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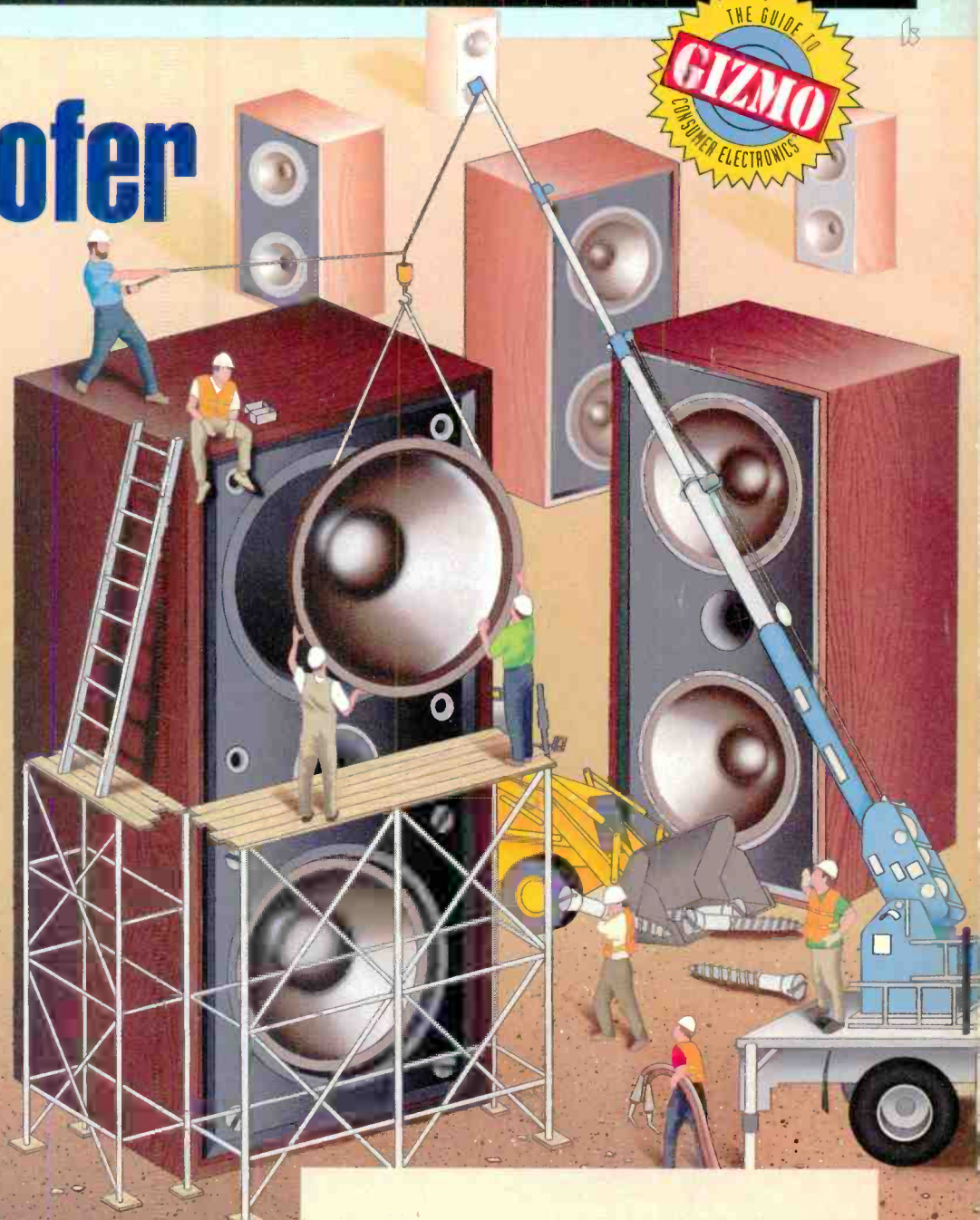

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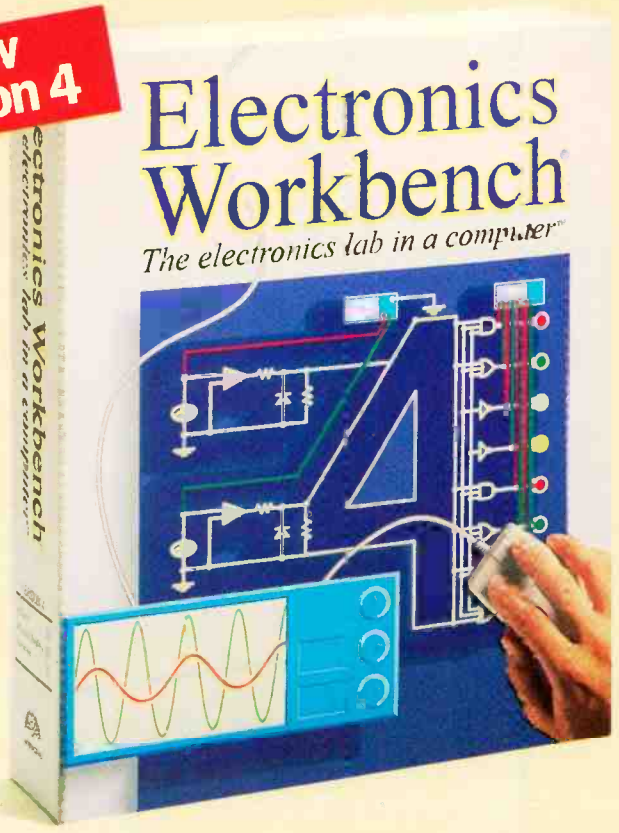

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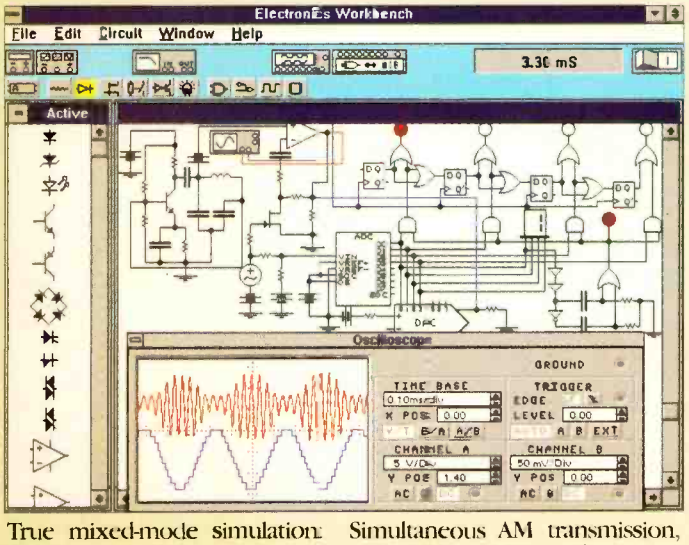

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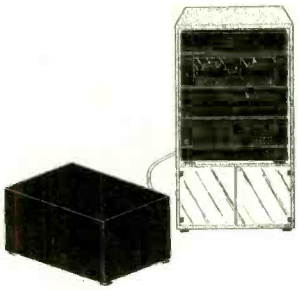

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EDITORIAL

A DBS ALTERNATIVE

Regular readers of my editorials might recall that earlier this year I dumped my cable service in favor of the DSS direct-broadcast satellite (DBS) system (see Editorial, February and March 1995). I've had the system for a while now, and I am as happy with it as I was the day I got it.

But that's not what we are going to talk about this month. Instead, we are going to turn our attention to another DBS system—Primestar. For those not familiar with it, Primestar was actually the first digital DBS service provider, and while DSS has, at least for the time being, passed it in size, Primestar has also shown dramatic growth over the past year.

Primestar and DSS probably have more in common than either would like to admit, but there are also some significant differences. Those differences might make one or the other more suitable for your needs.

The most glaring difference, and perhaps Primestar's chief advantage, is initial cost. If you want DSS, you must buy the hardware, then either pay for installation or install it yourself. With Primestar, you pay only an installation charge that varies by location. The installation charge is required because Primestar does not allow consumers to install the equipment themselves.

On the negative side of the ledger, Primestar's monthly fee for programming (which includes a charge for equipment rental) is slightly higher than that of DSS, and the service offers significantly fewer channels. Then again, Primestar's 70 channels might be more than enough for you!

In any event, if you are considering going the DBS route, Primestar represents a viable, and often more-practical alternative for many. This month, our Gizmo section takes a closer look at the Primestar system. Discussed are its strengths, weaknesses, costs, and much more. The story begins on page 9.

Carl Laron
Editor

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LETTERS

SQUARE-WAVE CORRECTION

I am writing in regard to Joseph Carr's article, "Making Square Waves at Home" (**Popular Electronics**, March 1995). Mr. Carr says that a square wave contains "only even-order harmonics." That is contrary to everything that I learned when I got my engineering degree. My training was that square waves were composed mainly of odd-order harmonics, while even-order harmonics produced triangular waveforms. Other engineers in my work group are in agreement that this is still true.

To test this theory, I checked the signal on an HP3585B low-frequency spectrum analyzer with the HP3325B synthesis/function generator as the square-wave source. The test frequency was 1 kHz, and the spectrum analyzer was set to a start frequency of 1 kHz and a stop frequency of 21 kHz. Sure enough, the peaks of the displayed signal were on the vertical graticule lines at 3 kHz, 5 kHz, 7 kHz, etc.

I have subscribed to many electronics publications over the past 40 years, including **Popular Electronics**, and have from time to time noticed some minor errors. To state that square waves are composed of even-order harmonics is more than a minor error—it's just plain wrong.

B.R.
Sunnyvale, CA

You are correct, and my article is wrong: Square waves are made up of odd-order *harmonics (3f, 5f, ...), not even-order (2f, 4f, ...) as stated. What bothers me the most about the mistake is that I've known the correct information since high school (late 1950s).*

The general rules are:

1. A waveform with symmetry across the zero axis has no DC component.

2. A waveform with half-wave symmetry (such as a square wave) has no even harmonics.

3. In a waveform with quarter-wave symmetry, but not necessarily half-wave symmetry, any odd-order harmonics present are in phase with the fundamental.

Sorry about the error.—JOSEPH CARR

SORRY, WRONG NUMBER

*There was an error made in the phone number listed for requesting Jensen Electronics' catalog (***Popular Electronics***,* Electronics Library, *March 1995). The correct number for phone requests is 1-800-426-1194. We're sorry for any inconvenience that this may have caused.—Editor*

$20 MINIMUM

*In the article, "Build a Solar Airplane" (***Popular Electronics***, February 1995), Kelvin Electronics (10 Hub Drive, Melville, NY 11747; Tel: 516-756-1750) was referenced as a source for parts. While the total cost for the parts required for that project is about $13, we have since become aware that Kelvin's policy requires a minimum order of $20. While Kelvin is a good source for a variety of hobbyist needs—soldering-iron tips, hobby-knife blades, test equipment, electronic components, and more—we nevertheless recognize that meeting that minimum could be a problem for some. We apologize for any inconvenience.—MARC SPIWAK*

CURRENT-CROWBAR CIRCUITS RE-EXAMINED

The discussion of current limiting and foldback current versus the current crowbar ("Current-Crowbar Circuits," **Popular Electronics**, April 1995) was extremely interesting, but a major protection-failure mode was completely ignored.

When the main high-current series-pass transistor, Q1, develops a collector-to-emitter short, essentially all of the regulator input voltage will be passed on to the output terminals. The over-voltage has the capability of doing great harm to the connected load if, for example, it was 5-volt logic circuitry.

The cute cartoon depicting a mechanical crowbar removing the power cord from the wall outlet is *not* true for the case described in Mr. Kaliangile's article. A true crowbar circuit will prevent over-voltage damage to the load. When Q1 develops an emitter-load short, a true crowbar circuit will blow either a primary circuit fuse or a secondary fuse—a small price to pay for not damaging the load.

The case in which the load represents a short on the power supply is only one of the protection modes to be considered. The most important protection mode—against over-voltage due to regulator failure—was not mentioned in the article. A true crowbar circuit incorporates such protection.

W.E.P.
Columbus, OH

HAVES & NEEDS

I am looking for service information on a Hanimex model 2818B AM/FM/CB portable radio (or another, similar, radio for reference). I also need a source for Goldstar TV parts.

KEITH TONA, N9PQU
741 Oconto Avenue
Peshtigo, WI 54157

I would appreciate any help in locating service literature for a Jerrold P.A. amplifier model CAP 40T. I would gladly pay copying and postage costs.

I would also like to find someone with software for the Atari 800XL computer.

J. H. SOUSER
511 West Wayne Street
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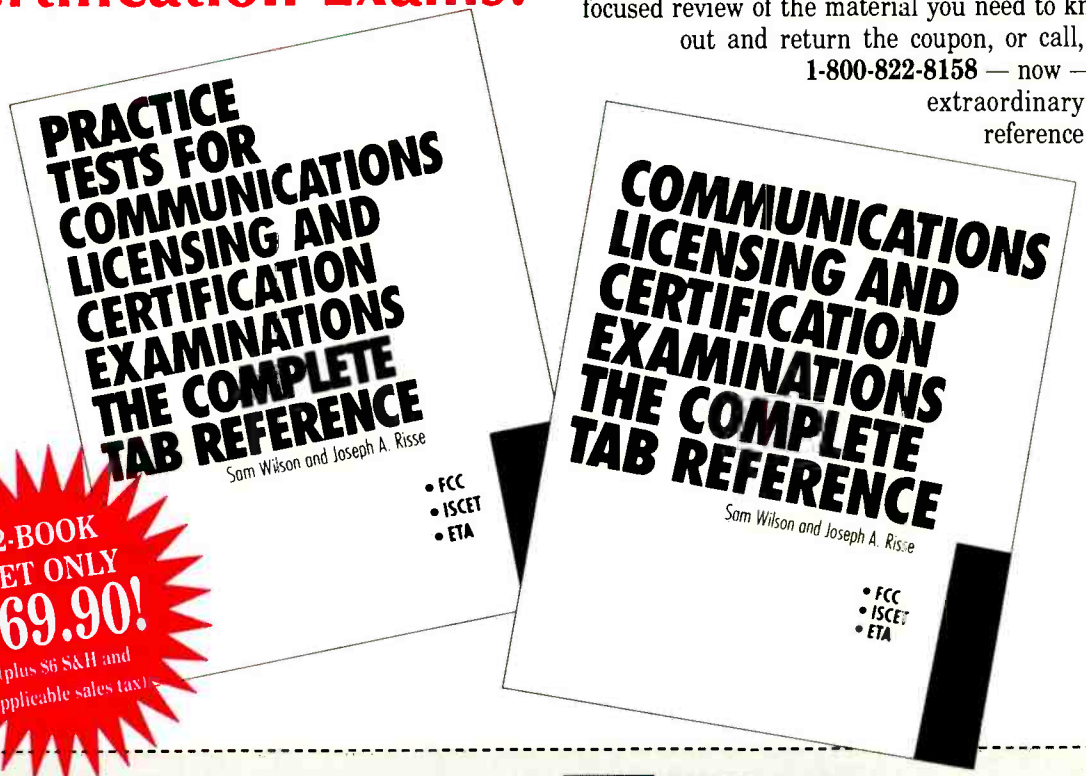

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NEW PRODUCTS

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ACI's Trident TR4500 pulls in broadcast frequencies from the shortwave bands through the microwave-range public-service bands—from below AM broadcast to 1.300 GHz—and can be controlled via a personal computer. Users can tune in to practically every type of voice broadcast from around the world, including the broadcast, world-band, and civil and military aviation frequencies found in AM mode; police, fire, and emergency services in Narrow FM; radio and TV-audio broadcasts in Wide FM; and even single sideband for transoceanic aircraft and ship communications.

Desired frequencies can be selected directly using the keypad, or the unit can be set to search through all active channels. The user can store any interesting frequencies in any of 2016 permanent memory locations. Up to 16 different search ranges can be set into memory. Tuning increments can be selected in steps as low as 5000 cycles. The TR4500 will scan through memorized frequencies at up to 36 channels per second, and will lock on active calls to receive the broadcast. The user can listen through the built-in speaker or use the supplied headphone.

With the TR4500 connected to a PC's serial interface, the computer can be used to set the search ranges. The computer allows various frequencies to be loaded and saved, and active frequencies to be stored. And, when used with a computer, the TR4500 effectively becomes a storage spectrum analyzer. An MS-DOS "comm" program is included.

The desktop scanner measures just 2¼ × 5⅝ × 6½ inches. It comes with a 12-volt DC cord, an AC adaptor, an earphone, a flexible antenna, software, and operating instructions that include a listing of allocated uses for all frequencies covered by the unit.

The TR4500 desktop scanner with computer interface has a suggested retail price of $849; the street price is expected to be under $500. For more information, contact ACI;
Tel. 1-800-445-7717 or
317-849-2570;
Fax: 1-800-448-1084 or
317-849-8794.

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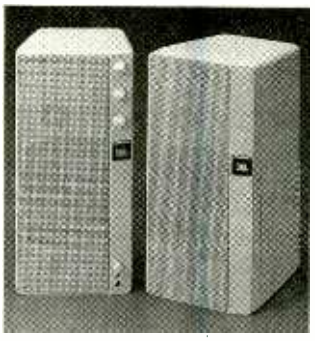
MULTIMEDIA SPEAKERS

Although many of today's personal computers are equipped with a CD-ROM drive and sound card, the built-in speakers are usually inadequate. The *Media 3* and *Media 4* speakers from *JBL Consumer Products* address the needs of PC users seeking to enhance their multimedia experiences in learning, entertainment, and game-playing.

The Media 3 powered speaker incorporates a 4-inch woofer and a 1.5-inch tweeter with a seven-watt-per-channel hi-fi amplifier. Subwoofer output allows the system to be further upgraded, dual inputs accommodate a second audio source, and a headphone jack provides private listening. The Media 3 speakers also feature separate bass and treble controls and automatic power on/off.

The Media 4 incorporates a five-inch woofer, a one-inch tweeter, and a 10-watt-per-channel hi-fi amplifier. Key features include switchable subwoofer output or headphone output, polyolefin cabinet material to dampen internal resonances, automatic turn on/off, and an acoustically efficient design for loud sound levels.



The Media 3 (pictured here) and Media 4 multimedia speakers have suggested retail prices of $199/pair and $299/pair, respectively. For more information, contact JBL Consumer Products, Multimedia Division, 80 Crossways Park West, Woodbury, NY 11797;
Tel. 516-496-3400.

CIRCLE 101 ON FREE INFORMATION CARD

FIELDPACK WITH "STICK" DMM

The *HS24K11 Fieldpack* from *Fieldpiece Instruments* consists of a leather holster that holds a heavy-duty *HS24* "stick" digital multimeter along with a 300-amp current clamp head, deluxe test leads, two short and two long probe tips, and one alligator ground clip. All the accessories are modular, using standard banana plugs and jacks for connections.

Specifically designed for field-service use, the leather holster holds the meter and test leads

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on the inside and has loops for the current clamp head and long probe tips on the outside. A belt loop on the back allows easy carrying.

The HS24 meter offers the 12 most popular ranges for field service and will withstand steady-state voltages up to 1000-volts DC and 750-volts AC. It measures volts, ohms, continuity, capacitance, and AC current (with the included current clamp). A HOLD button freezes the display to make one-handed testing easy. Its Valox plastic case withstands drops up to 10 feet, "O"-ring seals protect against contaminants, and metal-oxide varistors (MOVs) protect against voltage transients. An audible beeper and a blinking red LED warn of voltages over 28 volts, even if the meter is set to the wrong range or function.

The heavy-duty HS24K11 Fieldpack costs $159. For more information, contact Fieldpiece Instruments, 231 East Imperial Highway, Suite 250, Fullerton, CA 92635; Tel. 714-992-1239; Fax: 714-992-6541.

CIRCLE 102 ON FREE INFORMATION CARD

PCMCIA MODEM

The *MT2834LT* PCMCIA modem features a patent-pending "CoolJax" duplex phone connector, eliminating the need for messy cables. The modem is compliant with the recently adopted ITU standard for 28.8-kilobyte per second, V.34 modems, and also supports all lower

speed standards. It is designed for use in standard Type II PCMCIA slots, and comes with MultiExpress fax and data communications software for Windows. The MT2834LT uses industry-standard "AT" commands for modem configuration and dialing, and includes a remote configuration feature that allows the user to remotely change parameters and run diagnostics for troubleshooting, technical support, and system administration purposes.

The MT283LT PCMCIA modem costs $399. For additional information, contact Multi-Tech Systems, Inc., Tel. 800-328-9717 or 612-785-3500.

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PERSONAL POCKET DIGITAL MULTIMETERS

The *Model 380933* 3200-count, autoranging, digital multimeter from *Extech Instruments* offers high-resolution, bar-graph display, function indicators, data hold, diode test, and an audible continuity checker. It measures DC voltage from 300 mV to 450 volts, AC voltage from 3 to 450 volts, and resistance from 300 ohms to 30 megohms. The digital multimeter weighs just 3.4 ounces and measures 4.8 × 3 × 0.8 inches.

The Model 380933 pocket-sized digital multimeter, complete with a wallet-style carrying case, test leads, 1.5-volt batteries, and a user's manual, costs $39. A 2000-count, manual-ranging version (*Model 380929*), which features a larger display, 200-mA range, continuity indication, data hold, and diode test, costs $25. For further information, contact Extech Instruments, 335 Bear Hill Road, Waltham, MA 02154-1020; Tel. 617-7440; Fax: 617-890-7864.

CIRCLE 104 ON FREE INFORMATION CARD

DIGITAL STILL CAMERA

Casio's QV-10 handheld digital still camera allows you to view images as they are shot, thanks to a high-resolution, active-matrix, 1.8-inch color LCD screen. The images can then be transferred to a personal computer by using an optional transfer

package, or to a TV or VCR using a video cable.

The camera's semiconductor memory can hold up to 96 color still images that can be added or deleted at any time. The fixed-focal-length lens with macro positioning allows point-and-shoot picture taking. The camera also features a high-speed (1/8 to 1/4000-second) shutter, 1/5-inch CCD element, and aperture-priority automatic exposure system.

The QV-10 LCD digital camera has a suggested retail price of $700. For further information, contact Casio, Inc., 570 Mt. Pleasant Avenue, Dover, NJ 07801; Tel. 201-361-5400.

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LOW-PASS FILTERS

Intended for amateur-radio use, two low-pass filters from *Tucker Electronics* are designed to provide protection from TVI. The *T-100* and the *T-150* each use a 9-pole Chebyshev filter. They operate from 0–30 MHz and provide 70-dB or more of attenuation at 40 MHz and above. The filters' impedance is 52 ohms, and VSWR is less than 1.5:1 throughout their passband.

The T-100 will handle 1500 watts continuously. The T-150 is the first 2500-watt continuous low-pass filter for amateur-radio use. Each carries a one-year warranty and a 30-day no-questions-asked return policy.

The T-100 and T-150 low-pass filters have list prices of $49.95 and $109.95, respectively. For additional information, contact Tucker Electronics Company, 1717 Reserve Street, Garland, TX 75042-7621; Tel. 1-800-527-4642; in Texas: 214-348-8800; Fax: 214-348-0367. ■

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New device turns any electrical outlet into a phone jack

Engineering breakthrough gives you unlimited phone extensions without wires or expensive installation fees

By Charles Anton

You don't have to have a teenager to appreciate having extra phone jacks. Almost everyone wishes they had more phone jacks around the house.

When I decided to put an office in my home, I called the phone company to find out how much it would cost to add extra phone jacks. Would you believe it was $158?

No more excuses. Today, there are a thousand reasons to get an extra phone jack and a thousand excuses not to get one. Now an engineering breakthrough allows you to add a jack anywhere you have an electrical outlet. Without the hassle. Without the expense. And without the miles of wires.

Like plugging in an appliance. Now you can add extensions with a remarkable new device called the Wireless Phone Jack. It allows you to convert your phone signal into an FM signal and then broadcast it over your home's existing electrical wiring.

Just plug the transmitter into a phone jack and an electrical outlet. You can then insert a receiver into any outlet anywhere in your house. You'll be able to move your phone to rooms or areas that have never had jacks before.

Clear reception at any distance. The Wireless Phone Jack uses your home's existing electrical wiring to transmit signals. This gives you sound quality that far exceeds cordless phones. It even exceeds the quality of previous devices. In fact, the Wireless Phone Jack has ten times the power of its predecessor.

Your range extends as far as you have electrical outlets: five feet or five hundred feet. If you have an outlet, you can turn it into a phone jack—no matter how far away it is. The Wireless Phone Jack's advanced companding noise reduction features guarantee you crystal-clear reception throughout even the largest home.

Privacy guarantee. You can use The Wireless Phone Jack in any electrical outlet in or around your home, even if it's on a different circuit than the transmitter. Each Wireless Phone Jack uses one of 65,000 different security codes. You can be assured that only your receiver will be able to pick up transmissions from your transmitter.

Unlimited extensions—no monthly charge. Most phone lines can only handle up to five extensions with regular phone jacks. Not with the Wireless Phone Jack. All you need is one transmitter, and you can add as many receivers as you want. Six, ten, there's no limit. And with the Wireless Phone Jack, you'll never get a monthly charge for the extra receivers.

Works with any phone device. This breakthrough technology will fulfill all of your single-line phone needs. It has a special digital interface for use with your fax machine or modem. You can even use it with your answering machine just by plugging it into the Wireless Phone Jack receiver.

The Wireless Phone Jack lets you add a phone, modem, fax machine or answering machine almost anywhere.

Special factory-direct offer. To introduce this new technology, we are offering a special factory-direct package. For a limited time, the transmitter is only $49. One transmitter works an unlimited number of receivers priced at $49 for the first one and $39 for each additional receiver. Plus, with any Wireless Phone Jack purchase, we'll throw in a phone card with 30 minutes of long distance (a $30 value) for only $9.95!

Try it risk-free. The Wireless Phone Jack is backed by Comtrad's exclusive 30-day risk-free home trial. If you're not completely satisfied, return it for a full "No Questions Asked" refund. It is also backed by a one-year manufacturer's limited warranty. Most orders are processed within 72 hours and shipped UPS.

Wireless Phone Jack transmitter ...$49 $4 S&H
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Is the Wireless Phone Jack right for you?

The Wireless Phone Jack works with any single-line phone device. Almost anyone could use it, especially if...

- **Few jacks.** *You want more phone extensions without the hassle and expense of calling the phone company.*
- **Bad location.** *You have jacks, but not where you need them most, like in the kitchen, garage, home office or outside on the deck.*
- **Renting.** *You want to add extensions, but you don't want to pay each time you move.*
- **Other phone devices.** *You have an answering machine, modem or fax machine you want to move to a more convenient place.*

The Wireless Phone Jack System consists of a transmitter (right) and a receiver (left). One transmitter will operate an unlimited number of receivers.

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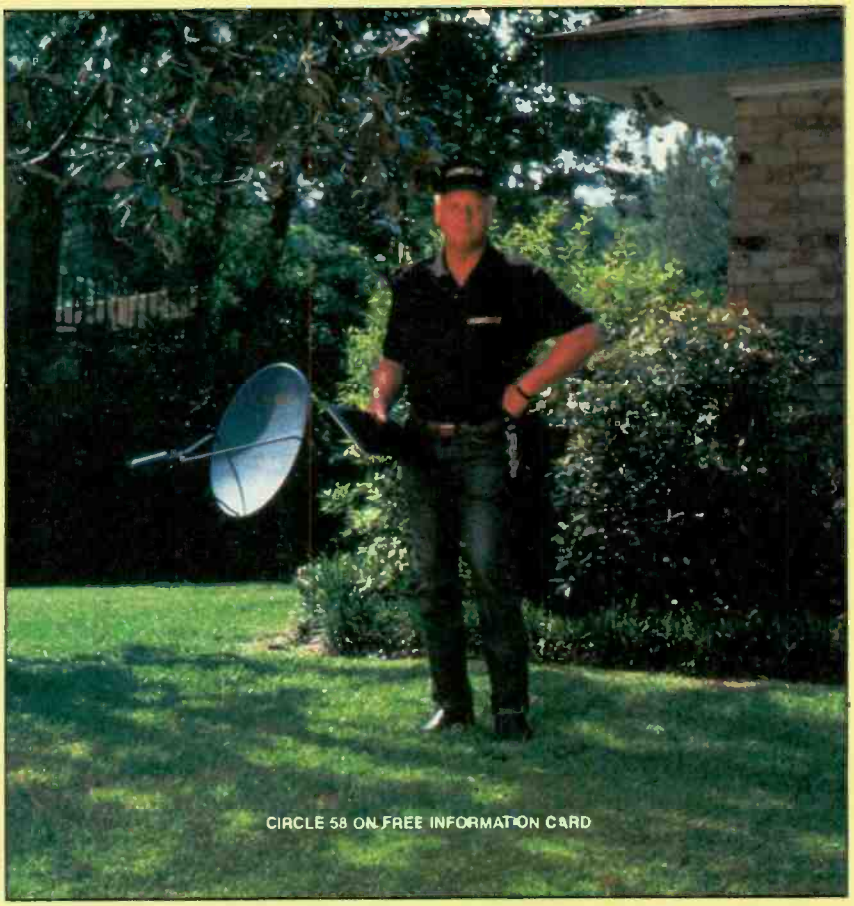
GIZMO®

Prime Star Gazing

PRIMESTAR DIGITAL DIRECT BROADCAST SATELLITE SERVICE. Primestar Partners, Three Bala Plaza West, Suite 700, Bala Cynwyd, PA 19004; Tel. 610-617-5300; Price: Monthly fee varies with distributor and program options.



Astronomers tell us that the universe is expanding. We'll have to take their word for it, because it certainly isn't apparent to us, and doesn't have much effect on our day-to-day lives.

We don't need astronomers, however, to tell us that the *television* universe is, has been, and continues to be, expanding. All we have to do is open up the latest issue of *TV Guide*, and then recall the way it looked during our childhood, when there were the three major commercial networks, three local stations, and PBS.

Then cable TV hit the scene, offering first better reception on local stations in many areas and, later, a host of new programming choices. Most people who lived in areas where cable was offered considered themselves lucky to be able to see recently released motion pictures, sporting events, MTV, and the like. They were even happy to pay the reasonable fees that were charged to receive the improved services being offered.

Over the years, however, the thrill wore off. Prices for services (many of which we no longer found enthralling) began slowly, but very surely, to rise, and the cable company began using equipment and techniques that tended to interact poorly with state-of-the-art TVs and VCRs. Movies came out on video long before they hit cable—and it was much easier to fit a rented movie into the viewer's busy schedule than to watch a movie as it was shown on cable.

With virtual monopolies in their markets, many cable companies have taken advantage of their subscribers, charging excessively high prices and offering poor service in return. We are certainly not the only folks to become disenchanted with the service offered by local cable companies, but we did something about it. We finally got fed up and went cold turkey, canceling our cable subscription, and reverting to watching only the UHF/VHF stations pulled in by our rooftop antenna.

Those who live in areas where decent network reception is not possible without cable haven't had the option to disconnect. And millions of households, mostly in rural areas, haven't even had the option to try cable to see if they like it—cable service simply isn't available in their neighborhoods.

One such spot is Arietta, New York, located in the Adirondack State Park, about 65 miles north of Albany. The rural town is so tiny that it has no doctor and no full-service grocery store. And, with only 301 residents, providing cable service is not an economically feasible proposition.

People living in Arietta had rather limited viewing options. They could use their rooftop antennas to pull in (under optimal reception conditions) two broadcast channels. Usually, those channels were plagued by interference, and sometimes they couldn't be seen at all. The only other option—besides giving up on TV altogether—was to buy and install a large-dish satellite system.

Satellite TV has been an option since the 1970s for cable-deprived (or anti-cable) people. It provides hundreds of channels, and generally better reception than

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that offered by cable. On the downside, it requires somewhat complex, usually professional installation, a major financial outlay, and a dish-shaped antenna that measures up to 10 feet in diameter and must be mounted with a clear line of sight to the satellites orbiting above the earth. Although there is plenty of free programming on satellite, owners still have to pay an additional monthly fee for subscriptions to traditional cable channels.

Last fall, however, Arietta entered the new age of satellite TV. The town was chosen as the site for a 60-day free trial of *Primestar*, a digital DBS (direct broadcast satellite) service. The residents' viewing options jumped overnight from two to 77 channels.

Primestar is one of two digital DBS systems making news across the country these days; the other is RCA's DSS. This month, Gizmo offers a hands-on review of Primestar; RCA, Primestar's main competitor, chose not to participate in a head-to-head review. Both systems are taking the television world by storm.

DIGITAL SATELLITE SYSTEMS

The two systems have a lot in common. Both Primestar and DSS use digital compression to squeeze more channels from less satellite, and both offer what they call "near laserdisc-quality" video and CD-quality sound. The move to digital transmission wasn't motivated to provide better picture quality, but to increase channel capacity. Both systems use higher-power satellites than standard satellite TV, allowing smaller dishes to be used. (DSS broadcasts from the FSS or fixed satellite band. Primestar broadcasts from a traditional, medium-powered Ku-band satellite.)

Both systems also promise to be an alternative to standard cable services and to standard satellite TV. However, each service shares many similarities with cable companies, and in fact, Primestar is owned by a consortium of cable providers.

The biggest difference between the two small-dish systems is that DSS is a consumer product, while Primestar is a "service." The potential DSS owner can go to his or her local electronics store and spend between $700 and $1000 for a basic system, and about $150 more for professional installation (although about 40% opt to install it themselves). Adding a second TV to the system requires the purchase of a $650 "slave" receiver. The DSS owner then calls one or two program suppliers to subscribe. Maintenance and upgrades are his or her responsibility.

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The Primestar receiver should look right at home on your equipment rack. It's about the same size as a VCR.

Primestar customers, on the other hand, don't buy any equipment. Instead, they pay a one-time installation fee of about $150, and then a monthly fee that starts at about a dollar a day for the rental of the dish, the decoder, the remote control, and some basic programming. A "nominal" fee is added to the monthly bill for extra set-top decoders. Maintenance and upgrades are handled, and paid for, by the Primestar supplier.

The buy vs. rent debate reflects philosophical as well as practical differences. DSS advocates tout the independence that comes with owning your own gear. Primestar stresses the worry-free nature of renting equipment, the lack of a high, initial cash outlay, and the promise of free upgrades as the technology improves.

Those opposing viewpoints are not surprising when you consider that DSS is the brainchild of a consumer-electronics company, Thomson Consumer Electronics. Primestar Partners, on the other hand, is a consortium made up of subsidiaries of six major cable companies—Tele-Communications, Inc., Time Warner Cable, Comcast Cable, Continental Cablevision, Newhouse Broadcasting, and Cox Cable Communications—and G.E. American Communications, Inc., which owns the satellite used by Primestar.

The two systems also use different compression methods and satellite dishes. Although both intend to upgrade to the international MPEG-2 standard in the near future, at present DSS uses MPEG-1, while Primestar uses General Instrument's DigiCipher compression scheme. Perhaps the most obvious physical difference between the two systems is dish size. Both use dishes that are much smaller than standard C-band antennas, but at 18 inches in diameter, the DSS dish is somewhat smaller than those used by Primestar. Primestar's antennas vary in size from 32 to 39 inches, depending on geographic location and weather patterns.

PUTTING PRIMESTAR TO WORK

Our installation, on the south shore of Long Island, New York—an area that is one of the most heavily penetrated by cable in the U.S.—contained one of Primestar's new elliptical dishes. It measures approximately 39 inches across, and 29 inches in height. For our temporary installation, the dish was mounted at ground level on the backyard lawn, with the mount secured by strategically placed cinder blocks. (Because we're familiar with C-band dishes mounted in concrete or something similarly stable, we worried that our cats might accidentally knock the dish off kilter. But the installers assured us that, while they had seen a few cases of *cows* rubbing against the dishes and causing problems in rural areas, not even our largest domestic cat could do any damage.)

Finding a clear line of sight to the Primestar satellite, even from ground level, presented no problem to the experienced installer. (The installer, from Halstead Communications in Albany, NY, actually used the installation to train a local crew.) Cable was run through a hole drilled in a basement-window frame, then up through a previously installed PVC conduit to the living room. The set-top decoder was connected to our TV and to a phone line, which allows the box's built-in modem to communicate billing and pay-per-view information.

The entire process was quick and painless. From the front of the house, no one would know that a satellite system had been installed. And, like the residents of Arietta, we suddenly had access to about 70 cable channels.

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TAKING CONTROL

The Primestar 300D decoder box is standard component size—much bigger than the typical cable box, but about the same size as a VCR. A prominent display shows the channel number, and also features signal, timer, and SAT/TV indicators. Front-panel controls are limited to POWER; CENTER, used to confirm and activate channel selections and to terminate user passwords; GO BACK, to return to the last-viewed channel; and CHANNEL UP and DOWN and VOLUME UP and DOWN arrow keys, arrayed around a MENU button that's used to access Primestar's on-screen menu system. When the menu is on-screen, the four up and down arrow keys take on a different role; selecting and maneuvering through sub-menus.

All of the front-panel control keys are duplicated on the remote. In addition, the remote control offers a numeric keypad for directly entering channel or password numbers, a BUY button for purchasing pay-per-view programming, a SAT/TV key for switching between Primestar and local TV inputs, and MUTE. Pressing the VIEW button calls up an on-screen display consisting of the currently selected channel, service, program name, rating (if applicable), and time of day. The NEXT key provides the same information about the next program that will be shown on the current channel. If the current channel is a pay-per-view station, the "view" or "next" display will also include prompt lines—for instance, "Press BUY to purchase program."

The remote control that came with our system was one of Primestar's new, upgraded units, that also features five buttons labeled "future entertainment services." Those buttons currently serve no purpose, but they eventually will be used to access the interactive guide Primestar plans to launch next year, along with any future interactive capabilities as they become available. For now, the only interacting you'll do is with the on-screen menu system.

The main menu offers eight options, any of which can be selected using the remote's numeric keypad or by scrolling through the main-menu options with the arrow keys and then pressing ENTER to access the submenu. Three of the submenus probably will be used only during the initial system set-up. Those include the Receiver Status Screen, used by the installers to check signal power and quality (if you call for service, your distributor might ask you to read some of the information shown on the status screen); the Set or Change Password menu; the Rating and Channel Lockouts screen, to censor your kid's viewing options; and Favorite Channel Scan, for deleting channels from the scan function.

The other on-screen display menus can be used to buy pay-per-view programs, view your purchase history, set program and sleep timers, and receive messages from your Primestar distributor. The purchasing submenu lets you know the name of the movie or event, the actors' names, the price, the rating, the starting time, and the amount of time remaining before it starts. The sleep timer turns off the audio and video—although not your TV or VCR—at a user-specified time. The program timer lets the Primestar decoder work in conjunction with your VCR. It won't control your VCR, but it allows you to set the decoder box to tune into as many as two daily programs and three one-time events up to a year in advance. The settings are saved in memory, and protected by a battery backup. You can use the program timer to purchase a pay-per-view event in advance for later viewing or taping. Should your distributor send you a message, the word "message" will appear the first time you press the VIEW key on the remote control, letting you know to check the message submenu.

TUNING IN TO PRIMESTAR

As soon as the installers left, we settled down, remote in hand, to see what Primestar was all about. A quick scan through the "dial" revealed several movie channels—three HBO, two Cinemax, and four Encore (each dedicated to a different theme: love stories, westerns, mystery, and general interest). Two versions of The Disney Channel and two versions of TV Japan (one in English, one in Japanese) rounded out the premium stations. Special interest programming included C-Span, The Weather Channel, CNN, Headline News, TNT, Turner Classic Movies (TCM), TBS, The Discovery Channel, The Learning Channel, A&E, USA Network, the Sci-Fi Channel, The Family Channel; the Cartoon Network, The Nashville Network (TNN), and Country Music Television (CMT). Besides ESPN and the Madison Square Garden Network (MSG), Primestar offers 14 regional sports channels. In addition, it's possible to buy "season passes" to NBA basketball and NHL hockey games. There are 10 PrimeCinema pay-per-view channels, and six PrimeAudio music channels—commercial-free, audio-only satellite radio.

All the major broadcast networks—ABC, CBS, NBC, Fox, and PBS—are also represented, but not as we're used to seeing them. Rather than local affiliates, Primestar delivers NBC out of Boston, ABC from Miami, CBS from Washington DC, Fox from San Francisco, and PBS from Philadelphia. Although the programming lineups are virtually identical to those on our local stations, it can be disconcerting to watch the evening news (particularly the weather reports) from other cities. Of course, the decoder's pass-

Primestar's new elliptical dish can be quite unobtrusive. For our temporary installation, no effort was made to hide it.

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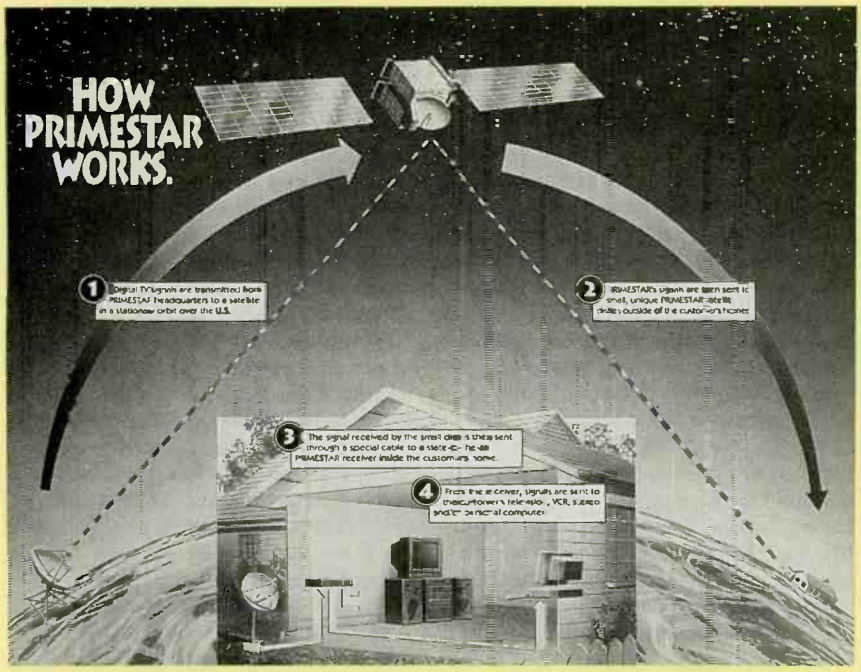

Primestar digitizes its signals before they are transmitted to a geostationary, medium-power, KU-band satellite. They are then distributed across the continental U.S.

through antenna connector (SAT/TV button) makes it easy to watch local broadcasts or cable-delivered programming as well.

Between our test period and our publication date, Primestar added six new services. Those include another premium movie channel, Starz!; Playboy TV pay-per-view adult entertainment; CNN International news; QVC home shopping network; CNBC for stock-market coverage and business features; and The Golf Channel, featuring all golf, all the time.

Completing the lineup is the PreVue Channel on-screen program guide. It offers a continuously scrolling program grid that displays what's on each channel for the next 1½ hours. Simultaneously, "coming attractions" or other advertising for various movies and events are shown at the top of the screen.

The current PreVue Channel is not interactive in any way—you can't click on a program choice for more details, or choose to view only certain categories of programming. Nor will the channels you blocked out using the "favorite channel scan" on-screen menu be deleted from the guide. You have to watch the entire thing. Beginning in 1996, however, Primestar expects to offer an interactive program guide.

In general, we found it much easier to refer to the free monthly program guide that's included with any Primestar subscription. To augment the printed guide—i.e., when we couldn't easily locate it—we made frequent use of the handy VIEW and NEXT keys on the remote control.

Watching, and listening to, Primestar programming is a delight. As promised, the digital satellite system provides excellent video and audio quality. We had no complaints about "rain fade," which is often associated with small-dish satellite reception. In fact, we experienced no interference whatsoever in our two-month trial period.

On a few occasions the picture would take on a very slight jumpiness. Perhaps that is an exaggeration—we couldn't pinpoint any digitization of the picture. On rare occasions, however, the video was less than smooth. The effect never lasted longer than a minute or so, however, and usually didn't detract from our viewing pleasure. The only exception was when watching hockey—perhaps because the white ice surface made artifacts more noticeable. However, during quick scene changes, say, from a face-off circle to a corner, we could detect a slight, but perceptible, delay.

HOW DOES IT WORK?

Primestar started out in 1990, delivering 20 channels of satellite service to subscribers located in rural areas not reached by cable. The original Primestar service delivered analog Ku-band signals to relatively small (36–39-inch) stationary dishes.

It wasn't until last year that Primestar began using the General Instrument DigiCipher digital compression system, which allowed them to squeeze 70 channels from the same satellite, provided by GE Americom. The April 1994 launch date did, however, make Primestar the first digital satellite system on the market.

April 1994 marked the beginning of Primestar's national roll out. It is now available to every household in all 48 contiguous states. Primestar announced in March at the SBCA show that their subscriber count had surpassed the 300,000 mark—a dramatic increase from the total of 70,000 subscribers just one year earlier.

Like all satellite delivery systems, the Primestar signal originates in ground stations, where it is digitized, compressed, and beamed up to a satellite, which then sends the signals back down to antennas on earth. Primestar uses several transmission locations in Colorado and New Jersey. The signal is boosted in power once it reaches the satellite. It is then channeled back via the dish antenna to the subscriber's set-top decoding box, where the signal is decompressed before being sent on to the television set.

Primestar dishes vary in size to suit the installation site, taking into account the geographic location and local weather conditions. They currently range in size from 32 to 39 inches in diameter.

That could change in the near future, however. Primestar plans to deploy two high-powered satellites in 1996. Those birds, built by Loral, are said to be the most advanced satellites of their type available. The more powerful satellites will allow the use of smaller dishes, and will increase Primestar's channel capacity to up to 200 channels with Dolby AC3 digital audio compatibility.

WHAT DOES IT COST?

Because Primestar is a service, not a product, initial costs are limited to installation fees, which vary by distributor. Generally, installation will set you back between $150 and $200.

Next, you start paying for the service itself. Again, prices are determined by the local distributor. Approximately $30 a month gets you the Primestar basic package, which includes use of the equipment and 30 or more "top" (not premium) cable channels. The 70-odd channels that we received would cost about $75 a month. If you want to hook up a second TV, a small additional monthly fee is charged for the extra decoder box required.

There are no other fees involved. As the new satellites and services are launched, Primestar distributors will absorb the cost of the required equipment upgrades. They will supply subscribers with updated remote controls, smaller dishes, and MPEG-2-compatible decoder boxes at no charge.

Of course, if programming pricing continues along the same lines (30-plus channels for $30, 73 channels for $76), those distributors are facing a no-lose situation when Primestar begins broadcasting more than 200 channels next year. ■

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How ultrasonic power can safely deter unwelcome animals from your yard...

Yard Gard creates a wall of silent noise that drives away annoying dogs, cats and many wild animals without harming them.

by Charles Anton

Be honest. Even if you're an animal lover, you don't want strange animals in your yard.

You know what I'm talking about... dogs that dig holes and foul your lawn, cats that trample your flowers and sleep on your car. If you live in a rural area, you've probably had trouble with uninvited visitors like raccoons, possums, rabbits, or armadillos.

Until now, there weren't many options. After all, you wouldn't want to harm a stray animal, and your animal control agency may take days to respond, if they ever do.

High-tech solution. Fortunately, modern technology has provided an answer: the new Yard Gard. It uses high frequency sound waves to force unwanted animals to leave the area.

Yard Gard eliminates the need for repellents, trapping or physical attacks. Pests learn to avoid the areas Yard Gard protects.

Ultrasonic Power. Yard Gard's electronic ultrasonic generator broadcasts powerful "silent noise" that repels four-legged yard pests, yet is generally unobtrusive to people. Tones are harmless but animals find the sounds so unpleasant that they flee.

Why it works. Small animals depend on their acute hearing for survival. They can hear in the 18 to 25.5 kilohertz range which is beyond the range of most humans. When critical hearing frequencies are disrupted by strong pulses, animals feel threatened and leave the noisy area. Yard Gard takes advantage of this fact to protect your yard from pests.

Break their habits. Animals are creatures of habit. They establish a territory and generally follow the same travel routes. Yard Gard forces animals to change their patterns and establish new ones. They soon modify their habitual routes to avoid Yard Gard zones.

Cruelty-free pest control that works...

In the past, people relied on poisons or violent means to get rid of unwanted animal pests. Recent environmental awareness has increased the demand for clean, non-lethal methods of pest control. Safe and humane, Yard Gard is the modern solution for pest control.

Humane. *Yard Gard causes no harm to animals. By creating a wall of high frequency sound, it forces them to leave the area and create new habitual routes. While the sound is very annoying to animals, it is virtually unobtrusive to people.*

Nature friendly. *Poisons and pesticides can pollute soil and water sources. Yard Gard deters pests with sound so it causes no damage to the environment.*

Non-toxic. *Chemicals used to eliminate pests can be dangerous to humans or neighborhood pets. Yard Gard poses no health risk when used as directed.*

Just plug it in. Yard Gard's transformer plugs into any standard household outlet. Electricity consumption is very low and costs only about 25¢ a month to operate.

Yard Gard is designed for outdoor operation in all types of weather. You can use your Yard Gard all year.

Mount your Yard Gard on a wall, post, or fence or place it on a flat surface. Yard Gard is essentially maintenance-free and requires only a minimum of care.

Three settings. Yard Gard has three frequency settings. At its lowest frequency setting, one Yard Gard covers an oval area of approximately 4,000 square feet the size of an average city lot. Additional units can be added to especially large yards.

Keep the birds. Do you love to watch and feed birds in your yard? If you have problems with cats chasing birds away or killing them, Yard Gard is the answer. Birds are not affected by the high frequency sound waves. They can't hear it, but cats can't stand it.

Risk-free offer. For a limited time, you can get the new Yard Gard at the introductory price of just $99. Call today to take advantage of this special factory direct pricing. All Comtrad products are backed by our "No Questions Asked" money-back guarantee. If you're not satisfied with the Yard Gard, simply return it within 30 days for a full refund. Yard Gard is also backed by a two year manufacturers warranty.

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Are animals turning your yard into a zoo?

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Are rabbits eating as much from your garden as you are?

Do you have problems with unusual animals?

Do neighborhood cats think your garden is a litter box?

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Beeper Babysitter

BEEPERKID CHILD MONITORING SYSTEM. From A+H International Products, Shoreline Square Tower, 301 East Ocean Boulevard, Suite 1010, Long Beach, CA 90802; Tel. 800-455-4345. Price: $149.95.

When friends who'd moved to the Midwest returned to Long Island with their kids for a visit last summer, the old gang immediately planned an outing to the beach. The group included four adults and eight kids, aged 11, 9, 6, 5, 4, 3, and 2 years, and 6 months.

As soon as we hit the sand, all of the kids who were old enough to walk stripped down to their bathing suits and raced for the ocean before we'd managed to spread out a single blanket. One of the adults went to the water's edge to keep an eye on the kids, while the rest of us set up "camp."

As soon as we'd settled in, the rest of us went down to the shoreline to help supervise the kids who were swimming. We automatically did the routine head count—and suddenly realized there were only *seven* kids with us. The three-year-old had wandered off.

In a state of barely controlled panic, we began to search for him. We knew he was too afraid of the water to have gone in without being carried, so we concentrated on the three other directions he could have headed. We split up, with one person looking either way along the shoreline, and a third heading back toward the parking lot.

Less than 10 minutes later, a woman, holding the little boy by the hand, found *us*. Having seen him wandering westward, she turned him around and led him back to where she'd assumed (correctly) that he'd come from.

Those few minutes seemed like hours. Although we were all pretty sure that he wouldn't have gone in the water by choice, there was always the chance that he could have fallen or been knocked down by a wave. And it was impossible not to think of all the horror stories of kidnappings that are in the news. It was an experience that none of us—except the boy himself, of course, who wasn't aware that anything was wrong—is likely ever to forget.

It's easy for anyone who doesn't have kids to think, "What kind of parents are you? Can't you keep an eye on your own kids?" But anyone who has ever cared for a toddler knows that, once they learn how to walk, children can move as fast as lightning on those stubby little legs. We rarely told the lost-at-the-beach story without hearing similar tales from other parents, whose kids had wandered off at amusement parks, tourist attractions, malls, playgrounds, or even from their own backyards.

It's often said that parents need eyes in back of their heads, and even that might not be enough. In the time it takes to pay for an admission ticket or a Happy Meal, tie another child's sneaker, or greet a friend, a small child can disappear.

Some parents rely on leashes and harnesses to keep their kids from straying away in crowded public places. Such rigs are likely to draw disapproving stares from strangers who believe leashes are proper only for pets. But if your child tends to wander, we believe it's better to keep him or her safe than to pacify strangers.

A less obtrusive, and more high-tech means of keeping track of your child is the *BeeperKid* child-monitoring system from *A+H International Products*. The wireless, digital system consists of a transmitter, worn by the child, that automatically sets off an alarm on the parent's receiver unit when it moves beyond a 15-foot range. A series of beeps warns the parent that his or her child is wandering.

The parent's unit is oval-shaped and measures approximately 2½ × 2 × ¾ inches. A clip built into the back of the receiver allows it to be attached to a belt or pocket. At the top of the unit is a yellow MUTE button. A green LED on the front blinks slowly to show that the unit is charged and working. When the child is out of range, the LED flashes, even if the unit has been muted. The speaker is also found on the front of the unit.

The transmitter is even smaller and plainer. The circular unit measures just over two inches in diameter and 3/4-inch wide. It also features a speaker and an LED on the front. Instead of a clip, however, the transmitter has a "safety pin" built into its back panel, and there is no MUTE button. That design makes it difficult for the child to remove or tamper with the monitoring system.

The BeeperKid also comes with a charging stand and an AC adapter cord.

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The two units slide together, back-to-back, and then snap into the stand. An overnight charge provides up to six hours of monitoring. When the two units are disconnected, the system powers up automatically and emits a confirming beep. Sliding the transmitter and receiver together again shuts down the system.

Once charged, the BeeperKid is simple to use. You simply clip on your receiver and your child's transmitter, and forget about it—until you hear a series of beeps, that is. Then it's time to locate your little wanderer, knowing that he or she can't have more than a half-second's lead, being approximately 15 feet away when the first beep sounded. Should the child roam back into range, or be found, the beeping will cease, and the unit automatically resets. The mute button will silence the alarm, but the LED will keep flashing as long as the child is out of range.

Although the idea behind BeeperKid is simple, its execution was anything but. According to A + H, the original concept relied on radio-frequency technology, but that design had several flaws. At the top of the list was reliability. Two units moving continuously, particularly in an urban environment, were subject to signal-strength variations—and dropouts—caused by reflection and blockages. Reflected signals could cross and cancel each other out, making the parent think incorrectly that the child was still within range. And the rate of false alarms was too high.

The performance of RF-based products technology is also highly dependent upon antenna orientation. At one point during the design process, it was suggested that the parent wear an antenna on his or her head to provide an unobstructed view of the child's transmitter. Somehow, we can't see adults rushing out to buy a product that required them to walk around with an antenna sticking out of their heads!

FCC regulations caused further problems with the original RF design. The FCC requires at least a ten-second delay between the time the child leaves the range and the time of transmission. To help eliminate false alarms, that delay is multiplied two or three times. That means that there could be a delay of up to 50 seconds in some situations.

A + H finally abandoned the early, RF model. Instead, it licensed from a Fortune 150 defense contractor a proximity-detection technology that had been developed for military applications by aerospace and defense engineers. The company is close-mouthed about the proprietary technology, except to say that it is "essentially a wireless modem, modulating and demodulating digital data across a wireless medium," and that custom Application Specific Integrated Circuits (ASICs) are used in its manufacture. The adapted military technology eliminates the reliability problems inherent in RF technology, and complies with FCC regulations.

In addition, each BeeperKid system has its own code. That allows it to recognize its companion transmitter/receiver even if other BeeperKid systems are being used in the area.

Despite the "secret" proprietary technology, the BeeperKid is affected by the presence of a strong interference source—such as a computer or a television—within a few feet of the parent's receiver unit. When there is strong enough interference present to affect communication between the transmitter and the receiver, the receiving unit will beep to alert the parent to the situation. The manual advises parents to become familiar with the effects of interference on the system before leaving home—by experimenting with the BeeperKid near a TV or computer—so that they will realize when it is detected in a public place—at a check-out counter, for instance. The more interference being emitted, the shorter the effective range becomes.

The range also shortens when the battery power is running low. The unit will also begin to beep, even though the child remains in range, letting you know that recharging is needed.

With those two exceptions, the BeeperKid's proximity-detection technology is extremely reliable in virtually all environments, even when there is no clear line of sight between the parent and the child. Our tests verified A + H's claims that the transmitter and receiver worked through walls, such as when the child moved into another room, up a flight of stairs, out the front door, or even into an elevator. Of course, it also worked when the toddler moved off a backyard deck toward the pool or the driveway, and out of the sandbox toward the swing area of the playground, where he was in danger of being hit by moving swings.

The 15-foot range was determined by the manufacturer's tests to be "the natural limit most parents place on their kids... when their child moves beyond that range, they immediately notice and pay more attention." We tend to differ with that opinion; in real life, the range would vary according to the situation. In the backyard, for instance, where there are few hazards and the parent has a fairly clear line of sight, a child could be given much greater leeway than he would, for instance, in a crowded mall or amusement park. In either of those places, he could quickly disappear behind a strangers legs, a ticket book, a rack of clothing, or a merchandise counter—without getting more than a couple of feet away from his parents. ■

The BeeperKid receiver (front) and transmitter (rear) slide together for easy storage and recharging when not in use. Note the "safety pin" fastener on the back of the receiver, which prevents toddlers from removing the transmitter.

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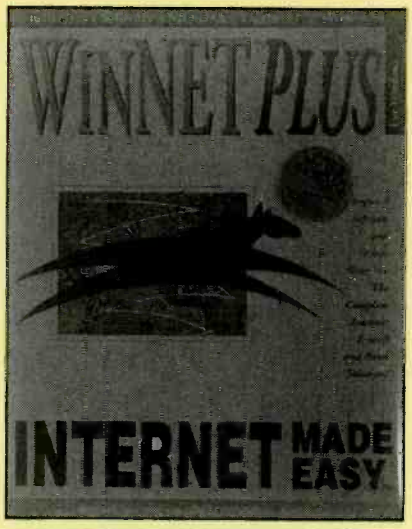
Entering the Internet

WinNET PLUS INTERNET ACCESS SOFTWARE. Published by: WinNET Communications, 330F Distillery Commons, Louisville, KY 40206-1919; Tel. 502-589-6800. Price: $39.95; Subscription also required.



CIRCLE 60 ON FREE INFORMATION CARD

Are you on the Internet? The worldwide network—the much-heralded information superhighway—is experiencing a fantastic population explosion with good reason: it's not only incredibly useful, but it can be a lot of fun, too.

Most people on the Internet don't pay for the access—it's provided by their companies or schools. But a growing number of individuals are recognizing the importance of the Internet and are setting up private accounts to obtain access. One popular way to get Internet access is through the "big five"—America Online, CompuServe, Prodigy, Delphi, or GEnie. But there are plenty of smaller companies that can provide access as well.

One of those is WinNET Communications, which has bundled an access program, WinNET Plus, together with its online service to give consumers an easy way to access the two most popular services available on the Internet.

There are many different ways to access the Internet, and before you can choose an Internet-access provider, you have to determine what *kind* of access you need. Some dedicated access providers will supply you with a Unix shell account. Others will set up what is known as a SLIP or PPP account that lets your computer actually become part of the Internet. WinNET Plus, and the corresponding service from WinNET Communications, offers Internet e-mail and Usenet newsgroups with the friendly face of Microsoft Windows—there's no need to even think about Unix.

The main benefit of WinNET Plus is that it is very efficient. The software is used primarily offline, so that users can compose mail and read mail and news "off the clock" without being charged for connect time.

By the time you read this, WinNET Communications will be able to provide other services beyond mail and news, including SLIP/PPP connections that put your computer directly on the Internet, and that provide access to the World Wide Web. That access wasn't available during our review.

Although the World Wide Web is getting the most attention these days, e-mail and Usenet are by far the most popular Internet services—each day, about 25 million people around the world access the Internet to exchange e-mail and to communicate on Usenet newsgroups. People who access the Web frequently are happy with the information it provides—but they still see much of it as a novelty. New Internet users find that e-mail and Usenet move beyond the novelty stage and become indispensable resources almost immediately.

The WinNET software is designed to work "hand and glove" with WinNET Communications' Internet/Usenet service. However, the software can work with other providers as well, as long as they support UUCP, the Unix-to-Unix Copy Protocol.

The primary use of e-mail is to send messages to other members of the online community. But there are ways to access other Internet services via e-mail as well, which we'll describe shortly.

Usenet can be thought of as a global bulletin board—the world's largest BBS. It is divided into thousands of categories or newsgroups (now about 7000 and growing all the time). Anyone is free to read and post bulletins in categories that range from computer security to gardening, and that cover virtually every subject in between. Newsgroups are an incredibly vast source of information because everyone can contribute—and people on Usenet talk about everything imaginable.

If you have a question, for example, about who played drums on John Coltrane's classic LP "Giant Steps," you might post your query in the newsgroup rec.music.jazz. If you are wondering about the security of the encryption in PKZIP file-compression software, you might ask for comments in the sci.crypt newsgroup. If you have a problem trying to choose the right analog-to-digital converter for a speech-recognition system that you are designing, you might post questions in sci.electronics.

The real value of newsgroups is the people who read them. If an engineer who regularly works on A/D-converter design reads your post and can contribute to solving your problem, he will.

The minimum computer requirements for running WinNET Plus are an 80386-based system with two megabytes of RAM and a modem. The software is supplied on a single floppy diskette and is very easy to set up: From the Windows Program Manager, just run SETUP.EXE.

The setup program copies all necessary program components to the directory of your choice, and sets up the subdirectories that are necessary for the program's proper operation. It then asks several questions so that it can configure the system properly. For example, it asks for your local time zone.

It also asks whether you wish to use WinNET Communications as your Internet/Usenet provider—an alternative provider can be chosen instead. If you do select WinNET as your Internet/Usenet provider (as we did), you must choose a system name and a User Name that will be used to create your Internet mailing address. Your Internet address then takes the form:

user—name@system—name.win.net

The program then asks you to provide the information necessary for WinNET Mail to talk with your modem—port, speed, and setup string. You can also set the CPU utilization in four steps from low to very high. Setting it high can improve the communications performance somewhat. However, it makes it difficult to run other programs concurrently. So, for example, if you wanted to run other applications while the mail program downloaded your e-mail and news, you would set the CPU utilization to a low or middle setting.

The setup software creates a new Program Group for WinNET programs. The five programs are: WinNET Plus, Call Server, Scheduler, WinNET Setup, and Account Setup.

WinNET Plus (WNMAIL.EXE) is the main program that is run daily to send and receive mail. Call Server (UUCICO.EXE) is the communications program that you can run directly when you want to send or receive your mail immediately.

Scheduler (DAEMON.EXE) is a background program that schedules communications calls for any time of the day or night. You might set it to call your provider in the morning before you get to work so that when you arrive at your desk, you'll have your mail and news waiting for you.

The Account Setup (ACCOUNT.EXE) program is run to establish your WinNET Internet account. WinNET Setup (SETUP.EXE) also provides an icon so that you can re-run it and adjust communications settings if it ever becomes necessary.

The rate for on-line usage of the Win-

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With convenient wireless installation, two lighting systems offer the brightest solar light ever available!

Alpan's industrially-proven solar technology harvests the power of the sun to protect your home and family.

by Bob S. Garrard

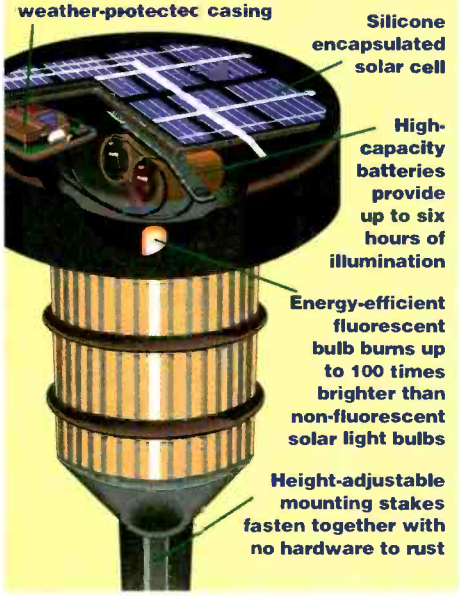
How many nights have you had to negotiate a dark walkway to the door hoping you wouldn't trip on something? Or how often have you stood in the dark fumbling with keys? If you're like me, you leave the porch light on all day, but you still have to find the porch in the dark!

Now there's a better way to come home to the warmth and safety of a well-lit home. Alpan, in colaboration with Siemens, has developed two new lighting systems—the Solar Pathway Light and Solar Sensor Light.

The fluorescent advantage. Built with a fluorescent bulb, the new Solar Pathway Light provides the maximum amount of illumination while using a minimum amount of energy. In fact, the unique fluorescent tube is up to 100 times brighter than non-fluorescent solar-powered lights.

Industrial technology. Alpan has put the *single crystal cell*, the same powerful cell found in industrial power modules, to work for you in the Solar Pathway Light. Using the energy collected by the cell during the day, the power source is charged. At night, the built-in photo sensor detects darkness and automatically turns the light on to provide up to six hours of illumination.

The brightest solar lighting system



No bills, no wires. The Solar Pathway Light can be installed in minutes. Simply twist the two parts together and put the light in the ground. All of the connections are internal, so there are no wires. And because these lights store and use energy from the sun, you'll never pay for outdoor lighting.

Ensured safety. Outdoor lighting is not just convenient. It makes your home safer. Well-lit walkways and yards discourage burglars and vandals. And they can keep you from tripping over unexpected objects in the path—like toys or ice and snow.

Factory-direct offer. This advanced solar lighting technology would retail for hundreds in stores. But through this special factory-direct offer, you can get the Solar Pathway Light for just $59. Order extras, and receive them for just $49. The Solar Sensor Light is available for only $79 with additional lights costing only $69 each. Take advantage of this special offer to add beauty and safety to your home and yard.

Solar Sensor Light for extra security. *Equipped with the same powerful technology as the Solar Pathway Light, the Solar Sensor Light offers you and your family extra protection for your home and outbuildings. This powerful floodlight uses solar power to light your yard with a powerful quartz-halogen bulb. And it has a built-in heat and motion sensor. With no timers or switches to set, this light automatically switches on when triggered and stays on after you leave for 30 to 60 seconds. The adjustable 30 to 60 second delay ensures that you'll never be left in the dark. With no wiring, it's easy to install. The solar panel mounts directly on your roof. The light mounts anywhere. The 14-foot plug-in cord simply connects the two. The solar storage system is so powerful it will switch on as many as 120 times with just a single full charge. And it's able to run for up to two weeks—even if there's no sun.*

Economical and dependable, the Solar Sensor Light has a built-in heat and motion sensor.

Try them both risk-free. Both systems are backed by a "No Questions Asked" 30-day risk-free home trial and a one-year manufacturer's limited waranty. If you're not satisfied, return them within 30 days for a full "No Questions Asked" refund. Most orders are processed in 72 hours and shipped UPS.

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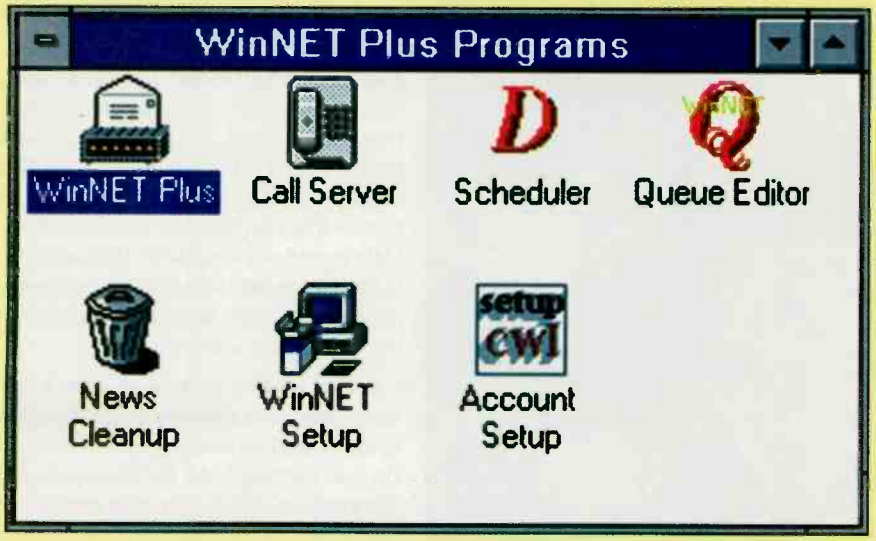
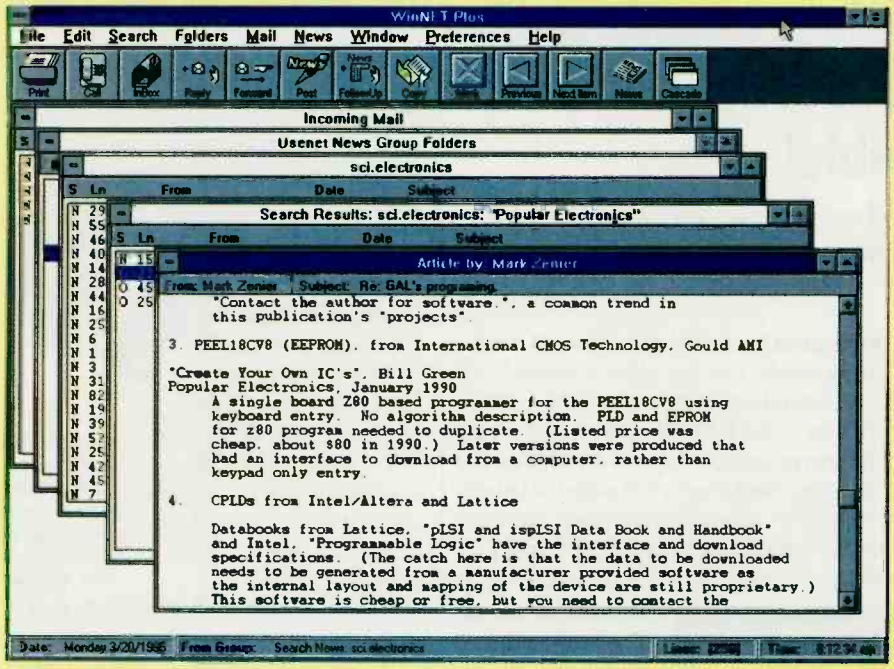


WinNET Plus includes seven applications, including an automatic scheduler that lets you access the Internet even when you're nowhere near your computer!



A search for "Popular Electronics" allowed us to quickly find how members of the Internet community were using the magazine.

NET system is $8.00 per hour, and the monthly minimum charge is $9.95. That means that if you use less than $9.95 worth of connect time, you will be billed the minimum of $9.95.

Unlike many on-line services and bulletin boards, you are only connected to WinNET for just long enough to send or receive any pending e-mail at speeds as fast as your modem will go. That results in connection times of typically one to just a few minutes. According to the company, its customers average 1.75 hours of connect time per month, which results in a charge of $14.00.

In addition to connect-time charges, you are responsible for phone-line charges. WinNET does have an 800 number—it isn't toll-free, however. Instead, it is billed at a rate of 18 cents per minute during peak times (8 AM to 5 PM Eastern Time) and 12 cents per minute of off-peak access.

The 800-number service is optional. If you are local to the company, or if you have a long-distance company with lower rates, you are free to access WinNET at its standard number.

A new price structure is due to go into effect when WinNET Communications introduces its new SLIP/PPP services. As of this writing, the service is expected to cost a flat $19.95 per month, for four hours of access though a toll-free number. After the first four hours, each additional hour will cost $5.40. According to WinNET Communications, less than 4 percent of its current customers use more than four hours of connect time. Current customers will be able to opt to keep their current pricing structure when the new pricing is introduced.

As mentioned previously, WinNET can communicate with alternate service providers. To do so, you need to give the software information about the provider. First, of course, is the provider's telephone number and such connection information as the maximum connect speed. Also, you must provide your assigned machine name or system name, your password, and your provider's server's UUCICO machine name.

You must also provide the login sequence for your provider's server. (Many providers can provide a sample login script that shows what prompts and responses are required). Next, you must provide the e-mail address of the news administrator so that you can subscribe to newsgroups.

The setup program generates a file called CHAT.RC that contains a simple script that the communications program uses to negotiate the login sequence after it connects to your UUCP provider. That chat.rc file will work unmodified for many systems, but in other cases additional configuration of the file might be required.

Although e-mail is primarily for sending and receiving personal messages to other members of the on-line community, you can do a lot more with it. For example, you can send a message to a list of users, send text files or binary files, and subscribe to mailing lists. The number and scope of available mailing lists is tremendous, and include everything from discussions of the TV show *Beverly Hills 90210* to calculus.

But e-mail can also be used to access other Internet services, too. For example, although WinNET Communications doesn't offer direct FTP (file transfer protocol) capability, we were able to use e-mail to retrieve files from FTP archives. Archie, Gopher, and other Internet services are also available via e-mail.

Archie is an Internet utility that lets you search indexes to locate files that are available on public servers. By e-mailing instructions to an Archie site, you can instruct the program to search through an index of files and e-mail a list of the matching files and the sites where they are located.

Archie knows only four commands: help, prog, list, and whatis. Those commands can be set to the Archie server in an e-mail message to locate files. The response that would be sent by e-mail would be the same as if you typed the commands at a terminal connected to the Internet.

Gopher is an Internet tool that allows

(Continued on page 20)

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Home Alone

PERSONAL EMERGENCY PHONE DIALER (CAT. NO. 61-2659). From Radio Shack, 700 One Tandy Center, Fort Worth, TX 76102. Price: $99.99.

CIRCLE 61 ON FREE INFORMATION CARD

Over the last half century or so, several demographic trends have led to an unprecedented number of senior citizens living alone. First, of course, we, as a society, are simply getting older. Advances in medicine and health care have resulted in longer life expectancies. While it used to be common for grown children to settle in the same areas in which they grew up, today's society is always on the move. Many young families pack up and move clear across the country, in search of better job opportunities, or simply "greener pastures." It is no longer common for grandparents to live in the same neighborhood, let alone in the same house, as the younger generations and their families.

It used to be the norm for several generations to live under one roof. These days, however, such a situation is often threatening to all parties concerned. In part, that's because older people no longer hold the same respected position that they once did, when their experience and opinions were valued. In our fast-paced, quick-changing, technologically oriented society, senior citizens can have a difficult time keeping up with, and fitting into, the lifestyles of their children and grandchildren. And it can be equally difficult for their busy, stressed-out children and grandchildren to find the time or patience to appreciate their older family members.

At the same time, over the last few decades, the number of women in the work force has dramatically increased. Many of those women have also postponed having children until they were established in their careers. As a result, many women—traditionally, the primary caregivers for young and old alike—now find themselves sandwiched between the demands of young children and elderly parents, while trying to hold down a full-time job and also care for the home.

As the nuclear family continues to replace the extended family, and the American population continues to age, the number of senior citizens living alone is on the rise. For many older Americans, such independence is welcome. They would much prefer to stay in their own homes, near the friends they've enjoyed for decades, and keeping to their own established routines, than uproot their lives to move in with one of the "kids."

As long as the older person is in good health, capable of taking care of her own daily needs, and not lonely living alone, there's no reason for her to relinquish her independence. The biggest potential problem in such a situation is the threat of sudden illness, injury, or other emergency. If an elderly woman living alone was to suffer a heart attack, or slip in the bathtub, how could she summon help?

Radio Shack provides one solution: the *Personal Emergency Phone Dialer*. It makes phone calls for you if you can't get to the phone in the event of an emergency.

The system consists of a pendant intended to be worn around the neck, and an easy-to-install phone-dialer console. The dialer plugs into an AC outlet and is connected to the phone line. The user then records a message ("This is Ann Jones. I'm at home at 222 Main Street and I'm in trouble. Please help."), and enters up to four phone numbers to be dialed in case of emergency.

Pressing the call button on the pendant sends a signal that sounds an alarm and activates the phone-dialer console. The console then automatically dials the preprogrammed phone numbers of family members, neighbors, or friends, and plays the prerecorded emergency message. A built-in microphone on the console allows the family member to listen to what is happening in the older person's home.

The pendant is a heart-shaped, off-white unit that's about two inches in length and slightly more than ½-inch thick. At the top of the heart is a loop through which a chain can be attached. The front of the pendant features two buttons labeled CALL and STOP. We would have liked to see a clip placed on the back of the device as well as the necklace loop, so that it could be attached to a shirt pocket or belt—an arrangement that most men would prefer. The pendant is water resistant, so it can be worn in the tub or shower, the sites of many household accidents.

The console measures approximately 7 × 5 × 1½ inches. Its front panel features a numeric keypad; two piezoelectric buzzers; a microphone; a RECORD button; an INSTALL/RUN switch; and AC power, low battery, and record indicators. A 9-volt battery provides memory backup in case of power failure. A telescopic antenna on the back of the console picks up the RF signals sent by the pendant.

To begin programming the console, you must switch it to its install setting, and then press the CALL button on the pendant, which lets the console recognize the transmitter. Next, you program in the phone numbers in the order you'd like them to be dialed, using the numeric keypad.

Keep in mind that the Emergency Phone Dialer will not "wait for the tone" before leaving a message on an answering machine, or "press 1" if it has a touch-tone phone. Make sure the numbers you input are likely to be answered by a real person, not an answering machine or voice-mail system!

Next, you can record your message. When you press and release the RECORD button, the record indicator will light to let you know to begin speaking. Unless you're leaving messages with four of your children—all of whom know who "Mom" is and precisely where she lives—it's a

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good idea to include in the message your full name and address. With the set-up complete, the front-panel switch can be moved to the RUN position.

Should an emergency occur, a press of the pendant causes a piercing piezoelectric alarm to sound, and activates the console phone dialer. It isn't necessary for the person wearing the pendant to be in the same room as the console for the signal to be picked up.

The console is also compatible with the X-10 control standard, so it can be used to control lights and appliances in the home. Using your home's wiring to send and receive signals to and from other, optional Radio Shack Plug 'n Power modules, the system can flash indoor and outdoor lights and sound a remote siren to help emergency personnel find your house or to attract your neighbors' attention.

The system might not be foolproof, but it will surely bring some peace of mind to the person living alone, as well as that person's loved ones. ■

WINNET

(Continued from page 18)

you to browse for resources using menus. When you find something you like, you can access it without having to worry about domain names, IP addresses, or other such details. Gopher Mail is a tool that allows you to use the Gopher search system to find items of interest. It allows you to see and use a site's Gopher menus through e-mail. Just send a message to a Gopher Mail server, and you'll receive its menu in an e-mail message. You then reply to the message, marking the menu item or items that interest you with an "X". The Gopher site then sends you the results by e-mail. It's not point-and-click access—it is a little cumbersome, and you have to become familiar with command-line options—but it does work!

Although UUCP service does have its limitations, we have no hesitation recommending WinNET Plus because of the ease-of-use and efficiency it brings to Usenet. Once you download the day's news, you are free to take as long as you want to read it and to compose replies. Better yet, unlike the "big guys" (read: America Online and CompuServe), you can be very selective in what you want to see thanks to the program's built-in search capabilities.

Let's say you are interested in electronics, but only as it pertains to digital signal processing. Rather than reading through all of the sci.electronics newsgroup, you could tell WinNET Plus to search through all entries for "DSP" or "digital signal processing," and increase the efficiency of your Usenet access. ■

GIZMO NEWS

New Little Dishes

DirecTv Inc. has selected three additional companies to manufacture DSS satellite receivers: Toshiba America Consumer Products Inc., Uniden America Corp., and Hughes Network Systems. The three join Thomson Consumer Electronics and Sony Corp.

Thomson, of course, rolled out the first receivers in June of 1994, and began its national rollout in October. Thomson had the exclusive right to manufacture receivers for 18 months or until the first million receivers were sold—whichever came first. The million came first, however, as DSS became the most successful new product introduction in consumer electronics history.

Sony, as of this writing, was gearing up to become the second supplier of DSS equipment, and was due to have product on the shelves by as early as May. The three new suppliers are expected to release product to the market in 1996. Hughes Network Systems will be first, early in the year. Toshiba and Uniden will follow in mid-1996.

Copy Protection

Macrovision Corporation's digital copy-protection scheme will likely become the de facto standard for the digital set-top decoder industry and for pay-per-view networks. The company recently signed a license agreement with Hyundai Electronics, the fourteenth manufacturer of digital set-top decoders to be licensed.

The copy-protection technology is based on a digital-to-analog converter that processes incoming digital video and converts it to an NTSC or PAL analog output. The output signal carries the copy-protection process that allows the video to be displayed normally on a TV screen, while at the same time preventing acceptable recording on VCRs.

According to Macrovision, its copy-protection scheme will allow pay-per-view system operators to "offer the most current hit movies and events to subscribers and to maximize current and future revenues for those programs."

Macrovision-enabled integrated circuits are available from nine authorized semiconductor manufacturers: Analog Devices, Brooktree, GEC Plessey, Philips, Raytheon, Samsung, SGS Thomson, Sony, and Texas Instruments.

Cassettes Live

A market-research study conducted early this year revealed that cassettes encoded with Dolby S-type noise reduction were preferred by consumers. That held true even when compared to the sound of compact discs.

Attendees of the Winter Consumer Electronics were asked to listen to audio demonstrations in different simulated environments. One survey was conducted in a home-listening situation, where the sound of mass-produced Dolby S-type prerecorded tape was compared to a compact disc. The tape was recorded on Type I (ferric-oxide) tape at 80 times normal speed. Eighty-five percent of the respondents claimed to have heard little or no difference or actually preferred the Dolby S-type sound.

In "beach" and "car" environments, listeners compared Dolby B with Dolby S. Dolby S noise-reduction clearly won with 88 and 90 percent, respectively, of the listeners in each environment preferring it.

The study was conducted by Dolby Laboratories. It was not a double-blind comparison—listeners were informed about what they were listening to.

Cable Interface

The Electronic Industries Association's Consumer Electronics Group has submitted a new proposal for an interface between television sets, VCRs, and set-top cable boxes.

The FCC—in an attempt to solve consumer complaints about the incompatibility of cable systems with such consumer-electronics features as picture-in-picture, on-screen tuning systems, and video recording of one program while viewing another—required the cable and consumer-electronics industries to adopt a suitable interface. If they are unable to come to an agreement, the FCC will impose an interface standard on them. Up to now, the two industries have been unable to reach agreement.

According to the EIA, the cable and electronics industries had agreed on all elements of a decoder interface that would make cable boxes obsolete. However, the cable industry insisted that an infrared bypass be included. That would have allowed cable systems to circumvent the interface and interfere with TV set and VCR functions.

The EIA's new proposal calls for a descrambling-only interface. Besides making it possible for consumers to use all of the features built in to their consumer-electronics equipment, the decoder interface should make set-top boxes open to competition. ■

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ELECTRONICS WISH LIST

A Remote Possibility

A new line of universal remote controls from *Sole Control* (46-23 Crane Street, Long Island City, NY 11101) promises to "forever change the shape of remote controls." The remotes are designed with a vertical, standard format that should make them easier to find on a cluttered coffee table. They are also designed to be easier to use. The keys, for example, are color coded and grouped by function. The remotes offer the ability to control DSS and other satellite receivers, and they are designed to access the menu systems that are now common to feature-laden TVs. As an added bonus, the remotes can provide a sleep timer even to components that don't have one. Just leave the remote aimed at the component, and set it to shut down after a predetermined interval from one to 90 minutes. Price: from $14.95 to $29.95.

CIRCLE 62 ON FREE INFORMATION CARD

Sole Control Universal Remotes

Superhighway Telephone

The multi-service *PhonePlus* telephone from *US Order* (13873 Park Center Road, Suite 480, Herndon, VA 22071) lets users pay their bills, shop from catalogs, and conduct ATM transactions from their homes. PhonePlus is a speaker phone built around a Motorola 68000 CPU and 256 kilobytes of memory. It has a normally-hidden full alphanumeric keyboard, a 4-line × 20-character display, and a credit-card and ATM-card reader. It can store up to 250 names, addresses, and phone numbers. The phone is designed to be used with BankPlus and ShopPlus, which are available by subscription for a monthly fee of about $15. Future services include EmailPlus and InfoPlus, which allow users to send e-mail through the Internet and to retrieve such information as sports scores, weather reports, stock quotes, and news. Price: $200.

CIRCLE 63 ON FREE INFORMATION CARD

US Order PhonePlus Telephone

Automotive Sound.

The *7004A* from *Autotek* (855 Cowan Road, Burlingame, CA 94011) is a four-band graphic equalizer that contains a two-way crossover and dual inputs. Each crossover switch has separate low- and high-pass crossover points and the dual inputs can accommodate dual-source units such as CD and cassette decks. The half-DIN sized chassis can be dash or console mounted. A front/rear fader is included, as are separate input sensitivity controls. Price: $199.

CIRCLE 64 ON FREE INFORMATION CARD

Bedside Phone

It's a close race between our desktop and night table—each is equally crowded. In an attempt to help out, *AT&T* (5 Wood Hollow Road, Parsippany, NJ 07054) has combined a clock radio and telephone in one package: the *Clock Radio Telephone 340*. The unit features such conveniences as a dual alarm (so that couples can wake up at different times), a sleep timer, a mute button, last-number memory, a lighted dial, and a 12-number memory. The AM/FM radio automatically lowers its volume when a phone call is answered. If that won't solve your clutter problem, you might choose to mount the unit on the wall. Price: $69.99

CIRCLE 65 ON FREE INFORMATION CARD

AT&T Clutter-Reducing Phone

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ELECTRONICS WISH LIST

Atari's Jaguar Videogame System

More than a Videogame

The *Jaguar* interactive multimedia home entertainment system from the originator of home videogame systems. *Atari Corporation* (1196 Borregas Ave., Sunnyvale, CA 94089) features 64-bit architecture that makes it "more than twice as fast as 32-bit platforms," according to the company. The system is designed for high-speed animation, textured 3-D graphics, and CD-quality sound. The system contains five processors: a proprietary graphics processing unit, a digital signal processor, an object processor, a "blitter graphics accelerator," and a Motorola 68000 16-bit microprocessor that handles secondary processing functions. The machine is supplied with Cybermorph, a flying/action videogame. Other games are available at prices between $50 and $70. Price: $249.95.

CIRCLE 66 ON FREE INFORMATION CARD

Cerwin-Vega Sensurround Speaker System

Home-Theater Speakers

Nothing brings video to life like great sound. *Cerwin-Vega* (555 E. Easy Street, Simi Valley, CA 93065) had that in mind when designing the *Sensurround Home Theater Powered System 8*. The system, which is designed for both home-theater and music applications, features three matched front speakers, a 150-watt, 12-inch powered subwoofer with remote volume control, and two rear-channel satellite speakers. The front speakers are magnetically shielded so that they can be placed directly above or beside a TV monitor. Each has dual 5¼-inch high-excursion midrange drivers and a 1-inch dome tweeter. They are rated to handle 80 watts. The rear-channel satellite speakers feature a single 5-inch midrange and a 1-inch dome tweeter, and are rated to handle 60 watts. A variable crossover control located on the rear panel of the subwoofer permits the crossover point to be adjusted from 45 to 150 Hz. Price: $1935.

CIRCLE 67 ON FREE INFORMATION CARD

Kenwood Car Stereo

On the Road Again

Those traffic jams will become a lot more bearable with *Kenwood's* (P.O. Box 22745, Long Beach, CA 90801) *KDC-PS900* car CD receiver. The head unit features the ability to control CD and MiniDisc changers, such as the KMD-C80 also offered by the company. Built with "autosound competition-level quality," the unit offers a signal-to-noise level of 96 dB and a dynamic range of 98 dB. The unit's total harmonic distortion (THD) is rated at 0.004 percent. Three RCA preamp outputs are available, and can be switched for either two- or four-volt operation. A digital output is also offered. Kenwood's proprietary digital control system, called K-Bus, allows for system expansion. Price: $600.

CIRCLE 68 ON FREE INFORMATION CARD

Eveready Automotive Lanterns

Shedding Some Light

Nothing is worse than breaking down on the highway—unless it's breaking down on the highway at night. *Eveready* has two products that are designed for just such an occurrence: the *Dashboard Plug-in Trouble Lantern* and the *Dashboard Plug-in Emergency Lantern*. The Trouble Lantern is equipped with a swivel hook that rotates 360 degrees and allows hands-free illumination. That rugged ABS plastic lantern comes with a 16-foot cord that is designed to plug into a cigarette lighter to run off a car battery, and uses a bright automotive bulb. The Emergency Lantern also comes with a plug-in adapter and 16-foot cord. Its head can tilt 120 degrees, and it comes equipped with an extra-bright krypton bulb. A red warning flasher is built into the handle. Both lanterns come with a lifetime warranty. Price: n/a.

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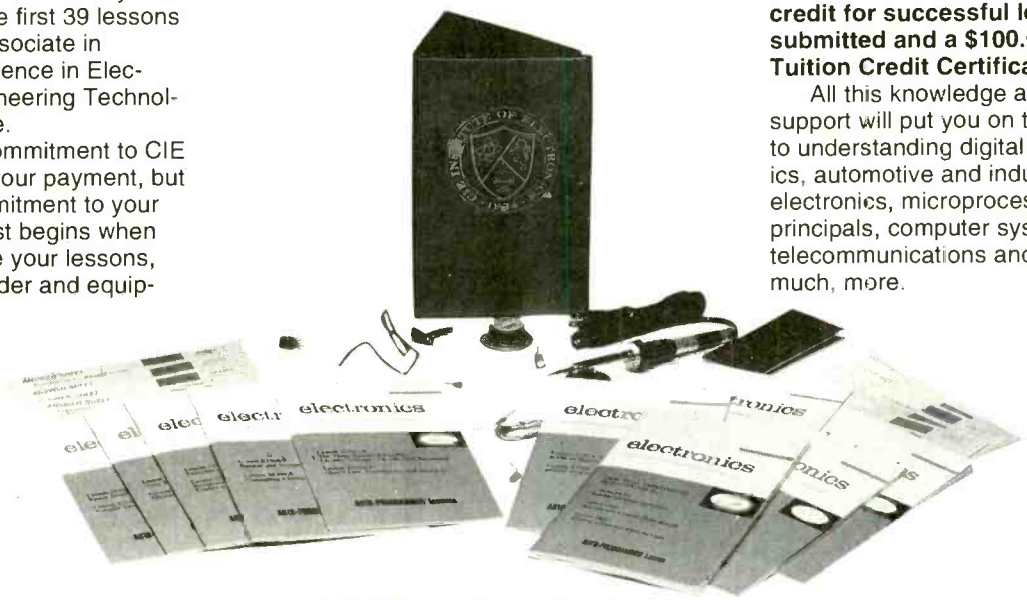

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MULTIMEDIA WATCH

By Marc Spiwak

Worth the Wait

Many of us remember *The 7th Guest* as being one of the best multimedia games to date. The 7th Guest took place in an eerie haunted mansion where the player had to solve the mystery of the house and its deceased owner, toy maker Henry Stauf. The game would keep a person busy for weeks on end playing it. That was the only problem I had with the game, that it was too much game for me to finish in the free time I have. Others, however, thought that it was the best game ever, and played it through to the end, solving its many mysteries.

It's been a long wait, but The 11th Hour, the sequel to The 7th Guest, is expected to be out by the time you read this.

The 7th Guest played well on most PCs, its graphics were superb, and there was obviously enough action there to keep millions of game players happy. But where was the long-awaited sequel? After a few false starts, it was rumored that *The 11th Hour* would be released in October '94. But it never arrived. Legions of game players were disappointed. What was taking so long?

TOPPING THE BEST

It's always hard to top the best, and The 7th Guest was one of the best. With multimedia technology accelerating at such a frantic pace, and all multimedia products continually improving, Trilobyte, Inc. had to make The 11th Hour even better than The 7th Guest, and not simply just as good.

The 11th Hour should finally be released by the time you read this, and I hope to take a look at it before then. The main reason its release has taken so long is that most of the technology that enhances the installation and playing of the game did not exist when its development and production phase began.

The game will be a story-telling thriller with multiple endings, and not just an interactive movie. Throughout the game, puzzles related to the thriller, but able to stand on their own, will help the player unlock bits and pieces of the story. The story will be divided into five acts, and solving the final puzzle in each act reveals the completed tale to that point. At the end of the final act, the player will decide how to end the story. All throughout the game's development, the intended content and how it would be delivered was what drove the technology's evolution.

One of Trilobyte's goals was to make the video quality of The 11th Hour indistinguishable from that of a TV show or movie. The game is to have instant responsiveness and speed, and will run at 30-frames-per-second in full-screen video—not just in a small window. There will be 65 minutes of full-motion video in all, and audio will be CD-quality.

It takes a lot of data to make a multimedia game of this magnitude. The 11th Hour is twelve times the size of The 7th Guest. Trilobyte got it to fit on two CD-ROMs, even though it is 134 gigabytes uncompressed—that would normally fill nearly 200 CD-ROMs. Clearly something had to be done, so Trilobyte set out to develop its own compression schemes.

Encode, Trilobyte's proprietary software tool, allows compression ratios far greater than MPEG, but does not require any special hardware for playback. Even with the newly developed compression techniques, it would have taken years to compress nearly 200,000 frames of video, so the animations were run on a number of computers simultaneously within a NEXTSTEP Distributed Computing Environment (DCE) network.

Another problem that can plague multimedia software is a difficult installation process for the game player. The 11th Hour will automatically retrieve configuration information from the machine on which it is played, so no one

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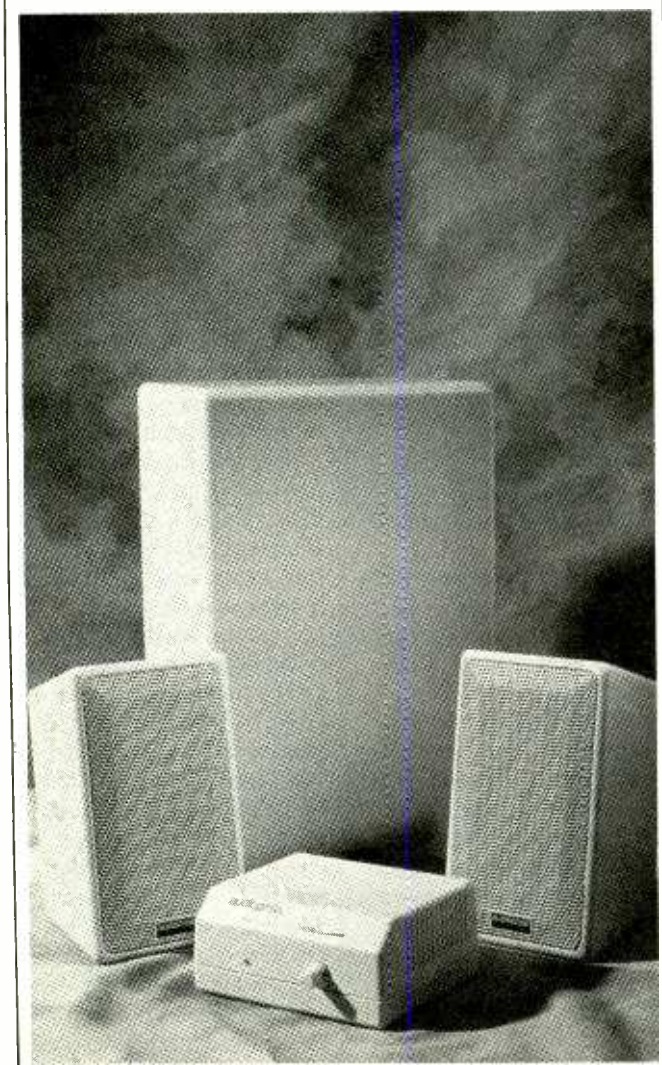
should have any trouble getting the game to work. Will The 11th Hour be worth the wait? I think so, considering how good The 7th Guest was, and how much more work is going into The 11th Hour. We're all anxious to see what The 11th Hour brings.

ANOTHER BIG ONE

While I'm on the subject of big games, I've got another one for you. *Under a Killing Moon*, from Access Software, is billed as an "interactive movie." UKM features a number of well-known actors including Brian Keith, Margot Kidder, Russell Means, and James Earl Jones, along with 25 others. The game takes you to the radioactive streets of post-World-War-III San Francisco, where you follow the exploits of a down-on-his-luck private eye, Tex Murphy, as he unravels a series of seemingly unrelated mysteries that eventually lead to a crime of timeless horror.

It is an understatement to say that this game is big. Two years and $2.5 million dollars in the making, the game is over 2.4 gigabytes in size, includes 3.5 hours of video sequences, and comes on four CD's! You'll also need a big computer to get the big results. While the minimum requirements seem modest enough (386/25 MHz, 4 MB of RAM), you will not be happy with the game's performance on such a machine. Indeed, the documentation that came with the game recommends a 486 DX2/66, local-bus video, and 16 MB of memory, and suggests that the game will perform even better on a Pentium. The documentation includes a card that explains why the memory is needed and illustrates a typical game scene on a system with 4 MB and on one with 16 MB. That said, the game performed fine on a 486 DX2/60 with 8 MB, although between-scene transitions could have been speedier.

On the plus side, installation was a snap (relatively), the richness of the detail made for a stunning visual experience, and the total freedom of movement within the game lets you explore every inch, including the ceilings and the floors, of the virtual world it presents. To be honest, I haven't gotten that far into the game, but so far the puzzles are challenging enough without being needlessly difficult to solve. If you do get stuck, an online hint system is available. If you have the hardware, Under a Killing Moon is a must have. If you don't, it's a great excuse to upgrade!



This Audiophile 10A/SW300 combo has some of the best desktop sound I've ever heard.

SUPERB SPEAKERS

We have some more software to cover this month, but first I'd like to report on one of the best multimedia speaker setups I've seen and heard so far. The *ProSound* product line from Audiophile includes speakers that are of very high quality and are also extremely versatile. I've tested their *Reference 10/Subwoofer SW300* combo, and I was very impressed. They also offer a more expensive combo, the *Reference 30/SW20*; the main difference in the latter combo is that it features slightly larger speaker elements.

To be more precise, I evaluated the Reference 10A speakers, the "A" meaning that they come with a 20-watt amplifier. (The equivalent Reference 30A speakers also come with the same 20-watt amplifier.) The Reference 10 speakers contain a 0.5-inch tweeter and 3-inch mid-bass speaker enclosed in a wood cabinet, while the 30s have a 1-inch tweeter and a 5-inch mid-bass driver.

One of the most important features that any good speaker should have is a solid cabinet. The ProSound speakers have wood cabinets. When I first looked at the Reference 10s, although they were extremely heavy for their size, I couldn't see how they were made of wood because there were no visible seams or joints. Upon further reading of the manufacturer's literature, I learned that the cabinets are made of medium-density fiberboard, assembled to tight tolerances with epoxy cement, sanded smooth to remove seams, painted, sanded again, and painted again. All I can say is that they are rugged, heavy cabinets, and that goes a long way toward producing excellent sound.

The SW300 subwoofer is about a foot tall, and very heavy; it's made with the same type of construction as the Reference 10s. The 20-watt amplifier, a small stand-alone unit, connects to the line-level output on a sound card or any other audio component and to the inputs on the subwoofer. The Reference 10s connect to outputs on the subwoofer, and additional speakers can be added to the setup.

The amplifier has a volume-control knob on it

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which eliminates the need for software volume controls. Plenty of wire is included to connect the speaker in any location. The system can also be connected to a regular stereo amplifier.

To get the best performance out of the system, it is important to place the speakers properly. That means setting the subwoofer on the floor, and placing the satellites on either side of the monitor, at about ear level. When set up that way, the highs were high, there was bass aplenty, and more than sufficient volume for any desktop applications. Games such as *Doom* are better with a subwoofer, and the PC now doubles as a Hi-Fi CD player in the living room. I even have to turn it down all the time.

Sony Imagesoft lets you decorate your screen with Playboy Playmates or the antics of Beavis and Butt-Head—you decide.

If you have been considering purchasing high-end speakers for your PC, you should seriously consider these. The 10A/SW300 combo lists for $299, but one national chain, Egghead Software, sells it for $199. Speakers and subwoofers are also sold separately. As far as desktop sound goes, the 10A/SW300 combo is hard to beat.

NEW STUFF

Getting back to the software, another big action/fantasy game this month is *Dragon Lore* from Mindscape. If dungeons and dragons excite you, then you'll love this game. Centuries ago, a fellowship of Dragons and Knights escaped a war-torn world and joined together in a beautiful remote valley, to establish peace of mind and a better quality of life. But today, after eons of peace, the most powerful enemy knight has sworn to destroy the valley. Only you can restore things to what they once were. Players can take multiple approaches to Dragon Lore. One can fight with weapons of steel or with intellect. There's over 50 hours of gameplay with rich, 3D graphics and fluid animation. Realistic sound effects and full voice support round off the game.

New from Creative Multimedia this month is *Automania*, a $29.95 CD-ROM filled with automotive information from the experts at *Automobile Magazine*. The disc contains specifications on thousands of new cars and trucks to help people make the right car-buying decisions. You can search through over 1600 vehicles and 75,000 specifications, view photos and video, see pricing information on new and used cars from 1977 to 1995, determine dealer invoices, and study over 275 reviews and road tests by the editors of Automobile Magazine.

WHERE TO GET IT

Access Software
4910 West Amelia Earhart Drive
Salt Lake City, UT 84116
CIRCLE 50 ON FREE INFORMATION CARD

Audiophile
7416 Washington Avenue South
Eden Prarie, MN 55344
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The Corel Building
1600 Carling Avenue
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Creative Multimedia
513 NW 13th Ave., Suite 400
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Novato, CA 94949
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Sony Imagesoft
2400 Broadway Ave., Suite 550
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1225 Crater Lake Ave.
Medford, OR 97504
CIRCLE 56 ON FREE INFORMATION CARD

Viacom Newmedia
1515 Broadway
New York, NY 10036
CIRCLE 57 ON FREE INFORMATION CARD

MTV is getting into the multimedia action with a new game that feature the network's unique graphics and captures its sense of humor. *Club Dead*, from Viacom Newmedia, lets you play Sam Frost, the best cyberplumber in the business, who also happens to be a virtual reality, or "V" addict. You've been plucked from jail to figure out why people who try to experience "V" at a posh resort are dying.

I've also got two new discs this month from Sony Imagesoft, and one of them features the two most famous personalities ever from MTV, Beavis and Butt-Head, in *MTV's Beavis and Butt-Head Multimedia Screensaver*. The disc lets you play preset or customized scripts of video clips pulled directly from the animated series. The disc also includes many .WAV files and wallpaper to let you customize your desktop with the pair of funny idiots. This one is $34.95. The second, *The Women of Playboy*, is another multimedia screen-saver package, but this one includes photos and video of the women from Playboy Magazine. You can even make your own custom screen-saver modules. The disc includes magazine covers, centerfolds, cartoons, bunnies, artwork, and more, from the 1950s through the 1990s. There's an adults-only version and a mature-audiences version; both cost $39.95. The disc is a must-have for fans of the magazine.

And now for something completely productive. *CD Creator* from Corel software, lets you create your own digital audio, data, or mixed-mode compact discs in the Windows 3.1x environment. A CD recorder becomes necessary only when it's time to make the disc; everything until that point is done on a PC. The software includes an audio-tracks editor, a data-files editor, a jewel-case insert editor, a photo-CD editor, and more. It keeps track of CD space used and space required for new tracks. For only $249, users can make their own custom CDs, right down to the artwork for the jewel box. ■

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A Hands-on Electronics® REPORT

MEDIA VISION RENO PORTABLE CD-ROM DRIVE

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Take CD-ROMs along for the ride with the Reno portable CD-ROM drive.

It seems that CD-ROM drives have become as popular in new computer systems as the venerable floppy drive. As a matter of fact, the double-speed CD-ROM drive has more or less replaced the 5¼-inch floppy drive as a standard PC peripheral. Most new PCs come with a CD-ROM drive and no 5¼-inch floppy drive.

With computer users beginning to rely on the presence of a CD-ROM drive, the absence of one can be a real nuisance. Once CD-ROM became standard on the desktop, it was only a matter of time before people wanted to use CD-ROMs on the go. People now want to be able to use a CD-ROM drive with their powerful laptops and portables, and maybe even swap a CD-ROM drive from computer to computer.

Short of buying a new laptop with a built-in CD-ROM, which can cost a king's ransom, the ideal way to do that would be to have a CD-ROM drive that you could take along with your laptop. But of course it would have to be light and portable, battery powered, and specially tailored for portable use. That fairly accurately describes the *Reno*, Media Vision's portable CD-ROM drive. As a bonus, the Reno can also double as a portable music-CD player. The Reno comes with an AC adapter, a SCSI cable, headphones, Mac and PC drivers, and a carrying case.

The Reno is a fully capable CD-ROM drive on the desktop or on the go. For desktop use, an AC adapter makes it behave just like any other CD-ROM drive; for portable use, a set of AA alkaline batteries is used for power.

Specifications. Reno will work with a PC or Mac. PC use requires a SCSI2 interface card—a tiny one is available for $39 from Media Vision. Macs have a SCSI connector built in, and so Mac users don't need the card. Reno's SCSI2 interface is more versatile than a proprietary interface, as the drive can be controlled by anything with SCSI2 compatibility. Many sound cards contain a suitable interface.

The double-speed Reno drive has a fast seek time of 180 milliseconds, which is faster than many other double-speed drives—portable or not. Transfer rate is up to 306 kilobytes per second. Discs load into the drive without a caddy, which is quite convenient. The drive easily meets MPC level-2 specifications. It is photo-CD and multisession compatible, and features a 64-kilobyte buffer memory.

Reno is about the same size as a portable music-CD player. The back of the drive docks into a similarly shaped SCSI interface/AC adapter that links the drive to the computer. The docking station adds about 4 inches in length to the player. A SCSI cable connects the docking station to your computer. The Reno will also work off a parallel port with an optional parallel-to-SCSI adapter, although performance will likely be reduced.

Four AA batteries install in the docking station, and two AA batteries install in the player. For portable use as a CD-ROM drive, Reno runs off all six batteries, while as a music-CD player, it works from only the two batteries in the player section. That eliminates the bulk and weight of the docking-station section, which is unnecessary for music CDs anyway. When used as a battery-powered CD-ROM drive, the six AA batteries will last about 1½ hours with continuous use, but rarely does a CD-ROM drive run continuously.

For fixed operation, an AC adapter can be used to save batteries. Both the player and docking station have 13.5-volt DC input jacks that the AC adapter can plug into; the jack on the docking station is used when the two pieces are joined together.

As a music CD player, Reno has the usual Open, Reverse, Stop, and For-

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ward play controls on the front panel, and a small liquid-crystal display. Reno is light in weight, even with the batteries installed (about one pound). The player can be shaken around pretty well while playing a music CD without skipping. An audio-output jack can be used with either the included headphones, or with a pair of amplified speakers.

Reno is a fine CD-ROM drive, and it doesn't take up a drive bay—another advantage as many of today's compact PC cases are short on drive bays to begin with. For portable use, an adjustable carrying case fits and protects Reno with or without the docking station attached. You won't be afraid to carry the unit around when it's in the protective custody of the spongy rubber case.

The portable CD-ROM drive can be purchased separately for a list price of $349; street prices are well under $300. The drive-only package includes an AC adapter, a SCSI cable, headphones, Mac and PC drivers, and a carrying case. The optional SCSI adapter card for a PC is $39. The unit is also available as part of a multimedia upgrade package that includes the drive, a 16-bit sound card, amplified speakers, headphones, microphone, a carrying case, and 15 CD-ROM titles; that package has a list price of $599.

Reno is a good investment for anyone who doesn't already have a CD-ROM drive, and who wants the added bonus of CD-ROM portability and a portable music CD player. Anyone contemplating the purchase of just a portable CD player might want to consider throwing in some extra bucks to get a CD-ROM drive, as well. Any way you look at it, you really can't go wrong with a Reno. The many ways it can be configured and used make it as versatile as a CD-ROM drive can get.

For more information on the Reno portable CD-Rom drive, contact Media Vision directly at the address given below, or circle no. 119 on the Free Information Card. ■

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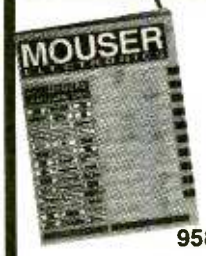

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THINK TANK

By John J. Yacono
Technical Editor
Windows Magazine

More Readers' Comments

We've almost completely covered resistors, so this will be the last tutorial regarding them specifically. Right after the tutorial we'll explore letters regarding past *Think Tank* columns.

As you know, the power (heat) dissipated by a resistor can be found if you know the amount of current flowing through the resistor and the component's value by using:

$$P = I^2R$$

which is Joule's Law. Now, let's use that with Ohm's Law:

$$I = V/R$$

and substitute V/R for I to get:

$$P = (V/R)^2R$$

That simplifies to:

$$P = V^2/R$$

That equation is typically more useful, as you usually know the voltage across a resistor rather than the current through it.

So far when we've talked about voltage and current, they have always been constant. But what if voltage and current change? How does that affect Ohm's Law and Joule's Law? Well the laws are still valid, but they only apply to the relationship between current, voltage, and power at any given instant.

To indicate the impermanence of the variables (when applicable), they would have to be written in lowercase. So our equations would become:

$$p = i^2R$$
$$p = v^2/R$$
$$i = v/R$$

Note that the resistor's value is constant (it does not vary over time), so it's written in upper case. Frankly, in most circumstances, knowing the heat dissipated by a resistor at a given instant is not very useful. If the changes in power dissipation (really in voltage and current) occur quickly enough, we really need to know the average power dissipation required. Averages of current, voltage, and power will be next month's topic; for now, let's read those letters.

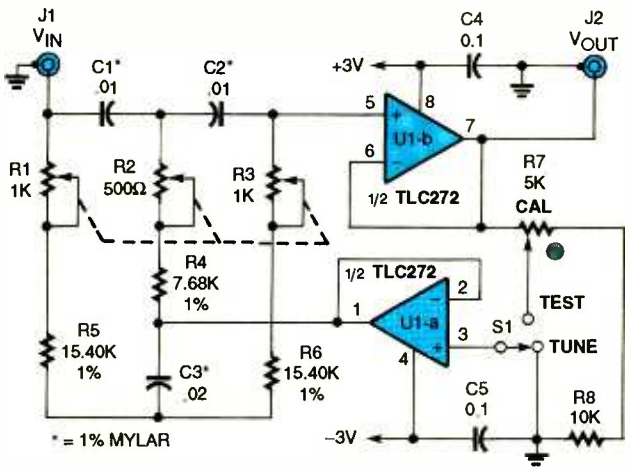

Fig. 1. This THD adapter can be enhanced by using a threaded rod to set the slide pots to precise values. That allows you to get readings down to 1 or 2 percent.

THD ADAPTER REVISITED

I just wanted to thank you for the nice write-up you did on my THD adapter (see Fig. 1) in your November 1994 *Think Tank* column. Your final comments were really appreciated. As a semi-retired electronics professional at 48, I still enjoy seeing my letters published. I figure that if I am successful in stimulating a few minds out there, it's worth the effort to write.

A couple of notes on the THD: I used a length of 6-32 threaded rod with a small nylon "clevis" (used on R/C servos) connected to the slide-pot sliders as a push-pull tuner. The pots were mounted in the cabinet with the rod protruding through a clearance hole in the side. Coarse tuning was done in the TUNE position, and a very fine null was accomplished by rotating a knurled 6-32 nut on the rod in the TEST position, using the cabinet side as a stop for the nut. That method is very useful for measuring THD below about 1 to 2 percent. Also, use a shielded cable on the input only—the twisted pair should only be used at the output to your RMS meter. You'll love the performance of this circuit!

Thanks again.

—Skip Campisi, South Bound Brook, NJ

You and I have the same opinion about what this column is about—stimulating the mind. Thank you for your continued participation. You have sent me more circuits than any other reader. The quality of your work is much appreciated, too.

WALKMAN AMP

How can the small amplifier circuit on page 31 of the December issue of **Popular Electronics** (shown here as Fig. 2) work? There are no bias resistors on either base. Also, C5, which bypasses R1, would bypass all the highs letting only very low frequencies come through. Both Q1 and Q2

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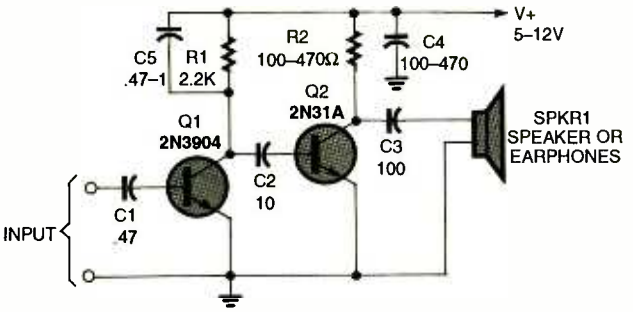

Fig. 2. If a down-and-dirty audio amp is what you need, try this miniature unit. Among other things, it can be used to boost the output of an earphone for the hearing impaired.

need some current flow in the base to function at any level. I bet you've received a lot of mail on that.

Incidentally, I have on my wish list a circuit suitable for a traffic sensor such as the type used at traffic lights to detect the approach of a car. My house affords no view to cars from my driveway, so I would like to put a sensing coil in the pavement to alert me to an approaching car. You also might be interested in the fact that I have equipped my mailbox with a photocell and a music circuit. Now when the mail comes, a tune plays in the house.

I would appreciate a note back on the amplifier circuit.

—Dwight Eggleston, Hendersonville, NC

First, the main function of a bias resistor is to establish the output level of a transistor when no signal is applied. Because Q1's output is AC coupled to Q2, Q1's output level is unimportant—only its alternations are passed to Q2.

Second, Q1 does receive base current—the current from the input signal. Transistor Q2 also receives current via C2, provided C2 is being charged and discharged.

Third, with regard to C5, if that capacitor went to ground you'd be right, highs from Q1 would be grounded. However, C5 actually provides a good high-frequency path to the voltage source. So it helps charge C2 more rapidly than R1 when high frequencies are present, thus enhancing HF response.

That said, I like your car sensor idea—any takers out there? And by the way, why don't you send in your mailbox circuit? It sounds like a worthy contribution, and I need a letter on alarm circuits to round out a column.

LOW-RF SWITCH

I read, with interest, your *Think Tank* column in the February 1995 issue of **Popular Electronics** regarding the Low-RF Switch (See Fig. 3). After finally locating the TL783 chip and assembling the project, I found that I couldn't regulate the current. Were there are any changes to the circuit? If possible could you also tell me how much current the circuit will handle? I couldn't find any details concerning the TL783 chip. Also, I can't locate your earlier article, "Soldering Iron Controller," which was listed as being on page 53 of the May 1994 issue of **Popular Electronics.**

Thank you very much for your consideration.

—William J. Tannahill, Whittier, CA

The circuit prevents current from going above a specified value. It does not limit current in a linear fashion. Therefore, if you measure the current-limiting effect of the circuit with a digital multimeter that reads the slope of an AC waveform, or if you do not have a load that draws current above the circuit's set limit, you will not detect any current drop. To date, a number of people have reported success with the circuit and I have made no changes to my unit, which still functions. However, please see the next section for details on the types of resistors used.

The earlier article was incorrectly listed as appearing in 1994; it was in the May 1992 issue. Sorry for the inconvenience. It explains the controller more thoroughly; however, it does not mention the device's maximum current, which is 0.7 amps. Reaching that maximum requires an excellent heatsink, though, and you will have to reduce

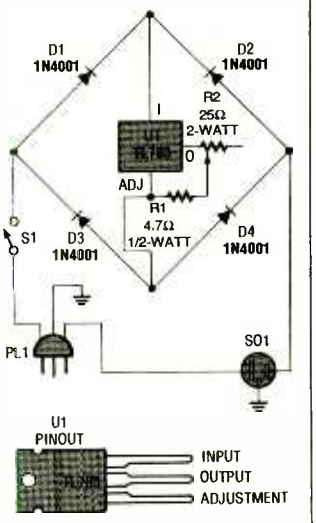

Fig. 3. This is the soldering-iron controller in the buff. The application is unusual, but functional. With the component values specified, the circuit should be used with a soldering iron of 25 watts or less.

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the value of R1 to around 1.7 ohms, at 5 watts.

SWITCH II

I would like to build the low-RF switch mentioned on pages 29–30 in the February 1995 **Popular Electronics**. You stated that it had previously appeared on page 53 in the May issue under "Soldering Iron Controller." Guess what, it is not there! I also researched every issue from April 1994 to January 1995 and I could not find it.

Even if I find your old article, however, I would still have difficulty with it if the schematic is the same as that shown in February. I'm skeptical about the wattage of the resistor and the pot. Following the discussion of this circuit is a section called "Label Dilemma," which states that unless otherwise indicated on a schematic or parts list, all resistors are ¼-watt units in this magazine. With 110-volts AC applied to the circuit, should the resistor values still be ¼-watt?

My other problem is that no electronic parts store in town can cross reference to a TL783 part. I have a suspicion that it might be a 9- or 12-volt-DC voltage regulator. Am I right? I want to use the circuit to dim a 100-watt light on my ceiling fan. Would any 1-amp 12-volt DC regulator work?

I'm sorry to bother you on all those details, but there is limited space in my light/fan, and store-bought dimmers are too large. I hope I could fit this dimmer into the light. Thanks, I'm waiting to hear from you.

—*George Kozar, Erie, PA*

You are right about the resistor wattage; however, not because it is exposed to 110-volts AC. In fact, because of the regulator, the resistor never sees more than 1.25 volts, even with the pot shorted. Nonetheless, the resistor should have been denoted as a ½-watt unit. The artwork was lifted from the old article, in which the wattage was mentioned in the parts list instead of the drawing (the reprint of the schematic in Fig. 3 reflects those changes).

The TL783 is actually a special, floating, high-voltage regulator (see the old article for more information on the chip's features). I would not recommend using another regulator in its place. I got mine from Active Electronics (Tel. 800-677-8899), so give them a call to get one.

Unfortunately, even under optimal conditions (see the previous letter), the best you can do is control a 75-watt bulb with the circuit. Of course you might be able to piggyback two such circuits, provided that you can mechanically connect the two pots.

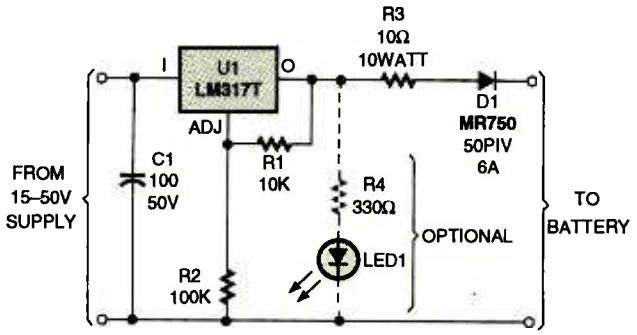

Fig. 4. Keep those batteries nice and juicy all year long with this trickle battery charger. Be sure to use heavy-gauge wire for all connections.

CHARGE!

I have found a circuit in *Think Tank* that I have problems with. It was Joseph Gaskill's *Charge It* in the June 1994 **Popular Electronics** (see Fig. 4). In that circuit, the values of R1 and R2 are much larger than are usually used with an LM317T. Most circuits I have seen, and some spec sheets, use a value of 240 ohms for R1, and a correspondingly lower value for R2. Sometimes smaller values such as 220 or 120 ohms are used for R1. Because the LM317T maintains a voltage of 1.25 volts between the output and adjust terminals, that gives a current of 5 mA in R1 and R2. A 12-volt battery charger shown in the "Typical Applications" section for the 317T in the 1990 *Radio Shack Semiconductor Reference Guide* shows a value of 240 ohms for R1 and 2400 ohms for R2, even though Radio Shack does not stock either value.

In the last few months, I have built battery chargers and power supplies using the LM317T and other 3-terminal regulators. The trickle-charge voltage for a 12-volt lead-acid battery should be about 13.8 volts. If 5-percent resistors are used, the output could vary by a volt. Therefore, either 1% resistors should be used, or R2 should be variable. There are also slight differences between LM317T's. I would use a 240- or 220-ohm resistor for R1, and a pot (either 2000 or 5000 ohms) in series with a 1000-ohm resistor for R2.

My next concern is the value of R3. Although the LM317T can supply 1.5 amps, with a 1-amp current the voltage drop across 10 ohms is 10 volts! The Radio Shack circuit uses 0.2 ohms. I think I would use one or two ohms as a starting value. Because the LM317T has internal current limiting and thermal overload protection, little external protection is needed.

When I started building my battery charger, I used D1, but because of the voltage drop across it, which varies non-linearly with current, I took it out. Removing D1 causes one possible problem: if the charger is connected to a battery before power is applied, a backwards current will flow through U1 to charge C1. The LM317T does not like backwards current! That can be remedied by connecting a 1-amp diode between the input and output terminals of U1 (connect the cathode to the input terminal). Then C1 would charge through the diode instead of U1. That diode, although often omitted, should always be used with three-terminal regulators in battery chargers or other circuits where there is a possibility of a voltage on the output terminal that is higher than that on the input terminal.

Next, the value of R4 (330 ohms) will give a current of 36 mA—rather high for a standard LED. I like to keep LED current at or slightly below 20 mA, which would require a resistor of 590 ohms (the standard value of 560 should be close enough). In my charger, I used a 300-mA transformer and wanted the entire 300 mA available for charging, so I used a low-current LED (Radio Shack 276-044 or similar) which is easily visible at a current of 2 mA.

A 7805 or 7806 regulator will also work well in this circuit. Use the ground terminal of the 78xx as the adjust terminal, and

(Continued on page 81)

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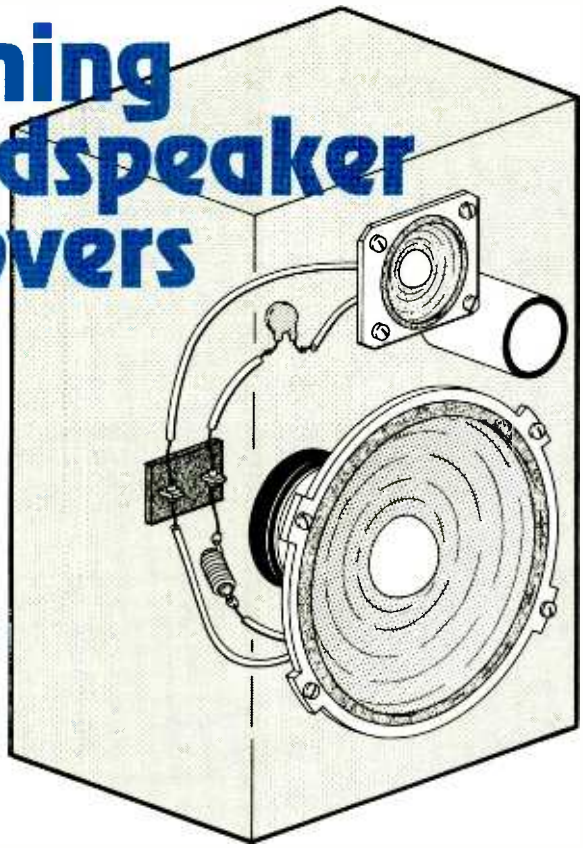

Some easy-to-use programs to help you create impressive-sounding speaker designs.

BY WILLIAM R. HOFFMAN

Designing loudspeakers might seem like an occult art to those who are not initiated in the techniques used. There's obviously a lot more involved than just hooking up a few drivers together and applying a signal. Now, with the help of the simple computer programs presented here, you can lift the veil of mystery from the practice of loudspeaker design, and create terrific-sounding speaker systems of your own.

Incidentally, this article builds upon a previous one, "Design Your Own Loudspeakers" (**Popular Electronics**, February 1994), in which we took a look at three BASIC programs for designing loudspeaker systems using a PC. Those programs calculated the correct dimensions for an enclosure for a particular bass driver, and aided in the design of a simple, speaker-crossover network. The five programs in this article make it possible to design even-more-sophisticated crossovers, as well as compensate for driver-efficiency differences, and eliminate peaks in a speaker's response.

Before we start, though, something should be made clear: These new programs will require highly accurate information about your drivers, and might require actual measurements of a speaker's frequency-response, impedance, and its voice coil's DC resistance and inductance values. If you purchase raw drivers from one of the more reputable sources, you might find that they can provide you with much or all of that information, making use of these new programs a lot easier. Now, let's proceed.

Program Use. The programs in this article were written in generic BASIC, and should work with all current versions of both GWBASIC and BASICA for the IBM-compatible PC. Enter the programs into your computer and save them in the directory that is used by your computer for its BASIC interpreter, being sure to use all the letters, punctuation, and spacing exactly as shown. If you aren't familiar with BASIC, just ask a friend who is; entering programs is as easy as typing a letter.

Once the programs are entered, accessing them is also simple. If you have GWBASIC on your PC, do it like this: from the DOS prompt type GWBASIC, a space, and the filename of the program (for example, XDES-2.BAS); then hit enter. In a few seconds the opening screen of the program should appear on your monitor. If you have BASICA, then start with: BASICA, a space, the filename, and the enter key. Once you have the program running, simply answer the various prompts that appear on the screen by entering the data required, and the program will automatically calculate the values for the circuit components.

XDES-2.BAS. The program XDES-2.BAS, shown in Listing 1, will provide crossover-circuit values for first-, second-, and third-order networks (6-, 12-, and 18-dB-per-octave filter slopes, in that order). Figure 1 shows the circuits and component designa-

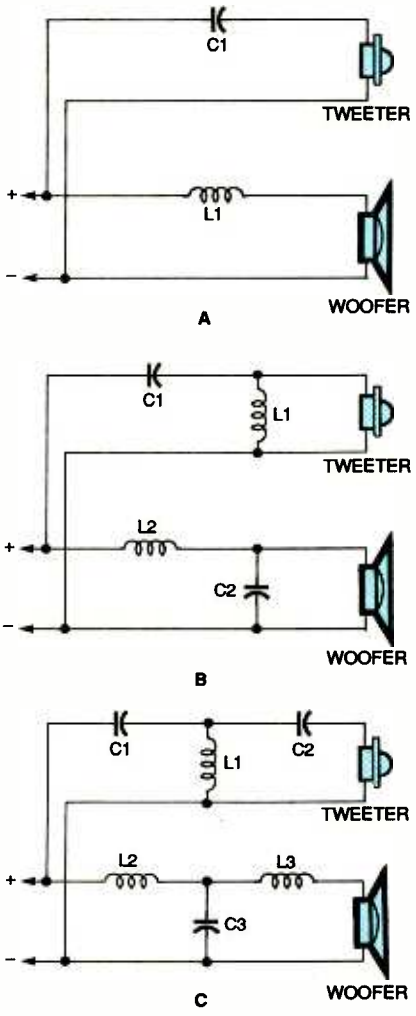

Fig. 1. The three crossover circuits that can be used with a two-way speaker configuration (consisting of a woofer and tweeter) are first-order (A), second-order (B), and third-order types (C).

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LISTING 1

```
5     CLS
10    PRINT:PRINT:PRINT:PRINT
20    PRINT "  A PC BASED PROGRAM TO
      CALCULATE CROSSOVER"
25    PRINT
30    PRINT "  NETWORK VALUES FOR 2-WAY
      SPEAKER SYSTEMS"
35    PRINT
40    PRINT:PRINT
45    PRINT "  By William R. Hoffman"
46    PRINT
55    PRINT "  The following program computes
      crossover network values"
60    PRINT "  for 2-way speaker systems using
      either L/R or Butterworth"
65    PRINT "  transfer functions and first thru third
      orders."
70    PRINT:PRINT
75    INPUT "  Do you wish to continue? (1=yes
      2=no) and Enter.";A
80    ON A GOTO 85
85    IF A=1 THEN 100
90    IF A=2 THEN 990
100   CLS:PRINT:PRINT:PRINT "
      CROSSOVER TYPE SELECTION"
110   PRINT:PRINT:PRINT
120   PRINT "  (1) First order Butterworth (all pass)."
125   PRINT:PRINT
130   PRINT "  (2) Second order Linkwitz-Riley."
135   PRINT:PRINT
140   PRINT "  (3) Third order Butterworth (all
      pass)."
155   PRINT:PRINT:PRINT
160   PRINT "  Enter number of crossover type and
      order from above list,"
165   INPUT "  then <ENTER>.";B
175   CLS
190   PRINT:PRINT:PRINT
200   PRINT "              CROSSOVER
      PARAMETERS"
201   PRINT:PRINT:PRINT
205   INPUT "  Crossover frequency is (Hz) =";C
206   PRINT:PRINT
210   PRINT "  Impedance of low frequency driver at
      the crossover"
211   INPUT "  frequency is (ohms) =";D
212   PRINT:PRINT
220   PRINT "  Impedance of high frequency driver at
      the crossover"
221   INPUT "  frequency is (ohms) =";E
222   CLS
250   IF B=1 THEN 300
260   IF B=2 THEN 400
270   IF B=3 THEN 500
300   LET C1=.159/(E*C)*10^6
310   LET L1=D/(6.28*C)*10^3
320   PRINT:PRINT:PRINT:PRINT
330   PRINT "  The inductor/capacitor values for a
      first order"
331   PRINT "  Butterworth crossover at "C"Hz are:"
335   PRINT:PRINT
340   PRINT "  L1 ="L1" mHy."
341   PRINT:PRINT
345   PRINT "  C1 ="C1" uF."
350   PRINT:PRINT "      Where the LF driver has an
      impedance of"D"ohms,"
355   PRINT "  and the HF driver has an impedance
      of"E"ohms."
360   PRINT:PRINT "      To print above information,
      use <PRN SCR> key now."
365   PRINT:PRINT "      Do you wish to try another
      set of values?"
370   INPUT "  (1=yes 2=no, and Enter) =";F
375   IF F=1 THEN 100
380   IF F=2 THEN 990
400   LET C1=.0796/(E*C)*10^6
410   LET C2=.0796/(D*C)*10^6
420   LET L1=(.3183*E)/C*10^3
430   LET L2=(.3183*D)/C*10^3
440   CLS
445   PRINT:PRINT:PRINT:PRINT
450   PRINT "  The inductor/capacitor values for a
      second order"
455   PRINT "  Linkwitz-Riley crossover at ";C"Hz
      are:"
460   PRINT:PRINT
465   PRINT "  L1 ="L1" mHy."
466   PRINT:PRINT
467   PRINT "  L2 ="L2" mHy."
468   PRINT:PRINT
469   PRINT "  C1 ="C1" uF."
470   PRINT:PRINT
471   PRINT "  C2 ="C2" uF."
475   PRINT:PRINT "      Where the LF driver has an
      impedance of "D" ohms,"
476   PRINT "  and the HF driver has an impedance
      of "E"ohms."
477   PRINT:PRINT "      To print above information,
      use <PRN SCR> key now."
478   PRINT:PRINT "      Do you wish to try another
      set of values?"
479   INPUT "  (1=yes 2=no, and Enter) =";F
480   IF F=1 THEN 100
481   IF F=2 THEN 990
500   LET C1=.1061/(E*C)*10^6
505   LET C2=.3183/(E*C)*10^6
510   LET C3=.2122/(D*C)*10^6
515   LET L1=(.1194*E)/C*10^3
520   LET L2=(.2387*D)/C*10^3
525   LET L3=(.0796*D)/C*10^3
527   CLS
530   PRINT:PRINT:PRINT:PRINT
535   PRINT "  The inductor/capacitor values for a
      third order"
536   PRINT "  Butterworth crossover at "C"Hz are:"
537   PRINT:PRINT
538   PRINT "  L1 ="L1" mHy"
539   PRINT "  L2 ="L2" mHy"
540   PRINT "  L3 ="L3" mHy"
541   PRINT "  C1 ="C1" mHy"
542   PRINT "  C2 ="C2" mHy"
543   PRINT "  C3 ="C3" mHy"
544   PRINT:PRINT "      Where the LF driver has an
      impedance of"D"ohms,"
545   PRINT "  and the HF driver has an impedance
      of"E"ohms."
546   PRINT:PRINT "      To print above information,
      use <PRN SCR> key now."
547   PRINT:PRINT "      Do you wish to try another
      set of values?"
548   INPUT "  (1=yes 2=no, and Enter) =";F
550   IF F=1 THEN 100
551   IF F=2 THEN 990
990   PRINT:PRINT:PRINT:PRINT "Good listening!"
999   END
```


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tions (the values of which are calculated by the program) for a two-way speaker with a bass (woofer) and a high-frequency driver (tweeter). Figure 1A is a first-order crossover, Fig. 1B is a second-order crossover, and Fig. 1C is a third-order crossover.

You might notice references to unfamiliar names in the program; let's clear that up now. Butterworth was the name of a mathematician who showed that a particular set of mathematical coefficients will give the fastest filter slope possible with both flat-in-band response and minimum phase shift in the circuit. In speaker design that is highly desirable, so we'll use that filter type. Also, two engineers at Hewlett Packard whose names are Linkwitz and Riley noted that cascading two Butterworth filters to create a second-order type (which is not possible directly with the Butterworth equations) will provide a more desirable flat phase and amplitude, along with a faster 12-dB-per-octave filter action.

XDES-3.BAS. This second program is another crossover program, like XDES-2.BAS, that also allows for filter slopes of 6-, 12-, and 18-dB per octave, but this time for a more advanced three-way system. That is, we can use three drivers: bass (woofer), midrange (sometimes called a squawker), and high-frequency (a tweeter). Input the XDES-3.BAS program from Listing 2, once again being careful to see that it is entered exactly as shown, and access it by typing either GWBASIC XDES-3.BAS or BASICA XDES-3.BAS at the DOS prompt.

When you run the program and the opening screen comes up, simply answer all the prompts for information. The program will then automatically calculate all the values of the components shown in Fig. 2 (Fig. 2A is a first-order crossover, Fig. 2B is a second-order crossover, and Fig. 2C is a third-order crossover). Note that the mathematical coefficients used in deriving those circuit values do not exactly match those of Butterworth or Linkwitz-Riley. The reason for that is that all passive filters of the type used as speaker crossovers are never ideal (i.e. their effect never sharply starts and ends). Because of that, the action of the filter for the lower-frequency crossover point (between the woofer and midrange) and the higher-frequency crossover (between the midrange and tweeter) will interact with each other. Therefore, the calculations must take that into account. Provided that the upper crossover frequency is at least 4–5 times the lower one, the calculated component values should provide a good "all pass" type of response, similar to the Butterworth filter.

(One important thing to note here is that if you use the second-order design, be sure and reverse the connections to the midrange driver as the crossover network inverts its signal phase relative to the other drivers.)

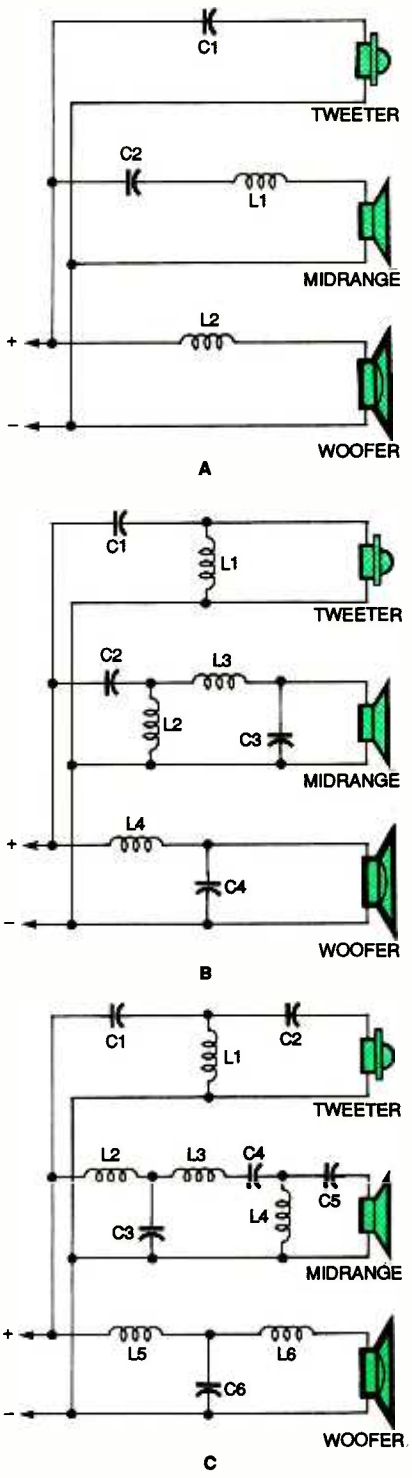

Fig. 2. Here are the three crossover circuits that can be used with a three-way speaker configuration (consisting of a woofer, midrange, and tweeter): they are a first-order crossover (A), a second-order crossover (B), and a third-order crossover (C).

Some General Rules. Here are a couple of things to keep in mind: First, while a 6-dB-per-octave crossover (first order) can be designed with only approximate driver-impedance values, a second- or third-order design requires more-exact information to be successful. That means you have to know the precise values of driver impedance and, in the case of a third-order (18-dB per octave) crossover, the acoustic response of the drivers used. That is because the sharper the filter action, the more the driver's impedance and frequency response

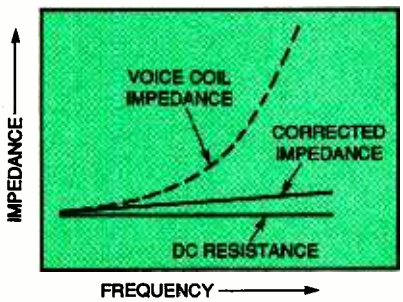

Fig. 3. This graph shows the rising impedance curve of a typical moving-coil driver in comparison to the corrected impedance of the same coil connected to a Zobel circuit.

become significant. As mentioned earlier, quality drivers from major suppliers will usually come with that information, or the information will at least be made available from the manufacturer. The same goes for recommended crossover frequencies.

Second, the impedance of the drivers in a second- or third-order crossover system must be constant to make the network work correctly. Because a driver's voice coil has substantial inductance (about 30 to 300 μH for tweeters and 0.5 to 1.5 mH for

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large woofers) the impedance might vary quite a bit with frequency. Therefore, compensation must be added to make it appear to the crossover as if it were constant instead. Compensating for the individual drivers with a capacitor/resistor combination is the purpose of our next PC program.

Driver-Impedance Equalization. Figure 3 is the impedance curve of a typical moving-coil driver, the kind we all commonly use. The voice coil is essentially a coil of wire and therefore has inductance; it produces a rising impedance with frequency because of inductive reactance.

So how can we make sure that a

LISTING 2

```
10    PRINT:PRINT:PRINT:PRINT
15    PRINT "  A PC BASED PROGRAM TO
      CALCULATE CROSSOVER"
16    PRINT:PRINT "     NETWORK VALUES
      FOR 3-WAY SPEAKER SYSTEMS"
20    PRINT:PRINT:PRINT "          by"
21    PRINT:PRINT "     William R. Hoffman."
22    PRINT:PRINT
25    PRINT "  The following program calculates the
      inductor and capacitor"
26    PRINT "  values for first thru third order
      crossovers for a 3-way"
27    PRINT "  speaker system."
30    PRINT:INPUT "     Do you wish to proceed?
      (1=yes 2=no) and Enter ",A
31    ON A GOTO 35, 990
35    PRINT:PRINT:PRINT
40    PRINT "  What order of crossover do you
      wish?"
42    INPUT "  (first=1, second=2, third=3) and
      Enter? ",B
43    PRINT
45    PRINT:PRINT "     Crossover frequency from
      low frequency driver to"
46    INPUT "  midrange driver is (Hz) = ",X1
47    PRINT:PRINT "     Impedance of low
      frequency driver at "X1"Hz is "
48    INPUT "  (ohms) = ",Z1
49    PRINT:PRINT "     Impedance of midrange
      driver at "X2"Hz is"
50    INPUT "  (ohms) = ",Z2
52    PRINT:PRINT "     Crossover frequency from
      midrange driver to"
53    INPUT "  high frequency driver is (Hz) = ",X2
54    PRINT:PRINT "     Impedance of midrange
      driver at "X2"Hz is"
55    INPUT "  (ohms) = ",Z3
56    PRINT:PRINT "     Impedance of high
      frequency driver at "X2"Hz is"
57    INPUT "  (ohms) = ",Z4
60    IF B=1 THEN 100
61    IF B=2 THEN 200
62    IF B=3 THEN 400
100   LET C1=(.16/(Z4*X2))*10^6
110   LET C2=(.53/(Z2*X1))*10^6
120   LET L1=((.047*Z3)/X2)*10^3
130   LET L2=((.16*Z1)/X1)*10^3
150   PRINT:PRINT:PRINT
155   PRINT "  Crossover values are:"
160   PRINT:PRINT "     C1 ="C1" uF."
16    PRINT:PRINT "     C2 ="C2" uF."
170   PRINT:PRINT "     L1 ="L1" mHy."
175   PRINT:PRINT "     L2 ="L2" mHy."
180   PRINT:PRINT "     To print the above
      information, use <PRN SCR> key."
185   PRINT:PRINT "     Would you like to try
      another set of values?"
190   INPUT "  (1=yes 2=no) and Enter? ",Y
195   ON Y GOTO 35, 990
200   LET     C1=(7.900001E-02/(Z4*X2))*10^6
205   LET     C2=(.31/(Z2*X1))*10^6
210   LET C3=(.023/(Z3*X2))*10^6
215   LET C4=(7.900001E-02/(Z1*X1))*10^6
220   LET L1=((.32*Z4)/X2)*10^3
225   LET L2=((.1*Z2)/X1)*10^3
230   LET L3=((.088*Z3)/X2)*10^3
235   LET L4=((.32*Z1)/X1)*10^3
240   PRINT:PRINT:PRINT
245   PRINT "  Crossover values are:"
250   PRINT:PRINT "     C1 ="C1" uF."
251   PRINT:PRINT "     C2 ="C2" uF."
252   PRINT:PRINT "     C3 ="C3" uF."
253   PRINT:PRINT "     C4 ="C4" uF."
254   PRINT:PRINT "     L1 ="L1" mHy."
255   PRINT:PRINT "     L2 ="L2" mHy."
256   PRINT:PRINT "     L3 ="L3" mHy."
257   PRINT:PRINT "     L4 ="L4" mHy."
258   PRINT:PRINT "     NOTE: midrange driver
      must be wired out-of-phase"
259   PRINT "  to correct for phase inversion by
      crossover network."
260   PRINT:PRINT "     To print the above
      information, use <PRN SCR> key."
270   PRINT:PRINT "     Would you like to try
      another set of values?"
275   INPUT "  (1=yes 2=no) and Enter? ",Y
295   ON Y GOTO 35, 990
400   LET C1=(.11/(Z4*X2))*10^6
402   LET C2=(.29/(Z4*X2))*10^6
404   LET C3=(.083/(Z3*X2))*10^6
406   LET C4=(.33/(Z2*X1))*10^6
408   LET C5=(.99/(Z2*X1))*10^6
410   LET C6=(.21/(Z1*X1))*10^6
412   LET L1=((.12*Z4)/X2)*10^3
414   LET L2=((.062*Z3)/X2)*10^3
416   LET L3=((.027*Z3)/X2)*10^3
418   LET L4=((.36*Z2)/X1)*10^3
420   LET L5=((.22*Z1)/X1)*10^3
422   LET L6=((.086*Z1)/X1)*10^3
425   PRINT:PRINT:PRINT
430   PRINT "  Crossover values are:"
431   PRINT "  C1 ="C1" uF."
432   PRINT "  C2 ="C2" uF."
433   PRINT "  C3 ="C3" uF."
434   PRINT "  C4 ="C4" uF."
435   PRINT "  C5 ="C5" uF."
436   PRINT "  C6 ="C6" uF."
437   PRINT "  L1 ="L1" mHy."
438   PRINT "  L2 ="L2" mHy."
439   PRINT "  L3 ="L3" mHy."
440   PRINT "  L4 ="L4" mHy."
441   PRINT "  L5 ="L5" mHy."
442   PRINT "  L6 ="L6" mHy."
450   PRINT:PRINT "     To print the above
      information, use <PRN SCR> key."
460   PRINT:PRINT "     Would you like to try
      another set of values?"
465   INPUT "  (1=yes 2=no) and Enter? ",Y
470   ON Y GOTO 35, 990
990   PRINT:PRINT "     Good listening!"
999   END
```


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crossover has a constant impedance instead? Many years ago, an engineer by the name of Zobel showed that it is possible to make a circuit operate as if it has a constant impedance by adding a series network of electronic components in parallel with it. The program, ZOBEL.BAS (shown in Listing 3), will give us a set of values for a resistor/capacitor series combination that will do just that. That will give the result in Fig. 3 that is shown as "corrected impedance."

After entering the ZOBEL.BAS program, run it as you did with the others, and follow the prompts. The voice-coil's DC resistance and its inductance can usually be found in the manufacturer-supplied specifications. If the information is not there, or if it's not available, the values can be measured using an ohmmeter and an inductance meter. The values that the program calculates will be for the capacitor and resistor shown connected to the block diagram in Fig. 4.

LISTING 3

```
10      PRINT:PRINT
15      PRINT "  LOUDSPEAKER ZOBEL DESIGN PROGRAM"
20      PRINT:PRINT:PRINT
25      PRINT "              by"
30      PRINT
35      PRINT "  William R. Hoffman"
40      PRINT:PRINT:PRINT
45      INPUT "  Proceed? (1=yes 2=no) and Enter ",A
50      ON A GOTO 60, 990
60      PRINT:PRINT:PRINT
65      INPUT "  Driver voice coil DCR is (ohms) = ",R
70      PRINT
75      INPUT "  Driver voice coil inductance is (millihenries) = ",L
76      LET L=L*10^-3
80      LET R1=R*1.2
85      LET C=(L/(R1^2))*10^6
90      PRINT:PRINT:PRINT
100     PRINT "  Series resistor-capacitor combination in parallel"
105     PRINT "  with the driver voice coil is:"
110     PRINT:PRINT:PRINT
115     PRINT "              R = "R1"ohms"
120     PRINT:PRINT
125     PRINT "              C = "C1"microfarads"
126     PRINT:PRINT "      To print above values, use <PRN SCR> key"
127     PRINT:PRINT:PRINT
130     PRINT "  Would you like to try another set of values?"
135     INPUT "  (1=yes 2=no) and Enter ",B
140     ON B GOTO 60, 990
990     PRINT:PRINT "      Good listening!"
999     END
```

LISTING 4

```
100     PRINT:PRINT:PRINT
110     PRINT "  DRIVER RESISTIVE ATTENUATION"
115     PRINT:PRINT "      CALCULATION PROGRAM"
120     PRINT:PRINT:PRINT "          by"
125     PRINT:PRINT "      William R. Hoffman"
130     PRINT:PRINT "      Do you wish to continue?"
135     INPUT "  (1=yes 2=no) and Enter. ",B
140     ON B GOTO 200, 990
200     PRINT:PRINT:PRINT
210     INPUT "  Driver average in-band impedance (ohms) = ",Z
215     PRINT
220     PRINT "  Required attenuation, in dB, as a negative"
230     INPUT "  value (i.e. -3dB) = ",A
300     LET R2=(10^(A/20)*Z)/(1-(10^(A/20)))
310     LET R1=Z-(1/R2+1/Z)^-1
320     PRINT:PRINT:PRINT
400     PRINT "  Resistor in series with the driver is = "R1" ohms"
410     PRINT:PRINT
420     PRINT "  Resistor across the driver voice coil is = "R2" ohms"
430     PRINT:PRINT
440     PRINT "  To print the above values, use <PRN SCR> key."
450     PRINT:PRINT "      Do you wish to try another set of values?"
460     INPUT "  (1=yes 2=no) and Enter. ",C
470     ON C GOTO 200, 990
990     PRINT:PRINT "      Good listening!"
999     END
```

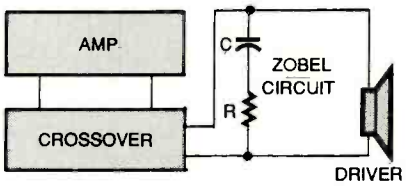

Fig. 4. A Zobel circuit is nothing more than a capacitor and resistor connected in parallel to the driver's leads.

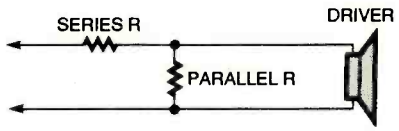

Fig. 5. These two resistors, one in parallel and one in series with the driver, make up the attenuator circuit.

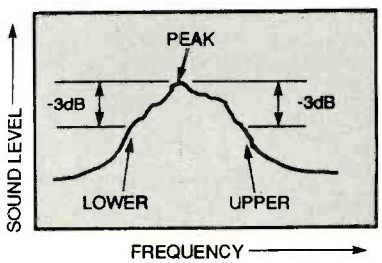

Fig. 6. This graph shows the parameters for determining the upper- and lower-frequency ranges of an audio peak.

Driver-Level Matching. Not all speaker drivers are matched in their efficiency (or more properly, sensitivity), with the result that a system might not have flat frequency response. Typically, a tweeter or mid-range is several dB more sensitive than a woofer, which will make the sound of a system very "forward" or "bright." Check and compare the driver-sensitivity specifications using the data supplied by their manufacturers, or use a small sound-level

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LISTING 5

```
100     PRINT:PRINT:PRINT
110     PRINT "  PARALLEL ELEMENT TRAP FILTER"
120     PRINT:PRINT "      CIRCUIT CALCULATION PROGRAM"
125     PRINT:PRINT:PRINT
130     PRINT "                by"
135     PRINT:PRINT "      William R. Hoffman"
140     PRINT:PRINT:PRINT
145     PRINT "  To calculate a parallel L/C/R filter that will"
150     PRINT "  selectively reduce a band of frequencies in the"
155     PRINT "  output of the loudspeaker."
160     PRINT:INPUT "      Proceed? (1=yes 2=no) and Enter? ",A
165     ON A GOTO 200, 990
200     PRINT:PRINT:PRINT
210     PRINT "  What is upper -3dB frequency of the peak to be"
220     INPUT "  reduced (Hz) ? ",FH
230     PRINT:PRINT
240     PRINT "  What is lower -3dB frequency of the peak to be"
250     INPUT "  reduced (Hz) ? ",FL
300     LET B=FH-FL
310     LET FM=(FH+FL)/2
320     LET C=.03/FM
330     LET L=.023/((FM^2)*C)
340     LET R=1/(6.28*C*B)
350     LET C1=C*10^6
360     LET L1=L*10^3
370     IF L1>8 THEN 380 ELSE 400
380     LET R=R-.5
400     PRINT:PRINT
410     PRINT "  The parallel L/C/R network values are:"
420     PRINT:PRINT "      L ="L1" mHy."
430     PRINT:PRINT "      C ="C1" uF."
440     PRINT:PRINT "      R ="R" ohms."
450     PRINT:PRINT "      NOTE: this network is wired in series with the driver."
455     PRINT:PRINT "      To print the above values, use <PRN SCR> key."
460     PRINT:PRINT "      Would you like to try another value?"
470     INPUT "  (1=yes 2=no) and Enter. ",C
480     ON C GOTO 200, 990
990     PRINT:PRINT "      Good listening!"
999     END
```

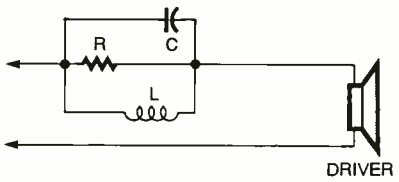

Fig. 7. A trap filter contains three components—a capacitor, a resistor, and an inductor—in series with a driver.

meter like the inexpensive one from Radio Shack (part no. 32-2050), and an oscillator or tape with test tones on it to determine each driver's sensitivity. Then, to compensate for the level differences, use two resistors to form a voltage divider that will reduce the input power to the more sensitive driver. Calculating those resistor values is done in our next PC program: DRIVERAT.BAS, shown in Listing 4. Enter that program into your BASIC directory, and load it as you did the others.

Once the program is running, answer the prompts asking for the driver impedance and attenuation required, and it will calculate the values of series and parallel resistors needed (the placement of those resistors is shown in Fig. 5). That circuit arrangement keeps the apparent load impedance of the crossover network the same as that of the driver alone. Therefore you don't have to go back and recalculate any crossover-component values. If the required resistor values are odd, simply use the nearest standard value available, or a combination of resistors in either series or parallel to get the necessary value. Exact values are not usually required as the application is not very critical; however, be sure the resistors have an adequate power rating, because quite a bit of current might be flowing through them. For a tweeter, use at least a 5-watt unit, and for a midrange, use a resistor rated at 10 watts or more. If you encounter a situation where the woofer is more efficient, *never* "pad it down" with resistors because that will reduce the amplifier's damping effect upon its bass resonance, and likely create a muddy bass sound. In that case, start over with either a less-efficient woofer, or a more-efficient tweeter.

Smoothing the Sound. Our last program, TRAPFIL.BAS, can be very useful if a driver is discovered to have a peak in its response, especially if that peak happens to be in the mid range, where the ear is most sensitive. TRAPFIL.BAS designs a trap filter that can "notch out" or attenuate a small band of frequencies in the speaker's response. Enter the TRAPFIL.BAS program shown in Listing 5 and run it.

(Continued on page 93)

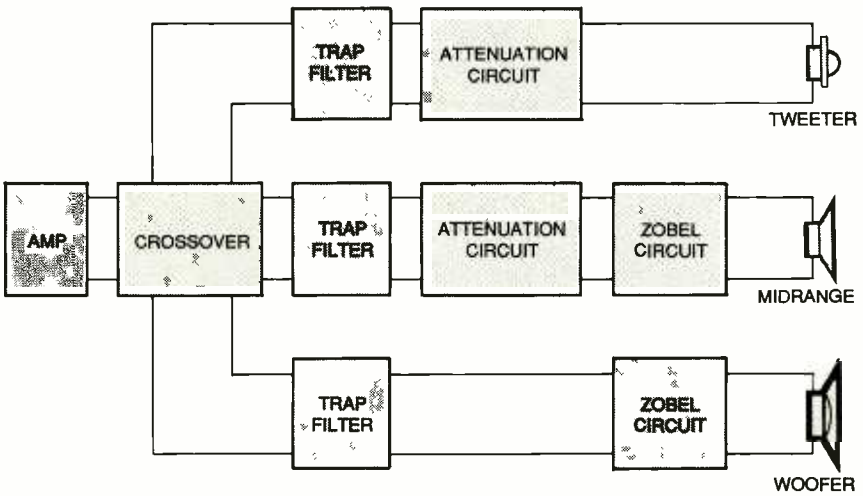

Fig. 8. This block diagram shows the proper way to make all the speaker circuits described in this article work together.

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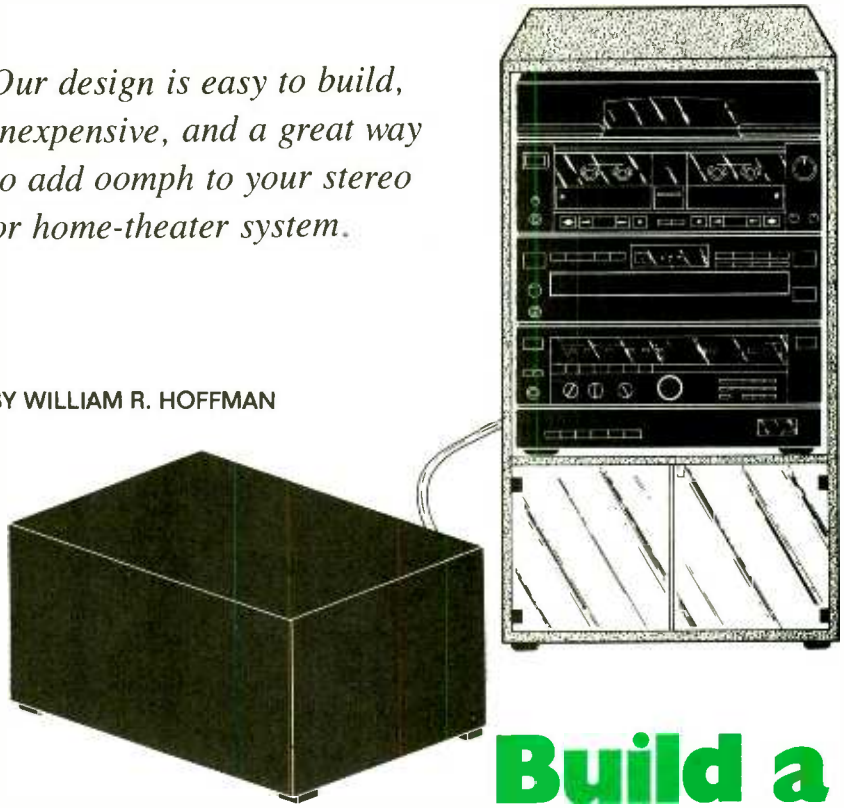
Our design is easy to build, inexpensive, and a great way to add oomph to your stereo or home-theater system.



Build a Subwoofer

BY WILLIAM R. HOFFMAN

The first thing that everyone notices about a big, expensive stereo or home-theater speaker system is always the bass. Whether you're listening to the sound of a giant pipe organ, or the footsteps of the T. Rex in *Jurassic Park*, it's always the bass that makes the sound so exciting!

So, does your own speaker system provide you with all the bass that you want? If your answer is no, then how about making some changes to your system so that it does! By building the *Subwoofer* described in this article, it is possible to get all the extra bass you could possibly use in an average-size living room or den. Best of all, you can build it for less than $50, and in about an evening.

About the Subwoofer. Figure 1 contains two graphs that display the performance of the Subwoofer. The graph in Fig. 1A is the actual frequency response of the unit (measured with a PC-based FFT analyzer and condenser microphone) in a room of about 1600 cubic feet, with the known standing waves and resonances of the room eliminated. Note the flat response down to a solid 35 Hz—the system will have little trouble meeting the frequency-response requirements of the current THX/Dolby home-theater standards!

Shown in the graph in Fig.1B is the maximum, continuous sound-pressure level that the system is capable of: 105 dB SPL above 35 Hz and more than 100 dB at 28 Hz, with both readings taken at a 1-meter distance from the system. Again, those are definitely up to home-theater standards! (For additional information on the woofer used in the unit, see the "Subwoofer Specifications" box.)

The Cabinet. Let's begin by looking at the general assembly of our system. Figure 2A shows the construction of the cabinet itself. It is a simple rectangular box that measures about 1 × 1½ × 2 feet, and is made from ¾-inch-thick chipboard material. The bass driver is placed on the cabinet's bottom side behind the larger hole shown in Fig. 2B, and faces downward toward the floor. As shown in Fig. 2B, the Subwoofer is a vented system, with the ducted port cut adjacent to the woofer. In addition, the aforementioned particular set of physical dimensions, taken from the requirements for a box with 1.8 cubic feet of interior volume, was chosen to minimize any possible standing waves within the enclosure.

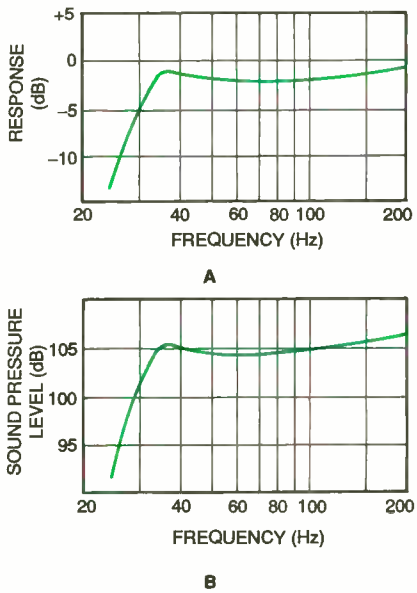


Fig. 1. This graph (A) shows the frequency response of the unit; note the flat response down to 35 Hz. That response, along with the speaker's maximum continuous sound-pressure level (B) is up to home-theater standards!

Supports that raise the cabinet about 3 inches above the ground are also required. Those can be rubber feet, short blocks of wood, or even nicely carved rounded feet with brass or plastic glides. That's up to the builder. Finishing of the system is also up to the builder. The cabinets can be either covered with veneer in a finish to match the furniture in the room, or else given a painted finish. The author's prototype Subwoofer was finished with textured, interior house paint that matched the color scheme of the room it was intended for.

Construction. The process of building the Subwoofer, as described here, is simple enough so that even the most amateur of wood workers can probably build one or more of them. Simple "butt joints" are used throughout the design. But that is not meant to prevent more-advanced cabinet builders from using other woodworking methods. Provided that the interior volume and shape of the enclosure remains as specified, mitered, dovetailed, or even routed corners

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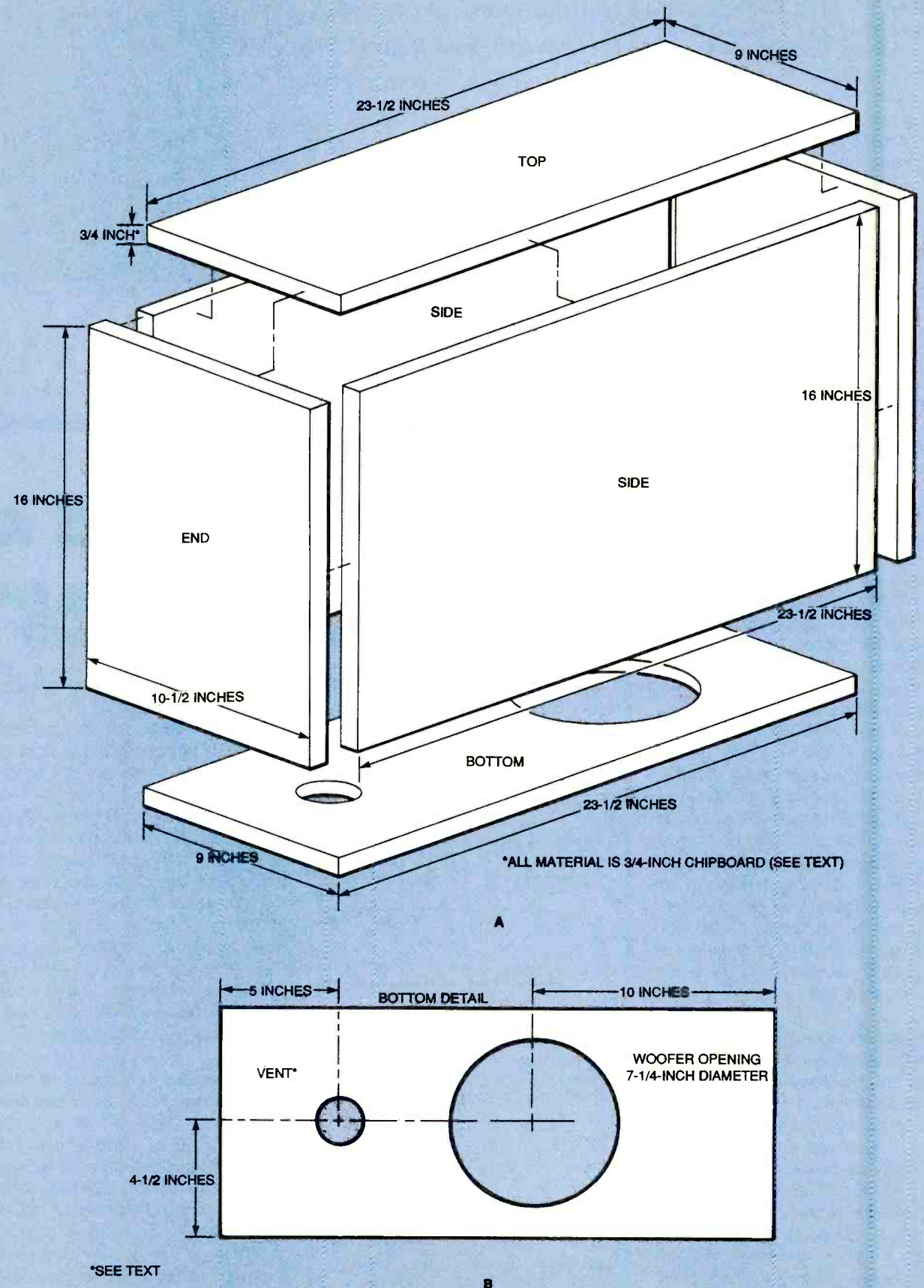

Fig. 2. When assembling the cabinet (A), attach the top and bottom pieces last, as they must be inserted flush with the side and end pieces. As the bottom detail shows (B), two holes must be cut—one for the speaker and one for the port-tube vent.

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PARTS AND MATERIALS LIST FOR THE SUBWOOFER

Note: All wood material is ¾-inch thick chipboard, plywood, or similar material; see text.

End pieces (2): 10½ × 16 inches
Side pieces (2): 23½ × 16 inches
Top and bottom pieces: 23½ × 9 inches
Low-pass filter (see text)
8-inch woofer (see text)
Two-position pushbutton terminal (Radio Shack part no. 274-315)
2⅛-inch diameter, 3-inch-long port tube (see text)
Wood glue, 2-inch finishing nails, support legs (see text), ¾-inch wood screws, 18-gauge 2-conductor wire, solder, hardware, etc.

Note: The following are available from Parts Express (340 E. First St., Dayton, OH 45402; Tel. 800-338-0531): An 8-inch Thruster woofer, part no. 290-053—$26.80; a port tube, part no. 260-322—72 cents; any of the inductor coils mentioned in the text—call for prices. Shipping costs vary by region and type of delivery chosen; please contact Parts Express for more information.

can be used to make the cabinet's corners. Also, solid wood material, or plywood, as long as it is ¾ inches thick, can be used instead of chipboard. In addition, extra internal cabinet bracing can be added to make the system more rigid. For those who wish to do any of those things, just study Fig. 2, draw up your own plans, and then proceed!

Now, let's take a look at the method that was used to build the Subwoofer prototype, step-by-step: First, you will of course have to get all the materials together. The woofer, as well as other speaker components are available from the source given in the Parts and Materials List. Also, be sure and arrange for whatever you will use for legs to support the cabinet off the floor.

Second, cut the wood to the sizes listed, and cut the openings for the bass driver, and port-tube vent, as indicated in Fig.2B. The hole for the port tube is slightly larger than 2 inches in diameter; that extra thickness is to accommodate the width of the tube itself, which has a 2-inch inside diameter, and a 2⅛-inch outside diameter. With the tube on hand, cut and file the cabinet's bottom panel until the tube just slides into the hole. When the cabinet is actually assembled, the port tube will protrude into the Subwoofer cabinet.

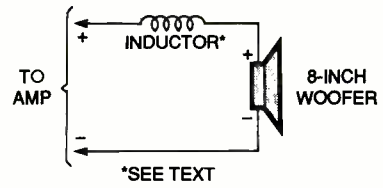

Fig. 3. Here's how to wire the low-pass inductor in series with the speaker. It can be placed either inside or outside of the cabinet.

Now it's time to assemble the Subwoofer cabinet. Because all of the enclosure joints are butt type, they can be assembled by applying a thin line of wood glue along the surfaces to be joined. After the pieces are carefully fit together to make sure they are straight, finishing nails will be used to hold the wood pieces together. Let's use that technique to assemble the cabinet in the following order:

Attach one of the side panels to an end piece; consult Fig. 2A. Note that in the cabinet assembly, the side pieces are fitted in between the ends. That makes up the four walls of the box. When those are glued and nailed together, insert the top and bottom panels down flush with the top or bottom edges of the cabinet's walls. When fitting the top and bottom pieces, first nail them in place, and then reach in through the woofer's cutout and run a bead of glue around the joining areas. Using your finger or a rag, smooth and spread the glue around until all the seams are filled. Also, go back over all the other cabinet seams as well, and fill and seal them as necessary so that there is no possibility of small air leaks occurring. That is important, as leaks will cause the enclosure to be tuned improperly, affecting the system's performance.

The 8-inch Thruster woofer shown here makes the Subwoofer really come alive.

SUBWOOFER SPECIFICATIONS

DRIVER
Cone: 8-inch diameter
Voice coil: 1.5-inch diameter
Magnet weight: 20 ounces
Nominal impedance: 6 ohms
Resonance frequency: 26 Hz
Sensitivity: 88 dB@1W/1M

ENCLOSURE
Enclosure type: vented, 4th order
Tuning frequency: 33 Hz
Internal volume: 1.8 cubic feet

SYSTEM
–3dB frequency: 31 Hz
Frequency response (± 3dB): 29 Hz to > 1 kHz
Maximum continuous SPL: about 105 dB above 35 Hz
Power capacity: 50 watts RMS, 70 watts maximum

Now you are ready to mount the woofer and make the wiring connections. Pick a place on the enclosure's bottom, preferably near where the woofer mounting hole is, and install a terminal block. Drill the necessary holes for the electrical connections on the enclosure's bottom, and after soldering some short lengths of 18-gauge wire to the terminals, feed them through into the cabinet's interior, toward where the woofer will be mounted. Also, be sure and mark which wire goes to the red or "hot" terminal on the strip. That one must go to the "+" or "hot" terminal on the woofer so that the Subwoofer and other speakers in the system will be connected in phase. If the wires were reversed, nothing would be harmed, but less bass would result.

After mounting the terminal strip, seal around its edges (or around the holes going through into the interior of the cabinet) with more glue so that everything is airtight. Solder the wires from the terminal strip to the terminals on the woofer. Mount the woofer by inserting it face out into the hole cut for it in the cabinet. It will rest in place because of its outer rim. Secure the woofer by fastening a ¾-inch wood screw through each of the mounting holes in the rim, making sure that the

(Continued on page 92)

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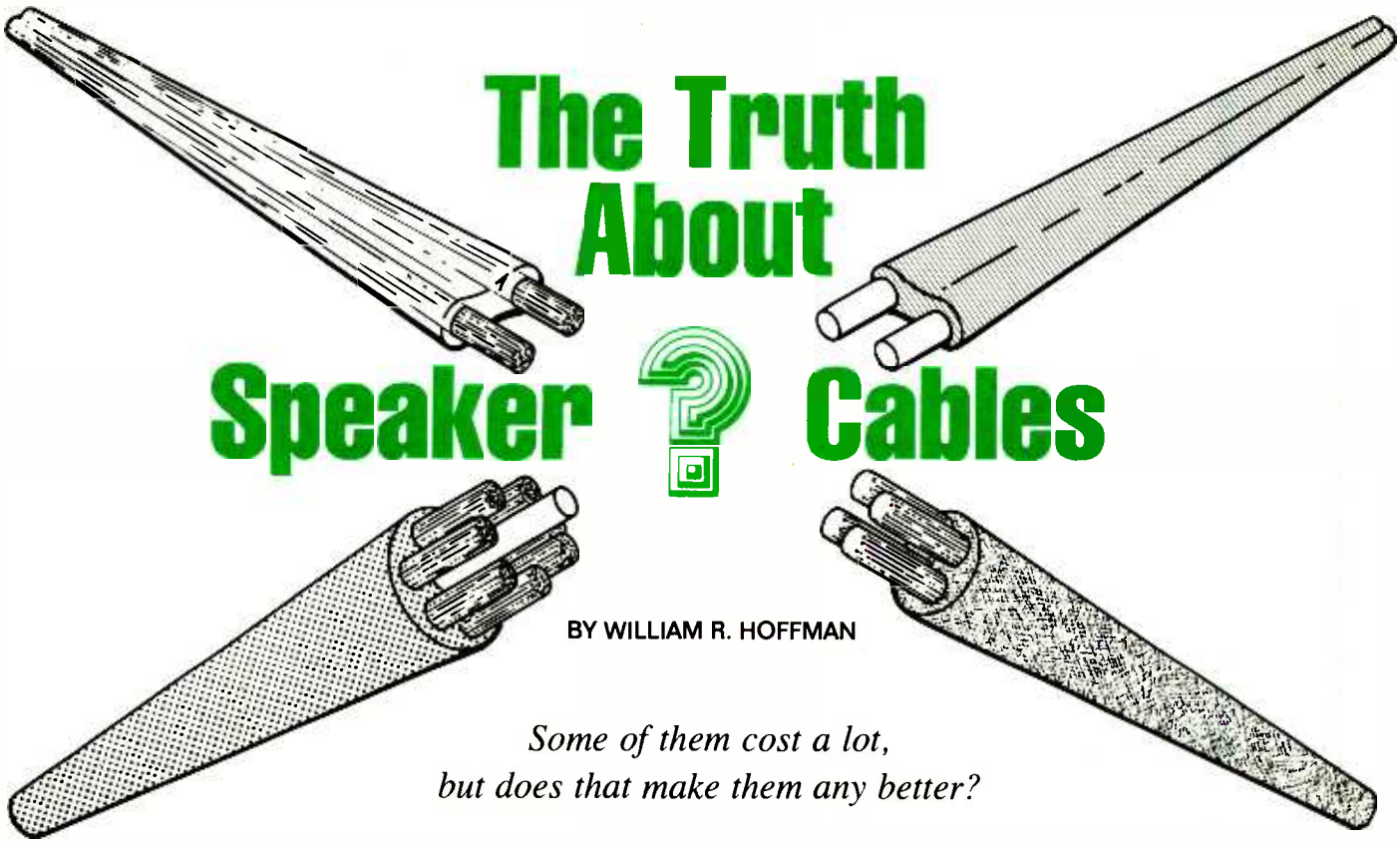

The Truth About Speaker Cables

BY WILLIAM R. HOFFMAN

Some of them cost a lot, but does that make them any better?

Any audiophile who has ever seen one of those monstrous sets of speaker cables protruding out of the back of an amplifier and running to the nearest loudspeaker, might have wondered what was so important about them. Or more important, how could they be worth their enormous asking prices? And then, if audiophiles look to buy a pair for themselves, they discover that there are about 60 manufacturers offering them in a bewildering array of shapes, materials, and designs! On top of all that confusion, is it really possible to hear a difference in sound quality at all?

Starting with the last question first, try asking some of your audiophile friends what they think. It's likely that as many as you ask, you would probably also get the same number of different answers! Although each would likely acknowledge that differences exist, it is doubtful that any two would consider the same manufacturer's product as being the "best." Still no help!

Then, if you approached an "expert" with questions about speaker cables, what could you expect to get? Many researchers in the electronics and audio field would probably say there is no audible difference. They might even cite tests and studies, "proving" their point. So then, where does that leave you?

Well, the best bet is to decide on your own if there really is a difference. And the best way to start is to understand just what is inside some of those fancy audiophile cables.

Some Cable Basics. To begin with, the conductors (wires) in a cable come in two basic forms: round (circular cross-section) conductors, and flat (square or rectangular cross-section) "ribbon" types. Both those forms are used today by many manufacturers, although the round conductor is certainly the most common. By using one of those wire types, most manufacturers attempt to create a cable that has low DC resistance, and a low, or selective, reactance characteristic (capacitive or inductive) that they feel will make a stereo system sound better.

But how does a speaker cable have inductance and capacitance? Any current flowing through a conductor induces a magnetic field around itself; a wire is therefore said to have inductance. In a single speaker cable there are usually two conductors, one for the current from the amplifier to go out on, and the other for it to return by. Because of that, there is a difference in potential between the two adjacent conductors, which gives the cable capacitance. The currents in the two conductors, being in opposition to each other, cause the inductive fields to be opposing, and therefore to partially cancel each other.

(**Note:** Low capacitance can be especially important with some types of solid-state amplifiers that use large amounts of negative feedback. Too much capacitance can lead to instability and oscillation, and can be damaging to the amplifier's circuitry.)

Now, lets move on to the cable designs themselves. To begin with, we'll review those that are based on the use of round conductors—the most common type in use today.

Round-Conductor Cables. Cables using round conductors generally come in 7 basic configurations. In Fig. 1, those types of cables are illustrated (A through G). Let's discuss each one in turn:

Figure 1A shows a stranded parallel pair. That is the common "zip-cord-type" speaker wire we're all likely to be familiar with; part of the wire's popularity has to do with the fact that it's

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mass produced and quite cheap. The conductors are stranded (usually 7-25 strands per conductor), and commonly used in 14-, 16-, and 18-gauge sizes for a home stereo. Because it is stranded, the wire is quite flexible and has a greater surface area than a simple, solid-conductor type would have. The circumference, and therefore the surface area, is proportional to the radius squared. Also, as we have just discussed, the proximity of the two conductors affects both the capacitance and inductance of the complete cable assembly. The conductors are usually molded into a thermoplastic-type material, for flexibility and ease of cutting and stripping.

In Fig. 1B is shown a round, solid-core, parallel pair. That type of wire is commonly used for household AC wiring, and comes in 12- through 16-gauge sizes. Being a solid core wire, it has the most conductivity for a given conductor outside circumference (there are no wire strands with air spaces between them). As far as the other properties go, it is similar to the stranded type mentioned above. Some years back, 4- or 6-gauge, solid-core conductor cables commonly used in arc-welding rigs were used for audio, and some audiophiles liked them very much, despite the difficulty with the stiffness and bulkiness of the cables. Such speaker wiring certainly had low DC resistance because of its large cross-sectional area and circumference!

Shown in Fig. 1C is a circumferentially distributed, stranded, multiple-conductor cable. One of the first attempts at improving the standard, two-conductor parallel-pair cable types was to break up each of the conductor-wire bundles into multiple smaller ones, and distribute them around the circumference of the cable surrounding an insulated, solid core. That method of construction allowed the manufacturer to maximize the number of wire strands (and therefore the wire surface area), and to keep the two sets of conductors apart as much as possible (reducing the cable capacitance). The only slight disadvantage is that the cable inductance rises because the effect of parallel inductive-field cancellation due to opposing currents in adjacent conductors is reduced.

Figure 1D shows a radially distributed, stranded multiple-conductor cable. With that design we have the unique opportunity to have the low audio frequencies pass through a different set of wires than the high frequencies! Consider the arrangement of the cable wire bundles shown in Fig. 1D. Those near the center of the cable assembly will be completely surrounded by others nearby and therefore have very low values of inductance (because of the mutual cancellation effect). High frequencies will therefore find that the easiest path. While at the same time, those near the outer circumference will have minimized cable-to-cable capacitance, making that the easiest path for the low frequencies.

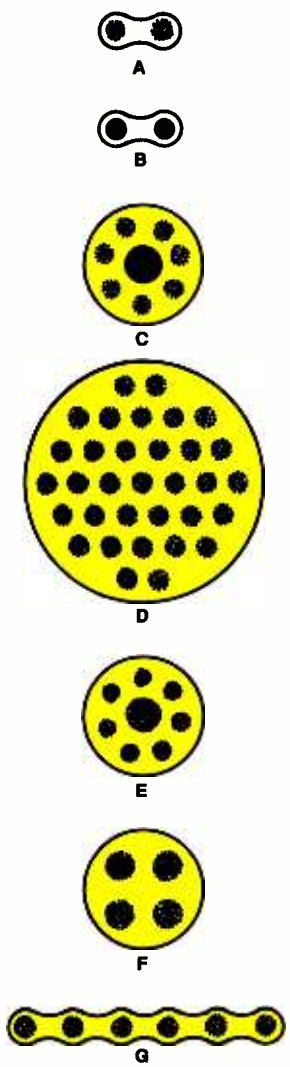

Fig. 1. Cables containing round conductors come in the seven basic configurations shown here. They are: a stranded parallel pair (A); a round, solid-core, parallel pair (B); a circumferentially distributed, stranded multiple-conductor cable with a colid core (C); a radially distributed, stranded multiple-conductor cable (D); a cable with multiple, circumferentially stranded sets around a large-core conductor (E); a cable with multiple parallel pairs, terminated at ends (F); and a cable with parallel stranded wires woven together as a parallel flat braid (G).

Figure 1E shows a cable with multiple, circumferentially stranded sets around a large-core conductor (a variation of the design shown in Fig. 1C). Here, the cable is designed to have an absolute minimum of inductance. With the center, large-wire bundle as one conductor, and the multiple, smaller-wire bundles circumferentially arranged around it as the other, the surface area between the two conductors is maximized, therefore also maximizing the mutual inductance cancellation effect between them. (The only way that could be made more effective is by creating a cable with a single, round inner conductor surrounded by another conductor formed as a solid circumferential shell.) The down side of that is, of course, the very high conductor-to-conductor capacitance.

Figure 1F shows a cable with multiple parallel pairs, terminated at ends. That design consists of multiple parallel bundles of smaller bundles of stranded wires. The many small wires make for a low DC resistance, while the spacing of the bundles can allow the maker to adjust the values of inductance and capacitance to anything desired. It's an interesting "universal" design.

A cable with parallel stranded wires woven together as a parallel flat braid is shown in Fig. 1G. It is an interesting design, based loosely on the parallel-conductor ribbon cables used in computers. In the only known example of the flat-braid design, 36 heavy, 16-gauge insulated wires were woven together to form a ribbon about 5-inches wide. Very low DC resistance and minimum capacitance were its features. On the other hand, the weight and extreme stiffness of the cable made it extremely difficult to use.

Ribbon-Conductor Cables. Figure 2 shows three (A through C) basic flat-wire (ribbon conductor) cable designs. Those are usually much more

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expensive than the simple round-wire types because of the cost of the wire in the ribbon form, and the increased cost during manufacturing of molding the conductors accurately into the insulated sheathing around them. Let's discuss the designs in order.

Figure 2A shows a cable design that has ribbon conductors that are spaced apart with parallel flat sides. That is probably the most common flat-wire cable form. The advantage is, of course, that each conductor has a large cross-sectional area, yielding a low DC resistance. But there are some definite problems with the design too. The cable can be very stiff and difficult to use; it might be possible to bend it in only one direction, perpendicular to the large, flat sides of the conductors. Also, unless the conductors are spaced some distance apart, high capacitance from wire-to-wire is possible—something that is definitely not desirable.

The type of cable shown in Fig. 2B contains ribbon conductors that are spaced apart with their edges closest together. That is a variant on the cable in Fig. 2A. By placing the ribbon conductors with their edges (instead of flat faces) facing each other, cable capacitance is much reduced—a good feature to have. On the other hand, the cable's bending problems might even be worse with that design.

Another variant, shown in Fig. 2C, features multiple ribbon conductors per cable. Unfortunately, that conductor arrangement has the potential to be worse than either of those we have already mentioned, combining the potentially high cable-to-cable capacitance of the cable shown in Fig. 2A, with the very stiff physical form of the cable shown in Fig. 2B.

Conductor Materials. Because it is very desirable to have a cable with the highest conductance possible, a good cable should start out with a basic wire type that has the lowest possible resistance. Two choices are possible: The first is to make the wire as large as possible, and the second is to use a conductor material that has as low an intrinsic resistivity as is possible.

Taking those in order, let's start out with conductor size, (or more properly, cross-sectional area). Table 1 shows us, by A.W.G. (American Wire Gauge), the

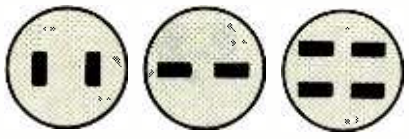

Fig. 2. The three basic flat-wire cable types shown here are designed to have either: ribbon conductors that are spaced apart with parallel flat sides (A); ribbon conductors that are spaced apart with their edges closest together (B); or multiple ribbon conductors per cable (C).

TABLE 1

A.W.G. Gauge	Resistance (Ohms per Foot)
4	.00026
6	.0004
8	.0065
10	.0010
12	.0016
14	.0026
16	.0042
18	.0066
20	.0105

resistance of stranded, drawn copper wiring (7 strands per conductor). Note that the sizes commonly used for speaker cables, 14, 16, and 18 gauge, have very low resistance: from about 2 to 6 milliohms per foot. For cable lengths of, say, 30 feet or less, that will be only about a third of an ohm in total resistance, which is probably small enough that it can be ignored. Why? Let's look at an example for the answer.

Let's say the damping factor of the bass driver in our speaker system is what we are most concerned about. The higher the DC cable resistance, the poorer the damping will be, so it should be kept down. An audio power amplifier might have an output impedance of about 50 milliohms, which will act like a near dead short (and a good "brake") on the back EMF (electromotive force) generated by the dynamic motion of the woofer's voice coil. That is good because it would control the driver's bass resonance, and lower its distortion. But there is one other factor here we cannot forget: The crossover inductor placed in series with the woofer's voice coil might have a DC resistance of 0.5 to 1.2 ohms by itself. So, as long as we keep the speaker cable's resistance down to a few tenths of an ohm, or less, the inductor's resistance will make those cable losses insignificant.

Now, let's turn to the basic resistivity of the metal conductor itself. If we look at Table 2, we can see that copper (which is commonly available and quite cheap) is almost as good as can be had. Only silver is better, and then only slightly. But considering the cost of silver, most manufacturers would agree that using copper is just fine.

What about the exotic alloys, pure metals, and other "special" materials used by manufacturers to eke out extra performance? We'll get to them in a moment.

TABLE 2

Material	Resistivity (Ohms/Meter × 10)
Aluminum	2.7
Beryllium	4.6
Copper	1.7
Gold	2.3
Magnesium	3.9
Molybdenum	5.7
Nickel	6.8
Rhodium	4.7
Silver	1.6
Tungsten	5.5
Zinc	5.9

About Insulation Materials. Besides preventing electrical shorts between conductors in a cable, insulation has only one other significant effect: It is one of the factors that determines the capacitance between opposing cable conductors.

Conductor-to-conductor capacitance is basically determined by four factors: conductor spacing, area of conductor surfaces facing each other, potential difference, and the dielectric constant of whatever is between the conductors (the constant of air is approximately 1). The first three capacitance-defining parameters are determined by a cable's physical design, so we now need to examine only the dielectric constant. Because it is desirable to keep cable capacitance down, a material with the

(Continued on page 93)

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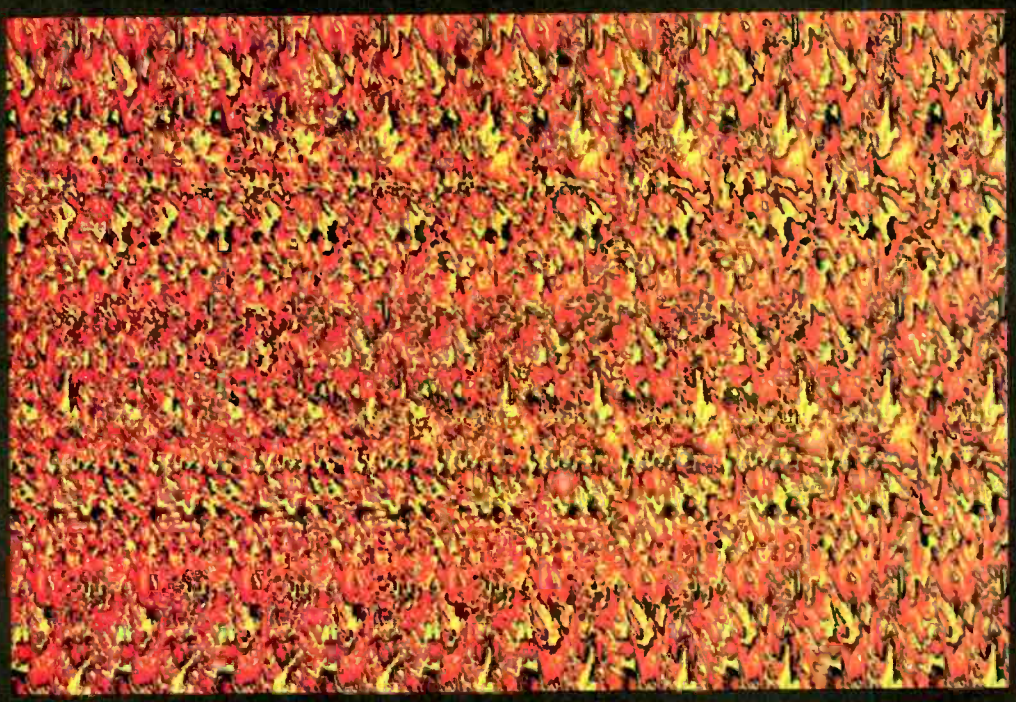
Fun With



Random-Dot Images

Random-dot images are lots of fun, and it is easier than ever to make your own.

BY MARC SPIWAK

The image that appears at the beginning of this article might appear as a random hodgepodge of color, but if you look at it correctly (or is it incorrectly?), a 3-D image of a warrior with a sword will jump out of the page. That image is an example of a Single Image Stereogram (SIS), and it is a member of a family of related images that also includes random-dot images, stereograms, Single Image Random Dot Stereograms (SIRDS), 3D images, and more.

Those images have become quite popular in recent years with T-shirts, posters, greeting cards, and puzzles decorated with them for sale in stores everywhere. The images can be in black and white or in color, and can be formed from patterns, photographs, drawings, or any other kind of image.

The trick to seeing the stereograms is to focus your eyes not on the image, but *behind* it. It's like having droplets of water on a pair of glasses; you don't really see the drops unless you try, but you can see them. Some people find it easier to see the image when looking at it through glass, and focusing their eyes not on the image but on the glass.

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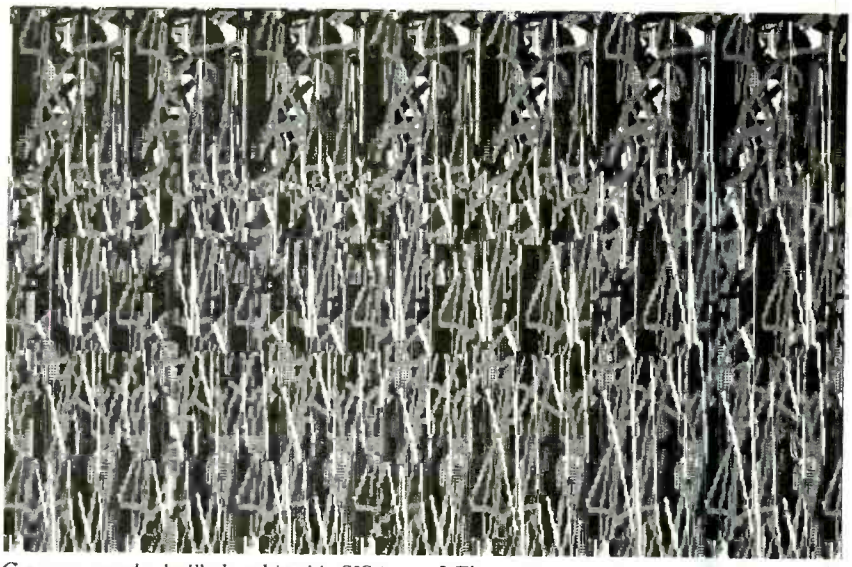
Seeing Random-Dot Images. There are various tricks and techniques to seeing the images. One is to relax yourself and hold the image between 8 and 16 inches from your eyes. Get into a trance-like state, and try to "unfocus" your eyes on the image. If you are quick to pick up the technique, you'll see the image after only a few seconds.

Another technique is to bring the image to the tip of your nose. Let your eyes settle into focus, then slowly move the image away without changing that focus.

Some images, like the black-and-white ones that accompany this article, include two dots to aid the viewer. Before you try the dots, though, try this: Hold two fingers in front of your eyes and focus them on something farther away. At first you should see four fingers. If you vary your focus, the two center finger images will overlap at some point and you'll see the illusion of three fingers. The two dots at the top of each image are used in the same way to help focus your eyes. When your eyes are properly focused to see the image, the two dots should appear as three dots. Once you see that, the trick is to transfer your focus from the dots to the image below.



Can you see the bull's head in this SIS image? The pattern used to form the image was supplied with the Stereolusions package. Unlike some SIS images, this one also works in black-and-white.

The image of a horse, a flock of birds, and the planet Saturn are hidden in the random-square pattern of this SIRDS picture.

How The Images Are Formed. When you look at a three-dimensional object, your brain uses the different perspective between your two eyes to judge depth. Most people have seen stereoscopic art that provides a slightly different image for each eye to give the illusion of depth. Three-dimensional movies require the viewer to wear glasses with different-colored filters for each eye to achieve the same effect.

The random-dot images do the same thing by hiding different images for each eye in vertical strips of dots. The strips are as wide as the distance between the two dots. When one eye is looking at a dot in one strip, the other eye should be looking at the same dot two strips over. Sometimes you'll see some very unusual double images when one eye focuses on a dot three strips away from the other. Some people find it easier to see the image if they cross their eyes slightly.

Where You Can Get Them. If you haven't seen any of these images anywhere, it's probably because you don't go out to the shopping malls very much; the images are everywhere. But there is also a mail-order company that specializes in these im-

(Continued on page 92)

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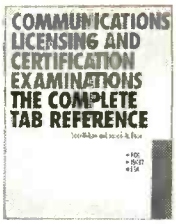

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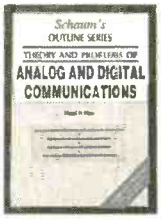

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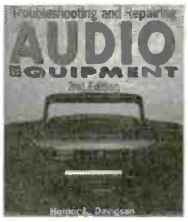

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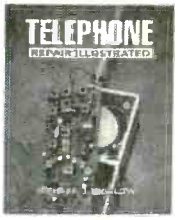

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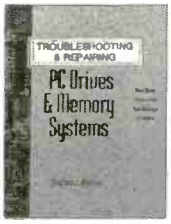

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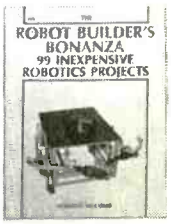

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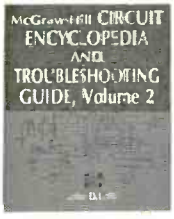

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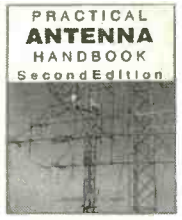

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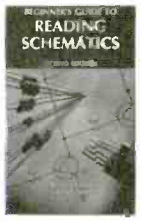

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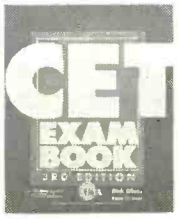

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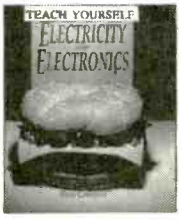

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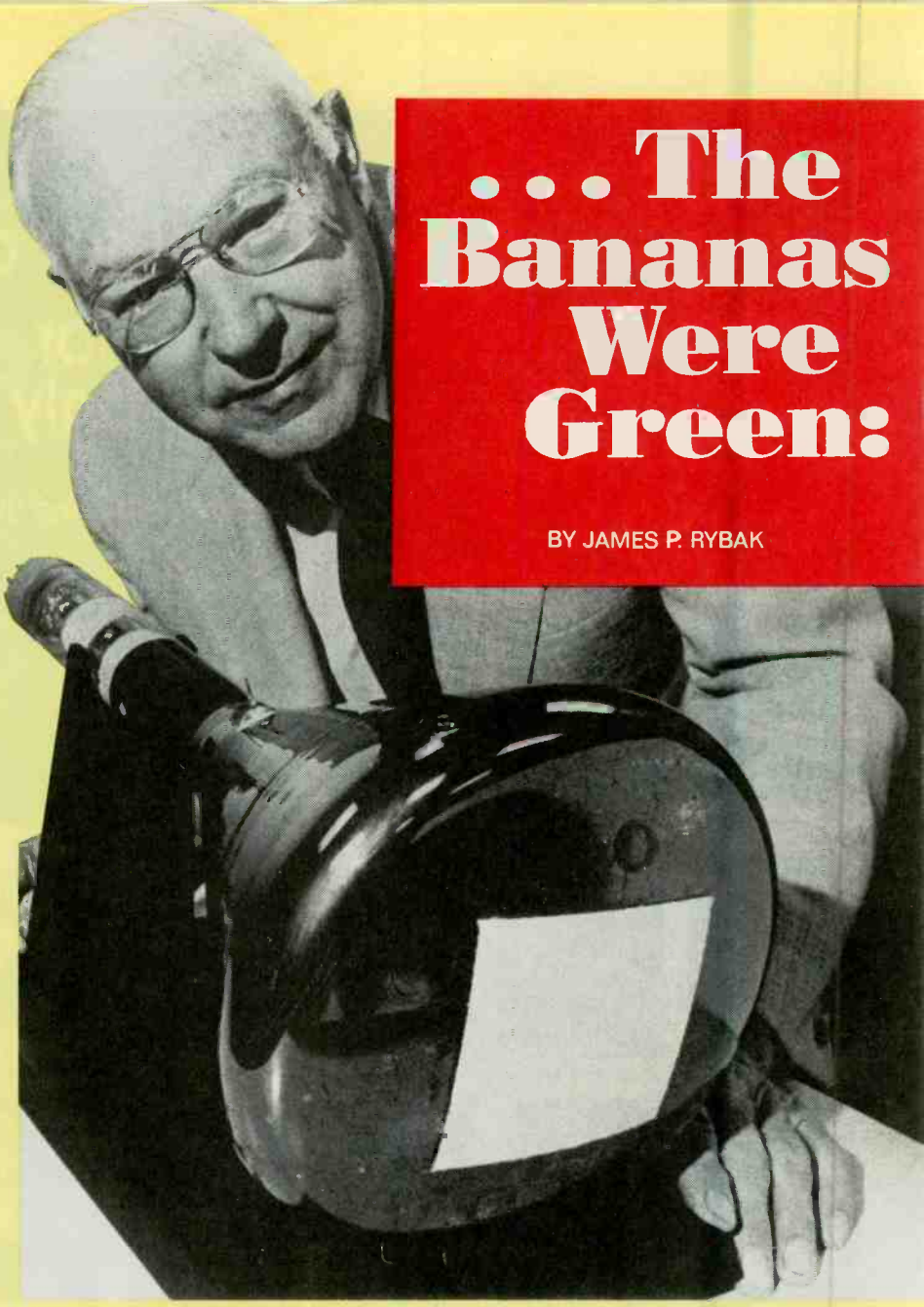
. . . The Bananas Were Green:

BY JAMES P. RYBAK



Harold B. Law led the team that developed the three electron-gun shadow-mask color-TV picture tube.

The monkeys were green, the bananas were blue, and everyone had a good laugh," according to David Sarnoff, RCA's president and chairman. The "everyone" who had laughed at the 1949 demonstration of RCA's experimental, all-electronic, and compatible color-television system, however, had not included Sarnoff. At the time, the situation had not been the least bit funny to him.

That's because Sarnoff and RCA were locked in battle with CBS, who advocated an electromechanical, non-compatible, color-TV system. While in hindsight, the winner of that battle should have been obvious, in 1950 things were not so clear. In fact, after hearings and demonstrations that dragged on for eight long months, the FCC disregarded the compatibility issue and endorsed the CBS system.

What Does "Compatible" Mean? A "compatible" color-television system is one that is capable of producing, without any modification, a high-quality monochrome version of a color transmission on an ordinary black-and-white receiver. Similarly, in a compatible system, a monochrome television transmission produces high-quality monochrome images on a color receiver. If the new color system were not compatible with the existing monochrome system, the millions of monochrome receivers already in existence at the end of 1949 would have to undergo expensive modifications in order to receive the color transmissions in black and white.

The FCC seemed not to realize that the technologically outmoded CBS system, although it seemed to offer somewhat better picture quality, was performing about as well as it ever could and was fundamentally incapable of achieving compatibility with the then existing monochrome-television systems. The commissioners also apparently did not realize that the RCA system, in addition to already having demonstrated that it was compatible with existing monochrome television receivers, still was in the developmental stages and clearly had the potential for greatly improved picture quality.

David Sarnoff, however, was confident that while he had lost that particular "battle," the "war" to establish the ultimate superiority of RCA's color-television system was far from over. He was convinced that he would have the last laugh.

The Beginnings of Color Television. Most people are not aware that the birth of color television occurred in the late 1920s. However, the technology did not exist at that time to produce a color- (or even monochrome-) television system capable of transmitting and receiving "entertainment quality" broadcasts. The American public had to wait well over thirty years until color television became a practical reality that could be enjoyed by all.

On July 3, 1928 in England, John Logie Baird conducted the world's first documented demonstration of color television. Baird also had conducted in London the first public demonstration of a crude monochrome "television" system in March of 1925.

Work was taking place on this side of the Atlantic as well. Three months after Baird's 1925 demonstration of monochrome television, Charles Francis Jenkins demonstrated his own, similar, monochrome system near Washington, DC. By 1928, there were 15 licensed experimental mono-

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The road to an all-electronic, compatible, color-TV system was far from smooth. Here's a look at the people and discoveries that made such a system possible.

The Early Days of Color TV

chrome-television stations in the U.S. broadcasting over the airwaves at various times. In June of 1929, scientists at Bell Laboratories demonstrated a color-television system that was somewhat different from Baird's. All those color and monochrome systems displayed only coarse images due to the type of "scanning" used.

What Is "Scanning?" When a person reads a page of printed text, all the information on that page is not transmitted to the brain instantaneously. Rather, the person's eyes "scan" the page, line by line, from left to right and from top to bottom (assuming, of course, that the page is written in English or another Western language). The video information to be transmitted by television must be scanned in a similar manner.

In the early days of television, the scanning of a scene to be transmitted and its reconstruction at the receiver was achieved through the use of a rotating "Nipkow" disk (see Fig. 1). The Nipkow disk consists of a thin, circular sheet of metal with a series of small holes arranged in a single spiral ring around the circumference. Each hole in the Nipkow disk allows only the light from a designated portion of the scene to be televised to reach a photocell.

A scene was completely scanned in one complete revolution of the Nipkow disk. The spacing between the holes in the Nipkow disk determined the width of the reproduced image while height of the image was determined by the pitch of the spiral pattern of holes. Putting more holes in the Nipkow disk increased the number of scanning lines and, hence, increased the amount of definition, but decreased the size of the image reconstructed at the receiver.

An identical Nipkow disk at the receiver was located between a neon glow lamp and the surface on which the image was to be reconstructed. The intensity of the neon lamp was proportional to the intensity of the light reaching the photocell at the transmitter. Because the rotation of both Nipkow disks was synchronized, the light passing through the Nipkow disk at the receiver reconstructed the televised image. As long as the rotational speed of the Nipkow disks exceeded 15 revolutions per second, and the brilliance of the image was kept low, the persistence-of-vision capability of the human eye and mind interpreted the reconstructed image as being "flicker free."

Very large, rapidly rotating Nipkow disks were required to achieve even moderately high-definition, flicker-free images of what then was considered "acceptable" size. Disks with a diameter of approximately 40 inches and rotating at 1200 rpm were required to produce twenty 60-line images per second with an image width at the receiver of two inches.

John Logie Baird used special Nipkow disks, each with three separate spiral sets of holes, in his 1928 color television demonstration. At the transmitter, the three sets of holes were covered with red, blue, and green filters, respectively. That produced sequential scanning in the three primary colors. Each of the three spiral sets of holes had its own photocell detector.

At the receiver, Baird also used a Nipkow disk with three sets of spirals. He used two gas-discharge tubes as his light sources. One tube contained neon and provided light for the "red" spiral of holes. The other tube contained a mixture of helium and mercury vapor. That tube provided the light for both the "blue" and "green" spirals. A commutator was used to turn the gas-discharge lamps on and off at the proper times. That arrangement, coupled with the persistence-of-vision effect supplied by the observer, resulted in sequential reconstruction of the image in recognizably appropriate colors.

Researchers at the Bell Laboratories used a color-television system in 1929 that had some somewhat different features from Baird's. The Bell Laboratories' system was based on the "flying spot scanner" principle. Rather than flooding the entire scene to be televised with bright light, a carbon arc lamp was located behind a rotating Nipkow disk that had only one set of spiral holes. That caused a moving or "flying" spot of intense light to scan the objects comprising the scene.

Photocells responding only to red, green, or blue light, respectively, and located at strategic locations around the scene detected the reflected light. The selective responses of the photocells were achieved through the use of appropriately colored filters. The outputs of those three sets of photocells were transmitted to the receiver using three separate wire circuits.

Reconstruction of the image in color at the receiver was accomplished using a single Nipkow disk, like that used in monochrome television, together with separate red, green, and blue light sources. The intensities of the three light sources were made proportional to the light detected by the photocells at the transmission location. The outputs of the three light sources were simultaneously directed on the appropriate portion of the Nipkow disk through the use of specially designed semi-transparent mirrors.

All Electronic Television. It was clear to many by the early 1930s that mechanical scanning could never

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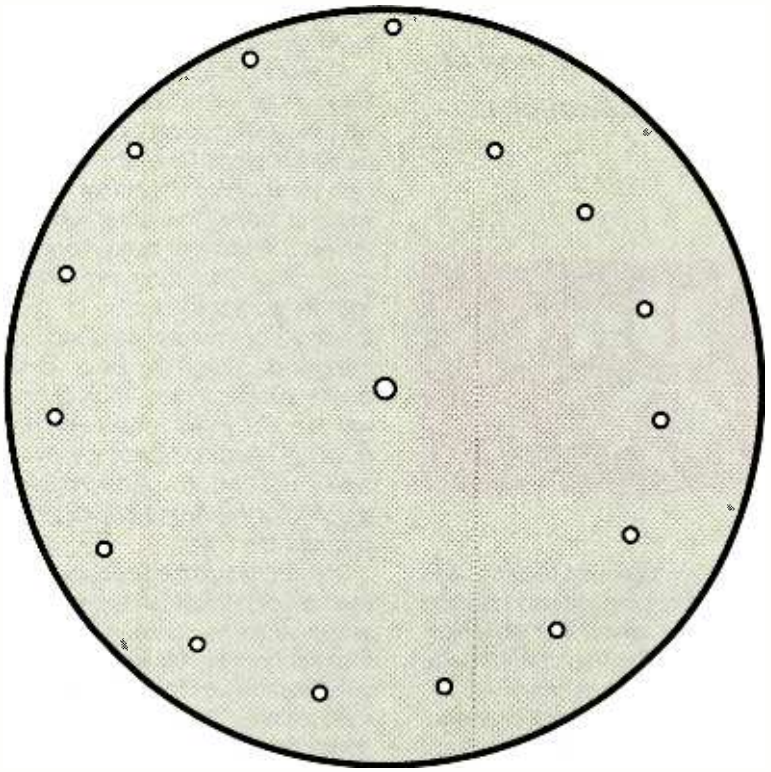

Fig. 1. A Nipkow disk, like the one shown here, consisted of a thin, circular sheet of metal with a series of small holes arranged in a single spiral around its circumference.

achieve the "entertainment-quality" images necessary to make television commercially successful. In addition, the large physical size of the equipment required for reception of even very small color images made mechanical scanning impractical for home use. Although John Logie Baird continued his work with mechanical scanning until the late 1930s, most of the research was by then being directed toward developing all-electronic television.

For some time, many researchers had recognized that the ability to control a beam of electrons in a cathode-ray tube offered the possibility of completely electronic image scanning at both the transmitting and receiving ends of a television transmission. The companion technology needed to achieve electronic scanning was lacking, however. Vladimir Zworykin achieved the first step toward that goal while working for the Westinghouse Electric & Manufacturing Company in Pittsburgh in 1923, a mere four years after immigrating to the United States from revolution-ravaged Russia.

Zworykin realized that a scene to be televised had to be broken down into literally millions of individual points of light at the transmitter in order to achieve high-quality image definition at the receiver. He and his research associates developed a means for producing a mosaic of microscopic individual photocells on a mica or glass surface.

The photocells converted the points of light from the scene into electrical charges proportional to the amount of light received. The charges were sequentially converted into electrical impulses by a scanning beam of electrons. Those impulses then were transmitted. Zworykin called his device the "Iconoscope." (The Greek word *eikon* means image and *skopon* means to watch.) He filed a patent application on the Iconoscope in 1923, but legal challenges delayed the granting of the patent until late in 1938.

Vladimir Zworykin also had begun work on developing a cathode-ray tube suitable for displaying the received television image. His progress in that area came more slowly, however. Zworykin was working for RCA in 1933 when he developed his first "Kinescope" (*Kinema* means moving in Greek) receiving tube. He used magnetic deflection of the electron beam in both the horizontal and vertical directions, together with electrostatic focusing. With the Kinescope and the Iconoscope, Zworykin was able to achieve monochrome television consisting of 120 lines per image and 24 images per second.

Philo Farnsworth, working by himself and without the financial backing of a large corporation, was developing similar all-electronic television equipment concurrently with Zworykin. By 1930, Farnsworth had obtained patents on his "Image Dissector" camera tube and "Oscillite" receiving tube.

Work on developing all-electronic television was progressing in Europe as well. However, while a definite improvement over mechanical scanning, the expensive equipment required for all-electronic television still could not produce "entertainment quality" images.

One problem was the flicker associated with high-brilliance images. It was eventually found that the flicker problems could be reduced by using a process called "interlaced scanning." With interlaced scanning, lines 1, 3, 5, 7, etc. are scanned first. The result is called a "field." Lines 2, 4, 6, 8, etc. are then scanned to produce a second field. The two fields are finally combined to produce a complete picture, called a "frame."

Work also was continuing during the 1930s to develop a practical color-television system. The lack of phosphors capable of producing the primary colors of red, green, and blue in the receiving tube, together with numerous other technological problems, kept the development of all-electronic color television considerably behind that of its monochrome counterpart. As a result, color-television systems that used some mechanical moving parts continued to be investigated.

First Color-TV Broadcasts. In 1940, Peter Goldmark, President of the Columbia Broadcasting System (CBS), demonstrated a color-television system based on Farnsworth's "Image Dissector" camera tube. Color was added to that fundamentally monochrome system by placing rotating disks containing red, green, and blue filters in front of both the camera tube and the receiver picture tube.

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The 1200-rpm rotation of the filter disk in front of the camera tube was synchronized to the scanning process. Three fields, formed by using only alternate scanning lines, were scanned in succession. The first field was scanned with the red filter in front of the camera tube, the second with the green filter, and the third with the blue filter. The process was then repeated to generate three additional fields with the scanning lines unused in the previous field of a given color.

The filter disk in front of the picture tube rotated in synchronization with that at the camera tube. Consequently, a red field was formed first, followed by a green field, then a blue field, and so on. Those fields, comprised of alternate scanning lines, were effectively combined into 60 fully scanned fields (20 red, 20 green, and 20 blue) per second by the persistence-of-vision capability of the human eye and mind. Persistence-of-vision then effectively combined the 20 fields in each of the primary colors to produce 20 complete color pictures (or frames) per second. That resulted in flicker-free viewing, even at moderately high brilliance levels. The CBS technique for generating color television pictures was called the "field-sequential" method because the red, green, and blue fields were produced sequentially.

CBS began demonstrations of color television broadcasting using the aforementioned system on August 28, 1940 in New York City. Initially, color motion-picture films were broadcast but soon after, "live" broadcasts were made as well. On July 1, 1941, CBS began a limited daily schedule of color-television broadcasting. During that same year, RCA rushed to put together a similar field-sequential system of its own design and also began test transmissions using that system. Color television seemed to be off to a good start.

Several problems existed, however. A filter disk 20 inches in diameter was required for the 9-inch-diameter picture tube Goldmark used in his demonstration. In an attempt made after World War II to demonstrate the impracticality of rotating disks for color television, engineers at the DuMont Laboratories constructed a model of the disk needed for a larger picture tube. A 21-inch-diameter picture tube would require a filter disk 5 feet in diameter. For a home-receiver picture tube, 30 inches in diameter, the engineers showed that a filter disk 8 feet in diameter, driven by a 5-horsepower motor, was required!

An equally important negative feature of those color-television systems was that they were incompatible with the industry-wide standards adopted for monochrome television in 1941. The National Television Systems Committee (NTSC), an agency of the Radio (later Radio and Television) Manufacturers Association, had established 525 scanning-lines per interlaced frame, and 30 interlaced-frames per second, as the standards. The CBS color system used 343 scanning-lines per interlaced frame and produced 60 interlaced-frames (20 in each of the primary colors) per second. RCA's field sequential system also was incompatible with the monochrome standards.

The Second World War brought all commercial television research to a halt. During that period, the major re-

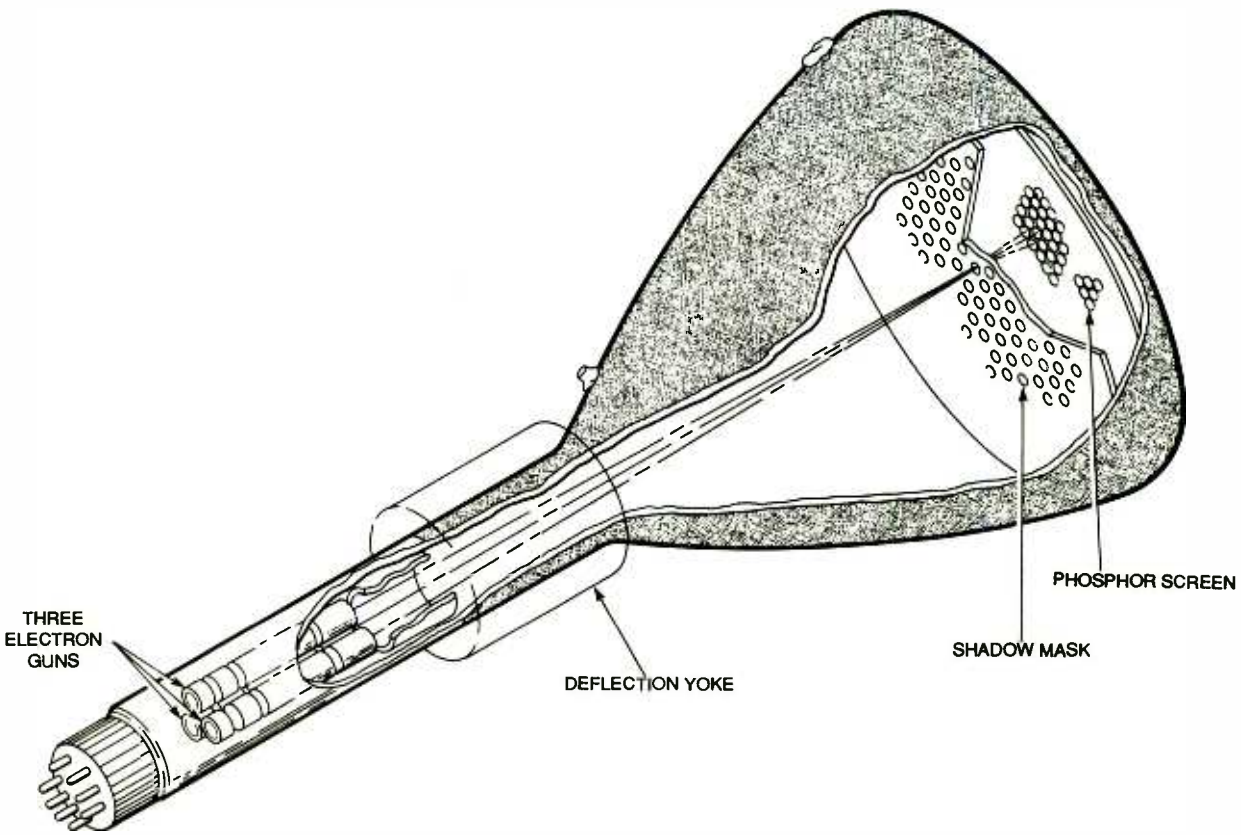

Fig. 2. The three electron-gun, shadow-mask color-TV picture tube led to RCA's successful development of a compatible color-TV system.

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David Sarnoff of RCA led the fight to develop an all electronic and compatible color-TV system.

search laboratories devoted their efforts to war-related work.

Post-War Developments. In the fall of 1946, CBS petitioned the FCC to approve a field-sequential color-TV system with 144 fields per second and 525 lines per frame as the color-television standard. That required a 12-MHz bandwidth per channel, twice that used by monochrome broadcasting. The FCC denied the CBS request.

At the same time, RCA was developing a "simultaneous" color-TV broadcasting system that required four separate transmitters (one for each of the primary colors and one for the sound) that occupied a total bandwidth of 14 MHz per channel. RCA claimed that its system was "compatible" by maintaining that one video signal (the green one) together with the sound signal could be viewed in black and white on monochrome receivers equipped with a UHF-to-VHF frequency converter. Unfortunately for RCA, that system could produce shades of gray and good detail on monochrome receivers only if green subjects were being televised!

Both the field-sequential and simultaneous color-television systems actually transmitted three separate pictures. As a result, the bandwidths required for those transmissions were inherently greater than that required by monochrome television. With more and more television stations being licensed all the time, available frequency space was becoming scarce. A new color-television system that could operate within the 6-MHz channel bandwidths used by monochrome television had to be developed.

Color television experiments of various types continued at both CBS and RCA. CBS began demonstrating a modified field-sequential system that now occupied only a standard 6-MHz bandwidth. The CBS engineers accomplished that using 405 scanning lines and 144 fields, but could achieve only 77 and 55 percent, respectively, of the vertical and horizontal resolutions of standard black-and-white transmissions. Even though the bandwidth of the CBS color system now was the same as monochrome television's, the two systems were not compatible due to the different number of scanning lines and field rates used.

By early 1949, RCA was committed to developing a truly compatible, all-electronic, color-television system that occupied the standard monochrome-channel bandwidth of 6 MHz. That reduction in bandwidth was achieved using a "time-division multiplex" system for transmitting periodic samples of the signals rather than transmitting entire signals. In addition, RCA soon incorporated a technique called "dot interlacing." That permitted increased picture brightness without increased flicker, while still maintaining a 6-MHz bandwidth.

CBS continued to produce color pictures at the receiver through the use of a large filter disk rotating in front of a monochrome kinescope (picture tube). RCA, however, used three separate picture tubes, each one with its own special phosphors, to produce the red, green, and blue images, respectively. The three picture tubes were mounted in a single very large cabinet with mirrors to combine the three images into a single picture.

RCA knew that the large size and high cost of the three-picture-tube, or "triniscope," receiver was not likely to have much appeal to potential home viewers. A crash program was initiated to develop a single display tube that would produce a color picture without the use of rotating disks and other external equipment. David Sarnoff made sure that all the resources of RCA were made available to that project.

Standards for Color TV? In September of 1949, the FCC began hearings to determine if industry-wide standards now could be established for color television. Testimony began immediately, while demonstrations of

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the systems being proposed were scheduled to begin later on, in October. The testimony and demonstrations would continue off-and-on for many months. The only serious contestants in that technological competition were CBS and RCA.

The RCA system required numerous adjustments to be precisely set in order to have it perform reasonably well. Color instability, a serious problem even under the best of conditions, was aggravated by temperature and humidity effects. The day of RCA's initial demonstration was one of record-breaking heat and humidity. It was in reference to that initial demonstration that David Sarnoff later reported that "The monkeys were green, the bananas were blue, ..."

The demonstration of the CBS system went much better. The picture quality was more than acceptable; it was good. However, the hearings were not yet over. Many more months of testimony and demonstrations remained.

RCA engineers were at work virtually around the clock to improve the design of their system. Noticeable improvements were made prior to the next demonstrations, held in November. By the end of the November demonstrations, the most serious and obvious remaining drawback to the RCA system was its need to use three picture tubes in the receiver. RCA already could very convincingly demonstrate the compatibility of its color system with existing monochrome television.

CBS engineers also were busy at work during that time. They attempted to overcome their "incompatibly" problem through the use of a converter circuit that could be added to monochrome television receivers built in the future. The question of how to enable the millions of already existing monochrome sets to receive the CBS color transmissions was left unanswered, however.

Vladimir Zworykin, who made many important contributions to the development of all-electronic television, is shown holding his "Iconoscope." (All photographs courtesy of the David Sarnoff Research Center.)

The Shadow-Mask Picture Tube. RCA's crash program to produce a single-tube color display paid off. After only approximately four months of intensive work, RCA scientists and engineers succeeded in producing prototypes of two versions of what was called a "shadow-mask" picture tube. The company then planned to use both types at the next round of demonstrations scheduled for March, 1950.

The shadow-mask picture tube used many tiny phosphor clusters, each consisting of three different light-emitting phosphors arranged in tiny dots on the surface of the viewing screen. One dot in each cluster emitted red light when activated by a

(Continued on page 94)

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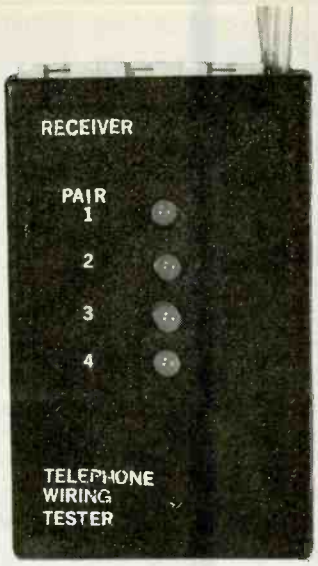
Save time and money with this easy-to-use tester that can check the condition of telephone lines, jacks, and more.



BUILD THIS TELEPHONE-WIRING TESTER

BY CHRISTOPHER ZGURIS

As most of you probably know, since deregulation allowed homeowners and businesses to own their own telephone equipment, phone companies have responded by taking no responsibility for any gear, including the wiring, inside a building unless an extra charge is paid. As a result, calling the phone company in the event of a service outage can be an expensive proposition. If the problem does not lie with the phone company's equipment outside, you can be charged a hefty fee for a service call, and the problem might still not be resolved.

If you'd like to avoid that problem, or if you regularly install or maintain telephone equipment, the *Telephone-Wiring Tester* described in this article could be for you. The Tester consists of two units, a transmitter and a receiver, and is designed to test installed telephone wire, modular cords, modular jacks, or any combination of those for continuity and reversed polarity.

As we will see later on, the transmitter and receiver can be used together or individually, depending on what is being tested. When both units are used together, the 9-volt battery in the transmitter provides power (on the transmitter's face, there are four standard single-color LEDs that will glow when the two units are properly connected to each other).

The receiver uses tri-color LEDs to indicate line operation and polarity. Each tri-color LED contains a red and green element wired in parallel. When DC is applied to the LED, it will glow either green or red (depending on the polarity); if AC is applied, both internal elements will glow, resulting in an orange color. The Tester can test up to four voice pairs at once using one tri-color LED for each voice pair (each voice pair has two wires that carry one telephone line).

Modular-Jack Basics. Both the transmitter and receiver each contain three modular jacks: one 6-position, 6-contact jack, and two 8-position, 8-contact jacks. Let's look closely at each of those, as well as the plugs that match them.

The 6-position, 6-contact jack is similar to the jack used for single-line telephones, with one difference: the single-line version of the jack has 6 positions and 4 contacts. Even though the 6-position, 6-contact jacks used in the Tester units have more contacts than the ones used for single-line telephones, they are compatible and the latter can still be tested. If you look at the clear modular plug on the end of a telephone cable, you will notice from four to six gold "teeth;" those are the contacts. You should also notice that the "teeth" are set within grooves; those grooves are the positions. Not all the grooves (positions) will necessarily have "teeth" (contacts).

Now, if you look straight into a modular jack you will notice tiny bare wires. When the modular plug goes into the modular jack, the grooves on the modular plug guide those little wires onto the teeth and contact is made. The 6-position jack is designed to carry up to three voice pairs, depending on the number of contacts. Even though the jack could be a 4-contact unit, it can only carry two voice pairs if it is hooked up to multi-pair wire.

If the wire going to and from the jack has four conductors (red, green, yellow, and black) it is a quad cable and not meant for two voice pairs. That cable is meant for a single voice pair, carried on the red and green wires, with the yellow and black ones carrying power for telephone accessories. If the cable going to and from the jack has white-with-blue, blue-with-white, white-with-orange, and orange-with-white wires, it is twisted-pair cable that is designed to carry more than one voice pair. The difference between the quad and twisted-pair cable is that the latter has the two voice-pair wires twisted together throughout the length of the cable, as opposed to the bundled, individual wires in quad cable. The twisted voice-pairs are highly immune to crosstalk and noise.

If you find a modular plug that has eight teeth, then it is not compatible with a 6-position jack. Although it looks similar and works in the same manner, it is noticeably larger and can only be

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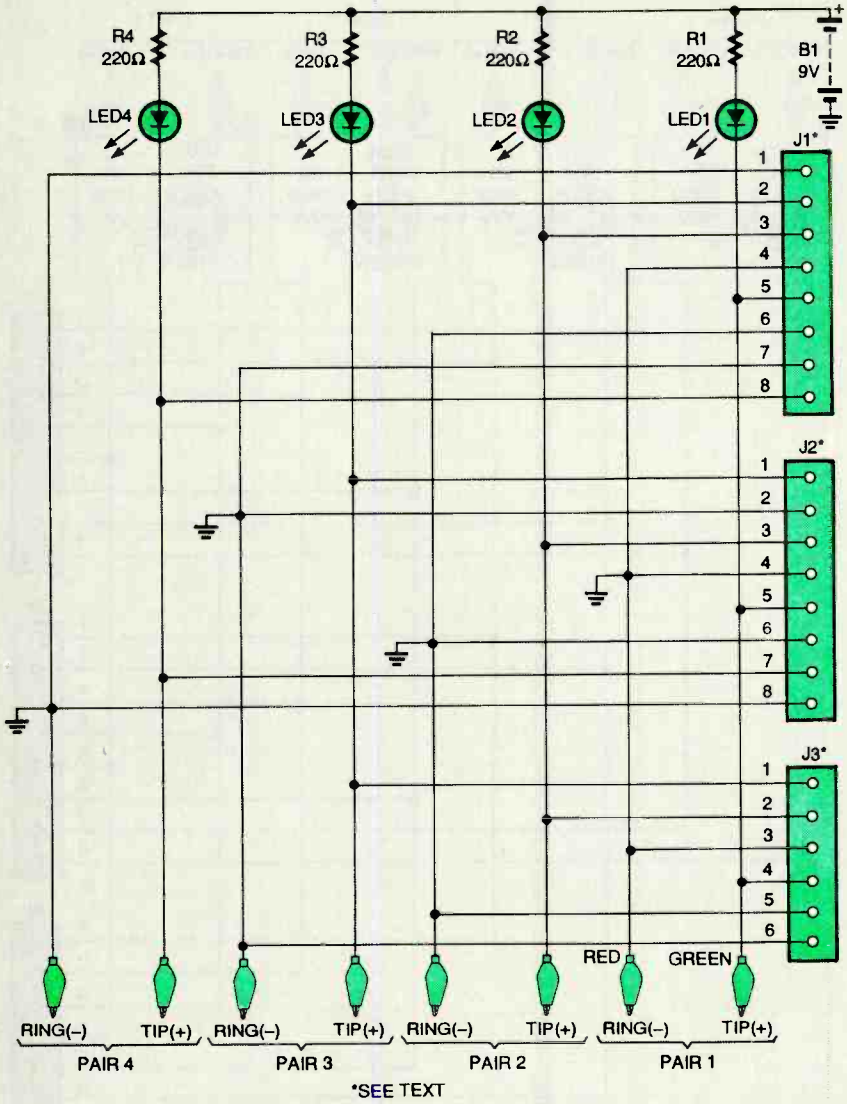

Fig. 1. Here is the schematic for the transmitter unit of the Telephone Wiring Tester. The alligator clips shown at the bottom of the diagram can be used to connect the transmitter to the receiver or to telephone-line voice pairs. Of course, telephone lines can also be connected to modular-jacks J1–J3.

used with an 8-position, 8-contact modular jack.

The two 8-position, 8-contact jacks in each unit are wired differently. One is wired as a USOC (Universal Service Order Code) jack (usually used to carry four telephone lines) and the other is wired for the AT&T standard (used for the Merlin and other key systems). The 6-position, 6-conductor jack in each unit is wired to the USOC standard, which is what most standard telephone devices use.

How it Works. Figure 1 shows the schematic of the Tester transmitter. No power switch is used in the unit; the circuit is turned on either when the clips in pairs 1–4 or jacks J1–J3 are connected to a closed circuit (that could be the receiver unit, a telephone line, etc.). When all the lines (pairs) of the circuit are closed, power from the 9-volt battery, B1, flows through the 220-ohm current-limiting resistors, R1–R4, to the single-color LEDs, LED1–LED4, causing them to light. If only some of the line pairs are connected to closed circuits, then only the LEDs in series with those lines light up (LED1 connects to pair 1, LED2 connects to pair 2, etc.).

Power from the transmitter goes out the positive contacts on the modular jacks or green alligator clips. The negative contacts and red alligator clips are attached to ground (the negative terminal of B1).

PARTS LIST FOR THE TRANSMITTER

LED1–LED4—Light-emitting diode, any color (see text)
R1–R4—220-ohm, ¼-watt, 5% resistor
J1, J2—8-position, 8-contact, modular phone jack
J3—6-position, 6-contact, modular phone jack
B1—9-volt battery
Perforated board, project enclosure, red and green alligator clips (four of each), battery clip and leads, telephone wire, wire, solder, hardware, etc.

PARTS LIST FOR THE RECEIVER

LED1–LED4—Two-lead, tri-color light-emitting diode (see text)
R1–R4—330-ohm, ¼-watt, 5% resistor
J1, J2—8-position, 8-contact, modular phone jack (see text)
J3—6-position, 6-contact, modular phone jack
Perforated board, project enclosure, red and green alligator clips (four of each), telephone wire, wire, solder, hardware, etc.

Note: The following is available from Christopher Zguris (521 West 26th St. 5th Fl., New York, NY 10001): A partial kit of parts for both Tester units containing all LEDs, resistors, modular jacks, alligator clips, and four-conductor wire: $23.00 + $4.00 S/H. New York residents please add appropriate sales tax.

When the receiver (see Fig. 2) is attached to the transmitter (using the modular jacks or the alligator clips), power flows through the 330-ohm current-limiting resistors, R1–R4, to the tri-color LEDs, LED1–LED4. If power comes through the modular jack contacts or alligator clips with the correct polarity, the tri-color LEDs on those lines will glow green. When power comes in reversed, the tri-color LEDs in the proper lines will glow red. Finally, if there is a short, the LEDs in the transmitter will glow because the short has completed the circuit, and the tri-color LEDs in the receiver will not glow.

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Jacks J1–J3 in the transmitter (Fig. 1) are exact matches for jacks J1–J3 in the receiver (Fig. 2), and are wired in the same way. Modular-jack J1 is a 8-position, 8-contact unit that is wired as a USOC jack. Jack J2 is also an 8-position, 8-contact unit, but is wired for the AT&T standard. Finally, jack J3 is a 6-position, 6-contact unit, that is also wired as a USOC jack.

Construction. The author's prototype units were built on perforated board using point-to-point wiring, but any standard project-building method can be used. Just make sure that the correct wires are connected to the correct LEDs. To make things easier, use multicolored connection wires to connect each point on the modular jacks to the correct component or common point.

The project enclosures used for the prototype units are the transmitter cases available from Radio Shack (catalog no. 270-293); they have built-in 9-volt battery compartments with slide-off covers. You will probably have to cut the circuit boards to make them fit into the cases. For that reason, make sure to keep the circuit connections close together; the wiring can get a bit cramped, but if you are careful you should have no problems. You will also have to cut holes in the cases for the LEDs. Make sure to label those holes with the matching pair number (LED1 in both units should be labeled "Pair 1," LED2 is "Pair 2," etc.).

The tri-color LEDs used in the receiver have to be of the type with only two leads; the ones used in the prototype are available from Radio Shack (catalog no. 276-012). Three-lead tri-color LEDs are available, but they will not work in the receiver circuit. If you cannot find two-lead tri-color LEDs you can get the same result by taking a red LED and a green LED and wiring them together in parallel with their polarities crossed (anode-to-cathode, cathode-to-anode), or you can order the LEDs as part of the partial kit available from the source given in the Transmitter Parts List. Tri-color LEDs must be installed correctly to get the color results mentioned in the tests. In the Radio Shack LEDs that were mentioned earlier in this article, the flat pin should be connected to the negative line.

The next step is to create wire assemblies for the pairs of alligator clips. To do that, take eight short lengths of 4-conductor, 22-gauge, solid-copper station wire, strip off the ends of the outer sheaths, and clip the protruding yellow and black wires at both ends. Then solder one red and one green alligator clip to the remaining red and green leads on one end. Repeat that for the other seven cables. When that's completed, solder the red and green leads at the other end of the cable pairs to the correct points in the circuit.

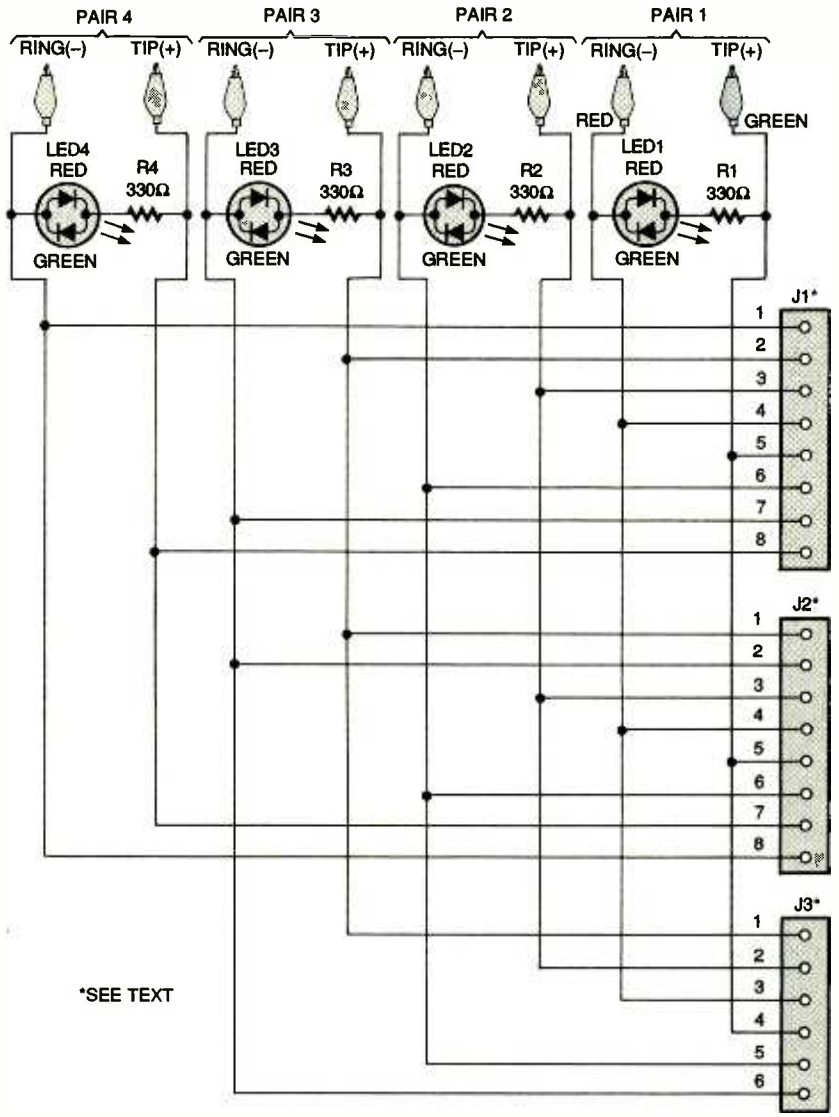

Fig. 2. The receiver circuit shown here contains tri-color LEDs to let the user determine whether polarity on a phone line is correct (a green glow) or reversed (a red glow). Also, it indicates if AC is on the line (an orange glow).

Each cable pair should be numbered to correspond with the voice pair it is connected to. To accomplish that, you could use colored wire-marking tape and write the pair numbers on it. If you use the colored tape, the colors should be blue for pair 1, orange for pair 2, green for pair 3, and brown for pair 4. Those colors correspond with the standard color order for twisted-pair cable.

When you have completed all the electrical connections in the circuits, it is time to attach the modular jacks to each other, side by side, using a few drops of epoxy. Then take those three-jack assemblies and attach to them to their respective project cases using epoxy. After the epoxy dries, use a few more drops of epoxy to glue the wire assemblies to the cases. Once the epoxy dries the whole assembly should be very strong.

(Continued on page 94)

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Build the "Galviamp"

BY JOSEPH J. CARR

It's two handy devices—a galvanometer and variable-gain amplifier—in one compact case.

A zero-center DC voltmeter, often called a galvanometer, is a useful addition to any hobbyist's workbench. That's because many circuits, including the Wheatstone bridge, need to be used with that type of null indicator. Also, another handy device to have around is a variable-gain amplifier that can be used with an external device, such as an oscilloscope. Of course, purchasing both of those devices could be expensive.

So, do you want an inexpensive way to get both units? Build the *Galviamp* described in this article. The project is a combination of a galvanometer and a variable-gain amplifier in the same package. And best of all, the Galviamp doesn't sacrifice performance for compactness.

Circuit Description. Figure 1 shows the schematic for the Galviamp. Op-amps U1-a, U1-b, and U2-a form a differential amplifier with a very high input impedance, while U2-b is used as a driver for a pair of back-to-back LEDs (LED1 and LED2) that help find the null condition. Both U1 and U2 are CA3240 BiMOS dual op-amps, available from Digi-Key (P.O. Box 677, Thief River Falls, MN, 56701-0677; Tel. 1-800-344-4539), as well as other sources.

A differential-input amplifier is formed by U1-a and U1-b. Each of those op-amps is connected in a noninverting-follower configuration. That configuration is used because the input impedance of the overall amplifier is essentially the input impedance of the device (which is not true if the inverting follower circuit is used). For a BiMOS op-amp, the input impedance is approximately 1012 ohms!

Op-amp U2-a is configured as a DC-differential-amplifier circuit that combines the outputs of U1-a and U1-b. The output of U2-a is equal to the difference between the outputs of U1-b and U1-a. That output voltage is applied to both meter M1 and output-jack J4 (which can be used to send the analog output signal to an oscilloscope, external voltmeter, or other display device).

The voltage gain (A_v) of the Galviamp is a function of the resistance between the inverting outputs of U1-a (pin 2) and U1-b (pin 6). That function can be solved for using the formula:

$$R = 112{,}000/(A_v - 1)$$

where R is the resistance in ohms between the two inverting outputs. In the Galviamp, that resistance value is selected by a double-pole triple-throw (DP3T) switch, S1. That switch selects a 220-ohm resistance in the HIGH position, a 2200-ohm resistance in the LOW position, and a variable resistance of 150 to 1150 ohms in the VARIABLE position. The HIGH and LOW positions produce fixed gains of about 500 and 50, respectively, and the VARIABLE position results in a variable gain of 96 to 745 (depending upon the adjustment of R4).

There are three output indicators used on the Galviamp. First, there is the analog-output jack, J4, which can be used to drive any of several display or recording devices (for example, an external voltmeter, an oscilloscope, or the analog-to-digital-converter input of a computer).

Second, the built-in meter, M1, is also an output indicator. That device is a zero-center milliammeter with a range of −1 to +1 mA. Because the output signal at pin 1 of U2-a is a voltage, and the meter is a current meter, it is necessary to convert M1 into a voltmeter. That is accomplished by resistor R13, which is connected in series with the meter. The value shown for R13 is probably suitable for most common milliammeters, but there is a possibility that it will have to be replaced for certain meters (more on that later). The value of R13 is set to produce a 1-mA current in M1 when the output voltage of U2-a is at its maximum permissible value. Because 9-volt batteries are used for the power supply in the Galviamp, the maximum output voltage will be around 8.5 volts.

The third output indicator for the Galviamp is made up of LED1 and LED2. Because they are connected "back-to-back," the LEDs become forward biased with opposite polarities. In other words, when a positive voltage is applied to the point where pins 6 and 7 of U2-b are connected, LED2 emits light and LED1 remains off. But when the voltage is negative, LED2 remains off and LED1 lights. Resistors R11 and R12 limit the current to protect the LEDs.

The LEDs are driven from the output of U2-b. That op-amp is connected in the unity-gain, noninverting-follower configuration, which is when the output (pin 7) is connected to the inverting input (pin 6). The voltage gain is +1, so the voltage where pins 6 and 7 meet is equal to the output of U2-a.

The DC power for the Galviamp is supplied from a pair of 9-volt batteries. The op-amps require two power supplies because their outputs might have to swing either positive or negative, depending on the input signals and their polarities. Battery B1 supplies a negative power source with respect to ground or common, while battery B2 supplies a positive source with respect to ground or common. Those power-supplies are switched on and off by switch S4, a

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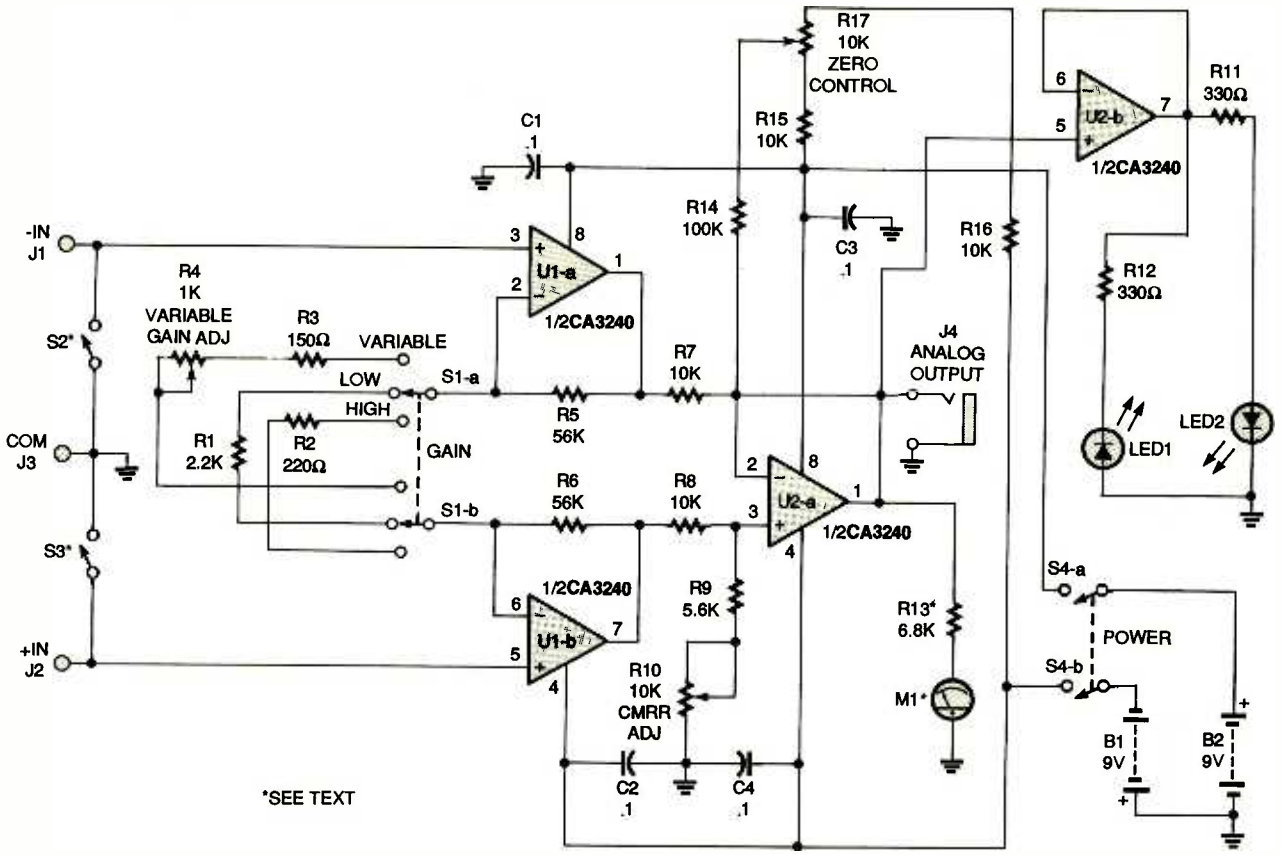

Fig. 1. Here's the schematic for the Galviamp. Notice that batteries B1 and B2 are configured to provide either positive or negative power to U1 and U2; those op-amps require two power supplies because their outputs might have to swing either positive or negative, depending on the input signals and their polarities.

double-pole single-throw (DPST) toggle switch.

Note that a 0.1-μF capacitor is connected between the power-supply pins of both op-amps and ground. Those capacitors are needed to prevent the op-amps from bursting into self-oscillation—an undesirable problem. Those capacitors must be mounted as close to the power-supply pins (pins 4 and 8) of each op-amp as possible, and the leads must be kept as short as possible.

Potentiometer R17, the zero control, is essentially an offset null control. It is adjusted to force the output voltage of U2-a to zero when the input voltage is zero. That is done with both inputs, J1 and J2, shorted to the common terminal, J3 (more on that later). The CMMR (common-mode rejection-ratio) adjust control, potentiometer R10, is used to balance the amplifier to make it truly differential (a differential amplifier does not respond to common-mode signals—signals that are applied equally to both inputs).

The Galviamp uses a differential input. That is, there are two inputs (each of which are referenced to ground) and the amplifier responds to the difference between the signal voltages applied to each. The +IN input, J2, is "noninverting" (that is what is indicated by the "+" sign) so it produces an output that is in-phase with the output. In other words, a positive signal at J2 will produce a positive-polarity output signal at J4 and M1; similarly, a negative input on J2 places a negative signal at J4 and M1.

The −IN input, J1, is inverting (as indicated by the "−" sign), so it produces an output signal that is 180-degrees out-of-phase with the input signal. That is, a positive signal applied to J1 produces a negative signal at J4 and M1, while a negative signal at J1 produces a positive signal at J4 and M1.

Switches S2 and S3 can be used to set the circuit to four operating modes: First, when both S2 and S3 are closed, both inputs (J1 and J2) are shorted to ground; that mode can be used for testing, and for ensuring the zero-volts baseline is, indeed, zero volts. Second, if S2 is open and S3 is closed the input of J2 is grounded, so the Galviamp operates as a one-input inverting amplifier. Third, when S2 is closed and S3 is open, the J1 input is grounded, and the circuit operates as a noninverting amplifier. Fourth, if S2 and S3 are both open, the circuit goes into a differential mode.

Construction. In the author's prototype, the amplifier electronics were built on a perforated board with a ground bus, using point to point wiring, but any other project-building technique can be used. The interconnections on the board can be made with 24-gauge solid hook-up wire. As with most projects, install the ICs last, to prevent them from being damaged. Several components mount off-board, on the front panel of the project enclosure. Those are: J1–J4, S1–S4, R4, R17, LED1 and LED2, and M1.

Before mounting milliammeter M1, make sure that you have a proper-value resistor for R13. If you find that a value other than 6800 ohms is needed, try this method to find a suitable substitution: To begin, determine

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the value of your meter's resistance. You might find that number inscribed in nearly imperceptible type in a lower corner of the meter face. Otherwise, you might have to consult the manufacturer's catalog or data sheet. In a pinch, you can measure it with an ohmmeter, but that might be dangerous to the milliammeter.

If you use an analog ohmmeter to measure the resistance, then make sure that it doesn't use an internal battery with a value of more than 1.5 volts. Some older-model vacuum-tube voltmeters used a 22.5-volt battery, and those are guaranteed to wipe out a milliammeter being tested. Your best bet is to use a digital multimeter on the low-powered ohmmeter setting. Be careful not to use the "diode" setting, however, as that will probably damage the milliammeter as well.

Whichever ohmmeter you use, start at the highest ohms scale and connect one lead of the ohmmeter to the milliammeter. Then quickly and lightly tap the other lead to the other milliammeter terminal while watching that meter's pointer. If that pointer doesn't deflect rapidly, then it's probably safe to continue. If it does move rapidly to one end, then lower the ohmmeter scale and try again until you don't get a deflection.

Once you know the value of the meter's resistance (R_m), then the value of R13 (in ohms) can be calculated from:

$$R13 = 1000V_{max} - R_m$$

where V_{max} is the maximum output voltage at pin 1 of U2-a (that should be approximately 8.5 volts).

Once the value of R13 is determined, select an actual resistor that is of the next-higher standard value. Alternatively, make a series combination of a potentiometer and a fixed resistor; adjust the potentiometer so that the combination equals the calculated required resistance value.

There are two other components that need to be selected carefully for use in the circuit: LED1 and LED2. They are connected in a back-to-back configuration, and to work properly, the LEDs should be uniform in output light levels. To test LEDs for that, connect them in series with 470-ohm resistors to 9-volt batteries and compare their light output. Try several, and use the pair that seem to match the best.

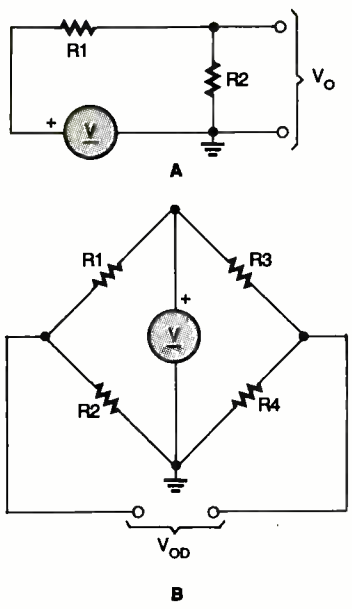

Fig. 2. A simple resistor voltage-divider network (A) is one half of a Wheatstone-bridge circuit (B).

The project enclosure used in the author's prototype is the Radio Shack "Experimenter's Box" (270-627)—it is made of plastic, and has an aluminum front panel (if the Galviamp is to be used in the presence of strong RF fields, then an all-aluminum cabinet can be substituted to provide shielding). Insulated 24-gauge hook-up wire can be used for connecting the panel-mounted components to the remainder of the circuit. However, you might want to use wires of different colors to spare yourself some eye strain.

When you are done wiring all the on- and off-board components together, carefully go over all your connections a second time. Make sure in particular that the ICs are hooked up correctly.

Adjustment and Setup. Adjusting the Galviamp is relatively simple, especially if you have an oscilloscope or AC voltmeter available to use as an AC output indicator. To begin, turn on switch S4 and note the indication on M1. If M1 slams to one peg, *immediately* turn off S4 and look for a wiring error. But if M1 is either at zero, or some moderate positive or negative deflection, then proceed with adjustment after letting the unit warm up for about 5 minutes (to control drift).

Next, short J1, J2, and J3 together by closing switches S2 and S3. Turn R10 approximately to the middle of its range, and set S1 to the LOW position. Adjust R17 (zero control) for a zero-mA indication on M1. Then set S1 to the HIGH position, and re-adjust R17. Connect either an AC voltmeter or an oscilloscope to analog-output-jack J4. Open switches S2 and S3, and connect a short piece of uninsulated wire from J2 to J3. Connect an audio-signal generator to that wire (use 100 to 2000 Hz if an oscilloscope or AC voltmeter is used at J4, or 100 to 400 Hz if the "AC" function of an ordinary multimeter is used). Adjust the signal generator output to about 1- to 3-volts peak-to-peak.

Set S1 to the LOW position again, and adjust R10 for minimum AC-signal output. Set switch S1 to the HIGH position and adjust R10 again until no further improvement is possible. Disconnect

PARTS LIST FOR THE GALVIAMP

RESISTORS
(All fixed resistors are ¼-watt, 5% units, except where noted.)
R1—2200-ohm
R2—220-ohm
R3—150-ohm
R4—1000-ohm, linear-taper potentiometer
R5, R6—56,000-ohm
R7, R8, R15, R16—10,000-ohm
R9—5600-ohm
R10, R17—10,000-ohm, linear-taper potentiometer
R11, R12—330-ohm, ½-watt
R13—6800-ohm (see text)
R14—100,000-ohm

ADDITIONAL PARTS AND MATERIALS
U1, U2—CA3240 BiMOS dual op-amp, integrated circuit
LED1, LED2—Red light-emitting diode (see text)
C1–C4—0.1-μF, Mylar capacitor
M1—Zero-center milliammeter (see text)
S1—DP3T rotary switch
S2, S3—SPST miniature toggle switch
S4—DPST miniature toggle switch
J1–J3—Binding post
J4—Phono jack, chassis-mounted
B1, B2—9-volt battery
Perforated board, project enclosure (Radio Shack 270-627 or equivalent), two battery clips, two 8-pin IC sockets for U1 and U2, wire, solder, hardware, etc.

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the audio-signal generator and remove the short from between J2 and J3. The Galviamp is now ready for use. As a matter of practice, keep S2 and S3 closed when the amplifier is not being used.

Wheatstone Application. The Galviamp can be used for a wide variety of workbench and experimenter applications, but it also has its applications in scientific instrumentation. One such application is to use the Galviamp as an amplifier for a Wheatstone bridge.

A Wheatstone bridge can be developed from a simple resistor voltage-divider network, shown in Fig. 2A. Output-voltage V_o is a fraction of applied-voltage V. The value of V_o is found from:

$$V_o = VR2/(R1 + R2)$$

In the context of the Wheatstone bridge, Fig. 2A is sometimes called a half-bridge circuit. If R2 is either a thermistor or a photoresistor, then the output voltage will be proportional to either the temperature or light level, respectively. A disadvantage of that circuit is that there is a perpetual DC offset unless R2 has a value of zero ohms. If we have a temperature probe at R2, therefore, a zero-degree temperature does not yield a zero-volt output state. That problem can be solved by the Wheatstone bridge circuit shown in Fig. 2B.

If we connect two half bridges in parallel, as in Fig. 2B, we have the classic Wheatstone bridge circuit; R1 and R2 form one half of the bridge, while R3 and R4 form the other. The differential output voltage V_{od} is the difference between the output voltages of the two half bridges, and can be calculated using:

$$V_{od} = V\left(\frac{R2}{R1 + R2} - \frac{R4}{R3 + R4}\right)$$

When the two half bridges are in balance, the output voltage is zero. In that state, the bridge is said to be in a null condition. If the values of resistors R1 through R4 are correctly selected, then the null condition can exist when the physical parameter (*e.g.* temperature) is also zero. Exact values of the applied parameter can be read as deviations of V_{od} from zero.

The Wheatstone bridge can also be used for comparison measurements.

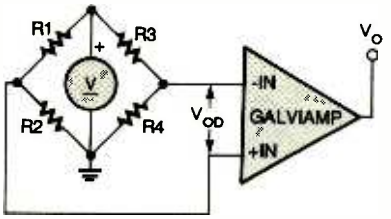

Fig. 3. Simply connect the V_{od} output of a Wheatstone bridge to the −IN and +IN inputs of the Galviamp to use the two circuits together.

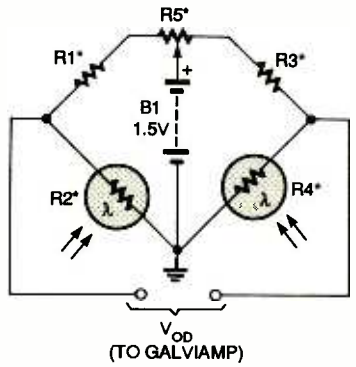

Fig. 4. By using two photoresistors in a Wheatstone bridge, and adding a potentiometer, you can make a colorimeter for use with the Galviamp.

Suppose R2 is a potentiometer, and R4 is a temperature sensor. Calibrate a dial connected to the shaft of R2 in units of temperature, using the characteristics of the thermistor used for R4 to determine the range. If you allow the thermistor to stabilize, and then adjust R2 for a null condition on M1, the temperature can be read from the dial attached to R2.

When designing Wheatstone bridge circuits for an experiment, remember this: The ratio of the two half bridges must be equal for a null to occur, but the actual resistance values can be different. That is:

$$R1/R2 = R3/R4$$

Figure 3 shows how to connect the Wheatstone bridge to the Galviamp. The output voltage V_{od} is connected across the differential inputs (−IN to +IN) of the Galviamp. The output voltage V_o is equal to the product of the differential gain of the Galviamp and the bridge output voltage (V_{od}).

A Colorimeter. Figure 4 shows an application for the Galviamp that uses two photoresistors, R2 and R4. That little circuit is called a colorimeter, and is the basis for a large family of medical, engineering, and scientific instruments.

The photoresistors can be any two matching units. Once you have selected two identical ones, use an ohmmeter to measure their nominal resistance at normal room-illumination levels (be sure that the resistance is not less than about 500 ohms, or battery life will be short, and the photoresistors might self-heat, causing errors). Select fixed resistors for R1 and R3 that have approximately the same resistance value as the photoresistors. The value of R5 should be from 0.3R1 to 1.5R1 to make it easy to balance the bridge.

Build the circuit on a piece of perfboard, keeping photoresistors R2 and R4 about 2 to 3 inches apart. If the photoresistors have clear edges, cover the perimeter with black tape or black paint to prevent scattered light from entering. Make sure that light only enters through the front of the lens over the active region.

Connect the output of the colorimeter (V_{od}) to the input of the Galviamp, and then expose the photoresistors to room light so they are equally illuminated (with no shadows). Adjust R5 for a null condition on the Galviamp meter. By interposing colored filters between the light source and one (only one) photoresistor, it is possible to get a rough idea of the percentage of the white light that the color represents. Just consider the one-milliampere range of M1 to be a 100-percent range.

(Note: The response of a photoresistor is not consistent across the entire visible-light spectrum, so any percentages derived with the colorimeter are approximate only.)

One use for the colorimeter in science is to measure the absorption of certain wavelengths of light or infrared (with different sensors) of a sample. In one measure of blood-oxygen level (pO_2), for example, a standard-wavelength red filter is placed in front of one photoresistor, and a calibrated volume of blood is placed in front of the other. The unbalance of the bridge is proportional to the oxygen saturation of the blood sample. Although blood analyzers are now complex instruments driven by computers, early models (some still used) are little more than expensive, precision versions of Fig. 4! ■

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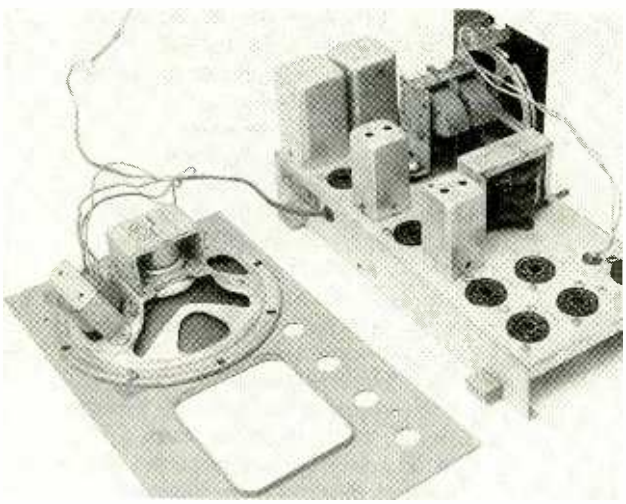
ANTIQUE RADIO

By Marc Ellis

Putting Minerva Back Together

As those who have been following this column for the past few months know, we're in the process of restoring a *Minerva Tropicmaster Model W-117*. Not much is known about the history of either the set or its manufacturer, but the radio's high-performance circuitry, battleship construction, and just-post-WWII release date war strongly suggest that it is really a surplus military morale radio in civilian dress.



The early stage of the reassembly process. The filter choke (behind the forward IF transformer) and the dial plate are in place; the speaker is mounted on the front panel.

At the start of last month's session the set was already partly dismantled to facilitate the restoration work, and the top surfaces of the chassis were given a careful cleaning with Brasso, a relatively non-abrasive metal polish. The radio was also completely recapped, a procedure deemed necessary because of its obviously long residence in a damp environment (very destructive to the wax-covered paper capacitors found in sets of that era).

Later on in the session, I treated all of the controls with a control cleaner/lubricant and spent some time on the damaged filter choke, which had been dismantled for inspection and repair in the last session. Both choke leads had become disconnected from the winding inside. They were successfully reconnected, then secured in place on the surface of the winding with a couple of globs of epoxy cement.

Finally, the tuning capacitor frame, which someone had dismounted from the chassis (it was held in place only by its wiring), was snugged down against its rubber-grommet shock absorbers with a new set of screws, nuts, and washers.

REINSTALLING THE CHOKE

I had gotten a lot of satisfaction out of replacing the Tropicmaster's dingy and mold-covered paper and electrolytic capacitors with a new set of dependable, modern units. But I was no less pleased to be putting the filter choke back together at last. Digging out the ends of the winding from the sticky layers of electrical and Scotch tape that had temporarily secured the leads to the choke core had been an annoying experience, but it felt good to have successfully reconnected a new set and securely anchored them so that they would not pull loose again.

Now that the epoxy "anchors" had completely set, I carefully taped a layer of black duct tape around the outside of the winding to further protect the leads and give the repair a more finished appearance. The winding was then slipped back on the choke's "E"-shaped iron core, and the iron pole-piece was laid across the open end of the "E." After returning a fiber spacer/shim to its place on top of the pole piece, the choke's metal frame could be slid over this assembly to hold everything together.

The metal tabs that locked the coil/core assembly into the frame had been removed during a previous disassembly, but that didn't matter. Once the choke was reinstalled, the open end of the frame would be pressed tightly against the chassis, locking all parts together. I now fed the choke's new leads down through the grommeted "pass-though" hole provided for them and refastened the frame to the chassis. It certainly felt good to have the unit's leads, coil, core, and other parts securely reunited once and for all!

SPEAKER AND DIAL REASSEMBLY

Next, I took a look at the speaker, which those who have been following the story from the beginning know was covered by a coating of fine rust. I had originally intended to clean up the rust a bit and try to duplicate the original finish of the speaker frame with coat of aluminum paint. But now I reexamined this plan and decided not to go through with it.

The chassis itself had not come out exactly pristine-

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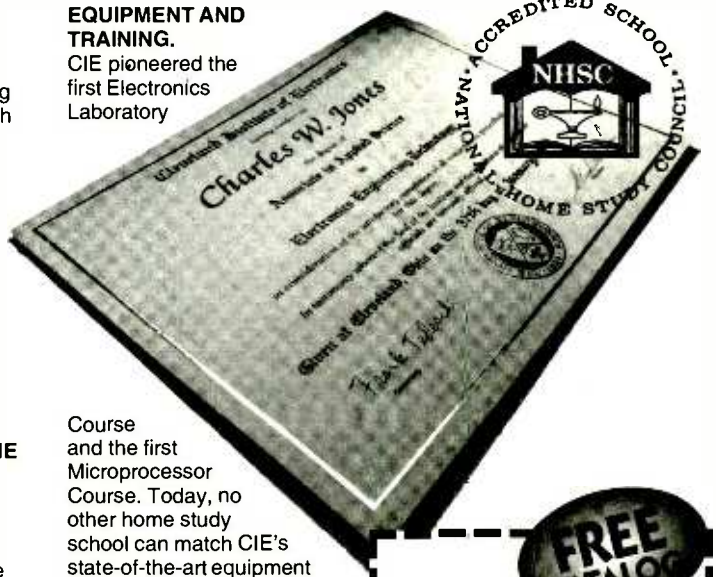

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looking after cleaning. The grime was gone, but there were plenty of dark and pitted spots where moisture had attacked the anodized finish. A completely refinished speaker frame would look quite out of place, and I'm not sure how well the aluminum paint would have matched the frame's original paint (or anodizing) anyway.

Using a fine emery cloth (I had to stay away from steel wool because of the danger of fouling the speaker's permanent magnet with metal dust), I cleaned off as much rust as I could. That resulted in a speaker that was definitely better looking and quite consistent in appearance with the rest of the chassis.

The speaker was now mounted on the front panel and that assembly was set aside while I turned my attention to replacing the dial cord. That is something I do with every set I restore whether it needs it at the time or not. I've had too many old cords break after a set was reassembled and put back into use!

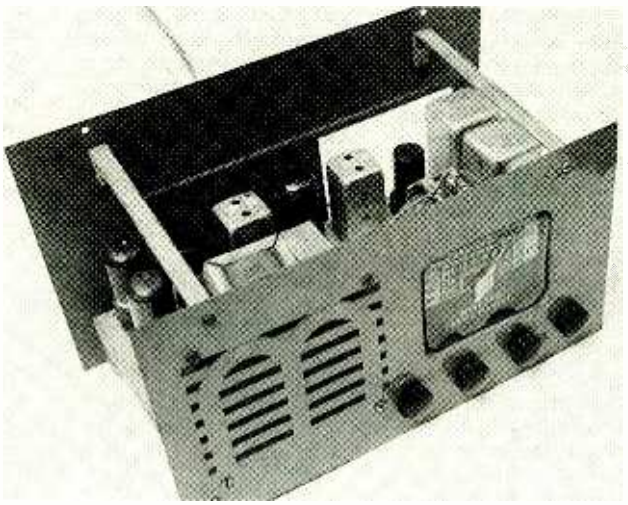
The Tropicmaster's dial-cord arrangement was quite simple and the re-stringing was accomplished in a matter of minutes.

PANEL INSTALLATION AND FINAL WIRING

With that done, I re-mounted the dial plate and was ready to reinstall the radio's front and rear panels. Those fasten, at their bottom edges, to pairs of Bakelite spacers mounted on the front and rear chassis apron (the idea is to insulate the front panel and cabinet from the chassis, which—being of AC/DC design—has the potential of being "hot" to ground). The tops of the panels are fastened together by a pair of transverse braces, which complete the panel-and-radio sandwich—locking everything together in a rigid assembly.

Once mounted between the panels, the radio chassis is suspended about a half-inch above their bottom edges so that—after the set is mounted in its metal cabinet—the chassis can't come in contact with the cabinet floor. All of that went together quite smoothly, although I had to stop and backtrack a bit when I realized I had forgotten to install the new "cabinet isolation capacitor," a 0.005-μF unit wired between the chassis and the front panel.

After poking the leads from the speaker's output transformer primary down through their pass-through grommet, I was ready to finish the last few wiring connections that would need to be made. Those included hooking up the output transformer primary to the push-pull audio-output stage and wiring the choke back into the set's filter circuit. The last capacitor to be installed in the set (the second of the two electrolytics) would also be installed in conjunction with the wiring of the choke.



Here's the Tropicmaster chassis completely reassembled, re-tubed, and ready to try out.

SMOKE TEST TIME

Now all I had to do before it would be possible to try the set out was to reinstall the tubes. They had been tested when the set was originally dismantled, and (although some of the metal tubes had suffered from corrosion) all except the 25Z6 rectifier had tested good. The latter was dead as a doornail, probably a casualty of the same shorted capacitor that caused the demise of the filter choke.

The 25Z6 is not the most common rectifier tube, and I didn't happen to have one on hand. However, I was able to buy a new-old-stock replacement at a local hamfest and had it standing by to fill the empty socket. Before installing it, I ran it by my tube checker, which gave it a clean bill of health.

That was something of a relief because the original 25Z6 had given no reading at all on the tester. I had never seen a tube with a good filament not cause at least a flicker on the meter and wondered if the fault might be in the instrument.

But the moment of truth had now arrived; it was smoke test time! Since the Tropicmaster does not have a built-in loop antenna, I moved the set into my radio shack, where I could hook it up to the long-wire ham antenna.

However, I decided to check for signs of life before actually connecting the set to the skywire. Since all of the capacitors were new, there was no need bring the line voltage up slowly during start-up. I just flicked on the power switch, whereupon the room was bathed in white light from the biggest dial-light flare-up I had ever seen! I don't know why the bulb didn't burn out before it dimmed down to its normal operating level.

Making a mental note to investigate the pilot-light situation later, I continued to observe the set as it warmed up. No plumes of smoke drifted out of the chassis, but—even after several seconds—there was no sound from the speaker. It was beginning to look as if more troubleshooting would be necessary before I could have an operating set.

As sometimes happens during moments that are pregnant with tension, the phone rang. Being the only one in the house (and because the ringing phone was at my elbow and couldn't be ignored), I had to take the call. It was brief and, returning my attention to the Tropicmaster, I could hear a reassuring low hum in the speaker when the volume control was turned up full. Tuning around on the broadcast band, I heard a couple of faint stations.

Now I hooked up the outside antenna to the Minerva's antenna post and was gratified to hear many strong signals all over the broadcast band. Switching over to shortwave, I was

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alignment, which will (hopefully) return it to top operating condition.

Looking into the pilot-light problem, I checked the Tropicmaster's original specifications. They called for the usual type-47 (brown bead) 6–8-volt lamp. The lamp in the set was marked "6–8 volts," all right, but had a white bead. It also had a round bulb instead of the elongated cylinder usual on the type 47.

Searching through my stores, I was able to find the proper lamp. It was marked as a type 47, and had both a brown bead and the usual elongated envelope.

When that lamp was substituted for the one originally in the set, things returned to normal. Flare-up was reduced to a proper level and died down much more quickly.

POSTSCRIPT FROM THE PREVIOUS OWNER

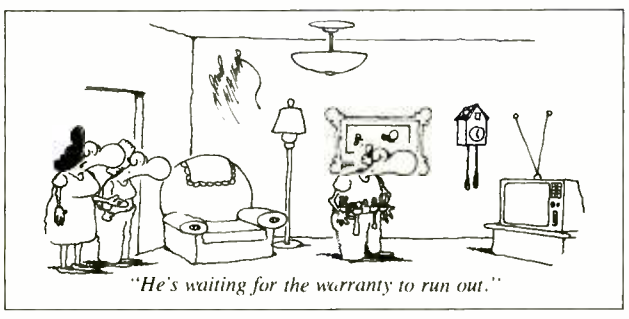
I just received a note from Alan Douglas, from whom I purchased the Minerva at last September's AWA Rochester meet. He had just seen the first column in this series and wanted to let me know that the set's cabinet-insulating spacer blocks were not original, having been replaced by him some time in the past.

He also informed me that the cabinet had been spray-painted by a prior owner. That would certainly explain why the outside of the radio looks so much better than the inside! However, I never suspected a repaint because the cabinet color was such a good match to the front panel (which still has its original silk-screened control labels, not to mention its rust spots, and so probably wasn't part of the repaint project).

The paint also didn't look new, perhaps because it was done some time ago. And, more important, the flamboyantly calligraphed silk-screened Tropicmaster logo on the cabinet's front door—which would have been all but impossible to mask for repainting—was in perfect condition with no sign of any overspray. Alan tells me that this is due to his meticulous clean-up with acetone.

Thanks, Alan! I think that was the only true restoration work done on the radio. My own efforts have been confined to making practical repairs and returning the set to serviceable operating condition.

That's it for now. See you all next month. ■



"He's waiting for the warranty to run out."

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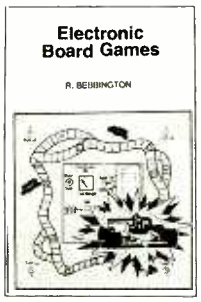

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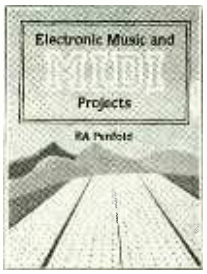

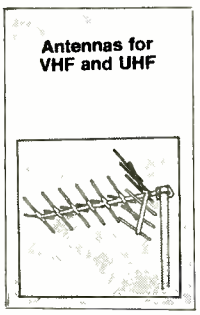

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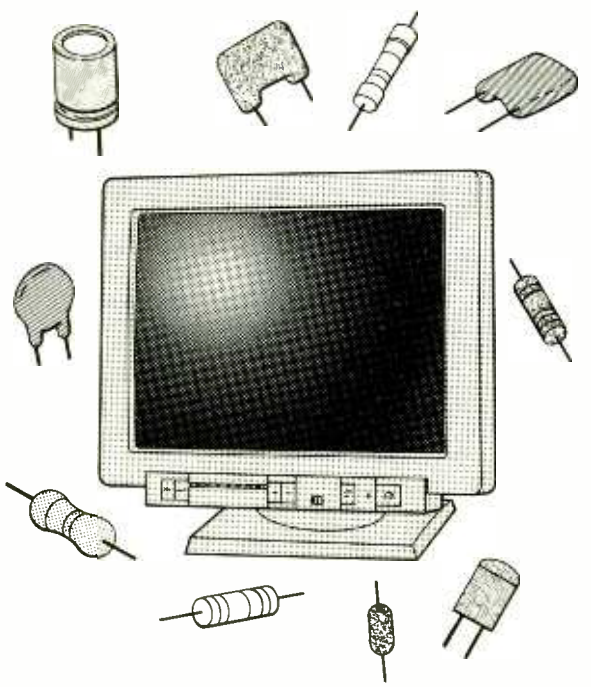
By Jeff Holtzman

Soldering Irons And Cyber Circuits

I was just a kid when LEDs came along (ca. 1965). Before LEDs, there were incandescent lamps and neon lamps. Incandescent lamps are available in a wide range of voltages, but they have an insatiable appetite for electrons (current). Plus, they generate heat, they're fragile, and they're simply not cool. Neon lamps, on the other hand, have very low current drain, and they do produce a cool glow. But they require voltages much higher than are available in a typical solid-state circuit. They're also fragile.



As our world becomes ever more cyber, will the components and test gear of our hobby give way to computer software and hardware?

I remember seeing ads for the first LEDs. They were expensive. Eventually, prices dropped, and surplus vendors and other retailers began selling grab-bags of LEDs. For a couple of dollars, you could get perhaps ten LEDs, of which six or seven wouldn't even work!

I remember the thrill I had when I connected my first LED to a nine-volt battery and a resistor. My ten-year-old perception of the world changed in an instant, and my expectations changed forever. I couldn't have articulated it at the time, but something in me knew that the bulky old vacuum-tube radios and TVs were dead. They might not have known it yet, but they were dead; walking dead perhaps, but nonetheless dead. I did know that I wanted to have as little as possible to do with that dingy, dusty, hot, fragile, high-voltage world of vacuum tubes; and as much as possible with cool, clean, miniature semiconductor devices like LEDs.

I experienced a similar thrill when interesting, useful integrated circuits were introduced. Devices like the 78xx series of voltage regulators totally changed the scope of project building. Prior to the 78xx, just creating a reliable source of power for a given project could consume a major part of the project. In fact, general-purpose, variable power supplies were themselves popular projects.

I remember when the 555 "programmable" timer was introduced. Another messy, repetitive problem solved once and for all.

I also remember when National Semiconductor started introducing its LM line of audio amplifiers, preamplifiers, tuners, and so on. Ditto.

When I was a kid, n ous magazines were publishing articles on ele tronics, parts were readily available, and there was a incredible feeling of innovation and experimentation.

LATER

Fast forward about ten years. A magazine called *Radio-Electronics* published plans for building a computer. Six months later, another magazine called *Popular Electronics* (then owned by Ziff-Davis Publishing Corp.) published its own plans for a computer called the Altair. And the Altair changed history.

The energy and innovation once seen in electronics was now shifting to computers, *micro*computers. A new generation of magazines (*Byte, Kilobaud, 80 Micro,* and many, many others) sprung up to fuel that revolution, and to profit from it. Only a few of those original publications remain today, and those in a much-altered format. Where once they catered to technical users and hobbyists, they focus now on business users and product reviews. That's where the money is. But where is the fire?

Look at it another way. As I define it, the "Golden Age of Electronics" occurred (roughly) from 1965–1975. The "Golden Age of Personal Computers" occurred from 1975–1985. What happened between 1985 and 1995? And what will the next decade bring?

VIRTUAL, CYBER, AND ARTIFICIAL

I experienced and participated directly in those

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first two Golden Ages. But then I entered the work force, had my own family, and settled into middle age. I simply don't have the same type of intuitive, certain knowledge about the last decade as for those preceding it. But I do have a theory (and you're welcome to challenge it, confirm it, or confound it; you can e-mail me at jkh@acm.org). The theory goes like this:

I believe that technically inclined youth need a channel for communicating, experimenting, challenging, building. It is both an intellectual and a social channel. I believe that prior to the 1960s, that channel evolved much slower. For perhaps as long as five decades leading up to the 1960s, that channel centered on vacuum-tube electronics, ham radio, and shortwave listening. In the 1960s, things burst wide open. Technology started to evolve much faster, and so did people.

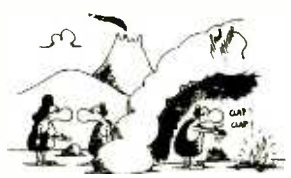
From roughly 1965 to 1985, hardware reigned in that channel, first in analog electronics, then in digital electronics. After 1985, the channel turned "virtual" or "cyber." I dislike both words because of their appropriation by the technically illiterate, but I have nothing better to offer. Whatever you call it, the idea is that the underlying physical reality became infinitely less important than the things you could do in the "artificial" or "virtual" or "cyber" space offered by the computer.

After 1985, people put down their soldering irons, and started to learn BASIC, C, or the script language of their word processor or multimedia-authoring environment. The reason is that it's hard to do anything really new or interesting in hardware on a hobbyist scale. The closest we've come is projects based on microcontrollers, which represent a real boundary-crossing phenomenon between physical and cyber spaces.

I'm not saying that no one uses a soldering iron—it hasn't come to that yet. I am saying that fewer people are doing it, and of those who do, they do it not as a socially compelling and captivating activity, as occurred in the 1960s and 1970s. I don't know what the next step will be. But given both the popularity and the immaturity of the on-line-services industry in general, and the Internet in particular, my hunch is that networking—internetworking—will be a strong area of growth. And there's no soldering on the net.

About ten years ago, in a discussion with a popular author of electronics projects, I made the rash prediction that it wouldn't be long before people wouldn't know how to use a soldering iron, that they would never have seen a real resistor, capacitor, transistor, or LED. I had a hunch that we would be building "circuits" (or actually, cybercircuits) on computer screens and viewing voltages and waveforms on simulated test equipment. My friend laughed. Today, however, every issue of this magazine advertises several such programs.

The days of the soldering iron may soon be over. Long live the computer. ■



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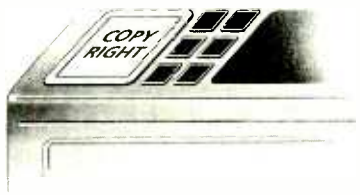

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CIRCUIT CIRCUS

By Charles D. Rakes

Voice Recording and Playback

Gather around, circuiteers, because this visit we're going to investigate a most interesting voice-record/playback integrated circuit. It's the ISD1000A Direct Analog Storage Technology (DAST) IC manufactured by Information Storage Devices; the chip is available from Radio Shack (catalog no. 276-1325), as well as other sources. That neat little 28-pin chip stores data in analog form in a special EEPROM requiring neither an analog-to-digital nor a digital-to-analog converter.

The ISD1000A can sample an audio signal at a 6.4-kHz rate, store each input bit in a single sample-and-hold circuit, and then record it in one of 128,000 EEPROM cells. That amount of memory allows the storage of a 20-second sample with 8-bit accuracy. After the data has been stored in the EEPROM, the memory is maintained without power.

Only a minimum amount of external components are required to build a complete voice recording and playback system. The preamplifier, filters, AGC, power amplifier, control logic, and analog storage are all in the same chip!

SIMPLE RECORDER/PLAYER

Our first entry is a recorder/player circuit (see Fig. 1) that is similar to the one shown in the IC's data sheet. When switch S3 is set to RECORD, pin 27 (P/$\overline{R}$) and pin 24 (PD) of U1 go low. Holding down switch S1 will then cause pin 23 ($\overline{CE}$) to go low. That starts the recording process and activates the electret microphone, MIC1.

During recording, LED1 will remain on and will go out when the end of memory is reached. Letting go of switch S1 will stop the recording process. If the recording is stopped before the end of memory is reached, an end-of-message bit is set internally to mark where the message ended. That allows other messages to be recorded in a sequential manner until the total memory is used up.

Setting switch S3 to PLAY causes pin 27 to go high, and pin 24 to go low. To

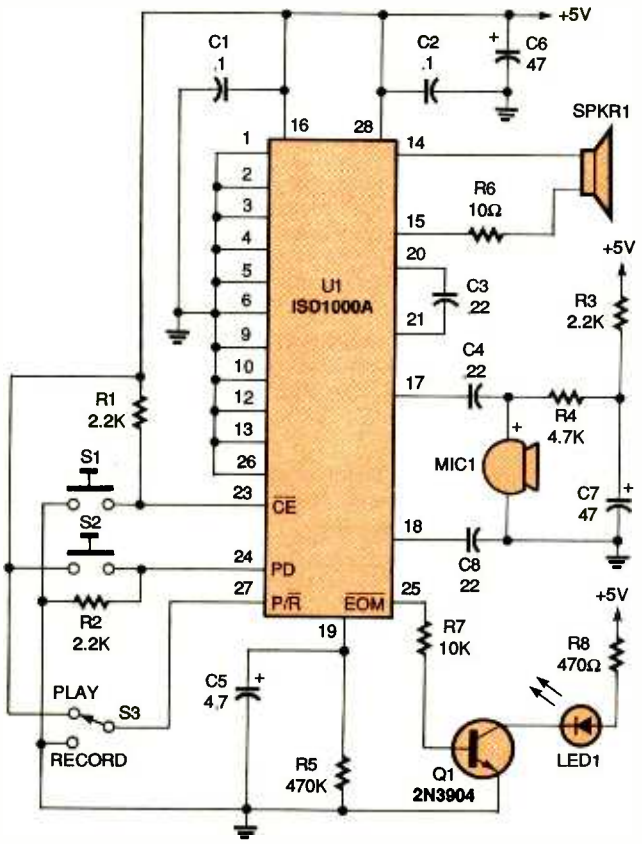

Fig. 1. This basic recorder/player circuit is easy to use. Turn S3 to RECORD and hold down S1 to record your message. To play it back, turn S3 to PLAY and press S2.

PARTS LIST FOR THE SIMPLE RECORDER/PLAYER (Fig. 1)

SEMICONDUCTORS
U1—ISD1000A voice record/playback, integrated circuit
Q1—2N3904 NPN transistor
LED1—Light-emitting diode, any color

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1–R3—2200-ohm
R4—4700-ohm
R5—470,000-ohm
R6—10-ohm
R7—10,000-ohm
R8—470-ohm

CAPACITORS
C1, C2—0.1-µF, ceramic-disc
C3, C4—0.22-µF, Mylar
C5—4.7-µF, 16-WVDC, electrolytic
C6, C7—47-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
S1, S2—Pushbutton switch, normally open
S3—SPDT switch
MIC1—electret microphone
SPKR1—8-ohm speaker
Wire, solder, etc.

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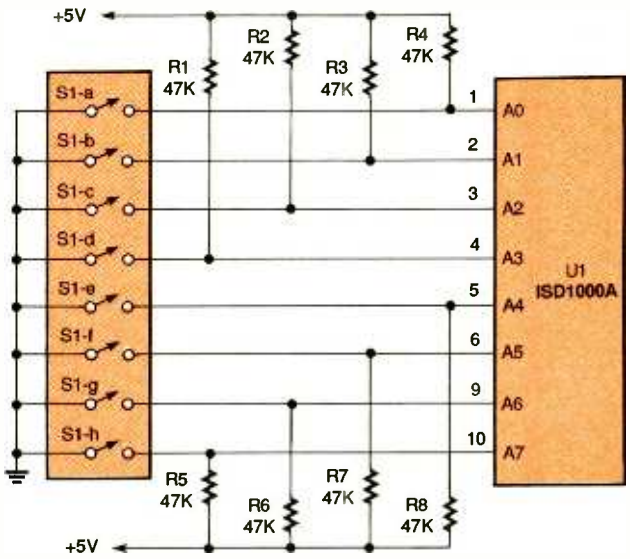

Fig. 2. Adding an 8-position DIP switch to the ISD1000A makes it possible to find a particular location in the 20 seconds of message time.

PARTS LIST FOR THE MESSAGE-START LOCATOR (Fig. 2)

U1—ISD1000A voice record/playback, integrated circuit
R1–R8—47,000-ohm, ¼-watt, 5% resistor
S1—8-position DIP switch
Wire, solder, etc.

begin playback, switch S2 must be depressed momentarily to set pin 23 low.

MESSAGE-START LOCATOR

Pins 1–6, 9, and 10 can be used to address the ISD1000A for multiple messages. Those pins control an internal register called the Message Start Pointer, or MSP. The MSP indicates the location where the next record or play operation will begin.

So, how do you find a particular message location to either begin playback or recording? To do that, an eight-section DIP switch, S1, must be connected to the eight address inputs of the IDS1000A (see Fig. 2). Address inputs A0–A7, which correspond to switches S1-a to S1-h, allow you to split the message area into 160 equal

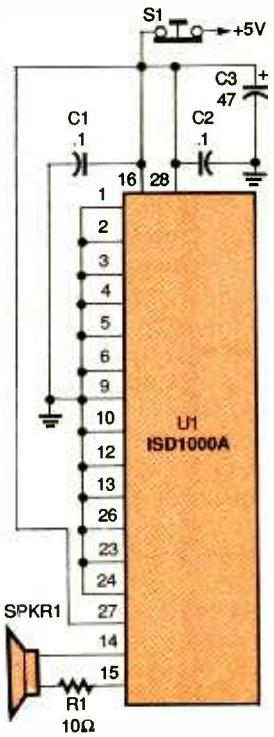

Fig. 3. This circuit could make a favorite picture frame speak out.

PARTS LIST FOR THE PICTURE-FRAME AUDIO (Fig. 3)

U1—ISD1000A voice record/playback, integrated circuit
R1—10-ohm, ¼-watt, 5% resistor
C1, C2—0.1-µF, ceramic-disc capacitor
C3—47-µF, 16-WVDC, electrolytic capacitor
S1—Pushbutton switch, normally closed
SPKR1—8-ohm speaker
Wire, solder, etc.

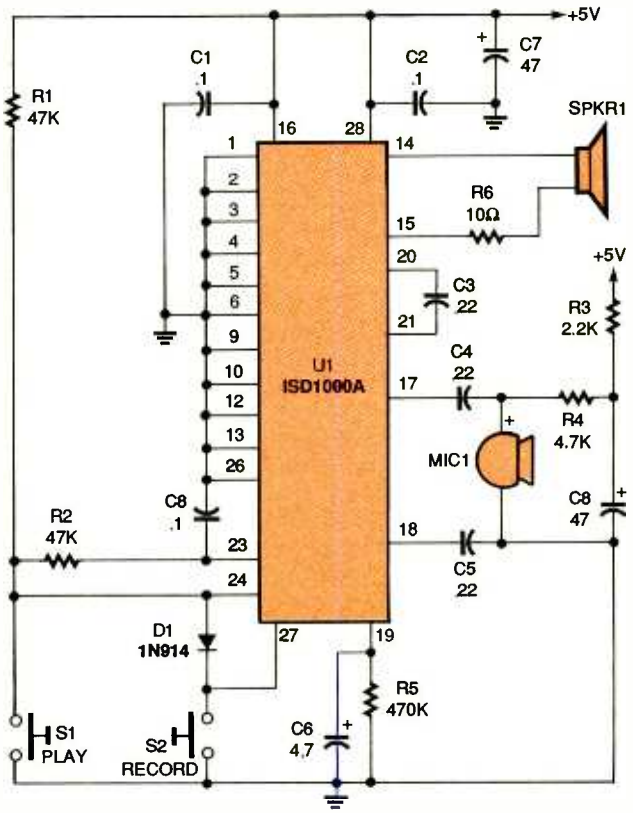

Fig. 4. This recorder/player is real easy to use. Hold down S2 to record a message and then hold down S1 to play it back.

segments of 0.125 seconds each. The address-input decimal values are as follows: A0 = 1, A1 = 2, A2 = 4, A3 = 8, A4 = 16, A5 = 32, A6 = 64, and A7 = 128.

To start the recording or playback function at a desired time (MSP), divide the time in seconds by 0.125. That will be the decimal number that is set by the address switches of S1. As an example, to start the recording or playback function at the 10-second point of memory, you would have to first divide 10 by 0.125; that equals 80. Because the address inputs use positive logic, switches S1-e (decimal value of 16) and S1-g (decimal value of 64) are placed in the open position to obtain the decimal value of 80. All other switches must be closed.

PICTURE-FRAME AUDIO

Now that we know how to make the ISD1000A perform, it's time to have some fun. Add the simple playback circuit shown in Fig. 3 to a photo of a special

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PARTS LIST FOR THE ADVANCED RECORDER/PLAYER (Fig. 4)

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1, R2—47,000-ohm
R3—2200-ohm
R4—4700-ohm
R5—470,000-ohm
R6—10-ohm

CAPACITORS
C1, C2—0.1-μF, ceramic-disc
C3–C5—0.22-μF, Mylar
C6—4.7-μF, 16-WVDC, electrolytic
C7, C8—47-μF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
U1—ISD1000A voice record/playback, integrated circuit
D1—1N914 silicon diode
S1, S2—Pushbutton switch, normally open
MIC1—electret microphone
SPKR1—8-ohm speaker
Wire, solder, etc.

PARTS LIST FOR THE SOUND-ACTIVATED PLAYER (Fig. 5)

SEMICONDUCTORS
U1—ISD1000A voice record/playback, integrated circuit
Q1–Q3—2N3904 NPN transistor
D1—1N4002 silicon rectifier diode
D2–D4—1N914 silicon diode
LED1—Light-emitting diode, any color

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1, R2—47,000-ohm
R3—2200-ohm
R4, R5—4700-ohm
R6—1000-ohm
R7, R10—10,000-ohm
R8, R9—220,000-ohm
R11—10-ohm

CAPACITORS
C1–C3—0.1-μF, ceramic-disc
C4, C5—0.22-μF, Mylar
C6, C7—4.7-μF, 16-WVDC, electrolytic
C8, C9—47-μF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
MIC1—electret microphone
SPKR1—8-ohm speaker
Wire, solder, etc.

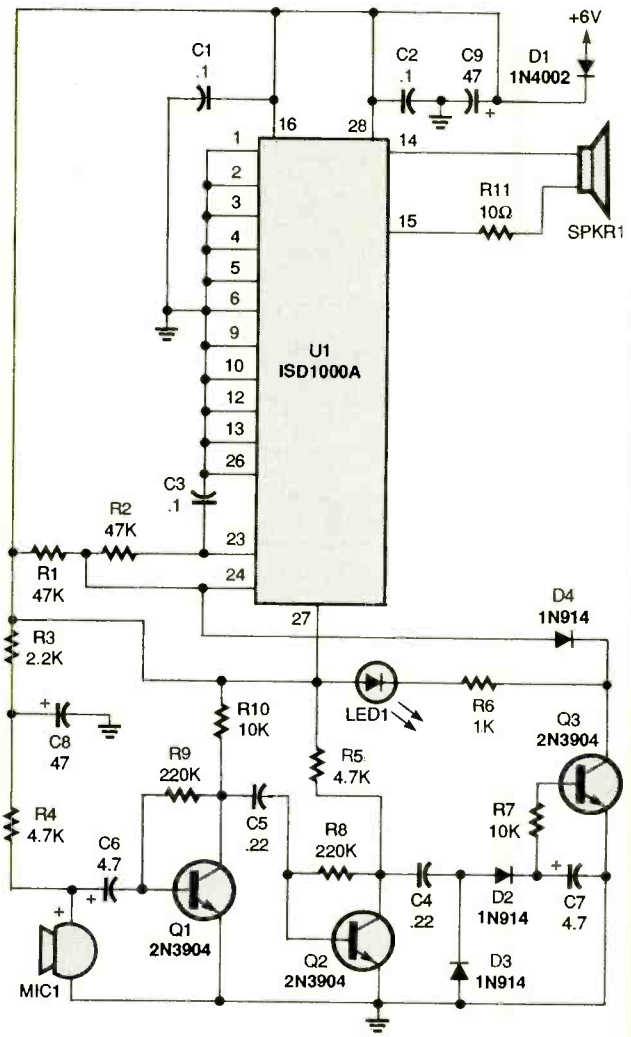

Fig. 5. When this circuit "hears" a noise, it plays back a prerecorded sound, such as a dog barking.

friend or relative and you can have his or her looks and voice frozen in time. Place the circuitry in a small plastic case and attach it to the back of the picture. Mount S1, the normally closed pushbutton switch, on the bottom of the case so that when the picture frame is resting in place, the switch is open. When the picture is picked up, the switch will close and the frame will appear to speak. Of course, that might cause the person holding the frame to drop it when it starts talking!

The playback-only circuit in Fig. 3 is a good choice for the photo caper because it makes it impossible to accidentally erase a message which at a later date might be impossible to recreate. So how do you get a message onto the chip? Simply use either the circuit in Fig. 1 or Fig. 4 (we'll get to that in a moment) to record the message and then move the chip to the playback-only circuit.

ADVANCED RECORDER/PLAYER

Our next entry (see Fig. 4) is a mini solid-state message recorder/player circuit. To keep Murphy at bay, follow good project-building practices by keeping all component leads short and close to the IC.

Using the solid-state recorder is easy. To record, depress switch S2 and hold it closed until you have completed your message or until the 20-second message limit has run out. To play the message back, hold switch S1 closed.

SOUND-ACTIVATED PLAYER

Now let's take a look at a sound-activated talk-back circuit (see Fig. 5). One great application for the circuit is as a simulated watchdog. You could record the sound of a barking dog onto the ISD1000A using either of the recorder

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circuits we already examined, insert the chip into the sound-activated player, and locate the circuit near an entry door. When someone bangs on the door a ferocious dog will bark back. With a little thought, I am sure you can come up with other uses for the circuit.

An electret microphone, MIC1, picks up sounds which are amplified several-hundred times by transistors Q1 and Q2. The audio output at the collector of Q2 feeds a voltage-doubler detector circuit that supplies a positive bias to Q3. Transistor Q3's collector then goes low, lighting LED1 and forcing pins 23 and 24 of U1 low. That starts the play function. As long as the sound level reaching the microphone is sufficient to keep Q3 on, the recording will continue to play until the 20-second time period runs out. When the audio reaching the microphone ceases, the playback will stop within a few seconds (the value of C7 determines how long that is; increase the value of C7 to make it longer, and reduce the value to make the time period shorter). The next time the circuit is activated, the playback will start over at the beginning and repeat the message.

While the circuit is not playing, power consumption is only a few milliamps. When pins 23 and 24 of U1 are high, the IC is in a sleep mode drawing only about 10-microamps of current.

If you would like to increase the playback audio level, you can connect an external amplifier to the circuit. The audio can be taken from either pin 14 or 15 through a suitable coupling capacitor.

That's all for now. If you would like to see more on the ISD1000A, check out the "Circus" next month. ■

THINK TANK

(Continued from page 32)

change R1 from 240 ohms to 1000 or 1200 ohms.

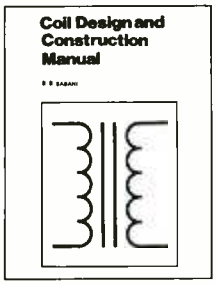
—Bill Stiles, Hillsboro, MO

The values of R1 and R2 are not too important; their ratio is. That's why the ratio of the values in the spec sheet is the same as that shown here. The 240- and 2400-ohm values are hard to find (even at Radio Shack), and that's probably why Joseph used more-common stock. That aside, your comment about using precision units or an adjustable circuit is well taken.

Regarding R3, the circuit is designed to be a trickle charger—a 1-amp current draw is not a trickle. The circuit is supposed to keep batteries at the ready, not to recharge them after a significant drain. For that reason, the drop across D1 is insignificant. It can also be overcome by adjusting the value of R2. Placing a crowbar diode across a regulator in most power-supply circuits is a good idea. But in this case, using it to replace D1 still does not prevent the battery from discharging through the resistors if the charger losses power. As shown, D1 protects both the regulator and the battery.

You are absolutely right about the value of R4—it's too low. I generally shoot for an LED current of 15 mA, but LED life should not be significantly reduced with your value of 20 mA. However, I generally round-up a current-limiting resistor's value to the next standard value, not down. That provides a tiny safety margin.

That's all until next month. In the meantime, send your circuits to Think Tank, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■



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DX LISTENING

By Don Jensen

Fun in the Summertime

Some SWLs abandon their listening during the summer months. More static, some say, and yes, there's some truth to that. For others, there are too many other outdoor activities to compete with DX listening, and that's true too. But before you pull the plug on shortwave listening until autumn, be aware that if you're up to battling the band noise, there can be some terrific DX out there.

Summertime can produce some of the best trans-equatorial signals to Northern Hemisphere SWLs. Those signals can include some very elusive African and South American SW ones. And, as I suggested last month, you can add more fun to your summer SWLing by doing at least some of it in the great outdoors.

In our June column, longtime DXer Rich D'Angelo told us about his regular DXpeditions with a group of friends to a state park in eastern Pennsylvania for a weekend of alfresco listening fun. This month, Rich continues with his answers to questions I put to him about organizing a SW DXpedition.

What goes into planning a shortwave DX outing, Rich?

"In addition to bringing along the receivers and other gear, it is wise to plan your listening time. You want to maximize the opportunities to catch those DX signals when they appear.

"Have a list of 'target' stations ready to go. Since, hopefully, you are in a DXing environment that's better and quieter than home, don't be afraid to stretch your listening goals and interests.

"For example, maybe you've never heard a SW station from Indonesia before. Decide in advance which frequencies and times may give you the best opportunities. Then, with a good propagational opening and reduced band noise, Indonesian reception may become a reality!"

What sort of DXing equipment should one bring along?

"At more primitive locations, battery portables would be required, but since the cabin where we set up has electrical power, that's not a concern for us.

"Today's AC-powered tabletop SW sets are lightweight and compact, excellent for our SWLing in the 'wild.' But one of our guys, Hans has brought along his old and very heavy military surplus R-390 tube receiver, which is a real 'boat anchor.'

"In addition, don't forget to bring along the other things you'll need for your SW listening, maybe a tape recorder to capture those rare SW signals you hear, reference books, frequency lists and the rest."

How about creature comforts?

"Our cabin is comfortable and little more than an hour's drive away for most of us. And we all cook, sort of. I'm in charge of the traditional Friday-evening spaghetti dinner. Fred brings lunch meats and rolls. Hans has made his breakfast muffins legendary. Dave's mom has supplied us with delicious pies. . . ."

Okay, okay, Rich, we get the idea. Is there an ideal size for a DXpedition group?

"Four or five, and their listening setups, fit easily in a cabin. More can fit in with a bit of crowding, but a larger group means plenty of enjoyable conversation and storytelling. And it's nice to have the extra ears listening for the rare DX signals.

"Actually, though, we've had DXpeditions with as few as two people and we had a ball. What's important is that everyone has similar DX interests."

What about antennas?

"Gifford Pinchot State Park in eastern Pennsylvania is a wooded area, which allows the opportunity to experiment with antennas, more so than back home. We've tried truly long, long-wire antennas. We've used special switching arrangements to couple several antennas to a receiver. We've experimented with

Thanks, Mr. Jensen, ... for the report on a United Nations broadcast at 0815-0830 GMT, 26 Oct. on KNBH, 9,515 kcs. . . . the details of which are correct.

RADIO DIVISION
DEPARTMENT OF PUBLIC INFORMATION

Here's a vintage QSL card from United Nations Radio, which at the time was rebroadcast via the powerful Voice of America shortwave transmitters.

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'delta loops' and 'eavesdroppers,' and they've worked well.

"I may be an antenna cynic, but I'm convinced that in a low-noise environment, just 100 feet of wire produces as good results as almost any other antenna combination. Our long antennas are simply strung over low tree branches. At the state park, fortunately, there is no shortage of tree branches. Although we'd love to leave them up, making for a more permanent installation for our next visit, that's not possible in the park. We put them up when we arrive and take them down when we leave.

"Although I wouldn't recommend going on a DXpedition with only the portable receiver's built-in whip antenna, Larry managed to log the Indonesian station, *RRI Tanjunkarang* on 3,395 kHz two years ago on a Sony 2010 with just its whip. Since the station was booming in on our Drakes and NRDs with long wire 'Beverage' antennas, he thought it worth a try with the portable and whip. It worked, but I wouldn't expect results like that on a regular basis."

Any other tips?

"Be careful during hunting season? Stringing an antenna in the woods, and hearing gunshots in the distance, can shorten a longwire antenna faster than bad weather! And the usual camping-out cautions also apply.

"As far as our group is concerned, another safety tip is to keep Hans away from the stove. He earned the nickname 'Torch' last year when he almost burned the cabin down while cooking a shrimp dish. It made for some great conversation and pictures!"

Thanks, Rich, for your vivid picture of an SWLing weekend.

AN INTERESTING IDEA

In an Op Ed think piece in the *New York Times*, Keith Spicer, chairman of the Canadian Radio-TV and Telecommunications Commission, noted that hate broadcasts have helped to brew some of the worst horrors in places like Bosnia and Rwanda.

In those trouble spots, the United Nations staggers under huge peacekeeping bills that are a result of those conflicts. Couldn't the UN head off or stop ethnic wars by mobilizing airwaves that are too often used to set them off?

Spicer notes that broadcasts can convey anti-racist facts and perspectives in the same powerful way that broadcasts now are used to inflame ethnic hatreds. Unlike the print media, radio can reach all social and cultural groups, especially the illiterate or poorly educated, he points out. Broadcast stations require only a modest amount of equipment and supplies, and only a few staff members. Volunteers from the West's private media-aid organizations could be enlisted to help the U.N., Spicer suggests.

"We're talking about technology, a few volunteers and some vision—all at a pittance—to stop ethnic bloodbaths," Spicer says.

Longtime SWLs remember that the U.N. once was a major presence on shortwave. U.N. Radio, then relayed by powerful Voice of America transmitters, was easily heard around the world. But in 1985, faced with a hike in airtime charges levied by the VOA, the U.N. decided it could no longer afford to lease the facilities.

The United Nations, of course, didn't abandon radio entirely. It continued to furnish brief weekly news and current-event programs to world SW broadcasters willing to rebroadcast them. Today, those continue, broadcast by just a handful of stations in places like Nigeria, Egypt, China, Zambia, Poland, and others.

Needless to say, the impact of these broadcasts is insignificant. So maybe Spicer has a worthy idea. Maybe U.N. Radio should be beefed up to air "Propaganda for Peace."

DOWN THE DIAL

Time again to turn our attention to some of the SW broadcasts that are being logged on the bands these days. What are you hearing? Drop a line to me in care of "DX Listening," **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

CUBA—9,820 kHz. *Radio Havana Cuba* was heard at 0345 UTC with its English-speaking shortwave-listeners program, "DXers Unlimited," with host Arnie Coro. It's also on 6,010 kHz at the same time.

JAPAN—11,885 kHz. *Radio Japan*, out of Tokyo, was noted at 0530 UTC with an English-language feature, then into Japanese programming at 0600 UTC.

MOROCCO—17,595 kHz. *Radio TV Morocaine* was logged at 1400 UTC announcing, "Welcome to the International Service of Radio Morocco." ■

CREDITS: Richard D'Angelo, PA; Marie Lamb, NY; Ed Rausch, NJ; Robert Tucker, GA; North American SW Association, 45 Wildflower Road, Levittown, PA 19057.

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By Joseph J. Carr, K4IPV

Receiver Selectivity

Although transmitter power is often the first thing a ham looks at when looking for a transceiver, that's actually one of the least important specifications. For overall operating usefulness, the specs of the receiver are much more important. And among receiver specs, one of the most important is selectivity.

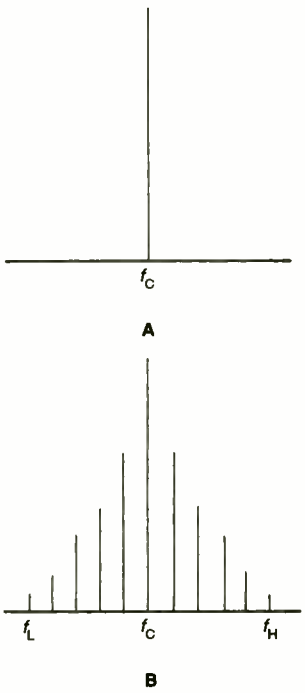

Fig. 1. An unkeyed carrier (A) has only a very small bandwidth, but when the carrier is keyed, the signal spreads out as shown in B.

Of course, sensitivity, dynamic range, third-order intercept point, and other matters are important as well, but in the limited space that a column affords us we can tackle only one topic at a time . . . so this month it's selectivity.

Selectivity is the measure of a receiver's ability to reject adjacent-channel interference. Or to put it another way, it's the ability to reject interference from signals on frequencies close to the desired signal frequency.

In order to understand the selectivity requirements of a receiver, you must first understand a little bit of the nature of real radio signals. An unmodulated radio carrier theoretically has an infinitesimal bandwidth (although all real unmodulated carriers actually have a very narrow bandwidth because they are modulated by noise and other artifacts). As soon as the radio signal is modulated to carry information, however, the bandwidth spreads. An on/off telegraphy (CW) signal spreads out on either side of the carrier frequency by an amount that depends on the sending speed and the shape of the keying waveform. Figure 1A shows an unmodulated CW signal. When the carrier is keyed, however, the signal spreads out as shown in Fig. 1B, with a bandwidth centered on the carrier of $f_H - f_L$.

An AM signal spreads out an amount equal to twice the modulating frequencies. That means that the AM waveform will occupy a spectrum that is equal to the carrier frequency (f_C) plus/minus the audio bandwidth. For example, in the case of an AM transmitter with audio components from 300 to 3,000 Hz transmitting on a carrier frequency of 14,300 kHz, the upper and lower sidebands will extend from 14,297 kHz to 14,303 kHz ($f_C \pm 3{,}000$ Hz) as shown in Fig. 2.

An implication of the fact that radio signals have bandwidth is that the receiver must have sufficient bandwidth to recover all of the signal. Otherwise, information might be lost, resulting in distorted audio. On the other hand, allowing too much bandwidth increases the noise picked up by the receiver and thereby deteriorates the signal-to-noise ratio. The goal of the selectivity system of the receiver is to match the bandwidth of the receiver to that of the signal. That is why receivers will use a 270 to 500-Hz bandwidth for CW, 2 to 3 kHz for SSB, and 4 to 6 kHz for AM signals. They allow you to match the receiver bandwidth to the transmission type.

The selectivity of a receiver has a number of aspects that must be considered. Those are the front-end bandwidth, IF bandwidth, IF shape factor, and more.

FRONT-END BANDWIDTH

The "front-end" of a modern superheterodyne radio receiver is the circuitry that is between the antenna input terminal and the first mixer stage. Front-end selectivity is the key factor that keeps out-of-band signals from raising havoc with the receiver. For example, AM-broadcast band transmitters located near your QTH can easily overload a poorly designed shortwave receiver. Even if those signals are not heard by the operator (as they often are), they can desensitize a receiver, or create harmon-

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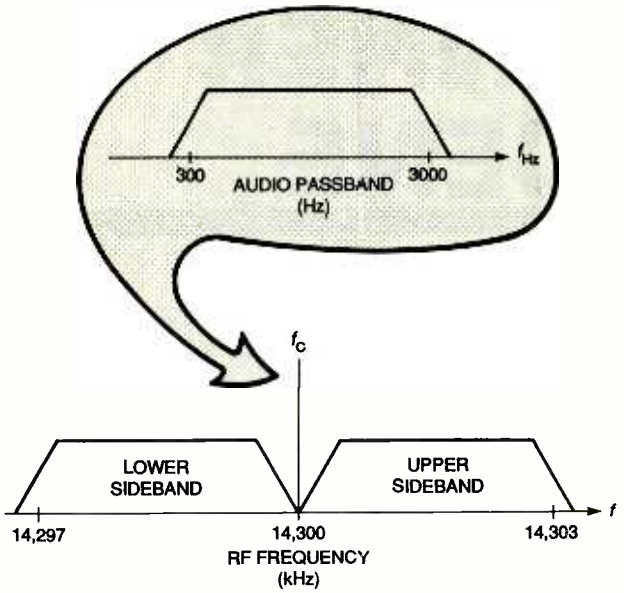

Fig. 2. Assuming an audio spectrum of 300 Hz to 3,000 kHz, and a carrier frequency of 14,300 MHz, an AM signal's upper and lower sidebands will extend from 14,297 to 14,303 MHz.

ics and intermodulation products that show up as "birdies" or other types of interference on the receiver. Strong local signals can take a lot of the receiver's dynamic range, and thereby make it harder to hear weak signals.

Two forms of front-end frequency selection are typically found. A designer might choose to use only one of them in a design. Alternatively, both might be used in the design, but separately (*i.e.* the operator selects the type used). Or finally, both might be used together. Those forms can be called the resonant-frequency-filter and bandpass-filter approaches.

The resonant-frequency-filter approach uses L-C elements tuned to the desired frequency to select which RF signals reach the mixer. In some receivers, those L-C elements are designed to track with the local oscillator (LO) that sets the operating frequency. That's why you see two-section variable capacitors for AM-broadcast receivers with two different capacitance ranges for the two

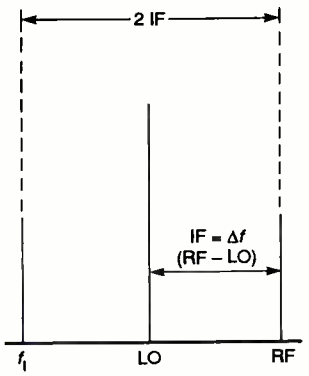

Fig. 3. An image is a response to a signal that is located the same distance away from the desired signal, but on the opposite side of the local oscillator frequency.

sections; one section tunes the LO and the other section tunes the tracking RF input.

The other approach uses a bandpass filter to admit only a portion of the RF spectrum into the front-end. For example, a shortwave receiver that is designed to take the HF spectrum in 1-MHz hunks could have an array of RF input bandpass filters that are each 1 MHz wide (for example, 7–8 MHz).

In addition to the reasons cited above, front-end selectivity also helps improve a receiver's image-rejection and 1st-IF-rejection capabilities. All superheterodyne receivers are subject to image responses. An image is the response to a signal that is located at a point that is the RF frequency plus/minus the IF on the other side of the LO from the RF signal. In the example shown in Fig. 3, the LO is on the low side of the RF signal, so the IF frequency is Δf, or RF − LO. But if there is a signal at frequency f_I, it also is Δf from the LO, so it is seen as a valid IF signal by the receiver!

If the IF frequency is low compared to the RF frequency, the image might well fall within the passband of most front-end tuning schemes. For example, at 25 MHz, a 455-kHz IF could produce images at 24.55 MHz and 25.455 MHz. A 1-MHz bandpass filter would scarcely affect that problem. However, if the first IF frequency is 9 MHz or 50 MHz (as it is in many modern shortwave receivers), then the images would be far enough removed from the RF signal that a 1-MHz bandpass front-end design would work well.

The 1st-IF rejection specification refers to how well a receiver rejects radio signals operating on the receiver's first-IF frequency. For example, if your receiver has a first IF of 8.83 MHz, it must be able to reject radio signals operating on that frequency when the receiver is tuned to a different frequency. Although the shielding of the receiver is also an issue with respect to that performance, the front-end selectivity affects how well the receiver performs against 1st-IF signals. If there is no front-end selectivity to discriminate against signals at the IF frequency, then they arrive at the input of the mixer unimpeded. Depending on the design of the mixer, they then may pass directly through to the high-gain IF amplifiers and be heard in the receiver output.

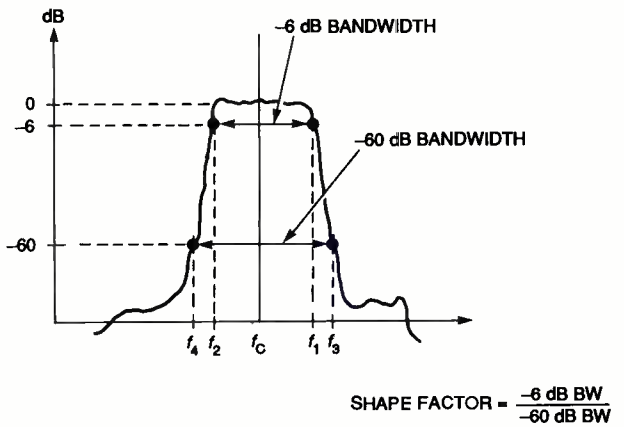

Fig. 4. The shape factor is determined by measuring the ratio of the bandwidths at the −6 dB and −60 dB points.

IF BANDWIDTH

Most of the selectivity of the receiver is provided by the filtering in the IF-amplifier section. The filtering might be L-C filters (especially if the principal IF is a low frequency, like 50 kHz), a ceramic resonator, a crystal filter, or a mechanical filter. Of those, the mechanical filter is usually regarded as best, with the crystal filter and ceramic resonator coming in next.

The bandwidth is expressed in kilohertz, and is

(Continued on page 90)

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SCANNER SCENE

By Marc Saxon

Up In The Air

Uniden America Corporation tells us that their new *BearTracker BCT-7* scanner is the most complete highway-information system available. If it isn't, it must be pretty close to the top of the list.

Uniden's BearTracker BCT-7 "highway-information-system" scanner detects and alerts the driver to the presence of any mobile extenders—used by state police and highway patrols—in a three-mile radius. It also comes preprogrammed with thousands of highway-patrol, local-police, D.O.T. and weather channels.

Basically, the BCT-7 is a "Highway-Patrol Driver-Alerting Machine." The sophisticated, multiband scanner responds to transmissions from what Uniden describes only as "special secondary radios installed on most highway patrol vehicles across the United States." You and I know that such non-technical wording refers to mobile extenders, which are low-powered, short-range mobile transmitters used especially by many state police and highway patrols. For example, Florida Turnpike mobile extenders use 156.18 MHz, while the Ohio Turnpike extenders are on 465.525 MHz.

The BCT-7 is preprogrammed to alert its user with audible and visual alarms announcing the presence of any mobile extenders within a three-mile radius. One might then assume that there's a possibility that the vehicle is heading toward a speed-clocking area.

More than that, the BCT-7 is also preprogrammed with a complete frequency list of highway-patrol, local-police, Department of Transportation, and weather channels. Literally thousands of frequencies are stored in a state-by-state matrix. All U.S. and Canadian weather channels can be scanned.

The BCT-7 is also a full-featured scanner that covers all of the standard action bands (including the 800-MHz band). It offers 100 user-programmable channels, and features 12 separate band-search capabilities, including CB radio and the VHF aeronautic band. One-touch band-search includes weather-scan, news, police, fire, and more.

You can get a look at the versatile BearTracker BCT-7 at any of Uniden America's many dealers.

DEMO TEAMS

Since 1946, millions have been awed by the inspiring aerial artistry of the U.S. Navy's flight demonstration squadron, the Blue Angels. Their name has become synonymous with precision. Those who have attended their demonstrations and seen others there with scanners often write requesting frequency information so they can tune in as the sleek FA-18 aircraft go through their paces.

Thanks to Ron Bruckman, of the *Radio Monitors Newsletter of Maryland*, we have the following current (and confirmed) frequencies used by the Blue Angels. Even better, Ron has furnished frequencies for the other military demonstration teams. Now you can get in on all the action.

The U.S. Navy Blue Angels' lead pilot uses 238.15 MHz. Air coordination at show sites is on 123.4, 142.00, 143.00, and 241.4 MHz. Show-site frequencies include 250.8, 251.6, 275.35, 360.4, 384.4, 391.9, and 395.9 MHz. Other related frequencies include 34.35, 118.1, 118.2, 121.9, 141.45, 142.025, 142.625, 143.60, 250.4, 251.4, and 394.4 MHz.

The U.S. Air Force Thunderbirds' show-site frequencies are 114.95, 118.1, 120.45, 123.4, 123.45, 124.925, 138.875, 141.85, 148.552, 236.55, 236.6, 241.4, 241.6, 250.85, 273.5, 283.5, 294.7, 295.7, 322.3, 322.6, 382.9, 394.0, and 413.025 MHz. Listen for ground support on 66.90 MHz.

The U.S. Army Golden Nights Parachute Team uses 32.30, 42.35, 123.4, and 123.6 MHz.

The Canadian Snowbirds operate on 227.0, 227.6, 236.0, 236.6, 239.4, 239.8, 240.5, 243.4, 245.0, 245.7, 266.3, 275.8, 283.9, 294.5, 295.6, 310.8, 316.5, 322.8, and 344.5 MHz.

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Readers who would like to obtain a sample copy of the *Radio Monitors Newsletter of Maryland* can obtain one by sending $2 to Radio Monitors of Maryland, P.O. Box 394, Hampstead, MD 21074-0394. A one-year membership, which includes 12 newsletters, costs $15.

MONITORING DATA

The updated and expanded *Air-Scan Guide to Aeronautical Communications, 6th Edition* has just come out. It is the one all-inclusive scanner-monitoring guide to VHF aeronautical communications facilities in the U.S. and Canada. Civil and private airports, seaplane bases, heliports, military fields, and some "unlisted" landing towers are listed. Frequencies are provided for control towers, approach/departure, ground control, clearance delivery, unicom, ATIS, weather, operations, Flight Service Stations, VOR, etc.

If you're looking for a single source of VHF aeronautic listings, your search is ended with the 6th edition of Air-Scan Guide to Aeronautical Communications.

U.S. listings are supplemented (as known and applicable) with additional on-site frequencies, in the 30–800-MHz range, for aeronautic-related activities including airline ground operations, airport security and fire, Air and National Guard, ultralights, and more. There are complete VHF listings of all U.S. and Canadian ARTCC remote sites and all their frequencies. Much more is also contained in the sixth edition of the largest single source of aeronautical frequency listings.

Air-Scan, 6th Edition can be ordered for $18.95, plus $5 shipping and handling ($6 to Canada), from CRB Research Books, P.O. Box 56, Commack, NY 11725-0056; Tel. 1-800-656-0056 (1-516-543-9169 in Canada, Alaska, and Hawaii). New York State residents must add $2.36 tax. MasterCard and Visa are accepted.

BYE, BYE BIRDIE

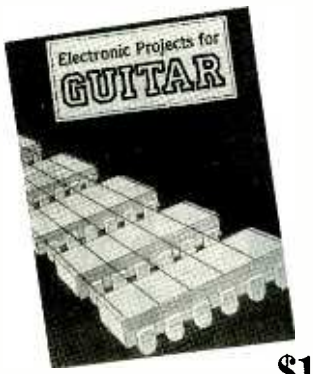
Ben, from Cherry Valley, New York, writes that he purchased a used scanner at a ham swapmeet. Ben didn't say which scanner it was, but it worked fine. Fine, that is, except that he can't hear stations on 155.295 MHz, which is an active EMS channel in his area. All he hears on that frequency is an "open carrier," although 155.295 MHz comes in without any problems on his other scanner.

Alas, Ben has encountered a *birdie*. It happens in the best of scanners! In order to function, all scanners require circuits that use certain frequencies. Those frequencies vary from one model to another, and every modern scanner has its own share. As an example, the sophisticated Radio Shack PRO-2035 has no less than 91 birdies sprinkled between 25 and 1200 MHz.

Usually, a birdie won't coincide with a particular local frequency that you want to monitor. The PRO-2035 can receive nearly 200,000 different frequencies, so 91 birdies really isn't many. Many lie on oddball spots, including frequencies that the set doesn't receive. The odds are long that you'd ever be inconvenienced, but it does happen on occasion—for instance, if you wanted to monitor a PRO-2035 birdie frequency such as 155.625 MHz. It's a real police frequency and is used in some cities. Ben "beat" the odds with 155.295 in his particular scanner.

Try backing down on the scanners squelch to see if you can knock out the birdie. If the scanner has a sound squelch, try that as well. Maybe readers can suggest alternate cures that have worked for them.

That's all for now. See you next time. ■



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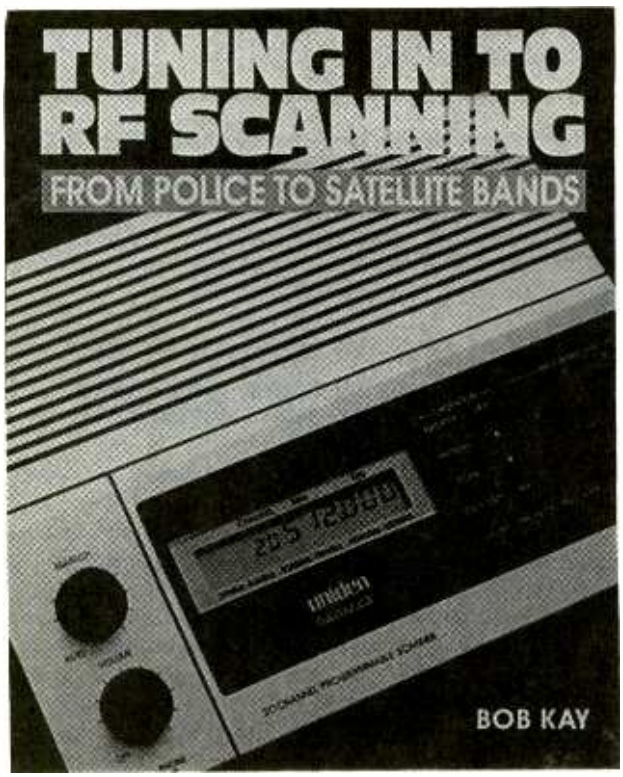
Tuning in to RF Scanning From Police to Satellite Bands

by Bob Kay



There's much more to radio-frequency scanning than listening to police, fire, and ambulance calls. If you know where to tune, you can also monitor aircraft communications, satellite signals, and even the Space Shuttle.

This guide to the world of scanning teaches beginners all they need to know to get started, and provides experienced scanners with the information they need to make their hobby more interesting and exciting. It begins with the basics: choosing a scanner and an antenna, buying and installing accessories, and laws and regulations. The book goes on to tell you how to monitor cordless telephones and baby monitors; military aircraft, exercises, and ground maneuvers; NASA; sports and entertainment frequencies; computers; and radios. The book also explains how to establish a professional listening post and find scanning clubs and publications. It includes a chart that lists hundreds of frequencies.

Tuning in to RF Scanning; From Police to Satellite Bands costs $14.95 and is published by Tab Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

CIRCLE 98 ON FREE INFORMATION CARD

MACINTOSH REVELATIONS: Customizing, Upgrading & Troubleshooting Using System 7.5

by Ken Maki

Macintosh computers are particularly easy to use. With a simple click of the mouse, Mac users can play games, write letters, enter a spreadsheet, or do almost anything else. But they are also powerful machines, and this book shows users how to unleash that power.

With an emphasis on the undocumented features of the Mac's latest operating platform, the book and its included CD-ROM provide practical advice and valuable hints that can make a System 7.5 run like a 10. It teaches readers how to customize their Macs, guides them through the upgrade process, and provides troubleshooting help for both software and hardware. The book also offers chapters on networking and system enhancements.

The CD-ROM contains more than 600-MB of System-7.5-compatible software. It contains software for games and entertainment; telecommunications; fonts, graphics, and sounds; educational programs; programming utilities; PowerPC utilities; and BMUG information.

Users can design their own icons, paint their desktop with interesting patterns, have Elvis drop by, or have Bullwinkle the Moose remind them to call home.

Macintosh Revelations costs $32.95 and is published by John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012; Tel. 1-800-CALL-WILEY.

CIRCLE 92 ON FREE INFORMATION CARD

WERNER VON SIEMENS: Inventor and International Entrepreneur

by Wilfried Feldenkirchen

Although Werner Von Siemens is best known as an inventor and pioneering electrical engineer—he developed the electric dynamo and an improved pointer telegraph—this biography focuses on his life as a businessman. Siemens was also an entrepreneur with a broad and international business vision.

His firm, Siemens & Halske, built Germany's first important telegraph line and then built lines elsewhere in Europe and Asia. When he later turned his hand to electric technology, Siemens was instrumental in creating the conditions for the advancement of electrical technology, helping to bring it from the experimental stage into the modern electrical industry.

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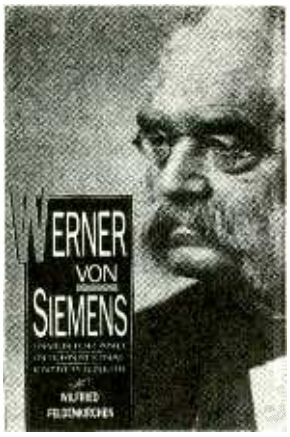


From their earliest days, Siemens' businesses had a multinational flair, with activities nearly spanning the globe. In covering the business history of Werner Von Siemens, this book also depicts the history of European industrialization, German history, and the history of business and technology.

Werner Von Siemens: Inventor and International Entrepreneur is available for $19.95 in hard cover and $12.50 in paperback from Ohio State University Press, 180 Pressey Hall, 1070 Carmack Road, Columbus, OH 43210-1002; Tel. 614-292-6930; Fax: 614-292-2065.

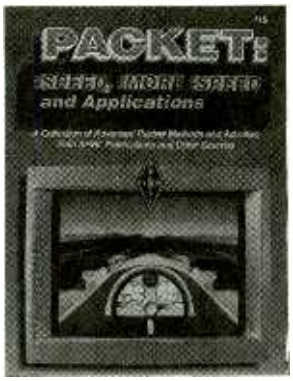
CIRCLE 93 ON FREE INFORMATION CARD

PACKET: SPEED, MORE SPEED, AND APPLICATIONS

compiled by Bob Schetgen, KU7G

There have been a lot of exciting developments in packet radio recently, if you look beyond the local BBS and packet cluster. Hams are increasing their speed, building high-speed LANs that span whole towns, using packet to report weather conditions automatically, mapping positions using Global Positioning receivers or LORAN-C, tracing the flow of messages through the packet network, and exchanging packet information via meteor scatter propagation. This book—actually a collection of articles from such publications as *QST* and *QEX*, and ARRL Conference Proceedings—shows you how to find the areas that interest you.

The book is divided into five sections. The first, "9600 Bits/s," shows readers how to increase their basic packet speed to 9600 bits per second. It includes basic information on high-speed packet, hands on advice for getting started, and a review of modems that work at both 1200 and 9600 bps. The second section, "56 kBits/s and Faster," is aimed at those who



want to go even faster—up to two megabits per second. Section 3 is devoted to packet projects, including modems, a telemetry adapter, and a modem interface. The fourth section covers special topics including the future of packet radio, and Section 5 provides references.

Packet: Speed, More Speed, and Applications costs $15 and is published by The American Radio Relay League, 225 Main Street, Newington, CT 06111; Tel. 203-666-1541; Fax: 203-665-7531.

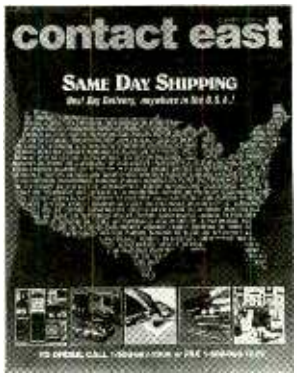
CIRCLE 94 ON FREE INFORMATION CARD

1995 GENERAL CATALOG OF PRODUCTS FOR TESTING, REPAIRING & ASSEMBLING ELECTRONIC EQUIPMENT

from Contact East

The 144 pages of this full-line catalog are filled with hundreds of new test instruments and tools for engineers, technicians, hobbyists, and managers. Quality, brand-name products for electronic testing, repair, and assembly are featured.

Highlights of the 1995 catalog include digital multimeters and accessories, soldering tools, EPROM programmers, power supplies, custom tool kits, measuring tools, adhesives, data-communication tools and testers, heat guns, reference books, portable and bench-top digital storage oscilloscopes, ELF meters, precision hand tools, and breadboards. The catalog also offers full lines of communication test equipment, static-protection products, inspection equipment, soldering/desoldering systems, ozone-safe cleaners, workbenches, and cases. All products are fully guaranteed, and orders placed by 4 PM will be shipped by 5 PM that same day.



The 1995 Catalog of Products for Testing, Repairing & Assembling Electronic Equipment is free upon request from Contact East, 335 Willow Street South, North Andover, MA 01845-5995; Tel. 508-682-2000; Fax: 508-688-7829.

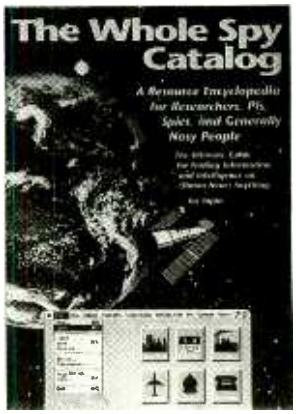
CIRCLE 85 ON FREE INFORMATION CARD

THE WHOLE SPY CATALOG

by Lee Lapin

This 440-page, hands-on encyclopedia of "secret sources" provides a wealth of professional secrets, tricks of the trade, "insider" phone numbers, and cutting-edge techniques for tracing, tracking, surveillance, and investigating anyone or anything.

The book shows how to locate and bug people, using the latest audio bugs and telephone taps. It shows where to buy exotic and inexpensive subcarriers, narrow-band, and burst bugs that are easy to hide and almost impossible to find; and how to turn a $45 tape recorder



into a powerful room monitor. It also offers a look at the newest bugs, antennas, listening-post equipment, and intelligence kits from around the world, and lists sources for buying it all—even actual KGB surveillance equipment.

The book also shows readers how to locate and tap any telephone. It provides distribution schemes, details the equipment needed, and shows how to use it. Photos, tips, and tricks from professionals are included, as are tests of cellular-phone interceptors (including how they work, and how to follow and intercept any nearby cellular calls). Also included is software that turns your PC into a cellular reader, as well as sources.

The book explains how to research a person's background and finances from the comfort of your living room, using mail forwarding, warranty-card information, magazine subscriptions, reverse directories, and credit information to find and build a dossier on anyone. It shows how to track down a person's real property, bank accounts, stocks, bonds, offshore accounts, and cars.

Other chapters cover Starlight night-vision technology, on-line resources, scrambling and encryption to protect your own personal information, high-tech countermeasures, and how to find and hire a good private detective.

The Whole Spy Catalog costs $44.95 and is published by Intelligence Incorporated, 2228 South El Camino Real #349, San Mateo, CA 94403; Tel. 415-851-3957 (1-800-805-5544 for credit-card orders); Fax: 415-851-5403. ■

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HAM RADIO

(Continued from page 85)

measured from the points on the IF frequency-response curve where gain drops off −3 dB from the mid-band value. That is why you will sometimes see selectivity referred to in terms such as "2.8 kHz between −3 dB points."

The IF bandwidth is that which must be matched to the bandwidth of the received signal for best performance. If a too-wide bandwidth is selected, then the received signal will be noisy, and the signal-to-noise ratio deteriorates. If too-narrow, then you might experience difficulties recovering all of the information that was transmitted. For example, an AM-broadcast-band radio signal has audio components to 5 kHz, so the signal occupies up to 10 kHz of spectrum space ($f_C \pm 5$ kHz). If a 2.8-kHz SSB IF filter is selected, the audio will tend to sound "mushy" and distorted.

IF-PASSBAND SHAPE FACTOR

The shape factor is a measure of the steepness of the receiver's IF passband, and is taken by measuring the ratio of the bandwidth at −6 dB to the bandwidth at −60 dB (see Fig. 4). The general rule is that the closer those numbers are to each other, the better the receiver. Anything in the 1:1.5 to 1:1.9 range can be considered high quality, while anything worse than 1:3 is not worth looking at for "serious" use. If the numbers are between 1:1.9 and 1:3, then the receiver could be regarded as being middling, but useful.

The importance of shape factor is that it modifies the notion of bandwidth. The cited bandwidth (e.g. 2.8 kHz for SSB) does not take into account the effects of strong signals that are just beyond those limits. Such signals can easily "punch through" the IF selectivity if the IF passband "skirts" are not steep. After all, the steeper they are, the closer a strong signal can be without messing up the receiver's operation. Thus, selecting a receiver with a shape factor as close to 1:1 as possible will result in a more usable radio.

Some manufacturers specify the shape factor based on −50-dB bandwidth, rather than −60 dB. That could indicate that the receiver is being made to appear a lot better than it really is . . . so be careful. When comparing shape factors, make sure that you are comparing apples and apples, not apples and oranges.

MORE ON THE SID RECEIVER

Following the offer of a schematic for the AAVSO-Solar Division VLF SID receiver I made a few months ago (**Popular Electronics**, February, 1995), I received and filled more than 80 requests. Since then, the Chairman of the AAVSO-SD, Peter O. Taylor, contacted me and informed me that they have a new receiver design based on the op-amp gyrator circuit. That new SID receiver does not require the hard-to-find inductances needed by the older design. Pete offers information on the gyrator SID receiver to anyone sending him a business-sized (#10) self-addressed envelope with 32-cents postage affixed. If you are interested in getting that information, his address is: 4523 Thurston Lane, #5, Madison, WI, 53711-4738. ■

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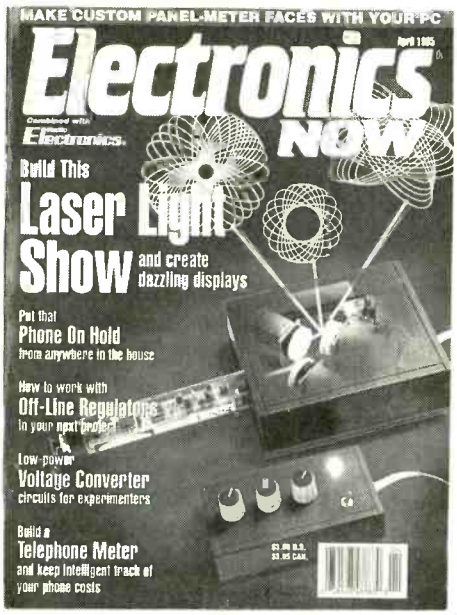

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BUILD A SUBWOOFER

(Continued from page 45)

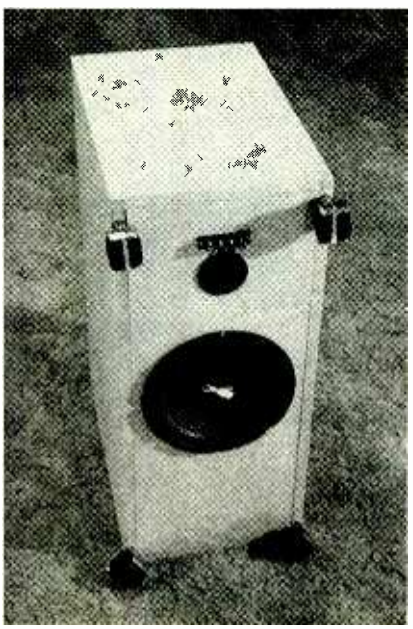
driver is tightly fastened down to the surface. If necessary, use a little silicon sealer, or putty, to make sure the mounting is really airtight.

Of course, the type of finishing chosen for the Subwoofer cabinet is at the discretion of the individual builder. Here are a few of suggestions that you might want to consider: Foil-backed wood veneer is available at cabinet shops and some lumber-supply houses. Those might require a special adhesive, so check with the person who sells you the veneer for the right product to use. Also, applying the veneer will require a very smooth, clean surface, so be sure and sand off or fill-in any ridges or uneven edges on the cabinet's walls.

As was mentioned, painting the enclosure is also a possibility. After sanding and priming the cabinet's surfaces, use a good grade of house paint. It fills small surface imperfections easily, dries quickly, and can be selected to match any room interior.

Wiring and Testing the System. Before you try out your system, you should arrange some kind of crossover filter for it, to allow only low frequencies to go to the Subwoofer. Here are the values of inductor coils that can be used as low-pass filters, followed by the crossover frequencies they work with: use a 10-mH inductor for an 80-Hz crossover frequency; an 8-mH inductor for 100 Hz; a 7-mH inductor for 125 Hz; and a 6-mH inductor for 150 Hz. Those inductors can be obtained from the source given in the Parts and Materials list; prices vary from about $10 to $15 each.

Figure 3 shows a wiring suggestion for the inductor. The distance between the inductor and the woofer is not important, so the coil can be located outside of the speaker cabinet, or if you know ahead of time just what value you want, then it could be mounted inside. However, if it is mounted inside the enclosure, make sure it is very firmly secured to one of the cabinet surfaces with glue or silicon sealer so that it doesn't rattle. After installing the inductor and wiring the Subwoofer to the terminals of your amplifier, along with the other speakers, you are finally ready to enjoy some first-class bass! ■



This bottom view shows the placement of the woofer and the vent.

RANDOM DOT IMAGES

(Continued from page 50)

ages. N.E. Thing Enterprises (19C Crosby Drive, Bedford, MA 01730; Tel. 617-275-6960) carries a full line of clothing, calendars, posters, post cards, puzzles, software, and more, all in full color. All kinds of three-dimensional images and illusions are featured. But there's also another way to get your hands—or eyes—on some of these images: You can make your own on your personal computer. We took a look at *Stereolusions*, which is just one of the several software packages available that let you have fun with 3-D images.

Stereolusions. The Windows environment has become a great place to work with images. With all the software that lets you create and manipulate graphic images, it's the perfect place to create an image that you want turned into a 3D image. Stereolusions from I/O Software (10970 Cucamonga, CA 91730; Tel. 909-483-5700) lets you import any image in the Windows Bitmap (BMP) or Windows Metafile (WMF) format and turn it into a Stereolusion. The images pictured in this article were created using that software, which has a list price of $39 (street prices are, of course, lower).

The Windows software is very easy to use. Several sample images are included; you simply open them as you would any other file. Then you select "Render" from a menu that transforms the image. Special adjustments can be made, if necessary or desired, for such things as coarseness, depth, color, and so on.

An image can be imported and instantly turned into a Single Image Random Dot Stereogram (SIRDS) that hides the image in a field of small squares or circles. Or a separate pattern or image can be used to disguise the hidden image in a Single Image Stereogram (SIS), rather than just appearing as dots or squares. Stereolusions comes with several sample images and patterns that can be superimposed on other included images, or on ones you import or make on your own. The possibilities are endless, and the ease with which the software works makes it very encouraging to keep trying new possibilities that stretch the imagination.

The rendered images appear on-screen in the colors that they are created. The beauty of Windows is that anything can be printed easily, including the 3D images. And if you are fortunate enough to have a color printer, you can print the images in color as they appear on your computer screen. When printed on a black-only printer, a few of the SIS images lose some of their effect. But the SIRDS images, which appear as multi-colored speckled patterns on-screen, don't lose any of their visual effect when printed in black and white, as you can see from the ones that are presented in this article.

The worst thing about these 3D images is that a lot of people don't believe they are there, and think they are being made fools of. But for people who can see them, there's nothing like making your own. Making these images is just one more thing that a personal computer makes short, and entertaining, work of. ■

BUY BONDS

www.americanradiohistory.com

DESIGNING CROSSOVERS

(Continued from page 42)

Now, using the program will require some exact knowledge of just what the sonic problem is: With a test tape or oscillator and a sound-level meter, take a series of readings to determine just what the frequency range of the peak is. See Fig. 6 for an example of the type of measurement to be made. Once that is done, answer the program prompts with the required information and it will calculate the necessary component values for a trap filter (see Fig. 7). Inserting that circuit as part of the speaker's crossover and compensation network should have the desired effect, but it is always good to go back and check because the other networks in the system might affect the filter's action a little, in which case, some trial-and-error work with other component values might be required to make things work just right. Also, be sure that the resistor that is used in the filter has an adequate power rating—at least 10 watts or so.

Putting it all Together. The complex network of circuits with varying component values that we have just calculated might seem confusing to a home experimenter. Where do all the pieces fit in relation to each other; can we just put them anywhere, in any circuit arrangement? In this case, the answer is no. To work correctly, they must be assembled in a particular sequence in the overall circuit.

Figure 8 shows, in block-diagram form, the wiring sequence that should be used. Here is that sequence in order, along with the programs used to determine the component values:

1. The crossover network, 2- or 3-way as needed—XDES-2.BAS or XDES-3.BAS.
2. The trap filter, as needed—TRAP-FIL.BAS.
3. The attenuation circuit, as needed—DRIVERAT.BAS.
4. The Zobel impedance-compensation circuit, as needed—ZOBEL.BAS.

Note: All circuits are independent of each other, and any can be deleted anywhere in the network without significantly changing the performance of the other circuits, as long as the sequence of those remaining are as shown in Fig. 8. ■

SPEAKER CABLES

(Continued from page 48)

lowest dielectric constant possible should ideally be used in its design. Table 3 is a listing of the standard dielectric constants for most of the common speaker-cable insulating materials. Note that the values of those materials do not vary by much.

TABLE 3

Material	Dielectric Constant (At 1 kHz)
Polyethylene	2.26
Nylon	3.5
Vinyl Chloride/ Vinyl Acetate (Polymer)	3.15
Polypropylene	2.25
Teflon	2.1

Resistance and Capacitance. Now that we have reviewed several cable designs, you might have noticed just how many factors determine the resistance and capacitance of the cables. That results in there being a range of resistance and capacitance values for currently produced speaker cables. The minimum resistance value is less than 1 milliohm per foot, and the maximum value is about 50 milliohms per foot. The minimum capacitance value is about 5 pF per foot, and the maximum is about 160 pF per foot.

Note that the resistance values have an upper to lower value spread of about 50 to 1. Also, the capacitance values have a spread of about 30 to 1. Most manufacturers don't give inductance values, so none were available to make a comparison. That is not unreasonable, because it is resistance and capacitance that are the most critical parameters.

Weird Science? Anyone who keeps up with all the happenings in the audio world knows that from time to time there are claims made of unexplained physical processes, especially when it comes to cables and wire. In many cases, though, only a few people have been able to "hear" the results of those phenomenon.

Is it possible to sort through (and avoid) some of the more suspect of these theories? Let's see if we can by limiting our discussions to those with at least some backing in reality:

Wire Metal Crystals: Back in 1980, A. J. van den Hul did some research on the electrical behavior of speaker cables. Using a spectrum analyzer, he discovered that "good-sounding" cables seemed to have one characteristic in common: they produced a "regular set of harmonics" starting above 500 Hz. He then went on to attribute that to an effect of the crystal structure of the wire, and developed a wire-manufacturing process to duplicate the effect.

Pure-Metal Conductors: Research by some cable manufacturers suggests that very pure metals (specifically copper) make a more perfect conductor. From that, the use of very pure copper (more than 99.99%), oxygen-free copper, and long-grain copper, is presumed to make a noticeable difference. Based on that, a great-many manufacturers use those materials in their products.

Litz Wire Cables: Some years ago, when the first special-purpose audio cables were being developed, insulated, fine, stranded wire woven in a braid was thought to be very good. That was a form of what is commonly called Litz wire. Typically it is used where extreme flexibility is important, like in headphone cable wiring. The problem with those early cables was that the two conductors' wires were all braided together in one piece, making the inductance extremely low, but the capacitance extremely high! Many amplifiers didn't "like" that much capacitance, and blew fuses or activated their protection circuitry.

Stranded-Wire Noise: Some manufacturers have claimed that in stranded but uninsulated wiring bundles, a small amount of "noise" is generated by the wire current crossing back and forth from strand to strand as it moves down the length of the cable. For that reason, some manufacturers use wire where each strand is individually insulated from the next.

Metal-Alloy Wire Materials: This is a relatively new development, and only a few commercial cables of that type exist. Companies using alloys in their cables are not saying too much at this time, other than that some of the alloys are a hybrid of a certain metal and carbon. ■

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COLOR TV

(Continued from page 59)

beam of electrons, the second dot emitted green light, and the third emitted blue light. Those three primary colors of light could be combined to produce any desired color.

Three separate electron guns directed beams toward the phosphors through a metallic grid of tiny holes located only one-half inch from the phosphor screen. The holes were arranged so that only the electrons from the red gun could strike the red-emitting phosphor dots, the beam from the green gun could strike only the green-emitting dots, and the beam from the blue gun could strike only the blue-emitting dots. The three-gun shadow-mask picture tube is illustrated in Fig. 2.

The demonstrations by RCA of its shadow-mask picture tubes (a single-gun prototype had also been developed) went well. The RCA color-television system still had a few "rough edges" but improvements and modifications were being made almost daily. Because of that, RCA could not provide the FCC with exact numerical recommendations for the "standards" that would have to be established if its system were to be adopted by the industry.

The First Standard. The color-television hearings ended in May, 1950 after eight months of testimony and demonstrations. Over 9700 pages of testimony had been taken from 53 witnesses. The FCC issued its "First Report of the Commission on Color Television Issues" on September 1st.

It was obvious in the "First Report" that the FCC had relatively little concern about the issue of compatibility with existing receivers despite the fact that now some 8-million monochrome television sets were in use. The television industry was told that it had only three months to demonstrate a color system superior to CBS' field-sequential system.

Despite the formal protests by RCA and most other manufacturers (with the obvious exception of CBS), the Commission soon issued its "Second Report on Color Television." In that report, the CBS system was established as the industry standard effective November 20, 1950. A furious David Sarnoff directed RCA's legal staff to file suit to reverse the FCC's directive. The legal challenge ultimately reached the Supreme Court where the FCC's ruling was upheld.

CBS was then forced to begin color broadcasting despite the fact that virtually no one owned a CBS color receiver. The incompatible broadcasts caused video "garbage" on monochrome sets. CBS rapidly lost viewers and sponsors. Fortunately for CBS, the government suspended the manufacture of color-television equipment late in 1951 so that manufacturers could direct their efforts toward aiding the Korean War effort. That allowed CBS to stop color telecasting.

RCA Vindicated. An ad hoc subcommittee of the NTSC had been established in November, 1950 to review the state of the art as it existed with respect to color television. Clearly, most of the industry had not been pleased with the FCC's decision to endorse the CBS system. After many months of discussion, the subcommittee's report recommended establishing a totally electronic and compatible color-television system that was remarkably similar to the one RCA had been proposing.

The result of that report was the creation of what became known as the "Second NTSC" to conduct additional tests of and establish complete standards for the system proposed by the subcommittee. Field tests and system modifications would take place for approximately two years.

On July 21, 1953, the NTSC filed a petition with the FCC proposing the adoption of the color-television standards we know today. To his credit, Peter Goldmark of CBS took a lead part in recommending the adoption of those standards. The FCC adopted the NTSC-recommended standards on December 17, 1953. While those color television standards were not established solely from RCA's efforts, they did follow directly from RCA's work to achieve "all electronic compatible color television." The fact that those same standards remain in use in the U.S. today attests to the job done by the television engineers and the NTSC at that time. Indeed, David Sarnoff now was able to have the "last laugh." ■

TELEPHONE TESTER

(Continued from page 62)

Checkout and Use. To test the transmitter and receiver, connect a battery to the transmitter. Then attach the pairs of alligator clips on one of the units to the corresponding pairs on the other unit. Make sure that the proper colors are connected and the pairs are matched. The LEDs on both units should glow green. If some or all of the tri-color LEDs on the receiver glow red, something has been wired backwards (possibly the LEDs themselves). If an LED on either unit doesn't glow, check for a poor connection.

Once you have verified proper operation of the clips on the units, check the modular jacks of the transmitter and receiver using a patch cable. If the patch cable you are using has reversed the voice pair or pairs, the tri-color LEDs will glow red. If you are testing the 6-position, 6-contact jack, the third voice pair might not be present in your patch cable and the LEDs for that voice pair won't glow.

In addition to being used with the transmitter, the receiver can be used on its own to test "live" voice pairs. When the receiver is connected directly to a live, standard telephone line (using the modular cord, alligator clips, etc.) the proper LEDs should glow. Red indicates that the respective voice pair is polarity-reversed, green means its polarity is correct, no glow means the circuit is dead, and orange means that there is AC on the line (if you get that indication you should determine where it is coming from and have the problem corrected immediately).

Please note that the test just described should not be done on multi-line key-system wiring. If the system in question is a multi-line telephone unit (especially with more than two lines) the modular cable and jack might only appear to be standard telephone jacks. Those systems usually have digital signals—not telephone lines—that are carried on one or more of the pairs. If you use the Tester on one of those you might damage the telephone, the telephone system, or both. For those systems, the Telephone-Wiring Tester should be used to test cables only after they have been disconnected at both ends. ■

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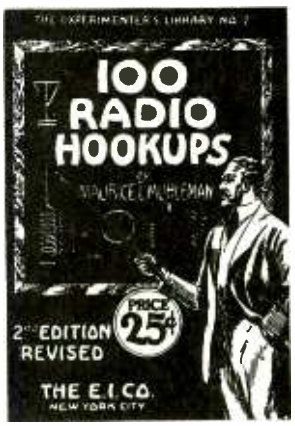

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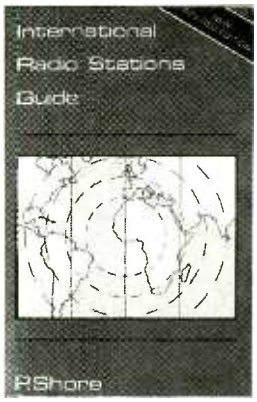

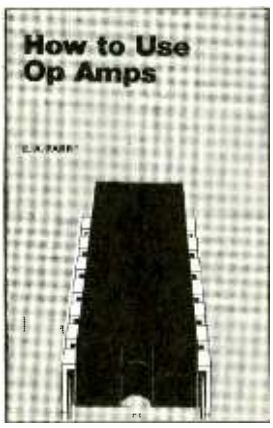

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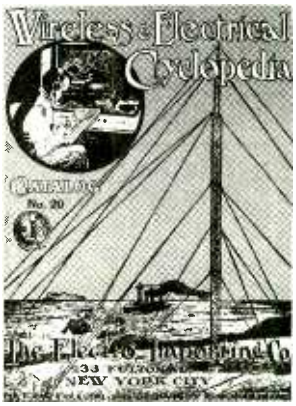

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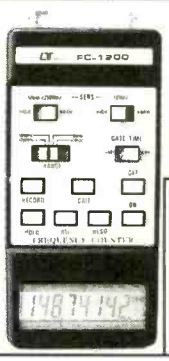

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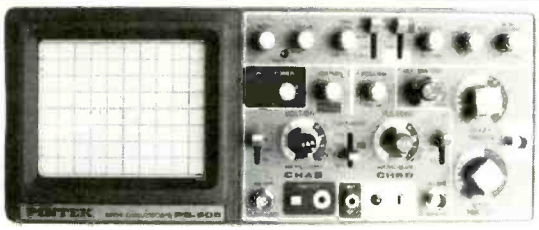

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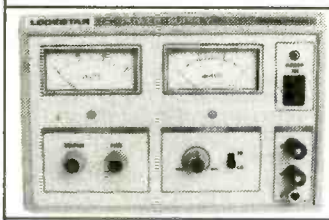

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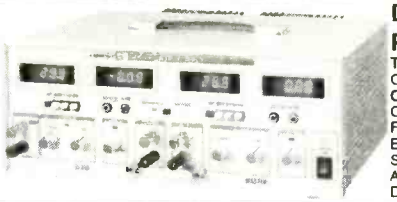

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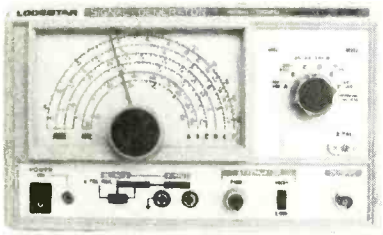

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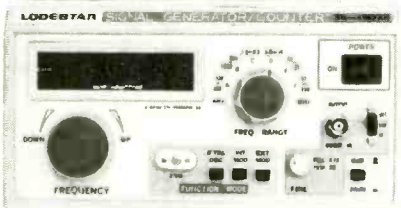

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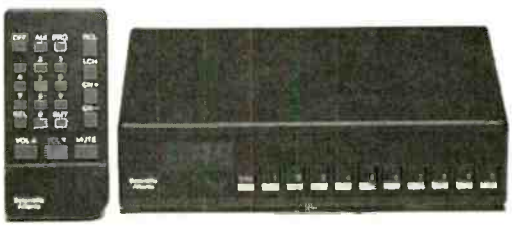

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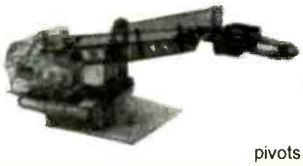

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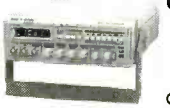

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Auto/manual ranging
Capacitance meas
Temperature probe

Digital Multimeter Kit w/ Training Course
M-2665K
$49.95
Full function 34 ranges
Ideal school project
M-2661 (Assembled) $55.00

Frequency Counter
F-1225
$225.00

8 Digit LED display
Wide meas range
High sensitivity
Data hold function
Input impedance 1MΩ or 50Ω
10:1 input attenuation function

Fluke Multimeters
(All Models Available Call)

Scopemeters		70 Series	
Model 97	$1,795	Model 70II	$69.95
10 Series		Model 73II	$97.50
Model 10	$62.95	Model 77II	$149
Model 12	$84.95	Model 79II	$175
20 Series		80 Series	
Model 29II	$175	Model 87	$289

Triple Power Supply
XP-620
By Elenco
$75.00
3 fully regulated supplies; 1.5-15V @ 1A, -1.5 to -15V @ 1A or 3-30V @ 1A & 5V @ 3A **Kit XP-620K $49.95**

Quad Power Supply
XP-581
By Elenco
$79.95
Four supplies in one unit; 2-20V @ 2.5A, 5V @ 3A, -5V @ .5A and 12V @ 1A. All regulated and short protected

High Current DC Power Supply
BK-1686 $169.95
3 to 14 VDC Output
12A @ 13.8V
For servicing high power car stereos, camcorders, ham radios, etc.
Connect 2 or more in parallel

Wide Band Signal Generators
SG-9000
$124.95
RF Frequency 100K-450MHz
AM modulation of 1KHz Variable
SG-9500 150MHz $239.00

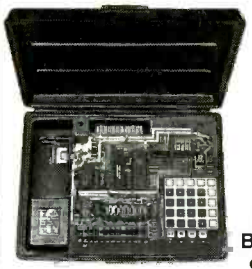
Telephone Kit
PT-223K
$14.95

Available Assembled
PT-223
$15.95

Function Generator Blox
#9600
By Elenco
$29.95

Kit $28.95
Sine, Triangle, Square Wave

Learn to Build & Program Computers with this Kit



MM-8000
By Elenco
$129.00
From scratch you build a complete system. Our Micro-Master trainer teaches you to write into RAMs, ROMs and run a 8085 microprocessor, which uses similar machine language as IBM PC.

Digital/Analog Trainer
Complete Mini-Lab For Building, Testing, Prototyping Analog and Digital

By Elenco in U.S.A.
XK-525
$159.95
Kit XK-525K
$129.95
Designed for school projects, with 5 built-in power supplies. Includes a function generator with continuously variable, sine, triangular, square wave forms. All power supplies are regulated and protected against shorts.

AM/FM Transistor Radio Kit
with Training Course
Model AM/FM 108
$29.95
14 Transistor, 5 Diodes
Easy to build because schematic is printed on the PCB
Makes a great school project
Model AM-550 AM Only $17.95

Telephone Line Analyzer

Kit TT-400K $19.95
Assembled TT-400 $26.95

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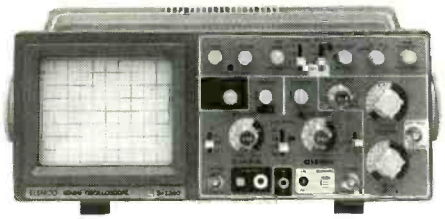


60MHz

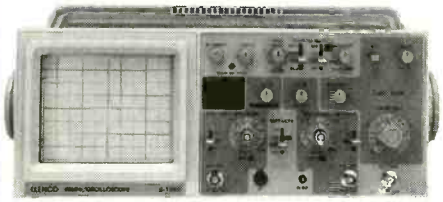
S-1360 $775

Delayed Sweep

S-1365 $849

Cursor Readout

- Voltage, Time
- Frequency differences displayed on CRT



40MHz

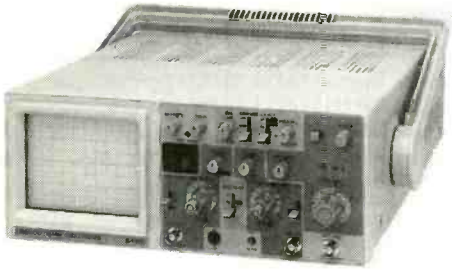
S-1340 $495

2- Channel

S-1345 $575

Delayed Sweep

- Beam Find
- Component Tester



25MHz

S-1325 $349

2- Channel

S-1330 $449

Delayed Sweep

- Beam Find
- Component Tester

Dependable Equipment at Affordable Prices

B+K 20MHz

2 Channel

Model 2120 $389.00

Delayed Sweep

Model 2125 $539.95

40MHz DUAL -TRACE

Model 1541B

$749.95

- 1mV/div sensitivity
- Video sync separators
- Z axis input
- Single sweep
- V mode-displays 2 signals unrelated in frequency

60MHz DUAL-TRACE

Model 2160

$949.95

- 1mV/div sensitivity
- Sweep to 5ns/div
- Dual time base
- Signal delay line
- Component tester
- V mode-displays 2 signals unrelated in frequency

100MHz THREE-TRACE

Model 2190

$1,379.95

- 1mV/div sensitivity
- Sweeps to 2ns/div
- Dual time base
- Signal delay line
- 19kV accelaerating voltage
- Calibrated delay time multiplier

20MHz ANALOG with DIGITAL STORAGE

Model 2522A

$869.95

- 20MHz analog bandwidth
- 20MS/s sampling rate
- 2k memory per channel
- 20MHz equivalent time sampling

HITACHI POPULAR SERIES

V-212 - 20MHz, 2 Channel	$425.00
V-222 - 20MHz, DC Offset	$695.00
V-422 - 40MHz, Dual Trace	$849.00
V-522 - 50MHz, Dual Trace	$975.00
V-523 - 50MHz, Delayed Sweep	$995.00
V-525 - 50MHz, w/ Cursor	$1,069.00

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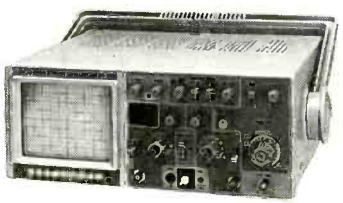
V-660 - 60MHz, Dual Trace	$1,375.00
V-665A - 60MHz, DT, w/cursor	$1,449.00
V-1060 - 100MHz, Dual Trace	$1,549.00
V-1065A - 100MHz, DT, w/cursor	$1,695.00
V-1085 - 100MHz, QT, w/cursor	$2,125.00
VC-6045A - 100MHz, Digital Stor	CALL
VC-6025A - 50MHz, Digital Stor	CALL

Elenco DS-203 20MHz, 10MS/s Digital Storage Oscilloscope



$749 2K Word Per Channel • Plotter Output 8 Bit Vert. Resolution • 2048 Pts Hor. Resolution • Much More.....

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A handheld instrument that combines a 50MHz, 25MS/s dual channel digital storage oscilloscope with feature-packed 3000 count digital multimeter.

Model 93 - $1,225
Model 95 - $1,549
Model 97 - $1,795

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Total Coverage Radios

TRIDENT
TR1200XLT
AM Broadcast to Microwave 1000 Scan Channels $389.00

500KHz to 1300MHz coverage in a programmable hand held. Ten scan banks, ten search banks. Lockout on search and scan. AM plus narrow and broadcast FM. Priority, hold, delay and selectable search increments. Cell Lock. Permanent memory. 4 AA ni-cads and wall plus cig charger included along with belt clip, case, ant. & earphone. Size: 6 7/8 x 1 3/4 x 2 1/2. Wt 12 oz. Fax fact document # 205

TRIDENT
TR4500 $449
2016 Channels 1 to 1300MHz Computer Control

62 Scan Banks, 16 Search Banks, 35 Channels per second. Patented Computer control for logging and spectrum display. AM, NFM, WFM, & BFO for CW/SSB. Priority bank, delay/hold and selectable search. Cell Lock Permanent memory. DC or AC with adaptors. Mtng Brkt & Antenna included. Size: 2 1/4H x 5 5/8W x 6 1/2D. Wt. 1lb. Fax fact #305

TRIDENT
TR980 $279.00
125Channels 5MHz to 999MHz

NEW

Most Economical receiver in its class, offers AM, NFM Wide FM, modes. 5KHz increments. Delay & hold & Search. Cell Lock NiCads, chger & whip ant. Size: 5 7/8H x 1 1/2W x 2 D.Wt 14oz.

Continuous Coverage

Three new Bearcat units offer expanded coverage and more memory than before. The 890 offers 200 channels, base/mobile operation, VFO tuning, service search, weather alert, search and store, and more. The 2500 hand held has 400 channels, fast scan and more. The Bearcat 8500 has 500 channels in 20 banks, VFO, auto store, alpha numeric display, 10 priority channels, aux tape output jacks, and coverage to 1.3 Gigahertz.

Bearcat 2500XLTA hand held.....$349.95
Bearcat 8500XLTC mobile.....$389.95
Bearcat 890XLTB mobile.....$259.95
25-1300MHz, 500 ch. in 8500, 400 in 2500. 890 has 200 ch.& 29-956MHz. All cell locked. Features include turbo scan, VFO, search and store, Priority, LCD display, and more. Fax Facts474,475,476

Mobile Scanners

TRIDENT
TR2C
Police & CB
$69.95

Scans police pre-programmed by state channel *plus* the CB channel of your choice. Also has Mobile Repeater and Weather. Extra cost option of CB and laser detectors built in. Compact size allows for dash or visor mounting. Mtng hardware and power connectors included. Size: 5 5/8 x 4 7/8 x 1 3/4. Wt: 1.5lbs. Fax fact #580

Bearcat 700AX 50Ch w/800	**$159.95**
Bearcat 350A 50 Ch H/L/U	**$119.95**
Bearcat 560XLJ 16 Ch H/L/U	**$ 89.95**
Bearcat 760XM100Ch H/L/U/Air/800	**$219.95**
Bearcat T2 state/state scan	**$144.95**

Shortwave Radios

Sangean ATS-818CS	**$219.95**
Sangean ATS-818	**$184.95**
Sangean ATS-803A	**$169.95**
Sangean ATS-808	**$179.95**
Sangean ATS-606	**$149.95**
Sangean ATS-606P	**$169.95**
Sangean ATS-800	**$89.95**
Grundig YB400	**$219.00**
Grundig Satelit 700	**$399.00**

Hand Held Scanners

Bearcat 200XLTN
$209.95 200 Channels 800 MHz

Ten scan banks plus search. Covers29-54, 118-174, 406-512 and 806-956MHz (with cell lock). Featuresscan, search, delay, 10 priorities, mem backup, lockout, WX search, keylock. Includes NiCad & Chrgr. Size: 1 3/8 x 2 11/16 x 7 1/2.

Bearcat 120XLTJ 100Ch H/L/U	**$149.95**
Bearcat 150XLT 100Ch H/L/U/8	**$199.95**
Bearcat 220XLTJ 200 Ch H/L/U/8	**$249.95**

Coverage of above hand helds is: 29-54, 136-174, 406-512, and 800MHz band as indicated. Fax facts #475

Table Top Scanners

Bearcat 855XLTE 50 Ch w/800	**$159.95**
Bearcat 142XLM 10Ch H/L/U	**$ 73.95**
Bearcat 147XLJ 16 Ch H/L/U	**$ 89.95**
Bearcat 172XM 20Ch H/L/U/Air	**$124.95**
Bearcat 145 16Ch H/L/U	**$ 79.95**

Accessories & Etc.

Mag Mount Mobile Ant MA100	**$ 19.95**
Base Ant. 25-1000MHz AS300	**$ 59.95**
Pre-Amp .1-1500MHz GW2	**$ 89.00**
Wide Coverage Antenna	**$ 119.95**
Base Discone Ant DA300	**$ 89.00**
External Speaker MS190/opt. amp	**$ 19.95**
Old Scanner Repair, all brands	**$ *CALL***
Extended Warranties	**$ *CALL***
Frequency Info FaxFact/Modem	**$ *FREE***
On Glass Mobile Antenna	**$ 32.95**

2 Way Radios

VHF hi band programmable mobiles as low as $299.95. Call for quotes or Fax Fact #775

TRIDENT Winner of the 1994 INNOVATIONS Design & Engineering Honors, Electronic Industries Association. Trident TR2400 Total Coverage Receiver

Trident TR2400: 100KHz to 2060MHz. Ten scan banks of 100 channels each, ten search banks. Tuning increments as low as 1KHz. Beat Freq. Oscillator for SSB and CW modes. Search lockout and store. VFO tuning knob. Permanent memory. Bank lock and linking. Attenuator switch. Backlit LCD. 1 Yr Warranty. AM/NFM/WFM. Selectable increments . Delay, Hold, Priority. 5 7/8H x 1 1/2D x 2W. Wt 14 oz. **$499.00**

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Service & Support hours: Mon.-Fri. 9AM to 6PM, Sat. 10-4 EST. Mastercard, Visa, Checks, Approved P.O.'s & COD (add $5.50) & AMEX, Discover. Prices, specifications and availability subject to change. Flat rate ground shipping and handling charge only $6.95 per unit. Express Air only $9.95 , for most units, to most locations. One week trial, no returns accepted two weeks after original receipt without substantial restocking charge. All units carry full factory warranty. Indiana residents add 5 per cent sales tax.

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Check Out These Deals From CIRCUIT SPECIALISTS!

Circuit Specialist's Positive Photo Resist Pre-Sensitized Printed Circuit Boards

These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
PP101RE	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114RE	114mm x 185mm/4.6" x 6.6"	2.98	2.45	1.98
PP152RE	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153RE	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10

Single-Sided, 1oz. Copper Foil on Fiberglass Substrate

CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GS101RE	100mm x 150mm/3.91" x 5.91"	$ 3.90	$2.98	$2.60
GS114RE	114mm x 185mm/4.6" x 6.6"	4.80	3.49	3.20
GS152RE	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153RE	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

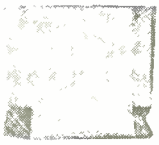
CAT NO	DESCRIPTION	PRICE EACH 1	10	50
GD101RE	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114RE	114mm x 185mm/4.6" x 6.6"	5.95	4.29	3.99
GD152RE	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153RE	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30

Etching Chemicals/Ferric Chloride

A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

CAT NO	DESCRIPTION	PRICE EACH 1	5
ER-3RE	Makes 1 pint	$3.50	$2.75

Developer



This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions. 50 gram package, mixes with water, makes 1 quart.

CAT NO	DESCRIPTION	PRICE EACH 1	10	25
POSDEVRE	Positive Developer	$ .95	$ .80	$ .50

Etching Tank

REDUCES ETCHING TIME!

This attractive injection moulded designed tank is ideal for etching your PCBs. It includes a thermostatically controlled glass heater, electric agitator and PCB hanging accessories. Measuring graduations are included. Maximum PCB size is 160mm x 250mm or 200mm x 250mm w/o heater. Typical etching time is 4 minutes.

CAT NO	DESCRIPTION	PRICE
ET10RE	Etch Tank System	$52.00

QUANTITY PRICING DOES NOT APPLY TO MIXED ITEMS!

Electronic Soldering System

Here's the ideal solution when **Temperature Control** is required. Easy to use slide control allows user to set system from 300°F to 840°F. Voltage to iron from control unit is 24V. Iron heating power is 48W. Replaceable 5.3mm tip is standard. Replacement irons and tips are available.

CAT NO	DESCRIPTION	PRICE EACH 1	5
SL10RE	Temperature Controlled Soldering Iron	$56.00	$50.00
SL24VRE	Spare 24V Soldering Iron	10.50	7.50

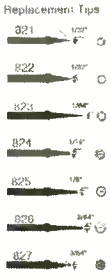
Electronic Soldering System with LED Display

AS LOW AS $75.00

Deluxe temperature controlled system with LED display for maximum accuracy. Temperature is adjustable from 160°-480°C (320°-900°F). Iron heating power is 48 Watts. Runs on 24V from controller unit. Replacement irons and tips are available. Tip size is 5.3mm

CAT NO	DESCRIPTION	PRICE EACH 1	5
SL30RE	Deluxe Soldering System	$86.00	$75.00
SL24VRE	w/LED Spare 24V Soldering Iron for SL10 or SL30	10.50	7.50

Replacement Tips for SL10/SL30



We now offer a variety of replacement tips for the SL10/SL30 soldering stations.

CAT NO	DESCRIPTION	PRICE EACH 1	5
821RE	1/32" Pencil Tip	$1.39	$1.19
822RE	1/32" Pencil Tip	1.39	1.19
823RE	1/64" Pencil Tip	1.39	1.19
824RE	1/16" Chisel Tip	1.49	1.29
825RE	1/8" Chisel Tip	1.49	1.29
826RE	3/64" Chisel Tip	1.49	1.29
827RE	3/64" Pencil Tip	1.59	1.39

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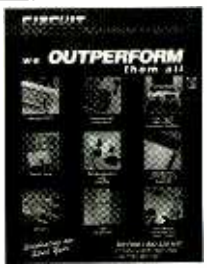

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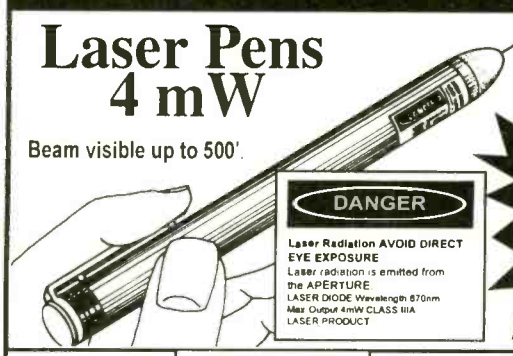

INCLUDES
2 AAA Batteries
Pen Size: 5 1/2" x 1/2"

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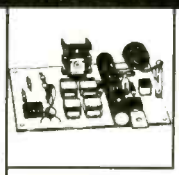
$59.95



STROBE LIGHT

Do you need an attention getter, warning light,or flashing light for model airplanes? Then this kit is for you. Use it as an emergency light for your auto, radio tower, even use it on your bicycle. Has a variable flash rate. Size 3.5"x1.8" operates on 6 or 12v DC only.

ST-1 $9.95

The Exciting New TELEPHONE MONITOR

Monitors your phone system, See how accurate your phone company really is!

1. RECORDS OUTGOING CALLS :
- Date & time of each call.
- Length of the call.
- What number was dialed.
- If you use a credit card it records the card number.

2. RECORDS INCOMING CALLS :
- Date & time of call.
- How many times phone rings.
- If answered the length of call.

3. RECORDS ANY DTMF TONE :
- Detects any tone on line sent by phone company or any other source.

Records to Screen or Floppy Disk

EASY TO INSTALL
- Connects to parallel port
- Phone line in.
- Phone line out to telephone.

All software included!

TM-1 ONLY $99.95 KIT

BUILT $169.95

WIDE BAND PREAMP

The ideal preamp for scanners, hand held radios, frequency counters. Amplifies low level (weak) signals. If the signal is extremely low 2 amps can be used in series. 1MHz to 2.5MHz @ 2.8dB nf 1dB compression = +0 dBm gain: 1MGHz-20dB to 2.5Hz-6dB Requires 12vDC @ 16Ma

WBA-6 $19.95

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 $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 & 9v it transmits about 1 mile. The kit is made with surface mounted parts, we have already mounted these parts. You install the leaded parts. Can operate on 6 to 12v DC. Size .35"x.9"

MMWM5 $34.95

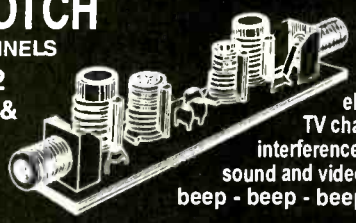
WIRELESS FM MICROPHONE

Small but mighty this little jewel will out perform most units many times its price. It really stomps out a signal. The WM-1 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. SIZE: .8"x1" 6 to 12vDC

WM-2 $14.95

TV NOTCH FILTERS

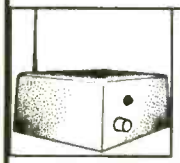
FOR CHANNELS
2 thru 22
SNOOP & BULLET



Our TV filters eliminate unwanted TV channels or interference that alters both sound and video with a beep - beep - beep.

NOTE: All TV Filter Kits are sold for educational purposes only. You must obtain permission from your local cable company before using these filters on your cable system.

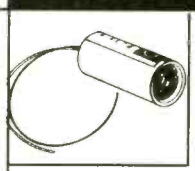
DF-222 Kit $14.95



FM STEREO TRANSMITTER

Own your own FM radio station. Any stereo signal you plug into the FMST-100 will be transmitted to any FM radio tuneable from 76 to 108MHz FM. Transmit a wireless link through an auditorium, from your car to your camper, listen to your cd's while mowing the lawn,Play music on one channel sing on the other. Clarity is excellent, aprox. 40dB stereo separation. Length of antenna determines the distance of transmission. Complete with stereo input level controls , & crystal for stereo separation. 9v battery operation

FMST-100 $29.95 / FMSTC cabinet $8.95



5.0 mW Laser Diode

Great for making a gun sight, use as a transit, makes a super experimenters project. The beam is visible with a wavelength of 670 nm. Size of beam is 6mm at 5 meters. Operates on 3 volts DC at 85mA. Size: 10.5mm x 18.5mm with an adjustable collimating lens.

LDM-5

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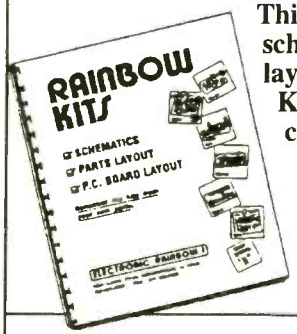

This Manual contains all schematics, parts lists , P.C.B., layouts for most of the Rainbow Kits. Use your own parts to construct any of our kits.

KIT BOOK $14.95

$9.95 with the purchase of any kit.

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Small but mighty,it fits anywhere. Phone line powered, never needs batteries. Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances. Variable tunes from 70MHz to 130MHz FM. You can also use it as a speaker phone. SIZE .5"x1"

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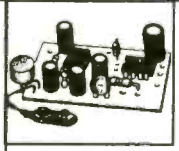

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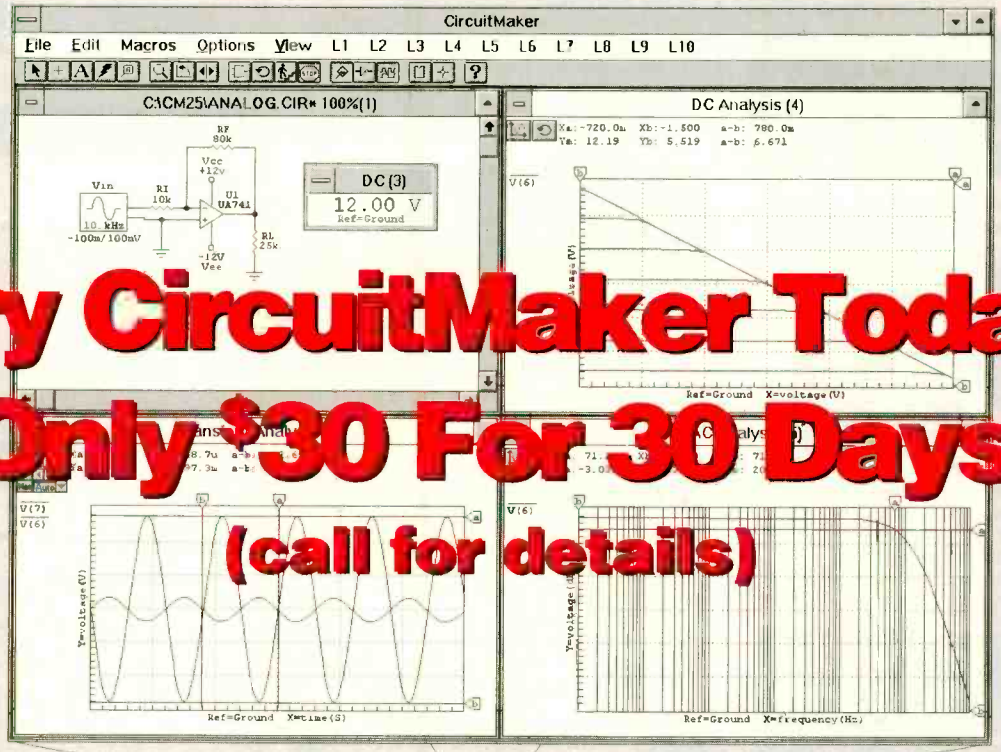
Electronic Workbench has no interactive logic probe or Trace capability and no Hex or ASCII keys. Their "word generator" is limited to 16 words. EWB does not have tri-state devices and digital devices do not have programmable propagation delays.



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Comparison based on CircuitMaker 2.6 for Windows and Electronics Workbench 3.0 for Windows. All products and company names are trademarks of their respective owners.

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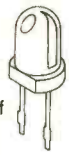

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4", 4 ohm, speakers mounted in an unbreakable black plastic, slant-faced enclosure. They are rated 5 watts. Enclosure measures 4.82" X 4.5" X 2.45"h. Each pair is boxed and includes two short pieces of hook-up wire.

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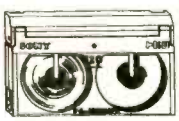
8 mm Video Camcorder Users!.



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0.31" diameter X 0.325". 0.7" long leads terminated with a two pin connector (0.1" centers).

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ALCOSWITCH # MTM206NPC
Short bat handle,,0.25" long.
PC terminals
CAT # MTS-82PC **$1.25 each**
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These 6" X 6" glass enclosed photovoltaic panels produce 9 Vdc at 60 ma. Ideal for charging batteries and powering small devices. Put two or more together for more current and voltage. Includes hook-up instructions.

CAT # SPL-960
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Matsushita
MMX- 7AC O 8A
1.25" diameter x 1.25" high motor. Prepped with 1.61" diameter flywheel, pulley and fiberglass mounting board.

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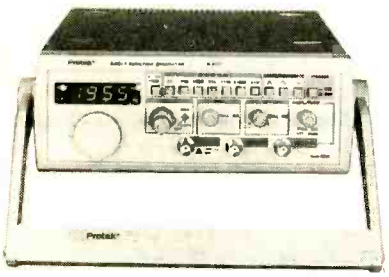

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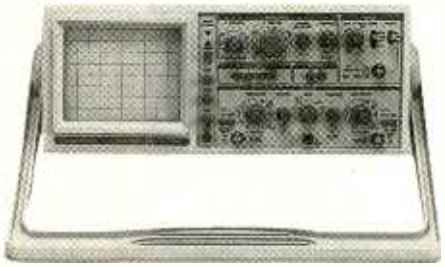

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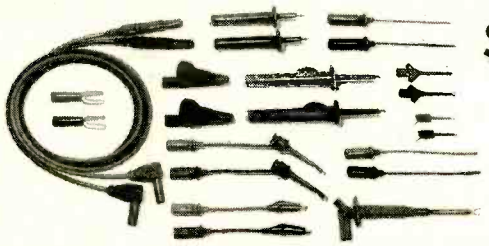
12 PIECE KIT $75

PM3915 Master Kit
100 MHz

The **PM3915 "Master Kit"** contains three probes (a 1X, 10X and switchable probe) in a high impact protective case. Included are sprung hooks, ground leads, trimmer tool, and a 4" extender tip.

Modular Test Lead Kit 9100 SERIES



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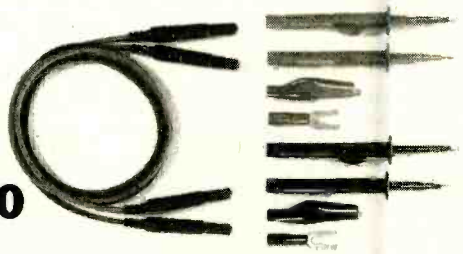

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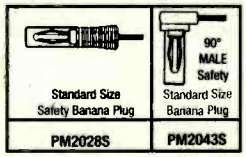

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ARE YOU BEING "BUGGED?"

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OUR FINEST Counter-Surveillance Device

THE ULTIMATE IN "BUG" DETECTION EQUIPMENT "DEBUGS" ROOMS AND TELEPHONES!

If you require GUARANTEED PROTECTION against electronic telephone monitoring devices and also require COMPLETE CONFIDENTIAL PRIVACY in certain rooms and areas, we highly recommend the COUNTER-SURVEILLANCE DETECTOR CSD-18.

CONDUCT A PROFESSIONAL SEARCH... ANYTIME...ANYWHERE!

Every newspaper and magazine article and every radio and TV story discussing some new episode involving "Bugging" devices, continues to increase the ever growing demand for electronic Counter-Surveillance "sweeps" and equipment. The very limited supply of competently trained and equipped Counter-Surveillance specialists has created a situation where "sweep" rates exceeding $250 per hour are now considered reasonable and appropriate.

This is an exciting, immensely interesting and profitable field that you can enter with a minimum investment. Two hours actual practice with the CSD-18 will have you "reading" and "clearing" telephones and rooms with professional ease and competence. The average fee for "debugging" a single telephone is over $200.00. It requires about 45 minutes to complete the job and once it gets around that YOU can provide this service, you'll quickly have more clients than you can handle. Even if you choose to provide "sweeps" for only a small number of friends and associates, your initial investment will quickly be returned many times over.

EXTREME SENSITIVITY!

This is our finest piece of detection equipment! The CSD-18 quickly locates electronic eavesdropping devices in telephones, homes, offices, vehicles, boats, or concealed on the body. It will actually pick up many eavesdropping transmitters at ranges exceeding 25 feet! Extreme sensitivity is obtained via ultra-efficent amplification circuitry following the RF detection stages. Excellent quality Dynamic Headphones exclude all external sounds to further enhance detector output.

The presence of any "bug" is immediately indicated via a pronounced meter deflection. The CSD-18 quickly "homes-in" on eavesdropping transmitters and immediately pinpoints their location. The closer you get to the "bug", the further the needle moves to the right. It's as simple as that.

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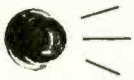

And, for maximum telephone security, the CSD-18 automatically analyzes a sophisticated series of electronic measurements along the telephone line and converts the analysis into an easy to follow, step by step, test procedure. No technical knowledge is required or necessary. A visual indication (via a flashing LED) immediately reveals the presence of the various types of telephone "taps" and the flashing sequence identifies the actual type of eavesdropping device.

MAXIMUM SECURITY — EASY OPERATION!

Latest Computer-Age IC circuitry designed exclusively for maximum security and ease of operation, assures the utmost privacy protection possible today against virtually all types of room "bugs" and telephone "taps". The CSD-18 detects even the very latest ultra-sophisticated devices specifically designed to defeat detection via polarity negating circuitry. Also includes multi-line option for testing business telephones.

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BIG MONEY IN COUNTER-SURVEILLANCE

Complete information describing the fantastic opportunities that are now open to trained Counter-Surveillance technicians and exactly how a number of individuals and firms are reaping a huge bonanza in the booming "Debugging" business! You'll learn how the ever increasing use of Electronic Listening Devices by investigative agencies, government agencies, unscrupulous business competitors, jealous suitors, etc., has created a tremendous demand for this type of service.

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THE ONE "BUG" TO FEAR MOST!

While most individuals are now somewhat guarded in their telephone conversations, they still rather naively feel secure in the "privacy" of their own home or office. However, the most common type of tap presently used by eavesdroppers picks up ALL SOUNDS AND CONVERSATION WITHIN A ROOM....WITH THE TELEPHONE STILL ON THE HOOK!

Due to this devastating capability, this "Infinity" tap (variously referred to as Infinity Transmitter, Hookswitch Bypass, 3rd Wire, Harmonica Bug, etc.), has become the "bug of choice".

In flagrant violation of federal law prohibiting their use and sale, these devices in various forms are openly advertised in many technical publications for as little as $75. Literally thousands of these devices are now in the hands of unscrupulous individuals all over the country!

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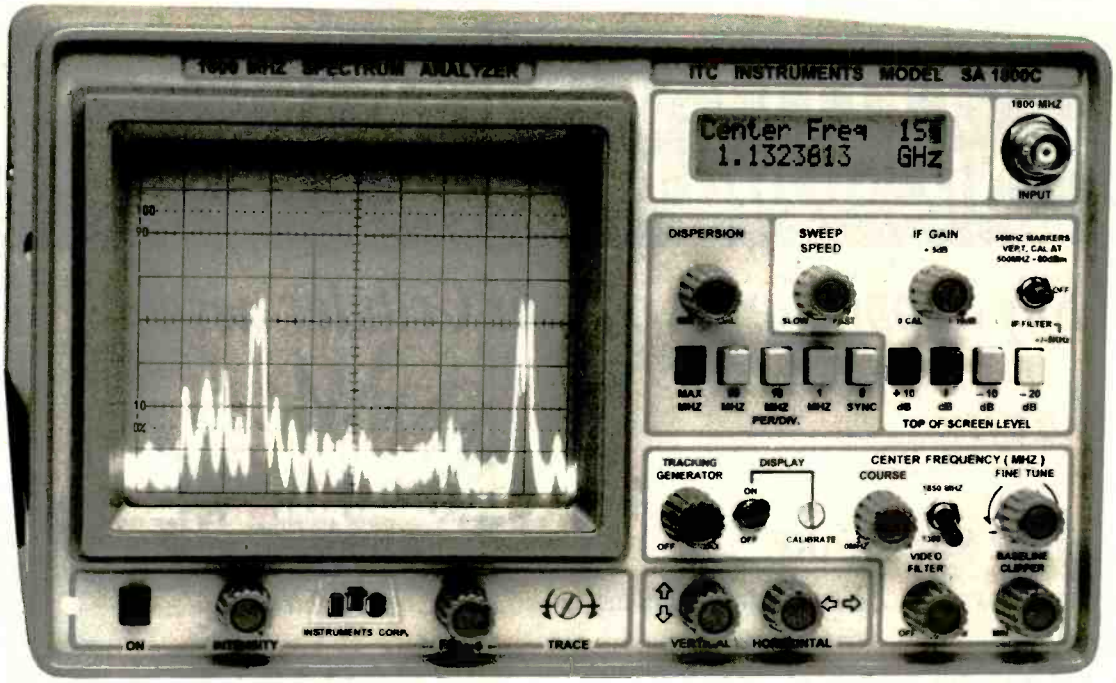

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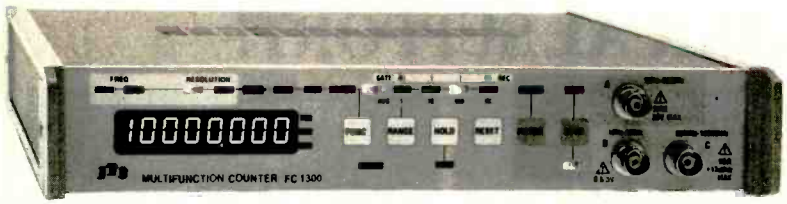

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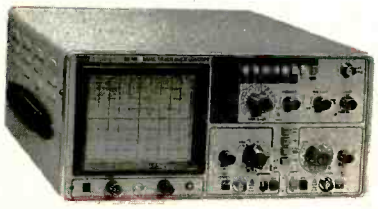

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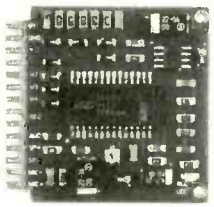

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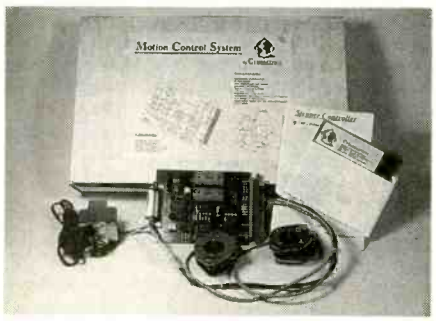

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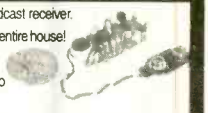

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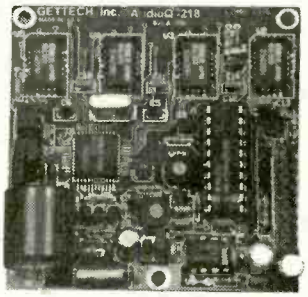

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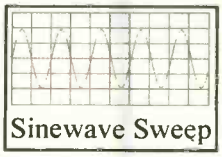

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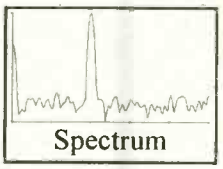

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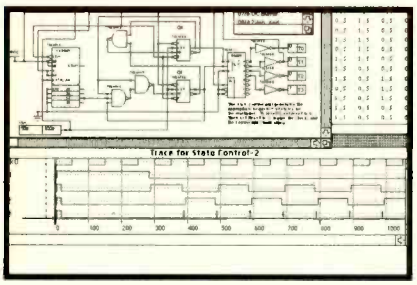

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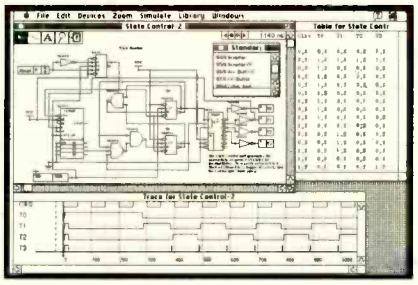

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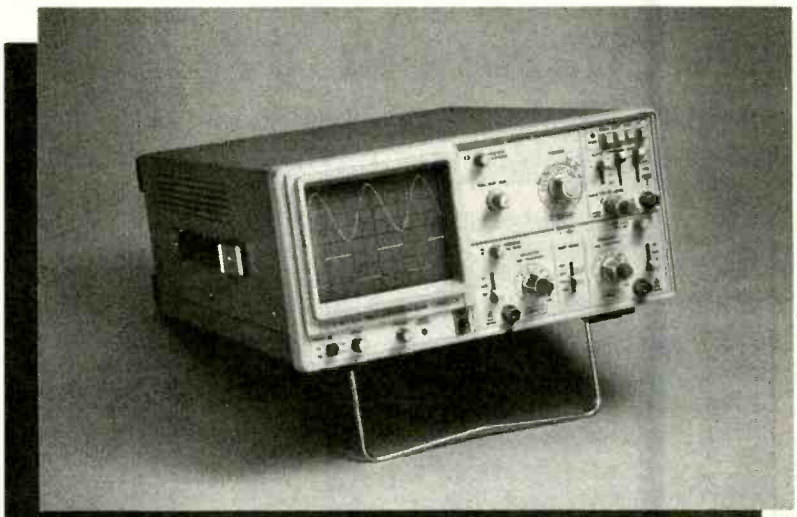

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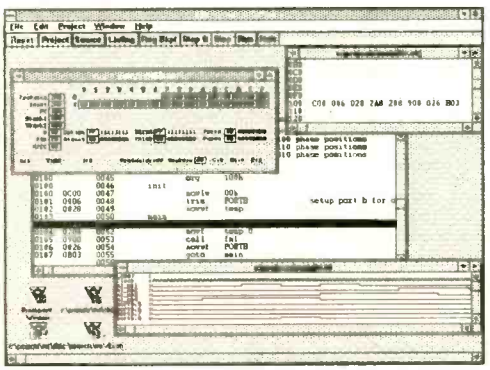

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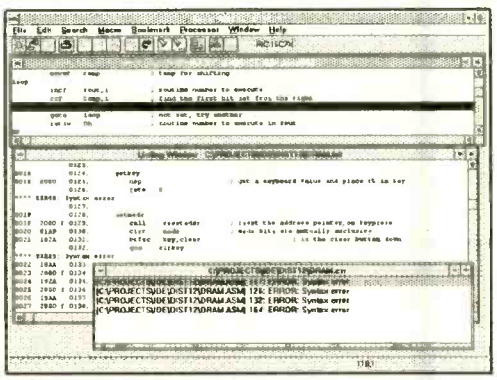

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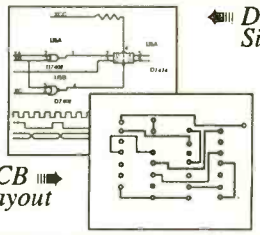

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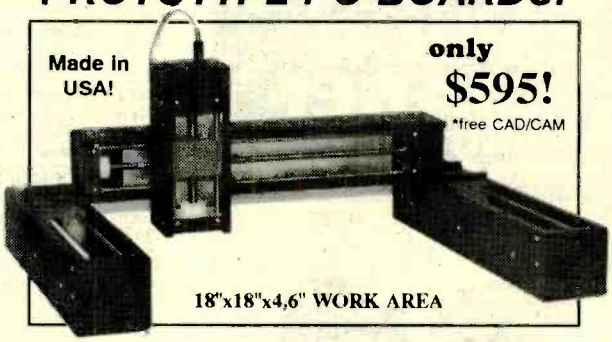

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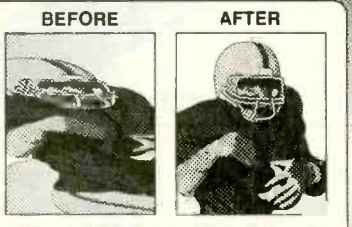

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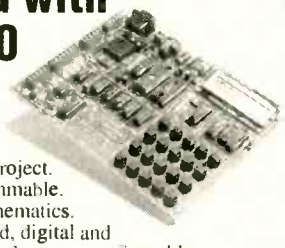

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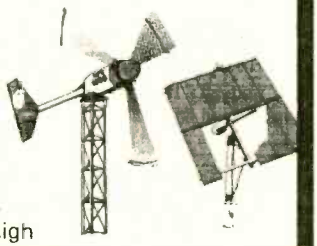

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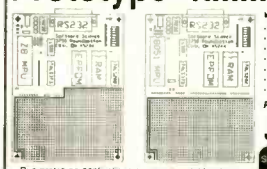

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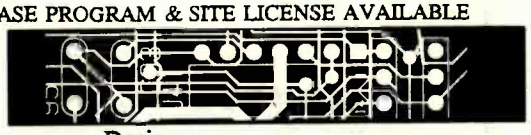

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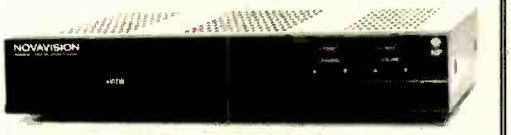

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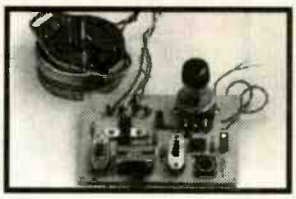

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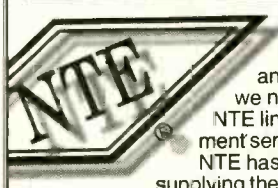

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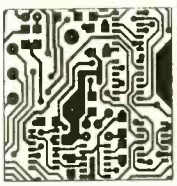

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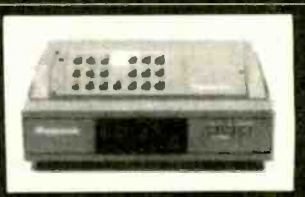

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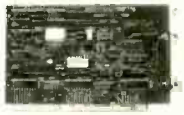

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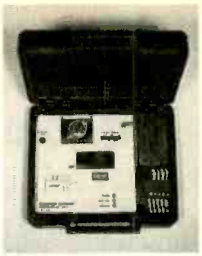

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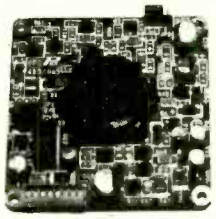

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21 - $21.00	22 - $22.00	23 - $23.00	24 - $24.00
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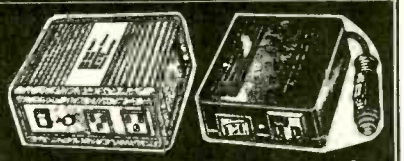

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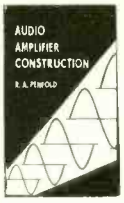

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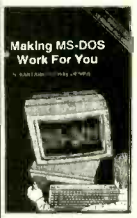

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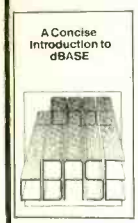

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