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April 1996

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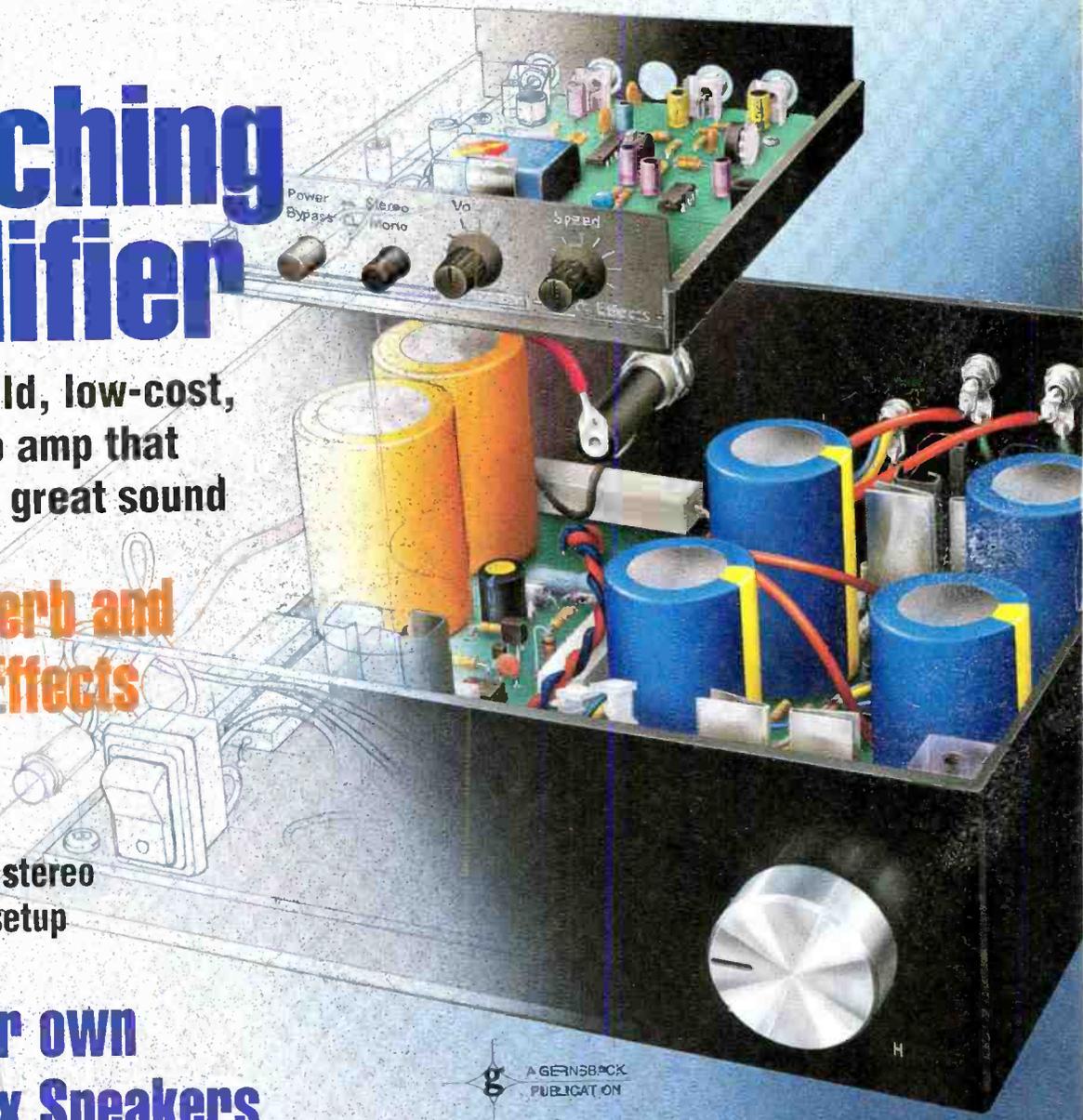
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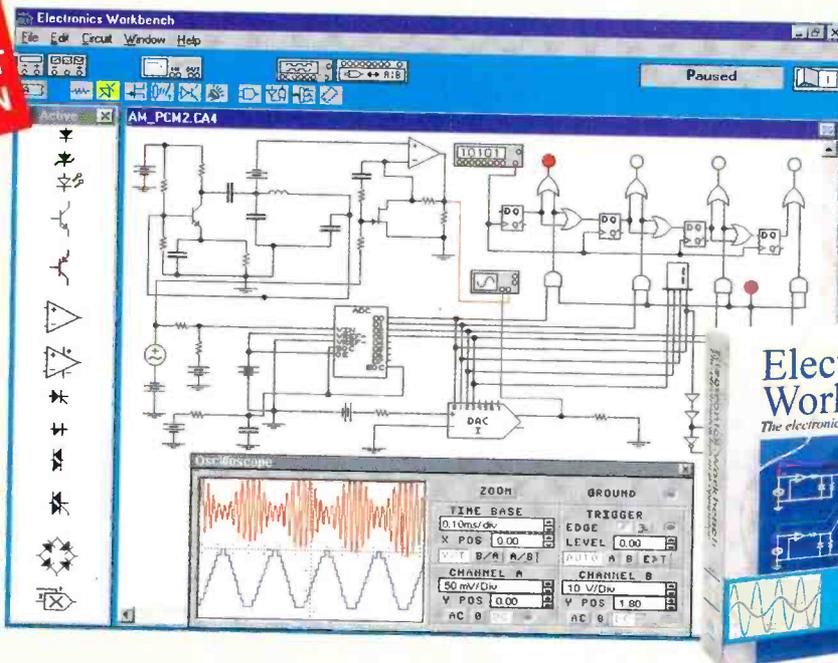
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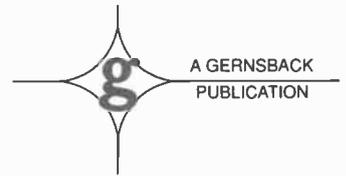


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Vol. 13, No.4



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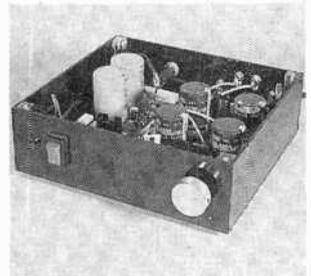
A low-cost, lightweight, easy-to-build, 60-watt stereo amplifier that's ideal for use as a main or backup unit—*Rolando R. Burbon*

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Add concert-hall ambiance to your home theater or stereo setup with this versatile circuit that can be configured for a variety of applications. It even works with live audio—*Marc Spiwak*

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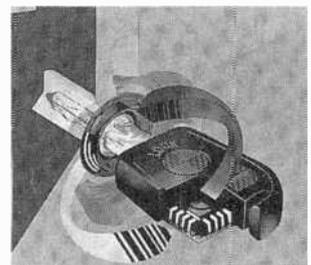
A handy little light for emergencies, or whenever you need it, that seems to never burn out. As a bonus, it doesn't affect your night vision—*Dean F. Poeth*



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In the never-ending battle to protect your automobile and its contents, even keys are gaining some electronic-aided intelligence—*Bill Siuru*

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Learn how vented enclosures affect loudspeaker performance, and how to design your own vented-box, or bass-reflex, speakers using our simple PC program—*William R. Hoffman*

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EDITORIAL

FOR AUDIO ENTHUSIASTS, AND EVERYONE ELSE!

While all aspects of the electronics hobby have their devotees, few, if any, are more ardent than audio hobbyists. Well, this month **Popular Electronics** presents a trio of stories sure to please even the most jaded audio tinkerer.

The first is a great-sounding, 60-watt, stereo amplifier that's lightweight and inexpensive to build. Ideal for use as a main or backup amp, what makes it really different is that it is a "Class D," or "switching" amplifier. To learn more about it turn to page 30.

The second audio article is a simple reverb-effects generator that can be configured for a variety of applications. For instance, it can be used to add the ambiance of a theater or auditorium to your sound system, simulated stereo to a mono source, or surround effects to the audio track of a video program. The unit also has a microphone input for adding reverb effects to speech or vocals. That story begins on page 38.

Finally, there's another installment in our occasional series on designing and building your own speakers. This time, we turn our attention to the vented-box, or "bass-reflex" speaker. In the article we present a design program that can make short work of designing an enclosure that's ideal for your selected drivers, and practical pointers that can make the whole procedure nearly foolproof. The story begins on page 57.

And we have not forgotten all of you non-audio hobbyists. This issue offers a variety of stories and columns for you, too. For instance, shortwave listeners, especially newcomers to that fascinating hobby, won't want to miss "Choosing the Right Shortwave Receiver." That story provides you with the essential information you need to make an informed decision when purchasing your next, or first, shortwave receiver. The story begins on page 48.

Add to that a neat little solid-state penlight that seems to last forever, and more, and you can see that we have another fun-packed issue for you, no matter what your interests. Enjoy!



Carl Laron
Editor

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LETTERS

Citing SETI

SEARCHING FOR EXTRATERRESTRIAL INTELLIGENCE

While The SETI League, Inc. greatly appreciates the favorable exposure given us in Karl Thurber's article "The Search for Extraterrestrial Intelligence" (**Popular Electronics**, December 1995), we must hasten to point out that at least two of the author's sources were not cited. Much of the material on The SETI League's upcoming all-sky survey first appeared in my articles "Searching for Life Among the Stars" (*QST*, August 1995) and "SETI Made Simple—What Can We Do?" (Proceedings of the 1995 TAPR Annual Meeting). Your readers should be made aware of those prior publications.

SETI seeks to determine through microwave measurements whether humankind is alone in the universe. Since Congress terminated NASA's SETI funding two years ago, The SETI League and other scientific groups have been attempting to privatize the research. Experimenters interested in participating in the search for intelligent alien life, or citizens wishing to help support it, should contact The SETI League, Inc. membership hotline at 1-800-TAU-SETI. The SETI League, Inc. is a membership-supported, non-profit [501(c)(3)], educational and scientific corporation dedicated to the electromagnetic Search for Extraterrestrial Intelligence.

H. PAUL SHUCH, Ph.D., N6TX
Executive Director
The SETI League, Inc.
Little Ferry, NJ

I regret the complaint received from Dr. Shuch. I was surprised to learn that The SETI League took exception to an article that promoted their programs, an article whose publication they encouraged and in which they cooperated in supplying materials. I apologize to him for any misunderstanding on the use of those materials.

I employed SETI League material, particularly in the "A Basis for SETI?" and "What You Can Do for SETI" sections, and for the quotes attributable to Dr. Oliver. Those sections promoted SETI research and the League's upcoming all-sky survey.

As a result of the League's cooperation in furnishing a variety of materials, I thought I had tacit approval to use those materials and did not think it necessary to specifically cite them at each point where they were used. But I did mention the League prominently in the article and attributed material to the League and to Dr. Shuch personally on pages 54 and 94. In retrospect, it would have been more appropriate to have provided several formal bibliographic citations.

The original manuscript also contained a brief "acknowledgments" section thanking Dr. Shuch and others for their assistance in preparing the article. Unfortunately, that paragraph did not survive the editorial process.

Nevertheless, Dr. Shuch's concern for protection of copyrighted material and proper attribution is a valid one. It points to the need for more rigorous documentation of sources by technical writers. It also suggests that securing explicit permission to use copyrighted material, regardless of the circumstances, is absolutely essential to avoid any possible misunderstanding.—Karl T. Thurber, Jr.

AN ABSOLUTE DELIGHT

I found L.G. Robertson's article, "Restoring a Vintage Radio" (**Popular Electronics**, February 1996) an absolute delight! I think that the most enjoyment I've ever derived from the electronics hobby has come from reviving a "basket-case" like his.

That is not to say that I do not enjoy other aspects of our wonderful hobby. That's why I appreciated the wide spectrum of articles—tube projects/technology/surplus information/etc.—

in the February issue. Thank you and keep up the good work!

A.B.
Columbus, OH

HAVES & NEEDS

For over a year now, I've been looking for specific information on a number of "acquired" devices, as well as some general information.

I could use data and schematics on my Excursion 6000 cordless Bell phone; a model HE-52 Lafayette receiver; and EICO 427 and Heath Model 10-18 oscilloscopes.

I also need a source for data on tube pinouts, high-voltage and microwave (as in the oven and fly-backs), as well as tube and transmitter cross references. I could also use a schematic for a 1990-92 KTV 13-inch television.

I will reimburse anyone for copying and postage costs.

MICHAEL KELLER
322 S.W. End
Lancaster, PA 17603

I am in need of the instructions and guide charts for the EMC Model 213 tube tester by Electronic Measurements Corp. Any assistance in obtaining the instructions and guide charts is greatly appreciated. I will cover expenses for the data. Thank you in advance.

EUGENE R. MARTIN
345 Eggert Road
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I would like a copy of the operating manual, circuit diagram, and parts list for a Pyramid Phase III power supply. I will, of course, pay any copying and mailing expenses. I've enjoyed reading **Popular Electronics** for many years.

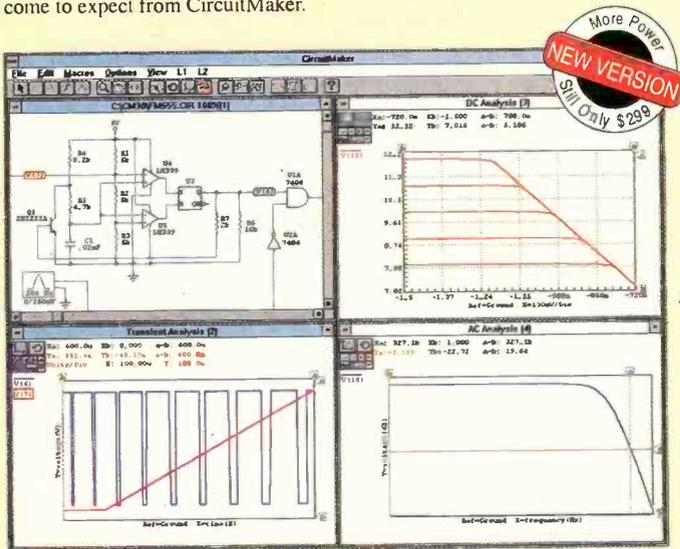
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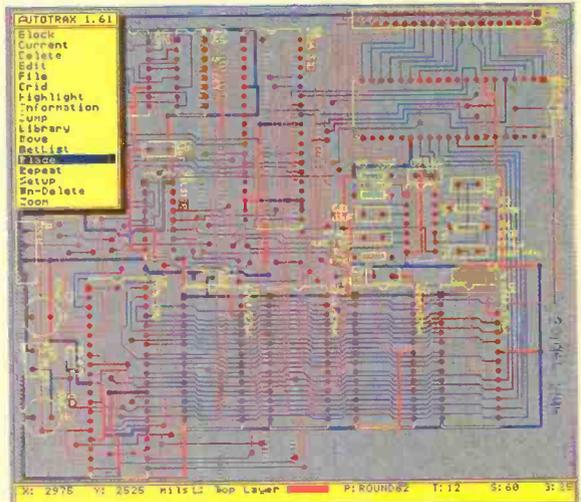
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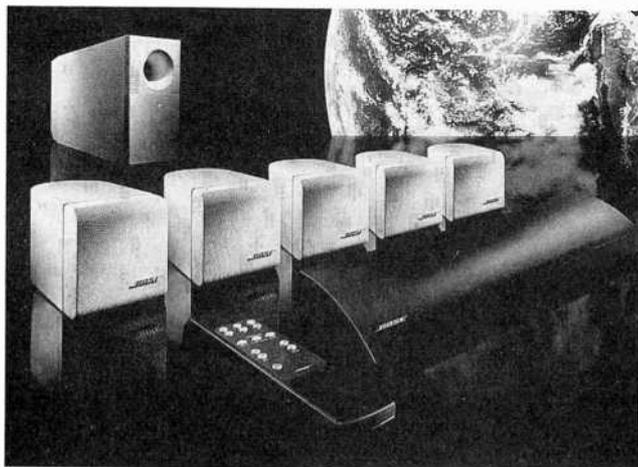


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NEW PRODUCTS

Satellite Surround-Sound System

According to *Bose*, its *Companion* satellite surround-sound system is the first speaker system specially designed to bring high quality audio-for-video performance to direct-broadcast satellite (DBS) users. The system includes, in one convenient box, all the audio equipment needed to turn an existing satellite receiver into a fully integrated, high-performance, easy-to-use home-theater system. It features Bose Acoustimass speakers, which are well-known for their small size and big sound, and proprietary Videostage circuitry, which provides accurate and efficient surround decoding of all program material, including Dolby.



The *Companion* system includes five matched cube Acoustimass speakers. Each speaker contains one 2.5-inch transducer and is separately powered with a matched amplifier to provide uniform coverage from the front left, right, and center channels and the rear channel of any surround-sound video or television broadcast. The magnetically shielded cubes can be positioned near video monitors without interfering with the picture. They are available in either black or white and can be mounted on the wall or ceiling, or on optional floor stands.

Also included is a patented,

three-chamber Acoustimass bass module, which can be completely hidden from view. The module uses a pair of high-performance, low-frequency drivers and launches sound waves via a moving air mass, unlike conventional systems that rely on the direct vibration of a speaker cone. It is claimed to provide purer sound, wider dynamic range, and virtually no audible distortion. The bass module also contains a sophisticated electronics assembly including amplification, active and automatic dynamic equalization, real-time signal processing, and the Videostage full-logic surround-sound decoder.

Videostage is not an adaptation of a system designed for large theater applications, but is an entirely new process specifically designed for in-home use. Videostage steering logic is designed to decode all video programs and play them back to their full effect. It is compatible with Dolby surround sound, Dolby Pro Logic, and other two-channel matrix encoding systems.

The *Companion* system can be easily integrated with a DSS or Primestar satellite receiver via a unique system controller. Measuring just 13 x 4 x 2 inches, the controller provides connections and switching facilities for up to six component sources: four audio/video (including S video), and two additional dedicated audio inputs. The controller can be completely hidden from view in a cabinet or behind a television, or can be placed directly on the set.

Users can operate virtually all surround-sound system functions with their existing DSS satellite-receiver remote control. A dedicated remote is also included with the system. Bose is making available a modified Primestar remote that operates the receiver's functions as well as those of the *Companion* system.

The *Companion* surround-sound speaker system costs \$1300. For more information, contact Bose Corporation, The Mountain, Framingham, MA 01701-9168; Tel. 800-576-BOSE.
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DIGITAL MULTIMETER

The *Rangemaster II* digital multimeter from *Extech* is designed for everyday heavy-duty use. It offers a large (0.95-inch), 3½-digit LCD readout for easy viewing of both measurements and function, and comes with a protective rubber holster.



The *Rangemaster II* features 45 ranges and 11 functions that include voltage, current, resistance, frequency, capacitance, and logic, with very wide ranges and high resolution. The range for DC voltage is 200 mV to 1000 volts (0.6% basic accuracy); AC voltage is 200 mV to 750 volts (1.2%); DC/AC current is 20 μ A to 20 amps (0.8% and 1.2%, respectively); resistance is 200 ohms to 200 megohms (0.8%); capacitance is 2 nF to 200 μ F (3%); and frequency counter is 2 kHz to 20 MHz (1%).

Other functions include data hold, peak hold, TTL logic test, continuity, and diode test. The

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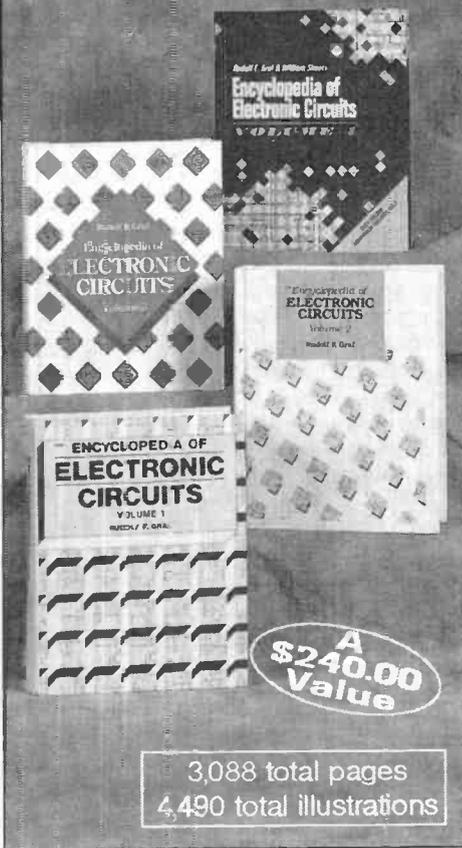
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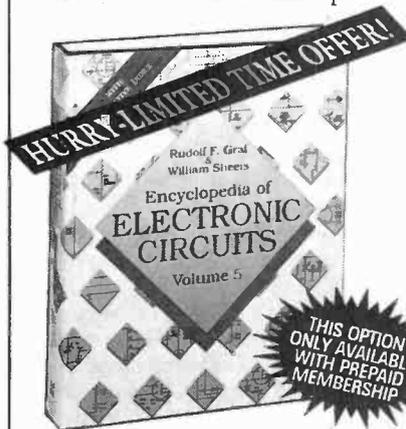
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Rangemaster II comes with the holster with a built-in stand, test leads, and a 9-volt battery. It measures 3.5 x 5 x 1.4 inches and weighs 10.6 ounces.

The Rangemaster II digital multimeter (catalog number 380278) costs \$89. An optional carrying case is available for \$15. For additional information, contact Extech Instruments Corporation, 335 Bear Hill Road, Waltham, MA 02154-1020; Tel. 617-890-7440; Fax: 617-890-7864.

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Antex Gold Plated Tips from M.M. Newman come in a variety of shapes for various electronics-assembly and repair applications. The soldering-iron tips are made from a proprietary copper alloy that provides maximum strength and heat conductivity, and are then gold plated for easy wetting. Compatible with all Antex Miniature soldering irons, the tips slide directly over the heating element for optimum thermal efficiency and quick recovery times.



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Antex Gold Plated Tips are priced from \$5.51 each; soldering irons are priced from \$19. For further information, contact M.M. Newman Corporation, 24 Tioga Way, P.O. Box 615, Marblehead, MA 01945; Tel. 617-631-7100; Fax: 617-631-8887.

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CELL-PHONE CHARGE & TALK

In addition to offering portable cellular-phone users the benefits of private, hands-free conversations in a vehicle, *ORA Electronics' Charge & Talk* functions as a power/charging cord, allowing the user to simultaneously operate the phone and charge its battery. The system consists of an earpiece, a microphone, and a power cord, all in one. The foam-enclosed earpiece is comfortable to wear, and the proximity-sensitive microphone allows normal conversational levels.



Compatible with both digital and analog portable cellular phones, *Charge & Talk* is simple to use, requires no installation, and can be easily transferred from one vehicle to another. The user simply plugs the device into the car's cigarette-lighter receptacle and the phone.

The first *Charge & Talk* system to go on the market is intended for use with Motorola Micro TAC series portable cellular phones, and has a suggested retail price of \$69. For more information, contact ORA Electronics, Division of Alliance Research Corporation, 9410 Owensmouth Avenue, P.O. Box 4029, Chatsworth, CA 91313; Tel. 818-772-2700; Fax: 818-718-8626.

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RF DETECTOR PROBES

ITT Pomona Electronics' Micro-LC series of narrow-bodied, monolithic RF detector probes are intended for use with a wide



range of digital multimeters. The product family is capable of RF measurements from 500 Hz to 1 GHz, ± 2 dB. *Models 6104* (500 Hz–30 MHz), *6105* (100 kHz–300 MHz), and *6106* (1 MHz–1 GHz) are all IEC 1010 compliant. Each comes with a replaceable gold-plated test tip and twin 4-mm banana-plug connectors to accommodate attachment to a digital multimeter. All components are laser-trimmed to ensure the highest accuracy. Electrical characteristics include 1-volt DC output for a 1-volt RMS sinewave input and low input capacitance.

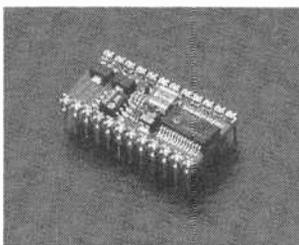
Micro-LC Models 6104, 6105, and 6106 RF detector probes have list prices of \$59.95, \$69.95, and \$79.95, respectively. For additional information, contact ITT Pomona Electronics, 1500 East Ninth Street, Pomona, CA 91766-3835; Tel. 800-241-2060; Fax: 909-629-3317.

CIRCLE 64 ON FREE INFORMATION CARD

BASIC STAMP II PROGRAMMABLE MODULE

The *Parallax Stamp II* is a complete BASIC-programmable computer in a 24-pin DIP package. It has 16 I/O lines, 2K of non-volatile memory, and a clock speed of 20 MHz.

The I/O lines are used to connect the Stamp II to the outside world. Most I/O functions are digital, and include serial communications, plus measurement, button input, transition counting, and more. A



few functions are pseudo-analog, such as resistance measurement and PWM. The Stamp II even has functions for transmitting X-10 power-line control signals, as well as for generating accurate audio frequencies (including DTMF tones for dialing telephones).

An 8-pin EEPROM provides 2K of non-volatile memory, which is used for both program and data storage. Each BASIC instruction takes three or four bytes of space, so the memory can store about 600 program instructions (assuming no space is used for non-volatile data storage).

The 20-MHz operating speed yields several benefits, including fast serial I/O (up to 50K baud), and accurate pulse measurements (2- μ s resolution). It also results in fast program execution of about 6000 instructions per second.

The Stamp II's simple "PBASIC" language makes all of its features easy to use. The language includes all familiar BASIC instructions, as well as special instructions for the I/O functions.

Stamp II modules are available for \$49 in single quantities. For more information, contact Parallax, 3805 Atherton Road, #102, Rocklin, CA 95765; Tel. 916-624-8333; Fax: 916-624-8003; e-mail: info@parallaxinc.com.

CIRCLE 65 ON FREE INFORMATION CARD

COLOR MONITOR

ViewSonic's Optique V775 color monitor provides a flat-square 17-inch screen (16-inch viewable), with an ultra-fine 0.26-mm dot pitch for high-definition displays and a maximum non-interlaced resolution of 1600 x 1280 for sharpness and clarity. Its Invar Shadow mask keeps electron beams aligned with proper target location, dramatically reducing color-convergence error. Anti-glare, anti-static coating makes viewing easier.

The Optique V775 features the one-touch OnView control system for easy adjustments of screen images, and ViewMatch to match screen colors to printer output. The monitor also offers

(Continued on page 25)

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COMPUTER BITS

Long Live the CMI

BY JEFF HOLTZMAN

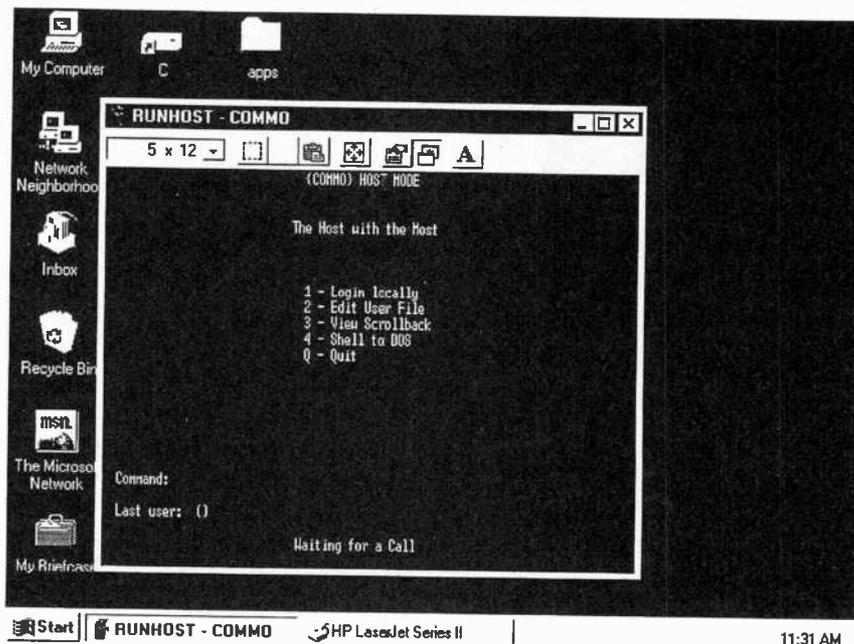
Although Microsoft's marketing department would have you believe otherwise, DOS is far from dead. Win95 is full of legacy DOS code. But DOS is not really my topic this time. Instead, the topic is really the character-mode interface traditionally available with DOS, but also available in Windows 3.x, Win95, OS/2, Unix, and just about every operating system except the Macintosh.

When Windows 3.0 came out in May of 1990, I immediately started looking for ways to jettison all my old DOS—I mean character-mode—applications. But I never got there. Some things seemed easier using a command-line interface (CLI) than a graphical user interface (GUI).

Actually the term CLI is at least partially a misnomer. Some programs (like PKZIP) are true CLI programs. Others provide a character-mode interface (CMI) that takes over the whole screen, optionally uses menus and mice, but still operates wholly in character mode. As you'll see, I'm including both CMI and CLI programs in this discussion.

The point is that I swung from being a CLI/CMI bigot to a would-be GUI bigot. In reality, however, there is a place for both. So in that spirit, I've recently returned to some old standbys, and have begun using some newcomers to the CMI/CLI world. What follows are brief profiles of some of my favorites. Most of them are shareware; a few are commercial applications that most likely have been discontinued by the manufacturer, but might still be available at computer shows and elsewhere. One good source for "out-of-date" software, both GUI and CLI/CMI, is Surplus Software (489 North 8th Street, Hood River, OR 97031; Tel. 800-753-7877, 503-386-5215). If you don't have your own source, why not give them a try.

For example, Surplus Software recently advertised a program called



Commo, a jewel of a communications program, is relatively small in size, but big in features and versatility. A copy of that shareware program is available on the Gernsback BBS.

GrandView, which it was selling for about \$25. GrandView was the premier member of a group of programs that was popular throughout the 1980s, but that seems to have died off in the past few years. Seeing that ad inspired me to dust off my copy of GrandView, and I'm glad I did.

GrandView is a program that allows you to create and maintain outlines. Some might say that there's nothing you can do in an outline program that you can't do in a word processor. From a limited perspective, that's true. In fact, modern GUI word processors, with fonts, graphics, and so forth, far exceed what an outliner can do. But outliners were never intended to compete with word processors. They're really tools for thinking, as opposed to typing or desktop publishing.

If you're the type of person who prefers to plan before doing, you'll love GrandView. On the other hand, if you're the type of person who has trouble organizing your thoughts, GrandView can help, because it

explicitly provides tools for precisely that problem. And once you develop your outline, you can export it in several word-processing formats, then read it into your WYSIWYG Windows word processor and pretty it up.

TELECOMMUNICATIONS

I've been using telecommunications software since the mid 1970s, and Windows-based telecommunications programs since the late 1980s. I used ProComm for years, but never got used to its ridiculous selection of keystroke commands. I also found it bulky. After Windows 3.0 came out, I developed great hopes of finding something that ran reliably in the background and that provided an easy means of maintaining the dialing directory. At one point or another, I tried various programs, but always ended up coming back to CrossTalk for Windows.

What I really wanted was not a huge monster that emulated every type of dumb terminal under the sun,

(continued on page 28)

Virtual Reality technology creates the world's first portable big-screen television

Breakthrough portable TV from Virtual Image Displays, Inc. creates a virtual image that simulates a 60" big-screen image at a distance of six to 15 feet away.

by Timothy B. Arnett



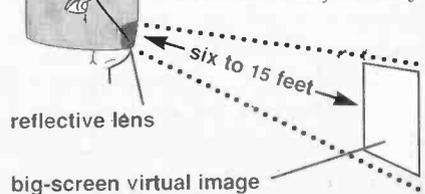
VIRTUAL TECHNOLOGY

How does Virtual Vision Sport create a virtual image that floats in space? Within the eyewear is a miniature video display and a sophisticated reflective optical system. Part of the optical system is a small, specially-engineered reflective lens which is mounted slightly below your normal field of vision on your dominant-eye side. (Your brain gives priority to whatever image is viewed by your dominant eye, so the image will seem to appear in both of your eyes. See the inset box at the right to determine which eye is your dominant eye.) The lens bounces the video image from the video display so that it appears to be focused a comfortable distance (about six to 15 feet) in front of you.



The Sport eyewear is easy to wear, and it lets you see your environment as well as the TV image.

video display Video Vision's reflective lens bounces the image from the video display, simulating a 60" big screen six to 15 feet away.



Virtual reality. We've all heard about it. But if you're like me, you figure you'll never get the opportunity to experience it in your lifetime. Think again! The Virtual Vision Sport 200 is a breakthrough invention that uses virtual reality (VR) technology to bring big-screen virtual images to a portable TV.

Virtual Vision Sport is the ultimate portable television. You can wear it on the beach, in the gym, wherever you want. And because the TV image is part of the eyewear, it moves with you. With the Sport, you can maintain your active lifestyle without missing your favorite shows!

How it works. The Sport's portable battery-operated tuner picks up TV signals from the airwaves and transmits images to a miniature LCD video display in the eyewear. The image is reflected to your dominant eye, resulting in a floating virtual image that appears to be a comfortable distance away. The farther away you focus your vision, the larger the image appears. Special color optics provide projection TV-style imagery. The eyewear contains a pair of high-fidelity earphones. It also comes with an AC adapter for indoor use!

Monocular technology. The Sport uses monocular technology to create the virtual image. While your retinas are presented with different images, they are not so different that the brain can't fuse them together. The process of fusing two slightly different retinal images into a single picture with depth, called *stereopsis*, is the way most of us see the world around us.

VR, only better.

Ordinary VR equipment is cumbersome and uncomfortable. Plus, the dual video displays used in VR can confuse the visual system, resulting in eyestrain and *binocular dysphoria*, a defect in depth perception that can last for hours.

The Sport is different. Weighing a mere five ounces, you will forget you're wearing it. And because you see your environment and the virtual image, eyestrain is minimized and depth perception is unaffected.

More than TV. You can connect the Sport to a camcorder, video game system or VCR. Watch a movie from your VCR in bed without disturbing your spouse. Plug the Sport into your video game system to battle life-size virtual characters. Used with a camcorder, the Sport serves as the ultimate viewfinder—no more missing any action. The Sport is also great for training and education—students can watch a training video while working. You can even use the Sport to impress your clients with a personalized multimedia presentation!

Risk-free. The Sport is backed by our risk-free home trial. If you're not satisfied, return it within 90 days for a refund, "No Questions Asked." The manufacturer provides a 90-day labor and one-year parts warranty. Most orders processed within 72 hours and shipped UPS.

Virtual Vision Sport 200 \$499 \$19 S&H
PLEASE SPECIFY RIGHT- OR LEFT-EYE DOMINANCE.
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DETERMINING YOUR EYE DOMINANCE...

Extend your arm out as far as you can.

Bring your index finger and thumb together to form a circle.



With both eyes open, visually center a small, distant object (like a light switch or door knob) within the center of the circle.



Without moving your head or arm, close one eye at a time. The eye that keeps the object centered in the circle of your fingers is your dominant eye.

MULTIMEDIA WATCH

The MPC3 Specification

BY MARC SPIWAK
TECHNICAL EDITOR
WINDOWS MAGAZINE

The old MPC2 specification for multimedia hardware guaranteed, or at least bettered the odds, that a given piece of software would run reasonably fast on a given platform. The main problem with that specification is that it's already old, and multimedia never really ran all that well on hardware that just met the specs.

Let's face it: The 486 was considered a "hot" system before multimedia came along. (My home computer came loaded in its day, but not a scrap of multimedia hardware was installed—not even a sound card!) Then we asked our computers to run CD-ROM drives and belt out sound as we watched real-time video. Even with a tiny video window, that was asking a lot from the computer. Throw in a few extra mouse clicks, and you might have to wait minutes for the CPU to catch up to what you wanted it to do. By then you had probably pushed too many buttons and a crash or lockup was near.

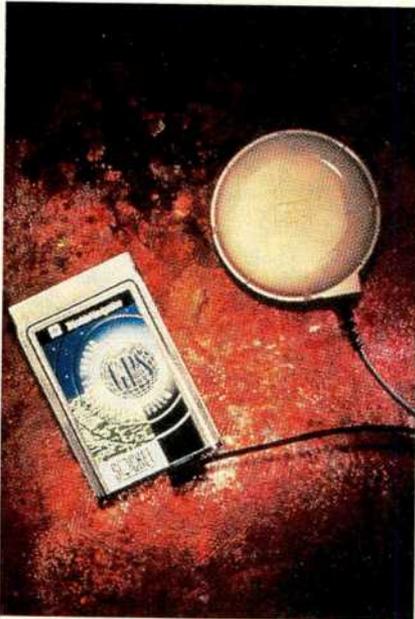
I've been playing with a lot of Pentiums lately, and let me tell you that once you run multimedia on one, you won't want to run it on a lesser system—it's just too slow. And it's not just the CPU difference; newer systems have faster hard drives, faster video, better PCI buses, and so on. It all helps contribute to a system that doesn't get upset with every click of the mouse.

Considering how much better computer hardware has gotten over the past couple of years, it's about time that the MPC2 specs were updated. The new specification defines the minimum hardware necessary for Level 3 compliance, but not any particular configuration. MPC3 does not replace MPC2. It simply defines an updated platform that's better suited for multimedia. Keep those specs in mind when buying your next computer or multimedia upgrade. Or better yet, buy 12 stuff that blows away these specs and

you're set for at least a couple of years!

MPC3 SPECIFICATIONS

I'm going to go over the most important parts of the specifications, and leave out some of the less interesting details. The microprocessor in an MPC3-rated system must be at least a 75-MHz Pentium with only a level one cache. Other microprocessor brands or architectures might also be suitable. Personally, I would recom-



The GPS Card package contains the PC Card receiver and a magnetic antenna for auto-roof mounting.

mend getting at least a 90-MHz machine, or better yet, a 120- or 133-MHz one. Always buy the fastest CPU possible, and you'll get the most life possible out of the system.

The computer must also have at least 8 MB of RAM, but, again I would suggest that you go for at least 16 MB, especially if you're planning on using Windows 95. A 3fi-inch, 1.44-MB floppy drive is also required, but I haven't seen a computer without one of those in years—it's the 5/4-inch drive that's no longer needed. The minimum hard

drive specification is 540 MB, with 15-ms access time and 1.5-MB/second sustained throughput. Any new drive meets those specs, and 540 megabytes is actually very small these days.

As for the CD-ROM drive, it should be at least a 4X unit with a sustained 600-KB/second transfer rate and average access time of 250 ms. Pretty much any 4X drive will be satisfactory here, but why not go for a 6X and be ahead of the game? No more than 40% of the CPU's resources may be consumed while transferring data at 600K/second and no more than 20% of the CPU's resources may be consumed while maintaining a transfer rate of 300K/second. You can't really worry about CPU usage, and definitely won't have to with a 75-MHz CPU or better. The CD-ROM drive must be able to read audio CDs (Red Book); Mode 1 and Mode 2, including mixed mode and multisession media; CD-ROM; CD-ROM XA; Photo CD; CDRs (recordable discs); Video CD; and CD-i discs.

Next comes the sound card. Wavetable capability is required, and it must have a 16-bit digital-to-analog converter (DAC); 44.1-, 22.05-, and 11.025-kHz sampling rates; and stereo audio channels. No more than 10% of the CPU's resources should be required for 22.05- and 11.025-kHz sampling, and no more than 15% for 44.1-kHz sampling. A microphone input must also be present. The sound card must be able to mix at least three and preferably four sources and output them as stereo, line-level audio.

There are even specifications for speakers. The speakers must be at least a two-piece system with a frequency response from 120 Hz to 17.5 kHz and a minimum rating of 3 watts/channel into 4 ohms. The input connector must be a 3.5-mm stereo jack where the tip is the left channel, the sleeve is the right channel, and the

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13

body is ground, supplied with at least a six-foot cable. Volume, treble, and bass controls should be included. In a three-piece system, the satellites should have the same requirements as above and the subwoofer should have a frequency response from at least 40 Hz to 250 Hz with a minimum power rating of 15 watts.

A fast video card goes a long way toward better multimedia, too. Today's video card must offer color space conversion and scaling. It must have direct access to the frame buffer for video-enabled graphics with a resolution of 352 x 240 at 30-frames-per-second at 15-bits-per-pixel, unscaled, without cropping. The card must also offer MPEG1 video playback (hardware or software) and must support a synchronized audio/video stream. Hardware MPEG, however, is always preferable to software.

What does all that mean? It means that if you're just getting by with an older computer, it will soon be unusable for new multimedia software. In other words, you'll soon need a new computer. Don't even consider upgrading. If you haven't seen the difference that a fast Pentium makes to multimedia, do yourself a favor and check one out in a computer store. You'll be amazed at how smooth multimedia can be. And naysayers will soon realize that computers were always intended for multimedia. It's just that they weren't using the right computers.

FAST MODEMS

While I'm on the subject of fast, new hardware, let me tell you about a modem I've been playing with. It's a tiny little 28.8 PCMCIA modem manufactured by Megahertz, the mobile communications division of US Robotics. I've got a 14.4 modem in my home computer, and the 28.8 in a laptop, and what a difference the faster modem makes, especially for cumbersome Internet stuff and the like.

Megahertz manufactures a lot of slick communications gear, including a wireless e-mail card that I'll talk about in a future column. The Megahertz XJ2288 modem features an XJACK connector, a tiny little pop-out RJ-11 jack which makes it easy to connect

the modem to any phone line, at home, at the office, or in a hotel. The XJ2288 is not a brand new model, and will be upgraded by the time you read this, but boy is it fast. The newer PCMCIA modems are coming with network adapters built in, which makes it very easy to pass data between a network and laptop computer.

SOCKET COMMUNICATIONS GPS CARD

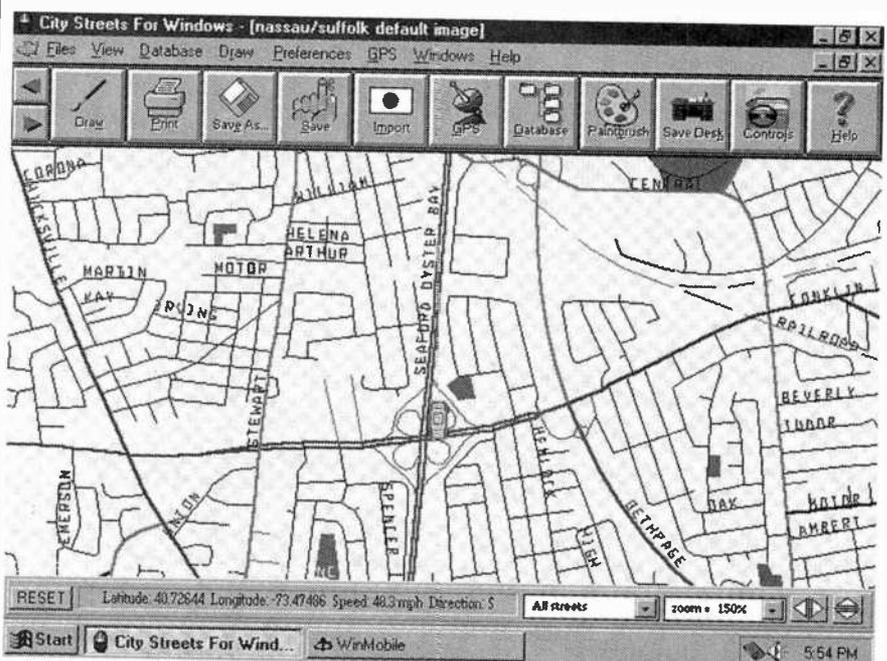
Speaking of mobile gear, I've been playing with something a lot neater than a modem. It is inevitable that some day you will be stopped somewhere asking for directions after having made a wrong turn somewhere. Now if only you had a laptop computer and the GPS Card from Socket Communications, you wouldn't be in that predicament. The GPS Card is a miniature Type II GPS receiver that pops into an empty PC Card socket on your laptop.

The GPS card is very easy to use. You simply insert it in an empty PCMCIA slot and the computer instantly recognizes what the card is. If it doesn't, there are procedures that can make it recognize the card. The software that does all the dirty work is a program called WinMobile. WinMobile interprets GPS data coming from the receiver card and displays it as longi-

tude and latitude readings. It also displays altitude, speed, course, and time of readings. WinMobile also displays the relative signal strength of all satellites being received. If your GPS system is not locking on to your location, you can watch the progress in the WinMobile window to see which satellites are detected and how well data is being received.

But now for the neat part: The GPS Card also works with City Streets for Windows, a mapping program from Road Scholar. With City Streets running, you can see in an instant where you are on the map as you drive—a little car on the map traces your route as you go. City Streets is a fully functional mapping program in itself, and it can provide you with directions, distances, and other travel information. But hooked up to GPS, the City Streets' Etak maps become the best back-seat driver you ever had. Maps of over 1600 U.S. cities are available. Many major European cities are also available. The city map of your choice is yours for free with a coupon included with the GPS Card package. Additional maps cost \$29.95 each, or less if you buy more than one.

The Global Positioning System, or GPS, is a constellation of 24 Navstar satellites that orbit the earth in 6 orbital planes. That number ensures that at



The little car followed me home as it made its way across the map. Here I am on the Seaford Oyster Bay Expressway.

How to stay warm without turning up the thermostat...

New device redirects heat to rooms that need it most so you can be more comfortable without inflating your electric bill.



by Rebecca Storden



Controlled by a microprocessor, the Equalizer EQ2 will solve your heating problems without inflating your fuel bills.

Do you constantly adjust the thermostat in your home every time you're uncomfortable—turning it up in the winter, down in the summer? Do you manually open or close vents just so air will be redirected to rooms that are too cold or too hot? Most homeowners who have central heating and air conditioning systems have this same recurring problem. High utility bills are the unfortunate result of manually adjusting your home's vents and thermostat.

Forced air problem. If you have rooms that never seem warm enough in the winter, no matter how the thermostat is set, the problem isn't your furnace or blower speed—it's your registers and ducts.

Some rooms have poor airflow because of bends in the ductwork or their distance from the blower. So if your home has central heating and cooling, you'll probably have at least one room that is always too cold or too hot.

The better solution. Now there's the Equalizer EQ2 by Suncourt. Its built-in fan is designed to pull extra air out of poor-performing registers, helping equalize the temperature in

your home. Every time your heating or cooling system operates, the Equalizer EQ2 will pull twice as much air through the duct. This provides 80% more of the air you've already paid for—air that usually gets lost in the ductwork.

Efficiency. Because it spends less time getting to the vents, the air doesn't cool down. The Equalizer EQ2 even continues to run after your system shuts off, making sure all the conditioned air is out of the duct.

Air from the Equalizer EQ2 is not diverted from other vents in your home. It is made up of air from the furnace instead. The effect on the other registers of your home is negligible. The Equalizer EQ2 installs in just seconds—simply place it on top of your existing floor or wall vent and plug it into a standard electrical outlet.

Intelligent thermostat. This sophisticated electronic thermostat consists of dual solid-state sensors. When your heating system starts, it measures the temperature of the air in the register and in the room and then calculates the temperature differential. You can adjust the

thermostat for the automatic on/off function best suited for the register air temperature. In the continuous running mode, the fan, designed to increase airflow in several directions at once, will provide constant airflow from the register.

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- **Apartments.** You live in an apartment and want to increase fuel efficiency without making a permanent investment.
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Costs next to nothing. The Equalizer EQ2 has no heating or cooling elements, and it turns on and off automatically with your central system. It costs less than two cents a day to run. Compared to the cost of constantly adjusting the thermostat by 4° (\$1.25 a day) or using a 1500-watt heater (\$1.80 a day), the Equalizer EQ2 is the most efficient way to keep your home comfortable!

Try it risk-free. Suncourt Equalizer EQ2s are backed by Comtrad's exclusive risk-free home trial. Try them, and if you're not completely satisfied, simply return them within 90 days for a full "No Questions Asked" refund. They also come with a full one-year manufacturer's limited warranty. Most orders are processed within 72 hours and shipped via UPS.

MONEY-SAVING OFFER. For maximum efficiency, you should place several Equalizer EQ2s throughout your home. To make this easier, we're making a special offer for a limited time. The first two Equalizer EQ2s you order are \$49 each, but when you order a third Equalizer EQ2 or more, the price is reduced to just \$24.50 each. Call today to make your heating and cooling system run more efficiently!

Suncourt Equalizer EQ2 \$49 \$4 S&H
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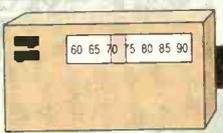


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Adjusting the thermostat in your home by just 4° can add up to \$456.25 a year.



\$657.00

Heating your home with a supplemental 1500-watt space heater could cost \$657 a year.



\$7.30

Costing less than 2¢ a day, Suncourt can equalize your home's climate for about \$7.30 a year.

*Figures listed above were calculated based on 365 days of use.

VENDOR INFORMATION

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INFORMATION CARD

IntraCorp
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Miami, FL 33131
CIRCLE 51 ON FREE
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Megahertz
605 North 5600 West
Salt Lake City, UT 84116
CIRCLE 52 ON FREE
INFORMATION CARD

Socket Communications, Inc.
6500 Kaiser Drive
Fremont, CA 94555
CIRCLE 53 ON FREE
INFORMATION CARD

Symantec Corporation
10201 Torre Avenue
Cupertino, CA 95014
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Vision Software
505 Fourteenth Street, Suite 940
Oakland, CA 94612
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INFORMATION CARD

least five satellites will be in "view" from anywhere in the world at any given time. If a GPS receiver can lock onto at least three of those satellites, a position fix can be maintained.

The GPS Card package consists of the PC-card receiver, a magnetic antenna for auto-roof mounting, the basic City Streets program, and the coupon for the map of your choice. Living on Long Island, I chose the combination Nassau/Suffolk map that covers pretty much everywhere I ever go.

I found the system to be a little bit fussy at first, but then I learned that my GMT offset time was set incorrectly. That basically tells the system which satellites to expect overhead at any given time. Even if set incorrectly, the unit will eventually pick up the correct time from one of the satellites, and then figure out where it is. But once it's set up properly, the system works in minutes.

Leaving work one day, I placed the antenna on my dashboard. (As the owner of a 1994 Camaro, I can tell you that there's not a lot of metal on the car. Only the hood and rear clip are steel, with the rest of the car made from various composites and plastics).

Fortunately the sensor doesn't mind

being on my dashboard. (Glass is transparent to satellite-signal reception, while steel and other building materials definitely are not.) Anyway, I then brought up City Streets and started the GPS.

Before I even got out of the parking lot, City Streets popped a little car into position in Jericho, New York. Inch by inch, the little car followed me home as it made its way across the map to the Long Island Expressway, the Seaford-Oyster Bay Expressway, the Southern State Parkway, and then on local roads and little streets until it reached my own block. The maps continuously update as the little car leaves one section and enters another. Speed indication is very accurate; if my speedometer showed 55 MPH, so did the GPS display. The biggest problem I have with the system is that it's not easy to drive and work a laptop at the same time, so I couldn't play with it as much as I would have liked. Next time I'll have to bring an assistant, or go in someone else's car and let them do the driving.

Now I know how to get home from work. But I can see how useful this system would be if I did not. And certainly there are people who could benefit from GPS a lot more than me. Emergency personnel, delivery men, and anyone else who works out in the field could spend a lot less time asking for directions and more time at the job site if only they had a GPS Card and laptop computer. And any gadget freak will not want to be without one of these. The only problem is that you'll have to have a laptop computer and shell out about \$799 for the GPS Card.

DOS GAMES AND WINDOWS 95

Windows 95 has a DOS mode, and DOS games, old and new, will run in it. But it turns out that you have to play the same old configuration games to get DOS games to work in Win 95. Fortunately Windows 95 has a few new features that make some of those configuration games easier to "play."

Everyone is probably familiar with boot disks, and having to make them for certain DOS games that have demanding resource requirements. Boot disks still work with Win 95, but one nice feature of Win 95 does away

with the need for boot disks.

Windows 95 is full of shortcuts, or at least it is after you make them. A shortcut is basically a custom icon that performs a specific function. You can make a shortcut to a disk drive, to a program, to a file, to another shortcut, and so on. And you can even make a shortcut to a DOS window. That DOS shortcut can run a batch file or include special configuration information, the same information that a boot disk would contain. Those shortcuts are easy to make. And from now on, instead of having a collection of boot diskettes for different games, you can have a neat little group of shortcuts on your desktop that will never get lost or damaged.

NEW STUFF

Ever since I switched over to Windows 95, I've missed my Norton Desktop. Fortunately Symantec has released new utilities for Windows 95 that give me back some of the things I was used to. *Norton Navigator* provides me with the same file-management utilities that I was accustomed to in *Norton Desktop*. And the functions work similarly to the way they did before. It even restores old Norton "Quick Access" groups, something that Microsoft didn't want to do for Norton Desktop users.

The *Norton Utilities* package provides all the system protection and data recovery tools you'll ever need for Windows 95. The Norton AntiVirus package provides Windows 95 with automatic virus detection, elimination, and prevention features. Even though Windows 95 is fully customizable, and can match many of the features I used to like in Norton Desktop, it's still nice to be able to hang onto a little of that Symantec look and feel.

Two new titles available through Electronic Arts this month are *Magic Carpet 2 The Netherworlds* and *Road & Track Presents The Need For Speed*. *Magic Carpet 2* takes you to a city in which lies a gateway to ultimate evil. You must descend through the portal on your magic carpet and defeat the Demon Lord and his minions. The *Need For Speed* puts you in the driver's seat of eight different high-performance

(continued on page 69)

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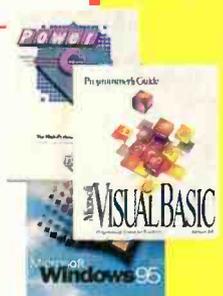
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NET WATCH

April Online Hours

BY DAN KARAGIANNIS

Will there be April showers where you live this year? If you're on the Net there's no need to worry about what it's doing outside, because this month we'll look at a couple of sites that will help you pass the time on rainy days. Let's get right to them, beginning with a great site for hobbyists.

MOTOROLA SEMICONDUCTOR

In the first installment of *Net Watch* (November 1995), I covered the Harris Semiconductor site, which features a great search engine for finding technical information on components from that company. This month, we'll look at a similar, and in some ways more-impressive, site—the Motorola Semiconductor Products Sector.

page as well. But it's the Products Sector page that should be of most interest to hobbyists.

Before we even look at what's found at the site, I have to first comment on the fact that it's really user friendly. If you feel lost, or would just like a better idea of what is on the server, you can click on a "help" link. There's even a link to the server guide in Japanese! But I don't think you'll need to access either link to understand the options available to you on the site.

Now, on to the goodies available at the site. We'll begin by discussing each of the three major databases you can choose from: the Master Selection Guide, Price Book & Product Guide, and Data Library. All feature full-text search engines, and require the use of

countless semiconductors listed by entering either part numbers (2N6400, MM4209, etc.) or part type (diodes, transistors, etc.).

The Price Book & Product Guide contains prices in U.S. dollars for many Motorola data books, brochures, and other selected literature. The site recommends that those outside of the U.S. contact their local Motorola sales representatives for price quotes on all items listed.

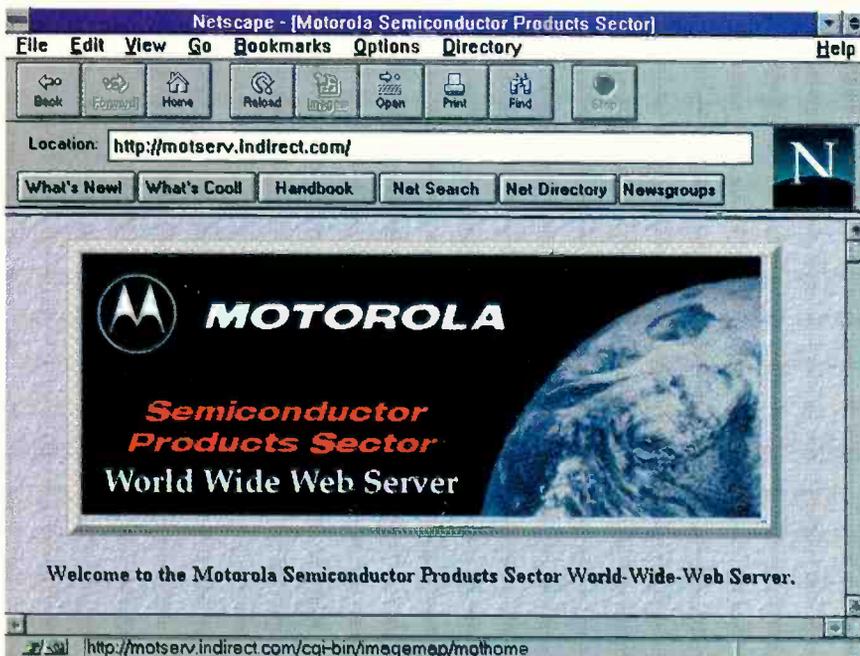
By selecting the Data Library, you can access numerous Motorola data books online. You can search either by part number or using descriptive text. Believe me, it's great being able to call up on your screen a data sheet of almost any component any time you need it. Although the Library is incomplete at the time of this writing, the majority of the Motorola data books should be online by the time you read this. But if you still can't find a particular sheet, you could try requesting it via Mfax, which we'll cover in a moment.

Also available at the site are some more direct ways of interacting with Motorola. I'm referring to their Online Forms, which include: Literature Ordering, Mfax Literature Request, and Technical Questions. You will of course need a forms-capable browser to use those features as well.

As the name implies, Literature Ordering is a form that lets you order Motorola literature directly from their Literature Distribution Center. Check the Price Book & Product Guide first so you'll know what you're looking for.

Mfax Literature Request makes it possible to have any of over 32,000 data sheets, application notes, engineering bulletins, and selector guides delivered to your fax machine within minutes. Until all the data books are online, you might find that feature quite useful.

Finally, you can receive prompt answers to your technical questions by



Just about any hobbyist would be impressed by the search engines found at the Motorola Semiconductor Products site.

The site is designed to provide customers with comprehensive data and technical information. If you'd like to get financial or general news about the company, you can access other pages on the company's server from this

a forms-capable browser such as Netscape.

The Master Selection Guide database lets you search the online version of the Motorola book of the same name. You can look for data on the

choosing the Technical Questions form and filling it out. The form will then be sent directly to Motorola engineers for what the company promises to be "a prompt response."

At the risk of sounding like a commercial I have to say "Wait, there's more!" You can search Literature Abstracts for more information on selected literature available either through Mfax or the Literature Distribution Center, peruse the Press Releases database for the latest Motorola Semiconductor Product Information, check out the Case Outline database for mechanical drawings of component packages, and contact Motorola by e-mail.

All in all, Motorola has put together a high-quality, and immensely useful, site. Definitely put their page in your browser's bookmark file.

THAT'S ENTERTAINMENT

Well, it's time for me to attempt the impossible. I have to cover all the features found at the following site, and still give it all the praise it deserves, without filling ten pages or so.

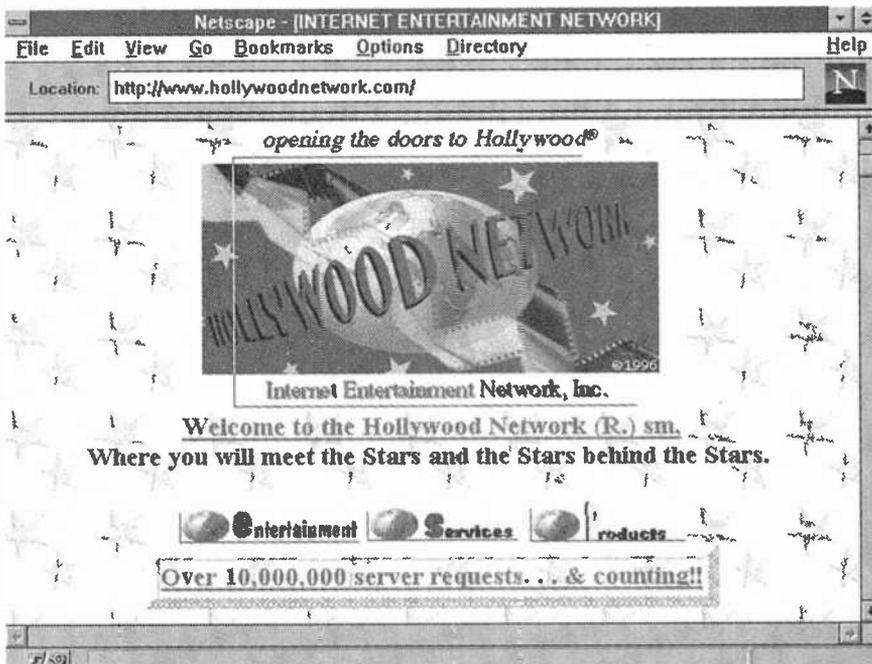
This spot on the Web is for anyone who ever dreamed of being famous, or is just interested in all the goings on of the entertainment industry. (I must warn you, as an aspiring vocalist and novelist, I'm somewhat biased!) The Hollywood Network can literally bring the city of lights and stars to your fingertips.

Browsing the Hollywood Network is made effortless by its simple and well-organized layout. There's no pointless searching for what you want—everything is broken up into 12 main areas. Let's get right to what each area contains:

The Hollywood Actors Network lets you access professional information and resources in the entertainment industry, such as agents and casting directors. Who knows, could this be your ticket to a film role?

In the Hollywood Cafe—Chat Lounges you can "kick back" and socialize. Chat with others about various topics like favorite stars, movies, videos, TV shows, CDs, and the industry in general.

Hollywood Insider is an excellent source for trade bulletins. Access Box



The Hollywood Network is your ticket to the entertainment world.

Office sales, Production Charts, Scripts Sales, and much more.

Within the Hollywood Events Calendar you'll find a compilation of events in the entertainment industry. Categories include: Acting, Awards, Directing, Music, Producing, Publishing, and Writing.

HOT SITES

Motorola Semiconductor Products Sector

<http://motserv.indirect.com>

Hollywood Network

<http://www.hollywoodnetwork.com>

Hollywood Producers Network lets you access professional information and resources in the entertainment industry, from entertainment attorneys to deal-making opportunities. Make sure to check out the Insider's Tip section.

Want to find a home page of a particular favorite star? The links found in Hollywood Star Chatter might be of some help.

The Hollywood Intertainment Cybercenter gives you a pass to enter the cyberworld of entertainment magazines, music sites, newspapers, networks, and movie studios. Be careful, you might really eat up some time here!

Another fun section is the Hollywood Shopping Network. It's a virtual store where you can browse

and buy computer software, photos, fashion items, games, souvenirs, publications, videos, and more.

Do you enjoy games? If you do, definitely visit the Internet Game Network. You can play games like Trivianet, or Husband, Lover, Spy, or visit the *Price is Right* online.

The Internet Movie Database is a great way to find facts on favorite movies, directors, and stars.

Planning on writing a script for a crime show? You might find a visit to the Internet Crimewriting Network useful. The site lets you get in contact with agents, attorneys, detectives, police officers, scientists, and other writers.

Finally, if you plan on writing any type of script at all, stop by the Internet Screenwriters Network. It provides the aspiring scriptwriter with several links to industry experts who are looking for new talent.

Whew! That about scratches the surface of the Hollywood Network's attractions. Actually, each of the above sections deserves a column all to itself, but hopefully I've given you a good enough idea of what's there to want to browse the site for yourself.

Well that's about it for this time. Until next month, you can drop me a line via either E-mail at peeditor@aol.com or snail-mail at *Net Watch*, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735.



SyQuest EZ135 Removable Hard Drive



CIRCLE 119 ON FREE INFORMATION CARD

Own an ever-expandable hard drive, back up files as fast as lightning, and carry or ship huge files from place to place.

The role of computer hard-disk drives hasn't changed much since they became available, although the way in which people use them has. In the "beginning," computers didn't have hard drives, only floppy drives. And for a while, hard drives were too expensive for the average person to own. Software would be loaded from floppy into RAM; and work would be saved to floppy as well. Some deluxe systems actually came with two floppy drives to help eliminate disk swapping!

Early hard drives, which cost a pretty penny, held only 10 or 20 megabytes. That precious space was never used in a wasteful manner, and unnecessary stuff was constantly erased to keep free space to a maximum. Backups were done on floppy diskettes in those days, and to back up even 10 to 20 megabytes still required quite a few 360K floppies!

As hard drives grew in size to keep up with the bloated new software, more elaborate back-up methods had to be devised. A tape-backup unit became the most practical way to back up hard disks. In the early 1990s, an inexpensive tape backup (intended for home use) could back up a 200-megabyte drive in about an hour. At the time, some folks actually considered a PC with a 200-megabyte hard drive to be a file server! But within a year or two, half-gigabyte drives were standard in new PCs—the work stations, mind you, not the file servers. Today, 1-gigabyte hard drives can be purchased for as little as \$300, and that, in the view of most, is the

minimum-size drive that any new PC should contain.

With the ever-continuing need for more and more hard-disk space, and for some special niche applications, the removable hard-disk drive has always been appealing. A removable hard drive is almost like a floppy drive in that you pop in and out different disks, except that cartridges containing hard-disk platters are used instead of disks. When you run out of space on one cartridge you simply pop in another.

The main problem with removable hard drives in the past has been that to pop in a new cartridge you had to first shell out big bucks for one. After owning the removable drive for a year or two, you would be able to buy a whole new, faster drive, with greater capacity than a new cartridge, for the same price or less. And the capacity of older, removable hard-drive cartridges was never enough to be used for backing up other hard drives or for carrying around huge graphics or multimedia files. They were also too expensive for that. But those and other limitations have been overcome thanks to the SyQuest EZ135 removable hard drive.

The EZ135. The EZ135 truly is an affordable, removable hard drive, selling for \$199 for the internal IDE model and \$239 for an external SCSI version. (A parallel-port model was also in the works at the time this was written.) Those prices include the drive and one removable 135-megabyte cartridge. Now before you say, "Hey,

that's a lot of money for a 135-megabyte drive!" note that new 135-megabyte cartridges sell for only \$19.99 each! One hundred dollars buys you 675 megabytes of disk space, and that's quite a value. If you run out of space, simply buy more cartridges.

The EZ135 is also an excellent way to back up or archive data from other hard drives. At \$20 per 135 megabytes, it's an affordable method, and fast as well—data is backed up in seconds. And unlike a-tape backup, you don't have to restore the data to disk to run it; it runs right off the disk like any other hard drive. Another good use for the EZ135 drive and its removable cartridges is for transporting huge files. Each 3½-inch cartridge holds the equivalent of about 100 floppies! The only catch is that both parties must own an EZ135 drive. In addition, the EZ135 drive can only read EZ135 cartridges.

Like any other hard drive, the EZ135 can be set to work as a master or slave drive. As a slave, you can add on more and more disks as necessary. Or you can install games on one or more cartridges, use another for desktop publishing software, another for multimedia stuff, and so on. As a master drive, you can have many different boot options or operating systems depending on the boot cartridge. Or you can let every family member have their own custom tailored PC cartridge, loaded with software, fonts, games, and more, to taste. Children can be allowed to use the PC without worrying that important files might be accidentally damaged by youthful

curiosity. The drive also provides an ideal way to safeguard confidential files.

Performance is not sacrificed to convenience with the EZ135 drive. With an average seek time of 13.5 milliseconds and a maximum sustained data-transfer rate of 2.4 megabytes per second, the drive is for the most part as fast as any other. You won't notice any difference between the removable drive and a permanent one when running software.

Windows and DOS software is included with the drive, which helps make it easier to use. The software mainly consists of utilities that let you partition the drive, manage files, perform simple backups, and so on. Additional software helps the user determine jumper settings for various master/slave configurations. A database of jumper settings for all popular hard drives is included. The software is unnecessary if you are familiar with the master hard drive in your computer.

We installed an internal EZ135 drive and took it for a test spin. Here's how it did.

Installing the EZ135. The internal IDE model requires a free 3½- or 5¼-inch external bay in a PC. The drive will fit by itself in a 3½-inch bay, and a mounting kit and faceplate is included for mounting it in a 5¼-inch bay.

The drive installs on the IDE controller cable in parallel with a master or slave drive or by itself. A 40-pin IDE ribbon cable is included with the drive for connecting up to two drives to the controller. (That's a convenience because some computers come with an economy cable that has only one connector.) All you have to do is match the red stripe on the ribbon cable with pin 1 on each drive and the motherboard connector. (Actually the connectors are keyed so it's hard to put it in wrong.) You must also connect the drive to an unused 4-pin DC power connector from your PC's power supply.

A jumper on the drive configures it for either master or slave operation. Jumpers on your permanent drive might have to be changed, as well. If it is to be used as a boot drive, it must be formatted as such by the user.

(Continued on page 76)



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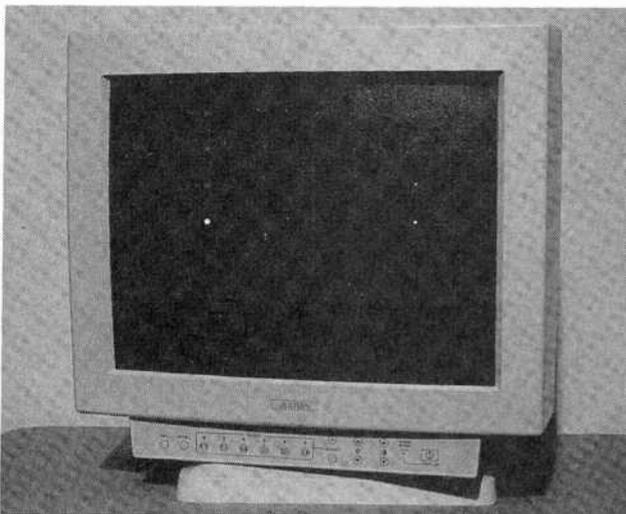
PRODUCT TEST REPORTS

By Stephen A. Booth

Axion CF-1754 Computer Monitor

The wham-bang graphics and, in some cases, full-motion video available from multimedia computers screams out for a canvas bigger than the standard-issue 14- or 15-inch monitor. Moreover, dealing with the multiple panes of Microsoft's Windows 95 can be a pain on a small screen. At this writing, 17-inch monitors are the practical limit for most households—anything beyond that size gets into the specialty realm of corporate graphics departments with price-is-no-object budgets.

CIRCLE 120 ON FREE INFORMATION CARD



The Axion CF-1754 17-inch computer monitor.

Even so, 17-inch tubes are anything but cheap. Typical list prices are \$800, though you might find units with street prices that are a hundred or two below that.

Then there's the Axion 17-inch CF-1754 color monitor that is tested here. It carries a \$425 suggested sticker

and you might find it for less. So what's the catch? The catch is that this otherwise-decent monitor has a 0.42-mm dot-pitch; that's the distance in millimeters between image-making pixels and is a third more than higher-priced 17-inchers, which clock in at around a 0.28 mm. Consequently, the image produced will not be as sharp.

Should you worry? It depends on how you use a PC. Compare the Axion side by side to a 0.28-mm screen and the difference is apparent. For gaming, though, or general multimedia home computing, you'll probably appreciate the greater size more than you'll notice the slightly coarser resolution. But if you use your PC to make a living at graphics-critical applications, you ought to be shopping for a monitor with finer pitch. Ditto if you spend your day at extensive word-processing jobs, though here, you probably don't need a 17-inch screen anyway.

FEATURES

Despite the low price, Axion's CF-1754 has a relatively flat faceplate. Accordingly, it scores well in the tests for geometric distortion. The monitor doesn't offer the bells and whistles of higher-priced CRTs—nor their multiple color-temperature settings. But its bezel-mounted, touch-sensitive controls work just fine, and the single color-tempera-

ture (nominally 9300° Kelvin) is close enough to spec.

For your information, color temperature means tint, or hue. The CF-1754 does have separate controls for brightness and contrast. In a camcorder, color temperature would be called "white balance." The lower the temperature, the "warmer" the image—more to the red scale of the spectrum. The most neutral color setting (yielding ideally pure white) occurs at 6500° Kelvin. That is the NTSC standard for color TVs. It's seldom encountered, however, even in expensive TVs, and 9300°K is pretty typical of PC monitors.

TEST RESULTS

The Axion CF-1754 underwent electrical testing and visual exams at the Advanced Product Evaluation Laboratory (APEL), an independent testing facility located in Bethel, Connecticut. The electrical measurements for geometric distortion and color appear in the accompanying chart, and indicate that this monitor's a good value for its price—its overall Screen Distortion Index is 0.5%, same as the more feature-laden, \$799 NEC MultiSync XV17 tested in the November 1995 issue.

APEL's test procedure also involves hands-on evaluation, and subjective visual exams based on viewing computer-generated images and patterns. Except for some moire patterns

noted in the appropriate tests, and attributable to the 0.42-mm dot-pitch, the CF-1754 looks just fine. But as with most monitors, an optional lens-screen is recommended to reduce reflections and glare.

The test results published here were derived at the 1024 x 768 resolution mode, but performance was similar at the 640 x 480 and 800 x 600 modes.

Regarding color temperature, the CF-1754's stated value of 9300°K is close—APEL measured a value of 11,650°K.

Among the screen distor-

tion measurements, it's worth noting that APEL measured the visible display image at 15.6 inches, diagonally. That is the factory preset (you can boost it up to 16.75 inches). Remember that the total diagonal of the glass picture-tube is 17 inches—and that is the measurement that most manufacturers tout in advertising. Lately, though, many brands also publish the "viewable" image size.

Aspect ratio is another bit of TV jargon, referring to the width-to-height ratio of the display area. It's commonly

expressed as 4:3 (1.33:1). The 1.35:1 measured here is close enough.

Like any of the other screen-distortion measurements, the squareness error is negligible. All the measurements represent deviations from perfection—in this case, perfect 90-degree angles at each corner of the display.

Keystone and pincushion distortion would look just like the objects they describe. Keystone distortion creates a trapezoid, wider either at the top or the base. Pincushioning gives the display the appearance of being pinched inward from the sides.

With bow distortion, opposite borders of the display—top and bottom, or left and right sides—might appear concave and convex. Another way to look at it: One side seems pincushioned, its opposite barreled, but the other two sides are parallel.

Linearity error looks for any variation from straight lines on any side of a square—waviness, for example. It's a pretty exacting exam that puts a variety of square patterns across the screen, from large to minute, and looks for nonlinearities in any size and at any point on the display.

CONCLUSION

When all is said and done, with a screen distortion index of just 0.5%, the CF-1754 did a lot better than its price might lead you to believe. Remember, 0.5% equals 0.005—the kind of score you expect in audio gear but seldom see with video.

Meanwhile, in the two-dozen subjective (or visual) exams, the only fails from grace were reflection (or glare) and the relative coarseness of the 0.42-mm

dot pitch. That's relative in side-by-side comparisons with 17-inch monitors of finer pitch. If you've been waiting for those to come down in price, don't hold your breath—it's not likely to happen until the next model-year at the very least. Meanwhile, for big-screen PC gaming and video, this Axion monitor will look swell.

For more information on the Axion CF-1754 17-inch computer monitor, contact the manufacturer at the address given below, or circle 120 on the Free Information Card. ■

Vendor Information

America Action, Inc
100 Exchange Place
Pomona, CA 91768-4307

NEW PRODUCTS

(Continued from page 8)



an overscan capability that allows viewers to use the entire screen as a display area, and digital controls that provide 20 custom-programmable modes for automatic screen adjustments. Its Plug and Play + feature supports Microsoft's Windows 95 when used with a Windows 95-compatible video card.

The Optquest V775 has a suggested retail price of \$895. For additional information, contact ViewSonic Corporation, 20480 Business Parkway, Walnut, CA 91789; Tel. 800-888-8583 or 909-869-7976; Fax: 909-869-7958. ■

CIRCLE 66 ON FREE INFORMATION CARD

TABLE 1—TEST RESULTS

The following test results were furnished by the Advanced Product Evaluation Laboratory, an independent testing facility located in Bethel, CT. All measurements reflect factory-preset conditions and were taken in the 1024 x 768 resolution mode, using the Display Mate Professional test program from Professional Video Utilities.

| | |
|---|--|
| Brand | Axion |
| Model | CF-1754 color monitor |
| Price | \$425 |
| Display | 17-in. diagonal (factory-preset 15.6-in. viewable) |
| Weight | 38 pounds |
| Power | 64 watts |
| Color Temperature Measurements (°Kelvin) | |
| Factory presets | 9300°K |
| APEL tests | 11,650°K |
| Screen Brightness (foot-lamberts) | |
| Factory preset | 20 |
| APEL tests | 27 |
| Screen Distortion Measurements | |
| Display image height | 9.2 inches |
| Display image width | 12.4 inches |
| Display image diagonal | 15.6 inches |
| Aspect ratio | 1.35:1 |
| Aspect ratio error | 1.5% |
| Squareness error | 0.5% |
| Horizontal keystone error | 0.3% |
| Vertical keystone error | 0.0% |
| Horizontal pincushion error | 0.2% |
| Vertical pincushion error | 0.4% |
| Horizontal bow error | 0.3% |
| Vertical bow error | -0.5% |
| Horizontal linearity error | 0.6% |
| Vertical linearity error | -0.4% |
| Screen distortion index | 0.5% |
| Features | |
| Dot pitch | 0.42mm |
| Scanning | Non-interlaced |
| Refresh rate | Up to 100 Hz, depending on video card scanning frequency. |
| Resolutions supported (SVGA, VESA, 8514A, Mac) | |
| | 320 x 200, 640 x 200, 640 x 350, 640 x 400, 640 x 480, 800 x 600, 1024 x 768 |

ANTIQUE Radio

Trying Out the 1930's Ham Receiver

BY MARC ELLIS

Last time, our attempt to test the completed 2-tube regenerative ham receiver (built from the 1930 ARRL handbook *How to Become a Radio Amateur*) ended in disaster. Although I'd been very careful to clean up and rehabilitate the other vintage parts used in the set, I hadn't thought about the tube sockets. As luck would have it, their contacts were loose and dirty. So much so, that the 01-A tubes wouldn't stay lit until I wiggled them around to locate "sweet spots" that worked.

However, the intermittent load presented by the tube filaments during all of that wiggling was apparently too much for the solid-state wall transformer/rectifier I was using to light up the tubes. Eventually, a thin plume of white smoke—accompanied by an exotically odd smell—wafted up from baseboard level, signaling the untimely demise of the little power cube.

APPLYING FILAMENT POWER

This month's work session focused first on the tube sockets. Disconnecting both, I removed them from the board and took a look underneath. It appeared that, with a little judicious bending, I could improve the grip of the spring contacts on the tube pins. After bending all four sets of contacts on both tubes, I went ahead and cleaned up the tube pins themselves with some fine steel wool. Finally, in the hope of getting rid of any oxidation that might have formed on the gripping surfaces of the tube contacts, I sprayed some contact cleaner into each "pin hole"—inserting and removing the tube several times to work the cleaner in well.

With the sockets reinstalled, I decided to hook up some filament power and see if the tubes would light reliably. I would have liked to test another power cube in that application, but couldn't find a second appropriate one in my junk box. Maybe a suitable

candidate will fall into my hands at some future time. As a substitute, I wired in an old Eico battery eliminator/charger with which I had successfully operated the filaments of various battery sets of the five-tube, three-dialer type.

Plugging in both tubes, I found that one worked okay, but the other was dark. Apparently my socket rehabilitation procedure wasn't quite foolproof. Pulling the recalcitrant tube about an eighth of an inch out of its socket established the required contact and the filament gave off a steady warm glow. Moral: Be very careful with old friction-grip tube sockets; clean up, tighten, and test before wiring them into a circuit! (By the way, those were "Buffalo" brand surface-mount types.)

PLATE POWER PROBLEM

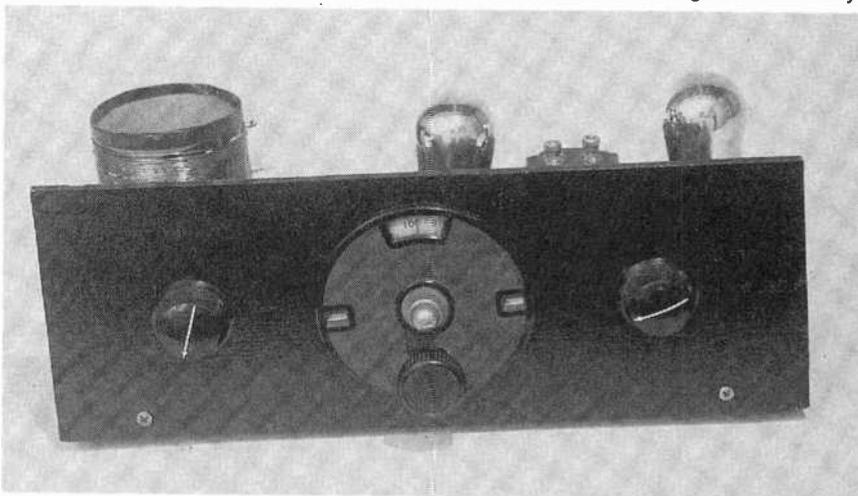
Next, I began to hook up the two surplus 45-volt batteries that I'd purchased to supply voltage to the plates of the detector and audio amplifier. All went well until I tried to connect up the common B- lead, and was greeted by a snapping blue-white spark. Oddly enough, that hadn't happened the first time I'd hooked up the batteries. Checking with an ohmmeter, I discovered that there was virtually a dead

short between the +45 and B- terminals of the receiver.

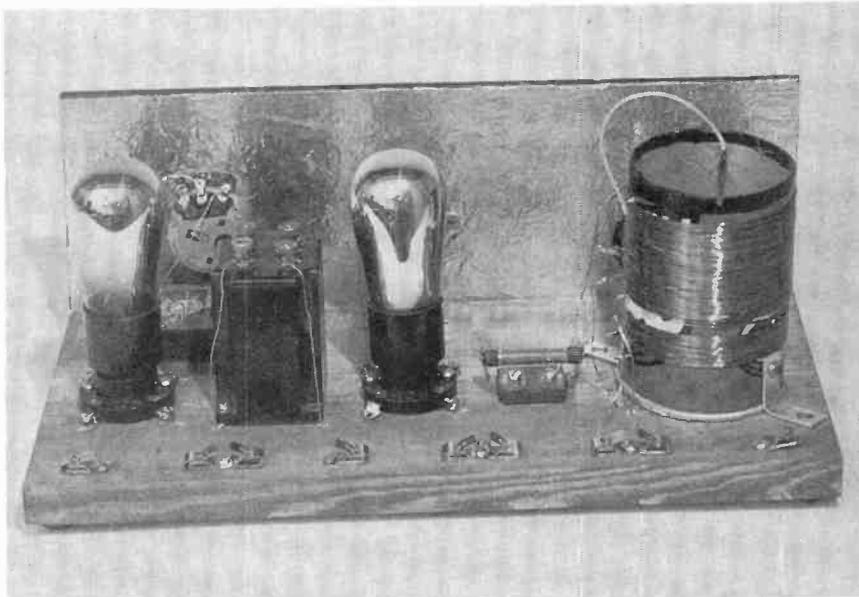
Now began quite a perplexing search, as I disconnected component after component to isolate the location of the short. Finally I found it, almost by accident. One of the staples securing a wire to the underside of the board had passed through some plastic tape insulation and was making intermittent contact with a second wire beneath. Relocating that staple solved the problem quickly and permanently.

With the set fully powered, I could now tell that the Eico power supply wasn't going to cut it as a source of DC for the 01-A filaments. The loud 120-cycle buzz in the headphones was not only unpleasant, but easily capable of drowning out any signals that the set might happen to pick up. Making a quick run to the nearest home-center store, I picked up a couple of six-volt lantern batteries (the small square kind with spring contacts). They would hardly be an economical power source for serious use of the radio, but—I hoped—would at least get me through the testing phase.

Wiring the batteries in parallel, I connected them to the radio's filament terminals and slowly advanced the rheostat. The tubes glowed warmly,



Here's the front of 1930's ham receiver complete and ready for testing. Note the Marco three-window dial (see text).



This is the 1930's ham set as seen from the rear. The audio transformer is between the two tubes; the grid-leak assembly is between tube and the coil.

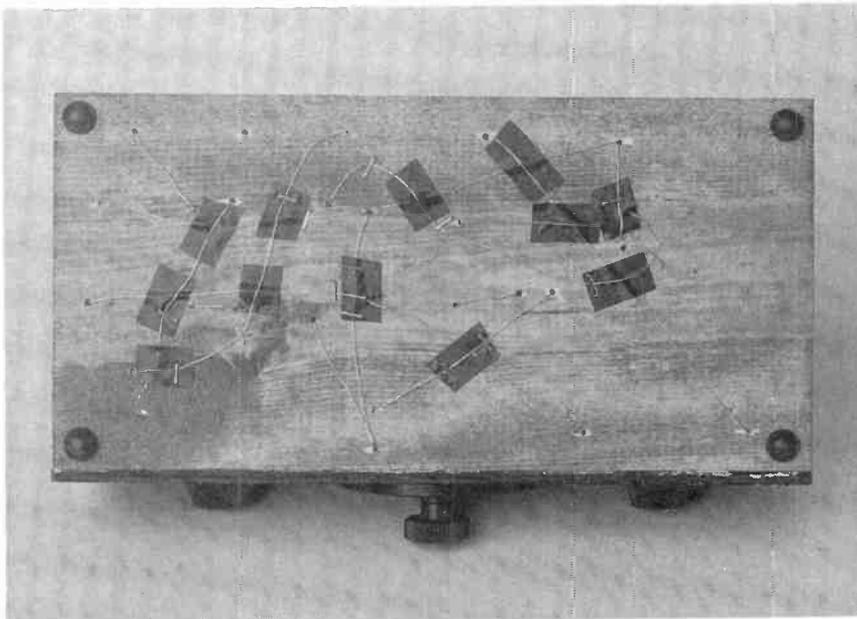
and the headphones stayed nice and quiet. Too quiet, in fact. There was not a signal to be heard, and the set would not oscillate even with the regeneration control in the full on position.

MORE TROUBLESHOOTING

Forewarned that the sensitive, cranky regenerative circuit would "choke" on a long antenna, I'd been using a 20-foot length of wire thrown out of the window. My first move was to disconnect that and hook up my 100-foot-long, 40-foot-high ham anten-

na. The result: a loud and untunable jumble of local broadcast stations. Still no regeneration.

Back to the drawing board. I carefully rechecked my wiring, and everything seemed okay there. Then I got out my grid dip meter and checked the resonance point of the full coil with the tuning capacitor wide open. It read a little over 2 MHz, which is a bit above the top of the 160-meter ham band (as it is now and as it was in 1930). All as it should be. However, I was not able to find a resonance "dip" after connect-



Most of the wiring is done beneath the breadboard. Short pieces of electrical tape keep the wires from touching where they cross. Staples keep the wires in place.

ing the coil clip to either the 80-meter tap or my experimental 40-meter one.

What to try next? Reviewing schematics of similar sets in other vintage publications, I noticed something. Most circuits that use a variable-resistance regeneration control in series with the tickler coil also include a bypass capacitor from the transformer side of the tickler coil to ground "to promote regeneration." Our set had the former but not the latter. I decided to try installing a 0.001-microfarad bypass capacitor, which was the typical size used in that setup.

THE SET COMES TO LIFE!

Slowly advancing the regeneration control to the right, I suddenly heard a squeal and a hiss. Turning the main tuning dial, I was now able to pick up several signals—mostly obscured with squealing and distortion. As with any regenerative set, the regeneration control had to be cut back to just below the point of oscillation to clarify the signal and maximize receiving sensitivity.

I wish I could claim to have spanned a continent or two with that minimal vintage hardware. However, other than a few local broadcasting stations from the high end of the band, I wasn't able to identify much. I heard someone speaking what seemed to be Arabic, as well as a few Hispanic language stations, but I wasn't able to identify call letters or locations. I also heard a few ham sideband stations, but was not able to decipher their "Donald Duck" transmissions with the primitive detector I was using.

The fact is, 160 meters is not a very interesting band for shortwave listening. Unfortunately, the 80-meter tap, installed according to the specifications in the original article, did not work. Neither did the experimental 40-meter tap that I added—not even with the set connected to my 100-foot antenna.

Although it's fun to build, and also has a very interesting and nostalgic appearance, this is not a very satisfying radio to use in its present form. I think I'd like to explore replacing the present coil with a tried-and-true coil design for a more interesting short-wave band. I'll let you know how I make out.

MARCO DIAL INFO

Back in the January issue, when I was just beginning to put the receiver together, I was puzzled by the extra windows (the ones at "three o'clock" and "nine o'clock") on the face of the Marco brand vernier dial used to drive the main tuning capacitor. The usual 0-100 calibration scale appears in the large central window. The subsidiary windows show only white space, unless the dial is turned far enough in one direction or the other so that some of the scale markings appear under one of them.

Reader Wells E. Burton (Summerville, SC) responded to my query in detail, and I'll quote liberally from his nice long letter. Back in the mid 1920s to early 1930s, Wells' dad owned a radio store where many of the popular brands of the era were sold. That afforded Wells the opportunity to study the early battery sets when they were new and, later, to dismantle them and file the parts after they were traded in on AC models. Many of those parts found their way into the ham receivers and transmitters that he built as a boy. Here's what he tells us about the Marco:

"Regarding the subsidiary windows on the Marco dial. Radio dials not being calibrated in kHz (kc in those days), it was up to the listener to find the settings for the stations ... the listener would often keep a calibration log of the dial settings for future use. The Marco dial (presumably patented), provided the auxiliary windows for recording the call letters of the stations received.

"If a station was heard on a dial setting between 0 and 49, the listener would use a sharp pencil to mark the station call letters in the left window. If the station was received on a dial setting between 51 and 100, he would put the marks in the right window ... In those days there were not many stations on the air and they were usually widely separated in frequency. Thus it was possible to show the call letters of every station that could be heard. Evidently, the dial you are using on your '1930's ham receiver' was either brand new (straight out of the box), or was taken from a receiver previously owned by someone who did not use

the 'side windows' for their intended purpose.

"I have had at least three of the Marco dials, and the two still in my possession have penciled markings for such stations as KDKA, WJZ, WHAS, WOR, WLW, WMCA and WBT. I consider the Marco to be a very desirable dial. It has negligible back-lash and a narrow hair-line indicator. Its resettability is precise. It has another feature I like; the direction of the rotation of the dial is the same as the knob rotation. If the knob is turned clockwise, the dial goes clockwise."

So that's the deal on the Marco. I knew that when the explanation appeared, I'd feel like a fool for not figuring it out on my own! Wells is right; my dial came from a receiver project that seems never to have been completed. And, moving the dial through its complete range, I could find no sign of anything ever having been written under either of the subsidiary windows.

The only thing that I don't understand is how the average person would be able to actually write anything in those slit-like, deep-set windows—much less make erasures and corrections. It seems like it would take an impossibly long and fine point and the coordination of an engraver or a forger. Oh well, maybe it's not as hard as it seems; after all, my unbelievably poor handwriting skills even easy things look hard.

That's all the room we have for now, so I hope to see you all again next month! In the meantime, please send your questions and comments to me c/o *Antique Radio, Popular Electronics*, 500 Bi-County Blvd., Farmingdale, NY 11735. ■



"Overheating problem?
What overheating problem?
By the way, how do you like your hot dogs?"

COMPUTER BITS

(continued from page 10)

but something that just did the basics really well. Recently I ran across a little shareware jewel called COMMO. It was love at first sight. After doing fairly extensive testing, I registered the program, and it has now become my primary telecommunications vehicle.

Features I like about COMMO include its ASCII configuration files, its scripting language, its host mode (which allows you to set up your own private mini BBS), and its extremely compact size. The main executable weighs in at about 45K (yes K, not Meg!). With required configuration files, the program still takes less than 100K—small enough to fit on the emergency diskette I described in last August's instalment of this column.

COMMO is written in assembly language, and its scripting language reflects that heritage. I'd prefer to see something more like Pascal, as in The SemWare Editor, which I last wrote about here in April of 1994. I'd also like to see a way of binding all the configuration files together with the executable. Those features would be icing on the cake. But even as it is, COMMO is a wonderful piece of work. (The SemWare Editor, by the way, is another CMI program on my list of all-time favorites. Watch for an update that should be available soon.)

Incidentally, COMMO runs just fine under Win95. I automatically run a copy of it on my central print/communications server, an older IBM PS/2 Model 70 with a 386/25 and 8 MB of RAM. COMMO loads as part of the boot sequence, so my mini BBS is always up and running. That is useful when I'm at a client's site and discover I'm missing a file. Because COMMO includes the complete source for the mini BBS, I can (and have) customized it to meet my needs, all in a few hours of work, and with no additional expense over the \$40 shareware registration fee. COMMO is available on CompuServe, many BBSes, and directly from the author: Fred P. Brucker (P.O. Box 141537, Columbus, OH 43214). I'll also post a copy on the Gernsback BBS (516-293-2283); look for a file named COMMO65.ZIP. ■

New breakthrough clones TV signals and sends them to any other TV in your home

Recoton's new development duplicates cable, TV, VCR and satellite signals and transmits them...without any wires!

by Charles Anton

Today, television choices are virtually unlimited. Between cable, satellite TV, videos and network programming, it's almost a full-time job trying to keep up with all the alternatives. And it promises to get more complicated in the future. Breakthroughs in fiber optic technology will bring over 500 channels into your home.

Home broadcasting breakthrough. The problem with all this technology is the expense required to maintain your system and keep it up-to-date. Now, a wireless video broadcasting system from Recoton gives you the power to utilize this technology without the hassle and expense of re-wiring your entire home.

Today, Recoton introduces the next generation in wireless broadcasting. The wireless video broadcaster transmits (re-broadcasts) cable, TV, VCR or satellite programs to any other TV in your home...wirelessly!

Wave of the future. Never drag your VCR from room to room again: Recoton's wireless video broadcasting system transmits video or TV signals to any other TV in your home.

Because the system is totally wireless, you won't have to worry about running miles of wires. Besides, who wants to install cable in every room of their home? With Recoton's wireless video broadcasting system, you



won't have to. You can even watch one program on your main TV while someone else watches something different on another TV. It's just like having a personal broadcasting system in your home—and it's legal in every state.

Hi-tech home broadcast. Recently, the Federal Communications Commission allocated a band of radio frequencies specifically for wireless, in-home product applications. Recoton took advantage of the FCC ruling by creating and introducing wireless equipment that can transmit within the prescribed frequency over distances of up to 150 feet.

Wireless Video Breakthrough...

Cable Broadcast cable channels, even premium channels, to other TVs in your home that are not wired for cable.

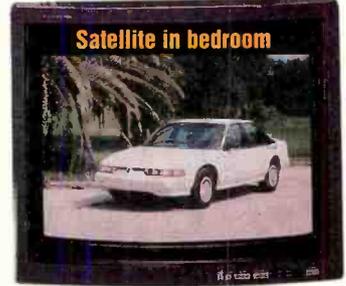
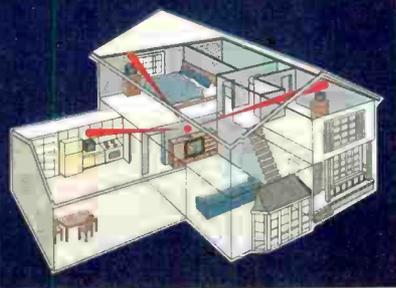
Videos Transmit signals from one VCR to any room, even if someone is watching TV in the room that the VCR is in.

Satellite programs Watch satellite programs throughout your home without stringing miles of cable everywhere.

Live video View home videos as you film them or turn your camcorder into a security camera.

Network programs If the main TV is hooked up to an antenna, you can broadcast its clear signal to all the others.

Recoton's video broadcasting system clones the accessories (cable, satellite, VCR, etc.) of one TV and broadcasts it to any other TV in your home...without wires!



Exclusive factory-direct offer. With this breakthrough in home video broadcasting technology, you can have the convenience of your own personal wireless broadcasting system for a fraction of the cost of owning your own TV station. For a limited time only, we are offering Recoton's wireless video broadcasting system (one transmitter and one receiver) for the low price of \$99. You can order additional receivers for other TVs for just \$59 each.

Risk-free offer. The wireless video broadcasting system is backed by Contrad's exclusive risk-free home trial. Try it, and if you are not completely satisfied, simply return it within 30 days for a full "No Questions Asked" refund. It also comes with a 90-day manufacturer's limited warranty. Most orders are processed within 72 hours and shipped UPS.

Video Broadcasting System \$99 \$9 S&H
Includes one transmitter and one receiver.

Additional receivers (each) \$59 \$7 S&H

Please mention promotional code 173-PL-6650 .

For fastest service, call toll-free 24 hours a day

800-704-1201



To order by mail, send check or money order for the total amount including S&H (VA residents include 4.5% sales tax). Or charge it to your credit card by enclosing your account number and expiration date.

CONTRAD INDUSTRIES

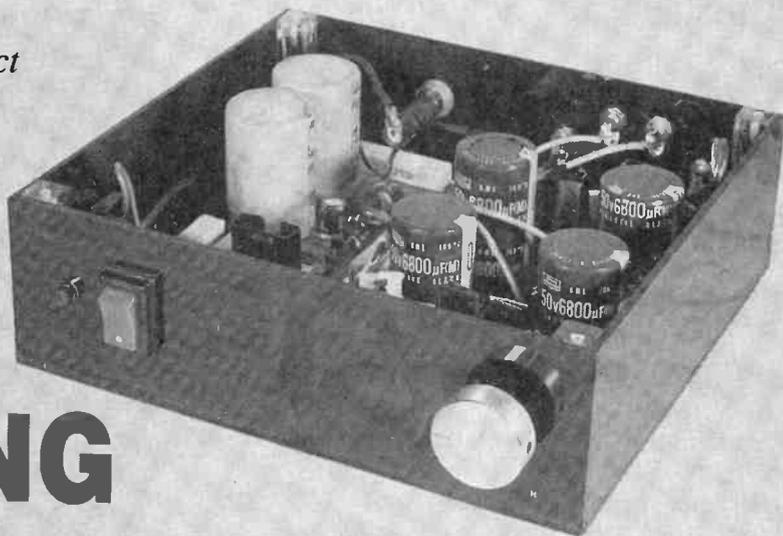
2820 Waterford Lake Drive, Suite 106
Midlothian, Virginia 23113

ADD A TV TOWER?



Buying your own TV tower would cost you about \$3.5 million. The video broadcasting system is like buying your own TV station, but without the expense. For just \$99, the Recoton system is like adding a cable box, VCR and satellite dish to every TV in your home.

It's a 60-watt, dual-channel project that lets you decide for yourself if you prefer the sound of nonlinear amplifiers.



BUILD A SWITCHING AMPLIFIER

BY ROLANDO R. BURBON

When it comes to most audio-related issues, there's usually an argument. You know how it goes: audiophile number one prefers one type of cable, speaker, or amplifier, while audiophile number two prefers a different type. Although such audio debates will probably go on until the end of time, you can do something to drown out all the ruckus generated by audiophiles: Build the *Switching Amplifier* described in this article and let it fill your home with the sounds of your favorite music. It's a 60-watt, dual-channel unit that can be used as a main or backup amplifier.

Switching Amps. Class-A and Class-B linear amplifiers (as well as their derivatives) are routinely used to amplify audio signals in most common applications. However, it is also possible to amplify audio signals with a nonlinear amplifier. Such nonlinear amplifiers are also known as "switching" or Class-D amplifiers, because the output transistors used in the units switch on and off.

In a switching amplifier, almost all power is delivered to a load when the amplifier circuit is fully switched on. The largest amount of power is dissipated during the turn-on and turn-off transitions; the faster the transition, the smaller the amount of power dissipated in the output transistors.

As a result of switching amplifiers' design, their efficiency can exceed 90%. In comparison, Class-A and -B

amplifiers have maximum efficiencies of 20% and 78.5%, respectively. An added benefit of the high efficiency of switching amplifiers is that they can be smaller, lighter, and less expensive than Class-A and -B units.

The Switching Amplifier (and many other units of its type) uses a pulse-width modulator to obtain the required switching action. Audio signals are converted into a series of pulses, each of which is directly proportional to the original audio-signal frequency and amplitude when compared to a fixed-frequency, fixed-amplitude, triangular reference waveform.

Therefore, for a given input frequency, the signal's amplitude varies the output's pulse width (duty cycle). Those deviations are amplified and directed to full-range, 8-ohm speakers, which in turn demodulate the pulses producing an amplified audio output.

Circuit Description. The schematic for the Switching Amplifier is shown in Fig. 1. A separate 51-volt-DC source is required to power the Amplifier circuit (we'll deal with that power-supply circuit later on). The 51-volt-DC source is fed to a pair of Zener diodes, D5 and D6, and is filtered by capacitors C11 and C12 to provide a 12-volt-DC source for part of the circuit. Also, part of the 51-volt-DC source bypasses the Zeners to power the sections of the circuit that require such a high voltage.

The right and left signals are input to the Amplifier through jacks J1 and J2, respectively. Two sections of a TL074 op-amp, IC1-c and IC1-d, generate a 4-volt peak-to-peak, 50-kHz triangular reference waveform. The generated waveform is then fed to potentiometer R19, which provides an adjustable reference for the voltage comparators. That enables the amplifier to use input signals with amplitudes ranging from 1 volt p-p to 4 volts p-p. The other two op-amp sections, IC1-a and IC1-b, function as comparators to produce the pulse-width-modulating output for the left and right channels of the Amplifier.

In the right channel of the Amplifier, the output of the voltage comparator is coupled to the bipolar translating circuit through a current-limiting resistor, R5. The translating circuit has a positive and negative "leg"; Q1, D1, and R1 make up the positive leg, and Q3, D3, and R11 make up the negative leg. Both legs are tied to ground through the emitters of Q1 and Q3, providing a reference point for the translator.

The translator arrangement results in 17 volts being present across Q1, Q3, and Zener diodes D1 and D3. Sufficient current is then present to overcome the power MOSFET gate capacitance; that rapidly switches on and off the power MOSFET complementary push-pull output stage, composed of Q5 and Q7.

Resistor R3 keeps the output swing

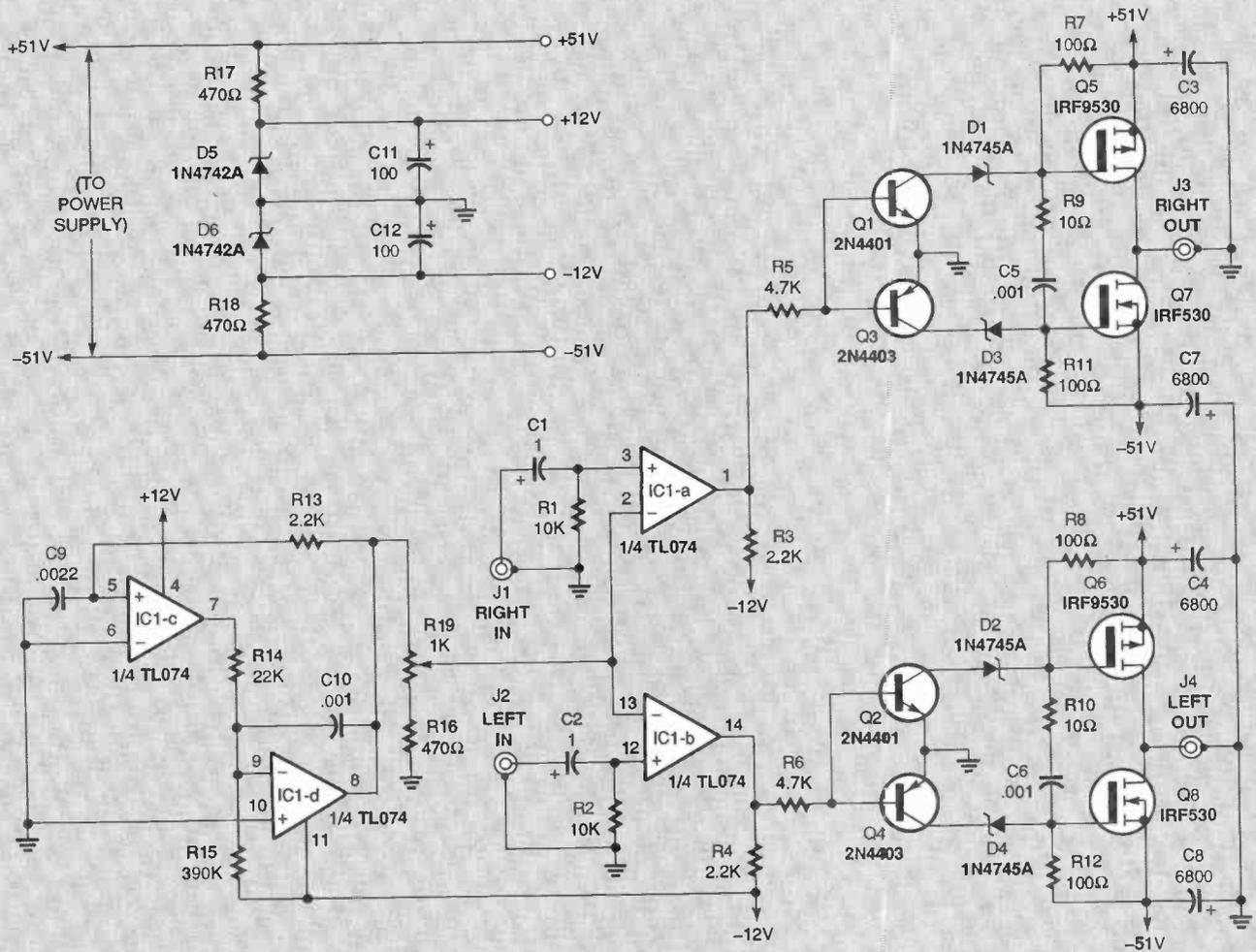


Fig. 1. Here's the schematic for the Switching Amplifier. A separate power-supply circuit is necessary to provide a 51-volt DC source. Two Zeners, D5 and D6, drop some of that voltage to also provide a 12-volt DC supply for the circuit.

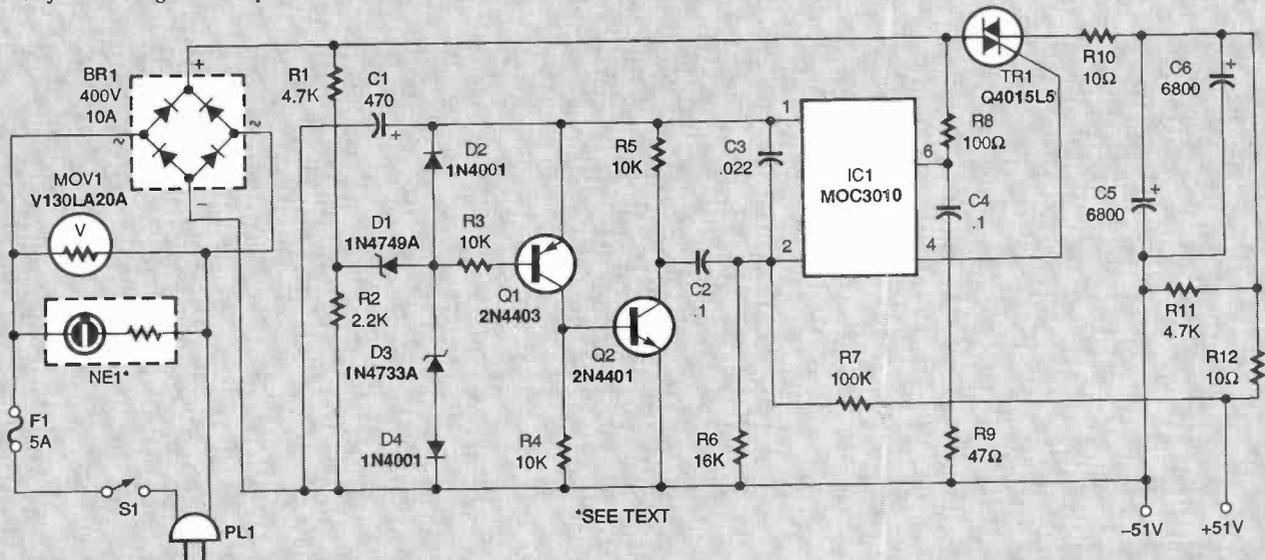


Fig. 2. This power supply rectifies 117-volts AC and uses a triac circuit to produce a 51-volt DC source for the Amplifier.

centered at the midpoint of the supply voltage. Without R3 the square-wave output drifts down towards the

negative rail. The RC network composed of R9 and C5, which connects to both N- and P-channel gates, mini-

mizes switching noise and sharpens the squarewave output.

There's no need to go into how the

PARTS LIST FOR THE SWITCHING AMPLIFIER (Fig. 1)

SEMICONDUCTORS

IC1—TL074N quad JFET op-amp, integrated circuit
 Q1, Q2—2N4401 small-signal NPN transistor
 Q3, Q4—2N4403 small-signal PNP transistor
 Q5, Q6—IRF9530 P-channel, 100-volt power MOSFET (see text)
 Q7, Q8—IRF530 N-channel, 100-volt power MOSFET (see text)
 D1—D4—1N4745A 16-volt, 1-watt Zener diode
 D5, D6—1N4742A 12-volt, 1-watt Zener diode

RESISTORS

(All fixed resistors are 1/4-watt, 5% units, except where otherwise noted.)

R1, R2—10,000-ohm
 R3, R4, R13—2200-ohm
 R5, R6—4700-ohm
 R7, R8, R11, R12—100-ohm, 2-watt
 R9, R10—10-ohm
 R14—22,000-ohm
 R15—390,000-ohm

R16—470-ohm
 R17, R18—470-ohm, 2-watt
 R19—1000-ohm potentiometer

CAPACITORS

C1, C2—1- μ F, 16-WVDC, electrolytic
 C3, C4, C7, C8—6800- μ F, 50-WVDC, electrolytic
 C5, C6, C10—0.001- μ F, polyester
 C9—0.0022- μ F, polyester
 C11, C12—100- μ F, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

J1—J4—RCA jack
 Printed-circuit materials, project enclosure (see text), 5-watt heatsinks (clip-on type) for Q5—Q8, 2 tin-can bottoms, 14-pin IC socket, two-connection wire connector (should match the one used in the power-supply board), potentiometer knob, 4-40 1/2-inch machine screws, #4 washers, 4-40 hex nuts, wire, solder, hardware, etc.

left channel operates. If you examine Fig. 1, you'll notice that the left channel is identical to the right one we just dealt with. They both operate in the same way. Also note that both channels contain power-supply elements to split the incoming, single-polarity voltage in half. Capacitors C3, C4, C7,

and C8 make up a series-parallel circuit that converts the 51-volt-DC supply to 25.5-volts DC.

The right and left outputs of the Amplifier are jacks J3 and J4, respectively. The output can feed full-range 60-watt RMS speakers, which demodulate the signal and produce an ampli-

fied audio output. (At peak output power, the current draw for an 8-ohm dynamic load is approximately 1.2 amperes at 51-volts DC.)

Let's now turn our attention to the power supply. Figure 2 is the schematic diagram for that circuit. The AC voltage taken from PL1 feeds into bridge-rectifier BR1, which delivers a fullwave output of approximately 165-volts DC.

The network composed of R1, R2, D1, D3, and D4 generates a series of 5-volt pulses that provide two important functions: First the pulses are used as a 5-volt power source for the pulse shaping and monostable network through D2 and C1. Second, the pulses trigger optoisolator IC1 and power-triac TR1 via the pulse-shaping network composed of Q1, Q2, and R3—R5, and the monostable circuit made of C2 and R6. Resistor R2 sets the maximum pulse width and therefore the maximum output voltage.

Without feedback the unfiltered peak voltage is approximately 90 volts. To obtain the required 51-volt output, the feedback network composed of R6, R7, and C3 reverse biases the optoisolator whenever the output voltage exceeds 51 volts. That then forces TR1 to turn off as the unfiltered voltage goes to zero volts. The RC feedback network therefore regulates the output voltage by actively modifying IC1's conducting state.

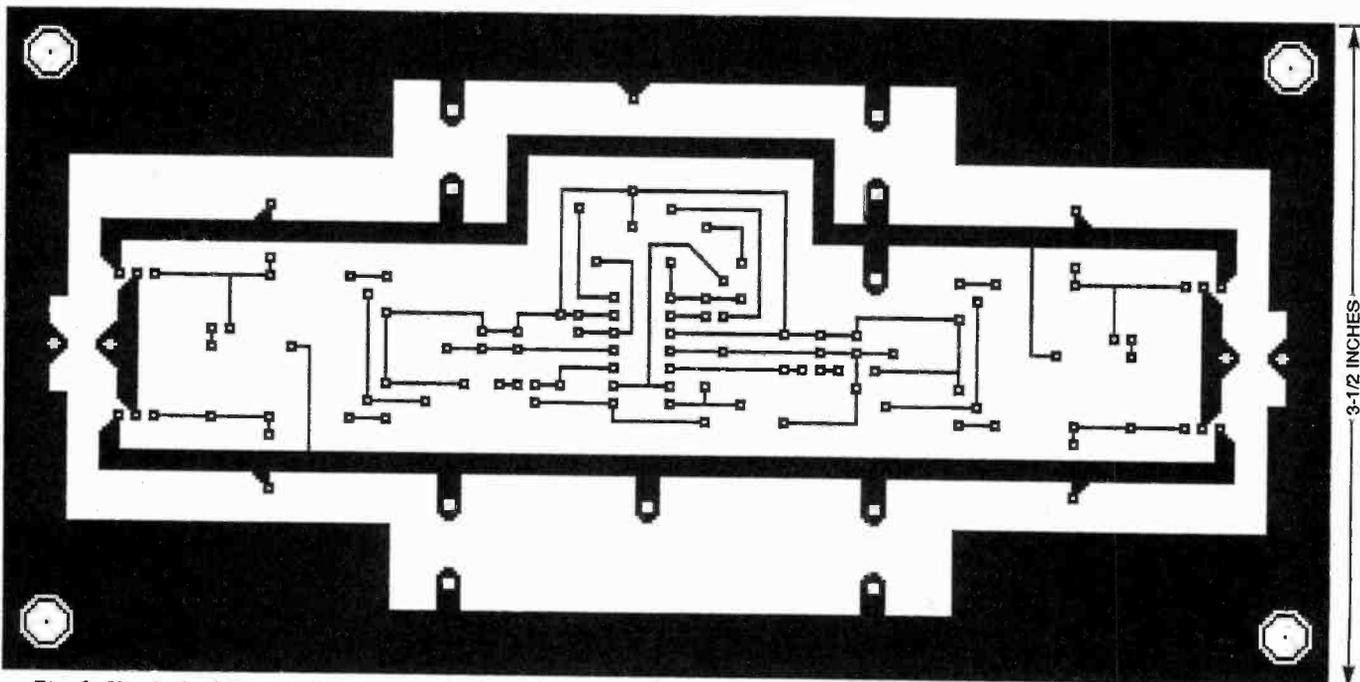


Fig. 3. Here's the full-size foil pattern for the Amplifier circuit board.

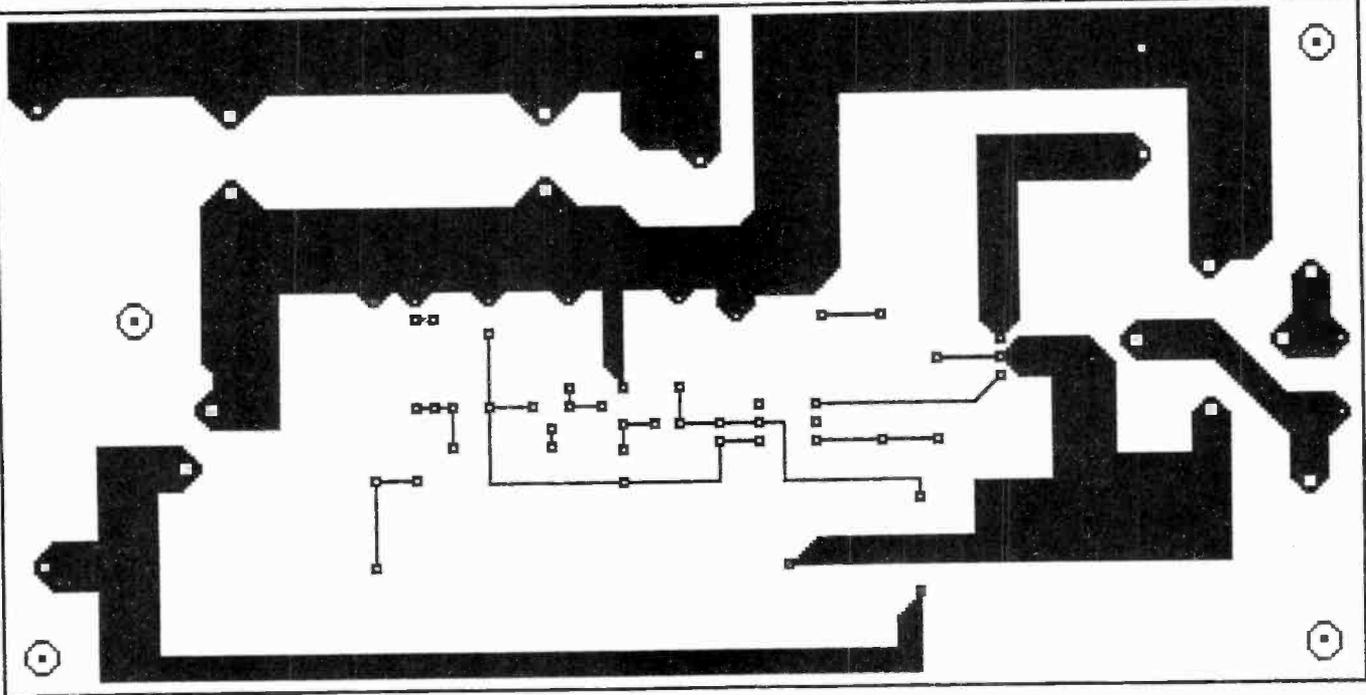


Fig. 4. This is the pattern for the power-supply board.

Resistor R8 limits the current through the optoisolator, and C4 and R9 ensure that the optoisolator's operation is stable and safe. Also, R10 limits surge current through TR1 when the supply is first turned on. Capacitors C5 and C6 along with R10 form a low-pass filter stage that minimizes ripple current. Resistor R11 discharges C5 and C6 when the power supply is turned off.

Construction. The author's prototype for the Switching Amplifier was built on two PC boards—one for the amplifier circuit itself, and one for the power-supply circuit. If you would like to do the same, use the amplifier and power-supply board templates shown in Figs. 3 and 4, respectively.

Assemble the amplifier board first, using the parts-placement diagram shown in Fig. 5 as a guide. Begin by installing an IC socket for IC1. Then mount all the fixed resistors.

Next, install the Zener diodes. Because the 1-watt units specified for D1–D6 dissipate quite a bit of heat, they must be heatsinked. You could instead replace the Zeners with 5-watt units, but such large Zener diodes are difficult to obtain and are expensive.

To create heatsinks for the Zener diodes, cut the circular bottoms of a couple of tin cans to make four 1.4- × 1.2-inch rectangular pieces. With a file or abrasive stone, smooth all the

PARTS LIST FOR THE POWER SUPPLY (Fig. 2)

SEMICONDUCTORS

IC1—MOC3010 triac optoisolator, integrated circuit
 TR1—Q4015L5 400-volt, 15-ampere isolated triac
 Q1—2N4403 small-signal PNP transistor
 Q2—2N4401 small-signal NPN transistor
 BR1—400-volt, 10-ampere bridge rectifier
 D1—1N4749A 24-volt, 1-watt Zener diode
 D2, D4—1N4001 silicon rectifier diode
 D3—1N4733A 5.1-volt, 1-watt Zener diode

RESISTORS

(All resistors are ¼-watt, 5% units, except where otherwise noted.)
 R1—4700-ohm, 10-watt
 R2—2200-ohm, 2-watt
 R3–R5—10,000-ohm
 R6—16,000-ohm (see text)
 R7—100,000-ohm (see text)
 R8—100-ohm
 R9—47-ohm

R10, R12—10-ohm, 10-watt
 R11—4700-ohm, 2-watt

CAPACITORS

C1—470-µF, 16-WVDC, electrolytic
 C2—0.1-µF, polyester
 C3—0.022-µF, polyester
 C4—0.1-µF, polyester
 C5, C6—6800-µF, 63-WVDC, electrolytic

ADDITIONAL PARTS AND

MATERIALS

MOV1—V130LA20A 130-VAC, 70-joule varistor
 NE1—120-VAC neon assembly
 F1—5-ampere, 125-VAC, fast-blow fuse
 S1—SPST switch
 PL1—AC plug, two-terminal
 Printed-circuit materials, 4-40 ½-inch machine screws, #4 washers, 4-40 hex nuts, two-connection wire connector (should match the one used on the Amplifier board), IC socket, fuse holder, AC line cord, rubber grommet, 5-watt heatsinks (clip-on type) for TR1, wire, solder, hardware, etc.

edges before proceeding to the next step.

Now fold each piece in half to form two 1.4- × 0.6-inch fins. Then, using a 7/64-inch drill bit, drill a hole at the mid-points of each heatsink where each Zener will be fitted. After fitting the diodes in place and noting their cath-

ode sides, apply epoxy to set the diodes in place. Take care to ensure that the leads are not touching the heatsink.

Once the epoxy has cured, solder each heatsink/diode combination in place on the printed-circuit board, noting polarity, and apply more ep-

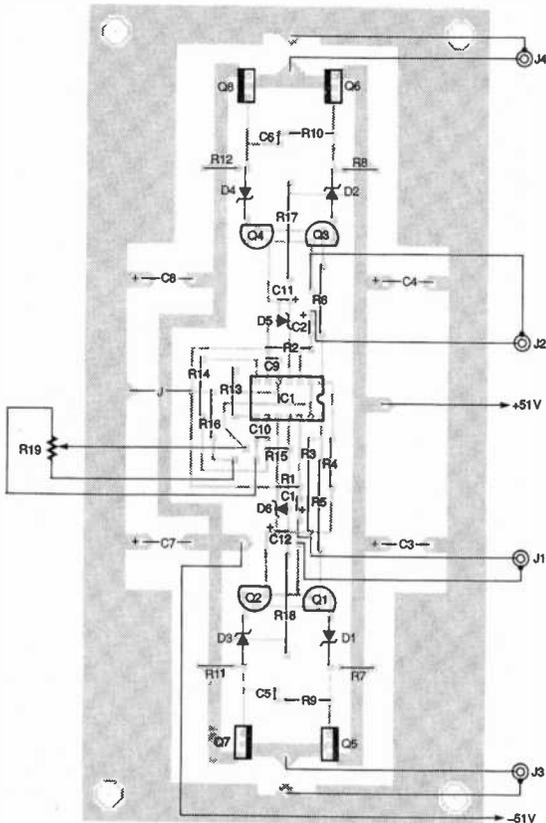


Fig. 5. When assembling the Amplifier board, use this parts-placement diagram as a guide. Watch the polarity of those off-board jack connections!

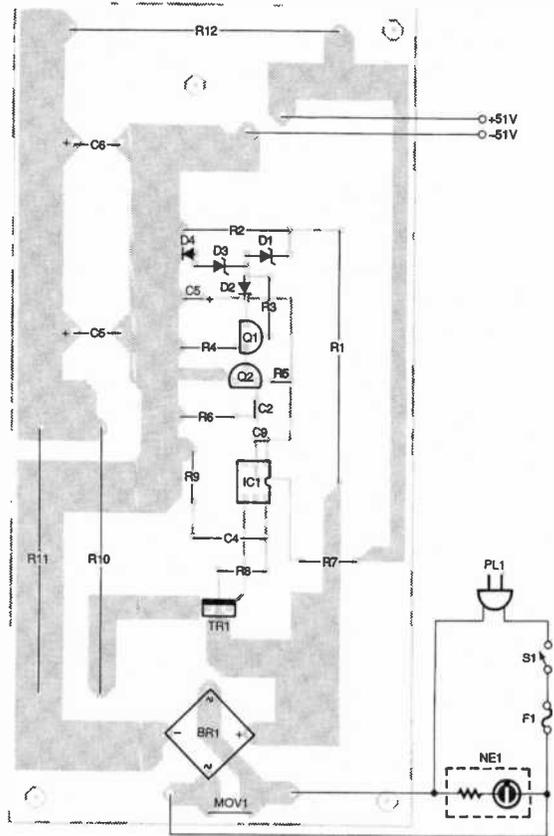


Fig. 6. Here's the parts-placement diagram for the power-supply board.

oxy at the points where the heatsinks meet the board. That is done to ensure that if the heat generated by the diode causes the epoxy at the diode/heatsink junction to deteriorate, the heatsink will remain properly secured.

Next, install the transistors and the MOSFET transistors. The latter also require heatsinks; you can use 5-watt, clip-on types. Notice in the Parts List that IRF9530 and IRF530 transistors are specified—both are 100-volt units. The author actually used 80-volt MOSFETS (IRF9531 and IRF531 types) in the prototype, but those are harder to find. You can get the 100-volt MOSFETS from Mouser Electronics (Tel. 800-346-6873).

Go on to mount the capacitors to the board, being sure to double check the orientation of the electrolytic ones. Solder 18-gauge wires to the board for the connections to potentiometer R19. Then, connect speaker wire to the appropriate points on the board for attaching jacks J1-J4. The jacks and the potentiometer mount on the project enclosure, so they should be connected later on.

Attach two 18-gauge wires to the board for the power connections. Solder a two-connection wire connector of whatever type you can find to the other ends of the wires. You will use a matching connector later on the power-supply board, thereby making it possible to easily attach or separate the two boards. That simplifies testing of the power supply and Amplifier boards, by allowing you to work on each separately.

To complete the on-board assembly, insert the TL074 into its socket. If you can't obtain that chip, do not substitute an LF347 for it. Due to internal differences of those parts, problems will result in the Amplifier's operation. If you must, substitute a TL084 instead.

Now go on to assemble the power-supply board. Keep in mind that the project will derive its output voltage directly off the main AC line. While that doesn't present any dangers during the assembly of the project, you have to make sure you avoid touching the circuit boards while the Amplifier is plugged in.

Start by mounting an IC socket for IC1. Then install the resistors, keeping

the following in mind: In the author's prototype, two of the resistors, R6 and R7, were measured with a DMM to have values of 15,800 and 99,400 ohms, respectively. Those values gave a 51-volt output from the circuit. You might have to get 16,000- and 100,000-ohm resistors that actually measure closer to the values just mentioned to ensure your board outputs the correct voltage.

Next mount the diodes to the board, making sure they are oriented properly. Install the transistors next, followed by the capacitors. Check the orientation of both the transistors and the electrolytic capacitors.

Triac TR1 should be installed next. To ensure cool operation of TR1, you should use a 5-watt, clip-on heatsink on the part.

Next, mount BR1 and MOV1 to the board. Attach wires to the appropriate points on the board for connections to the neon assembly, switch, fuse, and power cord. We'll get to those parts in a moment. Now, also solder on 18-gauge wires for the power connections to the Amplifier

(Continued on page 74)

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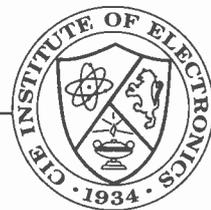
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BUILD A REVERB AND SURROUND-EFFECTS GENERATOR

BY MARC SPIWAK

If it seems that you don't hear people talking about surround sound and home theater as much anymore; maybe that's because most people are now at home actually enjoying home-theater sound. As you probably know by now, real Dolby Surround Sound adds a rear channel to the traditional left and right audio channels to add more depth and realism to movies and music. It does that by decoding special information embedded within a video signal. But what you might not know is that you don't need expensive equipment just to add more depth to audio. In fact, all you have to do to add depth to audio is to add some delayed sound, preferably from behind where you are sitting.

The *Reverb and Surround Effects Generator* described in this article can add a variable time delay to a stereo audio signal or can be set up in mono-only configurations—you can use the unit with a microphone, for example, to obtain interesting reverb effects on your voice. Those with experience using reverb units will like the Effects Generator because its time delay can be varied (between zero and half a second); you can make adjustments for decay time, volume, delay rate, and reverb duration.

The circuit can be built from a kit that sells for under \$60, or from scratch, as we will present complete

plans for it in this article. The unit can be configured for line-level or microphone inputs and speaker, microphone-level, or line-level outputs.

Circuitry. The schematic for the Effects Generator is shown in Fig. 1. Power for the circuit is obtained from either a 9-volt battery or a 9-volt DC supply plugged into power-jack J5.

Even though the parts count isn't that large, the circuit is somewhat complex. At its heart is a fairly specialized integrated circuit, IC3, which is an MN3007 1024-stage bucket-brigade device (BBD). That IC uses a set of switched capacitors to pass charges from one "bucket" to the next on every clock cycle. In general, a signal presented to the input of a BBD will be delayed at the output, with the time delay depending on the clock rate and the number of "buckets" contained within the IC—in this case it's a 1024-stage device. When the delayed sound is fed back into the input, it has the effect of adding reverb, or an echo.

Before we go any further, it's important to note that the jumpers shown in the schematic, JU1–JU9, are not all supposed to be in place. As we'll discuss later on, the configuration of the jumpers determines what kind of setup the unit can be used in. For the sake of this circuit description, assume that only jumpers JU5 and JU7 are in place. That's the configuration for a surround-sound reverb effect on a

stereo audio signal; the inputs are set for line-level to accommodate the signal of equipment like a stereo VCR or laser-disc player.

Now back to the circuit. The left and right inputs at jacks J1 and J2 are passed directly to the outputs at J3 and J4 via resistors R1 and R4. That allows the original signal to be heard with no delay, if you wish. Both the left and right inputs are also added together in IC1-a, an LM324 op-amp, and amplified or attenuated depending on the setting of trimmer-potentiometer R25. The output of IC1-a is fed to the input of IC3, the BBD. A MN3101 clock generator, IC2, in combination with potentiometer R16 and the surrounding components set the delay for the BBD.

Trimmer-potentiometer R33, in series with R35 and C19, lets you control the feedback level to the inputs. That level determines how long a delayed signal will be allowed to recycle through the circuit. The delayed output from IC3 is low-pass filtered by IC1-c and the surrounding components to remove the clock signal from the BBD output. Then, part of the filtered output is fed to the left channel and some of it is fed back to the input to create the reverb effect.

For the surround-sound effect, the output of IC1-c is sent to inverting-amplifier IC1-d, which generates a signal that is 180 degrees out of phase with that at the output of IC1-c. When that out-of-phase signal is fed to the right channel, it cancels some of the audio from the left channel when played through speakers. Because the can-

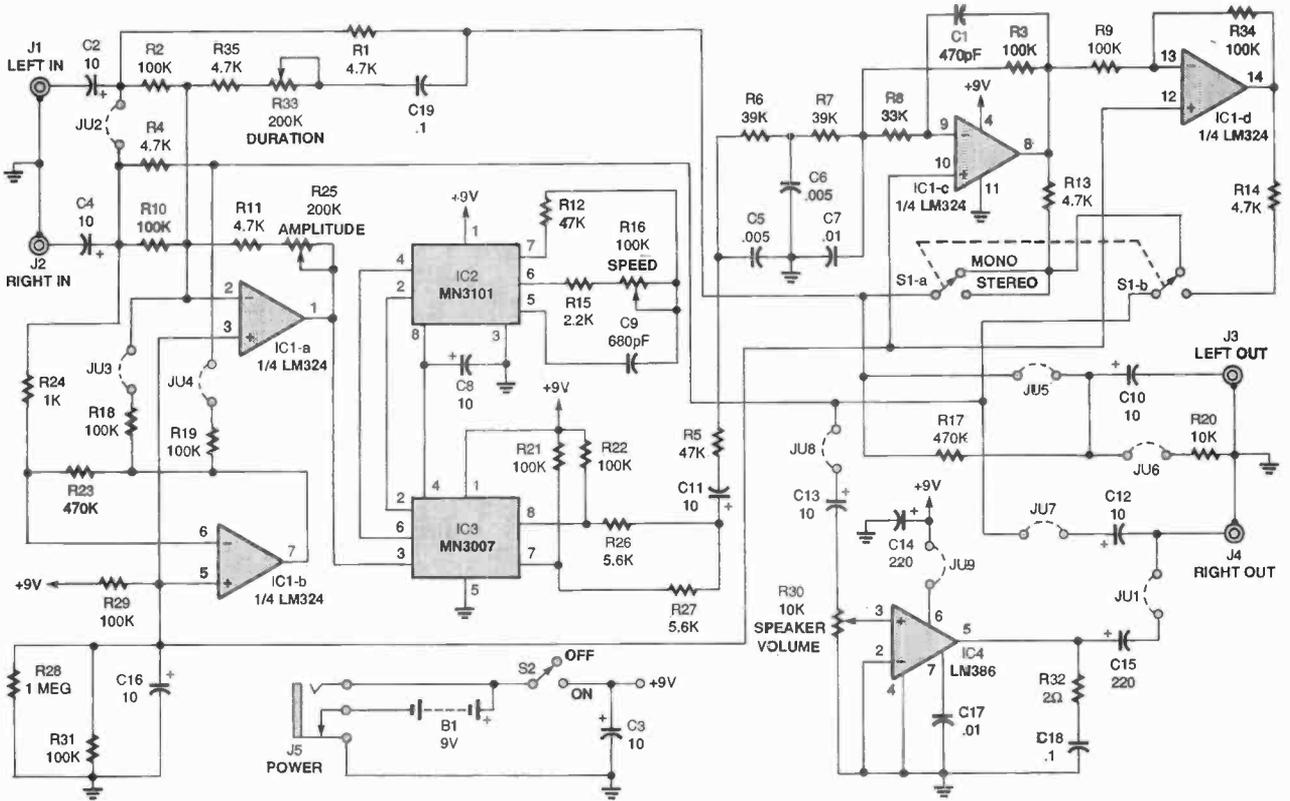


Fig. 1. Here's the schematic for the Reverb and Surround Effects Generator. The heart of the circuit, IC3, is an MN3007 1024-stage bucket-brigade device.

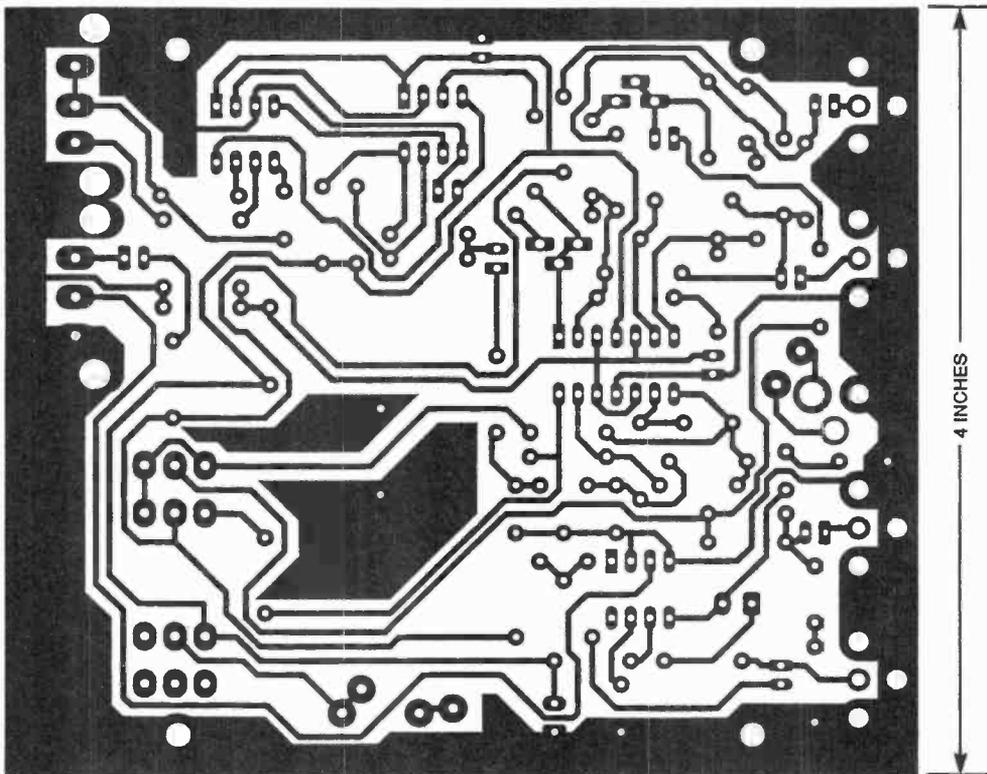


Fig. 2. If you'd like to etch your own PC board, use this full-size template.

celed audio is from the delayed sound and not the original sound, it has the effect of widening the sound

field, or making your speakers sound like they are spaced farther apart.

Switch S1 lets you select between

the surround effect, or stereo mode, and the normal effect, or mono mode, where the output from the low-

PARTS LIST FOR THE REVERB AND SURROUND EFFECTS GENERATOR

SEMICONDUCTORS

- IC1—LM324 quad op-amp, integrated circuit
 IC2—MN3101 BBD clock generator, integrated circuit (Digi-Key MN3101-ND or equivalent)
 IC3—MN3007 bucket-brigade device, integrated circuit (Digi-Key MN3007-ND or equivalent)
 IC4—LM386 audio amplifier, integrated circuit

RESISTORS

- (All fixed resistors are 1/4-watt, 5% units.)
 R1, R4, R11, R13, R14, R35—4700-ohm
 R2, R3, R9, R10, R18, R19, R21, R22, R29, R31, R34—100,000-ohm
 R5, R12—47,000-ohm
 R6, R7—39,000-ohm
 R8—33,000-ohm
 R15—2200-ohm
 R16—100,000-ohm, potentiometer
 R17, R23—470,000-ohm
 R20—10,000-ohm
 R24—1000-ohm
 R25, R33—200,000-ohm, PC-mount trimmer potentiometer
 R26, R27—5600-ohm
 R28—1-megohm
 R30—10,000-ohm, potentiometer
 R32—2-ohm

CAPACITORS

- C1—470-pF, ceramic-disc
 C2—C4, C8, C10—C13, C16—10-μF, 25-WVDC, electrolytic
 C5, C6—0.005-μF, ceramic-disc
 C7, C17—0.01-μF, ceramic-disc
 C9—680-pF, ceramic-disc
 C14, C15—220-μF, 16-WVDC, electrolytic
 C18, C19—0.1-μF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS

- J1—J4—RCA jack
 J5—Power jack
 S1—DPDT switch, PC-mount
 S2—SPDT switch, PC-mount
 B1—9-volt battery

Printed-circuit materials, project enclosure, battery connector, PC-mount battery holder (optional), AC-to-DC adapter (which matches power-jack J5), wire, solder, etc.

Note: The following items are available from Ramsey Electronics (793 Canning Parkway, Victor, NY 14564; Tel. 716-924-4560 or 800-446-2295): RV-1 Reverb Effects/Surround Sound Kit (includes all parts and PC board)—\$59.95; custom case—\$14.95.

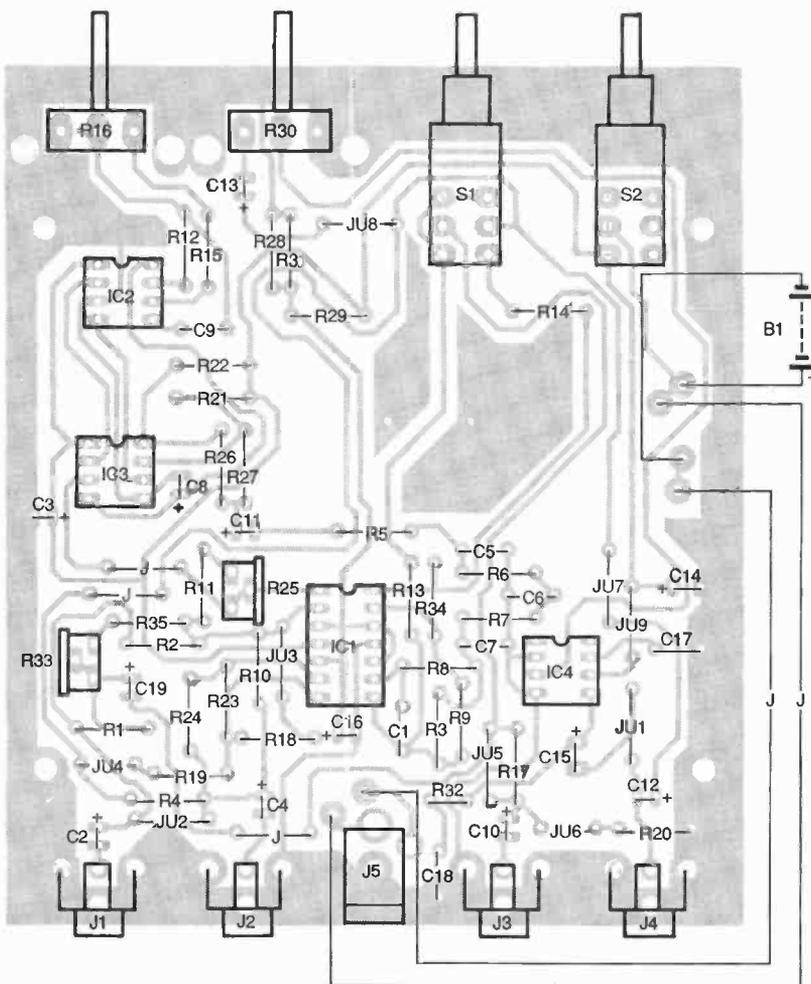


Fig. 3. Use this parts-placement diagram as a guide when assembling the board. Consult Table 1 to determine which jumpers should be installed for your particular application.

TABLE 1

| Installed Jumpers | | | | | | | | | Resistors | | Sound Effect | Inputs | Outputs |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----------|-----|-------------------------|--------|---------|
| JU1 | JU2 | JU3 | JU4 | JU5 | JU6 | JU7 | JU8 | JU9 | R1 | R4 | | | |
| | | | | X | X | | | | in | in | stereo reverb | line | line |
| | X | | | X | X | | | | in | in | simulated stereo reverb | mono | line |
| X | | X | X | | X | | X | X | in | in | mono reverb | mic | speaker |
| | | X | X | X | X | | | | in | in | mono reverb | mic | line |
| | | | | X | X | | | | out | out | TV surround | line | line |

pass filter is fed directly to both the left and right outputs. If jumper JU2 is also installed, a mono signal can be input at J1 or J2 and a simulated stereo signal will be heard at the outputs.

For a microphone input, only jumpers JU1, JU3, JU4, JU6, JU8, and JU9 must be installed. The microphone should be plugged into J2. In that configuration the right output at J4 is a speaker-level amplified output from an LM386 op-amp (IC4) and the left

output at J3 is a microphone-level output. Potentiometer R30 controls the volume of a speaker connected to J4. Amplifier IC4 and all components between JU8 and JU9 are not used if the microphone-input option is not used.

If only jumpers JU3, JU4, JU5, and JU7 are installed, the unit will have a microphone input and a surround-effect, line-level output. If only jumpers JU5 and JU7 are installed and R1

and R4 are removed, only the delayed signal and none of the original will be present at the outputs. That is best suited for the rear channels in a television surround system.

To prevent confusion regarding the preceding configuration details, refer to Table 1. It shows at a glance what jumpers to use and whether you need R1 and R4 for the various applications for this very versatile circuit.

Construction. Although there's no specific reason why you can't build the circuit on a perforated board using point-to-point wiring, audio projects are always better overall when done on a PC board. You can use the foil pattern shown in Fig. 2 to make your own board, or order a pre-drilled and etched board as part of the kit available from the source mentioned in the Parts List.

While all of the components are obtainable from hobbyist sources, you might be best off buying the unit as a kit because two of the ICs alone, the BBD and its associated clock generator, will cost you more than \$10; those two devices are relatively obscure and not likely to be found in even the most well-stocked "junk box." Add in the rest of the parts and the cost and time involved in making a PC board, and the kit price of \$59.95 seems more and more attractive.

On the other hand, if you have access to a hoard of parts, and only need to buy the BBD and the clock generator, you might want to simply get those two ICs. They're available from Digi-Key (Tel. 800-DIGI-KEY) as well as other hobbyist sources.

Assuming you decide to build the circuit on a PC board as suggested,

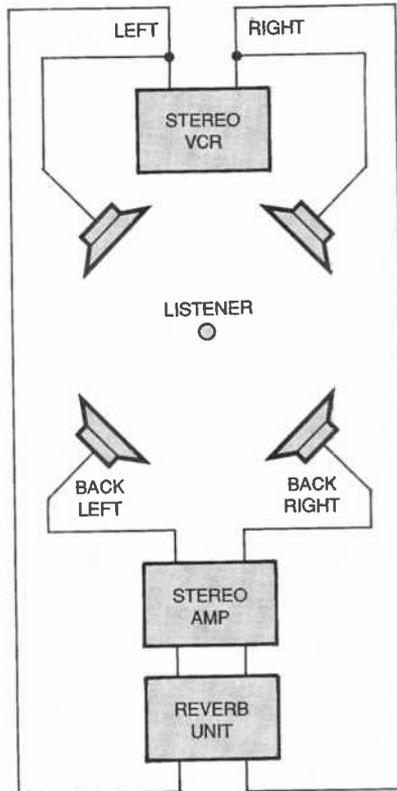


Fig. 4. If you would like to set the unit up for surround effects, feed it a stereo signal and amplify the resulting output with a stereo amplifier.

an appropriate parts-placement diagram is shown in Fig. 3. Begin by installing the fixed resistors, except for R1 and R4. Then go on to mount the capacitors, making sure the electrolytic ones are oriented properly.

Mount the potentiometers, switches, and jacks next. Then solder the battery connector leads to the board. The kit also comes with a holder for a 9-volt battery; solder that in place next if you have it. You can then install the four ICs.



The finished unit can be housed in this attractive custom case, which is available from the source given in the Parts List.

To complete the assembly, you will have to decide which jumpers to install and whether to add resistors R1 and R4. Those decisions depend on your intended application. Again, refer to Table 1 for configuration details. **Note:** Regardless of your application, all of the un-numbered jumpers shown in Fig. 3 must be installed!

If you are using point-to-point wiring, you will need to make connections in the circuit that reflect your particular configuration of choice. In other words, if JU1 is called for, make sure C12 is connected to C15 in your circuit, etc. Also, remember that this is an audio project and that leads should be kept as short as possible and that inputs and outputs must be shielded.

The finished board can be mounted in the case of your choice or in the custom one available from the source mentioned in the Parts List. That case comes complete with matching knobs.

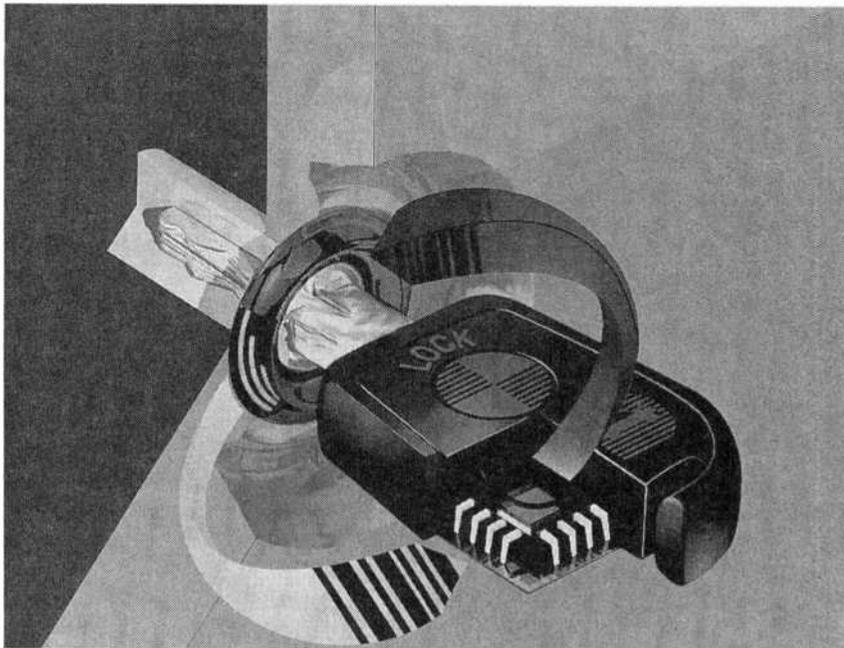
Before shutting the case, you can set R25 and R33 to their minimum resistance. That will provide your unit with the greatest duration and amplitude. You can of course experiment with those trimmer settings as well.

Setup. As mentioned earlier, the Effects Generator is basically intended for stereo surround effects, stereo simulation from a mono source, and vocal reverb effects. During assembly, you had to configure the board as appropriate for your intended application. Let's now look at the external connections that are necessary for each of those.

Figure 4 shows how to set up the unit for surround effects. The Effects Generator should be fed with a stereo signal and its outputs amplified by a stereo amplifier. You could also connect the unit directly to a pair of amplified speakers.

To connect the unit for stereo simulation from a mono source, input the mono signal at either J1 or J2. Simulated stereo outputs are then available at J3 and J4.

To set up the unit for vocal effects, input the microphone signal to J2. That signal is both delayed and amplified by the unit, and a microphone-level output is available at J3. You can plug a speaker into J4 to make use of the amplified output. ■



SMARTER KEYS FOR SMARTER CAR

A look at the sophisticated electronic systems now being used in the never-ending battle against car thieves.

BY BILL SIURU

According to the FBI, 1.5 million cars worth \$7.5 billion were stolen in the United States in 1993 alone, and, of all things stolen, vehicles top the list in terms of total dollar losses. And, while many cars are stolen by joyriders, professional car theft is a growth industry in the U.S. Professionals steal vehicles primarily to cut them up for their parts or to ship them out of the country. Car thefts have also soared in Europe since the fall of Communism. It seemed that a good portion of the pent-up demand for cars in former Iron-Curtain countries is being satisfied by vehicles stolen in Western-European countries.

Combating car theft has also become a huge business with anti-theft measures ranging from low-tech devices that lock the steering wheel to advanced electronics that include tiny transmitters hidden in the car that can be used to track a vehicle if it is stolen. Much of that anti-theft technology is coming from Europe, where insurance companies are beginning

to require anti-theft immobilization systems that prevent a car from being started unless a code, embedded in the owner's key, is recognized. Likewise, some American insurers offer discounts for vehicles equipped with engine-immobilizer systems, and in fact, nearly a dozen states already mandate such discounts.

Unfortunately, professional car thieves eventually find ways to outwit just about every anti-theft device. Professional thieves are so sophisticated that they have even found ways to defeat the factory-installed anti-theft systems with microchips that have to transmit a correct security code before the ignition can be engaged and the engine started. That's done by using a "code grabber" to learn the code. Using the code grabber, they can stand at a distance while you use the key to start the car. Incidentally, thieves can also use the same technology to learn the code for your garage-door opener, then come back later to ransack your house.

Ford's Passive Anti-Theft System.

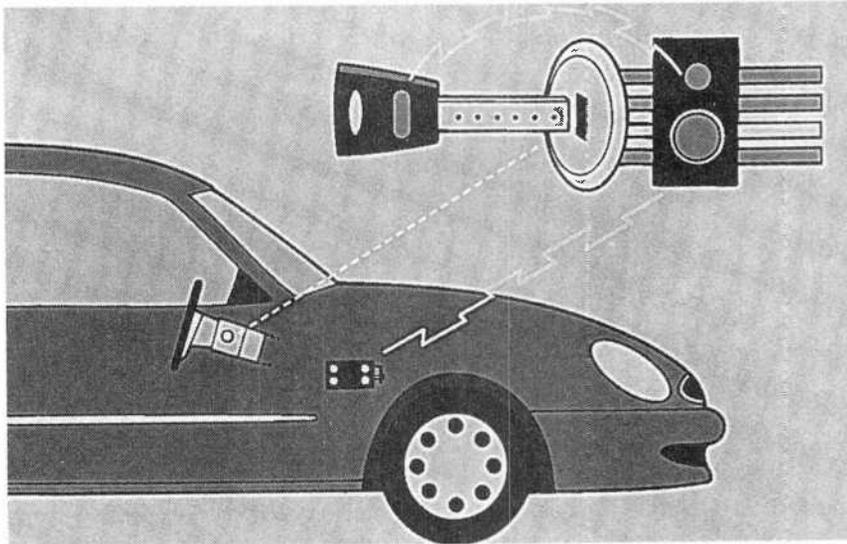
Automakers, with the help of electronic suppliers, are developing even "smarter" keys to foil the code grabbers. The first line of defense are microchips with rolling codes (the code is changed after each use); those are now used in some security systems. Unfortunately, even those are not thief-proof as computer-smart thieves are able to learn the algorithms used to create the new codes. Now, a solution has been found to even overcome that—encrypted systems, or ones that use randomly generated codes that are virtually impossible to decipher.

For instance, Ford is one of the first U.S. automakers to offer a theft-deterrent system that should be virtually impossible to defeat. There are some 72 quadrillion (million billion) possible electronic codes available with the Ford "Passive Anti-Theft System" (PATS). PATS, now offered on the 1996 Ford Taurus, Ford Mustang, and Mercury Sable, was introduced on European-built Fords in 1993. With more than 500,000 Ford cars and trucks in Europe now equipped with PATS, it has been very successful in deterring thefts.

PATS uses a special ignition key with a miniature transponder containing an antenna and integrated circuit in the key handle. It uses radio frequencies for communication between the key and the car. According to Ford, low-frequency radio transmission rather than physical contact should prove to be more reliable over many years of service.

When the key is placed in the ignition key slot and the cylinder is rotated to the on position, RF signals are sent from an antenna ring in the ignition switch to the transponder in the key. The transmitted signal includes power to operate the IC in the key so the transponder can transmit its code back to the antenna ring.

The received code signal is put through an integrated amplifier, and then goes to a PATS control module, which compares the transmitted code to the previously stored code. If the codes match, the module sends a signal through the vehicle's partial multiplex-wiring system to the engine's EEC-V control system allowing the engine to start cranking and be started. If the code that is received is incorrect,



Ford's Passive Anti Theft System (PATS) uses a special ignition key with a miniature transponder containing an antenna and integrated circuit in the key handle. The system is offered in several of Ford's 1996 models.

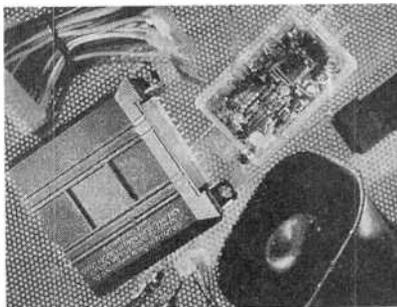
or if there is no code transmitted because a counterfeit key has been used, the engine will fire for just one second and then will shut down electronically.

The EEC-V electronic-control system is encoded at the plant when the vehicle's electrical system is first tested. Should a key be lost, uncoded keys can be encoded at Ford or Lincoln-Mercury dealerships. Spare keys can be programmed in the same way. PATS is fully compatible with the optional Ford Electronics Total Anti-Theft System (TATS) that protects the vehicle and its contents by sounding an alarm, flashing the vehicle's lights, and disabling the starter motor if a door, trunk lid, tailgate, or hood is opened by force.

BMW's Coded Driveaway System.

All BMWs now come with a similar high-tech ignition key called the "Coded Driveaway System." The BMW key looks like an ordinary plastic encapsulated key, but there is an integrated circuit inside. A coil-shaped antenna is wrapped around the ignition lock. When the key is turned in the lock, the antenna—working like a transformer—feeds electrical energy to the IC. When it has been energized, the IC instantaneously determines via a sequence of codes if that particular key is authorized for that particular BMW vehicle.

If authorization is verified, the key transmits a coded signal to the engine-management system and the



To combat thieves simply "hot-wiring" a car, new theft-deterrent systems, like the one shown in this photograph, will activate if the car is started without the proper key being inserted in the ignition.

car will start. The system also enters a new, individual code into the system's memory that will be used the next time that particular key is used to start the car. The new code is determined by a random-number generator so some 100-billion different code variants are possible.

To prevent any chance of unauthorized keys, owners can only obtain a new key by submitting proper documentation and identifications to a BMW dealer, who will then order the key. Because all keys are documented and accounted for, buyers of used BMWs can find out how many keys, including spares, have been delivered in total for the car. If a key is lost or misplaced, the owner can cancel that key individually, much like canceling a lost or stolen credit card. While the lost key no longer works, the other keys that have been issued are still valid, eliminating the need to

change the lock in the vehicle. Because the key gets its energy from the ignition system, like in Ford's PATS, it does not require a battery and so has an unlimited life.

Other Theft Deterrents. Thieves can, of course, bypass encryption chips by hot-wiring the car. Therefore, new security systems will feature chips and other electronic devices that will shut down other systems in a car if the proper key is not used. For example, the Siemens Automotive Group in Munich, Germany has developed a miniature relay that blocks the operation of the starter, fuel line, ignition, and central engine-control until the ignition key sends the right code to the control unit.

Cars in the future might not even use keys. Siemens and TRW, Inc. are working on "smart cards" that could replace keys entirely. Credit-card-sized devices carried in a pocket or purse would not only unlock car doors and start the engine, but also automatically adjust mirrors and seats for the particular driver carrying the smart card. The same card could also activate a panic alarm, open garage doors, turn on house lights, or perform other security-related functions.

The card would include a battery-powered transceiver. Copper-coil antennas about the size of a package of cigarettes would be located in the front doors and trunk. Those antennas would send out radio signals to the card with the card sending back a response. The car's electronic control unit determines if the response is the correct one for the vehicle. If so, the electronic unit unlocks the car; otherwise, the car remains locked.

The card could even enable a driver loaded down with packages to automatically unlock the door or trunk when within 3 to 6 feet of the car without a key or even the need to press a button on the fob of today's keyless entry systems. Once inside, the driver could then start the car by pushing a button or speaking a command to the car's voice-recognition system. Of course, people would have to be convinced to give up the habit of carrying and using keys. The system would also have to be made "child proof" so that youngsters will not be able to inadvertently start the car with the card. ■

BUILD A Solid-State

*It's a handy little flashlight
that doesn't affect
night vision and will never burn out!*



PENLIGHT

BY DEAN F. POETH

Anyone who's used or relied on incandescent penlights knows how annoying they can be. The batteries you put in them seem to go dead way too fast, and their bulbs eventually burn out (some after only an hour of continuous use). Well, thanks to LED technology, those old power-guzzling penlights just might be made obsolete.

If you'd like to ensure that you'll always have a little light on hand when you need it, and you have a free evening to spare, build the *Solid-State Penlight* described in this article. The Penlight has an output of over 5000 millicandles, and has an incredibly long battery life—it will continue to light even after four weeks of continuous operation. Also, the LED should never burn out!

The Solid-State Penlight also eliminates other problems common penlights have. For one, incandescent bulbs are fragile and often suffer filament breakage if dropped. The LED used in the Penlight is practically indestructible unless it is severely mistreated.

Another problem with common penlights is that they produce white light, which inhibits night vision. An amateur astronomer who tries to read a star chart with such a light will become temporarily "blinded," and his or her eyes will need to become dark

adapted all over again (which could take several minutes to a half hour). However, the red beam produced by the Penlight's LED does not affect night vision.

Circuit Description. The schematic diagram for the Solid-State Penlight is shown in Fig. 1. Power for the simple circuit is provided by two AA batteries, B1 and B2, in series. Switch S1 turns the unit on and off.

A 1N4001 diode, D1, drops the bat-

tery voltage to 2.3 volts to supply LED1. That ultrabright LED has the useful property of sharply increasing its internal resistance as the applied voltage drops. Therefore, as the batteries fade, LED1 will demand less and less current, thereby maximizing the life of B1 and B2 (to truly astronomical values).

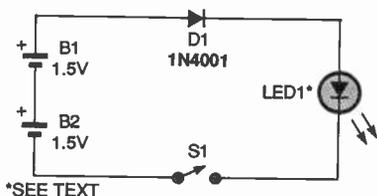
Construction. The author's prototype for the Penlight was built into a pre-existing, incandescent penlight available from Radio Shack (part number 61-2626). You can do the same, or assemble the circuit in some other type of enclosure. The following assembly instruction assumes that you are using the Radio Shack penlight case.

To begin, cut the positive lead of LED1 so that it measures $\frac{5}{16}$ inch. Then, cut the cathode lead of D1 so that it measures $\frac{3}{16}$ inch. Solder those two components together, as shown in Fig. 2, so that the overall length of the cut and soldered leads is $\frac{3}{8}$ inch. Do not substitute another diode for D1 unless you are sure it has the desired 0.7-volt forward voltage drop.

The penlight used for the author's prototype case has a built-in power switch that greatly simplifies building the project. Let's now look at how to wire the LED and diode to that case and switch.

Remove the lamp assembly from the penlight, and remove the incandescent lamp and its metal lamp-holder clip from the plastic part of the assembly. Epoxy the LED into the front of that plastic piece. After the epoxy has cured, replace the metal lamp-holder clip and solder the negative LED lead to it (See Fig. 3; the square piece of metal shown at the top of the

(Continued on page 76)



*SEE TEXT

Fig. 1. Here's the schematic for the Solid-State Penlight. Circuits just don't get simpler than this.

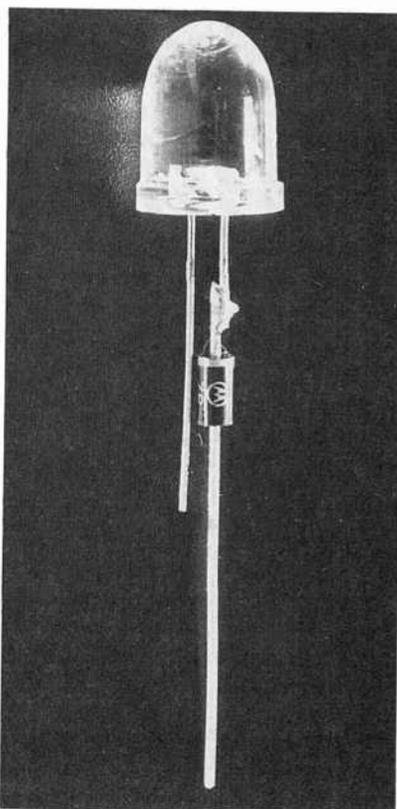


Fig. 2. Solder the LED and diode together, as shown here, so that the overall length of the soldered leads is $\frac{3}{8}$ inch.

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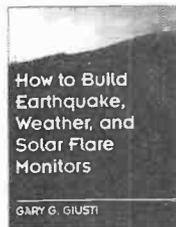
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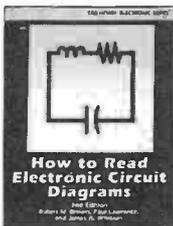
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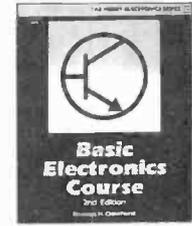
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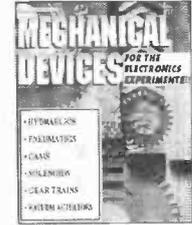
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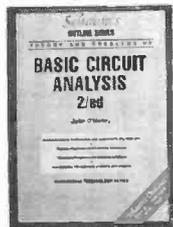
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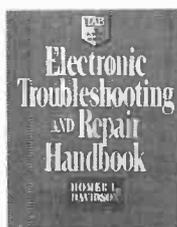
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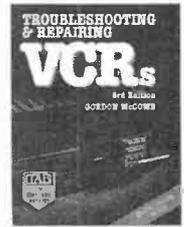
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CHOOSING the RIGHT SHORTWAVE RECEIVER

Keep these tips in mind when shopping for a communications receiver, and keep from getting shortchanged.

If you're shopping for any kind of expensive equipment, you should know exactly what you're after. For instance, when setting out to buy a TV or VCR, you'd most likely have a mental list of desirable features and an idea of what you're willing to pay. But what if you're shopping for a shortwave radio? What should you look for? Do you know just how well a receiver should perform to meet your needs? Also, do you have an idea what accessories are worthwhile?

Those questions are not easy to answer, which could make selecting a shortwave radio a very difficult task. Obviously, the performance of the radio you buy should be as good as possible, consistent with both the state of the art and your wallet. But how good is "good enough?" We'll try to answer that question by first examin-

BY KARL T. THURBER, JR.

ing just what goes on under a shortwave radio's "hood."

Receiver Basics. In this article, we're concerned with shortwave communications receivers, not just "any old radio." A communications receiver is more than just a consumer appliance. Rather, it's an advanced device that receives a variety of signals (AM, CW, SSB, RTTY, and possibly FM and digital modes) under difficult conditions. Modern communications receivers are usually of the "tabletop variety" and are offered by such well-known manufacturers as Icom, Yaesu, Drake, AOR, Japan Radio, Kenwood, Lowe, and Watkins-Johnson.

Today many high-end portable and so-called "portatop" sets qualify

as communications receivers, or world-band radios as they are often referred to in radio advertisements. Excellent portables and portatops are offered by such well-known makers as Sangean, Grundig, Sony, Panasonic, Radio Shack, and others.

It's important that you have a basic understanding of the specifications used to describe the performance of such receivers. While few reputable manufacturers lie about specs, making comparisons between competing units is difficult or impossible when you have specs that don't share the same baseline. To avoid comparing apples and oranges, you should be familiar with receiver basics and read the claimed specs carefully.

As a rule of thumb, selectivity (the narrower the better), sensitivity (the higher the better), and stability (the

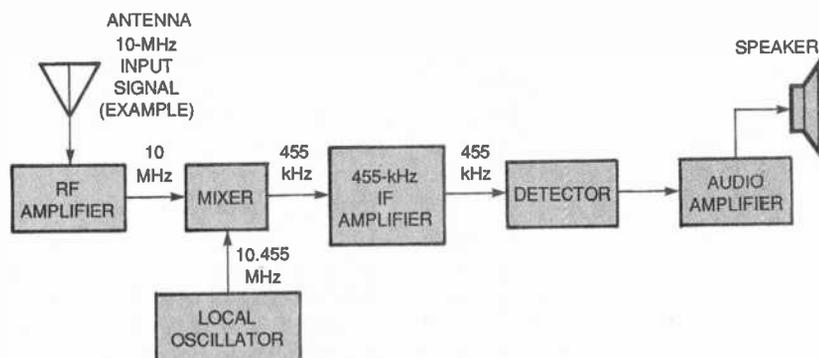


Fig. 1. The basic, single-conversion receiver, shown here, combines the incoming signal with the local-oscillator (LO) signal to produce the intermediate frequency (IF) signal. The resultant IF signal then is converted to audio by the set's detector stage.

more the better) are the main—but certainly not the only—determinants of a set's quality. But, let's not get ahead of ourselves, let's first look at some receiver fundamentals.

Practically all communications receivers today are of the superheterodyne variety. The "superhet" is popular because certain functions, such as amplifying the received signal and rejecting interfering ones, are better accomplished at a single, fixed frequency than over a wide range of frequencies.

A single-conversion receiver (see Fig. 1) involves conversion to only one fixed frequency, the intermediate frequency (IF). There also are double-conversion sets (see Fig. 2) with additional fixed frequencies. Such radios use a relatively high first IF to minimize image responses, and a relatively low second IF that lets the set achieve high selectivity.

Early communications receivers were almost all single-conversion types. Then, for many years, double-conversion receivers became the choice of manufacturers and shortwave listeners (SWLs). In the future, as the state of receiver art improves, the pendulum might slowly swing back to well-engineered single-conversion radios because they can offer cleaner performance in terms of spurious responses ("birdies") and dynamic range.

In the single-conversion superhet, incoming signals from the antenna are amplified in the radio-frequency (RF) amplifier; that signal is applied to the mixer stage. A signal from the local oscillator (LO) is also applied to the mixer. It combines the signals from the RF amplifier and the LO to produce a new signal, the IF. The IF is fixed: it re-

mains constant regardless of the actual frequency to which the radio is tuned.

The mixer is followed by an IF amplifier stage or stages; it amplifies the signal at the IF and feeds it to the detector. That is the heart of the radio—the stage that converts the IF to audio in a process known as demodulation. If the signal is SSB or CW, a beat-frequency oscillator (BFO) supplies a "replacement carrier" to make the signal intelligible. The audio amplifier stage amplifies the audio from the detector and feeds the detected audio to the speaker or to headphones.

Frequency Tuning, Readout, and Coverage. Fifteen or twenty years ago, finding a specific station's frequency on a shortwave receiver was much like taking a stab in the dark. Most sets used an indirect, analog (slide-rule-tuned) frequency readout that was neither precise nor reliable.

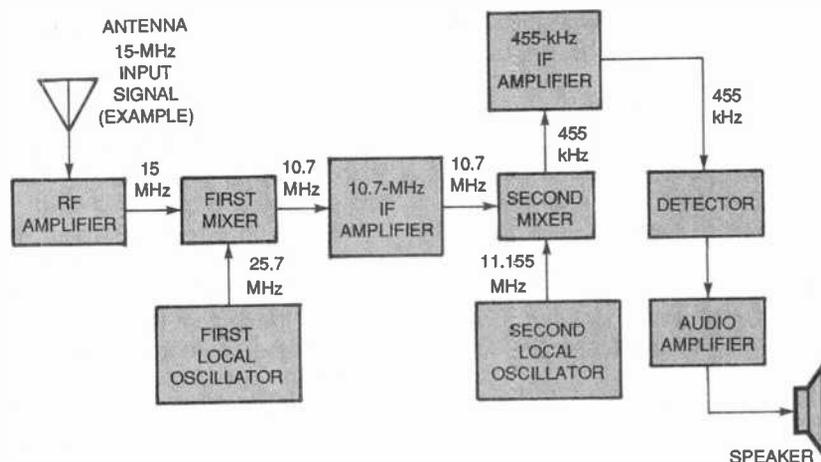


Fig. 2. The dual- or double-conversion receiver, shown here, promotes overall greater receiver selectivity than does the single-conversion set. The superheterodyne design also helps to keep out unwanted signals such as images.

Often, tuning was made more difficult by having both a main tuning dial and a separate bandspread or fine-tuning dial that complicated frequency readout and often limited frequency resolution to 1 kHz (sometimes more). Today's radios often have an accuracy of ± 100 Hz.

Today, with digital radios being both affordable and commonplace, there's little reason to use a receiver that doesn't precisely indicate frequency. Most modern sets use a direct frequency readout where the frequency to which the radio is tuned (either using a knob or a keypad) is indicated digitally using LEDs or LCDs.

Most receiver experts consider a direct frequency readout to be a "must" on today's crowded bands. Many desirable older sets don't have that feature, but you can add an accessory external readout device to most otherwise acceptable radios. Palomar Engineers offers "outboard" digital frequency displays for classic receivers such as the SP-600, SX-88, SX-100, HQ-180, and others.

The frequency of modern radios is controlled by tuning circuits based on phase-locked loops (PLLs) and digital electronics. The frequency is precisely controllable and the set tunes in increments or steps rather than continuously. Look for a radio that has a tuning rate (or speed) of 100 Hz or less; some sets have multiple tuning rates so you can "speed dial" across bands but slow down for fine tuning.

Besides frequency tuning and readout, another major decision involves frequency coverage. There are

three major types of sets: (1) general-coverage receivers, which have full, continuous shortwave coverage from at least 1.8 to 30 MHz; (2) shortwave-bands-only receivers, with coverage of selected international shortwave bands; and (3) ham-bands-only receivers, which cover the HF amateur bands. Note that older, ham-bands-only radios normally cover just the "old" amateur bands from 1.8 to 30 MHz and might not cover the newer "WARC bands" at 10, 18, and 24 MHz.

Sensitivity and Signal-to-Noise Ratio.

Sensitivity describes how well a receiver responds to faint signals and produces usable audio; that is mainly a function of the radio's RF amplifier stage. Sensitivity typically is defined as the input signal level, delivered from the antenna, that's necessary to give a "signal plus noise" or "S+N/N" (S+N/N) output from the receiver at a specified point above the internal noise generated by the receiver. That level normally is specified as 10 dB.

Input signals from the antenna are measured in microvolts. In a receiver-sensitivity specification, the smaller the number of microvolts, the more sensitive the receiver. A typical communications receiver might have a stated sensitivity of "0.25 microvolt for a 10-dB S+N/N ratio." That figure is measured at a given impedance, typically 50 ohms.

In modern, solid-state receivers, achieving adequate and uniform sensitivity is rarely a major problem. However, it was a big problem with tube-type receivers, which often suffered from inadequate sensitivity, especially on the higher HF bands.

With such sets, you might need an accessory low-noise RF preamplifier to bring sensitivity up to par. An amplified preselector, described later, could be used; it will also help improve image rejection. Preamps and preselectors aren't impedance-matching devices, so you can also consider an antenna tuner ("trans-match") to improve feedline-to-receiver matching.

Selectivity. Selectivity refers to how well the receiver rejects signals on undesired frequencies, that is, how well it attenuates an interfering signal so many Hz or kHz away from the desired

signal. The desired range or signal window is referred to as the receiver's bandwidth or bandpass. The overall width of a receiver's bandpass commonly is stated as the two points at which an interfering signal is reduced by 6 dB and by 60 dB.

Most communications receivers have user-selectable bandpass settings for different types of signals or emission modes. Typical AM selectivity might be stated as "6 kHz at -6 dB down," while typical desirable bandpasses for CW often are 200–500 kHz,



All-mode, dual tunable filters like this let you pull out stations from the clutter and notch out interference at the same time.

for RTTY about 1.8 kHz, and for SSB about 2.4 kHz. Those bandpass specs normally are stated in ads as the "6-dB-down" attenuation points.

Complicating selectivity spec statements is the shape factor of the radio's bandpass, which is the ultimate determinant of rejection ability. That factor is the ratio of a bandpass measured at the -6-dB and -60-dB attenuation points. The ideal shape factor is 1:1, but that is rarely achieved in practice in that ordinary tuned circuits have difficulty achieving such "tight skirts." A mechanical or crystal filter in the set's IF amplifier section can improve the set's shape factor.

Several additional features can improve receiver selectivity considerably. One is passband tuning (PBT), sometimes known as variable bandwidth tuning (VBT), which allows the receiver's bandpass to be varied continuously over a wide range. A closely related feature is passband offset, or IF shift, which effectively varies the center frequency of the set's bandpass without changing the frequency to which the radio is tuned.

Still another useful feature is a notch filter, which allows sharp filtering-out of offending signals. You also can use accessory audio filters to help improve selectivity, but they're not a substitute for adequate selectivity in the set's IF section and good front-end RF stage selectivity.

One new technology involves Digital Signal Processing (DSP) filters, "virtual" filters that simulate conventional analog audio filters. They vary their characteristics to react to changing conditions and offer superior performance in reducing interference on voice, CW, and RTTY by converting the received audio, both signal and noise, to digital data, and then processing it. Several firms offer inexpensive DSP-based accessory filters, and a few new tabletop radios (such as the high-end Watkins-Johnson HF-1000, at around \$4000) have built-in DSP filters.

Image Rejection. Image rejection is the ability to reject the undesired "ghost signal" generated by the mixing or heterodyning characteristics of superhets. In the superhet, the image is separated from the true frequency by twice the IF (or twice the first IF in multiple-conversion sets). That signal might appear above or below the true position of the desired signal, depending on whether a higher or lower LO frequency is used.

To improve image rejection, a relatively high first IF is used so the image and true signals are widely separated and thus are easier to filter. Dual-conversion superhets could have a first IF frequency of 20 MHz or higher; in dual-conversion sets, the second IF might be at 455, 100, 80, or 50 kHz, or another low frequency. Image rejection typically is 60 or 70 dB or greater.

The front-end selectivity of low-cost receivers is often minimal and represents an obstacle to good reception. But you can insert an external preselector or an antenna tuner between the antenna and the receiver antenna input. It passes desired signal frequencies while rejecting all others. The fact that the preselector is tunable improves the set's overall performance by filtering out images and other off-band signals that might otherwise creep through to cause a variety of problems, including overload, intermodulation, and receiver desensitization.

Often the preselector is combined with a preamplifier, which boosts performance in sets with low sensitivity. The preselector is then referred to as an amplified preselector.

Dynamic Range. Dynamic range is

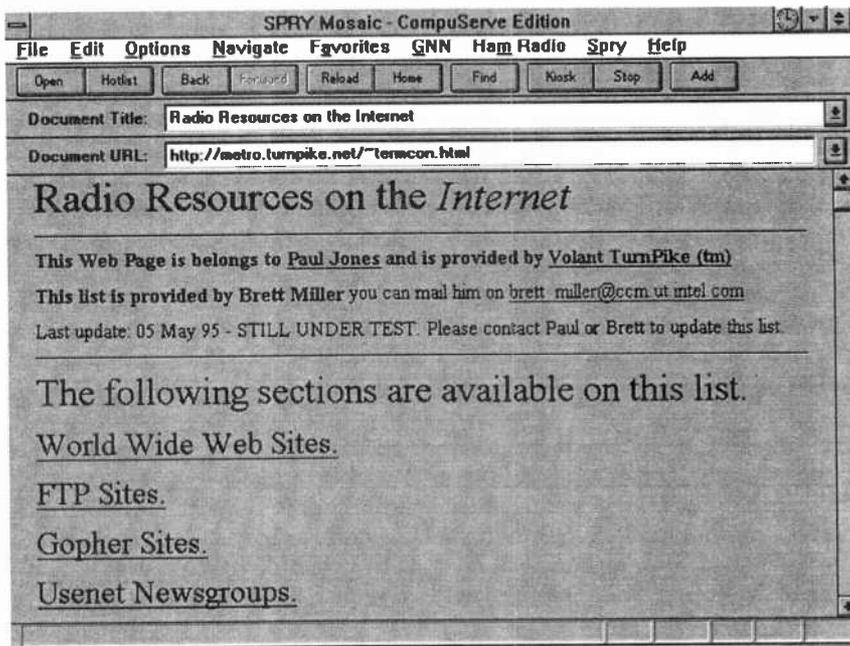


Fig. 3. A good starting point for Internet radio-hobbyist information is the Radio Resources on the Internet Web page. It lists many other Web sites, as well as FTP and Gopher sites, USENET newsgroups, and mail servers and lists.

an important but often overlooked receiver specification. It refers to the range between the set's internal noise level (or minimal acceptable signal level) and the "overload point," the signal level at which signal overloading begins to occur.

The dynamic-range spec is measured in dBs; most modern communications receivers have a dynamic range of 70 dB or more. A set with a 95- or 100-dB dynamic range is considered particularly good.

Stability. Receiver stability is rated in two ways: electrical stability and mechanical stability. Electrical stability indicates how well the radio's LO maintains a constant frequency without drifting off frequency. That figure indicates how much drift will occur, after initial warm-up, over time as the result of changes in the electrical properties of circuit components with temperature changes. Many modern radios have a frequency stability of about ± 10 ppm (parts-per-million) or greater.

Receiver mechanical stability is rarely stated specifically. But that characteristic refers to the ability of a receiver to maintain its frequency if you gently bump it, or if you apply light hand pressure to the case. In neither case should the reception frequency change significantly.

Both types of stability were more problematic in the past. Such developments as the use of PLLs, replacement of heat-producing vacuum tubes with cooler solid-state devices, and better mechanical construction, have reduced the problem considerably, even with inexpensive radios.

Noise Limiters and Blankers.

Reception often is marred by natural and man-made noise that masks the desired signal. Both noise limiters and blankers are devices that can be effective against certain types of noise, such as short-duration pulses like auto-ignition and lightning-burst noise, but might be ineffective against continuous static.

The automatic noise limiter (ANL) is the older and simpler circuit, one that merely clips off noise-pulse peaks, reducing them to more tolerable levels.



Using a low-noise amplified preselector helps you copy weak signals and reject out-of-band signals and images; a gain control and a built-in attenuator help minimize intermodulation effects.

A drawback to the ANL is that it also usually degrades the receiver's audio somewhat. An automatic noise blanker (ANB) is more complex; it silences the receiver during the noise pulse. The noise blanker often is adjustable whereas the noise limiter is normally an on/off device. The ANB usually doesn't degrade audio performance as much as a noise limiter.

A new noise-canceling technology, presently available as an add-on receiver accessory, is RF-based, unlike ANLs and ANBs, which work on audio. Installed at the antenna connector, the noise canceller "zeros out" locally generated noise. The signals from the main antenna and those from a noise antenna or probe are combined, with the noise antenna signal equal to, but 180-degrees out of phase with, the main signal. Panel controls let you adjust phase and magnitude of the local interference for deep cancellation. At least one device presently is available, the JPS Communications ANC-4 Antenna Noise Canceller.

Automatic Gain and Volume Controls.

Most communications receivers have some form of automatic gain control (AGC) or automatic volume control (AVC). Such circuitry is used to maintain the audio output level of the receiver at a fairly constant level over a wide range of signal strength by adjusting the gain of the set's RF and IF amplifier stages accordingly.

Most AGC and AVC circuits can be turned off to allow you to manually manipulate rapidly fading signals and maximize receiver sensitivity. Many advanced AGC and AVC circuits also feature user-selectable "attack speeds" with which you can fine-tune how quickly the circuits react to amplitude changes in the received signal. A fast AGC/AVC usually is best for SSB and CW signals while a slower speed is best for AM reception.

Beat-Frequency Oscillators and SSB Reception.

Your radio needs to have a BFO for reception of CW and SSB signals to supply a "replacement carrier" to make the signal intelligible; the BFO output is fed to the detector for further processing. Many receivers have a special circuit, a product detector, that combines BFO functions with a special detector for SSB.

Less expensive receivers typically have a continuously variable BFO you manipulate to yield the most intelligible SSB or CW reception. More upscale receivers use a fixed-frequency BFO hooked to the set's mode selector for optimum reception of CW, SSB, and RTTY signals. You usually don't need variable BFO tuning in the modern receiver, though some transceivers have an ultra-fine-tuning control known as "receiver incremental tuning" (RIT) to minutely adjust tuning for best audio, especially on SSB.

Many SWLs also find they can get better AM reception using the set's BFO in "exalted carrier selectable sideband" reception, or ECSSB. With ECSSB, which sometimes is a special option, the operator "zero beats" the AM signal to "exalt" the BFO carrier over the AM signal, and selects just one of the two sidebands, tuning it as though it were SSB. That minimizes selective fading on weak signals—another reason to purchase a set with a BFO.

A related technology advance is synchronous detection, a sort of automatic ECSSB reception that produces the same result. Special receiver circuitry produces an internal carrier to simplify SSB-like reception of AM signals.

Signal-Strength Indicators.

Though not a "must," it's useful to have a front-panel S-meter, or signal-strength indicator. Those analog meters usually are calibrated in so-called "S-units" from 1 to 9, with signal strength above the S-9 level being indicated in increments of 20, 40, or 60 dB. Alternatively, some receivers have LED signal-strength indicators in the form of a vertical or horizontal bar graph; here, stronger signals illuminate more of the LED elements.

In practice, S-meter readings are relative indicators of signal strength. You should take the readings with the proverbial grain of salt; almost no two receivers will indicate the same reading on a given signal. Other than just being used as a casual indicator of band conditions and a rough indication of received signal strength, the greatest use for S-meters is in adjusting or visually "peaking" external RF accessories such as antenna tuners, preamplifiers, and preselectors for best performance.

Memories, Frequency Storage, and Scanning. Modern communications receivers also are digital devices that resemble miniature computers in many ways. For example, many include internal memories for storing frequencies and other operating parameters, much like the "memories" included in personal computers (PCs) and in consumer appliances such as telephones, TV sets, VCRs, digital clocks, and microwave ovens.

Frequency scanning isn't limited to VHF and UHF scanners. Today, many communications receivers have a scanning or bandscan function that lets you tune the radio continuously through the memories or the normal tuning circuitry until a signal is received. Frequency memories and scanning functions are very handy, because you can store your favorite frequencies and other reception parameters, and go to them simply by punching a button.

Computer Interconnections and Receiver Control.

Equipping communications receivers with programmable memories was an early step in marrying the radio with the PC. Some radios, with their digital circuitry, now make it possible to effectively extend the set's front-panel controls to your computer's keyboard.

Some SWLs use "smart" computer

control of most receiver functions. Many radios have interfacing ports (usually RS-232 serial-based) that allow computer manipulation of most functions of receiver control and frequency storage using software and/or hardware. Management is through a graphic interface on the computer screen that is operated by a mouse or by the keyboard.

Such software programs provide full automation of all microprocessor-controlled receiver functions including frequency tuning, mode, band selection, scanning, sweeping, and memory. Tasks might encompass scanning of preprogrammed frequencies, scanning of frequencies from banks of preprogrammed frequencies, searching a user-selectable frequency range, automatic loading of frequencies from disk, and more.

Some control programs allow complete management of all radio functions that are addressed to the radio's microprocessor. That means that in some cases you can even perform functions that are not available through the front-panel controls.

Of course, you need a PC, appropriate software, and sometimes additional hardware and interfaces to do all that. You might wish to go slow with computer control at first, because its setup can complicate your enjoy-

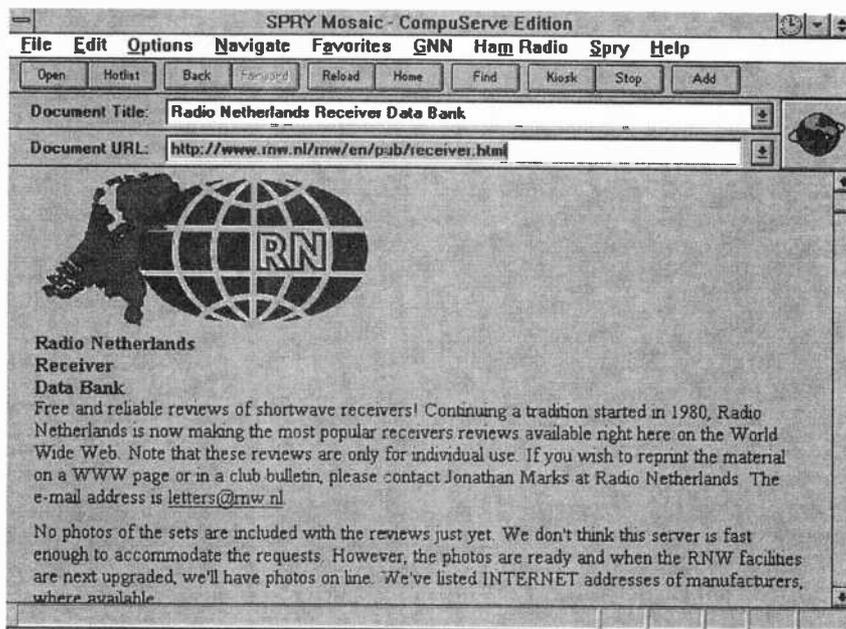


Fig. 4. In a cooperative arrangement with the World Radio TV Handbook (WRTH), Radio Netherlands offers an online compilation of numerous shortwave receiver reviews. The Web page also lists the Internet addresses of most receiver manufacturers.

SUGGESTED READING

Books and Booklets

Following are books of interest to the shortwave receiver information-seeker. These are primarily sources of receiver technical information, although some have pricing data.

Buying a Used Shortwave Receiver by Fred J. Osterman is a booklet for the SWL who's looking for a used solid-state (not vacuum-tube) set. The author discusses the relative merits of purchasing radios privately, at hamfests, or from radio stores. He also offers a receiver-performance checklist for radio evaluation at a flea market or hamfest. You'll find the table of prices and an overall rating score for 70 popular used receivers to be quite handy. The book is \$3.95 plus \$2 shipping from Universal Radio, Inc.

Shortwave Receivers Past and Present, also by Fred J. Osterman, is a 1993 "blue book." It's a 106-page directory of the vital statistics of more than 200 communications receivers, both tube-type and solid-state, marketed over the past 20 years. It provides specs and photos of most of the receivers. Also included is a chart showing the new and approximate used cost of each set. It's \$8.95 plus \$2 shipping and handling from Universal Radio, Inc.

Offered by the publishers of the authoritative shortwave reference book, the *World Radio TV Handbook (WRTH)*, the *WRTH Equipment Buyers Guide* presents test results on most modern receivers and features a handy price versus performance evaluation. Also included is a used-radio-equipment checklist. It's published by Billboard Publications, Inc. and is available for \$24.95 from radio booksellers including Radio Bookstore, Gilfer Shortwave, Universal Radio, and others.

Communications Receivers, 3rd Edition, by Raymond S. Moore, ex-K1DBR, is published by RSM Communications. Moore has amassed data on American-made, general-coverage communications receivers from 1932 to 1981. He covers RME, National, Hallicrafters, Hammarlund, Collins, and others; including variations on the 400 sets profiled, over 700 sets are covered. The 125-page book is \$19.95 plus \$2.50 shipping and handling.

The Tiare book, *BBS Radio: The National Directory of Radio Hobby Bulletin Board Services*, written by Mike Witkowski, lists in a simple computer-printout format several-hundred BBSs devoted to the radio-communications hobby. It includes BBSs of interest to radio amateurs, shortwave listeners (SWLs), and scanner buffs. The BBS listings show the board's name, area

code, and telephone number. A location is also shown for most listings. It's \$9.95.

A DXers Technical Guide, now in its second edition, is a 120-page book published by the International Radio Club of America (IRCA). The guide answers questions on receiver and antenna theory and performance, receiver accessories, and radio modifications. Although the focus is on mediumwave, it's also of interest to SWLs. It's available from the IRCA Bookstore for \$6 to members, or \$8 to others.

Passport to World Band Radio. The 528-page, 1996 version of this complete annual shortwave guide by Lawrence Magne includes a "What to Listen With" section that offers information on how to choose a radio and includes test reports on over 100 portable, portatop, and tabletop receivers. The annual is published by IBS North America and is available at major radio booksellers. The editors also offer a series of in-depth *Radio Database International White Papers* that include reviews of selected premium receivers. Those are \$5.95 each, postpaid from Passport RDI White Papers; fax them for a list of available papers.

Magazines and Newsletters

Popular Electronics. The column *Antique Radio*, published monthly in this magazine, is a great source of techniques for restoring vintage radios. Columnist Marc Ellis takes readers step by step through many such projects.

Electric Radio. Published by Barry R. Wiseman, N6CSW/O, the magazine is devoted to older, tube-type radio receivers and transmitters. Each issue explores vintage radio gear and the people who produced it. Issues also provide information on equipment modification and repair, and there is a large classified-ad section. Domestic subscriptions are \$28 by second-class mail and \$38 via first class; Canada and overseas subscriptions cost more, write for rates.

Ham Trader Yellow Sheets. This publication helps radio amateurs, scanner enthusiasts, and SWLs buy, sell, and trade their gear. The newsletter ads also serve as guideposts to current market prices and values. *HTYS* is published twice monthly. A one-year subscription is \$16.50.

The Universal Radio Sales-Alert. This is a sales newsletter, published every ten days or so by Universal Radio, that includes used equipment, demos, closeouts, and special sales. You can use it to help obtain pricing and availability information. ■

Other Considerations. We already discussed the main receiver specifications—the ones that directly affect performance—with which you should be most concerned. However, other nice-to-have but non-essential features and options can also play a part in selection. Those could include an RF attenuator, antenna trimmer, separate audio tone controls, frequency calibrator, audio squelch, crystal control, on/off timer, 24-hour clock, built-in programmable cassette recorder, and various other amenities. However, the presence or absence of such auxiliary features shouldn't override the basic, performance-related selection factors we already discussed.

Having absorbed all the technical details, specifications, and features, how do you make a reasoned selection? Notwithstanding real differences in specs between radios, the best radio is the one that is best for you, given your interests, experience level, and finances.

There are many considerations other than pure technical specs and features that might influence your choice. Those could include such considerations as portability, battery-power options, the ability to use an external antenna, and the type of signal reception to be emphasized (SSB, CW, AM, etc.), to name but a few.

If you're a beginner, consider a limited dollar investment in a simple portable receiver (but one that features direct frequency readout). If it turns out that all you're really interested in is receiving the strong international broadcasters, you probably won't have to look further. Also, if SWLing doesn't hold your interest, you'll still have a good radio for travel use in which you haven't made a big investment.

For an initial receiver, it's wise to limit your choice to a recent solid-state set. While there are values available in older, tube-type receivers, those classic radios represent obsolete technology and they can be difficult to restore to, and maintain in, good working order. They also often lack many 1990's amenities, which might sour you on your first SWL experience. It's probably best to save most such sets for collectors or for when you gain greater experience. Unlike tube sets, solid-state sets' performance deteriorates very little with time.

ment of the hobby considerably. However, if you can afford to do so, consider the purchase of a receiver

with built-in control capabilities or options that you can easily implement later as your experience increases.

Buying a New Receiver. Buying top-quality, brand-new gear at the start is great if you can afford to do so. You have the warranty backing of the dealer and manufacturer, and you know the specs the equipment should meet. If the radio doesn't measure up, you usually can return it. Buying new gear is usually safe.

Still, when placing your order, don't rely completely on the salesman and the ads for critical information. Check out the facts, query experienced friends, and consult reviews published in the shortwave radio books and magazines. Observe ordinary ordering precautions, as in buying any major item.

If you buy locally, you might pay more than if you shop nationally. Buying from the discount 800-number market is fine, and can get you the best "street price." Most mail-order vendors are reputable, though using a credit card to make the purchase adds protections for you. But check on post-sale service and other details—determine who will back the equipment just in case something goes wrong. Inquire about refund and exchange policies. There might be a restocking charge should you return your gear, although returns often are penalty-free for a short period after purchase.

You could also try hamfests, which are frequented by dealers and manufacturers; they're especially active at the larger events where they display their newest gear. That instant availability is great if you're in the market for a new radio because you easily can compare specifications and get a good, on-the-spot feel for competing equipment lines.

It's often possible to buy your radio at a substantial discount at a hamfest (the so-called "show price"), either directly from the manufacturer or from a dealer. At the very least, you'll save on shipping costs.

But as we said earlier, no matter where you shop, know what you're looking for. Know the facts and specifications, carefully assess the differences between competing equipment, and consider price. Equipment performance generally improves as price goes up but the improvement isn't always proportional.

Reference information on specs and pricing on shortwave receivers is

available from a variety of sources. If you'd like to find some books on the subject, see the "Suggested Reading" box. Also you might want to look at some of the classified-ad publications listed in the same box.

Buying a Used Receiver. Why would anyone buy a used shortwave receiver? The answer, of course, is the same as that for a used car: potential savings. As a rule, you might expect to save 25 to 40 percent off the "street price" of a current-model receiver. On older sets you should expect to save 50 to 60 percent, and frequently much more.

In some cases, used gear might actually provide better value for you than new gear. Depreciation takes its toll on radio gear as it does on anything else, so on older gear, cost decreases considerably. Actual prices depend on the condition of the equipment, sale terms, current demand, availability of the operating and service manuals, and other factors.

Most radios today are solid-state, and many hobbyists consider buying tube gear to be asking for grief, thinking such radios are best left to collectors. But some quality vacuum-tube-era equipment can still do a creditable job. For many listeners, there's magic in the old sets whose tube filaments glow brightly and warmly in the dark.

Some of the more well-known, older tube sets include radios by Drake, Collins, Hallicrafters, National Radio, Hammarlund, RME, and TMC. Some of the better ones are the R-390A, a military radio made by a variety of manufacturers; the Collins 75A-4, 51J-4, 51S-1, and 75S-3 series; National NC-303, NC-400, and HRO-60; Hallicrafters SX-73, SX-88, SX-101, and SX-115; Hammarlund



The core activity of most hamfests is the radio flea market or swap meet area where amateurs and other radio hobbyists buy, sell, and swap equipment and parts.

PRO-310 and SP-600 series; and TMC GPR-90 and GPR-91.

However, you must be especially critical of the condition of a tube set. Performance depends on the present condition of the set's tubes and other components, as well as the condition of mechanical devices—tuning gears, dial cords, bandswitches, and other difficult-to-replace components.

Where to Shop. Sources of used radios include radio-equipment dealer trade-ins, radio flea markets and hamfests, and private sales. In all cases, satisfaction depends largely on the integrity of the seller.

You might fare better buying your used receiver from a dealer, local or mail-order, who sells clean used gear that's been traded-in on new equipment. The dealer often offers a limited warranty and, in some cases, a return privilege, so you shouldn't be stuck with a lemon. Most of the dealers we mentioned as sources of new radio equipment also accept trade-ins and have good reputations among SWLs and radio amateurs.

Normally, a trade-in is at least checked over, and usually the radio is put into good working order. In some cases it's reconditioned to like-new condition. In any case, the condition should be clearly known and appropriately graded, even if subjectively (new, mint, excellent, good, fair, poor, etc.). Most dealers don't accept beat-up, modified, kit, or homebrew gear in trade. If they do, it's usually sold "as-is" for a low price.

Before dealing, check to see if the firm allows you to return unsatisfactory gear for a refund or credit. There normally is a specific time limit—say, 10 to

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rec.antiques.radio + phono
 rec.radio.amateur.equipment
 rec.radio.amateur.misc
 rec.radio.broadcasting
 rec.radio.cb
 rec.radio.info
 rec.radio.shortwave
 rec.radio.swap
 sci.electronics
 sci.electronics.repair

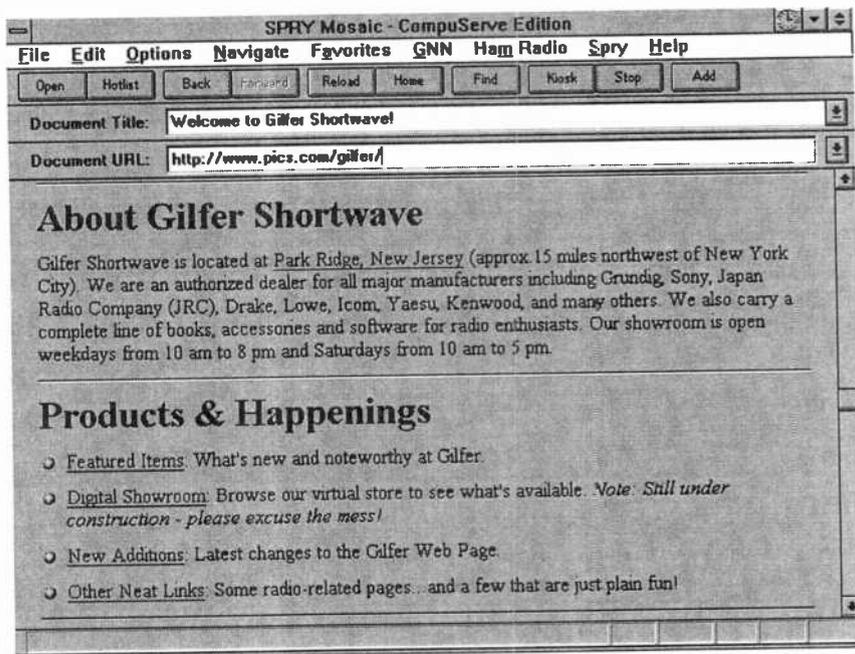


Fig. 5. One of the first shortwave dealers to offer a Web page was Gilfer Shortwave of Park Ridge, N.J. The Gilfer page offers several useful features, including the ability to browse their "virtual store" and the company's online catalog.

30 days—on a free-trial or return privilege, often up to 90 days for a trade-back on new gear. Check also to see who pays for repairs after the return period has expired, and for how long the warranty is valid.

Your local radio flea market or hamfest might be the place to find your receiver. You often can buy what you need to equip your listening post for as little as \$100 or \$200. Nevertheless, the watchword at radio swap meets and hamfests is *caveat emptor*—let the buyer beware! Flea markets can yield savings for the well-informed buyer, but there's little protection from bad deals, and there's no scarcity of junk at the typical meet. Bargains abound, but be skeptical, canny, and wary.

Most flea-market deals are on a no-refunds basis, so ascertain that what you buy is in good shape. You must rely on the integrity of the seller and your own judgment; there's no warranty and there's lots of risk. It's best to shop with specific equipment in mind and know the range of acceptable prices. Let's now look at some precautions you should take when buying a used receiver at such events.

Used-Equipment Buying Tips.

Before you venture into the flea-market world, know what you want, and come armed with a detailed shop-

ping list. Here are some sound, radio flea-market guidelines:

- If you're a beginner, have a more experienced individual accompany you. The visit might prove frustrating without guidance.

- Arrive early: The best bargains often disappear in the first few hours of the first day. Everyone knows that, so the flea markets tend to be most crowded in the morning.

- Paying by check offers you some protections, but checks and credit cards are rarely accepted. In the cash-and-carry flea market, cash is obviously king—at least with private sellers.

- Check to see if the event sponsors have set up a test bench to check out used gear. Just in case, carry simple checkout tools yourself. A small screwdriver set, pair of pliers, knife, and pocket multimeter are helpful, as are batteries.

- Avoid buying equipment without an operating or service manual, unless you know how you can get one (see the article "Super Surplus Sources" in the February 1996 issue of **Popular Electronics** for more information).

- Ask the seller to demonstrate the item; thoroughly check and test equipment before taking it home.

- Try to buy expensive items "on approval," agreeing on a return pol-

icy. Obtain a receipt showing the seller's name, address, and telephone number—and the right to return it within a reasonable period if something proves wrong with it. But recognize that it's almost impossible to enforce such agreements.

- Bring a long AC power cord with you; that is especially important if the swap meet is outdoors. Scout out a nearby AC power source if there's no power at the seller's booth or table.

- Bring a pair of headphones and a 15- to 20-foot length of plastic insulated wire to use as a test antenna. That "cheater antenna" will be most useful if you solder a banana plug to one end and an alligator clip to the other end, to accommodate a variety of antenna connectors.

- Attach the antenna, plug in the headphones, and listen to the receiver. Even indoors, you should hear some signals. Tune in signals across the set's entire range, checking each band. Don't buy a receiver unless you can see and hear it operate!

- Testing a receiver should include examination of the radio's most important features to see that they work and respond properly. Those quick-and-dirty tests include checking the frequency display to see that all display indicators, including the S-meter and all LED segments, work properly. Listen to the radio's audio for hum.

- Closely inspect the radio. Open it to check for damage, rust, burn marks, corrosion, missing parts, mustiness, and butchered internals. Feel and listen to the equipment's controls, especially dial indicators, gain controls, and bandswitches, checking for smoothness of operation. Note the condition of the power cord. Give kits a particularly close internal look for construction and soldering quality.

Private Sales. Another source of used shortwave receivers is other hobbyists. Sometimes you'll see such sets at auctions, estate sales, and yard sales, or in classified ads in newspapers, trader sheets, and radio magazines. There are, of course, advantages and disadvantages associated with private sales. Much of what we said about hamfests and swap meets also applies here. Buying from local amateurs and SWLs known to you often is preferred, because it's less likely that a friend or a member of

NAMES AND NUMBERS

Amateur Electronic Supply

5710 W. Good Hope Road
Milwaukee, WI 53223
Tel. 800-558-0411

Amateur Radio Trader

P.O. Box 3729
Crossville, TN 38557
Tel. 800-774-2623

American Radio Relay League

225 Main St.
Newington, CT 06111-1494
Tel. 203-594-0200

Ardco Electronics

P.O. Box 95
Berwyn, IL 60402

Associated Radio

8012 Conser
Box 4327
Overland Park, KS 66204
Tel. 913-381-5900

Barry Electronics Corp.

540 Broadway
New York, NY 10012
Tel. 800-990-2929

Billboard Publications, Inc.

1515 Broadway
New York, NY 10036
Tel. 212-764-7300

C. Crane Company

558-10th St.
Fortuna, CA 95540-2350
Tel. 800-522-8863

CRB Research Books, Inc.

P.O. Box 56
Commack, NY 11725
Tel. 800-656-0056

Cardwell Condenser Corporation

80 East Montauk Highway
Lindenhurst, NY 11757
Tel. 516-957-7200

Electric Radio

P.O. Box 57
Hesperus, CO 81326
Tel. 303-247-4935

Electronic Distributors Co. (EDCO)

325 Mill St., N.E.
Vienna, VA 22180
Tel. 703-938-8105

Electronic Equipment Bank (EEB)

323 Mill St., N.E.
Vienna, VA 22180
Tel. 800-368-3270

Grove Enterprises, Inc.

P.O. Box 98
Brasstown, NC 28902-0098
Tel. 800-438-8155

Ham Radio Outlet

933 N. Euclid St.
Anaheim, CA 92801
Tel. 800-854-6046

The Ham Station

P.O. Box 6522
Evansville, IN 47719-0522
Tel. 800-729-4373

Ham Trader Yellow Sheets (HTYS)

P.O. Box 2057
Glen Ellyn, IL 60138
Tel. 708-690-6230

Hi-Manuals

P.O. Box 802
Council Bluffs, IA 51502

IBS North America/Passport RDI White Papers

Box 300
Penn's Park, PA 18943
Tel. 215-794-8252
Fax: 215-794-3396

International Radio Club of America (IRCA)

P.O. Box 1831
Perris, CA 92572-1831

IRCA Bookstore

Attn: Phil Bytheway
9705 Mary N. W.
Seattle, WA 98117-2334

JPS Communications, Inc.

P.O. Box 97757
Raleigh, NC 27624-7757
Tel. 800-533-3819

Lentini Communications, Inc.

21 Garfield St.
Newington, CT 06111
Tel. 800-666-0908

The Manual Man

P. A. "Pete" Markavage
27 Walling St.
Sayreville, NJ 08872

Tel. 908-238-8964

Musty Manuals

645 Wheeling Rd.
Wheeling, IL 60090
Tel. 708-634-6467

National Radio Company

229 Marginal St.
Chelsea, MA 02150
Tel. 617-884-8100

Nuts and Volts Magazine

430 Princeland Ct.
Corona, CA 91719
Tel. 800-783-6467

Puett Electronics

P.O. Box 28572
Dallas, TX 75228
Tel. 214-321-0927

RSM Communications

P.O. Box 1046
Key Largo, FL 33037-1046
Tel. 305-853-0379

Radio Bookstore

P.O. Box 209
Rindge, NH 03461-0209
Tel. 800-457-7373

Radio Nederland Wereldomroep

(Radio Holland)

P.O. Box 222
1200 JG Hilversum
The Netherlands

Tiare Publications

P.O. Box 493
Lake Geneva, WI 53147
Tel. 800-420-0579

Universal Radio, Inc.

6830 Americana Pkwy.
Reynoldsburg, OH 43068-4113
Tel. 800-431-3939

W7FG Vintage Manuals

3300 Wayside Drive
Bartlesville, OK 74006
Tel. 918-333-7893

Western Nebraska Electronics

Box 1
Potter, NE 69156
Tel. 308-879-4552

your own radio club would short-change you.

In a private sale, you'll normally pay less for the receiver than if you bought it from a dealer. On the other hand, you're strictly on your own; you must rely on the seller's word as to the set's condition and performance as there is no warranty that can be easily enforced.

Online Help. Whether you buy a new or a used radio, today you can go online to gather information to help you make your choice. You can use local bulletin-board systems (BBSs), several features of the Internet, and other online vehicles including communications utility services such as America Online and CompuServe. Let's now take a moment to examine those options:

Bulletin-Board Systems: BBSs can be excellent sources of information for SWLs, amateur-radio operators, scanner buffs, and other radio hobbyists. Besides thousands of programs, data files, and shortwave-broadcast schedules available to download, some hobbyist BBSs have text files with tips on buying new and used receivers as well as reviews of new equipment. Some boards also have online classified ads.

Just a few of the dozens of BBSs of interest to SWLs are the Grove System BBS at 704-837-7081; Radio Hobby Online BBS at 708-238-1901; Radio Sport BBS at 619-279-3921; Shortwave Network at 701-746-4814; SWL BBS at 718-761-5727; and the American Radio Relay League (ARRL) BBS at 203-594-0306.

World-Wide Web Sites: Recently, the hot place to be on the Internet has been the World-Wide Web. As a graphical system that simplifies navigating the Net, the Web has become an organizing system that makes it easy to find information. You can use a Web browser to access hypertext links, which are something like Windows help files. When you select a hypertext link by clicking on highlighted words or buttons, you can jump to another place in the same location or to another computer to browse that topic or information.

One of the beauties of Web browsing is that once you've located a few initial pages of interest, you'll find links

(Continued on page 75)

BY WILLIAM R. HOFFMAN

These days, loudspeaker systems come in all kinds of shapes and sizes. Designs based upon half-a-dozen different operating principles are available from various manufacturers and sold in retail outlets all across the country and the world. Of all those, the two most commonly seen types are the simple, sealed "acoustic-suspension" box, and the vented or ported "bass-reflex" enclosure; both types use very conventional cone- and magnet-type drivers to generate the sound. For those interested in designing and building their own loudspeaker systems, those two particular types are also the ones that have the most design data available about them. Also, they are by far the easiest to build; the builder can almost be certain of getting good results from either type.

Speaking about design data, even with simpler loudspeaker designs, it is not too hard to get bogged down in a lot of math. Fortunately, thanks to the work of several engineers, both here in America and in Australia, things have become a lot simpler for the basic speaker builder. With only a few bits of information about our selected loudspeaker drivers, information that's usually available from just about any loudspeaker source (including Radio Shack, for instance), and the PC-based software programs described here and elsewhere, we can easily and quickly design a complete loudspeaker system using either of those two basic enclosure types.

Those who are regular readers might remember "Design Your Own Loudspeakers" (*Popular Electronics*, February 1994), which gave us the first three of a series of programs by the author for designing loudspeaker systems. In that first installment, we had design programs, written in the BASIC computer language, that gave us all the proper parameters to design the easiest of all speaker types: the sealed-box speaker system. In a second work, "Designing Loudspeaker Crossovers" (*Popular Electronics*, July 1995) the author provided five more BASIC programs for finishing our speaker designs. Now, in this installment, we will go back and have another look at enclosure design: This time, however, we'll direct our efforts

Design your own Bass-Reflex SPEAKERS

Use this simple program to design your own great-sounding vented-enclosure speakers.

toward the vented or bass-reflex system.

But before we get too far into that, we first need to review some basics about speaker systems.

How Does The Speaker/Enclosure System Work? Before learning about the operation and design of a vented-box speaker system, let's back-track for a moment and review something of what we learned about the sealed, acoustic-suspension box system.

Because quite a bit of information about the sealed-box design was originally given in the first installment of this series, we need not repeat most of it here. But to summarize, the closed-box system uses a volume of air trapped in a sealed box behind the bass driver to mechanically create a springy "compression load" on it, and thereby raise its acoustic "Q" value so that it has the desired frequency response down to its low-frequency cutoff point. As we learned, the bass-cutoff frequency and the flatness of the system's bass response were determined by two factors: (1) the physical parameters designed into the driver, and (2) the amount of air loading on the driver.

What made that original design work so simple and easy was the research originally done by three engineers: J. E. Bensen, A. N. Thiele, and R. H. Small, all Australians. Those men took the literally hundreds of physical parameters that can be used to describe the operation of a cone driver, and from them synthesized a few numerical quantities that could be used in creating a complete system design. Those quantities, commonly called

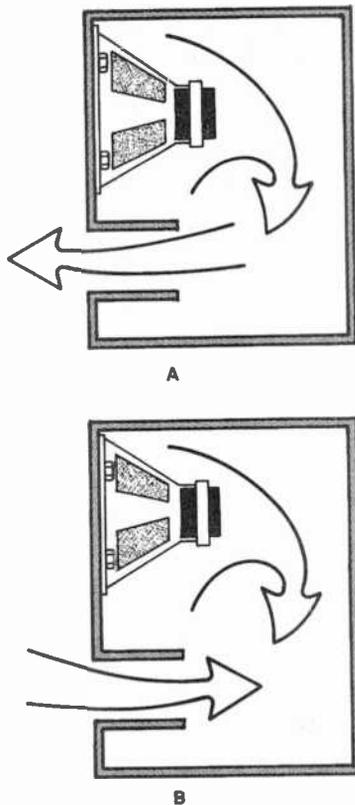


Fig. 1. Here's how the vent works in a bass-reflex speaker. The situation above the resonance frequency is shown in A, while B shows the situation below resonance.

the "Thiele Parameters" (or sometimes "Thiele/Small parameters", abbreviated "T/S"), were the ones used in creating the original program to design a sealed-box system. However, same Thiele parameters can just as easily be used to design a vented-box enclosure.

How the Vented-Box Speaker Works.

A cutaway view of a driver in an enclosure, with a port or vent added to the enclosure just below the driver, is shown in Fig. 1. That vent is designed to allow free passage of air from the inside of the enclosure to the outside. Figure 1A illustrates what happens when all frequencies are above or below the resonant point of the vent-enclosure combination. As shown there, the sound pressure from the back side of the driver is radiated into the enclosure, and then out of the port without any restrictions. Actually, at frequencies above the bass range, very little sound might come out of the port due to the typical addition of absorptive material in the enclosure, as well as the fact that the vent is not directed at the back of the driver itself.

Now, let's see what happens when the driver is generating sound at the resonant frequency of the enclosure and vent; that is the situation illustrated in Fig. 1B. In that situation, the flow of acoustic energy through the vent is in opposition to that from the back of the driver. In other words, as the driver cone moves backward into the enclosure, the direction of air motion through the vent is also inward into the enclosure, creating an increase in air pressure loading behind the driver. The reverse also happens when the driver cone moves forward, or out of the enclosure. It is that back pressure that provides the acoustical loading required by the driver, just as the trapped volume of air in the sealed cabinet did for a system using that particular design. Also, the sound radiated by the vent at the tuned frequency is now in phase with that from the driver's front, augmenting the driver's bass output. That last point is one very much in favor of the vented system when it comes to bass-frequency reproduction. More about that in a moment.

The Role of Q. Before we look a little closer at the concept of driver load-

ing, let's talk about something called Q: what it is, and what it means to us when we are doing our design work here.

Any cone-type loudspeaker driver operating in free air (without some kind of baffle around it) is usually going to be very over-damped. That is to say, that it will have very weak, or rolled-off, bass response. That is due to the lack of loading on the driver by the air around it. Using the term Q as it is used in electrical-circuit theory, we would say that at the driver's bass-resonance frequency, it has very low Q, or has a Q of less than 1. (The typical Q values for good drivers are around 0.2 to 0.6, or so.) Then, after we put the driver in some sort of enclosure, and measure its acoustic output, we will find, again by our electrical definition of Q, that it is much higher; usually somewhere between 0.6 and 1.2. If we then go back and do an analysis of our box, we find that it has the effect on the driver of being very high Q (much greater than 1) at the driver's bass-resonance frequency. It is the successful combining of the driver's Q, and the enclosure's Q in just the right way that will give us a speaker system with flat, extended bass response.

Let's next look at Fig. 2, which is a graph that illustrates what we just discussed. First, notice the dashed lines labeled Q = 0.2, Q = 0.4, and Q = 0.6.

Those are the frequency responses of a driver having the specified Q values and with no loading of any kind applied. As previously indicated, notice the rolled-down bass response being the worst on the driver with the lowest Q value.

Now, notice the dotted-line curves showing a peaked response in the upper part of the graph. Those curves are labeled Q = 2, Q = 4, and Q = 6. Those curves show the effect of an enclosure/vent combination tuned to the resonance frequency indicated by the dashed vertical line on the graph, which corresponds to the bass-resonance frequency of the driver. Now, as we have said, when the correct value of driver Q and bass-resonance frequency are mated with a particular value of enclosure-resonance Q and tuning frequency, the result will be the flat and extended bass response curve shown as **A** in the graph, which is just what we want.

Design Differences. Are sealed-box and vented-box systems exactly alike in their performance? The answer is no. So let's take a quick look at those differences, some of which might be important to us.

To begin with, the vented-box system is "double tuned:" first by the cone-mass/suspension-stiffness of the driver, and the second by the com-

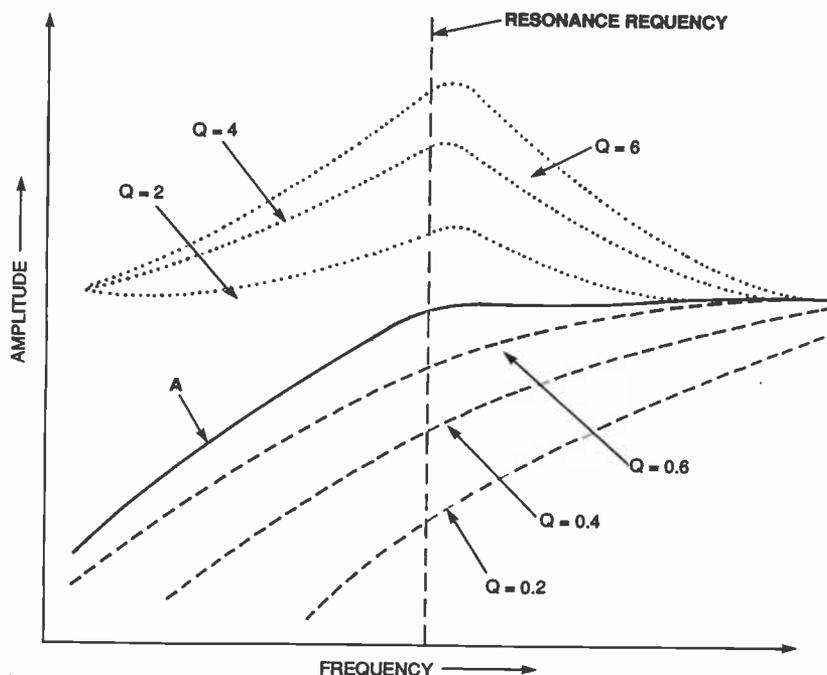


Fig. 2. The combination of driver resonance (dashed lines) and cabinet resonance (dotted lines) combines to produce a smooth response curve.

pliance of the air in the enclosure resonating with the mass of the air in the vent. Now the important thing to remember here is that the driver's resonant effects creates a 12-dB-per-octave bass-response falloff below the system resonance, while the enclosure-air-compliance/vent-air-mass creates a second 12-dB-per-octave rolloff. Now the two together will, being additive, give us a very fast 24-dB-per-octave rolloff. That means that the vented system has little output below its system-resonance frequency.

By contrast, the sealed-box system, which is only "single tuned," has only the bass driver's cone-mass/enclosure-air-compliance resonance to cause a low-frequency rolloff. Therefore, its response will be going down at a rate of only 12-dB-per-octave, half that of the vented system. That also means that the system will still have some usable response extending well below the system's cutoff. In a subwoofer system, that slower rolloff and extended bass can be very useful in getting the most out of a good bass driver.

One more point to consider is the excursions that the cone of the bass driver has to undergo to generate bass output. (The cone excursions are the distance the cone moves in and out when generating sound.) Figure 3 shows a comparison of the cone excursion requirements of a vented-box system and a sealed-box system.

Note that below the system's bass-resonance-frequency cutoff point the cone excursions of a sealed-box driver increase rapidly. Of course, such long excursions are what a bass driver has trouble doing. The result is an inevitable large increase in distortion generated by the speaker—harmonic-distortion figures of 5% to 20% are common at high sound levels.

Now, by comparison, we can see that the cone excursions of a bass driver in a well-designed vented system are not only much lower overall, but actually decrease at the system's resonance frequency. Needless to say, the bass harmonic distortion of the driver also drops dramatically as well, which is obviously a very good thing. At the tuning frequency of a vented system, bass distortion can be as low as only 0.5 to 1 percent.

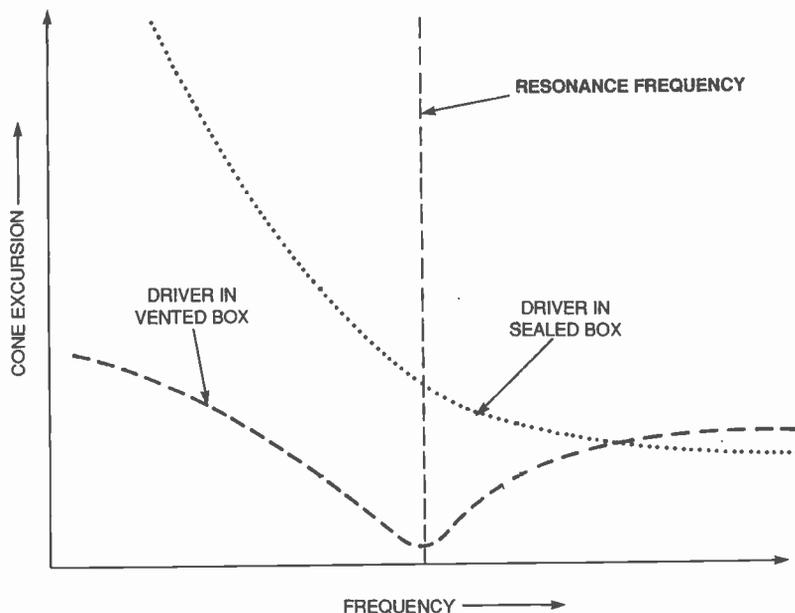


Fig. 3. At lower frequencies, the cone excursion is significantly lower in a vented-box (bass-reflex) system.

work of Thiele and Small went a long way toward making speaker-system design very simple and straightforward, another engineer, an American by the name of D. B. Keele, Jr., then working for a company called ElectroVoice, was able to refine those equations even further, down to just three to be exact; with his kind permis-

sion, those are the equations we are going to use in the PC design program we will discuss shortly. But before we can start, we first need to define the T/S parameters that we are going to be using in Keele's three equations.

The first of those T/S parameters is f_{∞} , which is the driver's free-air bass-resonance frequency, in Hz. The second

TABLE 1
THIELE ALIGNMENTS CHART

| # | TYPE | RIPPLE | f_3/f_s | f_3/f_b | C_{as}/C_{ab} | Driver Q_{ts} |
|----|------|--------|-----------|-----------|-----------------|-----------------|
| 1 | QB3 | — | 2.68 | 1.34 | 10.48 | .180 |
| 2 | QB3 | — | 2.28 | 1.32 | 7.48 | .209 |
| 3 | QB3 | — | 1.77 | 1.25 | 7.48 | .259 |
| 4 | QB3 | — | 1.45 | 1.18 | 2.95 | .303 |
| 5 | B4 | — | 1.000 | 1.414 | 1.414 | .383 |
| 6 | C4 | — | 0.867 | 0.935 | 1.055 | .415 |
| 7 | C4 | 0.2dB | 0.729 | 0.879 | 0.729 | .466 |
| 8 | C4 | 0.9dB | 0.641 | 0.847 | 0.559 | .518 |
| 9 | C4 | 1.8dB | 0.600 | 0.835 | 0.485 | .557 |
| 10 | B5* | — | 1.000 | 1.000 | 1.000 | .447 |
| 11 | C5* | — | 0.852 | 0.934 | 0.583 | .545 |
| 12 | C5* | .25dB | 0.724 | 0.889 | 0.273 | .810 |
| 13 | C5* | 0.5dB | 0.704 | 0.882 | 0.227 | .924 |
| 14 | C5* | 1.0dB | 0.695 | 0.877 | 0.191 | 1.102 |
| 15 | B6* | — | 1.000 | 1.000 | 2.73 | .299 |
| 16 | C6* | — | 0.850 | 0.868 | 2.33 | .317 |
| 17 | C6* | — | 0.698 | 0.750 | 1.81 | .348 |
| 18 | C6* | — | 0.620 | 0.698 | 1.51 | .371 |
| 19 | C6* | 0.1dB | 0.554 | 0.659 | 1.25 | .399 |
| 20 | B6* | — | 1.000 | 1.000 | 1.000 | .408 |
| 21 | C6* | — | 0.844 | 0.954 | 0.722 | .431 |
| 22 | C6* | — | 0.677 | 0.917 | 0.500 | .461 |
| 23 | C6* | — | 0.592 | 0.902 | 0.414 | .484 |
| 24 | C6* | 0.1dB | 0.520 | 0.890 | 0.353 | .513 |
| 25 | C6* | 0.6dB | 0.404 | 0.876 | 0.276 | .616 |
| 26 | B6* | — | 1.000 | 1.000 | 0.732 | .518 |
| 27 | C6* | 0.6dB | 0.778 | 0.911 | 0.110 | 1.503 |
| 28 | QB3* | — | 0.952 | 0.980 | 1.89 | .328 |

*These alignments require an additional electronic equalization circuit.

Some Numbers. While the original

parameter is Q_{ts} , which is the driver's total free air Q value and is derived from its mechanical and electrical characteristics. It is specified just as a simple number, usually between 0.2 and 0.5 (at least for the drivers we are interested in here). And finally we have " V_{as} ", which is a volume of air that will have the same compliance (or "springiness") as the driver's cone suspension. For our purposes, that volume of air is specified in units of cubic feet. As we mentioned back at the beginning, those three parameters are usually readily available from most driver manufacturers and distributors, simplifying our design process considerably.

Now let's look at Table 1. The information provided there is a summary taken from the important parts of a table generated by Thiele in his original work. The "alignments," as they are referred to, numbered in the left-most column as 1 through 28, are the so-called "classical" Thiele alignments. Each line here, taken for a particular value of driver Q_{ts} (listed in the right-most column), gives the relationships between several parameters that are important in getting our design right and in providing the most extended and flattest bass response possible. For instance, the fourth column gives the ratio between the system's -3-dB point (the frequency at which response is down 3 dB), designated f_3 , and the free-air resonance frequency (f_0) of the driver. The fifth column gives the ratio of the f_3 value to the frequency the box is tuned to (f_b). The sixth column is the ratio of the compliance of the driver's cone suspension (C_{as}) to the compliance of the air volume in the box (C_{ab}) if the box were sealed. All those are very important factors.

But what about the second and third columns? What are they telling us?

The information in those columns is very interesting, and leads us into the very heart of the work done here by Bensen, Thiele, Small, and others. What those men did is to look at the bass response of a loudspeaker system, which has a high-pass function just like an electrical filter, and analyze it in terms of electrical filters and filter theory. Specifically what they did was use mathematical coefficients determined by two mathematicians, one

```

LISTING 1
100 PRINT:PRINT:PRINT:PRINT:PRINT
110 PRINT"          LOW FREQUENCY VENTED BOX LOUDSPEAKER"
112 PRINT:PRINT
120 PRINT"          DESIGN PROGRAM."
125 PRINT:PRINT:PRINT
130 PRINT"          by"
135 PRINT
140 PRINT"          WILLIAM R. HOFFMAN"
145 PRINT:PRINT:PRINT
150 INPUT"          What is the drivers bass resonance frequency";A
155 PRINT
160 INPUT"          What is the drivers total Q (Qts) value";B
161 IF B>5.00000E-01 THEN 162 ELSE 166
162 PRINT
163 PRINT"          WARNING! This program will not be accurate with this"
164 PRINT"          Q value. Start again."
165 GOTO 145
166 PRINT
170 PRINT"          What is the drivers volume equivalent air compliance"
175 INPUT"          value (Vas) in cu. ft. ";C
180 PRINT
200 LET OV=15*C*(B^2.869999)
270 PRINT
300 LET BV=OV
310 LET F3=(2.599999E-01*A)/(B^1.399999)
320 LET FB=(4.199999E-01*A)/(B^8.999999E-01)
330 LET RI=20*LOG(2.599999*B*(C/BV)^3.499999E-01)
550 PRINT:PRINT
560 PRINT"          For a driver with a free air resoance of"A"HZ. and"
570 PRINT"          a Qts of"B" and a Vas of"C", the calculated values"
580 PRINT"          are as follows:"
600 PRINT
610 PRINT"          BOX VOLUME IS:"BV"CU. FT."
620 PRINT
630 PRINT"          FREQUENCY THE SYSTEM IS -3dB AT:"F3"HZ."
640 PRINT
650 PRINT"          TUNING FREQUENCY OF THE BOX:"FB"HZ."
660 PRINT
670 PRINT"          THE RIPPLE IN THE PASS-BAND IS"RI"dB."
680 PRINT
700 PRINT"          Do you wish to calculate enclosure dimensions for"
710 INPUT"          the system? (1=Yes, 2=No) and Enter=";D
720 ON D GOTO 750, 795
750 LET X=BV^(1/3)*12
760 LET Y=X*6.200000E-01
770 LET Z=X*1.620000
780 PRINT
785 PRINT"          These are the INSIDE dimensions of a box of"
786 PRINT"          "BV"cu. ft."
787 PRINT
788 PRINT"          HEIGHT = "Z" inches."
789 PRINT"          WIDTH = "Y" inches."
790 PRINT"          DEPTH = "X" inches."
795 PRINT
800 PRINT"          Do you wish to calculate the dimensions of the "
805 INPUT"          required duct? (1=Yes, 2=No) and Enter=";E
806 ON E GOTO 810, 990
810 PRINT
815 PRINT"          Choose any duct diameter you wish to use between"
820 INPUT"          1 inch and 6 inches, and Enter =";DI
825 LET DA=(DI/2)^2*3.145900
830 LET DL=((2691*DA)/(BV*(FB^2)))-(8.799999E-01*SQR(DA))
835 PRINT
840 PRINT"          For a duct"DI" in. in diameter, the required length"
845 PRINT"          is"DL" inches."
850 PRINT
855 PRINT"          Do you wish to try another duct diameter value?"
860 INPUT"          (1=Yes, 2=No) and Enter=";F
865 ON F GOTO 810, 990
990 PRINT
991 INPUT"          Do you wish to continue? (1=Yes, 2=No) and Enter=";Z
995 ON Z GOTO 145, 999
999 END

```

named Butterworth, (the "B" reference in Column 2) and the other Chebyshev (the "C" reference in the

same column) to describe a loudspeaker's measured bass response. That system of analysis by electrical

theory then allows us to synthesize a large number of ordered arrangements of the parameters of our speaker driver and enclosure, set in an exact mathematical form, and from that to predict just what the speaker system we design here on paper will actually do when we really build it. Just how we "align" each of the values of driver free-air resonance frequency, box-tuning frequency, box-air volume, etc. is spelled out, as we have seen, in the fourth through sixth columns of the table, and they are unique for each value of driver Q_{TS} . Also, as in all electrical filters, the response is not always completely flat in the operating frequency range of the system. That is, there is sometimes seen a small amount of "ripple," or unevenness in the system's response curve. Where a particular alignment has this effect, (only some of them do), it is so specified in the table's third column as some decibel value. As long as the value is less than 1 dB or so, its effects will be subjectively unnoticeable.

It is important to note that not all those Thiele alignments would be easy for us to implement. In fact, some (those with an asterisk, for instance) would require additional electronic equalization in our amplifier to assist the design of our system in getting flat bass response. Also, alignments 1 and 2 can only be made workable with a driver with very unusual characteristics. So those will not be dealt with here. Instead we will concentrate on the alignments numbered 3 through 8, which are easy to use, and therefore will be implemented by our computer program.

The Design Program. Listing 1 is our complete vented-box design program, VBDES-1.BAS, written in a generic version of BASIC; it will run as is under either GWBASIC or BASICA.

Entering the program in to your system is easily done—it's just like typing a letter to someone. Just open your BASIC interpreter program, and type it in, line by line, including all spacing, punctuation, etc. Once it is in, and saved to the same disk location as your BASIC interpreter, go back and double check it. But even if you happen to make a mistake and leave an error in your listing, once you start to use the program you will likely get a

TABLE 2—DRIVER LOW-FREQUENCY LIMITS

| Size (Inches) | Limit (Hz) |
|---------------|------------|
| 4-5 | 80-90 |
| 6-7 | 50-70 |
| 8-10 | 30-45 |
| 12-15 | 20-35 |

line number and "run error" message. Because you will then know which line the error occurred in, it will be very easy to go back and make any corrections necessary.

Once the program is loaded, running it is done by using either the command GWBASIC VBDES-1.BAS (if you are using GWBASIC) or BASICA VBDES-2.BAS (if you are using BASICA). After the opening screen appears, you will be asked for, in order, the three Thiele parameters defined above. Note that for this program to be successful in creating your vented-box design, the V_{as} value must be no high-

diameter of the duct (usually a piece of pipe or cardboard tubing) you want to use. The program will then calculate the length of the duct of that diameter that will properly tune the cabinet to the required frequency. Do not try to use a diameter less than 1 inch. Because even a 1-inch diameter duct might have trouble with whistles or swooshing noises in some cabinets, especially if the bass driver is a large one, always calculate several different vent diameters, and use the largest-diameter vent possible. In most cases the depth of the vent will be the limiting factor; select one that your box can accommodate conveniently.

Some Things to Remember. To help make sure our design work creates a successful speaker system, here are some guidelines we need to follow:

Despite some really wild advertise-

TABLE 3—SUGGESTED DRIVER USE

| Parameter | Sealed Box | Vented Box |
|--------------|------------|------------|
| Sensitivity | <92 dB/W/M | >92 dB/W/M |
| Q_{TS} | >0.4 | <0.4 |
| f_s/Q_{ES} | <50 | >50 |

er than 0.5. If you happen to enter one higher than that, the program comes back and tells you to start again.

Once the Thiele parameters are entered and accepted, the program will automatically calculate and display on your screen four pieces of necessary information: (1) the optimum box volume, in cubic feet; (2) the frequency at which the system's output will have fallen by -3 dB (the point below which the speakers response will start to fall off very rapidly); (3) the frequency the box needs to be tuned to; and finally, (4) the amount of ripple in the pass band of the speaker, in dB. Once that is done, the program asks you if you want it to design the enclosure for you. If you answer yes, it will calculate a set of *inside* dimensions for a box of the required volume and with dimensions that are staggered so that they will minimize the buildup of standing waves in the box. Following that, the program asks if you want it to design a duct that will tune the box to the required resonant frequency. If you answer yes, enter a value for the

ments to the contrary, a bass driver of given cone size has a lower effective frequency limit. By the laws of physics, which dictate that for every halving of the frequency, the driver's cone excursions must increase by four times their previous value to maintain the same sound-output level, it's easy to see that a small speaker cone, which must move quite far to generate even a small amount of bass, will quickly run out of output capability, even with the help of the vent. So based on that knowledge, we should respect the suggested low-frequency limits shown in Table 2 for any given driver size. Specifically, if in using our design program above, we calculate that the speakers' -3-dB frequency is lower than the suggested low frequency limits shown in Table 2 for the size of our driver, we should be very cautious about trying that particular system design.

Second, not all drivers are good for a vented enclosure (or for a sealed box, for that matter). Table 3 gives us three guidelines to help us select what

(Continued on page 75)

Think Tank

Another Winner!

BY JOHN J. YACONO
TECHNICAL EDITOR
WINDOWS MAGAZINE

Last month I promised to continue the tutorial on capacitors, but I'm afraid I can't deliver. I, like everyone around me, got a really, really bad case of the flu. (I haven't been to a doctor even once in over 25 years for that kind of thing, but this time I visited the doctor twice!) I'm getting better now, but must dispense with the tutorial to get this column finished on time. Next month I *promise* we'll pick up where we left off!

This time around we'll be looking at circuits from one prolific contributor: Nick Cinquino. Because he's contributed enough (actually, more than enough) quality circuits to fill out a column, he wins a kit and a 1967, individually packaged, MCL1010 chip in addition to the usual book. Congratulations Nick, and thank you for your work.

3, 2, 1, IGNITION

John, I'm too old to be flying model rockets, but my son isn't. Therefore, I built this rocket-engine igniter (see Fig. 1) so that, uh, we could fly model rockets.

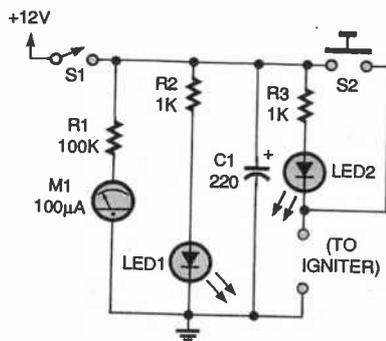


Fig. 1. This simple rocket-engine igniter requires a 12-volt DC source; try using a battery pack of eight AA cells in series.

The circuit requires a 12-volt DC source. A battery pack of eight AA cells in series will work fine. The whole circuit plus battery pack fits in a medium-size project enclosure from Radio Shack. I use a fancy key switch for S1, which turns on the circuit.

Meter M1 gives you an indication of battery voltage; change the batteries when you see a noticeable drop in current. The circuit contains two LEDs: LED1 reminds you that the circuit is powered up, and LED2 lets you know you have continuity through the igniter and are ready to fly. Capacitor C1 gives igniters that extra kick-in-the-pants they occasionally need. If you have a higher-value capacitor in your junk box, rated for 16 WVDC or better, use it! Pushing the momentary push-button switch (S2) sends the rocket on its way. Use a nice, big red switch for

that. And lastly, the igniter leads are connected to the plugs marked "igniter."

—Nick Cinquino, Schaumburg, IL

You're never too old for fun, or creativity for that matter! I don't have any experience with rockets, but I wonder how well two 9-volt batteries in series would perform as the power supply? They seem to last pretty long for high current drains and a pair of them is a little cheaper and smaller than eight AA cells. The voltage rating on C1 would have to be raised, though, prior to such an experiment.

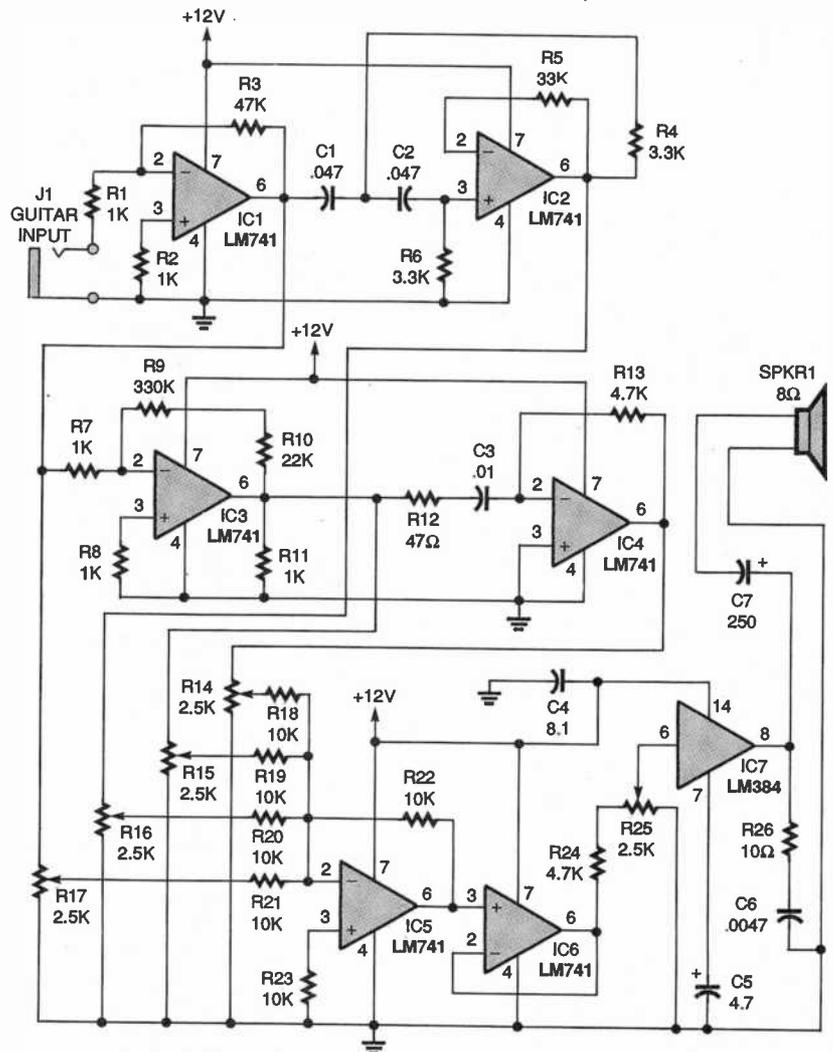


Fig. 2. Here's a neat little guitar amp that features fuzz and treble-boost effects.

WARM AND FUZZY

For this project I combined good soldering with questionable musical ability to create a nice little guitar practice amp with a couple of sound effects. On first glance at the circuit schematic (see Fig. 2) it looks complicated, but you'll notice that the unit can be broken up into familiar, everyday op-amp building-blocks, such as buffers, amps, filters, mixers, and differentiators. They produce effects like treble boosters, fuzz, and whatever you'd call a squared and differentiated audio output, which actually sounds pretty interesting! The power audio amplifier is an LM384, while all the other ICs are venerable LM741s.

The guitar output goes to IC1, a 741-based preamp. Notice that the preamp's output goes to three places; direct to the mixer, to a high-pass filter (because cheap electric guitars are weak in the treble department) built around IC2, and to a high-gain amp for clipping (to provide "fuzz"). The filtered output of IC2 also runs to the mixer, and the high-gain amp's output is split between the mixer and a differentiator, which turns the squared output of IC3 into a spiked waveform. Integrated-circuit IC4's output also leads to the mixer. So, we have variable, in-phase inputs to the mixer: clipped or fuzz, differentiated or spikey, and treble boosted or filtered.

Half the fun of using this thing is dialing up different mixer inputs! The mixer's output leads to IC6, a buffer. The buffered output runs, via a volume-control potentiometer, to IC7, the LM384 power audio amp (be sure to ground all unused pins of IC7). An 8-ohm speaker demonstrates your musical ability to anyone nearby. —Nick Cinquino, Schaumburg, IL

This would make an excellent op-amp trainer! Just about all the more typical audio applications for op-amps are in there.

It'd be cool to replace the feedback resistors in the high-pass filter (IC2), fuzz amp (IC3), and differentiator (IC4) with potentiometers. There'd be no end to the sounds (noises?) you could make.

NAILING NOISES

Most electronic stethoscope circuits

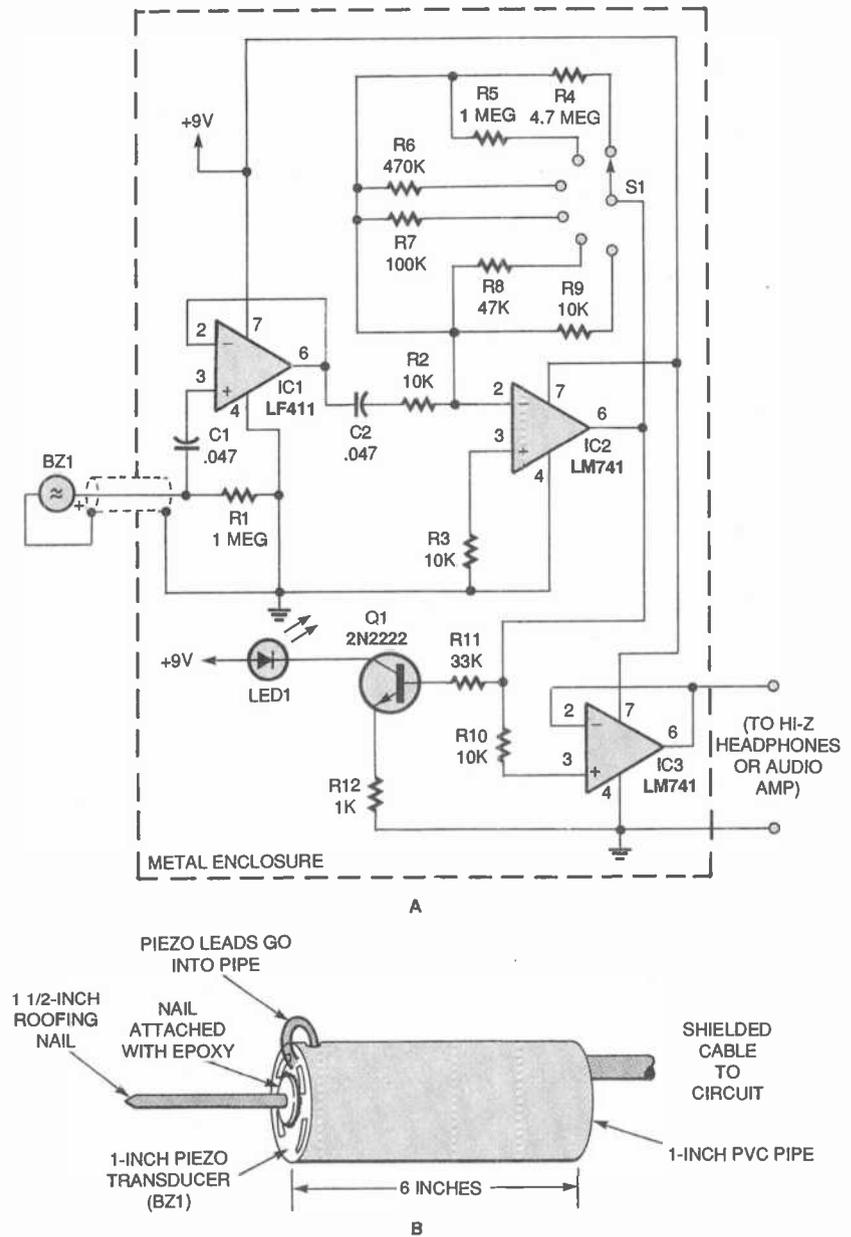


Fig. 3. As shown here, this electronic stethoscope picks up audio signals over a limited range. Replace the buzzer with a long wire and it functions as an AC-voltage detector.

feature a microphone assembly. Here's one based on a piezo disc used as the transducer (see Fig. 3A). Using 5-minute epoxy, glue a roofing nail to the center of the top side of a piezo disc (see Fig. 3B). Be generous with the epoxy and lay a bead over the top of the nail head. Later, epoxy the outer rim of the backside of the disc to a 1-inch diameter PVC pipe of roughly 6-inches in length, which will serve as a handle. Attach a shielded cable from the piezo-disc leads and secure them in place.

The piezo disc's signal is coupled by the cable to IC1, an LF411 FET op-amp configured as a buffer. The LF411 is pin-compatible with the trusty LM741, but has a super-high input impedance, which comes in very handy as we'll see later. The LF411's output is coupled to IC2, an LM741 op-amp configured for high gain. Resistors R4-R9 set the gain via a rotary switch, but a several-megohm potentiometer could be used instead. The amp's output goes to both IC3 (a final buffer stage) and Q1 (an

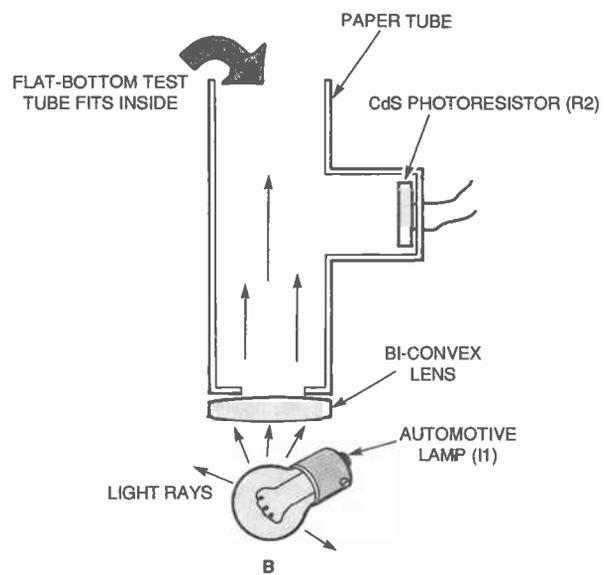
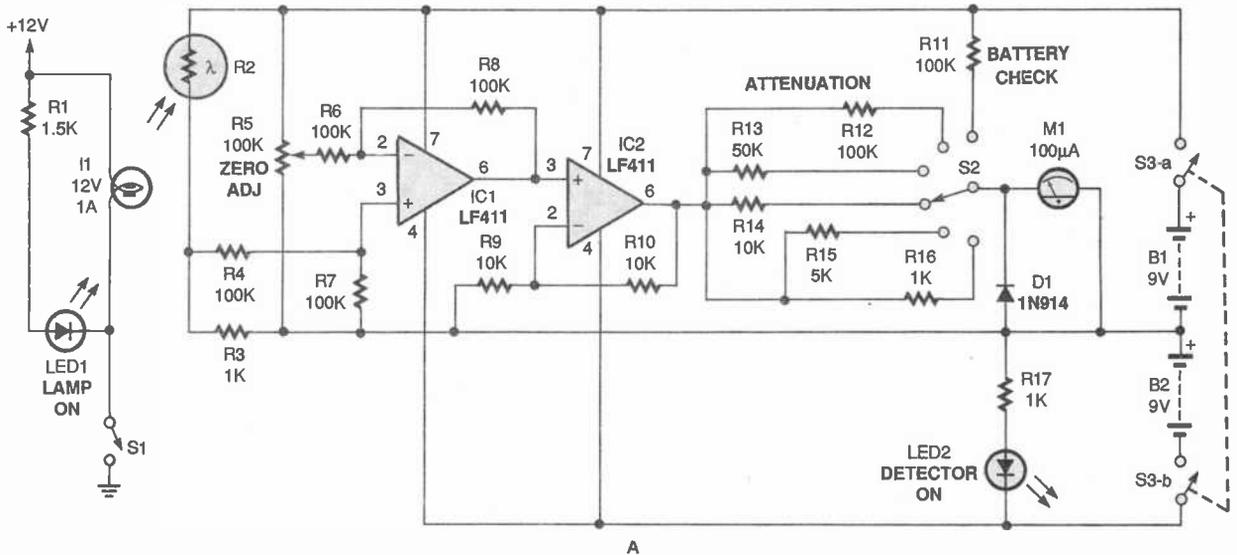


Fig. 4. This turbidimeter circuit (A) will let you measure or monitor the clarity of water. A simple optical assembly (B) lets light reflected by particles in a water sample hit a photoresistor, varying its resistance.

April 1996, Popular Electronics

MPS7965 general-purpose NPN transistor). Any similar transistor, such as a 2N2222 should work for lighting the detect LED, LED1. The output of the final buffer, LM741 (IC3), is connected to high-impedance headphones or a small LM386-based audio amp. Power is supplied by two 9-volt batteries configured as a split supply.

Audio purists may rightfully complain about the limited frequency response of a piezo disc, but this is definitely not meant to be a hi-fi circuit. Besides, this is an application where a tighter response is advantageous.

So what else can the circuit do, you ask? Unplug the roofing nail/piezo sensor and attach a short wire antenna. Now you have what I suppose must be called an electrophone, thanks to the high input-Z of the LF411. If you bring the wire near an unshielded 117-volt AC wire, or a wall outlet, you'll hear the usual irritating 60-Hz hum, so it functions as an AC-voltage detector.

Also, I've picked up several AM radio stations at once from an unshielded ceiling-fan motor winding, and heard a very weak VLF omega

signal by taking the circuit outside one night. Programmable thermostats, thermostat wires, and computers also make entertaining targets. Who knows what else I've missed

—Nick Cinquino, Schaumburg, IL
I'm surprised enough at the uses you've found for the circuit already! Hooking it up to a fan winding is pretty creative.

Personally, I think your use of S1 is better than replacing R4 through R9 with a single potentiometer. Unless it's linear, a high-value potentiometer
 (continued on page 77)

Circuit Circus

A Cable Tester, and More

BY CHARLES D. RAKES

This visit we've got a variety of circuits that we're going to share with you. Hopefully you will find at least one that will be useful.

WIRE TRACER

Tracing and connecting multi-wire cables can sometimes be an easy job; it can also easily become a real nightmare, especially if the cable wires are not color coded and if more than one cable is sharing the same bundle. In any case, our first entry consists of a pair of circuits that can rid you of any wire-tracing miseries forever.

The first circuit is a wire-tracer sending circuit, and is shown in Fig. 1. Four 567 tone-decoder ICs, IC1-IC4, are used to generate four different audio frequencies between 700 Hz and 950 Hz. The capacitor from pin 6 of each 567 to circuit ground, along with the resistor between pins 5 and 6, set the operating frequency.

A 2N3904 NPN transistor is connected in an emitter follower circuit to isolate the ICs from output loading. Each output supplies a different audio tone to four wires in a cable.

Now we'll move on to the tracer's

receiving circuit, which is shown in Fig. 2. There we have four 567s operating in four tone-decoder circuits tuned to the same four frequencies as the 567s in the sending circuit. Also that circuit contains three additional ICs that help to automate the tracing process.

To simplify the operation of the receiver's auto search circuitry, we'll jump ahead and look at the manual switching circuit in Fig. 3. That simple circuit replaces all of the Fig. 2 circuit-

ry on the input side of C16.

To illustrate how the circuit works, we'll connect the four outputs from the sending unit to the receiver inputs in the following manner: the 700-Hz output connects to input 4; the 775-Hz output to input 3; the 880-Hz output to input 2; and the 950-Hz output to input 1. Any interconnecting combination would have done, but this combination simplifies the explanation of the circuit's operation.

PARTS LIST FOR THE CABLE-TESTER TRANSMITTER (Fig. 1)

SEMICONDUCTORS

IC1-IC4—567 phase-locked loop, integrated circuit
Q1-Q4—2N3904 NPN transistor

RESISTORS

(All fixed resistors are 1/4-watt, 5% units.)
R1-R4—4700-ohm
R5-R8—1000-ohm
R9-R12—20,000-ohm, potentiometer

CAPACITORS

C1-C5—0.1- μ F, ceramic-disc
C6-C9—0.22- μ F, ceramic-disc
C10-C13—2.2- μ F, 16-WVDC, electrolytic
C14-C17—1- μ F, 16-WVDC, electrolytic
C18—100- μ F, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

IC sockets, perfboard, wire, etc.

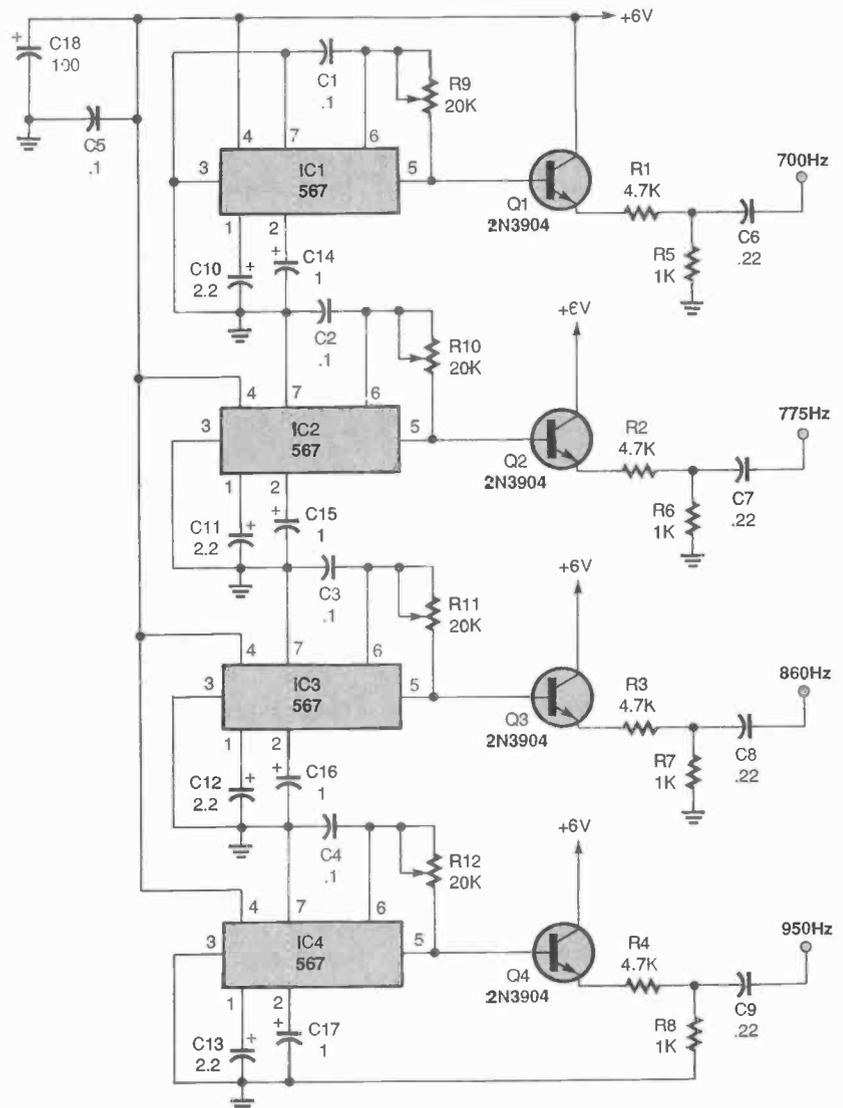
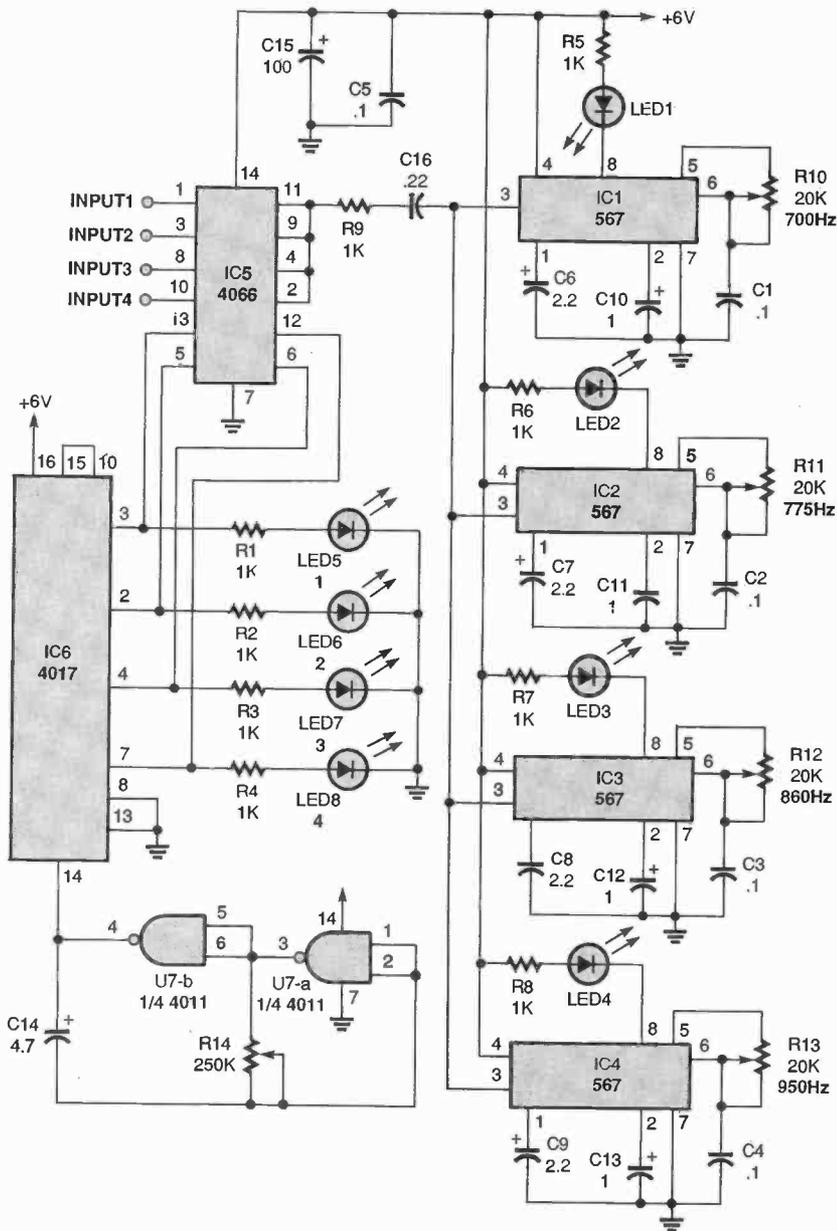


Fig. 1. Here's the transmitter for our cable-tester system. The circuit generates four distinct audio tones that are available at the output as shown.



PARTS LIST FOR THE CABLE-TESTER RECEIVER (Fig. 2)

- SEMICONDUCTORS**
 IC1-IC4—567 phase-locked loop, integrated circuit
 IC5—4066 quad bilateral switch, integrated circuit
 IC6—4017 decade counter, integrated circuit
 IC7—4011 quad two-input NAND gate, integrated circuit
 LED1-LED8—Light-emitting diode, any color
- RESISTORS**
 (All fixed resistors are 1/4-watt, 5% units.)
 R1-R9—1000-ohm
 R10-R13—20,000-ohm, potentiometer
 R14—250,000-ohm, potentiometer
- CAPACITORS**
 C1-C5—0.1-μF, ceramic-disc
 C6-C9—2.2-μF, 16-WVDC, electrolytic
 C10-C13—1-μF, 16-WVDC, electrolytic
 C14—4.7-μF, 16-WVDC, electrolytic
 C15—100-μF, 16-WVDC, electrolytic
- ADDITIONAL PARTS AND MATERIALS**
 IC sockets, perfboard, etc.

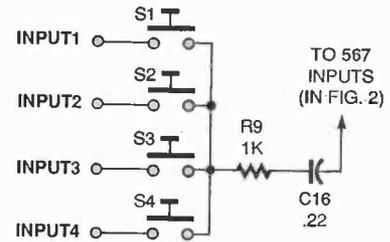


Fig. 3. This circuit illustrates the theory behind the routing system used in the cable tester's receiver.

Fig. 2. The receiver part of the cable tester uses a quad bilateral switch (IC5) and a decade counter (IC6) to "automate" the cable-testing procedure.

When S1 on the receiver is closed, a 950-Hz tone is connected to the input of the four 567 tone decoders. The tone decoder set to detect a 950-Hz tone, IC4, in Fig. 2, locks on to the signal and turns on LED4 indicating that the wire that is connected to the sending circuit's 950-Hz output goes to input 1 of the receiver. If we push S4, the 700 Hz-tone from the sending circuit will be detected by IC1 in the receiver, lighting LED1 and telling us that the wire connected to the 700-Hz output on the sender is connected to input 4 on the receiver. Likewise, pushing S2 will cause LED3 to light

and operating S3 turns on LED2. While the manual version of the receiving circuit certainly works well enough to use if you prefer simplicity and lower cost, the automatic version illustrated in Fig. 2 adds a really nice touch to your testing. Let's see how it works. The four inputs of Fig. 2 are connected to four input contacts of a quad bilateral switch, IC5, with the output contacts tied together and connected to the inputs of the 567 decoders through R9 and C16. The bilateral switch's four control inputs are operated by IC6, a 4017

decade counter IC, which is driven by a low-frequency oscillator made up of two gates of IC7, a quad two-input NAND gate.

Four LEDs, LED5 through LED8, are connected to IC6's four outputs and indicate which input is being checked, just as in the manual mode. When LED5 is on, input 1 is switched through to the four decoder circuits. The decoder that responds, by lighting its LED, indicates which output, 700 Hz, 775 Hz, 880 Hz, or 950 Hz, is connected to that input. Resistor R14 sets the input-stepping rate, which should be slow enough for recording.

TOUCH SWITCH

Our next entry, shown in Fig. 4, is a

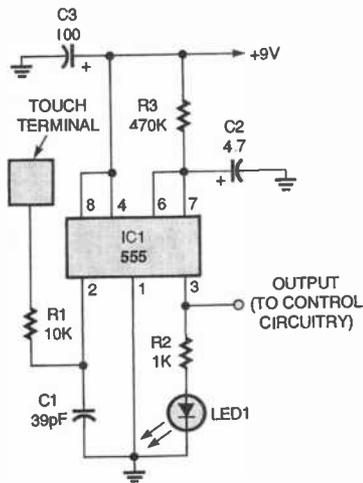


Fig. 4. Simply touching the "touch terminal" will activate the switch and keep it on for a duration set by R3 and C2.

touch-actuated timed-on switch. In it, IC1, a 555 timer, is connected in a one-shot multivibrator circuit that is triggered by touching the touch terminal. The timed-on period is about four seconds with the component values given. To increase the on time, increase the value of R3 or C2; to decrease the on time, reduce the value of R3 or C2.

The 9-volt output at IC1 pin 3 can be used to drive an optocoupler, a power transistor, a hexFET transistor, CMOS circuitry, and more.

DUAL-POLARITY POWER SUPPLY

Our next circuit, see Fig. 5, also uses the versatile 555 timer IC, but this time in a dual-polarity low-current power supply. The positive and negative 9-volt outputs could be used for an

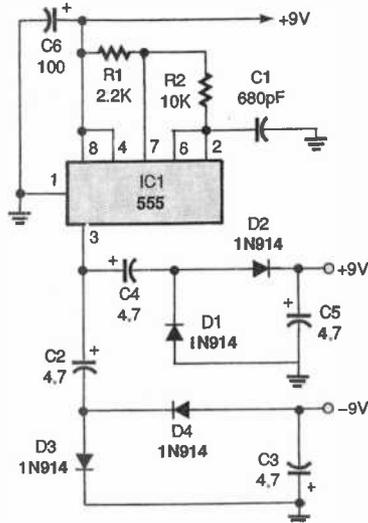


Fig. 5. This dual-polarity power supply is ideal for use with op-amps and in many other applications.

op-amp supply, or for any other application such as a low-current bias supply.

In this circuit, the 555 is operating in a free-running oscillator at about 120 kHz, producing a near-9-volt square-wave output at pin 3. Diodes D1 and D2, along with capacitors C4 and C5, make up the rectifier circuit for the positive supply, while D3, D4, C2, and C3 make up the rectifier for the negative supply.

BATTERY TESTER

Our last entry for this month is a simple battery-testing circuit. In the circuit shown in Fig. 6, six incandescent lamps, chosen for their voltage and current ratings, are selected as a load for the battery under test. The meter (M1) and the lamp's brightness will give a good indication of a battery's

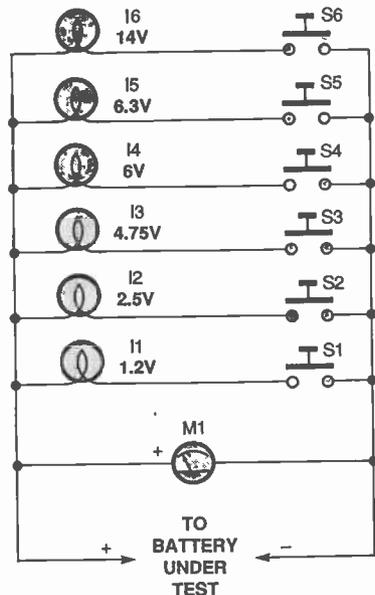


Fig. 6. Though deceptively simple, this battery tester can help you weed out marginal cells that might otherwise test good.

PARTS LIST FOR THE BATTERY TESTER (Fig. 6)

- S1-S6—Normally-open pushbutton switch
- I1—Incandescent lamp, type 112 (Radio Shack 272-1174 or equivalent)
- I2—Incandescent lamp, type 14 (Radio Shack 272-1132 or equivalent)
- I3—Incandescent lamp, type PR-12 (Radio Shack 272-1151 or equivalent)
- I4—Incandescent lamp, type T-1 3/4 (Radio Shack 272-1142 or equivalent)
- I5—Incandescent lamp, type 46 (Radio Shack 272-1130 or equivalent)
- I6—Incandescent lamp, type 1487 (Radio Shack 272-1134 or equivalent)
- M1—Voltmeter
- Perfboard, lampholders, etc.

output capacity. In addition, because the inrush current that occurs when the lamp is first connected across the battery is much higher than the rated operating value, the circuit makes it easy to spot marginal cells.

To use the circuit, connect a battery and observe the measured voltage on M1. Then close the switch that corresponds to the meter's reading and/or the batteries rated voltage and observe the brightness of the appropriate lamp.

Be careful to select the right lamp for testing. Never test using a lamp whose voltage rating is more than 30% lower than the battery's rating. Otherwise, damage to the lamp could result if the battery-under-test is good.

PARTS LIST FOR THE TOUCH OPERATED SWITCH (Fig. 4)

SEMICONDUCTORS

- IC1—555 timer, integrated circuit
- LED1—Light-emitting diode, any color

RESISTORS

- (All resistors are 1/4-watt, 5% units)
- R1—10,000-ohm
- R2—1000-ohm
- R3—470,000-ohm

CAPACITORS

- C1—39-pF, ceramic-disc
- C2—4.7-µF, 16-WVDC, electrolytic
- C3—100-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

- IC socket, perfboard, touch terminal, etc.

PARTS LIST FOR THE DUAL-POLARITY POWER SUPPLY (Fig. 5)

SEMICONDUCTORS

- IC1—555 timer, integrated circuit
- D1-D4—1N914 silicon diode

RESISTORS

- (All resistors are 1/4-watt, 5% units.)
- R1—2200-ohm
- R2—10,000-ohm

CAPACITORS

- C1—680-pF, ceramic-disc
- C2-C5—4.7-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

- IC socket, perfboard, etc.

DX LISTENING

50 Years of Belgian Shortwave

BY DON JENSEN

As we near the new century, Belgian shortwave broadcasting marks its half century on the air. Back when I first became interested in SWling, in the late 1940s, Belgium was one of the major international broadcasters. Like its neighbor, little Belgium had a loud SW voice.

Then, it was *ORU*, "Belgium calling the world" from Brussels. Its slogan, "The International Goodwill Station" dated back even earlier, to the WWII years, when the Nazi occupation of Belgium forced the government-in-exile to transmit its programming to the world from the Belgian Congo.

But, in the past decade, as has been the case with other, smaller European nations, Belgium has found it increasingly difficult to keep up with the costs of maintaining a major presence in the world of international shortwave broadcasting. Today, the shortwave voice is called *Radio Vlaanderen International*, the world service of the Belgian Radio and Television (BRTN) Network. Its mission, RVI says, is to serve as the cultural ambassador of the Flemish community.

RVI's international programming is aired in Dutch, German, French, Spanish, Arabic, and English. The daily English service, known as "Brussels Calling," includes news and press reviews, plus, depending on the day of the week, features on Belgian life, the economy, ecology, the arts, music, tourism, and the nation's role in European society.

Radio Vlaanderen International remains a rather easily heard shortwave outlet. But its future is a bit cloudy, according to the current edition of the annual *Passport To World Band Radio*. *Passport* says that it has been told by a spokesman for RVI that Belgium doesn't intend to make further investment in new transmitting equipment because it considers shortwave "an old obsolete medium."

A glance at its programming schedule indeed suggests that Belgium is looking more toward direct satellite communication to reach overseas audiences. It makes special note that RVI programs can be received "in the larger part of Europe on the ASTRA satellite system." In North America, it continues, the English language "Brussels Calling" service is carried via satellite as a part of the 24-hour English-language news service of World Radio Network at 3:30 p.m. Eastern Standard Time.

RVI says that U.S. and Canadian

Monique Delvaux, chief editor of "Brussels Calling," says that the station aims to keep in close touch with English-speaking listeners. "All letters are answered and members of our International Listener's Club receive our 'bi-monthly' Club Echo Magazine."

The address to write is: Brussels Calling, Radio Vlaanderen International, P.O. Box 26, Brussels, Belgium, B-1000. If you write, why not tell the powers-that-be that there are plenty of SWLs out here who definitely don't think of world-band radio as "obsolete."

Maybe eventually, Belgium's broadcasters will get the message: When it comes to reaching its world-wide radio audience, who needs satellites?

LETTERS FROM YOU

"Is there any bluegrass, old time fiddling or Cajun music being played regularly on shortwave?" asks Larry Bruttomesso, North Fort Myers, FL.

A great place to hear Cajun music on shortwave, Larry, is on Pete Bergeron's "Voix de la Louisiane" program aired weekly on *WRNO Worldwide* in New Orleans. That program has been carried by *WRNO* for years; it is currently heard at 2130 UTC, Mondays (and repeated at the same time, Wednesdays) on 15,420 kHz.

For a decade, Bergeron, program director for an FM public-radio station, has been producing the half-hour program that showcases the French culture and traditions of the Cajun country of southern Louisiana. The program is presented in the Cajun language, the two-century-old French dialect spoken by the descendants of Acadian exiles from Canada's Atlantic coast who settled in Louisiana in the 1700s.

If you understand French, you can make your way through Bergeron's Cajun. If you don't, it doesn't matter, because you should love the music he plays: Cajun—a melange of Country



Here's the logo of Radio Vlaanderen International, the international shortwave voice of Belgium's Flemish community.

homes equipped with a 4- to 7.5-foot satellite dish can receive "Brussels Calling" on an audio subcarrier of channel 6 of the Galaxy 5 satellite; that's the channel that carries the popular WTBS TV super-station.

RVI explains that dish owners may tune WTBS, then adjust their receiver to tune the 6.8-MHz audio-subcarrier frequency, to hear the Belgian station's English programming on WRN.

Well, okay, but, frankly, I'd rather do it the old-fashioned "obsolete" way—via shortwave radio! You, too, can tune Radio Vlaanderen's "Brussels Calling" programming at 0030 UTC (7:30 p.m. EST) on 6,030 or 9,925 kHz, beamed to North America. There's another North American transmission on 13,670 kHz at 1400 UTC (8 a.m. EST) Monday through Saturday, and at 1330 UTC (7:30 a.m. EST) on Sunday.

and Western, French-Canadian folk, Spanish, and African rhythms played on the fiddle, guitar, drum, bass, and old-fashioned button accordion—and Creole—a brand of New Orleans rhythm and blues, which also leans heavily on the accordion.

Another recommended program, Larry, is "Folk Routes," on the *British Broadcasting Corporation's* English-language World Service. That weekly collection of folk music from around the world is listed by Passport To World Band Radio as one of the Ten Best SW Programs of 1996.

On a given program, you might hear Appalachian old-time fiddling, or, perhaps folk sounds played on the Irish pennywhistle, Northumberland pipes, Canadian slide-guitar, or West African thumb piano. Listen for that 15-minute BBC program at 0030 UTC Tuesday (that's Monday evening in the U.S. and Canada) on 5,975, 6,175, or 7,325 kHz. Or try Tuesdays at 1615 UTC on 9,515 or 11,755 kHz, or Wednesdays at 1130 UTC on 6,195 or 9,515 kHz.

Anybody have any other musical programming suggestions for Larry and the rest of us?

CLANDESTINE RADIO

When a revolutionary group attempts a coup, somewhere in the world, what's one of their first takeover targets? Usually it's the local radio station. The ability to quickly reach and rally supporters by radio broadcasts often makes or breaks a revolution.

But even before things reach that point, radio broadcasting, particularly on shortwave, is a key element in any dissident organization's plan, regardless of its cause or ideology. When your group is "out," and your opponents are "in," clandestine radio, operating secretly or not-so-secretly outside of the "ins" is the only answer available.

Richard D'Angelo in the North American Shortwave Association's *Journal* writes: "Clandestine broadcasting operations mirror the unrest around the world. These radio stations broadcast material of an 'outlawed'

Credits: Brian Alexander, PA; Jerry Berg, MA; Marie Lamb, NY; Ed Rausch; North American SW Association, 45 Wildflower Road, Levittown, PA 19057

political nature which has most often been declared illegal by governments of the stations target area or country.

"Many of these stations are jammed to prevent their messages from getting through to the target area. Consequently, frequencies are often changed . . . the clandestine broadcasting scene changes quickly."

To keep current, D'Angelo recommends the *Clandestine Stations List* compiled annually in Denmark by ace DXer Finn Krone. That 28-page listing includes data on programming schedules, frequencies, languages used, the political organizations behind the stations, and their mailing addresses.

The list is available via airmail for 10 International Reply Coupons (IRCs cost \$1.05 each at your local post office) sent to Danish Shortwave Clubs International; c/o Bent Nielsen; Egekrogen 14; Vaerloese, Denmark DK-3500.

DOWN THE DIAL

Here are some target stations for your SW tuning. Remember that times are listed in Universal Coordinated Time (abbreviated UTC), which is equivalent to EST+5 hours, CST+6, MST+7, and PST+8.

What are you hearing? Why not drop me a line listing some of your shortwave loggings. The address is "DX Listening," **Popular Electronics**, 500 Bi-Country Blvd., Farmingdale, NY 11735.

ALGERIA—16,160 kHz. *Radio Algiers International* has English transmissions from 1800 to 1900 and 2000 to 2100 UTC. Reception of the latter transmission usually is better.

CLANDESTINE—11,470 kHz. Although this station programs in Iran's Farsi language, its name would translate into English as the *Voice of Human Rights and Freedom*. It supposedly is operated by a dissident Iranian group, transmitting secretly from Egypt. It can be heard, mostly with talk and some Middle-Eastern music from 1645 to sign off at 1825 UTC.

HUNGARY—7,250 kHz. *Radio Budapest* is noted at 2112 UTC in English. It operates parallel frequencies of 5,935 and 9,835 kHz at the same time.

MULTIMEDIA WATCH

(continued from page 16)

sports cars and lets you see what it's like to pilot them. Each car's characteristics are accurately simulated.

Two new titles from IntraCorp are *Witchaven* and *William Shatner's Tekwar*. *Witchaven* pits you against evil as you descend into the volcanic crater on the island of Char. It's bloody warfare with medieval weapons, demons, and monsters. *Tekwar* brings William Shatner's best-selling books to life in a 3D action game in which you explore a future world hunting for dangerous criminals.

Last this month is a piece of software that helps Visual Basic software writers create documentation for the project. Many people are experts at writing software, but not very good at preparing material that explains how the software works. Visual Basic makes it very easy to assemble a piece of software, but it has never been helpful in documenting the software. *Vision StoryBoard 3.0* works hand in hand with Visual Basic to produce accurate documentation. It runs alongside Visual Basic and it stores software specifications along the way. Blank menus pop up for each panel constructed within Visual Basic for the developer to fill in. Those menus describe each button, control, and function. Changes made to the software bring up the appropriate menu for revision. The information compiled by *Vision StoryBoard* can be imported into another program, such as Word, to create a complete manual for the new piece of software. ■

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Variable Capacitors

BY JOSEPH J. CARR, K4IPV

Variable capacitors are used extensively in amateur-radio and general radio-frequency circuits. Indeed, aside from simple single-frequency units, it's not really possible to build a receiver, transmitter, or linear RF power amplifier without using at least one variable capacitor. Although some receivers use varactor diodes—*i.e.*, diodes that produce a capacitance change when a DC reverse-bias voltage is applied—a large number of designs still use mechanical variable capacitors of one sort or another.

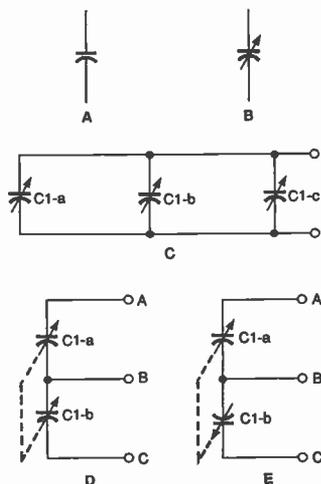


Fig. 1. These symbols are commonly used to designate a variety of fixed and variable capacitors.

Figure 1 shows several different capacitor symbols. In Fig. 1A is the symbol for a fixed-value capacitor. It consists of two plates facing each other, which is what a capacitor actually is, by the way. The basic variable-capacitor symbol is shown in Fig. 1B. It is the same as the fixed capacitor, except that it has an arrow drawn through the plates to denote the variable nature of the beast.

The value of a variable capacitor is determined by two factors: the area of the plates facing each other and the spacing between the plates. The rule

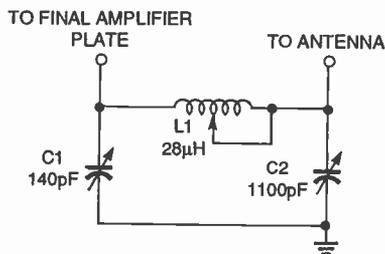


Fig. 2. In a pi-network, the output capacitor (C2) is typically a 1100-pF, three-section, broadcast variable with relatively wide spacing.

is simple: the more the area of the two plates "shade" each other, the higher the capacitance. What a variable capacitor does is make it possible to change the effective area in play at any one time by rotating a shaft. There are usually two plates (or plate sets): the stator plates remain stationary as the shaft is rotated, while the rotor plates move.

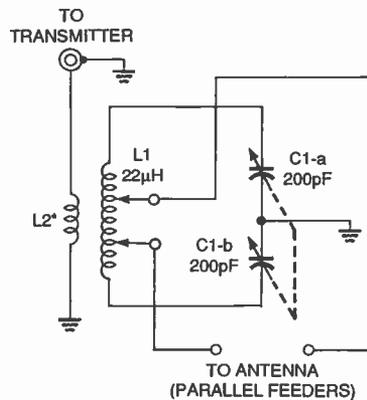
The spacing between the plates is a critical factor. To make the capacitance higher, reduce the spacing between facing plates. However, remember that the operating voltage rating of the capacitor also depends on the spacing: the smaller the spacing (hence higher capacitance), the lower the arc-over voltage. It's always a trade-off in variable-capacitor design to determine whether we need wider spacing and lower capacitance (but higher voltage), or narrower spacing with higher capacitance and lower voltage.

A multi-gang capacitor is shown in Fig. 1C. That capacitor actually consists of several capacitors in parallel on the same shaft. The minimum capacitance of the set is the sum of the minimum capacitances of all of the units in the set, and the maximum is the sum of all the maximum capacitances. You will often see that type of capacitor in the output network of vacuum-tube linear amplifiers and trans-

mitters. If a pi-network (like the one shown in Fig. 2) is used, then, for the high-frequency bands, the output capacitor (C2) is typically a 1100-pF, three-section, broadcast variable with relatively wide spacing (though not as wide as needed for C1).

Figure 1D shows the split-stator or two-section capacitor. Those capacitors consist of two rotary variable capacitors on the same shaft. The two sections are on the same shaft, and each has the same capacitance (within manufacturing tolerances) at every shaft setting. Such capacitors are often used in parallel antenna tuners for tuned lines; a typical circuit of that type is shown in Fig. 3. Note, by the way, that the "balanced" output on most antenna tuning units is a BALUN transformer, and while it works nicely with parallel feeders and twin-lead for some antennas, it doesn't work well at all for tuned feeder antennas. For tuned feeder antennas, an antenna-tuning unit such as the one shown in Fig. 3 is needed.

The capacitor symbol in Fig. 1E indicates a differential capacitor. Like the capacitor of Fig. 1D, the differential capacitor consists of two capacitors sharing the same shaft. But in the dif-



*L2: 4 TURNS OVER CENTER OF L1

Fig. 3. Capacitor C1 in this antenna-tuning circuit is a split-stator or two-section capacitor that consists of two rotary variable capacitors on the same shaft.

ferential capacitor, the two capacitors are mechanically 180-degrees out of phase with each other. That is, as you turn the shaft, as one section increases in capacitance, the other section decreases in capacitance. If you measure the capacitance across terminals A-C in Fig. 1E, the capacitance will be the series capacitance of C1-a and C1-b. If the capacitor were a standard split stator form (Fig. 1D), then that series capacitance would vary from a minimum value to a maximum value. But in the differential capacitor, the A-C terminal-to-terminal series capacitance remains constant as the shaft is rotated.

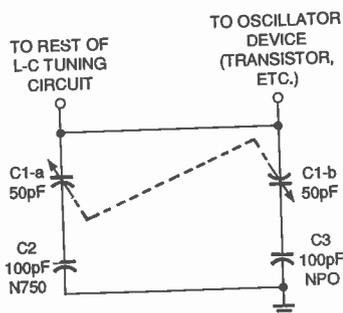


Fig. 4. One use for the differential capacitor is in an RF-oscillator temperature-stabilization circuit like the one shown here.

One use for the differential capacitor is in RF-bridge circuits or in RF-oscillator temperature-stabilization circuits (see Fig. 4). In the latter case, each section of the differential capacitor (C1-a/C1-b) is in series with either an NPO, zero-temperature-coefficient, ceramic-disc capacitor, or an N750, negative-temperature-coefficient capacitor. The shaft angle of the differential capacitor is varied until the total temperature coefficient of the assembly is just what is required to cancel drift. I first saw the circuit shown in Fig. 4 in an old Hallicrafters HT-32 single-sideband transmitter in the 1950s.

Two different forms of the air-dielectric variable capacitor are shown in Fig. 5. The model on the left is called a *straight-line frequency model*, while that on the right is a *straight-line capacitance model*. The difference is due to the fact that, in L-C resonant circuits, the change of frequency (F) is proportional to the square root of the

change of capacitance (C). In the straight-line frequency model, the rotor plates are offset, and shaped such that the frequency change is the same for each degree of shaft rotation.

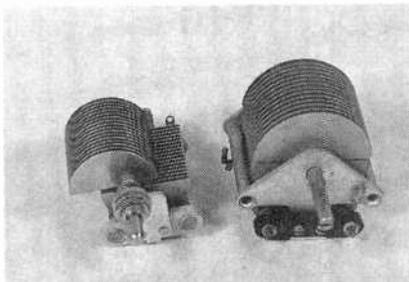


Fig. 5. The capacitor on the left in this photo is called a *straight-line frequency model*, while the one on the right is a *straight-line capacitance model*.

In the straight-line capacitance model, however, the *capacitance* change is the same for each degree of shaft rotation. You can see the effect of straight-line capacitance capacitors on radio receivers: The frequency calibrations will be scrunched up on the low end of the dial. Either that, or the frequency change represented by equal-size ticks on the dial scale are not the same number of kilohertz. Take a look at a number of radio receivers, and you'll soon be able to guess which type of capacitor is used in the tuning circuit.

VARIABLE-CAPACITOR SOURCES

Variable capacitors are hard to come by these days, but some companies still stock both used and new air-dielectric variable capacitors in both receiver and transmitter voltage ratings. One such source is Ocean State Electronics, (6 Industrial Way, Westerly, RI, 02891; Tel. 401-596-3080). They don't have every type of capacitor all of the time, but do manage to have most types much of the time (as stocks become available). Some of their variable capacitors are older but unused stock, while some are used, but you'll know which if you call and talk to the Ocean State people.

I do a lot of electronic business in England, so from time to time come across various components that are not easily available in the United States. For example, the capacitor shown in Fig. 6 is a Jackson Brothers

LA1/xxx dual air-dielectric variable capacitor. It's used in low-power (QRP) and receiver antenna-tuning units, lower-power pi-network output circuits, and in receiver and preselector input-tuning circuits. Two are available: the LA1/200 is a 2- × 200-pF unit, while the LA1/400 is a 2- × 400-pF unit.

Both models (LA1/200 and LA1/400) are priced at £11.50, including postage and packing, outside the European Union. The British pound sterling (£) is worth something around \$1.55 as of this writing, so that translates to a price of \$17.83 in U.S. currency. The retail supplier is a company called Isoplethics (13 Greenway Close, North Walsham, Norfolk, NR28 0DE, England).

They do not appear able to accept American credit cards as of yet, but a note in their literature states that they will accept foreign currency for a £4 surcharge. Also, you can obtain international money orders at the U.S. Post Office denominated in dollars, or at many banks (that have an international department) you can obtain checks denominated in pounds sterling. You can also get American Express and other traveler's checks denominated in pounds sterling, rather than dollars. When Isoplethics signs on with a credit-card company, I'll let you know in this

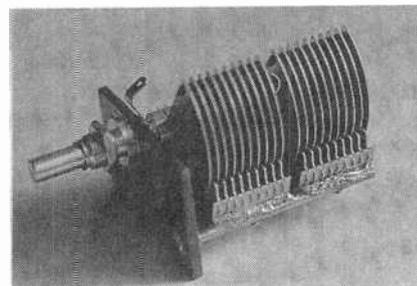


Fig. 6. The Jackson Brothers LA1/xxx dual air-dielectric variable capacitor is used in low-power (QRP) and receiver antenna-tuning units and elsewhere.

column.

I also bought a set of three Jackson Brothers dial drives from Isoplethics. Those have a 6:1 reduction ratio, with both coarse and vernier knobs. The cardboard dial scale has a 0-100 logging scale, plus three arcs for calibrating up to three bands worth of frequencies.

(continued on page 78) 71

SCANNER SCENE

Monitoring the U.S. Mail

BY MARG SAXON

Here's a handheld scanner with 200 memory channels and a generous helping of operating frequencies. It's Radio Shack's triple-conversion PRO-60. The unit has neat frequency coverage—30 to 1000 MHz, except for the UHF-TV frequencies between 512 and 760 MHz and, of course, the cellular-telephone bands.

The memory channels are set up in 10 storage banks of 20 each. There are 10 additional, temporary monitor channels for storing channels discovered in searches until you can transfer them into permanent memory. In Hyperscan mode, the unit searches through frequencies at 50 steps per second, and scans stored channels at 25 per second.

The PRO-60 receives NFM/WFM/AM modes, automatically selecting the appropriate one for the band being monitored. That feature can be manually overridden by the operator. Direct frequency search allows quick access to any band or frequency.

We liked knowing that stored frequencies remain in the memory even if the NiCd batteries are removed or become discharged. A battery-saver circuit draws only 40% of the normal operating power. The PRO-60 can also be powered by an optional AC adapter or an automotive DC adapter.

The first IF frequency is 609 MHz, the second is 45 MHz, and the third is 10.7 MHz in WFM mode. In NFM/AM modes, the third IF frequency is 455 kHz. NFM/AM selectivity is rated at -6 dB at 10 kHz, and -30 dB at 15 kHz. Spurious rejection (NFM at 328 MHz) is rated at 40 dB. NFM sensitivity is rated at 1 volt for 20 dB (S+N)/N at 3 kHz deviation; AM sensitivity at 2 volts with 60% modulation.

The PRO-60 is a good-looking little handful, too. And we especially like the fact that it includes the exciting 225- to 400-MHz UHF aeronautics band. You can check it out at any Radio Shack store.

SEALED WITH A KICK

People send all sorts of things through the mail besides the usual bills, catalogs, greeting cards, payments, and personal letters. Those things include rare coins, expensive jewels, contraband, narcotics, stolen property, threats, pornography, and



Radio Shack's PRO-60 puts a lot of scanning power in the palm of your hand. It covers everything from 30 to 1000 MHz, with the exception of the cellular bands and the UHF-TV frequencies.

mail bombs. Some of those are dangerous to postal workers as well as to the public. Other items are so valuable that they attract larcenous attention while they are in the hands of the Postal Service. Credit cards, money orders, and Social Security checks are often stolen out of people's mailboxes.

Investigating criminal activity related to the mail service, and enforcing postal law, is the job of the U.S. Postal Inspection Service. More than 2000 agents are fanned out across the nation, investigating crimes that range from mail pilferage to murder, as well as postal employee dishonesty, and robbery from and of mail vehicles.

The work of postal inspectors is every bit as exciting and intriguing as

that of other federal enforcement agents. They perform surveillance, serve federal warrants and subpoenas, and make arrests.

In addition to the agents of the Postal Inspection Service, the U.S.P.S. also has an extensive armed, uniformed security force that provides on-scene protection at certain post offices and mail distribution centers.

Those important enforcement and security activities have never been fully appreciated by scanner owners. As a result, the frequencies used by the Postal Inspection Service have not been shown as much interest as they deserve.

There are probably other active repeater frequencies in addition to those listed here, but these are the ones we have monitored in recent months: 413.60, 413.70, 415.05, 415.15, 415.95, 414.75, 414.975, 416.075, 416.225, and 418.30 MHz. Let us know about others you know of or discover, and we will share them here.

AIRPORT: BEHIND THE SCENES

A. Panzini writes that when he was seeing someone off at Chicago's O'Hare Airport, he saw FAA personnel in mobile units using two-way radios. That made him curious about the frequencies used by FAA people at some airports.

The two-way radio systems are needed by the personnel responsible for the lighting, navigational, communications, and other facilities of controlled airports. They might also be used for some on-field communications between the control tower and other FAA personnel. At some locations, phone calls can be placed from the mobile units through the FAA's VHF repeaters.

Depending upon the size of the facility, more than one frequency might be in use. Nationally, simplex channels

noted are 166.175, 172.125, 172.15, and 172.9125 MHz. Repeaters around the nation seem to operate on 172.825, 172.85, 172.875, 172.90, 172.925, 172.95, and 172.975 MHz.

INTERCEPT THAT CALL!

Tune In On Telephone Calls!—the controversial book of “recreational eavesdropping” on cellular, cordless, and other wireless telephones, as well as pagers—has just come out in its updated third edition. The 160-page illustrated handbook is filled with frequencies and techniques. It even has a new cover design.

The new edition has the 30 new cordless-phone frequencies, and also shows specific 900-MHz cordless channels. You can learn about scanner accessories such as descramblers and DTMF tone decoders that display the digits people enter into pushbutton telephones. The book also covers specialized scanner eavesdropping antennas, an accessory to decode digital non-voice pager messages, and more.

According to our mail and media reports, recreational eavesdropping on cellular, cordless, and air/ground phones continues to fascinate scanner owners. The third edition of *Tune In* continues as the primary source of information on the subject.

Tune In On Telephone Calls! (Cat. No. TT-3) is available from many leading hobby communications suppliers. It can also be ordered from the publisher for \$16.95 plus \$5 shipping and handling (\$6 to Canada). New York state residents must add \$1.87 sales tax. The book is published by CRB Research Books, Inc., P. O. Box 56, Commack, NY 11725. MasterCard and Visa orders can phone 1-800-656-0056; in Canada, Alaska, and Hawaii, call 516-543-9169.

CAN'T SEE THE FOREST?

An unsigned postcard asks us to publish the frequencies to monitor in the Eldorado National Forest in Placerville, California. We suggest trying 164.125, 166.675, 168.20, 169.445, 170.00, 171.525, 172.325, 415.225, 415.25, 415.325, 415.525, and 415.575 MHz. That should put an ear on most things the Forest Service is doing there. ■

It started in America!

The creators are the masters in manufacturing the finest video products...

You probably don't associate VCR's with American technology. Fact is, video recording has its origins in America and it was 3M that brought video recording out of the lab and into your living room. Today, 3M video tape is the choice of all the major networks. No other tape company has ever won an Oscar or an Emmy. 3M Black Watch tape follows in this tradition—service and quality go hand in hand. Here are three Black Watch products you should be using at home!

Clean up! With constant playing and using of degrading dry or wet cleaners, the output of your video tapes has slowly diminished to an unacceptable level and the VCR plays as if it has a head cold! The culprit is most likely clogged and dirty video and/or audio heads. The 3M Black Watch™ Head Cleaner Videocassette uses a patented magnetic tape-based cleaning formation to remove head clogging debris. No foreign substances such as cloth, plastics or messy liquids and no harsh abrasive materials are present. The cleaner's usable life is 400 cleanings or more!

It's easy to use. Place the 3M Black Watch™ Head Cleaner Videocassette in the VCR and press the Play button. A pre-recorded message will appear clearly on your screen and an audible tone is heard, telling you that the cleaning process is now completed. No guess work; you never over clean! Priced at \$19.95.

For the VCR! Once your VCR's record and playback heads are cured, and the unit plays like new, consider using the finest videocassette you can buy—the 3M Black Watch™ T120 Hi Pro VHS 4410 Videocassette. The 4410 is the highest performing videocassette available today for use with all standard format VHS recording hardware!

Here's what you hear and see....A sharp, clear picture—brightest ever colors—freedom from streaks, flashes and snow—outstanding high-fidelity audio reproduction—optimum camcorder performance—maintains recording integrity. 3M Black Watch™ video tape is 100% laser inspected to guarantee surface smoothness and drop-out free performance. Priced at \$8.00

You saw it here first! 3M Black Watch™ 0900 8mm video tape cassette loaded into your Hi Band camcorder delivers the finest picture and sound possible in the 8mm format. Extremely fine particles of pure iron alloyed with nickel and cobalt deliver a video performance exceeding 400 lines of horizontal resolution. You get the advantage of an exceptional video image with superior audio re-



For the clearest pictures you ever record!

production. This means your Hi 8 format camcorder will produce the best video and audio definition possible. With the 3M Black Watch™ 8mm cassette, the recording capability and performance of your camcorder will be significantly enhanced. Priced at \$14.95.

Claggk Inc. — 3M VHS Special Offer
P.O. Box 4099,
Farmingdale,
New York 11735

Yes, I like your offer and here is my order for 3M Black Watch™ products!

- ___ 3M Black Watch™ 0900 Hi Band-120 8mm Cassette (\$14.95 each) \$ _____
- ___ 3M Black Watch™ T120 Hi Pro VHS 4410 Videocassette (\$8.00 each) \$ _____
- ___ 3M Black Watch™ Head Cleaner Videocassette (\$19.95 each) \$ _____

Shipping and handling per order \$4.00

Total Amount in U.S. Funds only \$ _____

New York residents add local sales tax. Canadians add \$6.00 per order. No foreign orders. Do not send cash.

Bill my VISA MasterCard
Card No. _____
Expire Date ___/___/___
Signature _____
Name (Please print) _____
Address _____
City _____ State _____ ZIP _____

RAIN FOREST RESCUE: TO HELP SAVE HALF OF THE PLANTS AND ANIMALS ON EARTH

In the rain forest, the sounds of fires and bulldozers are replacing the sounds of nature.

Recent studies show that the destruction of the rain forests wipes out 17,000 plant and animal species each year. That's about 48 extinctions per day, two per hour. These are plants and animals that will simply cease to exist, gone forever from the planet. And the toll mounts every day.

Even though they occupy less than 2% of the earth's surface, rain forests are home to over half the world's plant and animal species. When we destroy the rain forest we are endangering our planet's future. The chain of life depends on a variety of plants and animals that are being

destroyed by the day... from the smallest tree frog to the largest tropical tree.

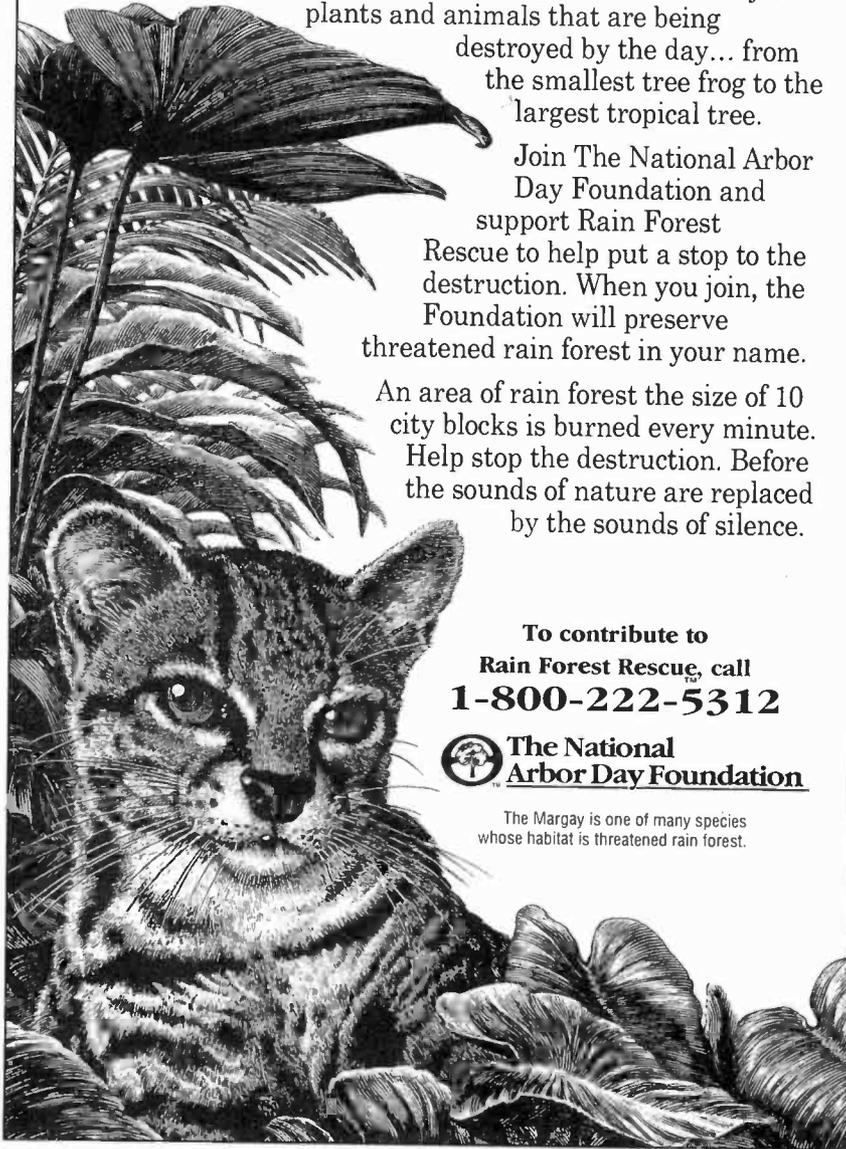
Join The National Arbor Day Foundation and support Rain Forest Rescue to help put a stop to the destruction. When you join, the Foundation will preserve threatened rain forest in your name.

An area of rain forest the size of 10 city blocks is burned every minute. Help stop the destruction. Before the sounds of nature are replaced by the sounds of silence.

To contribute to
Rain Forest Rescue, call
1-800-222-5312

 **The National
Arbor Day Foundation**

The Margay is one of many species whose habitat is threatened rain forest.



SWITCHING AMPLIFIER

(Continued from page 34)

board. Attach to the other end of those wires a connector that matches the one you used on the other board's power-connection wires.

To finish the on-board assembly, insert IC1 into its socket. Then examine both circuit boards to make sure all your electrical connections are correct and error free, be especially careful to check for solder bridges.

Now you are ready to mount the boards in a project enclosure. You should buy or make a plastic case with minimum internal measurements of 8.2 x 7.7 x 2.5 inches. Make sure it has adequate ventilation holes for letting out the heat produced by the high-wattage resistors, MOSFETS, and diode heatsinks. The author's prototype was built in an attractive home-made enclosure.

Drill holes in the bottom of the case to match the mounting holes on the PC boards. Then do the following for each of the holes: Slide a washer onto a round-head screw and insert the screw from the outside into the drilled mounting hole on the bottom of the enclosure. Next, use a hex nut to secure the screw and washer in place. Then place another nut on top of the one just put in place to form a spacer. The last step is to install the boards and secure them at each screw with another nut.

Once the boards are in place, begin mounting the components that go onto the enclosure itself. Place the four jacks on what will be the back of the case and solder each to its proper pair of wires. Then mount the potentiometer to the front panel of the unit and connect it to its respective wires.

Mount the neon assembly and rocker switch to the front of the case. The fuse assembly should be mounted on the rear of the case. Make all the electrical connections between those components and the proper wires on the power-supply board. Finally, attach a power cord with a two-terminal AC plug to the unit.

Make sure the two boards in the Amplifier are connected before plugging the unit into an outlet. If all is well, you'll soon be enjoying great-sounding audio. ■

SHORTWAVE RECEIVERS

(Continued from page 56)

to other related pages. With that in mind, here are just a few pages featuring shortwave topics to get you started:

Radio Resources on the Internet is at the Web URL <http://metro.turnpike.net/~termcon/radio.html>. It lists lots of links, so it's a good place to begin your search for Web-based radio-hobbyist information (see Fig. 3). You can use its links to jump to other Web, FTP, and Gopher sites, as well as USENET newsgroups, mailservers, and lists.

The Radio Netherlands Receiver Data Bank is at <http://www.rnw.nl/rnw/en/pub/receiver.html> (see Fig. 4). The site offers an online compilation of numerous shortwave receiver reviews. Also, the Web page lists the Internet addresses of most receiver manufacturers.

Gilfer Shortwave, a major shortwave dealer, is at <http://www.pics.com/gilfer/> (Fig. 5). The page offers several useful features, including the ability to browse its "virtual store" and its online catalog.

The Shortwave Radio Catalog Web page is found at <http://itre.ncsu.edu/radio/>.

HamNet Companion, which we'll mention later, is at <http://www.web-com.com/~sjl/HamNet—Companion>.

Ham Radio Outlet, a major amateur and shortwave dealer, is at <http://www.hamradio.com/>.

Kenwood Communications can be found at the URL <http://www.accessnv.com/kenwood/amateur.html>.

Lowe Technical Services is yours for the browsing at <http://www.demon.co.uk/lowe/index.html>.

USENET Newsgroups: There are several shortwave and amateur-radio resources in Internet USENET newsgroups. Those are discussion groups that focus on specific subjects; they're the Internet equivalent of online-service and BBS forums.

You might find the discussions and information postings on several recreation and science newsgroups to be helpful in searching for a receiver. The most useful newsgroup to SWLs is rec.radio.shortwave. Other USENET newsgroups, most of them having to do with amateur radio, include the

ones shown in the "USENET Newsgroups" box.

FTP Sites: FTP, or File-Transfer Protocol, is a standard method of transferring files between computers on the Internet. FTP sites let you download from on-screen lists of files.

The ARRL Technical Information Service (TIS) has several downloadable text files that deal with equipment topics. You can access that service and other amateur-radio- and electronics-related information via BBS or America Online. Probably the easiest way to access the ARRL is by "anonymous FTP" on the Net. If you have FTP access, take a look at the oak.oakland.edu FTP site. There you will find the ARRL files in the "pub/hamradio/arrl/infoserver" directories; you also can reach the ARRL files at a second FTP address: mgate.arrl.org.

There are other, mostly amateur-radio-oriented FTP sites you can check for radio information. For starters, try these sites:

- ftp.cs.buffalo.edu/pub/ham-radio
- nic.funet.fi
- ftp.cri.com/users/ro/vhealey/www
- scitsc.wlv.ac.uk/pub/hamradio

AOL Ham Radio Club and CompuServe HamNet Forum: Check out the Ham Radio Club (Keyword: HAM or HAM RADIO) and ARRL areas (found in the Ham Radio Club) on America Online, or in the HamNet Forum (GO HAMNET) on CompuServe. The CompuServe HamNet Forum has swapshop and vintage-gear areas in which you can exchange messages and download software files; there's also a shortwave section. (The related HamNet Companion Internet Web page is at the URL <http://www.web-com.com/~sjl/HamNet—Companion>.)

CompuServe and America Online Classifieds: Both online services have classified advertising sections you can peruse for shortwave equipment. On CompuServe, GO CLASSIFIEDS; on America Online, use the Keyword: CLASSIFIEDS.

Conclusion. Choosing a shortwave radio that's right for you can be a formidable task. But, armed with the information in this article, and using the resources we suggested, you're at least halfway there. Good luck and happy listening! ■

BASS-REFLEX SPEAKER

(Continued from page 61)

box design to use for any particular driver we might have. The first is to look at the driver's sensitivity specification, if the manufacturer offers one. Usually, if the sensitivity is specified to be much above 92 dB/watt/meter, then the driver might best be used in a vented system; if it is much less than that, it might be better suited for use in a sealed box.

The second criterion is the driver's Q_s value. If it is less than about 0.4, or so, the driver is also probably best used in a vented box; if it is greater than that, it would perform better in a sealed box. And, finally, the best test of all is if we have access to another Thiele value, Q_{es} , the driver's electrical Q value. As Table 3 shows, if we take the value of f_s , which we already know from above, and divide it by the value of Q_{es} , and we get a number greater than about 50, then we have a driver that's best for a vented box. Otherwise, if the calculated value is much below 50, the driver would probably perform best in a sealed box instead.

Conclusion. Well, now with all this said, there is no reason that anyone with a little woodworking experience, and some patience, can't design and build a perfectly good set of speaker systems for the living room or bedroom. And save a bundle of money doing it! Good listening! ■

THE COLLECTED WORKS OF MOHAMMED ULLYES FIPS

#166—By Hugo Gernsback. Here is a collection of 21 April Fools Articles, reprinted from the pages of the magazines they appeared in, as a 74-page, 8½ × 11-inch book. The stories were written between 1933 and 1964. Some of the devices actually exist today. Others are just around the corner. All are fun and almost possible. Stories include the Cordless Radio Iron, The Visi-Talkie, Electronic Razor, 30-Day LP Record, Teleyeglasses and even Electronic Brain Servicing. Get your copy today. Ask for book #166 and include \$16.00 (includes shipping and handling) in the US and Canada, and order from CLAGGK Inc., P.O. Box 4099, Farmingdale, NY 11735-0793. Payment in US funds by US bank check or International Money Order. Allow 6-8 weeks for delivery. MA05



SOLID-STATE PENLIGHT

(Continued from page 44)

photograph is the clip to which the lead is soldered).

Next, make a lamp "button" from a piece of 1/32-inch-thick-plane epoxy board. Using a number-53 drill tip, drill two holes into the button, spacing

PARTS LIST FOR THE SOLID-STATE PENLIGHT

D1—1N4001 silicon rectifier diode
LED1—Ultrabright light-emitting diode, 5000-mcd intensity (Radio Shack part number 276-086 or equivalent)
B1, B2—1.5-volt AA alkaline battery
S1—SPST switch (part of penlight case)
Penlight with rear on-off switch (Radio Shack part number 61-2626 or equivalent), wire, solder, hardware, etc.

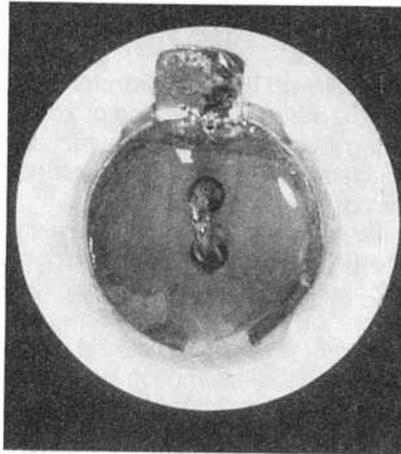


Fig. 3. This rear view of the plastic lamp assembly shows both the negative lamp clip (the metal square at the top) and the positive, bent diode lead (located in the center).

them about 3/32 inch apart. Epoxy that button in place at the rear of the assembly, and bend the positive or diode lead through it as shown in Fig. 3. That bent lead makes the positive connection to the batteries in the case.

Using the Penlight. Reassemble the Penlight and insert a set of fresh, alkaline AA batteries; the positive battery terminals must point toward the front. For best results, wipe the LED lens with a soft tissue before turning the unit on—even a small amount of dirt or dust on the lens will noticeably reduce the light output.

Tests performed by the author showed that the battery had an effective life of about 40 hours (with a 50% loss of brightness); however, the Penlight continued to light for over 4 weeks of continuous use. As you can imagine, the light output at the end of 4 weeks was too low for use as a flashlight, but it was still bright enough to read by!

Compare that to a test performed on an incandescent penlight. After only 20 minutes of use, the light intensity was down to about 50%. The filament burned out after 65 minutes of use. Quite a difference from the Solid-State Penlight!

If you'd like to test the fact that the Penlight helps you keep your night vision, try this simple experiment: Take a slip of newspaper, a regular penlight, and the Solid-State Penlight into a completely dark room. Wait five minutes for your eyes to become adapt-

ed to the dark. Then, turn on the Solid-State Penlight and read the slip of newspaper. You will find that, when you are finished, your eyes are still dark adapted (they should still be at near-maximum sensitivity). Next turn on the regular penlight and try it! When you are finished you will be nearly as night blind as you were when you began!

So, whether you like amateur astronomy, work in a photographic dark room, or just want a neat little light for emergencies, you'll find the Solid-State Penlight to be a perfect project to build. Have fun! ■

HANDS-ON REPORT

(Continued from page 23)

The cartridge included with the drive slides into a door in the front of the drive. A lever then must be switched into a locking position that prevents the cartridge from being removed at the wrong time. The cartridge can be removed only by pressing a stop button while the drive is running. That spins down the drive and prepares it for ejecting the disk. Cartridges can also be software locked to prevent removal unless a software unlock command is issued. In addition, cartridges can be write-protected after data is stored on them to prevent inadvertent deleting of files.

Once the drive is installed, the computer can be turned on. Most likely the computer's BIOS will report a setup error, allowing you to change CMOS settings for the installation of the new drive. Sometimes a BIOS will adjust itself automatically without worrying you about it. The drive is now ready to be loaded with software.

Now we're set with our removable hard drive. If you have a need to transport or back up large files, or are constantly running out of disk space, then the EZ135 might be just what you need. For more information, contact the manufacturer directly at the address given below, or circle 119 on the Free Information Card. ■

Vendor Information

SyQuest Technology, Inc.
47071 Bayside Parkway
Fremont, CA 94538

You don't
have to know
someone
really well
to give
the perfect gift.
In fact,
you don't have
to know them
at all.

Please give blood.
There's a life to be saved right now.

Call 1-800 GIVE LIFE

Ad
Council



American Red Cross

THINK TANK

(continued from page 64)

would squish some of the values at one end of its range.

MUDDY WATERS

A turbidimeter is a scientific instrument used to measure the cloudiness of solutions such as water. Cloudiness usually results because particles suspended in a liquid scatter light. Therefore, if you measure the amount of scattered light, you can measure the turbidity. Once you've built a turbidimeter (see Fig. 4A), you can use it to measure or monitor drinking water,

joint with a glue fillet followed by flat black paint. Paint the inside of the test-tube holder flat black also.

Glue a cadmium-sulfide photoresistor (R2) to a cardboard disc, and glue the assembly to the open end of the 90° tube. Next, cement a biconvex—curves outward on both sides—lens (also available at science/surplus places) to the bottom of the test-tube holder. Power up I1, a 12-volt, 1-amp automotive light bulb, and hold it at various distances below the biconvex lens. Find the distance at which a beam of light comes straight up the tube or converges slightly, but does not diverge. Mount the lamp and

played on the 100- μ A meter, and the resistors on the rotary switch set the sensitivity or attenuation. Power is supplied to the circuit by two 9-volt batteries in a split supply, and I run the lamp off a separate 12-volt supply.

If you want truly calibrated readings, you'll need to buy a turbidity standard solution, available in JTU (Jackson Turbidity Units) and NTU (Nephelos Turbidity Units) from a science-supply company. In operation, zero the meter to a clean-water blank, note the reading from a known standard, note the reading from the unknown sample, and calculate sample turbidity, based on the needle's

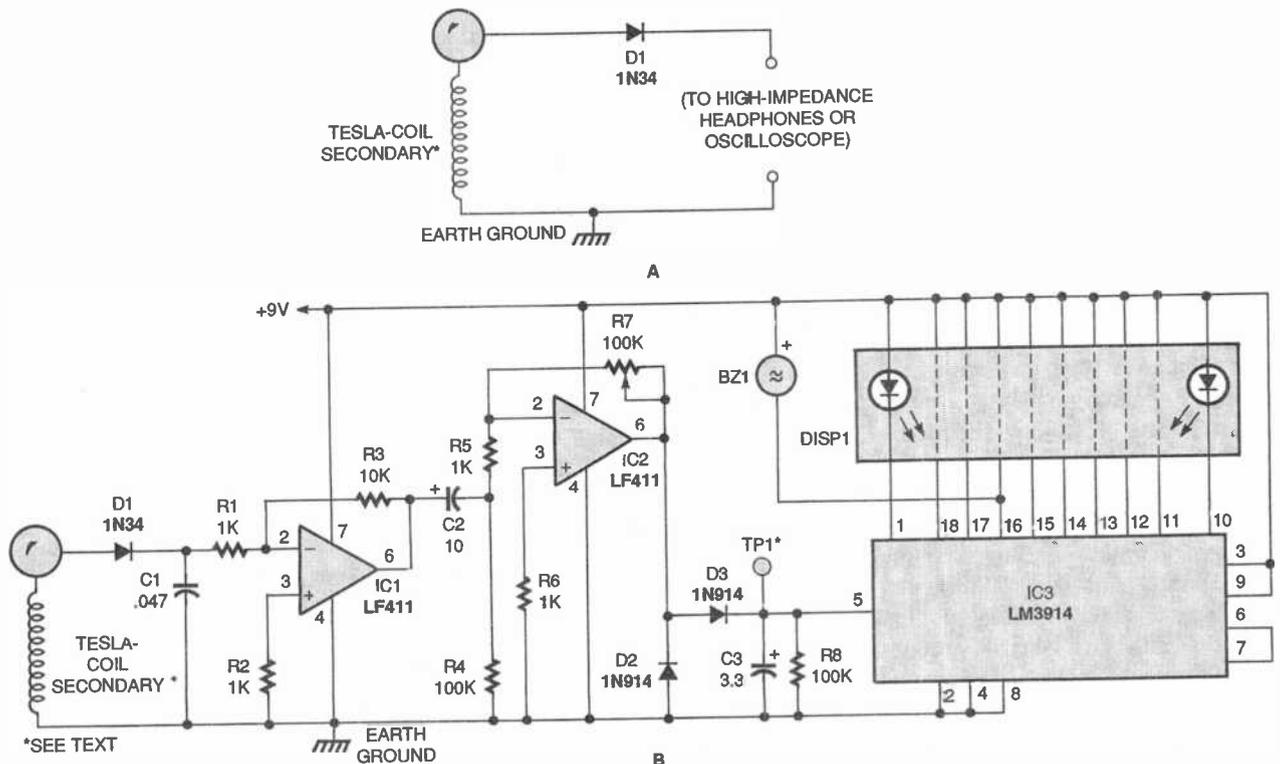


Fig. 5. You can use a Tesla-coil secondary as a simple receiver (A) or as a lightning indicator (B).

well water, rain water, river and lake water, pool water, etc.

Acquire a few flat-bottomed test tubes, available from scientific-surplus supply companies. Find a cardboard tube into which the tube just fits, or if unavailable, roll and glue a tube from paper around a test tube. In the center of the test-tube holder tube, cut a circular hole of roughly 1/2-inch diameter. Cut and shape another tube to fit perfectly over the hole you've made on the test-tube holder at a 90° angle, and glue it on (see Fig. 4B). Lightproof the

detector assembly in your chosen enclosure at the distance determined.

In operation, some of the light scattered by particles bounces down the 90° tube, lowering the photocell's resistance. The photocell is in a divider that provides a light-dependent voltage to IC1, an LF411 set up as a difference amp. The difference or subtracted voltage lets you zero the meter reading to clear water by adjusting the zero potentiometer. The output voltage is amplified by IC2, another LF411. The amplified voltage is dis-

position.

—Nick Cinquino, Schaumburg, IL

Very nice. Users should block ambient light from entering the test tube from above or adding to the bulb's light from below. That would prevent additional light from reaching the photocell, which would shift the unit's accuracy under different lighting conditions.

SECONDARY USES

A typical Tesla coil incorporates two coils, a primary and a secondary. The

primary coil, along with a capacitor, has a resonant frequency equaling the quarter-wave frequency of the secondary. The secondary coil is simply a very long length of enamel or plastic-insulated wire wound on a tube. It has a fairly sharp resonant frequency without a separate tank capacitor because the windings have a capacitance and resistance.

Part of the reason why Tesla developed the Tesla coil was to send RF energy from a powered coil to a distant coil with the same resonant frequency. So I started to wonder what would happen if I used the secondary as an RF receiver coil, without any tuning capacitor. The two circuits in Fig. 5 were developed as a result.

For safety's sake, if you have a Tesla coil, temporarily remove the secondary from its assembly to repeat these experiments. The thought of somebody inadvertently powering up the coil while you're connected to its secondary via headphones is really not funny. If you don't have a Tesla coil, you can make just the secondary for these circuits, and who knows, you might build a full Tesla coil around the secondary at a later time.

Here's a Tesla-coil-secondary recipe to try: Wind 750 turns of 24-gauge, enameled magnet wire onto an 18-inch-long piece of 1.9-inch-outer-diameter PVC pipe. The large coil has an inductance of about 2800-mH, with a self capacitance of about 20 pF. One end of the coil should be earth grounded. Put a metal ball like a drawer pull knob or door knob at the other end.

Now to attach it to a couple of circuits. In Fig. 5A we have a setup that resembles a crystal radio. The RF is detected by a 1N34 germanium diode, D1, and you will note that signal strength is high. What you should hear is one or possibly several AM radio stations, depending on the coil, the radio frequencies in your area, and distance to the transmitter(s).

The next circuit (Fig. 5B) is more useful than the first. There we have a circuit that monitors the RF resonating in the coil by lighting an LED bargraph display in response to signal strength. So, what signal do we want to monitor, you ask? Well, because Tesla coils are designed and built to make artificial

lightning, it is appropriate to use the secondary to monitor the RF from natural lightning. This circuit can be modified to count the number of flashes during a storm's passing, or record amplitudes as the storm approaches and passes your location.

Again, a 1N34 diode does the detecting. Integrated-circuit IC1, an LF411 FET op-amp, amplifies the signal a bit. Another LF411, IC2, adds more gain. The two 1N914 diodes, D2 and D3, rectify the signal; C3 and R8 smooth the signal for IC3, an LM3914 bargraph-display driver, which controls the 10-LED bargraph, DISP1. The low-voltage piezo beeper will work as a lightning alerter. When the bargraph hits the level that BZ1 is connected to, the beeper sounds letting you know you've got lightning approaching.

To use the circuit, connect test-point TP1 to an event counter, chart recorder, or oscilloscope. And that is all there is to it.

Now, if only the coil of this lightning detector could fit in a golfer's pocket!
—Nick Cinquino, Schaumburg, IL

Wow, now that's creative. The counting device idea is a nice touch. In his original drawing of Fig. 5B, Nick mentions that R6 should be adjusted so the first LED segment just lights up under clear conditions (that's the segment connected to pin 1 of IC3).

It's time to close this month. If you'd like to participate in an upcoming column, send a circuit drawing and letter to *Think Tank*, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735. If we print your letter, you'll receive a book from our library. Send in enough quality circuits to fill a column, and you'll get an electronic kit and a MCL1010 chip, too. ■



"It doesn't do anything, but it only cost me \$10 to build."

HAM RADIO

(continued from page 71)

AC LINE VOLTAGE

A reader wrote in to criticize my use of "110 volts" to refer to AC line voltage in the October 1995 column. He states that the U.S. standard has been 120 volts for many years, and while small motors are rated at 115 volts, light bulbs are rated at 120 volts and some appliances at 117.5 volts.

He is, of course, correct. However, the matter is actually moot. Why? Because everyone knows that what is meant is ordinary household AC current from an ordinary, regular wall socket, no matter whether the stated voltage is 110 volts, 115 volts, 117.5 volts, or 120 volts (all those are rms voltages, by the way). Whether I plug a light bulb, a small motor, an appliance, or a ham-radio set into the AC plug on the wall, they all see the same voltage no matter the rating on the label.

Another reason why it's no big deal was given in the October 1995 column: no matter what the specified voltage is, the actual voltage will vary considerably. As I stated in October, on my line-voltage monitor, I've seen 105 volts during summer heavy air-conditioning-use days, and as high as 128 volts at other times. Also, one fellow told me of seeing 95 volts rms during a summer "brown-out" (and, as Paul Harvey would say, the "rest of the story" is that the local power company was warning people in affected areas to turn off air conditioners and other heavy electric-current users). Most common electronic equipment is designed to operate normally over the 105- to 125-volt rms range without harm because of that normal variation.

CONNECTIONS

I can be reached by snail mail at P.O. Box 1099, Falls Church, VA, 22041, or by e-mail at carrij@aol.com. ■

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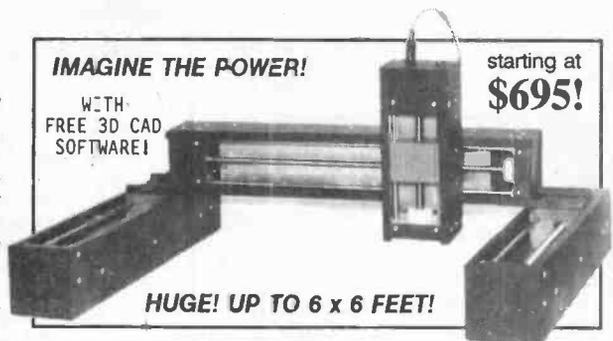
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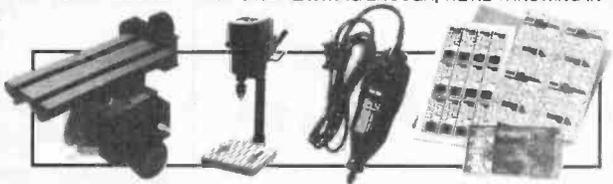
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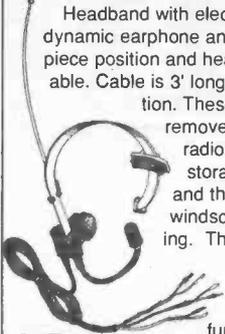
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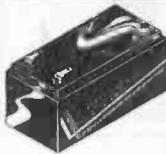
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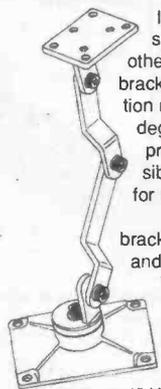
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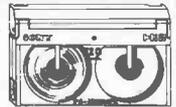
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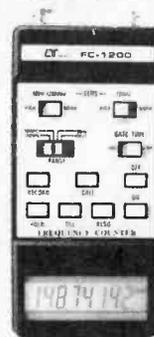


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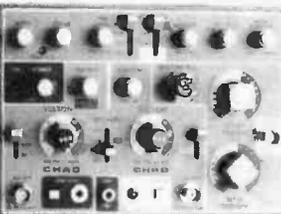
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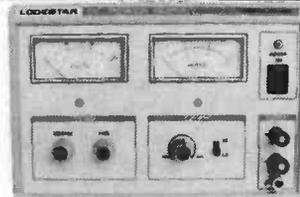
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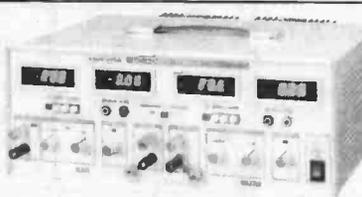


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PS-1000 100 MHz DUAL TRACE \$999.95
Scope Probe: 60MHz x1, x10 \$15, 100MHz x1, x10 \$22, 250MHz x1, x10 \$29, 250MHz x100 \$39

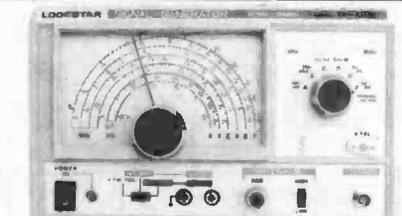
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0-30 VDC, 0-3A output
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Output 0-8Vrms sinewave
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Output impedance: 600 ohm

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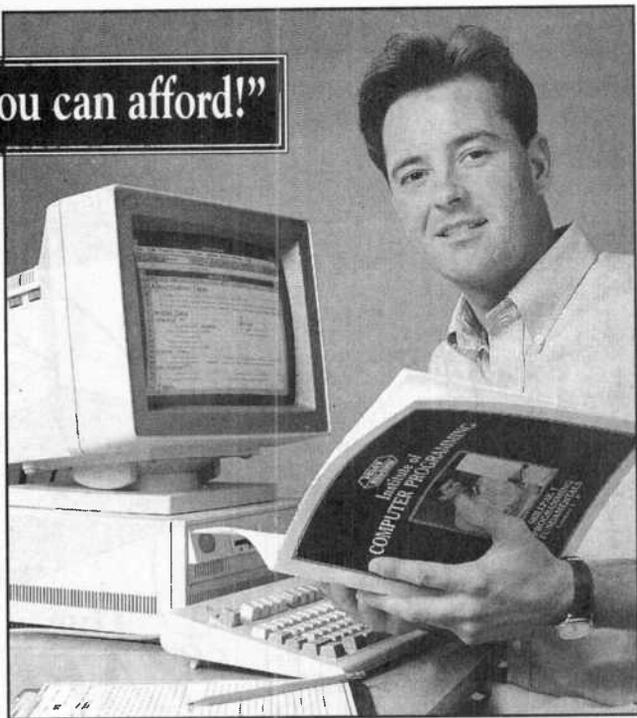
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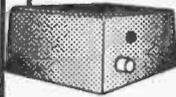
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FMST-100 Cabinet \$8.95 KIT \$29.95



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TEL-B1 BUILT \$29.95 KIT \$12.95

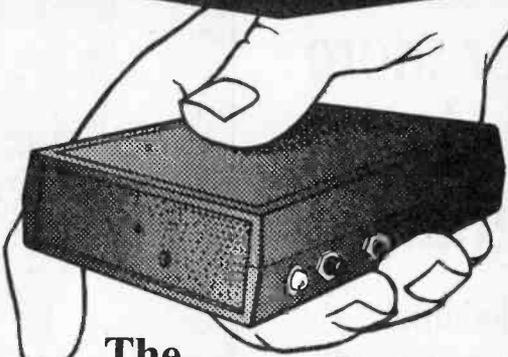


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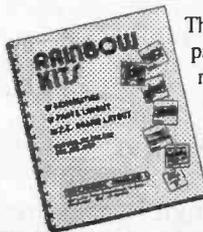
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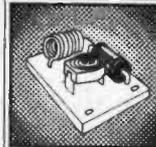


WIRELESS

FM MICROPHONE

Small but mighty this little jewel will out perform most units many times its price. It really stomps out a signal. The WM-2 kit is a buffered wireless mike that operates from 80MHz to 120MHz

FM, the frequency of any broadcast FM radio. Includes a mini-electret mike. 6 to 12v DC. SIZE: 1.25" x 1"
WM-2 KIT \$14.95



MICRO-MINIATURE PHONE TRANSMITTER

We haven't seen a smaller phone transmitter than the MMPT2 kit. Powered by the phone, it requires no battery. Transmits both sides of a phone conversation to an FM radio up to a 1/4 mile away. Tunable from 88 to 108MHz FM. Attach it to one phone or add it to the line to pick up all incoming calls. The MMPT2 is undetectable if properly installed. Unit has surface mounted parts, you install the leaded parts. Size .45" x .6"

MMPT2 KIT \$29.95



MICRO-MINIATURE WIRELESS MIKE

So small you could hide this one on some real bugs! It's the smallest we've ever seen. With it's super sensitive mike it transmits a whisper or a room of conversation to an FM radio, tunable from 88 to 108MHz FM. With a proper antenna it transmits about 1/2 mile. The kit is made with surface mounted parts, we have already mounted these parts. You install the leaded parts. Power requirement 6 to 12v DC. Size .35"x.9"

MMWM5 KIT \$34.95



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Power requirement 6 or 12v DC. Size 3.5"x1.9"
ST-1 KIT \$11.95



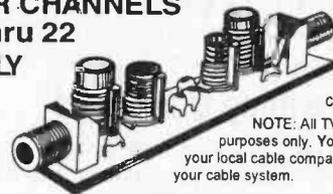
Press a button and learn every number dialed on your phone

Okay. Caller ID's tell you what number is calling you. But what about the calls made from your phone? Now, return from work or vacation and know the answer. The new DTMF Recorder electronically logs and saves every number dialed. This is the same high-tech magic used by detectives and government spies. Now yours. Does your wife or husband make expensive long -distance calls and then deny it? Does your son or daughter call that low-life you forbade them to talk to? Now know.

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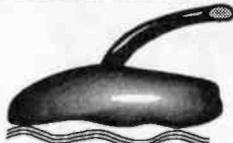


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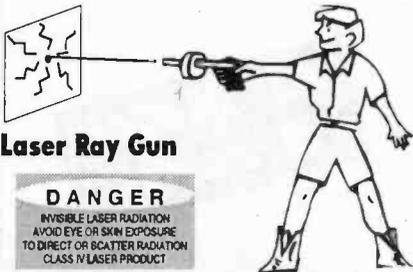
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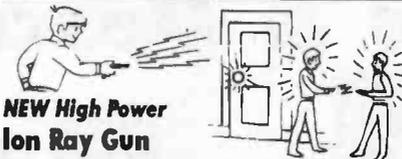
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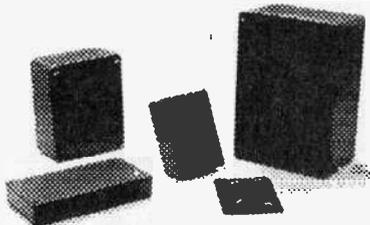
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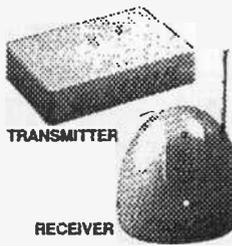
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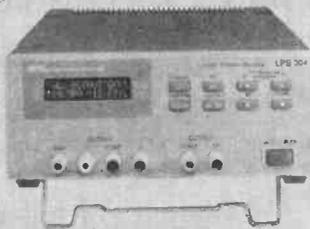
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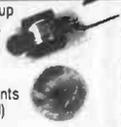
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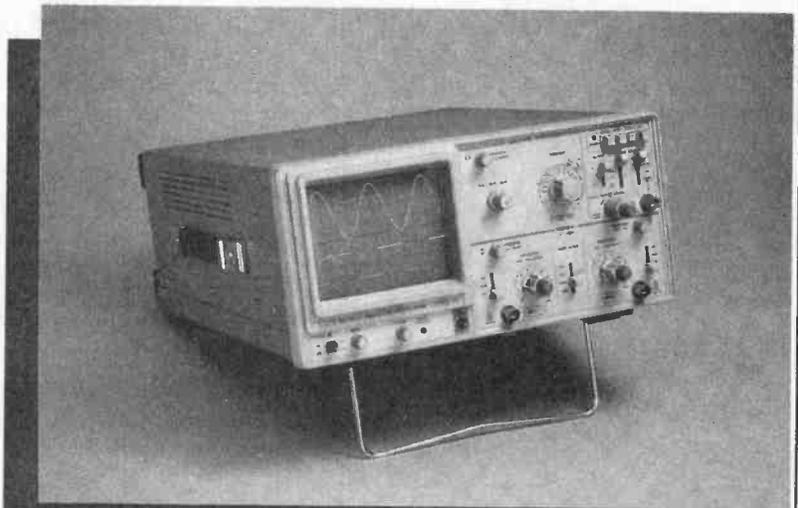


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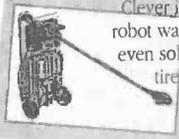
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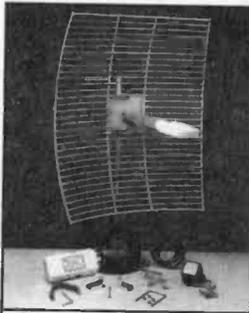
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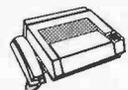


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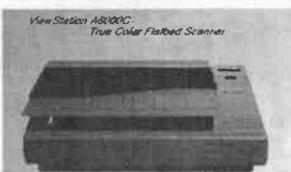
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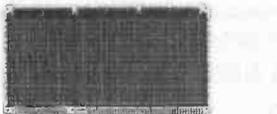
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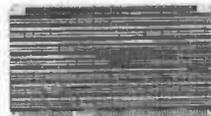
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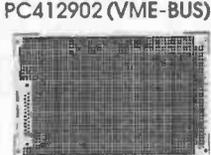
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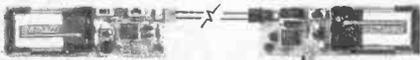
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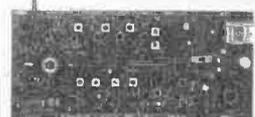


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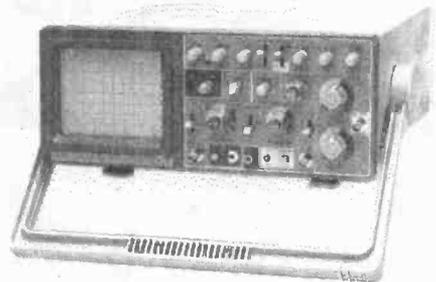
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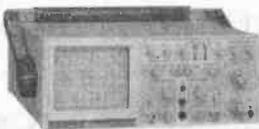
| ANALOG | | Sensitivity (max) | No. of Channels | Sweep Rate Max ns/div | Delayed Sweep | Video Sync | Component Tester | Beam Find | Time Base |
|--------|------------------|----------------------|--------------------|--------------------------|------------------|---------------|---------------------|--------------|--------------|
| Model | Bandwidth MHz | | | | | | | | |
| S-1365 | 60 | 1mV/div | 2 | 10ns/div | Yes | Yes | Yes | Yes | 2 |
| S-1360 | 60 | 1mV/div | 2 | 10ns/div | Yes | Yes | Yes | Yes | 2 |
| S-1345 | 40 | 1mV/div | 2 | 10ns/div | Yes | Yes | Yes | Yes | 2 |
| S-1340 | 40 | 1mV/div | 2 | 10ns/div | No | Yes | No | No | 1 |
| S-1330 | 25 | 1mV/div | 2 | 10ns/div | Yes | Yes | Yes | Yes | 2 |
| S-1325 | 25 | 1mV/div | 2 | 10ns/div | No | Yes | No | No | 1 |

| DIGITAL STORAGE | | Analog Sen (max) | No. of Channels | Sampling Rate | Memory Channel | Internally Backed Up | Pretigger % | Output |
|-----------------|------------------|---------------------|--------------------|------------------|-------------------|-------------------------|----------------|--------|
| Model | Bandwidth MHz | | | | | | | |
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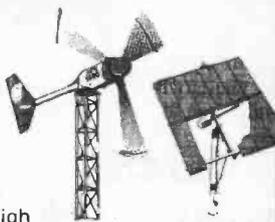
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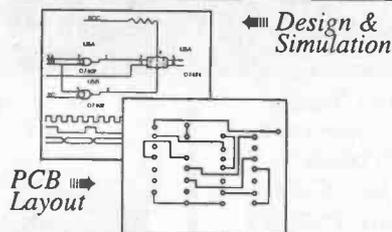
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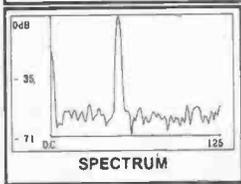
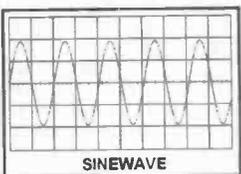
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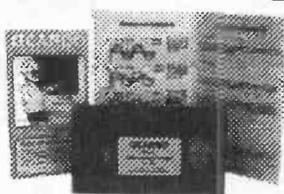


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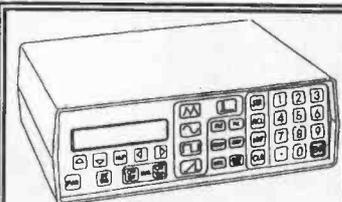
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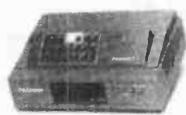
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USE POPULAR ELECTRONICS CLASSIFIEDS

READ BY BUYERS OF ELECTRONIC EQUIPMENT ACCESSORIES AND PARTS

INSTRUCTIONS FOR PLACING YOUR AD!

HOW TO WRITE YOUR AD

TYPE or **PRINT** your classified ad copy **CLEARLY** (not in all capitals) using the form below. If you wish to place more than one ad, use a separate sheet for each additional one (a photo copy of this form will work as well). Place a category number in the space at the top of the order form (special categories are available). If you do not specify a category, we will place your ad under miscellaneous or whatever section we deem most appropriate.

We cannot bill for classified ads. **PAYMENT IN FULL MUST ACCOMPANY YOUR ORDER.** We do permit repeat ads or multiple ads in the same issue, but, in all cases, full payment must accompany your order.

WHAT WE DO

The first word and company name of each ad are set in bold caps at no extra charge. No special positioning, centering, dots, extra space, etc. can be accommodated.

RATES

Our classified ad rate is \$1.75 per word. Minimum charge is \$26.25 per ad per insertion (15 words). Any words that you want set in bold are each .40 extra. Indicate bold words by underlining. Words normally written in all caps and accepted abbreviations are not charged anything additional. State abbreviations must be post office 2-letter abbreviations. A phone number is one word.

If you use a **Box** number you must include your permanent address and phone number for our files. **ADS SUBMITTED WITHOUT THIS INFORMATION WILL NOT BE ACCEPTED.**

For firms or individuals offering Commercial products or Services. **Minimum 15 Words.** 5% discount for same ad in 6 issues within one year; 10% discount for same ad in 12 issues. **Boldface (not available as all caps), add .40 per word additional. Entire ad in boldface, add 20%. Tint screen behind entire ad, add 25%. Tint screen plus all boldface ad, add 45%. Expanded type ad, add \$2.25 per word.**

General Information: A copy of your ad must be in our hands by the 13th of the fourth month preceding the date of issue (i.e. Sept issue copy must be received by May 13th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding work day. Send for the classified brochure.

DEADLINES

Ads not received by our closing date will run in the next issue. For example, ads received by November 13 will appear in the March issue that is on sale January 17. **POPULAR ELECTRONICS** is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. **NO REFUNDS, advertising credit only. No phone orders.**

CONTENT

All classified advertising in **POPULAR ELECTRONICS** is limited to electronics items only. All ads are subject to the publishers approval. **WE RESERVE THE RIGHT TO REJECT OR EDIT ALL ADS.**

AD RATES: \$1.75 per word, Minimum \$26.25

Send you ad payments to:

POPULAR ELECTRONICS 500 Bi-County Blvd, Farmingdale, NY 11735-3931

CATEGORIES

| | | | |
|-------------------------------|----------------------------------|---|----------------------------|
| 100 -- Antique Electronics | 270 -- Computer Equipment Wanted | 450 -- Ham Gear Wanted | 630 -- Repairs-Services |
| 130 -- Audio-Video Lasers | 300 -- Computer Hardware | 480 -- Miscellaneous Electronics For Sale | 660 -- Satellite Equipment |
| 160 -- Business Opportunities | 330 -- Computer Software | 510 -- Miscellaneous Electronics Wanted | 690 -- Security |
| 190 -- Cable TV | 360 -- Education | 540 -- Music & Accessories | 710 -- Telephone |
| 210 -- CB-Scanners | 390 -- FAX | 570 -- Plans-Kits-Schematics | 720 -- Test Equipment |
| 240 -- Components | 420 -- Ham Gear For Sale | 600 -- Publications | 730 -- Wanted |

CLASSIFIED AD COPY ORDER FORM

Place this ad in Category # _____

Special Category \$20.00 Additional _____

| | | | | | | | |
|---------------|--------------|---------------|---------------|-----------------------|--------------|----------------------------|--------------|
| 1 - \$26.25 | 2 - \$26.25 | 3 - \$26.25 | 4 - \$26.25 | 29 - \$50.75 | 30 - \$52.50 | 31 - \$ 54.25 | 32 - \$56.00 |
| 5 - \$26.25 | 6 - \$26.25 | 7 - \$26.25 | 8 - \$26.25 | 33 - \$57.75 | 34 - \$59.50 | 35 - \$61.25 | 36 - \$63.00 |
| 9 - \$26.25 | 10 - \$26.25 | 11 - \$26.25 | 12 - \$ 26.25 | 37 - \$64.75 | 38 - \$66.50 | 39 - \$68.25 | 40 - \$70.00 |
| 13 - \$26.25 | 14 - \$26.25 | 15 - \$26.25 | 16 - \$28.00 | Total words _____ | | \$1.75 per word = \$ _____ | |
| 17 - \$29.75 | 18 - \$31.50 | 19 - \$ 33.25 | 20 - \$35.00 | Bold Face _____ | | \$0.40 per word = \$ _____ | |
| 21 - \$36.75 | 22 - \$38.50 | 23 - \$40.25 | 24 - \$42.00 | Special Heading _____ | | \$20.00 = \$ _____ | |
| 25 - \$ 43.75 | 26 - \$45.50 | 27 - \$47.25 | 28 - \$49.00 | Other _____ | | = \$ _____ | |

Total classified ad payment \$ _____ enclosed

TOTAL COST OF AD \$ _____

Check Mastercard Visa

Card # _____ Expiration Date ____/____

Signature _____

Name _____ Phone _____

Address _____ City State Zip _____

EPROM+ PROGRAMMING SYSTEM USES PARALLEL PORT

EPROMS (24,28,32 & 40 PIN)*+27C AND 25XX
1702*, 2708, TMS2716*, 32,32A, 64, 64A, 128, 128A
256, 512, 513, 011, 010, 101, 1001, 1000, 1024, 210, 020
2001, 220, 2048, 4001/2, 040, 080, 240, 4096, 68764/66
FLASH EPROMS 28F256, 28F512, 28F010
28F020, 29C257, 29C010, 29C040, 29F010, 29F040
EEPROMS & NVRAMS (18,24 & 28 PIN+CXX)
2210, 2212, 2804, 2816, 2816A, 2817, 2864, 2865
28256, 28C010, DS1220, DS1225, DS1230
SERIAL EPROMS* (8 & 14 PIN PLUS CXX)
ER1400, M58657, 2401, 02, 04, 08, 16, 32, 65, 2444
59C11, 80011A, 9306, 46, 56, 66, 8572, 82, 92, 168/9XX
BIPOLAR PROMS* (16 THROUGH 24 PINS)
74SXXX AND 82SXXX FAMILY
MICROCONTROLLERS* 8741, 42, 48, 49, 8751
C51, 52, C52, 87C5XXX, 87C75X, 89C5X, 68705
68HC705, 68HC711E9, PIC16CXX, TMS7742

*ADAPTER REQUIRED - DIAGRAMS INCLUDED

SOFTWARE - READ, VERIFY, PROGRAM, COPY
DISK FILE LOAD/SAVE, CHECKSUM, FULL
SCREEN BUFFER EDITOR W/20 COMMANDS
READS HEX, S-RECORD AND BINARY FILES
FAST-DEVICES PROGRAM IN UNDER 20 SEC
RUGGED (9"X6"X3") ENCLOSURE W/HANDLE
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SYSTEM INCLUDES:
PROGRAMMING UNIT
PRINTER PORT CABLE
POWER PACK, MANUAL
AND SOFTWARE.

\$289

ADD \$5.00 SHIPPING
\$5.00 C.O.D.
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800-SMART-HOME Call 24hrs for FREE 64 page Color Catalog **Over 500 unique products!**

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CABLE TV CONVERTERS

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Wholesalers Welcome
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SAVE 40% - 60%
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Be a PC repair expert!

Approved home study. Learn to troubleshoot, repair, install, upgrade, and service computers.
Free literature: 800-223-4542

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Address _____ Phone (____) _____
City/State _____ Zip _____
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8065 Roswell Road, Atlanta, Georgia 30328

PROFESSIONAL COUNTERSURVEILLANCE EQUIPMENT

**A1 6600
Phone Tap Detector**
Detects:
•Radio Frequency Taps
•Series and Parallel Taps
•Line Impedance Taps
•Extension Phone Listeners
\$149.95

**A1 2100
VIBRATING TRANSMITTER
DETECTOR**
Detects:
•Body Wires
•FM Wireless Mics
•AM Transmitters
•UHF Transmitters
\$189.95

**A1 5500
COMPLETE SAFETY SYSTEM**
Detects:
•All Phone Taps and Extension
Phone Listeners
•All Body-Wires, Wireless Mics, AM, FM
and UHF Transmitters
Detects:
•All Body Wires, Transmitters and
Distance Microphones with its built in
white noise signal breaker
\$379.95

CABLE TV

**Universal Descrambler
NEW PRODUCT**

UNIVERSAL 5000 \$199.95
Our fully assembled product is factory tested and **GUARANTEED** to work on your system.

MODEL 4000 KIT \$ 79.95
The 4000 KIT comes with all the electronic parts and our Cad designed PC board. We provide parts list, full schmatic, wiring diagram and tutorial.

MODEL 4000A Enclosure \$ 44.95
The 4000A Enc. Package will provide the hobbyist, who has our 4000 Kit, a custom enclosure, AC adaptor and finish accessories to enclose their kit.

MODEL 4000 And 5000 Features

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- **NO CONVERTER BOX** is necessary.

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- COMPREHENSIVE REPLACEMENT PARTS LISTS
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Yes, Please rush me my copy of Electronics Repair Manual for only \$59.95 (I may take \$10 off the price when I enclose my check or credit card authorization with my order within the next 30 days. Plus, I get free shipping and handling!) I understand that if I am not satisfied I may return the book within 30 days for a full 100% refund of the purchase price.

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Optional express delivery (available in U.S. only). Enclose an additional \$10.00 and we'll guarantee delivery within 5 business days from receipt of your order (prepaid orders only).

Credit card no.

Expiration Date Daytime phone no.

Signature

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Company

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City State Zip

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April 1996, Popular Electronics

CABLE TV DESCRAMBLER KITS

Universal-New Product

This Product includes all the Parts, PC Board, Complete Schematic with Functional Guide. Generates Sync for most Video Applications.

\$79.95

Tri-Mode Descrambler

This product includes all the parts PC Board and AC Adaptor. NO Enclosure included.

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SB-3 Descrambler

This Product includes all the Parts, PC Board and AC Adaptor. Enclosure is not included.

\$44.95



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M & G Electronics, P.O. Box 3310, No. Attleboro Mass. 02761



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Pro-Kit™

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Home Automation

Connects between a TW523 and an RS-232 serial port. Use your computer to receive and transmit all X-10 commands. Create your own program to control your home automation system, turning on/off any device plugged into an electrical outlet with response to time/date, or another X-10 transmission. \$38.50

Caller ID / RS-232

Connects between a telephone wall jack and an RS-232 serial port. Decodes the caller ID data sent over the phone line and sends it to your computer in a pre-formatted ASCII character string. Create your own program to log the name, number, date, time of all incoming calls. \$34.50

Telephone Call Restrictor

Connects to telephone wall jack. Disables all phones on the line if attempting to either: dial a number that has been stored in memory "Block Mode" or, dial a number that has not been stored in memory "Allow Mode". Use touch-tone phone to enter telephone numbers into memory, and choose mode. Program from any phone on the line using your password. \$35.00

50 MHz Frequency Counter

Reads frequency from 1Hz to 50MHz and displays it on a 16x1 character LCD display. Auto-range feature provides floating decimal point and automatically affixes the correct suffix (Hz, KHz, or MHz). Microcontroller based, very few additional components. \$48.50

Telephone Scrambler

Scrambles your voice before sending it over the telephone line, and descrambles it on the other end. Connects between your telephone and wall jack. No modifications are required to your telephone. Full duplex operation. \$43.00

IR Remote Control Receiver

Learns and records the data patterns emitted by standard infrared remote controls used by TVs, VCRs, Stereos, etc. Lets you control all your electronic projects with your TV remote. Seven individual I/O pins can be assigned to any button on your remote, and can be configured for either "toggle" or "momentary" action. \$32.00

Vocal Filter

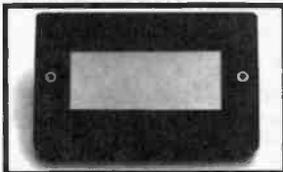
An audio device which can be used with a home component stereo system, to filter out the main vocal sound track from standard stereo recordings (CD, tape, record or FM), leaving the background music to sing along with. Produce your own karaoke tapes. \$39.00

DTMF Decoder/Logger

Keep track of all numbers dialed or entered from any phone on your line. Connects to your telephone wall jack. Decodes all 16 touch-tones and displays them on an LCD display. Holds the last 240 digits in a nonvolatile memory. Scroll through and view all telephone numbers dialed, credit card numbers entered, etc. \$54.50

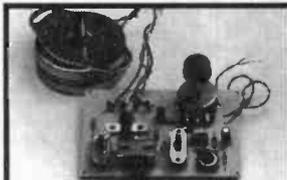
BLACK FEATHER ELECTRONICS

3 1/2 Digit LCD Panel Meter



Features: 200mV full scale input 9VDC operation. Decimal point selectable. 13mm digit height, auto polarity indication, zero reading for 0 volt input. Measures 2.67" x 1.73" x 0.28" above panel thickness, 0.57" overall thickness. LCD size: 1.83" x 0.8". Has many useful applications and is easy to install.
CAT# PM-1 **\$9.95 each**

Stepper Motor Controller Kit



This kit allows you to adjust the speed and direction of a stepper motor. You can move the motor in one step increments or rotate it at a constant speed. Visual indicators show the sequence of motion. Includes stepper motor, pc board, parts and instructions. (12vdc power source not included.)
CAT# SMK-1 **\$25.00 each**

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HI-8 120 MINUTE TAPE (used)
They were recorded on once and played only a few times. Made by a major brand name manufacturer. Professional series metal tapes. Includes plastic jewel box.
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10 or more - **2.80 ea**
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2. Visa, MC, & money orders accepted
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4. Shipping \$4.⁹⁵ & up.



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3,000,000 matches.



One match can burn
3,000,000 trees.



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You Go
DEPENDS ON
WHERE
You GET YOUR
START.**

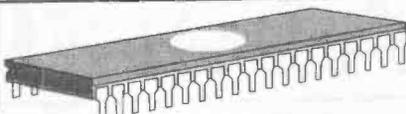


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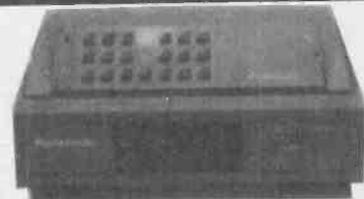


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OR YOUR MONEY BACK!**

BEST PRICES FREE CATALOG

Please have the MAKE & MODEL # of your full
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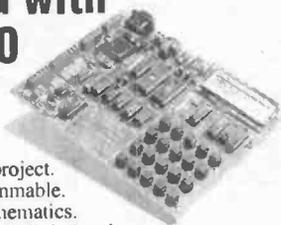
ALLSTAR ELECTRONICS

800-782-7214

HOURS: 9-6 M-F 10-3 Sat EST

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The AES-10... a complete learning system, a complete embedded control system. Extensive manuals guide you through your 8051 development project. Assembly, BASIC, and C programmable. All hardware details, complete schematics. Learn to program the LCD, keypad, digital and analog I/Os. The entire board is software reconfigurable for your applications. Everything you need, nothing extra required.

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CLASSIFIED

PLANS-KITS-SCHEMATICS

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All-in-one catalog. AM/FM/ham/spy, transmitters, amplifiers, receivers. Voice scramblers/disguisers, audio, TV, Tesla coils, plans, "secret" books, kits, imports, exports and more. Start your own licensed or unlicensed radio station, 60 full pages for \$1.00. **PAN-COM INTERNATIONAL**, PO Box 130-H4, Paradise, CA 95967.

FIBER optic educational experiments kit. Includes: Tutorial, w/experiments, 40ft fiber assortment, + cutting tool. \$19.95 + S/H (609) 468-1660.

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HEATH COMPANY is selling photocopies of most Heathkit manuals. Only authorized source for copyright manuals. Phone: (616) 925-5899, 8-4 ET.

GREEN Thumb alert — Electronics enters the garden! New exciting book points out how gardeners can build simple gadgets to promote success where the elements work against you. Some of the projects are: over/under temperature monitoring, dusk/dawn switching, automatic plant watering, warming cables, etc. "Electronic Projects for the Garden" only \$9.95 (price includes shipping) **ELECTRONICS TECHNOLOGY TODAY, Inc.**, PO Box 240, Massapequa Park, NY 11762-0240.

SILENT SAM Turn Signal Reminder. This patented reminder keeps you from going down the road flashing, inadvertently. Just \$30.00 postpaid. Visa/MC, 30 day money back guarantee. Great gift for that forgetful someone. Literature available. Toll Free 1 (800) 398-5605.

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AUDIO-VIDEO-LASERS

FREE Catalog on Hi-tech electronic products. Write: **JP SPECIALTIES**, Dept. PE4, 401 South 29th, McAllen, TX 78501.

VIEW Color Negatives on TV. Use your light box and camcorder with the **Video Inverter** to see positive color images. Kit \$69.95. PC Board & plans \$29.95. Send Check/MO/Visa/MC to **J. SOUSA**, 38 Cornish Street, Lawrence, MA 01841-1226.

CABLE TV

"BULLET Buster." Protect your cable box against the infamous cable "bullet." The "Bullet" Buster acts as an electronic shield. Installs in-line in seconds. Don't wait until it's too late! \$19.95 + \$3.00 S&H. Visa/MC/Amex. **ELECTROMAN**, Box 24474, New Orleans, LA 70184. (504) 482-3017.

CABLE —safe. Guarantee cable privacy. The one way valve for your cable TV signal. Cable signals come in, but they don't go out! \$29.95, + \$3.00 S&H. Visa/MC/Amex. **ELECTROMAN**, Box 24474, New Orleans, LA 70184. (504) 482-3017.

CABLE unscrambled. Everything you want to know about cable, but are afraid to ask. \$10.00. Visa/MC/Amex. **ELECTROMAN**, Box 24474, New Orleans, LA 70184. (504) 482-3017.

"DESCRAMBLER Schematics Revealed." A powerful guide to descrambling schemes. \$10.00. Visa/MC/Amex. **ELECTROMAN**, Box 24474, New Orleans, LA 70184. (504) 482-3017.

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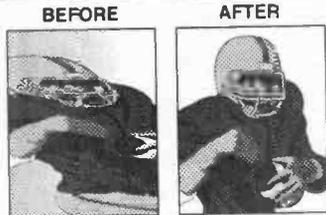
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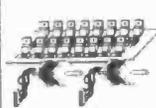
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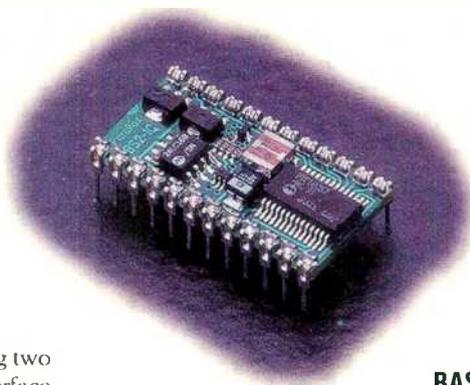


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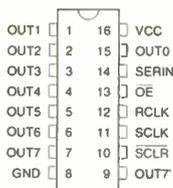
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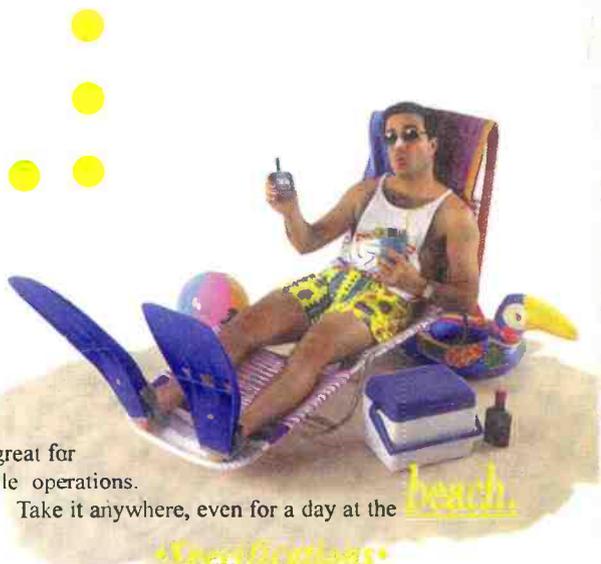
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