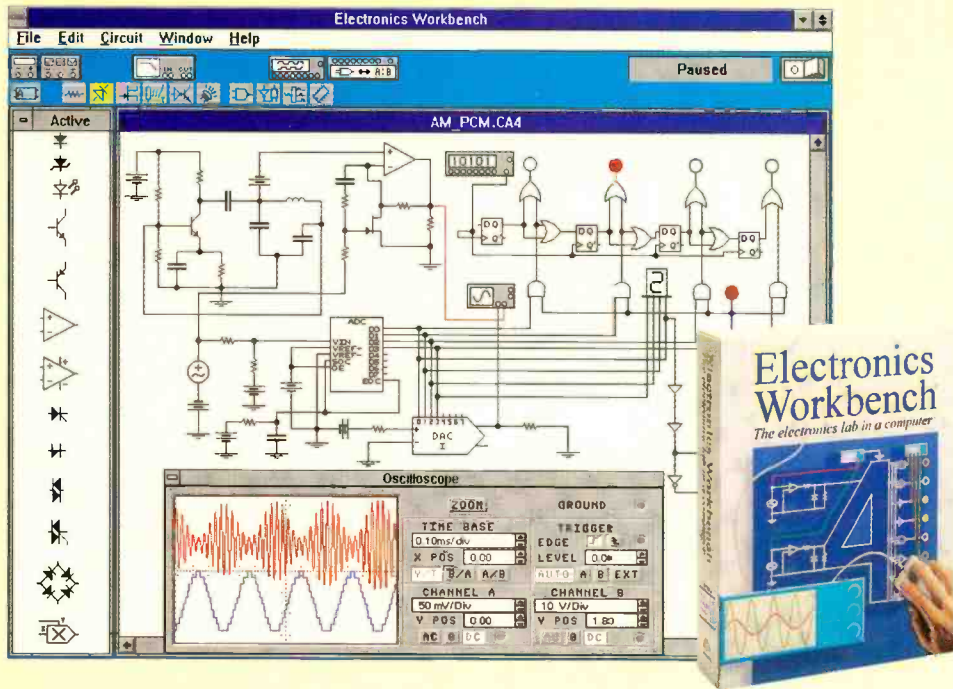


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DECEMBER 1995

Vol. 12, No. 12

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PUBLICATION

COVER STORY

9 Popular Electronics Holiday-Gift Buying Guide

Find the right electronics gift, at the right price, for anyone on your shopping list

CONSTRUCTION

39 Build an Electronic Xmas Tree

Brighten up your home or office this holiday season—*Gary Clifton*

64 Expanded Resistance Ranges for your DMM

Two projects to let you measure very high or very low resistances on any digital multimeter—*Bill Stiles*

67 Build the Magic Eye

It's an interesting conversation piece, or use it to help tune any radio—*Larry Lisle*

FEATURES

41 All About MMIC Amplifiers

Learn about those versatile, new devices, and how easy it can be to use them in your own projects—*Joseph J. Carr*

46 The Search for Extraterrestrial Intelligence

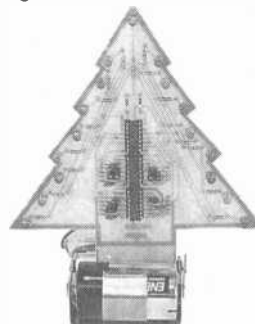
How scientists are attempting to answer the question: Are we alone?—*Karl T. Thurber*

55 Analyzing AC Circuits

Some techniques to make a tough job easier—*James E. Tarchinski*



Page 9



Page 39



Page 46

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PRODUCT REVIEWS

9 Gizmo

Popular Electronics' annual holiday-gift buying guide

30 Hands-On-Report

VersaTimer Programmable Power Scheduler

32 Product Test Report

Samsung VR8905 hi-fi VCR with StarSight

COLUMNS

23 Multimedia Watch

A new multimedia keyboard—*Marc Spiwak*

28 Net Watch

Music online—*Dan Karagiannis*

69 Antique Radio

From the mailbag—*Marc Ellis*

72 Computer Bits

Going online—*Jeff Holtzman*

74 Think Tank

Radiating circuits—*John Yacono*

77 Circuit Circus

Some one-transistor circuits—*Charles D. Rakes*

80 DX Listening

The voice of terror—*Don Jensen*

82 Ham Radio

A great straight key—*Joseph J. Carr*

84 Scanner Scene

A holiday-gift idea—*Marc Saxon*

DEPARTMENTS

3 Editorial

4 Letters

6 New Products

86 Electronics Library

95 Popular Electronics Market Center

133 Advertiser's Index

135 Free Information Card

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EDITORIAL

ARE WE ALONE?

Ever since humans first learned about the true nature of the stars, we've gazed upon the nighttime skies and wondered if we were unique in the universe. Could it be that we are all alone, or are there beings circling one of those stars, staring back up at their sky, and asking the same questions?

Well, speculation is one thing, but scientific proof is another. While statistical studies indicate a high likelihood that intelligent life has evolved elsewhere, there has not yet been any solid, incontrovertible proof that such life exists. That's one of the reasons why NASA abandoned its work in this area, at congressional direction, in 1993.

Even so, it is possible that such proof will be found within our lifetimes. That's because the work NASA began is being continued by non-profit, non-government organizations. The projects backed by those organizations, which are either underway or about to begin, will have access to sophisticated new search tools and will use new search techniques.

If all of that excites you, then you must read "The Search for Extraterrestrial Intelligence" in this issue. That article documents the history of the search for extraterrestrial intelligence (or SETI), describes some earlier searches and the reasons why they might have failed, and looks at today's projects and the organizations that are running them.

What's more, if you want to do more than just read about SETI, and you are a radio experimenter or a ham-radio operator, the article details ways that you can get involved in the search. The journey begins on page 46.



Carl Laron
Editor

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LETTERS

Speaking of Speakers

THREE-WAY THIRD-ORDER CROSSOVERS

I'd like to make a few points and corrections regarding William R. Hoffman's article, "Designing Loudspeaker Crossovers" (*Popular Electronics*, July 1995). Formulas for calculating circuit components for three-way third-order crossovers are usually given for a certain bandwidth. By deviating too much from the given bandwidth, serious interference problems arise in the combined response.

By slightly modifying Mr. Hoffman's formulas in his XDES3.BAS program to the ones shown in Table 1, I obtained a much more linear three-way, third-order crossover model (i.e., flatter combined response curve). The FX and FM

TABLE 1

$C1 = (.11/(Z4 * X2)) * 10^6$
 $C2 = (.29/(Z4 * X2)) * 10^6$
 $C3 = (.083/(Z3 * FM)) * 10^6$
 $C4 = (.33/(Z2 * FX)) * 10^6$
 $C5 = (.99/(Z2 * FX)) * 10^6$
 $C6 = (.21/(Z1 * (X1 - 17))) * 10^6$
 $L1 = (.12 * Z4) / X2 * 10^3$
 $L2 = (.062 * Z3) / FM * 10^3$
 $L3 = (.027 * Z3) / FM * 10^3$
 $L4 = (.36 * Z2) / FX * 10^3$
 $L5 = (.22 * Z1) / (X1 - 17) * 10^3$
 $L6 = (.086 * Z1) / (X1 - 17) * 10^3$
where $FX = (X1 * X2)^{.51}$ and $FM = (X1 * X2)^{.5}$

terms have been added to set the size of the bandwidth on the mid driver's bandpass filter and to align the crossover point to -5.5 dB at the lower crossover frequency. The (X1-17) term is introduced to align the crossover point on the low-pass filter to -5.5 dB at the lower crossover frequency. The adjusted formulas are for a given bandwidth on the bandpass filter; ideally, you want $X2/X1 = 8$. For example, if you want your lower crossover point at 350 Hz, the upper crossover frequency should be $X2 = X1^8$ or 8×350 , which equals 2800 Hz. For different bandwidths, the for-

mulas need to be slightly changed.

In order for your crossover to yield the desired acoustic response, several conditions must be met. First, the driver's impedance is corrected with a Zobel circuit to a nearly constant magnitude and zero phase. Second, the driver's response should be nearly flat for a minimum of 1.5 octaves from the crossover frequencies, down for highpass and up for lowpass. Finally, you want your drivers radiating from the same plane.

One final note: Those conditions in no way guarantee a flat acoustic response, but provide a good starting point to arrive at an acceptable acoustic response. The final test is how the speakers sound!

For information on BASIC programs for plotting crossover response, call 410-646-5830 and leave a mailing address with your request.

Timothy P. Bresnan
Baltimore, MD

SPEAKER CORRECTIONS

It has come to my attention that there were some errors in the programs listed. Here are the corrections:

LISTING 1:
Lines 541-543 should end with "μF" instead of "mH."

LISTING 2:
In line 49, substitute X1 for X2. The line following number 160 is, of course, line 165.

LISTING 3:
In line 125, "C1" should be replaced with "C."

—William R. Hoffman

A HAPPY MUSICIAN

Just a note to let you know how much I liked the "Guitar Pre-amp/Distortion Box" project by Ken Wilmott (*Popular Electronics*, August 1995). His design sounds really good compared to a lot of commercially

available distortion boxes that I've purchased. And it cost almost nothing to build!

I'm kind of new at building electronic projects, but after I finally got it put together I was very pleased with the sound of it. Now a couple of my fellow guitar players want me to make one for each of them, too.

Thanks a lot!
T.M.
Omaha, NE

HE'S GOT THE POINT

It has been more than two years (April 1993) since you published my letter ("Plus Side of Surplus"). I am pleased to report that the response has been excellent. I encourage anyone needing help or advice on any electronic subject to write to *Popular Electronics*.

I was surprised at how many people still have a warm spot in their hearts for the surplus gear on which many of us cut our teeth. At the time I wrote my letter, I had two half-working receivers and no parts. Thanks to readers' responses, I now have over 15 receivers, all restored to near-perfect condition, plus a good supply of technical data and spare parts.

I know that there will be some who wonder why anyone would waste time with such antiquated stuff—junk, by today's standards—but they miss the point. There are many avenues that one can take in the pursuit and enjoyment of our hobby. Mine has been the little ARC-5 receiver. I have spent numerous hours with the headphones on, enjoying the fruits of many a successful restoration. Plus I have made new friends—and that is the point!
J.B.

Breaux Bridge, LA

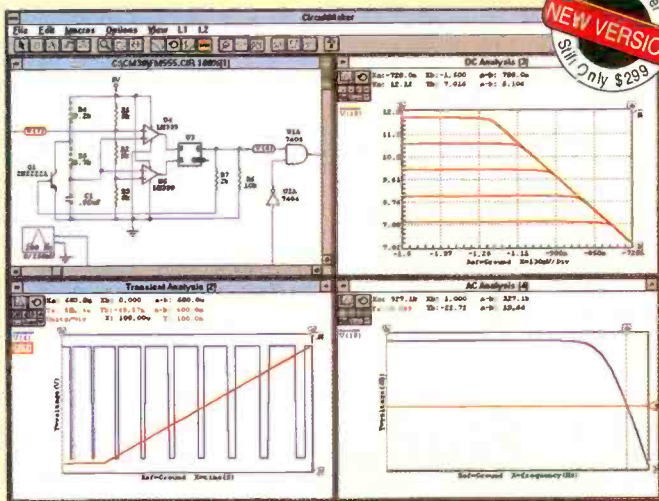
I am glad that you got the help you needed. If anyone else out there would like a hand from your fellow readers, you can write to: Letters, Popular Electronics, 500 Bi-County Blvd., Farmingdale, NY 11735.

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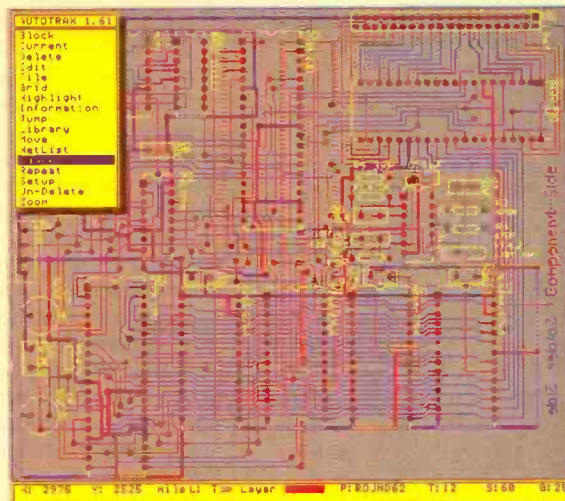
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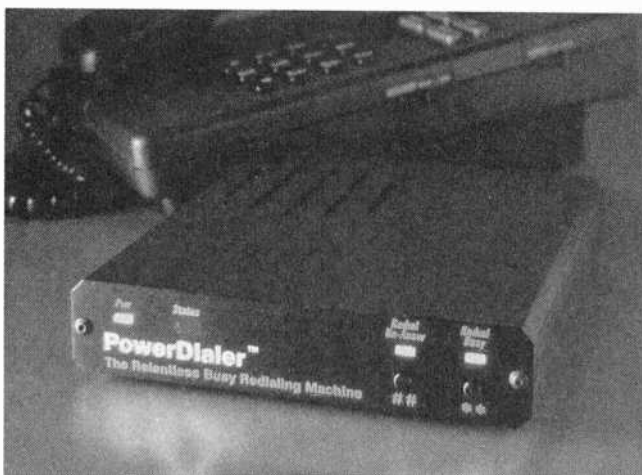


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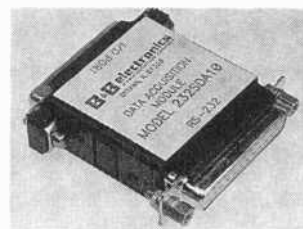


The *PS Arcade* Playstation joystick has a suggested retail price of about \$59.95. For additional information, contact *STD Entertainment (USA), Inc.*, 110 Lakefront Drive, Hunt Valley, MD 21030.

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(Continued on page 88)

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by Charles Anton

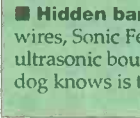


One of the hottest ideas in recent years has been electronic pet containment. Unfortunately, these systems require wires that have to be buried in your yard to create a boundary and communicate with the dog's collar. Although effective for some, they can cause an installation nightmare!

Elexis Corporation, one of the major players in the industry, asked its team of engineers, "How can we eliminate the wires?"

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Wireless pet containment system breakthroughs...

■ **Affordable.** Costs much less than installing an unsightly chain-link fence.

■ **Easy installation.** No more digging up your yard to bury wires. Just place the emitters six inches into the ground.

■ **Totally portable.** Take it with you! It's perfect for picnic areas or campsites.

■ **Security.** Sonic Fence keeps your dog within your yard...safe and out of trouble.

■ **Hidden barrier.** Without fences or wires, Sonic Fence creates a hidden ultrasonic boundary that only your dog knows is there.

the boundaries with the sonic emitters. Sonic Fence creates a boundary 20 feet thick



Computerized collar interacts with the sonic emitters in your yard.

As the signal intensifies, the collar will keep your dog.

If your dog enters, the boundary area, the collar will administer a correction.

The system resets when your dog returns to the safe zone.

The system is simple: it consists of a computerized collar and sonic emitters. A sonic emitter sends a signal of up to 75 feet. The containment area is expandable to an unlimited range. The computerized collar interacts with

the sonic signal of the emitter, sensing when your dog nears the boundary. The strength of the signal is evaluated as your dog nears the perimeter that you have defined. He will first receive an audible beep. If he continues, a mild correction will be administered.

The humane solution. Sonic Fence will work with virtually any size or breed of dog. The correction is similar to a static electricity charge, and it won't harm your pet in any way.

Patented design. The Sonic Fence system operates with a computerized collar and sonic emitters, so you get the advantages of pet containment without digging up your yard to bury wires. Installation is complete within minutes by simply defining

and 10 feet high to create the only safe zone in your yard for your pet.



The humane alternative to fencing.

Sonic Fence is totally portable—no more leaving your dog at home while you're on vacation or chaining him up at a campsite. Now he can freely interact with your family within the temporary barrier you establish.

Easy training. By spending as little as 15 minutes a day working with your dog, your pet could be fully trained in about three weeks. Plus, you can train as many dogs as you like on the same system—as long as they're each wearing a computerized collar.

Risk-free. Sonic Fence is made in the USA and is backed by our exclusive risk-free home trial. Try it, and if you're not satisfied, return it within 90 days for a full "No Questions Asked" refund. It's also backed by a one-year manufacturer's warranty. Most orders are processed within 72 hours and shipped UPS.



Not available in stores!

For a limited time, Sonic Fence is available at the factory-direct price of just \$199! The system includes: one sonic emitter, one computerized collar, 24 training flags, batteries for the emitter and collar, an installation planning diagram and an instructional video.

Free emitter! To help you create your perfect customized yard, we will give you a free emitter for every two emitters you purchase!

Sonic Fence.....\$199 \$16 S&H

Extra computerized collar.....\$119 \$9 S&H

Extra emitter* (and training flags)...\$89 \$8 S&H

* Buy two additional emitters, get a third emitter free!

Please mention promotional code 624-PL-6639.

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

800-992-2966



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

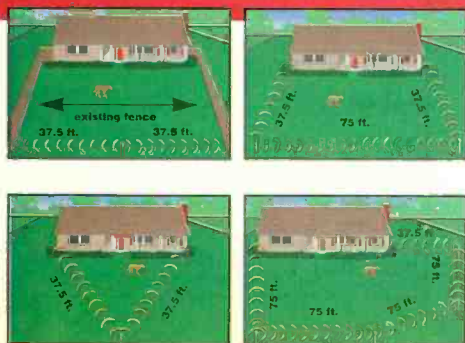
CONTRAD INDUSTRIES

2820 Waterford Lake Drive, Suite 106
Midlothian, Virginia 23113

TOTAL FLEXIBILITY

Design the perfect layout for your yard and your pet with Sonic Fence. The four-post layouts are perfect for typical back yards. And the two-post and one-post layouts are ideal for city lots or lots with partial fencing. Each emitter protects 75 feet of perimeter. Add as many emitters as you like for unlimited coverage! Each X represents one emitter.

Each Sonic Fence emitter broadcasts an ultrasonic signal. The Sonic Fence computerized collar constantly checks for the perimeter signal acting like a security system to keep your pet within the protected area.



GIZMO®

GIZMO'S HOLIDAY GIFT GUIDE

A tie for Dad? A robe for Mom? A new CD for each of the kids? *Fruitcake?*

Are your holiday gift ideas a bit, well, boring? Scarves and gloves, sweaters and shirts, pajamas and slippers might all be functional, but they're not likely to add much cheer to your holiday.

Perhaps your family tends to give more exotic presents—a hydraulic wine-opener for Dad, sea-shell jewelry for Mom, a glow-in-the-dark ant farm for the kids. Definitely not boring, but they're all likely to end up in the closet or basement, nonetheless, adding to the clutter that fills your home.

We'd like to offer a different approach to gift-giving. Instead of buying a bunch of individual goodies that are destined to be forgotten by spring, why not splurge on one big-ticket item that the whole family can enjoy for years to come?

The consumer-electronics industry offers a huge selection of products that could make a difference in the time your family spends together. Many of them fall under the general heading of home theater—a projection TV, a surround-sound speaker system, or an A/V receiver, for instance. But also consider a new camcorder for recording family holidays and special events; a new VCR for watching those recordings as well as movies; a multimedia personal computer for work, learning, and game-playing; or a satellite-TV system to expand your viewing options.

The following pages are filled with gift suggestions. Some are quite practical: For instance, a multimedia PC with a built-in stereo TV and FM radio, and a remote control, would get very little down time at our house. Others are audiophile or videophile flights of fancy that stretch the imagination—and the bank book.

There needn't be just one box under the Christmas tree. If you decide on a new PC, you could also give indi-

vidual gifts of software or CD-ROMs. A new VCR could be accompanied by movies to reflect each person's tastes. And don't forget accessories! We haven't—we've included some inexpensive electronic "stocking stuffers" to round out your holiday gift giving.

Just read on page to start your shopping. And happy holidays to all of you from all of us here at Gizmo!

THE SKY'S THE LIMIT

RCA's Digital Satellite System (DSS) made quite a splash in 1995. The 18-inch satellite-dish system, offering more than 175 channels from DirecTV and USSB, provides a welcome alternative to cable TV. If your family hasn't already jumped aboard the DSS bandwagon, you have quite a few DSS systems to choose from this holiday season, including three new ones from *Sony*. Sony's DSS lineup includes the basic model *SAS-BS1* with a single-output LNB antenna; the step-up *SAS-BD1*, whose dual-output LNB allows the use of two or more IRDs throughout the house; and the advanced *SAS-AD1* (shown here), which adds another audio output, a 9-pin low-speed dataport, a joystick-style universal remote commander, IR/RF capability, and a multiple-event program timer. Sony's DSS models feature

the Express Navigator on-screen menu system to guide viewers comfortably and intuitively through the extensive program choices. Menus can be tailored to match your family's viewing preferences. An optional multi-room distribution unit allows one antenna to feed several TVs throughout the house. Prices: *SAS-BS1*, \$749; *SAS-BD1*, \$849; *SAS-AD1*, \$949.

CIRCLE 60 ON FREE INFORMATION CARD



Sony's SAS-AD1 DSS receiver

BIGGER IS BETTER...

... when it comes to TVs. And you won't find one much bigger than the *ProScan PS80690* from Thomson Consumer Electronics. The rear-projection set has an 80-inch diagonal screen. It has more than sheer size going for it. An advanced 9-inch optics system (as opposed to the standard 7-inch system) boosts overall light output by more than 50%. Thomson's "RawPower" video amplifier generates 68 watts of "picture power." The set also features a 55-watt Dolby Pro Logic surround system with built-in center-channel speakers and subwoofer. Dual tuners allow you to view split-screen action, picture-in-picture (PIP), 12 channels simultaneously in Channel Guide mode, and picture-outside picture, which delivers three "virtual motion" channels on one side of the screen while the main program is viewed in a larger window—all without the addition of a second video source. On the set's 80-inch screen the color PIP inset picture is the same size as a 35-inch screen! Price: \$8499.

CIRCLE 61 ON FREE INFORMATION CARD

LARGE-SCREEN VIDEOVIEWER

TVCRs are getting bigger, too—big enough to move out of the kitchen or dorm and into the family room. *Quasar's Video-Viewer* line now includes a 27-inch, four-head, stereo model, the *VV2705*. It features VCR Plus+ for easy recording, a Super-Black picture tube for improved contrast, an English/Spanish on-screen display, and Auto Clock Setting with automatic Day-

light Savings Time adjustment. The TVCR can decode the Extended Data service signal transmitted over the Public Broadcasting System, so it will always hold and display the correct local time. The *VV2705* is equipped with MTS Hi-Fi stereo and Second Audio Program (SAP) capability. Price: \$749.95.

CIRCLE 62 ON FREE INFORMATION CARD

WIDE RECEIVER

You'll almost feel like you're in a movie theater when you watch a film on a widescreen TV, such as *Proton's WT-3650* 34-inch direct-view stereo monitor/receiver. The dual-tuner set offers 600 lines of horizontal resolution in your choice of four different formats. "Standard" is the traditional 4:3 aspect ratio; "full" enlarges the central image of a standard program to fill the wide screen; "16:9" frames letterboxed source material; and "zoom" allows central and vertical adjustment of letterboxed images. The dual tuner lets you watch two programs at once, and the picture-in-picture mode offers a range of special effects including strobe, still, swap, and position. Price: N/A.

CIRCLE 63 ON FREE INFORMATION CARD

Thomson's ProScan PS80690



Fisher's PC5531 television

PROJECT A POSITIVE IMAGE

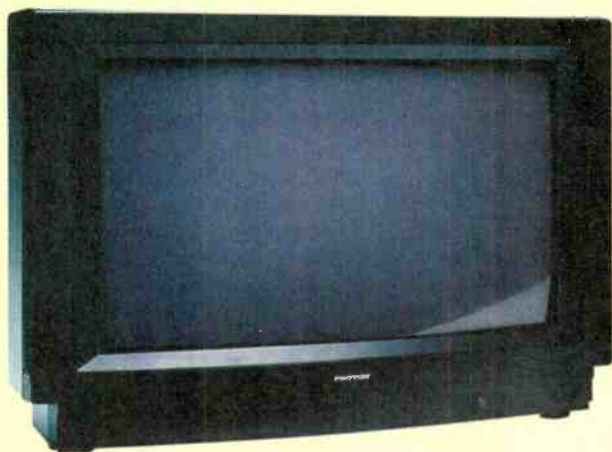
Of course, the biggest video images come from projectors such as *Sharp's XV-P15U*. The lightweight, compact, portable projector uses Sharp's single-panel LCD technology and a newly developed optical system to deliver an image that's almost four times brighter than previous single-panel models, and with improved center-to-corner uniformity. The short-focus lens allows crystal-clear images up to 100-inches (diagonal) even when viewing at close range in a small room. Measuring slightly more than 13 x 13 inches and weighing just 13.6 pounds, the *XV-P15U* can be ceiling mounted, set on a table, or even moved from room to room. A speaker is built in for portable use, and multiple video inputs are provided. The wireless remote control is backlit for use in darkened home theaters. Price: \$2500.

CIRCLE 64 ON FREE INFORMATION CARD

PARENT POWER

Fisher's PC5531 television might not be at the top of your kids' holiday wish list, but if you have young children and you're thinking of buying a new family television, this could be the one for you. The 31-inch set features a Parental Control function that allows parents to select up to three channels to block out for a total of up to nine hours. The kids probably won't miss those channels as they enjoy the *PC5531's* 600 lines of horizontal resolution, MTS/dbx

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Proton's WT-3650 34-inch direct-view TV

stereo and SAP reception, picture-in-picture, surround-sound circuitry, front-firing speakers in a double-baffle cabinet, on-screen picture control, and pre-programmed universal remote control. Price: \$949.95.

CIRCLE 65 ON FREE INFORMATION CARD

SMALL BUT SWEET

The *LCD-410* personal color television from *Marantz* is proof that good things can come in small packages. Weighing in at a feather-weight 13 ounces, the portable LCD TV features a four-inch, backlit, Thin Film Transistor (TFT) active-matrix color screen—the same type used in top-quality laptop computers. Its bright, crisp, high-contrast picture can be clearly seen from several feet away, allowing the whole family to watch at once. The LCD-410 is only one-inch thick when closed, so it fits easily into a jacket pocket. It is equipped with A/V inputs and outputs for connection to a VCR or laserdisc player, and allows you to select widescreen (16:9) or standard (4:3) aspect ratios. The portable TV can be used for viewing on the go and as an instant playback monitor for camcorder users. It is compatible with both NTSC and the European PAL video standard, and includes a built-in AM/FM radio tuner. Price: \$799.

CIRCLE 66 ON FREE INFORMATION CARD

FLOATING ON AIR

Hitachi's VM-H81A Hi-8 camcorder has a couple of unique attributes. First, it floats;



Sharp's XV-P15U

a sealed, air-tight chassis gives the camcorder complete buoyancy. Second, it eliminates clumsy hookups to your TV or VCR by allowing wireless playback of videotape via its "Optical Link." A small transmitter built into the camera allows it to send video and stereo audio directly to a tiny receiver that is connected to the

television or VCR. The wireless receiver comes with a small tripod to ensure easy pickup of the signal. The Optical Link beam is emitted by two LEDs. The infrared signal is converted by a photo diode in the receiver into a video and an audio signal for the TV set. The water/weather-resistant camcorder has a low-light sensitivity rating of 2-lux, an *f*1.8 lens with 12× (optical) and 24× (digital) instant zoom, a 0.7-inch color LCD viewfinder, and digital electronic image-stabilization circuitry. Advanced features include a two-line, two-page titler; digital signal processing; 16:9 capability; digital fade and other digital effects; and artificial intelligence for iris and white balance. Price: \$2099.

CIRCLE 67 ON FREE INFORMATION CARD

OUT, OUT, DAMNED SPOTS

Get rid of those annoying commercial spots with the *RCA VR678HF Commercial Advance* VCR from *Thomson Consumer Electronics*. When you record a program, the VCR's circuitry detects and marks commercial segments on the tape. During playback, it automatically skips past those segments, allowing you to watch commercial-free recordings. During the approximately 8½ seconds that it takes the VCR to fast forward through three minutes of commercials recorded in SLP speed, you can opt to see a solid blue screen or watch the ads zoom by. The VCR also offers Auto

Clock Set and VCR Plus+ simplified programming with End Time Adjustment, which allows you to adjust the end time of a show that might extend beyond its scheduled time slot, such as an extra-inning baseball game. Cable Box Channel Control ends recording headaches by automatically selecting the proper channels on most remote-controllable cable boxes. The *VR678HF* is compatible with the *RCA DSS* system, which sends an infrared command signal to the *RCA* satellite receiver for time-shift recording capability. Price: \$499.

CIRCLE 68 ON FREE INFORMATION CARD

3D VCR

The *PV4564* VCR from *Panasonic* features the *Spatializer* Audio Processor, an exclusive audio technology that promises to "transform any stereo TV into a dynamic source of lifelike, enveloping sound . . . without extra speakers and sophisticated surround-sound components." Developed by *Desper Products*, *Spatializer* technology brings a three-dimensional effect to

Quasar's VideoViewer VCR



Marantz's LCD-410 personal color television

sound by unmasking the multiple layers of recorded audio from stereo sources. Every instrument and sound effect is perceived to occupy its own point in space, even if it is beyond the speakers' normal listening boundaries. Two levels of audio processing are available to suit individual tastes, or you can opt to bypass the Spatializer entirely. Price: \$429.95.

CIRCLE 69 ON FREE INFORMATION CARD

SPEAKERS OF THE HOUSE

It's easy to create a home theater with today's all-in-one surround-sound speaker systems. From *AudioSource*, the *SS-5001* package comes complete with the SS-Five ProLogic Surround Sound processor with built-in center- and rear-channel amplifiers and remote control, the VS One video-shielded center-channel speaker, and a pair

control, and a variable sound-delay time control to adjust the apparent size of the listening space. Price: \$950.

CIRCLE 70 ON FREE INFORMATION CARD

SHAKE, RATTLE, AND ROLL

Make your home theater a room-rumbling affair by adding a THX A/V receiver such as the *SA-TX1010* from *Technics*. The stand-alone receiver meets Lucasfilm's stringent THX requirements to provide full dynamic range with low distortion, proper stereo imaging and localization, and clearly understood dialog even in scenes with loud sound effects. The SA-TX1010 pumps out 120 watts to all four channels in Home THX and Pro Logic modes, and 125 watts each to the left and right channels in stereo mode. Technic's Sound Stage Imaging adds a realistic surround effect to

quency response, causing the earpads to "move to the beat of the music." Panasonic's XBS Extra Bass System boosts the lower frequencies for an added punch. The RQ-SW20 features an auto-reverse tape player and a quartz-synthesized digital tuner with 20 memory presets. Two modes of five AM and five FM stations allow "His" and "Hers" use. A rugged, water-resistant shell makes the personal stereo ideal for sports or a trip to the beach. Price: \$119.95.

CIRCLE 72 ON FREE INFORMATION CARD

BIG SOUND, SMALL PACKAGE

A small-size stereo system can bring the sound of music to a bedroom, den, kitchen, or family room. *Kenwood's UD-303* mini system provides 50 watts per channel, a three-disc CD changer, and a dual auto-reverse cassette deck with Dolby B and HX Pro. The compact system features Low-Level Control, which, when activated, boosts the treble and bass to ensure rich, full sound even at low volumes. Natural Bass keeps the music from sounding "boomy" at moderate and high volumes. The system's dynamic rotary volume con-



The RCA VR678HF Commercial Advance VCR

of surround-channel speakers. The system even includes interconnect cables and 100 feet of speaker wire. Price: \$429.95.

CIRCLE 115 ON FREE INFORMATION CARD

Sony's home-theater-in-a-box solution is the *SA-VA55*, which includes two front and two rear speakers with a built-in subwoofer and a center-channel speaker. The Dolby Pro Logic system features wireless infrared rear-channel speakers, so there's no need to run wires around the room. Installation takes about 10 minutes. The system features five surround modes, a remote



The PV4564 VCR from Panasonic

stereo music, with two hall modes, a live mode, and a simulated surround mode. A help function with on-screen graphics and written prompts make the receiver extremely easy to set up, test, and use. Price: \$999.95.

CIRCLE 71 ON FREE INFORMATION CARD

control responds to the speed at which the volume knob is turned. Price: \$500.

CIRCLE 73 ON FREE INFORMATION CARD

FEEL THE MUSIC

Now you can get a real-life listening experience out of a personal stereo. *Pana-*

sonic's RQ-SW20 features the Virtual Motion Sound System (VMSS), which allows you to feel the music as well as hear it. A

tiny voice-coil-and-spring system in the headphones reacts in time with the music's low-fre-

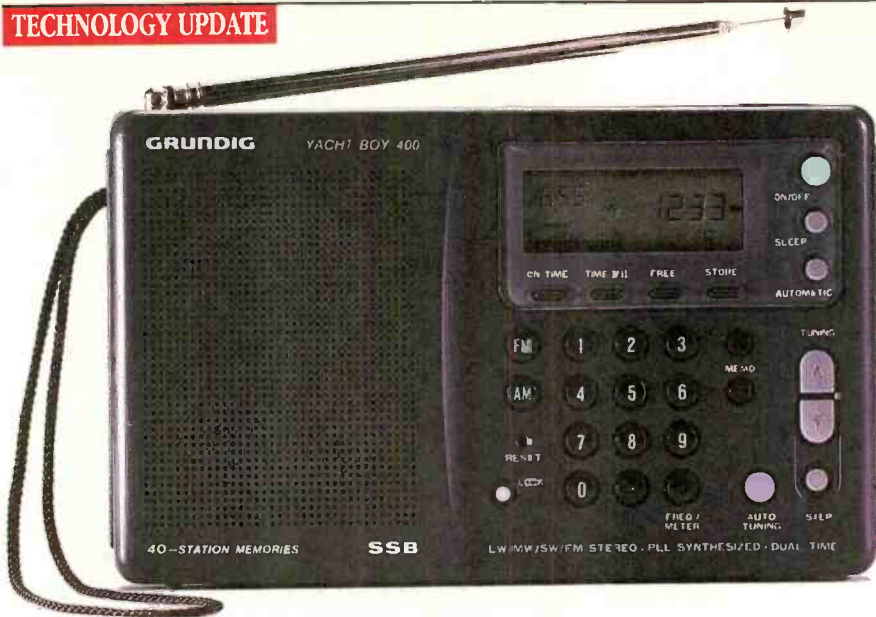
TAPE IT TO THE MAX

If your family still prefers cassettes to CDs, you might consider the *RD-960BX* cassette deck from *Rotel*. For your listening pleasure, the deck includes Dolby B and C noise reduction, HX Pro headroom extension, and automatic settings for bias and EQ to match the type of tape being used. The transport mechanism features two motors—a high-torque servo motor for capstan drive and a separate motor to ensure accurate tape handling when rewinding or fast-forwarding. The RD-960BX has a separate, switchable MPX filter circuit to prevent audible distortions when recording from FM radio. The deck provides accurate recording of the wide dynamic range and extended frequency response of digital sources. Convenience features include remote control, music search, memory rewind, and repeat functions. The counter displays tape travel information in your choice of real time or four-digit index formats. Price: \$399.90.

CIRCLE 74 ON FREE INFORMATION CARD



12 The AudioSource SS-5001 surround-sound speaker system



It's 7 p.m. in your Chicago hotel room and you're catching up on the news from Radio Moscow

Whether you're home or travelling the globe, get up-to-the-minute news, weather, sports or music from all over the world.

by Matthew Zielh

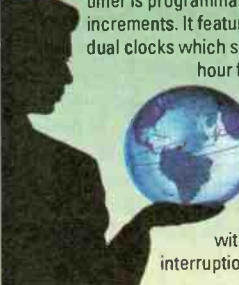
Keeping in touch with the news isn't easy. You can read the paper, but to get the latest news you have to wait until the next morning for the latest edition. TV news broadcasts are only truly up-to-date if they are live, otherwise the same information soon becomes "old news." The last way you'd keep yourself informed is the radio. The only way you can hear the news is between music or on a good AM station—if you can find one and tune it in.

Radio revolution. Now the new Grundig Yacht Boy 400 AM/FM/shortwave radio will change the way you think about radio. The Grundig world travel radio keeps the most current news and financial information coming in from all over the world. It broadcasts directly to you whether you're in Paris, Texas or Paris, France.

The Yacht Boy 400 is portable and small enough to fit into a jacket pocket or a purse and weighs only two pounds. You can take it with you absolutely anywhere. It operates on three AA batteries, but also has a port for an external power source.

TOP FIVE REASONS TO REPLACE YOUR RADIO WITH THE YACHT BOY 400

- 1 Legendary Sound Quality.** Grundig is famous throughout the world for its sound quality. The Yacht Boy 400 has a built-in telescoping antenna and an external reel antenna.
- 2 40 Programmable Presets.** Forty programmable memory presets allow for quick access to favorite stations. Plus PLL-synthesized tuning delivers solid frequency stability.
- 3 Ultra-wide Range.** Continuous shortwave from 1.6 to 30 MHz [with no tuning gaps] covers all existing shortwave bands plus FM-stereo, AM and longwave. Shorter amateur, aeronautical and maritime two-wave communications can be heard.
- 4 Programmable Sleep Times.** LCD simultaneously shows time, frequency, band, automatic turn-on and sleep timer. Sleep timer is programmable in 15-60-minute increments. It features dual alarm and dual clocks which show time in 24 hour format.
- 5 World News.** Listen to news broadcasts, including the BBC, live from around the world without commercial interruption.

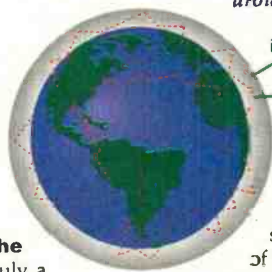


Broadcasts from around the world. The Yacht Boy 400 is truly a technological innovation. To receive broadcasts from around the world, the Yacht Boy 400 covers all shortwave bands (1.6-30 MHz) without gaps. To listen to your local radio station, simply switch to AM or FM tuning. Tune in signals using the dial or the built-in keypad.

Plus its 40 randomly programmable presets allow for quick access to favorite stations.

Clock radio. The Yacht Boy 400 radio can be programmed to automatically turn on or sound an alarm by using the auto on feature. If you want to catch an early program or just wake up for work, simply set the alarm. Other features include sleep and snooze and dual alarm modes: radio and beeper. With the multi-function Liquid Crystal Display (LCD) you can easily check the time in the dark.

Use it all day long. Imagine your typical day. It's 5 a.m. and you are awakened by the radio on your Yacht Boy. While you're getting ready in the bathroom you tune in to BBC London and listen



ionosphere
shortwave signals

HOW DOES SHORTWAVE RADIO WORK?

Shortwave signals depend on factors such as the sun, the ionosphere and even the earth itself to broadcast around the world. The ionosphere is a cloud-like layer surrounding the earth consisting of ions and electrons. The process by which these radio waves travel is called radio wave deflection and ionospheric propagation. In simple terms, radio waves travel the earth by bouncing around. Once transmitted from earth, the radio waves travel up, bounce off the ionosphere back down to earth and up again. This process repeats several times. Because this takes place at low angles, radio waves travel great distances with every bounce taken.

Many of the major countries use shortwave radio to transmit broadcasts for worldwide listening. There are international broadcasts that are specifically intended to be heard by North American audiences.

to all the latest events before work. After your morning meetings you pick up some amateur radio. In the afternoon you have some time to catch a few minutes of the soccer game between Spain and Italy. On the way home you flip on the news again, but this time it's Radio Beijing. After dinner you tune in to an exotic music special coming directly to you from West Africa. Finally, before bed you set the Yacht Boy alarm.

Risk-free home trial. The Grundig Yacht Boy 400 is backed by Comtrad's exclusive risk-free home trial. Try it. If you're not completely satisfied, return it within 30 days for a full "No Questions Asked" refund. The Yacht Boy 400 is also backed by a one-year manufacturer's warranty. Most orders processed within 72 hours.

Special limited-time offer. If you order the Grundig Yacht Boy now you will receive it at the factory-direct price of only \$199. In addition, you'll receive FREE: a carrying case, telescoping antenna and advanced external compact reel antenna, three AA batteries and the Grundig Shortwave Listening Guide. Call today to take advantage of this limited-time offer.

Grundig Yacht Boy 400 \$199 \$12 S&H
Please mention promotional code 763-PL-6638

For fastest service call toll-free 24 hours a day

800-992-2966



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

COMTRAD INDUSTRIES

2820 Waterford Lake Drive, Suite 106
Midlothian, Virginia 23113

Hitachi's VM-H81A Hi-8 camcorder



The Sony SA-VA55 surround-sound speaker system

INFINITELY STYLISH

As pretty to the eyes as they are to the ears, *Compositions* speaker systems from *Infinity Systems* provide a solution for home-theater enthusiasts who don't want to have to hide their components. Each tall, slender *Prelude* full-range speaker incorporates an efficient, amplified, 100-watt, 12-inch subwoofer in its base. The upper portion contains four 5/8-inch drivers, two 4-inch drivers, and a 1-inch dome tweeter. The *Prelude* center-channel speaker is matched both acoustically and aesthetically to the full-range right- and left-channel speakers for seamless soundfield reproduction. It contains two 5/8-inch drivers, two 4-inch drivers, and a 1-inch dome tweeter. Rounding out the home-theater system are *Quadpole* surround speakers, which are designed for installation flexibility. Each contains one 5-inch driver that faces straight out, and two pairs of 3/8-inch drivers that angle gently off to either side to provide diffuse surround audio. Price: *Prelude* front speakers, \$3000 per pair; center-channel speaker, \$779; surround speakers, \$669 per pair.

CIRCLE 75 ON FREE INFORMATION CARD

SEEN, BUT NOT HEARD

Give one family member the gift of sound—and everyone else the sounds of

silence—with *Sennheiser's IS 850* infrared digital headphone system. The system couples the *HDI 850* dynamic stereo headphones with the world's first digital wireless infrared transmitter, the *S 850*. It can be used with either analog or digital sources. The transmitter automatically detects and processes different digital sampling frequencies. Analog frequencies are digitized with a 64-times oversampling, high-resolution A/D converter. An anti-aliasing filter reduces noise and distortion. The headphones' optical receiver transfers the digital signals to a "Bitstream Continuous Calibration" converter, which converts them back to analog signals. A "Duofol" diaphragm, consisting of two wafer-thin films, avoids harmonics at high frequencies and all but eliminates tonal coloration. Price: \$1395.

CIRCLE 76 ON FREE INFORMATION CARD



The SA-TX1010 from Technics



Panasonic's RQ-SW20

Kenwood's UD-303

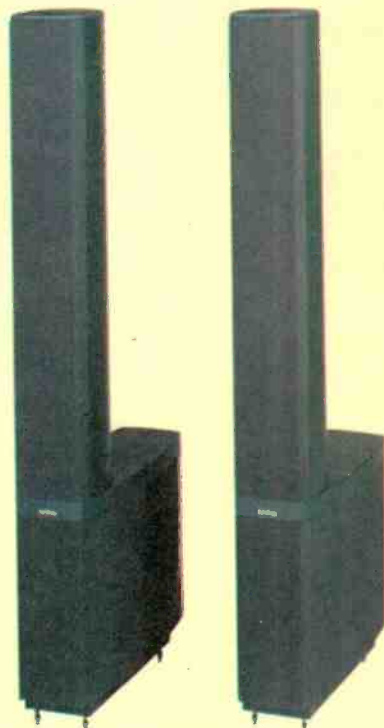


CD HOME AND AWAY

Your family can enjoy listening to CDs at home, on the road, and just about anywhere else with *Onkyo's DX-F71*. The self-contained CD player includes a rechargeable battery and power adapter for portable and at-home use. It comes with a pair of high-quality headphones, but can also be used with any set of powered speakers. For automotive use, the *DX-F71* is available with a 12-volt cigarette-lighter adapter, a cassette-adaptor for in-dash use, and a backlit LCD control panel for night driving. Almost skip-free play is provided by the player's suspension sys-



Rotel's RD-960BX cassette deck



Compositions speaker systems from Infinity Systems

tem, which provides mechanical isolation, along with its electronic digital anti-shock system, which processes and stores three seconds of CD data in a dedicated buffer chip. That buffer gives the player time to recover from the bumps and jolts of everyday use. The DX-F71 features the single-bit D/A converter and 8-times oversampling found in home players, 22-track random programming, three repeat-play modes, and a built-in equalizer with three playback options—flat, enhanced, and boosted. Price: \$240.

CIRCLE 77 ON FREE INFORMATION CARD

FIVE-IN-ONE BOOMBOX

Mom and Dad can enjoy their extensive cassette collections, the kids can play their favorite CDs, and the whole family can move into the next age of audio with Sanyo's MDC-2000 portable music system. The boombox for the '90s brings together the most popular music mediums of the past, present, and future—AM, FM, cassette, CD, and MiniDisc—in a package that can fill in as an audio mini-system at home or be carried along just about anywhere else. For easy CD-to-MD recording, the system features one-touch digital recording. You can change the order in which the tracks are

recorded, and even insert the title of the disc in the MD recording. One-touch synchronized dubbing from CD to tape is also provided. The MDC-2000 also offers AM/FM digital tuning, a remote control, dual-cone speakers, bass-enhanced sound, a fluorescent dot-matrix display, and a seven-level spectrum analyzer. Price: \$999.99.

CIRCLE 78 ON FREE INFORMATION CARD

IT'S A TV! IT'S A PC! NO, IT'S BOTH!

Thinking of buying a second TV for the den? Or maybe a new multimedia computer? How about a mini-stereo system?



Sennheiser's IS 850



Packard Bell's new line of multimedia PCs can serve as all three, and then some. Select models feature built-in stereo TV and FM radio. You can watch TV and work at the same time, or input images from a VCR or laserdisc to be printed or stored. The television includes closed captioning, 1024 × 768 maximum resolution, and stereo sound decoding. The FM radio has 24 programmable, preset stations, automatic scan and manual seek modes, and alarm and sleep functions. TV, radio, and CD-ROM functions can be controlled with the on-screen media controller, the Fast Media key, or the included remote control. All models in the PC family include direct Internet access with seven free hours of access time; Prodigy, AOL, and CompuServe access; a built-in telephone answering system with pager service; SRS 3-D Amphitheater Sound system; online documentation; and a quad-speed CD-ROM drive. More than 40 productivity, entertainment, and reference titles are included in the PC's software bundle. Packard Bell's Navigator software interface organizes all the applications, functions, and appliances into three "virtual multimedia environments"—the Living Room, the Software Room, and the Information Room—from which applications can be launched instantly. The Pentium-based computers come in 75-, 100-, 120-, and 133-MHz models. Hard-drive storage starts at 540MB and increases up to 2.1GB with 8MB or 16MB of RAM installed on various models. Prices: N/A.

CIRCLE 79 ON FREE INFORMATION CARD

MOVABLE MULTIMEDIA

How to add multimedia to an existing notebook or laptop computer? Sony's PRD-155SB portable CD-ROM Discman player combines a sleek, double-speed, MPC-2 CD-ROM drive with a tiny sound-box unit. Together, they provide everything you need for both multimedia computing



Onkyo's DX-F71



Sanyo's MDC-2000 portable music system



Sony's PRD-155SB portable CD-ROM Discman player

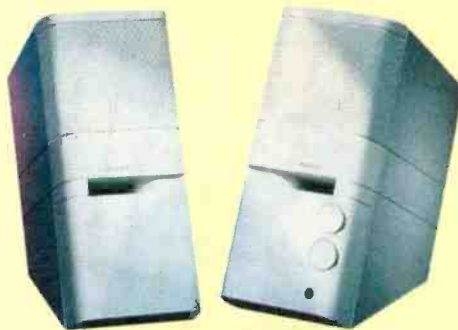


and CD listening on the go. The CD-ROM Discman weighs only 10 ounces, runs on AA batteries, and is about the size of an audio Discman. Its sound box, which is about the size of a three-by-five index card, provides an all-in-one multimedia solution, including a 16-bit Soundblaster-compatible soundcard; a built-in speaker; audio line-out, headphone, and microphone jacks; and a MIDI/joystick port. The box connects directly to the CD-ROM Discman with no additional cable. Both the data and audio signals are passed from the combined unit to the computer via a single PCMCIA interface. With two AA batteries in the player and six in the Soundbox, the system delivers nine hours of audio CD or six hours of CD-ROM playback. Price: \$749.95.

CIRCLE 80 ON FREE INFORMATION CARD

SPEAKER POWER

Perhaps your family already has a multimedia PC with built-in speakers. You can increase everyone's computing and listening pleasure with the addition of a pair of multimedia speakers, such as the Bose MediaMates. Like speakers designed for music listening, the MediaMate speakers provide outstanding performance over the en-



Bose MediaMates

tire audio spectrum. To accommodate CD-ROM use, they offer dual-source input capability. Mixing capability lets you control the amount of computer sound relative to outboard sound. The speakers are specially equalized for close-up listening, with full reproduction even at low volumes. The slim, rectangular MediaMates take up less space than most diskette-storage boxes. They can be placed right next to or on top of a computer, or can be mounted right on the side. A headphone jack and volume controls are up front for easy access. Sold as a pair, one speaker is the "powered master" and the other is the unpowered auxiliary. Price: \$339.

CIRCLE 170 ON FREE INFORMATION CARD

Packard Bell's multimedia PC



VIRTUAL VISIONS

Take your family on a virtual joyride, with *Virtual i-glasses* from *Virtual i-O*. The eight-ounce virtual reality (VR) headset features real-time head-tracking technology, so when you move your head to the right or left, up or down, the video environment moves with you. It can display two- and three-dimensional video, PC games, laserdisc movies, VHS tapes, and television programs. The headset is also compatible with major gaming systems including Nintendo, Sega, and Sony. The fully adjustable headphones provide high-fidelity stereo sound. Prices: The PC version with head-tracking and PC capabilities costs \$799; the video-only unit for TV and video costs \$599.

CIRCLE 171 ON FREE INFORMATION CARD

PC SOUNDOFF

A multimedia PC can really be an entire entertainment center by itself whether you want to play CDs or listen to .WAV or MIDI



Breakthrough sonic toothbrush delivers 31,000 brush strokes per minute... dissolving away stains and plaque!

Developed by bioengineers and periodontists, Sonicare uses sonic technology to promote the health of even sensitive teeth and gums. It is so effective that Optiva, the makers of Sonicare, guarantee you a better check-up after 90 days of use!

by Brian Greenwall

If you're like me, you don't take proper care of your teeth. I admit it—I don't floss as frequently as my dentist recommends. Out of curiosity, last night I actually timed my brushing. I was done in less than 30 seconds! (A recent dental study found that most people brush for an average of 50 seconds.)

But my teeth look and feel clean, so what I'm doing is good enough, right? Wrong. Three out of every four people will develop gum disease, and most won't even know it. Today there is a remarkable device that can help combat this problem—it's called Sonicare.

Silent attacker. Gum disease is caused by plaque bacteria, originating in hard-to-reach areas between teeth and below the gumline—places toothbrushes can't reach, no matter how well you brush. Plaque bacteria forms in colonies, releasing toxins that make gums red, swollen, tender and prone to bleeding. However, you may have gum disease without any of these symptoms. If not treated, gingivitis can lead to periodontitis, a more advanced stage of gum disease that can lead to tooth loss. Daily cleanings to remove this plaque are essential to a healthy mouth. Sonicare, clinically proven to reverse gingivitis, is the perfect tool.

A powerful weapon. Sonicare is a breakthrough product that combines up-to-date information on dentistry with sonic technology. Developed by a team of dentists and bioengineers, it is the first high-frequency toothbrush to produce gentle sonic vibrations that turn toothpaste into a penetrating foam.

Sonicare is the ultimate in-home dental hygiene system, creating 520 brush strokes a second.

How it works. Electronics housed within the Sonicare handle create acoustic energy that is transmitted through a drive-bar and emitted through the high-frequency motion of the bristles. Laboratory studies have proven that these vibrations alter and weaken the hairlike structures that bacteria use to attach to your teeth and gums. Without those adhering structures, bacteria are easily swept away.

State-of-the-art. Sonicare's computer-controlled electronics not only regulate brushing frequency, but also enable the *smartimer™* to monitor brushing time, turning Sonicare off after two minutes. Solid-state electronics in the handle, with only one moving part, also make Sonicare's operation highly reliable.

COULD YOU USE SONICARE?



Sonic vibrations turn toothpaste into a penetrating foam that reaches between teeth and below the gumline. Floss daily.

✓ You are concerned with the health of your teeth and gums.

✓ You want to brighten your teeth, but don't want to use home bleaches.

✓ You have orthodontics, implants, crowns, bridges or other dental work.

✓ You use a special toothpaste such as baking soda or desensitizing formula for sensitive teeth.

✓ You travel a lot and want a high-quality portable electric toothbrush.

Quadpacer. Because dentists divide the mouth into four quadrants (upper left, upper right, lower left and lower right), Sonicare's innovative *quadpacer™* feature divides the two-minute cycle into four 30-second intervals. It will beep after each interval and pause long enough for you to switch quadrants. This encourages users to brush all teeth surfaces evenly and thoroughly.

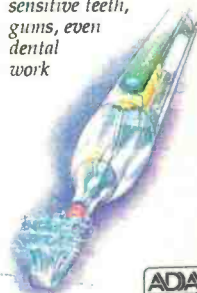
Sonicare's built-in rechargeable battery will operate for up to two weeks on a full charge. The Sonicare system includes the handle, a recharging base, two color-coded interchangeable brush heads, a brush head holder and caps for travel!

BENEFITS

"Sonicare represents a giant leap in technology. It is the first product in my 17 years of practicing dental hygiene that truly will help patients at home."

—Willi Ellis, Dental Hygienist

- Clinically proven to reverse gingivitis
- Whitens teeth by removing over 80% of coffee, tobacco and tea stains
- Recommended by 98% of dentists who have tried it
- Will not irritate sensitive teeth, gums, even dental work



The sonicare® sonic toothbrush is Accepted as an effective cleansing device when used as part of a program of good oral hygiene and regular professional care. Council on Scientific Affairs, American Dental Association.

Proven effective.

Sonicare is clinically proven to remove plaque between teeth and below the gumline and significantly reverse gingivitis. It has been accepted by the American Dental Association. Sonicare removes over 80% of coffee, tobacco and tea stains. That may be why 92% of dental professionals who've tried Sonicare prefer it for their own use, and 98% recommend it to their patients.

Guaranteed better check-up.

Brushing, flossing and regular dental check-ups are equally important parts of your dental health. We believe that Sonicare can significantly improve your dental health. In fact, we guarantee that after using Sonicare for 90 days, you will have a better check-up. If you and your dentist don't agree, simply return your Sonicare and receive a complete refund.

Try it risk-free. Sonicare is backed by Comtrad's exclusive risk-free home trial. Try it, and if you're not completely satisfied, simply return it within 90 days for a full refund, "No Questions Asked." It is also backed by a two-year manufacturer's warranty. Most orders are processed within 72 hours and shipped UPS.

Sonicare with Quadpacer \$129 \$11 S&H
Additional brush head \$19.95 \$3 S&H
BETTER BUY: get two heads for . . \$34 \$4 S&H
Portable carrying case \$17 \$2 S&H
 Please mention promotional code 1001-PL-6640.

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

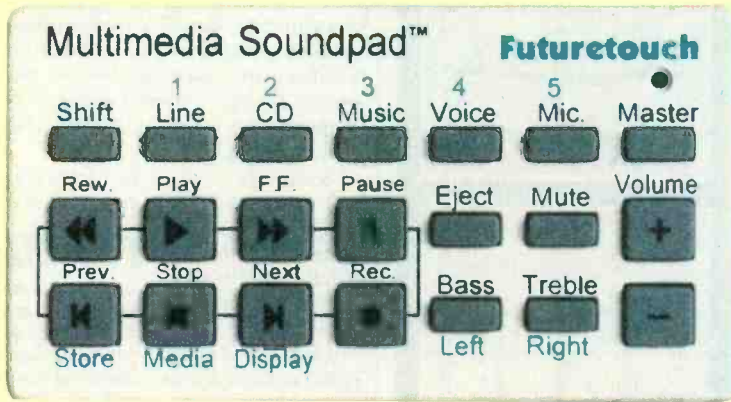
800-992-2966



To order by mail, send check or money order for the total amount including S&H (VA residents add 4.5% sales tax). To charge it, enclose account number and exp. date.

COMTRAD INDUSTRIES

2820 Waterford Lake Drive, Suite 106
 Midlothian, Virginia 23113



The Multimedia Soundpad from Futuretouch Corporation

files. Add an FM or TV tuner board, and you might never leave your PC again! Unfortunately, many new computer users are confused by the necessity of running an audio-mixer program to control CD audio functions and to get the sound configured properly. To the rescue is the *Multimedia Soundpad* from *Futuretouch Corporation*. The Soundpad is a credit-card-sized 21-button keypad the gives PC users one-touch control of their computer's CD player as well as full audio mixing control—including volume, tone, balance and relative output levels. The Soundpad attaches to the computer's serial port and comes with software that contains device drivers for both DOS and Windows. Price: \$39.

CIRCLE 31 ON FREE INFORMATION CARD

OUT OF THIS WORLD

The *Sega Saturn* system promises to "take players right inside the game experience with compelling visual, audio, and kinesthetic effects." It not only brings new

interactive experiences to game players, but also breathes new life into their home-theater equipment. Its sound system uses two digital signal processors, surround-sound encoding, and QSound technology for sound effects. Two video-display processors provide high-speed video capabilities and 3D graphics. Its arcade-style architecture allows for software development with 3D rendering, 360-degree action, dynamic perspectives, and surround

sound. The game player comes with "Virtual Fighter" and a video sampler of 20 Sega Saturn titles. Price: \$399-\$449.

CIRCLE 32 ON FREE INFORMATION CARD

GOOSENECK MIKE

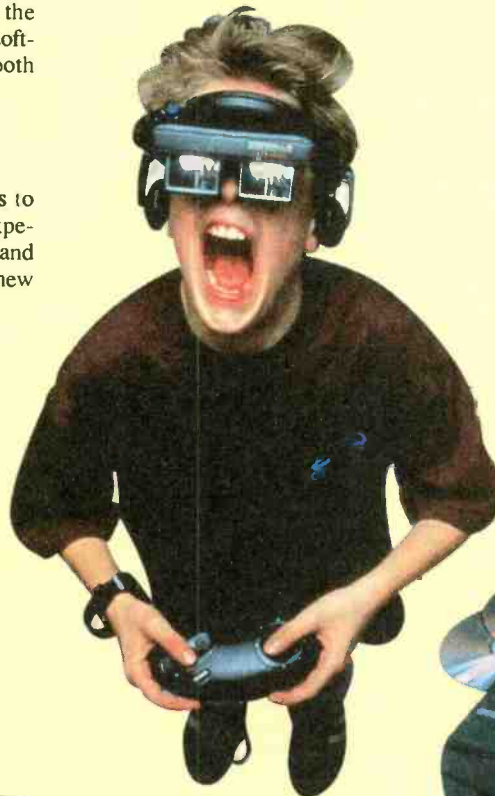
Multimedia PCs seem to be taking over more and more of the desktop. One of the culprits is the microphone that's required for such applications as recording digital sound files, or incorporating telephony features. To the rescue is *MIDI Land, Inc's Free-D* (Free Direction) desktop microphone. The microphone features a unique gooseneck design that allows it to be placed in perfect position. It can be attached with a self-stick stand and adjusted, or it can even be twisted to form its own base so that it can free-stand on the desktop. The *Free-D* supports all sound card inputs whether they are dynamic or condenser types. Price: \$29.95

CIRCLE 33 ON FREE INFORMATION CARD

WINDOWS ON THE WORLD

If the family receives a new multimedia computer for the holidays, it will undoubtedly come with *Microsoft Windows 95* pre-installed. But you can bring older computers up to speed with Microsoft's latest Windows 95 operating-system upgrade. Windows 95 not only promises to be easy to install—it also makes installing new "Plug-and-play" hardware and software a real breeze. The new Windows 95 graphical interface is even easier to use than Windows 3.1, the current version. Windows 95 is a 32-bit operating system, so it can run new 32-bit software. Perhaps most important, Windows 95 is compatible with most existing Windows software packages, and it promises to run them in a more stable environment. For best performance, you'll want to make sure that your computer has at least a 486DX CPU and 8 megabytes of RAM. If it doesn't, perhaps you might want to consider adding memory and processor upgrades to your gift list as well! Price: \$100.

CIRCLE 34 ON FREE INFORMATION CARD



Virtual i-glasses from Virtual i-O



18 MIDI Land's Free-D desktop microphone



The Sega Saturn system



Microsoft Windows 95



Broderbund's Alien Tales



L3 Interactive's Slopestyle

ALIEN ATTRACTION

Getting children to read—and to enjoy it—gets ever more difficult as other forms of entertainment compete for their attention. *Broderbund's Alien Tales* encourages reading among kids aged 9 to 13 years by exposing them to some of the greatest children's literature. Kids play against a celebrity panel of aliens who claim authorship of books from Earth. To match wits with those alien impostors, kids must read passages, answer questions, and solve puzzles to reclaim the famous works for their true authors. The CD-ROM contains some 450 passages, including plot synopses, excerpts, and author background from 30 lit-

erary books. Featured titles include *Charlotte's Web* (E.B. White), *The Outsiders* (S.E. Hinton), *The Adventures of Tom Sawyer* (Mark Twain), *The Call of the Wild* (Jack London), *Around the World in Eighty Days* (Jules Verne), and *The Wind in the Willows* (Kenneth Grahame). Price: about \$45.

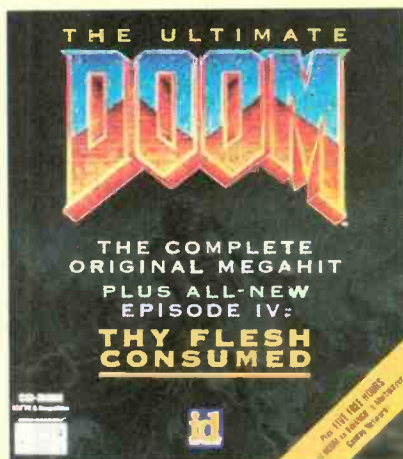
CIRCLE 35 ON FREE INFORMATION CARD

SNOWBOARD KNOW-HOW

Some kids will be dreaming of a white Christmas so they can try out their new snowboard. Because the weather doesn't always cooperate, consider giving *L3 Interactive's Slopestyle*, a "how-to" title that teaches everything about snowboarding, from the basics to advanced maneuvers. The title is available for 3DO Interactive Multiplayers and MPEG-compatible personal computers. It contains more than 50 minutes of extreme snowboarding action,



Merriam-Webster's Collegiate Dictionary, Deluxe Electronic Edition



The Ultimate DOOM from GT Interactive Software

including 27 lessons in full-motion video—the disk contains more than 50 minute's worth of video. The music that accompanies the lessons is from alternative rock bands including Jawbreaker, April's Motel Room, Wax, Glu Gun, Wool, and Inch. Price: about \$45.

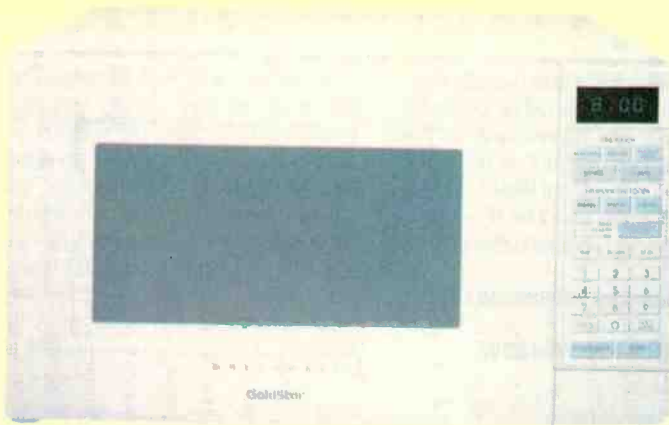
CIRCLE 177 ON FREE INFORMATION CARD

LOOKING IT UP

Merriam-Webster's Collegiate Dictionary, Deluxe Electronic Edition on CD-ROM makes a practical gift for any student on your gift list. Available for both Macintosh and Windows, the disc contains the full text of the print editions of *Merriam-Webster's Collegiate Dictionary, Tenth Edition* and *Merriam-Webster's Collegiate Thesaurus*. That's more than 160,000 dic-

Sirius Publishing's 3-Ft. 6-Pak





Goldstar's Multiwave II microwave ovens

tionary entries, and 130,000 synonyms, antonyms, related and contrasted words, and idioms. More than 1000 illustrations and tables are also included. The dictionary takes advantage of the computer platform in interesting ways. For example, information including the words, pronunciations, etymologies, part-of-speech labels, dates of first recorded use, and definitions are presented in distinct data fields, which can be searched individually. For example, you can produce a list of words first recorded in English in 1960. Or you can search fields in combination to find, for example, a list of slang nouns that come from Spanish. Hot-keys let you look up words while you are in other Windows applications. Word-game lovers will appreciate the puzzle-solving search options. Price: \$35.

CIRCLE 178 ON FREE INFORMATION CARD

A YARD'S WORTH OF FUN

Sirius Publishing provides one-stop CD-ROM shopping for your youngsters, with the *3-Ft. 6-Pak*, a three-foot-long compilation of six best-selling, full-version CD-ROMs from top publishers. The included titles are: *Lenny's Music Toons* by Paramount Interactive, a musical adventure that teaches children the basics of musical notation, pitch and harmony. *Our House*, from Context Systems, is based on the Family Circus comic strip. It teaches kids about household objects and about home life in past decades. *Cinderella, the Original Fairy Tale* from Discis Books increases kids' language and comprehension skills as the computer "reads" the entire story to children and explains unfamiliar words. *Basic Spelling Tricks* from Sierra

On-Line combines words, spelling, and puzzles with an adventure story in an attempt to boost kids' confidence and improve long-term memory skills as they head up the treacherous Spelling River, trying to avoid lions, tigers, and other dangers. *Sing-Along Kids*, from Sirius Publishing puts children at center stage and lets them sing to their hearts' content. The words to each song are displayed carefully paced with music, so the kids can learn about reading and spelling as they sing classics like "She'll Be Coming Around the Mountain," "Clementine," and eight others. *Putt-Putt's Fun Pack* by Hum

gungous contains six fun CD-ROM games designed to im-



Aiwa's CR-A24 armband radio

prove a kid's ability to think ahead. Included are three-dimensional puzzles and classics like tic-tac-toe and checkers. Price: \$29.95.

CIRCLE 179 ON FREE INFORMATION CARD



YOU'RE DOOMED!

... unless you come up with a title that's sure to get your jaded teen excited when he opens his gifts. *The Ultimate DOOM* from *GT Interactive Software* is available for the IBM-PC both on floppy and CD-ROM. The new, nine-level episode of the popular DOOM series also comes with five free hours on DWANGO, the Dial-Up Wide Area Network Game Operations that links up millions of DOOM and DOOM II players. Subscription Prices: \$20 for ten hours, or \$35 for twenty hours.

CIRCLE 180 ON FREE INFORMATION CARD

WAVE OF THE FUTURE

Keep your family well fed with a minimum of fuss and bother with one of *Goldstar's Multiwave II* microwave ovens. The Multiwave II system reduces cold spots in food by dispersing microwaves more evenly. Three international food keys—Italian, Spanish, and Oriental—are preprogrammed for heating such ethnic specialties as lasagna, burritos, or sweet-and-sour chicken, as well as popular brand-name frozen foods. An EZ ON key activates the oven at programmed cook times in 30-second intervals. The Auto Weight Defrost function takes the guess-work out of defrosting foods. A self-instruction display guides you through the programming process. The 900-watt, 1.5-cubic foot *MA-1523* also offers a child-proof safety-lock mechanism. Price: \$299.95

CIRCLE 108 ON FREE INFORMATION CARD

TELE-PHONE/VISION

Make easy work of managing the household's personal information needs—including telephone answering, electronic banking and bill-paying, topic-specific news items, local traffic and weather, sports scores, and daily stock and portfolio updates—with AT&T's *TV Information Center*. The device provides easy access to interactive information and telephone-answering services by linking the telephone and the television, allowing information delivered over regular phone lines to be displayed on the TV screen. A handheld remote control is used to operate on-screen menu of information and phone-answering services, and can also control many brands of TVs and VCRs. Price: \$329.

CIRCLE 109 ON FREE INFORMATION CARD



Sunsound Straps

HOME VOICE MAIL

Give your family members some privacy, with *Cobra's AN-8630* digital answering system and cordless telephone. The answering system features one general "mailbox" plus four individual mailboxes for personal messages. It can hold six separate greetings and 20-minutes of recorded messages. Individualized access codes ensure privacy for each user. Calls can be screened from the base or the handset, and the handset can also be used to access the answering system. Privacy is also built into the telephone portion of the unit, where Private Call scrambling circuitry prevents accidental or deliberate eavesdropping on cordless conversations.



ProLine's Compact Disc Storage Cases

The phone also features Cobra's Intenna system; built-in handset and base antennas leave nothing to bend or break. A two-way intercom system with page/find signals allows a person near the base to talk to someone using the handset in a different location. Price: \$229.95.

CIRCLE 110 ON FREE INFORMATION CARD

STRAP ON THE SOUND

Before you're ready to roll—or ski, jog, paddle, or hike—you probably put on your sunglasses and grab your personal stereo. Now you can eliminate some of the sports-gear clutter with *Sunsound*



Cobra's AN-8630 digital answering system



The EZ-CD from MacTec Products

MANUFACTURER INFORMATION

AIWA AMERICA, INC.
800 Corporate Drive
Mahwah, NJ 07430
Tel. 201-512-3600

AT&T
5 Wood Hollow Road
Parsippany, NJ 07054
Tel. 201-581-3000

AUDIOSOURCE, INC.
1327 North Carolan Ave.
Burlingame, CA 94010
Tel. 415-348-8114

BOSE CORPORATION
The Mountain
Framingham, MA 01701-9168
Tel. 800-444-BOSE

BRODERBUND SOFTWARE, INC.
500 Redwood Blvd.
P.O. Box 6121
Novato, CA 94948-6121
Tel. 415-382-4400

COBRA ELECTRONICS CORPORATION
6500 West Cortland Street
Chicago, IL 60635
Tel. 312-889-8870

FISHER
21350 Lassen Street
Chatsworth, CA 91311-2329
Tel. 818-998-7322

FUTURETOUCH CORPORATION
2020 East Fourth Street #152
Santa Ana, CA 92705
Tel. 714-558-6824

GOLDSTAR U.S.A., INC.
1000 Sylvan Avenue
Englewood Cliffs, NJ 07632
Tel. 201-816-2000

GT INTERACTIVE SOFTWARE
16 East 40th Street
New York, NY 10016
Tel. 212-679-6850

HITACHI HOME ELECTRONICS (AMERICA)
3890 Steve Reynolds Blvd.
Norcross, GA 30093
Tel. 800-241-6558

INFINITY SYSTEMS, INC.
20630 Nordhoff Street
Chatsworth, CA 91311
Tel. 818-407-0228

KENWOOD USA CORP.
P.O. Box 22745
Long Beach, CA 90801-5745
Tel. 310-639-9000

L3 INTERACTIVE
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Santa Monica, CA 90404
Tel. 310-264-4188

MACTEC PRODUCTS
21416 Velicata Street
Woodland Hills, CA 91364
Tel. 800-MACTEC-1

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440 Medinah Road
Roselle, IL 60172
Tel. 708-307-3100

MERRIAM-WEBSTER INC.
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Springfield, MA 01102
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MICROSOFT CORPORATION
One Microsoft Way
Redmond, WA 98052-6399
Tel. 206-882-8080

ONKYO U.S.A. CORPORATION
200 Williams Drive
Ramsey, NJ 07446
Tel. 201-825-7950

PACKARD BELL
1 Packard Bell Way
Sacramento, CA 95826
Tel. 916-388-0101

PANASONIC
One Panasonic Way
Secaucus, NJ 07094
Tel. 201-348-7000

PROLINE/AMI CORPORATION
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Denver, CO 80227-0683
Tel. 800-325-0853

PROTON
13855 Struikman Road
Cerritos, CA 90703
Tel. 310-404-2222

ROTEL OF AMERICA
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North Reading, MA 01864-0008
Tel. 800-370-3741

SEGA OF AMERICA
255 Shoreline Drive
Redwood City, CA 94065
Tel. 800-SEE-SATURN

SEIKO INSTRUMENTS USA INC.
2990 West Lomita Blvd.
Torrance, CA 90505
Tel. 310-517-7700

SENNHEISER ELECTRONIC CORP.
6 Vista Drive
P.O. Box 987
Old Lyme, CT 06371
Tel. 203-434-9190

SHARP ELECTRONICS CORPORATION
Sharp Plaza
Mahwah, NJ 07430-2135
Tel. 800-BE-SHARP

SIRIUS PUBLISHING, INC.
7320 East Butherus Drive, Suite 100
Scottsdale, AZ 85260
Tel. 800-247-0307

SONY ELECTRONICS INC.
1 Sony Drive
Park Ridge, NJ 07656
Tel. 201-930-1000

SUNSOUND CORPORATION
4848 South Highland Drive, Suite 248
Salt Lake City, UT 84117
Tel. 801-942-2425

TECHNICS
One Panasonic Way
Secaucus, NJ 07094
Tel. 201-348-7000

THOMSON CONSUMER ELECTRONICS
10330 North Meridian Street
Indianapolis, IN 46290-1024
Tel. 317-587-4450

UNIVERSAL ELECTRONICS INC.
1864 Enterprise Parkway West
Twinsburg, OH 44087
Tel. 216-487-1110

VIRTUAL I-O INC.
1000 Lenora Street, Suite 600
Seattle, WA 98121
Tel. 206-382-7410

Straps. Available in a range of fashion colors, they look just like the straps worn to prevent glasses from getting lost. But they add tiny earbud speaker assemblies, equipped with samarium-cobalt magnets to produce excellent high-fidelity sound. The straps plug into any portable radio, CD, or cassette player. A "tail-piece jack" allows them to be worn without the audio cord attachment, and provides a safety release in case the cord gets tangled. Price: \$24.95, plus \$3 shipping and handling.

CIRCLE 111 ON FREE INFORMATION CARD

OPEN CD-SESAME

If you've ever struggled to get a new CD out of its shrink-fit plastic wrap, you can appreciate the *EZ-CD* from *MacTec Products*. The small plastic device features a

precision blade set off-center to cut along the ridge of the jewel-box spine. It severs both the shrink wrap and the factory seal in one stroke. No more searching for a knife or scissors—a two-piece Velcro fastener with adhesive backing allows you to store the *EZ-CD* for safe-keeping wherever CDs (or CD-ROMs) need to be opened. Price: \$2.99.

CIRCLE 112 ON FREE INFORMATION CARD

COLOR-CODED COLLECTION

Have your compact-disc and CD-ROM libraries gotten out of hand? Do you find your favorite discs mixed in with your kids' collections? *ProLine's Compact Disc Storage Cases* and their inside trays are molded in transparent red, blue, green, smoke, and clear, allowing you to color-code your

CD and CD-ROM collections. Assign a different color to each type of music, or to each family member. Each color is available in packs of five; multi-color five- and ten-packs are also offered. Price: five-pack, \$5.95; ten-pack, \$10.95.

CIRCLE 113 ON FREE INFORMATION CARD

ARMBAND RADIO

Stay unencumbered with *Aiwa's CR-A24* armband radio. Designed for use while engaged in sports activities, the AM/FM stereo radio is worn on the arm, attached with a Velcro strap. The strap is reflective for added safety after dark. *Aiwa's Super Bass* circuitry and *Power Bass* headphones provide big sound from the tiny radio. Price: \$30.

CIRCLE 114 ON FREE INFORMATION CARD

MULTIMEDIA WATCH

By Marc Spiwak

A New Multimedia Keyboard

Keyboards have certainly been around as long as computers, and even longer if you want to be technical about it. But the basic computer keyboard design hasn't really changed all that much over the years. If anything, most newer keyboards are much lighter and more stripped down than they used to be. But the basic layout hasn't changed.

That's not to say that there haven't been several attempts to "update" the conventional keyboard, including ones with

Recently, however, I had the pleasure of testing out a rather unusual-looking keyboard, one that retains the traditional keyboard layout. It's unusual because it houses stereo speakers; power-level indicators; an amplifier; volume, bass, treble, and balance controls; a microphone; and more. While it's not the sound system you want for an all-out, high-end multimedia system, it is perfect for some applications.

A KEYBOARD WITH SOUND

The *Platinum Sound MSK-200* is the top-of-the-line multimedia keyboard from SC&T². The MSK-200 basically adds the amplifier, its controls, and power indicators to its little brother, the *MSK-100*. The MSK-200 comes in black and includes a matching black-foam rubber wrist rest. While the keyboard has the same width as a regular keyboard, it is a bit deeper to accommodate its extras. Two 4-inch, 16-watt, magnetically shielded speakers are mounted on the top left and right of the extended keyboard base. Slide controls for volume, bass, treble, and balance fit between the speakers, and LED power-level indicators are placed above the controls. A 13-watt stereo amplifier drives the speakers. An AC adapter supplies power to the amp.

The MSK-200 also includes a built-in microphone so there's always

one around when you need it. It also has a jack for an external microphone, which eliminates the need to reach around to the back of the sound card to connect one. For private listening, a built-in headphone jack can be used with the pair of included headphones.

Cables for all of its features are permanently connected to the keyboard. They connect to a computer in the same way as separate peripherals would. It really is very convenient to have an entire sound system complete with controls built into the keyboard. The only problem I have with it, and it's a very slight one, is that the monitor must be placed a little bit farther away from the keyboard than I'm used to. The deeper keyboard is also a tight fit on my crowded desktop.

The MSK-200 is not intended to be the heart of a family-entertainment PC. However, that multimedia keyboard is the perfect companion for computers used in schools, libraries, and at the office, where separate speakers and microphones are just asking to be broken, lost, or stolen. It's also good where desk space is at a premium or when a cluttered look is unacceptable. Sound quality is more than adequate for such situations.

NEW STUFF

This being the last issue of Popular Electronics for 1995,



The MSK-200 multimedia keyboard, with built-in amplifier, speakers, and microphone, will put an end to cluttered desktops.

rearranged keys, split keyboards, and keyboards sculpted to fit your hands, but I believe that because most people can't touch type very well (myself included), the conventional layout is the one most people are familiar and most comfortable with. And for most, I think it's going to stay that way.

it's good that I was able to squeeze in the 1995 *Guinness Multimedia Disc of Records* from *Grolier Electronic Publishing*. The Guinness Book of Records has probably won more bets for people than any other—or lost them, depending on how you view it. The CD-ROM version of the book includes lists of the biggest, the smallest, the hottest, the coldest, the fastest, and the slowest of everything there is. Everything else on record is there, too. The 1995 Guinness Multimedia Disc of Records contains everything from the book, plus video clips, audio, and sound effects. The disc has a list price of \$49.95.

I recently received the latest update to *Books in Print Plus* from *Reed Reference Publishing*. That is basically a database of all books that are in print. A deluxe version of the disc includes 238,000 book reviews, and sells for about 50% more than the one without reviews. The power of a computer and a CD-ROM make it easy to find what you are looking for. If there's a book in print on a certain subject, by a particular author, or whatever, you can find it with *Books in Print*. Pricing is geared more toward library or retail book-seller use than for an individual. A year's subscription to the disc sells for \$1095 for the regular version and \$1595 a year for the version that includes the reviews. For that price, an update disc is mailed to the user each month. While the product is DOS-based only, a Windows version is due out soon. As expensive as this disc is, it's also one of the most useful CD-ROMs around, especially for libraries or book sellers.

Full Throttle is a new action-adventure game from



Visit Nile: Passage to Egypt on one of the Discovery Channel's CD-ROMs.

LucasArts. The player is Ben, a hard-core biker gang leader who has been double crossed and framed for murder. Separated from his gang, he must hunt down the real killer and clear his name. Blended 3D and 2D animation and stereo sound set the stage. Actor Mark Hamill (*Star Wars*) does the voice-over for the main villain in the game.

If you like ocean life, you'll love *Coral Reef!* from *Arnowitz Studios*. This disc lets you descend below the ocean's surface and explore its sights and sounds. The disc includes 60 minutes of video produced by the creators of the NOVA documentaries and over two hours of underwater sounds, narration, and music. There are also beautiful watercolors, stories, tours, and more. *Coral Reef* has a suggested retail price of \$59.95.

The *EZ-Locator* disc from *Spica, Inc.*, is intended to help you locate online services and bulletin boards from over 3100 listings. Twenty four pre-sorted fields and key-word searches allow you to quickly find what you are looking for. Also included are over 800 e-mail listings from Bill Clinton

to Bill Gates. Tell *Spica* that you heard about the disc here and it's yours for only \$14.95.

More discs, that's what I always say. *The Super 10 Pack* from *Essex Interactive Media* bundles 10 titles for only \$29.95. There's something for everyone in the family here, all at a rock-bottom price. There's actually an 11th free disc, a CompuServe demo CD. The 10 titles include *That's Geek To Me* with Dennis Miller's witty computer definitions, the *Simply Money* financial-planning tool, the *MPC Wizard* multimedia test and tune-up disc, fun and games with *Dandy Dinosaurs*, *Americans in Space*, the *Cascoly Picture Puzzles Volume 2—Birds*, *Double Doozy* screen savers and screen art, *Aviator* learning adventure, *First Strike* Desert Storm game, and *Lucy is Lost/Gus is Gone* adventure game for kids. Whew!

I.M. Meen from *Simon & Schuster Interactive* is a new action/learning game for kids ages 9 and up. Open Ignatius Mortimer Meen's book and you're drawn into a 36-level labyrinth of fun and games. Kids get to have fun while at the same time practicing reading and grammar skills.

VENDOR INFORMATION

Arnowitz Studios

One Harbor Drive, #200
Sausalito, CA 94965
CIRCLE 50 ON FREE INFORMATION CARD

Discovery Enterprises

7700 Wisconsin Avenue
Bethesda, MD 20814
CIRCLE 51 ON FREE INFORMATION CARD

Essex Interactive Media

560 Sylvan Avenue
Englewood Cliffs, NJ 07632
CIRCLE 52 ON FREE INFORMATION CARD

Grolier Electronic Publishing, Inc.

Sherman Turnpike
Danbury, CT 06816
CIRCLE 53 ON FREE INFORMATION CARD

Jasmine Multimedia

6746 Valjean Avenue
Van Nuys, CA 91406
CIRCLE 54 ON FREE INFORMATION CARD

LucasArts Entertainment Company

P.O. Box 10307
San Rafael, CA 94912
CIRCLE 55 ON FREE INFORMATION CARD

Reed Reference Publishing

121 Chanlon Road
New Providence, NJ 07974
CIRCLE 56 ON FREE INFORMATION CARD

SC&T²

3837 LaSalle Street
Phoenix, AZ 85040
CIRCLE 57 ON FREE INFORMATION CARD

Simon & Schuster Interactive

1230 Avenue of the Americas
New York, NY 10020
CIRCLE 58 ON FREE INFORMATION CARD

Spica, Inc.

P.O. Box 158
Grand Marais, MN 55604
CIRCLE 59 ON FREE INFORMATION CARD

Two new titles from *Jasmine Multimedia* include *Country Vid Grid* and *Wild West*. In *Country Vid Grid*, players must put country music videos back together after they have been broken up into a number of squares. The trick
(Continued on page 85)

Now! NRI gives you 3 great ways to make money in a computer career!

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2 Prepare for today's hot new multimedia programming opportunities

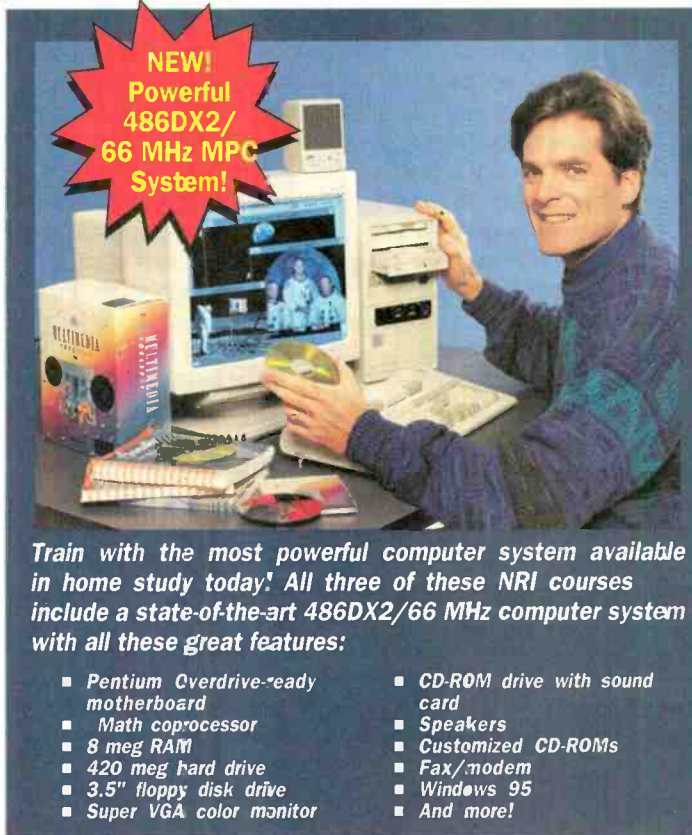
Pick up any computer magazine and you'll realize that multimedia is here to stay. If you can create the kinds of contemporary multimedia programs that make everything — from shopping to education to business presentations — easier and more exciting, you can expect financial success and job security.

NRI's newest programming course helps you explore multimedia from square one, so nothing will be a mystery to you as you bring text and graphics to life with sound, animation, and photo-quality images.

You learn how to take full advantage of the extraordinary capabilities of the 486DX2/66 MHz multimedia PC you train with and keep. As you become skilled with the

professional-level Asymetrix ToolBook authoring software also included in your course, you'll be able to add drama and

impact to all your computer applications, ultimately creating the kinds of dynamic programs that will put you at the forefront of multimedia technology.



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- Fax/modem
- Windows 95
- And more!

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No other training — in school, on the job, anywhere — prepares you so thoroughly for today's money-making opportunities in computer service. And only NRI builds meaningful training around the kind of powerful computer system you'll be called on to service and repair in the real world.

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NET WATCH

By Dan Karagiannis

Music Online

Want a great way to get some Christmas shopping done without even leaving your home? Well, if you're on the Net, and you happen to have some music lovers on your list, then you're all set.

This month, we'll take a look at three CD and tape stores on the World-Wide Web. All of the sites have something unique to offer, whether it's affordable prices, wide selection, or even images of the CDs and tapes you'd like to buy,

many titles as well, but when I searched for some hard-to-find import CDs on the Net, CDnow was the only site/store to offer them.

When you log on to the site, you are presented with a few options. First of all, if your connection to the Internet is a bit slow or shaky, you can enter a text only version of the store. Otherwise, you can enter the graphics-enhanced version of CDnow.

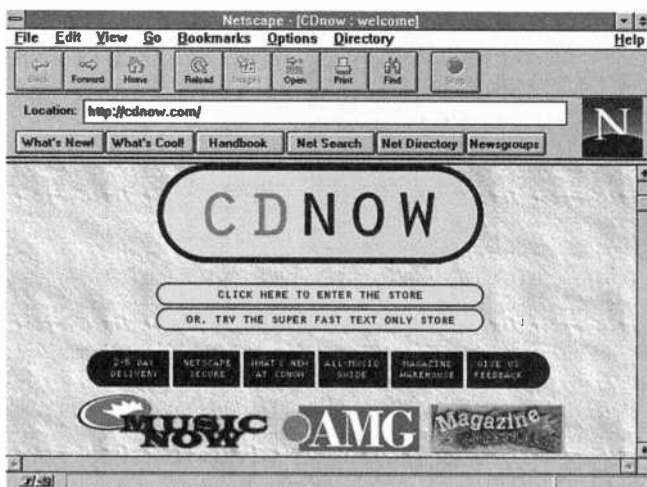
The search engine of CDnow is simple to use; just type the name of the artist or CD or video you're looking for in the box. When the engine finds what you're looking for, it presents you with a link to a biography of the artist, album reviews, and even track listings. Some biographies even have a photo or photos (the biographies and reviews are compiled from *All-Music Guide*, the music industry's leading information-database provider).

The prices are cheaper than you'd pay at most music stores, but you do have

to pay postage and handling. Ordering more than a couple of items can help lower the per-item cost of course. In the end, buying from CDnow should cost about the same as doing so from a reasonably priced music store.

CDnow claims a delivery time of two to six business days for most titles, and will airmail to most countries. The company accepts Visa, MasterCard, American Express, U.S. checks, and U.S.-denominated money orders.

For those who wish to pay with a credit-card number while online, CDnow provides Netscape-secure transactions and PGP encryption (Don't have Netscape or PGP software? Just download either from the links CDnow provides.) Customers can also phone or Fax their credit-card information after placing an order. No credit-card charges are actually made until the order is ready to ship. That's a good feature because some import items

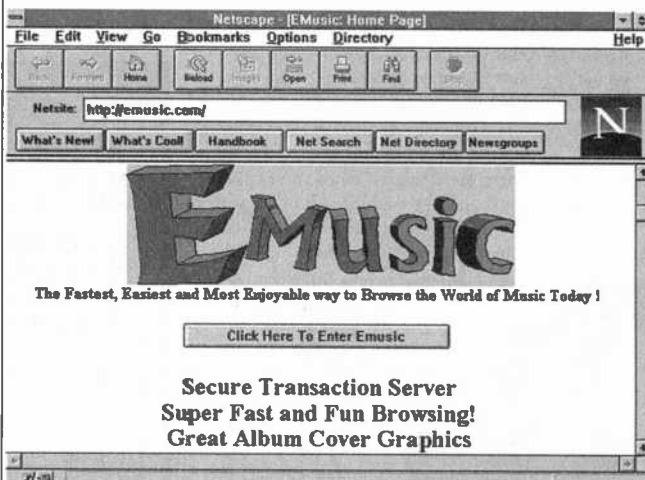


CDnow provides a convenient way to order over 100,000 music CDs (including many hard-to-find ones), and even lets you subscribe to more than 300 magazines.

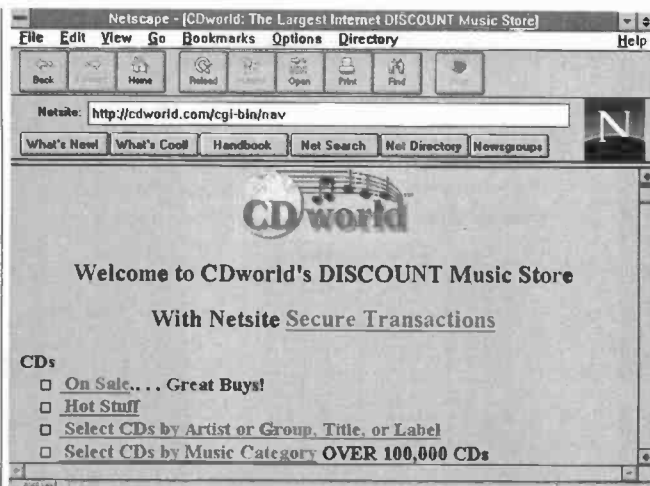
Following the music-store coverage, we'll turn our attention to some sites of interest to electronics hobbyists. In keeping with the music theme, this month's hobbyist sites deal with everyone's favorite electronic instrument: the theremin.

SHOPPING AT HOME

First up this month is CDnow, a truly impressive site that features a selection of over 100,000 CDs. Other companies do carry that



With EMUSIC, you can easily keep track of what CDs you wish to purchase in the future.



CDworld might not be as visually attractive as the other Internet music stores, but the site's inexpensive prices will definitely be attractive to your wallet.

might not be immediately available, and could end up not being available at all.

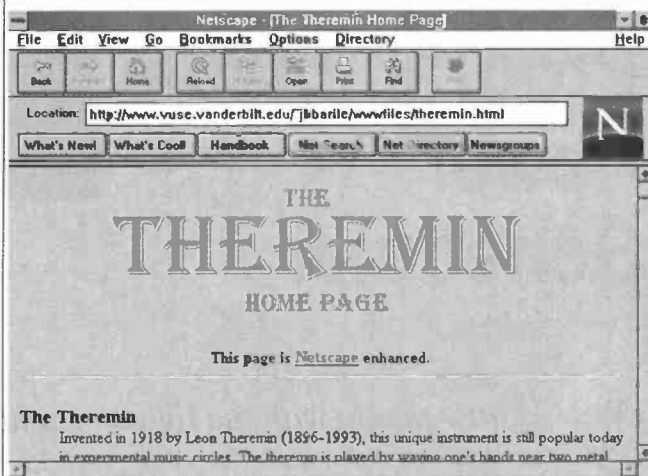
Also accessible at the CDnow site is the Magazine Warehouse. That service offers you a selection of more than 300 magazines at the guaranteed lowest prices. Just click on the Magazine Warehouse logo after entering the site.

Next up is EMUSIC, a site with features similar to those of CDnow. The site also has the capability to search for a particular CD from a list of 100,000. However, as mentioned earlier, the site doesn't seem to carry many (if any) hard-to-find imports.

If that doesn't bother you, though, you will find EMUSIC to be superior to other sites of its kind for a couple of reasons.

For starters, EMUSIC has images of most of its inventory available at a click of a selected item. That's front and back images of thousands of CDs, which comes in real handy if you just remember seeing a certain CD by an artist, but don't quite remember the name of it.

Another great feature of EMUSIC, which is really easy to use, is its Personal Music Catalogue Program. That lets you keep track of your own CD collection and lets



The Theremin Home Page lets you link up with all the information you need to build or buy a theremin.

you generate a wish list for CDs you might want to get at a later date. Then, in future visits, you can simply access that list and order items from it, instead of having to look for those items online again.

EMUSIC is definitely a site to keep your eyes on. In the future they plan on having downloadable sound clips of albums. Just like the listening stations of music stores, the sound clips will make it possible for consumers to be certain that they like what they're about to buy. Also coming to the site are biographies of artists, which will make EMUSIC a formidable competitor to CDnow.

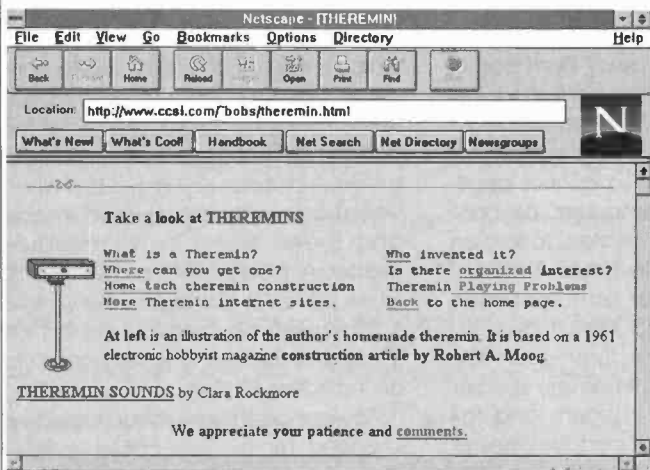
Well, so far we've compared EMUSIC and CDnow on the basis of appearance and content. But

what about price? For the most part, EMUSIC has prices that are very close to CDnow. In fact, for the consumer deciding which company to go with, there's not much difference between the two in terms of price.

Our last online store, however, is a bit on the cheaper side than the two we've looked at. The site, CDworld, carries the subtitle of "The Largest Internet Discount Music Store." And it lives up to its name.

I took five sample prices from CDnow and EMUSIC and compared them to the prices in CDworld. They averaged about two dollars cheaper in CDworld. Not an enormous difference, but if you're ordering a few items, it adds up.

(Continued on page 89)



Want to learn some theremin basics? This site should satisfy that need quite nicely.



VersaTimer Programmable Power Scheduler



CIRCLE 119 ON FREE INFORMATION CARD

Work a little magic with the lights in your home when you're away with VersaTimer.

Everyone is probably familiar with the common appliance timer. We use those to control lights in our homes when we're away, to automatically control plant and fish-tank lighting, and so on. Generally, they usually turn something on and off only once in a 24-hour period. Of course, there are also some fancier timer devices that have crude programming features to add a little variety to timing cycles.

There are also the specialty devices designed to boot or reboot a computer without you being there. Then there are the specialty outlet adapters that allow you to turn on devices from the power switch of another. But wouldn't it be great if one device could do the work of all those others? There is—the timer of the future is here with *VersaTimer* from *Server Technology, Inc.*

VersaTimer is basically a programmable appliance timer with three outlets on the back that all work in unison. One program controls all three outlets at the same time; outlets cannot be controlled individually. *VersaTimer* can supply a total current

load of up to 10 amps. The device is programmed from the serial port of a PC. So you need a PC that runs DOS or Windows to program the device. Software that installs and runs in either operating system is included.

The 7-day timer is programmed to turn its outlets on and off at 15-minute intervals for up to 700 control events per week. A program is loaded serially from a PC to the timer through a supplied cable or via a modem.

With *VersaTimer* controlling the lights while you're away from home, there's no predictable pattern for the burglars to notice. You can create as unpredictable a lighting pattern as you like. You can also control appliances, such as computers, air conditioners, fans, and heaters, to turn on only during certain hours. That not only saves on power consumption; in the case of computers it also increases security by turning on the equipment only at times you specify.

You could allow modem and fax transmissions only at certain times of the day or prevent people from turning on your computer when you're not there. You could also have a comput-

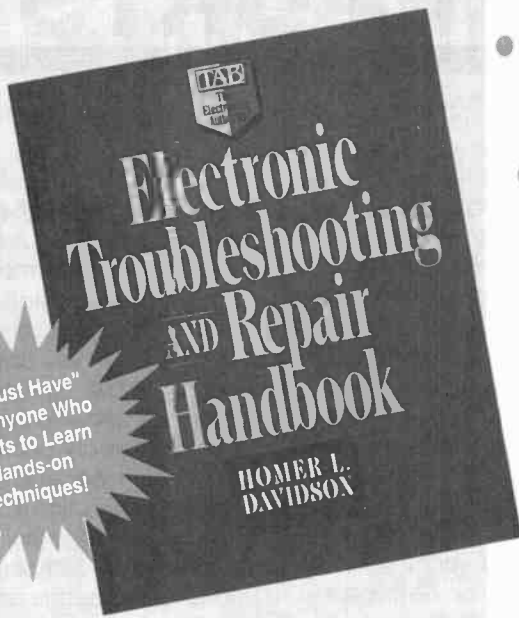
er turn on automatically for a nightly backup. Special features built into *VersaTimer* allow a clean, automatic reboot of a computer once a day. In another operating mode, the on/off switch on an appliance such as a monitor or lamp plugged into a "smart" outlet will automatically turn on anything else plugged into the other two outlets. All that versatility runs just \$109.95.

How It Works. Looking over the unit, which is the size of a small cable-converter box, the only control that you see is an on/off switch that turns the outlets on and off in the manual mode. A bi-color LED glows red when *VersaTimer* is in the manual mode and green when in its schedule mode. A power LED glows green when power is applied to the outlets. A grounded power-input socket on the side of the unit supplies power via an included AC line-cord.

A telephone-style jack on the side is provided for a serial cable (a telephone cable, actually) that connects to a PC's serial port via an included 9-

(Continued on page 92)

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PRODUCT TEST REPORTS

By Stephen A. Booth

Samsung VR8905 Hi-Fi VCR

There is a danger here of praising Samsung's new top-of-the-line VCR on account of something you normally do not see on your TV, but that makes possible the deck's most intriguing feature. The unseen hero is the VBI—vertical blanking interval—a brace of 21 scanning lines reserved for broadcast housekeeping that remain off-screen on correctly adjusted sets. It's here, concealed in the VBI, where Public Broadcast System (PBS) stations transmit

gram guide and programming guide would be a formidable feature in any VCR. Here, it complements the other high-end features such as jog/shuttle tape control for pin-point editing; hi-fi stereo recording; a real-time tape counter; and "Skip-Search" for powering past any recorded commercials.

Performance-wise, the VR8905 is worthy of its bells and whistles. Although it didn't set any records during bench tests at the Advanced Product Evaluation Laboratory, Samsung's new entry finishes well in the money among VCRs of its ambitious class.

FEATURES

As the StarSight system is both new and a value-adding feature of the VR8905, it pays to spend some time reviewing it. First off, it's something you pay for—a subscription service that's displayed and delivered electronically instead of in digest-book form and by mail. At about a dollar a week, it is competitive with magazine-type printed guides, and those can't program your VCR for you!

StarSight set-up couldn't be simpler. Everything is done through the combined Samsung/StarSight remote control (which also operates most TVs and cable boxes).

The first step is to perform a basic VCR-setup procedure, which memorizes a roster of all the TV channels you're able to receive. Next,

you tune to the PBS station in your area (channel-numbers and call-letters are listed in the owner's manual) or to the PBS channel assigned by your cable-TV provider. When you access the StarSight set-up menu, the system analyzes the channel-memory and PBS signal and furnishes your StarSight registration ID.

A toll-free call to StarSight completes the authorization process, and begins downloading program information to the memory board in the VCR. The initial download takes 4 to 12 hours—a function of your PBS station's position in the batch-data queue, and the sheer quantity of seven-days'-worth of broadcast schedules and program descriptions.

Throughout that vigil, you must keep the VR8905 tuned to the PBS channel. Subsequent dumps are briefer—only the seventh day is being sent—and virtually transparent. You'll select a data-reception time that's convenient (when you're not watching TV and when your PBS station is operating). As a default, StarSight will update the files whenever you're tuned to PBS.

StarSight organizes schedule information in a variety of ways. Those include daily time-grids for all stations and for single stations. You can peruse the telecast schedule by genre (e.g., movies, news, sports, education, etc.) or by theme (e.g., comedy,



CIRCLE 120 ON FREE INFORMATION CARD

Samsung's VR8905 hi-fi VCR features the StarSight on-screen programming guide.

the StarSight Telecast on-screen programming guide, the marquee attraction in Samsung's VR8905.

The StarSight service does more than list and describe a week's worth of TV fare at a time. When incorporated in a videocassette recorder, StarSight's point-and-click menu provides a simple and nearly "villain"-proof way to program a VCR for unattended recording. The VBI-borne signal even sets the VCR's clock automatically, and keeps it in sync with broadcast time.

The combination of pro-

TABLE 1—TEST RESULTS

Brand	Samsung
Model	VR 8905 VHS Hi-Fi VCR
Price	\$550
Video Measurements (SP Mode)	
Frequency response	-3.37 dB @ 2.0 MHz -13.4 dB @ 3.0 MHz
Signal-to-Noise Ratios	
Luminance Level	
@ 100 IRE	45.5 dB
@ 50 IRE	45.8 dB
@ 10 IRE	45.2 dB
Chroma AM	48.0 dB
Chroma PM	44.3 dB
Audio Measurements (HiFi Recording)	
Output @ 0 dB (1 kHz)	2.40 volts
THD @ 0 dB (1 kHz)	2.41%
Flutter (DIN)	
Average	0.002%
Peak	0.003%
Signal-to-Noise Ratio	84.7 dB
Frequency Response (-3 dB)	20 Hz to 20 kHz
Record/Play THD (@ -10 dB)	
@ 100 Hz	0.64%
@ 1 kHz	0.36%
@ 5 kHz	1.48%
(Conventional Recording)	
Output @ 0 dB (1 kHz)	0.49 volts
THD @ 0 dB (1 kHz)	2.90%
Flutter (DIN)	
Average	0.04%
Peak	0.06%
Signal-to-Noise Ratio	50.1 dB
Frequency Response (-3 dB)	90 Hz to 10.8 kHz
Record/Play THD (@ -10 dB)	
@ 100 Hz	0.95%
@ 1 kHz	0.48%
@ 5 kHz	1.52%
MTS Stereo TV Decoder Measurements (Stereo Mode/Left Channel)	
Signal-to-Noise Ratio (re 100% modulation)	58.4 dB
THD (@ 1 kHz -20 dB)	0.19%
Frequency Response*	44 Hz to 10.9 kHz
Separation*	25 dB
(Mono Mode)	
Signal-to-Noise Ratio (re 100% modulation)	61.1 dB
THD (@ 1 kHz -20 dB)	0.45%
Frequency Response (re 100% modulation)	30 Hz to 3.3 kHz
(S.A.P. Mode)	
Signal-to-Noise Ratio (re 100% modulation)	51.7 dB
THD (@ 1 kHz -20 dB)	0.81%
Frequency Response (re 100% modulation)	64 Hz to 7.4 kHz
Additional Data	
Fast Forward Time (T-120 tape)	2 min. 10 sec.
Fast Rewind Time (T-120 tape)	1 min. 53 sec.
Power Requirements	17 watts
Weight	9.75 lbs.
Dimensions (H x W x D, inches)	3.625 x 15.625 x 13

* Frequency response and stereo separation for Multichannel TV Sound broadcasts are measured using real-world reception conditions of -20dB relative to 100% signal modulation

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drama, sci-fi, children, etc.). Pop-up windows list the time slot and channel of a program, and a capsule description including MPA rating if available and applicable.

It's from those grids and windows that you program your time-shift recording. When you highlight a show in the grid and press "Record," a pop-up window asks how often you want to tape the selection (once, daily, or weekly) and at what tape speed (SP or SLP). Once you've made your call, that program becomes highlighted in red on the program grid. Yet another menu keeps track of your recording list (up to 25 events). If you've scheduled a conflict (for example, a time overlap), the menu will alert you by a question-mark symbol.

StarSight anticipates

snafus, but isn't foolproof. For example, if you program one recording through the StarSight menus and another via Samsung's own (and very good) on-screen recording guide, the StarSight selection takes precedence in any conflict. As with any VCR, loading a tape of sufficient duration is your responsibility.

Here, the VR8905 has a neat menu that cuts you some slack. Whenever you load a blank cassette, you can indicate its length (T-120, T-160, or T-180). The VR8905 keeps track of remaining time according to the record mode (SP or SLP) you've selected. If you select the auto record speed, the VCR will decide between modes depending on the amount of tape available and the length of the programmed recording. For your information,

the VR8905's real-time tape counter gives you a minutes and seconds readout of tape-time remaining and elapsed.

FUNCTIONS

The VR8905 controls cable TV converter boxes via a clip-on "mouse" that serves as an infrared repeater. Both the cable controller and the VCR's remote control can be programmed to operate virtually any brand of cable box and TV set (the brand codes are provided in the manual).

As mentioned previously, the VR8905 is a hi-fi stereo deck. Besides playing pre-recorded tapes with hi-fi soundtracks, it will record two-channel audio on its helical tracks and monaurally on the tape's linear audio track. That arrangement provides some flexibility in editing and post-production for home-movie enthusiasts—who probably will buy the VR8905 for its jog-dial/shut-tele control.

That item is a concentric dial and ring located on the faceplate of the VCR (and thoughtfully replicated on the remote control). It gives you greater control over the movement of the tape beyond the usual play, pause, stop, and fast-forward/reverse. For example, you can search for a scene in either direction at rates varying from 1/30th and 1/2th normal speed up through 9x normal. In the still mode, you can control tape movement one frame at a time—an important feature when editing. Camcorder owners should note that there's a set of convenient AV inputs on the deck's front panel.

PERFORMANCE

The VR8905 acquitted itself nobly in electrical tests at APEL. You'll find the raw

numbers in the accompanying chart. Video resolution was par for the format, with frequency response down 13.4 dB at the 3-MHz point. The sharpness does not come at the expense of excessive noise. The luminance signal-to-noise ratio was good: about 45.8 dB at the 50-IRE level. Color S/N was excellent at 48 dB for AM and 44.3 for PM.

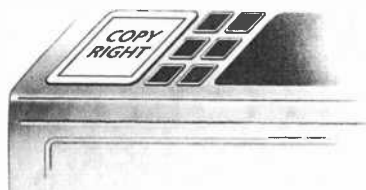
For audio recording, noise and distortion measurements were very good in both the hi-fi-stereo mode and the conventional- or linear-audio section. Regarding the latter, frequency response was typical, rolling off at 10.8 kHz.

Measurements for the MTS broadcast stereo decoder will delight videophiles. The all-important channel separation in stereo reception proved outstanding, at 25 dB, and over a decently broad frequency range of 44 Hz to 10.9 kHz. Signal-to-noise ratio (58.4 dB) is good, but could be better. Distortion is insignificant.

Reception performance for the monaural, SAP (Second Audio Program) channel is a mixed bag: wide frequency response, which probably accounts for the mediocre noise and distortion figures. Mono reception was just the opposite—low noise and THD, but the bandwidth would only be satisfactory in a telephone or AM radio. Your best bet would be to go only with the stereo mode, which probably is the reason for buying a high-end machine like the VR8905 in the first place. ■

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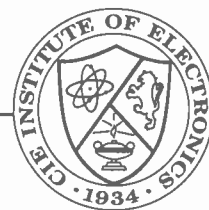
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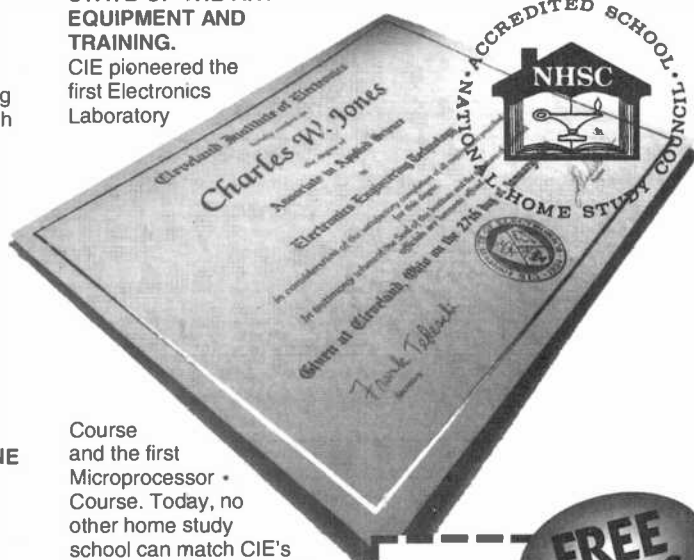
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Want an extra Christmas decoration that doesn't shed needles, require water, or take up a lot of room? If that's the case, then the *Electronic Xmas Tree* described in this article is definitely for you. It's a simple project that is sure to be an eye-catching conversation piece when finished.

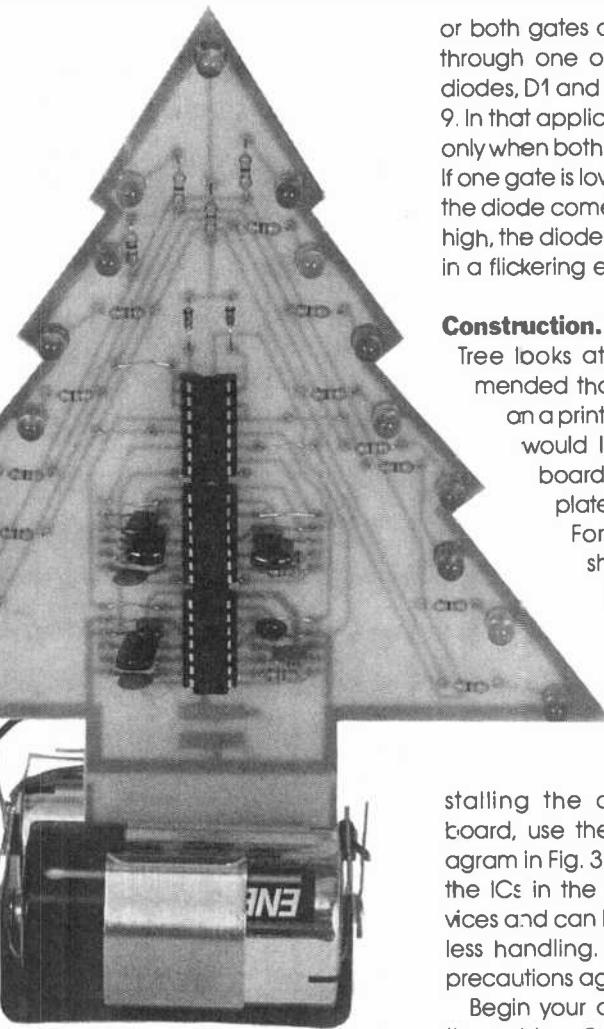
Of course, the little Xmas Tree is not meant to replace the full-sized Christmas tree on your floor. But it could help brighten up a desktop, bookshelf, or some other place with holiday cheer by blinking its LEDs in a seemingly random fashion.

Even though there's a fair number of components in the circuit, the Xmas Tree is suited to novices as well as experienced hobbyists. All of the parts are inexpensive and standard off-the-shelf items readily available from numerous sources. In fact, your junk box might contain most, if not all, of the components needed. The only drawback to building the Xmas Tree is that you might need to build a few extras for family and close friends!

Circuit Description. The schematic diagram for the Electronic Xmas Tree is shown in Fig. 1. Power is supplied from two D batteries in series.

The circuit uses a pair of 7556 dual timers, U1 and U2, to achieve the random blinking effect. Each half of each timer is used as an astable multivibrator (clock generator) set to a different clock speed. Slow speeds were selected to imitate the flashing bulbs used on real Christmas trees; the clock rates are 0.58, 1.02, 1.25, and 1.77 Hz. Those four clock signals are delivered to a 74HC04 (high-speed CMOS) hex inverter, U3.

Four of the inverters, U3-a, U3-b, U3-e, and U3-f, each receive one of the incoming clock signals from U1-a, U1-b, U2-a, and U2-b. When the inverter input is low, the output is high, and vice versa. Each inverter drives four LEDs interspersed around the edge of the



*Use it to brighten
up your home
this Holiday Season.*

Build This Electronic Xmas Tree

BY GARY CLIFTON

board; by mixing the colors of the LEDs, a random effect is achieved.

The two remaining inverters, U3-c and U3-d, are used to drive the top LED. They are joined together in a "diode or" configuration, so when either

or both gates are high, current flows through one or both of the 1N4148 diodes, D1 and D2, to the top LED, LED 9. In that application the top LED is off only when both of those gates are low. If one gate is low and the other is high, the diode comes on; if both gates are high, the diode gets brighter, resulting in a flickering effect.

Construction. To ensure your Xmas Tree looks attractive, it is recommended that the project be built on a printed-circuit board. If you would like to etch your own board, you can use the template shown in Fig. 2. (Note: For space reasons, it is shown here at half size.) For those who would like to order one, the board is available from the source mentioned in the Parts List.

When installing the components on the board, use the parts-placement diagram in Fig. 3 as a guide. All three of the ICs in the circuit are CMOS devices and can be damaged by careless handling. For that reason, take precautions against static discharge.

Begin your assembly by mounting the resistors. Solder them as close to the board as possible and clip the leads close to the board. Save the trimmed resistor leads for use as jumper wires, which should be installed next as some of them would be difficult to install later on. After that, solder in the IC sockets with pin 1 toward the bottom of the Tree as shown in the parts-placement diagram. Do not install the ICs at this time.

Next install the capacitors. Remember to keep the tip clean on the soldering iron and avoid using excessive solder; spacing is pretty tight around the capacitors and you don't

want to cause a short. Solder in the two diodes next, being sure to orient their bands toward the top of the Tree.

You can now install the LEDs. The cathodes go toward the outside edge of the board and can be identified two ways. Looking at the LED from the bottom, the cathode is nearest

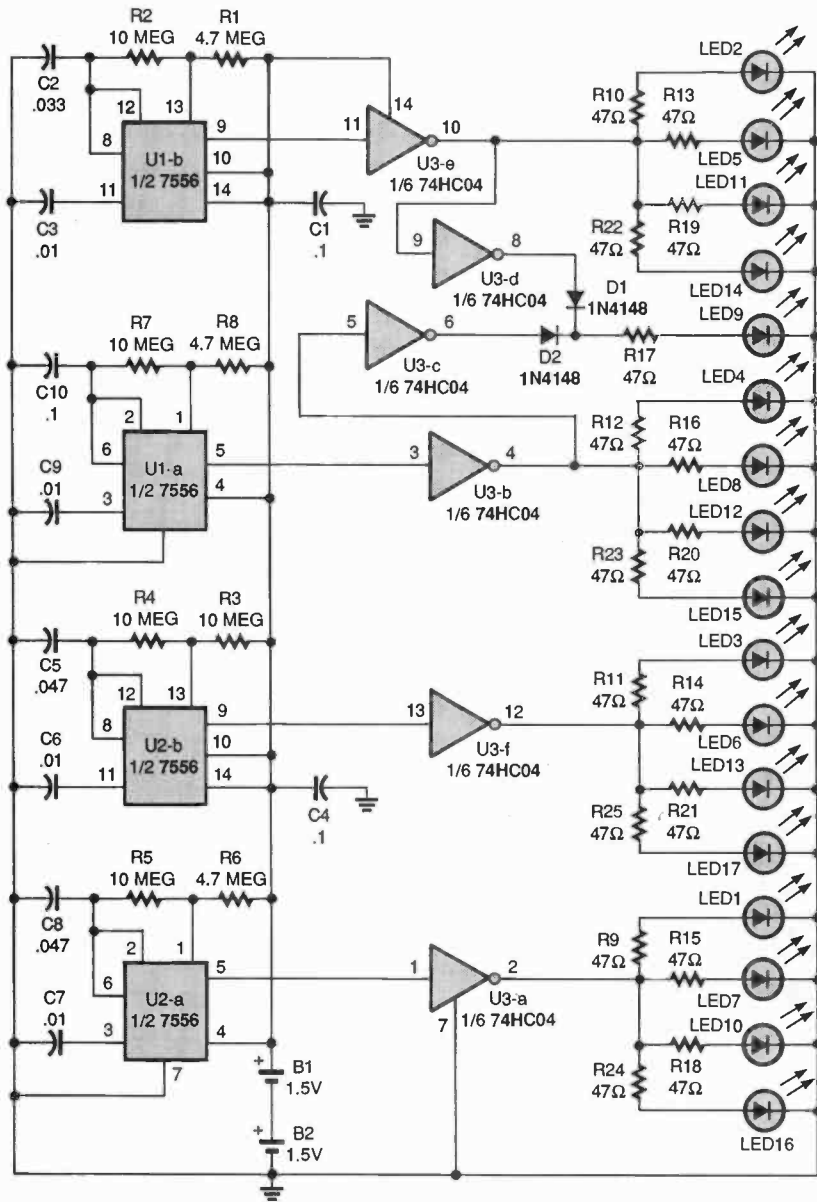


Fig. 1. This is the schematic of the Electronic Xmas Tree. Timers U1 and U2 are used as astable multivibrators set to different clock speeds. Those clock signals are inverted by a 74HC04 hex inverter, U3, which drives groups of four LEDs, causing them to blink in seemingly random patterns.

PARTS LIST FOR THE ELECTRONIC XMAS TREE

SEMICONDUCTORS

- U1, U2—7556 dual timer, integrated circuit
- U3—74HC04 hex inverter, integrated circuit
- D1, D2—1N4148 small-signal switching diode
- LED1, LED5, LED7, LED10, LED14, LED17—Green light-emitting diode
- LED2, LED4, LED8, LED11, LED13, LED16—Yellow light-emitting diode
- LED3, LED6, LED9, LED12, LED15—Red light-emitting diode

RESISTORS

- (All resistors are 1/4-watt, 5% units.)
- R1, R6, R8—4.7-megohm
- R2-R5, R7—10-megohm
- R9-R25—47-ohm

CAPACITORS

- C1, C4, C10—0.1- μ F, ceramic-disc
- C2—0.033- μ F, Mylar
- C3, C6, C7, C9—0.01- μ F, Mylar
- C5, C8—0.047- μ F, Mylar

ADDITIONAL PARTS AND MATERIALS

- B1, B2—1.5-volt alkaline battery, D-type
- Printed-circuit materials, battery holder (Keystone 2227 or equivalent), wire, solder, hardware, etc.

Note: The following are available from DC Electronics (2334 N. Scottsdale Road, Scottsdale, AZ 85257; Tel. 800-467-7736): complete kit of all parts, including the PC board—\$19.95; etched and drilled PC board cut to shape—\$12.95. Shipping and handling is \$4.00. Arizona residents please add appropriate sales tax.

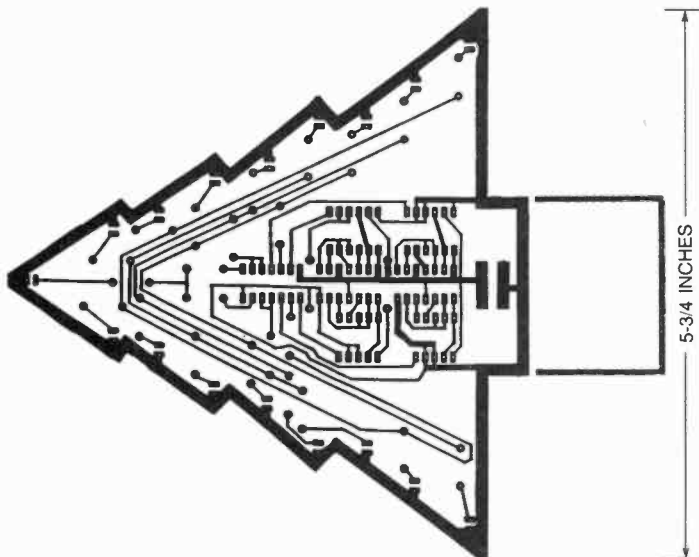


Fig. 2. The pattern for the Xmas Tree PC board is shown here half size.

the flat spot. Also, the cathode lead usually is shorter than the anode on new LEDs.

The holder specified in the Parts List (also available from the source mentioned there) is used to hold up the circuit board; the board can be wedged, standing up, between the

(Continued on page 91)

All About MMIC Amplifiers

Though a mystery to some, the versatility and simplicity of MMIC amplifiers make them ideal for a variety of applications.

BY JOSEPH J. CARR

Monolithic microwave integrated circuits (MMICs) are special IC devices that provide decent gain from near-DC to the microwave region. Examples of those devices include the Motorola CA-2820, with a bandwidth of 1- to 520-MHz; the MAR-x series, with DC to 1000- or DC to 2000-MHz bandwidths; the Hewlett-Packard/Avantek MSA-0886, with a bandwidth of DC to 3000 MHz; and special devices that operate up to 30,000 MHz (30 GHz). In this article we will concentrate on the MAR-x series from Mini-Circuits because of their easy availability to electronics hobbyists. Those devices can be bought in small quantities from Ocean State Electronics (6 Industrial Drive, P.O. Box 1458, Westerly, RI, 02891; Tel. 401-596-3080, Fax 401-596-3590). Larger quantities (25 or more) can be more economically bought directly from Mini-Circuits (P.O. Box 350166, Brooklyn, NY, 11235-0003; Tel. 718-934-4500).

MMIC Physical Attributes. The MMIC amplifier is characterized by simplicity. The typical MMIC has only a few connections. In the case of the MAR-x devices, there are only four

pins. Two of them are the signal-input and signal-output lines. There are also two grounds. The two grounds are needed in order to distribute the lead inductance and therefore overcome the problems of stray inductance, at least in the ground path.

Note that something is missing in the preceding; there was no mention of a DC-power connection. The DC power is applied to the MAR-x series through the signal output terminal (pin 3).

The basic package for the MAR-x series is shown in Fig. 1. The IC case diameter is 0.085 inch (2.15 mm), while the "wingspan" of the leads is 0.460 inch (11.68 mm). Note that the

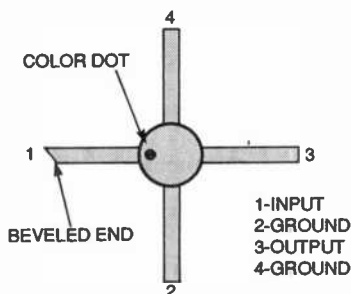


Fig. 1. Pin 1 of the MAR-x package is identified by the beveled lead and the colored dot.

index for the pinout is pin no. 1, the input terminal. There is a color dot on the top of the package that indicates pin 1, and the flat lead wire for pin 1 is beveled at the far end. Mind you, that bevel is a bit dicey to see (at least if you're my age!), so use some type of optical aid if necessary. The color of the color dot indicates which MAR-x device is being used; more informa-

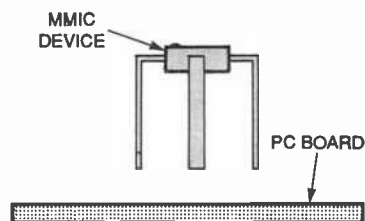


Fig. 2. Although it is often surface mounted, the leads of the MAR-x package can be bent for standard through-hole PC-board mounting.

tion on that, as well as key specifications for the MAR-x family can be found in Table 1.

For many applications, especially at the upper end of the device frequency-response range, the MAR-x device will be mounted directly to the tinned foil side of the printed circuit

TABLE 1
MAR-X SERIES MMIC DEVICES

Device	Dot Color	Max. Freq. MHz	Gain (dB)					1-dB Comp. (dBm)	3rd-Order Intercept (dBm)	I _{MAX} (mA)	I _{TYP} (mA)	V1 Volts
			100	500	1000	2000	Min.					
MAR-1	Brown	DC-1000	18.5	17.5	15.5	--	13	0	15	40	17	5
MAR-2	Red	DC-2000	13	12.8	12.5	11	8.5	3	18	60	25	5
MAR-3	Orange	DC-2000	13	12.8	12.5	10.5	8	8	23	70	35	5
MAR-4	Yellow	DC-1000	8.2	8.2	8	--	7	11	27	85	50	5
MAR-6	White	DC-2000	20	19	16	11	9	0	15	50	16	3.5
MAR-7	Violet	DC-2000	13.5	13.1	12.5	10.5	8.5	4	20	60	22	4
MAR-8	Blue	DC-1000	33	28	23	--	19	10	27	65	36	7.5

board. Many hobbyists, on the other hand, will probably want to mount a MAR-x device in the traditional manner on the top side of the PC board, as shown in Fig. 2.

Typical MMIC amplifiers, including the MAR-x series, are designed to operate into standard impedance loads (50 or 75 ohms). Devices in the MAR-x series operate with input and output impedances of 50 ohms, which is the standard for RF circuits other than television circuits. No impedance matching is needed for 50-ohm circuits.

A Basic MMIC Circuit. A basic MAR-x circuit is shown in Fig. 3. Input and output coupling are provided by a pair of capacitors, C1 and C2. Those capacitors are necessary to prevent DC operating levels inside the MAR-x from getting out, and DC in the external circuit from getting in. The capacitors can be ceramic-disc types up to about 200 MHz, but above 200 MHz, chip capacitors should be used because of their lower internal inductance and higher self-resonant frequencies. Of course, chip capacitors could also be used below 200 MHz.

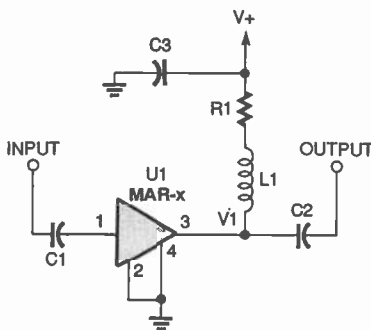


Fig. 3. Here is the basic MAR-x circuit configuration. The input voltage should be regulated and under +15 volts. Because it is often low valued, L1 is sometimes replaced by a ferrite bead slipped over a trimmed resistor lead.

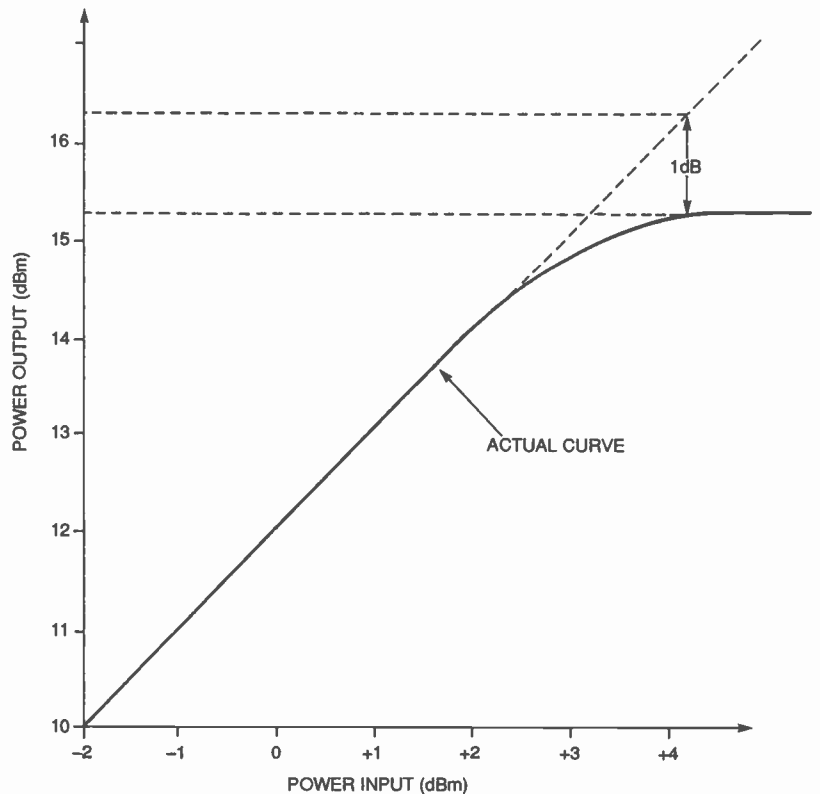


Fig. 4. The 1-dB compression point is the point at which the actual gain departs from the theoretical straight-line gain by -1 dB.

There are two ground lines for the MAR-x devices, and both should be connected in circuits. The reason for using two ground leads is that the parallel grounds reduce the effects of stray inductance. All wires have stray inductance, although the flat lead wires used at VHF and above have lower inductance values than the same-size round wires. At lower frequencies the inductance is negligible. At higher frequencies (of which MMICs are capable), however, the inductive reactance is much larger. The effect of using a ground lead with inductance is essentially the same as placing an RF choke in the ground line! The ground track on the PC board should be brought as close as

practical to the body of the IC to reduce the effects of ground inductance even further.

DC power is applied to a MMIC device through the output terminal (pin 3 in MAR-x devices). A current-limiting resistor (R1) is used between the V+ power-supply voltage and the output terminal of the device. The voltage obtained from Table 1 is shown as V1 in Fig. 3. The value of the resistor is found from Ohm's law:

$$R1 = (V+ - V1) / I_{TYP}$$

Where R1 is in ohms, V+ and V1 are in volts, and I_{TYP} is the "typical" current value for the particular MAR-x device (see Table 1).

Let's consider an example. Suppose

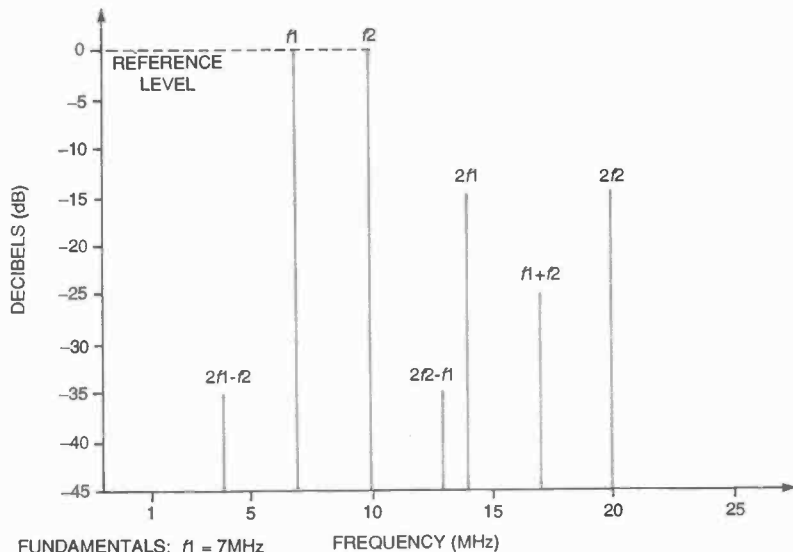


Fig. 5. Here's the intermodulation-product spectrum for an amplifier in which a 7-MHz and a 10-MHz signal of equal amplitudes has been input.

we want to use a low-noise MAR-6 device, which has an I_{TP} of 16 mA (0.016 A), and wants to see 3.5 volts at the output (V1 in Fig. 3). To operate the device from a 9-volt battery:

$$R1 = (9 - 3.5)/0.016 = 344 \text{ ohms}$$

The calculated value of R1 is not one of the standard values you can actually obtain, so select the nearest standard value that doesn't either starve the device for current or ask it to handle too much. The standard value of 330 ohms will not ask too much of the MAR-6, and is easily available.

It is not a good idea to use unregulated DC power supplies, or to use supplies with output voltages higher than about +15 volts in actual circuits. The best approach is to use a three-terminal IC voltage regulator such as the 78L05, 78L06, 78L08, or 78L09. Unregulated or higher voltage supplies can easily lead to MAR-x reliability problems.

The inductor in series with the resistor is optional, but is recommended for very wideband circuits. It serves as a "peaking coil" to increase gain at higher frequencies because its inductive reactance goes up with frequency. The coil should have a value that

will give reactance of four times the output impedance (200 ohms in the case of the MAR-x devices) at the highest frequency of operation. For most wideband amplifiers, that means a pretty-low value of inductance, and as a result many MAR-x users opt to replace L1 with a ferrite bead slipped over a piece of hook-up wire. The wire pigtailed cut from R1 when it is mounted do nicely. The coil should be deleted if R1 is greater than or equal to 500 ohms.

MMIC Specifications. Most of the specifications used for MMIC amplifiers, including the MAR-x series, are straightforward and easily understood; the MAR-x series specifications

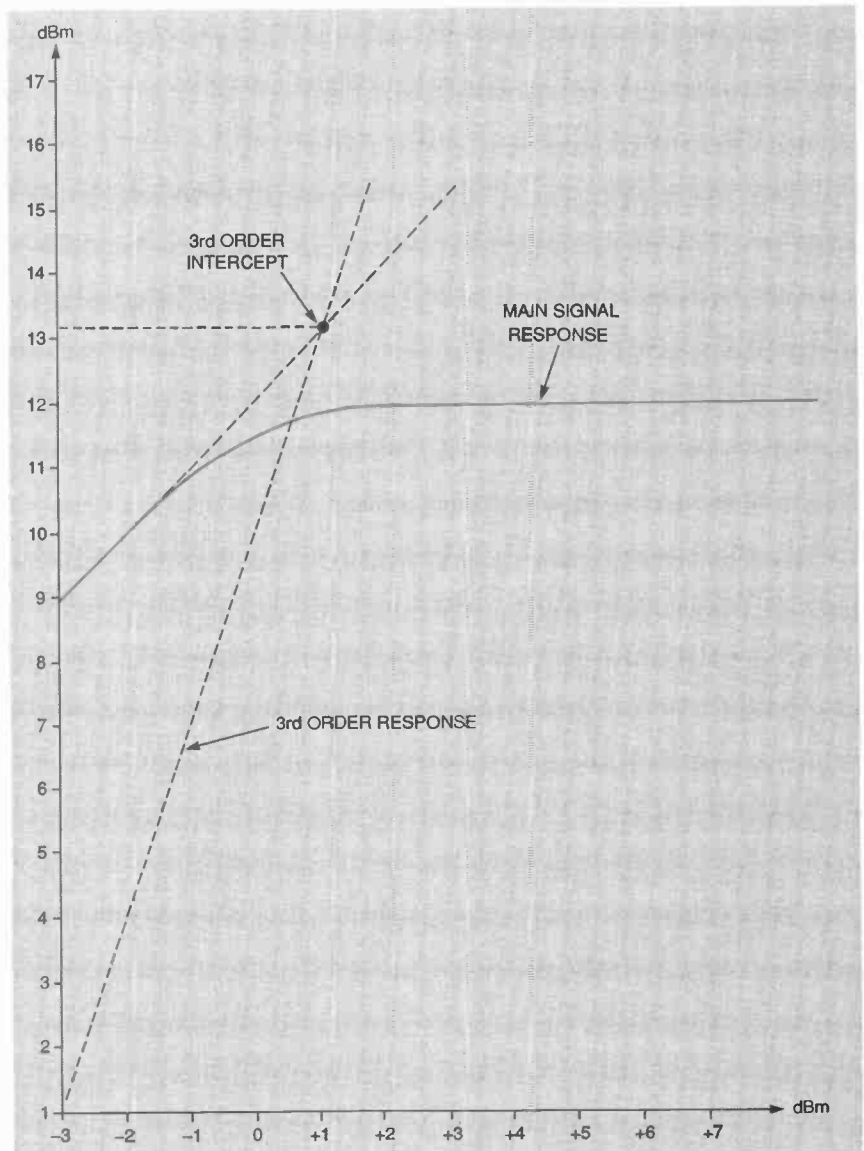


Fig. 6. The point at which the gain slope for the 3rd-order IMP signal crosses the gain slope of the fundamental signal is called the 3rd-order intercept point. Anything over 10 dBm is considered superb performance.

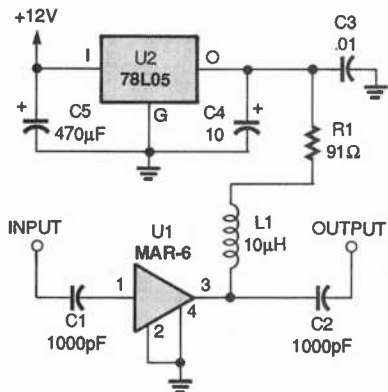


Fig. 7. Here's the schematic for a practical MAR-x circuit. Although specifically designed for the MAR-6, it can be easily adapted for use with any device in the series.

are summarized in Table 1. DC operating conditions (V_1 , maximum operating current, typical operating current, etc.) are specified by the manufacturer and are simple enough to understand. Gain, on the other hand, is usually specified at different frequencies in very wideband amplifiers, so one must be aware of whether the gain is proper for your application's operating frequencies by noting the frequencies and its associated gain figure. The upper frequency limit is usually specified as the frequency at which gain drops -3 dB compared to either the low frequency gain, mid-band gain, or gain at some reference frequency (it helps to know which is used!).

The minimum guaranteed gain might also be subject to some condition such as a maximum temperature that is less than the "survival" temperature given elsewhere in the specification sheet. For the MAR-x devices, a note in the spec sheet indicates that the minimum gain is that which is found at the highest frequency over the entire temperature range.

Signal levels are usually specified in terms of power, using decibel notation. The unit "dBm" is standard, and means power decibels in which 0 dBm is one milliwatt (1 mW) dissipated into a 50-ohm resistive load (+ dBm values are powers higher than 1 mW, and - dBm are powers lower than 1 mW).

The maximum input signal level is the largest sustained signal that the device can safely handle. The MAR-1 device will sustain input signals up to +10 dBm, while the others in the series

Fig. 8. If you want to build the circuit in Fig. 7 using a PC board, here is an appropriate pattern.

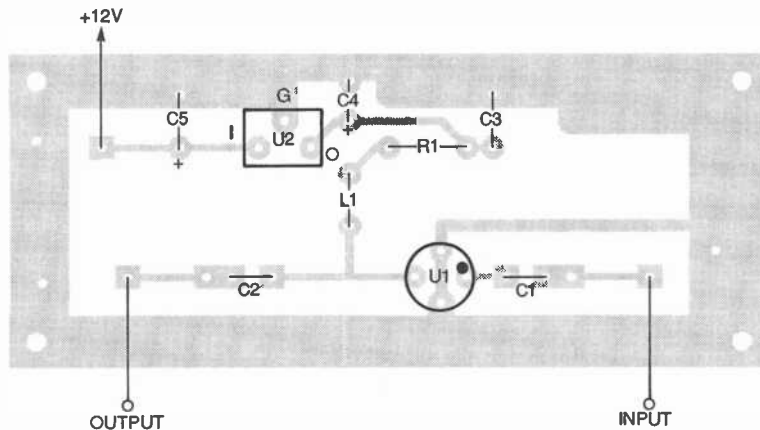
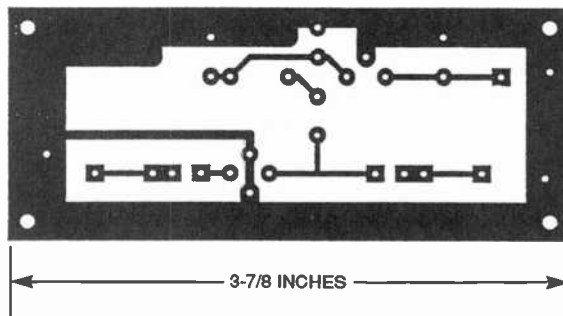


Fig. 9. Use this parts-placement diagram when mounting the components on the PC board.

sustain up to +15 dBm. A level +15 dBm into 50-ohms represents a signal voltage of 31.6 millivolts, which is pretty high for an RF signal in a receiver system.

The maximum output signal power is found in a specification called the "1-dB compression point" (see Fig. 4). At any one frequency, the gain should theoretically be constant. Although there is some dependence on the DC power-supply voltage used, there is another problem that is related to the input-signal drive level. Normally, the plot of power output versus power input is a straight line because the gain is constant. At some point, however, the gain is no longer linear, and the power-output vs. power-input curve departs from the straight line, as shown in Fig. 4. The "1-dB compression point" is the point at which the actual gain departs from the theoretical straight-line gain by -1 dB. For the case shown in Fig. 3, the 1-dB compression point occurs when the output signal is 16.25 dBm and the input power is +4.25 dBm.

The dynamic range of the device is seen in a specification called the

"Third-Order Intercept Point." All amplifiers produce some distortion of the input signal. That is seen in the fact that the output signal has more harmonic content than the input signal. If an amplifier is perfect (none are), then an input sinusoidal signal of frequency f would produce an output spectrum of f and only f . In real amplifiers, however, there will be harmonics present (f , $2f$, $3f$, and so forth). The harmonics are considerably lower in amplitude than the fundamental, and each higher harmonic is lower than the one before it. Thus, $2f$ has a lower amplitude than f , $3f$ is lower than $2f$, and so forth. In many practical cases, however, only the fundamental (f) and first harmonic ($2f$) are considered; the other harmonics are too low in amplitude to be of interest or concern.

As the input signal increases towards the 1-dB compression point, the distortion increases dramatically, as indicated by the sudden increase in harmonic content. A measure of that tendency is taken by applying a two-tone signal to the amplifier, and not-
(Continued on page 93)



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Are we alone? In this immense universe, with its billions of galaxies, each having billions of suns, could ours be the only solar system containing intelligent life? Speculation that there might be other worlds similar to ours certainly isn't new; the ancient Chinese and Greeks, for example, both pondered upon the idea. But what about scientific attempts to answer the question?

As part of our quest for knowledge, we have been observing the stars, first by eye alone and later with optical, infrared, and radio telescopes. But for centuries it looked as though there

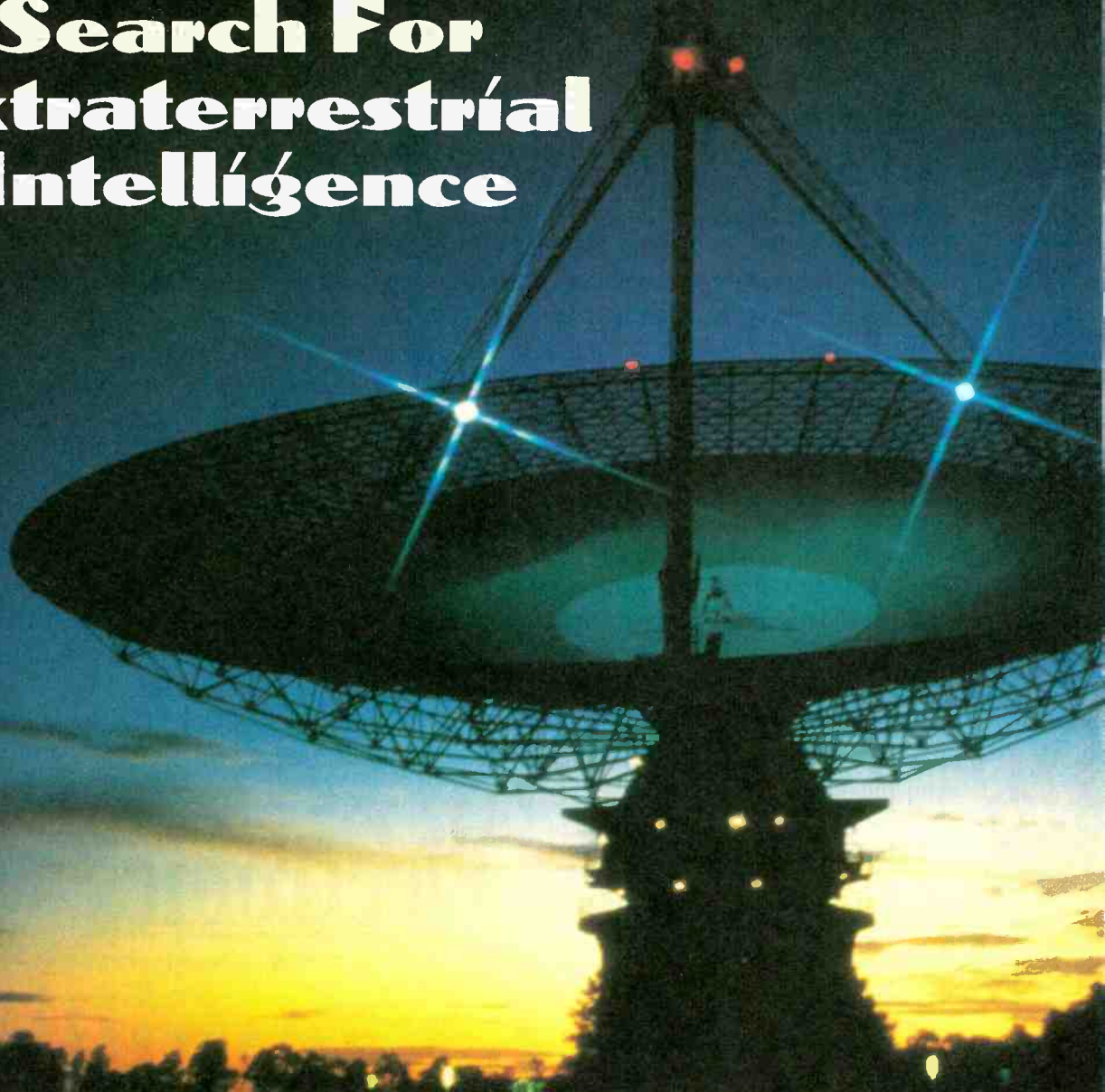
Is there intelligent life in the universe beyond Earth? Here's what scientists are doing to answer that question—and how you can take part in the research!

BY KARL T. THURBER

would never be a way of telling whether we on Earth are unique. Then, around 1960, all that changed with the introduction of a new strategy.

That strategy is SETI, the Search for Extraterrestrial Intelligence. It consists of the use of radio telescopes to detect electromagnetic (EM) signals of potentially intelligent origin from beyond the earth. Both an experimental science and a systematic process, SETI is an effort to find evidence of technological civilizations that might exist elsewhere. From a practical standpoint, SETI is limited to our

The Search For Extraterrestrial Intelligence





own galaxy, the Milky Way—all other stars are much farther away, and their radiation is much weaker.

The vast majority of SETI projects involve listening for signals in the microwave region, although some visible-optical SETI is conducted in the visible and near-infrared parts of the spectrum. One project, for example, searches for very short-pulse optical beacons from possible extraterrestrial intelligences (ETIs); one problem with that approach is distinguishing such pulses from pulsar-type stars.

A Brief History of SETI. SETI began more than three decades ago when scientists began to “listen in” at frequencies thought most likely to reveal the presence of signals produced by artificial means. We can define the modern SETI era as beginning in 1959, when Cornell University physicists Giuseppe Cocconi and Philip Morrison published an article in *Nature* magazine in which they pointed out the potential for using microwave radio for interstellar communication.

The first actual microwave SETI program was Project Ozma. That was run by SETI pioneer Dr. Frank Drake from the National Radio Astronomy Observatory (NRAO) at Green Bank, WV, in 1960. For two months in the spring of that year Drake aimed the 26-meter Green Bank radio telescope in the direction of two nearby Sun-like stars, Epsilon Eridani and Tau Ceti, which Cocconi and Morrison had suggested as possible targets.

Drake’s receiver, which had a single tunable channel with a 100-Hz bandwidth, was tuned to the 1420-MHz (21 centimeter) hydrogen line. While Drake didn’t detect any extraterrestrial signals, Project Ozma spurred the interest of others in the astronomical community, most immediately the Soviets, who initiated a number of large-scale SETI programs of their own.

In fact, in the 1960s, with the Cold War at its peak, the Soviet Union dominated SETI, and it frequently adopted bold, massive, military-like search strategies. Rather than searching the

vicinities of nearby stars, the Soviets used essentially omnidirectional antennas to observe large chunks of sky. They counted on the existence of at least a few very advanced civilizations capable of radiating enormous amounts of power.

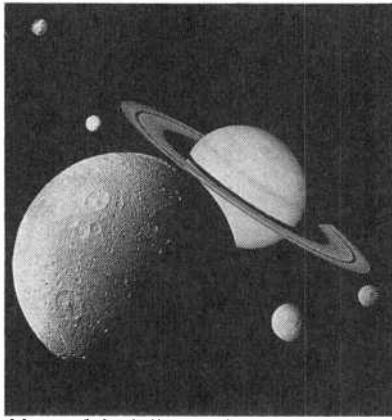
Back in the United States, at the beginning of the 1970s, NASA's Ames Research Center in Mountain View, California considered the technology required for an effective search. In 1971, a team of outside experts produced a comprehensive study for NASA. It was Project Cyclops, named after the mythical one-eyed giant.

The Cyclops report analyzed SETI science and technology issues that are the foundation upon which much subsequent SETI work is based. The objective was to assess what would be required in hardware, manpower, time, and funding for a realistic SETI effort, using present or near-term future technology.

As the perception grew that SETI had a reasonable prospect for success, Americans began again to search. During the 1970s, many radio astronomers started SETI projects, mostly using existing antennas and receivers. Some of those efforts, using improved technology, have continued to the present day.

By the late-1970s, serious SETI programs had been established at NASA's Ames Research Center and at the Jet Propulsion Laboratory (JPL) in Pasadena. Those groups arrived at a dual search strategy for large-scale SETI. Ames proposed to examine 1000 Sun-like stars in a targeted search that would be capable of detecting weak or sporadic signals. JPL would systematically sweep all directions in an all-sky survey. From those proposals, the systematic NASA High Resolution Microwave Survey (HRMS) search emerged in 1988. Then, on October 12, 1992, the 500th anniversary of Columbus' arrival in the New World, the observations began.

The HRMS program had two complementary components, a "Targeted Search" and an "All-Sky Survey." The Targeted Search was to have been the first high-sensitivity, wide-band search for carriers, pulses, and chirps from nearby stars, covering the lower 2 GHz of the microwave window. And if we guessed right as to which stars are likely candidates, the



Many of the billions of Sun-like stars in our Milky Way have their own sets of planets. Some might be closer in their characteristics to Saturn, shown here, but some could have characteristics like those of Earth.

Targeted Search would offer the greatest chance of immediate success.

The All-Sky Survey was to have been the first all-sky search over the entire 1- to 10-GHz earth-based radio window, making use of NASA's existing Deep Space Network (DSN). It would sweep the entire sky that can be seen from a given location; moderate size antennas and no special antenna tracking would be needed because the sky, rather than individual stars, would be surveyed.

HRMS was to be NASA's big 1990s SETI effort. But in the fall of 1993 (less than a year after HRMS was switched on), Congress eliminated the funding from NASA's budget, ostensibly owing to a lack of immediate results. Both the Targeted Search and the All-Sky Search efforts were "axed." With NASA no longer involved, SETI researchers and the public saw a greatly diminished chance to answer, within their lifetimes, the questions posed by SETI.

The SETI League, SETI Institute, Planetary Society, and other nonprofit, non-governmental organizations are now privatizing SETI. The Targeted Search component has become Project Phoenix under sponsorship of the SETI Institute, and the All-Sky Survey will start up in 1996 under the SETI League.

A Basis for SETI? Our Sun is just one of perhaps 400 billion stars in our galaxy. Although we can't detect planetary systems optically, they evidence themselves in other ways. Everywhere we have looked for planets, we've

found indications of their presence. In fact, planet formation probably is an essential process by which a rotating star dissipates some of its angular momentum.

Moreover, because there's no reason that the laws of physics or chemistry are different elsewhere, there might be billions of Earth-like planets circling sun-like stars. Most of those planets are older than the earth and so have had more time to spawn life. But have any evolved intelligent life? SETI hopes to answer that crucial question.

Data from space probes seems to rule out advanced life on the other planets in our solar system. But what about life beyond our own solar system? If solar systems can condense out of the interstellar medium, then the chemicals of life might be found on countless planets in those other systems. In fact, over the past 50 years, scientists have developed a theory of cosmic evolution that predicts that life is a natural phenomenon likely to develop on planets with suitable conditions.

The Drake Equation. Arguments that the universe is teeming with life have received increasing support in the 34 years since they were first stated by noted astronomer and astrophysicist Dr. Frank Drake. While not every scientist thinks that intelligence is widespread in the Milky Way, many of them feel that there could be civilizations out there with detectable transmissions.

A mathematical attempt has been made at estimating the number of such civilizations in the Milky Way galaxy. The result is the Drake, or Green Bank, Equation, which was devised by Drake in 1961 when he was at the NRAO. The equation rests on the basic assumption that life occurs only on planets that are fairly similar to the earth, and it applies solely to our own galaxy. Drake's equation expresses mathematically the relationship of seven hotly debated independent variables. Here's the equation:

$$N = R_s \times f_p \times n_e \times f_i \times f_l \times f_c \times L$$

Where N is the number of civilizations in the Milky Way galaxy whose signals are detectable; R_s is the rate of formation of stars suitable for the development of intelligent life; f_p is the fraction

of those stars with planetary systems; n_p is the number of planets, per solar system, with an environment suitable for life; f_l is the fraction of suitable planets on which life actually appears; f_i is the fraction of life-bearing planets on which intelligent life emerges; f_c is the fraction of civilizations that develop a technology that releases detectable signs of their existence into space; and L is the length of time such civilizations release detectable signals into space.

Cranking in the seven variables, the number of civilizations whose signals are detectable might range from practically zero to a million or more, depending on the assumptions and variables used. Drake himself estimates there are perhaps 10,000 advanced civilizations in the Milky Way Galaxy that meet the criteria for detectable emissions.

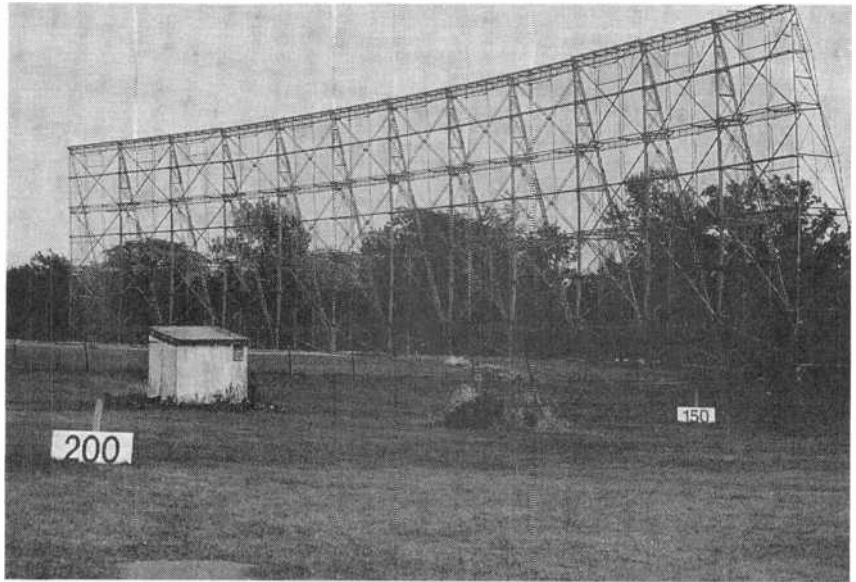
Regardless of the numbers you use, the Drake Equation is an effective tool for helping us to understand that life as we know it is the end product of a natural, cosmic evolution, and also for making us realize how much we're part of the vast universe surrounding us. It also offers us hope that, given resources and time, the search ultimately could prove successful.

Interstellar Communications.

While space travel is difficult, communication through space is relatively easy. In fact, electromagnetic (EM) radiation is the best and perhaps the only chance we have at interstellar communication, considering the immense distances involved (for more information on EM radiation and the EM spectrum, see my article, "Radio Astronomy," in the October 1995 **Popular Electronics**).

Radio waves, and all electromagnetic radiation, travel at the speed of light—300,000 kilometers per second. That is the fastest velocity possible. Yet even Proxima Centauri, our closest neighbor, is far enough away that light takes about 4 years to make the trip. In contrast to the speed of light, the fastest space vehicle we have available travels at a mere 25,000 miles per hour, making that quite a long trip.

While we don't know for sure that all species eventually develop EM communication, surely at least some do. Radio communication is cheap, quick, and easy to set up and learn.



Ohio State University's Big Ear radiotelescope consists of two large reflectors, each about 100-feet high by 300-feet wide. One is a fixed parabolic reflector, shown here, and the other is a tiltable flat reflector.

And if we can figure it out, it's a good bet that technological civilizations more advanced than ours can do likewise.

The greatest barrier to interstellar communications is naturally occurring noise: galactic, cosmic, quantum, and synchrotron sources. Radio waves are the choice for communication because radio wavelengths are relatively free of the absorption and noise that plagues other areas of the spectrum. Radio, visible light, and near infrared are the only EM radiation able to penetrate the earth's atmosphere. Besides, radio is not as easily absorbed by interstellar gas and dust as are the other two, and the stars themselves generally are quiet (dim) in the radio wavelengths.

However, many astronomers and astrophysicists believe that the best ETI hunting ground is in the microwaves, especially the 1- to 10-GHz region, or 30 centimeters to 30 millimeters. That is among the quietest reaches of the spectrum—a "window" of minimum sky noise and least absorption of signals by the earth's atmosphere. Of the roughly 100 serious, scientific searches since Project Ozma in 1960, most have used microwaves.

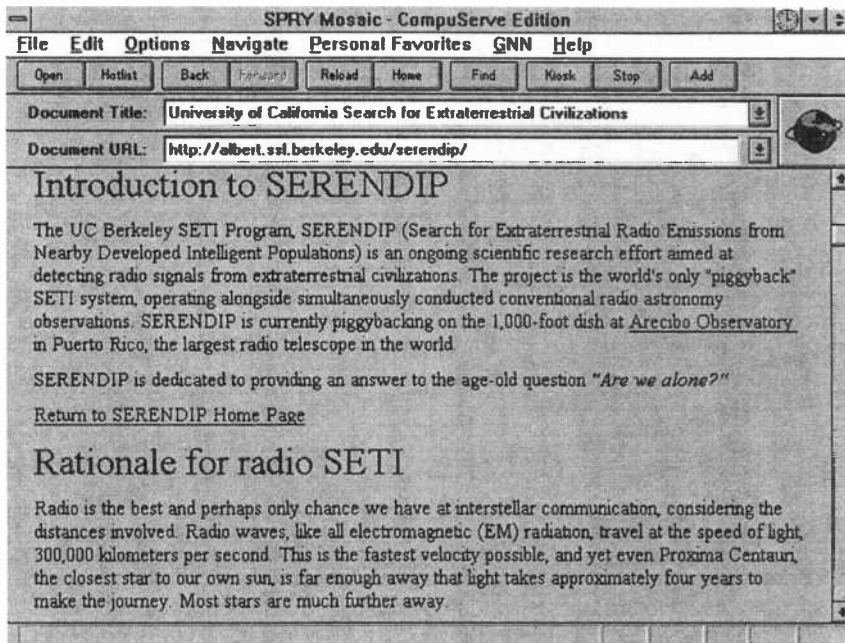
Most SETI scientists think we can narrow the search spectrum. The consensus is that the 18- to 21-cm region, or about 1.4 to 1.7 GHz, seems the most natural range to examine for signals from ETIs. Frequencies in that

"water-hole" region are also known as "magic" frequencies, and they are largely protected from interference by international agreement. The water-hole region gets its name from the two fragments (hydrogen and hydroxyl) of the water molecule that have "radio signatures" (radiation at specific frequencies) in that band.

Bernard Oliver, who headed NASA's SETI office, suggested scanning the region between the two markers, the hydrogen and hydroxyl lines, as a potentially universal communications band. In 1971 he coined the term for that proposed communications band. "Where shall we seek out our kind?" asked Oliver. His answer was simple: "At the water hole, where species have always gathered."

Now, surprisingly, the best approach to looking for ETI signals in those bands is *not* to use a broad, single-channel receiver that monitors the whole microwave range simultaneously. That's because ETIs would need truly immense power to create signals strong enough to be above the noise level on Earth. Any signals that get through would have to be concentrated in a very narrow band of frequencies, and a receiver used for SETI would therefore need to monitor a narrow band.

The use of ultranarrow bands of 1 to 10 Hz is desirable. But with such ultranarrow bands it would take much too long to use a single-channel receiver and scan the whole microwave



SERENDIP is the University of California at Berkeley's Space Sciences Lab SETI program. You can find out what's going on at the program by checking out the group's Web page, shown here.

range at each region of the sky. Far more preferable are multichannel receivers that can examine millions of channels at the same time. So, as you can see, searching the entire microwave range can be difficult. But there are still major projects working towards that goal.

Major SETI Projects. The world's longest-running SETI program, Big Ear, is part of the Ohio State University (OSU) Radio Observatory and was begun in 1973 using an eight-channel system. Using OSU's 110-meter telescope, the full-time OSU search is all-sky and now uses 50 channels; an improved SERENDIP III four-million-channel receiver is being installed (more on SERENDIP in a moment). OSU's search is run almost exclusively by volunteers and is funded by private donations.

The OSU telescope is the size of three football fields. It consists of two large reflectors, each 100 feet high by 300 feet wide. One is a fixed parabolic reflector and the other is a tilt-able flat reflector. The reflectors are situated on opposite ends of a 300-by-600-foot-long aluminum ground plane. Dual feed horns are mounted between the reflectors on a railway that provides tracking.

OSU scientists have also worked on

an advanced system, Argus, which is named after the mythical, Greek, hundred-eyed monster that could watch all directions at once. Argus is a radically different radio telescope.

In contrast, most SETI work uses conventional dish antennas optimized for other purposes. A major deficiency is that they look in only one direction at a time, making the detection of transient signals unlikely and also possibly missing promising signals because of limited sky coverage. They also ignore most of the energy that impacts them, making them very inefficient.

The Argus array, sometimes called a "radio camera" because it forms an image of the whole sky at one time, consists of hundreds of very small, omnidirectional antennas arrayed over a large flat conducting surface. Those antennas conveniently use the existing OSU Big Ear antenna as the ground plane.

Argus would let radio astronomers have a more global view of the electromagnetic environment. They could detect suspicious signals, from whatever part of the galaxy, with Argus, then use Big Ear for detailed surveillance. A small, eight-element Argus prototype, operating at 162 MHz, already has been built.

Over at the University of California, Berkeley Space Science Lab scientists

have developed a SETI program: Search for Extraterrestrial Radio Emissions from Nearby Developed Intelligent Populations (SERENDIP). It began in 1979 using a 100-channel spectrum analyzer at the Hat Creek Observatory. SERENDIP instrumentation and software also have been used widely in other SETI projects.

SERENDIP is a unique "piggyback" SETI system, operating alongside simultaneously conducted conventional radio-astronomy observations to share telescope time. SERENDIP III currently uses the huge, 305-meter (1000-foot) dish at the Arecibo Observatory in Puerto Rico, which is the largest radio telescope in the world. That makes SERENDIP very cost effective and allows it to run full-time on Arecibo and other world-class radio telescopes.

Weekly, SERENDIP data is transferred via the Internet to the SERENDIP lab at Berkeley (see the "Selected Internet Points for SETI" box for more information on what SETI resources are on the Internet). There, researchers run the data through algorithms to reject radio-frequency interference (RFI) and detect signals that possibly are both artificial and extraterrestrial. Since 1979, SERENDIP has undergone a series of sequential improvements. SERENDIP II ran from 1986 to 1988 and was thousands of times more powerful than its predecessor.

SERENDIP III is the first megachannel, high-sensitivity search at UHF. The SERENDIP III spectrum analyzer examines 4.2 million channels every 1.7 seconds in a 12-MHz-wide band centered at 429 MHz. It's been operating in a sky-survey mode at Arecibo since April, 1992. Since then, it's logged more than 8000 hours of observation time and has probed over 70 trillion channels.

SERENDIP IV is due at Arecibo soon; it will be able to observe 167 million channels every 1.7 seconds. That will boost the project's number of channels observed per second by a factor of 40, and will be the most sensitive SETI receiver in the world.

The Arecibo project has observed over 92 percent of the visible sky at least once and has passed over 37 percent of the Arecibo sky at least 5 times. In its first 3 years, SERENDIP has probed more "search space" than all previous searches combined: some

RESOURCES FOR AMATEURS

Do you want to learn more about radio astronomy and SETI? Here are selected organizations and publications you can contact for more information.

The Astronomical Society of the Pacific (ASP) is a scientific and educational organization, founded in 1889, which links professional and amateur astronomers, educators, and laypeople. ASP is the largest general astronomy society in the world and welcomes anyone with an interest in astronomy. The Society publishes the bimonthly *Mercury* magazine, which features non-technical articles, and a refereed monthly technical journal, *Publications of the Astronomical Society of the Pacific*. For more information, contact the The Astronomical Society of the Pacific (390 Ashton Avenue, San Francisco, CA 94112; Tel. 415-337-1100).

The SETI Institute (2035 Landings Drive, Mountain View, CA 94043; Tel. 415-961-6633) is a nonprofit educational and scientific corporation that was founded in 1984. The Institute, which doesn't have a general public membership, serves as an institutional home for scientific and educational SETI projects. The largest research effort is Project Phoenix, the privately funded continuation of the Targeted-Search portion of NASA's HRMS.

The nonprofit Planetary Society was founded in 1980 to promote the exploration of our solar system (and others) and the search for ETI. The Society has over 100,000 members and is the largest non-governmental space organization in the world. It publishes *The Planetary Report* six times yearly and

Bioastronomy News four times a year. The Society is supporting several major SETI projects, META, BETA, and SERENDIP. The combination of those three projects makes for what it believes is the most dedicated and continuous search effort on earth. For more information contact the Planetary Society (65 North Catalina Avenue, Pasadena, CA 91106-2301; Tel. 818-793-5100).

The SETI League (P.O. Box 555, Little Ferry, NJ 07643; Tel. 800-TAU-SETI), founded in 1994, is a membership-supported, educational and scientific nonprofit corporation. The League publishes a quarterly newsletter, *SearchLites*. Their major effort is organizing and coordinating the efforts of experimenters interested in SETI and acting as an information clearinghouse. The League's All-Sky Survey will effectively continue the All-Sky Survey component of the canceled NASA HRMS.

If you're interested in hands-on radio astronomy, consider joining the Society of Amateur Radio Astronomers (SARA). The Society is inspired by the pioneering 1930s and 1940s work of amateur astronomer and amateur radio operator Grote Reber, W9GFZ.

SARA was organized in 1981 and has about 275 members worldwide. Though small, it probably is the largest amateur radio astronomy group in the world. Its members are involved in solar radio astronomy, sky surveys, and SETI experiments. SARA's yearly conference normally is held in June at the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia. Membership includes a year's subscription

to the SARA Newsletter. For more information, contact SARA (c/o Vincent Caracci, 247 N. Linden St., Massapequa, NY 11758).

SETIQuest is a new publication for SETI professionals and serious amateurs. It's devoted to SETI and is a sort of digest of current experiments, projects, and techniques used by various individuals and organizations worldwide. The publication also reviews important SETI books and periodicals. Annual subscriptions (four issues) are \$29 and can be obtained by contacting *SETIQuest* Subscriptions (Helmets Publishing, P.O. Box 874, Peterborough, NH 03458-9989; Tel. 603-924-9631).

Signals is the official newsletter of the Ohio State University's radiotelescope, Big Ear. Produced more or less monthly, it describes current OSU projects and offers research updates, and also presents other articles of interest to the SETI enthusiast. Subscriptions are \$25 per year and are available from *Signals* Newsletter, NAAPO, Subscriptions (c/o Otterbein College, Department of Physics/Astronomy, Westerville, OH 43081; Tel. 614-823-1516).

Finally, if you want to pursue radio-astronomy projects such as the All-Sky Survey, a small Georgia firm offers most everything from radio telescopes to amplifiers, bandpass filters, feed horns, mixers, A/D converters, noise sources, software, and various "how to" publications. For a brochure on available parts and supplies, contact Jeff Lichtman (190 Jade Cove Drive, Roswell, GA 30075; Tel. 404-992-4959). ■

100 trillion radio channels, over one-third of the sky.

Now, as mentioned earlier, the demise of HRMS in 1993 almost killed American SETI. But the notable Project Phoenix was reborn from the ashes of HRMS and undertaken by the SETI Institute. Phoenix takes advantage of the technology developed by NASA to make a sensitive and thorough survey of nearby star systems.

The Phoenix search strategy is to scrutinize approximately 1000 sun-like stars less than 150 light-years away for candidate microwave signals, from about 1.2 to 3.0 GHz. The project relies on 10-MHz Multi-Channel Spectrum Analyzers (MCSAs).

The Phoenix project is different from other SETI efforts in several ways: Its approach is systematic; it places a premium on sensitivity to detect very weak signals; it can identify terrestrial-

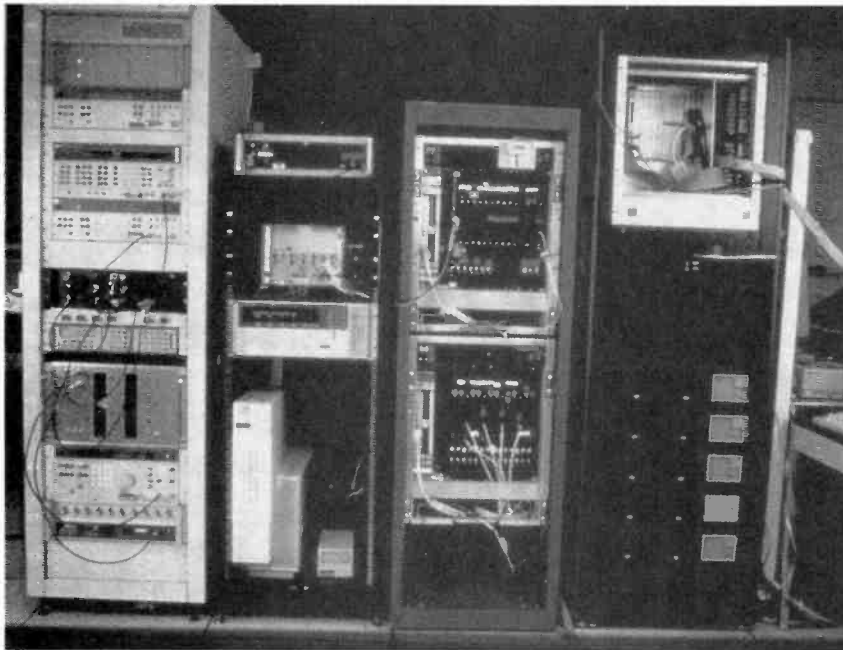
based interference using a Follow Up Detection Device (FUDD) technique; it examines a broad range of frequencies (1.2 to 3.0 GHz), not just 18-21 cm; spectral resolution is high, typically 1 Hz; and it can detect a wide variety of signal types.

Phoenix seeks out both monochromatic carriers (continuous wave, or CW, signals), and intermittent carriers, called pulsed signals. Special FUDDs are used as a sort of verification system: the FUDDs makes use of a second, remotely located radio telescope, the tandem telescope being used to check for and screen out terrestrial interference.

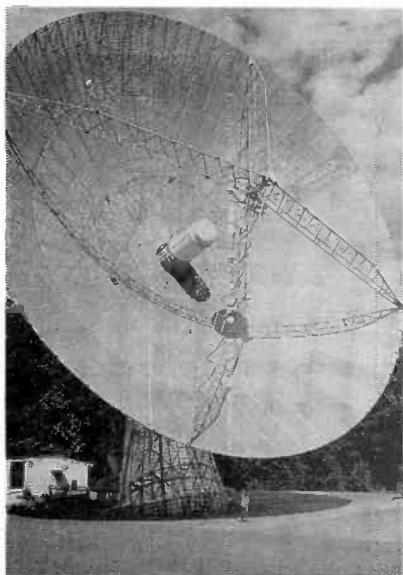
In June, project scientists completed observations using a 64-meter dish at the Parkes Observatory in New South Wales, Australia. For 5 months, the Parkes antenna scanned the vicinities of nearby stars from a unique

Southern Hemisphere vantage point. The gear is being tested and upgraded, and will be moved to Arecibo, probably early in 1997. Because the project uses some of the largest radio-telescope antennas in the world, and because the receivers used are unequaled in terms of frequency coverage and signal-analyzing ability, the search promises to be the most comprehensive ever undertaken. Over the full 10 years of the project, about 1000 stars will have been targeted for a cost of about \$30 million.

Another organization, The Planetary Society, funds Project META, the Megachannel ExtraTerrestrial Assay, which began in 1985. It's the world's first megachannel and ultra-high-spectral-resolution search at preferred frequencies—one of the most thorough SETI efforts to date. The



Shown here are the SETI Institute's state-of-the-art signal-processing systems for Project Phoenix. The sophisticated analysis circuitry examines all receivable channels approximately once per second, searching for both steady signals and pulsed transmissions.



Project META is the world's first million-channel search. The northern sky component, shown here, is a 26-meter diameter antenna located at Oak Ridge, MA.

northern-sky-search component uses a 26-meter diameter antenna located at Oak Ridge, MA. It has 8,388,608 channels, plus another 1,048,576 redundant channels to check up on the main ones.

META searches the northern and southern skies for an intentional beacon carrier signal. META I, oper-

ated by Harvard University, slowly scans the northern sky—it takes about eight months to scan it completely. META II, operated by the Argentine Institute of Radio Astronomy since 1993, scans the southern skies using a 30-meter antenna. Both survey at the celebrated 21-cm wavelength and also at its "second harmonic" of 10.5 cm. The latter wavelength also is used in case alien beacon operators choose to keep the 21-cm wavelength clear for radio astronomy.

META is highly sensitive and discriminating. It also is well-matched to the expected properties of an ETI signal that might ultimately arrive on earth: a "narrowband carrier" with a changing, but predictable, "Doppler chirp signature."

A more powerful search tool will be Harvard's BETA, the Billion-channel ExtraTerrestrial Assay, which was due to go online in October 1995. It's a joint venture of the Planetary Society, NASA, and the Bosack/Kruger Foundation.

BETA not only will cover a much greater frequency range than META, but it also will cure META's inflexibility by having two beams viewing the sky. And BETA, like Phoenix, also uses a third terrestrial antenna to identify interference from earth-based sources. It's to be the first high-resolution, dual-

SELECTED INTERNET POINTS FOR SETI

The Internet is one of the most important astronomical resources; it links students, researchers, scientists and others. Here are the World-Wide Web URLs and e-mail addresses of selected SETI-related resources:

AstroWeb Consortium (European):
<http://vilspa.esa.es:80/astroweb/astronomy.html>
 e-mail: jdp@vilspa.esa.es

Astronomical Society of the Pacific:
<http://www.physics.sfsu.edu/asp/asp.html>
 e-mail: asp@stars.sfsu.edu

Ohio State University Radio Observatory:
<http://everest.eng.ohio-state.edu/klein/ro/>
 e-mail: klein@ee.eng.ohio-state.edu

The Planetary Society:
<http://wea.mankato.mn.us:80/tps/>
 e-mail: tps@genie.geis.com

Robert Lentz's Astro Resources (Northwestern University):
<http://www.astro.nwu.edu:80/lentz/astro/home-astro.html>
 e-mail: lentz@rossi.astro.nwu.edu

The SETI Institute:
<http://www.seti-inst.edu/>
 e-mail: web@www.seti-inst.edu

The SETI League:
<http://seti1.setileague.org/homepg.html>
 e-mail: info@setileague.org

SERENDIP/University of California at Berkeley:
<http://albert.ssl.berkeley.edu/serendip/>
 e-mail: sereninfo@ssl.berkeley.edu

STSci Astronomical Internet Resources:
<http://marvel.stsci.edu/resources.html>
 e-mail: astroweb@nrao.edu

WebStars: Astrophysics in Cyberspace:
<http://guinan.gsfc.nasa.gov>
 e-mail: StarTraxhelp@athena.gsfc.nasa.gov

beam, three-antenna search that combines all-sky survey coverage with the spectral resolution of a targeted search. Equipment based on the more advanced SERENDIP IV design and architecture will be used.

BETA, which will replace the current system at Harvard, will increase META's search capability by a factor of 1000. It will be able to analyze 240 million channels simultaneously, reportedly making it the world's "largest" radio receiver.

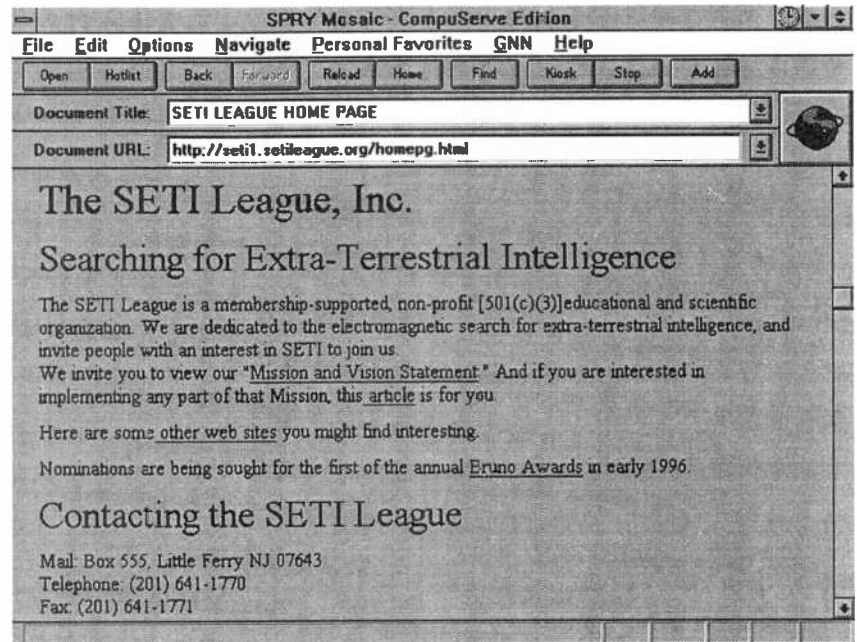
What Have We Found? Of the more than 100 searches that have been conducted to date, have any found something? The answer is no. Unfortunately, no one as yet has produced a single verified and convincing signal of intelligent extraterrestrial origin. That supposed "lack of progress" resulted in NASA's congressionally directed termination of HRMS.

There have, however, been a number of "false starts" (highly suspicious beeps and blips) over the years, including some strong sources clustered near the plane of the Milky Way. For example, at OSU there was the famous "Wow!" signal found in 1977, named from the observer's written comments in the margin of a computer printout when he noticed a highly suspect signal. The strong, apparently extraterrestrial 1420-MHz signal was only detected once, despite extensive searching. Its source never has been discovered.

There also have been other, less-famous false starts. Most of those unexplained, transient signals have mostly been narrowband pulses lasting less than 10 seconds. There have been thousands of such signals from all over the sky, but not from precisely the same direction more than once. Their origin is unknown, but some suspect that the signals could be terrestrial interference or some sort of previously unknown astrophysical phenomenon.

Still, some searches have found unexplained signals that appear to be more than just false starts. Because data collected often was processed long after the observations, candidate signals couldn't be checked to see if they were extraterrestrial. Subsequent observations conducted days to months after the original observations have never found any of the signals. New SETI experiments such as Phoenix and BETA will be able to test candidate signals immediately: to be absolutely sure that a signal is from another civilization, it must be independently verified and shown to originate from beyond the Solar System.

Scientists are learning that SETI simply isn't the kind of science that produces immediate results. All searches so far have been very limited in one way or another. The searches faced limitations in sensitivity, frequency coverage, the types of signals they



The SETI League has announced an All-Sky Survey that will effectively continue the All-Sky Survey component of the NASA HRMS.. The League is well represented on the Internet with their Web page, shown here.

could detect, and the number of stars or the directions of the sky that were observed. They also generally used equipment designed for other purposes. Still, SETI pioneer Drake believes we will detect an ETI signal by the year 2000.

So far, we have surveyed several thousand stars, for brief periods of time, at limited frequencies. But with an estimated 400 hundred billion stars in our galaxy, and perhaps 100 billion other galaxies, we have a long way to go before we can start drawing conclusions. In fact, we haven't really started yet.

What if We're Successful? If a suspicious signal is detected, that might suggest ETI but it's not of itself conclusive. To confirm that a signal is from another civilization, and not really from a satellite or terrestrial source, the signal must repeat and display constant sidereal coordinates, and at least two different observatories must be able to receive and follow up on the signal. As part of the confirmation and verification process, scientists will contact other observatories to investigate candidate signals using their own equipment and techniques.

Once a signal is confirmed to be of extraterrestrial intelligent origin, it's expected that the discovery will be announced quickly and widely. A

"Declaration of Principles Concerning Activities Following the Detection of Extraterrestrial Intelligence," endorsed by six international space organizations, addresses how to make such a portentous announcement. The private SETI Institute also has a similar plan for a signal detection.

The signal would then have to be examined carefully. Periodic Doppler variations in the signal's frequency would have to be considered, as would the type of binary or analog information or modulation contained in the signal's bandwidth. We then would have to interpret what information is present, which could be a lengthy task with ultranarrow bandwidth signals having very low data rates.

If the signal is intentional, it probably will be fairly easy to decode: to send or receive an interstellar signal, a civilization must understand basic science and math. Hence, a message probably would use a language based on universal mathematical and physical principles. Of course, an advanced society's transmissions might not be understandable to us. Signals they use for their own purposes could be especially difficult to understand, and might have no detectable message content.

But would we derive a practical benefit from SETI? Probably not from

two-way interactive communications: the light-years of separation between Earth and other possible civilizations prohibit that. But, consider what we might learn from and about them if we're able to decode the signal. And, if a confirmed signal is received, should we respond to it? That is a big policy question that could have far-reaching consequences for many aspects of both present and future human existence.

No discovery could stir one's imagination more than the revelation that we are not alone and that beings potentially far more advanced than us share the universe. The impact on how we see ourselves, our philosophy, and our religious beliefs would be truly enormous. In fact, it could be the greatest discovery in history. But even if our SETI efforts do nothing more than determine that a signal exists—and thereby show that we are not alone—the effect will be profound.

But what if no signal is ever detected? Even if the search doesn't ferret out a signal from a distant civilization, the effort likely will provide many benefits to society. The technology developed to search for faint signals from distant planets could be applied to practical problems in any number of important scientific areas. And bear in mind that no search ever will establish that extraterrestrial intelligence *doesn't* exist, just that we haven't found it.

What About Sending Signals?

Current and projected SETI projects only listen for signals, they don't send them. However, since the early part of this century, humans have been unintentionally sending signals into space—radio, television, radar, and other transmissions. Already, our early TV transmissions have traveled over 50 light-years. Consider what ETIs could learn about us if they were able to receive our radio and TV signals!

Still, a few symbolic, intentional messages have been sent. One, sent in 1974 from Arecibo by Frank Drake and Carl Sagan, was a simple picture describing our solar system, elements important for life, the structure of the DNA molecule, and the form of a human being. The message was transmitted in the direction of the globular star cluster Messier 13, about 25,000 light-years away.

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What You Can Do for SETI. Radio amateurs and microwave experimenters could play a pivotal role in SETI. On the horizon is the SETI League All-Sky Survey that will effectively continue the All-Sky Survey component of the canceled NASA HRMS.

The SETI League plans to conduct a thorough survey of the entire sky in the water-hole region, between 1.4 and 1.7 GHz. The search is to be kicked off on Earth Day, April 20, 1996, and it will involve thousands of radio amateurs, microwave hobbyists, and digital-signal-processing (DSP) experimenters.

As we've seen, the water hole extends from roughly 1420 to 1660 MHz, a bandwidth of 240 MHz. Monitoring it at a 10-Hz resolution, there are 24 million channels to scan. While much "professional" SETI research has been devoted to developing megachannel, real-time spectrum analyzers, the band also can be approached as a DSP project, one in a technological area that amateur-radio operators

recently have embraced. A coordinated effort of more than 5500 participants will be required.

An all-sky survey makes no assumptions as to the direction to explore; it sweeps the entire sky that can be seen from a given location. No antenna tracking is required, because it is the sky, rather than individual stars, that's being surveyed. That means that antennas can be in a "virtual transit-mount mode," aimed due south, letting the earth turn them, varying only their elevation. And because large antennas have a narrow beamwidth, the sky survey actually is better performed with dishes of modest size.

According to Dr. H. Paul Shuch, N6TX, Executive Director of the League, that approach is ideally suited to the broad-based community of radio amateurs and microwave experimenters. Shuch notes that the average ham moon-bounce or TVRO dish has a beamwidth on the order of

(Continued on page 94)

Analyzing AC Circuits

BY JAMES E. TARCHINSKI

If you're new to electronics, or just want to brush up on your knowledge of AC circuits, this tutorial's for you.

In the recent blockbuster movie *Speed*, the heroine states that driving a huge passenger-laden bus is just like driving a Pinto—only bigger. A similar statement could be made about solving alternating current (AC) electrical circuits: It's just like solving direct current circuits—only more difficult. Actually, difficult is the wrong word. Let's just say it is more "complex."

To solve AC circuits, engineers and mathematicians generally use a technique called complex analysis. That method uses some very special properties of what are known as complex numbers to simplify an otherwise difficult task. Prior to the development of that technique, AC circuits were solved by using calculus and differential equations. However, that was a laborious process, and very prone to human error because of the difficult calculations involved. The process is greatly simplified by the use of complex numbers.

In this article, we'll look at that easier method of solving AC circuits—by using complex numbers. For starters, though, let's examine how to solve DC circuits, as the basic techniques used there are also used in AC circuits.

Solving DC Networks. In this article we will solve circuit problems by using repeated applications of Ohm's Law. We can "make do" with that law because all of the problems have been designed to be relatively simple. More

complicated circuits, such as those containing multiple voltage or current sources, will require more detailed solution methods.

Other analysis techniques, such as nodal analysis or the superposition theorem, can handle any class of problem—even those with multiple sources. If you are already familiar with those methods for DC circuit analysis, after reading this article you should be able to apply complex analysis procedures to them. Hence, you will be able to solve AC circuits using the same basic steps you now use for DC networks. The steps are the same, only the type of numbers used will need to change.

The simple DC circuit shown in Fig. 1A contains a single voltage source driving a total of three resistors, one in series with a pair connected in parallel. Our goal for this example is to find the amount of current flowing through R1.

Because of the simple nature of the circuit, it might be tempting for some readers to solve this problem "in their heads." However, our ultimate goal is to derive a process we can use for AC computations as well, so we'll look at each step of the solution in detail.

To solve the problem with Ohm's Law, use the following procedure: First, calculate the total current supplied by the source, V1. Next, determine how much of the supplied 9 volts are dropped by R3 and by the R1 and R2 parallel combination. And finally,

knowing the voltage across the R1/R2 pair, calculate the amount of current flowing through resistor R1.

In parallel, the total resistance produced by R1 and R2, which we will call R_p can be found by the following formula:

$$R_p = (R1R2)/(R1 + R2) = (12 \times 24)/(12 + 24) = 288/36 = 8 \text{ ohms}$$

The total resistance in the circuit is now the combination of resistors R3 and R_p in series. The total resistance, which we'll call R_t , would then be

$$R_t = R3 + R_p = 10 + 8 = 18 \text{ ohms}$$

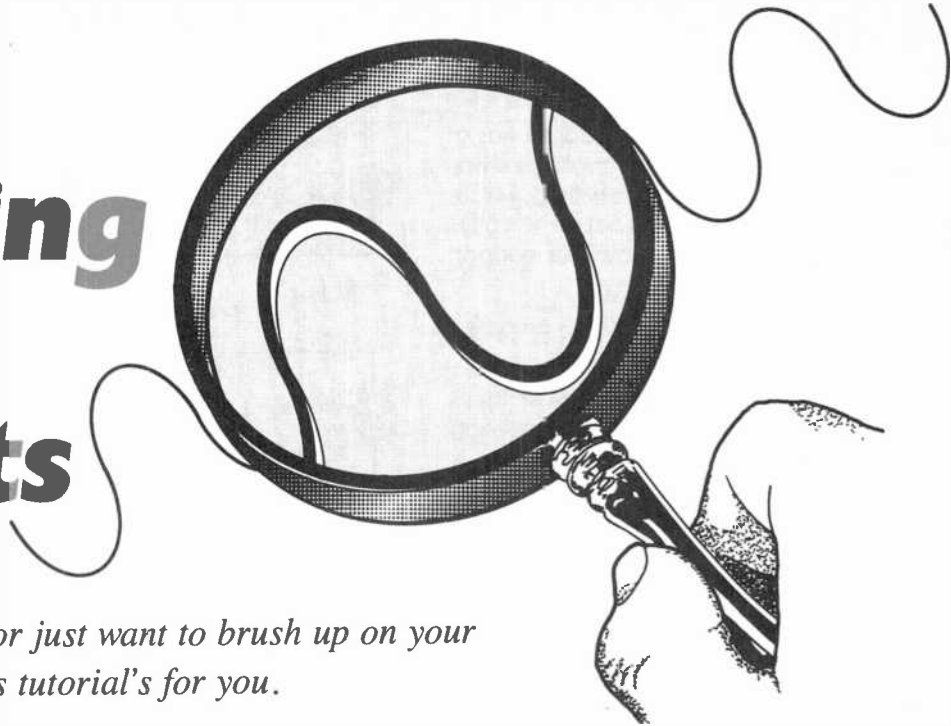
We now have a nine-volt source driving the equivalent resistance of 18 ohms. Hence, by direct application of Ohm's Law, the total current generated by the supply (and called I_t), would be:

$$I_t = V_t/R_t = 9/18 = 0.5 \text{ ampere}$$

The circuit has now been reduced to its simplest equivalent form: one voltage source in series with one resistor. From that we were able to determine the total amount of current flowing in the network, 0.5 amperes. Now we can use that information to work our way "back up" the equivalent circuit shown in Fig. 1B. Knowing that there is half an ampere of current flowing through R3, its voltage (V_3) drop must be:

$$V_3 = R3I_t = (10 \times 0.5) = 5 \text{ volts}$$

If 5 volts is dropped by R3, then the R1/R2 pair must drop



$$V_1 = V_2 = V_1 - V_3 = 9 - 5 = 4 \text{ volts}$$

We're almost there. Resistor R1 has a value of 12 ohms, and a voltage drop, V_1 , (not to be confused with V_1 , which is the voltage source) of 4 volts. Hence, by Ohm's Law the current through it (I_1) must be:

$$I_1 = V_1/R1 = 4/12 = 0.333 \text{ ampere} \\ = 333 \text{ milliamperes}$$

And at last we have our answer: There is 333 mA of current flowing through resistor R1 of the circuit of Fig. 1A.

The Sinewave. Now it's time to change gears a little bit. We've just seen how to solve a simple DC circuit using only Ohm's Law, along with a few basic properties of how resistors behave when they are placed in series and parallel. Now it's time to look at how AC circuits are different than their DC counterparts.

The main difference is that voltages and currents in an AC circuit are constantly changing. Luckily, they always change in the same manner, following a standard sinusoid curve as shown in Fig. 2. Starting at a value of zero at time $t = 0$, the sinewave increases in amplitude until it reaches a maximum. Then the signal starts to fall off, again crossing zero, and then plunging to a maximum negative value, and then again increasing until it returns to a value of zero. That up-and-down process is known as one cycle of the sinewave.

A total of three parameters completely describe a sinewave. Let's now look at each:

Frequency: The frequency of a wave is the number of cycles that are completed by the wave in one second. It is the inverse of the period of a sinewave, which is the length of time between any two corresponding points on contiguous waves. For example, if a wave reached a maximum positive value at time $t = 0.01$ seconds and again at $t = 0.03$ seconds, it would have a period of 0.02 seconds. Because frequency is the inverse of period, the wave would have a frequency of $1/0.02$ seconds or 50 Hz.

Amplitude (or Magnitude): Amplitude is the maximum positive value the wave obtains. The sinewave shown in Fig. 2 has a magnitude of ten. It is possible for a sinewave to be offset by some value, so that its max-

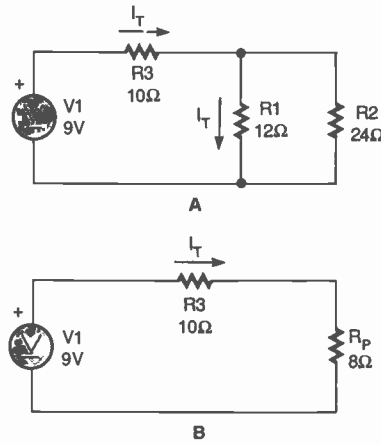


Fig. 1. Here's a simple DC circuit that shows how Ohm's law can be used to solve for the current through a given component.

imum positive value is different than its maximum (lowest) negative value. In this article we will only deal with sinewaves that are centered about the x-axis, so that the two "maximums" will always be the same.

Phase angle: This is the most difficult of the three parameters that define a sinewave. It is a measure of how "early" or "late" one sinewave is when compared to another. If you compare the two sinewaves shown in Fig. 3, you'll see that they have different amplitudes but the same frequency, and that one of them starts its increase about 60 degrees after the other. That wave is said to "lag" the other by 60 degrees, and therefore has a phase angle of -60 degrees.

Looking at the above three parameters from a mathematical perspec-

tive, the standard equation for a sinewave is:

$$x(t) = M\sin(360^\circ ft + \phi) \quad [\text{Eq. 1}]$$

where t is the time in seconds, $x(t)$ is the wave's magnitude at time t , f is the wave's frequency in Hertz, M is its magnitude, and ϕ is its phase angle.

The constant value of 360 in Eq. 1 is needed to make certain that both terms inside the equation's parentheses are represented in degrees, so that they can be added together and correctly interpreted by a calculator. For example, suppose we have a sinusoidal voltage with the three parameters: $f = 128$ Hz, $M = 36$ volts, and $\phi = -72$ degrees. To find the voltage of that wave at any particular time, such as $t = 0.2$ seconds, we simply need to insert that information into the form of Eq. 1. We get:

$$x(t) = 36\sin(360^\circ(128)t - 72^\circ) \\ x(0.2) = 36\sin[(360^\circ)(128)(0.2) - 72^\circ] \\ x(0.2) = 36\sin(9216^\circ - 72^\circ) \\ x(0.2) = 36\sin(9144^\circ) \\ x(0.2) = 36(0.58778) \\ x(0.2) = 21.16$$

Hence, we see that at time $t = 0.2$ seconds the voltage would be a positive 21.16 volts.

When solving AC networks, it's very difficult to perform calculations when all the currents and voltages have the form shown in Eq. 1. When a sinusoidal voltage is divided by a sinusoid current, for instance, the result is something related to the circuit's impedance. The trouble is that dividing one

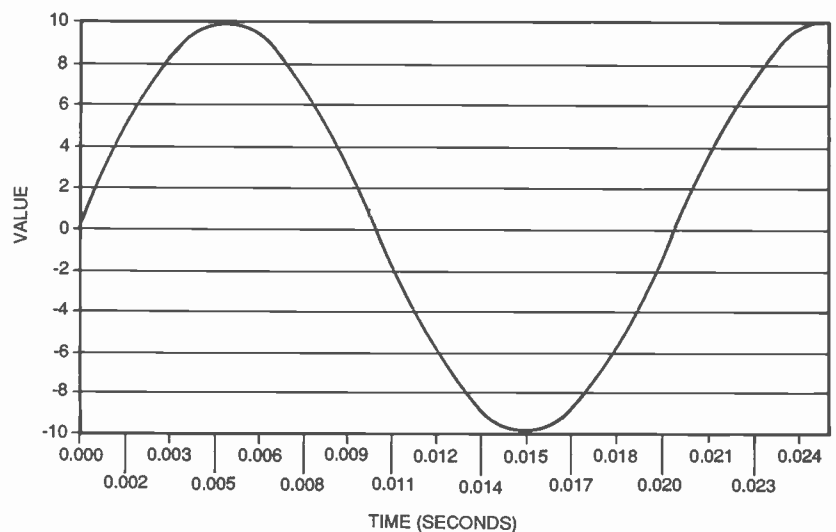


Fig. 2. A sinewave is the basic waveform for both voltages and currents in an AC circuit.

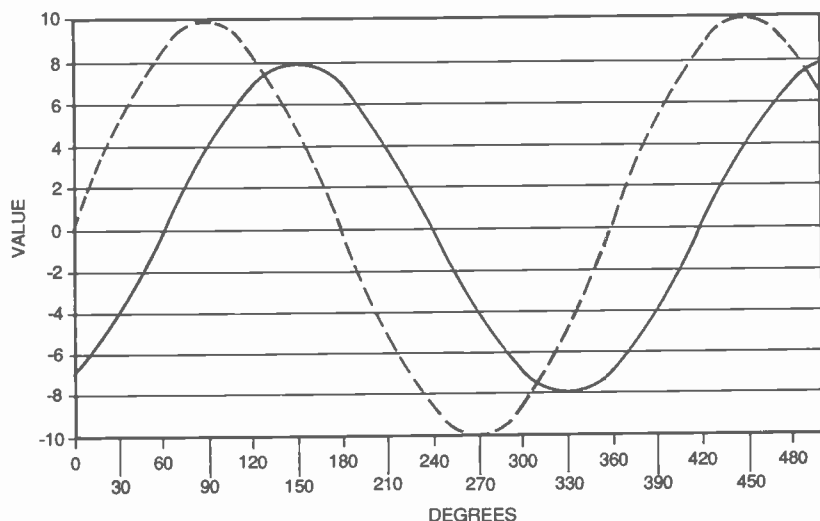


Fig. 3. Here are two sinewaves; both have the same frequency, but one "lags" the other by 60 degrees.

trigonometric equation by another is no simple task, and the equations are very difficult to solve.

Complex analysis is a technique that reduces the problem's difficulty. By using complex numbers, all the difficult trigonometric functions are hidden from view, and a solution can be obtained without the use of calculus or differential equations. So now let's turn to complex numbers—what they are and how they are used.

Complex Numbers. In this section we'll introduce the concept of complex numbers and present two different formats that they can be written in. For some readers this might be one of the most difficult sections of the entire article. If you fall into that category, don't worry. A complete understanding of this section is not required to actually use complex numbers to solve AC circuits.

So what exactly does a complex number look like? Well here are three examples of complex numbers:

$$\begin{aligned} &6 + j3 \\ &-1.3 - j2.61 \\ &+j4.5 \text{ (which could also be written} \\ &\text{as } 0 + j4.5) \end{aligned}$$

As you can see, a complex number contains two numerical components, which are called a real part and an imaginary part, respectively (because of the imaginary part, complex numbers are sometimes called imaginary numbers). By convention, the real part is usually written first, fol-

lowed by the imaginary part, which is signified by the label "j" (imaginary parts of numbers are also labeled "i" in some sciences, but not in electronics where that letter can be mistaken for current). It is unfortunate that history selected those names, because the word "imaginary" tends to make the subject sound more difficult than it is in reality. Better names might have been a horizontal part and a vertical part. The reason for that is easy to see if you look at Fig. 4.

Figure 4 shows what is called the complex plane—every complex number is located somewhere on it. The first term in the pair tells how many spaces right (for positive terms) or left (for negative terms) from the origin you must move to get to a particular number. The second, or imaginary, term tells how far above (positive terms) or below (negative terms) the real axis a number is located. All three of the example numbers given earlier are also shown in Fig. 4. A line drawn between the origin and any point in the complex plane is called a phasor.

Let's consider the "j" used in writing complex numbers. That term really has two basic functions: First, it is used as a convenient separator so that it is perfectly clear which term is real and which is imaginary. Second, it turns out that j is a real mathematical operation. If you multiply a phasor by the j term it turns out that you are really "rotating" that phasor counter-clockwise (CCW) by 90 degrees on the complex plane.

COMPLEX NUMBER CALCULATIONS: THE EASY WAY

It is time consuming to perform calculations with complex numbers. Even simple calculations are really two calculations: either one for the real part and one for the imaginary part (in rectangular coordinates), or one for the magnitude and one for the angle (for polar coordinates). That is slow, to say the least.

One way to speed it up the process is to use a calculator that is designed to handle complex numbers. Unfortunately, they still have a major drawback: they do not have the ability to store numbers in memory or to use the parentheses keys to order the operations you want to perform. You therefore end up writing intermediate results on scrap paper, and when you need them again you have to reenter them. There is a faster way.

The Complex Calculator (CMPX-CAL) is a DOS program that turns your computer into a five-function calculator for complex numbers. The five functions are addition, subtraction, multiplication, division, and "parallel impedance," which will automatically calculate the total impedance of two complex components in parallel.

CMPX-CAL is a Shareware program, and is available for the \$10 registration fee (plus \$2 shipping) from Aurora Software (P.O. Box 080133, Rochester, MI 48308-0133). Please specify whether you prefer either a 3.5- (1.44M) or 5.25-inch (360k) disk. Sorry, but no Michigan orders are accepted. ■

Consider the phasor $2 + j1$ shown on the complex plane of Fig. 5. If we rotate it 90 degrees CCW we get another phasor, $-1 + j2$. In the last paragraph it was stated that multiplying a phasor by a j was the same as rotating it CCW 90 degrees; let's see if that is correct. If it is, then j multiplied into $2 + j1$ must be the same as $-1 + j2$. Mathematically we would say:

$$j(2 + j1) = -1 + j2$$

By multiplying both parts of the $2 + j1$ number by the j term, we would get

$$\begin{aligned} j2 + jj1 &= -1 + j2 \\ j2 + j^21 &= -1 + j2 \end{aligned}$$

The j^2 terms "match up" on both sides of the equation, but if the two sides are really equal, then the j^2 term must equal a negative one. That is true (in fact, that is the real definition of the "j" operator); as a result, all the identities shown in Table 1 can also be easily

TABLE 1

$$\begin{aligned}
 j &= j \\
 j^2 &= -1 \\
 j^3 &= j^2 j = -j \\
 j^4 &= j^3 j = (-j)j = 1 \\
 j^5 &= j^4 j = j \\
 j^6 &= j^5 j = -1 \\
 j^7 &= j^6 j = (-1)j = -j \\
 j^8 &= j^7 j = (-j)j = 1
 \end{aligned}$$

And the pattern continues...

Raising j to negative powers gives:

$$j^0 = 1 \text{ (anything raised to the power of 0 equals 1)}$$

$$j^{-1} = \frac{1}{j}$$

$$j^{-2} = \frac{1}{j^2} = \frac{1}{-1} = -1$$

$$j^{-3} = \frac{1}{j^3} = \frac{1}{-j} = -j^{-1}$$

$$j^{-4} = \frac{1}{j^4} = \frac{1}{1} = 1$$

$$j^{-5} = \frac{1}{j^5} = \frac{1}{j} = j^{-1}$$

Again, the pattern continues

$$M = \sqrt{X^2 + Y^2} \quad [\text{Eq. 2A}]$$

$$A = \arctan(Y/X) \quad [\text{Eq. 2B}]$$

$$X = M \cos(A) \quad [\text{Eq. 3A}]$$

$$Y = M \sin(A) \quad [\text{Eq. 3B}]$$

The equations might look a little intimidating, but they are not too difficult to work with. If you have a scientific calculator, chances are it has the sine, cosine, and arctangent (sometimes labeled \tan^{-1}) functions on it. There is even a good chance that it will automatically perform rectangular to polar conversion—you might want to check your owner's manual. With either the calculator or manual method you'll want to get very good with the equations. As we're about to see, they will be used quite often in solving AC-circuit problems.

Mathematical Operations. The four basic mathematical functions become slightly more time consuming to perform with complex numbers. For numbers in rectangular coordinates, addition and subtraction are fairly easy while multiplication and division are fairly difficult. In polar coordinates just the reverse is true—multiplying and dividing are easy but addition and subtraction are more of a challenge. To keep things simple, in this article we'll perform all the mathematical operations in whatever coordinate system works out best; that is, addition and subtraction in rec-

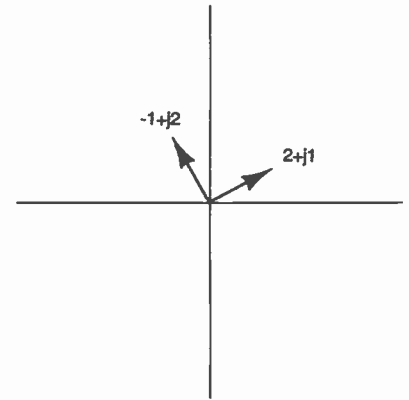


Fig. 5. In the complex plane, a rotation of 90 degrees is the same as a multiplication by j , the complex operator.

tangular and multiplication and division in polar.

Addition: This is the simplest of all operations. In rectangular coordinates, two complex numbers (or phasors) are added together by adding their respective parts: the real part of the result is the sum of the two real parts of the original numbers, while the imaginary part of the result is the sum of the two imaginary parts of the original numbers. For example:

$$\begin{aligned}
 (-3 + j5) + (14 - j7) &= (-3 + 14) \\
 &+ (+j5 - j7) = 11 - j2
 \end{aligned}$$

Subtraction: The same rule applies for subtraction as with addition; pair the two real parts and the two imaginary parts and perform the operation. The only trick with subtraction is that you do not inadvertently lose the negative sign introduced by the subtraction when you get to the imaginary half of the numbers. Here's an example:

$$\begin{aligned}
 (-3 + j5) - (14 - j7) &= (-3 - \\
 (+14)) + (+j5 - (-j7)) &= -17 + \\
 &j12
 \end{aligned}$$

Multiplication: In polar coordinates, multiplication of two numbers becomes a multiplication of their magnitudes and an addition of their phase angles. For example, to multiply $3 \angle 15^\circ$ by $2 \angle -60^\circ$, the magnitude of the result would be 6 (3×2) and the angle of the result would be -45° ($15^\circ + (-60^\circ)$). Therefore:

$$(3 \angle 15^\circ) \times (2 \angle -60^\circ) = 6 \angle -45^\circ$$

Division: By drawing an analogy with the multiplication operation, you can probably guess how to divide

derived. Those properties will be important later, when they allow us to simplify more-complicated-looking terms of complex numbers.

All of the examples so far have shown complex numbers in what are called *rectangular coordinates*. There is another notation that can be used called *polar coordinates*. There are pros and cons to both methods, and therefore we're lucky that it is relatively simple to convert a number from one notation to the other. If you've studied any trigonometry you probably already know the process.

To find a complex number on the complex plane using polar notation you would use a distance and an angle, as opposed to horizontal and vertical distances that are used in rectangular notation. For example, the number $4 + j4$ (as shown in Fig. 6) could be located relative to the origin by traveling at an angle of 45-degrees counter-clockwise from the x-axis, and at a distance from the origin of 5.657 units. Therefore $4 + j4$ in rectangular coordinates is the same as $5.657 \angle 45^\circ$, which is how "5.657 units (generally volts or amps) at 45° " is written in polar coordinates.

To convert back and forth from a rectangular number, $X + jY$, to the polar number $M \angle A^\circ$, the following equations are used:

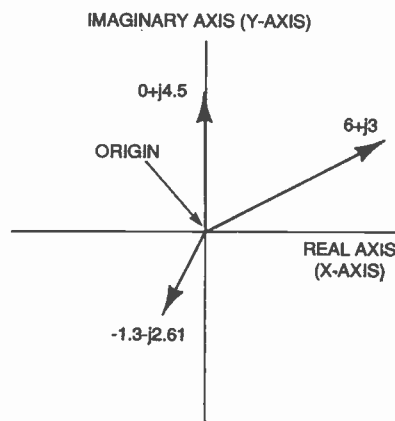


Fig. 4. Because complex numbers have two components, a real part and an imaginary part, they can not be illustrated by a number line. They are therefore shown on what is called the complex plane.

one complex number into another. Divide the magnitudes into one another to get the magnitude of the result, and then subtract the two phase angles. If you want to divide the number $3\angle 15^\circ$ by the number $2\angle -60^\circ$, you would divide 3 by 2, getting 1.5 for the magnitude, and subtract -60° from 15° to give 75° as the resultant phase angle. Therefore:

$$3\angle 15^\circ / 2\angle -60^\circ = (3/2)\angle (15^\circ - (-60^\circ)) = 1.5\angle 75^\circ$$

Capacitors and Inductors. In DC circuits, capacitors and inductors are used infrequently. The reason is fairly simple: under pure DC excitation a capacitor looks like an open circuit and an inductor looks like a dead short. Those components are used to control either voltage or current fluctuations in DC circuits. In summary, they are used for filtering. Things are much different in AC circuits.

When capacitors and inductors are excited by AC, they act a little more like resistors in that they impede the flow of current. How much they impede it is actually called the component's impedance, and depends on both the size of the component as well as the circuit's operating frequency. The mathematical symbol for impedance is a capital Z.

Ohm's Law is nearly the same for both DC and AC circuits, with two potential differences: One customary difference is that the symbol for impedance, Z, replaces the familiar symbol for resistance, R. Another change, which is less commonly used, is that some books will print bars over each of the symbols in Ohm's Law for AC circuits; the bars indicate that the voltage, current, and impedance terms are all complex numbers. (We will not use that convention in this article.) Putting that all together, the DC version of electronics' most basic law is: $V = IR$, while the AC version is $V = IZ$.

Now, returning to the subject of impedance, we are ready to write the equations to determine the impedance values of capacitors, inductors, and resistors. The equations are, respectively:

$$Z_c = 1/(j2\pi fC) \quad [\text{Eq. 4}]$$

$$Z_l = j2\pi fL \quad [\text{Eq. 5}]$$

$$Z_r = R \quad [\text{Eq. 6}]$$

The first thing to notice about the

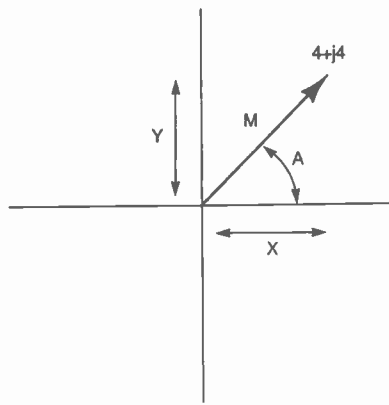


Fig. 6. Rectangular coordinates use horizontal and vertical distances from the origin to locate a point. Polar coordinates use an absolute distance from the origin at some angle to the positive horizontal (x) axis. Any complex number can be represented in either coordinate system.

three equations is that the impedance of a resistor is the exact same as its resistance. That's certainly easy enough.

The next thing to notice is that the impedance of both an inductor and a capacitor is the imaginary part of a complex number: the inductor carries a $+j$ term while the capacitor has a $-j$ term (that is the same as a $1/j$ term; again, see Table 1). As we have seen, a j is really a 90-degree change in phase. The basic idea is that capacitors and inductors cause a phase-angle change between voltages and currents in an AC network.

A third noticeable thing about the equations is that an inductor's impedance gets larger as its inductance, L, gets larger, but a capacitor's impedance actually decreases as its capacitance, C, increases. In mathematical terms, the impedance of an inductor is directly proportional to its inductance, while the impedance of a capacitor is inversely proportional to its capacitance.

The frequency of the circuit, f , also plays a role in determining impedance. Once again, with an inductor the impedance is directly proportional to frequency, while it is inversely proportional with a capacitor. Therefore, at a frequency of operation of zero (which is the same as saying it's a DC circuit), an inductor has no impedance—it acts like a dead short. Similarly, with a capacitor at a frequency of zero, its impedance goes very high,

approaching infinity as a limit—it acts like an open.

Complex Analysis. We now have all the tools we need to analyze AC circuits. The only thing missing is a process to put all those tools together; that process is called complex analysis.

Unlike its name, complex analysis is actually fairly simple, although it does sometimes take a considerable amount of time to complete the mechanics of it. There are three steps to the process:

Step 1: Convert the problem from the time domain into the complex domain.

Step 2: Solve the problem using Ohm's Law or any other analysis technique that you know.

Step 3: Convert the answer from the complex domain back into the time domain.

Because the last step is often done simply to make the result more understandable, it is sometimes skipped.

Example 1. At this point, an example is appropriate. The circuit shown in Fig. 7A contains two components and a voltage source all in series. The goal of this example will be to determine the current flowing through the circuit. Following Step 1 of the process, we need to convert the circuit into the

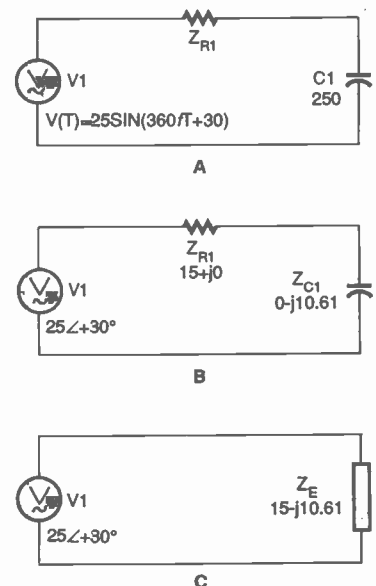


Fig. 7. This series combination of an AC voltage source, a capacitor, and a resistor serves as our first complex analysis example.

complex domain. That is done one element at a time. Let's start with the voltage source.

The voltage source has an output of

$$v(t) = 25\sin(360ft + 30^\circ)$$

and is operating at a frequency of 60 Hz. In phasor (complex) notation that becomes $25\angle 30^\circ$.

Converting the resistor's value to an impedance is as easy as copying a number down and adding a complex value of zero. That is, a 15-ohm resistance becomes a $15 + j0$ -ohm impedance in the complex domain.

The capacitor's impedance requires we use the equation Eq. 4, and plug in the values for f and C . Doing that, and then simplifying the expression a bit (using the properties of Table 1) gives:

$$\begin{aligned} Z_{C1} &= 1/(j2\pi fC) \\ Z_{C1} &= 1/(j2\pi(60)(250 \times 10^{-6})) \\ Z_{C1} &= 1/(j94.248 \times 10^{-3}) \\ Z_{C1} &= 10.61/j \\ Z_{C1} &= 0 - j10.61 \end{aligned}$$

We now have converted all three of the circuit's components into the complex domain. To make certain we now only deal in that domain, it's a good idea to redraw the circuit and to label each component with its complex impedance or supply value. For the example circuit, that is done in Fig. 7B.

Step two of the complex analysis

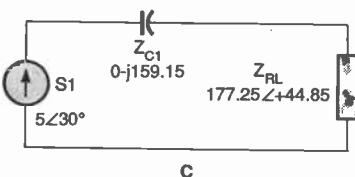
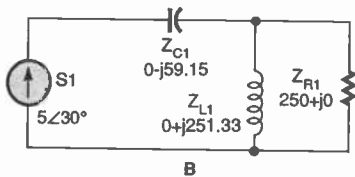
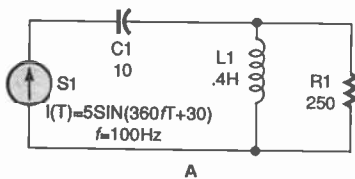


Fig. 8. This second example is a more difficult AC circuit to solve for. It's three components driven by a single current source.

procedure is to solve the network just as you would a similar DC circuit, so we'll follow the same method we used for the DC network of Fig. 1. Start by finding the equivalent impedance seen by the voltage supply. In the DC circuit above that was the two resistors in parallel, but for this circuit it's two complex impedances in series.

When two (or more) complex impedances are in series they simply need to be added together to calculate the equivalent impedance. For our example that means adding the values of Z_{R1} and Z_{C1} together.

$$\begin{aligned} Z_E &= Z_{R1} + Z_{C1} \\ Z_E &= (15 + j0) + (0 - j10.61) \\ Z_E &= (15 + 0) + (j0 - j10.61) \\ Z_E &= 15 - j10.61 \end{aligned}$$

The circuit can now be updated with the new equivalent impedance, as shown in Fig. 7C.

All that remains is to use Ohm's Law to calculate the current flowing in the circuit. Current is the circuit's voltage ($25\angle 30^\circ$) divided by its total impedance ($15 - j10.61$). To perform that calculation we'll convert the impedance to polar coordinates and then perform the division. We'll leave the answer in polar form, because that will be the easiest to convert back to the time domain. We get:

$$\begin{aligned} M &= \sqrt{X^2 + Y^2} \\ M &= \sqrt{(15)^2 + (-10.61)^2} \\ M &= \sqrt{225 + 112.572} \\ M &= \sqrt{337.572} \\ M &= 18.373 \end{aligned}$$

and

$$\begin{aligned} A &= \arctan(Y/X) \\ A &= \arctan(-10.61/15) \\ A &= \arctan(-0.7073) \\ A &= -35.273^\circ \end{aligned}$$

And now, knowing that $Z_E = 15 - j10.61$ is the same as $Z_E = 18.373\angle -35.273^\circ$, we can perform the Ohm's Law calculations:

$$\begin{aligned} I &= V/Z \\ I &= 25\angle 30^\circ / 18.373\angle -35.273^\circ \\ I &= (25/18.373)[(30^\circ) - (-35.273^\circ)] \\ I &= 1.361\angle 65.273^\circ \end{aligned}$$

From all that we see that the current flowing in the circuit has a magnitude of 1.361 amps and it is at a phase angle of positive 65.273 degrees.

The last step in the process is to convert the answer from complex domain back into the time domain. Because the result is simple, and be-

cause it is already in polar form, that can be done easily:

$$I = 1.361\angle + 65.273^\circ$$

becomes

$$I = 1.361\sin(360ft + 65.273^\circ)$$

in the time domain.

Example 2. Although it did take some time, the first example was not that difficult. We'll now look at another example that will get a tad bit more arduous. The circuit shown in Fig. 8A has a capacitor in series with a parallel combination of an inductor and a resistor, and it is all powered by an AC constant-current source. The problem: find the voltage, V_1 , across the independent current source, I_1 .

Step one is to convert the problem to the complex domain. By inspection, the constant-current source is converted from $5\sin(360ft + 30^\circ)$ to $5\angle 30^\circ$. Also, the resistor converts from 250 ohms to $250 + j0$.

Converting for the capacitor, C_1 , gives:

$$\begin{aligned} Z_{C1} &= 1/(j2\pi fC) \\ Z_{C1} &= 1/(j2\pi(100)(10 \times 10^{-6})) \\ Z_{C1} &= 1/(j6.28310 \times 10^{-3}) \\ Z_{C1} &= 159.15/j \\ Z_{C1} &= 0 - j159.15 \end{aligned}$$

And now converting for the inductor, L_1 :

$$\begin{aligned} Z_{L1} &= j2\pi fL \\ Z_{L1} &= j2\pi(100)(0.4) \\ Z_{L1} &= j251.33 \\ Z_{L1} &= 0 + j251.33 \end{aligned}$$

Combining all those results, we end up with the complex domain circuit shown in Fig. 8B. Next we'll add the two parallel impedances together to find their equivalent complex impedance, which we'll call Z_{RL} . That is done with the same formula that we used in the DC circuit—the equivalent impedance is the product of the two impedances divided by their sum. Finding the sum is easy, because both components are in rectangular components. To calculate their product, however, we need to convert them into polar form.

The resistor's impedance has no imaginary part, so it is just $250\angle 0^\circ$. Similarly, the inductor's impedance only has a positive imaginary part, so it must be $251.33\angle +90^\circ$. Both of those can be easily confirmed by examin-

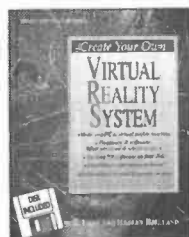
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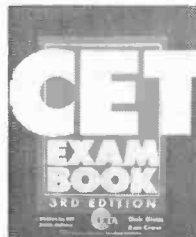
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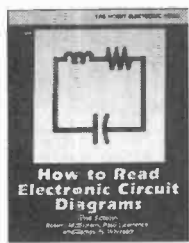
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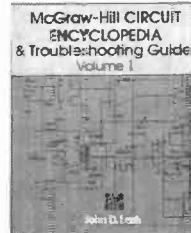
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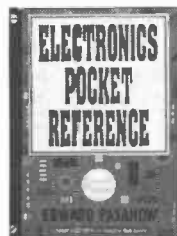
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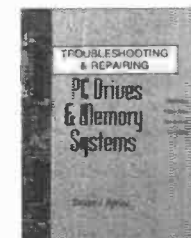
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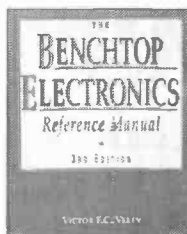
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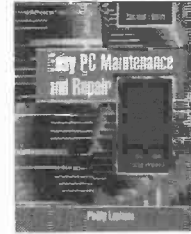
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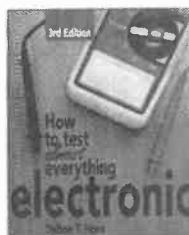
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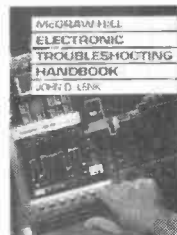
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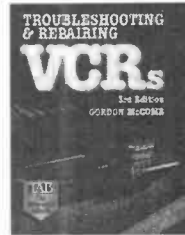
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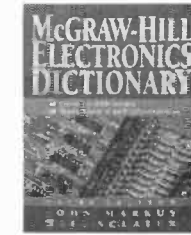
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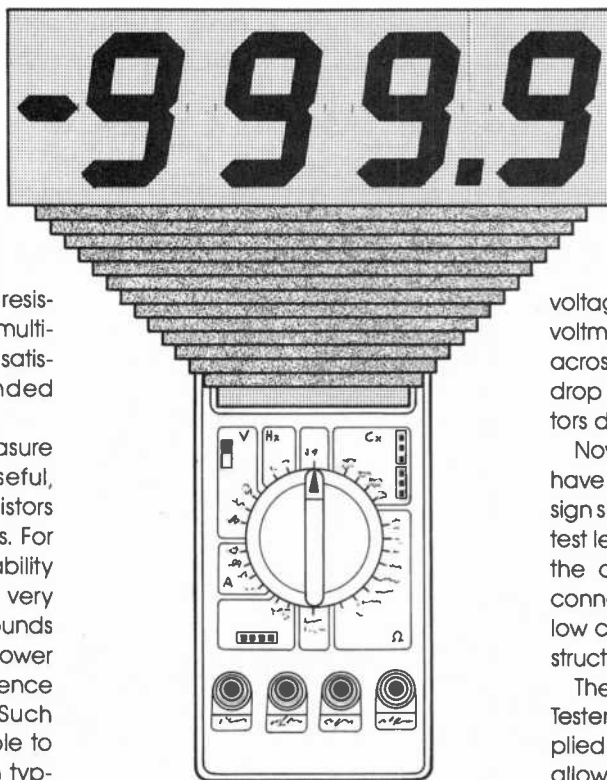


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For most applications, the resistance ranges on digital multimeters (DMMs) are usually satisfactory. But sometimes, extended ranges are needed as well.

First of all, the ability to measure smaller resistances can be useful, both to measure low-value resistors and to locate poor connections. For example, the author found the ability to read resistance to 0.001 ohm very helpful in finding the poor grounds that were causing an audio power amplifier to have severe interference from AM broadcast stations. Such measurements can be impossible to do using standard DMMs, which typically can measure and display resistances only as low as 0.1 ohm.

Now, the upper reading of many DMMs is 20, 30, or 40 megohms. But there are also some units that only read up to 2 or 3 megohms, and there are instances when higher ranges are desirable.

So what do you do to add the extra ranges? Build the *Low-Ohms Tester* and the *Megohm Tester* described in this article. They can be used with nearly any DMM to extend the resistance ranges down to 0.001 ohm and up to hundreds of megohms. The Low-Ohms Tester lets you take a direct reading from your DMM's display and simply multiply the reading by 10 or 100. The Megohm Tester requires a two- or three-step calculation with a pocket calculator to determine the resistance.

How they Work. Two basic methods of resistance measurement are used in these circuits: the constant-current four-wire method in the Low-Ohms Tester, and the constant-voltage method in the Megohm Tester. Both circuits use a three-terminal voltage regulator to improve accuracy and take advantage of the high sensitivity of the DC voltage ranges of DMMs (usually the lowest readout is 0.1 millivolt, even on low-priced DMMs).

In the four-wire constant-current method shown in Fig. 1, the voltage drop across the resistance being

Expanded Resistance Ranges for your DMM

BY BILL STILES

With the help of these two simple devices your DMM can take readings on much lower or higher ranges.

measured is directly proportional to the resistance. Therefore, by choosing a current of 10 or 100 mA, the calculation is reduced to multiplying the voltage reading by 100 or 10. An advantage of the four-wire method eliminates the effect of test-lead and contact resistance by using four test leads, two to carry the constant current to the resistance being measured, and two for measuring the

voltage across the resistance. Thus the voltmeter reads only the voltage drop across the test resistance; the voltage drop in the current-carrying conductors does not affect the reading.

Now, because it is inconvenient to have four test leads, the type of design shown in Fig. 1 is used. There, each test lead is a two-wire cable. To make the circuit work properly, test clips connected to the leads should have low contact resistance (see the Construction section for more on that).

The actual circuit for the Low-Ohms Tester is shown in Fig. 2. Power is supplied by a 9-volt battery, B1. Switch S1 allows the selection between a current of 10 or 100 mA. As mentioned earlier, that means you would either multiply the voltage reading by 100 or 10, respectively, to find the resistance being measured. The remaining components make up the constant-current circuitry represented in Fig. 1.

Now let's look at the constant-voltage method. There, the resistance being measured is proportional to the current flowing through it. To measure high resistances, a sensitive current meter and/or a high test voltage is needed. The Megohm Tester uses a modified constant-voltage method (shown in Fig. 3), which lets you determine current by measuring the voltage (V_x) across a resistor (R) in series with another resistance being measured (R_x). Resistor R , shown as a value of 1 megohm, is actually the parallel combination of the DMM's input resistance and a calibration resistor in the Tester.

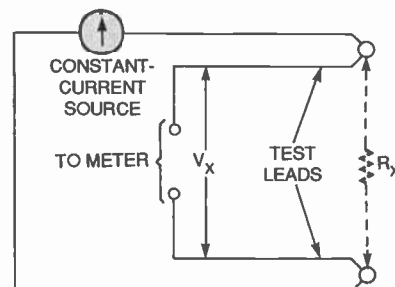


Fig. 1. Shown here is the four-wire constant-current method of measuring resistance.

Now, it's not possible to directly measure V_x because the input resistance of the meter (10 megohms for many DMMs) would be in parallel. However, because V_{in} is constant and V can be measured, V_x can be calculated by subtracting V from V_{in} .

For two resistors in series, the voltage drop across each is directly proportional to its resistance. A formula for the ratio is:

$$R_x/R = V_x/V$$

In this case, with resistances in megohms, R equals one and the formula becomes:

$$R_x = V_x/V$$

Because $V_x = V_{in} - V$, the final formula is:

$$R_x = (V_{in} - V)/V$$

where V_{in} is the regulated input voltage and V is the measured voltage (in either volts or millivolts, if they are both the same units), and R_x will be the resistance being measured (in megohms). For resistances over 100 megohms, the simplified formula:

$$R_x = V_{in}/V$$

can be used with an error of less than one percent. The error does increase at low resistances, though. An error of one percent in V_{in} or V gives an error of two percent in R_x at 1 megohm, three percent at 0.5 megohm, and six percent at 0.2 megohm.

Voltage V_{in} must be high enough to produce a readable voltage across R . For a V_{in} of 6 volts (using a 9-volt battery and a 6-volt regulator) and a DMM whose lowest valid measure-

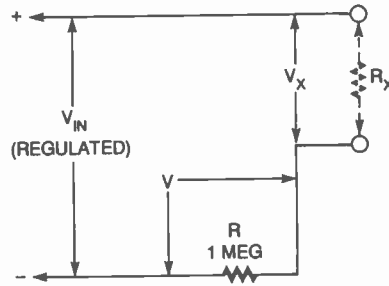


Fig. 3. This is the modified constant-voltage method of measuring resistance. It lets you determine current by measuring the voltage (V_x) across a resistor (R) in series with another resistance being measured (R_x).

ment is 0.1 millivolt, a maximum of 600 megohms can be measured before V becomes less than three digits. By using two 9-volt batteries in series and a 15-volt regulator, the maximum becomes 1500 megohms.

The actual circuit for the Megohm Tester is shown in Fig. 4. Power is supplied by a 9-volt battery, and switch $S1$ is a power switch.

As just mentioned, different V_{in} voltages can be used, so a number of different regulators can be used for $U1$. The component chosen for $U1$ determines the values used for $R1$ and $R2$ (see the Construction section and the Parts List for more on that).

Potentiometers $R2$ and $R4$ are used to calibrate the circuit. Resistor $R3$ takes the place of the R value mentioned in the earlier calculations.

Construction. The two circuits should be built on separate circuit boards, using any standard project-building method; layout is not critical.

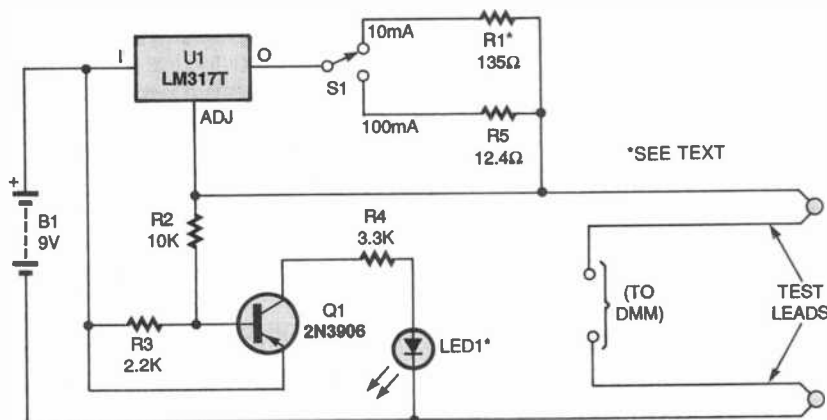


Fig. 2. Here's the schematic for the Low-Ohms Tester. Switch $S1$ allows the selection between a current of 10 or 100 mA, which means you would either multiply the voltage reading by 100 or 10, respectively, to find the resistance being measured.

PARTS LIST FOR THE LOW-OHMS TESTER (Fig. 2)

SEMICONDUCTORS

- U1—LM317T adjustable-voltage regulator, integrated circuit
- Q1—2N3906 PNP transistor
- LED1—Low-current light-emitting diode (see text)

RESISTORS

- (All resistors are 1/4-watt, 5% units, unless otherwise noted.)
- R1—135-ohm (see text)
 - R2—10,000-ohm
 - R3—2200-ohm
 - R4—3300-ohm
 - R5—12.4-ohm, 1%

ADDITIONAL PARTS AND MATERIALS

- S1—SPDT miniature toggle or slide switch
- B1—9-volt alkaline battery
- Perforated board (see text), enclosure, 9-volt battery snap with leads, zip cord (18 or 20 gauge), alligator clips (see text), tip jacks or banana plugs, wire, solder, hardware, etc.

You could then mount the two completed boards in the same case and, if you wish, power them from the same 9-volt battery.

When building the Low-Ohms Tester, start by mounting the resistors. Then install $Q1$ and $U1$, making sure to observe proper orientation for each. Switch $S1$ and LED1 can be mounted to the case.

To make test leads, you can use zip cord (18 or 20 gauge). For the test connectors at the end of the leads, don't use ordinary plated-steel alligator clips because their contact resistance is too high. Kelvin Clips, which are designed for four-wire resistance measurement, are recommended. The jaws of those clips are insulated from each other, and you can connect one wire of a test lead to each jaw. The drawback to Kelvin Clips is that they are rather expensive; contact Hosfelt Electronics, Inc. (2700 Sunset Blvd., Steubenville, OH 43952-1158; Tel. 800-534-6464; Fax: 800-524-5414) for more information.

An alternative to the Kelvin Clips are large, solid-copper alligator clips, which work almost as well and are much cheaper. They could have contact resistances of less than 0.001 ohm, but you could have to move them slightly, after clipping them on

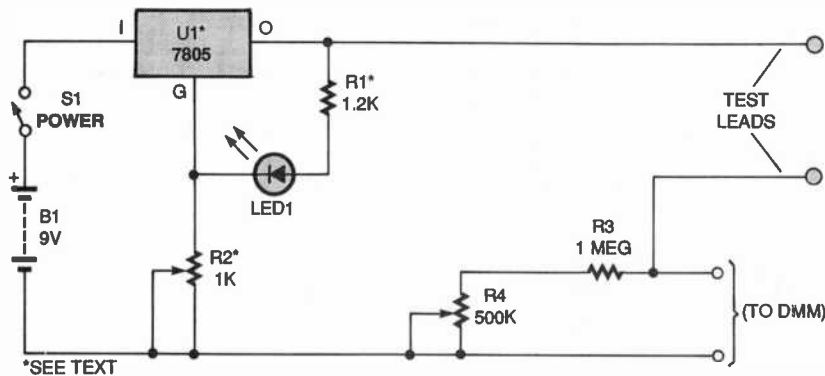


Fig. 4. Here's the schematic for the Megohm Tester. Because different V_{in} voltages can be used, U1 can be either a 7805, 7806, 78L05, or 78L06. However, the regulator used determines the values used for R1 and R2.

PARTS LIST FOR THE MEGOHM TESTER (Fig. 4)

RESISTORS

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

R1—1200-ohm (see text)

R2—1000-ohm multi-turn trimmer potentiometer (Bourns 3006P series, Spectrol 43P series, or equivalent; see text)

R3—1-megohm

R4—500,000-ohm multi-turn trimmer potentiometer (Spectrol 43P504, Bourns 3006P-504, or equivalent)

ADDITIONAL PARTS AND MATERIALS

U1—7805, 7806, 78L05, or 78L06 voltage regulator (see text)

LED1—Low-current light-emitting diode (see text)

S1—SPST, miniature toggle or slide switch

B1—9-volt alkaline battery

Perforated board (optional, see text), enclosure, 9-volt battery snap with leads, tip jacks or banana plugs, wire, solder, hardware, etc.

the object to be measured, to get the lowest resistance. The alligator clips are available from any supplier carrying Mueller clips. Hosfelt Electronics has them, as does Mouser Electronics (2401 Highway 287 North, Mansfield, TX 76063-4827; Tel. 800-346-6873; Fax: 817-483-0931).

Tip jacks can be used to connect the circuit to the DMM (the meter test prods plug into them). Or you can attach wires, ending in banana plugs, to the circuit and simply plug them into the DMM test-lead jacks.

The LED used in the Low-Ohms Test-

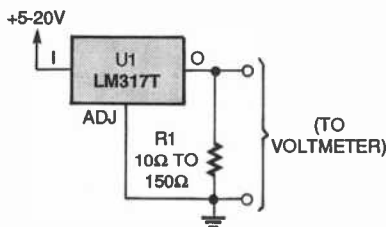


Fig. 5. To determine which LM317T regulator is the best to use in the Low-Ohms Meter, temporarily connect each available LM317T to this circuit. Choose the one whose output voltage is nearest to 1.24 volts.

er is a low-current type, needing a current of only 2 to 2.5 mA, which extends the life of B1. Radio Shack offers a low-current LED (stock number 276-044). Another source is Digi-Key Corp. (P.O. Box 677, Thief River Falls, MN 56701-0677; Tel. 800-344-4539; Fax: 218-681-3380); they have red (stock number HLMP-4700QT-ND) and yellow (HLMP-4719QT-ND) LEDs available.

The one-percent resistor, R5, can be obtained from Digi-Key, Mouser Electronics, or numerous other sources. No power switch was used in the prototype, as the current is extremely low when the test clips are not connected. The original battery used for B1 has lasted for several months and is still working.

Note that the value necessary for R1 is not a standard value. You can either use two resistors in series (for example, a 120-ohm and 15-ohm) to get the correct value, or use a 200-ohm multi-turn trimmer potentiometer and adjust it to the correct resistance.

If an accurate voltmeter and more than one LM317T are available, slightly higher accuracy can be ob-

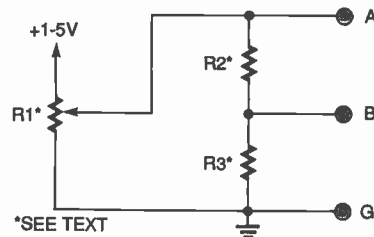


Fig. 6. The circuit shown here can be used to check for a change in input resistance between the lowest DC voltage ranges of a DMM.

tained on the 100-mA range. To determine which regulator to use, temporarily connect each available LM317T to the circuit of Fig. 5, and choose the one whose output voltage is nearest to 1.24 volts. That output will match the standard one-percent resistor value for R5: 12.4 ohms. Any source of 5- to 20-volts DC can be used.

When building the Megohm Tester, you have the option of not using a circuit board at all. The regulator, switch, potentiometers, and LED can all be mounted to the case. The leads of R2, R4, and U1 can be used as tie points for the fixed resistors.

Note that a 7806 or 78L06 that has an output slightly below 6 volts can also be used for U1. However, you will have to replace R1 with an 1800-ohm resistor, and R2 with a 100- or 200-ohm unit. The current through R1, LED1, and R2 is about 2.5 mA. That is less than the recommended 5 mA, but it works fine.

Again, tip jacks or banana plugs can be used to connect the Megohm tester to the DMM. Just make sure you label which leads connect the meter to which of the circuits.

Calibration and Use. The 10-mA range of the Low-Ohms Tester has to be calibrated for the circuit to be accurate. There are two ways of doing that: One way is to connect a milliammeter to the test leads and adjust R1 for a reading of 10 mA. Or, you can attach one or more precision resistors (with values of 1 to 10 ohms) to the leads and adjust R1 for a correct reading.

There are two calibration adjustments that need to be made to the Megohm Tester. For starters, connect your DMM to the Megohm Tester. Short the test leads (of the Megohm Tester), and adjust R2 for a reading of 6 volts.

(Continued on page 90)

Build The Magic Eye

Bring back some of the nostalgia of the golden age of radio with this tuning indicator.

BY LARRY LISLE

Anyone who enjoyed radio in the 1940s might remember sitting in front of a big console radio, watching its green, glowing, magic-eye tuning indicator and listening to those great programs. Of course, the golden age of radio faded away in the fifties, taking big consoles and magic-eye tubes with it, but that doesn't mean you can't recapture some of the magic of that bygone era.

The *Magic Eye* described in this article lets you add a for-display-only magic eye (with the same green glow) to your modern stereo. Or, you can add a few parts and use your Magic Eye as an actual tuning indicator for an AM radio. Because the tube used in the project will work on AC as well as DC, no rectifier or filter is needed. For that reason, the project is really simple to build. And best of all, it really looks great in the dark while playing an old-time radio tape!

Magic-Eye Tubes. Invented in the mid-1930s, the magic-eye tube is basically a triode vacuum tube with a fluorescent target in the dome of its glass envelope. The target operates at a positive voltage and attracts electrons from the cathode. As a result of those electrons striking the target, a characteristic green glow is formed. A "ray-control" electrode between the cathode and target casts a wedge-shaped shadow on the target, varying from zero to about 100 degrees, depending on its voltage, which is determined by the voltage on the grid of the triode.

In practice, the grid was connected to the automatic-volume-control (AVC) circuit of a superheterodyne receiver. When a station was centered in the bandpass, the AVC voltage would be maximum and the eye would close. Magic-eye tubes were

also used in a variety of test instruments because of their very-high input impedance and because they wouldn't be harmed by a momentary overvoltage.

If you recall, it was mentioned that the tubes work on AC as well as DC. While that is true, when a magic eye is operated with AC on the plate and target, the tube is turned off on the negative peaks. That isn't noticeable, however, and shouldn't affect the application described here.

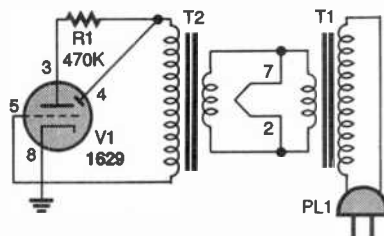


Fig. 1. The simple version of the Magic Eye circuit, shown here, is a for-show-only unit.

Circuit Description. Figure 1 shows the schematic for the Magic Eye. The version of the circuit shown in that figure can be used only for show. Transformer T1 steps the 117-volts AC from the wall outlet down to 12.6-volts AC for the filament of the 1629 tube, V1. The other transformer, T2, then steps the voltage back up to 117-volts AC for the target and plate. The two transformers isolate the tube from the power lines for safety.

Figure 2 shows how a few additional components can be added to make the circuit a real tuning indicator for old radios. While the grid of the tube in Fig. 1 is simply grounded, in Fig. 2 it's connected through resistor R2, capacitor C1, and potentiometer R3 to the circuit ground and AVC line of a radio. Potentiometer R3 lets you calibrate the circuit so that the Eye will close when a station is tuned.

Construction. The author's pro-

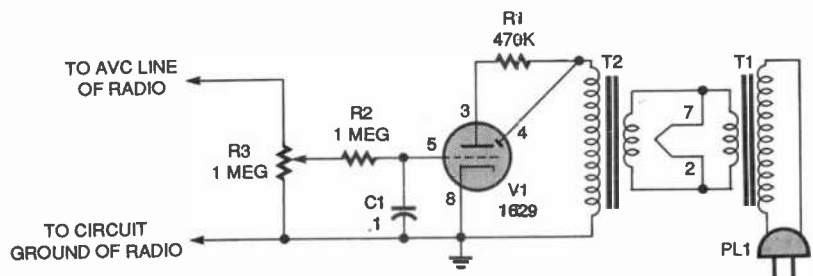


Fig. 2. By adding a few components, you can use the Magic Eye as a tuning indicator. Adjust potentiometer R3 so that the eye tube, V1, will go out when a station is tuned in.

Some types of magic eyes, such as the 6G5 and 6U5, are getting scarce and expensive, and should be reserved to keep radios designed for them glowing. However, the 1629 used in the Magic Eye described in this article, which was made for the "command-set" transmitters of World War II as a calibration indicator, is fairly plentiful.

totype of the Magic Eye was built in an 8- x 6- x 3-inch project box, but it could just as easily be built in a wooden box or in the bottom of a speaker enclosure. You can use any project-building method as well, because layout is not critical. However, you really don't need to use a circuit board for the project; simply use the

(Continued on page 94)

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CB06

ANTIQUE RADIO

By Marc Ellis

From the Mailbag

Our regenerative receiver project had to be put on hold this month because of the upcoming (just a few days away) "Radiofest 95" meet in Elgin, Illinois. Most of you know that Radiofest is one of the major antique-radio events of the season. And this year I'll be giving a talk there: a

retrospective on the restoration projects that have been done in *Antique Radio* during the almost ten years we have been in business. Wish you could all attend!

It seems odd that I have to change the course of our December column because of an event taking place in early August, but such is the time frame of the magazine-publishing industry. In any case, you readers, never shrinking violet, are well able to fill the void. Even though we had a mailbag column just a few months ago, several more interesting letters have already come in.

MORE ON THE MINERVA

We said earlier that the Minerva Tropicmaster was being sold in military PXs as recently as the later 1940s, but had disappeared from the market—along with its manufacturer—soon thereafter. Radio Historian Alan Douglas (Pocasset, MA) provides the epitaph with a clipping from *Radio and Television News* of November 1951. It's an ad from Leotone Radio, that well-known surplus firm of old, and I'm running a detail from it here.

The distinctive Minerva cabinet (there's no mistaking that speaker grill and schematic chart frame) is being offered as a "Radio-Amplifier Steel Cabinet" for \$2.49. Oddly enough, the color is given as "walnut." So far, I haven't come across a walnut Tropicmaster—but such a change might have been made late in the manufac-

turing cycle to make the set more acceptable in the civilian market. Elsewhere in the same issue, Alan highlighted an item indicating that a gentleman named Ignatius Volpe, formerly with Minerva, had been appointed chief engineer of Steelman Phonograph and Radio Co.

Anyone who might have doubted that the Tropicmaster was built along the lines of a military morale set should take a look at the photos of the Model 6000-BAC troop entertainment radio belonging to Bill Morris of Indiana. Built under "USN Contract N-140 S 70560A," it has a very similar cabinet, which is also finished in battleship gray and fitted with a chart frame on the inside of the front cover. The front-panel design of the 6000-BAC is a lot cruder, though.

It's interesting to note that the set has a front-panel-mounted antenna-ground terminal as well as a switch for "6VDC-115V AC/DC" operation. There must be a vibropack inside, and I assume that the six volts would have come from an external battery (or possibly from ship's power?) because it doesn't look as if there'd be room for a battery pack of any size in the cabinet.

Bill's set has been modified, and he's looking for schematics, etc. so that he can restore it to original condition. He'd also like to get his hands on information relating to the SSR-5 psy set manufactured for the OSS during World War II. Unfortunately, I can't read the town name on his re-

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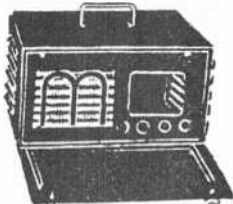
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ALNICO MAGNET KIT .. Powerful Bar, Black,

By 1951, it was all over for the Tropicmaster, as this detail from a Leotone ad of that year suggests. The sturdy metal cabinets were being offered as surplus at \$2.49.

turn address. But anyone who has such information can send it to me for inclusion in the column (and for forwarding to Bill if he sees this item and sends me his address). By the way, Bill is looking for sources for four-tube pre-World War II miniature personal battery portables like the Emerson 640 and Emerson 14WG438.

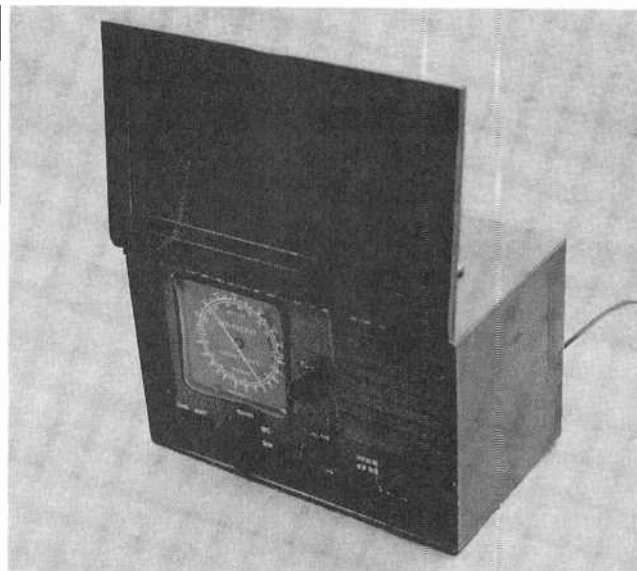
RECAPPING WITH CLASS

Until recently, I've resisted wholesale recapping of old sets. I hated to spoil the authenticity of a radio by removing the original units, with their charming typography and interesting logo designs. If the caps were okay, I left them in. However, that's really a short-sighted point of view.

During the years I've been writing and reading about antique radio, I've come to understand that those decades-old paper caps (especially the wax-covered ones, which are more susceptible to degradation by moisture) are really not trustworthy. They can fail at any time, taking with them additional components that might be expensive and/or unobtainable. Further, many are leaky without being obviously so, subtly degrading the performance of the set.

I now feel that if any set is worth restoring it's worth recapping, unless you are just going to put the radio up on a shelf and look at it. After reading the *Antique Radio* installment in which the Tropicmaster got a complete recap, reader Kurt Lamoreaux (Lomita, CA) wrote the following note, which I'll quote essentially verbatim.

"The June 95 *Antique Radio* column in **Popular Electronics** was excellent. The Minerva Gets a Recap-



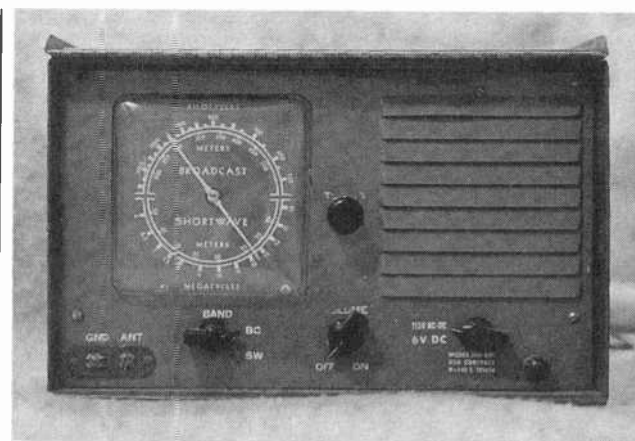
The model 6000-BAC Navy "troop entertainment radio" belonging to Bill Morris. You'll note a strong resemblance to the Minerva Tropicmaster.

ping' outlines very good capacitor replacement techniques for restoring antique radios. In my experience, re-capping is well worth the trouble. In the interest of authenticity, the paper and wax-type caps can be 're-packed.'

"First, the locations, polarities, and values are all recorded. Caps are then removed from the equipment. The wax is melted out carefully using a small sauce pan. While the paper tubes are still hot, the contents are pulled out.

"Suitable replacement caps are obtained and inserted into the empty tubes. Molten beeswax (which can be obtained from a beeswax candle) is now poured into the ends of the tube. The last step is to dip the caps into the molten wax several times, allowing them to cool between dips. The completed caps are now ready to be reinstalled and they look very authentic."

I had been aware, of course, that some restorers were melting out and replacing the insides of old paper caps. But I'd never read up on the details be-



A close-up of 6000-BAC's front panel shows its Spartan layout. The 6/115-volt power switch is under the speaker.

cause I didn't think I'd have the patience to do it myself. However, Kurt got it all out on the table with a few well-chosen sentences, and makes the process sound fairly easy to boot.

If you want to recap, but don't have the time or the patience to go through Kurt's process, here's what I'd recommend. Put the old capacitors inside a plastic baggie, with a note attesting their authenticity, and store the package inside the cabinet. That way another restorer (or perhaps you, when you're in a more mellow mood) can make the conversion later.

NO STOOP, NO SQUAT, NO SQUINT

Reader Raymond Shetrone (2313 Harvard Ave, Ft. Meyers, FL 33907) sends some very nice photos and a question or two. Remember those "No Stoop, No Squat, No Squint" Philco ads circa 1938? They featured a woman "with a very large rear end" trying to tune an old straight-front console.

Ray has a Model 38-7, one of the slant-top console Philco was marketing for folks who wanted to avoid stooping. He noticed an inscription that appears to be in French at the bottom of the dial, and doesn't re-

member seeing anything similar on other Philcos. Could it be the name of the dealer? Unfortunately, Ray didn't copy it for us.

Studying the photos with a magnifying glass, I can make out the words "Made in United States of America" at the bottom of the dial. About an inch below that is a three-word inscription I can't make out. Perhaps it's the mystery one that Ray described. Ring a bell with anyone?

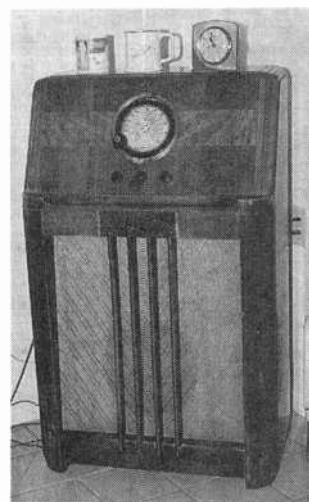
HELP WANTED

The Tropicmaster articles caught the eye of Peter Maisch (816 Alderleaf Dr.,

Fuquay-Varina, NC 27526) because he is also restoring one of those sets. Peter's was modified (the rectifier tube was replaced with a selenium unit) and he needs a schematic.

Actually, a good copy of the Tropicmaster schematic can be found in the May, 1995 column. But anyone with further information should contact Peter directly.

Bill Exley (271 Northgate Dr., Tarpon Springs, FL 34689) has a Silvertone AM radio/record player/wire recorder and is enjoying listening to the recordings



Raymond Shetrone's slant-top Philco Model 38-7 allowed listeners to tune with "No Stoop, No Squat, No Squint."

that came with it (family meetings, music of the '30s and '40s, an auction). Everything works fine; Bill would just like more background information on the set.

Richard R. Ellis (2796 N Co. Rd. 260-E, Seymour, IN 47274-8615) seeks sources of parts and construction specifications for different types of old-time crystal sets. Jim Dutridge (1139 Shadowlawn, Toledo, OH 43609) could use some advice on reviving a Brunswick Balke Collender "Madrid" phono (circa 1923) that appears to have a broken

drive-motor mainspring.

Anyone familiar with the Electronic Measurements Corp. Model 101A VOM? Harold W. Taylor (336 De-catur Ave., Apt. 5B, Bronx, NY 10467) needs operating instructions and would also like to know the purpose of the male plug set into the right side of the instrument's wooden case. Can someone assist Ronald R. Care (104 N. Main St., Suite 214, Greensburg, PA 15601) with parts and schematics for Zenith R246853 Model 12-S-265? Chris Hodges (POB111 Woosung, IL 61091) is looking for suggestions on how best to market his Magnavox M-2A5P which is complete, original, and in nice condition.

Denys Fredrickson (3923 E. Funston, Wichita, KS 67218) requires a schematic for a Jackson & Bell cathedral (model unknown;

swan on speaker grill; tubes: 3-24As and a 45). The model number is also unknown on a Zenith Trans-oceanic discovered by Donald LaPierre (44 Walnut Dr., Whitesboro, NY 13492) in an attic. It has flip-up and whip antennas and miniature glass tubes. He needs technical information.

How about schematics and technical information for a Lafayette All Band Radio Model HA-230 and a Hallicrafters Model S-86. If you can help, contact Leonard Frankenhouser, Unit 901, 291 Scarborough Dr., Conroe, TX 77304. Rick Newton (2384 Bellwood Dr., Pittsburgh, PA 15237-6634) needs the same for a Grundig Majestic 2120U. Ray Moran (3316 Guadalupe St., #213, Austin TX 78705, Phone: 512-458-1476) is legally blind but likes to work on old TVs (with the help of

very powerful eyeglasses). He's stumped by a 1964 RCA color set (CTC-16E chassis) with vertical linearity problems. He would like to consult with older technicians who have worked on the model and also to acquire a test jig with appropriate adapters.

How about a power transformer and schematic for a Telefunken S/N 11561? Carl Louis (1407 New York Ave., Brooklyn, NY; Phone: 718-826-3212) needs them. Can anyone send Alan Johnson (2490 Sharon Way, Reno, NV 89509) a copy of the dial-stringing diagram for a Hallicrafters S-19R Sky Buddy?. Finally, Albert C. Anderson (5258 Cordelia Ave, Baltimore, MD 21215-5023) could use advice on jury-rigging a battery pack for a Triplett VOM/VTVM, as well as Triplett's address, if the firm still exists. ■

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CIRCLE 172 ON FREE INFORMATION CARD

COMPUTER BITS

By Jeff Holtzman

Going Online

Here's a quick quiz for you to take: Which of the following statements are true: The online world is fascinating. The online world is boring. There is lots of useful information online. The vast majority of the online information is garbage. There is intelligent, informed discussion on every conceivable topic. There is a bunch of offensive, boorish dolts who have no other way of getting an audience. It's a home for

extremist groups. It's middle-America's newest playground.

Answers:

- A.** All of the above.
- B.** Some of the above.
- C.** None of the above.

If you chose A, go to the head of the class. The rest of you need to fire up those modems and get connected!

GETTING CONNECTED

In the past, there were

three basic choices: traditional bulletin-board services; commercial online services such as America On-line (AOL), Byte Information Exchange (BIX), CompuServe, GENIE, MCI Mail, Microsoft Network (MSN), and Prodigy; and the Internet. Now, however, most if not all commercial services offer some type of Internet connectivity, ranging from just e-mail to full Internet access, and many BBS systems are following suit.

The Internet has changed the rules of the online game, probably forever. Originally, the Internet was just a bunch of UNIX computers linked together. Using arcane command-line programs, you could send files and e-mail, log in to remote systems, and more. Most of those services are still available, and you can often get GUI front ends that take care of some of the gory details for you.

Running over the Internet is the World-Wide Web (WWW). You can access the Web by either character-based or graphical systems. Mosaic, Netscape and similar software programs are Windows-based GUI packages for accessing the Web. They rely on underlying UNIX-based programs and protocols for transferring screen-image data, files, and data returned as the result of a search.

The graphical nature of the Web has made it famous and has attracted huge publicity. But, in my opinion, it is also the weakest and most abused feature. At first it's thrilling to

(Continued on page 85)

TABLE 1 — ONLINE SERVICE ACTIVITIES

Activity	Description
E-mail	Essential for interacting with readers, business clients, vendors, and friends. Nearly all on-line services can now exchange e-mail with each other and with Internet addresses. In this context, "e-mail" means ASCII text. Among members of a given service, it is often possible to exchange binary files, but that's not a given. Binary files can be converted to ASCII format for transfer, but file size increases, and the converters occasionally have incompatibilities. Nonetheless, the capability can be a life-saver in some situations. The key utilities are "UUencode" and "UUdecode." These utilities resemble PKZIP, except that they do not compress and expand files, but rather convert to and from ASCII. You can get copies from most commercial services, many Internet/Web sites, and from BBS systems.
Product Support	Useful for downloading drivers and patches to computer products, for interacting with tech support staff, and for interacting with other users, who may have already solved the problem I'm experiencing.
Vendor Interaction	Useful for getting product information, participating in beta programs, learning about new releases.
File Downloading	Occasionally useful for getting shareware and public domain program and data files.
Research Information	Commercial services offer indexed databases of textual information, including scientific and technical journals, popular magazines, electronic dictionaries and encyclopedias, business and personal information (name, address, etc.), and more. The Internet also contains much research information, but finding what you need is difficult, and attributions and citations for academic and professional work may be unavoidable, rendering the information all but useless.
Conferences, "Chatting," and CB Simulators	I don't have much use for these, but many people find them entertaining.
Vanity Publishing	It is very trendy now to have your own "home page" on the Web. Most often these are silly self-indulgent sites with no value other than feeding the ego of the author.
Advertising	Early in its life, Prodigy (a joint venture of Sears and IBM) attained infamy for being the first on-line service to constantly bombard the user with advertising. This means that a percentage of the bandwidth you pay for is constantly used for transferring commercials to your PC. If you don't want the commercials, too bad. Fortunately, the practice has not spread to other services.

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THINK TANK

By John J. Yacono
Technical Editor
Windows Magazine

Radiating Circuits

Before I continue our tutorial on capacitors, I'd like to ask a question. It's been my goal to write tutorials for the beginning hobbyist, while presenting letters to appease the more advanced. My question is whether both are at the right level for the intended reader? If you have an opinion, please reply so that I can make adjustments.

Last time, I introduced the idea of electrolytics, which

enhance the charge a capacitor can hold. I also pointed out that the electrolytic used determines the voltage a capacitor can handle. That points to a defining characteristic of a capacitor: its working voltage at DC, or its WVDC rating. To expose a capacitor to voltages above its WVDC is asking for trouble, so when choosing a capacitor for a DC circuit, make sure its WVDC is at least 20% higher than the voltage applied by the circuit. For AC circuits, make sure the capacitor's WVDC is 20% higher than the rms (root-mean squared) value of the voltage to be applied.

By the way, the 20% safety margin I'm using is just a figure I've found to work for me. If you're more cautious, you might want to use a larger margin. I wouldn't suggest going much lower, however.

That brings us to another restriction of certain electrolytic capacitors: polarization. Most electrolytics only work properly when exposed to voltage applied in the right direction. Those capacitors charge and discharge like any other, but one plate must always be more positive than the other if a significant charge is present. Violating that rule for polarized electrolytics can damage them if the reverse voltage is large enough.

Next time we'll talk about how capacitors are rated and how to read their markings. For now, let's look at some illuminating circuits from our friends.

BAR-GRAPH DISPLAY

Sure, your capacitance meter will read the value of your capacitors, but will it check their discharge rate? Here is a circuit (see Fig. 1) that enables you to watch low-voltage capacitors discharge. The circuit contains an extended voltage divider that feeds reference voltages to the sections of two LM339 comparators. Each comparator drives its LED, provided the voltage of the capacitor under test is greater than the comparator's reference voltage.

High-capacity electrolytics, up around 220 μF , will take about 15 to 20 seconds to start turning off the LEDs; that indicates that the capacitors are discharging. Therefore, the rate that the LEDs extinguish is in direct relation to the capacitor's capacitance. Small-value capacitors around 0.002 μF will only flash the lower LEDs at a fast, but visible, rate.

The circuit can be adjusted with R1, a 200,000-ohm (or higher) potentiometer. That component will vary the rate that the LEDs extinguish. You will probably want to decrease the rate for small-value capacitors and increase it for electrolytics. That can also be accomplished somewhat by changing the value of R10, the 56,000-ohm resistor across the input at pin 10 and pin 12 (ground) of U2-d.

The bar graph can be made smaller by using only one LM339 and four LEDs. Or, it can be made larger by using as many as five LM339s and twenty LEDs.

You could use a battery

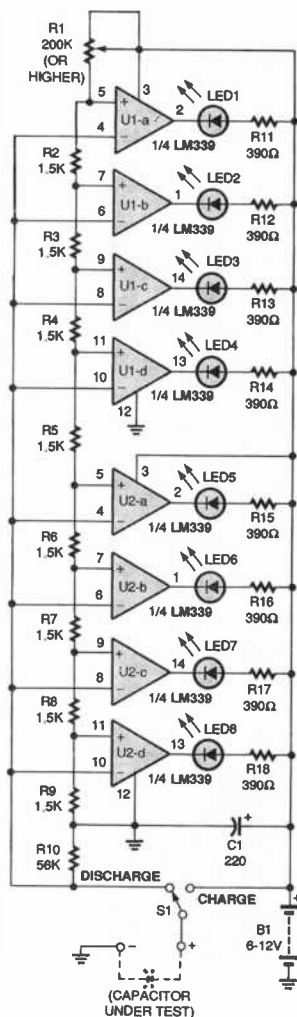


Fig. 1. This circuit actually lets you watch low-voltage capacitors discharge.

supply of between 6 to 16 volts. Just make sure to select a battery that is of a lower voltage than the rated working voltage of the capacitors that you are testing.

—Lawrence J. Patalunas, Langhorne, PA

This is a neat circuit loaded with possibilities. One great use for the circuit is to check electrolytics before placing them in timing circuits. The timing of electrolytics is notoriously unpredictable because of their high leakage current, and unusual (not entirely exponential) charge curves.

For that, I'd start by adding a charging resistor and connecting the positive post for the capacitor directly to the inverting inputs of the comparators (bypassing S1). Then I'd rewire R10, S1, and the charging resistor so that S1 switches the capacitor between the charging and discharging resistors. Also, making a socket for R10 and the charging resistor would allow you to experiment with their values. Then I'd adjust R1 to set the reference voltages of two of the comparators to be roughly equal to the trigger and threshold values of the timing circuit I would build. Submitting various electrolytics and discharge resistors for the test should produce a timing I could live with.

Making R10 and the charging resistor variable would make the job even easier. However, I would place protective resistors in series with them to prevent damage from excessive current.

Another thing I would do is simplify the circuit by using dot/bar-display-driver chips. Three that come immediately to mind are the LM3914, LM3915, and the LM3916. The LM3914 con-

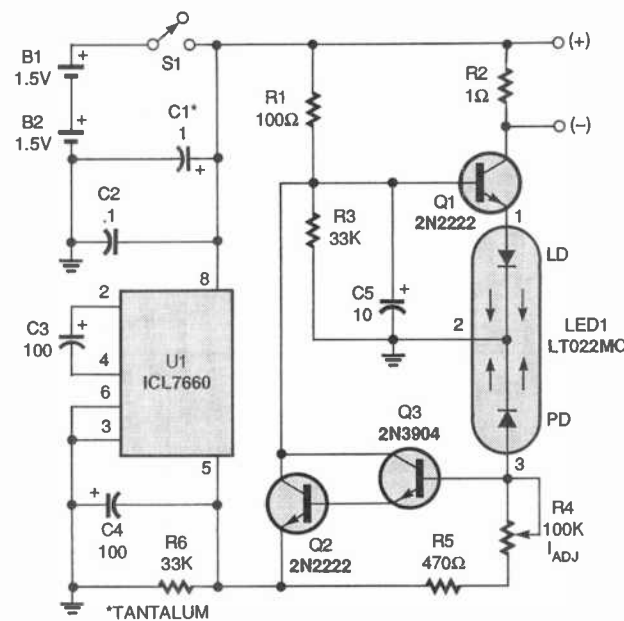


Fig. 2. Here's a simple laser-drive circuit that's based on Sharp's LT022MC infrared laser diode. It's an ideal low-cost circuit to build for laser enthusiasts; the diode is available for approximately \$5.00.

tains a voltage ladder that divides the supply voltage for a linear display (like yours), while the other two produce logarithmic displays.

DH LASER DRIVE

This simple circuit (see Fig. 2) is based on Sharp's LT022MC infrared laser diode. It is a CW double hetero-structure device that emits 3 to 5 mW at 780 nm. Those are available at \$5.00 each in small lots.

I advise bread-boarding the circuit first, so that trimmer-potentiometer R4 (the current-adjust control) can be optimized. Please note: the laser diode and the ICL7660 are ESD sensitive, so take proper precautions when handling them! The laser also requires minimum heat sinking of 1 square inch. Lead dress isn't critical in the circuit, which was optimized for operation on two "AA" cells. The cells will function for several hours, down to about +2.5 volts, before needing replacement.

Integrated-circuit U1 is a

voltage-converter chip (available from Digi-Key and other sources) whose output of -2.6 volts is used for the negative supply. Transistor Q1 drives the laser, while Q2 and Q3 control the drive to Q1 via negative feedback derived from the PIN photo-diode (PD) in LED1.

With power off, set R4 to its maximum resistance, connect a DVM (in the 200-mV range) across R2, and then turn on the power. Lower R4 very slowly towards minimum resistance while you monitor the current (1 mA/mV) through R2. The current (40 to 45 mA, typically) will gradually rise

to a peak about 5 mA above your initial current, fall slightly, and then level out.

The typical efficiency of the LT022 is about 0.3 mW/mA, so, slowly advance R4 until you reach operating current, which is about 10 mA higher than the threshold current. The output will be about 3 mW, a safe level for the laser. Turn power off and measure the resistance in R4 (mine was about 2000 ohms). Replace R4 with a lower-value trimmer potentiometer that's large enough to give you the measured resistance for more precise adjustment (I used a 5000-ohm unit). Set it at maximum resistance, power up, and adjust for operating current.

You can safely test the beam with Radio Shack's Infrared Sensor Card (No. 276-0099). Avoid exposing your eyes to the beam to prevent radiation damage!

—Skip Campisi, South Bound Brook, NJ

Very nice circuit. I really like the Darlington-pair-based feedback section for controlling Q1. By the way folks: Only build this circuit if you know how to properly handle lasers. They can easily damage your eyes if not handled with caution.

Oh, I've also come across 7660s that enter into metastable states (and get very hot) under the right conditions. Try using a 7662 instead.

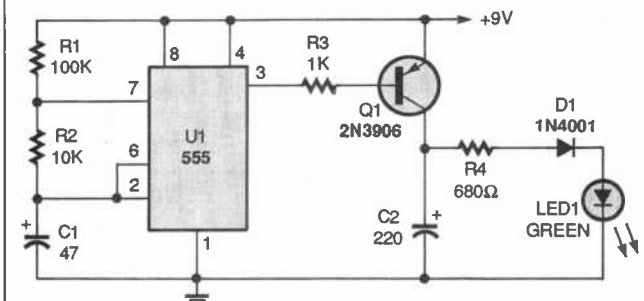


Fig. 3. This simple circuit emulates the flash of a firefly with respect to the light's color, attack and decay time, intensity, and flash frequency.

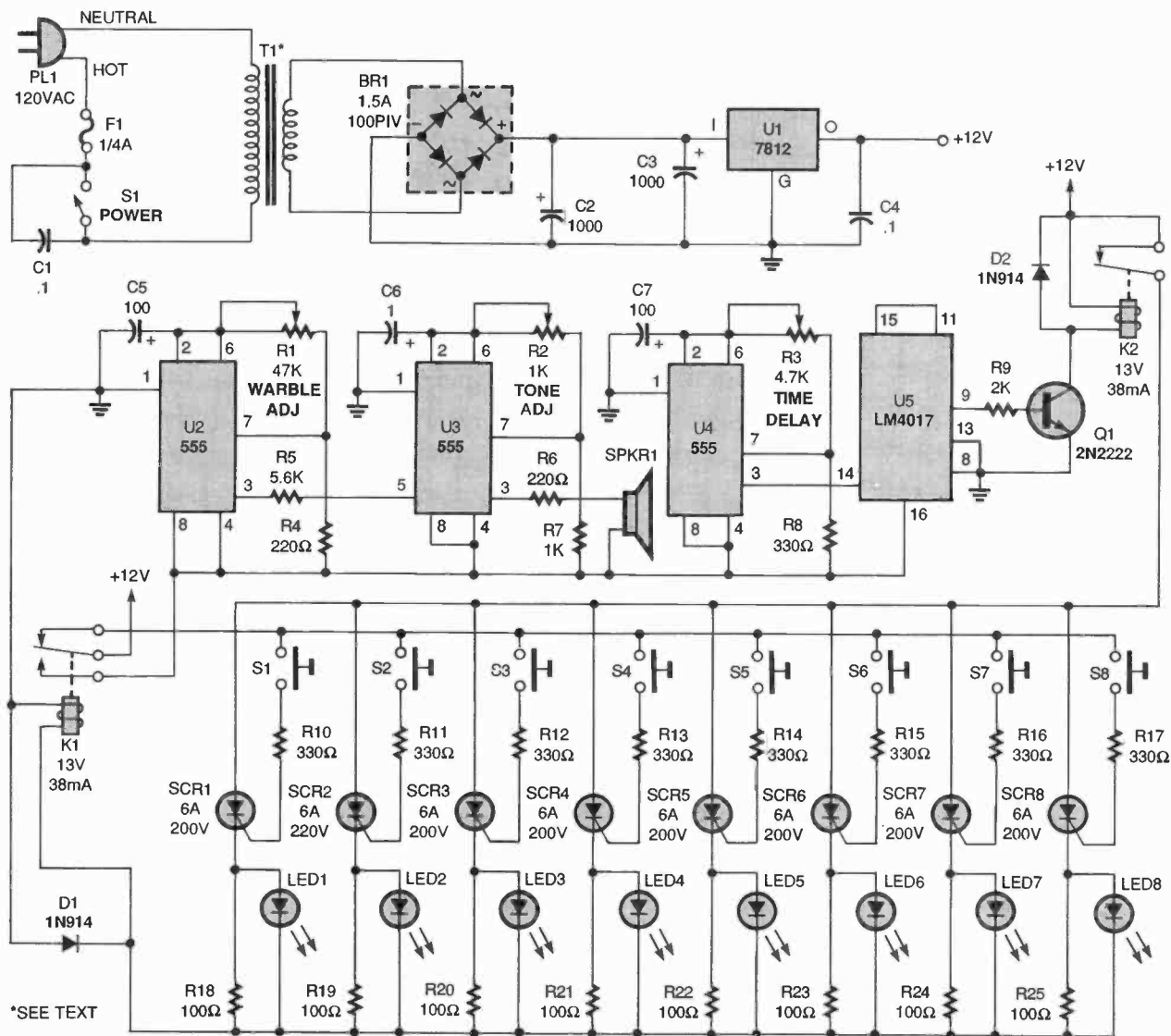


Fig. 4. Do you enjoy games like Family Feud and Jeopardy? Here's a contestant lock-out circuit that indicates which of up to eight players rings in first.

ELECTRIC FIREFLY

Using a flashlight to attract fireflies for summer-evening fun with the kids is not necessarily the most elegant technique. To the rescue is this simple circuit that emulates a firefly flash much better, with respect to the light's color, attack and decay time, intensity, and flash frequency. Our firefly lasts indefinitely, dislikes moist soil, doesn't eat bugs (but consumes electrons supplied by a 9-volt battery), and is adjustable to match the flash characteristics of any of the 125 types of firefly found nationwide.

The circuit (see Fig. 3) is nice and simple. A 555 timer generates a 0.25-Hz, high duty-cycle square-wave, with timing characteristics set by R1, R2, and C1. The PNP transistor inverts the output to create a low duty-cycle signal. The 680-ohm resistor (R4) and the 220-µF capacitor (C2) cause the light intensity to decay as the capacitor discharges through the green LED.

End result: an electronic firefly that flashes every four seconds. The green flash lasts about half a second and displays notable attack and decay characteristics.

—Nick Cinquino, Schaumburg, IL

My five-year-old is going to love this one. While this column will appear in our December issue, it's mid-July as I write this, and lately at night she's been running around the yard with a jar in her hand after the elusive illuminaries.

One thing I think I'll experiment with is the type of LED. I've got some high-intensity green LEDs that are easy to see from a distance, but they lack the warm glow of a firefly or a frosted-lens LED. I'll do some experimenting and find out what works best.

CONTESTANT LOCK-OUT CIRCUIT

Here's a circuit (see Fig. 4) that I built and perfected for my school. It is a Jeopardy-type buzzer, and its purpose is to indicate who of up to eight contestants rang in first so that he or she can answer a question. It also gives an audio signal to the contestants so that they will stop attempting to ring in. The circuit is very fast, which almost eliminates the chance of two or more people having a tie.

The circuit contains eight silicon-controlled rectifiers (Continued on page 89)

CIRCUIT CIRCUS

By Charles D. Rakes

One-Transistor Circuits

Welcome back, circuiters! This time around we are going to take a look at some simple single-transistor circuits. Looking back it sure doesn't seem like it has been over forty years since the first low-cost transistor hit the scene. But it has. Now, without further ado, let's get to our circuits.

VOLTAGE REGULATOR

Our first transistor circuit is an application that takes advantage of the device's base/emitter relationship when used in the common-collector mode of operation. Take a look at the circuit in Fig. 1, and you will probably recognize it as a simple, but often used,

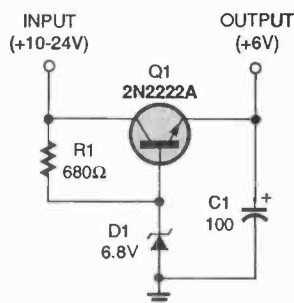


Fig. 1. This simple regulator circuit will output a constant 6-volts DC.

positive voltage regulator.

In a common-collector circuit, the transistor's emitter will follow and maintain the base voltage minus the device's junction-voltage

PARTS LIST FOR THE VOLTAGE REGULATOR (Fig. 1)

Q1—2N2222A NPN transistor
 D1—6.8-volt Zener diode
 R1—680-ohm, 1/4-watt, 5% resistor
 C1—100-μF, 16-WVDC, electrolytic capacitor
 Wire, solder, power source, etc.

losses. The circuit's output will be about one volt less than the Zener diode's rated voltage. As shown, the circuit will output a constant 6 volts as long as the DC input voltage is within the range shown.

CONSTANT-CURRENT SOURCE

Our next transistor application is in a constant-current-source circuit. In the circuit of Fig. 2, the transistor's base voltage is set by the 6-volt Zener diode, D1, and the emitter's current is determined by the value of

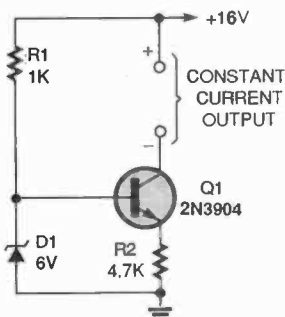


Fig. 2. The value of the constant-current output is found by dividing the Zener's voltage rating by the value of R2.

PARTS LIST FOR THE CONSTANT-CURRENT SOURCE (Fig. 2)

Q1—2N3904 NPN transistor
 D1—6-volt Zener diode
 R1—1000-ohm, 1/4-watt, 5% resistor
 R2—4700-ohm, 1/4-watt, 5% resistor
 Wire, solder, power source, etc.

R2. Dividing the Zener voltage by R2's resistance gives the constant current value. The current flowing through the transistor's collector circuit, for all practical purposes, is the same as the current flowing in the emitter circuit.

SIMPLE AUDIO AMPLIFIER

About the simplest common-emitter audio-amplifier circuit you could throw together is shown in Fig. 3. While the circuit is shown with a 2N3904 for Q1, just about any junction

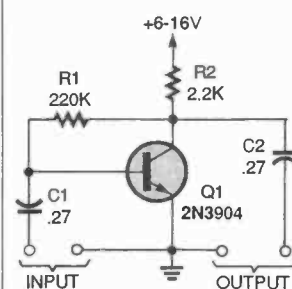


Fig. 3. This is about the simplest audio amplifier to build and use. Virtually any other NPN transistor can be used in place of the specified 2N3904.

transistor will work fine in this circuit. The reason for that is the biasing technique used in the circuit—the transistor's base bias current is fed in a negative feedback fashion from the collector. That allows satisfactory results using transistors with widely

PARTS LIST FOR THE SIMPLE AUDIO AMPLIFIER (Fig. 3)

Q1—2N3904 NPN transistor
 R1—220,000-ohm, 1/4-watt, 5% resistor
 R2—2200-ohm, 1/4-watt, 5% resistor
 C1, C2—0.27- μ F, Mylar capacitor
 Wire, solder, power source, etc.

varying gain.

If you choose to use a different transistor for Q1, you might also need to change the value of R1 to get the best results. To find the appropriate R1 value, connect a voltmeter to the transistor's collector and circuit common, and then select a value for R1 that produces a meter reading that is half the supply voltage.

IMPEDANCE-MATCHING CIRCUIT

The circuit in Fig. 4 places the transistor in an emitter-follower circuit configuration. That arrangement makes a good impedance-matching circuit. That is, the circuit will take the high-

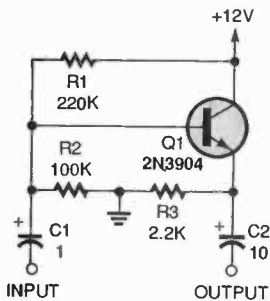


Fig. 4. This circuit matches a high impedance at its input to a low impedance at its output.

impedance output of a circuit that precedes it and matches it to the low-impedance input of a circuit that follows it with little, if any, loss. Again, the circuit can be optimized by connecting a voltmeter to the emitter and circuit common and selecting R1 to produce a reading that's half the supply voltage.

PARTS LIST FOR THE IMPEDANCE-MATCHING CIRCUIT (Fig. 4)

Q1—2N3904 NPN transistor
 R1—220,000-ohm, 1/4-watt, 5% resistor
 R2—100,000-ohm, 1/4-watt, 5% resistor
 R3—2200-ohm, 1/4-watt, 5% resistor
 C1—1- μ F, 16-WVDC, electrolytic capacitor
 C2—10- μ F, 16-WVDC, electrolytic capacitor
 Wire, solder, power source, etc.

PARTS LIST FOR THE LED-ON DRIVER (Fig. 5)

Q1—2N3904 NPN transistor
 LED1—Light-emitting diode, any color
 R1—3300-ohm, 1/4-watt, 5% resistor
 R2—1000-ohm, 1/4-watt, 5% resistor
 Wire, solder, power source, etc.

PARTS LIST FOR THE LED-OFF DRIVER (Fig. 6)

Q1—2N3904 NPN transistor
 LED1—Light-emitting diode, any color
 R1—3300-ohm, 1/4-watt, 5% resistor
 R2—1000-ohm, 1/4-watt, 5% resistor
 Wire, solder, power source, etc.

LED-CONTROL CIRCUITS

Our next entry, see Fig. 5, features a transistor operating as an LED driver that turns on the LED when the transistor's base goes positive. Input voltages from 5- to 9-volts will turn on the circuit and the LED's current is set by the resistance value used for R2.

If, on the other hand, you want the LED to be on in the absence of an input, the circuit in Fig. 6 will do the trick. In that circuit, the LED turns off when a positive input is fed to the base of Q1.

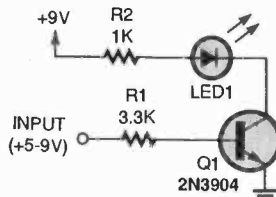


Fig. 5. When a positive 5- to 9-volt signal is present at the input, the LED is turned on.

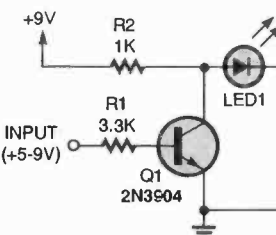


Fig. 6. This circuit turns the LED off when a voltage is present at the input.

If you wish, PNP transistors can be used in either or both circuits. However, you will have to reverse the polarity of the power supply voltage and the LED.

RELAY DRIVER

Our last circuit this month is a single transistor relay driver with a contact-activated latching function (see Fig. 7). When +5 volts or more are present at the input, Q1 turns on, activating the relay.

Once the relay has closed, the circuit is latched through the relay contacts carrying current to the base of the transistor, keeping it on and the relay energized.

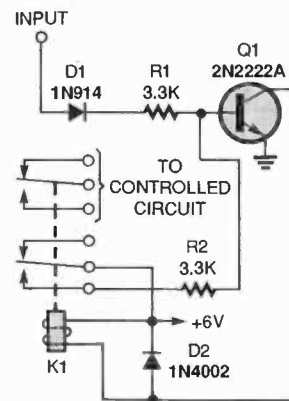


Fig. 7. This relay-driver circuit has a latching feature that keeps the relay on once it is initially energized.

PARTS LIST FOR THE RELAY DRIVER (Fig. 7)

Q1—2N2222A NPN transistor
 D1—1N914 silicon diode
 D2—1N4002 silicon diode
 R1, R2—3300-ohm, 1/4-watt, 5% resistor
 K1—DPDT relay, 5-volt coil
 Wire, solder, power source, etc.

The circuit can be unlatched by interrupting the circuit's power source, or by taking the base of Q1 to ground.

While there are enough single-transistor circuits to fill several volumes, and then some, that's all the room we have for now. See you all soon.

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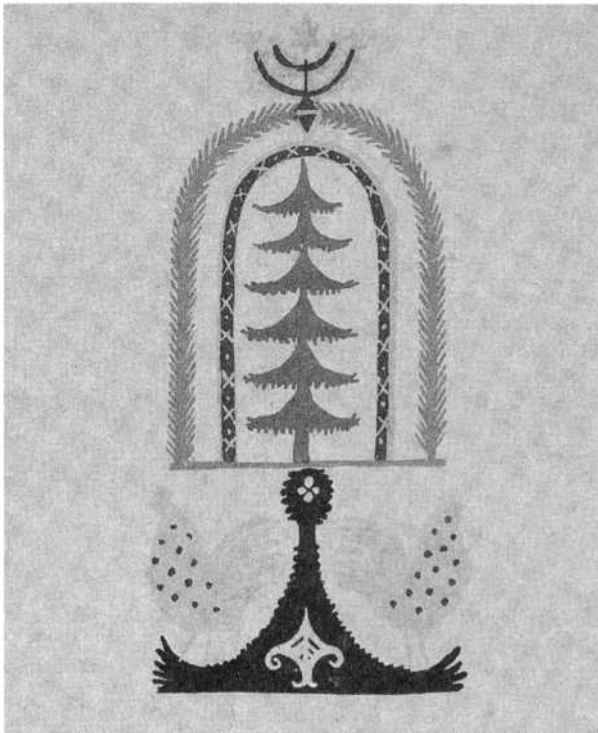
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DX LISTENING

By Don Jensen

The Voice of Terror

This was a year when many shortwave listeners came face to face—or more aptly, speaker to ear—with terrorism. Listeners have long known that when something important happens, wherever in the world, firsthand reports are no further away than their shortwave receiver. Unfortunately, in 1995, that included some tragic events.



In time for the holiday season, here's a bit of Christmas folk art from Polish Radio, Warsaw.

Before March 20, most Americans never heard of Aum Shinrikyo, a Japanese-based cult that claims some 30,000 followers worldwide. On that day, though, a deadly nerve gas, Sarin, was released in Tokyo's crowded subway system during the morning rush hour. The terrorist attack, allegedly by members

of the cult, killed ten people. More than 5000 were treated for gas exposure and injuries in what the Tokyo daily, *Nihon Keizai Shimbun* termed "an assault against society."

Alert shortwave listeners, however, had heard about Aum Shinrikyo—Japanese for "Supreme Truth"—long before. The apocalyptic cult had been broadcasting English-language programs on shortwave for some time. The broadcasts, pre-recorded in Aum Shinrikyo's studios in Japan, were aired at 0430 and 2030 hours UTC from Russian SW transmitters near Vladivostok in the Far East.

Those cult programs might have gone relatively unnoticed by SWLs but for the fact that they immediately followed, on the same frequencies, the *Voice of Russia* World Service broadcasts in English. Other broadcasts of *Radio Aum Shinrikyo* were in Japanese. Some listeners even received QSL replies to their reception reports.

Moscow-based *Voice of Russia* denied any involvement, saying it had rejected a 1992 bid by the Japanese cult to buy broadcasting facilities in the former Soviet Union. However, Russian authorities in the Far East leased airtime to Aum Shinrikyo.

The broadcasts via Vladivostok even continued for several days after the subway terrorism, when suspicion had fallen on Aum Shinrikyo. Monitors reported that the cult's "venerated master," Shoko Asahara, called upon his followers to be prepared "to face

death without regrets."

Asahara also spoke of police injustice in raiding cult compounds in Japan and claimed the media was spreading false information to prejudice the public against his group.

As evidence increasingly focused on Aum Shinrikyo, the Japanese applied diplomatic pressure and Russian officials ended the cult's programs on March 23. Nearly a month later, a Moscow district court banned the domestic cult's activities and forbid any future broadcasts from Russian soil.

Less than a month later, a huge explosion caused massive death and destruction in Oklahoma City. This time it was home-grown terrorism. As the FBI rounded up suspects, the spotlight was turned on right-wing extremist groups.

Though not tied to the Oklahoma City bombing, self-styled militia and "patriot" organizations soon were being publicly criticized for their extremist dogma. Such groups, reportedly, are linked by an informal communications net of faxes, e-mail, and shortwave broadcasts.

A Nashville, TN, shortwave station, *WWCR* owned by F.W. Roberts Broadcasting, New Orleans, LA, sells air time to many organizations, most of them—83 percent, according to the station—religious. But, as many SWLs know, *WWCR*, like some other private U.S. SW broadcasters, also rents radio hours to spokesmen with other agendas, mostly from the far-right of the political spectrum.

One such program, Mark Koernke's "The Intelligence Report" draws particular fire. Koernke, a "militiaman" from Dexter, MI, was widely quoted in the days after the Oklahoma blast as alleging the whole thing was a plot by the federal government. Eight days after the blast, the station responded with a press release, announcing that, "at least temporarily," it would not air Koernke's program.

WWCR said it was "wrong to accuse any one group, no matter how 'far right' it might be of responsibility for the Oklahoma City incident," but it urged broadcasters like Koernke to consider that their words, "no matter how innocent or rhetorical or satirical they may in fact be, have the power to push certain people over the edge into violence."

WWCR claimed it is unable "to review programs in advance, or even during their airing, for content," but said if there are complaints, "programs that are offensive to our listeners are censored and/or canceled." Despite that, the station concluded its press statement flamboyantly: "Going boldly where no other shortwave broadcaster dares. WWCR."

As of this writing, WWCR broadcasts from 0000 to 1100 UTC on 7435 kHz; 0100 to 1200 UTC on 5935 kHz; 1100 to 2100 UTC on 15,685 kHz; 1200 to 0100 UTC on 13,845 kHz; 1400 to 2300 UTC on 12,160 kHz; 2100 to 0000 UTC on 9475 kHz; and 2300 to 1400 UTC on 5065 kHz.

*Credits: Marie Lamb, NY; William McGuire, MD; Don Moore, IA; Marina Pappas, SD; Ed Rausch, NJ; North American SW Association (45 Wildflower Road, Levittown, PA 19057); World DX Club (c/o Richard D'Angelo, 2216 Burkey Drive, Wyomissing, PA 19610)

IN THE MAIL

Harold McQuade, Memphis, TN, writes with word of a contest for SWLs: "Your readers might be interested in entering a contest sponsored by Radio Havana Cuba. The station will celebrate its 35th anniversary in 1996. To mark the event, it is asking listeners to write an essay on the theme: What has Radio Havana Cuba meant to you in these 35 years?"

"The writers of the five best entries will win an all-expenses-paid week in Cuba during the station's anniversary celebration. RHC doesn't say how long the essay is supposed to be so I guess it doesn't matter. Entries must be received by the station before March 31.

"The address is: 35th Anniversary Essay Contest, Radio Havana Cuba, Box 6240, Havana, Cuba."

Thanks, Harold, for the information. Good luck, all you essayists!

Brad Danley, Chicago, IL, offers some information about Croatia's shortwave programming: "Croatian Radio now has news bulletins in English, about ten minutes long, on the hour during the evening hours. Its frequencies are 5895, 7370, and 13,830 kHz."

Much appreciated, Brad. And here's a bit more Balkan news from the Italian shortwave journal, *PLAYDX*. *Radio Bosnia Hercegovina* has replied by fax to a listener's report. Reports should go to Technical Manager N. Dizdarevic. The fax number is 387-71-645152. Radio Bosnia Hercegovina has been reported on 7108 kHz, upper sideband, at about 0100 to 0200 UTC.

Just back from a holiday in Lisbon, Len Costas, Dubuque, IA, writes to say that he'd like to relive some of his travel memories via

shortwave radio. "When and where can I tune in Radio Portugal on shortwave," Len asks. "While I did pick up a few words of Portuguese, I'd rather try for their English programs, if any."

Here's the schedule, Len: Weekdays, English is broadcast from 1900 to 1930 UTC on 6130, 9780, 9815, and 15,515 kHz, and from 1330 to 1400 UTC on 21,515 kHz.

If you've got a question, or if you have SW information to share, drop me a line. If you'd like, send me a photo of you, listening to your shortwave receiver. Photographs will appear in future columns. Write to: is DX Listening, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735.

DOWN THE DIAL

Here are some SW stations to tune:

CUBA—6000 kHz. *Radio Havana Cuba* can be heard in English on this frequency at about 0230 to after 0300 UTC. You could also try 9820 kHz.

ERITREA—7020 kHz. *Voice of the Broad Masses of Eritrea* began its broadcasting life some years ago as a clandestine rebel station. When Eritrea gained its independence, the station became the legitimate voice of that new nation near African's "Horn." Look for it in a local language around 0330 UTC. A parallel frequency is 4000 kHz.

JORDAN—15,270 kHz. *Radio Jordan* is heard at 1430 UTC in English with U.S. popular and country music, identification, and international news.

SWITZERLAND—6135 kHz. *Swiss Radio International* is noted here in English at 0110 UTC. ■

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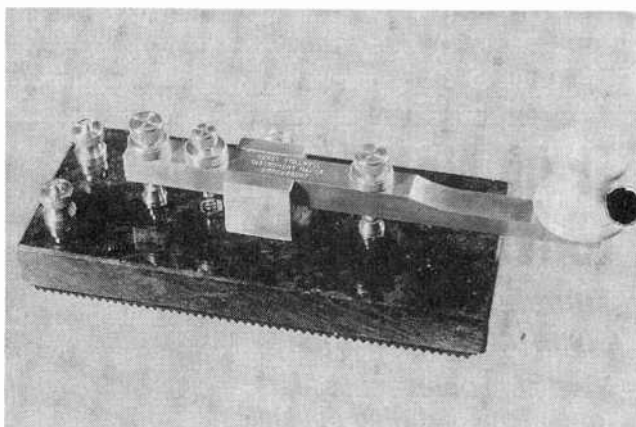
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HAM RADIO

By Joseph J. Carr, K4IPV

A Great Straight Key



Lovers of CW in general, and straight keys in particular, will get a kick out of the Stillwell telegraph key.

Earlier this year, the U.S. Coast Guard turned off their "watches" on CW, but does that mean that Morse code is dead? Not by a long shot, judging from the sound of the ham bands. There are still a lot of people out there using radiotelegraphy, the Coast Guard notwithstanding.

I am an unabashed CW fan from a long way back. In my early ham-radio career, I was a stone-broke teenager, with little prospects for getting the kind of money required for more than a modest transmitter.

My E.F. Johnson Viking Adventurer was a kit-built, CW-only transmitter. The Heathkit DX-35 that replaced it was supposedly equipped with amplitude modulation, but that was a joke. It used "controlled-carrier" modulation that was a variant on screen-grid modulation, and didn't work very well. On CW, though, the rig was a real workhorse.

Even today, when I fire up my high-frequency rig, it's more often than not on a CW band than anywhere else. Even though I can now

afford a nice, modern, solid-state SSB rig, with a digital readout and speech processor, I still gravitate towards CW. Besides, Morse code takes a certain skill level that radiotelephone does not. And while I favor a code-free license class to bring in new blood, I also like to use CW because anyone can be an SSB "appliance operator" . . . real radio operators use CW (at least some of the time). So much for my prejudices!

A HAND-MADE STRAIGHT KEY

Electronic keyers are the normal way that people operate a CW transmitter today. I saw my first one in the early 1960s when a model based on a ferrite toroidal-core memory was published as a construction project. Vacuum-tube keyers had been designed even earlier. One attribute of keyers is that they make every dot, dash, and space the same. There is no individuality in using a keyer (unless you make a lot of sending mistakes, but that's hardly useful). A bug is a semi-automatic key, all mechanical not electronic, and it does allow some individuality to creep in. But for personalizing your sending, there is nothing like an old-fashioned straight key.

A straight key requires you to form the dots and dashes perfectly, and does not aid you in any way. The characteristics of your sending constitute a highly personal "fist" that can be recognized by others. I still recall a chap in the late 1950s who was talking to

me in his basement, while a receiver was on 80-meter CW. He heard a CQ call, and immediately jumped to the operating position saying "That's ol' Harry . . . I shipped out with him in the Merchant Marine in the war (WWII) . . . I'd recognize that fist anywhere!" He called the other station, and sure enough it was old Harry, who had a new call sign, but was still recognizable by his fist nearly 12 years after the two men worked together as "Sparks" (radio operators) in the World War II Merchant Marine.

Straight-key CW still commands a following, and is especially common amongst the QRP (very low power) crowd. There is even a "Straight-Key Night" operating event every year.

One of my collateral hobbies is collecting radio memorabilia, including antique radios (Marc Ellis' column in this magazine is must reading for me). Old telegraph keys are an especially fond treasure. In this day and age of mass-produced junk keys, with cast or stamped pot metal "works" and plastic bases that move around too much for practical use in "real" radio stations, those old war horses are real treasures . . . reminders of what quality use to be.

But, guess what? A high-quality, hand-made straight key is now available from a custom instrument maker in England. I ordered my key from Mister Derek Stillwell, Instrument Maker (27 Lesley Owen Way, Shrewsbury, Shropshire, England, SY1 4RP; Tel. 011 01743 354119).

Let me tell you, friends,

that Derek Stillwell makes one big telegraph key! It measures $7 \times 3 \times 0.75$ inches, and weighs 2 lb 10 oz (1.19 kg). That key does not walk around the desk as you use it; it remains in place, where it ought to be. The arm is solid brass, and is 0.50-inches square, and 7-inches long. The bearing on which the arm rests is also of brass, and measures $1 \times 1 \times 1$ inches. The electrical contacts are large-diameter silver alloy.

The base of the key is polished Portuguese marble, with a non-skid rubber bottom. The large wooden knob is reminiscent of the "North Atlantic" keys made for the U.S. Navy at one time (those were designed to be used with mittens on; if anyone has one for sale, contact me). The knobs are turned from a hardwood of your choice: Box, Zebrano, or Padauk. Each key is engraved with the instrument maker's name and a serial number.

The Stillwell key handles better than any I've used to date. Being a CW nut, and a telegraph-key collector (of sorts—I only own a few), I relish using the Stillwell, and count my money well spent.

The cost of the key is 75 British pounds sterling. If you want your name or call sign engraved on the key, either is an additional 4.50 pounds (being a bit vain, I had both engraved on my key). International shipping runs about 16 pounds. The British pound sterling has been worth between \$1.50 and \$1.65 recently, but it all depends on the exchange rate at the time of order. Mr. Stillwell doesn't appear to take credit cards, so obtaining one of his keys will require that you obtain an international money order in pounds, or an international cashier's check in

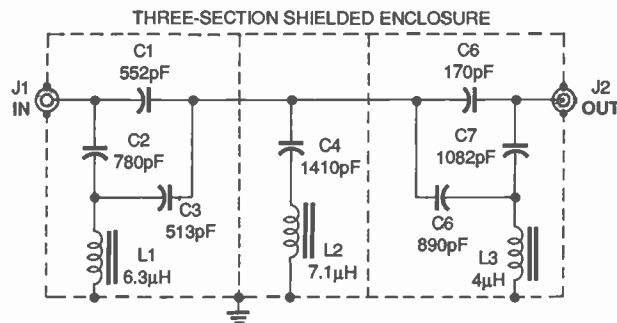


Fig. 1. This high-pass filter with a 1600-kHz cut-off frequency can be used to cut down interference from AM-broadcast stations.

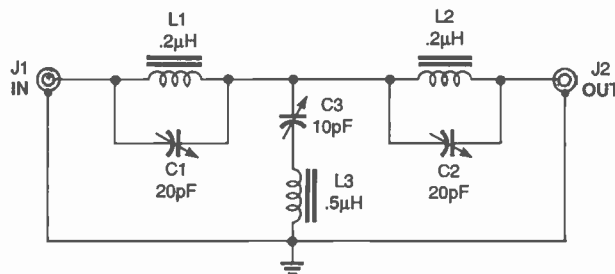


Fig. 2. This FM wavetrapp filter contains both series- and parallel-resonant trap circuits.

pounds. American Express and the other travelers-check companies can also sell you travelers checks in pounds, but those are usually only available in 20-pound increments.

Stillwell makes all of the parts himself, and does not stock items. In other words, your key will be made for you when an order is received. It's rare to be able to have something hand made, and of high quality today.

MORE ON QRM

More and more hams are experiencing receiver overload from local AM and FM broadcast stations. That is an unfortunate consequence of high-density population areas, and will only get worse. The best solution is to buy a good receiver, or transceiver with a good receiver section. By "good" I mean a receiver with a high third-order intercept point (+10 dBm or more), a high dynamic range, and general freedom from front-end

overload by off-channel, out-of-band signals.

Unfortunately, giving that advice is easier than living by it, because good receivers cost money. But there is hope: filter the front end. For AM-station interference, I use a high-pass filter with a 1600-kHz cut-off frequency (see Fig. 1). That filter is able to deliver -40-dB signal attenuation above the second octave from the cut-off (i.e. around 3200 kHz).

As shown in the figure, the capacitors are odd values that are made up from several individual capacitors in parallel that total the desired capacitance (or a small variable, if need be). The values are not too critical unless the offending station is close to 1600 kHz. For example, you could easily substitute a 560-pF unit for the 552-pF unit called for. The coils can be either store-bought, or wound on toroid cores. If you decide to use toroid cores, then use the Amidon Associates T-50-15 (red/

white) core, and wind as follows: L1: 6.3 μ H—22 turns; L2: 7.1 μ H—23 turns; L3: 4 μ H—17 turns.

The FM band occupies 88 to 108 MHz, and can cause considerable interference on 2 meters, especially in overload situations where intermodulation takes place. For 2 meters and up, a high-pass filter, with a cut-off frequency above 108 MHz, can be used. However, a high-pass filter won't help on 6 meters, 10 meters, TV low-VHF channels, or some of the bands favored by scanner users. For that problem, a wavetrapp is indicated.

A wavetrapp (see Fig. 2) is a kind of notch filter that is tuned to a specific frequency. Two kinds of wavetrapps are used in Fig. 2: series and parallel. The combinations L1/C1 and L2/C2 are parallel resonant traps. Such circuits have a high impedance at the resonant frequency, and a low impedance at frequencies away from resonance. Thus, when a parallel trap is placed in series with the signal path, it knocks down signals at the resonant frequency. Alternatively, a series resonant trap (L3/C3) can be used in shunt with the signal line. The series-resonant LC trap has a low impedance at the resonant frequency, and a high impedance at other frequencies. The coils can be wound on Amidon T-50-0 (tan) toroid cores as follows: L1, L2: 0.2 μ H—18 turns; L3: 0.5 μ H—28 turns. The wavetrapp in Fig. 2 should be built in such a way that the coils will not interact with each other. That usually means placing them at right angles with respect to each other.

The FM-band wavetrapp can also be used with FM-broadcast receivers to reduce front-end overload. ■

SCANNER SCENE

By Marc Saxon

A Holiday Gift Idea

Here's one of the heftiest handfuls you could hope to find in your 1995 holiday stocking: Radio Shack's PRO-26 handheld scanner. It's a new 200-channel job that radiates an undeniable "top-of-the-line" aura of performance and class.



Ask Santa for a Radio Shack PRO-26 handheld scanner and you'll be getting quite a gift!

Look! Continuous coverage from 25 to 1300 MHz, except for the two non-recoverable 800-MHz cellular bands. Note that the PRO-26 includes reception of the 225- to 400-MHz

UHF military aeronautics band, plus full coverage between 512 and 805 MHz, and that's worth special mention. Select between NFM, WFM, and AM modes.

You get instant, single-button access to scan the NOAA weather channels. The PRO-26 also offers auto sort, which lets you scan the stored channels in order from the lowest to the highest to increase scanning speed. You can skip up to 50 selected frequencies during a search if you want to avoid them.

The memories are set up in 10 banks of 20 channels each. In addition, there are 10 monitor channels for storing active channels located while searching. "HyperScan" scanning speed is 50 channels per second. Direct search speed in normal mode is 100 steps per second, but on bands with 5-kHz steps it can operate in "HyperSearch," which is 300 steps per second. Auto Store quickly finds and automatically stores active frequencies in the selected banks, but doesn't store the frequency if it's already stored in another channel.

The first IF frequency is 380.7 or 254.4 MHz, the second IF is 58.075 MHz, and the NFM third IF is 455 kHz. (For WFM it is 5.5 MHz.) FM sensitivity is rated at 0.6- μ V in the VHF high band as well as the UHF/UHF-T bands. AM sensitivity in the VHF and UHF aeronautic bands is rated at 1.5 μ V.

The PRO-26 operates

from four AA-size alkaline batteries, from rechargeable NiCd batteries, or (with the proper adapter) from AC or DC power sources.

FAR OUT SCANNING

In looking over the specifications of the PRO-26, you might wonder why any hobbyist would care about complete scanner coverage between 512 and 805 MHz, as that part of the spectrum is allocated to UHF TV channels. That's true, but holes are always being carved in the UHF-TV channels so that they can be used for other, more interesting things—such as the UHF-T band and cellular phones. What else is there?

TV Channel 37 (608–614 MHz) is set aside for important radio-astronomy purposes. It is seriously monitored from at least 13 sites in the U.S. for signals from cosmic sources. This year the FCC sought to protect the work of astronomers monitoring those frequencies from possible TV signal contamination. The agency proposed establishing restrictions on broadcast uses of TV channels 36 and 38.

That is only one example. A scanner, a preamp, and a good antenna would give you the inside track on a cosmic frequency band being monitored by scientists.

RIDING THE RADIO WAVES

Get those scanners ready to pick up more activity in

the 216- to 217-MHz band. A possibility exists that the FCC will open a new low-power radio service there to include law-enforcement tracking systems (LETS), auditory assistance devices for the hearing impaired, and health-care assistance devices for disabled and ill persons. On a secondary basis, Automated Maritime Telecommunications System (AMTS) coast stations would share the band for point-to-point network control uses.

The proposal would establish 30 channels spaced at 25 kHz for the low-power service, and 10 channels spaced at 25 kHz allocated to AMTS. Most low-power channels would fall under the FCC's Part 90 (Personal Radio) regulations, although two dedicated LETS channels would be administered under the Police Radio Service rules.

In a separate action, the FCC is suggesting that in certain instances, it be permitted to authorize stations under its rules rather than through individual licensing. That would include the operation of radio equipment on domestic ships, aircraft, and in the personal radio services. Presumably, that would mean no call signs for those stations.

Do you live in a land-locked area about 72 to 116 miles from shore lines, ports, navigable lakes, and inland waterways? If so, you will soon notice activity on those formerly quiet VHF-FM marine operator channels. The frequency crunch has now convinced the FCC to allow private industrial and land mobile stations to share those frequencies. Even if you live close to a navigable waterway, you will find those new entries being permitted on certain marine operator frequencies on a secondary, non-interference basis.

Therefore, if you have inactive marine operator communications frequencies in your general area, get your scanner and listen for a new wave of arrivals on VHF-FM Channels 24 to 28 and 84 to 87. That translates into the following frequencies: 157.20, 157.225, 157.25, 157.275, 157.30, 157.325, 157.35, 157.375, 157.40, 161.80, 161.825, 161.85, 161.875, 161.90, 161.925, 161.94, 161.975, and 162.00 MHz.

Surely the concept was spurred on because versatile cellular phones have put the awkward VHF-FM marine operator services on a one-way cruise to oblivion. Marine operator calls can't be dialed, are virtually useless for taking incoming calls, a PTT button must be pressed each time before speaking, and there are only a couple of active channels available at even the busiest ports and locations.

THE CAUSE OF SAFETY

On occasion, we see TV news reports showing investigators from the National Transportation Safety Board (NTSB) doing what has to be one of the most difficult jobs around. They are the federal employees whose task it is to appear at every major maritime, rail, or civil aircraft disaster in order to painstakingly search for and determine its causes. They interview witnesses, make measurements, take photos and samples, run numerous tests, and often bring millions of collected pieces of the wreck to a place where they can reconstruct it in its entirety.

The frequencies used nationwide by NTSB investigators are 165.70, 165.765, and 166.175 MHz.

That's all for now! I hope to see everyone back here again next time! ■

COMPUTER BITS

(Continued from page 72)

transfer graphic files from a computer halfway across the globe. But after you've done it a few times, you start getting impatient waiting for transfers to occur.

While commercial services are looked upon with disdain by some Internet users, they have one important strength that should not be overlooked: While lacking the globe-hopping variety of the Internet, what they do offer is typically better filtered, so you can spend less time searching for what you want, and more time accessing it.

For my money, among commercial services there's no choice: CompuServe is your best bet. There are cheaper services, and there are flashier services. But CompuServe has longevity, depth, and breadth that the others lack. (That still doesn't keep me from having three different external e-mail systems, not counting their internal one.) At one time, CompuServe was more expensive than the other services, but in the past 18 months or so, prices have fallen drastically, to where it is now competitive. CompuServe now offers full Internet access.

Microsoft is just getting into the online service business; it remains to be seen whether it can attract the breadth of offerings that those who have been around longer already have. On the other hand, Microsoft knows how to build front-end software that users like. It will be interesting to see how their effort plays out.

Bulletin board services (BBSs) traditionally provide file-download services and limited e-mail, and, as we said earlier, some are start-

ing to provide Internet connections. Also, in the past, many vendors operated BBSs to support their products; however, many are now moving to CompuServe and other commercial services, and limiting their BBS support. BBSs are far from dead, but the most interesting activities occur in the commercial services.

WHAT'S HOT, WHAT'S NOT

As a programmer and consultant, I find certain aspects of the on-line world ("cyberspace") useful, and others useless. Table 1 shows some of what I consider to be its high and low points.

The online world is fiercely competitive, and as hinted above, is evolving rapidly. No one can claim to be computer literate who hasn't spent some time online. Don't let the revolution pass you by! ■

MULTIMEDIA WATCH

(Continued from page 24)

is, that you must do this while the video is playing. Wild West educates the user as to what really went on out there back then.

A while back, I mentioned that *The Discovery Channel* plans on producing lots of new CD-ROMs on various topics. I've got a bunch of new ones. *Nile: Passage to Egypt* is an all-inclusive tour of that legendary river and all the riches you'll find as you wander through Egypt. *Ocean Planet* explains how water is what makes this planet Earth (and wet). *How Animals Move* explains all the unique and bizarre methods animals use to get around. If you like to experiment with exotic beers, then check out *The Beer Hunter* CD-ROM. ■

ELECTRONICS LIBRARY

The Radio Collector's Directory and Price Guide 1921-1965; Second Edition

by Robert E. Grinder

With interest in collecting vintage radio receivers booming, this comprehensive book is a valuable resource for collectors, hobbyists, antique specialists, and historians. The directory spans the years 1921 to 1965, covering the vacuum-tube era of broadcast radio manufacturing. The second edition has been thoroughly revised and expanded to feature an extensive historical overview of the vacuum-tube era, a directory of more than 20,000 models manufactured during that time span, and a directory of 1400 trade names. Descriptions of distinguishing features and cabinet styles, along with price esti-

mates, help the collector and dealer make informed judgments about radio sets found in antique stores and at flea markets, swap meets, auctions, and yard sales.

The book is divided into three parts. The first section provides background information. It examines how the rise of the radio manufacturing industry influenced and was affected by technical advances, government regulations, and social trends. Special attention is given to receiver circuitry and designs. Part II contains a complete listing of vacuum-tube radio receivers, identified by manufacturer, model number, year of manufacture, source of power, style, and in many instances an estimate of current market value. The third section—the Trade Name Directory—is further divided into two parts. The first lists trade names and identifies who the manufacturer was, while the second is a list of manufacturers that also identifies the various trade names used by each to market their radios.

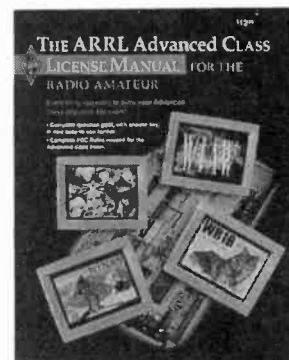
The Radio Collector's Directory and Price Guide 1921-1965, Second Edition costs \$26.95 and is published by Sonoran Publishing, 116 North Roosevelt, Suite 121, Chandler, AZ 85226; Tel. 602-961-5176; Fax: 602-961-5256.

CIRCLE 90 ON FREE INFORMATION CARD

THE ARRL ADVANCED CLASS LICENSE MANUAL FOR THE RADIO AMATEUR

edited by Larry D. Wolfgang, WR1B

The ARRL has been publishing licensing study guides for more than 60 years now, and the fourth edition of this book includes some significant improvements to help simplify the process of studying for your

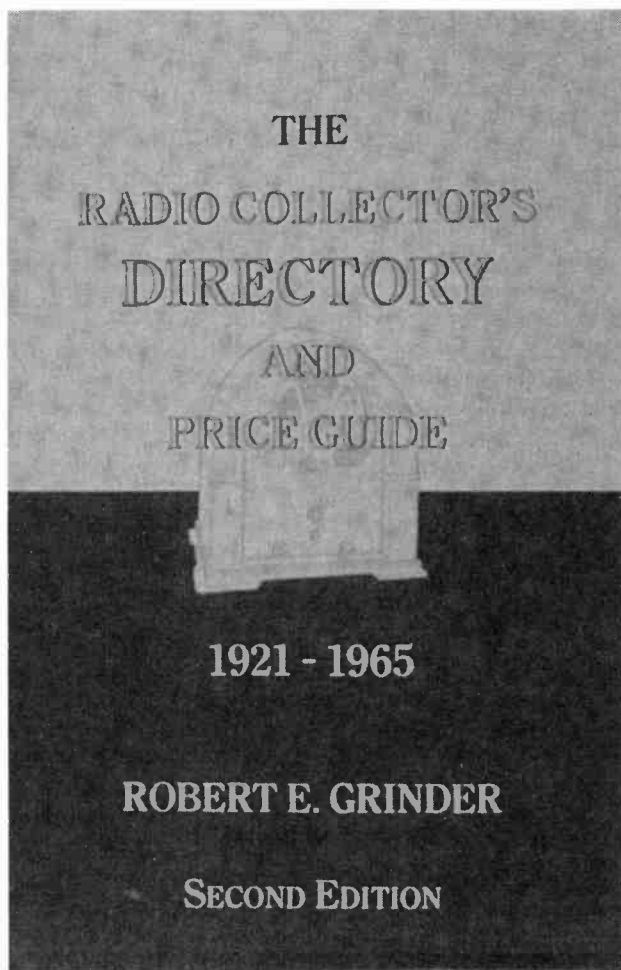


Advanced class license exam. Stepping up the licensing ladder earns you some privileges—access to some small frequency segments set aside for exclusive use of Amateur Extra and Advanced class licensees. But passing the exam requires increased knowledge of electronics terminology and the understanding of and familiarity with some of the more exotic communications modes used by amateurs.

This book contains all the information you'll need to pass the Element 4A written exam. Chapter 1 covers all the FCC Rules questions. Where the exact text will foster better understanding, actual sections of the current FCC Rules, Part 97 are quoted in their entirety. Chapters 2 through 9 explain the electronics theory and amateur operating principles that you'll need to know to pass the test.

The complete Advanced class question pool, as released by the Volunteer-Examiner Coordinators' Question Pool Committee for use beginning July 1, 1995, is presented in Chapter 10. It is designed to allow you to quiz yourself on the material, to be sure you have a thorough understanding of the concepts. The answer key is conveniently included on the same page as the questions.

The ARRL Advanced Class License Manual for the Radio



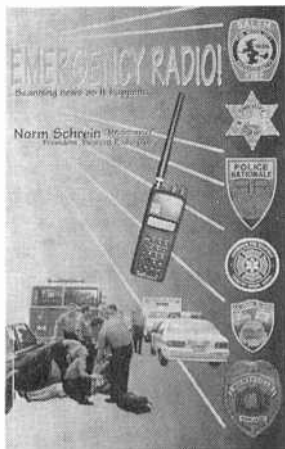
Amateur costs \$12 and is published by The American Radio Relay League, 225 Main Street, Newington, CT 06111; Tel. 203-666-1541; Fax: 203-665-7531.

CIRCLE 91 ON FREE INFORMATION CARD

EMERGENCY RADIO! Scanning News as it Happens

by Norm Schrein

This book, written by a true authority in the emergency communications world, provides real-life, action-oriented insights into listening to a broad array of emergency services. The book also provides practical guidance on how amateur radio operators, as well as average citizens, can monitor their communications to stay informed before the news happens. It includes pointers on scanning



police, SWAT teams, fire departments, medical services, disaster teams, public safety agencies, and even the emergency facilities at Disneyworld and in Washington, DC. The book teaches readers about scanning in foreign countries and on the high seas, in Las Vegas casinos and major-league ball parks, in big cities and out in the country—and even in outer space. An easy-going, anecdotal style makes for fun, exciting reading.

Emergency Radio! Scanning News as it Happens is available for \$14.95 plus \$3 shipping and handling from Index Publishing Group, Inc., 3368 Governor Drive, Suite 273F, San Diego, CA 92122; Tel. 800-546-6707.

CIRCLE 92 ON FREE INFORMATION CARD

NETWARRIORS: Programming 3D Multiplayer Games

by Joe Gradecki

Computer games that are designed to work over networks and to support virtually unlimited numbers of users playing simultaneously provide the ultimate challenge—pitting your wits against one or more quick, smart, human opponents. This book/CD-ROM set allows you to create sophisticated three-dimensional multiplayer games that work over modems, ethernet networks, and the Internet—and you don't have to start from scratch.

The CD-ROM provides a 3D game engine and a set of communications utilities that help you quickly and easily develop your own games. It includes a real-time 3D ray-casting engine; a visual map editor and other utilities for creating animated monsters, texture-mapped walls, and elaborate mazes; a music editor for adding sound effects and music; and code for adding modem, ethernet, and Internet communications. The CD-ROM also features Minotaur, a 3D multiplayer game with real-time graphics, as well as source code and executables for hundreds of games, game demos, game libraries, graphics converters, and memory management.

The book provides all the tips and techniques needed to create a graphical network game. It shows the reader how to directly interface to a network and implement this interface when programming a 3D game. It provides complete instructions and code for programming a network interface. The book also teaches programmers about the many different graph-



ics screens and how to use a shareware graphics engine, such as the ACK3D, which mimics graphics used in the popular game "Castle Wolfenstein."

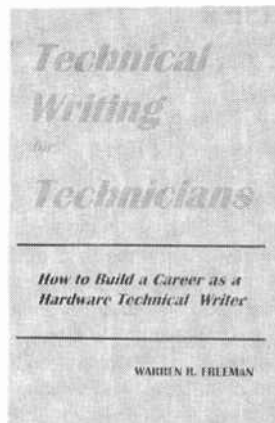
NetWarriors: Programming 3D Multiplayer Games costs \$34.95 and is published by John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158-0012; Tel. 800-CALL-WILEY.

CIRCLE 93 ON FREE INFORMATION CARD

TECHNICAL WRITING FOR TECHNICIANS: How to Build a Career as a Hardware Technical Writer

by Warren R. Freeman

If you're a technician who's considering a career move, you might want to put your technical training to a different use. This one-of-a-kind book should help expand the career opportunities of many technicians, by providing an introduction to the field of hardware technical writing.



The book presents a clear look at what it takes to be a technical writer, and then helps you to master the necessary skills. It describes possible employers, jobs, and work relationships. It looks at what goes into a technical manual—both content and appearance—and covers practical considerations such as interfacing with engineers, giving a cost estimate for the job, and meeting deadlines.

The book helps you develop a clear, concise writing style. The basics of grammar are covered, and a step-by-step approach to text preparation is presented.

Samples of poorly written technical instructions are followed by improved versions of the same material. Explanations of why the changed text works better help you learn to apply those rules to other situations. The preparation and use of illustrations is also covered, as is the layout and printing of a technical manual.

The final section of the book—an in-depth look at the writing of an actual manual—shows you how to put together all the information presented in the preceding chapters. To make things easier to follow, "manual" pages are printed on the right-hand pages of the book; the author's comments appear on the facing pages.

Technical Writing for Technicians costs \$19.95 and is published by Contemmax Publishers, 17815 24th Avenue North, Plymouth, MN 55447; Tel. 612-473-6436.

CIRCLE 94 ON FREE INFORMATION CARD

MCM ELECTRONICS CATALOG 35

from MCM Electronics

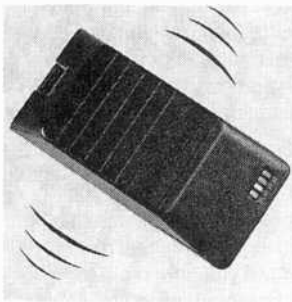
Aimed at service technicians and electronic enthusiasts, this 323-page catalog contains more than 21,000 consumer-electronics repair parts and accessories, with many major brand names to choose from. More than 1000 new items are featured, including project accessories; test equipment; semiconductors; computer products; and TV, VCR, audio, and appliance repair parts. Other new items featured in the catalog include TT Systems' caller-identification products, automotive head units and amplifiers from Sherwood, Motorola two-way radios, SL Waber power-distribution products, and more. To make part selection easier, the catalog provides a handy quick-index up front, a complete index at the end, and cross references for more than 50,000 parts.

Catalog 35 is free upon request from MCM Electronics, 650 Congress Park Drive, Centerville, OH 45459-4072; Tel: 800-543-4330.

CIRCLE 95 ON FREE INFORMATION CARD

NEW PRODUCTS

(Continued from page 6)



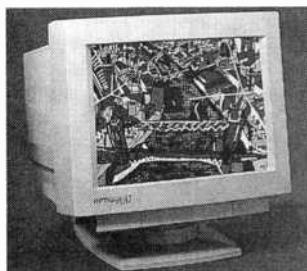
veniently attaches to the phone in the same way as any other phone battery. It is quick-charge capable and fully compatible with ORA Electronics' Quick Charger/Conditioner.

The first VibraRing model, for use with Motorola Micro TAC Series portable cellular telephones (Model VRBP5B), has a suggested retail price of \$99. For additional information, contact ORA Electronics, 9410 Owensmouth Avenue, P.O. Box 4029, Chatsworth, CA 91313; Tel. 818-772-2700; Fax: 818-718-8626.

CIRCLE 102 ON FREE INFORMATION CARD

PLUG AND PLAY MONITOR

The Optiquest 1769DC Value Line Monitor from ViewSonic offers Plug and Play compatibility to support Microsoft Windows95. When used with a compatible video card, the monitor supplies an interface for automatically configuring the graphics controller. The 1769DC offers a fine 0.28-dot pitch for high-definition images and a maximum non-interlaced resolution of 1280 x 1024. An Invar Shadow mask enhances image quality by reducing misconvergence and more.



The Optiquest 1769DC meets or exceeds all energy-certification and radiation standards,

including MPR-II. To minimize power consumption and extend monitor life, free, proprietary Opti-Green software powers down the monitor in three user-programmable stages.

The 17-inch (15.5-inch diagonal viewing area) monitor provides 28 custom-programmable memory modes for automatic screen adjustments. The Advanced Color Management System matches screen colors to actual color printer output. Overscan capability allows viewers to use the entire screen as a display area. On-screen programming provides easy adjustment of all monitor controls. The monitor comes with a tilt-and-swivel base and an anti-glare/anti-static coating.

The Optiquest 1769DC has a suggested list price of \$795. For more information, contact ViewSonic Corporation, 20480 Business Parkway, Walnut, CA 91789; Tel. 800-843-7684; Fax: 909-468-3370.

CIRCLE 103 ON FREE INFORMATION CARD

THE SCOUT REACTION TUNER

Optoelectronics has announced that the Scout now performs "Reaction Tune" and "Memory Tune" with the following receivers: ICOM R700, R7100, and R9000; AOR AR2700 and AR8000; and Radio Shack PRO-2005/2006 (equipped with an OS456) and the PRO-2035 (with the OS235). When in capture mode and connected via a mono cable to any of those receivers, the Scout automatically tunes the receiver to a captured frequency for monitoring. For Memory Tuning, a recorded frequency can also be recalled from any one of the Scout's 400 memories to tune the receiver.

With a frequency range of 10 MHz to 1.4 GHz, the Scout distinguishes itself from a frequency counter by being able to differentiate between random noise and coherent RF transmissions. An embedded microprocessor evaluates each measurement to determine when an actual RF frequency is dominant. That digital signal processing makes possible Auto Capture and recording.

The Scout is a single-range operating counter. A distinctive



double beep lets the user know that a new frequency has been recorded. A single beep indicates that an already stored frequency has been hit again. A pager-style vibrator can also let the user know a frequency has been recorded. When in recall mode, the user can scroll through and view all of the 400 frequencies and hits stored in memory. The sleep mode allows the data in the Scout to be saved in non-volatile memory.

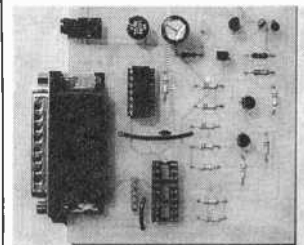
The Scout features a custom, 10-digit LCD readout and a backlight for night operation. A 16-segment signal-strength bar graph provides an indication of RF signal strength.

The Scout has a suggested retail price of \$449. For more information, contact Optoelectronics, 5821 NE 14th Avenue, Ft. Lauderdale, FL 33334; Tel. 305-771-2050; Fax: 305-771-2052.

CIRCLE 104 ON FREE INFORMATION CARD

LOW-PRICED PIC PROGRAMMER

ITU Technologies' Model PIC-1 PIC programmer is designed for programming Microchip's PIC15C6x/7x/8x family of microcontrollers from an IBM PC-compatible host. An on-board 18-pin socket is provided for programming 18-pin PIC devices; 28/40 pin adapters are also available. An expansion header is provided for adapters and in-system programming of EEPROM-based PICs.



Aimed at students, hobbyists, and novice programmers, the PIC-1 includes everything needed to get started programming. It comes with a cable to interface to the PC's parallel port, a power supply, software, and a user's manual. The PIC-1 is available as a kit or fully assembled and tested. The kit includes a high-quality printed-circuit board and an easy-to-follow instruction manual.

The PIC-1 costs \$29 in kit form and \$49 for the assembled/tested version. Educational and quantity discounts are available. For further information, contact ITU Technologies, 3477 Westport Court, Cincinnati, OH 45248-3026.

CIRCLE 105 ON FREE INFORMATION CARD

UNIVERSAL PUSH-TO-TALK SWITCH

Azden's Model PTT-01 push-to-talk (PTT) switch can give any radio the advantages of remote PTT, variable microphone gain, adjustable frequency response, and automatic timed shut-off. It can be used with all types of microphones, including dynamic and electret. A removable belt clip, Velcro tape, and a soft desk pad provide universal mounting options.



An OFF-LOCAL-DX switch permits either flat frequency response or a peaked response at 2 kHz, both with adjustable gain to match most microphones to most radios. A Lock button allows hands-off operation, and the built-in adjustable timer will shut off the transmitter after a preset time of from one to five minutes.

The PTT-01 push-to-talk switch has a suggested price of \$40. For additional information, contact Azden Corporation, 147 New Hyde Park Road, Franklin Square, NY 11010; Tel. 516-328-7501; Fax: 516-328-7506.

CIRCLE 106 ON FREE INFORMATION CARD

NET WATCH

(Continued from page 29)

Of course, the site does have its drawbacks. I couldn't locate any of the hard-to-find examples at the site that I found at CDnow. Also, the appearance of the site is not very appealing. There are no album-cover or recording-artist images.

As you can see, each site has something different to offer. Give them a try and see which one suits your particular needs. Believe me, no matter which one you use, your Christmas shopping will be made a lot easier.

THEREMIN SITES

Most long-time readers of this magazine have probably heard of an obscure musical instrument called the theremin (named after its inventor, physicist Lev Sergeivitch Termen, whose name was anglicized to Leon Theremin). The device, which produces bizarre whistling noises when a hand is waved near it, has maintained popularity through being used for sound effects in the original *Star Trek* TV series, and in rock music by Jimmy Page of Led Zeppelin and Tracii Guns of L.A. Guns.

Sure enough, there are Web sites devoted to the strange instrument. The first site, THEREMIN, does more than just answer in detail the important questions: What is a theremin and who invented it? It also includes information on where you can get a working unit.

What fans of the theremin might also find interesting is that they are not alone. The THEREMIN site provides a link to the home page of the International Theremin Enthusiasts Club, which is a

"loosely organized association of theremin builders and players." At the club's site you can find out how to become a member.

Also, on the topic of builders, the site provides a link with another HTML document that it maintains. That page gives information on how to create circuit boards (providing patterns that you can use), and even how to wind your own coils. Definitely check this page out!

Finally, like any good Web site, THEREMIN contains a list of links to other related sites. One of those, the Theremin Home Page, was particularly interesting. When you first access the site, you are presented with an impressive list of links; here are the titles of them: Theremin Availability, Projects and Schematics, Where to Find Parts, Publications—The Theremin Bibliography, Known Theremin Recordings, Bands Currently Using Theremins, and (of course) Other Theremin Links.

The first three of the links just listed are of extreme interest to hobbyists. By applying the information found through the links you can probably have a working theremin, whether homemade or purchased, sooner than you think. Just prepare your family members for the weird sounds that they'll hear coming from your room—all courtesy of the Net.

Well, that's it for this month. If you have any questions, comments, or suggestions for what you'd like to see covered in future columns, you can snail-mail (s-mail) them to me at *Net Watch*, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735. (We hope to announce our permanent e-mail address in the near future. Watch for it!)

THINK TANK

(Continued from page 76)

that, when triggered by closing switches S1–S8, conduct, energizing relay K1. That in turn switches on the audio oscillator/timer section and disconnects power from the switches, making it impossible for anyone else to ring in. The contestant's LED will light because of the drop across the corresponding 100-ohm resistor.

Timers U2 and U3 make up the audio oscillator, which produces a warble sound. Their frequencies can be varied by adjusting potentiometers R1 and R2. The timer section is composed of 555 timer U4 and the 4017 decade counter/divider, U5. That 555 produces timing pulses that can be varied by adjusting potentiometer R3. When the 4017's timer sequence reaches pin 9, which goes

high, that turns on transistor Q1 and activates K2, which will then reset the circuit.

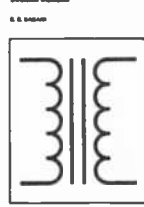
The circuit is powered by a simple 12-volt DC supply composed of an AC plug, a transformer, a bridge rectifier, three capacitors, and a regulator. The transformer, T1, is a 120- to 12.6-volt AC, 1.2-ampere unit.

—Cullen Overstake,
Arvada, CO

Well done. I hope this one helps a lot of the Scout troops, science groups, and any other youth organizations that might read this column.

Well, I guess I'll end this here. Remember, in addition to our usual award of a book from our library, by sending in enough quality circuits to fill a column, you can now win a kit and an MCL1010 chip, too. Submit your work to *Think Tank*, **Popular Electronics**, 500 Bi-County Blvd., Farmingdale, NY 11735. ■

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EXPANDED RANGES

(Continued from page 66)

Then, connect a precision 1-megohm resistor to the test leads, and adjust R4 for a reading of 3 volts.

If a meter with different input resistance is used, R4 must be recalibrated. Most DMMs have an input resistance of about 10 megohms. However, catalog descriptions of some of the lower-priced DMMs quote an input resistance of 1 megohm. If the resistance of your DMM is 1 megohm, it could be used with the Megohm Tester by removing R3 and R4, but there is no way to adjust R (in Fig. 3) to a value of exactly 1 megohm.

Another problem is that on some DMMs that are specified as having a 10-megohm input resistance, the input resistance changes for different ranges. On one meter the author checked (a Micronta 22-185A), the change in input resistance occurred between the 3-volt and 300-millivolt ranges, resulting in a 6-percent error

when measuring 30 megohms with the Tester. However, some other meters did not show that change.

The circuit shown in Fig. 6 can be used to check for a change in input resistance between the lowest DC-voltage ranges of a DMM. The circuit can be powered by 1- to 5-volts DC. Potentiometer R1 can be 100 to 10,000 ohms. Resistors R2 and R3 can be 1 to 5 megohms.

To use the circuit in Fig. 6, first check the meter calibration with a low-resistance voltage source. Set the meter to its lowest DC voltage range, connect it to points A and G, and adjust R1 for a reading slightly below the maximum reading (slightly below 200 millivolts for a meter with 200-millivolt and 2-volt scales). Then switch the meter to the next higher scale. If there is a significant difference in the reading (more than 2 or 3 millivolts), there is a problem with the meter divider resistors or internal calibration.

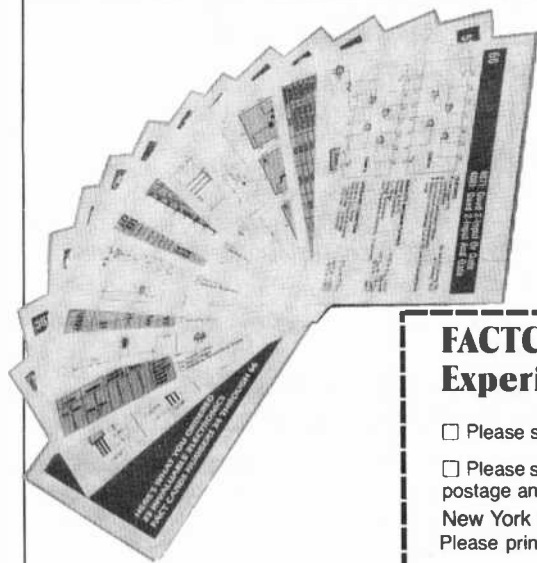
To check for a change in input resistance when the meter range is switched, connect the meter to points B and G. Readjust R1 for a reading

slightly below the maximum on the lowest scale. Again, switch between the two lowest scales. If the difference is significantly higher than in the first test, the meter is changing input resistance between scales, and readings from the Megohm Tester will be in error. That test is hard to do on an auto-ranging meter without scale hold, but adjusting R1 very slowly across the limit of the lowest scale will show if there is a difference between scales.

To use the Low-Ohms Tester, connect the test clips to the resistance being measured, and move them slightly to get the lowest reading. Unlike some circuits, the Low-Ohms Tester is not limited to very low resistances, as the current is nearly constant for voltage readings up to more than 5 volts. A 5-volt potential corresponds to 50 ohms on the 100-mA range ($R = V \times 10$), and to 500 ohms on the 10-mA range ($R = V \times 100$).

To use the Megohm Tester, connect the test leads to the resistance being measured, and use a calculator and the formulas given earlier to convert the voltage reading to resistance. ■

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BS168

XMAS TREE

(Continued from page 40)

batteries. Solder short hookup wires to connect the power and ground traces on the circuit board to the holder. The hookup wires should be long enough to allow you to move the circuit board out of the way to change batteries, but short enough to remain out of view. Four to six inches is a good length.

Install the batteries and wedge the circuit board between them. Visually examine the assembled board to ensure there are no solder bridges or cold joints. Double check for proper parts placement and orientation of the diodes, IC sockets, and LEDs. If everything checks out, install the ICs with pin 1 towards the bottom of the Tree. Then apply power by rotating the terminals (at the unwired end) of the battery holder until they come in contact with each other. If all is well, all 17 LEDs

should begin blinking in a seemingly random fashion, with the top LED flickering.

Troubleshooting. If the top LED isn't working properly, check the orientation of the two 1N4148 diodes as well as the LED itself. Check the orientation of the other LEDs if they aren't lighting either. If groups of four LEDs aren't working, trace them back to U3 and make sure that section of the 74HC04 is getting a clock signal. If it is, the problem is either one of the LEDs and/or resistors, or the IC itself. Double check for shorts or solder bridges before blaming the IC.

If some LEDs still aren't blinking, go back to the appropriate section of the timer circuitry and check the support components. To eliminate the possibility of the 7556 timers being at fault, switch them with each other. If the same LEDs are still not blinking, the problem is in the support circuitry. If swapping the 7556 chips causes one

group of LEDs to start working and a different group to fail, then and only then is it safe to assume one timer is defective.

Decorating Your Tree. Imagination is the only limitation in decorating the Tree. You can paint the Xmas Tree board (before mounting components) or use glitter (care must be taken in certain areas to avoid shorts across components or leads to the ICs if glitter is used). Another option is to glue cotton balls to the Tree. You can also use a scrap of felt to make a skirt that will hide the batteries, and string small beads to make garlands. For those inclined towards arts and crafts, the possibilities are almost endless.

A pair of fresh D batteries will provide power for about two months of continuous operation. And because there are no parts to wear out or burn out, the Electronic Xmas Tree will give years of enjoyment during the Holiday Season. ■

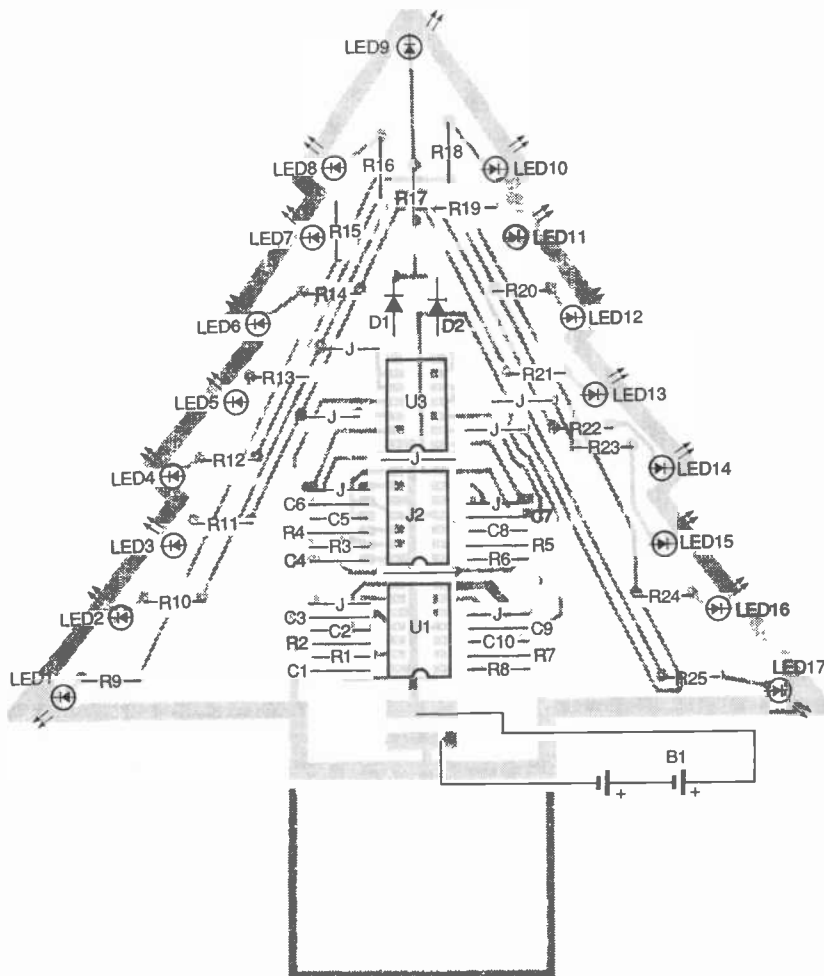


Fig. 3. Use this parts-placement diagram as a guide when mounting components on the Xmas Tree board.



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ANALYZING AC CIRCUITS

(Continued from page 60)

ing the rectangular to polar coordinates conversion equations listed earlier, or by directly examining the complex plane of Fig. 4.

We are now ready to calculate Z_{RL} , the total of impedance Z_R and Z_L in parallel. (Note that the equation has the same form as the one used in the DC section of this article to calculate the total of two resistors in parallel.)

$$Z_{RL} = ((Z_R)(Z_L))/(Z_R + Z_L)$$
$$Z_{RL} = ((250\angle 0^\circ)(251.33\angle 90^\circ))/((250 + j0) + (0 + j251.33))$$
$$Z_{RL} = ((250)(251.33)\angle(0 + 90^\circ))/(250 + j251.33)$$
$$Z_{RL} = (62832.5\angle 90^\circ)/(250 + j251.33)$$

We now almost have the calculation for Z_{RL} complete. Unfortunately, the denominator is in rectangular form and we need it in polar form to do the division. Again the coordinate conversion equations (Eq. 2A and 2B) are used to find the M and A components of the polar form. The calculations go like this:

$$M = \sqrt{X^2 + Y^2}$$
$$M = \sqrt{(250)^2 + (251.33)^2}$$
$$M = \sqrt{62500 + 63166.77}$$
$$M = \sqrt{125666.77}$$
$$M = 354.49$$

and

$$A = \arctan(Y/X)$$
$$A = \arctan(251.33/250)$$
$$A = \arctan(1.005)$$
$$A = +45.15^\circ$$

We can now return to our efforts to find Z_{RL} . Picking up where we left off:

$$Z_{RL} = (62832.5\angle 90^\circ)/(250 + j251.33)$$
$$Z_{RL} = (62832.5\angle 90^\circ)/(354.49\angle 45.15^\circ)$$
$$Z_{RL} = (62832.5/354.49)\angle(90 - 45.15)^\circ$$
$$Z_{RL} = 177.25\angle 44.85^\circ$$

Having combined Z_{R1} and Z_L and $Sb1$ into an equivalent component (see Fig. 8C), we next need to add the series impedance caused by the capacitor, C1. Unfortunately, Z_{RL} is in polar form, and we need it in rectangular form to perform the addition. So once again we must convert between the two coordinate systems, but this time we will convert from polar to rectangular.

$$X = M\cos(A)$$
$$X = 177.25\cos(44.85^\circ)$$

$$X = (177.25)(0.70896)$$
$$X = 125.66$$

and

$$Y = M\sin(A)$$
$$Y = 177.25\sin(44.85^\circ)$$
$$Y = (177.25)(0.70525)$$
$$Y = 125.01$$

And we see that

$$Z_{RL} = 125.66 + j125.01$$

when written in rectangular form.

The next step is to combine C1 and Z_{RL} into their equivalent impedance, which we'll call Z_T . That is the total impedance seen by the current source, and it will therefore be an easy Ohm's Law calculation to determine I_{C1} , the current through capacitor C1. From the complex current and impedance we can then calculate the voltage drop across the component.

$$Z_T = Z_{RL} + Z_{C1}$$
$$Z_T = (125.66 + j125.01) + (0 - j159.15)$$
$$Z_T = (125.66 + 0) + j(125.01 - 159.15)$$
$$Z_T = 125.66 + j(-34.14)$$
$$Z_T = 125.66 - j34.14$$

Converting that to polar form (which we will not show in detail because that type of calculation has been shown twice already), yields

$$Z_T = 130.21\angle -15.20^\circ$$

Knowing the total impedance seen by the current source, Ohm's Law is used to determine the voltage drop, V_1 , across the total equivalent impedance:

$$V_1 = I_T Z_T$$
$$V_1 = (5\angle 30^\circ)(130.21\angle -15.20^\circ)$$
$$V_1 = (5)(130.21)\angle(30 + (-15.20))^\circ$$
$$V_1 = 651.05\angle 14.80^\circ$$

So finally, we have the answer to the original question. The voltage across the independent current source is:

$$V_1 = 651.05\sin(360ft + 14.80^\circ)$$

where $f = 100$ Hz.

Final Thoughts. Keep in mind that complex analysis can be used in conjunction with any form of circuit analysis, not just Ohm's Law, which was used exclusively, in this article. Both loop and nodal analysis could be used by following the same basic procedure.

It might be a bit time consuming, but it's definitely quicker than working a series of differential equations, which is the other method used. ■

HANDS-ON REPORT

(Continued from page 30)

pin adapter. A small cover pops off to install a 9-volt battery that will retain VersaTimer's programming memory during power outages or to move the unit to another location after programming. A "hidden" pushbutton, accessed with a pencil point, turns on a green LED if the battery is good. A fresh battery will maintain memory for about three days.

To set up the unit, a power cord is connected to the unit and then plugged into a grounded AC outlet. When the unit is first plugged in, the mode LED will flash orange indicating that the internal clock needs to be set; don't worry, that is normal. Next, a serial cable plugs into the unit at one end and into an RJ-11-to-9-pin serial adapter at the other. That must connect to the serial port of a PC. If the serial port on the PC is a 25-pin connector, then you'll have to supply a 9-to-25-pin adapter.

The next step is to install the included software on your PC. When you first run the software it's a good idea to run a test routine that checks for proper communication between VersaTimer and the PC. Next you must set the timer's internal clock. That is done by pulling down a clock-set menu that lets you set the timer's time to that of the PC's internal clock or to some other time. The mode LED glows red once the clock is set.

An editor panel allows you to set up a 7-day program with time intervals 15 minutes apart each day. Editing is done by simply toggling boxes in a 7-day menu on and off. A program can be named and saved to disk allowing the use of multiple programs. Once a schedule has been defined it can be sent to the timer by activating a program function.

The mode LED flickers while the timer is receiving and storing a program and then glows red to indicate that it's still in the manual mode, in which the on/off switch will control the outlets. The switch to schedule mode can be made from the computer or by quickly toggling the on/off switch on the timer. The mode LED changes to green when the timer enters the schedule mode.

Special events can also be sched-

uled. In addition to 96 daily power events, up to five special events (on, off, reboot, schedule, and manual) can be scheduled per day, at any minute of the day. The on event simply turns power on and off turns it off, but at any given minute instead of a 15-minute interval.

If the reboot event occurs when power is on, power turns off and then back on 30 seconds later to properly reboot a computer. If power is off when that event occurs, it will turn on 30 seconds later. The schedule event puts the timer in the schedule mode and the manual event puts it in manual. On, off, and reboot events will occur only if the unit is in the schedule mode, while schedule and manual occur regardless of the mode.

One outlet on the back of the unit is labeled as "smart," and it can be used in that way only when the timer is in the manual mode. In that configuration, an appliance plugged into the smart outlet will control the appliances plugged into the other two outlets. The power switch on the device plugged into the smart outlet then mimics the on/off switch on the timer. That allows the timer to be placed in an out-of-the-way location. That feature can be used, for example, to turn on an entire computer system from only the monitor switch.

That's all there is to it. Once the unit is programmed it can be moved to any desired location, plugged into the wall, and the devices to be controlled are plugged into it. The only other thing to note is that anything that is to be controlled by the timer obviously must have its own power switch left on.

All in all, VersaTimer is quite a versatile device, and one the likes of which we've never seen before. If you have a need to control appliances at specific time intervals on a 7-day schedule, then VersaTimer is the answer. Just remember that you'll need a PC before you can use it! For more information on the VersaTimer, circle no. 119 on the Free Information Card, or contact the manufacturer directly at the address given below. ■

FOR MORE INFORMATION

Server Technology, Inc.
1288 Hammerwood Ave.
Sunnyvale, CA 94089

MMIC AMPLIFIERS

(Continued from page 44)

ing the degree of mixing that occurs; that mixing produces intermodulation (IM) distortion, and the products are called the intermodulation products (IMP). In a perfectly linear amplifier, simultaneously inputting two frequencies (f_1 and f_2) produces an output spectrum of only f_1 and f_2 . But in real amplifiers, there will be harmonics and mixing ("heterodyning") taking place, so a number of other frequencies are produced.

Figure 5 shows the IMP spectrum for an amplifier in which two equal amplitude signals are input; f_1 is 7 MHz and f_2 is 10 MHz. The harmonics produced are $2f_1$ at 14 MHz, and $2f_2$ at 20 MHz. The mixing products include the second-order IMP ($f_1 + f_2$) and the third-order IMP ($2f_1 - f_2$ and $2f_2 - f_1$). All of those frequencies are graphed in Fig. 5.

In tuned RF amplifiers, the generated harmonics are rarely of concern because they will fall way outside even fairly sloppy L-C tuned circuits. Similarly, with the second-order IMP ($f_1 + f_2$), because it will normally be outside the passband. The third-order products, however, often fall within the selectivity skirts of the RF front-end of receiver systems, so they are of concern.

In wideband amplifiers, the second- and third-order IMPs are of critical concern because at all but the highest frequencies they fall inside the passband of the amplifier. In the case of a MMIC, with a bandwidth of say DC to 1000 MHz, all signals in Fig. 5 will pass through the system. Receivers and subsequent amplifiers will see the distortion products of the input amplifier, so they become of critical concern. Further, power taken by amplifying the IM products is not available for the fundamental signal. In addition, those signals might cause interference in receiver systems.

As a rule, the third-order IMP increases more rapidly than the fundamental signals. A value frequently seen is that the third-order IMP increases 3 dB for every 1 dB increase in the fundamental signal. As a result, the gain slope for the third-order IMP is higher than that of the fundamental signal and will cross the fundamental

gain at some point, usually above the 1-dB compression point (see Fig. 6). That point is called the third-order intercept point, and is specified in dBm. According to some sources, anything greater than or equal to 10 dBm is superb, 0 dBm to less than 10 dBm is excellent, -10 dBm to less than 0 dBm is good, and less than -10 dBm is getting a bit shabby. The various MAR-x devices have third-order IMP figures of +15 dBm to +27 dBm.

A Simple MAR-x Project. Figure 7 shows the circuit for a practical MAR-x amplifier. Although designed specifically for the MAR-6 device, it can be used for any member of the MAR-x line with an appropriate voltage regulator at U2. The circuit is basically the same as that of Fig. 3, but with additional decoupling against noise on the DC power line outside the circuit (C4 and C5), and a 78L05 voltage regulator. The MAR-6 device wants to see a voltage of +3.5 volts DC on the output terminal, while other versions want a slightly higher voltage (e.g. +5 VDC for the MAR-1).

For those models select a higher voltage regulator (e.g. 78L08). You'll also need to change the value of R1; it can be calculated using the formula presented when we discussed Fig. 3.

A printed circuit board for this project is shown in Fig. 8, and the associated parts-placement diagram is shown in Fig. 9. I designed this board using the EASY-PC software, and had the prototype made by FAR Circuits (18N640 Field Court, Dundee, IL, 60118). If you want to build this project, and don't want to etch your own board, it can be obtained from FAR, although you will have to contact them directly for pricing. When writing, send them a copy of the pattern so that they can identify which of my designs it is. (They have done a lot of work for me!) ■



"That chip automatically withdraws your car payment from the bank on the first of each month."

MAGIC EYE

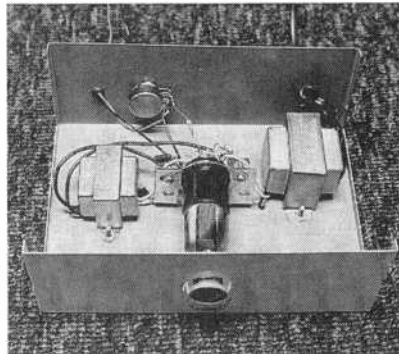
(Continued from page 67)

transformers and tube socket as connection points for the few other components.

Begin wiring the circuit by mounting a socket for the magic-eye tube on a couple of hardware-store, 1½-inch brass-corner "irons." The "shadow area" of the tube is oriented between pins 1 and 8. Keep in mind when mounting the tube that it's customary to have that area pointing down. You will need to cut a 1½-inch-diameter hole in the front panel to accommodate the tube.

Next go on to wire the rest of the circuit. If you are planning on using the circuit for show only, you will only need to wire the components shown in Fig. 1. Add the components shown in Fig. 2 if you would like to use the Magic Eye as a tuning indicator.

Whichever version you build, keep the following in mind: The center-tap



Note that no circuit board was used in the author's prototype. The transformers and tube socket can be used as connection points for the other parts.

connection to the 12.6-volt windings of T1 and T2 isn't used and can be trimmed short and either taped or curled out of the way. Tie a knot in the power cord so an inadvertent pull won't tear the wiring.

If you're using the Magic Eye as a tuning indicator, make sure that the input wires are kept short. Also, use grommets to protect them at their points of entry to the project box.

Using the Magic Eye. If you built the version of the Magic Eye shown in Fig. 1, then using it is simple. Just place it on top of your stereo or radio and plug the Magic Eye into the wall. Then, when you shut off the lights, you'll be ready to relive the old days.

If you built the version of the circuit shown in Fig. 2, you will need to attach your Magic Eye to your radio's ground and AVC line. In most radios, the AVC line is connected to the end of the loop antenna or to the antenna coil opposite the end connected to the grid of the input tube.

Note: Never attach any accessory to a radio without isolating the radio first. A so-called AC-DC radio can be made safe by using an inexpensive isolation transformer between the radio and power outlet.

Once the Magic Eye is connected to the radio, turn on both units. Then, adjust potentiometer R3 so that the Eye closes as stations are tuned in. That's all there is to it. ■

SETI

(Continued from page 54)

three degrees. With that dish placed on a transit mount, and letting the earth be the antenna rotor, the dish rotates at 15 degrees per hour. That means that a given star will be within its beam for about 12 minutes. Given existing amateur DSP technology, 12 minutes is enough time to thoroughly scan about 14.4 kHz of spectrum, at 10-Hz resolution.

Because the water hole is 240-MHz wide, to cover the assigned area of sky at all declinations, we need to listen for some 2760 years! That isn't practical. But, in Shuch's estimation, 5520 experimenters, scattered around the world and having the means to communicate, can do the sky survey in just one year.

What do you need in terms of receiving, computer, and DSP hardware and software to join in the search? The equipment you need includes a three- to five-meter parabolic reflector, similar to that used for TVRO or 23-cm amateur moon-bounce, and a low-noise amplifier (LNA) covering 1.4 to 1.7 GHz.

You also need a down-converter to shift that range to a suitable IF (intermediate frequency); IF amplifiers, filters, and a detector to derive audio from the IF; a digital signal processor (DSP); spectrum-analysis software; and a PC on which to run the software. All of that equipment costs about what it would to outfit a typical amateur OSCAR satellite station.

The League is developing a low-cost microwave receiver to scan the required 240 MHz at a 10-Hz resolution. It also hopes to publish and promote the best hardware and software ideas that emerge from the amateur community, and it will design, prototype, and evaluate various detection and signal-analysis technologies. Further details on participation are available from the League (for more information on the SETI League and other organizations of interest to amateur radio astronomers, see the "Resources for Amateurs" box).

So, are we alone in the universe? Perhaps yes, and perhaps no—at this point we just don't know. But we need to be in a position to take that very long-distance call, if it comes. ■

PARTS LIST FOR THE MAGIC EYE

RESISTORS

(All fixed resistors are ½-watt, 5% units.)

R1—470,000-ohm

R2—1-megohm*

R3—1-megohm potentiometer*

ADDITIONAL PARTS AND MATERIALS

MATERIALS

C1—0.1-μF, polyester capacitor*

V1—1629 vacuum tube

T1, T2—117-volt to 12.6-volt, 450-mA or greater, power transformer

PL1—AC plug, two-terminal

Project enclosure, octal tube socket, ½-inch brass corner irons, power cord, grommets, nuts, bolts, wire, solder, hardware, etc.

All parts marked with an asterisk (*) are only necessary for the tuning-indicator version of the Magic Eye shown in Fig. 2.

Note: The following are available from Antique Electronic Supply (6221 S. Maple Ave., Tempe, AZ 85283; Tel. 602-820-5411; Fax: 602-820-4643): A complete kit of all above parts (K-PE-EYEKIT)—\$29.95; a 1629 magic-eye vacuum tube—\$5.30. Contact Antique Electronic Supply for shipping and handling information.

BUY BONDS

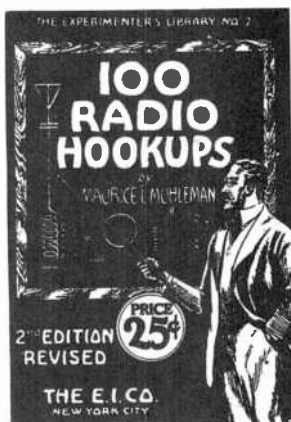
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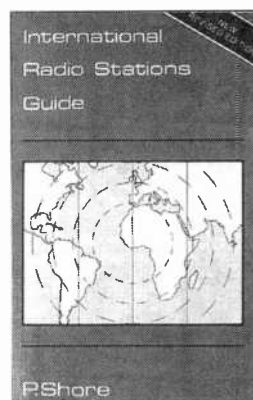
100 RADIO HOOKUPS
—#7—\$3.00

First published in May, 1923 this popular booklet went into reprint editions nine times. It is packed with circuits, theory, antenna installation and tips on consumer radio receivers that were popular in the early 1920's. Antique radio buffs and those inquisitive about the early days of radio will find this booklet an exciting, invaluable and excellent reference into the minds of early-day radio listeners. Sorry, we cannot honor the original 25-cent cover price.



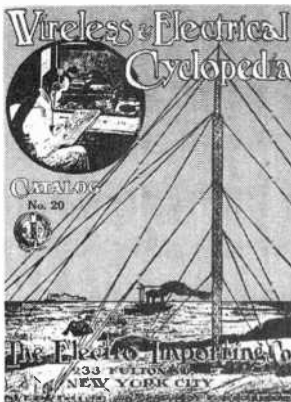
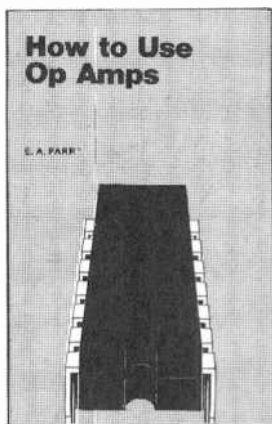
INTERNATIONAL RADIO STATIONS GUIDE—BP255
—\$9.95

Provides the casual listener, amateur radio DXer and the professional radio monitor with an essential reference work designed as a guide for listening to the complex radio bands. Includes coverage on Listening to Shortwave Radio, ITU Country Codes, Worldwide Radio Stations, European Long Wave and Medium Wave Stations, Broadcasts in English and more.



HOW TO USE OP AMPS
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The engineer's best friend is the op amp. This basic building block is found in many circuits, analog and digital alike. The op amp finds many useful purposes such as: oscillators, inverters, isolators, high- and low-filters, notch and band-pass filters, noise generator, power supplies, audio, MIDI, and much more. Prepared as a designer's guide, some limited math is used, however engineers and hobbyists alike find it a useful text for their design needs.



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A slice of history. This early electronics catalog was issued in 1918. It consists of 176 pages that document the early history of electricity, radio and electronics. It was the "bible" of the electrical experimenter of the period. Take a look at history and see how far we have come. And by the way, don't try to order any of the radio parts and receivers shown, it's very unlikely that it will be available.

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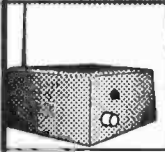
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December 1995, Popular Electronics

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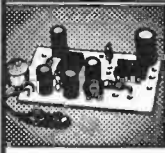
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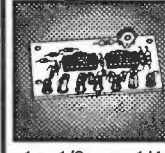


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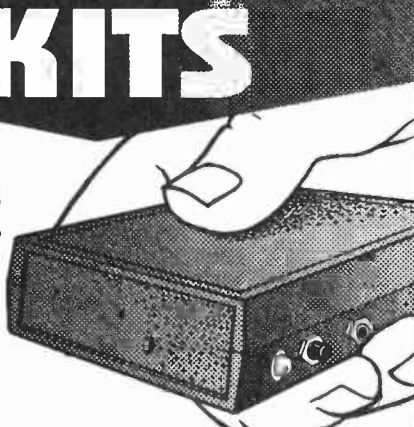


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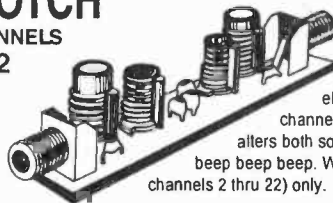
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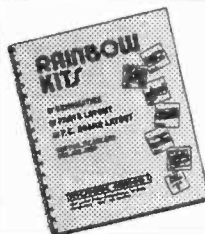


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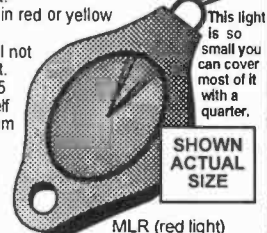
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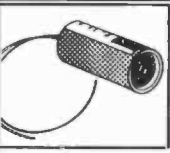
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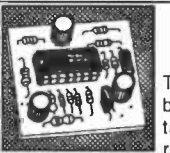


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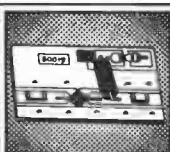


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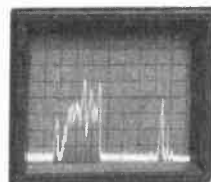
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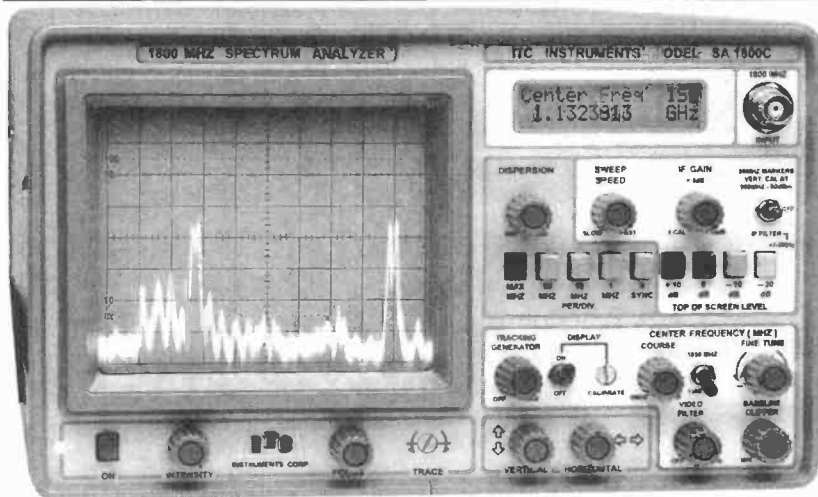
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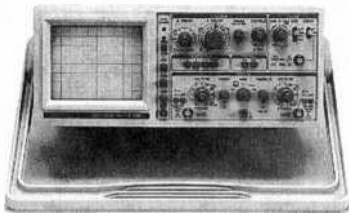
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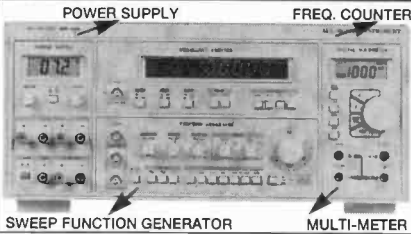


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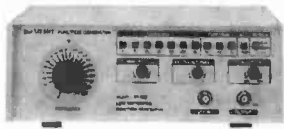


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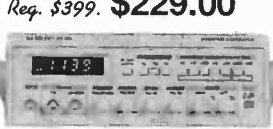
- 1** Function Generator
 - Sine, Square, Triangle, Pulse, Skewed Sine, Ramp, TTL
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 - ± (1 Hz + 1 dgt. + Time Base Error)
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 - 3-1/2 Digit LCD
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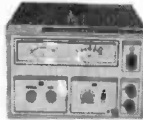


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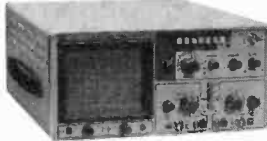
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- Rise time 14n Sec. or less.
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- Acceleration Potential 2kV
- 60MHz (X1.X10) Probe Kit: 2 sets
- Power: 115/230V AC

OS-3324, 3 Function

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- 2** • Dual Component Tester/Comparator

- 3** • Triple DC Power Supply 5VDC, +12 VDC, -12VDC

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- Uncalibration LED.
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- Acceleration Potential 12kV
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- 9 Function / 42 Range
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 - Ohm: Up to 2000MΩ
 - Amp: AC/DC 2 Amp
- Extended Capacitance Meter (9 Range)
 - 0.1pF ~ 20,000µF
 - Zero Adjust Knob
- Trig Lamp

DM5100, Wide Range w/Logic

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- Ohm: Up to 200MΩ
- Capacitance: 1p - 200µF
- Logic: TTL, TR hFE

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Reg. \$119. **\$69.00**



- DM230**
- 3 1/2 Digit LCD
 - Engine Analyzer Taco, Dwell, Duty Cycle
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 - Auto & Manual
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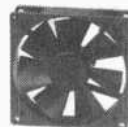
cod-4010



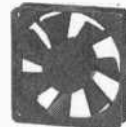
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cod-9225



cod-1225

These High Quality Fans feature Ball Bearings and Brushless DC Motors. All of them are designed to meet UL, CSA & VDE Standards. Design these fans into power supplies, computers or other equipment requiring additional air flows for heat removal. These fans are regular Circuit Specialists stock items — they are not surplus.

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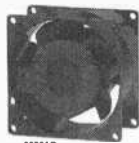
CAT NO	1	10	25	100
CSD 4010-12	\$ 9.88	\$ 6.38	\$5.48	\$4.87
CSD 6025-12	9.38	5.91	5.41	4.71
CSD 8025-12	8.88	5.85	5.19	4.49
CSD 9225-12	8.95	6.14	5.29	4.59
CSD 1225-12	11.45	8.96	7.82	6.85

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Specifications

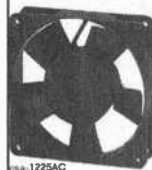
CAT NO	DIMENSIONS (MM)	RATED VOLTAGE (V)	START VOLTAGE (V)	INPUT CURRENT (A)	AIR FLOW (CFM)	STATIC PRESSURE (INCH-H ₂ O)	SPEED (RPM)	NOISE LEVEL (dB)	WEIGHT (g)
CSD 4010-12	40x40x10mm	12	7	0.06	5.1	0.19	5,500	26	20
CSD 6025-12	60x60x25mm	12	5	0.13	13.7	0.165	4,500	28	65
CSD 8025-12	80x80x25mm	12	5	0.16	37.8	0.177	3,000	31	80
CSD 9225-12	92x92x25mm	12	5	0.32	42	0.18	2,800	37	95
CSD 1225-12	120x120x25mm	12	5	0.35	62	0.180	2,500	42	135

Ball Bearing AC Fans



cod-8038AC

Size: 80 x 80 x 38.5mm (3.15 x 3.15 x 1.5")
 Weight: 370±10gm (0.82lb.)
 Frame/Housing: Aluminum
 Impeller: Glass reinforced thermoplastic UL94V-0
 Bearing Type: Ball Bearing
 Dielectric Strength: 1 minute at 1,500VAC/50-60Hz
 Operating Temp: -20°~+85°C
 Life Expectancy: 50,000 Hrs (at 25°C, 65%RH)
 Motor Protection: Impedance Protected
 Safety Approvals: Meets UL, CSA, VDE Standards



cod-1225AC

Size: 120 x 120 x 25.5mm (4.71 x 4.71 x 1.00")
 Weight: 390±10gm (0.86lb.)
 Frame/Housing: Aluminum
 Impeller: Glass reinforced thermoplastic UL94V-0
 Bearing Type: Ball Bearing
 Dielectric Strength: 1 minute at 1,500VAC/50-60Hz
 Operating Temp: -20°~+85°C
 Life Expectancy: 50,000 Hrs (at 25°C, 65%RH)
 Motor Protection: Impedance protected
 Safety Approvals: Meets UL, CSA, VDE Standards

CAT NO	1	10	25	100
CSA8038AC	\$15.26	\$12.92	\$10.98	\$9.73

CAT NO	1	10	25	100
CSA1225AC	\$15.28	\$12.94	\$11.01	\$9.88

Specifications

CAT NO	DIMENSIONS (MM)	NOMINAL VOLTAGE (V)	FREQUENCY (HZ)	SPEED (RPM)	INPUT POWER (W)	AIR FLOW (M3/MIN)	STATIC PRESSURE (MM)	NOISE LEVEL (dB)
CSA8038AC	80x80x38.5	110/120	50/60	2300/2600	9/7	0.63/0.72	3.5/4.5	31/34
CSA1225AC	120x120x25.5	110/120	50/60	2000/2300	12/10	1.56/1.70	4.6/4.8	23/36

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CAT NO	DESCRIPTION	1	5	10
CC-M3	Cooling Fan for 486 CPU's	\$7.50	\$6.00	\$5.00
PENTIUM FAN	Cooling Fan for Pentium CPU's (Will not fit Pentium 60 or 66MHz)	9.50	8.00	7.00

Plastic Fan Filter Assemblies

These fan filter packages consist of a guard, foam filter media and media retainer for tubeaxial fans. The retainer is easy to install without removing the fan or guard while the foam filter is also simple to clean and change. Use these kits to protect your equipment from airborne contamination and reduce external fan noise.

CAT NO	DESCRIPTION	1	10	25	50
GRM 60	Plastic Fan Filter Kit for 60mm Fans	\$1.76	\$1.42	\$1.20	\$.98
GRM 80	Plastic Fan Filter Kit for 80mm Fans	2.20	1.75	1.48	1.28
GRM 92	Plastic Fan Filter Kit for 92mm Fans	2.60	2.05	1.74	1.40
GRM 120	Plastic Fan Filter Kit for 120mm Fans	2.92	2.19	1.84	1.56

Fan Power Cord 2' Length, SPT-1, AWG18 x 2C, UL/CSA

CAT NO	DESCRIPTION	1	10	25	50
C180	Fan Power Cord	\$1.28	\$1.14	\$.94	\$.78

Metal Fan Filter Assemblies

For use with tubeaxial fans. These wire formed fan guards provide extra safety.

CAT NO	DESCRIPTION	1	10	25	50
FG40-2	Wire Formed Fan Guard for 40mm Fans	\$1.72	\$1.29	\$1.09	\$.86
FG60-4	Wire Formed Fan Guard for 60mm Fans	1.92	1.44	1.19	.96
FG80-5	Wire Formed Fan Guard for 80mm Fans	2.00	1.50	1.24	.99
FG92-5	Wire Formed Fan Guard for 92mm Fans	2.28	1.71	1.39	1.14
FG120-15A	Wire Formed Fan Guard for 120mm Fans	2.52	1.89	1.57	1.26

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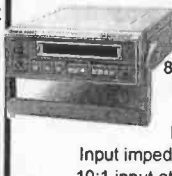
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\$239**
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\$75.00**
3 fully regulated supplies; 1.5-15V @ 1A, -1.5 to -15V @ 1A or 3-30V @ 1A & 5V @ 3A **Kit XP-620K \$49.95**



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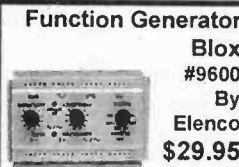
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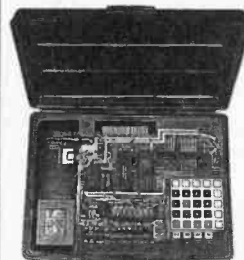


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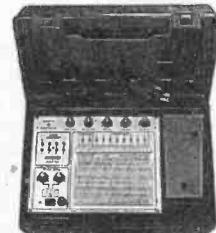
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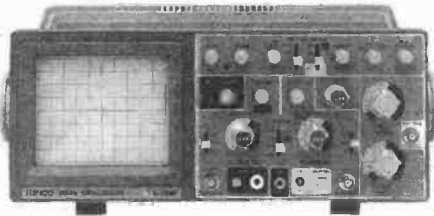
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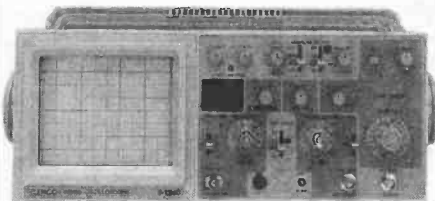
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40MHz

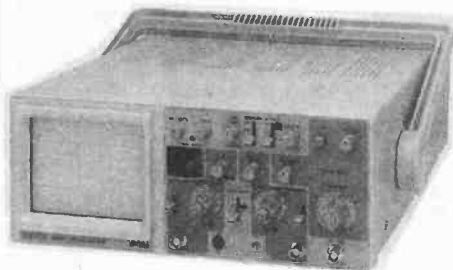
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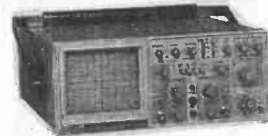
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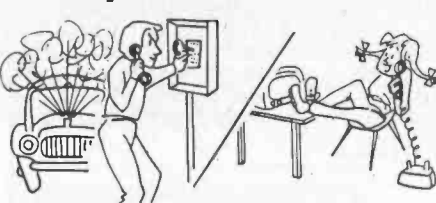
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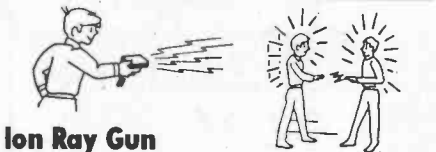
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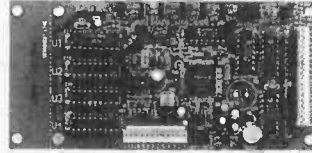
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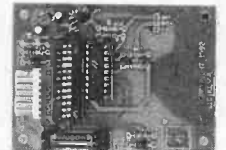
The TX-01 Motherboard can encode a 12-bit address code with 4096 possible code combinations or can be used to encode an 8-bit address code with a 4-bit data code.

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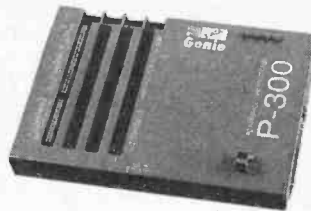


The RE-01 Motherboard will decode a 12-bit address or 8-bit address with 4-bits of data, depending on which of the two included IC's is installed into the board.

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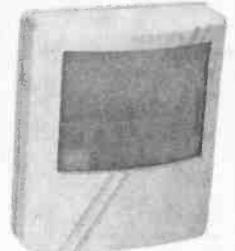


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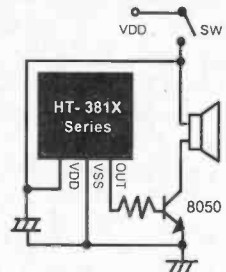
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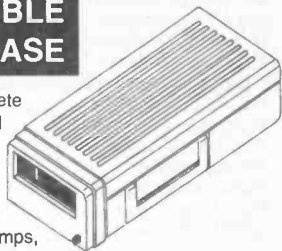
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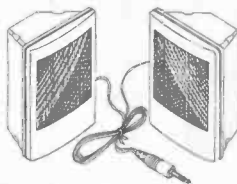
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2" X 3" full range portable stereo speaker system. 8 ohm impedance, 2 watts input power. Frequency response 100-20 Khz. 3' cord with 3.5 mm stereo plug. Ideal for use with "Walkman" style stereos and CD players or later model computer systems with stereo audio outputs. Taupe with gray grill.



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CAT# SK-020

MERCURY TILT SWITCH

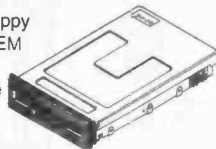
SPST mercury tilt switch. Glass bulb is 0.25" dia. X 0.67" long. Circuit is closed in vertical position. Rated 750 ma.

CAT# MS-15

\$1.00 each

720K 3.5" INTERNAL FLOPPY DRIVE

Sony # MP-F11W-2Z Brand new 720 KB floppy drives. Built for an OEM product, these are, in every way, compatible with PC/XT/AT computers except that the faceplate is slightly larger than those on exact replacements. The faceplate size on these is 4.04" X 1.23". (Normal size is 4" X 1"). The faceplate is removable and can be trimmed if desired. In some cases it may work without trimming. Also, we have found that, when used in 5.25" bays with the adapter kit below, the adapter can easily be modified to accommodate the unit. Because of this slight inconvenience, we are selling these drives at an incredibly low price.



\$14.00 each

CAT# MPF-11SF

10 for \$120.00

INSTALLATION KIT for MPF-11SF

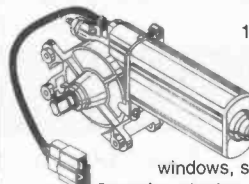
allows for installation into 5.25" drive bays. Simply cut and remove three plastic gussets to install. CAT# FDD-3.5 \$3.50 each

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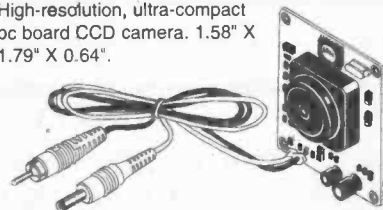
Great for robotics, winches and other hi-torque applications. 175 RPM @ 12 Vdc, 1.5 amps (no load). Works well from 6 to 24 Vdc. 10mm diameter X 15mm long dual flatted threaded shaft (thread pitch 1mm). Overall dimensions: 6.5" long X 2.75" X 3.5". 7" wire leads with molex-type connector.

CAT# DCM-61

\$17.50 each

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High-resolution, ultra-compact pc board CCD camera. 1.58" X 1.79" X 0.64".



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CAT# VC-200P

\$159.00 each

B/W CAMERA with AUDIO

Above camera with electret mike, audio board and 20" audio output cable with RCA plug. Same dimensions as above, but audio board adds 0.2" thickness to the assembly.

CAT# VC-200PA

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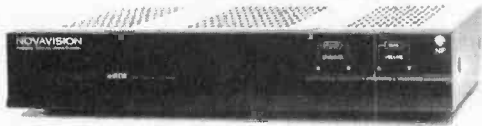
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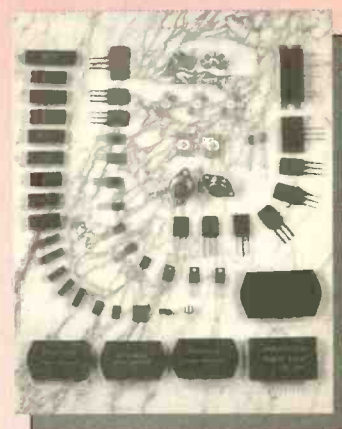
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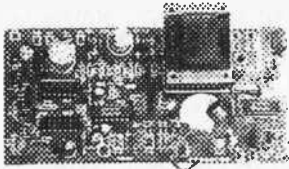
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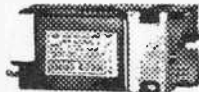


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120-220VAC input, 150W regulated. Attractive black shockproof case, 4 1/4" x 3" x 10 1/2".
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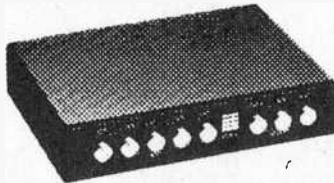


NEC NE710 FET
Ku-K Band GaAs.
92S073 \$9.95

MINI HI-VOLTAGE POWER SUPPLY
+24 VDC in, -6.3KV @ 0.5mA out. Use for lasers, photomultiplier tubes, ion generators, cattle prods, electrostatic air filters, etc. Yamata P/N HVH-C204L-1.



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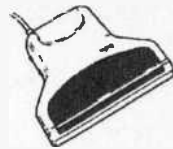
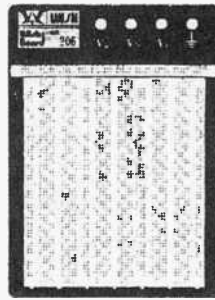


VIDEO SWITCHING CENTER
Five inputs (VCR, Game, CATV, Aux, Ant), two outputs (TV, VCR). Measures 6.25"W x 5.5"D x 1.5"H. These units are new in box and come with instructions.
94V004 \$9.95 each



CARVER FM-STEREO DECODER
Installs between existing FM tuner-receiver and stereo amplifier to improve stereo reception of stations with weak signals and/or multipath distortion problems by as much as 20dB. New, in box.
94V019 \$69.95 each

PROTOBOARD
9.1" x 6.9" x 1.2". Five distribution strips; 500 distribution points. Three terminal strips; 1,890 terminal points. Four binding posts.
SB2390 \$22.00



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New units with PC-compatible "Interpreter" Windows OCR software with imaging capability, 100-400 DPI resolution, LED and audible scanning speed indicators. 8-bit I/O card included. Requires Windows.
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Three extra-bright LEDs flash in unison on this 9V battery powered board. Use as safety warning for auto or bicycle, party gimmick, sea buoy, etc. Kits may be used in series to form an array.
95K001 Kit of Parts \$3.95

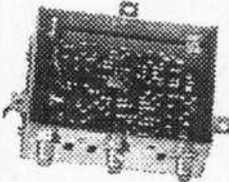


TIL311

Red hexadecimal display with logic.
93S033 \$9.95 each

VHF RF PREAMP AND SPLITTER

Contains two transistors with FT of 4GHz 10dB gain, 3dB NF. Soup up that VHF receiver, scanner, FM tuner, VHF-TV reception or whatever. Actually has two preamps in one case. Runs on 12VDC. Schematics included and hints for broadband use.
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12" Tall Teddy Bear Talk and it imitates your voice in "bear talk." Soft and cuddly.
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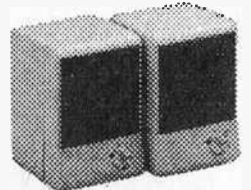
HELPING HANDS MAGNIFIER

Ball joints on all angles. Nickel-plated fittings. Heavy cast iron base. 2X 2.2" magnifying glass. Alligator spring clips. Locks at any angle.
93U002 \$5.95 each



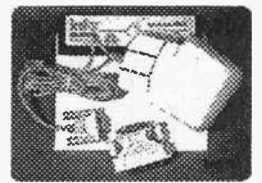
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This mouse comes with its own house - a pocket to hang on the side of your computer for storage. Three buttons with hi-res microswitch type click switches. Comes with its own mousepad, DB9 to DB25 adapter, DOS and Windows compatible software on both 3.5" and 5.25" disks.
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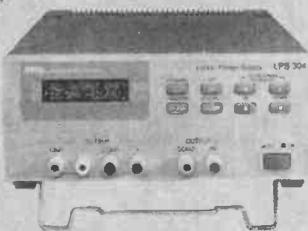
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- Powerful 2 stage audio amplifier.
- Sensitive, picks up sounds at the level of a whisper.
- Up to 1 mile range.
- Requires 9V battery. (Not incl.)



SUPER-MINIATURE FM TRANSMITTER
Super small FM transmitter. Use with any FM broadcast receiver. Easy to assemble, all chip (SMT) parts are pre-assembled to the circuit board.

XST500 (E-Z) Kit \$44.95

- Miniature photo battery mounts right on circuit board. (Included)
- Tunes 88-108 MHz.
- Up to 1/2 mile range.
- Sensitive 2 stage audio amplifier, picks up sounds at the level of a whisper.



MICRO-MINIATURE FM TRANSMITTER
Including the battery, this is the Worlds smallest FM transmitter. Use with any FM broadcast receiver. Easy to assemble, uses pre-assembled circuit board.

XWB1000 E-Z KIT \$49.95

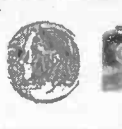
- Up to 1/2 mile range.
- Miniature photo battery mounts right on circuit board.
- Transmits at 143 MHz.
- Amazing audio sensitivity, picks up sounds at the level of a whisper.



CRYSTAL CONTROLLED FM TRANSMITTER
Including the battery, this is the Worlds smallest crystal controlled FM transmitter. Transmits to any scanner type receiver. Easy to assemble, uses pre-assembled circuit board.

XTL1000 E-Z KIT \$69.95

- Smallest phone transmitter anywhere!
- Tunes 88-108 MHz.
- No batteries required, powered by phone line.
- Up to 1/4 mile range.
- Attach to phone line anywhere in house.



SUPER-MINIATURE PHONE TRANSMITTER
Worlds smallest FM phone transmitter. Use with any FM broadcast receiver. Easy to assemble, all chip components are pre-assembled to the circuit board.

XSP250 (E-Z) Kit \$34.95

- Dial your phone from anywhere and listen to the sounds inside your home.
- Two digit Touch Tone code for secure operation.



TELEPHONE SNOOP

The latest in home or office security. Call home from anywhere, enter a two digit security code, and hear the sounds in your home. Automatically turns on without ringing the phone, verifies code, then activates for one and a half minutes.

XPS-CASE KIT \$13.95

XPS1000 (C) KIT \$49.95

- Transmits a continuous beeping tone.
- Adjustable from 88 to 108 MHz.
- Up to 1 mile range.
- Works with any FM broadcast receiver.



TRACKING TRANSMITTER

Only 0.7 by 2.4 inches, the XTR100 operates at voltages of 3 to 18 Volts and is ideal for use in locating lost model rockets, bicycles, automobiles, games of hide and seek, and contests.

XTR100 (C) Kit \$33.95

- Uses sensitive microwave transistor amplifier.
- Covers 1 to 2,000 MHz.
- Compact hand held unit.
- Includes miniature loud speaker for audio indication of detected signals.



SUPER SENSITIVE BUG DETECTOR

When the XBD200 intercepts a signal in the 1 to 2,000 MHz range, it emits a growl that increases to a high pitched squeal as the signal strength increases.

XBD200 (C) Kit \$49.95

- Use with any FM broadcast receiver.
- Hear every sound in an entire house!
- Up to 1 mile range
- Powerful 2 stage audio amplifier.



MINIATURE FM TRANSMITTER

The XFM100 has a super sensitive microphone and is capable of picking up sounds at the level of a whisper and transmitting them to any FM broadcast receiver.

XFM100 (C) Kit \$32.95

- Digital voice changing: male to female, female to male, adult to child, child to adult.
- Anonymity on any call.
- Button for normal operation.
- 16 levels of voice masking.



VOICE CHANGING TELEPHONE

STOP THOSE ANNOYING TELEPHONE CALLS! Sound older and tougher when you want to. Not a kit. Fully assembled. Single phone operation only.

TRANSITION 2000 \$89.95

- Digital voice changing: male to female, female to male, adult to child, child to adult.
- Use with any modular phone.
- 16 levels of voice masking.
- Connects between handset and phone.



VOICE CHANGING ACCESSORY

STOP THOSE ANNOYING TELEPHONE CALLS! Sound older and tougher when you want to. Not a kit. Fully assembled. Use with single or multi-line phones.

TRANSITION 2001 \$59.95

- Uninterrupted coverage of 800 to 950 MHz.
- Works with any scanner that can receive 400 to 550 MHz.



800-950 MHz SCANNER CONVERTER KIT

If your scanner can receive 400-550 MHz, just add the XLC900 for uninterrupted 800-950 MHz coverage. It converts all 800-950 MHz signals down to 400-550 MHz so your scanner can receive them! Add our custom case kit for that "Professional" look.

XLC-CASE KIT \$13.95

XLC900 (C) KIT \$49.95

- Transmit high quality stereo to any FM stereo receiver.
- Built-in output level monitor for quick and easy tuning.
- Ideal for use with personal CD player.



FM STEREO TRANSMITTER

Transmit full-bodied Hi Fi stereo to any FM stereo receiver. Separate left and right inputs and gain controls. Includes an output booster stage for greater range.

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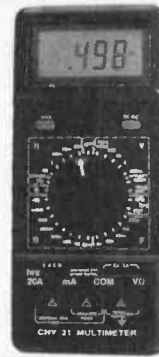
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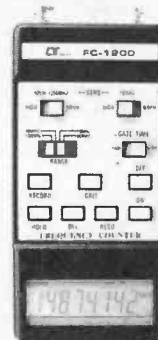
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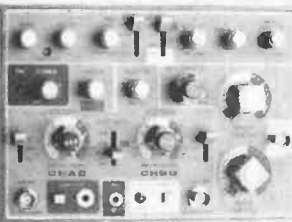
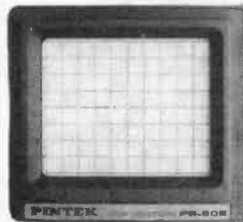


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0.1pF, 1μH, 10mΩ resolution



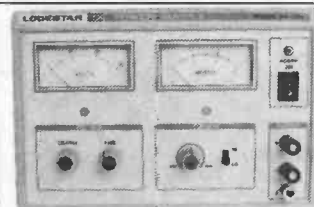
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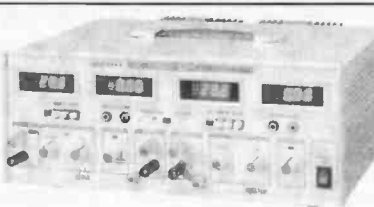


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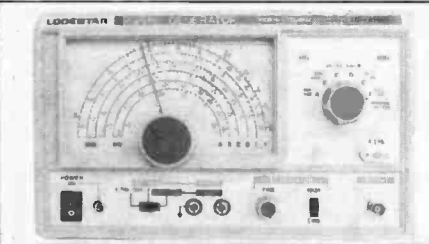
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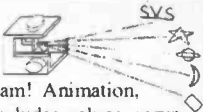
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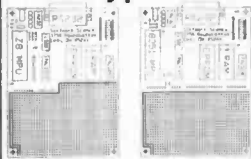
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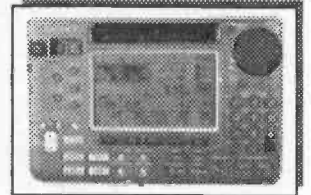
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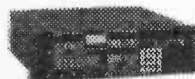
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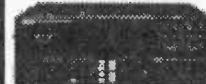
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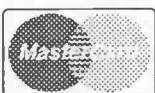
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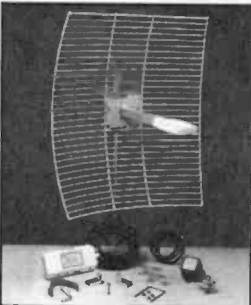
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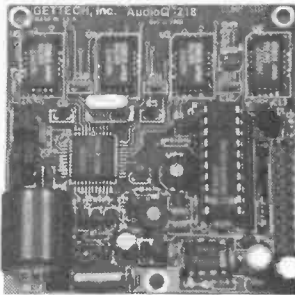
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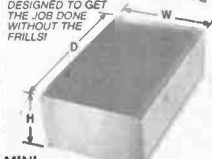
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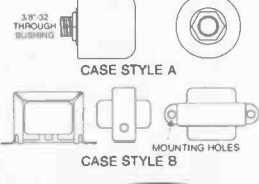


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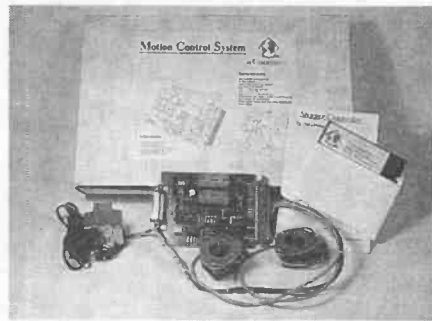
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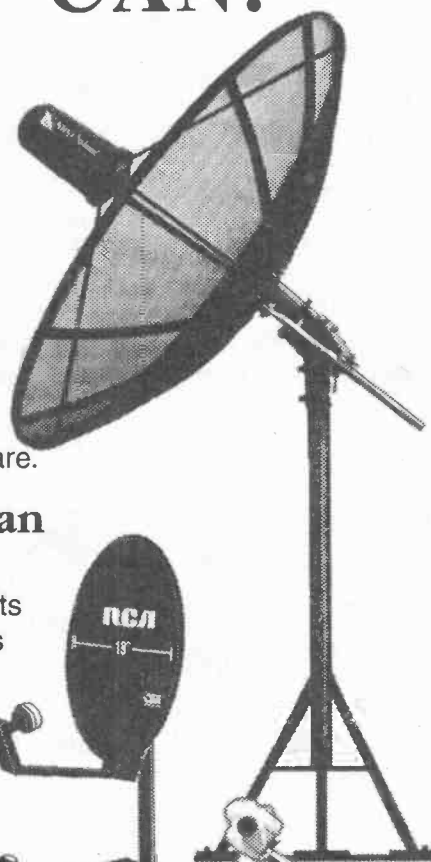
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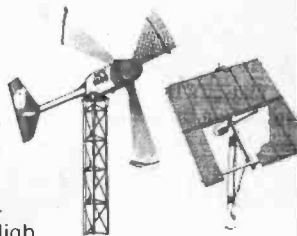
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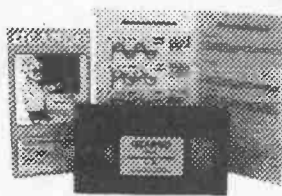
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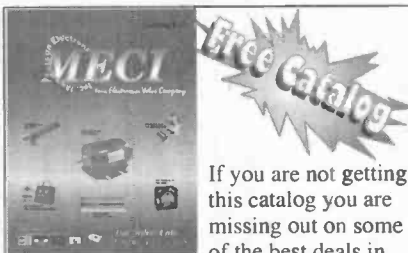
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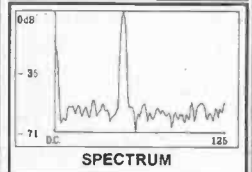
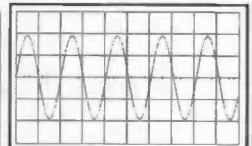
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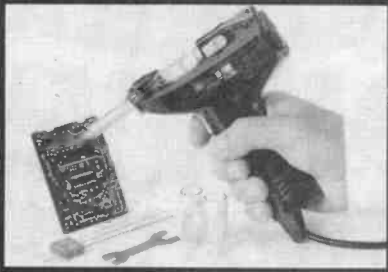
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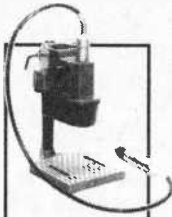
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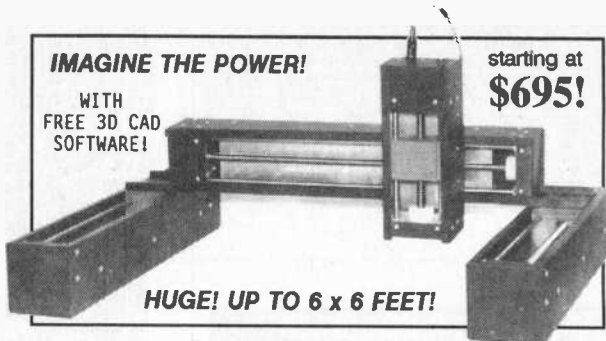
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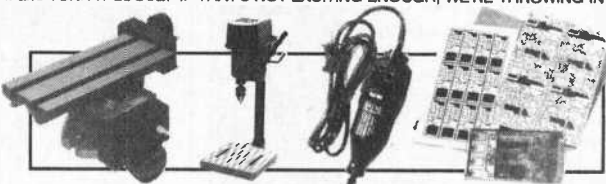
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For firms or individuals offering Commercial products or Services. **Minimum 15 Words.** 5% discount for same ad in 6 issues within one year; 10% discount for same ad in 12 issues. **Boldface (not available as all caps), add .40 per word additional. Entire ad in boldface, add 20%. Tint screen behind entire ad, add 25%. Tint screen plus all boldface ad, add 45%. Expanded type ad, add \$2.25 per word.**

General Information: A copy of your ad must be in our hands by the 13th of the fourth month preceding the date of issue (i.e. Sept issue copy must be received by May 13th). When normal closing date falls on Saturday, Sunday or Holiday, issue closes on preceding work day. Send for the classified brochure.

DEADLINES

Ads not received by our closing date will run in the next issue. For example, ads received by November 13 will appear in the March issue that is on sale January 17. **POPULAR ELECTRONICS** is published monthly. No cancellations permitted after the closing date. No copy changes can be made after we have typeset your ad. **NO REFUNDS, advertising credit only. No phone orders.**

CONTENT

All classified advertising in **POPULAR ELECTRONICS** is limited to electronics items only. All ads are subject to the publishers approval. **WE RESERVE THE RIGHT TO REJECT OR EDIT ALL ADS.**

AD RATES: \$1.75 per word. Minimum \$26.25

Send you ad payments to:

POPULAR ELECTRONICS 500 Bi-County Blvd, Farmingdale, NY 11735-3931

CATEGORIES

100 - Antique Electronics	270 - Computer Equipment Wanted	450 - Ham Gear Wanted	630 - Repairs-Services
130 - Audio-Video Lasers	300 - Computer Hardware	480 - Miscellaneous Electronics For Sale	660 - Satellite Equipment
160 - Business Opportunities	330 - Computer Software	510 - Miscellaneous Electronics Wanted	690 - Security
190 - Cable TV	360 - Education	540 - Music & Accessories	710 - Telephone
210 - CB-Scanners	390 - FAX	570 - Plans-Kits-Schematics	720 - Test Equipment
240 - Components	420 - Ham Gear For Sale	600 - Publications	730 - Wanted

CLASSIFIED AD COPY ORDER FORM

Place this ad in Category # _____

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9 - \$26.25	10 - \$26.25	11 - \$26.25	12 - \$26.25
13 - \$26.25	14 - \$26.25	15 - \$26.25	16 - \$28.00
17 - \$29.75	18 - \$31.50	19 - \$33.25	20 - \$35.00
21 - \$36.75	22 - \$38.50	23 - \$40.25	24 - \$42.00
25 - \$43.75	26 - \$45.50	27 - \$47.25	28 - \$49.00

29 - \$50.75	30 - \$52.50	31 - \$54.25	32 - \$56.00
33 - \$57.75	34 - \$59.50	35 - \$61.25	36 - \$63.00
37 - \$64.75	38 - \$66.50	39 - \$68.25	40 - \$70.00

Total words _____ \$1.75 per word = \$ _____

Bold Face _____ \$0.40 per word = \$ _____

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Total classified ad payment \$ _____ enclosed

TOTAL COST OF AD \$ _____

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Card # _____ Expiration Date ____/____

Signature _____

Name _____ Phone _____

Address _____ City State Zip _____

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EDUCATION

LEARN PC Assembly Language. Disk \$5.00, Book \$18.00. ZIPFAST, Box 12238, Lexington, KY 40581-2238.

BUILDING A Robot: A Straightforward Approach. 152 pages. Fully illustrated book. \$19.95 plus \$3.00 S&H. HUMANFORM ROBOTICS, PO Box 158486, Nashville, TN 37215.

LEARN PC repair-troubleshooting, servicing. Home study. Free literature. P.C.D.I., Atlanta, Georgia. 1 (800) 362-7070 Dept. JJP341.

TODAY'S Electronics. Don't get left behind! Top home-study courses developed by U.S. Military. Free catalog. FEDERAL TECHNICAL PUBLISHERS, Box 1218, E. Glen Lake, MN 55345.

BECOME a Locksmith. Approved home study. Free career literature. P.C.D.I., Atlanta, Georgia. 1 (800) 362-7070 Dept. LKP341.

ESP Bioelectricity, microwave hearing, comprehensive booklist... \$1.00; \$2.00 foreign. RESEARCH ASSOCIATES, PO Box 3583, Boynton Beach, FL 33424-3583.

BECOME an Electrician. Approved home study. Free career literature. P.C.D.I., Atlanta, Georgia. 1 (800) 362-7070 Dept. TEP341.

KNOWLEDGE CARDS. Tables. Formulas. Fun and educational. Package \$2.00. Box 12238, Lexington, KY 40581-2238.

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SCANNER modifications. Unlock 800 MHZ cellular bands. \$8.00. SCANNER MODS, PO Box 462042, Garland, TX 75046-2042. 24hrs. rec. msg. (214) 518-9999.

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IBM and Atari software! Free catalogs! Specify machine. LOTSA BYTES, PO Box 1756, Winton, CA 95388 (209) 358-1160.

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CABLE —safe. Guarantee cable privacy. The one way valve for your cable TV signal. Cable signals come in, but they don't go out! \$29.95, + \$3.00 S&H. Visa/MC/Amex. ELECTROMAN, Box 24474, New Orleans, LA 70184. (504) 482-3017.

CABLE unscrambled. Everything you want to know about cable, but are afraid to ask. \$10.00. Visa/MC/Amex. ELECTROMAN, Box 24474, New Orleans, LA 70184. (504) 482-3017.

"DESCRAMBLER Schematics Revealed." A powerful guide to descrambling schemes. \$10.00. Visa/MC/Amex. ELECTROMAN, Box 24474, New Orleans, LA 70184. (504) 482-3017.

UNIVERSAL descrambler. Unscramble signals using your VCR as the tuner. Works with virtually any system, this is the only one you need. Declare cable box independence! \$129.95 + \$5.00 S&H. Visa/MC/Amex. ELECTROMAN, Box 24474, New Orleans, LA 70184. (504) 482-3017.

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CABLE descramblers. Bargain headquarters, below wholesale prices. Absolutely the lowest prices! Money-back guarantee. Nobody beats us! RP ELECTRONICS, 1 (800) 304-3604.

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CATV test chips as low as \$8.95 for testing converter boxes in full service modes. Jerrold, Tocom, Scientific Atlanta, Pioneer BA5XXX — BA67XX cubes clear E2—E5. MICRO MASTERS, 1 (800) 360-7654.

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CABLE descrambling, new secret manual. Build your own descramblers for cable and subscription TV. Instructions, schematics for SSAVI, gated sync, sinewave, some free methods. (HBO, Cinemax, Showtime, UHF, Adult) \$12.95, \$2.00 postage. CABLETRONICS, Box 30502PE, Bethesda, MD 20824.

SECRET cable descramblers! Build your own descrambler for less than \$12.00 in seven easy steps! Radio Shack parts list and free descrambling methods that cost nothing to try, included. Send \$10.00 to: INFORMATION FACTORY, PO Box 669, Seabrook, Texas 77586. For Visa/MC, COD's, (713) 922-3512 any time!

CABLE descramblers and test turn-on kits available for most makes and models. No catalog, no 800 number equals your lowest prices. Call others, then compare our prices! We pay cash for unwanted cable boxes. No Florida sales. (305) 425-0751.

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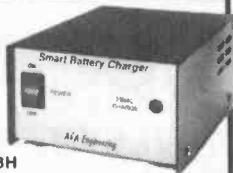
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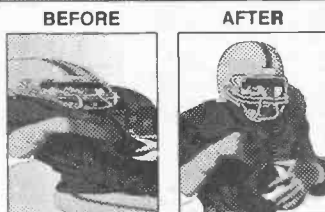
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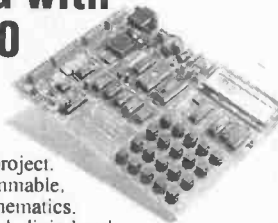
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ADVERTISING INDEX

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Free Information No.	Page	—	ISCET	91	
—	A&A Engineering	131	166	Jensen Tools	117
25	Ace Communications	120	—	KDE EElectronics	110
163	Advantage Instruments	97	—	Learn, Inc.	7
26	Alfa Electronics	114	—	Lindsay Publications	127
28	All Electronics	109	—	M&G Electronics	117
—	Allen Engineering	132	165	MCM Electronics	107
—	Allison Technology	124	—	MD Electronics	99, 123
—	Allstar Electronics	115	—	McGraw-Hill	31
27	Alltronics	112	—	Mega Electronics	126
140	AMC Sales	126	149	Mendelsohn's	123
—	Andromeda Research	118	175	MicroCode Engineering	5
—	Antique Radio Classified	71	—	Ming Engineering	108
—	Basic Electrical Supply	131	—	Modern Electronics	126
30	Bel Merit	102	—	Mondo-tronics	127
—	Black Feather	117	13	Mouser Electronics	33
—	C&C Electronics	127	—	Multi-Vision	79
—	C&C Specialties	126	—	Nabi's Byte	131
—	C&L Electronics	110	—	NRI Schools	27
132	C&S Sales	104	43	Optoelectronics	CV4
—	Circuit Specialties	103	—	Orion Electronics	127
—	CLAGGK, Inc.	68, 79, 81, 90	176	Parallax	CV3
—	Cleveland Inst. of Electronics	37	148	Parts Express	131
—	Command Productions	125	164	Phillips Tech	118
174	Communiations Elect., Inc.	134	47	Prairie Digital Inc.	124
—	Comtrad Industries	8, 13, 17	—	Precision Awareness Pub.	118
—	Consumertronics	132	46	Print	113
154	Contact East	127	130	Print	122
—	Copyright Clearance Center	34	—	Progressive Concepts	115
—	CTek	130	—	Protech Dist. Inc.	33
—	Cybermation	120	—	Rose Research	127
167	Dalbani	111	—	The School of VCR Repair	71
—	Design Computation	120	—	Self-Reliance Co. Inc.	122
—	EDE Spy Outlet	130	—	Sescom Inc.	119
—	Electronic Equipment Bank	116	—	Seymor Radix	127
137	Electronic Rainbow	96	—	Sheffield Electronics	126
—	Electronics Tech. Today	89, 95	—	Show Time	119
—	Firestik II	71	—	Silicon Valley Surplus	115
172	Foley-Belsaw Institute	71	—	Skyline	115
—	Forest Electronics	125	—	Skyvision Inc.	121, 130
—	Fotronic Corporation	98	—	Software Science	115
—	Gateway Products	107	—	Tab Books	63
—	General Device Instruments	126	168	Tech Serv.	124
—	Get-Tech Inc.	119	136	UCANDO Videos	122
—	Grantham College of Engineering	3	—	Universal Electronics Inc.	125
—	Great Southern Security	123	—	US Cyberlab	128
—	Greenleaf Electronics Inc.	132	—	Vector-Vid	115
—	Halcyon Group	110	—	Vision Electronics	131
—	Home Automation Systems	118	—	Visual Communications	115
—	Howard Electronics	126	—	Weeder Technologies	118
—	I.E.C.	123	—	Weka Publishing	100
—	Information Unlimited	106	—	World College (Div. of C.I.E.)	73
173	Interactive Image Technologies	CV2	—	WPT Publications	115
—	Intronics	123	134	Xandi Electronics	113

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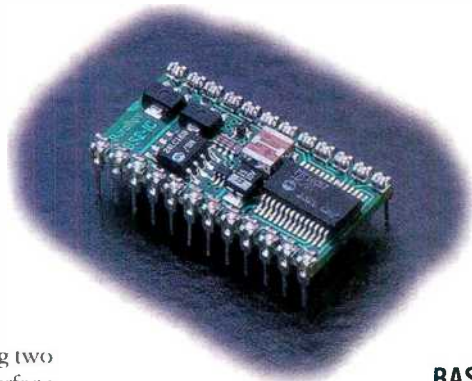
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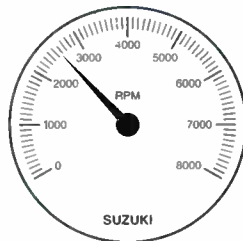
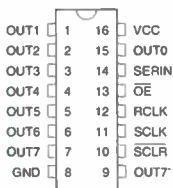
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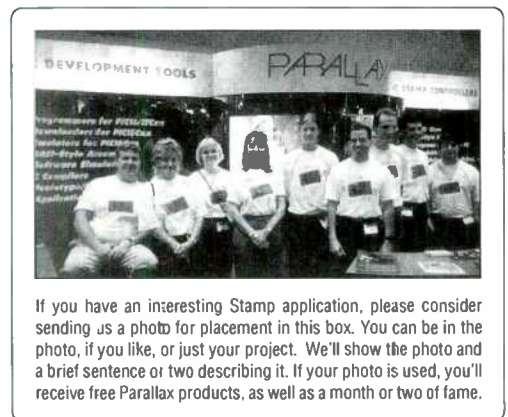


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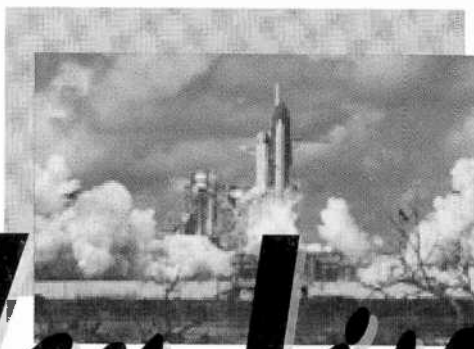
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