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JULY 1991, VOLUME 8, NO. 7

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CONSTRUCTION ARTICLES

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Send and receive video pictures over any telephone line

BUILD THIS 20-WATT STEREO AMP .... *Robert A. Young* 40
See what a difference a few watts can make when you add this amp to your home or automobile stereo system

BUILD THE QUAD TRACER .... *Charles D. Rakes* 59
Gain the advantages of an expensive multi-trace scope at a fraction of the cost with this channel multiplying circuit

FEATURE ARTICLES

ALL ABOUT OSCILLOSCOPES .... *Stephen J. Bigelow* 34
Learn how oscilloscopes work, the right way to use them, and what to look for when you buy your own

USEFUL RF GIZMOS THAT YOU CAN BUILD .... *Joseph J. Carr* 55
These useful circuits can make building, troubleshooting, and using radio projects much easier

PRODUCT REVIEWS

GIZMO 43
Including: Esoteric Sounds Turntable, Nikkodo CD + G Karaoke Player, Sharp VHS Camcorder, Laser PC4 Portable Computer, Kawai Personal Keyboard, and much more

HANDS-ON REPORT 63
Okidata OL400 LED Page Printer

PRODUCT TEST REPORT .... *Len Feldman* 64
Sylvania RKS240CH 20-inch TV Monitor/Receiver

COLUMNS

THINK TANK .... *John Yacono* 20
Adjustable regulators can control more than voltage

ANTIQUE RADIO .... *Marc Ellis* 66
Inside the theremin

COMPUTER BITS .... *Jeff Holtzman* 68
More on hypertext

CIRCUIT CIRCUS .... *Charles D. Rakes* 70
Build a voice scrambler/descrambler

FUN SOFTWARE .... *Fred Blechman* 74
Three fun games from England

HAM RADIO .... *Joseph J. Carr* 76
The new no-code license

DX LISTENING .... *Don Jensen* 78
In search of European DX

SCANNER SCENE .... *Marc Saxon* 80
Catching crooks, scanner style

DEPARTMENTS

EDITORIAL .... *Carl Laron* 2
LETTERS 3
ELECTRONICS LIBRARY 4
NEW PRODUCTS 12
ADVERTISER'S INDEX 92

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EDITORIAL

SIGNALS FROM SPACE: FACT, FICTION, OR APRIL FOOLS?

In the April, 1991 issue, without fanfare or comment, we ran a story entitled "Are We Receiving Biological Signals From Space," written by L. George Lawrence. While that story deviated greatly from our typical fare, we decided to publish the story as an experiment. We wanted to see how readers would react to a story that clearly strays from the mainstream and reports results that are controversial, to say the least. We were not disappointed.

We received a great deal of mail on this story. The responses ranged from "The worst piece of rubbish I've ever read" to "The funniest April fools put-on since Hugo Gernsback's 'Westingmouse' radio" to "Your article was very thought provoking." Several readers asked for more details in the hope of duplicating, or disproving, Mr. Lawrence's results. A few of the better letters will appear in the "Letters" column over the coming months.

To begin with, the story was *not* an April fools put on; at least not by us. When we first received the story, our initial reaction was to dismiss it out of hand. However, as is our standard policy, before reaching a final decision on the story we read it a second time several days later. This time we became curious; despite some gaps in the information, there was enough detail present to indicate that the author was serious. We decided to have someone more familiar with astronomy and physical science than we were look over the story. His reaction was: "Some strange stuff here, though it might be appropriate for your *April* issue!" A light bulb went on, and you know the rest.

I guess the best way to sum up all of this is to relate a story to you. In November, 1913, Lee de Forest went on trial in New York for mail fraud. He was accused by the Federal District Attorney prosecuting the case of making "...absurd and deliberately misleading statements..." in particular, stating that "...it would be possible to transmit the human voice across the Atlantic before many years..." DeForest was acquitted by the jury, but the judge advised him to "get a common garden-variety job and stick to it."

The moral is that controversial experimental work is almost always dismissed as rubbish at first, and often that's exactly what it is. Don't forget, however, that every once in a while it's the experimenter who has the last laugh.

Carl Laron
Editor

LETTERS

OUT OF LUCK

There are two errors in my article, "Build 'Sure-Luck' Ohms," as it appeared in the April 1991 issue of **Popular Electronics**. First, on page 55, in the second paragraph in the right-hand column, the second reference to S1 should read S4 instead. Also, in the parts-placement diagram, Fig. 3, LED24 is shown reversed.
Charles D. Rakes

REGENERATIVE-RECEIVER WRAP-UP

I am writing to thank author Stanley Czarnik and your staff for the excellent job they did on the article "Build a Regenerative Vacuum-Tube Receiver" that appeared in your April 1991 issue. That article is based on the 1-Tube Regenerative Radio Kit that we sell, and the response so far has been great.

However, there were a couple of errors and oversights that crept in and should be pointed out. The most serious is in the schematic diagram, where a line is missing. That line should run from the line between C2 and L2 to the line between R1 and JU3. That correction will place the grid leak resistor (R1) across the coupling capacitor (C2) and allow proper operation. Also, the article never mentioned what size wire to use in making the coils; use no. 26 enamel-coated wire for that. Neither of these problems would hamper those building the project from our kit, but they could cause difficulty for those attempting it from scratch.

I had a lot of fun in designing this project, and I hope your readers enjoy building it. Keep up the good work; I look forward to each new issue.
Mike Peebles, Design Engineer
Yeary Communications

WANTED: GUITAR-AMP

My father is 71 years old and in poor health. He hasn't built any electronics projects in years, but I got him to build (with some help from my 12-year old) the regenerative receiver in the April issue of **Popular Electronics**. Instead of using headphones, they fed the output to my "pig-nose" practice amp so that we could all listen in (howls and all). Of course, now I've got to dig up another small guitar amp for myself!
M.D.
Olathe, KS

SONIC DEFENDER CORRECTION

I just received the May 1991 issue of **Popular Electronics**, and was delighted by the presentation of my article, "The Sonic Defender." However, I did notice one error. In the parts-placement diagram (Fig. 3), the battery connections are reversed. The connections are correct in the schematic.
Phil Salas

MAIL-ORDER POLICIES

I'm writing in response to the letter from D.H.R., titled "Foreign Policy," which appeared in the April issue of **Popular Electronics**. Having been in the mail-order business, I would like to point out why many mail-order suppliers will not do business overseas. First, some businesses offer products that they import themselves and may only sell within their own area. One of the book distributors mentioned by D.H.R. falls into that category; they mainly import British books into the U.S., which, since he is in New Zealand, he could probably get much more easily from the U.K.

Another reason is that foreign customers often pay by check, which might be either a bank draft or a personal check and is often in foreign currency. Most of the small banks with which mail-order firms deal flatly refuse to handle such checks. And customers do not want to wait long enough for their checks to clear. (If a company ships before that, there is no effective recourse should the check bounce.)

As a collector of British and European electronic equipment and literature, I am well aware that American businesses are not the exception in this regard. Many foreign suppliers are quite difficult for Americans to deal with. Some small British firms will ignore American correspondence or quote magnificently outlandish prices (such as 214.74 pounds *each* for a DA100 valve, which is simply a 211 with a weird square base and six-volt heater) when pestered. Germans will tell you the item is out of stock and to call back next August. And the French will refuse to conduct business in any language other than French (ask any Citroen owner).

The bottom line is that small individual orders simply are not economically feasible on an international basis—which creates an opportunity for small businessmen in each country. Rather than complaining, I suggest that D.H.R. take advantage of the opportunity.
R.C.
Leneca, KS

REPELLING/ ATTRACTING COMMENTS

I liked two articles in the April issue of **Popular Electronics**: "Bug Off: The **Popular Electronics** Pest Repeller" and "Build an Electronic Fishing Lure." I built similar projects many, many years ago, using different designs, of course. For the pest repeller, I used a simple unijunction relaxation oscillator and miniature speaker that was aimed chiefly at the pests that spoil most outdoor activities: mosquitoes. Scientific research has revealed that when the female mosquitoes are incubating their eggs and searching for blood for that purpose, they can't stand the sight of the male mosquitoes. The lovelorn males, which do not bite, emit a sound in the 21- to 23-kHz range in the belief that it will woo the females. Luckily for us, however, all it does is drive them away. The electronic repeller, in fact, actually simulates a whole swarm of mosquitoes, so it is quite effective in keeping those little blood-sucking females away.

Regarding the fishing lure, a flashing light with a very fast pulse is much more effective than a continuous one for catching the attention of a passing fish. It also conserves power.
T.L.
Mount Martha, Victoria, Australia

HAVES AND NEEDS

I've enjoyed reading **Popular Electronics** for years, and especially enjoy the "Think Tank" and "Circuit Circus" columns. In fact, most of my knowledge of electronics I have learned from your magazine!

I need a service manual or schematic of a Sears brand garage-door opener, model number 139,655560. Sears no longer has references on it. I would be willing to pay anyone who could supply me with those items.

Thanks, and keep up the good work!
Howard P. Mayse
2009 Glenwood Avenue
Muncie, IL 47304

I am a long-time reader and subscriber to **Popular Electronics**, starting in the late 1950's, and this is my first request for help. I am restoring a McIntosh model MAC 1500, serial number 23F22, stereo receiver made in 1964 or 1965, and I need a schematic/wiring diagram or any other information anyone might have. I would appreciate any help that any fellow **Popular Electronics** readers could give me.

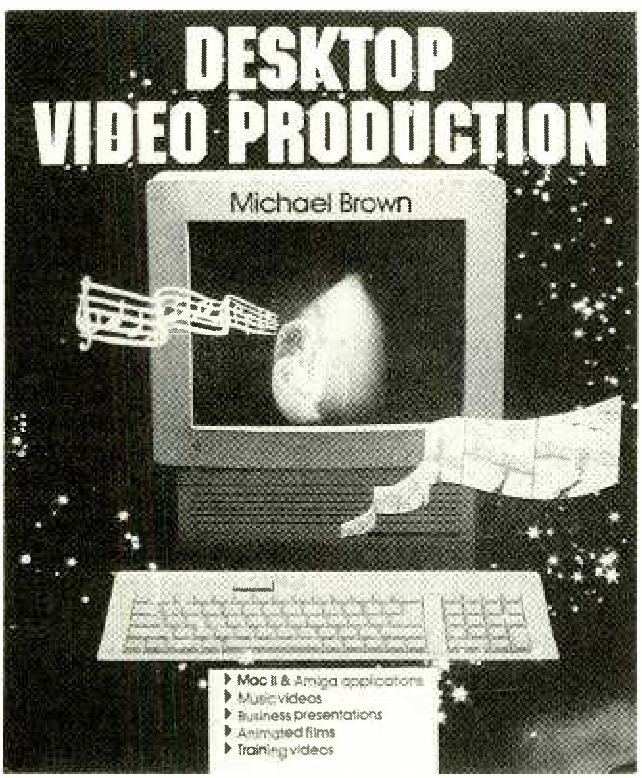
Incidently, I have all of the *Rider Perpetual Troubleshooter's Manuals* through volume 16 (1947), and will send photocopies to other readers upon request (but no more than two sheets per request, please).
Mervin H. McIntyre
18024 Clermont Circle
Seneca, SC 29678

ELECTRONICS LIBRARY

Desktop Video Production

by Michael Brown

Multimedia refers to the presentation of information using different communications media. Amiga and Macintosh computers offer several advantages to the aspiring multimedia producer of professional-quality music videos, business presentations, training films, and animated films. The same computer that's used to generate a multimedia presentation can serve as a playback device or can control other playback devices. Computers also can be used to provide interactivity and animation sequences. A new class of software, called "authoring software," lets even those who have no formal training



prepare relatively complex multimedia presentations.

This book describes one aspect of multimedia: desktop video production. It explains the hardware and software tools needed to produce video films, and the different standards—consumer, industrial, and broadcast—of video equipment. The book also provides practical advice to help readers determine which equipment is best suited to their needs. Included is an extensive overview of Amiga and Mac II hardware, software, and expansion capabilities; a description of the complete range of cameras, video digitizers, sound recorders, synthesizers, and other equipment; and practical production pointers on budgeting, rehearsal, and lighting. The book also takes a look at the future of desktop video production.

Desktop Video Production costs $16.95 and is published by Windcrest, Blue Ridge Summit, PA 17294-0850

CIRCLE 81 ON FREE INFORMATION CARD

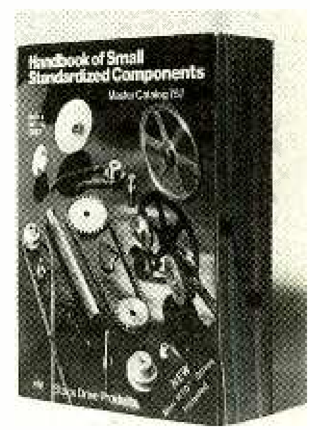
HANDBOOK OF SMALL STANDARDIZED COMPONENTS: Master Catalog 757

from Stock Drive Products

More than 24,000 small, off-the-shelf, inch and metric drive components are featured in this 768-page catalog. It features 55 pages containing 1,355 new components. Also included are four pages of polygon profile shafts, couplings and adaptors for high-torque applications, and a series of molded gears and sub-miniature roller chains and sprockets.

The handbook is divided into nine product sections, each with its own photographic and descriptive index. All components in the catalog adhere to the following parameters: 20-pitch or finer gears, ½-inch or smaller shafts, and ¼-horsepower or less devices. Every component is identified using an alphanumeric coding system, which is explained in the catalog. The catalog also includes a section containing useful technical tables, such as conversion to small-inch measurements, standards for inch-size threads, American/metric equivalents, and standards for metric threads.

The Handbook of Small Standardized Components, which



includes a registration card that entitles the bearer to receive additional catalogs and an extensive technical-reference handbook, is available for $5.95 from Stock Drive Products, a DSG company, 2101 Jericho Turnpike, Box 5416, New Hyde Park, NY 11042-5416.

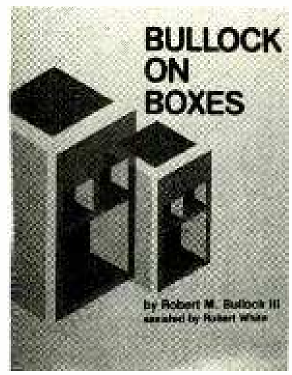
CIRCLE 82 ON FREE INFORMATION CARD

BULLOCK ON BOXES

by Robert M. Bullock III assisted by Robert White

The revolutionary work of Neville Thiele and Richard Small in the field of loudspeaker design has been one of the major audio developments in the last two decades. Back in 1981, Robert M. Bullock III began a series of articles in *Speaker Builder* magazine that explained, explored, and expanded on the work of Thiele and Small. Since then, he has continued to write articles and to deliver papers at sessions of

the Audio Engineering Society, as well as writing software programs to implement on personal computers the Thiele/Small design ideas. All of his magazine articles, as well as correspondence from readers, from over the past decade are included in this 80-page book, which provides an easy-to-read guide to designing and building vented-box loudspeaker systems based on Thiele/Small models. In addition to the background theory and descriptions



of the models, the book concisely presents a wealth of related information garnered from numerous sources. Computer modeling, as demonstrated by the author's BOXRESPONSE and BOXMODEL programs, is also explained in clear detail. The book is fully indexed and referenced, and contains a glossary, bibliography, and more than 100 illustrations.

Bullock on Boxes costs $10.05 and is published by Audio Amateur Publications, Inc., 305 Union Street, P.O. Box 576, Peterborough, NH 03458-0576; Tel: 603-924-9464; Fax: 603-924-9467.

CIRCLE 85 ON FREE INFORMATION CARD

1991 FULL-LINE CATALOG

from Tektronix

Tektronix' complete lines of products in three broad areas—electronic test and measurement instruments, professional broadcast test equipment, and computer peripherals—are featured in this 388-page, hardbound catalog. About a dozen new oscilloscopes have been added to a full line of analog and digital instruments. Other new test and measurement products include digital signal analyzers, communication signal analyzers, high-end digital-sampling scopes, mid-range scopes, a new handheld, battery-operated scope, and new plug-in card modular accessories. Also highlighted are pulse signal source generators, and the Centurion 100-MHz plug-in module for logic analyzers. Along with Tektronix' listing of VXIbus card modular plug-in products, this year's catalog includes the full line of VXI products from Colorado Data Systems, Inc., a Tektronix subsidiary.

New computer peripherals include TekXpress, a family of X window-based color graphics terminals; the Phaser II family of PostScript-compatible, thermal-wax color printers; a family of high-resolution display monitors; stereoscopic 3-D display systems; and a coprocessor plug-in board that increases the processing speed of a Macintosh II computer by up to 50 times.

In the professional broadcast test equipment category, new products include fiber-optics testers, audio signal generators, HDTV sync generators, programmable TV-signal generators, low-cost broadcast spectrum analyzers, cable television testers, a bit-error rate tester, and a vectorscope for TV test and measurement.

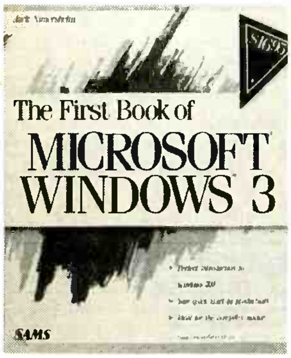
The 1991 Customer Catalog is published by Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077, and can be ordered by calling Tektronix' National Marketing Center at 1-800-426-2200.

CIRCLE 86 ON FREE INFORMATION CARD

THE FIRST BOOK OF MICROSOFT WINDOWS 3

by Jack Nimersheim

This book is intended to help even computer novices to quickly learn to perform daily computer tasks, with speed and efficiency, using Windows 3. It provides a complete introduction to Windows' true graphic display, icons, and added power. The book takes a step-by-step approach to help readers master the desktop accessories, organize files with the Program Manager, and navi-



gate through the Windows environment. Readers are shown how to implement proven file-management techniques from the "point-and-click" interface, how to use Windows Paintbrush and Windows Write desktop software, and how to customize their own Windows systems. A special chapter on Windows-compatible software provides an overview of many popular packages that are available for Windows 3.0. The book provides all the information needed to install and customize Windows; run applications and standard DOS programs in the Windows environment; create a program group with the Program Manager; navigate a Windows Write file; open, modify, and switch Windows applications; and speed up multitasking capabilities.

The First Book of Microsoft Windows 3 costs $16.95 and is published by Sams, 11711 North College Avenue, Carmel, IN 46032; Tel: 317-573-2676; Fax: 317-573-2645.

CIRCLE 83 ON FREE INFORMATION CARD

PANEL INSTRUMENTS
from Simpson Electric

Simpson's wide selection of analog and digital panel meters, meter relays, and controllers are described in this 27-page catalog. More than 2,000 stock ranges, sizes, and styles are featured in the catalog. Both AC and DC digital panel meters—including Wide-Vue, Century, designer, segmented scale, and round and rectangular models—are included. Also featured are analog Pyrometers, "Rugged Seal" controllers, edgewise instruments, and accessories. The catalog provides users with ranges and specification charts, as well as dimensional drawings and photos of each unit.

The Panel Instruments catalog is free upon request from Simpson Electric Company, 853 Dundee Avenue, Elgin, IL 60120-3090; Tel: 708-697-2260; Fax: 708-697-2272.

CIRCLE 84 ON FREE INFORMATION CARD

RADAR DESIGN PRINCIPLES: Second Edition
by Fred E. Nathanson

Providing a thorough, authoritative examination of today's radar technology, from the theory of radar detection to the practical aspects of equipment design and construction, the second edition of this book has been extensively revised and updated to reflect the developments and advances made in the last 20 years. The new edition of this classic reference book covers everything from waveforms to weather radio, and from digital technology to microburst detection. The emphasis is on designs that cope with "the total environment" rather than any single goal. According to the author, the total environment includes "the unwanted reflections from the sea, land areas, precipitation, and chaff, as well as thermal noise and jamming." In the upcoming era of adaptive radar, the author predicts that radar will sense the environment and adapt to that information.

The book devotes in-depth discussions to all facets of radar targets, including scattering from simple shapes, polarization properties, radar cross-section distributions, and frequency agility effects. It investigates signal attenuation in the atmosphere, in precipitation, and in foliage; describes backscatter coefficients, uniformity, and spectrum; and explores both refraction and the properties of chaff. The book also presents a greatly expanded treatment of backscatter from the sea to various angles and frequencies, examines the properties of sea "spikes," reports on the effects of ducting conditions, and explains terrain types and their reflectivity.

Radar Design Principles: Second Edition, costs $54.50 and is published by McGraw-Hill Book Company, 11 West 19th Street, New York, NY 10011; Tel. 1-800-2-MCGRAW.

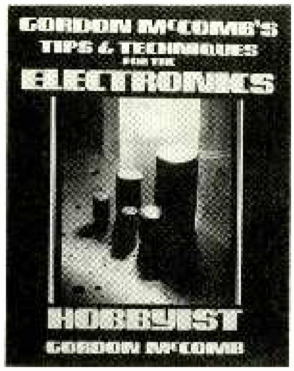
CIRCLE 96 ON FREE INFORMATION CARD

GORDON McCOMB'S TIPS & TECHNIQUES FOR THE ELECTRONICS HOBBYIST

by Gordon McComb

The goal of this book is to show its readers how to reduce the amount of time, money, and frustration spent on, and increase the enjoyment derived from, hobby electronics. It provides the basic information needed when experimenting with electronics—general information on electronics practice, tips on identifying components, and important formulas—and shows electronics enthusiasts how to work more efficiently and safely. A strong electronics background is not required to put this book to good use. Newcomers to electronics will want to read it start to finish, while more experienced hobbyists can pick out the information they need for specific projects.

The book explains what is needed to set up shop, including selecting the best place for electronics work, lighting, tools, toolboxes, and proper environment. Its discussion of the basics of test equipment describes each type of instrument used by electronics enthusiasts, including multimeters, scopes, logic probes, AF signal injectors, signal generators, and counters. The book also tells



readers where to buy components and where to find the best deals. It also describes the standard components to have on hand at all times. The book explains how to read a schematic, and illustrates and defines basic schematic signals. It shows how to properly identify components such as IC's, transistors, resistors, capacitors, inductors, transformers, and diodes. The direct-etch, photo-transfer, and dry-transfer techniques of making printed circuit boards are described, along with etching tips and information on repairing damaged boards. The book explains how to use and understand power; series and parallel resistor networks; series and parallel capacitor networks; the 555 timer IC; and electronic formulas, including those for Ohm's law. Construction plans are included for several money-saving bench-top instruments, such as a frequency counter, power supples, a log probe, and a logic pulser.

Gordon McComb's Tips and Techniques for the Electronics Hobbyist costs $17.95 and is published by TAB Books Inc., Blue Ridge Summit, PA 17294-0850; Tel. 1-800-233-1128.

CIRCLE 98 ON FREE INFORMATION CARD

ELECTRONIC RESOURCES CATALOG: A Guide for Technicians and Educators

from Electronic Industries Association

The Product Services Department of the Electronic Industries Association/Consumer Electronics Group (EIA/CEG) has a wealth of information available in the form of books, video cassettes, and pamphlets. This 12-page catalog provides descriptions and ordering information for each of the items, whose prices range from a small fee for shipping and handling, to $30.00. The informative products include video cassettes on troubleshooting, soldering, op-amps, power supplies, car audio installation, MTS television sound systems, and customer relations for technicians. Also described are several EIA-sponsored textbooks from Glencoe/McGraw-Hill and a digital microprocessor course plus high-tech parts kit ($69.95).

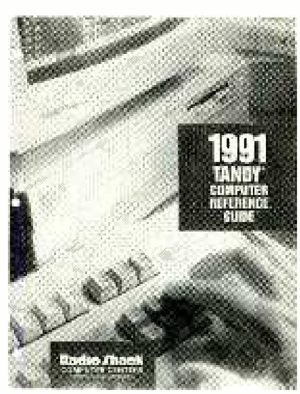
The Electronic Resources Catalog is free upon request from EIA/CEG, Department PS, 2001 Pennsylvania Avenue, NW, Washington, DC 20006-1813; Tel: 202-457-4986.

CIRCLE 87 ON FREE INFORMATION CARD

1991 TANDY COMPUTER REFERENCE GUIDE

from Radio Shack Computer Centers

Tandy's complete lines of personal computers, printers, word processors, cellular telephones, and accessories are featured in the updated 1991 catalog. Each item is accompanied by product specifications and pricing information. New items featured in the catalog include the Tandy 2500 XL/2 with increased clock speed and built-in support for VGA graphics; the 1000 TL/3



with increased speed and a standard PS/2-style mouse port; the 2810 HD 6.7-pound, 80C286-based laptop; a selection of hard-drive options; and an assortment of Intel math coprocessors.

The 1991 Tandy Computer Reference Guide and all the products shown in it are available at more than 7,000 participating Radio Shack Computer Centers, Radio Shack Technology Stores, and dealers nationwide.

CIRCLE 88 ON FREE INFORMATION CARD

SCANNER MODIFICATION HANDBOOK: VOLUME 2

by Bill Cheek

The popular first volume of the *Scanner Modification Handbook* proved that the average hobbyist could easily make some simple changes to come up with a greatly enhanced scanner. Volume 2 picks up where the first book left off, bringing readers 18 new enhancements for the Radio Shack Realistic PRO-2004, PRO-2005, PRO-2006, PRO-2022, and PRO-34; and Uniden Bearcat BC-100XLT, BX-200/205XLT, and BX-760/950XLT. Many of the modifications shown are adaptable to other scanners. The book provides new approaches to adding signal-strength meters, varying the scan delay time, speeding up the search/scan rate, decoding CTCSS tones, adding channels, adding an event counter, reducing interference, adding shielding, restoring locked-out bands, and adding a center-tuning meter. The book also includes some updates to the modifications depicted in Volume 1, and contains many other tips, hints, explanations, and tricks of the trade that readers can use to make their scanners more versatile. In addition to the modifications, there are do-it-yourself alignment instructions for the PRO-2004/2005/2006 that require only an S-meter and a few bench tools. Also featured are instructions for building a DTMF tone decoder and two bench power supplies, and an examination of the challenge of scanning 800-MHz trunked systems.

Scanner Modification Handbook: Volume 2 costs $17.95 (plus $3.50 shipping to North American addresses, and $1.35 sales tax for NYS residents) and is published by CRB Research Books, Inc., P.O. Box 56, Commack, NY 11725. ■

CIRCLE 89 ON FREE INFORMATION CARD

Why take chances in today's job market?

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To get ahead and stay ahead in today's economy, you need the electronics training CIE has been providing its 150,000-plus successful graduates with for nearly 60 years.

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And, beyond theory, some courses come fully equipped with electronics equipment to actually let you perform hundreds of hands-on experiments.

Experienced specialists work closely with you. Even though you study at home, CIE's faculty and staff stand ready to assist via CIE's toll free number. And, each time you return a completed exam you can be sure it will be reviewed, graded and returned with the appropriate instructional help, you get it fast and in writing from the faculty technical specialist best qualified to answer your question in terms you can understand.

Pick the pace that's right for you. CIE understands people need to learn at their own pace. There's no pressure to keep up...no slow learners hold you back. If you're a beginner, you start with the basics. If you already know some electronics, you move ahead to your own level.

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NEW PRODUCTS

1.75-MHz Universal Counter

Designed for use in engineering applications that require accurate measurements from very low frequencies to the microwave range, *B&K-Precision's Model 1823* is a universal counter with a 5-Hz to 175-MHz bandwidth and a 10-part-per-million timebase. It offers frequency, period, period-average, ratio, time-interval, and "totalize" functions. In addition, an external timebase is provided. For plant-equipment maintenance, the model 1823 meets the needs for testing and repairing electro-mechanical devices, low-frequency audio circuits, and control circuits. For communications applications, the unit exceeds FCC standards for making frequency adjustments on land mobile, radio-telephone transceivers.

Dual inputs and a ratio function permit display of the ratio of two input frequencies (from 5 Hz to 10 MHz on input channel A and from 5 Hz to 2 MHz on channel B). The period function's range extends from 0.5μs to 0.2 s, with 100-ps to 100-ns resolution. The period mode allows accurate low-frequency measurements to be made. The unit's low-frequency resolution exceeds the requirements of commercial modems and tone-decoding systems.

The counter's time-interval system measures the time difference from the edge of channel A's input to the edge of channel B's input. One-time events can be measured using the reset feature to prime the counter. The totalize function counts pulses from 5 Hz to 10 MHz, with front-panel reset (which resets the counter to zero) and hold (which holds the last complete measurement) features, or with remote start/stop control on the rear panel. The totalize mode is useful in counting the number of operations performed by production machines or in quality-control tests.

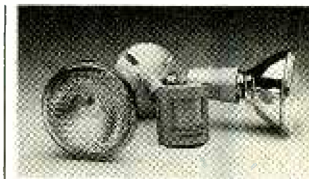
The universal counter has a high-intensity, red, 8-digit LED readout that features kHz/μs, MHz/ms, gate, and overflow indicators. The compact unit measures approximately 2½ × 9½ × 7½ inches, and weighs less than 3⅓ pounds. It comes with a detachable power cord, schematic, parts list, spare fuses, and an owner's manual. Optional accessories include a 10:1/direct probe and an accessory antenna for convenient transmitter-frequency checks.

The model 1856 universal counter has a suggested list price of $395. For further information, contact B&K-Precision, 6470 West Cortland Street, Chicago, IL 60635; Tel: 312-889-1448.

CIRCLE 101 ON FREE INFORMATION CARD

MOTION-SENSOR LIGHT CONTROL

It's not unusual for homeowners to be wakened in the middle of the night by a noise outside and not be able to see what caused the disruption, or to come home late at night to a darkened yard because they forgot to turn the light on when they left the house earlier in the day. One way to remedy both of those anxiety-producing situations is offered by *Heath Zenith*, in the form of their *REFLEX Model SL-5411* pre-assembled motion-sensor light control. It combines the convenience of a floodlight with the intelligence of a motion sensor, automatically sensing heat in motion and turning on a bright outdoor light that can startle intruders or welcome the



homeowner. It detects motion as far as 70 feet away, providing an effective coverage area of 4000 square feet. The SL-5411 is designed to control up to 500 watts of outdoor incandescent or halogen lighting. Motion-sensor control uses pulse-count technology, which enables it to "take a second look" at the moving object before switching the lights on. That significantly reduces the likelihood of false alarms due to falling snow, blowing leaves, or wind.

The light control is easy to install, requiring only that it be wired into a junction box. A built-in swivel plate allows it to be mounted on walls, under the eaves, and in other outdoor locations. Homeowners can adjust both the sensing field and the angle of the lights. To help save energy, a photocell turns the lights off during daylight hours.

The Model SL-5411 has a suggested retail price of $39.97. For further information, contact Heath Zenith REFLEX Brand Group, Hilltop Road, St. Joseph, MI 49085.

CIRCLE 102 ON FREE INFORMATION CARD

TEST LEAD KIT

To make it easier for technicians to access hard-to-reach areas, and to reduce hand fatigue and callouses, *Probe Master, Inc.* has introduced the *Softie Master Kit*. The kit contains "softie" flexible test leads with 12 accessories. The probe bends 90 degrees or more, and conforms to the shape of the user's hand. Although they're soft to the touch, the 48-inch silicone-insulated leads are impervious to burns from hot soldering irons. They have sharp, stainless-steel

tips and come with an assortment of screw-on, insulated accessories for positive connection to large, small, or subminiature components. A four-inch insulated extender tip allows testing in harder-to-reach areas.

The Softie Master Kit costs $34.90. For additional information, contact Probe Master, Inc., 4898 Ronson Court, San Diego, CA 92111-1807; 800-772-1519.

CIRCLE 103 ON FREE INFORMATION CARD

CLAMP-ON METER

To minimize reading errors, *D1 International's Model 1000* clamp-on meter features a rotary scale that displays one current or voltage scale at a time. It can measure AC current up to 1000 amps in five ranges, and up to 750 volts AC in three ranges at 50/60 Hz. The instrument's resistance-measuring range is 2000 ohms full scale, with the lowest scale calibration at 2 ohms. The scale center is 20 ohms. The model 1000's accuracy is +/−3% for all scales. Its insulation resistance is rated at 2500 volts AC for one minute. The unit has teardrop-shaped jaws that can reach wires, up to two inches in diameter, in cramped locations. A needle lock is provided to capture meter readings. Also supplied are a set of voltage test probes, a resistance test probe, a spare fuse, a carrying case, and an operating manual. The compact instrument weighs just over 16 ounces.

The Model 1000 clamp-on meter costs $99.50. For additional information, contact D1 International, Inc., 95 East Main Street, Huntington, NY 11743; Tel: 516-673-6866.

CIRCLE 104 ON FREE INFORMATION CARD

BATTERY-BACKUP SYSTEM

With 450-VA of power and LAN compatibility, the *Tripp Lite BC-450 LAN* battery-backup system is well-suited for PC workstations. The slim-line unit supplies 450VA of continuous power while providing complete spike, line-noise, and RFI/EMI filtering. It features brown-out protection at 103 VAC, four AC outlets, and network compatibility with the panel-mounted DB9 connector. Through the use of optional universal-power-supply monitoring software and cabling, the BC-450 LAN will provide automatic, unattended shutdown of LAN networks in the event of a power failure. Other features include system-status indicator lights and a resettable alarm that warns of operation from the battery. The small, lightweight unit provides quiet, unobtrusive operation.

The BC-450 LAN battery-backup system has a suggested retail price of $449. For more information, contact Tripp Lite, 500 North Orleans, Chicago, IL 60610-4188; Tel: 312-329-1777; Fax: 312-644-6505.

CIRCLE 105 ON FREE INFORMATION CARD

CIRCLE 10 ON FREE INFORMATION CARD

SOLDERING-STATION ANALYZER

CooperTool's Weller WA2000 soldering-iron analyzer provides electrical engineers, electronic reworkers, and quality-control personnel with an accurate, portable way to determine if their soldering stations are in compliance with the DOD-2000

specification. The WA2000 can be used to test tip-to-ground resistance and tip-to-ground noise, as well as testing the tip temperature. The test results are displayed on a large LCD in both Fahrenheit and Celsius degrees. The portable instrument has a battery life of 50 hours and comes with a zippered carrying case and accessories.

The WA2000 soldering-iron analyzer has a suggested retail price of $450.00. For more information, contact Weller, P.O. Box 728, Apex, NC 27502.

CIRCLE 106 ON FREE INFORMATION CARD

WIRELESS AUDIO SYSTEMS

Operating through your home's existing AC wiring, two audio systems from *Recoton* provide stereo sound in various rooms and locations without the need to run wires. *Model W 100* consists of two speakers/amplifiers and a separate transmitter. The wireless stereo speakers can be moved easily from room to room to meet changing needs. They can be used as extension speakers for audio or television systems, or with surround-sound systems. The speakers deliver 10 watts RMS per channel power output and 20–20,000-Hz +/−3dB frequency response. The speakers receive the stereo signal from a single transmitter that plugs into

the headphone, tape, or line-out jacks on the user's existing stereo. The transmitter plugs into the nearest AC outlet and transmits sound to the speakers.

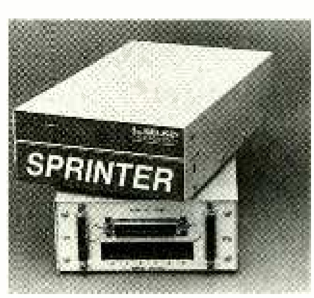
The *Model W 102* system uses the same technology as the model 100, but it allows the listener to use any available speakers. The ability to adapt existing speakers to the system allows users to locate the Model W 102 components away from the speakers for more convenient installations. Special electronic circuitry eliminates AC line interference from air conditioners, refrigerators, and other household appliances.

The models W 100 and W 102 wireless audio systems have suggested retail prices of $269.00 and $199.95, respectively. For further information, contact Recoton Corporation, 46-23 Crane Street, Long Island City, NY 11101; Tel: 800-223-6009.

CIRCLE 107 ON FREE INFORMATION CARD

PRINTER-SHARING DEVICES

A family of automatic, stand-alone printer-sharing devices from *Belkin Components*, dubbed *Sprinters*, allow multiple computers with serial ports to share two parallel printers. Each Sprinter unit accepts data from several users, and queues it in its buffer. The data is then directed to the user-specified printer in the order received. That frees users to continue other tasks while the document is being printed. Three models,



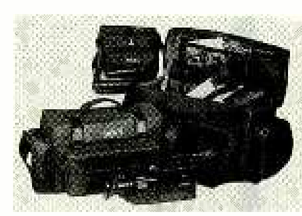
each including 256K memory (user upgradable to 512K, 758K, or 1 Meg with standard 256K DRAM chips), are available. *Model 6×2* accepts data from six computers with serial inputs; *Model 7×2* accepts data from six computers with serial inputs and one with parallel input; and *Model 10×2* accepts data from ten serial-input computers. All three provide two parallel outputs. The Sprinters are designed to be used with a variety of computers, including IBM PC's, XT's, AT's, and PS/2's; Macintosh; VAX, and HP 3000. They work with all Epson and HP Laserjet compatible printers with standard parallel ports. A simple pop-up menu allows the user to select to which printer the document is to be sent, and to request multiple copies of documents.

Sprinter models 6×2, 7×2, and 10×2 have list prices of $695.00, $849.00, and $995.00, respectively. For further information, contact Belkin Components, 14550 South Main Street, Gardena, CA 90248; Tel: 213-515-7585.

CIRCLE 108 ON FREE INFORMATION CARD

VIDEO LUGGAGE

Providing ample carrying space for camcorders and an array of videotapes and accessories, *Ambico's Blackhawk Series* of video bags come in three sizes to accommodate all the popular camcorder formats on the market today. The bags are made of weather-resistant "ballistic



nylon," and feature padded outer walls for protection, adjustable interior partitions, roomy outer pockets for accessories, and a convenient strap/handle combination. The *VHS Carryall (Model V-0425)* is designed for full-size camcorders. The *8mm/VHS-C Carryall (Model V-0426)* is sized to hold 8mm and VHS-C camcorders. Ultra-compact camcorders,

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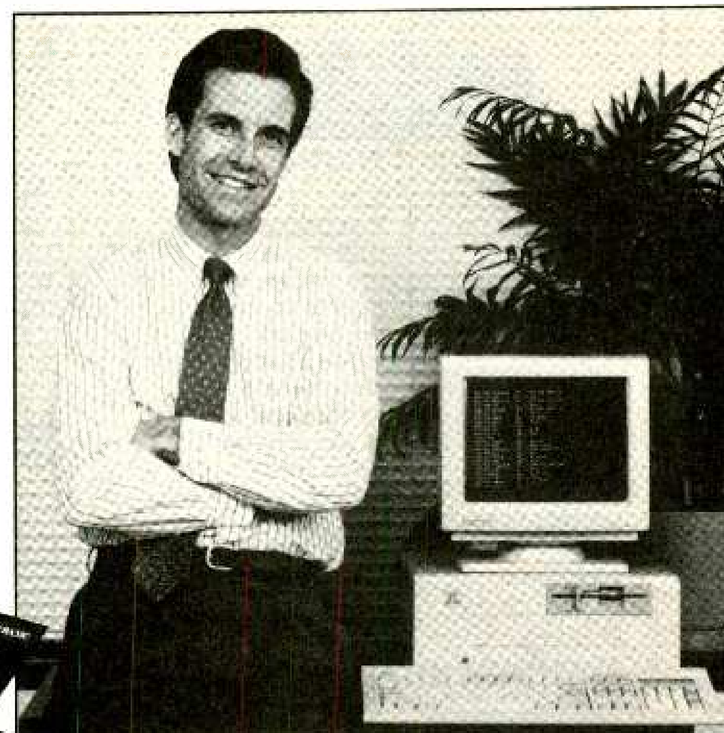

A top-paying career in computer programming is no longer out of your reach. Now you can get the practical training and experience you need to succeed in this top-growth field.

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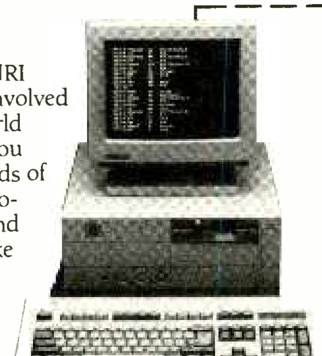

Plus you explore the extraordinary capabilities of not one or two but <u>four</u> in-demand computer languages. You learn to design, code, run, debug, and document programs in BASIC, Pascal, C, and COBOL. In the process you become uniquely prepared for the wide variety of programming opportunities available today.

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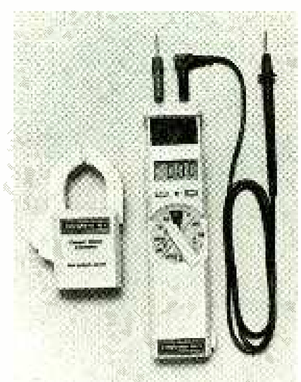
such as Sony's TR series and the Panasonic Palmcorders, fit perfectly in the *Mini-Cam Tote (Model V-0427)*.

The VHS Carryall, 8mm/VHS-C Carryall, and Mini-Cam Tote have suggested retail prices of $79.95, $59.95, and $34.95, respectively. For further information, contact Ambico, Inc., 50 Maple Street, Norwood, NJ 07648; Tel: 201-767-4100.

CIRCLE 109 ON FREE INFORMATION CARD

HEAVY-DUTY DIGITAL MULTIMETER

Each instrument in a line of compact (7-1/4 × 2 × 1-inch) multimeters from *Fieldpiece Instruments* integrates the functions of a digital multimeter, a voltage checker, and a current



clamp meter. The units are packaged in drop-proof, contamination-resistant, fully-sealed, yellow cases. Superior overload protection allows the meters to withstand 1000 volts DC and transients up to 6000 volts on any voltage range. Other ranges can withstand 500 volts. Metal-oxide varistors, instead of lower-cost spark gaps, are used in the meters for a greater measure of transient protection.

Two standard multimeter jacks on top of each unit accept test leads, specially designed probe tips, and a specially designed current clamp lead. With one probe tip and a test lead plugged into the jacks, the technician can hold the meter with one hand and test with the other. Using the hold button, he can keep his eyes and hands on his work while he takes his reading. On some models, an intermittent beeper and a flashing red LED are activated in any range when voltages in excess of 28 volts are measured, alerting the technician to the presence of dangerous voltage levels.

Plugging the current clamp head accessory onto the DMM converts the unit into a one-piece digital current clamp meter. Current measurements up to 300 amps can be read directly from the display without having to mentally convert or move decimals. All the meters in the line come with one red probe tip, one black test lead, an operator's manual, and a clear plastic carrying case. The *Model HS23* adds the dangerous-voltage red LED, the intermittent beeper, and the capacitance function. The *Model HS25* (pictured) also adds the logic probe.

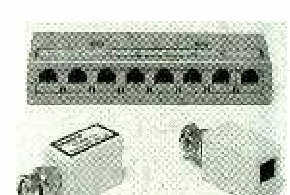
Suggested list prices range from $79 to $119 for the digital multimeters, and is $24.95 for the *Model ACH* accessory current clamp head, $3.95 for a pair of standard probe tips, and $4.95 for a pair of extended (2½-inch) insulated probe tips. For more information on the entire line, contact Fieldpiece Instruments, Inc., 8322B Artesia Blvd., Buena Park, CA 90621; Tel: 714-992-1239; Fax: 714-992-1239.

CIRCLE 110 ON FREE INFORMATION CARD

MEDIA CONVERTERS

As an alternative to the ThinNet coaxial cable used in bus topology, *Telebyte* has introduced an interconnection scheme that allows users of Ethernet LAN adapters containing ThinNet (Cheapernet) ports to use unshielded twisted pair (UTP) as the wiring media.

The transition from coax to twisted pair is accomplished by the *Model 171 Ethernet Balun*. The twisted pair cables from the model 171 Ethernet Balun are interconnected by the *Model 170 Ethernet Passive Star Wir-*



ing Concentrator. The model 171 is a small device that contains both a female BNC connector and an RJ-11 connector. The BNC allows attachment to LAN adapter cards designed for compatibility with IEEE 802.3 10 Base 2 (ThinNet). Those Ethernet signals are then transformed to those compatible with unshielded twisted pair. Both devices support the Ethernet data rate of 10 MB/sec and do not require any external power to operate.

Twisted pair from up to eight workstations using model 171's are interconnected by the model 170 Ethernet Passive Star Wiring Concentrator. Using the concentrator allows as many as eight users to communicate on an Ethernet LAN using one twisted pair as the transmission media.

Because the stations are wired in a star configuration, the wiring is simplified and changes to the layout of the stations is easily accommodated. The star network is more reliable and easier to maintain than a bus network, which goes down entirely even if one workstation fails. In addition, performing simple tests at the model 170 hub makes it easy to find and remove a faulty workstation from the network.

The model 170 Ethernet Passive Star Wiring Concentrator costs $120 and the model 171 Ethernet Balun costs $45. For additional information on both products, contact Telebyte Technology, Inc., 270 Pulaski Road, Greenlawn, NY 11740; Tel: 516-423-3232 or 800-835-3298; Fax: 516-385-8184 or 516-385-7060.

CIRCLE 112 ON FREE INFORMATION CARD

TELEPHONE-LINE SURGE SUPPRESSORS

With so many facsimile machines and modems in use, the need for surge protection on the phone line has increased. The *Perma Power model PXD209 Fax-Line* surge suppressor prevents damage or erratic operation of equipment caused by spikes or transients from both the telephone line and the power line. Power-line protection is provided in the normal mode and both common modes. The PXD209 features a patented circuit that automatically disconnects the

equipment from all power if the device's power-line surge-suppressor element wears out or burns out.

Surge protection guards faxes and modems against garbled messages, no-connect errors, and unnecessary re-transmissions and re-connects. The PSD209 can also be used to protect an answering machine or any other single piece of equipment connected to both the power line and the phone line.

The model PXD209 Fax-Line surge suppressor—which comes with a lifetime warranty that reimburses the cost of repairs if the equipment being protected is damaged by a surge—has a suggested user price of $59.95. For additional information, contact Perma Power Electronics, Inc., 5601 West Howard, Chicago, IL 60648; Tel: 312-763-0763; Fax: 312-763-8330. ■

CIRCLE 113 ON FREE INFORMATION CARD

THINK TANK

By John J. Yacono

Adjustable Regulators Can Control More Than Voltage

Another month has come and with it more reader's circuits. Last month a reader provided a circuit that contained an adjustable, voltage regulator (one of my favorite types of IC's). Unlike fixed regulators, adjustable units can be programmed to output any voltage within their operating range. (The minimum and maximum output of the device varies from model to model, and manufacturer to manufacturer.) This month, I'd like to explore those devices a little more before ripping open the mailbag. As I'll explain, some voltage regulators can tame current as well as voltage.

THE LMXX7 FAMILY

There are many programmable voltage regulators on the market. The reason they are so popular is their flexibility—if you've got a positive-voltage adjustable regulator in your parts box, it can be used to perform the same task as a 5-volt, 12-volt, 15-volt, or any common fixed-voltage regulator. But, for the sake of brevity, I'll present only the LMxx7 series of regulators. They are very versatile and commonly available. Furthermore, as regulators go they provide excellent ripple rejection.

The xx7 adjustable regulators can be divided into two main groups: positive regulators (denoted x17) and negative regulators (denoted x37). The first digit in the part's number (either 1, 2, or 3) indicates the grade or quality class of the component. If a regulator's first digit is 1, it falls into the military class, which means it's extremely voltage and temperature stable. If the first digit is 2, it falls into the industrial class and is stable enough for industrial use.

Hobbyists will find regulators beginning with a 3 (the commercial class) to be more than adequate for most projects. To summarize, that numbering scheme allows for three positive regulators (the 117, 217, and 317) and three negative regulators (the 137, 237, and 337). Since positive and negative regulators function in the same manner, I'll talk mainly about positive regulators. Keep in mind, however, that the exact same rules apply for negative regulators, they just require a negative input voltage and provide a negative output voltage.

All of them are capable of outputs of from around 1.25 to 33 volts (of course, negative regulators supply negative voltage over that range). Their output voltage is "programmed" by the value of two resistors (more on that in a bit). They also have a short-circuit, shutdown feature; *i.e.*, short the regulator's output, it turns off and automatically turns on again once the short is removed. They also shutdown if they become too hot.

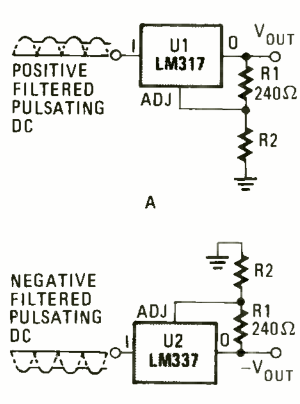


Fig. 1. Adjustable regulators are easy to use. Whether you need a positive (A) or a negative (B) output voltage, you just have to add two resistors and a filtered source of pulsating DC.

For all they do, the regulators are easy to use. A positive, adjustable regulator is shown in Fig. 1A with its two programming resistors in place (note that the pin numbers do not match those of other regulators). A negative adjustable regulator is shown in Fig. 1B (again with its distinct pin numbers).

For voltage-regulation applications, resistor R1 is usually chosen to be around 240 ohms to provide optimal performance. You can stray from that value a little (like down to 220 ohms), but not too far. Since the value of R1 is pretty well defined, the value of R2 actually determines the output voltage of the regulator according to the equation:

$$V_{OUT} = 1.25\ (1 + R2/R1) + R2 \times I_{adj}$$

where I_{adj} (the "adjustment current," as it's called) is usually between 40 to 50 µA. That current is so tiny that you can just assume that it's zero and use this equation:

$$V_{OUT} = 1.25(1 + R2/R1)$$

There are a couple of design considerations that you should keep in mind when using such devices to control voltage. First, the supply to the regulator should be filtered to provide at least 3-volts rms more than the desired V_{OUT}. Second, if hefty current (more than ¼ amp) is to be drawn from the regulator, use a heat sink. You should also use a heat sink if the input voltage is to be more than 6 volts greater than the output. Lastly, a 0.1-μF disc or a 1-μF tantalum bypass capacitor is recommended at both the input and output of the regulator.

Most manufacturers have designed such regulators for floating operation (see the application notes for a given unit to determine if it has that feature). What that means is that the regulator doesn't have to be referenced to ground—it can float. The main advantage of a floating regulator is that the value of R2 can be made pretty large to produce a high output voltage. However, there is another advantage: it permits the regulator to be used as a current limiter.

To perform their job as voltage regulators, the members of the xx7 series all try to maintain a 1.25-volt potential between their output and adjust terminals. They do that by regulating the current flow through R1. The current though the resistor can be found using Ohm's law:

$$I = 1.25 \text{ volts}/R1$$

Since the current through the adjustment terminal is very small, approximately the same amount of current flows through both R1 and R2—and that current is regulated! To take advantage of that fact in a positive-regulator circuit, just replace R2 with a load (see Fig. 2A); the current through the load will be less than or equal to I.

The principle is the same when using a floating negative regulator as a current limiter, however the circuit is a little different. Resistor R2 is shorted and the load is placed in series with the entire current-limiting circuit.

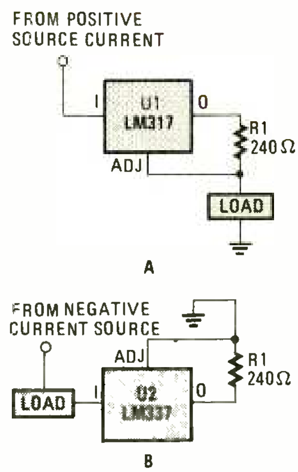


Fig. 2. Adjustable regulators that float can be used as current limiters. Positive regulators can limit the current from a voltage source to a load (A), and negative regulators limit the current from a load to ground.

For either positive or negative regulators, to set the maximum current through the load just select the value of R1 with the aid of this equation:

$$R1 = 1.25 \text{ volts}/I$$

By the way, the value of R1 should be between 0.83 and 125 ohms. That gives the device a usable range of from 10 mA to 1.5 A.

Now, let's see what you've sent in this month.

AN INTERCOM HORN

A friend of mine has an intercom station in his office and another in his shop. Sometimes he couldn't hear the intercom annunciator in the shop because of the noise level there. He asked me to make the sound much louder. The result is the circuit in Fig. 3.

I soldered a lead to each terminal of the shop intercom's speaker terminals. The wires were hooked up to the input of a MOC3010 optoisolator/coupler with a Triac-driver output. The Triac-driver output of the optocoupler is used to trigger a 6-amp Triac, which applies line current to a 12-volt, 6-amp power transformer. The transformer powers a car horn via an 8-amp bridge rectifier.

When the annunciator signal is present at the speaker, the optoisolator/coupler triggers the Triac, applying power to the transformer and sounding the horn. Normal speech produces too small a signal at the speaker terminals to activate the circuit.

Be sure to use a Triac, transformer, and bridge with more than enough power to spare; Car horns can draw several amps.

—Jay Hawthorne, Claresholm, Alberta, Canada

Pretty novel. If anybody has trouble because the circuit is too sensitive to normal speech, try using a variable resistor between the speaker and optocoupler. Set it high enough so that the unit is only triggered by the loud annunciator tone.

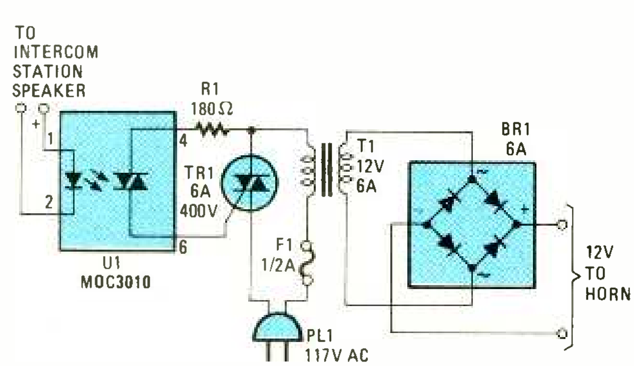


Fig. 3. If you can't hear your intercom above the noise in your shop or garage, then this circuit is the cure.

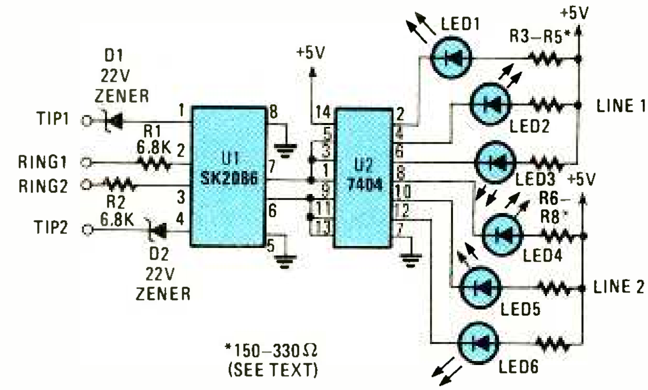


Fig. 4. If you have one or two phone lines that you need to monitor from remote extensions, then give this circuit a try.

PHONE-IN-USE INDICATOR

I designed this little circuit for our electronics shop in which 3 people share 2 phone lines from their extensions. Since the shop is divided by shelves, we needed an indicator to show which lines are in use at any given time. The result of my efforts are shown in Fig. 4.

The circuit receives its power from a 5-volt wall adapter (not shown). The circuit takes advantage of the fact that the phone line drops from 48 to 10 volts when an extension is taken off-hook. When the voltage on a line drops, let's say line 1, most of it sits across the Zener diode, in this case D1. That turns off the optoisolator/coupler so that the inputs to the line-1 hex-inverters (U2 pins 1, 3, and 5) float high. The corresponding outputs (U2 pins 2, 4, and 6) go low, lighting the line-1 LED's.

I installed one red and one green LED on each flush-mount modular jack (which are in plain view) to indicate the activity of the two lines—green for line 1 and red for line 2. The value of the Zener diodes is not critical, as long as they fall between 15–35 volts. You may have to experiment with the values of R3–R8 to accommodate the type and number of LED's you use.

We've been using this circuit for about 2 years and it has worked perfectly.

—James A. Jones, Baton Rouge, LA

I'm a little surprised that the high-voltage ring signal hasn't done any harm to the optoisolator/couplers. But the proof of the pudding... I think I'll try using optoisolator/couplers in my next phone project.

SELF-RESETTING ALARM

Once triggered by a power failure, many intrusion alarms continue to sound even when power returns. I developed an alarm circuit without that shortcoming (see Fig. 5).

When power fails, K2 drops out and connects the sounder to ground. If the sounder is a low-power type (such as a piezo-electric buzzer), the charge on C1 will cause it to produce a brief warning signal. When the charge on C1 is dissipated, K1 drops out shunting S1 (which is used to activate the entire alarm).

When power returns, K2 remains inactive until the charge on C1 is high enough. The charging of C1 also prevents K1 from becoming active, so the sounder is again activated. Once C1 is charged, K1 and K2 pull in, stopping the sounder. In that way, K1 latches itself on through the normally-closed, intrusion-sensor circuit, reactivating the alarm system.

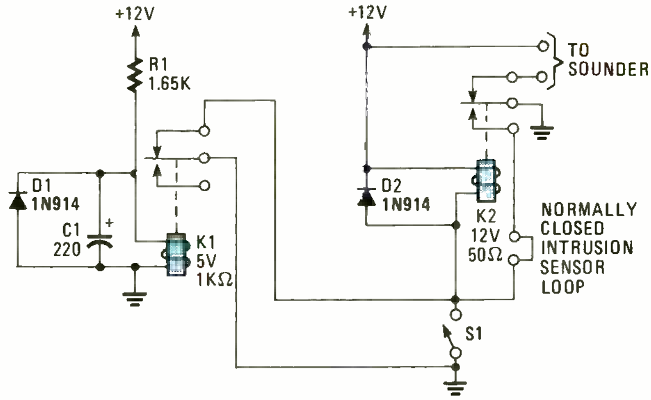


Fig. 5. Most alarms will continue to wail after a power failure whether or not the system has been breached. This circuit just lets you know when power has failed and returned, and it resets itself.

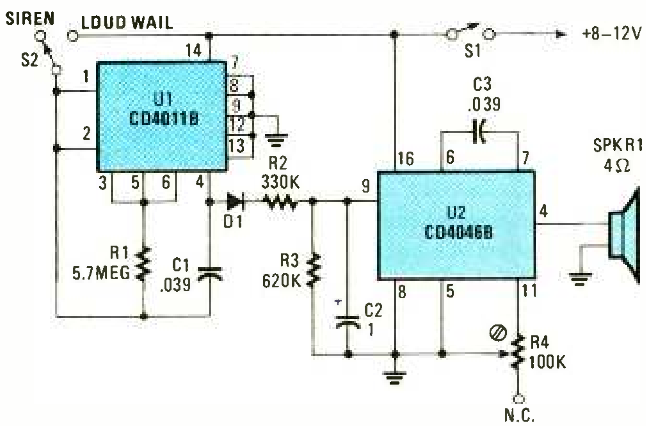


Fig. 6. This sounder has very low power consumption. It could sound-off for a long time before draining its battery power supply.

—*Benjamin W. Salavin, Pawtucket, RI*

I've got to admit that I've never seen anything like this before. I really like the way you got C1 to perform two jobs: as a time delay and power supply. I'm going to try to remember that trick.

VERSATILE SIREN

The included circuit diagram (see Fig. 6) is for an inexpensive and easy to build siren that uses two CMOS chips: a CD4011 quad NAND gate (U1) and a CD4046 PLL (U2).

Integrated circuit U1 is configured to generate 1-Hz clock pulses. If desired, the rate can be changed by altering the value of C1 or R1. The pulses from U1 are rectified by D1 so that a charge builds on capacitor C2, and is slowly leached off by resistor R3.

The varying waveform across C2 is sent to pin 9 of U2 (the control-voltage input) to U2's built-in voltage-controlled oscillator (VCO). That causes the frequency of the VCO output, which is sent to the speaker, to vary. Trimmer potentiometer R4 and capacitor C3 set the center frequency of the VCO. If S2 is closed, the unit produces a wail instead of a siren sound.

—*Luis Balpuesta, Texcoco, Mexico*

The CMOS design is great for low power consumption. If your alarm has a battery backup, it will last for a long time, even if active.

Well that rounds us off for another month. Remember to send your most successful efforts to *Think Tank*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

Popular Electronics®
JULY 1991

Build a project that lets you send pictures on the telephone line, record them on audio cassette, and more.

Build Your Own PICTURE PHONE

BY FRANK PERELMAN AND JOHN YACONO

As a kid (and sometimes now as an "older kid") I read the Dick Tracy* comic strip. What appealed to me most about the comic was the vast array of hi-tech gadgets Tracy and the police force had at their disposal. The one that first leaps into my mind (and probably yours too) was his wrist-watch picture phone. Would you be surprised to hear that not only has the day of personal video communication arrived, but you could build a video phone yourself? Further still, with one of the new LCD TV's, a portable phone, a video camera, and the device described in this article, you can come close to making Tracy's little gadget a reality.

The *Phonvu Camera Phone*, as the project is called, takes a digital "snapshot" of the video signal sent to one of its inputs. If you like how the snapshot looks on your video monitor, you can command the Camera Phone to transform the picture into a series of audio signals. The signal can either be recorded on an ordinary *cassette* tape (not a video tape) for video playback later, or sent across the phone lines to another Camera-Phone unit, which transforms the signal back into a picture.

The unit has automatic modes of operation, as well. Using these modes you can have the unit capture and transmit images all on its own so you don't even have to be present!

Some Possible Uses. Sending images over the phone is, of course, the most obvious application for the Camera Phone. In comparison to a FAX, the Camera Phone provides higher resolution, can be sent more quickly, doesn't require a halftone mode for photos, can transmit pictures of real objects—not just pieces of paper, and you can view a picture before it is transmitted to get it right the first time. Unlike some inexpensive or older FAX's, the unit automatically takes the phone off hook when transmitting or receiving data. That allows you to intersperse conversation and image transmissions without having to put the phone down.

Its automatic capabilities allow you to monitor a remote location from wherever you are. Say you've got a Camera-Phone unit connected to a video camera and the phone line at the place you wish to monitor. When set to automatically capture and "send" pictures, the unit captures an image, takes the phone off hook (without dialing), and attempts to transmit its data. When it's through with its attempt, it hangs up and tries again a few seconds later with a new captured image. Of course, having the unit pick up the phone costs nothing because it doesn't dial any number.

To view the remote location, you dial the phone number of that location. If the remote Camera-Phone has taken the phone off-hook in an attempt to transmit an image, you'll get a busy signal. The Camera phone will soon hang up the phone so it can capture the next picture, so keep dialing until you get a ring signal. If you then hang on, the remote Camera-Phone unit will take the phone off hook (effectively answering your call) and transmit an image to the Camera Phone at your location.

As I mentioned, the audio signals need not be transmitted by phone to be useful. By recording the audio-encoded video signals on one channel of a stereo cassette, and a regular audio soundtrack on the other, you could make an audio/visual "slide show." All you would need to playback the presentation is one Camera-Phone unit with the special audio option (we'll discuss that later), an ordinary stereo-cassette player, and a monitor.

It can perform other useful functions as well: For example, you could use it to add digital freeze-frame operation to your VCR or TV. When used to freeze VCR pictures, it will eliminate the annoying noise bars that many non-digital VCR's generate in their freeze mode. Using it with a TV is a great way to freeze addresses and phone numbers of mail-order companies without the need to fire up the VCR or waste videotape. Sports enthusiasts will enjoy the ability to freeze the bone-crunching action of most contact sports.

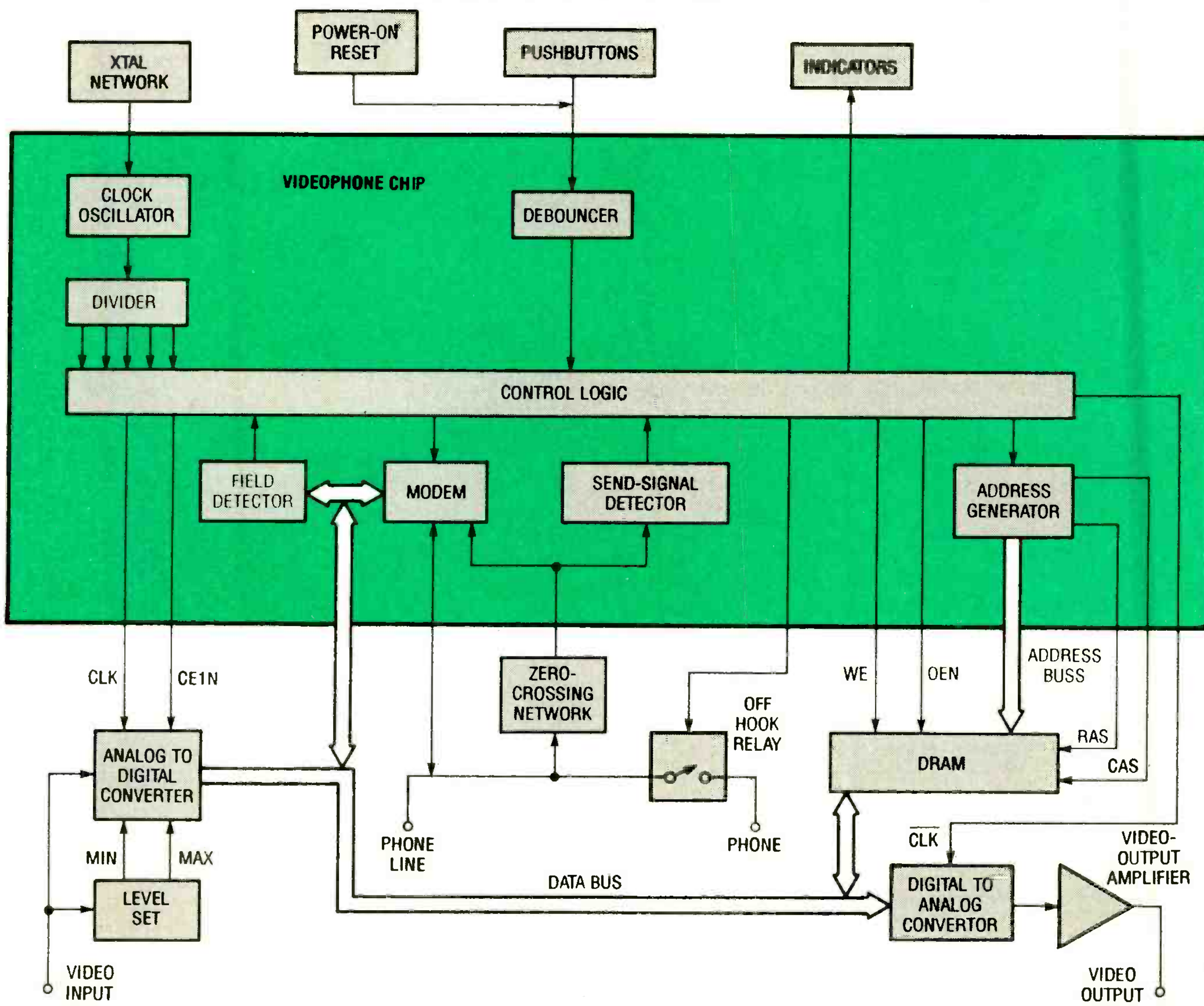


Fig. 1. The internal sections of the chip and the circuitry for the entire Phonvu unit are shown here. The interaction is pretty simple with the control logic running the show.

There are a variety of options available to expand the usefulness of the Camera Phone. For example, although the basic unit handles black and white images (even though you can feed it color signals) an adapter can be used to allow it to transmit and receive color images. Other options allow you to print received pictures, send them to your computer, modulate audio to come out of your TV speaker, remotely control the unit via a Touch-Tone phone, and more. (A more complete list of options is provided in the Parts List.)

You might be wondering what has made all this possible at a hobbyist price; Well there hasn't been an overwhelming breakthrough in technology, but there is a new IC on the market that drastically reduces the parts count needed for freeze-frame video communication. Aptly enough its name is "Phonvu" (also known as part number PMC-VIDRAM-027). As you'll see, the chip performs many tasks all by itself, so you'll only need one such IC and some commonly available support components to build a Camera-Phone unit. Keep in mind that you'll need two units for two-way communication, but only one for recording images on a cassette or for simple freeze-frame applications.

The Chip. As mentioned, the Videophone chip wears "many hats." The best way to explain what its many internal sections do is to describe how it functions in the Phonvu circuit. The diagram in Fig. 1 shows the blocks that make up the Phonvu circuit as well as a breakdown of the internal sections of the Videophone chip. Refer to that figure as we explain how the chip operates.

For the sake of discussion, we'll make no distinction between the blocks inside the Videophone chip and the blocks that make up the external circuit. For that reason it might appear that you'll need a lot of support circuitry, but that isn't really true.

Also, we'll describe how the circuit works when connected to a telephone, but keep in mind that you can alter the unit to accommodate your application. For example, you can leave off certain functional blocks (*i.e.*, the phone jacks, the zero-crossing network, and the off-hook relay) for simple freeze-frame operation. Or you could add the audio-option circuit (available as a kit from the chip supplier) to record on regular cassette tape.

On a final note, to give you a better feeling for each of the steps Phonvu must take when transmitting a picture, we'll avoid discussing the unit's automatic modes of operation until a bit later. Now let's take a qualitative look at how Phonvu works before getting down to the nitty-gritty.

Initialization. When you first turn on the Phonvu circuit, the Videophone chip needs to know which of its various operating modes it should be in. The operating modes are really beyond the scope of this article. Suffice it to say there are many of them and most are not applicable to building a Camera Phone.

During the first few moments of operation, the chip's control-logic section monitors the pushbuttons—labeled "Picture Adjust," "Send," "Capture," and "Auto"—and a special "Speed" pin to find out the desired operating mode. It checks to see if the pushbuttons or the speed pin are held low, held high, or pulsed, and sets the operating mode accordingly. (We'll explain the function of each pushbutton a little later on.)

The proper initializing signals are produced by a "power-on reset circuit" (look back at Fig. 1) that sets the mode of the Videophone chip by simulating pushbutton and speed pin activity. The POR, as we'll call that block, holds the capture and the speed pins on the chip high, and pulses the auto line. Then it sends a train of pulses to the speed pin to complete the initialization procedure.

That activity tells the chip a few things about the circuit it's in and how it must behave. For one, it indicates that a pushbutton will be used as the picture-adjust control instead of a potentiometer (which you needn't concern yourself with). Also, it sets the amount of memory and addressing scheme that will be used for each picture. Changing those parameters is only important for computer interfacing, so you needn't worry about the particulars. Pulsing the speed pin on the chip ensures that it will work in its "high-speed mode" as opposed to low-speed mode (which again, you need not bother with.) With the chip well informed, it waits patiently for your first command.

Idling. After initialization, the chip's control-logic section continues to monitor the pushbuttons, indicates the current operating mode via LED's that form the indicator section, and activates the various other blocks accordingly. (Note that the Videophone chip contains its own internal debouncing circuit to reduce the parts count of the Phonvu.) To summarize, the primary function of the control logic is to process a request made through the pushbutton circuit, and show the action it takes through the indicators. As you'll see, to do its job, it monitors and orchestrates the action of the other functional blocks.

However, much like a band leader, it requires timing. The timing is provided by an on-board clock oscillator that requires the support of an external crystal and resistor that form the crystal-network section. The clock signal is divided by various amounts and the resulting pulses will be used by the control logic as control signals (*i.e.* CLK, CE1N, WE, and OEN). Through the use of the control signals the control logic will act as a traffic cop for the flow of data, and set both the pace and mode of the whole Phonvu circuit.

Once turned on and initialized, the control logic initiates the "idle mode." That means that any composite-video signal entering through the video-input jack (from a VCR, video camera, or closed-circuit TV camera) will flow through some sections of the Phonvu circuit, and go through some digital maneuvers, only to reappear at the video-output jack.

More precisely, the composite-video signal is sent to an analog-to-digital converter (or ADC) that transforms it into a stream of parallel binary data. However, to do that properly, the ADC needs to know the maximum and minimum level of the video signal. That information is provided by the level-set block. In the idle mode, the control logic sends an output-enable signal and a stream of clock pulses to the ADC (at the CE1N and CLK terminals, respectively) permitting it to put the digitized picture data on the data bus.

The control logic also sends negative clock pulses to a digital-to-analog converter (DAC) section. With each pulse, the DAC picks data up off the bus and converts it back into a video signal. The video signal is provided with enough current to drive it into 75-ohm cable by a video-output buffer. From there it exits the unit through a video-output jack.

By connecting a monitor to the video output, you can view the image traveling on the data bus anytime. In the idle mode, the ADC places a real-time (continuously updated) image on the bus so the monitor would almost ap-

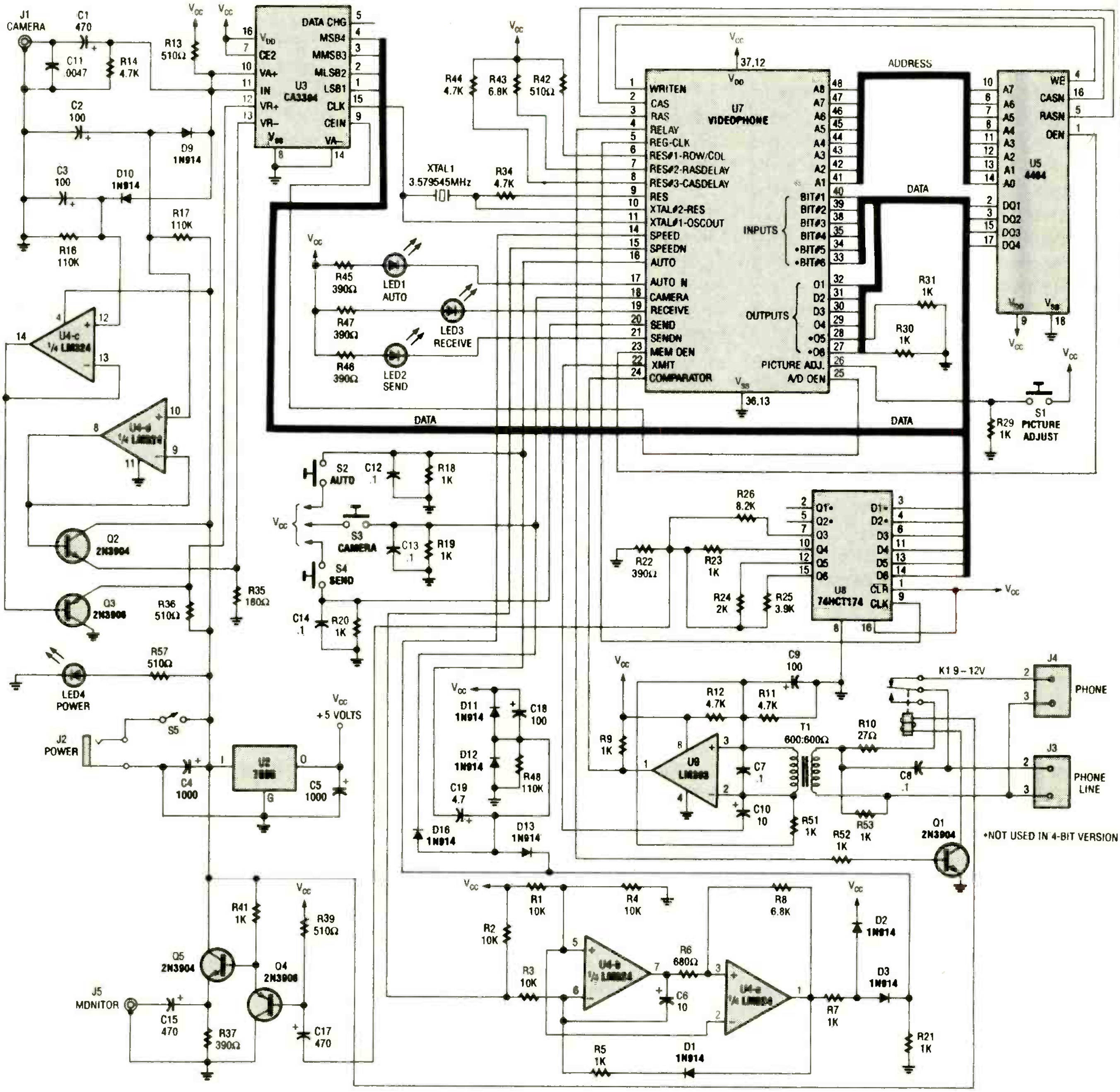


Fig. 2. These are the real "guts" of the 4-bit Phonvu. There are only five basic types of signals handled by the circuit.

pear to be connected to the video-input jack.

Capturing an Image. By pressing the capture pushbutton on Phonvu, the unit enters into the capture mode. In this mode the data from the ADC is recorded in the dynamic RAM (DRAM), but before the control logic can take any action to record an image, it needs to know when the beginning of the picture (the top-most portion) is being digitized. The field-detector section of the Videophone chip determines just that. It observes the incoming digitized video to find the data corresponding to the very top of the screen image. If it senses that data, it signals the control logic. If for some reason (such as poor video-signal quality) the top of the picture cannot be determined, the detector looks for "vertical-sync pulses." Those pulses are used by video equipment to synchronize many internal operations and to indicate that the top of the screen will be sent shortly. If it cannot find them either, then it signals the control logic anyway. If any misalignment occurs (*i.e.*, if the top of the picture appears in the middle) it can be adjusted using the picture-adjust button, as we'll explain later.

Upon receiving the go-ahead from the field detector, the control logic sends write signals to the DRAM. The pulses are synchronized with the ADC operation in such a way that the DRAM picks the picture data up off the bus and stores it in the memory locations dictated by the address generator.

Once the DRAM contains enough data for one picture (one field of video), the ADC is shut off and the DRAM is asked to write the picture data back onto the bus, again under the guidance of the address generator. The address generator causes the picture data to be written to the bus like an endless-loop tape (*i.e.*, the same picture is sent to the bus over and over again). The now-active DAC transforms the data back into a video signal. The result is a frozen picture on the monitor that shows what was captured in the DRAM.

If for some reason the picture is misaligned or starts in the middle, you can cause the image to shift to the left one pixel at a time by pressing the picture-adjust button. If you want to move a little faster than that, you can press and hold the button down—that simulates the action of pressing the button over and over. If you want to move to the right, release the button for one second and press it again. Each time the button is left idle for more than a second the direction of the shift will change. What the picture-adjust button does is tell the control logic to change the starting address used by the address generator. Once the address generator is adjusted, you should be able to capture picture after picture without further adjustment. The only exceptions to that rule would be using more than one video source (camera, VCR, etc.) or a video source whose timing circuits drifted a lot.

If the picture is properly aligned, but still not quite what you want, another press of the camera button puts you back in the idle mode. That allows fresh real-time video data to travel freely from the ADC to the DAC and tells the DRAM to be quiet. You can now try capturing the picture again.

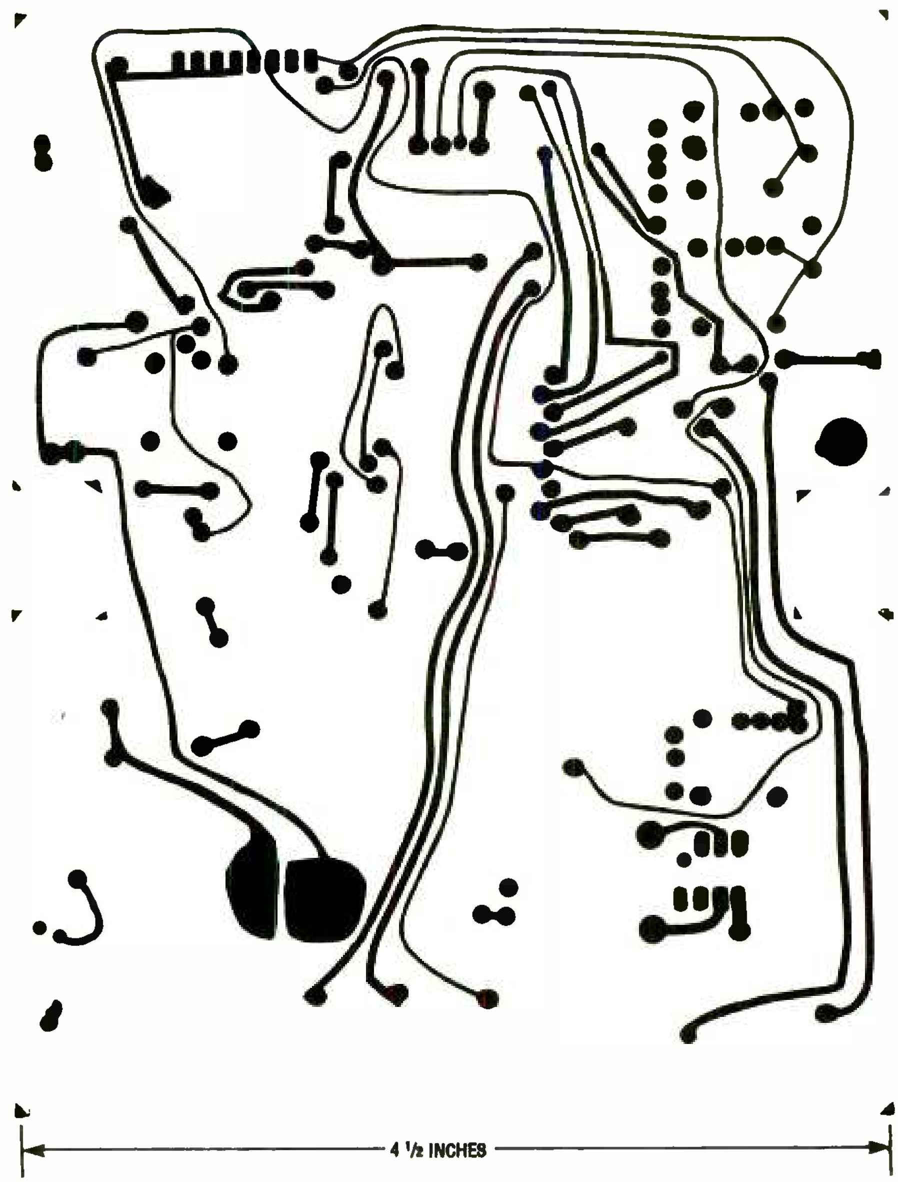


Fig. 3. This is one foil pattern for the main circuit board. Most of the components will be mounted on this side.

Transmitting and Receiving Picture Data. Once you get exactly the picture you want to send, you should call the Phonvu that's to receive the image. (Actually, the destination phone could've been contacted at any time before this.) You can hold a normal conversation with anyone at the other end at this point if you need to tell them to set up the receiving Phonvu.

Assuming the destination Phonvu is connected and turned on, and the phone link is established, you're ready to send the picture you've captured. That is accomplished, quite naturally, by pressing the send button. The control logic responds by lighting an LED indicator and then activates a relay that disconnects your phone from the phone line. It then tells the modem to transmit a special "send" signal. That signal prepares the receiving Phonvu as you'll see a little later. At the transmitting end, the control block then tells the modem to start picking the data (coming from the DRAM) off the bus, modulate it, and transmit the modulated data via the phone line. The data is pulse-modulated using a proprietary technique that is currently up for a patent, so we can't go into too much detail about the modem. When a "screen's worth" of data is sent (about 12 to 16 seconds), the LED shuts off, the modem is deactivated, and the phone is once again connected to the phone line. You can now converse with the receiving end to find out how things went.

The send signal informs the receiving Phonvu that picture data is to follow. Once the send signal is received, the receiving Phonvu activates its relay, effectively stealing the phone line and connecting it to a zero-crossing network, and disables the ADC. As picture data is received, it passes through the zero-crossing network, which detects each transition in the received audio signal and sends the transitions to the modem. The modem converts the audio transitions back into binary and places the data on the bus. Concurrently, the control logic forces the DRAM to read and store the data off the bus. The DAC and output buffer then transform and send the picture to the monitor. When the transmission is complete, the control logic in the receiver releases the phone line and turns the modem off. The DRAM places the received binary data onto the bus over and over again for the DAC to output, just as it would in capture mode.

The 6-Bit Option. Before we start discussing the Phonvu circuit, you should be aware that it can be built for 4- or 6-bit operation. The 4-bit version costs a little less than the 6-bit version, but has a limited gray scale (*i.e.*, it displays less variations in brightness). The 4-bit gray scale can reproduce 15 different levels of gray, spanning from black to white, while the 6-bit gray scale can discriminate between 50 levels of gray.

The expanded gray scale gives the video image enhanced clarity and sharpness. It also gives the appearance of higher resolution, although resolution has not actually been improved. That is due to the fact it can distinguish the difference in brilliance between adjacent pixels better.

If you're computer oriented, you might wonder why the 4-bit and 6-bit units aren't capable of generating 16- and 64-level grey scales, respectively, which are their theoretical limits. That is because video-sync signals have to be encoded along with the brightness information in this system. Those signals have a greater amplitude than the brightness information so they incur some overhead, which reduces the grey scale a little.

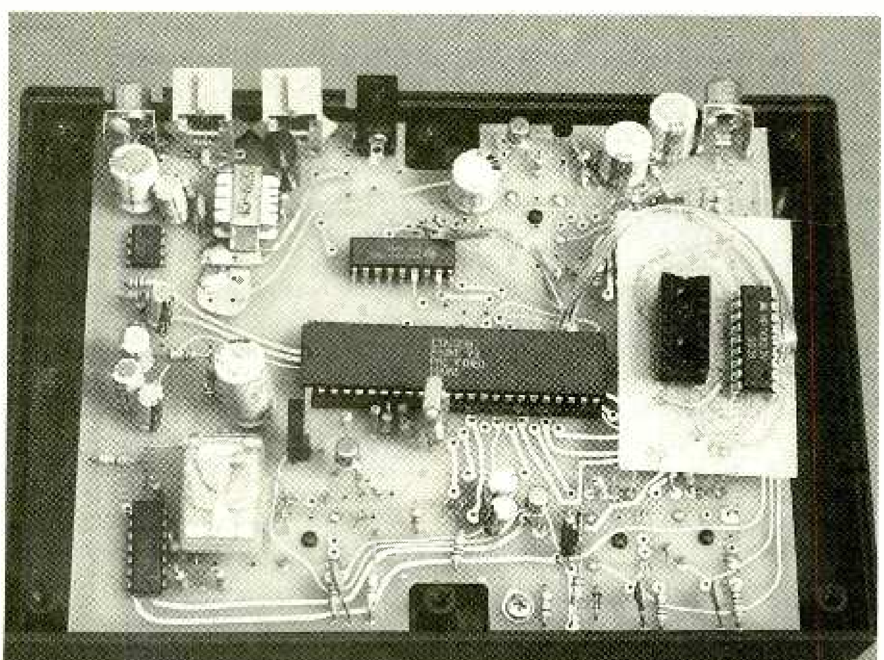
As far as parts are concerned, the two versions are almost identical. The 6-bit version requires a 6-bit ADC instead of a 4-bit ADC, and requires an extra DRAM chip to hold the two additional bits. Beyond that, you'd only need to alter a resistor value and add two more resistors elsewhere. That's not much to do for over 3 times the picture quality.

Both versions operate in an identical manner. So, for the sake of simplicity, we'll discuss the circuitry for the 4-bit version, but provide you with enough information to build the 6-bit version if you wish.

From Video to Data and Back. The 4-bit Phonvu circuit is shown in Fig. 2. The signals that flow through its circuitry can be divided up into five categories: data, data addresses, video, audio (or modulated video), and control/support. We have already discussed most of the control signals used by the circuit, so let's examine the other categories.

How the circuit processes a signal depends on the signal's use and the task the Phonvu unit is performing. For example, during idle mode the incoming analog-video signal needs to be converted to digital so that it can be placed on the data bus. The conversion is performed by U3, an integrated 4-bit ADC, which acts as the ADC block. (Note that chip should be replaced by a CA3306 6-bit ADC for 6-bit operation.) Resistors R13 and R14 adjust the video-signal voltage to a desirable level for the ADC (although R13 should be 4.7k for the 6-bit version).

However, the ADC needs to know the minimum and maximum signal levels to encode the data properly. Those voltage levels are stored on C2 and C3, respectively. The voltages are buffered by two op-amps in U4 and passed to the ADC via Q2 and Q3. The transistors are biased to overcome the voltage drop across D9 and D10. The circuitry just described forms the level-set block. The binary data generated in that fashion is placed on the data bus for use by the other functional blocks.



For all of its capabilities, the Camera Phone's printed-circuit board—even the full-blown 6-bit version (pictured here)—is rather small and sparsely populated.

Regardless of its source (the DRAM or the ADC), if data being placed on the bus needs to be converted into a video signal (such as for the idle mode, the capture mode, or when an image has been received from the phone line), it is sent through U8, a hex D-type flip-flop configured as a data buffer. It passes the data bits onto a network of resistors composed of R22–R26. The resistors' values are chosen so that the network reproduces the original video signal from the binary data (see *The Digital Electronics Course* **Popular Electronics**, February 1990 for more information on that topic). The resistor network and the hex flip-flop form the DAC block. For 6-bit operation you will also need to connect a 15k-ohm resistor and a 27k-ohm resistor to the Q1 and Q2 outputs, respec .vely. The free ends of those resistors should be tied together and connected to the junction formed by R22 and the four other resistors (R23–R26).

The analog signal generated by the resistor network is AC coupled to Q4 via C17. Transistors Q4 and Q5 along with some bias resistors (R37, R39, and R41)—which together form the video-output amplifier—boost the current and send it to the video-output jack through C15.

Data to Audio and Back. When data on the bus needs to be transformed into audio signals (for example, when transmitting an image over the phone), the process is handled exclusively by the modem in the Videophone chip (refer to Fig. 2). It picks the data up off the bus through the pins labeled Bit 1–Bit 6 (the pins for bits 5 and 6 are not needed for the 4-bit version). The audio signals that the modem generates are placed on the phone line via audio transformer T1.

When data is coming in from the phone line, it is AC coupled to Phonvu through T1. The signal is then sent to a comparator composed of an LM393 (U9), which changes state with each transition of the incoming audio signal. The comparator and its support components form the zero-crossing network. The pulses that it generates are

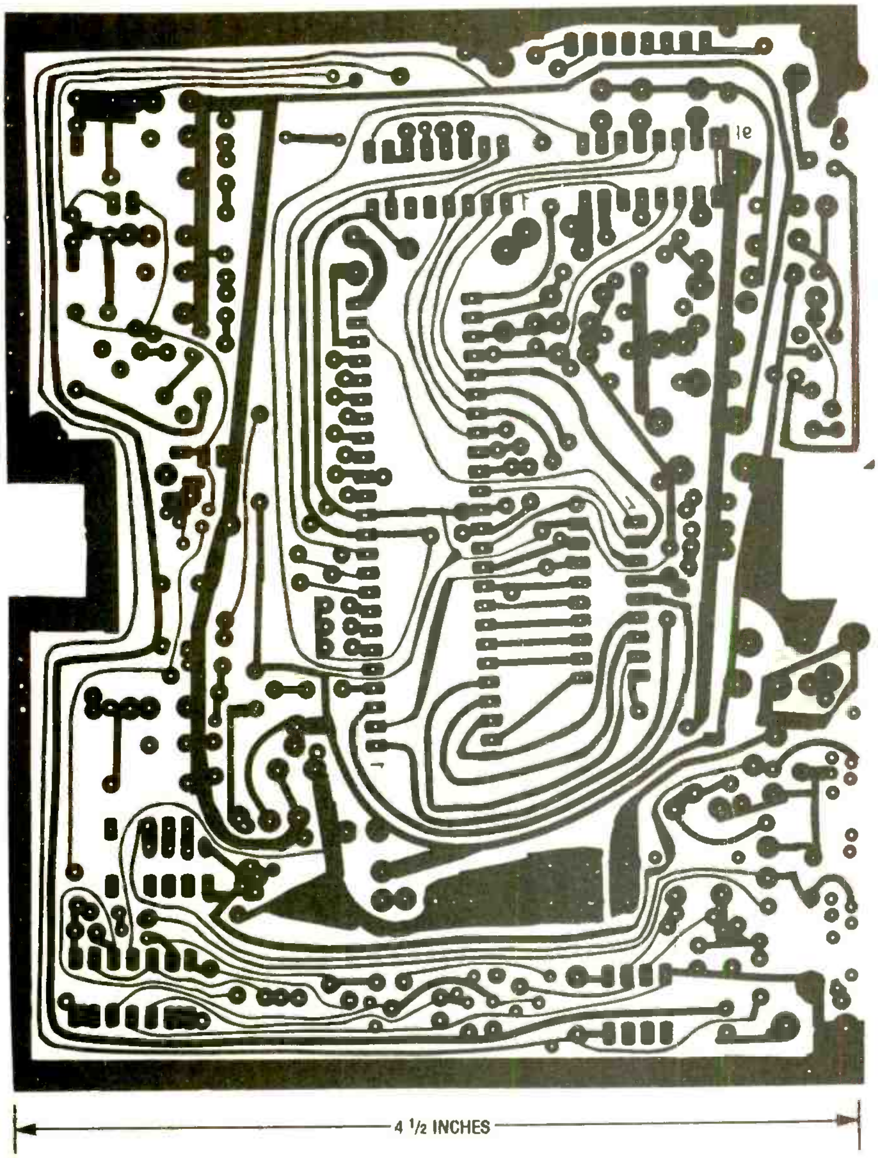


Fig. 4. This is the foil pattern for one side of the main board. It is called the "foil" side because only the LED's and switches are mounted on this side.

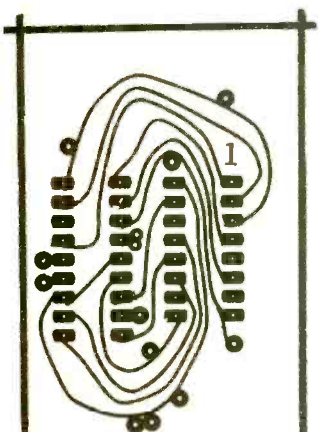


Fig. 5. The adapter board is very simple. It is single-sided, and this is the foil trace.

sent directly to the Videophone chip for processing. The chip places the demodulated digital information onto the data bus via outputs O1–O6.

Whether transmitting or receiving, the off-hook relay (K1) disconnects the phone and replaces it with R10, which acts as a dummy DC load. Resistor R10 tricks the phone-company equipment into thinking that the phone is still present, preventing it from hanging up on the Phonvu unit. Note that the relay is grounded through Q1, which is operated by the Videophone chip itself.

DRAM Operation and Connection. You may have noticed that the Videophone chip's binary inputs and outputs are tied to the same bus (refer again to Fig 2). That's because the DRAM specified for the Phonvu circuit uses one set of pins for both input and output. That greatly reduces the number of circuit traces needed to move the data around. However, since the Videophone chip has separate input and output pins, it can accommodate the more cumbersome memory chips that have dedicated input and output pins, should the need arise.

Since the DRAM uses the same pins for input and output, it needs to know whether to write data already on the bus into memory, or to output data from the memory. Those functions are triggered by signals presented to the WE (*W*rite *E*nable) and OEN (Output *EN*able) pins, respectively.

The memory locations in the DRAM are arranged in "row-and-column order." What that means is that the memory locations are laid out like a table—into rows and columns. To point to a particular memory location (whether for input or output), you need to specify its row and then its column. In effect, that means you need to specify two addresses: a row address and a column address. They are both sent to the same pins on the DRAM one at a time. That means the circuit must tell the DRAM whether it is currently sending a row or a column address. It does so by raising the RAS or CAS pins, respectively. The address generator inside the Videophone IC takes care of the rest.

Control and Miscellaneous Signals. There are just a few more bits and pieces of circuitry that bear explanation. For example, R42–R44 form a special timing network required by some internal circuitry of the chip. Those resistors could not be incorporated into the Videophone chip at the time of manufacture because their values could only be properly determined afterward.

Speaking of timing, the crystal-network block is composed of R34 and XTAL1. Note that the crystal is a commonly found TV-color-burst crystal. However, it is only used for timing purposes; the Phonvu shown here is a black-and-white unit. Color operation requires the color option (see the Parts List).

The indicator block is composed of LED1–LED3 and their current-limiting resistors R45–R47. Light-emitting diode LED1 indicates the automatic-mode the unit is in (if any). Light-emitting diodes LED2 and LED3 indicate whether the circuit is sending or receiving data, respectively.

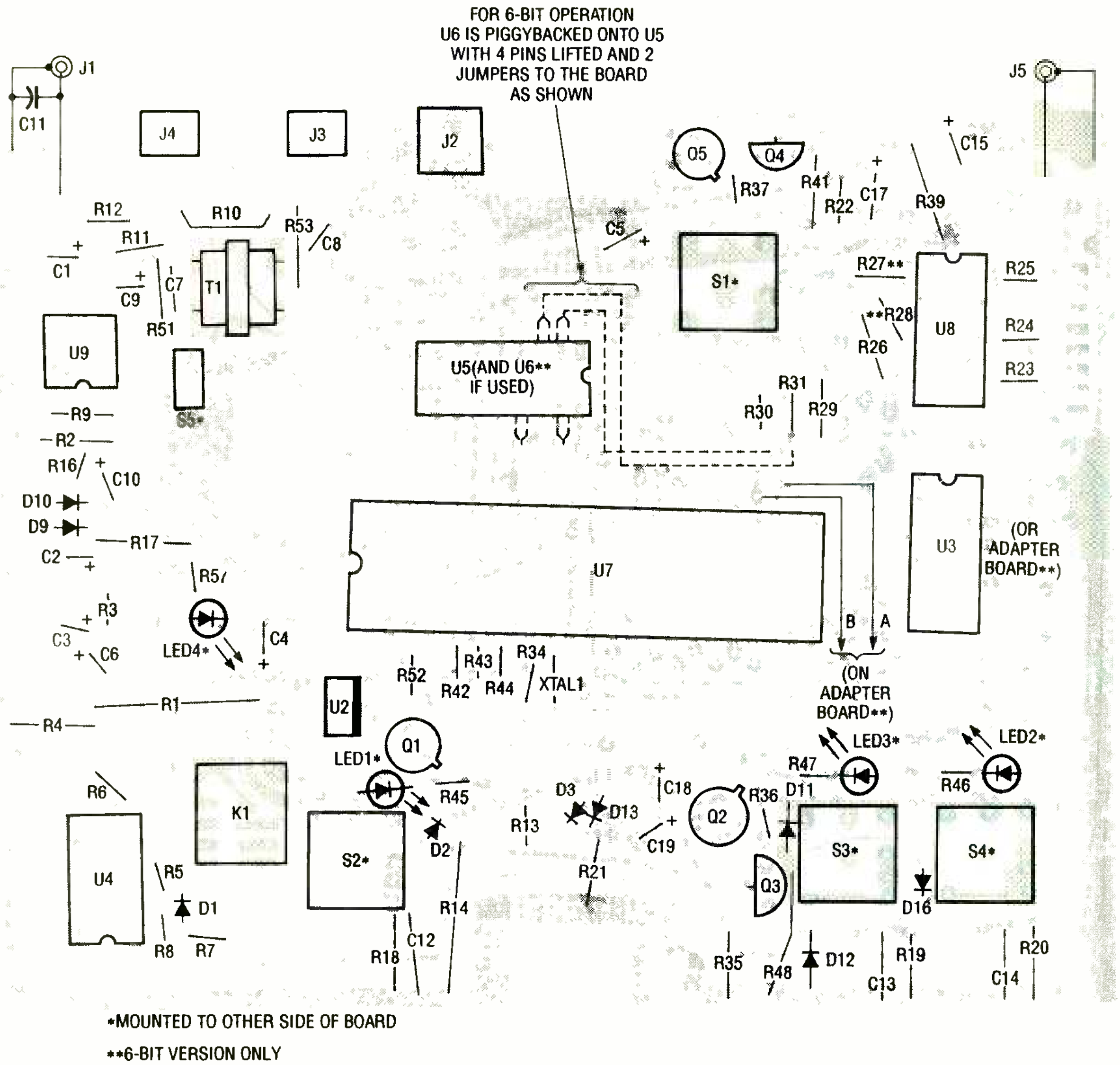


Fig. 6. This parts-placement diagram should help you stuff the main board. Note: the lifted pins on U6 (6-bit version only) and their associated connections are shown with dashed lines.

The four pushbuttons (S1–S4), bring their associated signal lines high when depressed. Resistors R18–R20, and R29, hold those lines normally low, except during initialization, and C12–C14 act as noise decouplers.

As we mentioned before there is a power-on-reset circuit that imitates the action of those switches when power is first applied. There is a special portion of the power-on-reset circuit that performs two jobs: it must first hold the speed pin high, and then send a series of pulses to that pin. That circuit is composed of two op-amps in U4, resistors R1–R8, diodes D1–D3, and capacitor C6. While the circuit holds the speed pin high, the camera pin goes high because of current through D16 via C18. Capacitor C19 charges and discharges, pulling the auto pin high and then low while the camera and speed pins remain high. Then the op-amps work together to send a series of pulses to the speed input. They stop producing pulses when the "speed" pin of the Videophone chip goes high. The chip sends that pin high when the high-speed mode is set.

Last and certainly not least is the power supply composed of a 12-volt DC power adapter (the wall-mount kind), which is not shown on the schematic diagram; C4; U2; and C5. Switch S5 is the on/off switch, and J2 is the jack for the 12-volt adapter. Light-emitting diode LED4 indicates that the power is on.

Automatic and Other Modes of Operation. From the discussion thus far, you already know how the camera, send, and picture-adjust buttons work. But we've saved the most interesting one—Auto—for last. If you press the auto button once, the unit will pick up the phone and transmit a new picture every 38.5 seconds. The unit indicates the automatic mode of operation by lighting the Auto LED (LED1). That mode is useful for hands-free operation so you can pose the object to be pictured. It is also useful for remote surveillance as we mentioned earlier.

Pressing the Auto button again puts the unit into semi-automatic mode and the Auto LED flashes. What that means is that the unit will automatically transmit a picture 4 seconds after one is captured. If you don't like the picture that you've captured, just press the capture button before the 4 seconds have elapsed to put you in the idle mode so you can try again. However, you'll still be in semi-automatic mode, so the unit will transmit a new picture 4 seconds after it is captured unless you interrupt the process again.

You can also get the unit to perform a

PARTS LIST FOR THE PHONVU CAMERA PHONE

SEMICONDUCTORS

U1—MP7682 or CA3306 6-bit analog-to-digital converter integrated circuit (6-bit version only)
U2—7805 5-volt regulator, integrated circuit
U3—CA3304 4-bit analog-to-digital converter, integrated circuit (4-bit version only)
U4—LM324 quad op-amp, integrated circuit
U5—4464, 64KB dynamic-RAM, integrated circuit
U6—4464, 64KB dynamic-RAM, integrated circuit (6-bit version only)
U7—PMC-VIDRAM-027 videophone, integrated circuit
U8—74HCT174 hex D-type flip-flop, integrated circuit
U9—LM339 comparator, integrated circuit
Q1, Q2, Q5—2N3904, or 2N2222 NPN bipolar transistor
Q3, Q4—2N3906 PNP bipolar transistor
D1–D3, D9–D13, D16—1N4148 or 1N914, small-signal, silicon diode
D4–D8, D14, D15—Not used
LED1–LED4—Red light-emitting diode

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1–R4—10,000-ohm
R5, R7, R9, R18–R21, R23, R29–R31, R41, R51–R53—1000-ohm
R6—680-ohm
R8, R43—6800-ohm
R10—27-ohm
R11, R12, R14, R34, R44—4700-ohm
R13—510-ohm for 4-bit version, 4700-ohm for 6-bit version
R15—Not used
R16, R17, R48—110,000-ohm
R22, R37, R45–R47—390-ohm
R24—2000-ohm
R25—3900-ohm
R26—8200-ohm
R27—15,000-ohm for 6-bit version only
R28—27,000-ohm for 6-bit version only
R32, R33—Not used
R35—180-ohm
R36, R39, R42, R57—510-ohm
R38, R40, R49, R50, R54–R56—Not used

CAPACITORS

C1, C15, C17—470-µF, 6.3-WVDC, electrolytic
C2, C3, C9, C18—100-µF, 10-WVDC, electrolytic
C4—1000-µF, 16-WVDC, electrolytic
C5—1000-µF, 6.3-WVDC, electrolytic
C6, C10—10-µF, 16-WVDC, electrolytic
C7, C12–C14—0.1-µF, ceramic disc
C8—0.1-µF, 100-WVDC, polyester
C11—0.0047-µF, ceramic disc
C16—Not used
C19—4.7-µF, 50-WVDC electrolytic

ADDITIONAL PARTS AND MATERIALS

K1—9–12-volt SPDT relay
J1, J5—RCA jack
J2—Coaxial power jack
J3, J4—Modular phone jack
S1–S4—SPST momentary-contact switch
S5—SPST slide switch
T1—600:600-ohm audio transformer
XTAL1—3.579545-MHz color-burst crystal
Printed-circuit board materials, adapter board (6-bit version only), 12-volt DC power supply, jumper wire, 16-pin wirewrap socket (6-bit version only), IC sockets, case, solder, etc.

Note: The following parts are available from PMC Electronics, PO Box 11148, Marina Del Rey, CA 90292; Tel. 213-827-1852: the Videophone chip and 4/6-bit circuit schematic ($59.95); 6-bit ADC, DRAM, and hex flip-flop chip set ($35); 4-bit ADC, DRAM, and hex flip-flop chip set ($21); 4-bit to 6-bit upgrade kit ($22.95); PC board ($18.95); resistors, capacitors, and diodes ($28.75); pre-cut cabinet ($12.75); 12-volt DC supply ($8.75); total kit of parts (components, cabinet, PC board, 12-volt supply etc.) for 4-bit unit ($150.15); total kit of parts for 6-bit unit ($164.15); completely assembled 6-bit unit ($235); completely assembled 4-bit unit ($210); cassette-recorder interface kit ($12.95); assembled cassette-recorder interface ($23.95); voice-mail adapter kit (reduces speed for voice-mail compatibility) ($23.80); assembled computer/voice mail interface, connector cable, software, and special 6-bit Phonvu unit ($549); video speakerphone TV-audio modulator ($79.95); Epson-compatible printer interface ($149.00); talk-while sending interface ($89.95); color-adapter kit ($119.95); assembled color-Phonvu unit ($299.95); Touch-Tone remote-control for security applications ($59.95); a variety of monitors and video cameras are also available (contact PMC for pricing). PMC offers priority-mail delivery at $2.40 for one kit and $3.45 for two kits (contact them directly to arrange for COD, UPS, regular mail, or other deliveries.) Include $4 for shipping and handling and California residents add 6.75% sales tax. Credit cards, COD, checks, and money orders are accepted (all orders must be payable in U.S. funds).

few extra functions by pressing combinations of buttons. For example, you can interrupt the send or receive mode by simultaneously depressing the Auto and Send buttons. If you depress and hold down the Capture button, then depress and hold the Send button, and press and release the Auto button, the unit will go into receive mode. It will then display any image that might be coming in on the phone line.

Construction. For a 4-bit unit, you'll only need a main circuit board. The main circuit board is double sided with plated-through holes. As it is very difficult to make such boards, it is recommended that you purchase the main board from the supplier mentioned in the Parts List. Nonetheless, we've provided the foil patterns for the component and "foil" sides of the main board in Figs. 3 and 4, respectively. If using a homemade board, you will have to overcome the problems caused by the lack of plated-through holes. To do that, you will have to solder all components on both sides of the board; you will also need to install feedthroughs (a small piece of wire, such as as a clipped component lead, that is soldered on both sides of the board) at all unused holes. Doing that completes the electrical connections between the two sides of the board.

In a 6-bit unit you'll need an additional adapter board. It is not double sided, but it is also available from the kit supplier. We provide the foil pattern in Fig. 5 for the more ambitious.

Once you've got the boards that you need, you can begin the assembly procedure. Use Fig. 6 as a guide to stuffing the main board. Start by placing the resistors on the board. Keeping in mind that R27 and R28 are only needed for a 6-bit unit, and that there are no resistors labeled R15, R32, R33, R38, R40, R49, R50, R54, R55, or R56 and no diodes D4–D8, D14, or D15 in either unit. Note that if you're building a 4-bit unit, the value of R13 is 510 ohms, but in a 6-bit Phonvu it should be 4.7k.

Next install the capacitors, making sure the polarity of the electrolytics is correct before soldering them in place. Solder C11 onto J1, which will be installed later. Note that there is no capacitor labeled C16.

(Continued on page 82)

All About Oscillo

BY
STEPHEN J. BIGELOW

The oscilloscope is perhaps the most powerful and versatile test instrument ever developed. Their great diversity of options and features make them suited to an array of important tasks. Although a scope can graphically display routine parameters such as instantaneous voltage and pulse width (for frequency estimates), their real strength is their ability to observe unusual signals that other pieces of test equipment cannot handle properly. As an example, scopes can detect line transients or other noise. They can also compare the phase and timing of two or more signals.

This article will cover the elements and features of typical oscilloscopes, as well as explain basic measurement techniques. The article will also explore some of the new advanced features that are available.

CRT Operation. In spite of the variations in features and complexity, all scopes can be broken down into eight basic functional blocks: the input circuit, the vertical driver, the trigger, the time-base (or sweep) generator, the horizontal driver, the cathode-ray tube (CRT) circuit, the power supply, and the probes. Figure 1 shows a block diagram of a simple oscilloscope broken down into those sections.

Since any signal to be viewed on the scope will appear on the CRT display, it is a logical place to start our discussion. The CRT circuit is composed of several key sections. The cathode-ray tube itself forms the heart of the circuit and functions very much like a television picture tube: In it a beam of electrons is created by applying a strong potential, produced by a high-voltage driver circuit, to a heated electrode (the cathode). The high voltage literally pulls the electrons off the cathode to create the beam.

The beam is aimed at the the front surface of the tube, which is coated with phosphor. At the point where the electrons strike the coating, the phosphor glows. By modulating the number of electrons that make up the beam, the brightness (or intensity) of the glow can be adjusted.

If we can move the beam around so it lights up a series of points on the face of the CRT, the beam can draw a plot, and that's what happens in a scope: Two electric fields generated within the CRT steer (deflect) the electrons to their correct destination on the tube face to trace a curve. The two fields are created by charging two pairs of deflection plates; one pair (called the "vertical deflection plates") steers the beam up and down, the other pair (the "horizontal deflection plates") guides the beam left and right.

The vertical and horizontal deflection plates are charged by vertical and horizontal driver circuits. In essence, the drivers are high-powered amplifiers whose output is modulated by the other sections of the oscilloscope to create the desired plot, as you'll see. In this fashion, the drivers permit those sections to indirectly steer the electron beam and yet remain isolated from the CRT.

The front surface of the CRT is divided into sections by a grid called a "graticule." Each of these "divisions" as they are called are further subdivided to permit the user to measure very small details in the plots generated. The plots are usually of voltage (along the vertical axis) versus time (along the horizontal axis). Used in this fashion, a scope can display the changes of a signal's voltage over time. Let's see how the other sections of the scope control the drivers to produce these useful plots.

Time-Base Generator. For almost all scope measurements the electron beam is swept from left to right. The "time-base generator" produces a signal that controls this motion. The rate of the sweep depends on the time base selected by the user via the time-per-division control. By setting the time base, that control also determines how much time is represented by each division on the graticule. The time per division is called the "horizontal sensitivity."

A fast sweep rate can show the detail of quickly changing signals better than a slow rate. However a fast sweep is unsuitable for observing slow events because they will not fit on the CRT face. As an example, if the time-per-division control is set to 1 µs/div, each horizontal division on the screen will represent 1 µs. If the CRT face is 10 horizontal divisions wide then a complete sweep can display only 10 µs of the signal. So a waveform greater than 10 µs in duration can not be entirely displayed at once.

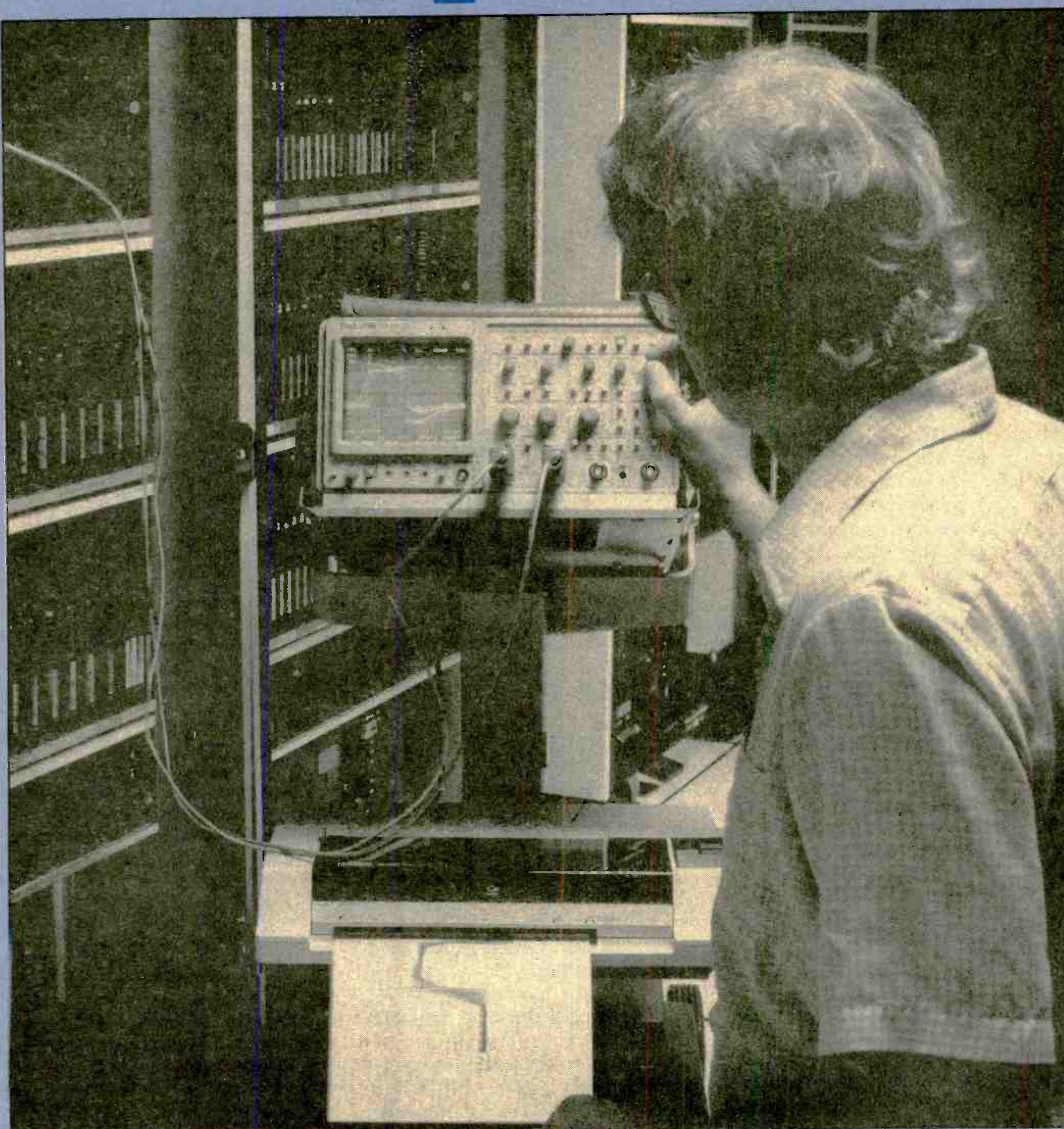
If the time-per-division control is moved to the 2-ms/div position, then each horizontal division represents 2 ms of time. The full ten divisions of the scope face would then represent a full 20 ms, but the plot would contain less detail.

This limitation can be lessened by using the "horizontal-offset" control and a fast sweep rate. That control is capable of shifting a trace left or right by a limited amount. It can be used to move a quickly swept (more detailed) trace left or right somewhat to display only the area of interest.

Many scopes now also have a special "magnified-sweep" mode that expands the displayed trace by 5 or 10 times, depending on the scope. The advantage of this is that it allows you to momentarily zoom in on a portion of a waveform without having to alter the time-per-division setting.

We present an overview of oscilloscopes: how they function, their proper use, and the features and specifications to look for.

scopes



While this mode is useful for close inspection of typical waveforms, it will not readily display small transient signals, which often require even faster sweep rates. Most scopes today have a "delayed sweep" feature that overcomes that. It allows a user to view any portion of a waveform at a very fast sweep rate to yield high horizontal resolution,

The Trigger. At this point you may be wondering how the time-base generator knows when to start sweeping the electron beam. It is told when by the trigger circuit, which helps to synchronize the display with the incoming signal or some reference signal to obtain a steady trace on the CRT.

Typically, oscilloscopes can respond to three different trigger signal sources. The easiest to understand is the internal trigger. For internal triggering, the trigger circuit steals a sample of the signal that will be viewed on the scope from the input stage. When the input signal reaches a user-set "trigger level," the trigger circuit activates the time-base generator and a sweep begins.

The second major triggering source is called "line" (or "60 Hz"). The trigger signal is derived from a 60-Hz signal provided by the scope's power supply. This is most often used for looking at signals related to the power-line frequency such as power-supply ripple. Line triggering will not necessarily provide good triggering in all situations.

Most scopes can also accept an external trigger signal. External triggering is primarily useful if a sweep must be started when some external event occurs. A minimum signal of 100 mV is usually needed to activate the sweep.

There are three common modes of triggering that can gate the sweep generator: automatic, normal, and manual (or "single sweep"). In the automatic mode, the scope sizes up the trigger signal and determines what voltage level is appropriate for triggering (although the user can vary it slightly). As a result, a trace is always displayed on the screen. Automatic triggering is useful for examining simple, low-frequency (or DC) signals.

Complex or high-frequency signals are best triggered in the normal mode. In this mode, only the user determines the best voltage level for triggering.

The manual mode only allows one sweep for each press of the "trigger button." This mode is handy when working with irregular events or very low-frequency signals

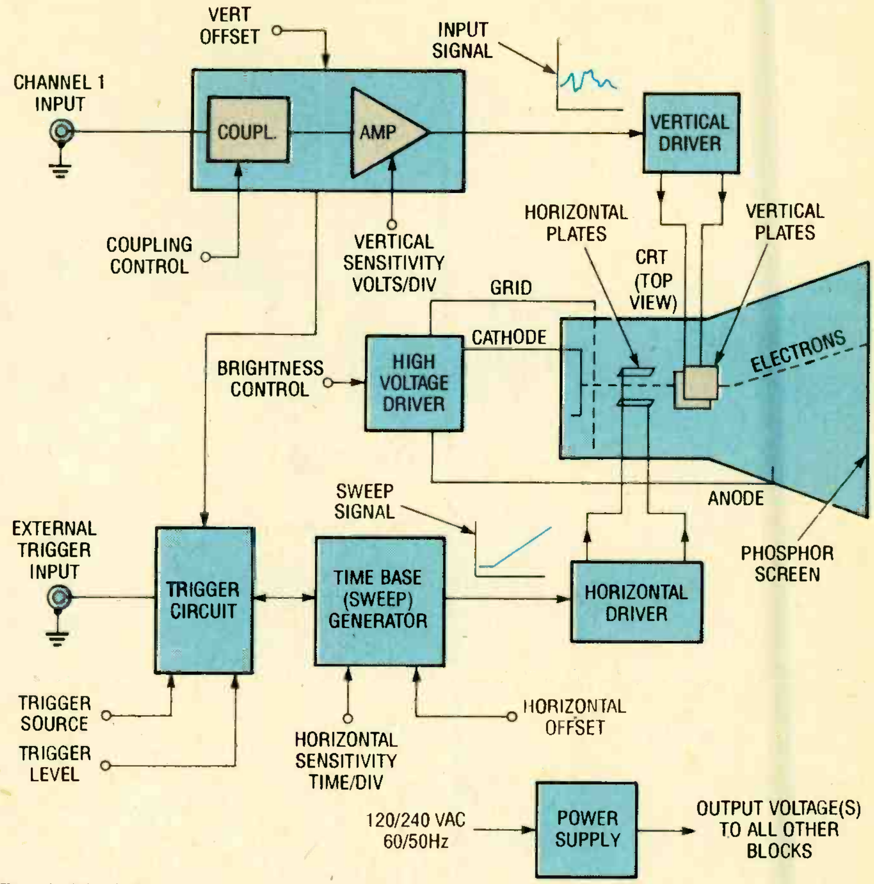


Fig. 1. Block diagram of a simple oscilloscope.

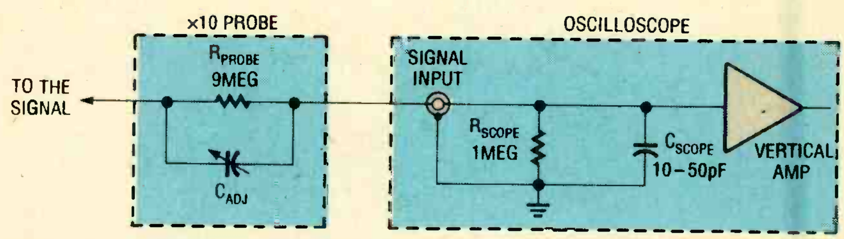


Fig. 2. This is the equivalent circuit of a typical oscilloscope input coupled to a ×10 probe. The two must be matched for accurate AC operation.

Input Circuit. When viewing the voltage of a signal, the signal is coupled to the scope and then amplified by the scope's channel-input circuit. Although Fig. 1 only shows only one channel input, many scopes have more than one input, as we'll discuss later.

There are two coupling modes a user can chose from: DC and AC. With DC coupling, the input signal is connected directly to an input amplifier. Since that permits DC components of the input signal to enter the scope, it allows the instrument to be used as a simple DC voltmeter or to display a DC level that an AC signal may be riding on.

Selecting the AC-coupling mode inserts a capacitor in the signal path. The presence of the capacitor effectively blocks any DC component of the signal, allowing only the AC portions through. This mode is very useful for studying small AC signals that are superimposed on larger DC levels: To closely examine the small AC variations you would need to amplify them. Using DC coupling you'd be amplifying the DC component too, pushing the whole waveform off the face of the CRT. With AC coupling, the DC level would be blocked, so only the AC portion of the signal would be amplified.

A "ground" setting is also usually included in the coupling control. That causes the scope to display a flat line representing 0 volts (or "ground"). This helps you use the "vertical-offset" control to set the 0-volt level to where you want it.

Once the signal is coupled, it is sent

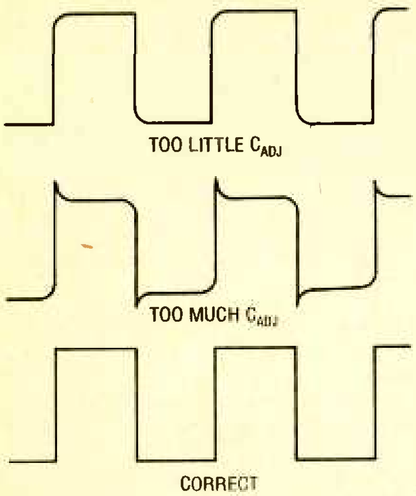
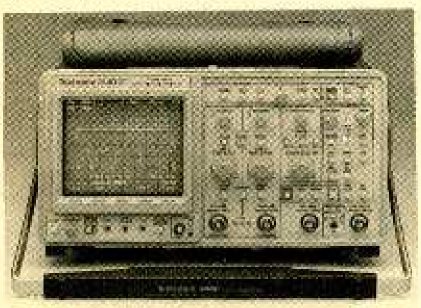


Fig. 3. This diagram shows the effects of the probe's capacitive reactance on an input square-wave signal.



This 300-MHz Tektronix 2440 digital oscilloscope has dual-channel simultaneous data acquisition. As you can see it also has cross-hair style cursors.

to a variable-gain amplifier circuit. Gain settings are usually scaled in volts-per-division (or volts/div for short). The greater the volts/div setting, the lower the sensitivity of the display—larger signals can be displayed, but resolution is reduced. A smaller volts/div setting will increase the sensitivity of the reading—a smaller signal will fill the screen, but more detail is provided. The amplified signal is now sent along to the vertical driver to control the vertical deflection of the electron beam.

Power Supply. This is the most straightforward portion of the oscilloscope. As you might expect, it converts 117 VAC into the DC voltage and current used by the oscilloscope circuits. Since the oscilloscope is a test instrument, noise in the supply voltage must be suppressed as much as possible to prevent erroneous readings. Precision linear power supplies are usually used for their low noise and high reliability.

Probes. The probes are just as important to the proper operation of an oscilloscope as any internal circuitry. Much more than a piece of wire with a handle, a good probe must deliver the best possible signal to the scope, yet place as little load as possible on the circuit under test. To achieve this, many passive probes attenuate the amount of signal flowing from the circuit under test to the oscilloscope input.

Most common probes have attenuation factors of ×1, ×10, or ×100. A ×1 probe has no attenuation—the signal amplitude at the probe input is the same as the input to the scope. To prevent the capacitive-loading effects commonly encountered with a ×1 probe, a ×10 probe is often used. For a ×10 probe, the signal reaching the scope is only 10% of the signal at the probe input. A ×100 probe can be used to lighten the load even more by letting only 1% of the signal through.

It is very important that the probe be properly matched to the input of the oscilloscope. As you can see from the sketch of the ×10 probe and the oscilloscope in Fig. 2, the 9-megohm impedance of the probe and the 1-megohm input impedance of the typical scope form a 9:1 voltage divider at DC.

However, unless the time constant of the probe ($C_{ADJ} \times R_{PROBE}$) matches that of the scope ($C_{SCOPE} \times R_{SCOPE}$), the voltage division afforded to an AC signal will depend on its frequency. That distorts the signal to the scope and the distortion really shows up at the edges of square waves (see Fig. 3). By adjusting the value of C_{ADJ} on the probe, the time constants of both networks can be made equal to alleviate the problem.

Many oscilloscopes come equipped with a calibrator signal that can be used to optimize the value of C_{adj}, although any good square-wave source will do.

Specifications. Oscilloscopes have several important operating specifications that you should be familiar with. An important one is vertical deflection. That is specified as the minimum and maximum volts-per-division settings the scope has and the number of steps that the range is broken down into. For example, a typical scope can range from 5 millivolts/div to 5 volts/div broken down into 10 steps. A variable control is often available to provide adjustment between voltage steps.

Another specification, the time-base (or sweep) range, is the range of time-base settings that the scope is capable of, along with the number of steps that are available within the range. A range of 0.1 μs/div to 0.2 s/div in 20 steps is not unusual. The horizontal sensitivity always has greater flexibility then the vertical sensitivity. A variable control usually accompanies the time base for measurements between steps.

Bandwidth is a very important specification. Bandwidth is essentially the range of frequencies that the scope is capable of displaying accurately. It is usually rated from DC (0 Hz) to some maximum frequency. For an inexpensive scope, the bandwidth may cover DC to 20 MHz, while a more expensive model may reach up to 150 MHz or more. Good bandwidth is expensive—more so than any other feature. For example, 100-MHz oscilloscopes can easily exceed $1200. A 20-MHz unit, on the other hand, can be bought for under $400.

Simply stated, the maximum input is the maximum voltage that can be applied to the oscilloscope's input. A maximum input of 400 volts (DC or AC peak) is common for many simple scopes. More sophisticated units can sustain better than 1000 volts. The range can be artificially expanded by the use of attenuating probes.

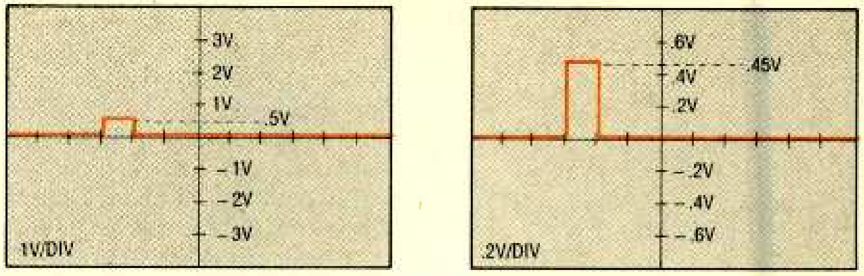
Another important specification, accuracy, is typically the accuracy of the screen display for voltage and time measurements. Although oscilloscopes are handy for making rough readings, they are not as accurate as voltage or frequency meters. As an example, a digital VOM can reach an accuracy of ±0.25% at full scale. That means that if you are measuring 1 volt (full scale), the meter may read as little as 0.9975 or as much as 1.0025 volts. An oscilloscope, on the other hand, can typically provide ± 3%. That same 1-volt measurement on an oscilloscope could range from 0.97 to 1.03 volts (not counting parallax errors in reading the trace on the screen). For most routine measurements, an oscilloscope will do just fine.

A scope's input impedance is the effective load that the scope will place on a circuit (rated as a value of resistance and capacitance). To guarantee proper operation over the bandwidth of the scope, it is a good idea to select a probe with characteristics similar to those of the particular scope. Most oscilloscopes have an input impedance of about 1 megohm, with 10 to 50 pF of capacitance.

It is also important to consider the operating modes of a scope. They determine how selected signals will be displayed. For example, on a multichannel scope channels could be displayed independently, together (in "dual" mode), or even summed algebraically in "add" mode. There are more options than those listed here and their number depends upon the particular scope.

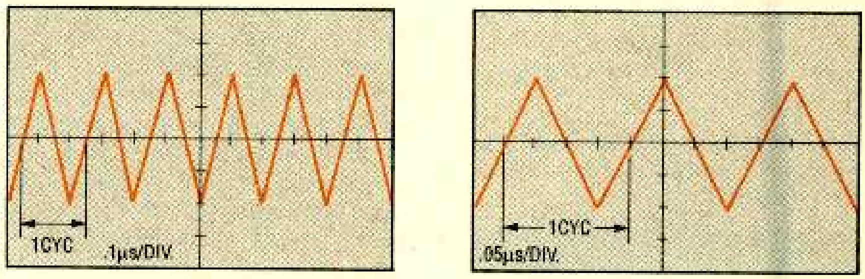
The number of trigger sources a scope can work with is another consideration. As mentioned earlier, most scopes offer triggering from one of their signal inputs, the AC line, or an external signal.

Tied to that specification are the number of trigger modes. That determines the way a trigger source is applied to the sweep generator. An "auto" mode allows the trigger source to run the time base continuously. Normal mode is used for unusual waveforms. There may be other modes as well depending on the sophistication of the scope.



A B

Fig. 4. Increased vertical sensitivity will enhance the accuracy of your readings. As proof of that, the detail lacking in A shows up in B.



A B

Fig. 5. Increasing horizontal sensitivity will enhance the accuracy of your time readings. The expanded version of the wave in A is shown in B.

Start-Up Procedure. Oscilloscopes are unusually flexible devices. Since oscilloscopes can display minute changes in signals over time, they are ideal for pulse width and frequency measurements. Let's look at some of the fundamental measurement techniques.

The first operation that you must perform after the scope is turned on is to locate the trace if it is not already visible. First, increase the trace intensity and set the triggering to automatic. Adjust the horizontal and vertical offset controls to the center of their ranges. Be sure that the triggering mode is set to trigger from one of the input signals, then adjust the trigger level until a flat, stable trace is displayed. Vary the vertical offset until you see a flat-line trace

Many oscilloscopes are equipped with a "beam finder" mode that compresses the horizontal and vertical ranges. It forces the trace onto the CRT and gives you a rough idea of its approximate location. With or without this feature, once you find the trace and move it into position with the offset controls, alter the focus and intensity to obtain a crisp, sharp trace.

Probe adjustment is a quick and straightforward operation. It requires a low-amplitude, low-frequency square-wave input (usually a 1-kHz 300-mV square wave with a 50% duty cycle) that can be provided from just about any waveform generator. Many scopes have a built-in calibration-signal generator to supply the test signal. Connect the probe to the test-signal output, then adjust the vertical and horizontal sensitivity so that one or two complete cycles of the signal are clearly shown on the CRT.

Observe the characteristics of the signal. If the corners of the waveform are excessively rounded, there may not be enough capacitance in the probe. Spiked corners suggest too much capacitance. Either way, the probe is not matched properly to the scope. Slowly vary the adjustable capacitance on the probe until the corners of the square wave are crisp and sharp. This indicates a good calibration. If you cannot achieve a clean square wave, try a different probe. Repeat the calibration each time a new probe is used on the scope, or when the probe is moved to a new scope. The scope is now ready for use.

Voltage Measurements. The first step in all voltage measurements is to set the zero-volt trace (or baseline) where you want it. To ensure that the oscilloscope is displaying zero volts, move the input-coupling control to the ground position. That disconnects the scope input from the probe and connects it to ground. Adjust the vertical-offset control to place the trace where you would like the zero volts indication to be (often the centered horizontal axis on the CRT is used).

To measure DC, set the coupling to the DC position, then select the appropriate vertical sensitivity. As a general rule, set your sensitivity to a high scale to start with, then carefully increase the sensitivity (reduce the volts/div) after the signal is connected. That prevents the trace from "jumping off" the screen when the signal is first applied.

Taking an example, with the vertical sensitivity set to 2 volts/div, each major vertical division on the screen represents 2 volts. A positive 4-volt signal will then appear 2 divisions above the zero axis (2 div × 2 volts/div = 4 volts). If the input is a negative voltage, the trace would appear below the zero axis, but it would be read the same way.

AC signal magnitudes (for sine, square, triangle, etc) can also be read directly from the scope. The key factor to remember in AC-voltage measurements is that the scope measures in terms of peak values. A regular AC voltmeter, on the other hand, measures in terms of rms (*R*oot *M*ean *S*quare), so the reading on a scope will not match the reading on an AC voltmeter. To convert rms values to amplitude simply multiply the rms value × 1.414. To convert an rms reading to a peak-to-peak quantity, multiply rms × 1.414 × 2.

The peak voltage of a sinewave can be read directly from the CRT by measuring the number of divisions there are between the zero axis to the positive (or negative) peak of the signal. For example, if the peak is 2 divisions above the zero line, and the vertical sensitivity is set to 5 volts/div, then the signal would be 10 volts peak (2 div × 5 volts/div). The peak-to-peak voltage can be calculated by multiplying the peak voltage × 2. It can also be measured by counting the divisions from the negative peak to the positive peak. If there are 4 divisions peak-to-peak at 5 volts/div, then the signal is 20 volts peak-to-peak (4 div × 5 volts/div). This signal would show up on an AC voltmeter as 7.07 volts rms.

Time Measurements. The oscilloscope is a handy tool for measuring such parameters as pulse width and period. Once the period is measured, a signal's frequency can be calculated. Duty cycle can also be calculated based on the high and low times for each cycle.

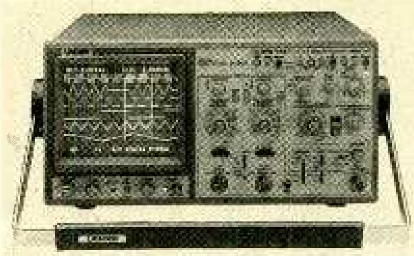
In order to measure the overall cycle time of the signal, adjust the horizontal sensitivity until at least one full cycle of the signal is shown. Simply multiply the number of divisions in one full cycle by the horizontal sensitivity setting. If the horizontal sensitivity is set to 1 ms/div and one complete cycle occupies 2 divisions, the period of the signal is 2 ms (2 div × 1 ms/div).

Since frequency is the exact inverse of the period, the frequency of the signal can be easily calculated by dividing the period into 1. For the above example, a period of 2 ms (.002 s) would yield a frequency of 500 Hz (1/.002 s).

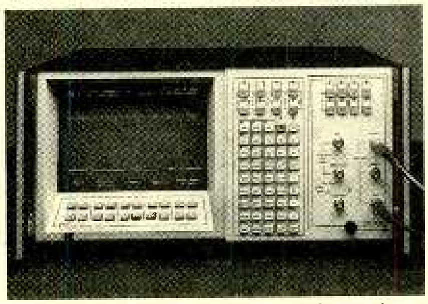
The duty cycle of a square wave is the percentage of time it spends high. To calculate the duty cycle, divide the on time by the total period × 100%. For the example we've used, if the on time is 1 ms, the duty cycle would be 50% (1 ms/2 ms × 100%).

Phase Measurements. Multi-channel oscilloscopes can be used to measure the phase relationship between two signals of equal frequencies (typically sine waves). One signal is sent to one scope input to control the horizontal driver and the second signal controls the vertical driver. Both channels must be set to the same sensitivity. The time-base control is then rotated to the X-Y setting. The combination of signals causes them to draw an ellipse on the screen. Phase can be determined from the shape of the figure.

Setting Sensitivity. As we have seen, vertical and horizontal sensitivity play an important role in the usefulness of the oscilloscope. As a rule of thumb, the most accurate image (and the easiest one to read) will be the largest possible image to fill the screen. You should set the horizontal and vertical sensitivity to achieve such ideal curves.



This is the control-panel of a Leader model 2100R 100-MHz oscilloscope. Note the horizontal cursors.



Advanced digital waveform analyzers have so many operating modes that they require a very large keypad. This one is menu driven as well.

Figure 4 shows an example of this principle. A pulse of fixed duration is sent to the scope. With the vertical and horizontal sensitivity set to 1 volt/div, the pulse appears as it does in Fig. 4A. With this setting, you would probably interpret the pulse to be 0.5 volt high. When you increase the sensitivity to 0.2 volts/div, you see the height of the pulse expands as shown in Fig. 4B. Notice how the pulse does not quite reach 0.5 volt, but only reaches about 0.45 volt. Keeping sensitivity as high as possible brings out subtle aspects of the waveform so your reading is the most accurate.

This principle also holds true for horizontal sensitivity. Figure 5 demonstrates a triangle wave as the input signal. At a horizontal setting of 0.1 μs/div, a signal might appear as it does in Fig. 5A. A full cycle could be read as 0.2 μs (5 MHz). By increasing the sensitivity to 0.05 μs/div, the display expands as shown in Fig. 5B. In this case, the waveform period is still accurate at 0.2 μs, but you can see that it would be possible to determine time more accurately.

Advanced Features. Modern electronics has made many more tools available on today's oscilloscopes. Although most of these extra features are currently less affordable to the electronics enthusiast, those costs will eventually decline. Let's look at several of these advanced features.

In an ordinary scope, voltage and time must be measured by eye, using the graticule marks on the CRT. That has been the tried and true approach since the days of the first vacuum-tube scopes. With the addition of a microcomputer, however, a set of on-board measuring markers (called cursors) can be included in the screen display to aid in the waveform analysis. Voltage, time, and frequency cursors are the most commonly available.

Voltage cursors are two horizontal bars that can be independently placed at any location on the screen. The on-board microcomputer automatically calculates the distance between the cursors, then multiplies that by the volts/div setting to produce the voltage reading. The resulting reading can then be displayed for quick and easy reference.

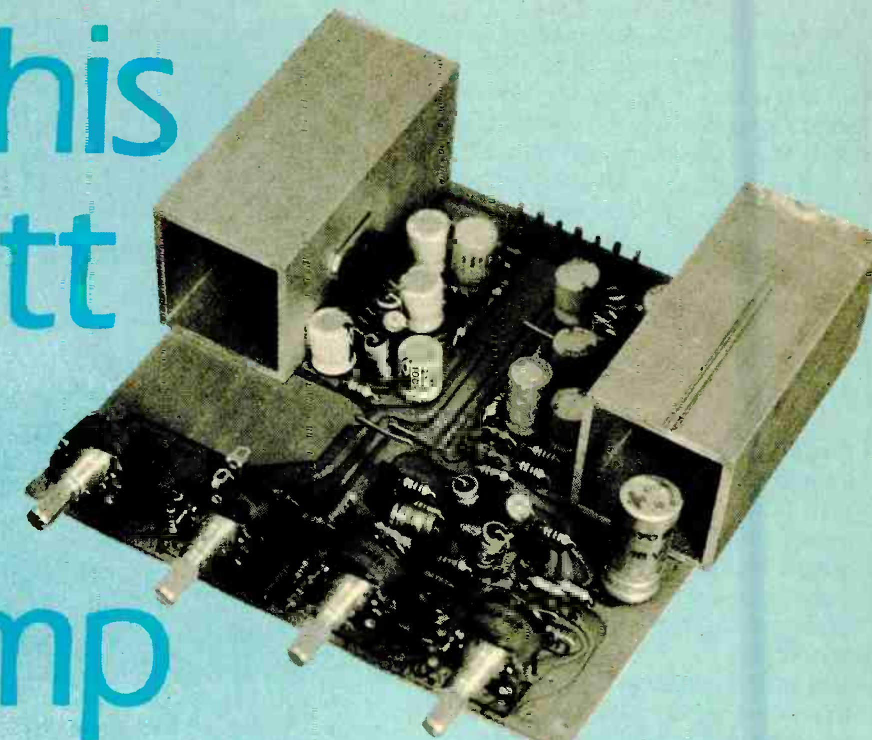
The time and frequency cursors work in much the same way as the voltage cursor. Two vertical bars can be located anywhere on the screen. The microcomputer can calculate and display time by multiplying the distance between the cursors by the time base setting. Since frequency is just the reciprocal of time, frequency can be calculated and displayed with just 1 extra step. The choice between time or frequency cursors is usually switch selectable.

Storage Oscilloscopes. Conventional oscilloscopes are versatile enough to tackle most typical applications, but low-frequency, irregular, or single-shot signals will be difficult to see. For low-frequency signals, the time base must be extended so far that you will only see a dot moving across the CRT. Unique or single-shot signals can be almost impossible to capture properly on an ordinary scope. A storage oscilloscope overcomes all those limitations. One can retain a trace on its CRT for several seconds to several days depending on the particular storage method.

The oldest form of storage was simply a camera which could be fitted to the CRT, but this method was bulky, awkward, and difficult to use. The CRT could not be viewed conveniently when the camera was attached, and timing the

(Continued on page 88)

Build This 20-Watt Stereo Amp



BY
ROBERT A. YOUNG

Does your present automobile- or home-stereo receiver lack punch? Add this amplifier to your present system and hear what a difference a few watts can make.

Having recently moved into a new apartment, I began scanning the local tabloids in search of a moderately priced (read that as cheap) stereo receiver—nothing fancy mind you, just something that would deliver reasonably clean sound at say 10-watts or more. After several weeks of tracking audio equipment costs in the local marketplace, I discovered what I thought was a real bargain—a stereo receiver that was advertised to deliver 30-watts of clean, crisp audio power. So after work that evening, I made a beeline to the audio dealer, whipped the plastic on him, and excitedly streaked home with my bargain.

Upon reaching my apartment, I hurriedly removed my purchase from the wrapping, and hooked up my old KLH Model 23 speakers. Now let me explain, I had hooked these speakers to several budget-priced receivers over the years and because of good past experiences, I had mistakenly assumed that even the shoddiest of receivers would make beautiful music through those old gems. Alas, it was not to be. First I tried listening with the volume barely above a whisper—not bad, I thought to myself. But now let's crank up the volume.

With the volume at about half power, there was so much buzzing that I thought my apartment was being invaded by killer bees. Boy was I angry, but more than that, I was embarrassed. After all, I'm an electronic tech, and with my background I should have known better. What was I to do; a sign over the store's sales counter said "Absolutely No Refunds," and I wasn't about to trade one dud for another. That's when I remembered a grade-school buddy of mine whom I'd run into a few days earlier. My friend, an enterprising fellow, had made a part-time career of purchasing cheap stereo equipment, and boosting the output power by installing a new, well designed and well made power amplifier.

I decided his part-time livelihood meant salvation for this piece of junk. But I wasn't about to spend countless hours designing, building, and testing a unit of my own. That's when I recalled that tucked away in the back pages of an electronics catalog I had seen an advertisement for a few TSM audio power-amplifier kits. I picked the *TSM 67*, a 40-watt peak, 20-watt rms, class-A, stereo-audio amplifier. Although the amplifier was designed for automotive use, it was well suited to my application. All I had to do was build the circuit, provide a power supply, and *presto*, inexpensive audio power and fidelity.

About the Circuit. Figure 1 shows a schematic diagram of the audio-power amplifier. The circuit is built around two TDA2004 bridged audio-amplifier IC's. Since both channels of the circuit are essentially identical, we'll look at only one channel.

The audio input to the circuit (at J1) is fed through C18 to the base of Q1, which serves as a preamplifier. A voltage amplifier to be precise. The preamplifier output, taken from Q1's emitter, is capacitively coupled through C17 to the bass and treble controls (R30 and R31, respectively). From there, the signal travels to the volume-control potentiometer R32. The desired amount of signal is then fed to pin 1 (non-inverting input 1) of U2, through the wiper of R32. The two outputs of U2 are then applied to SPKR1. The speakers attached to the circuit can have an impedance of from 2.5 to 8 ohms, making the circuit ideal for multi-speaker, low-impedance installations.

A portion of the two outputs of U2 are also fed back to the non-inverting inputs of U2, providing negative (degenerative) feedback, which reduces harmonic distortion, AC hum, and other noise, and improves the circuit's frequency response. Potentiometer R33 (labeled BALANCE) allows you to offset the

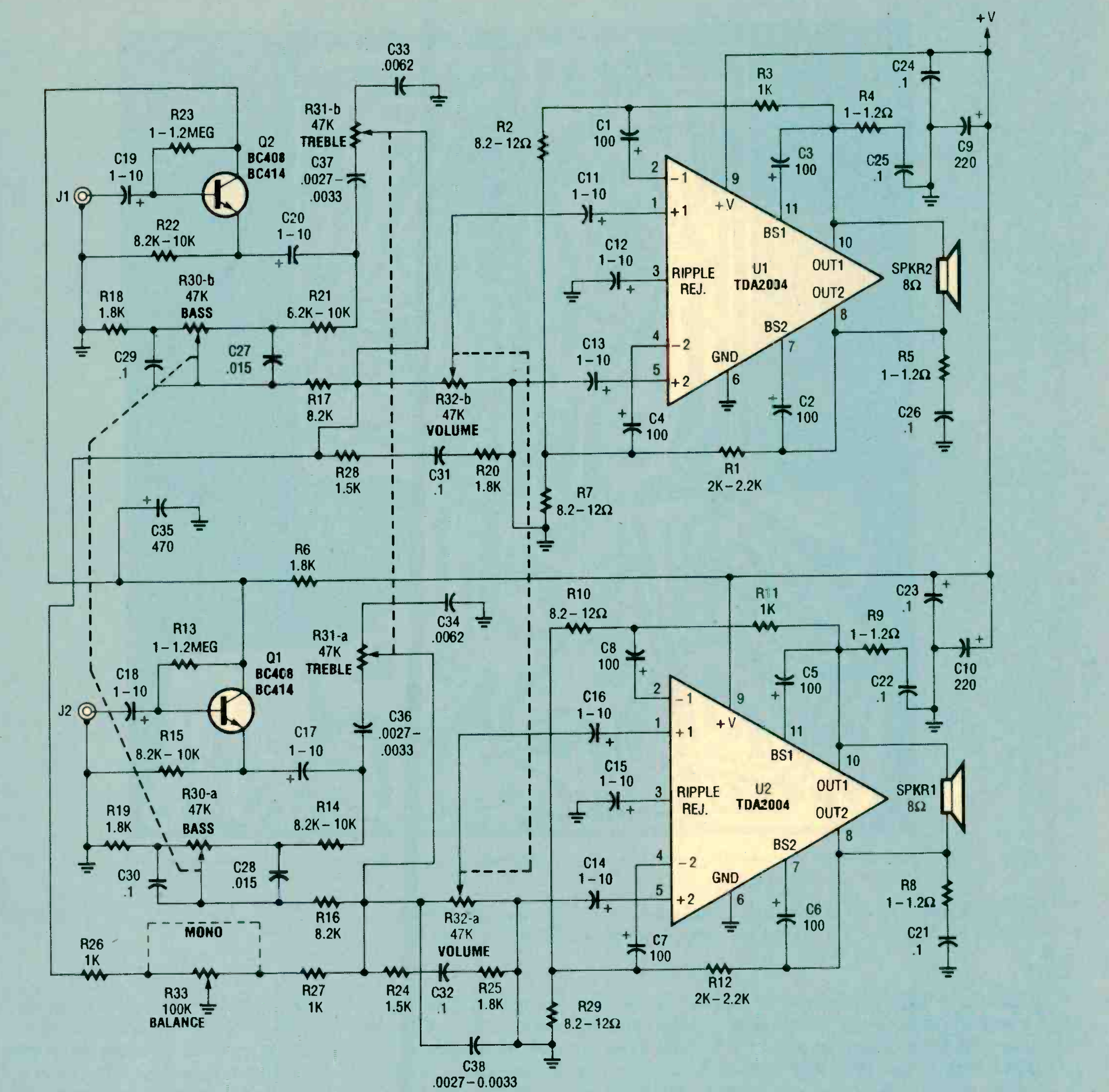


Fig. 1. The 20-watt stereo-audio power amplifier is built around a pair of TDA2004 integrated amplifiers. It also has a pair of transistors with a few support components as a preamplifier.

two channels of the amplifier to provide a more natural-sounding audio output. If the circuit is to be operated in the monophonic mode, that potentiometer must be bridged out of the circuit.

The circuit—which can be powered from a 12-volt, 4-amp power supply—can be used with tuners, tape decks, CD players, etc. It has an input sensitivity of 300 mV/47k.

Construction. The easiest approach to building the amp is to purchase the TSM67 kit. That kit comes complete with a 5½- by 5½-inch printed-circuit board and all the components (including jumper wires) necessary to put the circuit together; it can be purchased from the supplier mentioned in the Parts List.

For those of you who like to "roll your own" projects, Fig. 2 shows a foil pattern for the audio-amplifier circuit board. Note that if you decide to etch your own board, it will be necessary to purchase the parts from a different supplier (the one mentioned in the Parts List will not supply the parts alone). If you cannot locate a supplier for the TDA2004, a direct replacement for that unit is available from your local RCA/SK distributor as SK9225. If you can't get the specified transistors (BC408 or BC414), they can be replaced by RCA/SK parts

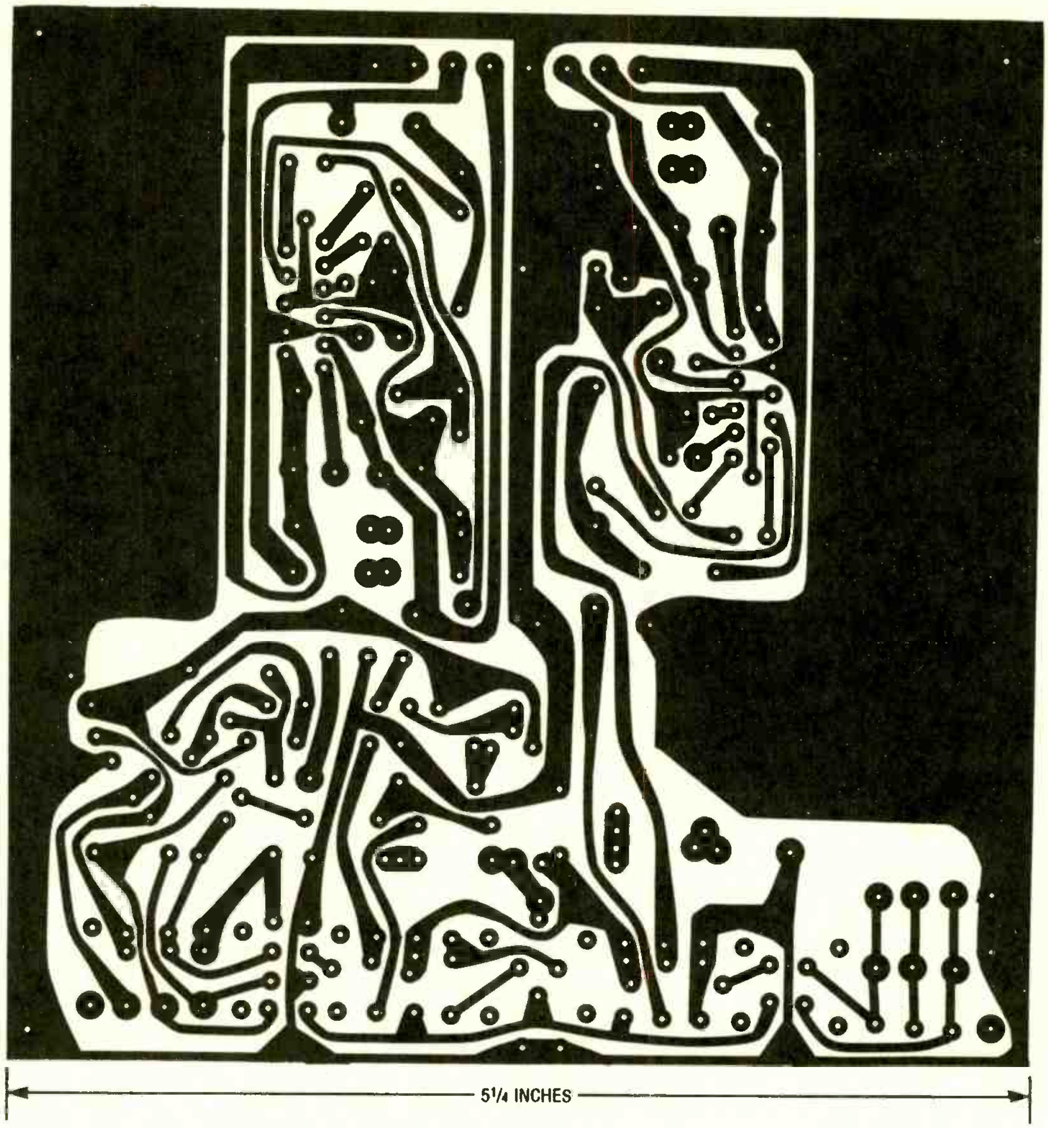


Fig. 2. The amplifier can be purchased in kit form (with all the components necessary to assemble the circuit), or you can etch you own board using the foil pattern shown here.

SK3444 or SK9459, respectively. All the other components are readily available from local as well as mail-order parts distributors. Note that where ranges of values are given, any value within the range will work.

Once you have the board and the parts, assemble the circuit using Fig. 3 as a guide. Begin assembly by first installing the jumper connections. (Note that several jumper connections are located under potentiometers; make sure that they are installed before the potentiometers are put in place.) Follow the jumpers with the passive components (resistors and capacitors), and watch the polarity of the electrolytic units.

Note that several areas of the board are set up for radial-lead capacitors. If you have axial-lead units, you will need to bend one lead flush to the body of the capacitor and mount it vertically. In a couple of places, where capacitors and resistors run parallel or perpendicular to each other, space is tight, and it will require some patience to get the components flush to the board.

Note also that the kit contains several capacitors that look very much like diodes. Use a magnifying glass to read the numerical capacitance codes on the body of the units. Interpreting the code is very simple: The first two numbers represent the first and second digits of the unit's capacitance value. The third digit is the multiplier. For example, if a unit is marked 104, its value is 10 followed by four zeros; that gives you the value in picofarads. So 104 means a capacitance of 100,000 pF (0.1-μF).

Next install the resistors and potentiometers. Note that several resistors—namely, R16, R17, R18, R26, and R27—must be installed vertically. All of the potentiometers, except R33, are dual PC-mount units; therefore, each requires a double set of mounting holes. Depending on the physical dimensions of the potentiometers, it may be necessary to bend the leads of the potentiometers ever so slightly to fit the board. Potentiometer R32 is a special case; aside from the jumper connection that runs beneath it and its mounting to the board, two wire leads are brought from the board to the top of that unit. Be sure to connect them as indicated in Fig. 3.

After the passive components are installed (and the electrolytic capacitors are checked for proper orientation), install the transistors, being mindful of

(Continued on page 84)

JULY 1991

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A CHRONICLE OF CONSUMER ELECTRONICS

VOLUME 4,
NUMBER 7

Who Needs CD's?

ESOTERIC SOUND MODEL V-2 TURNTABLE. Manufactured by: Esoteric Sound, 4813 Wallbank Ave., Downers Grove, IL 60515. Price: $375.

We consider the compact disc to be one of the most important developments of our lifetime. You may feel that that's an exaggeration, but it isn't. The CD will be around for a long time—longer, we expect, than the LP was. It's done more to help people appreciate good music than anything else with the possible exception of the Sony Walkman. And the acceptance of compact-disc technology into our homes has opened the door for the penetration of such new technologies as CD-I (Compact Disc-Interactive).

However, (and there's certainly no consensus here at **GIZMO**) some of the best music ever recorded predates the CD by about 40 years—and a great deal of the material was recorded on 78-rpm records. We've been pleased by the amount of reissues on CD that have been released—some with better sound than the originals, some sounding inexcusably worse.

Our music collections include hundreds of CD's and LP's, and a relative handful of 78's—mostly picked up as collector's items (78's predate *us*, too)—that never made it onto an LP, never mind a CD. We couldn't really listen to the 78's—we had nothing on which to play them except for an old, unreliable record player. And if *that* broke, then we'd be completely out of luck: You just can't find any decent, affordable turntables that include a 78-rpm speed.

Well, that's not really true, because we found one! It's the model *V-2* turntable from *Esoteric Sound*. Actually, we found two: the V-2 and its little brother, the *Vintage*, which has fewer features than the V-2, but costs almost $150 less.

The V-2 doesn't play just 78's. It also plays your common 33⅓-rpm LP, 45-rpm singles, and four speeds near 78. (No, it doesn't play CD's!) We'll be honest, before we encountered the V-2, we thought that a 78 was a 78. We've since learned

CIRCLE 50 ON FREE INFORMATION CARD

that for as long as there has been electronic equipment, setting standards has been a problem. Most "modern" 78's were recorded for play at 78.26 rpm. However, many acoustic Victor label discs were meant for play at 76.59 rpm. Other discs—Berliner, early Victor, Zonaphone—were meant to play at 71.29 rpm. Yet another speed—80 rpm—was used for Edison, Pathe vertical, acoustic Columbia, and Okeh discs.

To make things even more difficult, some discs were cut vertically (into the disc), while others were cut laterally (across the face of the disc). And you thought that we had trouble today with competing VCR formats! Today's (yesterday's?) stereo LP's are a combination of the vertical and lateral techniques.

Besides playing all the fixed speeds we mentioned, the V-2 features a variable pitch control that can be used for finer (±8%) adjustments. An option is available (for $22.50) that will allow you to play vertically cut discs as well.

The V-2 comes equipped with a standard P-mount head shell. Although a cartridge and stylus are not included in the basic price, our evaluation unit arrived with a Stanton 500EL cartridge with elliptical stylus, and a Stanton D5127 stylus for 78-rpm records. Other styli are available from Esoteric Sound. For example, while the D5127 stylus has a radius of 2.7 mils (0.0027 inch), custom styli for 78 rpm records are available with radii of 2.8, 3.3, and 3.5 mils. The reason for the different styli is a very practical one. As you might expect, most 78's are quite well worn from being played often over the years. However, it's unlikely that all depths of the groove are equally worn. By using styli with different diameters, you can often play above or below the worst wear to get a significantly cleaner sound—that you can then put on tape and store the original away to preserve it.

Since the same stylus cannot be used for playing all records, you're going to find yourself switching styli often as you switch from 78's to LP's. To minimize the possibility of damaging a stylus, we'd recommend using a separate headshell for each—especially since the V-2 provides a built-in holder that keeps the headshell out of harm's way under the dustcover (which is included with the turntable).

(Continued on page 7)

TURN PAGE FOR CONTENTS

This month in GIZMO®

Esoteric Sound V2 Professional Restoration Turntable .... pg. 1

Nikkodo CD-G100 Karaoke CD + G Player .... pg. 2

Cobra Intenna Plus CP-490 Cordless Phone .... pg. 3

Sharp VL-I510U Full-Size VHS Camcorder .... pg. 4

Kawai FS680 Personal Keyboard .... pg. 5

Laser Computer PC4 Portable Computer .... pg. 6

Ford Continental Communications Concept Vehicle .... pg. 10

Anti-Theft Car Stereo .... pg. 11

Compact Video Editor .... pg. 11

Portable Video Game .... pg. 11

TV/VCR Combination .... pg. 11

CD/FM Interface .... pg. 12

Cellular Antenna .... pg. 12

On-Cam Mixer .... pg. 12

PC Poker Game .... pg. 12

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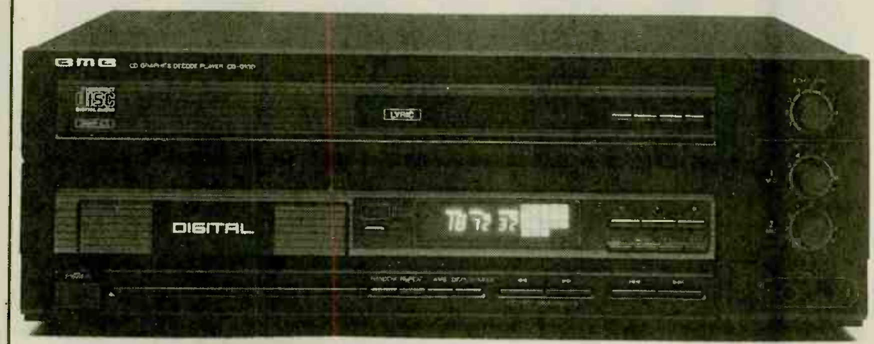

CIRCLE 51 ON FREE INFORMATION CARD

Follow the Bouncing Ball

CD-G100 KARAOKE SYSTEM. Manufactured by BMB/Nikkodo USA, 4600 North Santa Anita Avenue, El Monte, CA 91731. Price: $999.

Music has been a part of human culture for longer than we can know: It certainly predates written history. Across time and continents, song has been a powerful force, playing important roles in religious rituals and social events, and enhancing the storytelling that was the principle means of teaching people about their heritage and of imparting the practical information they needed for survival. As recently as the 1960's, music was credited with having a significant impact on the counter-cultural movement (remember the phrase "*tune in*, turn on, drop out"). And "Sesame Street" is a prime example of how music is being used today to educate our children.

Beyond its cultural significance, singing remains popular around the world for one basic reason—it simply feels good. Whether you do your warbling in the privacy of your shower, sing along to favorite songs on the car radio, put your child to bed with a lullaby, or go out Christmas caroling with friends, singing tends to put a smile on your face. Unless you have at least some semblance of talent, however, it can wipe the smile off the face of anyone within hearing range.

Karaoke is intended to allow anyone to belt out their favorite tunes, in public, and sound good doing it. In Japanese, the word "karaoke" literally translates to "empty orchestra." In real life, it translates to an assortment of audio/video devices that provide the background music and backup vocals to popular songs and allow regular people to sing their own lead vocals. To help the novice singer sound like a pro, karaoke equipment often offers such features as key adjustment and echo sound effects.

Karaoke is a real newcomer if you consider it in terms of the history of song—but in terms of electronic entertainment, it's actually been around quite awhile. In fact, the first karaoke systems used eight-track cassette tapes! Today's systems range from simple hand-held tape players to all-digital, complete audio/video systems using laserdiscs. Karaoke has been a popular form of entertainment in Japan for a decade or so, particularly among middle-aged businessmen, who unwind by gathering in karaoke "bars" where they can have a few drinks and pretend to be Frank Sinatra (whose songs are the most popular numbers in Japanese karaoke bars). With some aggressive marketing on the part of Japanese manufacturers, karaoke's popularity quickly spread throughout the Far East and Indonesia—in fact, software is available in Chinese (Cantonese, Taiwanese, Beijing, Fujian, and Guangdong dialects), Korean, Thai, Indonesian, Tagalog (the main Indonesian language of the Philippines)—and, of course, English.

It's only in the past year that karaoke started to catch on in the United States, and it seems to be growing quickly. As of January 1991, 2,000 bars, clubs, and other entertainment spots had installed karaoke systems. Even some restaurants—including the Shakey's Pizza chain—have jumped on the karaoke bandwagon. Clubs like New York's Singalong, where $10 buys you a videotape of your performance, Chicago's The Baja Beach Club, and Los Angeles' Crooners generally have an MC to announce the vocalists and keep the action moving.

For those who aren't into the bar scene, there are several systems that allow you to have your own private sing-a-long parties at home. Specialized stores have begun to spring up to meet the demand for consumer karaoke—which, according to the shop in our neighborhood, is primarily for the relatively inexpensive tape-based systems. There is quite a selection of karaoke cas-

(Continued on page 7)

Cordless Gramma-Phone

INTENNA PLUS MODEL CP-490 CORDLESS PHONE. Manufactured by Cobra Electronics Group, Dynascan Corporation, 6500 West Cortland Street, Chicago, IL 60635. Price: $159.95.

We've never been big fans of cordless telephones. Granted, the freedom of movement they offer is a big plus, but that was outweighed by the minuses—lack of privacy, poor sound, background noise, and, of course, lost handsets. It seems we're not alone in our complaints, either. According to a 1989 poll taken by *Consumer Reports* magazine, almost a third of cordless-phone owners were dissatisfied with at least some aspects of their phones. Two out of five people surveyed had run into trouble with static and interference, and one in four reported poor reception at one end of the line. Four separate problems were reported by one in six cordless-phone owners: operating ranges less than those advertised, batteries that run down too quickly, false ringing, and phones picking up other conversations.

Most of those problems stem from the internal "walkie-talkies" used for communications between the base and the handset of cordless phones. The conversation is carried on radio waves, which are subject to all sorts of interference, including the RFI, or radio frequency interference, generated by typical household appliances—refrigerators, televisions, computers, and even fluorescent lights. Like other kinds of radio broadcasts, cordless phone conversations can be picked up by anyone who's tuned into the same frequency. Under the right conditions, the conversation can be inadvertently overheard on other cordless phones, intercoms, baby monitors, or even an FM radio. Of course, there also are those who eavesdrop intentionally, using scanners.

Despite those problems, cordless phones continue to be popular consumer items. The Electronic Industries Association estimates that at the beginning of this year, more than a third of American households had cordless phones. That might not sound like many, but it's not far behind the 39% of homes with answering machines (a device we thought *everyone* considered essential), and in real numbers it translates to well over 31 million homes. So, does that mean that there are more than 10,000,000 "somewhat dissatisfied" consumers out there?

Actually, manufacturers listened carefully to those complaints, and have successfully addressed many of the problems. Those improvements are certainly evident after a couple of months spent using the *Cobra Model CP-490 Intenna Plus*.

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"Intenna" refers to Cobra's unique internal handset antenna—there's no telescoping whip to break off when you walk through a doorway, or to knock all the glasses off your kitchen counter when you turn around too quickly. (The base unit does have a standard telescoping antenna.) While some previous Intenna models suffered from background noise and short range, the CP-490 incorporates "clear call plus" circuitry, which includes a compander IC to reduce transmission noise.

What that all comes down to is that when we used the CP-490 as we would a standard phone—in the same room as the base—absolutely no one we spoke to had any inkling that we were speaking on a cordless phone. Even as we moved through other rooms and outdoors, we were told that the sound quality didn't suffer. While we did experience occasional minor interference, people who thought we were using a regular phone also thought they were hearing "regular phone line interference." When we got toward the end of the Intenna Plus' range—about 300 feet, in our tests with the base unit on the second floor of a building and the handset outdoors—the static increased dramatically.

While there is still some audible interference from electrical appliances (and here at **GIZMO** we have quite an assortment of them!), for the most part it was fairly unobtrusive and only mildly annoying. There appeared to be some "hot" spots, both indoors and out, where the static was always apparent. When walking around, however, it wasn't very noticeable. We couldn't comfortably use the phone when sitting directly in front of one of our computers—admittedly a horrendous source of RFI because its cover is never on as tightly as it should be. And the only truly terrible interference, which actually sounded like screeching feedback, resulted from talking on the cordless phone while sitting at that computer as it was receiving an incoming call on its modem—another prolific source of RFI.

To prevent interference from other cordless phones—including "false rings"—Cobra has added a "secur-loc" feature, which prevents the base unit from receiving transmissions from any other handset when its handset is in the charging well. In addition, the Intenna Plus has digital security coding to help eliminate interference. A digital signal is sent between the base and the handset whenever you dial out or receive an incoming call. Neither piece will accept transmissions unless it recognizes the other's matching code. (You can select your own codes by setting a small switch on one piece in one of three positions, and setting the switch on the other piece to match.) To prevent the code from being accidentally changed, on the base, the switch is recessed into the right side and is covered by a piece of plastic; on

(Continued on page 8)

Zooming In!

SHARP VL-L510U VHS CAMCORDER. Manufactured by: Sharp Electronics Corporation, Sharp Plaza, Mahwah, NJ 07430-2135. Price: $1749.95.

In Japan, mini-camcorders have always held the dominant market position, while Americans have favored the full-size VHS format—until now, that is. The latest numbers available as we go to press show that sales are now running 51.3% for small-formats (8mm and VHS-C combined) to 48.7% full-size VHS. But you shouldn't think that the full-sized camcorder format is doomed—far from it, for a number of reasons.

One major advantage is the convenience associated with the use of full-size video tapes. They're always easy to buy, and they don't require any adapters for viewing on a VCR. That means that you don't have to transfer from compact tape to standard size when sending videos of the kids to Grandma, and you don't *have* to use your camcorder to play back tapes. When you go on vacation, you not only can watch the day's taping as soon as you get back to your motel room, you can even use it to watch rented tapes should you run into a stretch of bad weather. The other advantage is, of course, that the quality of videos made with full-size camcorders is often superior, since the larger units are much easier to hold steady.

The "big" drawback (pun intended) is the inconvenience of lugging around a large, heavy piece of video equipment. But most people don't use their camcorders only on vacation (at least, we hope not, since most of us don't get away more than a couple of times a year!). And if you're filming a birthday party in the family room, or a backyard barbecue, the steadiness of a full-size camcorder "outweighs" its bulkiness. In fact, we suspect that a fair percentage of those Americans who are now buying mini-camcorders already own a full-size unit, and are buying the second specifically to use when they don't want to carry any extra weight—but still plan to use the big camcorders when they want to be sure to get a steady picture.

One camcorder that's likely to help the full-size format hold its ground is the *Sharp VL-L510U*. It offers something we've never seen on a camcorder before: a 16× zoom—the highest fully optical zoom ratio available in home equipment. It's hard to appreciate how impressive that is without actually looking through the viewfinder.

As with any other feature, the 16× zoom is open for a lot of abuse. Most amateur videographers tend to zoom too much as it is. Give them a 16× zoom, and the temptation will be just too much to resist. While the zoom does let you get nice close-up shots, it gets hard to watch wide-to-tele views over and over again. That's why we like the zoom-limit switch on the Sharp unit, which lets you set the maximum zoom to 6×, 10×, or 16×.

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As you increase the zoom, it can get difficult to hold any camcorder steady—even small motions are magnified. That's where the full-sized camcorders show one of their strengths. Since the back of the camcorder (and most of its weight) rests on your shoulder, it's much easier to keep the unit steady, and to pan scenes smoothly. It's still a good idea to use a tripod; but even without one, you should be pleased with the steady picture.

The speed of the zoom can be a pretty fast 6 seconds, or a leisurely 20 seconds—according to Sharp—depending on how hard you press the telephoto and wide controls. We were able to slow the zoom to as much as 35 seconds with a very light touch, although we admit that it was difficult to do so.

Although the 16× zoom is what makes the VL-L510U unique in the market, the camcorder does have other impressive features. Five shutter speeds are offered along with the standard 1/60 second: 1/100, 1/500, 1/2000, and 1/10000 second. When the "High Speed" button is pressed, the camcorder automatically switches from the normal 1/60 second to the highest 1/10000. Each additional press reduces the shutter speed.

With the standard shutter speed, a low-light sensitivity of 3 lux lets you shoot in all but the darkest situations. (As shutter speed increases, the minimum lighting necessary increases.) For those darker situations, you don't have to settle for dark, grainy videos—just hook up the supplied video light. Using the light, of course, shortens the battery life dramatically. (The camcorder uses about 60% more power when the light is on.) To help, the camcorder offers a sync mode that turns the auxiliary light on only when you need it—when it's dark and you're actively recording. When the lighting returns to a level that is bright enough, the light doesn't shut off automatically. It will, however, shut off when you return to the pause mode. When you again begin recording, it will turn on only if the ambient light demands it. If you prefer, the light also has manual on and off modes.

Even though we have quite a bit of experience with a wide variety of camcorders, we usually prefer to use an automatic mode unless particular shooting circumstances dictate that we can't. The VL-L510U offers a full auto lock that prevents you from changing any of the adjustable controls. When you remove the lock, everything still remains in the auto mode until you change one of the settings. The settings that you don't change remain in the auto mode, however.

Usually, some manual adjustments become necessary. Auto focusing is usually the first to go, because there are so many situations that can fool it. Unfortunately, we normally discover that we're in such a situation in the middle of shooting a scene. Usually we try to fumble for the auto/manual focus switch as our picture shakes uncontrollably. Other times we stop recording, switch to manual, and begin again. Yet other times, we've lived with out-of-focus spots as we waited for the auto focusing to again find the subject in which we're interested.

(Continued on page 8)

Chopsticks to Chopin

KAWAI FS680 PERSONAL KEYBOARD. Manufactured by: Kawai America Corporation, 2055 East University Drive, Compton, CA 90220. Price: $399.95.

Do you wish—with the benefit of adult hindsight—that you had heeded your parents' advice to stick with those piano lessons for a few more years? We're sure that there are a lot of folks out there who let the softball team lure them away from music lessons, and many others who had to stop the lessons when financial or educational responsibilities took priority.

We fall into the latter category. We have some musical education, but not enough to feel confident discussing music with "real" musicians, and certainly not enough to even think about "jamming" with musicians. Yet when we listen to music, we're always jamming in our heads, as we mentally compose musical ideas and riffs that we'd like to try ourselves ... but we can't. We don't have the formal training to do it. But that doesn't mean that we've given up our dream of creating good music.

Kawai seems to have had people like us in mind when they developed the *FS680*. Called a "personal keyboard," the FS680 lacks some of the features of Kawai's professional line. But what it does offer is remarkable: 100 sounds, 100 different rhythms, and 66 full-size keys, 17 of which are programmable "one-finger adlib" keys that make the keyboard something that almost anyone can play—and sound good doing so. Kawai calls the FS680 a "keyboard for people who can't even pick up *Chopsticks*." It lives up to that billing.

The 100 sounds offered by the keyboard range from acoustic guitar to vibes, from bagpipes to xylophone. To select a sound, you press a "sound" key (one of 39 small rubber buttons above the keyboard). A three-digit LED display indicates which sound is currently selected, and four "selector" keys can be used to scroll to another selection. (To minimize button-pushing, two keys add or subtract 10, and two add or subtract 1, from your current selection.) The sounds that correspond to the selected numbers are printed on the panel above the keyboard for easy reference. So, for example, if the display indicates "36" when you press the sound key, a glance at the chart will indicate that the current sound is that of a pipe organ.

Once you've selected your sound, you're ready to play the FS680 as you would any other keyboard. You don't have to worry if you don't have a band to play with—you can call one up with the touch of a few buttons. If you need only some rhythm accompaniment, you simply select one of the built-in rhythms in a similar manner as when selecting the sound: You hit the "rhythm" button, and then use the four selector keys to pick the rhythm you want. The rhythms that correspond to the number shown on the LED display are also printed along the top of the keyboard.

Choosing which rhythm to use to back up your playing is more difficult than actually selecting it—the choices range from ballet and waltz to reggae and salsa, from be-bop and bluegrass to polka and pop disco.

You can add more than percussion accompaniment. If you put the keyboard in the auto mode, the lower 19 keys can be used to create a realistic ensemble performance even if you're not accomplished with your left hand. Simply press and hold a chord (even a single key can be used to play a chord) and you'll be playing good left-hand phrases. You can start and stop your performance with special flair, and add fill-in flair with the touch of a key. The tempo can be changed as well.

If you need even more help to sound like an accomplished musician, it's time to call up the "one finger ad-lib" mode. Once you're set up in this mode, you don't have to worry if you've never even seen a keyboard before—the seventeen one-finger ad lib keys let you sound like a pro. The lower keyboard automatically accompanies your playing, changing chords depending on the rhythm you've chosen, and the one-finger ad-lib keys (17 keys from G2 to B3) can be used to play pre-programmed riffs. You don't even have to worry about playing in key—even as the accompaniment changes chords, the one finger ad-lib riffs change to keep on key. It's *possible* to sound bad, but even if you have no sense of rhythm, it's not very likely.

Playing the FS680 with auto accompaniment and one finger ad-lib is fun—and almost always sounds good. But it's not a challenge. We were anxious to put our past musical experience (none of it on keyboards, however) to work. And that's where we really found that the auto accompaniment and one-finger chords came in handy. We could set the tempo to as slow a pace as we were comfortable with, and then try our hand at playing melodies in key with different chord progressions. (Do *you* remember your scales?)

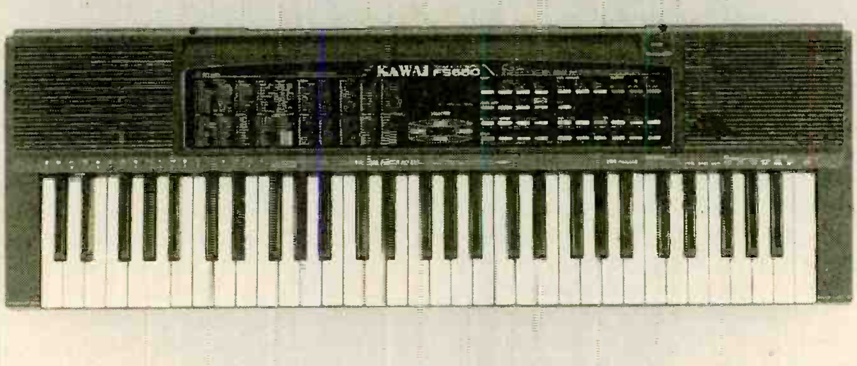
The sounds that the FS680 makes aren't synthesized as much as they are recorded. The sounds of actual instruments are "sampled" or recorded in 16-bit digital audio and stored in memory. However, you can manipulate the sounds to synthesize new ones. Five of the 100 sounds available can be created by the user. You can vary the level, attack, sustain, decay, and release of each sound. Once you store your new sound, you can use it as you would any other.

Just as you can create your own sounds, you can create your own rhythm and accompaniment patterns, including rhythm, bass, and chords. You can build your accompaniment from scratch if you wish, or modify one or more of the elements of a preset pattern.

The rear panel of the keyboard offers a headphone jack, AC-adapter input (the keyboard runs on 9 volts DC as supplied by 6 "C" batteries or an external adapter), and two jacks for sustain pedals (one for the accompaniment and one to act as a standard piano sustain pedal). RCA jacks are also provided so that you can hook the keyboard to other audio equipment such as your stereo system. For the greatest versatility, the FS680 is compatible with MIDI, the musical-instrument digital interface. MIDI in and out (but not thru) jacks are provided on the rear panel. Using the MIDI ports lets you connect the FS680 to other similarly equipped electronic instruments, computers, sequencers, and the like.

We had a lot of fun with the FS680. Our major complaint was that the 3-digit LED display isn't really adequate. As you switch modes, the display often prompts you for inputs using crude alphanumeric characters. Seven-segment displays just do not display letters properly—especially when the prompts flash by very quickly.

(Continued on page 9)



CIRCLE 54 ON FREE INFORMATION CARD

CIRCLE 55 ON FREE INFORMATION CARD

Tag-along Computer

LASER PC4 PORTABLE COMPUTER. Manufactured by: Laser Computer, Inc., 800 North Church Street, Lake Zurich, IL 60047-1596. Price: $249.95.

It's an unfortunate fact of life for many of us that our work follows us home from the office—and even tags along when we're on the road. Although we're resigned to the situation, we're determined that it should be as easy as possible. For example, if we're going to have to carry a computer around with us, it might as well not break our back—or our pocketbook. That's what first attracted us to the *Laser PC4*. It weighs less than two pounds and costs less than $300.

That sure beats spending several thousand dollars on something that weighs three or four times as much, right? Well, sometimes; as with any other computer equipment, *it depends on your application*.

The PC4 comes with 11 built-in applications: a word processor, spreadsheet, spelling checker, calculator, telephone directory, appointment book, alarm clock, expense-account manager, personal file, utilities, and the BASIC programming language. We added another application, Roget's Electronic Thesaurus, by plugging an optional cartridge into the unit's one available expansion port.

The PC4 is ready to go as it comes out of the box: simply insert 4 "AA" batteries or plug in the AC adapter—or preferably both to protect against the loss of power. When you turn on the computer (a small slide switch is located on the side of the unit) it comes up with a message "32 K RAM OK." Of course, if you have additional RAM—a 128K memory upgrade is available for about $40—an appropriate message will be displayed.

Following the memory check, the main menu is displayed. You can see only the first six choices on the 4-line by 40-character display, but of course you can scroll to see the remaining options. That may not seem like a very large display—and it isn't. But it's not fair to compare the PC4 to what we're used to working on (a standard 24-line by 80-character display.) After all, the PC4 obviously isn't trying to be a PC-compatible computer. And we should judge it in that light, not as we would a full-size or PC-compatible laptop. So, is the display big enough for what the PC4 is trying to be? Maybe.

We used the laptop primarily to create text files while we were on the road or when for some other reason we couldn't be tied to our desktop computers. For stream-of-consciousness writing, it did fine. But, like usual, we didn't even glance at the screen as we were typing. Going back to re-read what we'd typed thus far was easy. The characters are about ¼-inch high, so even though they don't have true descenders (the bottom part of a "p" or "g" that extends below the line), they were more than legible. But trying to edit the copy was quite difficult, mainly because you can't see enough at one time. (For example, this sentence and the previous one are too long to fit on the screen at the same time.) We imagine that moving blocks of type would be quite difficult—that's probably why the word processor doesn't give you the capability to do so. We found ourselves waiting to get our files on a desktop computer before trying to polish them up.

The spelling checker can be used independently or with the word processor. One feature we liked, although it's not available from inside the word processor, is the ability to select one of three search levels: high school, business, and college. The high-school level is the fastest of the three, but does the worst job in making suitable spelling guesses.

The calculator mode turns the PC4 into a minimum-level scientific calculator. Standard trigonometric functions are offered, (but only the inverse tangent function), as are logarithms. Ten memories are also featured.

The telephone directory lets you store up to five lines of data for every name you enter. You have to be careful when inputting the data; once they're stored, they can't be changed without deleting the entry and re-typing it from scratch. You can print out a complete "telephone book," or mailing labels (without the phone numbers) if you prefer. You can dial any of the numbers using the built-in tone dialer—A speaker is located on the bottom of the PC4.

The personal-file program acts just like the telephone directory except that you have better line-by-line editing capability. It doesn't have any auto-dial or label-printing capability, however.

On business trips, either the telephone directory or the personal-file program can be used each evening to input the names, addresses, phone numbers, etc., of the new contacts you had made that day. Once you got back to the office, you would have quick access to that information to add it to your phone book, or for sending out follow-up letters.

The appointment-book feature lets you record and keep track of upcoming appointments—it even has an alarm to remind you of your duties. You can also print out a list of your appointments if you wish.

The alarm-clock mode can also gently prompt you into action. Up to 16 different alarms can be set, and weekly and daily alarms are possible. Even if the computer is turned off, it will still alert you with a gentle beeping at its appointed time.

An expense-account program is a necessity for business travelers. The PC4's program lets you input, sort, and print out your expenses. Built-in expense categories include food, lodging, transportation, miscellaneous auto, entertainment, and telephone expenses. However, you are free to add additional categories and sub-categories. Three types of reports are available: Day, Week, and Complete.

A spreadsheet program, which is compatible with Lotus 1-2-3, is a handy tool for extended sales trips. When you return to your home base, you can upload the Lotus-compatible files to your PC, but to

(Continued on page 9)

WHO NEEDS CD'S?

(Continued from page 2)

Esoteric Sound calls the V-2 a "professional disc restoration deck," and it offers many features that justify the name. Its little brother, however, is geared more toward the non-professional collector. For example, while the V-2 (a retrofitted Gemini turntable) features a direct-drive motor, the Vintage (a retrofitted Technics turntable) is belt-driven. The wow and flutter specs (0.025 as compared to 0.045) show the difference between the two. The V-2 offers a calibrated tracking-force range of 0–3 grams, while the tracking force for the Vintage turntable is determined by the cartridge you install. Similarly, the anti-skating force is adjustable from 0–3 grams on the V-2, while it is not adjustable on the Vintage. The V-2 offers an XLR lamp output on the deck top and a solenoid break for instantly stopping the turntable, while no such options are available for the V-1. A cuing lever and motor-start switch are standard on the V-2, but they add $15 to the cost of the V-1.

We were generally impressed with the V-2—mostly because it made it possible for us to listen to the discs we had collected over the years, without fear of damaging them. It's not a turntable for everyone, however. Because it's a fully manual turntable (the Vintage is semi-automatic), you have to cue-up every selection, and remove the needle from the surface at the end of the disc. For CD-converts, accustomed to remote-controlled listening convenience, that can be disconcerting. For true collectors, however, that is a minor obstacle to listening enjoyment. And, for those who grew up with 78's, it's possible that the extra hands-on operation would be pleasantly nostalgic. Anyone who wants to be able to listen to even their oldest records should be glad that this versatile and affordable, if not perfect, turntable exists. ■

FOLLOW THE BOUNCING BALL

(Continued from page 2)

sette tapes currently available, priced at about $13. Generally, one side of the cassette contains complete songs with vocals (but not by the original artists) so that you can become familiar with the melody, and the second side has the same selections minus the lead vocals.

Consumer karaoke equipment runs the gamut from a basic under-$100 cassette player with a microphone input, to laser/compact-disc combi players with built-in amps, cassette decks, multiple mic inputs, and all sorts of sound effects that are priced well over $1000 and that play special karaoke discs. In between are tape-based karaoke machines with various combinations of features. CD players that will actually mask up to 85% of the lead vocals on standard compact discs, and CD + G (compact-disc + graphics) karaoke machines. While we've had the chance to experience karaoke bars in Japan, our first experience with a home karaoke system was with a CD + G-based machine, the *CD-G100* from *Nikkoko*.

In case you haven't heard of CD + G, we'll give you a quick rundown. A conventional compact disc can hold a lot more digital data than is required for 70 minutes of the dozen or so songs that you hear and the necessary tracking information. Some companies, notably Warner New Media, have begun using that empty space for graphics—generally still images mixed with song lyrics. Unless you have a graphics decoder, such discs are no different from standard CD's. In fact, you might even have some CD + G discs in your collection without being aware of it. We found that Lou Reed's "New York" was a CD + G only after quite a bit of searching. The only indication was on the disc itself: The distinctive "compact disc digital audio" logo that appears on all CD's included the word "graphics" directly underneath it. Until we hooked up the CD-G100 to our audio/visual system, we were unable to view the graphics.

Similarly, when you're not using it for karaoke, the CD-G100 works the same as any standard CD player, and offers some of the features you'd expect to see on any CD player: remote control; a display that shows time elapsed, track number, and time remaining; programming options including standard play, repeat track, automatic track scanning, random play, and random-access programming.

According to the Nikkodo press kit, the basic requirements for karaoke are microphones (to amplify the singers' voices); a digital key controller (to adjust the key to fit the singer's voice range); and an echo processor (to "give the singer's voice recording-star quality" by creating a reverberating sound from the microphone). The CD-G100, although it is billed as a high-end karaoke system, is missing one of those three basic requirements: It has no key controller. (It does, however, have input/output jacks for adding one—a $399 option we didn't have the opportunity to test). The CD-G100 does have inputs for two microphones, and includes a digital-echo processor.

When used with karaoke CD + G discs, the instrumental-only versions of popular songs, the CD-G100 displays the song's lyrics on the monitor. Other than the lyrics, the screen is blank, unless you add your own video from another source (the CD-G100 lets you choose one of three inputs). The singer is cued, line by line and word by word, as the words to be sung are highlighted in time with the music. The digital-echo processor can give a weak voice some added presence, but can't do anything about off-key singing. And the karaoke CD + G discs don't include any versions of the song with the vocals included (as do the karaoke tapes)—so unless you already know the song well, it's anybody's guess what the vocals are supposed to sound like.

Nikkodo initially supplied us with two karaoke CD + G's for our tests. Perhaps we're living in the musical dark ages, but out of the 38 total songs on the two discs, we were vaguely familiar with only about half, and knew the melody line of only three or four.

We did our best with those but we're definitely not professional-class singers. And because the CD-G100 offers no way to adjust the key of the song to match the singer's range, the few songs for which we did know the tunes sounded awful when we tried to sing them.

At that point, we decided to splurge and buy a disc with more singable songs. Unfortunately, we quickly discovered that CD + G karaoke has not made inroads into the karaoke market yet; our local karaoke store, which stocks hundreds of karaoke tapes and intends to begin carrying laser karaoke in a few weeks, had never heard of CD + G. Neither have any of the local music stores. We called Nikkodo to find out where we could buy some CD + G discs, and learned that the company is still in the initial marketing phase, trying to educate dealers and retailers about this karaoke format. Therefore, it could be quite some time before the discs—or, for that matter, the CD-G100—are readily available to the public.

Our call to Nikkodo did result in their faxing us a list of some 20 English-language CD + G's that they have on hand (they have selections in more than 20 languages). The songs included country classics, old standards from Sinatra and Crosby, disco tunes from the 70's, and rock ranging from Elvis to Bon Jovi. We selected three discs that included some classic 1960's rock: Beatles, Rolling Stones, and Simon and Garfunkel. We hate to admit it, but the songs we sounded best on were old Monkees' hits—at least they were simple enough not to strain our limited range.

We did quite a bit better with the new discs—and had a good time doing so. As a matter of fact, once you loosen up and start getting into it, it's hard to relinquish the microphone to the next would-be singing sensation. The CD-G100 is intended to work with your existing audio/video system, and it's aimed at sophisticated consumers. The fancier your existing setup, the more elaborate you can make your singing experience. In fact, CD + G karaoke offers something special: It allow ambitious folks to make their own karaoke music videos. For example, you could go down to the beach and shoot some surfing footage, come back and play a Beach Boys CD + G karaoke disc along with it, and record the whole thing on a videotape.

Incidentally, when a second video source is used, the lyrics from the CD+G move to the bottom of the screen so as not to obscure the picture.

In our limited experience, most of the videos shown as background in karaoke bars have little relevance to the song lyrics (they often just show pretty, generic images, like sunsets or flowers). So, we suppose you could use any favorite home video for background pictures and get results at least equal to, if not better than, that. The CD+G karaoke players are the only ones that grant singers enough artistic license to create their own images to accompany their vocals.

However, besides being able to sing well enough not to require key adjustments, the singer/video-director had better have an intuitive knowledge of how to hook up audio and video components. The manual that comes with the CD-G100 devotes 13 pages and dozens of illustrations to explaining basic CD-player functions—which are readily apparent, without consulting a manual, to just about anyone who's ever used a CD player. Unfortunately, the two very short paragraphs that are allotted to hookups are virtually useless. In addition, there's a connection diagram that shows such devices as a "BGV LD player" (which we suspect means a laserdisc player) and a "Key con" (which we suspect might be some sort of add-on key controller).

We had hoped that by connecting our laserdisc player to the CD-G100, we could play laser karaoke discs, which are available locally, and which would make the unit much more versatile. Unfortunately, the CD-G100 has no audio input, so that wasn't a viable option. We probably could have jerryrigged a working combination, but not without compromising the best features of the CD-G100. For portability, you can record your songs onto standard audio cassettes, just as you'd record from a standard CD player. (But you should not expect the manual to show you how to do that, either.)

The CD-G100 is the first CD+G karaoke we've seen, so we have nothing to compare it to other than "professional" laserdisc-based systems. Perhaps this is the way that CD+G (a format we've always been fond of) will be able to gain a toehold.

Since most laserdisc-based karaoke software has had pretty poor video accompaniment, the LD-G100 doesn't seem like too bad a bet. But if each format were to live up to its full potential—and be produced to fit American tastes—then the laserdisc format would win hands down. Our guess is that CD+G would have to be an almost no-cost add-on to a CD player to be successful (if that's possible). For now, however, we won't pretend to know what's the best format for you. We're taking—and suggest that you do, too—a wait-and-see attitude. ■

ZOOMING IN!

(Continued from page 4)

With the VL-L510U, we again found an advantage to the full-size camcorder. It's easy to keep shooting while you adjust the controls. Since the camcorder is resting on your shoulder, and not half-braced by the pressure of the eyepiece on your face, you can simply move your head away to the point where you can see the side of the camcorder and all its manual controls so that you can adjust them. While we'll admit that we couldn't do it without shaking the camcorder a *little* with the VL-L510U, with any mini camcorder we've tried, we couldn't do the same without shaking the camera a *lot*. Unfortunately, the Sharp camcorder's switches for the shutter speed, auto/manual focus, and white balance have very poor tactile feedback.

It took a while to get used to the manual focusing. Instead of an adjustable focusing ring, the camcorder uses a power focus system. Rather than a continuously adjustable ring, the focus adjuster is a three-position switch. The switch is operated by a ring in back of the lens—just where you'd expect the focus ring to be. Although it might sound that using it would be second nature, we found ourselves having trouble at first. We got pretty good at it, however.

The camcorder offers a number of other features. It can focus on objects as close as about ½-inch away (in the maximum wide-angle setting). A "record review" feature lets you review about the last 2 seconds of your recording. A date/time function lets you record the date, time, or both on your videos.

A self timer lets you record for 10 seconds (following a pause of 10 seconds so you can get in the picture). A light on the front of the camcorder blinks to let you know it's in the auto mode. Faster blinks let you know it's about to start. A second self-timer mode starts in a similar manner, but remains recording until it's turned off manually (which can be done remotely if you purchase the optional wired remote).

A special interval-recording mode is started in a similar manner to the self timer, but it records one second of video, and then pauses for 29 seconds, and repeats until either it's turned off or until 24 hours pass. We set the VL-L510U on a windowsill at 3 PM and then later watched the dramatic movement of shadows as the sun set.

A backlight-compensation button opens the iris up about 1 *f*-stop to improve the exposure of subjects who are in front of strong backlighting. When the button is released, the iris again closes to the value determined by its auto-exposure circuitry. (That is the only exposure control left to manual operation.)

A fade-in/fade-out control function lets you do smooth scene transitions. Both the audio and video are affected by the fade control.

The VL-L510U features a flying erase head so that you can insert edits without any transition noise. An audio-dubbing feature lets you add music or narration to a previously recorded tape without affecting the video on the tape.

Full-size camcorders aren't for everyone. Not every one would want to carry a 7.3-pound (with battery) camcorder around all day (even though the carrying handle and shoulder strap make it as convenient as possible to carry). And not everyone needs a 16× zoom capability. But for those who do, we find it hard to find any significant fault with the VL-L510U, although we'd like to have the ability to manually set the iris, and we'd like to see stereo VHS Hi-Fi capability. Its picture performance, ease of use, and 16:1 zoom, however, lived up to its $1750 suggested retail price. ■

CORDLESS GRAMMA-PHONE

(Continued from page 3)

the handset, it is hidden behind the plastic-covered window in which you display your phone number. Unless you're experiencing difficulty with interference from other phones, we'd suggest that you leave the switches in their original positions. (That falls under the "if it ain't broke, don't fix it" heading.)

Cobra's own market research uncovered the fact that more than one-third of all cordless phone sales are made to people who are over 50 years old. To attract that growing market, Cobra's designers took to heart two complaints commonly heard from seniors—that cordless phones are needlessly complex to use and that their dial pads are hard to see. The keys on the handset and the numbers and letters on the keys are larger than normal, and are backlit. The backlight goes on as soon as any button is pressed; if no other button is pressed within 10 seconds, the light goes out. (Seniors aren't the only ones to benefit from the larger sized keys—one of our testers, a woman with fairly long fingernails—reported that the keys were much easier for her to use than those on most telephones.)

Another feature aimed at seniors is a volume-control switch on the handset that amplifies the caller's voice. The CP-490 is fully hearing-aid compatible as well. For forgetful people of all ages, a pager button on the base activates a loud tone on the handset, so that you can locate it, wherever you might have left it. (Too bad no one's come up with a way for the handset to remind you to take it along *before* you've climbed to the second floor only to realize you left it down in the basement!)

In terms of complexity, the Intenna Plus is about as basic as you can get. Its only "special" features are two memory buttons, which are billed as "emergency dialing with one button operation" (presumably so that an elderly user could program in the numbers of their doctor and of a close relative to be used in a medical emergency), and a redial button. The direct-access memory buttons are very easy to program, and the manual avoids excessive use of technical terminology, which might scare off some users. In addition, the handset features a "talk" button that is used to initiate a call or to answer a call when the handset is out of the charger. (When the handset is resting in the base, there is no need to use the talk button to answer an incoming call or to disconnect when you finish talking.) Rounding out the handset are a tone/pulse switch and a button marked "flash" that simulates a hookswitch flash to allow you to switch back and forth between two calls if you subscribe to call-waiting from your local phone company.

Of course, what the Intenna Plus gains in simplicity, it loses in sophistication. Granted, at **GIZMO** we've become spoiled by devices with all the bells and whistles—but we would have liked to see a "hold" button, at least. Another feature we would expect to see, albeit one which probably wouldn't be missed by most people in the targeted market, is a replaceable telephone-line cord. The cord is hardwired into the base unit, instead of having a modular jack at each end. The Intenna Plus also lacks a jack for plugging in a standard extension phone at the base unit—not a standard cordless-phone feature, but one that certainly comes in handy for those of us who do tend to leave the handset in out of the way places, and find themselves madly dashing to pick up a call ... hey, wasn't avoiding that scenario one of the main reasons we needed a cordless phone in the first place?

One last complaint concerns the CP-490's "user-replaceable" battery. Our testers did just fine on "Remove the phone number display window and card" and "Remove screw in center of recessed area." But when they got to "At the top ... separate front from the back of handset by pressing down on top front section and carefully pulling these top sections apart," they were stumped. They pressed and they pulled, and they pulled and they pressed—eventually, they managed to pry the thing apart. (People who have experience taking apart molded plastic cases won't have too much trouble with that part.)

The directions continued, "Unplug the connector cord ..."—and a labeled diagram really would be helpful for those who are unfamiliar with the inner workings of electronic devices (assuming they'd managed to open the handset in the first place). The cord was also quite difficult to disconnect; someone who wasn't even sure if they were pulling the right wire would be likely to give up in frustration. We would hate to think what the process would be like for an arthritis sufferer.

On the plus side, the CP-490 is designed to extend the battery life between charges, so that you can keep the handset away from the base for several days. It is recommended, however, that you replace the handset in the charging cradle at the end of each day when convenient to do so. By the way, we didn't *need* to change the battery after two months of use; we just tried it so that we could write about it.

Actually, the pluses—clear audio quality, no telescoping whip antenna, ease of use, large backlit keys, and, of course, freedom of movement—far outweighed the minuses noted above. Of those common complaints noted in the *Consumer Reports* poll, we experienced only occasional, relatively minor, interference. Of course, we have no way of knowing whether some curious neighbor with a scanner has been monitoring our **GIZMO** gabs ... and, after two months, we still tend to leave the handset in out-of-the-way places. ■

TAG-ALONG COMPUTER

(Continued from page 6)

do that, you'll need to use the computer's utilities mode.

The utilities mode is used mainly for handling all of the input and output (file-transfer) functions and for configuring the I/O ports. It also allows you to determine how much memory is used by each function and how much is available. You can also delete data from other programs from the utility mode.

Transferring files between computers often is, for some reason, one of the most difficult concepts for most computer users to grasp. Since the PC4 would be of limited use without the ability to transfer files to "real" computers, it's a good thing they made it easy. Included in the PC4 package is PC Tools Desktop from Central Point Software. PC Tools Desktop is a "desktop manager" that offers such features as a notepad, appointment scheduler, database, calculator, communications program, keyboard-macro program, and the like in either memory-resident (pop-up) or standard stand-alone DOS mode. The main reason it's included, of course, is to make transferring files between the PC4 and your PC easy. (A Macintosh version is also available with the PC4.) While PC Tools isn't our program of choice for telecommunications, it does a good job here. (And it's nice to get the program essentially "free.")

In our experience with the PC4, it performed as it was supposed to with one exception: The keyboard was easily the worst "real" full-travel keyboard we've ever used. Bouncing characters during fast typing were the norm. "Rolling" from one key to the next (as you tend to do on those words you type most instinctively) caused the keyboard the most problems. Sometimes typing that way would cause a key to bounce two or three times, and sometimes keystrokes wouldn't be recognized. For example, our standard "test phrase" for determining how a keyboard feels would constantly come out something like: "This iss a ttesst o hee emerrgenccy broadcasst systtem." We almost started to get used to making sure we fully released one key before we struck the next—the way we used to type on our old Smith Corona manual typewriter.

We have to admit that we felt that we were in a bit of a time warp when we were using the PC4. We haven't programmed in BASIC (which is another capability of the PC4) since we discovered structured programming languages. And the last Z80-based computer we used was back in the days of CP/M! That's not to knock Laser's choice of processors—this machine would not benefit from a "higher-powered" CPU. We felt limited by the 4-line by 40-character display, but we did like the way the complete system was hardly noticeable when we carried it around in our briefcase.

In conclusion, if you want to run Windows on your lap, then forget about the PC4. But if you need a way to get data in electronic form when you're on the road—and you have only a few hundred bucks to spend—then you don't have too many options. If you're ready to accept its keyboard and display limitations, the PC4 can get the job done. ■

CHOPSTICKS TO CHOPIN

(Continued from page 5)

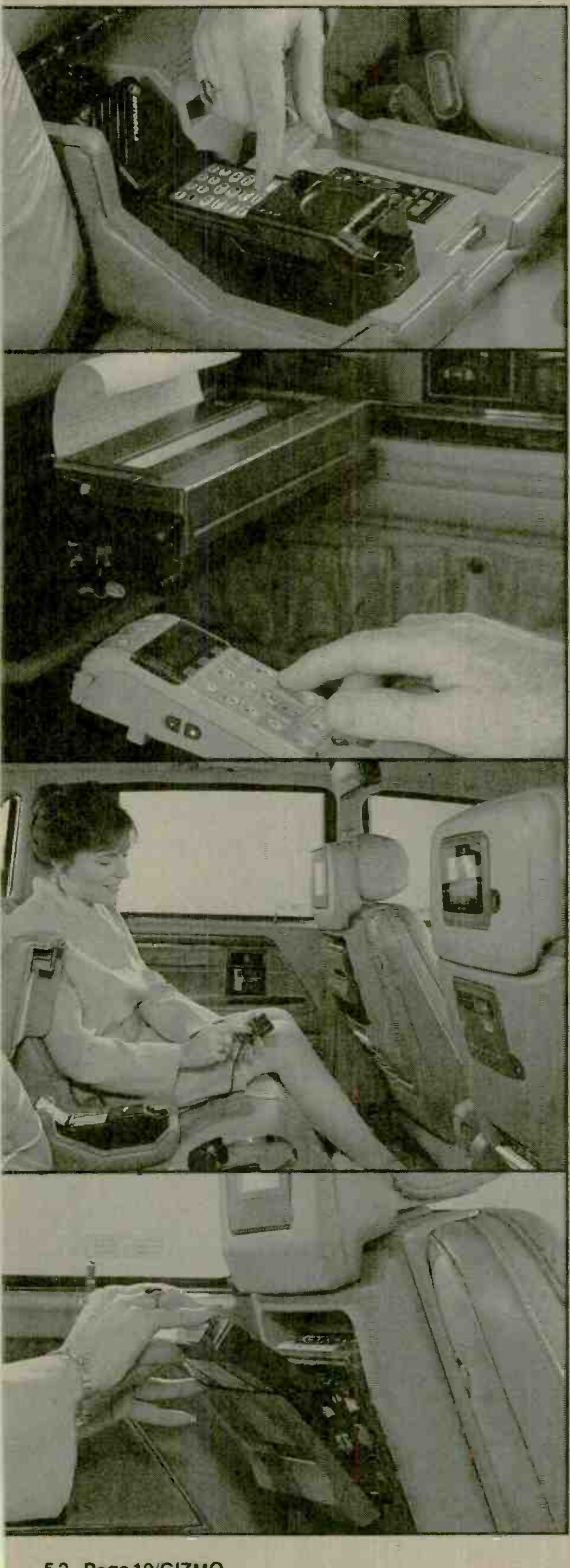
We would like to have seen separate displays to show which rhythm and sounds had been selected, and a clearer indication of what mode the keyboard was in would have been helpful.

Other than the poor display, we were impressed with how much was packed into the keyboard—we hardly mentioned any of its advanced features. In fact, aside from that display, the only qualities that make the FS680 unsuitable for professional use are that it isn't rugged enough to stand up to much abuse and its keys aren't touch sensitive—the keyboard produces the same sound no matter how hard you pound on the keys.

Then again, it is important to remember that the keyboard is not designed for professional use. Instead it's for people like us, who prefer the low-pressure environment of playing for ourselves or sitting in front of a computer programming a MIDI sequencer. For someone like that, it's hard to come up with a good reason not to recommend the FS680. ■

ELECTRONICS WISH LIST

For more information on any product in this section, circle the appropriate number on the Free Information Card.



Taking It (All) On The Road

Back in the 1960's, a picture of a typical upper-middle-class American family could realistically show Mom, Dad, Sis, Brother, and the dog gathered around the television enjoying *The Ed Sullivan Show* as a group. That picture has drastically changed for the 1990's family, who generally tend to "cocoon" separately—Mom in the family room watching *Dallas*, Dad in his study watching ESPN, Sis studying in her room with her Walkman on, and little brother in his room playing Nintendo games. If that image doesn't bring to your mind the fall of the American family, and the general decline of our values and our country, then you're ready for *Ford's Continental CCV (Communications Concept Vehicle).*

The CCV is a "mobile-engineering test bed," replete with the latest in electronic equipment, including a mobile fax machine, two cellular phones, three LCD television screens, one VHS and one 8mm VCR, two back-seat personal audio cassette players, and a main audio system with infrared remote controls and a trunk-mounted CD changer. Actually, the car isn't intended to discourage conversation between passengers. It's unlikely that anyone would opt for all those devices in one vehicle. Instead, the CCV is designed to explore and evaluate the various combinations of audio and video technologies in the automotive environment, and give consumers "an idea of what is possible when automotive engineering converges with consumer electronics."

At the heart of the display is a digital signal processing (DSP) system that allows the stereo system to simulate the sounds of different musical venues. With the push of a button, a studio recording can be transformed into a live performance as it would sound inside a small concert hall, an orchestra hall, a multi-tiered opera house, a large cathedral, a jazz club, or a sports stadium. With another button, listeners can electronically "change seats" within the venue, moving closer to or further away from the stage. DSP technology achieves those effects by manipulating the timing of the audio signal. Time delays, echoes, and reflections can be simulated electronically to replicate the acoustics of various venues.

A portable, pocket-sized cellular phone is concealed in the rear-seat arm rest (top photo). While in its cradle, the phone charges itself off the car's battery. Because it uses a different antenna from the front-seat phone, the two can be used simultaneously—in fact, the driver could use one phone to call the passengers on the other.

The driver's phone—which is mounted in the driver's side arm rest for privacy—is a special concept cellular phone that offers voice-activated operation as well as normal hands-free mode. When the driver asks the phone to turn itself on and speaks the name of the person to be called, the telephone, relying on a pre-recording of the driver's voice and the particular command, executes the call. The voice-activated system allows two users to each pre-program up to 20 different telephone numbers. Since it uses "speaker-dependent" technology, it can be taught to understand any accent or any language. For more conventional operation, the phone can be dialed manually and will store up to 99 numbers for manual speed-dialing operation. A glove-box fax machine, shown second from the top, is connected to the main cellular system.

Rear-seat passengers can watch TV or videotapes on any of three screens (third photo). One pulls down from the ceiling, and one each is mounted in the back of the front-seat headrests. Each of the seat-back-mounted television units is connected to a videocassette recorder/player (bottom photo). One uses the regular VHS format, and the other uses the 8mm format. According to Ford, the duplication of VCR's and screens is intended to show the flexibility of the formats, and to evaluate which technology is best suited for automotive use. (This is, after all, a concept vehicle.)

Below each VCR is a personal audio-cassette player. Two rear-seat passengers can listen to individual entertainment centers on wireless headphones.

The main audio center can be controlled from several points in the car, using infrared remote controls. The one located in front-seat arm rest also controls the main cellular phone. The stereo can also be controlled from a full remote-control panel in the back seat, or by using the controls mounted to the steering column.

Of course, we don't know how the Continental CCV drives—but even if it *doesn't*, we won't be bored waiting for the tow truck to arrive! Price: N/A ■

CIRCLE 56 ON FREE INFORMATION CARD

For more information on any product in this section, circle the appropriate number on the Free Information Card.

ELECTRONICS WISH LIST

Compact Video Editor

Dubbed "the industry's smallest and lightest consumer video editing controller," *Canon U.S.A., Inc.'s* (One Canon Plaza, Lake Success, NY 11042) *Canovision 8 VE-100* is only slightly larger than a remote-control, yet allows quick editing of video material with convenience features like four-scene sequential programming and remote-control capabilities. The VE-100 can memorize the cut-in points of up to four scenes, which can then be automatically assembled from the playback camcorder to the recording deck in the correct sequence. Although the editor can be connected via cable to a recording deck, its remote capability allows it to record to just about any other VCR with wireless remote control; it actually "learns" the remote commands for two different VCR's. The VE-100 works with videos from 8mm, Hi8, VHS, and even Beta formats, and can be played back on any camcorder that has the Local Application Control Bus (commonly called LANC). Price: $270.

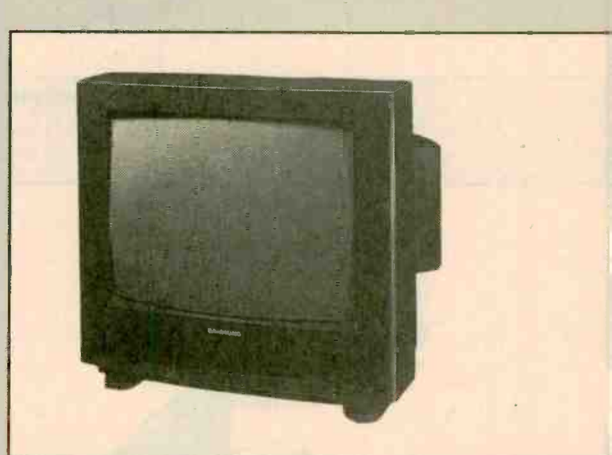
CIRCLE 57 ON FREE INFORMATION CARD

Compact Video Editor

TV/VCE Combination

Even in a sluggish economy, there are some growth areas—and if the EIA figures for the first month of 1991 are any indication, one such product area is the combined TV/VCR, or TVCR. *Samsung Electronics America, Inc* (301 Mayhill Street, Saddle Brook, NJ 07662) has three such sets on the market: the 13-inch *VM3105*, the 19-inch *VM6105*, and the 20-inch *VM7105* (shown). Other than screen size, each model offers the same features, including 155-channel cable-compatible tuning, on-screen programming, 1-year/8-event programmable timer, automatic channel program and skip memory, one-touch recording up to four hours, and VHS-index search memory. The remote-controlled one-piece video systems are targeted for personal use as well as use in business, educational, medical, and real-estate applications. Prices: $599.95, $749.95, and $799.95, respectively, for the VM3105, VM6105, and VM7105.

CIRCLE 58 ON FREE INFORMATION CARD



TV/VCR Combination

Anti-Theft Car Receiver

With a removable chassis, *International Jensen Inc.'s* (25 Tri-State International Office Center, Suite 400, Lincolnshire, IL 60069) *CS5500* AM/FM receiver with auto-reverse cassette deck provides anti-theft security. The 40-watt receiver, with a continuous power-output-per-channel of 18 watts, also provides high-performance sound without external amplifiers. The unit features automatic program-control PLL tuner circuitry that uses stereo blend, high-cut, and soft muting to assure sound quality under all reception conditions. An internal, self-charging lifetime battery maintains the clock memory as well as the 18 station presets. Auto store circuitry scans the frequency band and automatically stores six of the clearest sounding stations in order of their original strength. Price: $259.95.

CIRCLE 59 ON FREE INFORMATION CARD

Anti-Theft Car Stereo

Handheld Video Game

While handheld games provide the advantage of portability, usually they pay the price in video and audio quality. *Sega of America* (573 Forbes Boulevard, P.O. Box 2167, South San Francisco, CA 94080) addresses those problems by putting a full-color, 3.2-inch backlit screen and stereo sound (with headphones) in their *Game Gear* portable video game. Game Gear provides clear graphics in 32 on-screen colors. It comes with the puzzle game "Columns," and "Super Monaco GP" and "G-LOC" are currently available. At least 20 more games are expected to be released by the end of this year. Playing options include a "Gear-to-Gear Cable" for two-player challenges, and a color-TV tuner adapter that will be available this fall. Game Gear runs on for three or four hours on six "AA" batteries, and can be powered via optional AC or DC adapters or a rechargeable battery pack. Price: $159.95.

CIRCLE 60 ON FREE INFORMATION CARD

Portable Video Game

ELECTRONICS WISH LIST

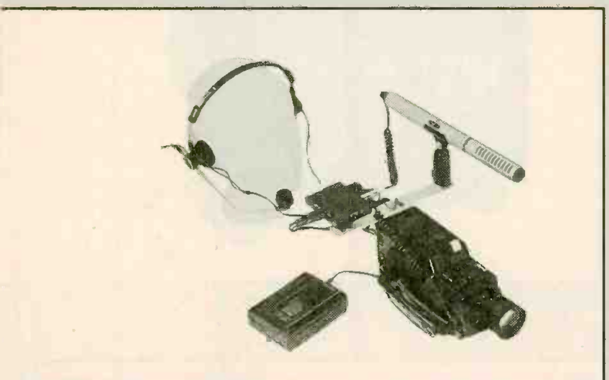
For more information on any product in this section, circle the appropriate number on the Free Information Card.

CD/FM Interface

CD/FM Interface

You can add a CD player (or DAT player, or CD changer) to your car audio system in minutes using the *FMS-2* CD/FM interface from *Scosche Industries* (5160 Gabbert Road, Moorpark, CA 93021). The interface has RCA inputs for easy installation of an additional source. The output is modulated onto an FM frequency of your choice. Built-in ground-loop isolation minimizes potential ground loop problems and allows for the use of cigarette lighter power adapters for portable CD players. A 19-kHz high-performance pilot filter provides maximum high-frequncy response without intefering with the stereo signal. Price: $99.95.

CIRCLE 61 ON FREE INFORMATION CARD



On-Cam Mixer

Real-Time Soundtrack

We have a stack of home videos to which we had every intention of adding a real soundtrack during editing. Unfortunately, good intentions go only so far, and most of those tapes sound the same as they did when they were made. Too bad we didn't have the model *V-0530 On-Cam* mixer from *Ambico Inc.* (50 Maple Street, P.O. Box 427, Norwood, NJ 07648-0427), which lets you add personal narration and background music on location, as you record. The mixer comes with a mounting shoe, 2 "AAA" batteries, cable, and a headset with built-in microphone. (It also has a second input for an optional auxiliary microphone.) Audio from the headset's microphone is blended with a music source (a personal stereo, for instance) to create a balanced soundtrack of music and narration. The On-Cam provides one balance control between the headset and the auxiliary microhpone and a second balance control between the two microphones and the music source, along with an overall volume control. Price: $99.95.

CIRCLE 62 ON FREE INFORMATION CARD

PC Poker Game

If you'd love to be part of a "Friday Night Poker Club," but your wife or your wallet forbids it, take heart. *Ante-Up* provides not just the thrill of gambling, but all the camaraderie you could want—with skilled but not professional players like Harry the used-car salesman, Mary the real-estate broker, restaurant-owner Chen, airline pilot Pete, and four others. There's even a house dealer, calling the plays in appropriate slang ("bullet" for ace, "lady" for queen, etc.). You can play five- or seven-card stud, five-card draw, or Texas hold'em, at your choice of four speeds and three tables ($5, $10, and pot limits). Beginners can call on the Capt (Computer-aided poker teacher) for pointers. Ante-Up, from *ComputerEasy International Inc.* (414 East Southern Avenue, Tempe, AZ 85282) requires an IBM-PC or compatible computer with DOS 3.0 or later, an EGA or VGA monitor, and a mouse. You have to supply your own drinks, chips, and cigar smoke. Price: $39.95.

CIRCLE 63 ON FREE INFORMATION CARD

Cellular Antenna

Cellular-Phone Antenna

Could it be that—thanks to dramatically lower prices and increased popularity—cellular phones are not quite the status symbol they once were? It wasn't that long ago that we saw press releases for *faux* antennas designed to make your neighbors *think* you had a car phone. Now things have come full circle, and *Terk Technologies Corp.* (233-8 Robbins Lane, Syosset, NY 11791) is offering a cellular antenna designed to be unobtrusive. The palm-sized *CFR-900*, which mounts to the inside of the windshield, is impervious to damage from car washes, is unaffected by wind and motion—and "doesn't clash with a car's design." Price: $79.95.

CIRCLE 64 ON FREE INFORMATION CARD

Useful RF Gizmos That You Can Build

BY
JOSEPH J. CARR

Here are a few sure-fire RF projects, with all the helpful tips you'll need to get them to work properly right away.

Radio frequency (RF) projects are widely believed to be difficult, or perhaps "black magic," to those who haven't tried too many of them. One of the reasons for this perception is that stray capacitance and stray inductance, which occur in all circuits, can cause difficulties at radio frequencies (from 20 kHz into the microwave range). For example, a circuit may have, say, 15 pF of stray capacitance formed by the interaction of the wires and chassis. At 1 kHz, that stray capacitance may not even affect a circuit, but at 10 MHz it becomes a significant portion of the total capacitance. An LC tank circuit with a resonant frequency at 10 MHz can be formed from a a 5-μH inductor and a 26 pF capacitor; to such a circuit, an additional 15 pF would causes a significant shift in the resonant frequency.

The rule to follow in RF construction is to limit the amount of stray inductance and capacitance by using short, direct wiring. It is also wise to use the larger wire sizes at very high frequencies. The reason for this is a phenomenon called "skin effect." The skin effect causes the apparent AC resistance of a conductor to be higher than its DC resistance. The reason is that AC tends to flow close to the surface of the conductor, rather than through the entire crossection.

With few exceptions, RF projects should be built in shielded metal boxes. But not all aluminum boxes available to hobbyists, or sold in local electronic-parts distributors, are really suitable for RF projects. The most useful are those that provide a tighter shielding effect by having a flange or lip all around the edges between the two half-sections of the box. The flange should overlap the adjoining edge at least ¼ inch. Some boxes just have a couple of "dimples" on the edges to fix the two halves in the right position with respect to each other, but they do not provide good shielding at radio frequencies.

RF Sniffer. One of the problems that people have with RF projects is that they don't know when the device is producing an output signal. Radio frequencies are too high to hear, so they cannot be detected with an audio amplifier or a pair of earphones. When you build an oscillator at 1 kHz, for example, you can use a pair of headphones to determine if the project is putting out a signal. But at 1 MHz, or any other frequency above the range of human hearing (about 20 kHz), the signal cannot be detected.

An RF Sniffer circuit is shown in Fig. 1. The circuit could be built into the front panel of RF projects to indicate the presence of RF. I've seen several signal generators, antenna meters, and other projects that used this circuit as a driver for a panel indicator.

Still another use is to detect RF emitted from high-power sources such as linear RF power amplifiers (used by hams), RF inductive-heating devices, or other RF-power generators used in industrial or medical applications. For such applications, the RF-input jack of the circuit should be connected to a short whip antenna that will pick up RF in the environment.

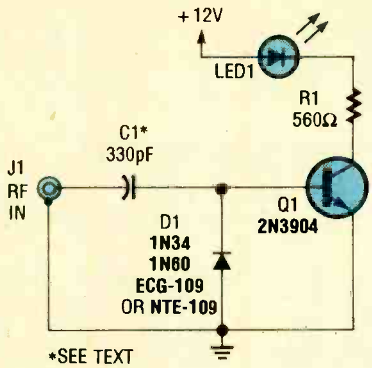


Fig. 1. The RF-Sniffer output-indicator circuit can be used to hunt for RF-noise sources or to indicate your transmitter is operating.

PARTS LIST FOR THE VOLTMETER PROBE

D1—1N34 small-signal germanium diode
R1—4.7-megohm, ¼-watt, 5% resistor (see text)
C1, C2—.01-μF, ceramic-disc capacitor (see text)
J1—Select to suit purpose
Shielded enclosure, perfboard, wire, solder, etc.

The circuit is very simple. It consists of an NPN transistor (Q1) used as a switch to turn on a light-emitting diode (LED1). When Q1 is turned on, the collector is close to ground potential, so the LED and its current-limiting resistor (R1) are effectively grounded. Thus, the LED is turned on when the transistor is turned on. But when the transistor is turned off, the collector is held at a high potential, so the LED remains turned off. The transistor can be any moderate-gain NPN device such as the 2N3904 or 2N2222. Note that the transistor in this circuit works at DC, not RF.

Although a silicon transistor is shown, a germanium type is also useful, and in fact may make the LED brighter with somewhat lower levels of RF excitation.

Bias for the transistor is provided by the germanium diode, D1. This diode acts like a signal rectifier, and produces a small DC voltage when RF is present. The DC voltage is capable of biasing the transistor into its forward-bias region. For lower signal levels, such as those produced by oscillator projects, a germanium diode such as the 1N34 or 1N60 is suitable. Alternatively, you can use the NTE109 or ECG109 devices; those are radio/TV replacement parts sold at electronic distributors that specialize in serving that industry.

PARTS LIST FOR THE RF SNIFFER

Q1—2N3904 general-purpose NPN silicon transistor
D1—1N34 small-signal germanium diode
LED1—Light-emitting diode
R1—560-ohm, ¼-watt, 5% resistor
C1—330-pF, ceramic-disc capacitor (see text)
J1—Select to suit purpose
Shielded enclosure, perfboard, wire, solder, etc.

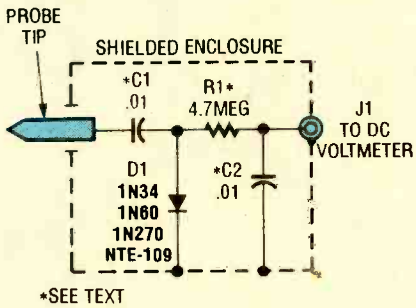


Fig. 2. This RF-detector probe can allow your DC voltmeter to indicate the presence of powerful radiowaves.

The capacitor in series with the base of the transistor can be adjusted for the operating frequency. The 330-pF value selected is for the lower end of the medium to high-frequency range, (*i.e.* about 400 kHz to 10 MHz). For higher ranges, decrease the value. Also decrease the value if the device seems too sensitive, or if it loads the circuits being tested too much. If the circuit is not sensitive enough, then experiment with increasing the value.

The RF-Sniffer circuit should be placed inside a shielded aluminum box. The DC power supply can be anything from about +7.5 to +15 volts. A single SPST switch in series with the LED will turn the project on and off as needed.

RF Voltmeter Probe. Most people who build or repair electronic equipment own some sort of DC voltmeter, probably in the form of an analog multimeter (FETVM, VOM, etc.) or digital multimeter (DMM). As useful as these instruments are, they are limited to DC and very low AC frequencies (and some of them won't even operate throughout the entire audio range).

Figure 2 shows a simple circuit that will function as an RF probe for measuring peak RF voltages, and also as a demodulator for detecting the amplitude modulation on an RF carrier. Like the RF Sniffer, the circuit uses a germanium signal diode as a rectifier. Again, the 1N34, 1N60, NTE109, or ECG109 devices are suitable. For higher signal levels, connect two or three germanium diodes in series, or use a silicon diode (1N914, or 1N4148 are suitable).

The RC filter (R1/C2) is used to smooth the DC output, and tends to yield the average RF voltage. The value of R1 is set for a voltmeter with a 10-megohm input impedance, and may have to be decreased for other instruments.

Capacitor C1 is used as a DC-blocking capacitor, and can have a value as low as 10 pF in very high-frequency applications. The value shown is useful for lower frequencies, and the shortwave (HF) region of the spectrum.

As in any RF project, this one should be built in a shielded metal cabinet. Some people use blank "probes" that allow you to build your own circuits inside. These are meter and oscilloscope probes fashioned from an aluminum or brass tube, an insulated end cap, and a probe tip. A small piece of perforated electronic construction board is used inside to mount the components.

Sensitive RF Detector. A limitation of the RF-detector probe circuit is that it requires a fairly hefty signal to make it work. That is so because germanium diodes have only a 0.2- to 0.3-volt junction potential. To amplify incoming signals to a suitable level for the diode, the circuit of Fig. 3 incorporates a junction field-effect transistor (JFET) RF amplifier and a voltage-doubler RF detector.

The amplifier consists of JFET Q1 and its associated components. The JFET is operated in the common-source mode, so the input signal is applied across the gate-source path, while the output signal is taken across the drain-source path. The input signal is coupled to the gate terminal of the JFET through a DC blocking capacitor (C1). The 100k resistor from the gate to ground is used to prevent leakage currents from the transistor input junction from charging the capacitor. It also keeps that capacitor drained of DC without reducing the input impedance too much.

The DC bias for the JFET is supplied by a resistor (R2) in series with the source and ground. The resistor places the drain at a small positive DC-bias voltage to make the JFET operate properly. However, that resistor would reduce RF gain unless it is bypassed with a capacitor (C2). The capacitive reactance of C2 should be less than 1/10 the resis-

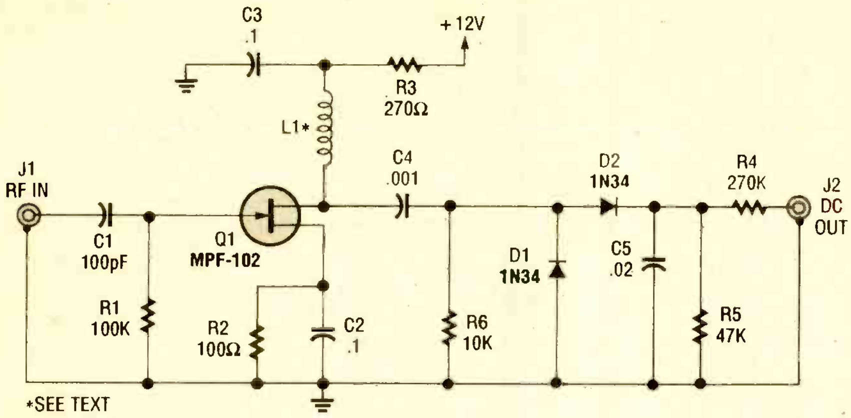


Fig. 3. An active (amplified) RF-detector probe like this one can allow your meter to detect small RF signals.

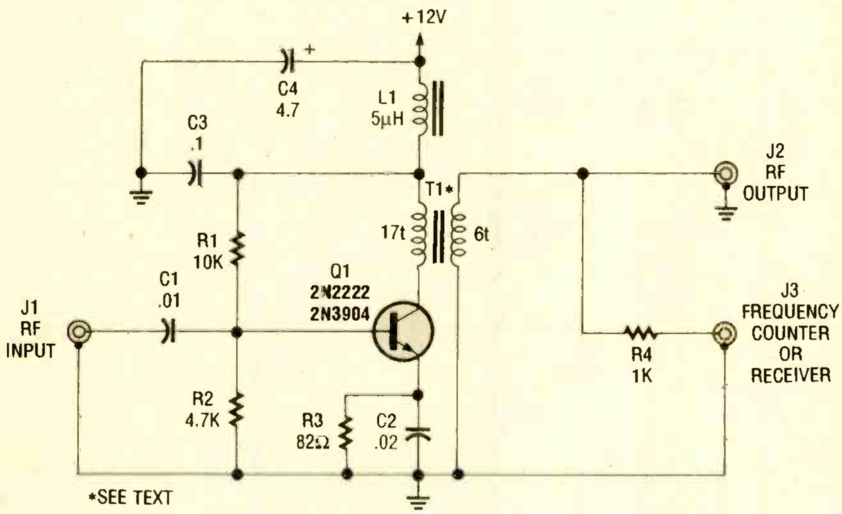


Fig. 4. This wideband-amplifier circuit has two outputs: one for equipment that needs some pre-amplification and another for devices that handle small signals.

PARTS LIST FOR THE SENSITIVE RF DETECTOR

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1—100,000-ohm
R2—100-ohm
R3—270-ohm
R4—27,000-ohm
R5—47,000-ohm
R6—10,000-ohm

CAPACITORS
C1—100-pF, ceramic-disc
C2, C3—0.1-µF, ceramic-disc
C4—.001-µF, ceramic-disc
C5—.02-µF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS
L1—See text
D1, D2—1N34 small-signal germanium diode
Q1—MPF102 junction field-effect transistor
J1, J2—Select to suit purpose
Shielded enclosure, perfboard, wire, solder, etc.

PARTS LIST FOR THE RF AMPLIFIER

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1—10,000-ohm
R2—4700-ohm
R3—82-ohm
R4—1000-ohm

CAPACITORS
C1—.01-µF, ceramic-disc
C2—.02-µF, ceramic-disc
C3—0.1-µF, ceramic-disc
C4—4.7-µF, 12-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS
J1, J2, J3—Select to suit purpose
L1—5-µH, RF choke
Q1—2N2222 general purpose NPN silicon transistor
T1—See text
Shielded enclosure, perfboard, wire, solder, etc.

tance of R2 at the lowest frequency of operation. With the values shown for R2 and C2, the circuit will operate down to about 160 kHz.

The drain circuit of the JFET is made into a wideband circuit by using a radio-frequency choke (L1). The value of the coil should be 100 to 200 µH for high frequencies (*i.e.*, >30 MHz), 1 mH for use over most of the HF spectrum, and 2.5 mH for operation below 3 MHz. For most cases, a 1-mH (*i.e.*, 1000 µH) choke will suffice. The RF choke tends to increase the drain impedance as frequency increases because the inductive reactance increases with frequency. Increasing the AC impedance tends to increase gain, overcoming the natural frequency roll-off of the circuit.

The RF-voltage detector contains a voltage-doubler circuit located between DC-blocking capacitor C4 and the output jack (J2). Like the previous circuits, germanium signal diodes are used (1N34, 1N60, NTE109, or ECG109), and for larger signal levels, a 1N914 or 1N4148 can be substituted.

When selecting capacitors for this project, be sure that they will operate well at the frequencies you desire. At one time, nearly all available capacitors of the values shown would work at least into the HF region. But today there are many different types on the market, and some of them don't like higher RF (25 MHz and up) very much. If the catalog lists the capacitor for DC blocking, bypassing, or coupling in the HF, VHF, or UHF region, then it will work nicely. Otherwise, make sure you use ceramic-disc capacitors.

Wideband RF Instrument Amplifier. Many RF instruments respond to very weak RF-signals. Dip meters, RF antenna-impedance bridges, and noise bridges, for example, are equipped with low-level signal sources (especially when used with a receiver as the detector). The circuit in Fig. 4 will permit you to use such instruments, but at high signal levels. It will also allow you to boost the output level of RF small-signal amplifiers, oscillator circuits, and signal generators.

The basic circuit is a common-emitter amplifier based on an NPN transistor such as the 2N3904 or 2N2222 (they are mentioned here because they are nearly universally available—many other transistors will work just as well). Bias current for the base of the transistor is provided by a voltage divider consisting of R1 and R2. A certain amount of thermal stability is provided by a series resistor (R3) in the emitter-to-ground circuit. That resistor is bypassed with a capacitor. With the values shown, the

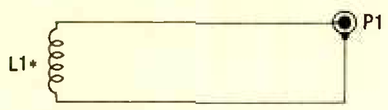


Fig. 5. A simple gimmick coil can be made from a few turns of wire around a medicine bottle and a plug.

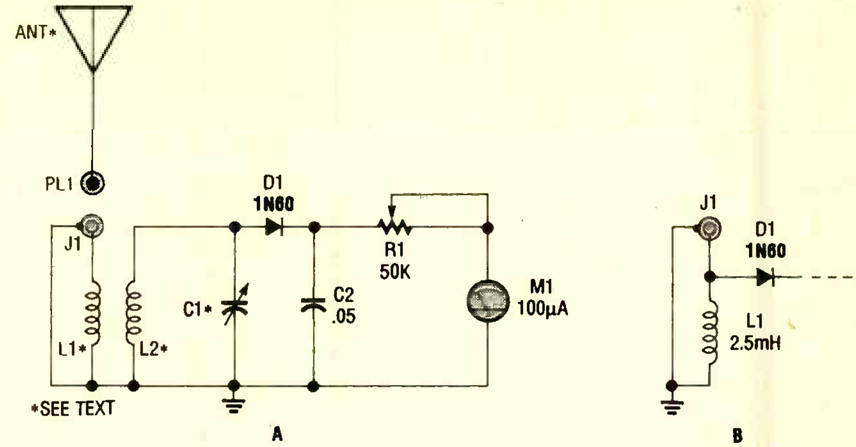


Fig. 6. To build a tuned RF wavemeter follow the schematic shown in A. For an untuned version replace L1, L2, and C1 in A with L1 in B as shown.

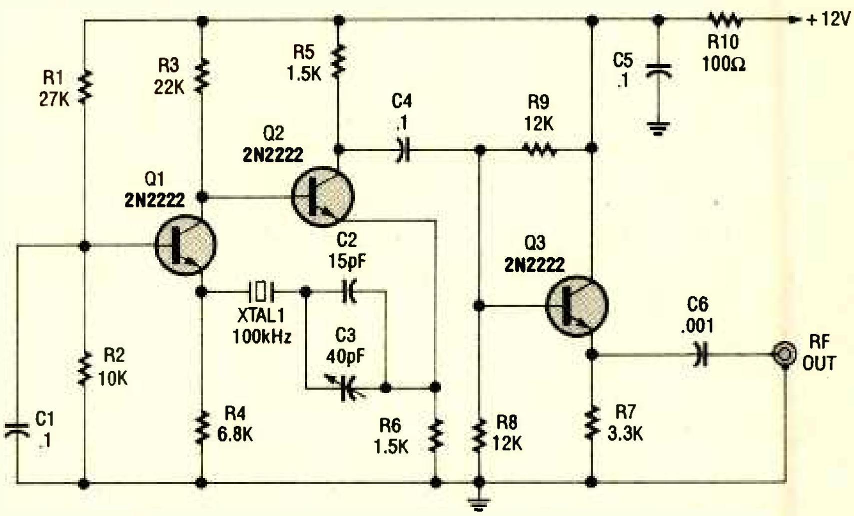


Fig. 7. This 100-kHz crystal-based calibrator can be built from readily available parts. It can be calibrated using the either the WWV or WWVH radio signals.

circuit will work down to a little less than 1 MHz, but for lower frequencies a higher value of capacitance is needed. The capacitor should have a reactance of ten percent or less of the resistance of R3 at the lowest frequency of operation.

The collector circuit of the wide-band-amplifier circuit is coupled to the output through a broadband RF transformer wound over a toroidal core. To cover the HF spectrum the Amidon Associates (12033 Otsego Street, North Hollywood, CA, 91607) type FT-23-43 core, wound with 17 turns of No. 26 enameled wire for the primary, and 6 turns of No. 26 for the secondary should be used.

The RF choke (L1) in the RC power-supply circuit can be a 5-µH factory-made inductor, or can be wound on a small Amidon core. To roll your own, the FT-23-43 core will provide the required inductance with 5 or 6 turns of No. 26 wire.

Two outputs are provided for this circuit. The direct RF output (J2) is used for the high-level main-output signal. A low-level output (J3) is used to drive a frequency counter to measure the frequency of the output signal. Alternatively, you can also use the J3 output to route a signal sample to a receiver. Given the uselessness of most dipper frequency-dial calibrations, this feature is not a bad idea. If you don't need this feature, however, then eliminate J3 and the associated isolation resistor (R4).

If you want to use this circuit with a dipper or other indirectly excited source, then use a "gimmick" coil (L1 in Fig. 5). The coil consists of two to seven turns (more turns at lower frequencies) of No. 20 or No. 22 insulated hook-up wire. The diameter of the coil should be large enough to fit over the output coil of the dipper or other source. I've found that winding the gimmick coil over a one-inch (or so) prescription medicine bottle works well.

Wavemeter. A wavemeter is an instrument that will provide an indication of the output level of a transmitter signal as it is radiated from an antenna or leaky dummy load (and, indeed, most amateur dummy loads are leaky). A practical circuit is shown in Fig. 6A.

The input circuit can be either a tuned transformer (as in Fig. 6A), or a simple RF choke (shown in Fig. 6B). If the tuned circuit is used, then it must resonate at the operating frequency being picked up. Typically, the maximum value of C1 can be 50, 140, or 365 pF for the high end of the HF region, but the proper inductance must be used. Use this resonant frequency equation to help you select L2:

$$f = 1/(2\pi\sqrt{L2\ C1})$$

The primary winding of the input network consists of coil L1. This coil is made from a few turns of wire wound over the cold (*i.e.*, ground) end of L2.

Alternatively, the RF-choke version can be used for an untuned wavemeter. In the latter case, use a 100-µH choke in the low VHF region, a 1-mH unit in the HF region, and 2.5 mH for frequencies below 4 MHz.

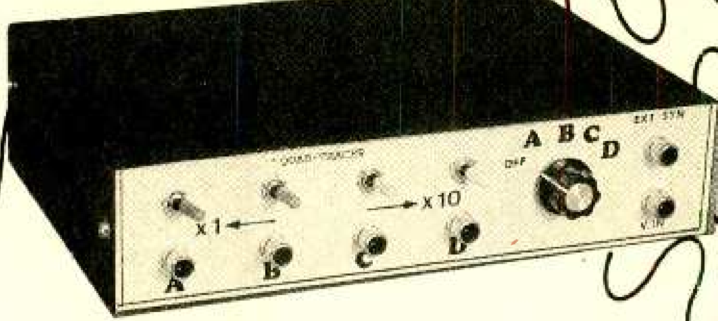
PARTS LIST FOR THE WAVEMETER

- D1—1N60 small-signal germanium diode
- R1—50,000-ohm potentiometer
- C1—See text
- C2—.05-µF, ceramic-disc capacitor
- M1—100-µA, meter movement
- PL1, J1—Select to suit purpose
- L1, L2—See text
- Shielded enclosure, perfboard, wire, solder, etc.

The antenna should be a small whip antenna (8 to 15 inches in length), and can be either a stiff piece of wire, brazing rod, brass tubing, or a telescoping replacement antenna intended for a portable radio.

The signal from either the resonant circuit or the RF choke is rectified by the

(Continued on page 85)



Build The QUAD-TRACER

BY CHARLES D. RAKES

Increase the usefulness of your oscilloscope by adding this channel multiplying circuit to your present setup.

If you were to survey any number of engineers and technicians for their opinion as to what they considered to be the single most important piece of electronic test equipment, there's no doubt that the results would place the oscilloscope at the top of the list.

When it comes to troubleshooting or checking a circuit, the scope is the eye of the electronic detective. The old saying that a picture is worth a thousand words is an understatement when it pertains to the information contained in the traces displayed on a scope's screen. The scope's display offers a great deal more than a single frozen snapshot: It shows an ongoing motion picture of a circuit while it is in operation.

The majority of today's scopes are of the dual-trace variety. Such units allow you to observe and compare two different waveforms at the same time. And that feature more than doubles the usefulness of the instrument when it comes to tracking down a glitch, or troubleshooting a multi-waveform circuit. But if adding a second trace more than doubles the usefulness of an oscilloscope, imagine the benefits of adding even more. Multi-trace scopes are commercially available, of course, but are usually priced beyond the bounds of a hobbyist's budget. If you would like the advantages of a high-priced, multi-trace scope without the corresponding expense, consider building the *Quad Tracer* described in this article.

The Quad Tracer, as the name implies, converts a single-trace scope into a four-trace unit; when used with a dual-trace scope, the circuit offers a total of five traces (four from the channel to which Quad Tracer is connected, and one from the second scope channel). The Quad- Tracer has four separate vertical inputs and a selectable sync output. Each of the four inputs can handle signal levels from a few millivolts to over 20 volts.

Here are a few examples of how the Quad Tracer can prove its worth. If you are checking an audio amplifier with several gain stages and would like to know if each stage is providing gain, all you have to do is connect each input of the Quad Tracer to the various inputs and outputs of the amplifier and observe the results on the scope. If you're troubleshooting a "hiccupping" digital circuit that defies logic, just connect the Quad Tracer inputs to the various stages and watch the results on the scope. In addition, the frustration of checking digital divider circuits is eased by using the Quad Tracer to observe each division on a separate trace.

I expect by now you have an idea or two of your own on how to use the Quad Tracer to make your next electronic "search-and-destroy" mission a wee bit easier. Not only is the Quad Tracer a useful troubleshooting tool, but it's also a fun project to build. If you're into making your own printed-circuit boards and you are a crafty parts procurer, the cost can be less than $30. Of course the condition of your junkbox, the accessibility of bargain parts, and your ability to scrounge for components will effect the final cost.

How It Works. The schematic of the Quad Tracer is shown in Fig. 1. The circuit is built around three IC's—an LM567 tone decoder (U1), a 4017 decade counter/divider (U2), and a 4066 quad bilateral switch (U3)—nine NPN transistors (Q1–Q9), and several miscellaneous support components. The tone decoder, U1, is connected as a fixed-frequency oscillator, the frequency of which is set by the values of R1 and C11 at about 125 kHz.

The square-wave output of U1 at pin 5 drives the clock input of U2 (the decade counter/divider); U2 is configured as a four-position sequential counter that advances one step for each positive input pulse. After the fourth step, the circuit resets and starts over to repeat the sequence as long as power is applied to the circuit.

The four outputs of U2 (A, B, C, and D)

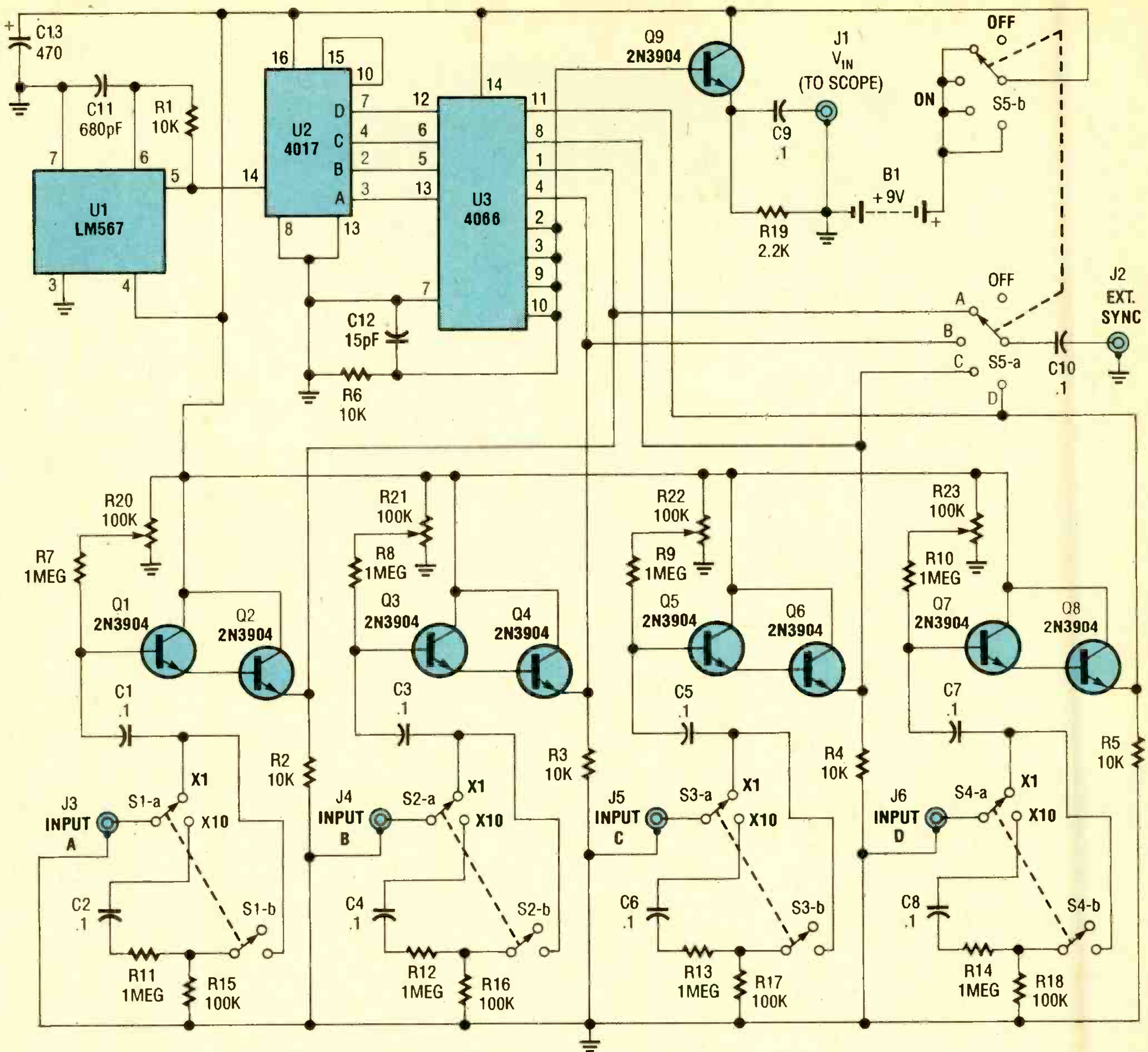
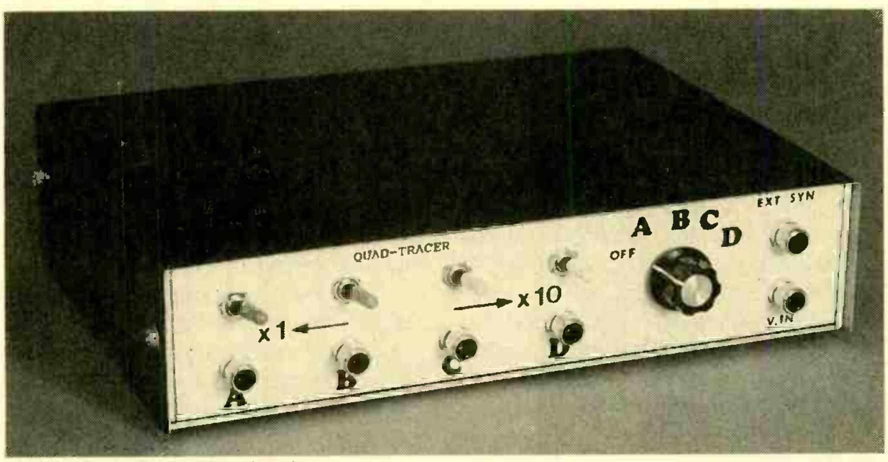


Fig. 1. The Quad Tracer is built around three IC's—an LM567 tone decoder (U1), a 4017 decade counter/divider (U2), and a 4066 quad bilateral switch (U3)—nine NPN transistors (Q1–Q9), and several miscellaneous support components.



Here's the author's completed prototype.

at pins 3, 2, 4, and 7 are tied to the control inputs of U3 (the quad bilateral switch). Each one of the bilateral switches is an electronically controlled single-pole, single-throw switch that remains open until a positive voltage is applied to the corresponding control input.

On the counter's first output step, the voltage at pin 3 of U2 goes positive, turning on the first of the four switches contained in U3. That allows the signal at pin 1 of U3 to be passed to pin 2 during the time the electronic switch is activated. The outputs of all four switches are tied together and connect to the base of Q9 (which is configured as an emitter-follower amplifier); that arrangement sends the four combined signals to the scope's vertical input.

Transistors Q1 and Q2 are connected in a Darlington-amplifier configuration that offers a high-input impedance to the INPUT A signal source. The output signal at the emitter of Q2, passes through pins 1 and 2 of U3, and on through Q9 to

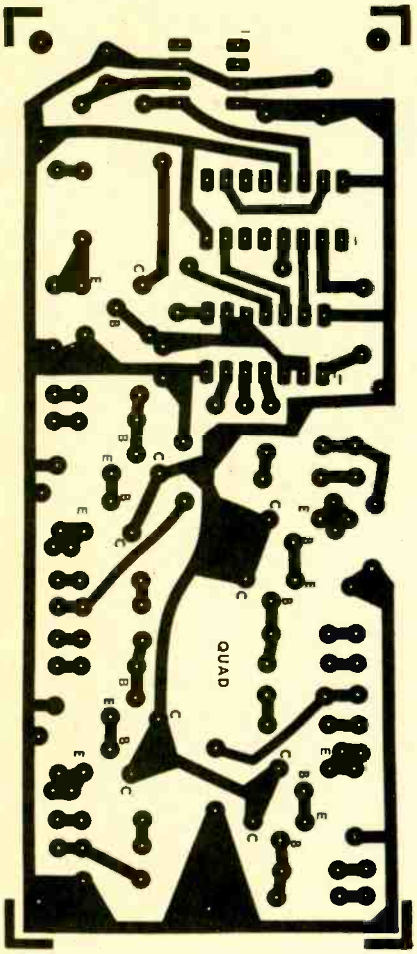


Fig. 2. The Quad Tracer was built on a printed-circuit board, measuring 4⅞ × 2⅛ inches; here is the full-scale template of that PC pattern.

J1. The output from that jack, labeled V IN, is fed to the scope's vertical or voltage input. Potentiometer R20 sets the position of the INPUT A trace and S1 selects between an input attenuation of ×1 or ×10.

The actual signal attenuation in the ×10 mode is closer to eleven-to-one, but due to the expense and difficulty in obtaining 1% resistors in my area, the slight error is of little consequence to the overall operation. The "B," "C," and "D" input amplifiers are duplicates of the "A" input amplifier and function in the same manner, but each at its own specified time interval.

The EXT SYN output (at J2) allows the scope to sync on any one of the four input signals. Switch S5-a selects the desired sync signal.

Construction. The Quad Tracer was built on a printed-circuit board, measuring 4⅞ × 2⅛ inches. Figure 2 shows a full-scale template of that printed-circuit pattern, with its corresponding parts-placement diagram appearing

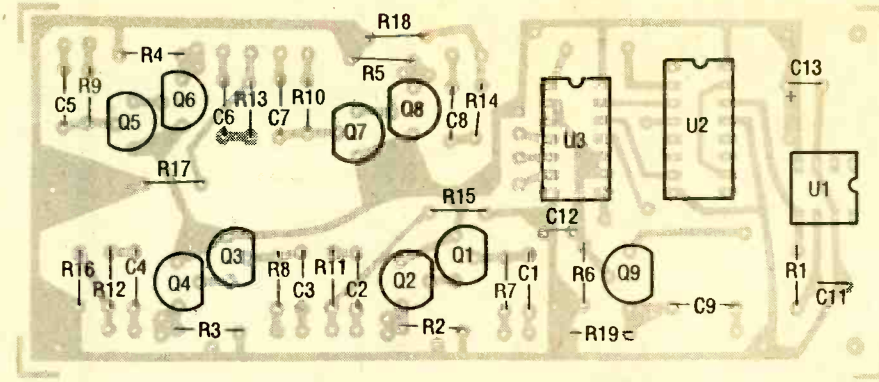


Fig. 3. Here is a parts-placement diagram corresponding to the template appearing in Fig. 2. Note that this diagram shows the placement of the on-board components only.

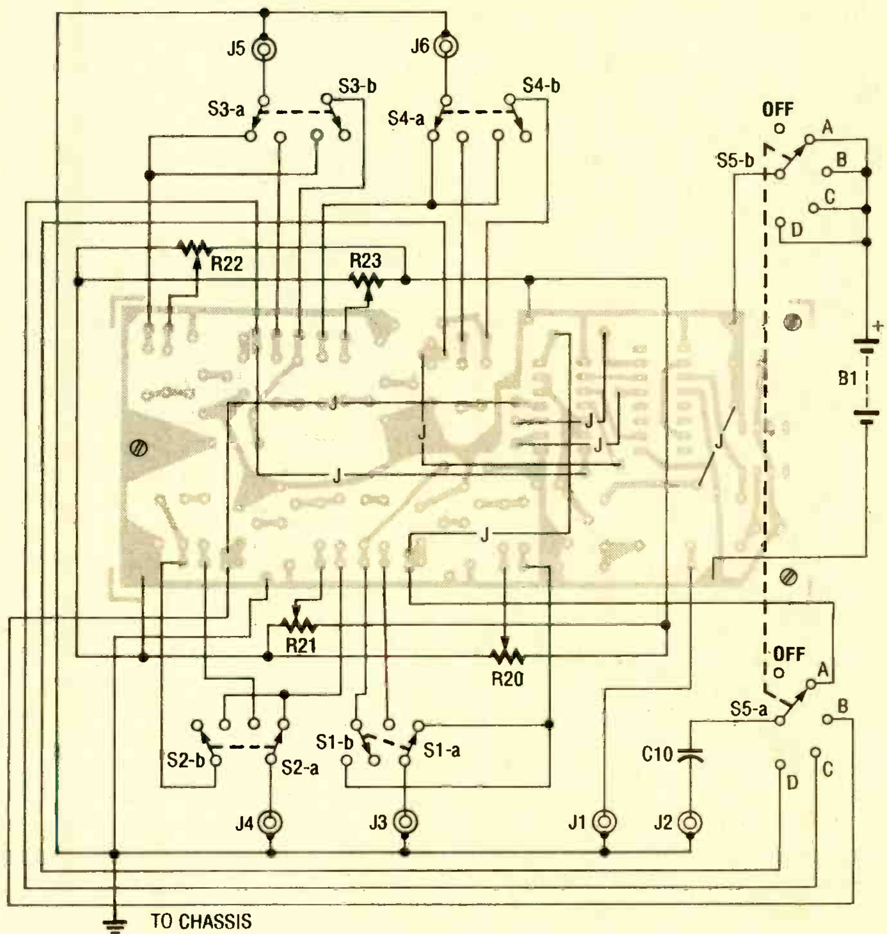


Fig. 4. To make wiring the off-board components a bit easier, those parts and their connections to the board are shown here. It's a good idea to check the layout against the schematic diagram and Parts List, as you install the components.

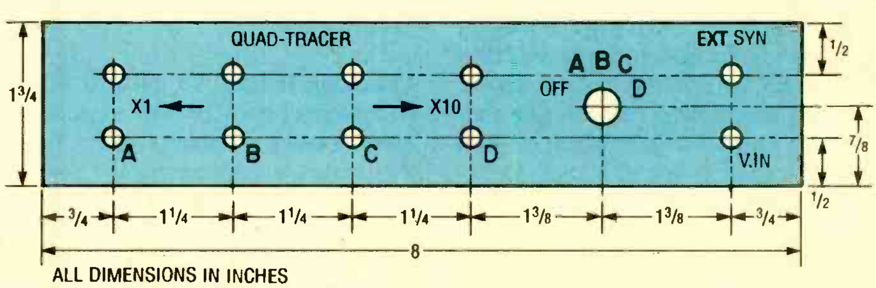


Fig. 5. If you decide to house the circuit in a cabinet like the one the author used, you can simply follow the front-panel layout shown here. In the author's prototype, potentiometers R20–R23 are lined up across the rear panel, directly opposite the positions of J3–J6 (inputs A through D).

PARTS LIST FOR THE QUAD TRACER

SEMICONDUCTORS

U1—567 tone decoder, integrated circuit
U2—4017 decade counter/divider, integrated circuit
U3—4066 quad bilateral switch, integrated circuit
Q1–Q9—2N3904 general-purpose NPN silicon transistor

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1–R6—10,000-ohm
R7–R14—1-megohm
R15–R18—100,000-ohm
R19—2200-ohm
R20–R23—100,000-ohm potentiometer

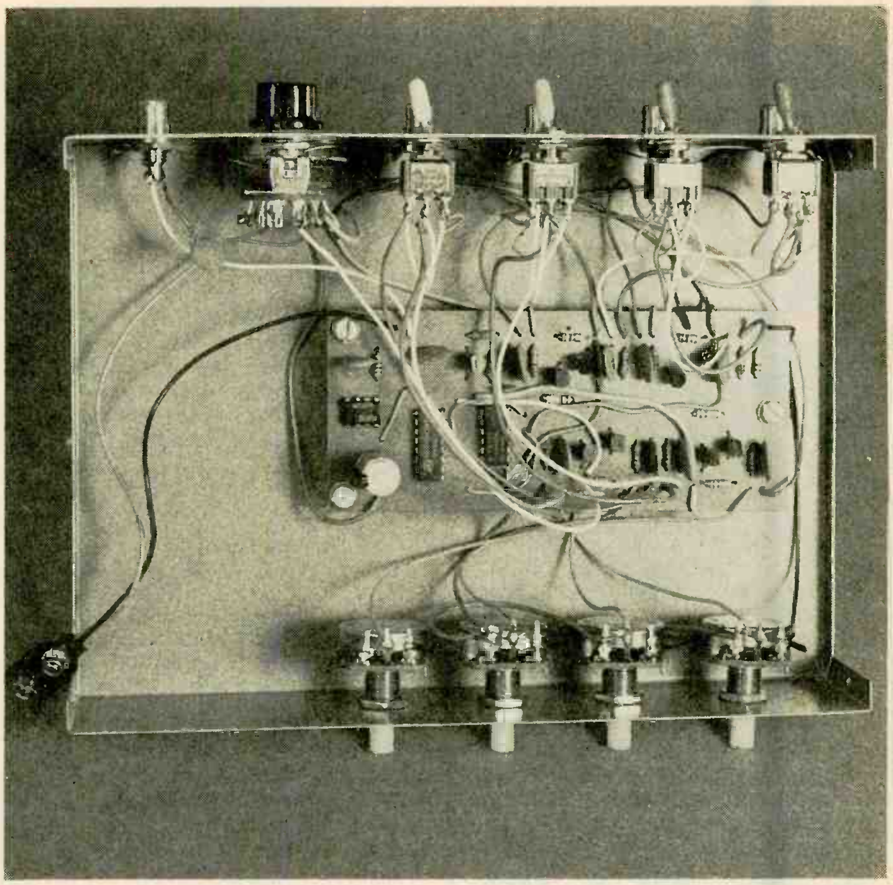
CAPACITORS

C1–C10—0.1-µF, ceramic disc
C11—680-pF, ceramic disc
C12—15-pF, ceramic disc
C13—470-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor-radio battery (see text)
S1–S4–DPDT miniature toggle switch
S5—DP5T rotary switch
J1–J6—RCA phono jack
Printed-circuit-board materials, RCA phono plugs, 1$^{15}/_{16}$ × 8¼ × 6⅛-inch metal enclosure (RS 270-272A or similar), knob, battery holder and connector, wire, solder, hardware, etc.

Note: A circuit board and all of the parts that mount on it, plus the four 100k potentiometers are available for $25.95 postage-paid from: Krystal Kits, PO Box 445, Bentonville, AR 72712. Arkansas residents, please add applicable sales tax.



Here is the Quad Tracer's printed-circuit board mounted in its metal enclosure, with the off-board components connected to the appropriate points on the board through hook-up wire.

in Fig. 3. Note that Fig. 3 shows the placement of the on-board components only; the jumper connections and off-board components are shown in Fig. 4 to make wiring the off-board components to the board a bit easier.

It's a good idea to check the component layout against the schematic diagram and Parts List as you install each part. Be careful when handling U2 and U3 (the 4017 and 4066); those chips are CMOS devices and as such are sensitive to electrostatic discharge. Also, before soldering any IC in place, double check to be absolutely sure that it is properly installed.

Once the printed-circuit board has been assembled and your work checked for the usual construction defects—cold solder joints, solder bridges, misplaced and misoriented components—it's time to consider the enclosure that will house your creation.

If you decide to house the circuit in a cabinet like the one the author used (see Parts List), you can simply follow the front-panel layout shown in Fig. 5. Potentiometers R20–R23 are lined up across the rear panel opposite to J3–J6 (the four input jacks). The actual layout isn't critical and you can follow any scheme you desire. Note that coupling capacitor C10 connects between the wiper of S5-a and the EXT SYN jack (J2), and is not mounted on the board. Since the circuit's current drain is only about 25 mA, a standard 9-volt battery will do, but for extended operation use six AA-cells in series.

Checking It Out. Set the R20–R23 at mid rotation, and connect a cable between the Quad Tracer's V_{IN} jack (J1) and the scope's vertical input. Set the scope's vertical gain for a .5-volt per centimeter deflection and center the trace. Turn S5 to the A position and one or more traces should appear on the screen. Turn R20 clockwise until the trace no longer rises. Back off R20 until the trace drops about one centimeter. Now adjust R21 to position the B-input trace about 1 to 1½ centimeters below the top trace, and do the same with R22 and R23 to equally space the four traces.

Connect a different audio signal, with an output level of about a 1-volt peak-to-peak, to each of the four inputs. Place all four of the attenuator switches (S1–S4) in the ×1 position. If you don't have four different signal sources handy, it's okay to feed the same signal into more than one input. Connect a jumper between the Quad Tracer's EXT SYNC jack and the scope's EXT. SYNC input, and if S5 is still in the A position, the sweep should sync to the A input signal.

Switch S5 to the B, C., and D sync positions and each corresponding trace should lock in position as you switch to that input. Unused inputs should be returned to ground to keep noise and erroneous signals from reaching the scope.

The Quad Tracer will display frequencies from the audio range to over 1 MHz; even higher frequencies can be seen by carefully adjusting the scope's trigger level. ■

A Hands-on Electronics REPORT

OKIDATA OL400 LED PAGE PRINTER


CIRCLE 119 ON FREE NFORMATION CARD

You can have a laser-quality printer without the big laser-size price tag.

It has been said that "you only get one chance to make a good first impression." There is no question that if you are a professional that relies on printed communication, from correspondence to sales brochures, the recipient's impression of you will be greatly influenced by the appearance of that printed material.

In the early days of microcomputing, daisy-wheel printers were commonly used to provide the quality required for business purposes, but they were s-l-o-w. Soon, dot-matrix printers began to appear. They were faster and less expensive than daisy wheel printers. Further, they were more versatile; offering a variety of computer-selectable fonts and graphics capability.

Although professional users clung to their daisy-wheel units because of the better "letter-quality" output, dot-matrix printers slowly replaced daisy-wheels. And the popularity of dot-matrix printers really began to grow once the under-$200 units began generating "near letter-quality" output.

When the first laser printers appeared they cost more than $2000, but the superior printing and the ability to produce very sharp graphics made them a big hit with businesses. Due to increased production and competition, the price for laser printers has dropped to where daisy-wheel printers originally were (that's especially true if you consider inflation). That may still be a little steep for most of us though, but there's a less expensive alternative technology that yields laser-quality results: the LED printer.

The Okidata Page Printer. With a list price of $999, the Okidata OL400 LED Page Printer is the lowest priced laser-quality printer available (at least at the time this is being written). Further, it has a "street price" of as low as $679.

The OL400 is not a laser printer. True laser printers use a laser beam, a mirror, and finely-aligned lenses to scribe an image onto a rotating photoconductive drum. The OL400 uses a row of 2,560 tiny LED's (*L*ight-*E*mitting *D*iodes) installed in a ½-inch wide 8-½-inch long stationary bar placed next to the drum. That eliminates the mirror and multiple lenses, and their potential alignment problems and expense. The LED system also uses fewer moving parts and allows for a lower printer profile. Okidata's warranty—five years on the LED printhead, one year parts and labor on the entire printer—reflects their confidence in this technology.

However, like a laser printer, the OL400 uses a photoconductive drum and charged toner. Another similarity between the OL400 and a true laser printer is that it creates an entire page in memory before printing, instead of printing letter-by-letter as daisy-wheels and dot-matrix printers do.

But what about the quality of the printed output? Does an LED page printer produce copy as good as a laser page printer? Well, controversy rages on this point.

The original standard resolution of laser printers was 300 dots-per-inch (dpi), or 90,000 dots packed into a square inch. Some laser printers, such as the NewGen Turbo PS/480 (list price $7495, call 714-641-8900 for details) now offer 800 by 400 dpi (320,000 dots in a square inch!)

If you are a true purist, or perhaps an old-time dyed-in-the-wool typesetter who scoffs at any printed resolution below 1200 dpi, you will not be truly pleased with 300 dpi resolution. But if you are like the rest of us, you'll probably be ecstatic with 300 dpi compared to the resolution produced by dot-matrix output.

Fonts. The OL400 comes with a bunch of resident fonts. There are twenty fonts in four typestyles (Courier, line printer, Helvetica, and Times Roman) for "portrait" printing (across the page), in sizes from 8 to 14.4 points (1 point is 1/72-inch high). For landscape printing (lengthwise) there are five fonts in two typestyles (Courier and line printer) in 8.5- and 12-point sizes.

Most of these fonts can be printed out with any of 39 different character sets (also called "symbol sets"), such as Spanish, Italian, Portugese, German, French, Chinese, and others. The character sets produce special characters and symbols required for languages, scientific notation, or special borders. Any of the allowed font and symbol combinations can be commanded from the front panel of the OL400, or by software commands using HP's PCL (Printer Control Language.)

Generally speaking, unless you want to print documents in one specific font, orientation, and character set, you

(Continued on page 88)

PRODUCT TEST REPORTS

By Len Feldman

Sylvania RKS240CH TV Monitor/ Receiver

The Sylvania RKS240CH is a 20-inch TV monitor/ receiver that comes with many of the "bells-and-whistles" normally found on larger, more expensive sets. The picture quality is outstanding, and the set's special features are well implemented, for the most part. It does fall short, however, in one important aspect that we'll get to shortly; first, let's look at the set's high points.

Among the unit's many features is a 36-pushbutton remote control that operates the TV set as well as a wide variety of wireless remote control VCR's and cable converters. Further, the set offers a picture-in-picture (PIP) capability that permits the display of a TV program and the direct video output from an accessory (such as a connected VCR) at the same time. The tuner is cable ready and can be easily programmed to receive only those channels that are available in your area.


CIRCLE 120 ON FREE INFORMATION CARD

The Sylvania RKS240CH 20-inch TV monitor/receiver

A sleep timer can be used to automatically turn the TV set off at a preset time. On-screen graphics are used to display information concerning the operation and adjustment of feature-control settings such as channel, programming, timer settings, etc.

An audio/video jack panel on this set permits direct connection of additional products such as a VCR, a camcorder, or a laser-disc player. This Sylvania monitor/receiver is also equipped with a built-in stereo amplifier and twin speakers for receiving TV programs broadcast in stereo. Those speakers can be switched off if you choose to connect the audio output to an external sound system. The audio output is of the variable type; the output level is controlled by the unit's volume control, either at the set itself or via the remote control.

As for the remote control, a simple procedure allows you to use it with any one of some 56 different brands of VCR's—or just about every brand sold in the U.S. And if by some chance the code for your brand is not listed in the set's manual, there is a "search" function available that helps you determine the correct code to use.

CONTROLS

Controls on the panel of the TV set itself are kept to a minimum. The display button calls up the various items to be adjusted and these are displayed on screen. They include picture, brightness, color, tint, sharpness, add/delete channel, cable/normal tuning, channel reminder display on/off, stereo/mono, and antenna/aux input. Once the desired adjustment type is displayed, + and − buttons are used to change the status. Other controls include channel up and down buttons and a power on/off button. When the + and − buttons are depressed without first depressing the display button, they serve as a volume control. A status button is used to call up on-screen information (channel number, etc.) and is also used to clear the screen after making control adjustments.

The supplied remote control duplicates the controls found on the TV set itself and also has number buttons for instant channel access, as well as buttons for activating the PIP features, a muting button, the sleep timer button, and buttons used for controlling a VCR (if the appropriate code has been entered).

The sleep timer function can be set to turn the TV set off in increments of 30 minutes, for up to 2 hours from the time it is set. This is done by pressing the sleep button on the remote sequentially until the desired time to turn off is displayed on screen.

When using the PIP feature, the smaller picture will be displayed in black-and-white, instead of color, but it can be swapped with the main, larger picture. The smaller picture can also be "frozen" and it can be

moved to any desired c
ner of the TV screen.

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...en the best
...n sources
...home-video
...such as laser
... S-VHS or Hi8 video
vertical resolution was
...o an excellent 400 lines.

Scanning interlace, while not perfect, measured an acceptable 60/40 (50/50 is considered perfect). Transient response was good, though, some "ringing" was evident along the edges of large objects where the transition from light to dark occurs. Black level retention could not have been better, and was rated by APEL as 100%. Color quality was also very good and there was only a marginal amount of overscan (no more than 1%), which means that when viewing programs you will get to see just about all of what is transmitted.

To test tuner sensitivity, a strong lab-generated signal (1000 µV/meter) was fed to the set's antenna input. As would be expected, the resulting picture was noise free. Then signal strength was reduced to 100 µV/meter to simulate fringe-area reception. The amount of additional noise noted was minimal, indicating that the tuner section of this TV set had very good sensitivity.

As for the basic audio section of this receiver, it delivered 1.7 volts maximum at the variable audio-output jacks on the rear panel. At that maximum level, harmonic distortion reached the 3% point. Backing off from that level by only 10 dB, distortion decreased to an insignificant 0.07%. Signal-to-noise ratio for the basic audio section was 56.5 dB, which is somewhat below the average we have come to expect from a set of this category.

The most disappointing aspect of this product was its stereo-decoder section. Either the stereo decoder section was completely misaligned, or else the circuitry did not fully implement the standard MTS stereo transmission system. While signal-to-noise in the stereo mode was still tolerable at 50 dB, and distortion was also within an acceptable range of only 0.28%, stereo separation was so poor that listeners could barely detect that there was any stereo effect at all. For example, for signals at 100% audio modulation, separation even at mid-frequencies was only 5 dB, while at high frequencies separation was virtually non-existent. Furthermore, what little separation APEL did measure varied widely with modulation levels. For example, for a test frequency of 1 kHz, separation decreased from 5 dB to a mere 3 dB when modulation levels were reduced to −20 dB below 100%.

To make matters even worse, the stereo circuitry provided in this set did not make provisions for receiving the SAP (secondary audio program) channel. While different broadcasters are using this extra audio channel for a variety of purposes, there is increasing use of the SAP channel (particularly by Public Broadcasting System stations) for narration for the visually impaired. When the mono mode of the stereo decoder was used, performance was a bit better, with distortion decreasing to 0.20% and signal-to-noise ratio increasing to 58.5 dB.

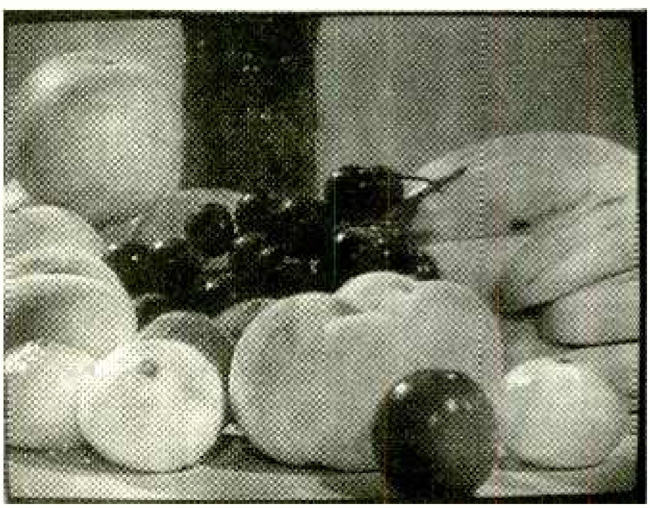
COMMENTS

Both APEL and we were quite satisfied with the picture performance of this 20-inch set, as well as with the manner in which its special effects capabilities were implemented. The ability of

(Continued on page 87)

TEST RESULTS—
SYLVANIA RKS240CH TV MONITOR/RECEIVER

Specification	PE Measured
Video Section	
Maximum usable luminance	105 foot-lamberts
Resolution (vertical/horizontal)	400/480 lines
Interlace	60/40
Transient response	Good (some ringing)
Black-level retention	100%
Color quality	Very good
Overscan	1% horizontal
Audio Section	
0-dB reference level (3% THD)	1.7 volts
Signal/noise ratio (A-weighted)	56.5 dB
Harmonic distortion (1 kHz, -20 dB)	0.07%
Stereo Decoder Section	
Stereo Mode	
Signal/noise ratio (A-weighted)	50.0 dB
THD (1 kHz, −20 dB)	0.28%
Stereo separation (100%/−20 dB modulation)	
100 Hz	7.6/23.5 dB
1 kHz	5.0/3.0 dB
10 kHz	0.8/1.5 dB
Mono Mode	
Signal/noise ratio (A-weighted)	58.5 dB
THD (1 kHz, −20 dB)	0.20%
Additional Data	
Picture size (Diagonal)	20 inches
Power requirements	66 watts
Dimensions (HxWxD)	17⅝x24x18½ inches
Price: $499	



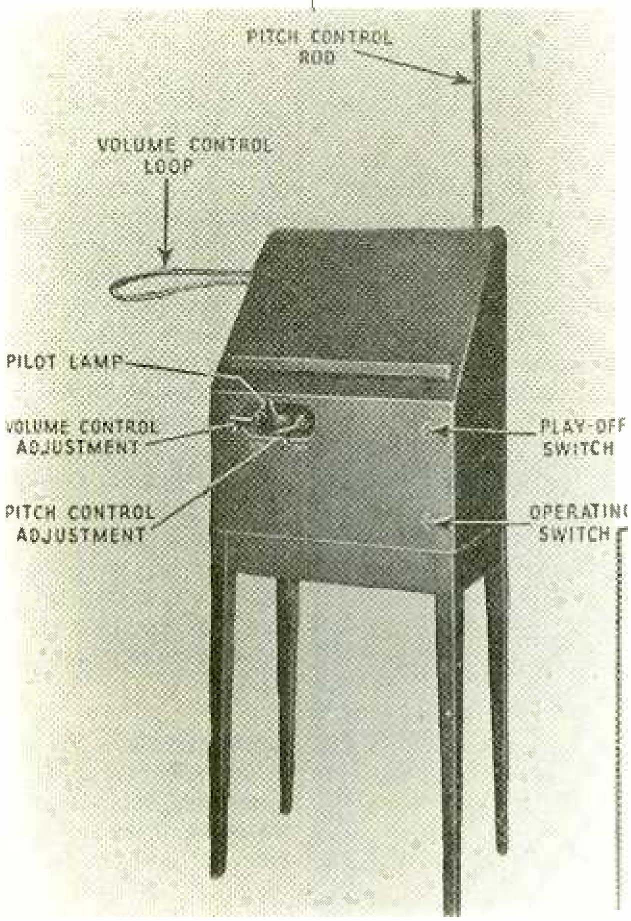
Even when signal strength was reduced to simulate fringe-area reception, the amount of additional video noise was minimal.

By Marc Ellis

Inside the Theremin

Back in 1927, a young Russian scientist named Leon Theremin arrived on these shores to demonstrate a highly unusual musical instrument of his invention. It was the first instrument to produce sound by purely electronic means.

There was nothing to blow into, saw on, or strike. In fact, the strange instrument produced music without even being touched at all! The musician simply moved his or her hands in front of the theremin (as the Russian's invention came to be called), varying their position relative to two antenna-like electrodes protruding from the apparatus.



Front view of theremin shows the location of all controls. Its sloping front makes a handy music stand.

In last month's column we talked about the history of the theremin in this country. Beginning with its enthusiastic 1927 reception by classical and experimental musicians, we followed the instrument to 1940's Hollywood, where it was used to produce chilling special-effect music. Then we discussed the theremin's modernization by Robert Moog in the 1960's, and subsequent adoption by rock bands such as Led Zeppelin.

This month, our focus shifts to the details of the theremin's construction and operation. And, in developing the story, I'll once again be relying on the wealth of information sent in by readers in response to our recent "theremin contest." By the way, the response to that contest was so positive that we're about to begin a new one. Details appear at the end of this column!

PHYSICAL CHARACTERISTICS

The theremin we'll be discussing is the RCA Model AR1264. Except for the relatively few instruments put together by Leon Theremin himself, and the modernized versions later manufactured by Moog, the AR1264 is virtually the only commercial form of theremin known to exist. About 200 of these instruments were produced in 1929 under a license agreement with Theremin. After that, production ceased, due to the economic effects of the Depression and the fact that (contrary to RCA's enthusiastic promotional brochures) was very di

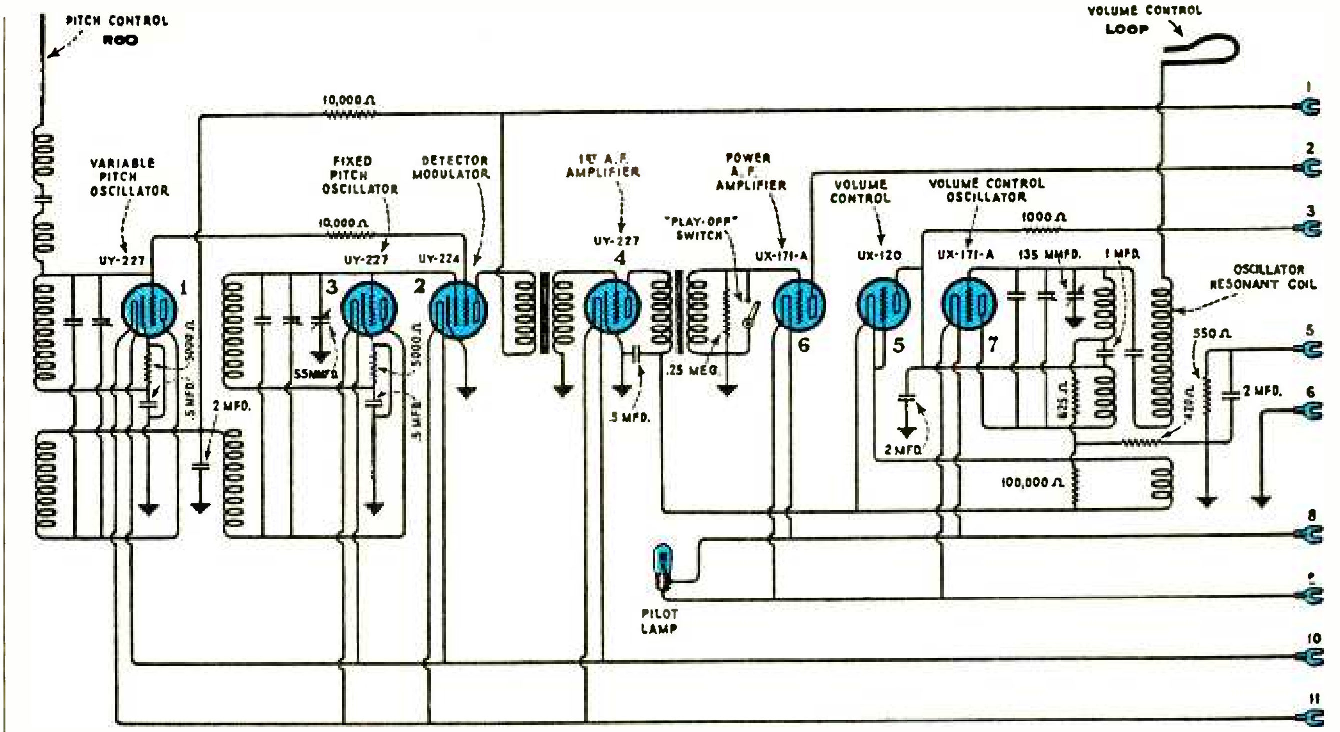
The theren front cabinet s inches high. It's wide, 12 inches c weighs in at 67½ Extending up from right of the cabinet is vertical pitch-control extending out from the side is the volume-contr loop. Both of those electrodes are removable, plugging into sockets set into the surface of the cabinet.

A small fold-down shelf converts the cabinet's sloping front into a handy music stand. The instrument's few controls, located on a vertical panel below the shelf, include the volume and pitch adjustments (flanking a small pilot lamp), a power switch, and a "play-off" switch that mutes the instrument—placing it on standby without cutting the power.

Double doors in the rear of the cabinet open to access the instrument's electronics, which are stacked in two compartments. Above is a seven-tube chassis containing the theremin's operating circuits; below is a separate power pack with a type-80 rectifier tube.

Looking at the chassis, one's eye is immediately drawn to two unusually large inductance coils. As we'll see later, the taller of the two (at the left of the chassis) is used in the theremin's pitch-control circuit; the shorter one (at the right of the chassis) is part of the volume control.

The tube complement includes three type 27's, two type 71-A's, a 24, and a 20. Except for the type 20,



The theremin's wiring diagram shows the functions of all tubes (see the text); the lugs at right connect with the power pack (not shown).

those tubes are all very typical of those used in the first plug-in (or "socket-powered," as they were called then) broadcast receivers. The type 20 is a relic from earlier battery-operated receivers and had to be verging on obsolescence at the time the theremin was designed. However, as you'll see, there's a special reason for its inclusion in the circuit.

The construction of the theremin's chassis and power pack is quite typical of late-1920's RCA broadcast receivers. In fact, one reader commented that both are (at least mechanically) similar to the ones used in the RCA Radiola 60. I haven't had a chance to verify that yet, because my own Radiola 60 is stored in a hard-to-reach spot. However, I hope to make the comparison before this series of articles is concluded.

An outboard speaker is required to complete the theremin, and RCA literature recommends the Model 106. Many readers will recognize that model as the tapestry-front, floor-standing unit often used with RCA broadcast receivers of the period.

TONE GENERATION AND CONTROL

The theremin uses the principal of beat-frequency oscillation to produce tones. To visualize how that works, think of the annoying whistle produced when two radio-station carriers that are very close to each other are picked up at the same time. Two close-together carriers mix to produce additional signals equal to the sum and difference of their frequencies. When the carriers are so close that their difference frequency falls in the audible range, you hear a whistle known as a "beat note."

In order to hear Morse code signals on a short-wave radio, it's necessary to *purposely* create a beat note. As normally received, the signals are heard only as an intermittent hissing noise. But every serious short-wave set contains a miniature radio transmitter called a BFO (beat-frequency oscillator). The BFO operates at a frequency very close to that of the signal being received. So turning it on converts the hissing noises into the familiar whistle of Morse code dots and dashes.

The frequency of some BFO's is adjustable by means of a front-panel knob. Turning the knob varies the tone of the Morse code beat note so that you can select one that is most pleasing to your ears. And that is a very good model for explaining the tone-generating circuits of a theremin.

Take a look at the theremin's schematic diagram. (It shows operating circuits only; the spade lugs at the right connect with the power pack—which is of conventional design and not shown here.) Tube number 3 (a type 27 labeled "Fixed Pitch Oscillator") is the equivalent of a small radio transmitter, and operates at a frequency of about 170 kHz. Tube number 1 (a type 27 labeled "Variable Pitch Oscillator") is equivalent to an adjustable BFO, and operates at a frequency close to that of the fixed-pitch oscillator.

The outputs of the two oscillators mix in tube number 2 (a type 24 labeled "Detector Modulator") to produce an audio tone equivalent to the difference of their frequencies. The tone is amplified by tube number 4 (a type 27 labeled "1st A.F. Amplifier") and tube number 6 (a type 71-A labeled "Power A.F. Amplifier") before being fed to the loudspeaker.

Different musical tones are generated by changing the frequency of the variable-pitch oscillator (V.P.O. from now on), and that is done in a very novel way. Just as with any oscillator, the frequency of the V.P.O. depends on the capacitance and inductance of its tuned circuits. However, the tuned circuits of the V.P.O. are designed to hit

(Continued on page 86)

COMPUTER BITS

By Jeff Holtzman

More on hypertext

For the past couple of months, I have been talking about an emerging technology variously called hypertext, hypermedia, and multimedia. The classic definition of hypertext is non-linear reading and writing. A hypertext document has built-in cross references, and in addition to text may include graphics, sound, and even full-motion video. Hypertext is an extremely powerful means of organizing information by computer.

Compton's Multimedia Encyclopedia is a flawed but, nonetheless, exciting new encyclopedia built using the principles of hypertext.

HYPERTEXT DEVELOPMENT

There are many ways of building hypertext documents on a PC, including both shareware and commercial products. My favorite hypertext environment is called *ToolBook.* ToolBook runs under Windows and provides the most robust environment for hypertext development that I've seen. However, ToolBook is slow; you'll want at least a 25-MHz 386 to do serious work. If you've got the horsepower, this is the hypertext-development platform of choice.

In a non-Windows DOS environment, I'd recommend a program called *HyperPAD* (a product of Brightbill-Roberts & Company, Ltd.), which I wrote about here in April, 1990. HyperPAD consists of a limited object-oriented message-passing environment (somewhat like Windows). If you don't know what that means, experimenting with HyperPAD is a good way to find out. HyperPAD runs in DOS text modes, so it's fast and runs well on less-powerful machines.

The company recently released a new version (2.0) of the program that includes better documentation, an on-line tutorial and on-line help, and many new features and functions. My only complaint is that HyperPAD 2.0 still does not include true hypertext linking. To link a word or phrase in a field to another portion of a document, you must place a transparent button over that text. If the position of the text changes, you must move the button. (The first version of Apple's famed *HyperCard* suffered that same limitation, although I believe that the latest version corrects it.) By contrast, ToolBook allows any arbitrary chunk of text in a field to be made into an object with its own script and link capabilities.

By the way, if you've done anything at all with Windows, you may have noticed its built-in hypertext help system. As a matter of fact, Microsoft includes a hypertext compiler in its Windows Software Development Kit (SDK). The compiler accepts a Word document file—complete with graphics and special formatting and cross-referencing instructions—and produces the kind of help files you see built into most Windows application programs, as well as Windows itself.

END-USER PRODUCTS

If you're interested in hypertext, but not in rolling your own, you may want to check out one of the electronic encyclopedias available on CD-ROM. In case you're unfamiliar with CD-ROM, it is similar to an audio CD, but has digitally encoded text and possibly other types of data, including sound, graphics, and video. Physically, audio CD's and CD-ROM's are manufactured identically. CD-ROM drives (also called readers) are similar to audio players; some CD-ROM readers can even play audio CD's under control of your PC. Because of its high data capacity (550 megabytes), CD-ROM is a natural medium for distributing substantial hypertext products.

The most ambitious CD-ROM encyclopedia is Compton's Multimedia Encyclopedia. In addition to the main text, the CME includes 60 minutes of audio, more than 15,000 pictures, an unabridged Merriam-Webster dictionary, and 45 animation sequences. The CME is published by Britannica Software, but unfortunately does not include text from the Encyclopaedia Britannica, but rather from Compton's, which Britannica bought several years ago.

The quality of the articles in the CME varies widly, and some of the articles are

VENDORS

Bureau of Electronic Publishing, Inc.
141 New Road
Parsippany, NJ 07054
Tel. 201-808-2700.

ToolBook 1.0 ($395)
Asymetrix Corp.
110 110th Avenue NE, Suite 717
Bellevue, WA 98004
Tel. 206-462-0501.

HyperPAD 2.0 ($99.95)
Brightbill-Roberts & Company, Ltd.
120 E. Washington Street
Syracuse, NY 13202
Tel. 315-474-3400.

Grolier's Electronic Encyclopedia, Version 2.0 ($395)
Grolier Electronic Publishing
Sherman Turnpike
Danbury, CT 06816
Tel. 800-356-5590.

World Book's Information Finder, Version 2.0 ($579)
World Book, Merchandise Mart Plaza
Chicago, IL 60654
Tel. 800-323-6366.

Compton's Multimedia Encyclopedia, Version 1.1 ($895)
Encyclopaedia Britannica Educational Corp.
345 Fourth Street
San Francisco, CA 94107
Tel. 800-554-9862.

very poorly researched and written. However, the CME has plenty of hypertext flash, so it's worth playing with, if only to get some idea of what that flash is all about. Some of the neater features include a scrolling timeline of American history. If you see an event that looks interesting, just click on it, and you move to an article on that event. Chances are that article refers to another; you can jump from article to article and traverse the hypertext web.

The CME also includes a scrolling, rotating world globe. Just click on an area to bring it to the center of the screen, and then zoom in several times to obtain progressively more detail on that region. An animation sequence shows how blood flows through the heart. You can search the encyclopedia by key word (but no Booleans); CME also includes a tree-structured list of topics.

The CME is a frustrating product because it doesn't fully live up to its ambitions. In addition to the impoverished articles, the CME's user interface is abominable. It uses a mouse and runs in a full bit-mapped graphic mode, and thereby proves that by themselves those elements are no guarantee of user-friendliness. It's also extremely slow. However, CME is an exciting product; in demonstrating it, I never fail to elicit oohs and aahs. If the company can straighten out the user interface and improve the articles, it will set a standard for all other products of the type.

Less flashy but more substantial is World Book's *Information Finder*. Although the Information Finder (IF) has no sound or graphics, it has a superb user interface that shows the outline of an article on the left side of the screen, and the text on the right. You can move through an article section by section by clicking on an outline heading, or line-by-line by scrolling the text window. Information Finder has a nice Boolean search function that allows you to restrict searches by combining terms (*e.g.*, "pets not cats"). The articles themselves are of higher quality than in the CME.

Information Finder includes the complete text of the World Book Encyclopedia, so you could use the CD-ROM version to do your searching, and then go to the hard-copy version for the illustrations. In fact, you can buy the IF together with the paper version for little more than the cost of either separately. That is a very nice package.

Grolier Electronic Publishing was first out of the starting blocks with a CD-ROM encyclopedia a few years ago. The latest version provides a much better user interface, including multiple open windows, Boolean searching, and thousands of photographs and other illustrations (VGA required).

If I had to choose just one of those works, right now my choice would be Information Finder. Information Finder has only text, but its superior user interface makes using the product a pleasure.

WRAPPING UP

Locating CD-ROM drives and products can be difficult; the best source I've found is the Bureau of Electronic Publishing. The Bureau has published several of its own titles, including a nice collection of 100 fully indexed books on U.S. history, and another collection of shareware software; the company also serves as a clearinghouse for many other CD-ROM related products. (I'd like to thank Barry Cinnamon, president, for the loan of a CD-ROM drive while researching this article.) ■

CIRCUIT CIRCUS

By Charles D. Rakes

Voice Scrambler/ Descrambler And More

This month we are going to take a very popular IC and use it in several circuits in the hope that at least one of them will tweak your interest enough for you to heat up your soldering iron and join in. We're going to spotlight on Signetics' NE602 low-power VHF double-balanced mixer. That 8-pin chip (see Fig. 1) features a built-in local oscillator, an differential input amplifier, and a voltage regulator. The internal oscillator circuit will operate up to 200 MHz with either an external crystal or tuned-tank circuit. Its input and output resistance is about 1.5k with an input capacitance of only 3 pF. The IC requires less than 3 mA of current with a supply voltage of from 4.5 to 8 volts.

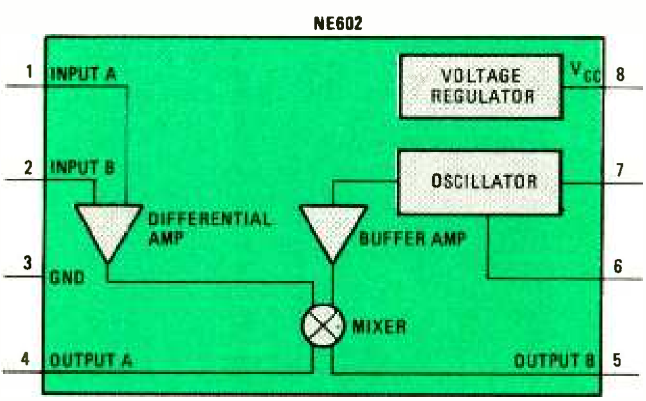


Fig. 1. Here's a block pinout diagram of Signetics' NE602 low-power VHF double-balanced mixer, which contains a built-in local oscillator, an differential input amplifier, and a voltage regulator.

VOICE SCRAMBLER/ DESCRAMBLER

After looking over the NE602's specification sheet, one of the applications that came to mind was how well the IC would perform as a balanced modulator/demodulator in a single-mode inversion voice scrambler circuit. Excellent results were obtained with the voice scramber/descrambler circuit shown in Fig. 2.

A 567 tone decoder (U2) operates as a carrier oscillator supplying a 2.5 kHz to 3.5 kHz audio square-wave to U1's (the NE602) oscillator input at pin 6. A voltage divider, consisting of R2 and R3, furnishes a square-wave signal of about 600-millivolts peak-to-peak to pin 6 of U1.

The two mixer outputs of U1 (at pins 4 and 5) are coupled through T1, a 1k to 8-ohm audio-output transformer, for a balanced output that provides maximum attenuation to the input and local oscillator signals. A 386 low-power audio amplifier (U3) is used to increase the descrambled output sufficiently to drive a small 4- or 8-ohm speaker.

When a single-mode inversion signal is fed to the input of the circuit and the carrier oscillator is tuned to the original encoded frequency, the audio is reassembled to its normal condition and sounds like a properly tuned single-side-band radio signal. Actually, the scrambler will operate either as a scrambler or a descrambler.

It just depends on what type of audio signal (scrambled or unscrambled) is fed to the circuit. When normal voice is applied to the input of the circuit, the circuit outputs an encoded signal. If the scrambled output is recorded and fed back into the circuit, the circuit outputs a decoded signal. You could use a cassette recorder with the scrambler/descrambler to give your personal notes a degree of security without spending a

PARTS LIST FOR THE VOICE SCRAMBLER/DESCRAMBLER

SEMICONDUCTORS

U1—NE602 low-power VHF double-balanced mixer, integrated circuit
U2—LM567 tone-decoder, integrated circuit
U3—LM386 low-power, audio-amplifier, integrated circuit

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1, R2—1000-ohm
R3—10,000-ohm
R4—10-ohm
R5—25,000-ohm potentiometer
R6—10,000-ohm potentiometer

CAPACITORS

C1–C5—0.1-µF, ceramic-disc
C6—0.27-µF, mylar or similar
C7—0.039-µF, mylar or similar
C8—0.05-µF, ceramic-disc
C9—100-µF, 16-WVDC, electrolytic
C10—220-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

SPKR1—4 or 8-ohm speaker
T1—1000-ohm to 8-ohm audio transformer
Perfboard materials, enclosure, 9-volt power source, IC sockets, knobs, wire, solder, hardware, etc.

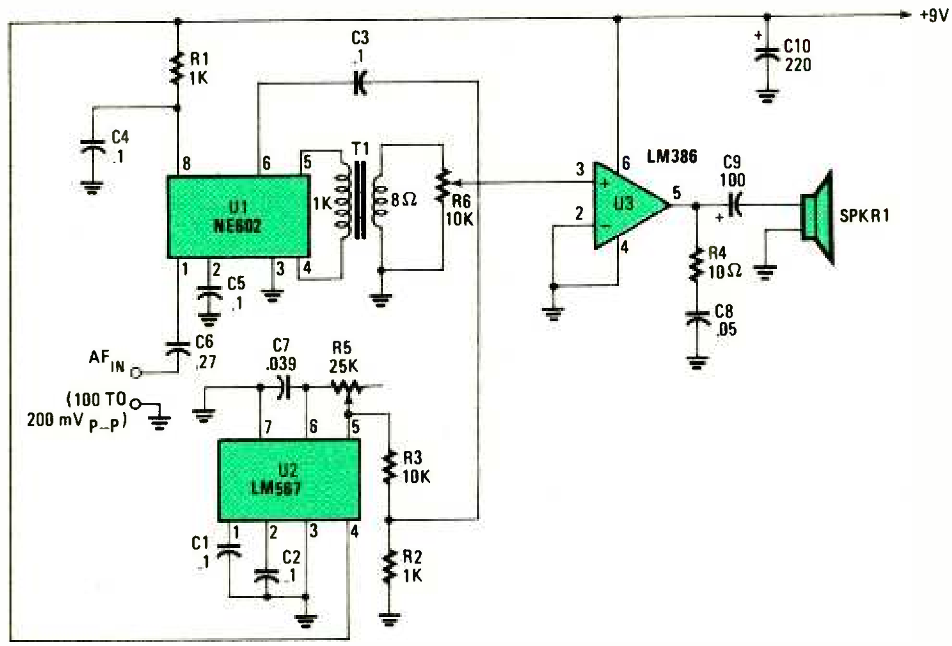


Fig. 2. In this single-mode inversion voice scramber/descrambler circuit, the NE602 is configured as a balanced modulator/demodulator.

bundle for a commercial system.

PERMANENT-MAGNET DETECTOR

In our next circuit (see Fig. 3), the NE602 is used as the heart of a permanent-magnet detector. The NE602's internal oscillator is tuned to about 15 kHz by an external tank circuit made up of L2, C7, and C8. Transistor Q1 and its associated components make up a similar oscillator circuit that operates at about the same frequency. The output of the transistor oscillator is fed to the A input of U1 at pin 1 and is mixed with the output of U1's internal oscillator.

The difference output of U1 (the mixer's low-frequency product) at pin 5 is fed through a low-pass filter, consisting of L3 and C16, to the base of Q2, which is configured as a grounded- (or common-) emitter low-frequency amplifier. High-frequency feedback is provided through C17 from the collector of Q2 to its base. The circuit's gain is high at frequencies below 10 Hz. The low-frequency component of the signal is fed through a 10-µF capacitor to a voltage-doubler/detector circuit to M1, which is used to indicate relative magnetic-field strength. When a magnet is brought close to either L1 or L2, the circuit produces a meter reading, indicating the relative magnetic-field strength.

The magnet detector is easy to adjust and use. First both oscillators must be tuned to the same frequency. If, by your good luck, the two tank circuits happen to oscillate within a few hertz of each other, then C15 can be used to zero-beat the two signals. If not, the two oscillators are too far apart in frequency. Determine which oscillator is operating at the higher frequency and add small value capacitors across the tuned circuit until that oscillator's frequency is about the same as the other. Then fine tune the circuit via C15 (the variable capacitor) for a zero beat.

When both oscillators are at zero beat (operating at the same frequency), the meter will indicate zero current flow. Positioning a magnet near the end of either L1 or L2 will cause the permeability of the choke's ferrite core to change, shifting the oscillator's frequency and producing a meter reading. The meter can be roughly calibrated to indicate the approximate strength of the magnet by positioning the magnet at a fixed distance from the coil and setting R10 for the desired meter reading.

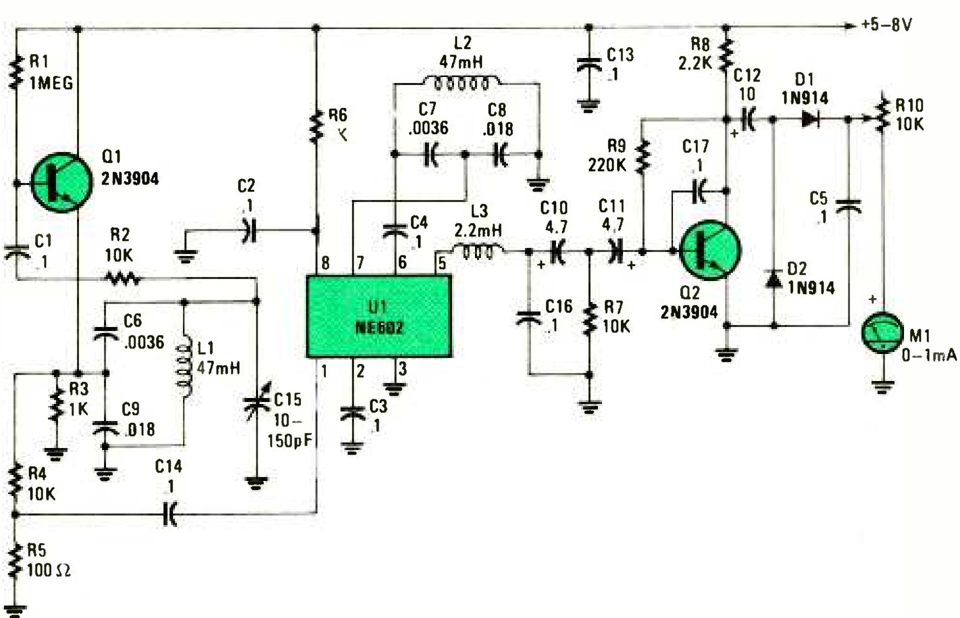


Fig. 3. The NE602 is the heart of the permanent magnet detector. By bringing a magnet close to either L1 or L2, the circuit will respond by producing a meter reading, indicating the relative field strength of the magnet.

AUDIO-FREQUENCY GENERATOR

Our last entry, shown in Fig. 4, places the NE602 at the center of an unusual audio-frequency generator. The circuit produces audio sine waves by mixing the outputs of two RF oscillators that are operating at about the same frequency. Varying the frequency of either RF oscillator causes the audio-output frequency to

PARTS LIST FOR THE PERMANENT-MAGNET DETECTOR

SEMICONDUCTORS

U1—NE602 low-power VHF double-balanced mixer, integrated circuit

Q1, Q2—2N3904 general-purpose NPN silicon transistor

D1, D2—1N914 general-purpose silicon diode

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)

R1—1-megohm

R2, R4, R7—10,000-ohm

R3, R6—1000-ohm

R5—100-ohm

R8—2200-ohm

R9—220,000-ohm

R10—10,000-ohm potentiometer

CAPACITORS

C1–C5, C13, C14, C16, C17—0.1-µF, ceramic-disc

C6, C7—0.0036-µF, mylar or similar

C8, C9—0.018-µF, mylar or similar

C10, C11—4.7-µF, 16-WVDC, electrolytic

C12—10-µF, 100-WVDC, electrolytic

C15—10–150-pF trimmer

ADDITIONAL PARTS AND MATERIALS

L1, L2—47-mH RF choke

L3—2.5-mH RF choke

M1—0–1-mA current meter

Perfboard materials, enclosure, 5–8-volt power source, IC socket, mangets, wire, solder, hardware, etc.

PARTS LIST FOR THE AUDIO-FREQUENCY GENERATOR

SEMICONDUCTORS

U1—NE602 low-power VHF double-balanced mixer, integrated circuit

Q1—2N3904 general-purpose NPN silicon transistor

D1—See text

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)

R1—2200-ohm

R2—220,000-ohm

R3—1000-ohm

R4, R5—10,000-ohm

R6—10,000-ohm potentiometer

CAPACITORS

C1–C4—0.1-µF, ceramic-disc

C5, C6—680-pF ceramic-disc

C7, C8—.0033µF, ceramic-disc

C9—0.01-µF, ceramic-disc

C10—0.0036-µF, Mylar or similar

C11—0.27-µF, Mylar or similar

C12—365-pF, variable

C13—220-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

L1, L2—2.5-mH RF choke

FIL1, FIL2—455-kHz ceramic filter (Murata CSB455E or similar)

Perfboard materials, enclosure, IC socket, wire, solder, hardware, etc.

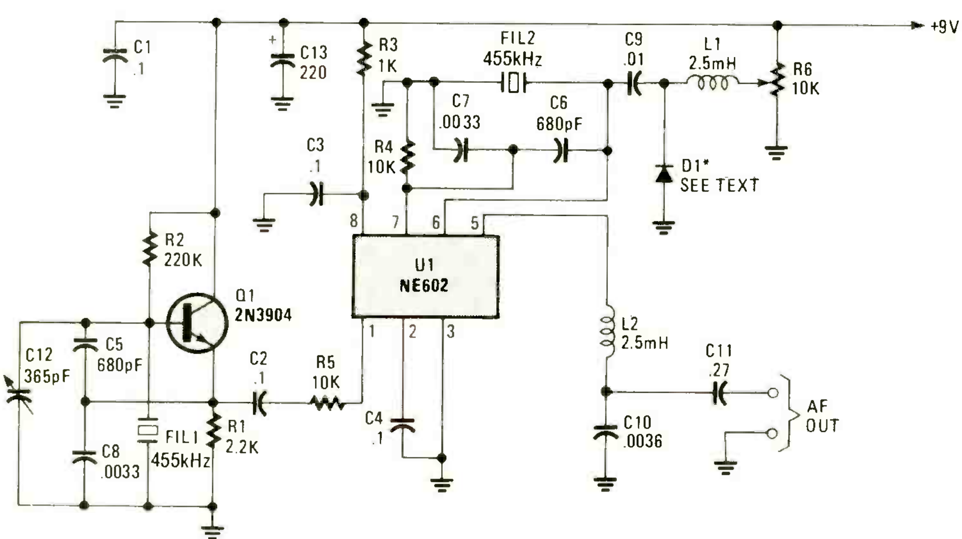


Fig. 4. Here is an unusual audio-frequency generator built around the NE602. It produces an audio sine-wave by mixing the outputs of two RF oscillators operating at about the same frequency.

change by the same number of hertz. It's much easier to shift an RF oscillator a few thousand hertz than it is to shift an AF oscillator the same amount. The method of shifting the RF frequency can be as simple as varying the value of a capacitor or a potentiometer.

Transistor Q1, along with FIL1 (a 455-kHz ceramic filter), and the few surrounding components make up one of the RF oscillators. The NE602's internal oscillator is set to about the same frequency via FIL2. A low-pass filter, consisting of L2 and C10, removes the RF component from the circuit's AF-output signal.

Diode D1 can be a common silicon diode (like the 1N4002) or transistor (base-collector) junction operating as a varicap diode. With the wiper of R6 at ground potential and C12 set so that both oscillators are operating at the same frequency no audio tone will occur at the output. But, by turning potentiometer R6, U1's oscillator will shift in frequency to produce an audio output.

Note: If you can't find the 455-kHz ceramic filters used in the Audio Frequency Generator, just send an S.A.S.E (self-addressed stamped envelope) to Charles D. Rakes, C/O *Circuit Circus*, **Popular Electronics,** 500-B Bi-County Blvd., Farmingdale, NY 11735 and I'll send two along. Also note that if you can not find the NE602 double-balanced mixer locally, it is available by mail order from DC Electronics, PO Box 3203, Scottsdale, AZ 85271-3203; for pricing, availability, and shipping charges, you can call them at 602-945-7736.

Well, that's a wrap for this month, but be sure to join us here again next month for another *Circuit Circus* roundup. Until then, happy experimenting. ■

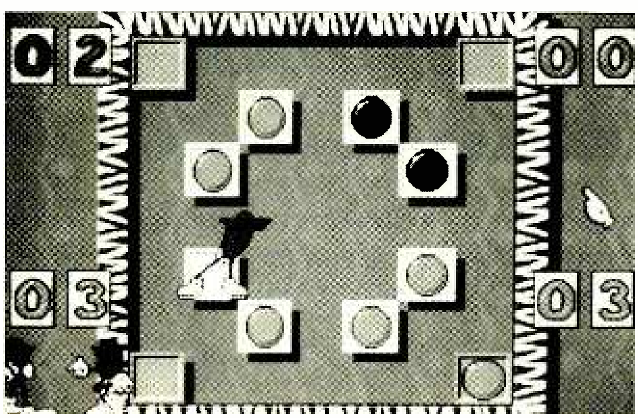
FUN SOFTWARE

By Fred Blechman

Three Fun Games From England

Our focus this month is on Virgin Mastertronic (18001 Cowan, Suite A, Irvine, CA 92714; Tel. 714-833-8710). Started in England by three British entrepreneurs in 1984 as Mastertronic, Ltd., the company introduced quality games at about half the price of games then on the shelves. They began operations in the United States under the direction of Martin Alper, one of the founders and now President of North American Operations.

Through various acquisitions and mergers, Virgin Mastertronic evolved by 1988 as one of the five largest computer-game companies worldwide. A recent 16-page full-color catalog shows 23 games, simulations, adventures, and the like for the IBM PC, 13 for the Atari ST, 4 for the Apple IIGS, 2 for the Macintosh, 17 for the Amiga, and 17 for the Commodore 64/128.



Follow the antics of 7-Up's Spot character in SPOT: The Computer Game.

I reviewed Virgin Mastertronic's Risk in the December 1990 Fun Software column. This time we'll look at SPOT, Monopoly, and Deluxe Scrabble, in some detail. Some of the more spectacular adventure titles like Spirit of Excalibur and Wonderland (with supertext) will have to wait for another time. Request Virgin Mastertronic's catalog for information on their many other programs.

SPOT: THE COMPUTER GAME

Who is Spot? He's that ultra-cool, wild, and unpredictable animated character used in 7-Up soft-drink advertisements. He is also the action element in SPOT: The Computer Game, which somewhat resembles the old favorite Othello, or its more recent revival as Reversi in Microsoft's Windows 3.0 for the IBM PC.

SPOT is played with up to four players, each with a different color, any or all of which can be human or computer controlled. If you want to see some wild action, set up all four players as the computer!

The game is played on a grid of 49 squares—seven across by "seven-up." Occupied squares are marked with a round spot the color of the player—red, green, blue, or purple. You can use a plain board (all squares available), or any of 512 pre-programmed boards with some squares blocked out of play, or design your own board by blocking any squares you choose.

You can also select timing options for each player and the length of the game, and even have a "Secret Spot Square" that produces a three-reel slot-machine-like display on the screen for an extra bonus (if you stop the reels so that the characters match in all three columns).

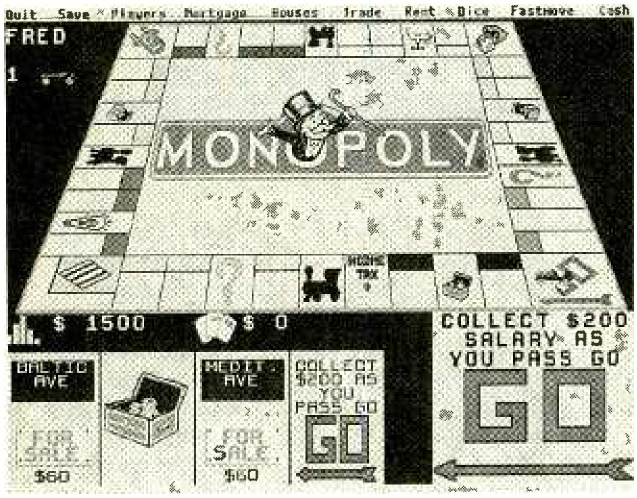
The animated 7-Up "Spot" character, complete with sunglasses, gloves, and big shoes, can slide, jump, cartwheel, or pole-vault to any empty square no more than two squares away, including jumps over its own or opponent markers. Wherever it moves, all adjoining squares (as many as eight!) change to that player's color, which can lead to wild changes in score. Each player's score is constantly updated by other Spots that run or leap across the screen to the next player's scoreboard. You will not be able to resist these animated characters that cannot avoid the description of "cute."

When you select a Spot to move, using either a mouse, trackball, joystick, or cursor keys, the marker on that location changes to a Spot character that looks around and sniffs (checking for nearby unoccupied squares), then waits for its move instructions. If the Spot is computer controlled, it makes the decision very quickly. Although I was able to beat the computer a couple of times, usually I was humiliated in hardly any time at all!

With an IBM PC or compatible you'll need EGA, VGA, or Tandy graphics, since Hercules and CGA graphics are not supported by the game. You'll also need a machine running at 10 MHz or better, or the action will drag.

(Virgin Mastertronic. IBM PC or compatible with EGA, VGA, or Tandy graphics, $39.99; Amiga, $39.99; Commodore 64/128, $29.99.)

CIRCLE 131 ON FREE INFORMATION CARD



Budding Donald Trumps can refine their real-estate buying, selling, and trading skills in this Virgin Mastertronic's computer version of Monopoly.

MONOPOLY

You can play this computer version of the bestselling board game of all time with friends, against the computer, or with a mixture of human and computer-controlled opponents. And unlike some earlier shareware simulations, this version of Parker Brothers' real estate trading game does not require the board game as the complete board, tokens, and cards are displayed on your screen.

As far as I can tell, the computer game plays by the same rules as the board game, but the computer does all the money calculations, randomly selects the chance cards, keeps track of who owns what property, and all the other details of game operation. You can build houses and hotels, collect rent, trade or mortgage property, and even get property at fantastically low prices in auctions.

The displayed playing board represents the various properties with colors and symbols, and the chosen token for each player is shown moving with each random roll of the screen dice. The details of the properties and rents, and the cash and property values held by the current player, are shown in detail on the lower third of the screen. You can also request screen reports about player token positions, who owns what property, where the houses are, and the financial status of all of the players.

If all you have is CGA, you may have difficulty interpreting the screen details. Hercules is much better than CGA (though not in color), and Tandy or EGA graphics are great.

I found playing the game a lot faster and easier than the board version since you don't have to take the time to count out money, select and replace chance cards, handle property cards, or do any calculations as banker.

You can also play against the computer, which is a mean machine! It's fascinating to watch the computer mortgage, build houses, and unmortgage, always operating with minimum cash and maximum property, just like very aggressive real-estate moguls.

If you are at all familiar with Monopoly, you'll quickly get up to speed with Virgin Mastertronic's version. Sometimes the screen is cryptic in its questions, but the 24-page user manual nicely summarizes the game rules, computer prompts, and expected responses. After an hour with the computer version, you'll be looking for your next real-life board Monopoly victim—and might even be sharpening your real estate savvy in the real world.

(Virgin Mastertronic. IBM PC or compatible with Hercules, CGA, EGA, or Tandy graphics, $39.99; Commodore 64/128, $29.99.)

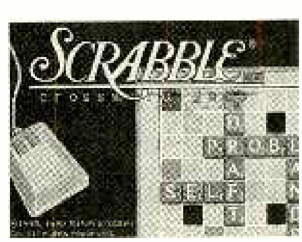
CIRCLE 132 ON FREE INFORMATION CARD

DELUXE SCRABBLE

If you are one of the estimated 33 million leisure Scrabble players in the U.S. or Canada, you will be fascinated by The Deluxe Computer Edition of Scrabble Brand Crossword Game, which I will simply call Deluxe Scrabble. This version, available only for the IBM PC and compatibles, replaces Virgin Mastertronic's earlier version; that original, non-deluxe version is still available for the Commodore 64/128 for $29.99.

Deluxe Scrabble goes beyond the original computer edition by adding a bunch of new features. For example, if you have about 2.5MB of free space on your hard drive, you can install an "Official Scrabble Player's Dictionary," which includes the definitions of thousands of rare and exotic words.

Anagram and crossword features allow you to make words from difficult letter combinations and use the power of the computer to build words in tight places. Up to four players (human, computer, or a mixture of each) can compete, with nine levels of skill for the computer players, and a wide range of play timers.



This Deluxe Scrabble computer game is as addictive as the board version.

Among the many, many options, you can save a game at any point, request hints, juggle the tiles, change tiles, pass, edit the board, printout the game history log, disallow 2-letter or S-words, edit the user dictionary, change skill levels, and even switch computer players to humans.

If you have a high-density 1.2MB 5.25-inch or a 720K 3.5-inch floppy drive you don't need a hard drive to run Deluxe Scrabble. Low-density 360K diskettes are also available on a trade-in basis (for $5) but you'll need a hard drive to play the game. Also, you'll need some kind of color display, since Hercules graphics are not supported.

You can use a mouse, trackball, keyboard, or joystick for screen navigation and command. I tried all four and (although I usually prefer the trackball to a mouse) I found the mouse a clear winner. The keyboard is slow, the joystick is too easily overcontrolled, and the trackball is somewhat awkward to use with this particular game.

As for displays, the game plays very well in CGA, but is much prettier in EGA or VGA. I could not get either my mouse or trackball to move to the right half of the screen with VGA. This may have been a problem with the mouse/trackball driver I was using, but I liked the more colorful EGA display better anyway!

When using a computer as one or more of the players, you might have to wait a considerable time for a move, unless you set a time

(Continued on page 83)

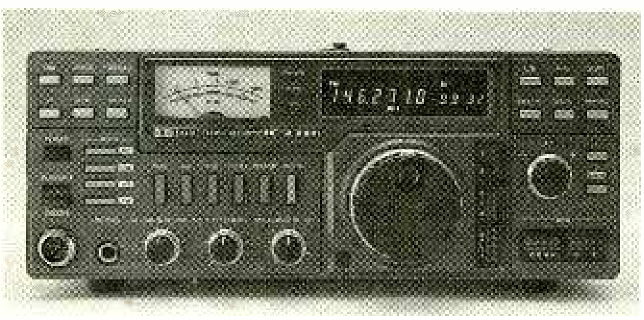
HAM RADIO

By Joseph J. Carr, K4IPV

The New No-Code License

From the mail that we been receiving, it's obvious that many of those who read this column month in and month out are not "licensed" amateur-radio operators. Some regular readers are "strikers" who are trying to get a ham license, but so far have not been sufficiently motivated to satisfy all of the requirements to obtain their amateur license.

Previously, one of the big impediments to getting a ham license was the Morse-code test. A lot of technically savvy readers would be able to pass the written test, but would "Foxtrot" the Morse-code test, no matter how slow the required minimum speed (or so they erroneously believe). But now there's one less excuse for not getting your ham "ticket": the Federal Communications Commission (FCC) finally did it!



The new technician class ham radio license allows full operating privileges in portions of the VHF/UHF bands without passing a Morse-code test. That allows hams to take full advantage of equipment like this Icom IC-271H 2-meter rig.

After many years of debate, with hams forming up on both sides (or all fifteen sides?) of the issue, the FCC now offers a technician-class, amateur-radio license that does not require a Morse-code examination. If you pass the appropriate level written, amateur-radio test, which covers theory, operating practices, and regulations, then you will be accorded amateur-radio operator privileges of the technician class in the 50 MHz and above (VHF/UHF) portion of the spectrum.

While you will have to pass the usual Morse-code test in order to gain additional privileges in the HF portion of the spectrum (where the big DX is found), there are still plenty of activities (including DX) on the high (VHF/UHF) bands. Now that the really big stumbling block is out of the way, perhaps it's time for you to reconsider getting into amateur radio.

Amateurs operating in the VHF/UHF bands use fixed (*i.e.*, "base station") equipment, mobile equipment, or handheld portable equipment in their activities. Perhaps nowhere has the miniaturization, and advancement in features available per dollar been seen more apparent than in the VHF/UHF spectrum. That's the spectrum occupied by the technician-class, amateur-radio operator.

The activities available in the VHF/UHF bands include old- fashioned simplex operation; *i.e.*, two stations on or near the same frequency talk to each other directly. Also available are innumerable repeaters located in all states across the country. The repeaters transmit on one frequency, and receive on another frequency.

For example, the repeater will transmit on *f*1, and listen on *f*2. Mobiles, portables, and even fixed stations operating through the repeater use the opposite protocol—they transmit on *f*2 and listen on *f*1. That way, a repeater located in an advantageous ("high") location can allow low-power stations to communicate with each other even though they would normally be out of range of each other. You can follow the highways from one repeater to another (often multiple repeaters), all across the USA and throughout Canada.

Amateurs in the high bands can also use a communications networking method called packet radio, and can communicate through local VHF nodes all over the country. And how about DX? Well...if you're a real VHF'er, then you might want to try EME...that's Earth-Moon-Earth "moonbounce" communications. That's real DX! It also requires a large investment in equipment, antennas, real estate, and raw patience.

DX does come to VHF'ers. On two-meters and above, various propagation phenomena occur to make DX possible, although it is really unusual. But on the 50-MHz amatuer band (6 meters), the DX is a lot more common.

The propagation on 6 meters is a bit like that on the 10-meter amateur band and the Citizen's Band. It is quite possible for my buddy in Norfolk, VA to work Anchorage, Alaska on the 6-meter ham band. Foreign DX is also possible, especially down into the Caribbean and Central America region (although Europe is not unknown). Not everyday, mind you, but DX occurs often enough to make it worth working towards.

RESOURCES FOR THE NEWCOMER

Once you decide to take the plunge and get that ham license, you'll want to find out what's available to make the hobby easier, especially in the area of obtaining the license. For starters, try contacting The American Radio Relay League—ARRL (225 Main Street, Newington, CT, 06111; phone 203-666-1541).

The ARRL offers a wide variety of publications and provides help for newcomers to ham radio, including the principal training materials. My advice to you is that you join the ARRL and take part in their local club activities. If you want to try for one of the code classes of license, then the ARRL offers practice tapes, and their radio station (W1AW) transmits code practice on several shortwave ham bands every evening.

The first publication to buy is the ARRL's *Tune in the World With Ham Radio*. It comes in two forms: book only and book plus code practice tapes ($14 and $19, respectively). The book will introduce you to all of the major aspects of amateur radio, and help to prepare you for the examinations.

Another ARRL publication is Doug DeMaw's (W1FB) *Help For New Hams*. That $10 book is billed as advice on getting started in Amateur Radio after you get your license. It discusses equipment, antennas, installation, operation, station layout, safety, TVI, DX'ing, and a host of other topics that new "hams" tend to ask of us older fellows.

Once you get above the elementary technical levels, you'll find that the ARRL has a wide variety of books written especially for the amateur-radio operator. The *ARRL Radio Amateur's Handbook* is a major annual that should be in your library; it changes insignificantly from year to year so you need only to purchase a new one every four or five years.

There are also a number of non-ARRL books that can help you. If you are just toying with the idea of becoming a ham, then try *The Wonderful World of Ham Radio: An Introduction For Young People* by Richard Skolnik, KB4LCS (MFJ Enterprises, Inc., PO Box 494, Mississippi State, MS, 39762; Tel. 601-323-5869). In the acknowledgements to his book, Dick Skolnik thanks friends of mine such as Dick Robinson, K4EIH, of Electronic Equipment Bank (323 Mill Street N.E., Vienna, VA 22180; 703-938-3350), a mail-order and local retail supplier of ham and SWL gear, and Darrell Earnshaw, NR3Y (who lives close enough to me to singe my receiver's RF amplifier with his kilowatt rig!).

If you want a good book on ham antennas, then let me immodestly suggest my own contribution: "Practical Antenna Handbook" (TAB Books, Blue Ridge Summit, PA, 17294-0850; Tel. 1-800-233-1128; Catalog No. 3270, $21.95). Judging from the response, the book has been well received, even if I do say so myself.

CONCLUSION

Ham radio has served me well as a hobby since 1958 when I first went goo-goo eyed over the ham gear in Allied Radio and Walter Ashe catalogs...and really flipped out when I found out that one of my paper-route customers was Mac Parker, W4II—my own fondly remembered Elmer. Now, more than three decades later, I'm still enjoying it, writing about it, and following ham radio. Once you get into this wonderful hobby, it may serve you well, too. ■

DX LISTENING

By Don Jensen

In Search Of European DX

One of our readers, Agnes Foscolou of the University of Houston's Department of Physics, contacted **Popular Electronics** recently with a question that is both easy and difficult to answer. "Can you tell me the frequencies for shortwave radio for all major European stations?"

The hard part is that there just isn't enough space to list all the frequencies used at all hours of the day and night for programs in all the languages used by the shortwave stations in Europe.

Shortwave listening can be a family affair. John Mosman, Olathe, KS, began his DX listening back in 1962. Seen with him in the Mosman listening post are his wife, Laura, and their two daughters, Courtney and Lindsay. John has heard over 150 countries on shortwave with his ICOM R71A receiver and two older SW sets.

A few years ago, for instance, "Passport To World Band Radio (PTWBR)," the annual publication listing in easy-to-use chart form the frequencies, languages used, and schedules of all the world's shortwave broadcasters, did a computer check of its own data. It showed, for instance, that the Soviet Union's total weekly spectrum occupancy—that is, the number of hours broadcast in all of its language services during a week multiplied by the number of frequencies used—was nearly 29,000 hours.

If you added the spectrum occupancy of the other major European shortwave broadcasters, the weekly total was nearly 56,000 hours! Since Europe is one of the most "radioactive" parts of the world when it comes to broadcasting hours, probably a majority of PTWBR's hundreds of pages of data involve the very shortwave stations that Ms. Foscolou has asked about.

For that sort of detail, I would refer her and other readers with a similar interest to the "1991 Passport To World Band Radio," available from book shops; stores and mail-order firms that sell shortwave radios; or the publisher, International Broadcasting Services Ltd. (PO Box 300, Penn's Park, PA 18943).

There is an easier answer, if the question is limited to *some* of the frequencies and scheduled hours for *English* programs from European SW stations, which are often heard in North America during prime listening times. That shortens our list considerably.

But first, just a reminder: The commonly used time reference Coordinated Universal Time (UTC) is equivalent to Eastern Daylight Time plus 4 hours, CDT + 5, MDT + 6 or PDT + 7. Times are given in the 24-hour system. For example, 0100 is 1 o'clock in the morning; 1300 is 1 PM. Frequencies are listed in kilohertz, which is abbreviated as kHz.

Some of those European programs—including those of the *British Broadcasting Corp., Germany's Deutsche Welle, Radio France International*, and *Radio Nederland*—are, in fact, being relayed by shortwave transmitters in the western hemisphere to give strong reception to North American listeners.

Here's a list of those English-language broadcasters, frequencies, and times:

ALBANIA—*Radio Tirana.* 0230 UTC and 0330 UTC on 9,670 kHz, and 0630 UTC on 7,205 and 9,500 kHz.

AUSTRIA—*Radio Austria.* 0130 UTC on 9,875 kHz, and 0530 UTC on 6,015 and 6,155 kHz.

BELGIUM—*Belgian Radio-TV.* 0030 UTC on 9,925 kHz, and 0730 UTC on 11,695 kHz.

CZECHOSLOVAKIA—*Radio Prague International.* 0000 UTC on 7,345 kHz, and 0100, 0300 and 0400 UTC on 5,930 and 7,345 kHz.

FINLAND—*Radio Finland.* 1130 UTC and 1300 UTC on 15,400 and 21,550 kHz.

FRANCE—*Radio France International.* 1230 UTC on 17,650 and 21,635 kHz; 1400 UTC on 21,770 kHz, and 1600 UTC on 17,620 kHz.

GERMANY—*Deutsch Welle.* 0100 UTC on 6,040 kHz, and 0300 and 0400 UTC on 6,040, 6,085 and 6,145 kHz.

GREAT BRITAIN—*British Broadcasting Corp.* 0000 to 0400 UTC on 5,975, 6,175, 7,325, 9,915 and 12,095 kHz.

*Credits: World DX Club, UK; Fine Tuning, PO Box 780075, Wichita, KS; Larry Yamron, PA

GREECE—*Voice of Greece.* 0145 and 0345 UTC on 9,395, 9,420 and 11,645 kHz.

HUNGARY—*Radio Budapest.* 0130 and 0230 UTC (except Sundays) on 9,835 and 11,910 kHz.

ITALY—*RAI.* 0100 UTC on 9,575 and 11,800 kHz.

NETHERLANDS—*Radio Nederland.* 0030 UTC on 6,165 and 15,560 kHz and 0330 UTC on 9,590 and 11,720 kHz.

NORWAY—*Radio Norway International.* 1600 UTC on 21,705 kHz, and 1700 UTC on 17,755 kHz (Sunday only).

POLAND—*Radio Polonia.* 0630 UTC on 7,270 and 9,675 kHz, and 2230 UTC on 7,270 kHz.

ROMANIA—*Radio Romania International.* 0200 and 0400 UTC on 5,990, 9,510 and 9,570 kHz.

SPAIN—*Spanish Foreign Radio.* 0000 and 0100 UTC on 9,630 and 11,880 and 0500 UTC on 9,630 kHz.

SWEDEN—*Radio Sweden.* 0200 and 0330 UTC on 9,695 and 11,705 kHz

SWITZERLAND—*Swiss Radio International.* 0200 and 0400 UTC on 6,135, 9,885 and 12,035 kHz.

USSR—*Radio Moscow.* 0000 to 0700 UTC on 6,000, 7,150, 9,685 and 9,765 kHz.

USSR—*Radio Kiev* (Ukraine). 0000 UTC on 7,400 kHz.

USSR—*Radio Yerevan (Armenia). 0350 UTC on 7,400 kHz.*

VATICAN—*Vatican Radio.* 0050 UTC on 6,150 and 9,605 kHz; 0600 UTC on 6,185 kHz, and 0730 UTC on 11,740 kHz.

YUGOSLAVIA—*Radio Yugoslavia.* 0100 UTC on 11,735 kHz and 1930 UTC on 15,165 kHz.

Now that should get everyone off to a good start logging European stations on shortwave.

FEEDBACK

Each month I read the mail and the most interesting letters wind up in this regular section of *DX Listening.* It might be your letter about some programming you've tuned on shortwave, or some station you want to hear and haven't yet logged. Maybe your comments about SWL'ing will appear here. Or perhaps a question about DX'ing that others also may be wondering about. Send along a photo of you and your shortwave listening post, if you'd like. All it takes is your letter. Send it to me, Don Jensen, *DX Listening,* **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

Jerry Santiago, Albuquerque, NM, writes to say that he is particularly interested in logging South American shortwavers. "But I haven't been able to hear any SW stations in Paraguay," Jerry notes. "Aren't there any Paraguayans on the air now?"

Paraguay always has been one of the tougher South American countries to log on shortwave, Jerry. Compared to, say Peru or Ecuador, for example, Paraguay always has had very few, active, shortwave broadcasters. But Gabriel Ivan Barerra, a top flight DX'er living in Argentina, reports *Radio Encarnacion* is still active on 11,945 kHz. This one has been logged in Argentina at around 1730 UTC.

"I used to listen to shortwave radio many years ago," writes Allen Borsuch, Madison, WI, "more years ago than I care to remember. Now I'm retired and have taken up SWL'ing again. I've come across a lot of the stations that I remember from my early days of listening, the Voice of America, the BBC, Radio Moscow, of course, Radio Nederland and HCJB, to name a few."

"But back then I used to listen regularly to United Nations Radio and now that's a station I cannot find on the air. What happened to it?"

What happened was that some years ago, the arrangement between the United Nations, which produced the programs and the *Voice of America,* which transmitted them, broke down. While the UN was able to arrange some limited broadcasting hours on a few other shortwave stations around the world, it no longer has access to the powerful VOA transmitters to get its programs on the air.

You may, however, again hear *UN Radio* with English programming to North America as broadcast via the relatively low powered *Radio for Peace International* in Ciudad Colon, Costa Rica.

Arthur Ward, writing in the World DX Club publication, "Contact," offers this schedule for UN Radio/Radio for Peace International: Mondays, Wednesdays, and Fridays, 2215–2300 UTC; Tuesdays and Thursdays, 2215–2230 UTC; Mondays, Wednesdays, and Saturdays, 0145–0230 UTC; Tuesdays, Thursdays, and Fridays, 0145–0200 UTC; Saturdays at 1900–1915 UTC; and Sundays at 0000–0015 UTC. Their transmission frequencies are 13,630 and 21,565 kHz, with 7,375 kHz added for the Monday through Friday transmissions. ■

"Look what I just made—I call it a 40,000 volt stun gun"

SCANNER SCENE

By Marc Saxon

Catching Crooks, Scanner Style

One step down from Radio Shack's top dog PRO-2006 scanner, and hot on its heels, is the *Realistic PRO-2022*. Frankly, if the $400 ticket hanging from the PRO-2006 gives you cold sweats, you might find the PRO-2022, priced at $50 less, to be just what you're looking for.

For your $350, you get a lot of scanner, including coverage from 30 to 54 MHz, 108 to 136 MHZ, 138 to 174 MHz, 380 to 512 MHz, and 806 to 960 MHz (minus the cellular bands). It has a 200-channel memory, plus dual-speed search, priority channel, and all of the standard frills. The fact is, circuit-wise, the Realistic PRO-2022 is essentially a desktop version of Realistic's hardworking PRO-34 handheld scanner. The main differences are that PRO-2022 is repackaged in a base-station cabinet, and operates on 117 VAC.

The Realistic PRO-2022, just one step down from their expensive, top-of-the-line PRO-2006, is basically a desk-top version of their handheld PRO-34.

If you are interested in examining that scanner, you can see the Realistic PRO-2022 at any of Radio Shack's 7,000 stores.

MAKING MODIFICATIONS

In case you were wondering, you *can* restore the factory locked-out cellular bands in the Realistic PRO-2022. You can also do other things to enhance its performance, like speed up the scan/search rate, install 3,200 memory channels, and lots more.

Those modifications, and many others for the PRO-2004/5/6, PRO-34, Bearcat BC-200/205XLT, BC-760/950XLT, and some other popular scanners are now in the new Volume 2 of Bill Cheek's *Scanner Modification Handbook*. Volume 1 was such an overwhelming success that Cheek developed about eighteen additional modifications and put them into a big, 220-page book, complete with photos and easy step-by-step instructions. Volume 2 also provides any new information and updated techniques for the modifications in Volume 1, and shows how to do all of Volume 1's modifications for the PRO-2004/5 on the newer PRO-2006 (including cellular restoration, etc.).

Volume 2 of the Scanner Modification Handbook is $17.95, plus $2 postage to any address in North America, from CRB Research Books, Inc., P.O. Box 56, Commack, NY 11725. Residents of New York State, please add $1.35 sales tax.

WORLD IN TURMOIL

Things certainly have been hectic throughout the world for the past several months, and that has resulted in greatly increased communications activity on some of the scanner frequencies used by federal agencies here in the States. Just in case you hadn't become aware of that, I thought I'd clue you in.

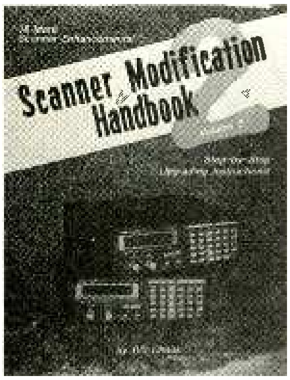
For example, listen on 409.625 MHz, which is the Security Service of the U.S. Department of State. That used to be a very quiet frequency (except when a visiting head-of-state was in town), but in recent months it seems to be busy on a far more regular basis.

We have also found increased activity on 413.60, 414.75, 415.05, 416.225, and 418.30 MHz, which are used by U.S. Postal Service security and inspection personnel. We heard them discussing their investigation of a mysterious package that was making beeping sounds.

Also, try 415.20 and 417.20 MHz. Those frequencies are popularly used by the General Services Administration police that provide security in and around federal office buildings and other facilities.

In general, the 406- to 410-MHz band seems to be producing a lot more to hear on a scanner. You might want to put your scanner into search/scan mode and see what you can discover.

When propagation conditions are right, you might even be able to hear military communications from the Middle East. It may help to scan in WFM (Wide FM) mode. Search through the following frequency ranges:



Volume 2 of the Scanner Modification Handbook provides 18 more modifications to enhance the performance of several popular scanners.

32 to 33 MHz, 34 to 37 MHz, 38 to 39 MHz, and 40 to 42 MHz. Mornings will be best; set your unit to scan at 50-kHz frequency separation.

TV REPORTERS

A letter from Gary C., of Anchorage, AK, said that his wife is a TV reporter who keeps in contact with her assignment desk via a two-way radio. Although he has tried, he's been unable to locate that frequency on his scanner, and asks if we can help.

We might have been able to be quite specific had Gary let us know the TV station in question, but he didn't. However, as general rule, those stations can be located by searching between 450 and 451 MHz, and also 455 and 456 MHz, in 12.5-kHz channel steps.

Also take into account that in addition to (or even instead of) those 450-MHz bands, some radio and TV reporters communicate with their stations from the field via cellular phones. Not only does that offer more privacy than the 450-MHz bands, but that method of communications is less subject to interference.

SCANNERS TO THE RESCUE

Law-enforcement officials were baffled when a rash of thefts broke out in Dickenson County, Virginia. It's a rural area that normally has a very low crime rate but, within a brief period of time, crooks had hit a grocery store, a car dealership, a home, and an elementary school.

The beginning of the end came when they broke into the local vocational school. Among the things they took were a pair of handheld transceivers. Sheriff's investigators knew that those units had a range of only about a mile, and they also knew the frequency. The sheriff guessed that the thieves might try to use the radios to aid them in their crime spree, so he asked local residents to keep monitoring that frequency on their scanners and let him know if they heard anything unusual.

It was a gamble that paid off. Within a short time, a scanner owner called in a report of what sounded like the prelude to a burglary. A call to the sheriff put officials on the right track and led deputies to two men and a 17-year old who were quickly arrested. Each was charged with nine counts of breaking and entering, 10 counts of grand larceny, and 10 counts of conspiracy to commit grand larceny. Authorities estimate that they had stolen at least $4,000 worth of items.

It points out how scanner owners are willing and able to be of genuine assistance to public-safety agencies. These are the kind of stories we like to hear about!

If you come upon any stories about scanner owners, why not pass them along? We'd also like to hear any questions, suggestions, and frequencies you'd care to submit. Our address: *Scanner Scene*, **Popular Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

BUILD A PICTURE PHONE
(Continued from page 33)

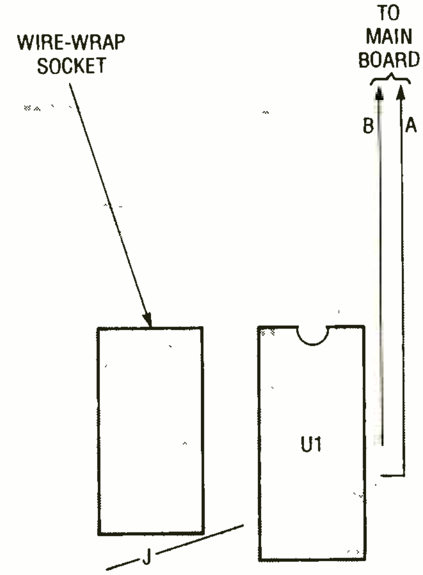


Fig. 7. The adapter board contains only two parts: an IC socket and a 6-bit ADC. Don't forget to add the jumper wire though.

Now you should install the electronic hardware (the jacks, the switches, and the relay). Soldering those components usually requires a little extra heat, so installing them before the semiconductors is prudent. Be sure that you install the switches on the "foil" side of the board. If you're building your units from the kit, be sure to position the switches correctly as it's possible to install them rotated by 90°. You can also install the transformer now.

If you plan to use IC sockets (which is recommended for at least the Videophone chip) install them at this time. If you're building a 6-bit unit, you must install an IC socket in the place marked for U3. That socket will be used to hold the adapter board.

Install the diodes and transistors, making sure that you install the LED's (LED1–LED4) on the same side of the board as the switches. Keep the leads of the LED's long so that you'll be able to position them to mate with the front-panel holes. Install the crystal now, but use a minimum of heat.

You can at last install the integrated circuits, but a few words are in order: First, there is no U6 in the 4-bit unit, but in a 6-bit unit U5 and U6 are piggy-backed (*i.e.*, U6 rests on top of U5). However, no matter what unit you build, install U5 in the board as you would any other IC and solder all its pins. We'll discuss the placement of U6 a little later. Second, there is no U3 in the 6-bit version; the adapter board takes its place—we'll discuss that a little later, too. On a final note, it's a good idea to install the Videophone chip last to avoid damaging it with heat.

If you're building a 4-bit unit, the circuitry is now complete.

Final 6-Bit Touches. A couple of extra assembly steps are required to complete a 6-bit unit. Pick up U6 (the additional DRAM) and bend pins 2, 3, 15, and 17 so that they're parallel with the body of the IC. Now place it on top of U5 so that the unmodified pins align and solder them to the pins of U5. When performing that operation, be extremely careful not to use too much heat. Excessive heat will damage the IC's. Solder jumper wires between pins 2 and 3 on U6 and the PC board as shown in Fig. 6.

Assembling the adapter board is easy. Start by installing a 16-pin wire-wrap IC socket onto the board as shown in Fig. 7. Solder it in place, but do not trim its leads. Solder the jumper wire as shown and install U1. Use the long leads of the wire-wrap socket to plug the adapter board into the socket that would have been used for U3 in the 4-bit version. Run wires between points A and B on the adapter board to the pads indicated in Fig. 6. The 6-bit unit now complete.

Setting-Up a Phonvu. Plug the 12-VDC supply into the unit via J2 and then into a wall outlet. Plug your video source (a video camera, VCR, closed-circuit TV camera, etc.) into the unit through J1. Plug the phone line into J3, and the phone into J4. Last, connect a monitor to J5. If you don't have a monitor, you can use a modulator to convert the video signals from J5 into TV signals and watch the video on channel 3 or 4 of a connected TV set.

Now you're all set to capture, receive, and send pictures via phone. You should try out all the operating modes we've mentioned to make sure everything is working properly. There is nothing to align or adjust so the unit should work right away. If a captured or received picture is a little misaligned, you should use the picture-adjust button as outlined earlier. The first picture you receive over the phone may tear and/or gyrate because sync signals have not been recorded in memory. The cure is simple enough, just capture a local image when you turn the unit on. The local image will provide sync signals that will remain in memory until the unit is turned off.

With the many optional features available through the kit supplier, you should have no trouble finding at least one good use for Phonvu. Whether you're installing a hi-tech surveillance system, enhancing a communications network, video interfacing with your computer, or just playing Dick Tracy with a friend, the Phonvu Camera Phone should prove to be one of the more rewarding projects you could build. ■

If you purchase the kit (or pre-assembled unit) from the supplier listed in the Parts List, this is what your finished unit will look like.

FUN SOFTWARE
(Continued from page 75)

limit. This is especially true with a slow machine; an 8-MHz or better computer-clock speed is recommended by Virgin Mastertronic. However, I played Deluxe Scrabble with two human opponents on a 4.77-MHz XT, using a floppy drive and a CGA screen, and found it entirely acceptable.

As with SPOT and Monopoly, I had a lot of trouble tearing myself away from the computer when testing Deluxe Scrabble. These are all addictive games.

(Virgin Mastertronic. IBM PC or compatible with CGA, EGA, VGA, or Tandy graphics, $59.99 .)

CIRCLE 133 ON FREE INFORMATION CARD

NEW FUN SOFTWARE

Here are some recently announced programs that you can order from your regular software supplier. Suggested retail prices, where announced, are shown in parentheses.

MicroProse has two new releases. Space 1889 (IBM, $49.95) is a computer adventure based on actual historic events on Earth in the late 19th century. It combines role-playing, history, and science fiction with many sub-plots. From an Egyptian expedition you find clues to reveal the answer to space travel, and make stops on various planets in search of immortality and ultimate knowledge.

The other new MicroProse release, The Amazing Spider-Man (IBM, Tandy, Amiga), is the most recent of a series of Paragon and Marvel Comics games. You assume the role of Spider-Man as you battle Mysterio, the master illusionist and arch-criminal, on six movie sets with robots, electrified floors, doors that aren't really there, and walls coated with a chemical that keeps your webbed feet from sticking. Gravity is turned upside-down and sideways in some of the over 250 screens.

Lucasfilm has released Night Shift (IBM, Atari ST, Amiga, $39.95; Commodore 64/128, $29.95). It combines exciting animation with spectacular graphics in an arcade-style computer simulation of a whimsical toy factory. As a night shift worker, you must contend with ever-increasing quotas, equipment failures, lawyers, lemmings, and a surly boss.

Cinemaware has two new releases, both distributed by Electronic Arts. It Came from the Desert (IBM) uses a full interactive sci-fi movie script with multiple storylines and in-depth character development, together with eerie sounds and visual effects. Monster-sized bugs attack a desert town. Blackmailing rivals, land scams, love triangles, desert cults, and all-out military action are included in this movie-like game.

Cinemaware has also introduced TV Sports: Basketball (IBM, $49.95), featuring full-court, 5-on-5, arcade basketball action, a 28-team league, a 24-game schedule, and post-season playoffs. You control the action on and off the court, with up to four players.

Strategic Simulations has a new release, distributed by Electronic Arts. Renegade Legion: Interceptor is a sci-fi strategy computer game based on the board game from FASA, the creators of the popular BattleTech. You fight a galactic struggle with any of 24 standard 69th Century starfighters, or design your own, in over a dozen missions ranging from anti-piracy to enemy fleet interceptions. ■

BUILD THIS STEREO AMP

(Continued from page 42)

their orientation. The installation of the amplifier IC's is a little more involved than the other components. Start by mounting the amplifiers on the board. Be sure that they are mounted correctly, with their tabs facing the edges of the board. Mount the heat sinks to the board and secure them in place with screws and nuts. Insert a screw through each amplifier tab and the hole in the heat sink, and secure each with a nut. If you don't purchase the kit, you will have to make the heat sinks from aluminum box-channel stock, or use conventional heat sinks.

PARTS LIST FOR THE 20-WATT STEREO AUDIO-POWER AMPLIFIER

SEMICONDUCTORS

U1, U2—TDA2004 20-watt audio power amplifier, integrated circuit
Q1, Q2—BC408 or BC414 NPN silicon transistor

RESISTORS

(All fixed resistors are ¼-watt, 5% units.)
R1, R12—2000–2200-ohm
R2, R7, R10, R29—8.2–12-ohm
R3, R11, R26, R27—1000-ohm
R4, R5, R8, R9—1–1.2-ohm
R6, R18–R20, R25—1800-ohm
R13, R23—1–1.2-megohm
R14–R17, R21, R22—8200–10,000-ohm
R24, R28—1500-ohm
R30, R31—47,000-ohm, dual potentiometer
R32—47,000–220,000-ohm, dual potentiometer
R33—100,000-ohm, potentiometer

CAPACITORS

C1–C8—100-µF, 25-WVDC, electrolytic
C9, C10—220-µF, 25-WVDC, electrolytic
C11–C20—1–10-µF, 25-WVDC, electrolytic
C21–C26, C29–C32—0.1-µF polyester ceramic-disc
C27, C28—0.015-µF, polyester or ceramic-disc
C33, C34—0.0062–0.01-µF, polyester or ceramic-disc
C35—470-µF, 35-WVDC, electrolytic
C36–C38—0.0027–0.0033-µF, polyester or ceramic-disc

ADDITIONAL PARTS AND MATERIALS

Printed-circuit board, connectors, heat sinks (2), wire, solder, hardware, etc.

Note: The TSM67 amplifier kit is available from American Design Components, 815 Fairview Ave., Fairview, NJ 07022, Tel. 800-776-3700 for $39.95 plus $3.00 shipping and handling. NJ residents must add appropriate sales tax. A free catalog is available on request.

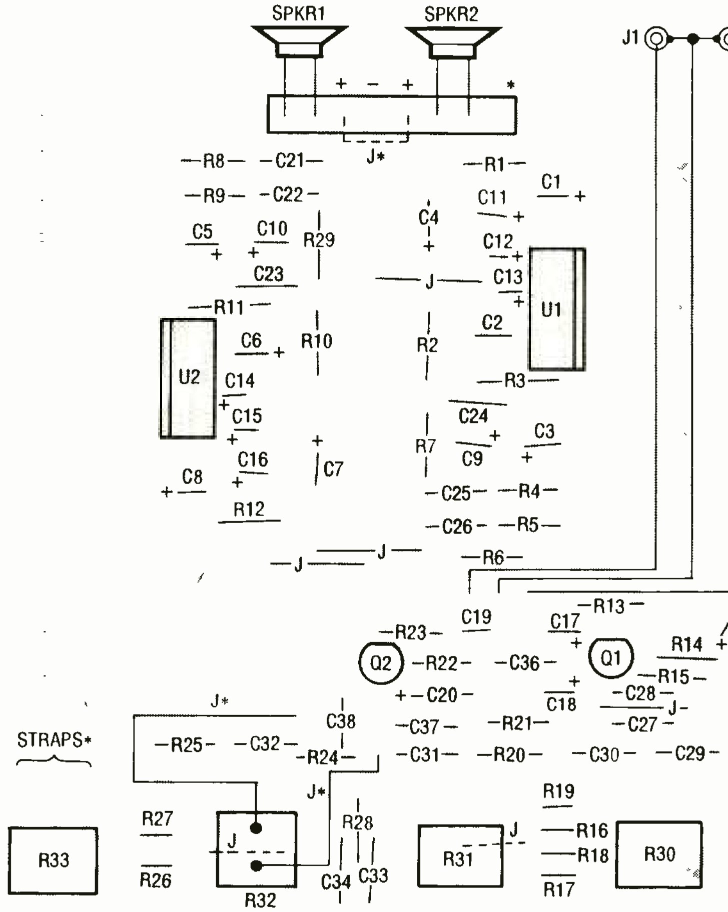


Fig. 3. Once you have the board and all the components specified in the Parts List, assemble the circuit using this layout diagram as a guide.

Now, it is time to decide whether the circuit is to be configured for mono or stereo operation. To do that, use the following procedure: To configure the circuit for mono operation, connect a jumper between points 2 and 4 near the "strap" label; doing so eliminates R33 from the circuit. To configure the circuit for stereo operation, place a jumper connection between points 1 and 3; that holds the wiper of R33 at ground potential as shown in the schematic diagram. It will also be necessary to bridge the two +V (labeled +) power-supply inputs on the opposite edge of the board.

Checkout. Once all the components have been installed and the circuit has been configured for the type of operation desired (mono or stereo), a simple operational check should be performed on the amplifier circuit before connecting it to your audio equipment. To test the circuit's operation, connect a variable power supply to the +V and ground inputs (denoted + and −, respectively) of the circuit, and connect a dummy load (a 2.5- to 8-ohm, 10-watt or higher resistor) or a speaker across the output terminals. Slowly bring the applied voltage up to about 6-volts and allow the circuit to idle for a while. If you detect any strange odors emanating from the circuit, immediately remove power, locate the source, and correct the problem.

If all seems well, apply an audio-frequency signal to the input of one channel, while monitoring the output with an AC voltmeter across the load resistor or by listening for output from the speaker. If you are using a dummy load, the voltage across the load is unimportant, all you want to know is whether there is an AC signal across it. If using a speaker, vary the volume control to see if that action has any discernible affect on the output level. If so, do the same with the other channel. If that channel also checks out okay, the circuit is ready for use. ■

RF GIZMOS
(Continued from page 58)

diode (D1), which is a germanium 1N34, 1N60, NTE109, or ECG109 device. The RF is smoothed by capacitor C2, and applied to a DC current meter. In most cases, the most sensitive configuration would need a 50- or 100-μA full-scale meter. For less sensitive meters (for use with high-power linear amplifiers) use a 0- to 1-mA meter for M1.

100-kHz Crystal Calibrator. A crystal calibrator is an RF source that is used to calibrate receivers, sweep generators, signal generators, or other RF sources. A properly made crystal calibrator will produce regularly spaced RF "birdies" at intervals well up into the radio spectrum. In most cases, the range of coverage should be from less than 500 kHz, to the HF (shortwave) spectrum. The circuit in Fig. 7 is a 100-kHz crystal calibrator that will produce usable markers up to about 30 MHz.

The basic oscillator consists of transistors Q1 and Q2 operating in an aperiodic "Butler-oscillator" circuit. The operating frequency is set by a piezoelectric crystal operating in series resonance. Select a unit that has a series-mode frequency of 100 kHz when operating into a 32-pF capacitance. If you can not locate the crystal locally, it can be obtained from JAN Crystals (P.O. Box 06017, Fort Myers, FL, 33906; 1-800-526-9825).

PARTS LIST FOR THE 100 kHz CALIBRATOR

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1—27,000-ohm
R2—10,000-ohm
R3—22,000-ohm
R4—6800-ohm
R5, R6—1500-ohm
R7—3300-ohm
R8, R9—12,000-ohm
R10—100-ohm

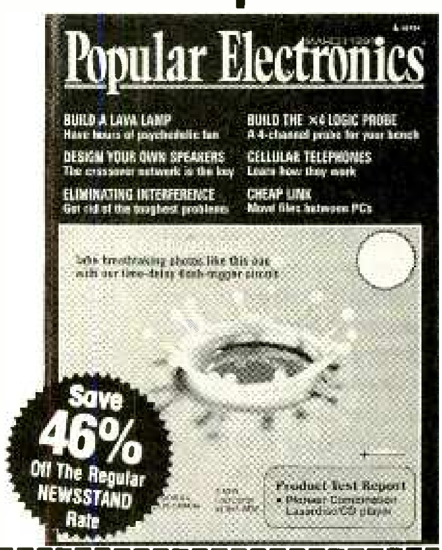
CAPACITORS
C1, C4, C5—0.1-μF, ceramic-disc
C2—15-pF, ceramic-disc
C3—40-pF, trimmer
C6—.001-μF, ceramic-disc

ADDITIONAL PARTS AND MATERIALS
Q1-Q3—2N2222 general purpose NPN silicon transistor
XTAL1—100-kHz, series crystal
J1—Select to suit purpose
Shielded enclosure, perfboard, wire, solder, etc.

Transistor Q3 operates as a buffer amplifier to isolate the oscillator from the effects of changing impedances at the output. Without that transistor, those changes could cause pulling of the operating frequency.

Adjustment of the operating frequency is done by varying capacitor C3. Use a digital frequency counter for this if you have one; if not, tune in either WWV or WWVH at 10 MHz or 15 MHz and use the following procedure: Allow the receiver and crystal oscillator to stabilize for a few minutes before making the adjustment. Center WWV (or WWVH) in the receiver passband. You should hear a heterodyne whistle as the crystal-oscillator signal beats against the WWV/WWVH carrier signal. Adjust C3 until this beat note drops in tone and then disappears. This "zero-beat" condition indicates correct adjustment.

RF projects are satisfying to build and operate, even more so if they are practical and useful. The circuits shown in this article have been useful to me, and should be to you; what's more, they can be built in just a short time. ■



ANTIQUE RADIO

(Continued from page 67)

their design frequency with a minimum of capacitance (making necessary the use of large inductances such as the outsize coils seen on the theremin chassis).

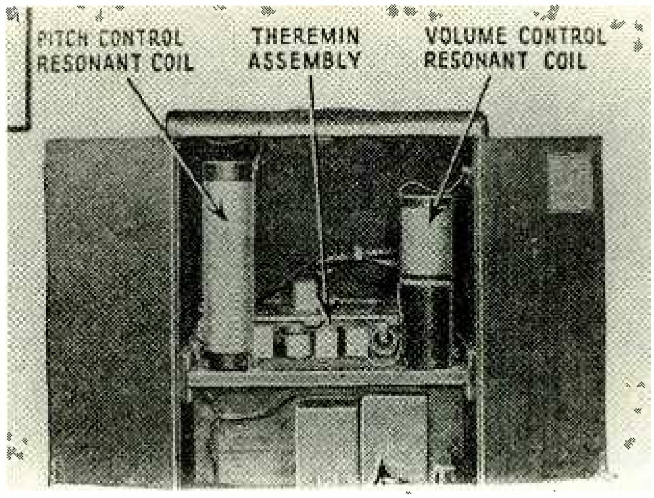
Since only a minimum of capacitance is used to determine the operating frequency of the V.P.O., even a small amount of additional capacitance, such as that of a hand brought near the pitch-control rod associated with tube number 1, can change that frequency. Hence, the musician can produce beat-frequency tones of different pitches by varying the position of his/her hand in relation to the pitch-control rod.

Of course, tones of the type produced by a radio-receiver BFO don't really have a musical sound. Their oscillations are too pure, containing only one frequency. Such oscillations are more like whistles than musical notes. In order for a note to sound musical, its oscillations must contain multiple extra frequencies called "harmonics."

Leon Theremin was able to design his tone-generating circuits to produce notes very high in harmonic content. That's what gives theremin music its special character and richness: Sometimes it sounds like a string or wind instrument, sometimes uncannily like the human voice.

CONTROL OF VOLUME

As you've seen, the theremin player controls pitch by varying his/her hand position in relation to the pitch-control rod. Volume is controlled in similar fashion, through varying the position of the other hand in relation to a second electrode (labeled "Volume Control Loop" on the diagram). And



Opening the instrument's back doors reveals the theremin chassis on the upper shelf and its power pack below.

that is made possible by a method that would have driven Rube Goldberg crazy with envy.

Tube number 7 (a type 71-A labeled "Volume Control Oscillator") is connected as a radio-frequency oscillator operating at about 420 kHz. That is different enough in frequency from that of the theremin's pitch oscillators to avoid interaction. But like the variable-pitch oscillator, its tuned circuits are designed to be very sensitive to small changes in capacitance (such as those caused by changing the position of a hand in relation to the volume-control loop).

Now take a look at tube number 5 (a type 20 labeled "Volume Control"). It's the relic from battery-set days I mentioned earlier in the article. The filament of that tube (which was designed for dry battery operation, and hence has a very low current drain) is heated in a very unconventional manner. It receives its energy via a pickup loop associated with the inductance of the tuned circuit controlling the frequency of the volume-control oscillator.

The tuned circuit is adjusted for peak oscillator output (and hence peak brightness of the type-20 tube filament) without the presence of a hand near the volume-control loop. Then, as a hand approaches the loop, the additional capacitance detunes the circuit and reduces the output of the oscillator. Thus the filament of the type 20 becomes dimmer. The closer the hand gets to the loop, the dimmer the filament gets.

But a study of the schematic shows that the type 20 is wired in such a manner that the plate current for tube number 4 (first AF amplifier) must pass through it. When the filament of the type 20 is dim, it can't pass as much current as when it's bright; then the amplifier stage can't amplify as much, and the volume goes down.

In that manner, then, the volume of the theremin is varied in accordance with the closeness of the musician's hand to the loop; the closer the hand, the lower the volume. And because the filament of the type 20 is a lightweight low-current one, it responds quickly to the changes in energy available from the pickup loop—not requiring a lot of time to heat or cool. That makes the volume control very responsive, and even allows the player to obtain violin-like vibrato effects.

A NEW CONTEST BEGINS!

Everyone (including me) seemed to have so much fun with the recently-concluded theremin competition that we've decided to run a new contest! So if you'd like another chance to win a copy of *100 Radio Hookups*, here it is.

This time what we're interested in is how you deal with the antique radios and related collectibles that you've acquired. For example, where do you put them? Do you pack them away in boxes? Display them in a special radio room? Integrate them into the decorating scheme of your entire home? How do you keep track of what you have? Do you keep a card file? Enter your sets on a computer database? Depend (like me) on your unreliable memory? And how do the non-collecting members of your family (spouse, offspring, parents, etc.) relate to your hobby? With interest? Amusement? Tolerance? Hostility? Have you used any clever tactics to gain the support of those who were negative?

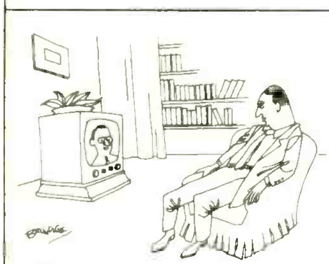
Tell us all about it, and try to include some photos to illustrate your points. All replies will be acknowledged in the column, and the eight judged to be most interesting will receive reprint copies of *100 Radio Hookups*, a 1924 Gernsback publication detailing virtually every radio-receiving circuit in use at that time. Only entries received before the Labor Day holiday will be considered, so you've got just a short while to get it together. Get busy now!

More on the theremin next month. In the meantime, send your contest entries to me c/o *Antique Radio*, **Popular Electronics** magazine, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

SYLVANIA TV
(Continued from page 65)

the supplied remote control to work with a wide variety of VCR's and cable converters is a feature that should appeal to those of us who hate the clutter of many remotes on our coffee tables. As for the audio performance, or, more specifically, the "stereo" performance of the set, suffice it to say that we enclose the word "stereo" in quotation marks here because what we heard hardly qualifies as true stereo reception. We and APEL have, in the past, measured and auditioned stereo TV sets in which alignment was somewhat off and separation was less than optimal. But this set—or at least the sample we and APEL tested—is far poorer in its stereo reception capability than just about anything we have measured since stereo-TV broadcasting first began. Perhaps the problem rests with our particular sample, but if the other worthwhile features and qualities of this model appeal to you, by all means audition the set using the stereo mode while tuned to a station that is broadcasting a stereo program before you take the plunge.

For more information on the Sylvania RKS240CH, contact the manufacturer (NAP Consumer Electronics, Interstate 40 and Straw Plains Pike, Knoxville, TN 37914) or circle no. 120 on the Free Information Card. ■



"We interrupt this program of uninterrupted music to bring you a special commercial in lieu of the regularly scheduled commercial."

OSCILLOSCOPES
(Continued from page 39)

shutter to the event was partly a matter of luck. It also took time to develop the film before the signals could be reviewed.

Early storage scopes used an enhanced phosphor layer that could be energized to hold the image of the trace. While that method added a great deal of convenience, the excitation required to sustain the image made the CRT very bright. That tended to burn the trace into the phosphor over time.

Digital circuitry has vastly improved the performance and reliability of storage functions. Since any input signal can be digitized (converted to a digital form), it can be held as binary data in the scope's memory. The stored signal can then be written and held on the CRT. The digitally stored image can be displayed continuously just as if it was an external input signal. Digital storage oscilloscopes are among the most expensive.

Conclusion. The future is bright for oscilloscopes. New approaches and features are being developed that will ultimately reduce their cost, while expanding their versatility. One current trend is to interface oscilloscopes to hard-copy devices such as printers, or to incorporate the printer into the scope itself. Hard-copy has a broad appeal, since it readily provides a permanent written record of the scope's measurements. Oscillographs are appearing on the market. These units combine the continuous paper readout of a chart recorder with the frequency response of an oscilloscope. Another trend is to integrate oscilloscope functions onto plug-in boards that can be used in personal computers.

Oscilloscopes, like most other pieces of test equipment, have advanced dramatically since they were first introduced. They are rugged and reliable devices that now can offer a selection of options and features that have made them useful for many diverse applications. Oscilloscopes are also affordable instruments. Many models can be purchased for less than the price of a good color television. If this trend continues, it will not be long before all hobbyists can enjoy a scope on their work bench. ■

PAGE PRINTER
(Continued from page 63)

should have a laser-printer driver for your software to make the necessary printer-configuration changes during printing. Fortunately, the OL400 claims 100% compatibility with the HP LaserJet II PCL command set, which has become the most common standard among those software producers that include laser-printer drivers in their products. If your program does not support an HP LaserJet II, you will have to be satisfied with plain-vanilla one-font output, unless you are very creative and willing to learn the HP PCL language, and how to send commands to the OL400.

That is not as limiting as it may sound. You can send most text files to the OL400, using the printer's default 10-character-per-inch Courier 12-point font and get a fine looking document. Or, with very little practice, you can use the printer's front panel switches to change various printing characteristics, as mentioned earlier.

You may need to change document margins and characters-per-line when you use proportional fonts, but that can usually be handled from within your word-processor. If you have page numbering, you'll have to consider that laser printers only print 60 lines to a page, instead of the 66-line pages produced on line printers.

Care and Feeding. Another consideration in using a page printer is cost. While a typical dot-matrix or daisy-wheel printer only requires occasional replacement of a relatively inexpensive ribbon, page printers use photoconductive drums and charged toner. The original laser printers used a single cartridge containing both the drum and the toner, much like many low-cost photocopy machines made by Canon and others. The OL400 uses a separate drum and toner.

The OL400 drum is expected to last for about 15,000 copies, with a replacement cost of about $120, while the separate small toner cartridges are good for about 2500 copies and cost about $30. The first toner cartridge, which lubricates the drum and fills the reservoirs, has a lifespan of about 1250 pages. Not counting paper (regular photocopy paper is used), it will cost you about two cents a copy after the first toner cartridge. If you do a lot of graphic-intensive or heavy-black printing, you'll use the toner more quickly, raising the cost per copy.

The OL400 comes with four manuals, all well written and liberally sprinkled with illustrations and tabulations. The 36-page Quick Start manual has you unpack the OL400, install the drum, toner cartridges, and the 200-page paper tray, and run a self-test to produce a sample of all of the fonts.

The 87-page Printer Handbook covers the printer interface (serial or parallel is available, not both), controlling the printer, paper handling, and working with commercial software. The 86-page Composition, Font and Accessories Guide discusses page design, typefaces, fonts, accessories, and options. For example, the OL400 comes with 512K RAM, but you can add up to two additional megabytes on a memory expansion board. A Courier or a Roman font card can be inserted into the appropiate slot on the side of the unit.

A 75-page Solutions manual covers paper jams, miscellaneous errors, cleaning and testing procedures. A Technical Reference Manual is also available.

Operation. Using a page printer is not difficult, especially if you just want to print documents from a program that has an HP LaserJet II printer driver. You can be up and running very quickly, and you'll be delighted with the output.

I was able to print out desktop publishing documents from my various IBM PC's using LaserJet II printer drivers with no problem, even without adding any additional memory. When using a word processor that did not offer a laser printer driver, I used the OL400 panel switches to specify the IBM-US symbol set, and I was able to produce beautiful copy.

I was even able to get perfect output from an old TRS-80 Model III computer, but that took sending a PCL command from the computer in BASIC to tell the printer to add a line feed after every carriage return. The IBM PC adds the line feed automatically, but the TRS-80 doesn't. (Incredibly, although printers for years have all included a CR/LF switch for just this reason, laser printers do not have such a switch!)

For further information about the full line of Okidata page printers, contact Okidata directly (532 Fellowship Road, Mt. Laurel, NJ 08054, Tel. 1-800-800-7333), or circle No. 119 on the Free Information Card. ■

ELECTRONICS MARKET PLACE

FOR SALE

REMOTE auto alarms Excalibur AL700 $89.00, AL800 $99.00, AL900 $109.00. Prompt delivery S&H add $5.99. **S.P.I. Inc.,** 4781 North Congress Ave., Dept. 159, Lantana, FL 33462. Free brochure.

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PLEASE INDICATE in which category of classified advertising you wish your ad to appear. For special headings, there is a surcharge of **$11.00.**

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PLEASE PRINT EACH WORD SEPARATELY, IN BLOCK LETTERS.
(No refunds or credits for typesetting errors can be made unless you clearly print or type your copy.) Rates indicated are for standard style classified ads only. See below for additional charges for special ads. **Minimum: 15 words.**

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6	7	8	9	10
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21 ($32.55)	22 ($34.10)	23 ($35.65)	24 ($37.20)	25 ($38.75)
26 ($40.30)	27 ($41.85)	28 ($43.40)	29 ($44.95)	30 ($46.50)
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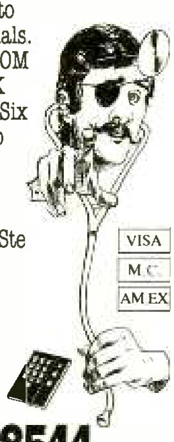

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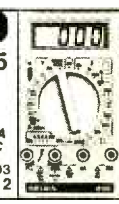

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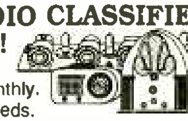

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ADVERTISING INDEX

POPULAR ELECTRONICS magazine does not assume any responsibility for errors that may appear in the index below.

Free Information No.		Page
13	AMC Sales	18
12	All Electronics	6
—	Amazing Concepts	81
—	Antique Radio Classified	90
—	Barta	91
8	C&S Sales	7
—	CBC International	90
—	CIE	11
—	Cable Plus	90
—	Cable Ready Company	91
—	Cable Specialists	91
5	Cable Warehouse	83
—	Command Productions	69
—	Computer Book Club	24
6	Cook's Institute	81
16	Datak Corporation	22
—	Electronics Book Club	5
—	Electronic Tech. Today	CV2
—	Firestik II	89
—	Global Cable Network	89
—	Grantham College	23
9	Heathkit	21
7	Howard W. Sams & Co.	19
—	Kelvin	90
—	Listen Electronics	90
—	Midwest Electronics	91
—	Monitoring Times	79
—	NAS/TransWorld	90
—	NPEC	92
	NRI Schools	17
18	Protel Technology	14
—	Pacific Cable	90
10	Parts Express	13
—	Phillips Tech	89
	R.E. Video Offer	CV3
—	Republic Cable	91
11	SCO Electronics	18
17	Sequoia Publishing	77
—	Silicon Valley Surplus	90
—	The School Of VCR Repair	91
	Video Tech	91
14	Viejo Publications	77
15	WPT Publications	83
—	Windjammer	CV4

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