all the tests that are possible with the available equipment, take the defective remote transmitter to your local TV dealer. They can test the unit and possibly repair it within a few days, or replace it. Most TV set manufacturers will (through local dealers) replace or exchange the unit, or the dealer can send it out for repairs.

If the remote transmitter is still under warranty, there's no charge. Repairing the remote transmitter is cheaper than exchange or replacement. See if you can borrow another remote transmitter to use while the defective one is being repaired. One thing is for sure, no one can do without a TV remote-control system after a week of easy tuning. ■

The Rabbit Ear

(Continued from page 90)

formica in line with the edges of the enclosure. The junction formed by the two pieces should be carefully beveled and, if desired, covered with some sort of finishing strip (piece of white vinyl tape) that can be neatly cut with a razor blade or straight edge.

Begin preparation of the cabinet by drilling holes in the chassis at the positions that you decide to place U4, T1, and the circuit board itself. Place the screws that will secure the components and circuit board in place through the holes, apply contact cement, and cover with the cut pieces of formica. Once dry, drill mounting holes for the controls, indicators, and jacks. Rub-on applique, of the type available at most art-supply houses may be used to label the front panel. Once completed, the circuit board and off-board components may be mounted. First, bring the P1/J1 assembly's cable into the cabinet and make the appropriate connections to the board. Then mount the printed circuit and components to the chassis.

In addition, a grounding post should be provided on the back panel (refer to photos) for connection to your stereo system's chassis ground. By connecting that jack directly to the cabinet, which (through the tab of the regulator) is at ground potential, no wire need be run between the jack and the circuit board. But, because the chassis is grounded, J2 (the +9-volt input) must be mounted with a piece of insulating material separating it from the chassis. A jack, which is not shown in the schematic of Fig. 1, through which the pickup will be connected to the circuit is mounted on the rear panel (see photos). Also, there's a small toggle switch, labeled pickup selector, on the rear panel near the speaker jack. It was originally intended for switching between internal and external speakers, to allow the use of local and a remote pickups.

An expansion on the external pickup idea might be to have a microphone located in another room, which would then function as a sort of one-way intercom. Regardless of how far away M1 is placed from the chassis, all connection between it and the circuit board should be made with shielded cable. But unshielded wire can be used if you don't mind the decreased performance due to powerline interference.

Test And Operation

To set the unit for proper operation, turn the THRESHOLD, VOLUME, and DULL controls to their midpoints, plug the wall transformer into J2 and a pair of headphones into J1 and turn S1 to SET. *Do not* plug P1 into your stereo system until the unit has been shown to work properly.

When power is applied, by turning S1 to the ON position, LED2 should come on and you should hear the noise picked up by M1. If not, try turning up the VOLUME control, R2. If the room is quiet, at power-up LED1 should light and remain that way for a brief period, and then go out. Any loud noise, such as a clap in front of M1, should cause it to light again. K1 should stay on for about a second after LED1 initially goes off.

If all goes well, insert P1 into the headphone jack of your stereo and turn it on. The music should be slightly audible above any room noises with K1 energized. On the other hand, the music should be completely audible with K1 off. With VOLUME control R2 at its loudest setting, a high degree of

(Continued on page 106)

HANDS-ON MARKETPLACE

FOR SALE

REPAIR shop gone out of business. All kinds of parts: transistors, I.C.'s, etc. Below cost. Call or write: **AMERICAN RECORDING**, Box 1109, Elizabeth, NJ, 07207-1109. (201) 355-6676.

RESISTORS—any value/quantity, ¼ **watt** @ **.01**, ½ **watt** @ **.015** ($1.00 minimum).Quantity discounts, 1000+. Send wattage(s), value(s), quantity(s), and remittance—**T.O.R.C.C.C. ELECTRONICS**, Box 47148, Chicago, IL 60647; (312) 342-9171.

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To run your own classified ad, put one word on each of the lines below and send this form along with your check to:

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(More classified on page 106)

The Rabbit Ear

(Continued from page 104)

distortion will probably result and cause LED1 remain on. As previously mentioned, R1 (DULL) and R7 (THRESHOLD) are used in conjunction with each other to set various sensitivities.

With R1 set to pass the maximum signal level, U2 will be saturated by moderately loud sounds at M1, allowing the THRESHOLD control (R7) to be set for the highest degree of sensitivity. In rooms where high noise-levels are likely to be encountered, DULL (R1) must be set to attenuate most of the signal in order for the the THRESHOLD control, R7, to have any effect. In simple terms, R1 is sort of a coarse tuning control, while R7 functions as a fine-tuning adjustment. The exact relationship between the two can only be understood through experimentation.

Setting the unit to its highest degree of sensitivity is not necessary; almost any setting of R1 at its lowest (least dulling) position is likely to cause the unit to be triggered by some one walking across a carpeted floor.

If, at power-up, the circuit fails to function properly or not at all, first check all polarity dependent components. Are the semiconductors and electrolytic capacitors properly oriented? Make sure that all write connections are going to the right pads on the printed-circuit board.

On the other hand, if everything is functioning normally, but triggering seems odd or non-selective, the problem is most likely caused by noise somewhere in the circuit. A bad solder joint is the prime suspect. The grounding might be uneven, creating voltage drops where there shouldn't be any. Try troubleshooting the unit stage-by-stage, because each operates fairly independent of each other. The noise will probably be of the 60-Hz variety, which will show up as spikes on an oscilloscope that's set at the powerline frequency. ■

Saxon On Scanners

(Continued from page 91)

quencies, most are probably out of monitoring range of listeners in any one given area—although the aircraft (flying at high altitudes) can be monitored while communicating with the out-of-range ground-based remote transmitters.

New Bearcat

Uniden Bearcat has come up with a really beautiful new hand-held scanner called the Bearcat 100XL. It replaces the former Bearcat 100 hand-held programmable scanner.

The 100-XL scans 16 channels at a clip, receives the popular VHF aero band plus the VHF hi/low bands, UHF/UHF-T, as well as the 2-meter and 70-cm Ham bands. What else can you ask for?

Try these features: keyboard lock switch, priority-channel function, backlighted display, scan-delay, search-scan, manual step-through tuning, squelch, individual channel lockouts, and rubberized whip antenna.

A nice handful that should appeal to many monitoring enthusiasts at its suggested list price of $349.95. Check it out at your nearest Uniden Bearcat dealer.

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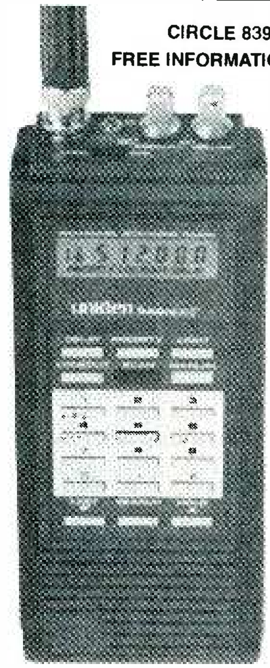

The Bearcat 100XL scanner from Uniden is a pace setter. Almost all its features are visible on the unit's switch panel surface.

A Few Quickies

Susie Roseberg of Marina del Rey, CA, would like to monitor the Civil Air Patrol (USAF Auxiliary) on their SARCAP (search/rescue) missions and wonders if we would pass along some frequencies for her (and others) to punch-up on programmable scanners. No problem!

Scan through the following channels for CAP activities: 122.9, 123.1, 143.75, 143.90, 148.15 and 148.925 MHz. One or more of them should be active during any CAP operation. CAP stations don't use regular callsigns and in California identify themselves as Brown Bear (plus aircraft number), White Bear (number of base), and Black Bear (plus land-mobile unit number). Each state has its own unique identification words.

Chuck Howard, who hails from Bean Town, writes to say that he likes to go to the Boston Gardens arena to take in the pro wrestling matches. He says that several times he's seen Gardens personnel using hand-held transceivers; and he'd like to do a little eavesdropping, but they won't tell him the frequency used. He asks if we could let him in on the secret.

Easy as Hulk Hogan tossing Rowdy Roddy Piper over the top rope! Listen on 154.60 MHz for those transmissions. And that frequency is popularly used in hand-held units at many other indoor and outdoor sporting events around the nation. Other similar frequencies include: 30.84, 33.12, 33.40, 33.42, 151.625, 154.57, 457.525, 457.55, 457.575 and 457.60 MHz. There are a few more but they aren't heavily used.

We're looking for your comments, station photos, and questions. Write to: Mark Saxon, Saxon On Scanners, Hands-On Electronics, 500-B Bi-County Boulevard, Farmingdale, NY 11735. We can't answer every letter, however; your contributions and comments are sorted and trends are spotted by our slick editor. That's how we decide what we cover and answer. Til next time. ■

ADVERTISING INDEX

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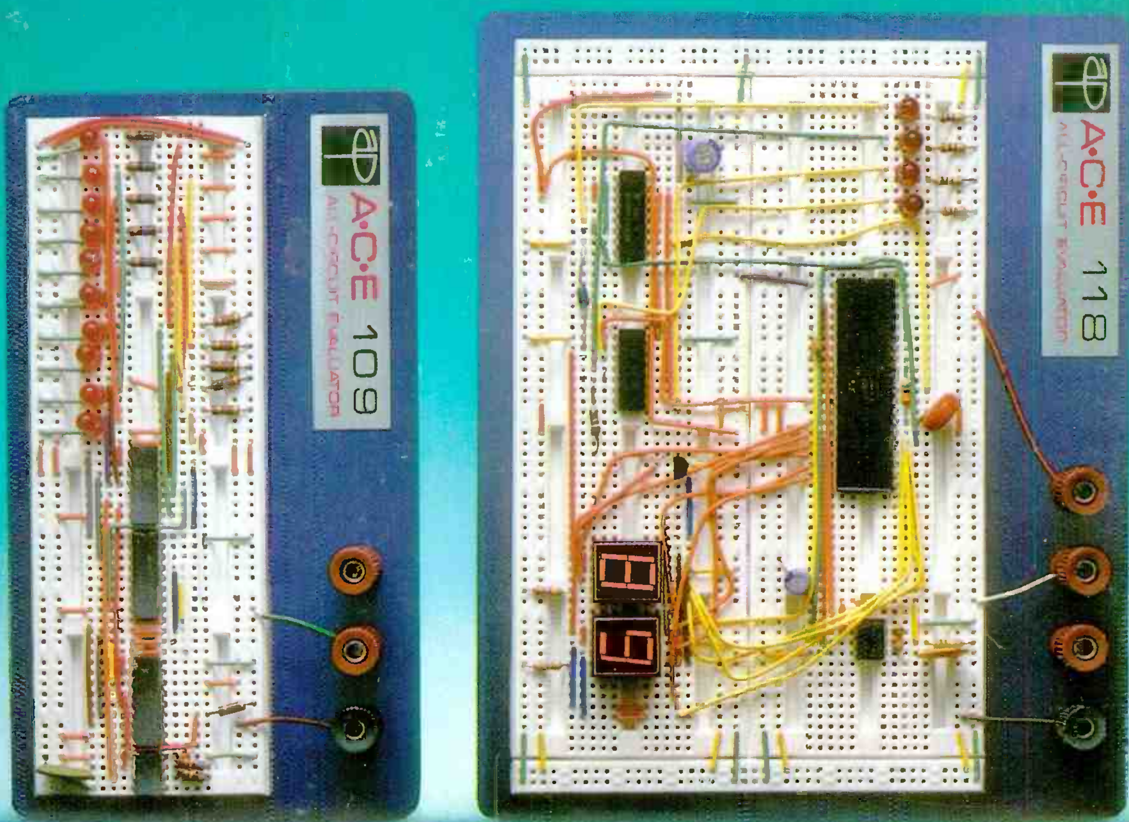

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