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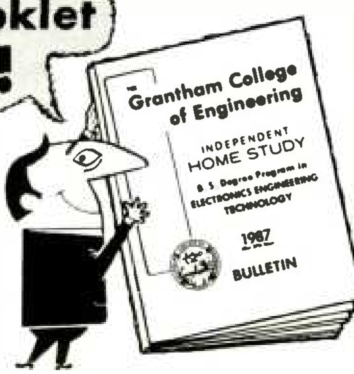

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Volume 4, No. 10

October 1987

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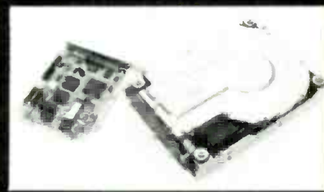

Friedman On Computers—page 20

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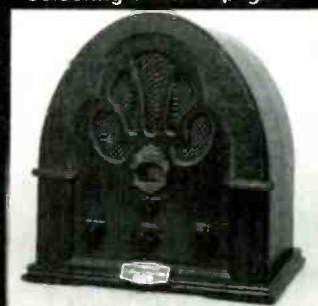

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Hands-on Electronics®

The Magazine for the Electronics Activist!

In the mail bag!

We get the most unusual mail at our office. The distribution of the various types of communications vary from the "absolute junk mail" to the reader who is responding to an item in a recent issue of the magazine.

The junk mail is claimed to be "astronomical" by the mailroom staff. That does not make our job easier, because we read it all! Trade and professional magazines fall into this category; I find them very valuable. Magazines intended for engineers, scientists, and manufacturing specialists reveal what the trends in consumer buying activity will be from three months to several years from now. For example, back in 1977 I forecasted a two-billion dollar consumer computer marketplace. (That's pre-IBM PC!) Yes, I was laughed at. Today, that sum is a drop in the bucket.

Other mail informs me of new scientific developments, new products, buying trends, trade meetings and shows throughout the world, and, of course, financial reports from successful companies. The latter sold my father on a dinky little company that sold a *Polaroid* camera back in the late forties. This mail is valuable, because it tells us, provided we are perceptive enough, what will happen to our hobby industry in the future.

And, of course, we receive lots of reader mail. We have all sorts of readers out there, from whom we get a corresponding diversification of ideas, complaints, suggestions, almost all the articles you see in this issue—you name it, we read it! And, it's in the reading of your mail that we form in our minds the composite voice of you. We get to know you better than some Madison Avenue huckster's readership survey would presume.

We have only one fault with the mail—it's the volume. We cannot hope to answer every letter sent to us. Some we do, most require no answer. Many letters are grouped and presented in our *Letter Box* column with comments from our staff; we answer many letters that way.

Nevertheless, we want you to write. Your response (letters) to our actions (magazine) makes for a better **Hands-on Electronics.** Please give us a hand.

Julian S. Martin, KA2GUN
Editor

STAFF

Volume 4, No. 10

October 1987

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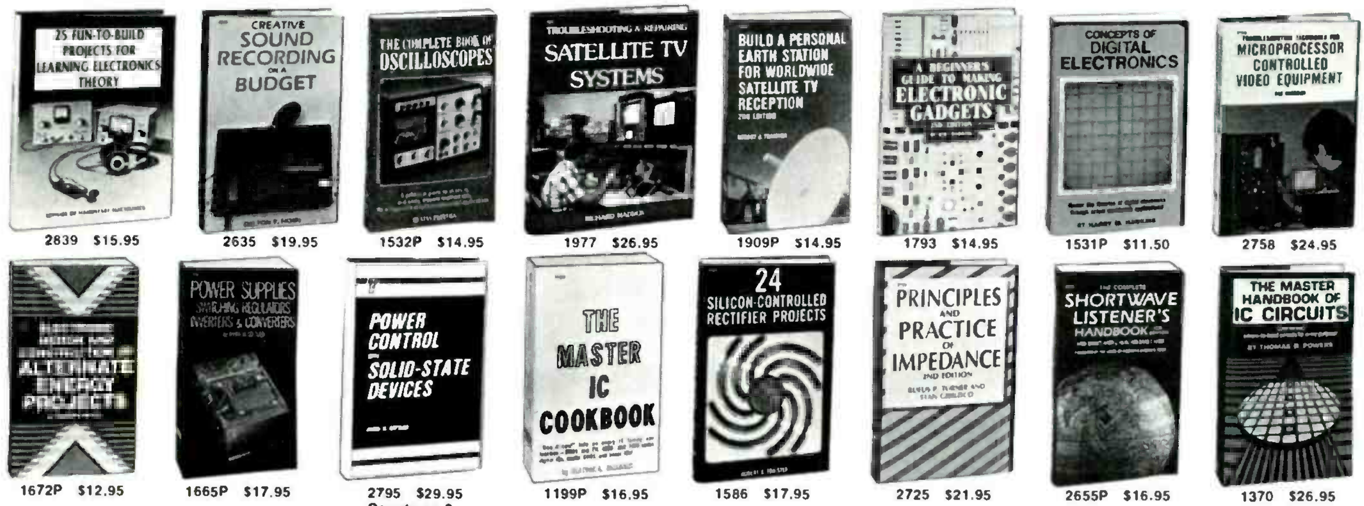

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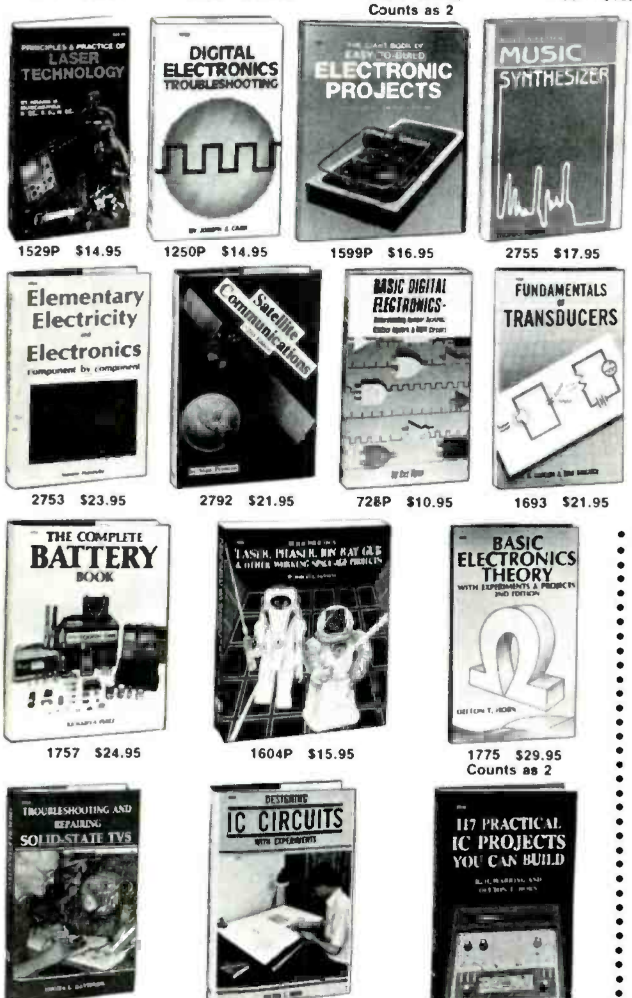

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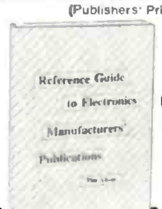

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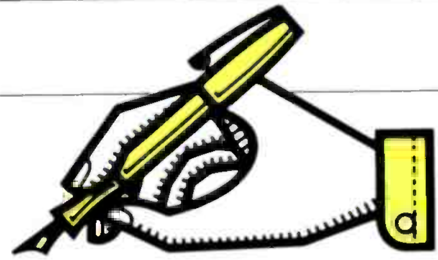

Hands-on Electronics, 500B Bi-County Boulevard, Farmingdale, New York 11735

Sedition, Abstraction, Uglification, & Derision

On page 78 of the July 1987 issue shouldn't the answer for the differential amplifier in Fig. 8 be +36 volts instead of –13? As the text states, the sums of the inputs are calculated algabraically. As far as I know a +7 minus a +3 equals +4. Then

$$E_o = 9 \times 4 = 36$$

If I'm not approaching this properly, please set me straight.
—W.J.D., Upland, CA

Part of the problem you're experiencing isn't with math, it's with the subscripts. You are subtracting E_2 from E_1, instead of subtracting E_1 from E_2. So, 3 minus 7 equals –4. Multiplying that by 9 does yield 36 as you say, but a negative 36. Thanks for the correction.

[For those of you interested, the heading for this letter was taken from "Alice In Wonderland."]

Idea Potpourri

I would like to see some more home-brew projects that would be helpful on the test bench, like a stable function generator, and possibly a triggered pulse generator. There are plenty of logic probes in kit form already, but perhaps you could throw one in to help complete my digital lab. I have copied such projects from some TAB books and several other books I have collected or checked out from my local library. Some of circuits and specifications are rather old in design and components. So, I thought you guys might be able to come up with better circuits and innovations of the day.

Anyway, thanks for the last hold out from total computer saturation. How about some ham-radio stuff? I think that Packett Radio is something that even the computer fans of your magazine would enjoy. Thanks for your time.
—P.F.C., Paris, KY

We'd like to see more of everything! The Great PC Clone Contest is still on, so get those manuscripts in. Whether it's about serious test equipment, fun projects, or information for the fast times we live in, send us your stuff! *Just think, not only do you get paid upon acceptance, get a chance to see your name in print, and have a go at winning a computer, but you also get to share your ideas. Who could ask for more from a hobby?*

Hanging On

I read in one of your other magazines (I forgot which issue), you had a musical hold button that readers could build for their phone using something from a Hallmark card. I'm really interested in that device. Unfortunately, I can't remember which issue it was in. I would really like to have an electronic hold button so that if I put a phone on hold on, any of my phones I can go to any other phone and pick up at that phone instead. I don't want to worry about the hold button still being on and having to speak from that phone or having to turn it off as soon as I hang up.

Could you please send me some information on it that would help me to design it for my house, and probably assist most of the readers out there with an interesting and useful project.
—J.K., Newton, NH

The issue in question was September/October of 1986. The project you mention will operate as you desire. To turn the hold off, just pick up any extension phone. That should hold you for a while.

Coiled and Ready

I have a copy of the September/October 1986 **Hands-On Electronics**. The story that intrigued me the most was "The Ultimate Burglar Alarm," by Byron G. Wels and Robert M. Wolet. I tried to construct the device, but the diagram shows a transformer that the story does not mention. My question is "What size is that transformer?" or, "What am I doing wrong?"
—M.L., W. Des Moines, IW

The item you call a transformer is the coil for the relay, K1. It is contained inside the relay housing, as is indicated by the dotted lines. The relay should have at least eight terminals: two for the coil and three for each switch. However, only two terminals are actually used for each switch, so familiarize yourself with the terminal layout and try again. Good luck.

From High to Low

Regarding "Electronic Fundamentals" in the March 1987 edition of your magazine, on pages 84 and 85, please clear something up for me. On page 84 Fig. 12B and Page 85 Fig. 15B. Shouldn't the diagrams be reversed. I understand the outputs of low-pass filters were taken from across capacitors. Looks to me like the diagram in 12B shows the output taken across the resistor.

Also in 15B, which is supposed to be a high-pass filter, it looks like the output is taken across the capacitor instead of the resistor. Could there possibly be a mixup of the figures, and should they have been reversed? Perhaps I do not understanding the definitions of the cutouts of LPF and HPF circuits.

I would appreciate your clearing that up for me and I thank you. I'm a subscriber to your fine magazine and look forward to each issue.
—W.J.D., Urbane, AL

You're right about the mix up, the figures were transposed. Both filters got passed us which indicates the need for a filter filter so any high-pass will show our high class. Thanks for pointing that out (and I hope this reply didn't cause too many groans).

Head Case

I built a "Fred-the-Head", and although not completed, his mouth, eyes, and microphone pick-up work fine. His eyes really do light up!

I modified his mouth circuitry and I'm constructing an FM-wireless transmitter so I'll be able to hear anyone who wishes to talk to me from a short distance. Can you imagine the effect—carrying on a conversation with that wooden head?
—R.E.C., Atoka OK

It's a great way to keep the kids busy. If anyone else out their has come up with an interesting twist for any of our projects, please let us know. ■

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To meet increasing demand for high performance, low cost RS-422 interface equipment, B & B Electronics has introduced the new RS-422A to Current Loop Converter. The Current Loop Converter is bi-directional and optically isolated. One channel accepts RS-422A data and output current loop; the other channel accepts current loop data and outputs 422A.

A male DB25P connector is used for the current-loop interface and a female DB25S connector is used for the RS-422A interface. The unit requires 12 volts DC at about 100 mA and can be purchased with an optional power supply (Model 422PS) which powers the RS-422A side of the isolators. No further power supply is needed if the existing current-loop interface is active.

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The RS-422A to Current Loop Converter model 422CL is priced at $44.95; Power Supply Model 422PS for the converter is $14.95; The Loop Current Power Supply Model 422PS is $14.95.

Further details may be obtained by writing or calling: B & B Electronics Manufacturing Company, 1500P Boyce Memorial Drive, PO Box 1008, Ottawa, IL 61350; Tel. 815/434-0846.

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Bundled with the Turbo-880-XT are The Executive Filer from Paperback Software, MyCalc from Software Tool Works, the ATI Interactive Trainer, and a custom version of HOT, the Desk Top Manager from Executive Systems.

At no time does the consumer have to read or study a manual. ATI, an interactive training program, will take the user through all the computers's functions and capabilities. In addition, each software package is color coded and identified by Vendex's Headstart Operating Environment, which makes using the Turbo-888-XT a breeze by leading the user through the computer's operations on a one key, point and select basis. All the user needs to do is move the cursor to a selection and press the help key, which will then give them on-screen information to proceed. Every Headstart menu is presented in clear and simple English.

HeadStart also provides and gives the user control of custom utilities that include Custom Diagnostics, all disc and file utilities available through MS-DOS (i.e., Copy, Format, Check Disc and Erase, DOS help screens, and printer utilities that enable the user to set up the printer default for the specific printer being used). In addition, Head Start provides a utility program for the advanced user that will explain the powerful commands of MS-DOS.

The Vendex Turbo-888-XT will accommodate the most popular accessories, because a parallel port, a serial port, a game port that can accommodate two joysticks, a floppy controller capable of handling four floppy disk drives, and an additional port (to attach a mouse, if desired) are built in. The unit will also accept an optional hard-disk drive.

For further information contact Vendex Pacific, Inc., 40 Cutter Mill Rd., Suite 438, Greatneck, NY 11021.

Bookshelf Loudspeakers

You may want to take these off Bose's shelf and put them on yours. Especially if you're seeking good performance from small speakers, at a modest $299 per pair suggested list price. The speakers measure 10 × 15 × 7 inches, and weigh only 12 pounds each.

Like the other models in the series, the 2.2 loudspeakers feature innovative technology for precisely controlled sound radiation, allowing listeners to hear balanced stereo from nearly anywhere in a listening room called the Stereo Targeting system, that new technology is used in all Point Two speakers. A driver array, designed in conjunction with the speakers' cabinet and crossover network, directs sound into the middle of the room.

As a listener moves toward one speaker, its loudness actually decreases relative to that of the other, so that they remain in balance.

CIRCLE 63 ON FREE INFORMATION CARD

The speaker's directional characteristics, combined with its controlled output, allow maintenance of a stable stereo image regardless of where the listener sits or stands. Consistent performance is assured by Bose's exclusive Syncom II computerized driver testing and matching system.

In addition, an advanced bass-tuning technique adds full-frequency realism by precisely controlling an air cushion inside each speaker cabinet. The result is deep, realistic sounding bass—without a large, bulky cabinet or extra amplifier power.

The system configuration will produce both high-fidelity stereo and video sound.

Other Bose Point Two loudspeakers are the 10.2 (suggested retail $1199) and 8.2 ($949) floor standing speakers and the 6.2 and the 4.2 bookshelf systems ($599 and $419 per pair, respectively).

For further information contact Bose Corporation, The Mountain, Framingham, MA 01701.

Relay Servicing Tool Kit

This may be the transistor age, but relays are still around, so Jonard created a 15-piece, precision relay tool kit containing a carefully selected group of tools for use by the electronic and telecommunications industries. The kit contains tools necessary for adjusting, servicing, and calibrating all types of relays.

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All tools are made of high-quality carbon steel, with heavy chrome plating, for long life and top efficiency. Dielectric tools permit adjustment and repair of "live" equipment without stopping operation—the most practical and economical way to service equipment. It comes with a leather zippered case engineered for maximum protection of each tool, ensuring long lasting performance. The case is compact for easy portability—eleven inches long, six inches wide.

The kit includes: 2 spring adjusters; 1 armature bender; 1 spring tension gauge; 1 four-way tool; 1 thickness gauge; 1 cleaning spray, 1 duck-bill plier; 1 inspection mirror; 1 pen-type contact burnisher; 12 burnisher blades; 1 screw driver; 1 tweezer; and 1 selector-switch brush.

The kit model #K-55 is priced at $54.00. For further information and literature write to: Jonard Industries Corp., 134 Marbledale Road, Tuckahoe, NY 10707.

Racing Pulse

Your heart may skip a beat over this pulse generator with repetition rate variable from 1Hz to 125MHz and a choice of fixed 2-, 1.5-, or 1-ns risetimes. The PM5785 has a wide choice of external-trigger and -gate functions, full control of pulse repetition rate, duration and delay, a presettable, high-speed burst option, and dual normal/complementary output with a choice of bipolar, positive or negative pulses. Setting error indicators simplify operation.

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The choice of fixed, high-speed transition times and output-pulse forms makes the PM5785 very well suited to a wide

(Continued on page 12)

NEW PRODUCT SHOWCASE

(Continued from page 8)

range of digital applications in research, production or service. The 2-, 1.5-, or 1-ns risetimes are equivalent to 1.4ns, 1ns, or 700ps for ECL work, (with 20% to 80% of pulse-amplitude, transition-time definition).

Output impedance back-matching absorbs more than 95% of reflections from mismatched loads, to provide very clean pulses under practically all conditions. There is a choice of four output-level ranges from 0.2 to 5 volts to match different circuit requirements.

Triggering, duration, and gating can all be controlled externally. External trigger-slope and level controls allow synchronization with an external clock. External duration control enables the unit to function as a signal conditioner. An external gating control makes it possible to provide synchronized bursts of pulses.

Careful circuit design, has made it possible to provide a burst option presettable from 1 to 9999 pulses. The number of pulses is set directly on the front panel and can be triggered manually or remotely via the external input.

Time-setting error indicators confirm correct setting of repetition rate, pulse duration, and delay. Pushbutton selection simplifies output-pulse choice with no time-consuming adjustment of inverter and/or offset controls, and a complementary switch allows instant inversion of the output without exchanging cables.

Prices for the PM785 start at $3,385. For more information contact Philips Test and Measuring Instruments, Inc., 85 McKee Drive, Mahwah, NJ 07430.

3 Remote Controls In One

With the universal remote control from R.L. Drake, you would no longer have to keep track of separate units for television, videocassette recorder, and other audio/video equipment.

The Model PRC/U allows the user to operate up to three different remote-controlled components from one device. By consolidating the functions of three remote-control units in one, this product solves the problem of multiple modules.

In addition to being versatile, Drake's universal remote control is extremely easy to program. The user simply flips the LEARN switch and places the Drake device against the component's original remote control unit so they're facing each other. He then presses the function he wants to program (such as on/off, change channel, or fast forward) on the Drake unit and on the original control. Every time that process is completed, Drake's control flashes a light to indicate it has "learned" the function. The user follows that procedure for each function he wants the Drake remote control to perform. Drake's unit can

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learn any function that's on the original remote control unit. And with 41 function keys, Drake's device can operate even the most sophisticated consumer-electronics components.

The Drake universal remote control has a 30-foot range and can be used with up to three remote-controlled products, as long as they're infrared, not ultrasonic.

The model PRC/U has a suggested retail price of $119.95 and is available from TV service shops, mass merchants, television and appliance stores and other retail outlets nationwide.

For further information contact the R.L. Drake Company, PO Box 112, Miamisburg, OH 45342; Tel. 513/866-2421.

Preamplifier/Equalizer

Looking for an ultra-compact car stereo preamplifier with seven-band equalizer, and subwoofer crossover? Well, the PS-7

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features front panel switchable tape and CD inputs (high- and low-level tape inputs, continuously variable CD-input sensitivity), built-in front and rear fader with outputs that can be full-range or a 12-dB per octave highpass filter at 150 Hz. The subwoofer crossover has a continuously variable crossover point (75 Hz to 150 Hz) with a 24dB per octave slope.

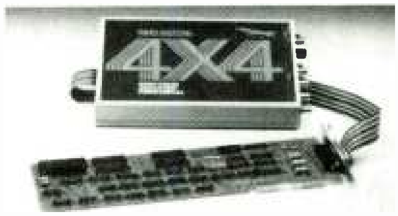
The PS-7 is only one-in. high and features LED equalizer position indicators which are also signal level indicators. The model carries a $165.00 suggested retail price.

For additional information contact Alphasonik, Inc., 701 Heinz Avenue, Berkeley, CA 94710; Tel. 415/548-4005.

Real-Time Spectrum Analyzer

Here's a unique combination of spectrum analysis and digital oscilloscope utilizing the versatility of any IBM PC, XT, AT, or compatible computer allowing the user to view both the input signal and its frequency spectrum in real time.

Useful anywhere spectrum analysis or event recording is needed, the digital oscilloscope features: 4 channels of simultaneous acquisition; 500KHz sampling rate per channel; 32K data buffer per channel; full pre and post trigger (up to 32K); triggering in: analog, digital, external, internal, and single-shot mode; grid display; lissajous plot of X vs. Y using any combination of the 4 channels; print-screen capabilities; automatic channel calibration; 10 mV to 50-Volt per division gain scaling; user definable headings for spectrum/oscilloscope displays; save/retrieve



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data to/from disk; menu driven, turnkey software; and more.

The spectrum analyzer features: 250 KHz bandwidth; 1024 point FFT; X or X & Y cursor; linear or log magnitude scaling; hanning or rectangular windowing; spectrum averaging 1 to 64 spectra; variable or fixed scaling; and menu driven, turnkey software.

Special features include display of multiple plots on a single screen for easy comparison; autoscaling of retrieved data to display screen parameters; options can be changed without leaving the real time display by use of the F keys; and color graphics displays.

With a suggested retail of $2995, the system is available from Rapid Systems Inc., 433 N. 34th Street, Seattle, WA 98013; Tel. 206/547-8311.

Car Amplifiers

High-end car audio installations are more complicated and more expensive than they have to be. But Denon's DCA-3500 combines a front stereo amplifier, a rear stereo amp, a crossover, and a subwoofer amplifier, in one compact

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chassis in order to cut down installation headaches and ultimately enable installer to do more work in less time.

In five-channel operation, the DCA-3500 is rated at 40 watts × 4 and 80 watts × 1, at 1 kHz and 1% THD. In three-channel operation, power increases to 80 watts for the subwoofer. The built-in subwoofer dividing network offers a choice of 80 Hz or 120 Hz crossover frequencies. For added flexibility, switchable high-cut and low-cut filters are also included. They take effect at 12 dB and 18 dB/octave, respectively.

Mounted in the trunk, the conventional car audio amplifier can "see" a ground potential different from that "seen" by the head unit mounted in the dash. That difference will be reproduced as noise. To solve that problem, the Denon *Real-World Grounding* system automatically senses voltage differences between the signal ground and the power ground. The amplifier applies an equal-but-opposite voltage to cancel supply-induced noise.

The DCA-3500 also takes advantage of two technologies originally developed for Denon home amplifiers. First, Non-Switching Class-A amplification eliminates crossover distortion from the output transistors. Second, Denon's Non-NFB circuit design corrects amplifier distortion without resorting to negative feedback — a "solution" that sacrifices transient performance. The DCA-3500 also features dual power supplies.

The new Denon DCA-3500 is thin enough to mount out of the way. To make sure heat dissipation is not a problem in close quarters, the unit uses Denon's special Compact-Star heat sinks. The design also uses efficient chimney-style heat sinks with star-shaped radiating fins to increase efficiency. Other features include remote-power on/off, adjustable input sensitivity, and gold-plated input jacks.

The amplifier carries a suggested retail price of $470, and For more information contact Denon America Inc., 27 Law Dr., Fairfield. NJ 07006; Tel. 201/575-7810.

Jumbo LED Clock

If you've got poor eyesight, or just like to say things in a big way, then this may be your clock.

The Model 1036 Jumbo LED Clock has

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12- or 24-hour display capability with 6 2.25-in. high, red LED digits. The battery backed-up, quartz-crystal, time base automatically takes over during power failures when the clock operates from a 60-Hz power line. The clock will also operate from 12 VDC. The high-tech black-plexiglas enclosure is attractive and functional, great for ham shack, computer room, radio station, communications center, home, office, and more. The dimensions are 15.25 × 4.75 × 1.5 inches with a viewing distance of over 100 feet.

The model 1036 is available in kit form with step by step instructions for $69.95 or assembled and tested for $99.95. For green LED's (model 1036G) add $10.00.

For more information contact NRG Electronics, PO Box 24138, Fort Lauderdale, FL 33307; Tel. 305/971-3823.

Radio/Cassette Recorder/CD Player

They've finally created a stereo radio cassette player with a built-in compact disc player. And the player offers the FF-1 fine-focus, single-beam laser pickup. Other features include 15-step random access programmability, skip and search

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functions, a repeat key, and a comprehensive LCD display.

The cassette deck section (operated via soft-touch controls) offers auto-reverse in playback and record modes, a Dolby NR system, and a reverse mode selector.

The selector allows the user to listen to just one side playback, one side followed by the other side, or repeated playback alternating from one side to the other.

Cue and review controls, a pause control, and a soft-eject system are included in the tape section as is a metal (playback)/CrO_2-normal tape selector.

The RX-FD80 offers improved sound dispersion from the two-way, four-speaker system. The speakers at either end of the unit each boast 5½-in., PM woofers with ¾-in. tweeters.

Ambience stereo—the feeling of having sound widely dispersed around the room—is created when a portion of the total sound is momentarily delayed and cross-fed between the two speakers.

There is a balance control, and the built-in graphic equalizer allows the individual to boost or attenuate the response of five separate frequencies.

The RX-FD80 operates on 10 D-batteries (not included). Jacks are provided for: AC-in, headphones, line-in (2), line-out (2), and mixing microphone.

The unit is currently available at a suggested retail price of $339.95. For more

(Continued on page 100)

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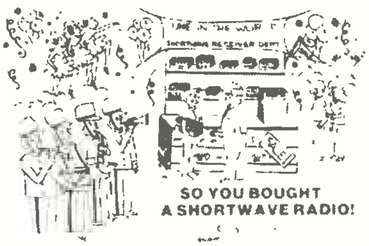
BOOKSHELF

So you Bought a Shortwave Radio
By Gerry L. Dexter

How often is there help for the person starting in a new hobby, especially a hobby like ham radio? If you need help, this text may be of use. The book places special emphasis on making the reader aware of the *audio warp* experienced by first-time shortwave radio listeners, and helping the reader over that obstacle.

Rather than bombard the reader with reams of information which he can't use right away and may not care about any-



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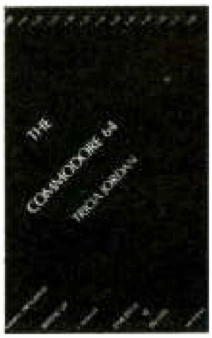
way, the material is brief and basic, with sources of more information provided for each area discussed. The book shows the reader where to tune for broadcast, aero, marine, amateur, and other stations; presents lists of clubs, publications, and shortwave dealers—all in a light and easy, non-technical style.

The book, which contains 74 pages, retails for $6.95 from Tiare Publications, PO Box 443, Lake Geneva, WI 53147; Tel. 414/248-4845.

The One-Hour Commodore 64
By Tricia Jordan, Ph.D.

Studies show that the first hour—indeed, the first few minutes—a person spends with a computer sets the pace for how that person reacts to and uses computers. Apple Computer certainly knew that when it spent millions ensuring that the first hour with a Macintosh would be easy, friendly, and successful.

This book follows in that trend. Here's what you'll find in it: setting up the computer, working with the keyboard, setting up the cassette recorder, saving and loading programs on cassettes, setting up the disk drive, a bibliography to help you find more information, booting up and exploring DOS, saving and loading programs on disk drives, playing around with sound,



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using the printer for letters, programs, and graphics, using the modem to connect to the outside world, and a glossary—definitions and fun with computer terms, and special chapter on software—word processing, financial management, data base management, education, games, graphics.

There are three working programs—a drawing program to create pictures on the screen and save them to cassette or disk; a tutor program to create question and answer quizzes on any topic you with; and a budget program to create expense reports and reconcile your checkbook.

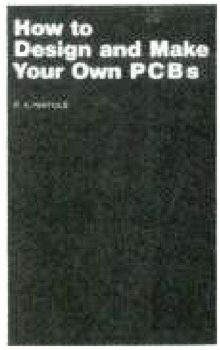
The softbound book contains 128 pages and costs $5.95, from Info Books, PO Box 1018, Santa Monica, CA 90406; Tel. 213/470-6786.

How to Design and Make Your Own PCB'S
By R.A. Penfold

A lot of electronics enthusiasts either don't know how to make their own PCB's or haven't gotten their technique straight yet. Perhaps this book would be useful to those of you in either category. The purpose of the book is to familiarize the reader with both simple and more sophisticated methods of producing printed circuit boards.

The subject is not covered in a vague and purely theoretical manner, as the emphasis of the book is very much on the practical aspects of printed circuit board design and construction.

Chapter 1 deals with simple methods of copying PCB designs from magazines and books and covers all aspects of simple PCB construction as comprehensively as possible. Chapter 2 covers photographic methods of producing PCB's. Chapter 3



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deals with most aspects of designing your own PCB layouts.

The book, containing 66 pages, costs $5.75, and is available from Electronics Technology Today, PO Box 240, Massapequa, NY 11762.

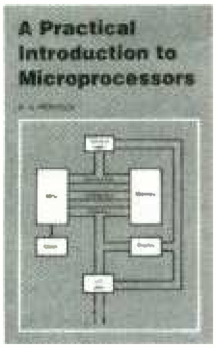
A Practical Introduction to Microprocessors
By R.A. Penfold

If you're a good electronics hobbyist, but the microprocessor is still a mystery to you, then this text may help clear things up. The purpose of the book is to provide a practical introduction to microprocessors by constructing a very simple microprocessor circuit that the reader can actually build and experiment with and thus hopefully gain a clearer insight into this complex subject.

The completed unit is only intended as an educational aid and is unlikely to be usable in any actual applications, but it can be built at quite modest cost and many of the parts should be suitable for re-use when the unit has served its purpose.

The book is not intended for complete beginners at electronics. It is primarily aimed at those who have some knowledge of general electronics, but have little or no understanding of microprocessors.

A Practical Introduction to Microprocessors costs $5.00, and contains 90 pages, from Electronics Technology To-



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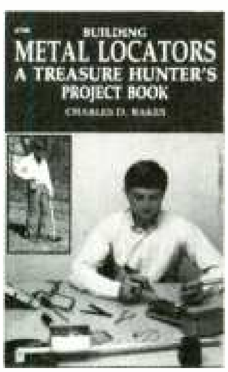
day, PO Box 240, Massapequa, NY 11762.

Building Metal Locators: A Treasure Hunter's Project Book
By Charles D. Rakes

With these electronics projects, the fun doesn't end after the construction is complete; it's only beginning! With the metal detectors you'll build using this one-of-a-kind project guide, you'll be ready to get started in a hobby that is exciting, challenging, and potentially profitable!

If you've ever dreamed of discovering a buried treasure—stop dreaming and open this guide of schematic diagrams, work-in-progress drawings, and photos, complete part lists, step-by-step instructions—everything you'll need to build the essential piece of equipment needed for a



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successful treasure hunt—a metal detector. An exciting, low-cost alternative to expensive commercially-made metal locators, the detectors included in this unique project guide will locate anything from coins and jewelry to gold and silver, and can be built quickly and easily by any electronics enthusiast!

With Charles Rakes' guidance in designing and building metal detectors, you'll be ready to hit the beach, old abandoned home sites, old carnival sites, recreational parks, playgrounds, racetracks, your own backyard, or wherever hidden or lost valuables might be found. Just some of the various types of detectors covered include frequency-shift metal locators such as a simple beat frequency oscillator (BFO), a BFO with selective filter detector, or a single oscillator high selective filter locator circuit; balanced inductance locators; transmitter/receiver circuits for both small and large objects; and unusual metal locator circuits.

You'll learn which types of components to use to achieve greater or lesser sensitivity, what types of circuits to build to locate objects at shallow or greater depths, even how to develop a special locator geared to finding buried treasure. Best of all, each one of the projects included are tested and proven original designs by the author, not just duplicates of commercially-available kits.

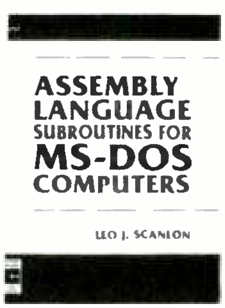
The 114 page book retails for $9.95 from Tab Books Inc., Blue Ridge Summit, PA 17214; Tel. 717/794-2191.

Assembly Language Subroutines for MS-DOS Computers
By Leo J. Scanlon

Do you want over 100 useful subroutines to put extra programming power at your fingertips? Let your fingers do some walking through these pages.

This collection of practical, easy-to-use subroutines is exactly what is needed for performing high-precision math, converting code, manipulating strings and lists, sorting data, displaying prompts and messages, reading user commands and responses, working with disks and files, and doing countless other jobs. Models are also included that provide the *boilerplate* the assembler requires for use in the programs and subroutines that the reader develops.

The routines are for all MS-DOS computers—IBM PC JR XT, AT; Tandy 1000, 1200, 2000, 3000; TI Professional; Compaq: and any IBM-compatible computer.



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Saving the programmer from having to constantly reinvent the wheel when creating assembly language code, this outstanding reference gives the computer user instant access to over 100 commonly needed routines. Never again will programmers be forced to waste valuable time wading through manuals or tutorials in search of a routine that reads a name from the keyboard, displays a message on the screen, or does some other common task.

To making it much more than just a subroutine sourcebook, the author gives real-world interaction with the software tools that assembly language programmers use. Step-by-step procedures are demonstrated for using the IBM and Microsoft Macro Assemblers, as well as the full details on the EDLIN line editor, SYMDEB and DEBUG debuggers, and the LINK and EXE2BIN utilities. Also included is a summary of the entire 8086, 8088, and 80286 microprocessor instruction sets, arranged in logical groups for quick learning and easy reference.

Assembly Language Subroutines for MS-DOS Computers contains 350 pages, costing $19.60 in paperback and $27.95 as a hardbound, from Tab Books Inc., PO Box 40, Blue Ridge Summit, PA 17214; Tel. 717/794-2191.

1001 Things to Do with Your Amiga By Mark Sawusch and Dave Prochnow

How about a book that puts the full applications potential of the Amiga within the reach of every one of its users? This book is a collection of more than 1000 ways for Amiga owners to take advantage of the unique features of one of today's most-sophisticated micros for uses ranging from household record-keeping and budgeting, to investment analysis and

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business management; from game playing and hobby use, to scientific and educational utilization.

Best of all, the guide reveals numerous techniques for using the Amiga in a huge variety of practical and just-for-fun ways: to forecast weather; to help youngsters make better grades; to calculate camera settings; to keep a business on the road to better profits; for technical applications; and of course, to play games.

It contains lots of ways to save time and money—even ways to use it to make money—it's a book that'll inspire the reader to come up with still more ideas.

The authors have provided all-new, commercial-quality programs for financial business and educational applications, unique games, a library of computer specific utilities and subroutines, sound and graphics, printouts, flowcharts, diagrams, and a wealth of illustrations.

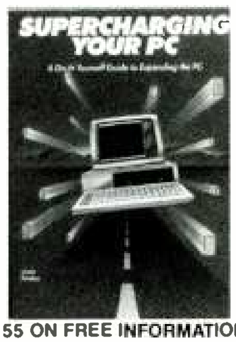
Containing 208 pages, the book retails for $12.60, from Tab Books Inc., PO Box 40, Blue Ridge Summit, PA 17241; Tel. 717/794-2191.

Supercharging Your PC By Lewis Perdue

We all know the PC has a wide variety of expansion options, but which is right for you? This book tries to make the list of choices clear.

Supercharging your PC is easy with this do-it-yourself expansion guide for your IBM or compatible PC. Perdue shows you tricks you can use to get your PC performing at top speed. You can add memory boards, RAM disks, print spoolers, hard disks, hardcards, bubble memory, graphics boards and monitors, modems, networks, electronic mail, mice, light pens, bar code readers, voice input, digitizers, scanners; optical disks, PC-Fax boards 80386 accelerator boards, AT emulation, and more.

Every chapter presents a hardware or software solution to an expansion prob-



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lem. You learn how to select and use utility software and hardware enhancements and implement other hardware enhancements and implement other techniques to gain greater RAM, more disk storage, and better graphics. You'll also find out how to choose a PC clone for maximum reliability and compatibility; and make powerful applications programs like Lotus 1-2-3 and dBASE run faster and more effectively.

Best of all, *Supercharging Your PC* has a do-it-yourself format—you'll save money while you become a PC expert.

Retailing for $19.95, the book contains 358 pages and is available from Osborne/McGraw-Hill, 2600 10th Street, Berkeley, CA 94710; Tel. 415/548-2805.

The One-Hour Atari XL By Tricia Jordan, Ph.D.

Info Books has designed its "One-Hour Books" to lead readers, page-by-page, from one easy, friendly, and successful experience with their computers to another. This book is an example of that user friendly technique.

Here's what you'll find in this compact, easy-to-read book: setting up the computer, working with the keyboard, setting up the cassette recorder, saving and loading programs on cassettes, setting up the disk drive, a bibliography to help find more information, booting and exploring DOS,

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saving and loading programs on disk drives, playing around with sound, using the printer for letters, programs, and graphics, using the modem to connect to the outside world, using the modem to connect to the outside world, and a glossary.

Also special chapters on software, word processing, financial management, data base management, education, games, and graphics.

The working programs contained in the text include: drawing programs to create pictures on the screen and save to cassette or disk; a tutor program to create question and answer quizzes on any topic you wish; and a budget program to create expense reports and reconcile your checkbook.

The 120-page softbound edition costs $5.95 from Info Books, PO Box 1018, Santa Monica, CA 90406.

Computer Integrated Manufacturing Handbook By Eric Teicholz and Joel N. Orr

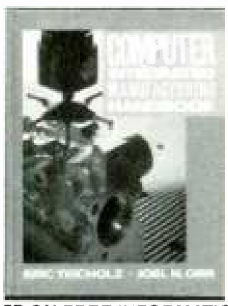
If you're into letting machines do all the work, then this is for you.

A highly practical treatment of the increasingly important technology of CIM, the book presents vital information for understanding and implementing issues in easy-to-understand terms (McGraw-Hill, $59.95).

Under the direction of Editors Eric Teicholz and Joel N. Orr, more than 20 specialists in the field have contributed significant material on their areas of expertise. They tell exactly what must be done to convert today's workplace into the factory of the future, emphasizing the economics and the specifics of CIM.

The Computer-Integrated Manufacturing Handbook shows how to utilize CIM technology by exploring the technologies and methodologies involved, by describing the obstacles to be overcome when CIM programs are started in typical industrial situations, and by examining the implementation issues to be considered.

This authoritative resource investigates a wide range of important aspects, from the role of CAD/CAM in CIM to numerical control systems, from a concise overview of the CIM industry to a projection of future trends and developments. Full discussions deal with such topics as group technology, robotics, process planning, production planning and control, the role of materials handling, technology management and factory automation, planning for a competitive CIM environment, and the considerations of controls, feedback, and benchmarking for successful implementation.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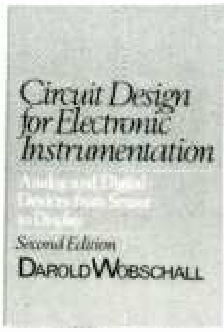
The Computer Integrated Manufacturing Handbook, contains 466 pages; and costs $59.95; from McGraw-Hill, 1221 Avenue of the Americas, New York, NY 10020.

Circuit Design for Electronic Instrumentation—2nd Edition
By Darold Wobschall

Sure you can build projects, but how about instruments? This book presents vital information on the standard devices and techniques for the electronic design process, and has been extensively revised and updated to reflect the latest changes in integrated circuit technology—such as the shift away from TTL IC's to CMOS and ECL devices.

Filled with stimulating ideas on and practical solutions to problems in electronic instrumentation design, the guide examines the entire process from input/sensor to output/display. It includes both analog and digital circuits, and emphasizes interfacing and the interrelation of circuits.



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With 80 percent of the material in the second edition either new or thoroughly revised, the book offers greatly expanded sections on sensors and communications. The author has also updated the circuits to employ newer and better devices, providing sufficient design information to allow for the construction of simpler circuits.

Subtitled *Analog and Digital Devices From Sensor to Display*, this reference has full coverage of everything from semiconductor devices and basic circuits, to signal amplification and processing; from data switching, control and readout, to power circuits. It explains in detail such diverse topics as temperature sensors, electro-optical devices, displacement sensors, chemical and biological electrodes, oscillators and signal sources, analog-to-digital conversion, noise and noise reduction, multiplexing, digital data communication, and power amplification and control circuits. In his discussions, the author avoids extended mathematical treatment except where it is needed for full comprehension.

Circuit Design for Electronic Instrumentation: Analog and Digital Devices From Sensor to Display, contains 377 pages at a retail price of $49.50, from McGraw-Hill, 2600 Tenth St., Berkeley CA, 94710; Tel. 415/548-2805.

Advanced Graphics in C
By Nelson Johnson

Add graphics to your C programs, and you'll add significant capabilities to your software. With *Advanced Graphics in C* you'll be able to write graphics programs for the IBM EGA (Enhanced Graphics

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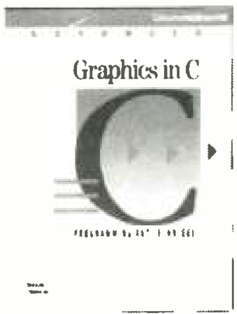
CIRCLE 13 ON FREE INFORMATION CARD

Adaptor)—the de facto standard for high-quality graphics programming on the IBM PC.

Advanced Graphics in C offers a special graphics program, called GRAPHIQ, that provides a complete toolkit of all the routines you'll need for graphics operations. Johnson shows you how to use GRAPHIQ to implement or adapt graphics in your C programs.

It also provides: A special appendix that includes the code for GRAPHIQ, a complete graphics program with a rotatable and scalable character set. It's full of



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tools not available elsewhere. An entire stroke/front character set; code for the AT&T Image Capture Board; information on serial and parallel interfacing to mice, light pens, and digitizers.

With this text you'll learn state-of-the-art techniques from Johnson so that you can easily create the graphics you need.

The book contains 660 pages and retails for $22.95 from Osborne/McGraw-Hill, 2600 10th Street, Berkeley, CA 94701; Tel. 415/548-2805.

Your Best Interest: A Money Book for the Computer Age
By Tom Weishaar

We are peasants in the Dark Ages of money. Compound interest confounds us. Interest rate magicians pick our pockets daily, monthly, and quarterly. But just as the printing press liberated us from feudalism and superstition, the personal computer can now free us from the deception of financial warlocks.

Until now, there have been books about money, and books about computers, and books for owners of one spreadsheet for one particular computer. *Your Best Interest* is a book that explains financial spreadsheet calculations in a generic fashion. The information can be used with any spreadsheet, on any personal computer.

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But more than that, you gain an understanding of how financial transactions ac-

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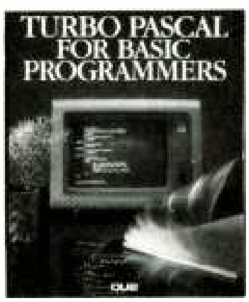
tually work. The book covers everything from calculating a percentage to determining the true cost of an adjustable-rate mortgage. In addition, you'll learn about the tricks professionals use to take advantage of unwary investors and borrowers. And you'll see the long-term effect taxes and inflation have on your personal wealth—and what you can do about it. Each chapter has real-life exercises so you can see how the formulas work.

The soft-bound book contains 172 pages and costs $9.95, from Info Books, PO Box 1018, Santa Monica, CA 90406; Tel. 213/470-6786.

Turbo Pascal For Basic Programmers
By Paul Garrison

Most computer programmers begin by learning BASIC. But as computer languages go, BASIC is slow and cumbersome. Now, with Borland's affordable Turbo Pascal software, individuals and small business owners are seizing the opportunity to step up to a high-level, structured language for faster, more efficient programming.

In this book, Paul Garrison draws from your knowledge of BASIC programming fundamentals to show you how Turbo Pascal works. BASIC programs are compared—side by side—with their Pascal equivalents so that you can see clearly the



CIRCLE 58 ON FREE INFORMATION CARD

similarities and differences of the two languages. The comparisons demonstrate why Pascal is easier to write, easier to read, and easier to test and debug.

Look inside this book and find: clear and easy-to-understand explanations of the specifics of structured programming with Turbo Pascal; a library of useful programs for personal and business uses. There are, for example, database programs, a financial projection program, a currency conversion program, a mortgage amortization program, and many more; seven appendixes that include the ASCII character codes, a Turbo Pascal dictionary, a glossary of computer terms and abbreviations, and other helpful aids.

If you want more information about Turbo Pascal procedures and functions; loops and arrays; pointers, heaps and stacks, *Turbo Pascal for BASIC Programmers* is for you.

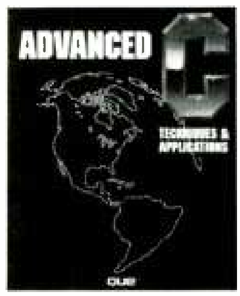
A hands-on tutorial, this book shows you how to use Turbo Pascal to turn your computer system into a powerful developmental tool.

The book is 406 pages, and retails for $16.95, from Que Corporation, 7999 Knue Road, Suite 202, Indianapolis, IN 46250; Tel. 317/842-7162.

Advanced C: Techniques and Applications
By Gerald E. Sobelman and David E. Krekelberg

If you have basic knowledge of the C programming language and are ready for more, then you should have *Advanced C: Techniques and Applications*.

By the time you finish Advanced C, you will have constructed several state-of-the-



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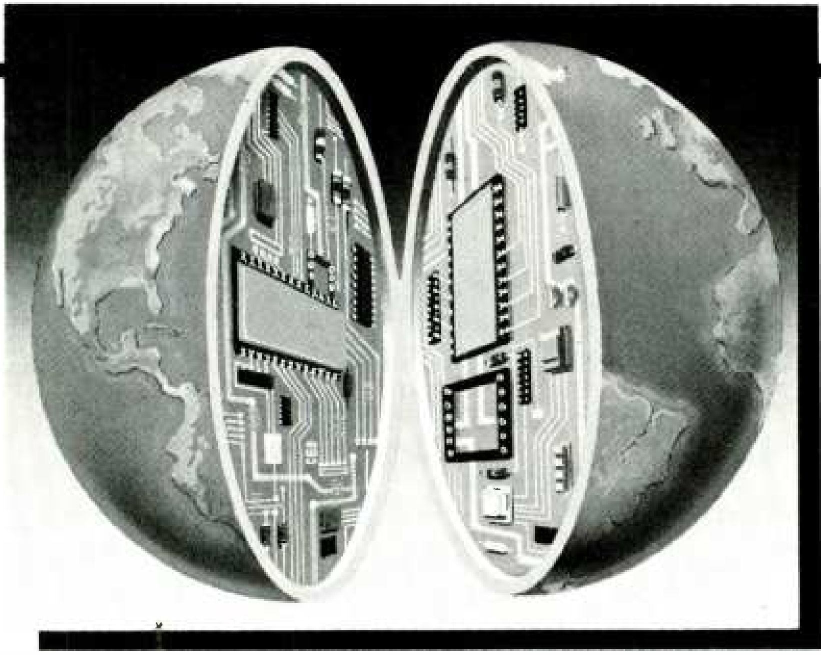
art applications. Learn how to: generate and control advanced graphics, develop a menu-driven, multiwindow environment, and construct advanced user interfaces.

Advanced C is one of the few books available that focuses on the advanced features and capabilities of the C programming language. Important topics in this book include C coding style pointers, recursion structures, linked lists, and trees.

The book can give you a deeper understanding of the C language and help you develop techniques that will enhance your programming skills.

The book, containing 316 pages, retails for $21.95 from Que Corporation, 7999 Knue Road, Suite 202, Indianapolis, IN 46250; Tel. 317/842-7162. ■



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CIRCLE 6 ON FREE INFORMATION CARD

By Herb Friedman

FRIEDMAN ON COMPUTERS

How to stretch your budget for hard-disk storage.

☐AS PROGRAMS CONTINUE GETTING larger and more complex, the standard, two-floppy configuration of IBM-compatible computers is hard-pressed to provide the necessary storage. Soon, the average user starts to think in terms of the megabyte storage capacity of a hard-disk system. Although the past year has seen the price of a hard-disk unit drop like a lump of lead, even the most-minimal hard-disk system comes out to several hundred dollars.

But there's a lot of inexpensive hard-disk hardware floating around the surplus- and mail-order dealers, not to overlook the flea markets. Even without a calculator, it's easy enough to figure out that a hard-disk system won't cost much beyond $225 if you *do it yourself*. Unfortunately, doing it yourself can turn out to be prohibitively expensive if you don't know what you're doing, and very few dealers—at least in our experience—will give you much assistance. In fact, some won't give any assistance—*What you order is what you get!*

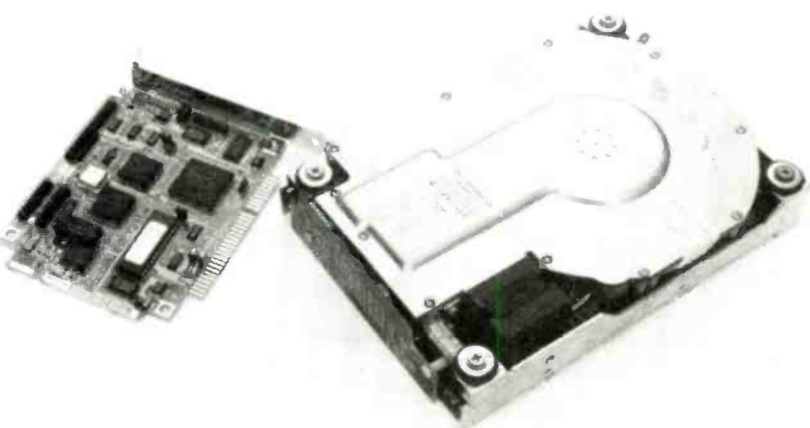
Why They're Cheap

First things first; why are some hard-disk drives so cheap? It's because the business market, for whom they're intended, want capacities exceeding 30 megabytes. Warehouses are overflowing with 10- and 20-megabyte hard-disk drives that the business community no longer wants, and so they're unloaded at bargain-basement prices—particularly the 10-megabyte models. But 10 or 20 megabytes is plenty of storage for most small users; so if you're willing to settle for less, you can upgrade to a hard-disk system for less than the original wholesale cost of the drive. In fact, if you can settle for 10-megabytes of storage, you can pick up the Microscience model *612* drive shown in the photographs—one of the best because it has a plated media and automatic head parking—for a little more than $100.

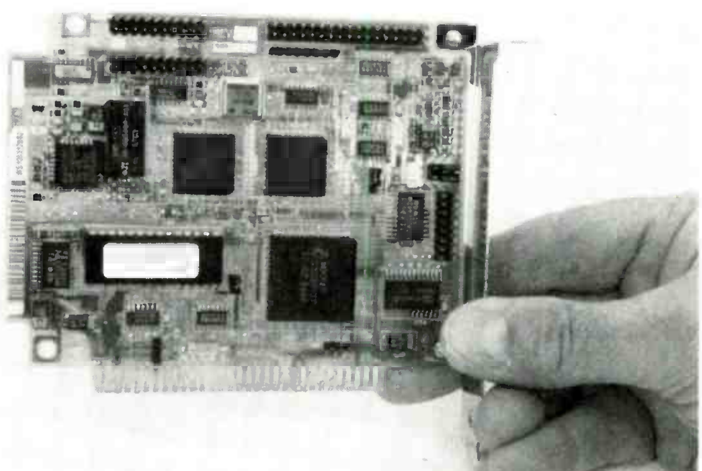
Actually, a basic hard-disk system consists of only the parts shown in the photos: a hard-disk drive mechanism and its controller. The controller, which is usually the half-slot size Western Digital *WX-1* (see photos)—or its almost functionally-identical full-size twin, the *WX-2*—is priced from $85 to about $100. The controller usually comes with a set of two cables that connect the controller to the drive. Depending on the particular dealer, you might have to do some *fast talking* to get the cables thrown in; but if he won't do it, try a different dealer or make the cables yourself—the connectors are standard. While there are other kinds of controllers in the marketplace, some of which—such as the RLL type—claim to provide greater disk storage capacity compared to the the Western Digital controller, if you want to have the system work the first time, or with a minimum number of headaches, stick with the *WX-1* and *WX-2* controllers.

Enough Power

If you have one of the older computers with a 60-watt power supply and full-size



A hard disk system consists of a controller and a hard disk drive. This pair cost less than $100. But notice the drive came without a front panel.

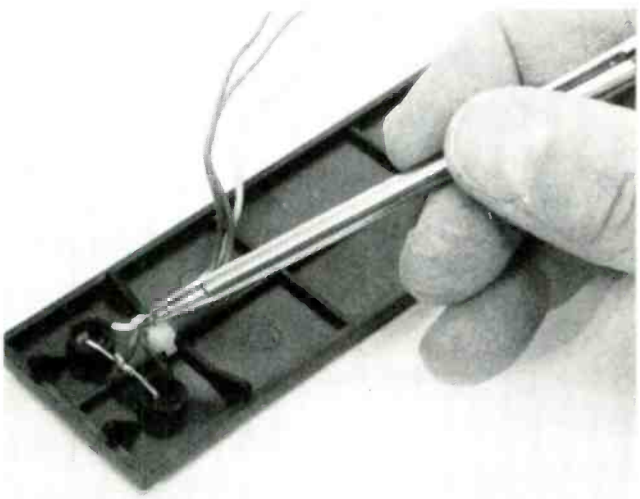


This half-size "WX-1" hard-disk controller has two smaller header terminal strips, which can each drive a disk drive. The larger header strip is split by a Y-adapter or a two-connector cable when using two disk drives.

drives, you'll probably have to remove the "B" drive, so that you'll have mounting space and power for the hard-disk drive—whether it's a half- or full-size drive. If you have one of the newer computers, it probably has half-size drives and a power supply of at least 120 watts that has two sets of extra power connectors (a total of four). You can fit either a half- or a full-size, hard-disk drive into the empty panel space and then simply plug it in to the power supply.

Now it's conceivable that your *el cheapo* hard-disk unit will arrive without a front panel. (Surprise! That wasn't even implied in the advertisement.) No problem. Simply make your own from one of the plastic filler panels that cover the disk drive openings in the front of the cabinet—just press the filler forward and out—or cut a piece of plastic to fit. The panel doesn't have to attach to the drive because the drive is really held in place by two to four screws, not by the front panel. The panel contains only two LED's, which indicate that power is on (red) and that the disk is in use (green or yellow). The connector for the LED's are three pins near the front of the drive.

Simply install two LED's on a plastic filler panel (see photos). Tie one lead from each into a common connection—which is usually negative—and pre-wire the three leads to a connector that matches the three pins on the disk drive.



If your hard disk drive came without a front panel, you can make your own by simply installing two LED's on one of the plastic filler panels; or cut a front panel from a piece of plastic. Use a small wire tie—indicated by the pointer—to keep the wires together.

Setting the DIP's

The drive comes with a data sheet that tells how to set the internal DIP switches for one or two drives. If you didn't get the data sheet, get on the phone and insist that they send the data or give you the information over the phone. Set the DIP switches accordingly, and install the drive in the computer.

Attach the LED connector, and then seat or tape the front panel onto the cabinet. Install the two connecting ribbon cables between the controller and the disk drive. The color-coded wire on one side of each cable is pin 1 for that cable.

Next, program the controller for the disk drive. Programming is done by simply moving a few jumper blocks to the appropriate pin connections, as the photos show. (For clarity, we have temporarily removed the cables.) How do you know what goes where? The controller should have been supplied with a small paper guide that shows which block goes where depending on factors, such as whether the drive is 10- or 20-megabytes, the sector arrangement, etc.

(Continued on page 100)

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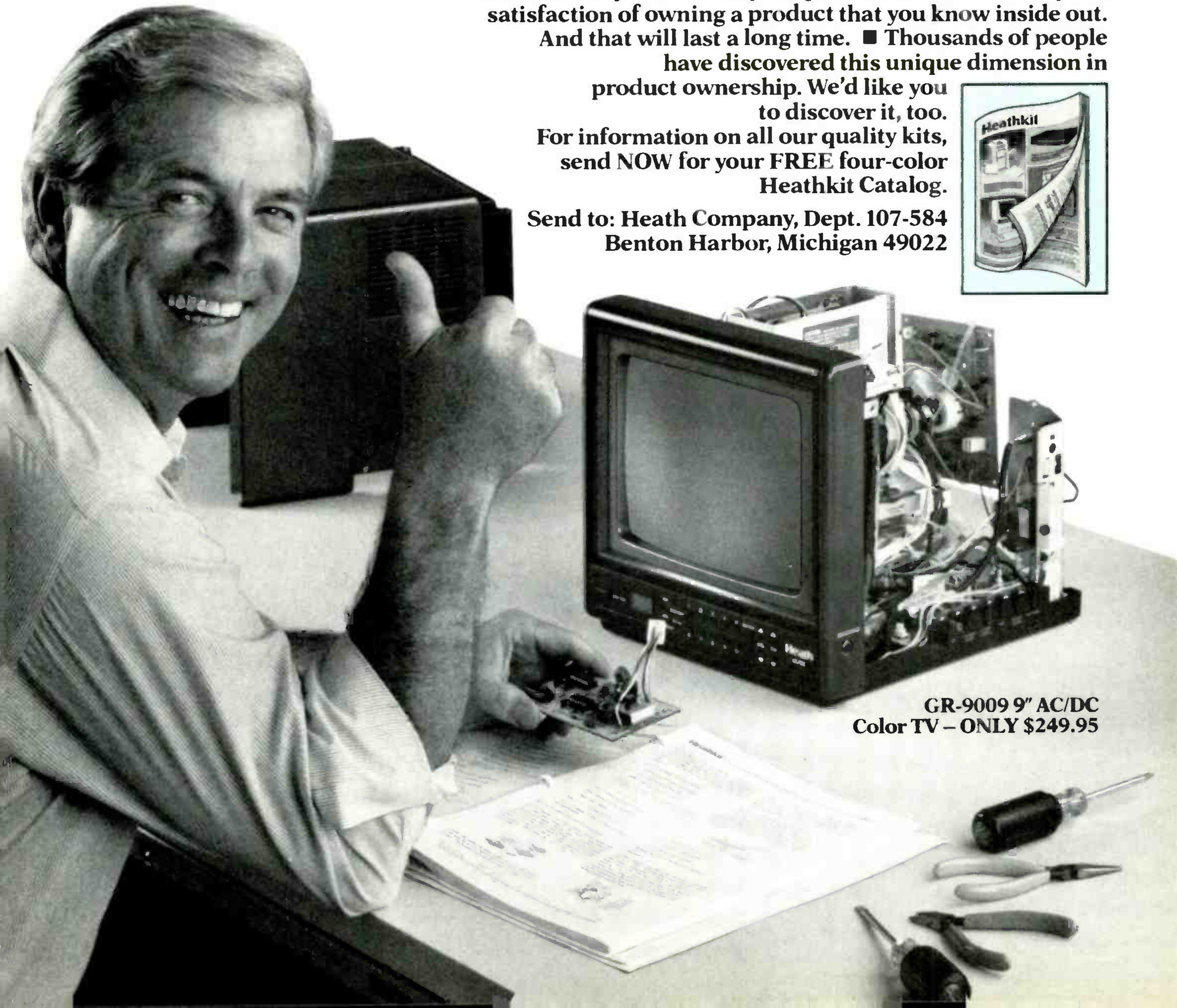

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CIRCLE 9 ON FREE INFORMATION CARD

KB-103

By Don Jensen

JENSEN ON DX'ING

Do you know what country is it?

☐ITS FLAG IS RED, WHITE, AND BLUE. Its currency is the US dollar. It was the first independent republic on its continent, and it is governed by a President, Senate, and House of Representatives. Its national capital is named after a famous American president.

Sure, it's a trick question. The country—and our DX'ing target this month—is the west African nation of Liberia. That Liberia's government is—in many ways—patterned after the United States is no accident. It was founded by an organization called the *American Colonization Society* in 1822 as a haven for freed slaves.

Unfortunately, Liberia never lived up to the dreams of its idealistic founders. It is today just another poor and undeveloped Third World country, steaming away in one of the hottest and most humid corners of Africa.

America, though, is still offering assistance to the tiny African country, which was once its ward. One way is the USAID-sponsored *Liberian Rural Communications Network*, which set up a series of broadcasting stations last year to bring local radio to the least developed parts of the country.

Those local stations—in places with names like Voinjama, Zwedru, and Gbarnga—are low-powered, medium-wave outlets, normally not audible much beyond their 75-mile primary range. But they are served by a LRCN shortwave link, which can be received by SWL's in North America.

There are three other shortwave services in Liberia for the shortwave listener to track down and log. One is the easy-to-hear, but not-very-exciting, *Voice of America* (VOA) relay station at the Liberian capital of Monrovia.

Tougher and, therefore, more challenging DX targets are two other shortwave services, the commercial *Liberian Broadcasting System* and the cultural and religious broadcasting service of the Sudan Interior Mission, *Radio ELWA*.

LRCN is the newest of the lot and the most recent to come to the attention of North American SWL's. It operates a 10-kilowatt independent sideband transmitter on 3,975 kHz, where, unfortunately, it often suffers interference from the *British Broadcasting Corporation*'s (BBC) more powerful signals.

According to William E. Mackie, who heads the USAID technical advisory team in Monrovia, the SW outlet is used to feed the national newscast to its remote microwave stations in the bush. The very brief shortwave schedule runs twice daily, Monday through Saturday, at 0700 UTC (when it can be heard in North American) and at 1900 UTC (when it cannot). Mondays through Fridays, the news is followed at 0715 UTC by a half-hour information program called "Network Liberia." Programming is all in English.

VOA has one of its worldwide network of shortwave relay operations in Liberia and beams programs to Africa from a series of six huge 250,000-watt transmitters and two older 50-kilowatt units.

Programming is standard VOA fare, hardly distinguishable from other Voice operations except for the occasional indentification.

You can find the VOA's Liberian relay at various times, such as between about 1600 and 2200 UTC. Some frequencies to try include 15,445, 15,600, 17,870 and 21,485 kHz.

Radio ELWA is a religious broadcaster that has been operating from Monrovia for years on shortwave. It is a rather substantial broadcaster, with a pair of 50-kilowatt and two 10-kW shortwave transmitters.

ELWA programs in English, French, Arabic, and several west African languages, such as Hausa, Ibo, and Fulfulde. Look for this one in English from 0600 UTC on 4,760 kHz. It is also scheduled from 0700 UTC on 11,830 kHz and from 0825 UTC on 6,070 kHz.

ELBC, the *Liberian Broadcasting System*, also in the capital of Monrovia, offers something a bit different to the SWL's ear—West African commercial radio.

It has a 50-kilowatt shortwave transmitter and can be best heard on 3,255 kHz, beginning at 0530 UTC. With some effort, good reception conditions, and a bit of luck, SW listeners in many parts of North America may manage to log all four of the Liberian shortwave outlets.

Book Look

One of the most commonly asked SWL questions is where should I tune to find a particular station and when? And one of the best answers to that question, in my view, is the annual *Radio Database International* volume, which is really a "Passport to World-Band Radio."

The third edition of the book is just out, some 400 pages of information. A big part of the RDI publication is its computer-generated graphic presentation of the shortwave frequencies—showing stations, frequencies, and daily schedules—based on actual worldwide monitoring. The graphic data also tells you the major languages being aired and when, the station's power, and much more.

In addition, you will find RDI's expert reviews of shortwave receivers, accessories and antennas, plus feature articles.

Radio Database International's new book is available from many shortwave-radio dealers around the world for $14.95, or from the publisher—RDI, Box 300, Penn's Park, PA 18943—for an additional $1.95 shipping and handling charge.

Weather Over There

J.N.M. Legate, a reader in Glovertown,

ABBREVIATIONS

BBC	British Broadcasting Corporation
CST	UTC +6 hours
DX	long distance (over 1000 miles)
DX'ing	listening to shortwave broadcasts
EST	UTC +5 hours
FM	frequency modulation (modulated)
kHz	kiloHertz (1000 Hertzs or cycles)
kw	kilowatt (1000 watts)
LRCN	Liberian Rural Communications Network
MST	UTC +7 hours
PST	UTC +8 hours
RAF	Royal Air Force
RDI	Radio Database International
SW	shortwave
SWL('s)	shortwave listener('s)
TV	television
UTC/GMT	Universal Time Code/ Greenwich Mean Time
VOA	*Voice of America*
VHF	very-high frequency

Newfoundland, Canada, says that SWL's planning a trip to Europe might be interested in the sort of weather they can expect before they depart. If a "listener" has a receiver that can tune in sideband signals, he says, Shannon Airmet is received quite well in Newfoundland, and may be heard in the USA too.

The aeronautical transmissions from Ireland's big international airport offer regular weather reports. Reception is variable, but not often inaudible with 5,640 and 8,957 kHz being the best during daylight hours and 3,413 kHz. at night.

Sometimes, he adds, 13,264 kHz is good for daytime reception. The weather is given for numerous international airports all over Europe, from Athens to Shannon. Reader Legate also says that the *British Royal Air Force Volmet* station gives weather for RAF bases, plus the major United Kingdom civilian airports such as London's Gatwick and Heathrow, plus Prestwick and Manchester. Reception is usually good on 11,200 kHz daytimes and on 4,722 kHz at night.

Down the Dial

In answer to some recent questions about this monthly feature, the times listed are in Coordinated Universal Time, abbreviated as UTC, which more veteran SWL's may know as Greenwich Mean Time or GMT.

UTC/GMT is a generally recognized time standard in international broadcasting. To convert to your local time, subtract 5 hours for EST, 6 hours for CST, 7 hours for MST or 8 hours for PST. SWL's also use 24-hour clock time, in which 0100 signifies 1 AM UTC; 1300 is 1 PM UTC; 2100 is 9 PM UTC, and so on.

Frequencies in the following reports are in kilohertz (kHz), and are stations that other readers (like yourself) are hearing. Your SW loggings can appear in this section too if you'll just drop me a note with your information to *Jensen On DX'ing*, **Hands-on Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

Belguim—15,590, *Belgian Radio and TV* has its English shortwave service, including news and features, at 1330 hours.

Czechoslovakia—5,930, *Radio Prague* is an eastern European broadcaster widely heard in North America. Its Sunday Magazine program in English has been logged here at 0100, and also at 0300. Try also 7,345 and 11,990 kHz.

French Guiana—3,385, FR3 is the SW voice of this colonial French outpost in South America, which has been noted at about 0930 hours with a program schedule, a rooster's crowing and then popular music.

Falkland Islands—3,958, from the South Atlantic comes the programming of the *British Forces Broadcasting Service*, aired by the *Falkland Islands Broadcasting Station*. Try this one around 0800 to 0900.

Greenland—3,999, *Gronlands Radio* is reported as heard with Danish programming, an interval signal, and choral music from just before 1000 hours.

Guatemala—4,825, *Radio Mam* is a Spanish-language shortwave outlet that can be heard around 1230 with lively Latin vocals.

Monaco—7,105, *Trans World Radio* opens in English at 0720 sign on with a music-box tuning signal and indentification announcements, then on to religious programming.

Tunisia—12,005, *Radio Tunis* is found here, just above the 12,000-kHz mark, with Arabic music and announcements at 1900 hours. ■

CREDITS: Pete Tutak, WA; Kirk Allen, OK; Norman Bobb, MN; Robert Tomko, NJ; Rufus Jordan, PA; Scott Nelson, ND; Paul Brouillette, IL; Brian Alexander; Richard D'Angelo; Peter Dillon, MD; Daniel Sampson, WI; North American Shortwave Association, 45 Wildflower Road, Levittown, PA 19059.

This slick listening post belongs to veteran SWL Kent Magill of Modesto CA. Kent's receivers are a Drake SPR4 with a Grunding 1000 as backup. He has QSL verifications from 213 different countries and has, thus, earned a *Master DX Centurian* award from the *North American Shortwave Association*, a club he has belonged to for the past dozen years.

By Marc Saxon

SAXON ON SCANNERS

The competition is heating up in the scanner industry

□SCANNER TECHNOLOGY SEEMS TO BE producing some healthy competition between manufacturers, each trying to outdo one another with super scanners offering all sorts of fancy features. This month, we just have to look at the scanner that Regency Electronics says is their latest entry in the sweepstakes.

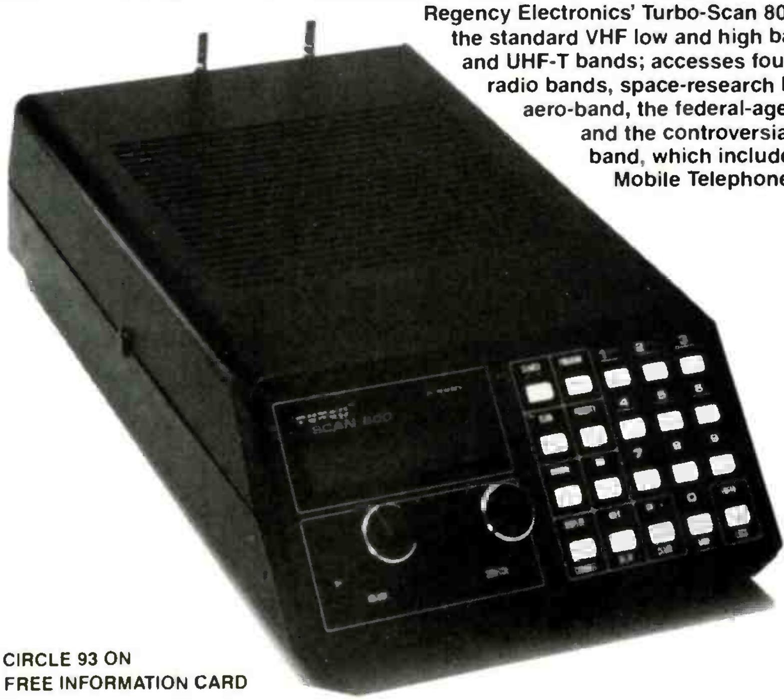
They're tossing around words like "ultimate scanner," so you know that the Turbo-Scan 800 is special. For starters, the Turbo-Scan 800 takes advantage of technology that permits the scanning of 50-channels per second. That's a quantum leap in scanning speed, and almost five times faster than most other scanners can manage to operate.

This baby can tune in all sorts of interesting things, too. In addition to the standard VHF low and high bands, plus the UHF and UHF-T bands, you can access four amateur-radio bands (1¼, 2, 6, and 10 meters), the 136 to 144 MHz space-research band, the 118 to 136 MHz VHF aero-band, the federal-agency band at 406 to 420 MHz, and the controversial 800 MHz band (actually 806 through 950 MHz). The 800 MHz band, of course, includes services such as Cellular Mobile Telephones.

It's a snap to program the Turbo-Scan 800, and it lets you carry out that task via its translucent, rubber keypad that's backlit for nighttime use, and a dual-level vacuum-fluorescent display. Frequencies can be entered randomly into any of the scanner's 75 channels, or grouped into any of six scanning "banks" for quicker and more convenient access. Once the frequencies have been programmed, the keyboard may be locked so the that programming can't be accidentally changed.

The Turbo-Scan 800 also offers a feature, which Regency has dubbed *Accuseek*, that permits the search/scan mode to operate at the scanner's special 50-channels-per-second speed. A weather key instantly tunes the unit to the nearest active 162 MHz NOAA weather channel; just push a button and you're there!

The Regency Electronics Turbo-Scan 800 also has the standard scanner features, scan delay, channel lockouts, direct channel access, as well as two telescoping antennas, an AC power-supply, plus a DC supply and mobile mount. The set is tagged at $499.95.



Regency Electronics' Turbo-Scan 800 features the standard VHF low and high bands, UHF and UHF-T bands; accesses four amateur-radio bands, space-research band, VHF aero-band, the federal-agency band, and the controversial 800 MHz band, which includes Cellular Mobile Telephone services.

Complete details are available from Regency Electronics, 7707 Records Street, Indianapolis, IN. 46226. That space-research band, by the way, is an interesting feature. It offers you the chance to tune in artificial satellites, many of which operate just above 136 MHz.

If you have coverage of that band on your scanner, you can monitor *birds*, such as the three NOAA weather satellites, which transmit on 136.77 and 137.77 MHz (in addition to their microwave frequencies above 1500 MHz). There are others, too. Checkout frequencies such as 136.125, 136.23, 136.32, 137.02, and 137.86 MHz, you might find activity there. In fact, put your scanner into search/scan mode and let it run through the 136 to 138 MHz portion of the spectrum and you might discover signals from any of the many space trinkets operating there.

Don't expect to hear conversations, though. You'll either hear an "open carrier" (that is, no modulation at all) or else you'll hear radiotelemetering (data) signals. Those satellites can be heard when they are triggered into activity by command signals from their associated ground stations. And you'll, of course, hear only those satellites that are in line-of-sight (so to speak) of your antenna. For the record, the channel used to send commands to satellite is 154.20 MHz.

Getting back down to earth, most scanner owners are not aware of the General Mobile Radio Service (GMRS) band. That's a sort of cousin to the 27 MHz CB band, although you won't hear the kids and truckers there. In many areas, however, you will hear REACT teams and any hobbyists on those frequencies, in addition to business users. For the most part, repeaters are the way to go in GMRS. Repeater frequencies are 462.55, 462.575, 462.60, 462.625, 462.65, 462.675, 462.70, and 462.725 MHz. The repeaters are paired with input frequencies exactly 5 MHz higher (467.55, 467.575, etc.). You'll be primarily interested in what's taking place on the 462 MHz channels.

E.J. "Coop" Cooper of Silver Springs,

MD, asks if we can root out the frequencies used in the National Capital area by Metrorail, the large public transit system there. You came to the right place! The Yellow Line in DC and the Red Line trains use 160.26 MHz.

The Yellow Line in VA, as well as the Blue/Orange Line trains are on 160.38. The yards and towers are on 161.235 MHz, and test trains use 160.605 and 160.62 MHz. Maintenance crews use 161.025, and the Metro Transit Police operate through a repeater on 161.365. Monitors in that area might also enjoy listening to some Coast Guard helicopter operations on 164.30 and 381.8 MHz, and Search/Rescue activities are found on 282.8 MHz. Operations in the 225 to 400 MHz band can usually be monitored only on a select few scanners (unfortunately).

What Does It Mean?

Fred Worthington of Alabama writes to say that when monitoring the local, county, and state law enforcement agencies in his area, he frequently hears the term "Red Direct" used, but he can't quite grasp its meaning. He guesses that the "Red" makes it some sort of emergency code and wonders if we can help with a more definite explanation.

What Fred heard is an expression used in many areas, although Fred was confused by the words. What they're saying may sound like "Red Direct," but what they're actually saying is *Read Direct*—a term used when one mobile unit asks the base-station dispatcher to relay information to another mobile unit.

If the unit who is to receive the relayed message overhears the message being given to the dispatcher, he simply comes on the air and announces that there is no need to tie up the channel since the message has already been "read direct" from the other unit. It takes on a whole new meaning when you realize that "red" and "read" may sound alike, but they're quite different.

Fred isn't the only scanner owner who has gotten confused by words overheard on a scanner. Many agencies, especially ones such as the FBI and Treasury, use numerous slang buzzwords in their communications and those are often especially confusing. A "boat" turns out to be a car; a "box" is a van, while a "Louie" is a left turn. There are dozens of those buzzwords!

Once again we've (sadly) used up the space allotted to us. We invite you to send any questions, comments, photos, and information to Marc Saxon, *Saxon On Scanners*, **Hands-On Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

GRANDPA'S ANTIQUE RADIO

By Homer L. Davidson

Make and enjoy a radio that reflects the early 1920's

BACK IN THE EARLY DAYS OF RADIO, THE VACUUM TUBE was king of the regenerative circuits. Any replica of a golden oldie should have visible one or more vacuum tubes pouring out heat from a red glowing filament. Although the project described in this article, *Grandpa's Antique Radio*, may appear as a two-tuber, it actually performs by using solid-state devices. The vacuum tubes are there just for show. The regenerative (regen) circuit used in the radio is very old, but the radio operates with modern-day FET transistors and a single audio integrated-circuit chip. A combination of the old and the new bring back the antique radio of yesterday.

The Circuitry

The FET transistors, Q1 and Q2, and the LM386 low-voltage, audio amplifier (U1) provide comfortable earphone reception (refer to Fig. 1). Transistor Q1 comprises a broadband RF amplifier and isolation transistor. Besides amplifying the weak broadcast signals picked up by the antenna, the RF amplifier isolates the regeneration circuit—preventing RF noise from radiating directly into the antenna. The RF signal is transformer coupled via L1/L2 to the regeneration circuit. Coils L1 and L2 interact mutually as a transformer, and incorporate a ferrite core to raise the circuit's Q.

Radios On the Cover

One of the radios on the cover is not the antique it appears to be but a replica (we'll tell you which one it is a little further down). However, the impressive looking Sonora at the bottom of the cover is the real thing. It dates back to 1944, which makes it one of the few radios manufactured during World War Two. At that time the countrys efforts turned from audio (which is said to calm the savage breast), to making war noises (said to be the great equalizer; no pun intended). That model was created in an effort to bolster up the civilian population's moral.

Next up on the totem pole is a General Electric model (also authentic) manufactured in 1948, making it a post-war item. At that time all of the entertainment industries enjoyed great patronage, not excluding radio. Even though many such models were sold, they are hard to come by, which makes them very valuable.

Taking things back a track is the radio above that; a Halicrafters Model S-38B from 1938. The unusual thing about that consumer baby is its metal cabinet; but that's Halicrafters style.

Now we come to the trickster in the group, the reproduced Thomas Model BD109. To look at it is to be taken in hook, line, and sinker. That little beauty carries a suggested retail of $79.95; not bad if you're a real antique enthusiast. ■

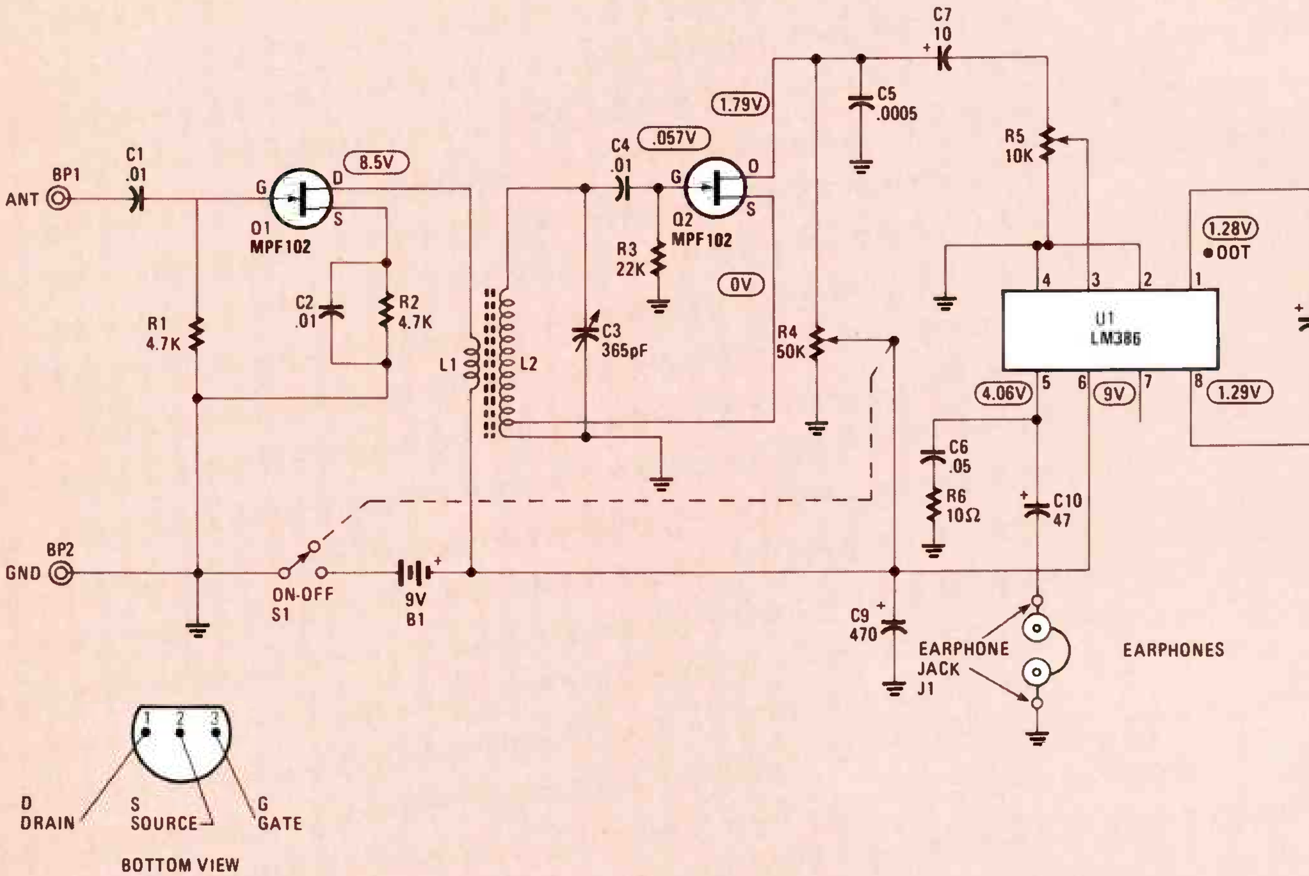


Fig. 1—Here is the schematic diagram of Grandpa's Antique Radio. It contains a regeneration circuit and modern solid-state devices. The RF and regen FET transistors (Q1 and Q2) amplify and detect the RF signal for the audio chip (IC1).

The regeneration circuit is centered about FET transistor Q2. Radio-frequency signals amplified by Ql are coupled to coil L2. The tuned circuit is composed of L2 and tuning capacitor C3, which tunes the tank circuit and selects the desired station frequency. The gate bias for the detector stage of Q2 is developed by a grid-leak combination, consisting of C4 and R3. That combination should be called a "gate-leak," but it's too late in the radio game to coin new phrases.

Regenerative feedback is provided by connecting the source (S) terminal to the 6-turn tap of L2. The regeneration is controlled by varying the voltage on the drain terminal of Q2 with regen control R4. Now, the detected audio signal from the drain terminal is capacity-coupled by way of C7 to volume control R5.

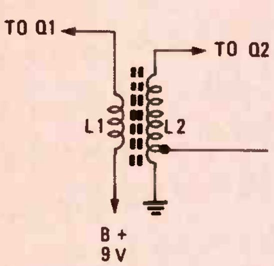


Fig. 2—Coils L1 and L2 are wound on a ½-inch diameter ferrite rod which may be cut to size from a longer rod. Mark a groove around the rod with a hacksaw or file and it will snap in two when tapped. Refer to text for coil winding information.

The controlled audio signal is applied to pin 3 of audio amplifier, U1. A stereo earphone jack, J1, is connected through electrolytic capacitor C10 to pin 5 of U1. Although Grandpa always used a pair of earphones (he called them cans), the LM386 power amplifier will drive a small PM speaker. The small radio circuit, powered by a 9-volt transistor battery, has a current drain of 10.7 milliamperes. Most small battery-operated radios have an operating current drain of 8.5–20 milliamperes.

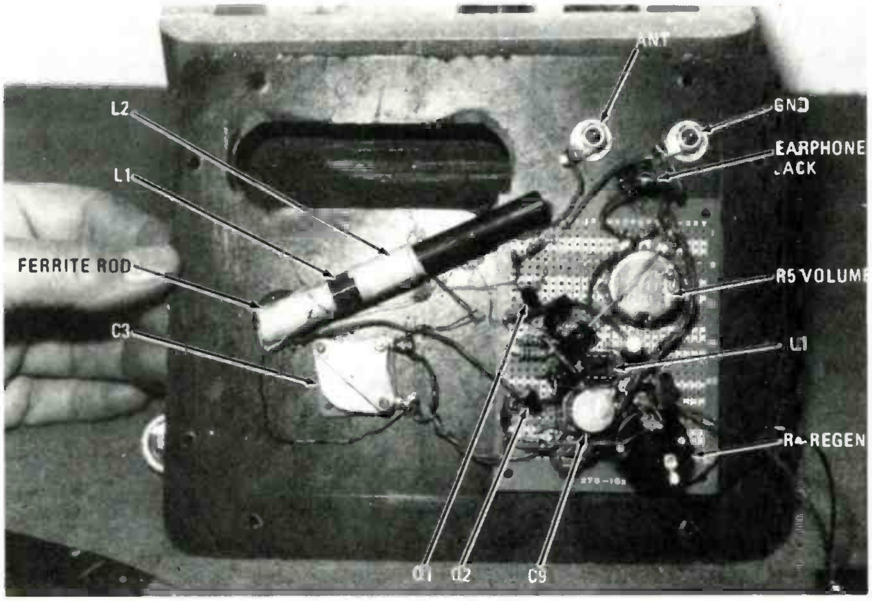
Winding the Coils

First, start winding L2 in the center of a AM-band ferrite rod with number 24 enameled wire. Refer to Fig. 2. Place a small piece of masking tape under the starting wire to hold it in place. Wind on approximately 73 turns and place a piece of masking tape over the winding while twisting the wire several times to make the tap connections. Now, wind on another six turns. A 3-inch rod should be able to hold those turns; however, you will find a slightly longer rod easier to work with. At the end of L2, place a layer of masking tape to keep the coil from unwinding. Clean off the enamel at the tap and solder a four-inch piece of hookup wire to the tap.

In the middle of L2, place a layer of masking tape. Wind 32 turns of number 28 enameled wire over the masking tape for the primary winding, L1. Secure both ends of the winding with masking tape. Both coils are close-wound (CW) and wound in the same direction. Leave four-inch connecting wires at each end of the coils.

The PC Board

A pre-drilled IC-LS1 perfboard was used as the PC board for mounting parts for Grandpa's Antique Radio. Of course, a regular perfboard will do. Here, a predrilled 2-¹³⁄₁₆- × 3-¾-inch perfboard was prepared by drilling two ½-inch holes to mount the regenerating and volume controls. Drill out the



Although an IC-LS1 perfboard was used to mount all small parts, a regular perfboard may be used. The small parts are mounted into position as they are wired into the circuit.

perfboard so both controls will fit flush with the top panel. Refer to the photos and Fig. 3. The shaft mounting nuts on the two controls will hold the PC perfboard to the front panel.

Wiring Up the Radio

The mounting and wiring of the various small components is not critical provided you follow the author's layout somewhat. Refer to the author's unit shown in the photos. Place the DIP socket between the volume and regeneration control. Transistor Q1 is mounted to the left, close to the antenna and ground posts. Transistor Q2 is mounted next to the outside, near the tuning capacitor. All other small parts may be mounted as they are wired into the circuit.

From pin 4 of the U1 socket run a length of bare wire up the row of soldering holes for easy ground connections. Likewise, run a bare piece of hookup wire from pin 6 of the DIP socket down the soldered holes for the B + connections. Be careful when soldering up the DIP terminals, so that excess solder does not establish a shorting solder bridge. Remove the excess solder with a piece of solder-wick mesh material. Use a pocket-knife blade between the two rows of terminals to clean out solder from the adjacent terminal as the solder is heated. Keep the soldered connection close to the perfboard, so the board fits tightly against the front panel.

Solder up two 3-inch pieces of hookup wire for the ground and antenna terminals. Likewise, solder another set of three-inch length pieces to tie the variable capacitor to the perfboard. Now, set the perfboard aside and finish up the front panel.

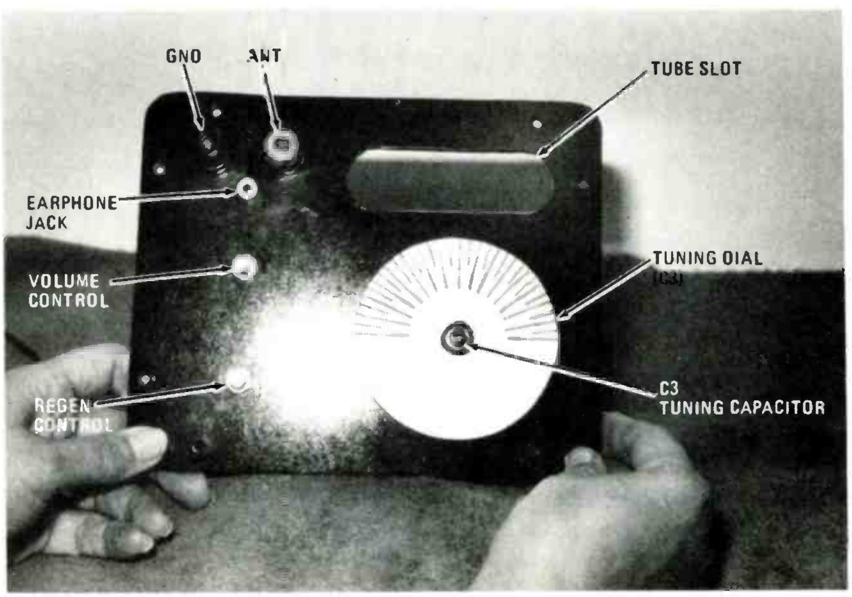
Cabinet Construction

The top and bottom panels are cut from hard-tempered Masonite stock to look like a bakelite finish. All holes were drilled into the top panel before applying two coats of black automotive, spray-enamel paint. Cut out the 1-¼- by 3-½-inch tube slot with a saber saw. Sand down the rounded corners of the slotted area. The two control holes must match exactly with the perfboard as the control mounting nuts hold the perfboard to the top panel.

The perfboard is mounted ⅛ inch from the cabinet sides. Draw the cabinet sides on the bottom side of the front panel so the perfboard holes will match those on the top panel. Lay the perfboard on the bottom side of the top panel and center the two holes for the regen and volume controls.

Cut the cabinet sides from a piece of scrap, one-inch, white-pine lumber. If the scrap lumber is already painted, place it on the inside of the cabinet. Run a line of wood glue between the board ends and place two small finishing nails to hold the pieces together. Nail and glue the bottom panel to the cabinet.

The top panel is held to the cabinet with eight metal screws. Round off the corners of the cabinet and panels with a bench sander, if handy. Countersink the finishing nails so that the corners can be rounded off. Finish up with fine sandpaper on the side and corner areas. Spray two coats of metallic-silver automotive paint on the wooden cabinet. Two coats of black auto spray paint is applied to the front panel before it is mounted. Sand between coats with real fine sandpaper or steel wool.



Shafts of both controls go through the perfboard and top panel. All parts of the radio are mounted upon the back side of the top panel, which is fastened to the cabinet with flathead screws.

Connecting Together

Bolt the ground and antenna post in their respective holes on the front panel. Refer to the photos. Next, mount the miniature variable tuning capacitor. Fasten the perfboard to the top panel with the control nuts. The antenna ferrite coil is not glued into position until Grandpa's Antique Radio is operating.

Connect the two wires to capacitor, C3, with the ground wire going to the rotor terminal of the capacitor. Solder the connections of L2 to C3 (as shown in Fig. 1) capacitor. Tie the ground and antenna wires to their respective posts. Connect the 9-volt transistor battery (B1) terminal to the on/off switch (S1, which is a part of the volume control, R5) terminals. Wire up the stereo headphone terminals to J1. Mount U1—be sure that pin 1 of U1 sits at the correct position in the socket. Now double check all wiring. An 8 to 39-ohm low-priced, light-weight, stereo headphone works nicely here.

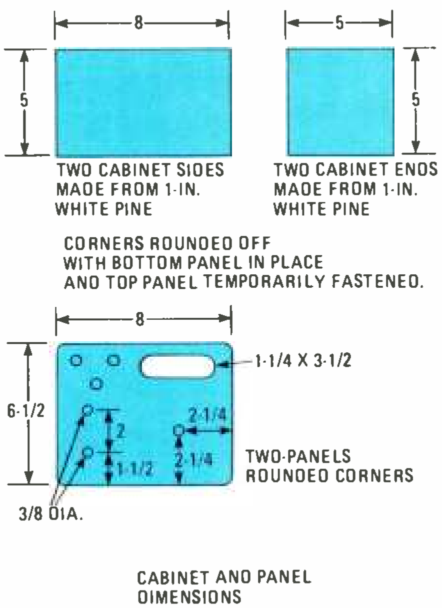


Fig. 3—Here are the cabinet's surface dimensions. Fasten top, and side panels to the cabinet and round off the corners together with a bench or portable sander. Drill out the ends of the slotted tube areas with a ¼-inch circle cutter.

Power Up the Radio

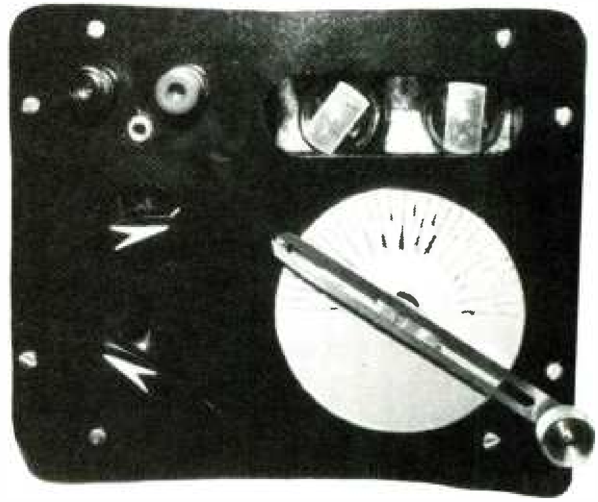
The antenna radio should be tested before the front panel is mounted to the cabinet. Plug in the earphones and battery. Turn the volume control full on. Now, rotate the regenration (C3) control until a squeal is heard. For best results, a 50-ft. outside antenna and a good earth ground should be used. Rotate the variable tuning capacitor and notice several squealing stations on the band. Readjust the regeneration and volume control for normal earphone listening. Fasten the coil in position with rubber silicone cement.

Troubleshooting the Radio

Double check all wiring if the radio does not operate the first time. If a VOM or DMM is handy, take voltage and current measurements. Insert the DC 20-milliampere meter leads in series with one lead of the battery.

If the radio is dead and the meter indicates heavy operating current over 20 milliamperes, suspect a leaky transistor or IC. This little radio pulls only 10.7 mA, with the volume clear down and 13.9 mA with a strong station turned in. No current indicates voltage is not applied to the correct IC or transistor terminals. Take critical voltage measurements on the IC and transistors. Compare your operating-voltage measurements with those found in the schematic diagram (Fig. 1).

Make sure that U1 is inserted into the socket with the polarization dot or slot near pin 1. Re-check the bottom view of each transistor connected with the circuit. If Q2 does not oscillate or make a squealing noise as the regeneration control is advanced, re-tap the coil at the 7th or 8th turn from the ground end of L2. For added volume, try reversing the terminals of L1.



If antique knobs are not available, make some of your own. The round dial assembly was made from a piece of plastic with lines drawn through with a small soldering iron. Two coats of silver metallic spray paint makes it appear like a metal dial.

Old Tube Mounting

To make the antique radio have a vacuum-tube operating

(Continued on page 106)

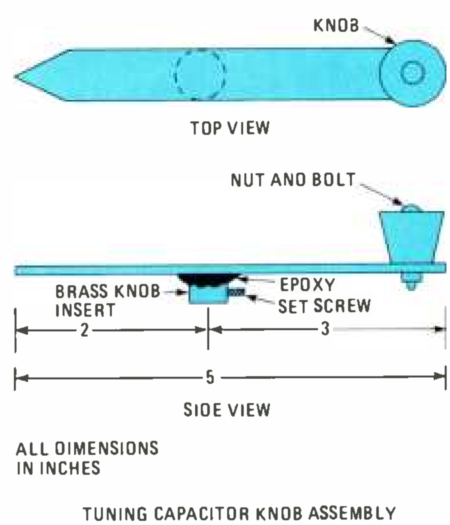


Fig. 4—The metal pointer was constructed from a discarded brass-plated lid support; use a piece of solid brass or copper. Drill a ⅛-inch hole to secure the small radio knob and epoxy the ¼-inch shaft insert to the under side of the dial pointer to attach to the shaft to the tuning capacitor.

TEMPERATURE-CONTROLLED SOLDERING STATION

By Ladislav Hala

Avoid destroying sensitive components during soldering with this soldering-iron temperature controller.

MANY TIMES WHEN YOU SOLDER, YOUR SOLDERING iron is kept switched on for unnecessarily long periods, consuming energy and allowing the soldering iron tip to burn, and develop a buildup of oxide. All because you didn't want to face a cold iron and have to wait for about 3 minutes while the tip heats to the proper temperature.

Buying a lower-wattage iron may solve some of the problems, but new problems arise when you want to solder some heavy-duty component (such as a filter capacitor to a huge bus terminal), setting the stage for creating "cold" connections. If you've ever tried to troubleshoot some instrument in which a cold solder joint was at the root of the problem, you know how difficult such defects are to locate.

Therefore, the only possible way to satisfy all your needs is to buy a temperature controller for your soldering iron. (A problem solver, but also a pocket drainer.) Since the price of commercially available units are rather high for the beginner or even advanced hobbyist, the next best solution is to build this *Temperature-Controlled Soldering Station*.

About the Circuit

Figure 1 shows the schematic diagram of the basic Temperature-Controlled Soldering Station. As mentioned, the unit is more or less pre-made, needing only to be outfitted with an AC plug and outlet, with additional connections to the switch and the neon lamp. That very-basic circuit can be found in any of the commercially available units or in any book dealing with AC control systems.

The operation of the circuit is very simple. Once the Temperature-Controlled Soldering Station is connected to the AC line, capacitor C1 starts to charge through a variable resistor R1. Note that a diac/triac combination—forming what is known as a *quadrac*—contained in a single TO-220 package, can be purchased from electronic parts-supply houses. When the voltage across C1 reaches the breakover voltage of the diac (around 30 to 40 volts), the diac conducts, dumping C1's charge across the gate of the triac, triggering it into conduction. The time constant for charging the capacitor is determined by the capacitor and R1 (a 200,000-ohm potentiometer, which is used as a rheostat).

Once the triac is turned on, it continues to conduct until the AC current applied to its two main terminals (MT1 and MT2) falls below the triac's minimum holding current. When the polarity of the AC input reverses, the cycle starts again, but with reversed polarity across C1. It must be noted that the triac does not conduct until the amplitude of the gate voltage reaches the breakover point, even when R1 is at minimum resistance.

The triac does not conduct unless the RC time constant is lower than the time required to change the amplitude of the mains below the breakover voltage of the diac. Thus we cannot obtain 100% (perhaps 2–98%) regulation. Note that the triac is either off or on, but not in an intermediate state, and therefore dissipates very little power. One drawback of the circuit is that a certain amount of RF interference is generated due to the fast switching of the triac.

Although power loss is negligible in either end position of R1, it is maximum in the middle position. In that position the difference of the voltage being switched is maximum, which leads to maximum power dissipation across the triac and increased generation of RF interference. The circuit can be simplified by using only a triac, diac, C1, and R1. Capacitor C2 and the inductor (L1) decrease the RF interference caused by the switching action of the triac.

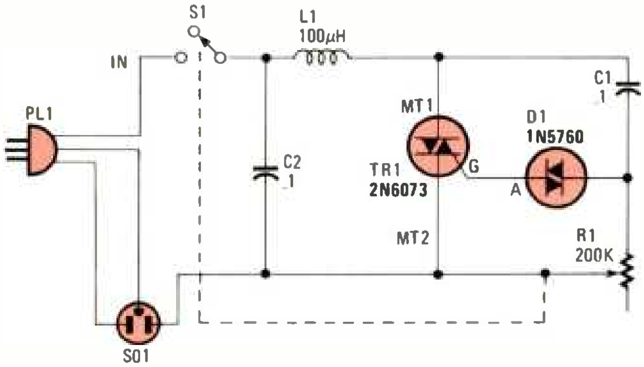


Fig. 1—When the Temperature-Controlled Soldering Station is turned on, capacitor C1 starts to charge through resistor R1. When the voltage across C1 reaches the breakover voltage of the diac (around 30 to 40 volts), the diac conducts, dumping C1's charge across the gate of the triac, triggering it into conduction. Note that although a separate triac and diac are shown, the author used a quadrac (a combination of the two contained in a single TO-220 package) in the prototype.

One Step Beyond

The basic circuit of Fig. 1 can be upgraded (as shown in Fig. 2) by the addition of a 3-position (center-off) switch and neon lamp (with self-contained resistor). Those few components make the circuit more flexible and useful. In order to get some light indication in the lower scale of the regulation, a neon lamp, NE1 (an NE2H from Radio-Shack), which has higher power capacity, has been used. The addition of the switch proved to be very useful, since the operation of the station became much easier.

Once you find a proper place for the temperature maintenance of the iron, you can switch S2 to the *thru* position without moving the setting of R1. Then when you don't need the iron for a few minutes, you may switch S2 to the *in* position. Depending on your needs and the position of R1, you can switch S2 to the *thru* position or leave it in the *in* position. For those that would like to *roll their own*, instead of buying it ready-made, the values of the components are given in the Parts List.

Generally, the triac has to have about twice the current-handling capability of the highest wattage iron that will be connected to the project. Note that there are two kinds of triac's: two mode and four mode. The four-mode device can have its main terminals in any order with respect to the gate, while two-mode units won't operate with their main terminals reversed. Be sure to check the data sheet before soldering into position.

Usually, triacs have their gates referenced to the main terminal 1 (MT1) and all conduct when the voltage between MT1 and the gate reaches about 0.9 to 1.4-volts (positive or negative) depending on whether the triac operates in quadrant I or quadrant III respectively. Four-mode triacs also operate in two additional quadrants: quadrant II and quadrant IV (see Fig. 3). It's important to know the lead configuration, so check the data sheet. If no data sheet is available, the gate can be distinguished from the main terminals with the aid of an ohmmeter.

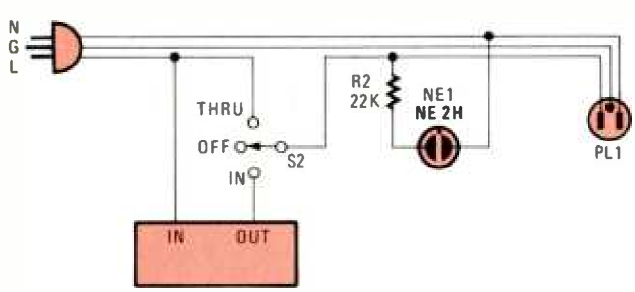


Fig. 2—The basic circuit of Fig. 1 can be upgraded, as shown here by the addition of a 3-position (center-off) switch and neon lamp (with a self-contained bias resistor).

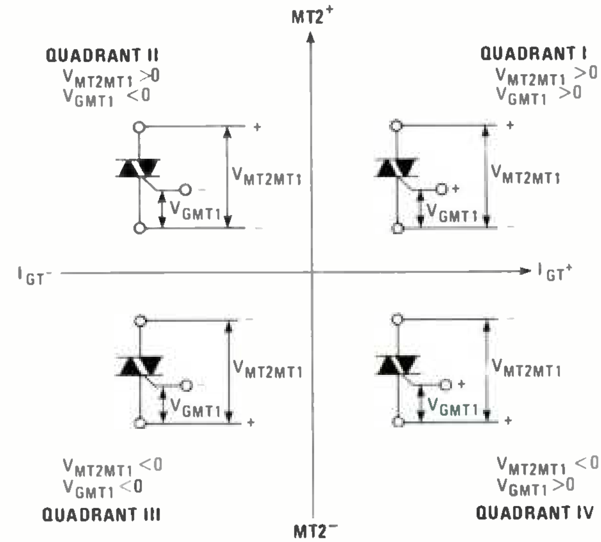
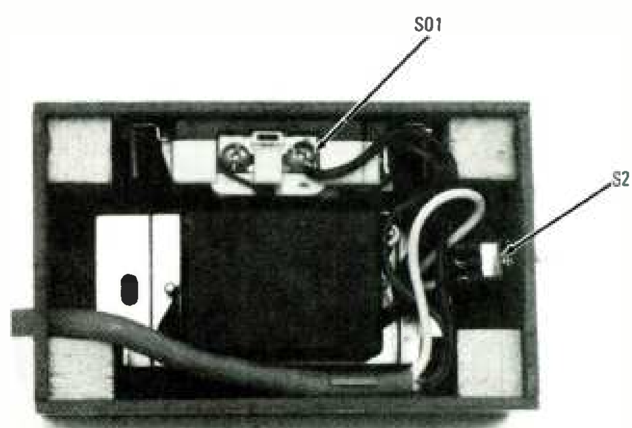


Fig. 3—Usually, triacs have their gates referenced to the main terminal (MT1) and all conduct when the voltage between MT1 and the gate reaches about 0.9 to 1.4-volts (positive or negative) depending on whether the triac operates in quadrant I or quadrant III respectively. Four-mode triacs also operate in two additional quadrants: quadrant II and quadrant IV.

Switch the ohmmeter (VOM or DMM) to the lowest resistance range to promote sufficient current flow (which must be greater than the holding current) through the device-under-test. Measure the resistance between all leads of the triac. If the resistance between any two leads is low (regardless of polarity), you located the gate and MT1, making the final lead (assuming a good unit) MT2. Check the resistance between the first two leads (the gate and MT1) the lead MT2. The resistance between MT2 and either MT1 or the gate should be at or near infinity (without respect to polarity).

Now with one test lead connected to MT2, connect the other test lead to one of the leads (which we now know have to be MT1 and the gate) and touch MT2 to the last lead. If the meter reading drops to some value substantially lower value than that obtained during your preliminary measurements, the lead shorted to MT2 is the gate. If not, with MT2 still



The prototype was built in an old light-dimmer case, but could easily have been built on perf- or printed-circuit board.

connected, switch the connection of the other two leads, and again short MT2 to the remaining lead. Now, while holding the test-lead in contact with MT2, release the test-lead from the gate.

If the resistance does not stay low in any one of the test situations, you probably don't have sufficient current flowing through the device to keep it turned on. This may be true for high current devices. In that case, try to use another VOM that provides a higher current for resistance measurements. Also, it helps to have a fresh battery installed in the VOM.

Change the polarity of the test-leads and repeat the whole procedure in order to assure yourself that you are dealing with the Triac and not with an SCR, which behaves just like the Triac, except that only when its cathode and anode are connected to negative and positive terminals (respectively) with its gate being triggered with positive voltage only (referenced to the cathode).

Construction and Applications

Putting the Temperature-Controlled Soldering Station together is quite simple and rather straightforward. The author's prototype unit was built inside of a discarded light-dimmer housing. However, the circuit might just as easily be built on perfboard or, if so desired on printed-circuit board—the choice is up to you. If perfboard is used, mount all components to the board. Then using insulated wire, connect the components as shown in Fig. 1. Figure 4 is a block diagram illustrating the finished *basic* circuit (with the box representing the circuit board).

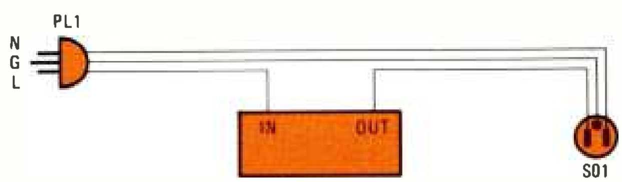


Fig. 4—This block diagram illustrates the finished *basic* circuit (with the box representing the circuit board). If your circuit is to include the neon-lamp indicator and switch S2, connect those components to the circuit, guided by Fig. 2.

If your circuit is to include the neon-lamp indicator and switch S2, connect those components to the circuit, guided by Fig. 2. For safety reasons, it should be remembered that the "hot" side of the line cord must be connected to the unit through switch S1. A 3-prong line cord must be used, with the third wire connecting the ground of the outlet with the ground of SO1 (to which the soldering iron is connected).

It is advisable to use a plastic or some other non-metallic box to house the project; thereby, arresting any possible shock hazard. If you use a metal box, be sure that the box is correctly grounded (via the line cord ground lead) and that the AC outlet is properly grounded as well. Otherwise, you'll be exposing yourself to almost certain shock hazard. Since the circuit described here does not use any isolation transformer, all components must be assumed to be "hot," conducting 117-volts AC. Therefore, it's advisable not to operate the unit without its case.

If it is necessary the operate the circuit outside of its enclosure, be sure to stick to the *one-hand* rule (which those of you with an military background in electronics are surely familiar with). The one-hand rule says that the unit should be operated with only one hand, while the other must be away from the vicinity of the circuit e.g., in the pocket. As an

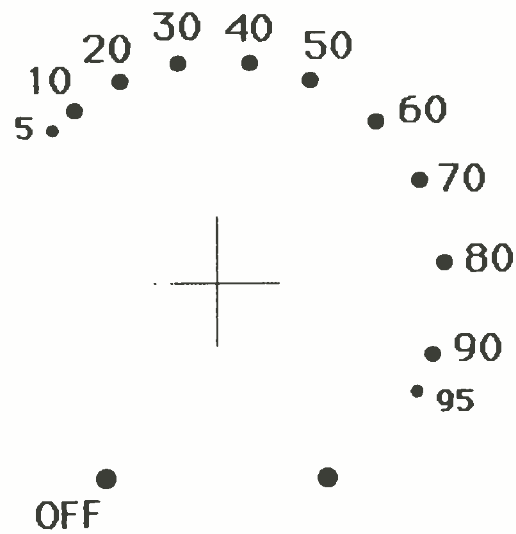


Fig. 5—To make the project easy to use, the controls should be labeled, as the author's, with a calibrated scale (like this one). Note this scale may be lifted from the page and used to adorn the project housing or you can concoct your own.

added precaution, remove all jewelry while operating the circuit.

Once the unit is assembled, the testing procedure is easy. First test for any short circuits with an ohmmeter connected between line and neutral cables of the line cord. The ohmmeter should show infinite resistance in either position of S2. Then switch S1 to the *off* position, and connect the unit to the AC outlet. Switch S2 to the *thru* position, and NE1 should light.

Calibrating the unit is a straightforward task. Simply connect a load to the output and measure the voltage in the *thru* (100% V) position. Then flip S2 to the *in* position and calibrate the R1 setting according to the voltage readings

PARTS LIST FOR THE TEMPERATURE-CONTROLLED SOLDERING STATION

C1, C2—0.1-µF, 400-WVDC, ceramic capacitor
D1—1N5760, 1N5761, or similar bilateral trigger (Diac)
L1—100-µH, 2-A RF choke (Radio Shack 273-102 or similar)
NE1—NE2H, or similar neon lamp (RS 272-1102, see text)
R1—200,000-ohm linear potentiometer
R2—22,000-ohm, ¼-watt, 5% resistor (see text)
S1—Single-pole, single-throw (SPST) switch
S2—Single-pole, 3-position, center-off switch (see text)
TR1—2N6073 4-A, 400-PIV (four mode) or 2N6343 12-A, 400-PIV (two mode) Triac
Three-conductor AC line cord with molded plug, AC socket, enclosure (non-metallic), wire solder, hardware, etc.

across the output terminals.

There are many more applications for this project than the one for which it is intended. The circuit can find use in any part of your household. It can be used to control any instrument or tool that is AC powered; regulate incandescent lights in your living room, greenhouse, or photo-processing room. (Note that the circuit cannot be used to control fluorescent lights.) In fact, there are so many applications that you are limited only by your own imagination. ■

ACNAP:

A program to analyze AC networks

By James E. Tarchinski

Now you can get a computer to do the number crunching for your circuit designs!

THE WORLD'S FIRST ELECTRONIC DIGITAL COMPUTER, THE ENIAC, was first demonstrated at the University of Pennsylvania in 1946. It is easy to imagine a witness of that historic event having thoughts similar to those of a mayor of the late 1800's, predicting the future of the telephone —"I can see the time when every city will have one." Back in 1946, it would have been hard to predict that in 1986, only forty short years later, over fifteen percent of all American homes would have personal computers.

With the increase in the number of computers, there has come a corresponding increase in the number of applications for those versatile devices. Because they are nothing more than complex electronic circuits, it should come as no surprise that one of the major application areas for computers is the design and analysis of electronic circuits.

There are numerous computer programs on the market to analyze circuits, and they all tend to have one factor in common: they cost a lot of money. Even small personal computer (PC) based analysis programs carry price tags anywhere from $1000–$10,000. If you would like to have such a program for your home computer, but you don't really want to mortgage your house to do it, you have an inexpensive option: ACNAP.

ACNAP is an acronym for the AC Network Analysis Program, a BASIC computer program to solve for the node voltages in AC (alternating current) networks. The listing for the program is given in Listing 1 on page xx.

Although the listing is for machines that utilize the Microsoft version of the BASIC language, the program is easily modifiable for just about any PC with at least 32K of random-access memory (RAM). To help you with those modifications, a special section of this article has been dedicated to just that issue.

At this point many of you are doubtlessly thinking about not reading the rest of this article. You'd rather just start entering the program in order to speed things up. Let me give you a word of advice: **Don't!**

The time you spend now, learning how the program is structured and how it is intended to be used, will help you ten-fold later on, when you try to find your "typos." That is especially true if your computer doesn't use Microsoft BASIC, and you must make slight modifications to Listing 1 on page xx.

Another reason to refrain from skipping ahead is that ACNAP, like any other program, has some limitations which should be understood, and some conventions that must be observed. By understanding what those are and why they exist, you will be better able to use the software, and more confident in its solutions.

With all that in mind, let's turn our attention to a brief examination of the program's structure.

Program Structure

ACNAP's structure is shown graphically in the generalized flow chart of Fig. 1. The numbers in square brackets on that chart reference the line numbers of the program listing associated with that block.

After the program is initialized on lines 1000 through 1060, two screens of text are displayed. The first is a general overview of the program and the second is a summary of the major conventions and limitations of the program. Those will be discussed in detail in the section on using ACNAP.

In lines 1600-1760, two network parameters are entered, the number of nodes in the circuit (not counting the ground node) and the frequency of operation of the circuit.

The number of nodes may range from 1 to 25. Single-node circuits can be solved by ACNAP very quickly, but circuits with many nodes may take several minutes to solve.

The frequency may be entered in either Hertz (Hz) or radians per second (Rad/sec). Keep in mind that ACNAP requires all power-supply devices to have the same frequency of operation, and it will give incorrect results if that rule is not observed. One way around that limitation would be to use the principle of superposition. The use of that principle, however, is beyond the scope of this article (cop-out #214).

You can use ACNAP to solve DC circuits by setting the frequency of operation to zero hertz (or zero radians per second). If you do that, however, make certain the network you enter doesn't contain any inductors, or the program will generate a "division by zero" error in line 2340.

The next seven sections of the program load the network description into the computer, one element at a time. Components are entered in the following order: resistors, conductors, capacitors, inductors, independent current sources (ICS), voltage-controlled current sources (VCCS), and finally, independent voltage sources (IVS).

Each of those seven sections have the same basic design. They begin by asking for the number of components of a particular type. The number of resistors, for example, is input on line 1790. If the number of components (the variable NC in the program) is less than one, the program skips ahead to consider the next type of component. If NC is not less than one, the program uses a FOR-NEXT loop to enter the components one at a time and to load them into the A matrix. More information on A-matrix is given in the "Technical Notes" section of this article.

Two subroutines are used to enter the component data. Input Subroutine #1 begins on line 3240 and is used to enter

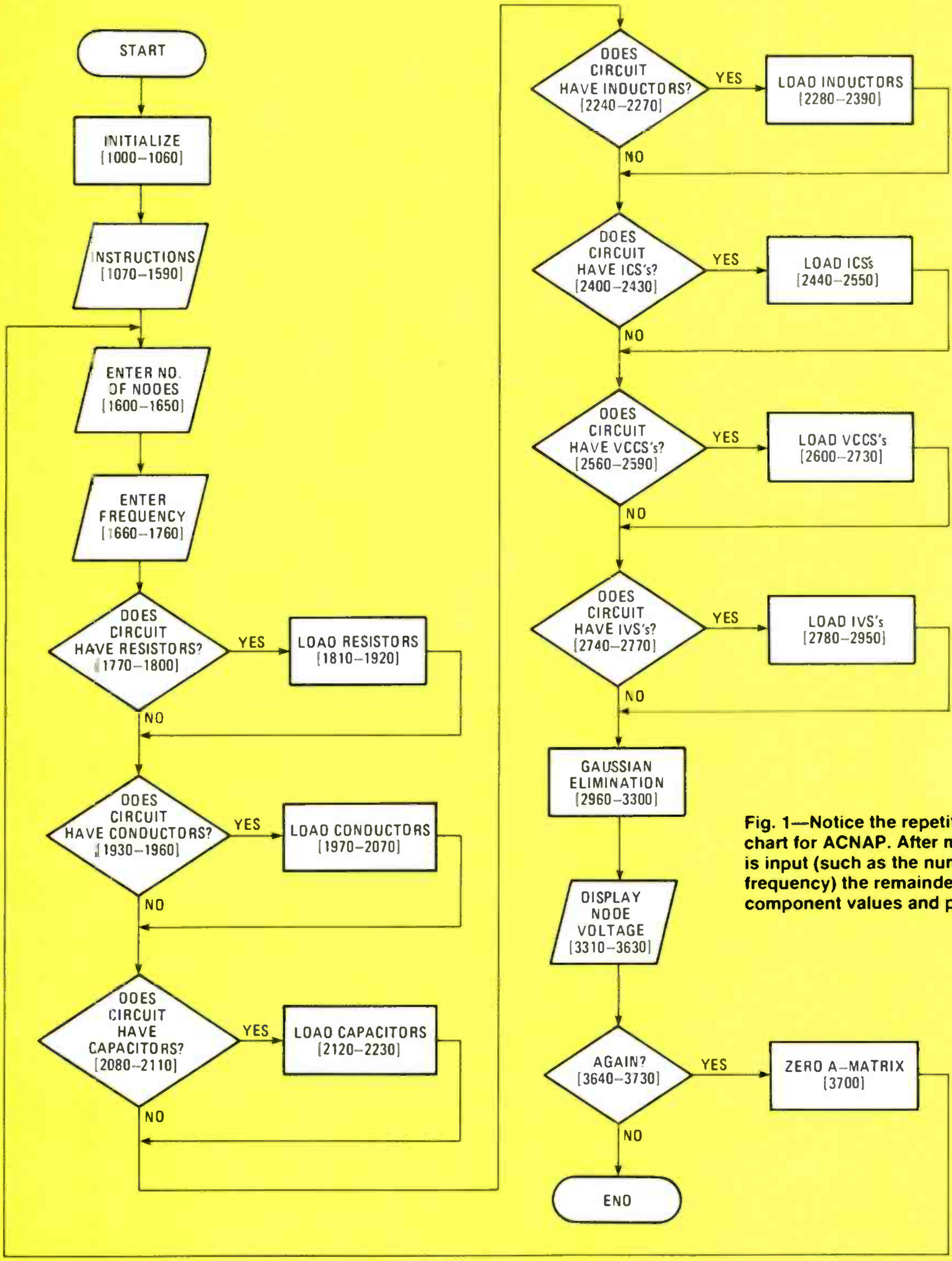


Fig. 1—Notice the repetitive nature of this flow-chart for ACNAP. After main data for the circuit is input (such as the number of nodes and the frequency) the remainder of the program accepts component values and performs algebra.

the value and the node connections of resistors, conductors, capacitors, and inductors. Beginning on line 3870, Input Subroutine #2 is used for the power supply devices, returning the node connections as well as the real and imaginary components (VR and VI, respectively) of the energy that those devices deliver to the circuit.

The "brains" of the entire program is the Gaussian elimination routine for complex numbers, found on lines 2960-3300. That is the section that solves ACNAP's simultaneous equations to obtain the node voltages of the circuit. Note that if the circuit you enter is not valid, or if the numbers in the program become too small for ACNAP to handle, the error message of line 3110 is displayed.

ACNAP's solution for a network—the node voltages in both rectangular and polar form—are displayed in the next section of the program. Line 3340 makes certain that only one screen of information is displayed at a time, keeping the solutions from rolling off the screen before you can write them down.

Finally, the last section of code asks if you would like to analyze another circuit. Answering with a "yes" will zero the necessary variables and then return you to line 1600. A "no" response will end the program on line 3700.

A listing of the variables used in ACNAP is given in

LISTING 1—ACNAP

```
1000 'AC NETWORK ANALYSIS PROGRAM  (ACNAP)
1010 '
1020 CLEAR : DIM A(25,26,1)
1030 SCREEN 0,0,0,0 : COLOR 10,0,0 : WIDTH 80 : CLS
1040 DEF FNMAG(I,J)=SQR( A(I,J,0)^2 + A(I,J,1)^2 )
1050 PI=3.141592654#   'value of PI
1060 '
1070 PRINT "*****************************************************************"
1080 PRINT "*                                                               *"
1090 PRINT "*              ACNAP - A.C. Network Analysis Program            *"
1100 PRINT "*                                                               *"
1110 PRINT "*                 (c) 1987 by James E. Tarchinski               *"
1120 PRINT "*                                                               *"
1130 PRINT "*****************************************************************"
1140 COLOR 11
1150 PRINT
1160 PRINT "  This program uses Nodal Analysis to determine the node voltages"
1170 PRINT "of linear A.C. networks.  These networks may range in size from"
1180 PRINT "1 to 25 nodes, not counting the ground, or datum, node."
1190 PRINT
1200 PRINT "  Seven types of devices are incorporated in this program:"
1210 PRINT "     1. Resistors"
1220 PRINT "     2. Conductors"
1230 PRINT "     3. Capacitors"
1240 PRINT "     4. Inductors"
1250 PRINT "     5. Independent current sources (ICS)"
1260 PRINT "     6. Voltage-controlled current sources (VCCS)"
1270 PRINT "     7. Independent voltage sources (IVS)"
1280 PRINT "
1290 LOCATE 23,1 : COLOR 7 : PRINT "Press any key ...";
1300 '
1310 IN$=INKEY$:IF IN$<>"" THEN GOTO 1310
1320 IN$=INKEY$:IF IN$= "" THEN GOTO 1320
1330 CLS : COLOR 10
1340 PRINT "For all circuits, these conventions must be followed:"
1350 COLOR 11
1360 PRINT
1370 PRINT "1. All nodes of the circuit must be labeled with consecutive"
1380 PRINT "   integers   (1, 2, 3, etc.)."
1390 PRINT
1400 PRINT "2. The ground node must be Node 0."
1410 PRINT
1420 PRINT "3. The ground node is not counted when determining the number"
1430 PRINT "   of nodes in a circuit."
1440 PRINT
1450 PRINT "4. For power supply elements (current source, voltage source, etc.)"
1460 PRINT "   a sine wave reference and polar coordinates must be used.  That"
1470 PRINT "   is, they must be in the form:  "
1480 PRINT
1490 COLOR 15
1500 PRINT "             12.56 SIN ( wt + 26.78° )"
1510 COLOR 11
1520 PRINT
1530 PRINT "5. No two voltage sources (IVS) may be connected to the same node,"
1540 PRINT "   not counting the ground node (Node 0)."
1550 PRINT
1560 LOCATE 23,1 : COLOR 7 : PRINT "Press any key ..."; : COLOR 10
1570 '
1580 IN$=INKEY$:IF IN$<>"" THEN GOTO 1580
1590 IN$=INKEY$:IF IN$= "" THEN GOTO 1590
1600 CLS
1610 PRINT "Enter the number of nodes in the circuit,"
1620 INPUT "not counting the ground node (1-25): ",N
1630 IF N > 25 OR N < 1 THEN  PRINT "PLEASE ENTER A VALID NUMBER!": GOTO 1610
1640 N1 = N + 1
1650 '
1660 PRINT
1670 PRINT "Do you want to enter the frequency in"
1680 PRINT "  1. Hertz,  or "
1690 PRINT "  2. Radians/second"
1700 INPUT "Your choice: ",A
1710 IF A < 1 OR A > 2 THEN BEEP : GOTO 1660
1720 PRINT
1730 IF A = 1 THEN INPUT "Frequency (Hertz):    ",F : W=2*PI*F
1740 IF A = 2 THEN INPUT "Frequency (RAD/SEC): ",W
1750 '
1760 '
1770 '********************* RESISTOR SECTION ******************************
1780 '
1790 CLS : INPUT "Enter number of resistors: ",NC
1800 IF NC < 1 THEN GOTO 1950
1810 P0$ = "RESISTOR"
1820 P1$ = "INITIAL NODE:  "
1830 P2$ = "FINAL NODE:    "
1840 P3$ = "VALUE (Ohms):  "
1850 FOR I = 1 TO NC
1860   GOSUB 3740
1870   VL = 1 / VL
1880      A(IN,IN,0) = A(IN,IN,0) + VL : A(IN,EN,0) = A(IN,EN,0) - VL
1890      A(EN,EN,0) = A(EN,EN,0) + VL : A(EN,IN,0) = A(EN,IN,0) - VL
1900 NEXT I
1910 '
1920 '
1930 '********************* CONDUCTOR SECTION *****************************
1940 '
1950 CLS : INPUT "Enter number of conductors: ",NC
1960 IF NC < 1 THEN GOTO 2080
1970 P0$ = "CONDUCTOR"
1980 P1$ = "INITIAL NODE:  "
1990 P2$ = "FINAL NODE:    "
2000 P3$ = "VALUE (Mhos):  "
2010 FOR I = 1 TO NC
2020   GOSUB 3740
2030      A(IN,IN,0) = A(IN,IN,0) + VL : A(IN,EN,0) = A(IN,EN,0) - VL
2040      A(EN,EN,0) = A(EN,EN,0) + VL : A(EN,IN,0) = A(EN,IN,0) - VL
2050 NEXT I
2060 '
2070 '
2080 '********************* CAPACITOR SECTION *****************************
2090 '
2100 CLS : INPUT "Enter number of capacitors: ",NC
2110 IF NC < 1 THEN GOTO 2240
2120 P0$ = "CAPACITOR"
2130 P1$ = "INITIAL NODE:  "
2140 P2$ = "FINAL NODE:    "
2150 P3$ = "VALUE  (F):    "
2160 FOR I = 1 TO NC
2170   GOSUB 3740
2180    VL = W * VL
2190      A(IN,IN,1) = A(IN,IN,1) + VL : A(IN,EN,1) = A(IN,EN,1) - VL
2200      A(EN,EN,1) = A(EN,EN,1) + VL : A(EN,IN,1) = A(EN,IN,1) - VL
2210 NEXT I
2220 '
2230 '
2240 '********************* INDUCTOR SECTION ******************************
2250 '
2260 CLS : INPUT "Enter number of inductors: ",NC
2270 IF NC < 1 THEN GOTO 2400
2280 P0$ = "INDUCTOR"
2290 P1$ = "INITIAL NODE:  "
2300 P2$ = "FINAL NODE:    "
2310 P3$ = "VALUE (H):     "
2320 FOR I = 1 TO NC
2330    GOSUB 3740
```

```
2340    VL = -1 / ( W * VL )
2350      A(IN,IN,1) = A(IN,IN,1) + VL : A(IN,EN,1) = A(IN,EN,1) - VL
2360      A(EN,EN,1) = A(EN,EN,1) + VL : A(EN,IN,1) = A(EN,IN,1) - VL
2370 NEXT I
2380 '
2390 '
2400 '************* INDEPENDENT CURRENT SOURCE SECTION *********************
2410 '
2420 CLS : INPUT "Enter number of ICSs: ",NC
2430 IF NC < 1 THEN GOTO 2560
2440 P0S = "ICS"
2450 P1S = "INITIAL NODE  (The tail):  "
2460 P2S = "FINAL NODE  (The point):   "
2470 P3S = "MAGNITUDE (Amps):          "
2480 P4S = "PHASE ANGLE (Degrees):     "
2490 FOR I = 1 TO NC
2500    GOSUB 3870
2510      A(IN,N1,0) = A(IN,N1,0) - VR : A(IN,N1,1) = A(IN,N1,1) - VI
2520      A(EN,N1,0) = A(EN,N1,0) + VR : A(EN,N1,1) = A(EN,N1,1) + VI
2530 NEXT I
2540 '
2550 '
2560 '************* VOLTAGE CONTROLLED CURRENT SOURCE SECTION *************
2570 '
2580 CLS : INPUT "Enter number of VCCSs: ",NC
2590 IF NC < 1 THEN GOTO 2740
2600 P0S = "VCCS"
2610 P1S = "INITIAL NODE  (The tail):  "
2620 P2S = "FINAL NODE  (The point):   "
2630 P3S = "MAGNITUDE (Amps/volt):     "
2640 FOR I = 1 TO NC
2650    GOSUB 3740
2660    PRINT
2670    INPUT "CONTROLLING NODE (Positive): ",CP: IF CP > N OR CP < 0 THEN BEEP:
 GOTO 2660
2680    INPUT "CONTROLLING NODE (Negative): ",CN: IF CN > N OR CN < 0 OR CN = CP
 THEN BEEP: GOTO 2680
2690       A(IN,CP,0) = A(IN,CP,0) + VL : A(IN,CN,0) = A(IN,CN,0) - VL
2700       A(EN,CP,0) = A(EN,CP,0) - VL : A(EN,CN,0) = A(EN,CN,0) + VL
2710 NEXT I
2720 '
2730 '
2740 '************* INDEPENDENT VOLTAGE SOURCE SECTION *********************
2750 '
2760 CLS : INPUT "Enter number of IVSs: ",NC
2770 IF NC < 1 THEN GOTO 2960
2780 P0S = "IVS"
2790 P1S = "NEGATIVE NODE:           "
2800 P2S = "POSITIVE NODE:           "
2810 P3S = "MAGNITUDE (Volts):       "
2820 P4S = "PHASE ANGLE (Degrees): "
2830 FOR I = 1 TO NC
2840    GOSUB 3870
2850    IF IN > EN THEN VR=-VR : VI=-VI : T0=IN : IN=EN : EN=T0
2860      FOR J = 1 TO N1
2870        A(IN,J,0) = A(IN,J,0) + A(EN,J,0)
2880        A(IN,J,1) = A(IN,J,1) + A(EN,J,1)
2890        A(EN,J,0) = 0 : A(EN,J,1) = 0
2900      NEXT J
2910      A(EN,EN,0) = 1 : A(EN,IN,0) = -1 : A(EN,N1,0) = VR
2920      A(EN,EN,1) = 0 : A(EN,IN,1) =  0 : A(EN,N1,1) = VI
2930 NEXT I
2940  '
2950  '
2960  '*************** GAUSSIAN ELIMINATION SECTION *************************
2970 CLS
2980 PRINT "CALCULATING, PLEASE WAIT..."
2990 FOR I = 1 TO N
3000    HF = I
3010    B =  FNMAG(I,I)
3020    FOR K = I + 1 TO N
3030     T = FNMAG(K,I): IF T > B THEN B =  T : HF = K
3040    NEXT K
3050    IF I = HF THEN GOTO 3110
3060       FOR K = 1 TO N1
3070         T0 = A(I,K,0): T1 = A(I,K,1)
3080         A(I,K,0) = A(HF,K,0) : A(I,K,1) = A(HF,K,1)
3090         A(HF,K,0) = T0 : A(HF,K,1) = T1
3100       NEXT K
3110    IF B < 9.999999E-21 THEN CLS : PRINT "ERROR! - The circuit entered is no
t valid.": GOTO 3590
3120 '
3130    T0 = A(I,I,0) : T1 = A(I,I,1)
3140    FOR K = I TO N1
3150        T2 = A(I,K,0)
3160        A(I,K,0)=( T2*T0 + A(I,K,1)*T1 )/ ( T0^2 + T1^2 )
3170        A(I,K,1)=( A(I,K,1)*T0 - T2*T1 )/ ( T0^2 + T1^2 )
3180    NEXT K
3190 '
3200    FOR K = 1 TO N
3210     IF K = I THEN 3280
3220     T0 =  - A(K,I,0) : T1 = -A(K,I,1)
3230     A(K,I,0) = 0 : A(K,I,1) = 0
3240       FOR L = I + 1 TO N1
3250         A(K,L,0) = A(K,L,0) + ( A(I,L,0)*T0 - A(I,L,1)*T1 )
3260         A(K,L,1) = A(K,L,1) + ( A(I,L,0)*T1 + A(I,L,1)*T0 )
3270       NEXT L
3280    NEXT K
3290 NEXT I
3300 '
3310 CLS
3320 PRINT "THE NODE VOLTAGES ARE:": PRINT
3330 FOR I = 1 TO N
3340     IF I=7 OR I=14 OR I=21 THEN INS="":LOCATE 23,1:PRINT "Press any key ...
";:WHILE INS="":INS=INKEYS:WEND:CLS
3350    'first, calculate rectangular coordinates  * * * * * * * * *
3360     P0S=" + j "
3370     IF A(I,N1,1) < 0 THEN P0S = " - j "
3380     P1S = STRS(A(I,N1,0))          ' real part
3390     P2S = STRS(A(I,N1,1))          ' imaginary part
3400     P2S = RIGHTS(P2S,LEN(P2S)-1)   ' imaginary part (less the sign)
3410     PRINT "V(";I;") = ";P1S;P0S;P2S;"  volts"
3420    '
3430    'now calculate polar coordinates * * * * * * * * * * * * * *
3440     MAG = FNMAG(I,N1)
3450     IF A(I,N1,1) = 0 AND A(I,N1,0) >=0 THEN ANG = 0   : GOTO 3510
3460     IF A(I,N1,0) = 0 AND A(I,N1,1) > 0 THEN ANG = 90  : GOTO 3510
3470     IF A(I,N1,1) = 0 AND A(I,N1,0) < 0 THEN ANG = 180: GOTO 3510
3480     IF A(I,N1,0) = 0 AND A(I,N1,1) < 0 THEN ANG = 270: GOTO 3510
3490     ANG = ATN(A(I,N1,1) / A(I,N1,0)) * 180 / PI
3500     IF A(I,N1,0) < 0 THEN ANG = ANG + 180
3510     P0S="t + "
3520     IF ANG < 0 THEN P0S = "t - "
3530     P1S = STRS(ANG)
3540     P1S = RIGHTS(P1S,LEN(P1S)-1)
3550     PRINT "        = ";MAG;" SIN (";W;P0S;P1S;"° )"
3560     PRINT
3570 NEXT I
3580 '
3590 LOCATE 23,1
3600 PRINT "Press any key to continue...";
3610 INS = INKEYS : IF INS <> "" THEN GOTO 3610
3620 INS = INKEYS : IF INS =  "" THEN GOTO 3620
3630 '
3640 CLS : PRINT "Would you like to analyize another circuit?"
3650 PRINT "  1. Yes,  or"
3660 PRINT "  2. No"
3670 INPUT "Your choice: ",A
3680 IF A =  2 THEN END                    'exit program
```

(Continued on next page)

LISTING 1—ACNAP (cont.)

```
3690 IF A <> 1 THEN BEEP: GOTO 3640      'inproper entry
3700 FOR I=1 TO N : FOR J=1 TO N1 : A(I,J,0)=0 : A(I,J,1)=0 : NEXT : NEXT
3710 GOTO 1600
3720  '
3730  '
3740  '****************** INPUT SUBROUTINE # 1 ****************************
3750 PRINT : PRINT
3760 PRINT "========== ";POS;" #";I;" =========="
3770 PRINT
3780 PRINT P1S;
3790 INPUT "",IN   : IF IN > N OR IN < 0 THEN BEEP : GOTO 3780
3800 PRINT P2S;
3810 INPUT "",EN   : IF EN > N OR EN < 0 OR IN = EN THEN BEEP : GOTO 3800
3820 PRINT P3S;
3830 INPUT "",VL: IF VL <= 0 THEN BEEP : GOTO 3820
3840 RETURN
3850  '
3860  '
3870  '****************** INPUT SUBROUTINE # 2 **************************
3880 PRINT : PRINT
3890 PRINT "========== ";POS;" #";I;" =========="
3900 PRINT
3910 PRINT P1S;
3920 INPUT "",IN   : IF IN > N OR IN < 0 THEN  BEEP : GOTO 3910
3930 PRINT P2S;
3940 INPUT "",EN   : IF EN > N OR EN < 0 OR IN = EN THEN BEEP : GOTO 3930
3950 PRINT P3S;
3960 INPUT "",MAG : IF MAG <= 0 THEN BEEP : GOTO 3950
3970 PRINT P4S;
3980 INPUT "",ANG : IF ANG < -360 OR ANG > 360 THEN BEEP: GOTO 3970
3990 '
4000 VR = MAG * COS( ANG * PI / 180 )  'calculate the real component
4010 VI = MAG * SIN( ANG * PI / 180 )  'calculate the imaginary component
4020 RETURN
```

Table 1. Those variables should be compatible with non-MICROSOFT versions of BASIC. (Apple BASIC, for example, only uses the first two terms in variable names).

Using ACNAP

When you run ACNAP, the first thing you should see is the introduction screen:

```
*********************************************
*********************************************
*                                           *
*   ACNAP - AC Network Analysis Program     *
*                                           *
*      (c) 1987 by James E. Tarchinski      *
*                                           *
*********************************************
*********************************************
```

This program uses Nodal Analysis to determine the node voltages of linear AC networks. These networks may range in size from 1 to 25 nodes, not counting the ground, or datum, node.

Seven types of devices are incorporated in this program:

1. Resistors
2. Conductors
3. Capacitors
4. Inductors
5. Independent current sources (ICS)
6. Voltage-controlled current sources (VCCS)
7. Independent voltage sources (IVS)

Press any key ...

As you can see that screen lists the seven types of components that ACNAP can handle, listed in the same order that they will be requested by the program. Pressing any key will bring up the next screen, an instruction page.

Five rules must be followed to use the program correctly—they are listed on the instruction screen as shown below.

For all circuits, these conventions must be followed:

1. All nodes of the circuit must be labeled with consecutive integers (1, 2, 3, etc.).
2. The ground node must be Node 0.
3. The ground node is not counted when determining the number of nodes in a circuit.
4. For power supply elements (current source, voltage source, etc.) a sinewave reference and polar coordinates must be used. That is, they must be in the form:
   12.56 SIN (wt + 26.78°)
5. No two voltage sources (IVS) may be connected to the same node, not counting the ground node (Node 0).

Press any key ...

The first two rules state that each circuit node must be given an integer reference number and that the ground node must be node 0. You don't need to number the nodes in any particular order, but you must make certain that no integer is skipped. If a number is skipped (for example, if there is a node 5 and a node 7, but no node 6) then the error message of line 3110 will be displayed.

The next rule states that the ground node (node 0) is not counted when determining the number of nodes in a circuit. Again, if that rule is not followed, the error message of line 3110 will appear.

One of the most important rules is Rule 4, which states that power supply elements must be entered in polar coordinates with a sinewave reference. If the circuit you wish to analyze has active components based on a cosinewave, you must convert it to a sinewave by adding 90 degrees to its phase angle. For an angle of 0 degrees, the following can be written:

$$\text{COS}(0) = \text{SIN}(0° + 90°)$$

Another important point should be brought out based on the equation for the sinewave given in Rule 4. Note that the "wt" term has units of radians (resulting from radians per seconds being multiplied by seconds) while the constant term is given in degrees. Although that may seem a bit unusual, such equations are generally written in that format. Because it is so common, ACNAP displays the node voltages in polar coordinates using that convention.

"That bring us to the last rule, Rule 5. It may sound very restrictive, but don't worry, it doesn't have to be followed—at least, not totally. Let me explain.

If Rule 5 is followed, ACNAP will correctly handle independent voltage sources. ACNAP, however, will still give correct answers if Rule 5 is broken, just as long as it is broken in the correct way.

Suppose you have a circuit with three IVS all in a row, as shown in Fig. 2. When numbering the four nodes related to the three IVS, make certain that they are numbered in sequential order. For example, 1, 2, 3, 4, as shown, would be a correct labeling, but 1, 3, 2, 4, would not be correct.

The other thing you must do is to enter the independent voltage sources into ACNAP in reverse order: the IVS connected to the highest node number must be entered first, the IVS with the second highest node number must be entered second, and so on. In Fig. 2 the correct order would be IVS(3), IVS(2), and finally, IVS(1).

If those steps are taken, ACNAP will be able to correctly solve circuits which have two IVS's connected to exactly

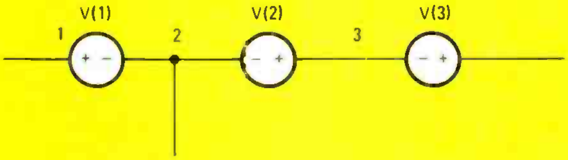


Fig. 2—Voltage sources must be assigned node numbers in consecutive order for proper processing by the program. Notice that their polarities have no effect on numbering.

the same node.

That concludes our discussion on the rules which must be followed while using ACNAP. We now turn our attention to solving a couple of examples using the program.

Example Circuit

Consider the three node network of Fig. 3, which has the following characteristics:

$$w = 100 \text{ rad/sec}$$
$$V_s = 10 \text{ Sin}(wt)$$
$$I_s = 1.5 \text{ Cos}(wt - 45°)$$

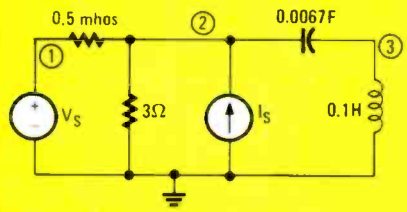


Fig. 3—Even though this circuit contains both constant current and voltage sources ACNAP eats up the data like a hungry lion. Just imagine doing this one by hand!

According to the rules, the first thing to do is give each node a reference number (as shown) and convert any cosine-wave power-supply devices to a sinewave reference:

$$I_s = 1.5 \text{ Sin}(wt + 45°)$$

Below is the listing of ACNAP interaction used to solve the circuit of Fig. 3. Please note that for resistors, conductors, capacitors, and inductors it does not matter which node is considered the "INITIAL NODE" and which is the "FINAL NODE."

TABLE 1—VARIABLE NAMES

Variable	Definition
A(i,j)	equation matrix
N	number of nodes in the circuit
N1	N + 1
NC	number of components
IN	initial node
EN	final (end) node
CP	controlling node; positive
CN	controlling node; negative
VL	component value
VI	component value; real part
VI	component value; imaginary part
MAG	magnitude
ANG	angle
F	frequency in Hertz
W	frequency in radians per second
IN$	input string
PO$	print string #0
P1$	print string #1
P2$	print string #2
P3$	print string #3
P4$	print string #4
I,J,K,L	counters
T0, T1, T2	dummy variables

```
Enter the number of nodes in the circuit,
not counting the ground node (1-25): 3

Do you want to enter the frequency in
   1. Hertz, or
   2. Radians/second
   Your choice: 2

Frequency (RAD/SEC): 100

Enter number of resistors: 1

======== RESISTOR # 1 ========

INITIAL NODE: 2
FINAL NODE: 0
VALUE (Ohms): 3

Enter number of conductors: 1

======= CONDUCTOR # 1 =======

INITIAL NODE: 1
FINAL NODE: 2
VALUE (Mhos): 0.5

Enter number of capacitors: 1

======== CAPACITOR # 1 ========

INITIAL NODE: 2
FINAL NODE: 3
VALUE (F): 0.0067

Enter number of inductors: 1

======== INDUCTOR # 1 ========

INITIAL NODE: 0
FINAL NODE: 3
VALUE (H): 0.1
```

Enter number of ICSs: 1

= = = = = = = = ICS # 1 = = = = = = = =

INITIAL NODE (The tail): 0
FINAL NODE (The point): 2
MAGNITUDE (Amps): 1.5
PHASE ANGLE (Degrees): 45

Enter number of VCCSs: 0
Enter number of IVSs: 1

= = = = = = = = IVS # 1 = = = = = = = =

NEGATIVE NODE: 0
POSITIVE NODE: 1
MAGNITUDE (Volts): 10
PHASE ANGLE (Degrees): 0

CALCULATING, PLEASE WAIT...
THE NODE VOLTAGES ARE:

V(1) = 10 + j 0 volts
= 10 SIN (100 t + 0°)

V(2) = 6.954887 + j 2.253797 volts
= 7.310955 SIN (100 t + 17.95541°)

V(3) = 8.175043 + j 2.6492 volts
= 8.593578 SIN (100 t + 17.95541°)

Press any key to continue...

Would you like to analyze another circuit?
1. Yes, or
2. No
Your choice: 1

The next circuit we will run through ACNAP is shown in Fig. 4. That two-node circuit is operating as follows:

$$w = 500 \text{ Hz}$$
$$I_s = 3 \text{ Sin}(wt + 150°)$$

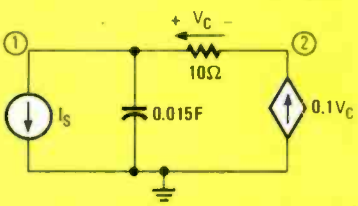


Fig. 4—Even circuits with voltage-controlled current sources such as opamps, can be analyzed by ACNAP. The polarity of the control voltage is important for proper analysis by the program, so be careful.

Note that the current supplied by the VCCS is controlled by the voltage VC, which is the voltage between node 1 and node 2.

Enter the number of nodes in the circuit, not counting the ground node (1-25): 2
Do you want to enter the frequency in
1. Hertz, or
2. Radians/second
Your choice: 1

Frequency (Hertz): 2.0
Enter number of resistors: 1

= = = = = = = = RESISTOR # 1 = = = = = = = =

INITIAL NODE: 1
FINAL NODE: 2
VALUE (Ohms): 10

Enter number of conductors: 0

Enter number of capacitors: 1

= = = = = = = = CAPACITOR # 1 = = = = = = = =

INITIAL NODE: 1
FINAL NODE: 0
VALUE (F): 0.015

Enter number of inductors: 0

Enter number of ICSs: 1

= = = = = = = = ICS # 1 = = = = = = = =

INITIAL NODE (The tail): 1
FINAL NODE (The point): 0
MAGNITUDE (Amps): 3
PHASE ANGLE S(Degrees): 150

Enter number of VCCSs: 1

= = = = = = = = VCCS # 1 = = = = = = = =

INITIAL NODE (The tail): 0
FINAL NODE (The point): 2
MAGNITUDE (Amps/volt): 0.1

CONTROLLING NODE (Positive): 1
CONTROLLING NODE (Negative): 2

Enter number of IVSs: 0

CALCULATING, PLEASE WAIT...
THE NODE VOLTAGES ARE:

V(1) = 2.093915 − j 1.748948 volts
= 2.728241 SIN (12.56637 t − 39.8704°)

V(2) = .3489858 − j .2914913 volts
= .4547068 SIN (12.56637 t − 39.8704°)

Press any key to continue...

Would you like to analyze another circuit?

1. Yes, or
2. No
Your choice: 2

Other BASIC Dialects

Below, twelve different commands and programming techniques used in ACNAP are listed and explained. If you are not using the MICROSOFT implementation of BASIC, those are the statements you might have to alter to get ACNAP to run on your system. Because I have an Apple computer, the Applesoft equivalent commands, when different, are also given.

1 CLS—Used through out the program, CLS stands for "clear screen." HOME is the Apple equivalent command.

2 LOCATE *r,c*—That statement positions the cursor on the screen at row "*r*" and column "*c*" in preparation for a PRINT command. Apple uses VTAB and HTAB commands to perform the same function.

3 CLEAR—Used only on line 1020, that command clears all the program variables. That statement can generally be

eliminated without disastrous repercussions.

4 SCREEN 0,0,0,0—That statement puts the computer into text mode, as opposed to a graphics mode. Apple uses the TEXT command for the same function.

5 COLOR *c*—That statement sets the color that will be used to write screen text. Those statements may be eliminated altogether if your system does not support that function or if you have a monochrome monitor.

6 WIDTH 80—Because of that command in line 1030, 80 columns of text characters can be displayed on the screen at a time. If your computer does not have an 80 column mode, you may wish to reformat ACNAP's PRINT statements so that its output looks better on your screen.

7 SQR(*x*)—That command takes the square root of the number or expression in parenthesis. If your computer does not support that function, try raising the expression to the 0.5 power (i.e. (*x*)**0.5). That should give the same results.

8 DEF FNMAG(*i*,*j*)—A function to determine the magnitude of a complex number in rectangular coordinates is defined by that statement. It is used in lines 3010, 3030, and 3440. If your system does not support that function, type those lines as shown below:

```
3010 BXSQR(A(I,I,0)**2 + A(I,I,1) **2)
3030 TXSQR(A(K,I,0)**2 + A(K,I,1) **2)
3440 MAGXSQR(A(I,N1,0)**2 + A(I,N1,1)**2)
```

9 ATN—That stands for the arctangent function. BEWARE! Many versions of BASIC have that function, but not all of them will return an angle that is in the correct quadrant. You may have to check the signs of your numbers and force them into the appropriate quadrant.

10 BEEP—Used whenever an incorrect number is entered into the computer, that statement simply causes the computer to beep. If your system does not support that command, you might want to try the statement "PRINT CHR$(7);." Another option would be to simply eliminate the command altogether.

11 An apostrophe (')—That is used to indicate a remark, or REM statement. Some versions of BASIC, such as the Apple version, require that "REM" be used instead.

12 The last potential source of difficulty we will consider are two lines used several places in ACNAP. They are:

```
IN$=INPUT$: IF IN$<>"" THEN GOTO xxxx
IN$=INPUT$: IF IN$= "" THEN GOTO xxxx
```

All the first line does is clear the keyboard input buffer of characters waiting to be read. That is to insure that an operator doesn't accidentally miss a screen of information. The second line waits for any key to be pressed before it allows the program to continue. On the Apple, the second line of code can be replaced with a "GET IN$" statement, while the first line would require the use of a PEEK or a POKE command.

Another way around using those lines would be to use an "INPUT IN$" statement. That would require that the RETURN key be pressed, instead of allowing any key to be pressed before the program continues.

That command sequence is used in lines 1310, 1580, 3340, and 3610 in the program.

Technical Information

To solve AC circuits, ACNAP uses a technique known as nodal analysis. A node is nothing more than a connection point between two or more components. Nodal analysis is essentially an organized method of solving for the voltage of each node in a circuit by repeated application of Kirchoff's Current Law—often denoted as KCL. That law states that the sum of the currents exiting a circuit node must be equal to the sum of the currents entering that node. That is,

$$I_{out} = I_{in} \text{ (Eq. 1)}$$

To use nodal analysis, one KCL equation is written for each node of a circuit, except for the ground node. The ground node is treated differently because it is used as a reference for all the other nodes of the circuit, and therefore, by definition, its voltage is zero at an angle of zero degrees. For a network with N nodes, N equations must be written and solved to determine the N node voltages.

For our purposes, all passive circuit elements (i.e. resistors, conductors, capacitors, and inductors) which are connected to a given node, will be assumed to have currents which run out of that node. In other words, the effects of those elements will appear on the left (I_{out}) side of Eq. 1.

Similarly, independent current sources will be assumed to supply current (I_{in}) to both nodes to which they are connected: they supply a positive I_{in} value to the node at the point, and a negative I_{in} value to the node at the tail. Using that convention, the effects of current sources will always be seen on the right side of Eq. 1.

The generalized IVS of Fig. 5 will help to illustrate how independent voltage sources are handled by ACNAP. It is easy to see from that diagram that the voltage at the positive node of the IVS is the voltage at the negative node plus the uvalue of the IVS (in this case V), or mathematically:

$$V_1 = V_2 + V$$

Subtracting V_2 from both sides, we get:

$$V_1 - V_2 = V \text{ (Eq. 2)}$$

That simple equation (Eq. 2) can be used as a replacement for the KCL equation at node 1.

Although we have an equation for node 1, we still must write an equation for node 2. To do that, let's consider nodes 1 and 2 to be one "super node," as depicted in Fig. 5B. We can now write a standard KCL equation for that super node, and use it for the equation at node 2.

Voltage-Controlled Current Sources

That brings us to the last component we will consider: the voltage-controlled current source. A generalized VCCS is shown in Fig. 6. The current into node 1 due to the VCCS

(Continued on page 102)

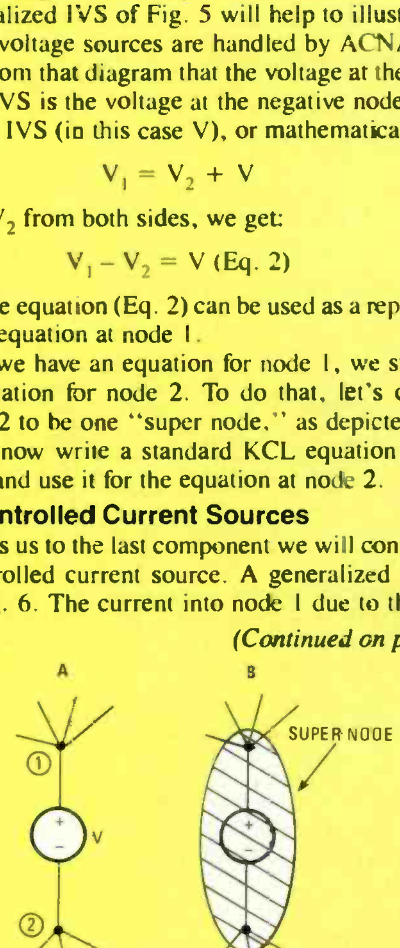


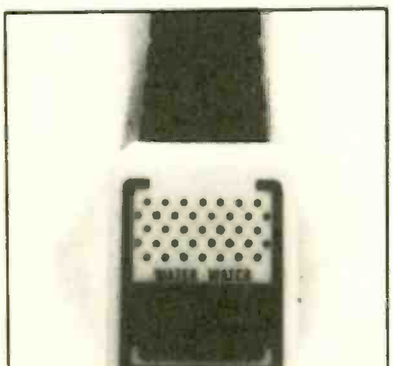
Fig. 5—A constant voltage source provides ACNAP with a way of computing the value of one node voltage by knowing another. That simplifies the matrix and speeds up analysis.

NUMBER 140

GADGET

OCTOBER 1987 THE NEWSLETTER FOR GROWN-UP KIDS VOLUME XII/NUMBER VIII

What's Inside...



Transparent Onyx

POLAROID SPECTRA ONYX. Manufactured by: Polaroid Corp., 575 Technology Square-9P, Cambridge, MA 02139. Price: $280.

We tested *Polaroid*'s highly publicized Spectra System when it was first introduced to the market (GADGET, February, p. 3). It was, and is, a highly advanced instant photography device, a new age melding of electronics and optical science capable, as *Polaroid* material always points out, of making "30 complex electronic focusing and exposure decisions within fifty thousandths of a second."

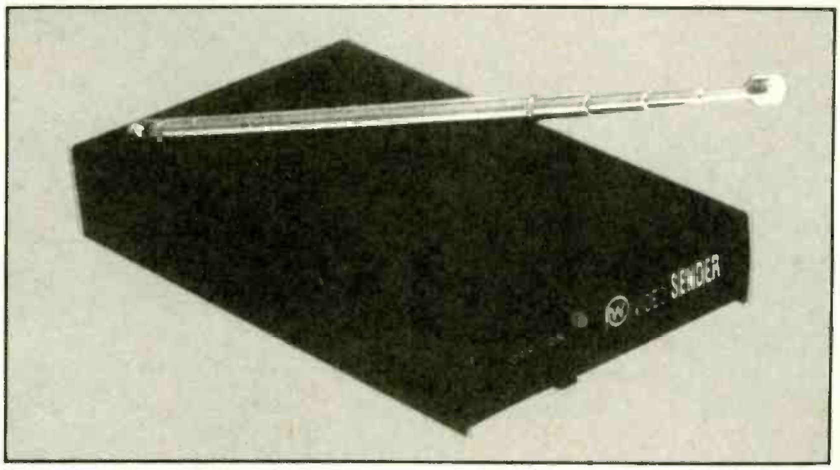
So how come only nine months later we are again featuring the *Spectra*? Because a new model, one introduced this spring, does something gadgeteers have always been fascinated by. This new *Polaroid Spectra* is called the *Onyx* and in all important technical aspects and in its performance, it's the same camera we tested earlier.

What makes the *Onyx* unique is its case. For the first time in its history, *Polaroid* is marketing a camera which allows users to see into the device's intricate electronic circuitry. Its see-through body, which *Polaroid* calls "the camera's unique smoked top," exposes the innards of this futuristic instant camera.

It's striking, if not spectacular. Which is to say, although the user can see the circuitry, there isn't much action visible to the naked eye. When a picture is taken, a rather restrained flash of light appears, briefly and faintly, at one electronic juncture. When we took the *Onyx* out of its case, the exposed workings conjured up visions of a pinball machine-like process of connections being made and electrons in motion as the camera makes its "30 complex electronic focusing and exposure decisions within fifty thousandths of a second."

Unfortunately, that was only a vision. The reality, a single flash of faint *(Continued on page 2)*

Wireless Video



VIDEOSENDER. Distributed by: Premier Electronics, 681 Main St., Bldg. 64, Belleville, NJ 07109. Price: $59.95.

It's an old story in the world of gadgetry: The idea is a good one, but the execution leaves a lot to be desired. The example, in this case, is a Taiwanese device called a *Videosender*. It's supposed to do wirelessly what the VCR Rabbit and the Multiplier do with cables, namely send audio/video signals from a VCR or television to another TV.

The instructions call it a "miniature wireless video transmitter" which utilizes the UFH frequencies 14-26 to "conveniently transmit TV signals to remote television locations within a 200 foot range." The *Videosender* itself is a black box, about the size of a small tape player, equipped with a telescoping antenna, a power switch with red signal light, audio, video jacks, three fine tuning screws and a jack for an AC adapter with which to plug the device into a wall outlet.

In operation, the *Videosender* is placed on top of the VCR originating programming with the device's antenna extended. The receiving TV must be equipped with a UHF loop-style antenna. A closer look at the enclosed instructions amends the original claim of transmitting signals to locations "with a 200 foot range" to 165 feet, if the distance between the sender and the receiving TV is "completely unobstructed by walls or other obstacles."

Our first test, conducted at the GADGET office, was a complete flop. We followed the simple instruction sheet but nothing happened on the receiving set, tuned to UHF channel 15, beyond some possibly *Videosender*-originated interference. This failure we were willing to write off to Manhattan's enormously crowded ether.

A second test, conducted in an editor's suburban home, had a different outcome. The *Videosender* transmitted a VCR program to a second TV in the home. It required some fine tuning and a little exploration of the UHF band to discover which channel was the best path for the device's signal.

But even in a suburban location, the transmission was far from a total success. The received image was full of horizontal red lines, indicative of interference even in a less congested location. So the *Videosender* "worked," but not very well.

Although not engineers, we suspect that to make this device work would require enough extra engineering and circuitry to boost its price to a noncompetitive retail level. And while the cables and lines of the VCR Rabbit or the Multiplier can be unsightly, they're not half the distraction represented by red, horizontal interference lines across the transmitted image. We give the manufacturers of the *Videosender* a B plus for conception and a D minus in execution.—G.A.

SPECTRA ONYX

(Cont. from p. 1)

strength, is nowhere near our imaginings. But this development is still significant, if only because a giant consumer corporation has taken a gamble on the visual appeal of modern electronic circuitry. Design visionaries of a half-century ago were enthusiastic about this kind of industrial (and, in today's terms, electronic) beauty. Now, with "high tech" one of the trademark cliches of this decade, *Polaroid* has introduced the visible *Onyx*.

Our cynical nature suggests that the *Onyx* isn't so much a gesture towards design as an attempt to pep up marketing of the *Spectra System*. *Polaroid*, in introducing the *Spectra* also fabricated a giant-sized, walk-through version of the camera to generate public interest.

But whatever the immediate motivation, the result is an extremely pleasing piece of consumer design. It may not be the beginning of a trend (although gadget fans can always hope), but it's a wonderful item in itself. When design awards are passed out, we'd be surprised if the *Onyx* doesn't manage to snag one for *Polaroid*, as well it should.—G.A.

CORRECTION

An editing error scrambled a sentence in our August review of the *F.R.E.D. III Stereo Television Decoder* (p. 3). The line should have read: "F.R.E.D. II also offers SAP and MTS capability, but lacks the built-in amplifier" [of the *F.R.E.D. III*].

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Touch Zone

WORLD TIME TOUCH SENSOR. Manufactured by: Seiko Time Corp., 640 Fifth Ave., New York, NY 10019. Price: $89.50.

We're slightly chagrined here at gadget central. Hardly had we finished telling readers about the high-priced Geochron World Time Indicator (August, p. 5), when our publisher discovered a similar device which does nearly the same job at nowhere near the same price.

A product of omni-active *Seiko Time Corporation*, the *World Time Touch Sensor* digitally provides the correct time in 27 different time zones at a touch, or two, of the finger. Measuring 7¾" by 5¼", the *World Time Touch Sensor*'s raked front presents a gold-finished map of the world, with major cities indicated, vertically divided into time zones. Above the map, two display windows indicate the zone and the correct day, date and time for that location.

In order to bring up the desired time on the display, it's only necessary to touch whichever time zone you're interested in. Automatically, the zone and the time displays go to the zone the user has pressed.

Setting the instrument is relatively simple. Three buttons, concealed under the battery compartment door on the back of the device, control its multiple functions—day, date, hours, minutes and seconds. Pressing all three buttons together activates the clock. The user then touches the local time zone.

Button "A" activates the time/calendar setting mode. Button "B" selects the set of digits to be adjusted, signaled by flashing of the designated numerals—minutes, hours, date, month, year and seconds in sequence. There's also a choice between 12- and 24-hour modes of timekeeping. Button "C" actually sets the indicated digits. Once the date, month and year are set, the device automatically displays the correct day of the week. Once set, according to *Seiko*, the *World Time Touch Sensor* "will automatically adjust for odd and even months up to the year 2035." *Seiko* cautions to make sure that the small AM/PM display is correct in the 12-hour timekeeping mode. In the 24-hour mode "24H" appears in place of the AM/PM designation.

There's a final adjustment on the map face in the lower, left corner. This is a boxed symbol of the sun with the initials "DST" (for daylight saving time) and "summer time" below it. If the home zone for the clock is on daylight saving time, a small sun appears above the day of the week in the time display, along with the corrected, adjusted time.

If the user should go to another time zone on the indicator, then return to the home zone, the time shown will not be adjusted for daylight saving. So, a second touch to the "summer time" box is necessary to bring up the correct time again. This feature, our publisher felt, was a bit fancy for its own good. It also meant that, at least during the summer, the *Seiko World Time Touch Sensor* might be better designated the World Time Two Touch Sensor. Power for all this global time spanning is provided by two 1.5V "AA" batteries. *Seiko* offers the usual one-year limited warranty on the product.

Handsome, simple to operate and ingenious, the *World Time Touch Sensor* would bring a touch of class to just about anyone's world.—G.A.

Unsilent Partners

AR POWERED PARTNERS. Manufactured by: Teledyne Acoustic Research, 330 Turnpike St., Canton, MA 02021. Price: $339.95.

As the market for consumer electronics expands, there are apt to be lags and disparities between certain market subsectors, pockets of technological resistance that stay stubbornly behind the times. In the realm of personal stereo, for example, the speaker components have remained steadfastly substandard.

Along come the speaker specialists, *Acoustic Research*, to bring the portable stereo to a state-of-the-art level of perfection. What the *AR* engineers have done is house a 15-watt amplifier in each of a pair of sturdily built two-way speakers, fit them each with a volume and bass control, and invite you to kick out the jams in your car, your campsite or your video system.

The speakers, which weigh in at seven pounds each, don't really qualify as portable—maybe "luggable" would be more like it. But their black, die-cast aluminum cases (triangular, with two corners squared off) seem to be hefty enough to take whatever low blows are dealt them in transport. The four-inch woofer is paired with a one-inch tweeter, both packed into a sleek, breadbox-sized unit. In a recessed back slot are three power connections—AC and DC power input, as well as an unswitched AC outlet—and the RCA-type input jack. On the front of each unit are the bass and volume controls, LED power-on indicator, and the on-off switch.

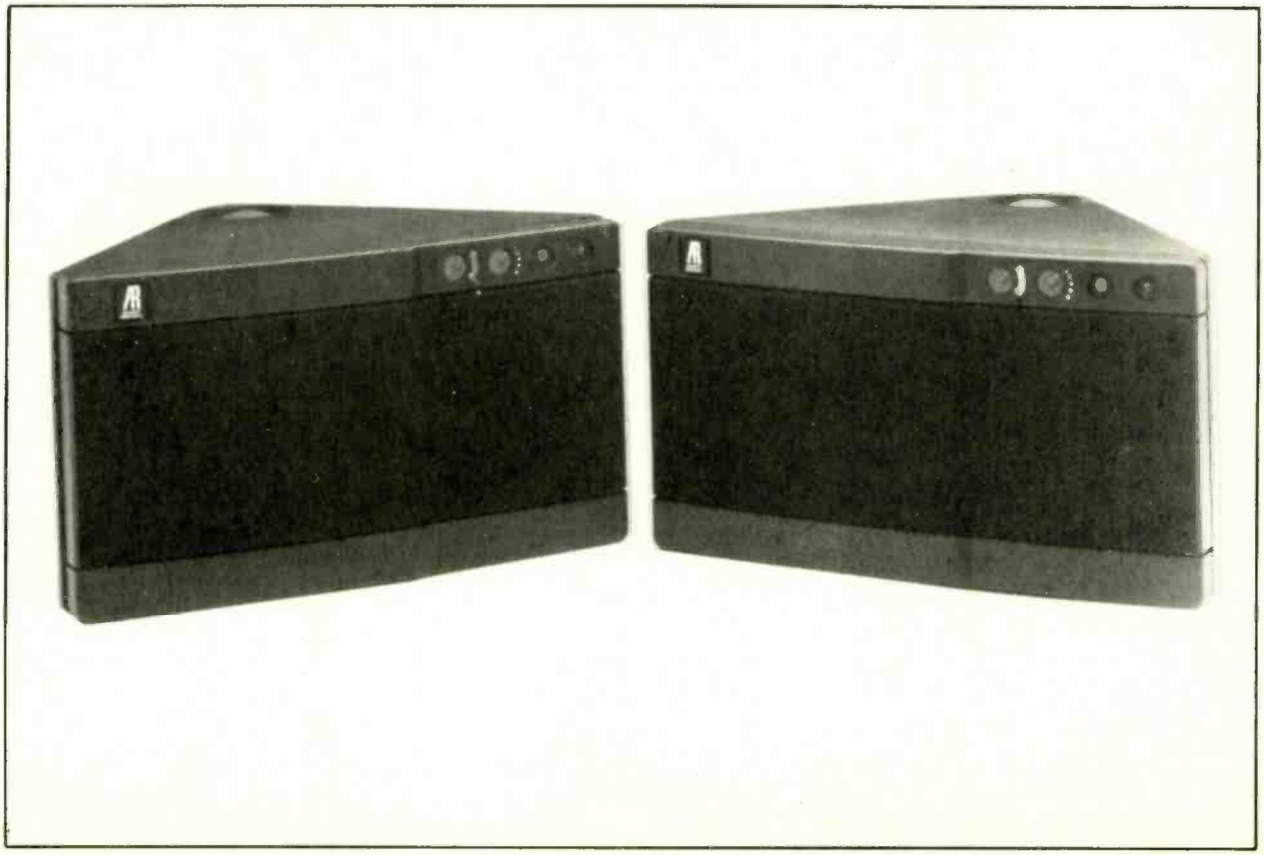
We tested the *AR Partners* in three configurations: car stereo, personal stereo and video speaker adjunct. For the personal stereo, the *AR*'s were harnessed to a Sony TC-DM5 field recorder and a small Panasonic "boom box"—model FM115. The Panasonic was connected directly through the headphone jack, while the Sony had dual output jacks. Both delivered superb, crisp sound when powered by the *AR* amps. The bass, of course, was what was immediately noticeable, and there was an absence of mid-range boominess also. The high frequencies were cutting and forceful without being too bright, and the whole effect belied the low wattage rating to remain distortion free even at high volume.

The car unit was a midline Pioneer cassette player, and we needed the DC adapter—which unfortunately wasn't supplied by *AR*, but was on hand anyway. The *Partners* were awesome when tested in the confined space of a Chevrolet Nova, providing a sound that was almost "too big" for the road. We found ourselves driving faster, hoping the generator's power supply could keep up to the demands of the pre-amps.

Finally, we connected the *Partners* to a top-of-the-line Sony Betamax Hi-Fi VCR. Again, they performed admirably, boosting MTV well into the "listenable" range, and making even Doc Severinson sound good. Again, however, we had to make do with our own speaker connectors, since the extension cables required were listed by *AR* under that odious category, "optional."

Indeed, that may be our only quibble with the *Partners*—a unit like this, sold to be compatible with any number of stereo configurations, should have more versatility in the cable couplings—and they should be supplied, not "optional." Other *Partner* optional accessories include a clamp system, *a la* Bose "Roommates."

Partners are, in fact, a response to the phenomenal success of the Roommate series. But as we've come to expect from *AR*, the company doesn't do anything unless they are going to do it well. *Partners* come out at the top end of the personal stereo spectrum, providing a clean, compatible adjunct to your Walkman, your car stereo or your home video system.—G.R.



Superiority Complex

PROTON 625 MONITOR/RECEIVER. Manufactured by: Proton Corp., 737 W. Artesia Blvd., Compton, CA 90220. Price: $1,099.
PROTON 313 LOUDSPEAKERS. Manufactured by: Proton Corp. Price (per pair): $300.

Recent print advertisements for *Proton* audio-video equipment were headed: "When you arrive. Proton." As an exercise in electronic-age snob appeal, the phrase "when you arrive," makes it clear that this 25" monitor/receiver is pitched as an accoutrement of life at the top.

For those of us who don't know if we're going anywhere—let alone, if we've "arrived"—the slogan doesn't really say much. "Monitor/receiver" is also an important snob-appeal buzz term. It's used by manufacturers and marketeers so that a low-brow term like "television set" won't demean their high-tech consumer dream.

The *625*'s straight, simple lines reflect *Proton*'s past as a manufacturer, primarily, of studio-grade equipment for professional use, source of much of the brand's current consumer reputation. This is what is called a "table model," at least in television terms and last year it was named "best product of the year" by *Video* magazine, the editor of which called the *625* "our favorite non-console."

All black (except for the green power switch on its front), the *625* has built-in stereo or can be used with several *Proton* loudspeaker systems. The *313* powered speakers GADGET used in its tests are designed to flank the unit and are finished in the same low-key black.

Equipped with an infrared remote control unit, capable of access to 139 channels and "cable compatible," there are only five controls visible on the front of the monitor/receiver itself. Power, channel selection (two keys which tune up or down through the signal sequence), volume keys, "TV/video" and "antenna/auxiliary" switches are located under the screen.

"TV/video" accesses any of a trio of possible external component input systems. "Ant/aux" selects for RF signal sources such as cable decoder boxes, some video games and VCRs. Tastefully discreet lights above these controls and others indicate which selections have been made.

Behind a door under the controls are the usual tuning adjustments (vertical hold, color, tint, picture, detail, "black level" or contrast plus bass, treble and balance). Other switches there adjust the *625* for cable use, mono or stereo audio, computer display, automatic or manual fine tuning and "second audio program" reception. There's also a two-position switch to engage the *Proton*'s video noise reduction system. "Add, erase" and "add/erase, skip" controls allow a user to set the *625*'s channel selection for only those channels actually transmitting. Finally, behind the same door is the monitor/receiver's third set of stereo audio, video and "TV out" jacks. "TV out" allows any TV channel to be recorded, even when the *625* is taking its programming from another source such as a VCR.

The back of the set presents further controls and a multiplicity of inputs and outputs suggesting the *Proton 625*'s studio origins. Besides the "master power" switch, there are controls to "disable internal speakers" for using the *625* with external audio equipment and a "sync positive/negative" adjustment for use with RGB components. There's also something called a "356 trap," which is not explained in the manual until the troubleshooting section. Apparently this trap locks out interference emanating from the 356 MHz band, which can make the unit's picture "fuzzy."

Proton says this monitor/receiver achieves "horizontal resolution approaching 400 lines, very low overscan, black-level compensation and 95 percent DC restoration." Even if you're not a video technician, this sounds as if it should result in a very fine picture. So how does the *Proton 625* perform? First, GADGET had to set this "monitor/receiver" up and that's when we were reminded of an important difference between this kind of unit and a mere television set.

With a TV, the device is removed from its packing box, plugged in, turned on and it works. With a "monitor/receiver," however, there's much necessary fiddling and adjusting before anything appears on the screen. We spent around 45 minutes trying to connect the *Proton* to a standard cable hook-up (sans scrambled signals) and finally called on the assistance of a video producer-technician.

Once functioning, the initial reception wasn't all that super; its picture was grainy and oddly indistinct. However, as the *625* warmed up, the image became crisper and altogether sharper.

Using the *313* loudspeakers, we were also disappointed in the monitor/receiver's audio adjustment sensitivity. Perhaps we mistuned each speaker's "input sensitivity" control, but for whatever reason, neither the front panel nor remote volume adjustment was very responsive. The audio level was either a shade too loud or else not loud enough. We never did find the happy medium.

Although the *Proton 313* speakers are shielded for magnetic interference, the same series' 301 units aren't. Hence the warning, "301 powered speakers should be at least one foot away." A further audio caution in the manual sounds more serious. If "unshielded speakers are too close to the *625*, you will see color smearing or purple blotches." In these circumstances, *Proton* warns, "immediately move the speakers away from the *625*" and turn the receiver off. "After ten minutes, turn it on again. Repeat as necessary." Likewise, placing a VCR too close to the *625* can interfere with this audio/video powerhouse's performance.

An entry in the manual's troubleshooting section adds the snobbish

(Continued on page 9)

Chicago Show Down

The hardware at this year's summer Consumer Electronics Show in Chicago seemed to be overshadowed by hard currency questions. As far as the general news media was concerned, the Chicago trade show was rather neatly summed up by the *Wall Street Journal*'s headline for its main CES story, "Consumer Electronics Industry Remains Beset by Strong Yen, Little Innovation."

General coverage of the show, in fact, seemed to relegate the CES to just another trade show, in contrast to last year and 1985 when the press discovered the glamour of consumer electronics. Particularly in those years, major newspapers and magazines gave the Consumer Electronics Show the kind of razzle-dazzle treatment usually reserved for show business.

But it shouldn't be denied that the Chicago show unveiled little in the way of genuine innovation. Instead, the emphasis was on fashion in electronics. All kinds of companies are marketing pastel-colored TV sets, portable sound systems, calculators and so forth. It seems a little silly and, considered in light of the confidence exhibited at past shows, maybe a little desperate. Still, it wasn't all fashion frou-frou and while spectacular innovations (with the exception of the controversial "digital audio tape," or DAT) were rare, CES this year did unveil some solid advances in consumer electronics.

Panasonic Personal Stereo

Panasonic Portable Stereo System

One of the most impressive developments amid all the high-fashion electronics was a group of audio products featuring "enhanced bass." The first to catch our attention was from *Panasonic (1 Panasonic Way, Secaucus, NJ 07094)*, the *RX-SA79 Personal Stereo* with XBS, "extra bass system."

Not only has this portable unit broken the two-battery barrier (it's powered by a single "AA"), but it has a built-in charger and power cell. The *RX-SA79* has all the standard features of personal stereo systems, like an auto-reverse tape deck with Dolby noise reduction and FM radio. But what makes it noteworthy is *Panasonic*'s XBS.

To our ears, the bass this player delivers sounds at least as rich as the bass CDs can produce. Of course, strong bass can be achieved by adjusting a player's tone control or equalizer, but those methods tend to muffle the music. Whatever *Panasonic*'s innovation, it was achieved without any negative effects on the over-all audio quality.

Sony was first with an enhanced bass system, introducing its *DD-100 Boodo Khan Stereo Cassette Player* last year. But *Panasonic* has gone that player one better with an auto-reverse feature, something missing from the *Sony* unit, as well as incorporating an AM/FM tuner into the *RX-SA79*. Innovation may receive the acclaim, but intelligent catch-up demonstrates marketing smarts on the part of *Panasonic*.

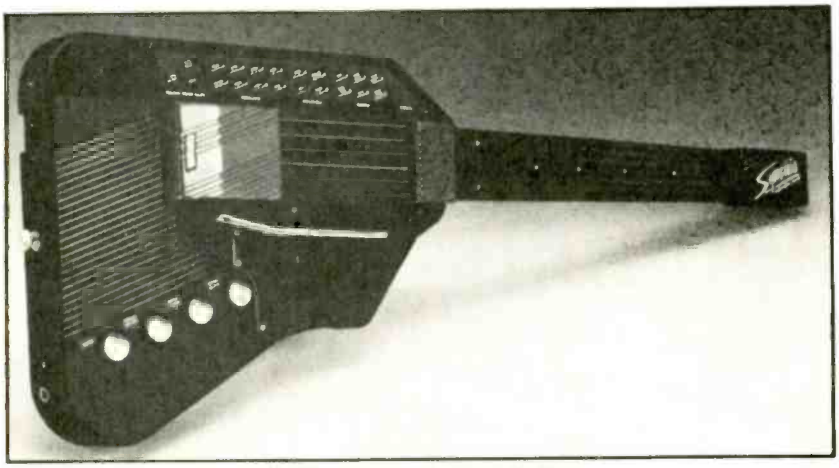
The firm also unveiled a portable stereo system with dual tape decks and a CD player, the *RX-CD100*, which also features XBS. The retail price for this unit has yet to be announced, while the *Panasonic RX-SA79* carries a suggested retail tag of $159.95.

Panasonic, however, doesn't have a monopoly on enhanced bass. Featured at the CES's annual "Design and Engineering Exhibit," a room devoted to the electronics industry's "most distinguished achievements," was a new portable system from *JVC Company of America (41 Slater Drive, Elmwood Park, NJ 07407)*. Ranked 80th among the 227 noteworthy products on display, the *JVC PC-V2* includes a tape deck, CD player, AM/FM and shortwave radio reception.

JVC calls its enhancement system, "hyper-bass sound." Of everything we examined at CES, the *PC-V2* was by far the best-looking new audio product, a favorite with us because of its fantastic combination of good design and excellent audio quality.

The exceptional quality of the *JVC* hyper-bass was amusingly illustrated by an incident in the Design and Engineering Exhibit. When the *PC-V2* was first turned on, its enhanced bass wasn't audible. When one of the onlookers accidentally hit the "hyper-bass" control, a rather inconspicuous switch, the milling crowd was actually hushed by the power and fidelity suddenly evident to everyone's ears. The unit's sub-woofer is so strong that we could almost feel a breeze coming out of the speaker. The *PC-V2*, we think, is the first portable system that does justice to the superior quality of compact disc audio.

Perhaps the most publicized innovation at this year's CES was also the most foolish. The largest exhibit booth was devoted to "*CD Video*," quite possibly the most idiotic idea to make it to the contemporary high-tech consumer market. The "*CDV*" is a laser disc which provides no more than five minutes of video and no more than 20 minutes of audio on a standard five-inch compact disc. A special player is required to play back the *CDV*, which contains basically one music video clip and a few audio selections. The marketing idea is that these will replace the 45 rpm single. Judging from the list of participants in *CDV* software—including Arista, A&M, MCA, CBS Records, Chrysalis, Capitol and Polygram Records as well as MGM/UA, CBS Fox, Warner, MCA, Paramount and



UniSynth Electronic Guitar

RCA/Columbia home video—both the music and video industries are betting on this laser hybrid. But from the consumer standpoint, the success of the *CDV* seems a long shot.

People buy 45s to sample the music of an album and decide whether or not to shell out for the entire LP. Given the retail price level of the *CDV* ($8 to $10), we don't think consumers will be rushing to buy a single music video and two or three songs. One observer quoted by the *Wall Street Journal* put it this way, "It requires a teen-ager to buy a $600 player to play back a five-minute video that costs $8 and that he or she has probably grown tired of already."

There was also a vast expanse of CES exhibition space given over to "digital" devices. It seems that consumers (or maybe just marketeers) were so amazed by the success of compact discs that companies are now flooding the market with other "digital" equipment.

Of course, there's DAT, digital audio tape. The cassettes look like videocassettes and the sound is truly outstanding. But the U.S. Congress is being heavily lobbied, primarily by the big-bucks record industry, to pass legislation which would require that all DAT decks on the American market have a special microchip installed to prevent duplication of commercial recordings, LPs and CDs.

This sounds like a rerun of the record industry's response to the introduction of audio cassettes. The music merchandisers were fearful that home recording would destroy the record industry, with piracy running wild and consumers building their music collections with illegal copies instead of the bonafide record label products.

A certain degree of genuine piracy does exist today, actively fought by the record industry trade association, the U.S. Justice Department and the Federal Bureau of Investigation. Whether home taping constitutes piracy is a philosophical, and pocketbook question, but whatever the situation, the record industry is hardly on its last legs.

A special "anti-copy" microchip in DAT decks would surely crimp that new market, create an entire underground industry for devices to abort the anti-piracy chip and, maybe most importantly, leave the consumer out in the cold as the electronics and record industries battle it out over profits and market protection.

A long-term perspective (which in American corporations seems to mean deciding what to have for lunch that day) and a little less panic in the executive suites should suggest to all interested parties that the best approach is to go with the DAT flow.

But beyond (or maybe beneath) weighty questions of market development and protective legislation and the future of digital gear, CES did present some intriguing new gadgets. And that, after all, is what brings us to the semi-annual convocation.

Remember 3-D movies? *Sega of America, Inc. (573 Forbes Blvd., South San Francisco, CA 94080)* has introduced two new games for use with home video systems called *3-D Zaxxon* and *World War 3-D*. Only *3-D Zaxxon* was exhibited, but what we saw seemed promising.

The graphics were nice, the animation was smooth and the vaunted three-dimensional effect (accomplished using the same red/blue process as 3-D movies and requiring the same kind of special viewing glasses) was spectacular. Both *3-D Zaxxon* and *World War 3-D* carry a suggested retail price of $39.95.

Although the *CES* fashion-consciousness was a little irritating, the *Elsi Mate LE-1600 Electronic Calculator* from *Sharp Electronics Corp. (Sharp Plaza, Mahwah, NJ 07430)* was genuinely well designed. It features 10-digit display, performs standard calculator functions and has a built-in printer. The keyboard's generous dimensions make use of the *LE-1600* comfortable and smooth.

If you've been looking for a high-resolution dot-matrix typewriter which prints in Chinese or Japanese, *International Quartz Ltd. (24-26, Sze Shan St., Yau Tong, Hong Kong)* has what you need. The company manufactures a typewriter which prints in both English and in Chinese and Japanese pictograms, some 3,000-plus characters in all. The machine is large compared to the standard compact typewriter and retails for $1,000.

Remember when electric pianos made their first appearance on the market? First Casio made tiny, electronic music machines which eventually evolved into the sophisticated synthesizers found in nearly every high grade studio and many rock bands. *Suzuki (P.O. Box 261030, San Diego, CA 92126)* may have started down the same road with guitars.

The *UniSynth* is an electronic guitar. Not an electric instrument, but one which synthesizes the music it produces. The instrument can play in six different digital "voices," including "guitar I, II, synth, vibes I, II" and "brass." It creates its own rhythms and can do "auto chord play" for non-guitarists. The *UniSynth* features metal strings between two bridges, for strumming or picking, and plastic buttons along the instrument's neck, a different button for each fret.

Sharp Elsi Mate Calculator

Perhaps the outstanding novelty of the entire CES was *The Levitator*, manufactured by *United Imports & Manufacturing (6846 Pacific St.,*

(Continued on page 9)

Aquatic Time

THE WATER WATCH (300-BBU). Manufactured by: VentuResearch, 1539 Vanderbilt Dr., El Paso, TX 79935. Price: $24.
H_2O WATCH. Distributed by: Admagination, Inc., 39 W. 32nd St., Suite 801, New York, NY 10001. Price: $25.

A gentleman we once knew had a thesis regarding what he called "abandoned technologies." His example was the rise of the internal combustion engine and what he suggested was that there were a number of alternative power sources being developed at the same time as the gasoline engine but which never came to fruition because their development was cut short by the supremacy of internal combustion. Could that research be continued usefully today in connection with new technology?

What brings this intriguing notion to mind is the recent appearance of digital watches powered by a primitive Voltaic cell. In the 18th century, Count Alessandoro Volta, a scientist of the era, discovered that when two dissimilar metals are immersed in water, a faint electric current is generated.

Moving on to the final quarter of this century, contemporary digital timepieces require only the tiniest of electric currents to operate. Enter *VentuResearch* of Texas and, presto, the *Water Watch* was born.

This same coupling of primitive power generation and fairly advanced electronics in the service of timekeeping actually surfaced a few years ago in the form of the Potato Clock, which GADGET reported on in July of 1984. But *VentuResearch*'s *Water Watch* appears to be the first miniaturization of this amusing hybrid of old and new technologies.

These timepieces, available in several styles, utilize tiny strips of zinc and copper separated by equally diminutive strips of what appears to be ordinary household-style sponge. Water is introduced via pin holes bored in the side of the plastic watch casing. Beyong its eccentric power source, the *Water Watch* is a fairly basic digital timepiece, capable of displaying time, day, date and seconds.

We had our problems with both the *Water Watch* and the virtually identical (if more imaginatively packaged and marketed) *H_2O Watch*. Water, water everywhere, but how do you get it into the watch?

We spent an afternoon holding these wristwatches under faucets, pouring water over them and finally dunking them into cups of water. The directions airily spoke of running cold tap water over the watch for "two seconds" or "placing it in a glass of water for a few minutes." We thought trying to fill these instruments with water was more like feeding fledglings with an eye dropper.

A darkening of the sponge signaled that the water was absorbed, but with each of the watches there seemed always to be one strip of sponge determined to stay dry. The case of one of *VentuResearch*'s models wasn't transparent, so there was no way to judge absorption.

Each of the watches was supposed to signal its activation by flashing a particular set of numerals on its display. "When you activate your watch . . . the display will show 1:00 with a flashing colon."

The *H_2O Watch* instructions proudly proclaimed it "a five function quartz solid state timepiece." Unfortunately, this meant that when activated, the display had to be interpreted as either the "time mode" or "the day and date mode"—important, in that this would determine which sequence of button pushing was to be followed to set each

(Continued on page 9)

WATER WATCHES

(Cont. from p. 8)

of the instrument's five functions. With at least one watch, what came up on the display didn't resemble anything the instructions had indicated. We attributed this phenomenon to insufficient current and went back to dunking, dousing and showering the watch and its stubbornly dry sponge.

It wasn't until after the numerals "18:88" appeared on one display that we found out that this indicated "overvoltage," i.e., too much *aqua pura*. Luckily, no damage was done, but the problem can also be triggered by "introducing certain liquids (other than water) into the *Water Watch*."

Our second major peeve about these otherwise fun timepieces is exclusively an aspect of its modern technology. Since these are relatively simple digital instruments, adjusted and set with just two buttons or pins, the sequential setting of functions drove us to distraction.

Maybe a mistake was working with several very similar watches at the same

time. In setting the time, for example, if we accidentally went beyond the proper hour or minute, we had to start all over again.

Not start all over again adjusting the time, but begin again with the entire process of setting the instruments' various functions in rigid sequence. Because a miscue in setting time couldn't be aborted and, as the watch is told which function to display for adjustment by various combinations of depressing its two adjusting pins, the entire process soon began to resemble being lost in a maze.

But this is a longstanding gripe which we have with most digital display wristwatches. For all the advances in miniaturization and multi-functionality, adjustment and setting are still too often crude and unwieldy. If multi-thousand-dollar computers can be user-friendly, why should we expect to get the cold shoulder from a $25 watch?

Despite cautions about shortening the life of the Voltaic cell, the *Water Watch* will "operate with liquids other than water such as beer, wine, cola and so on." The damage results because these liquids "contain sugar and other contaminants."

The last thing we'd want to do, however, is pour cold water on these otherwise marvelously simple technological toys. What we want is an easier way to pour water *into* them, and a less confusing way of adjusting and setting their functions. If only Count Volta had also thought to invent the digital wristwatch to go with the energy cell which bears his name, maybe all these problems could have been solved during the "age of reason," instead of hounding us in the contemporary "age of marketing."—G.A.

PROTON

(Cont. from p. 5)

note: If your VCR image is "fuzzy," it's probably because your equipment isn't good enough to use with the *Proton 625*. The cause of "fuzzy VCR picture" is given as "slow recording speed" or "normal low resolution of ½" system." It further explains, "all VCR pictures are grainy on a high resolution system."

So be prepared, if you tote this high-tech tube home to give serious consideration to upgrading all your equipment in order to be worthy of the *625*.

One video add-on which showed off the *625*'s touted high resolution performance to good effect was a Hitachi color video printer (the VY-100A). Connected via the front-panel "video 3" jacks, the video snapshots from the printer, taken from the *625*'s screen, were exceptionally detailed, while the color was balanced and even natural in appearance.

After living with the *Proton 625* for a month at GADGET's office, a high-tech hearsay suggested itself. What put the notion in our minds was a further note in the owner's manual. In discussing antenna and cable connections, *Proton* added as a note that it "does not recommend the use of indoor 'rabbit-ear' antennas." We're sure there are technical grounds for this, but we're also pretty certain that if *Proton* had anything to say about it, the company would not approve using this monitor/receiver to watch reruns of *The Beverly Hillbillies* or *Mr. Ed*, either. If you want to watch that kind of trash, get yourself a TV set.

Here's where we part company with the *Proton* cult. Maybe Mr. and Ms. Typical Video Consumer wouldn't derive any particular benefit from owning a *Proton*. Perhaps if your audio-video system consists of a VCR that's a few years old and cable service, the persnickity *Proton 625* would be more trouble than it's worth.

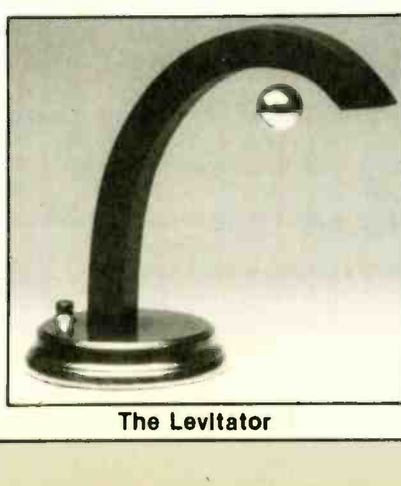
Of course, for the true video lifestylist, owners of extravagant home entertainment centers which are residential versions of a video production facility, the *Proton* with its multiplicity of input and output capabilities might be a must. If we were installing a home studio, we'd certainly consider a *Proton*, but in most other circumstances, you might be better off settling for a mass-market television.—G.A.

CHICAGO CES

(Cont. from p. 7)

Omaha, NE 68106). It looks like a desk lamp in that it has a heavy base and a pole. But this gadget is no lamp.

Instead, the device has a lightweight (but heavy appearing) chrome ball, a little over an inch in diameter, that's balanced magnetically underneath *The Levitator*'s arching pole. The ball is suspended in mid-air, about an inch away from the arch at its nearest point. It creates an eerie effect and allows its owner to have something different—

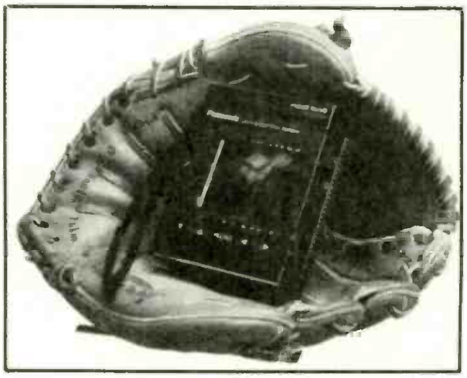


The Levitator

his or her own private magnetic field. The suggested retail price is $99.

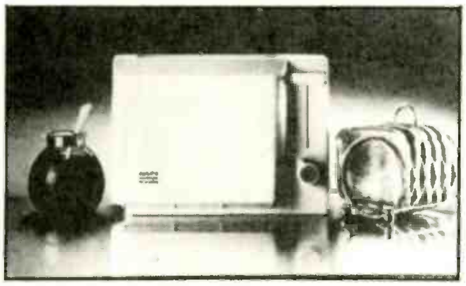
This is anything but an exhaustive rundown of the acres of products at the Consumer Electronics Show. In coming issues we'll be testing some of the products described above, as well as many which were shown at CES but which went unheralded here. Besides, given the characteristics of the Chicago exhibition this year, its most important developments will probably be reflected in trade economic journals (i.e., the Yen vs. the dollar) and, given pending legislative proposals regarding DAT, by political news coverage.—A.C.Z.

Bits & Pieces



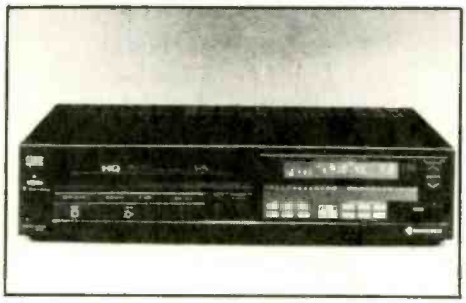
Panasonic Pocket Watch TV

Right after we reported last month on the mini-size Pocket-Watch TV, the CT-333S, *Panasonic (1 Panasonic Way, Secaucus, NJ 07094)* contacted us to say that the firm offers an even more compact version, the **Pocket Watch** model CT-311E. This model, which features a 3" diagonal LCD screen and AM/FM stereo radio, measures 4.3" high, 1.6" thick and 3.6" wide. The color TV, Panasonic says, "offers outstanding picture clarity and a wide viewing angle," as well as "sharp intermediate colors." What the company dubs "slide-rule tuning" is said to "simplify the locating of stations." Power is from six "AA" batteries, or the CT-311E can be used with an AC adapter. The batteries are good for a "maximum of five hours of viewing time." The unit's "auto-search tuning" helps "receive stations clearly." Price: To be announced.



Krups Toastronic II

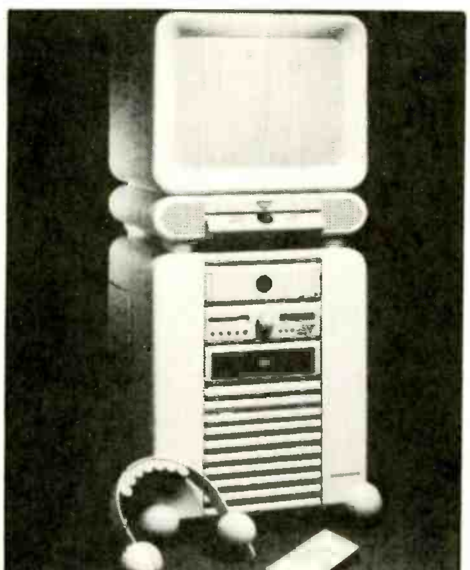
Contemporary electronic civilization has reached the stage where microchips are going into toasters. Is this a milestone or what? Not just any toaster, of course, but the new **Toastronic II** from *Robert Krups North America (7 Reuten Drive, Closter, NJ 07624)*. If the Starship Enterprise had carried a toaster, it probably would have been the Toastronic. The company says the unit's "microchip toasting technology," specifically a heat monitor, insures uniform, even toasting and makes manual resetting of the temperature level unnecessary. The Toastronic also features a triple insulated outer housing, rubber feet for secure footing and a cord storage bay for adjustable cord length. Price: $65.



Samsung Stereo VCR

Here's a new entry into the electronic fashion accessory sweepstakes. This one is called a **Switch Radio**, inspired, it appears, by the success of the Swatch watch. This AM/FM radio is a palm-sized, transparent plastic sphere (rather resembling an old-time diving helmet in miniature). Red, blue and yellow controls add color and the receiver can be used with either headphones (not supplied) or the unit's speaker, of only marginally higher quality than those in the most budget-priced transistor radios. It's packaged in a see-through plastic cube and comes equipped witn an antenna wire and a headphone adapter, both of which use the same jack. A semi-charming novelty, we were a bit surprised at its hefty price at *Saks Fifth Avenue (611 Fifth Ave., New York, NY 10012)*. But maybe that's why the radio's instructions spell the word "Switch" with a dollar sign. Price: $39.

As part of the battle to establish itself in the U.S. consumer market, the fiesty South Korean company, *Samsung Electronics America (301 Mayhill St., Saddle Brook, NJ 07662)* has just introduced its first **Hi-Fi Stereo VCR** with MTS decoder (VR6600F). The front-loading unit offers two video heads with HQ circuitry, stereo audio recording and playback, 110-channel cable compatible (a step beyond "cable ready," we guess) frequency synthesized tuning and a built-in MTS stereo decoder for reception of stereo TV broadcasts. Other features include a 14-day/six-event programmable timer, three-speed record and playback, auto still release, auto rewind, picture search, pause/still and "convenient one-touch recording." The unit's wireless remote control has 20 keys and 23 functions, including direct access tuning, channel up and down and picture search in all three VCR playback speeds. Price: $649.95.



Wondervision Entertainment System

The company behind the very popular Teddy Ruxpin talking bear is branching out in its attempt to market electronic products aimed at kids. One new product from *Worlds of Wonder, Inc. (4209 Technology Dr., Fremont, CA 94538)* is called **Wondervision** and besides being "the future of kids' entertainment," it's also "the only modular audio/video entertainment system designed just for kids." Wondervision is a modular product which can include a 13" color TV with video cassette player or just the TV or just the video player. The stand designed for the unit also can incorporate an AM/FM radio or a remote transmitter for cordless headphones or cordless speaker. Optional features are sold separately for prices ranging from $149 for the Wondervision stand to $49 for the cassette deck, remote speaker or headphones. Price: $499.

Bits & Pieces

Ever since the appearance of cellular car phones, we've wondered about the safety of driving and talking, or driving and dialing, at the same time. While we don't know if highway safety was the motivation, *Interstate Voice Products (1849 W. Sequoia Ave., Orange, CA 92668)* has a line of cellular add-ons called **VocaLink**, a "small, powerful speech recognition unit" for use with most cellular telephones. Dialing a number with the VocaLink is not only "hands-free," but "eyes-free" as well. Once connected to the instrument (usually a simple procedure), the speed recognition function is engaged by touching the keypad's "pound" symbol. The user can dial by voice command in three different ways: by speaking one of 40 programmed key words or phrases, by vocally recalling a number from the car phone's memory or by simply reciting the numbers into the telephone. Cellular phones with which VocaLink is compatible include General Electric and Oki instruments, as well as other popular brands. Price: $395.

Interstate VocaLink

The business traveler represents an important market for all sorts of equipment and accessories. *Sharp Electronics Corp. (Sharp Plaza, Mahwah, NJ 07430)*, for example, has introduced a new **Travel Partner Calculator** (EL-470). The calculator features an alarm clock which can store time-of-day for two time zones; an automatic currency conversion function, a calendar function and standard arithmetic operations, plus percent and square root calculations. The EL-470, in black, comes with an "attractive wallet case" and the purchase price includes batteries and an instruction booklet. Price: $34.95.

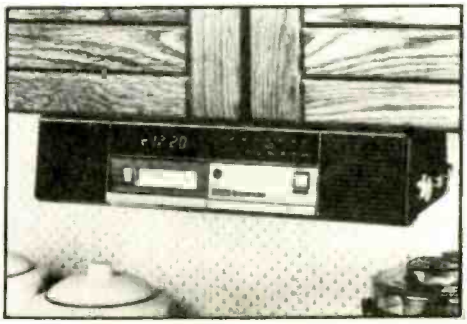
Travel Partner Calculator

This component combo isn't likely to win any performance awards, but as an example of ingenius design in the service of marketing, it has definite appeal. From an outfit calling itself the "Electronic Sports Collection, this **Electronic Cube** (CTV-38) features a 4" black-and-white TV on one face, an AM/FM clock radio on another and a cassette player/recorder on a third surface. Available from *Impact 2000 (60 Irons St., Toms River, NJ 08753)*, the cube is mounted on a swivel base with power supplied by an AC adapter plug. Kind of an electronic entertainment lazy susan in miniature, years ago catalogs would have called it "a conversation piece." Price: $179.95.

The big news about the recently introduced **Sports Watch** from *NDQ Marketing (989 Sixth Ave., New York, NY 10018)* is probably its low retail price. Not that this timepiece, built by Japan's Hattori-Seiko Co., Ltd., doesn't have a number of attractive features. Water resistant to 200 feet, the MWS-8 sports watch has eight functions, alarm and chronograph, hour, minute, second, day, date and month. Its laser-regulated quartz movement is said to assure accuracy "to within 20 seconds a month." It comes equipped with a black resin strap and NDQ Marketing is certain that its "streamlined styling" will appeal to "both male and female sports enthusiasts." The watch also comes with a one-year limited warranty with the company claiming a defective rate of "only one-third of one percent." Price: $9.95.

NDQ Sports Watch

Traditionally, anyway, the kitchen isn't thought of as a place of entertainment, dedicated as it is to preparing and consuming foods. *General Electric Consumer Electronics (Electronics Park, Syracuse, NY 13221)*, however, knows that the modern kitchen has changed. Hence the company's introduction of a **Stereo Kitchen Entertainment Center**, part of the very successful Spacemaker line of appliances. The unit (model 7-4269) mounts easily under cabinets and features an AM/FM stereo radio and cassette player with two "front-fired speakers for full stereo sound." Sold with the hardware necessary for mounting, it can also be used on a counter or table top. Besides its entertainment functions, the 7-4269 also includes a digital clock, kitchen timer, and an alarm which signals with either a "reminder tone" or by turning on the radio. Price: $99.95.

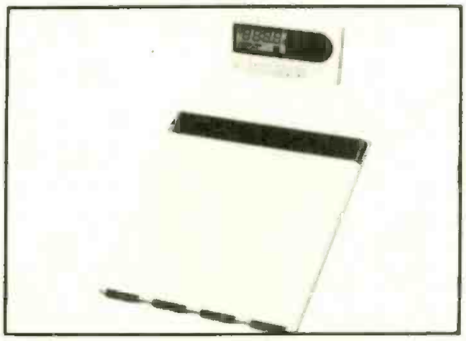


GE Kitchen Entertainment Center

Bits & Pieces

P3 Wrist-Watch Camera

In years past, ads in the backs of comic books often offered tiny cameras for secret picture taking. While we never ordered one, the products always intrigued us. Now a German firm which has just entered the American market, *Personal Protection Products (405 Park Ave., New York, NY 10022)* is offering a **Wrist-Watch Camera** which is a real-life version of those comic book novelties of the past. The fully operational digital watch conceals a miniature 35mm camera inside its case, with the unobtrusive lens mounted above the LCD. Eight exposures can be taken with one cassette of film. The watch itself offers time, calendar, lap and alarm functions. Personal Protection Products aims its line of security, counter-surveillance, communication and investigative equipment at "the security needs of the American business executive." The Wrist-Watch Camera is "one of many unique devices from the P3 catalog." Price: $2,450.



Sharp Electronic Digital Scale

Weight watchers dissatisfied with their present scale may be interested to know that *Sharp Electronics Corp. (Sharp Plaza, Mahwah, NJ 07430)* has entered the market for the first time. The company has introduced three slim-line home scales, including the top-of-the-line PH-430 **Electronic Digital Scale**. The unit is a cordless four-digit LCD with digital clock, calendar, time and alarm functions. Positioned at eye-level, the remote display unit shows time-of-day when the scale isn't in use. Sharp says its "new electronic strain gauge weighing system" assures accuracy and eliminates the bother of resetting the unit to "zero" after each use. The PH-430's most attractive feature, at least for the serious dieter, is a built-in memory which can store "four different weights and offers a comparison function that alerts the user to weight loss or gain." The display "alternately flashes previous and present weights," along with the legends "increase," "stable" or "decrease." Price: $79.95.

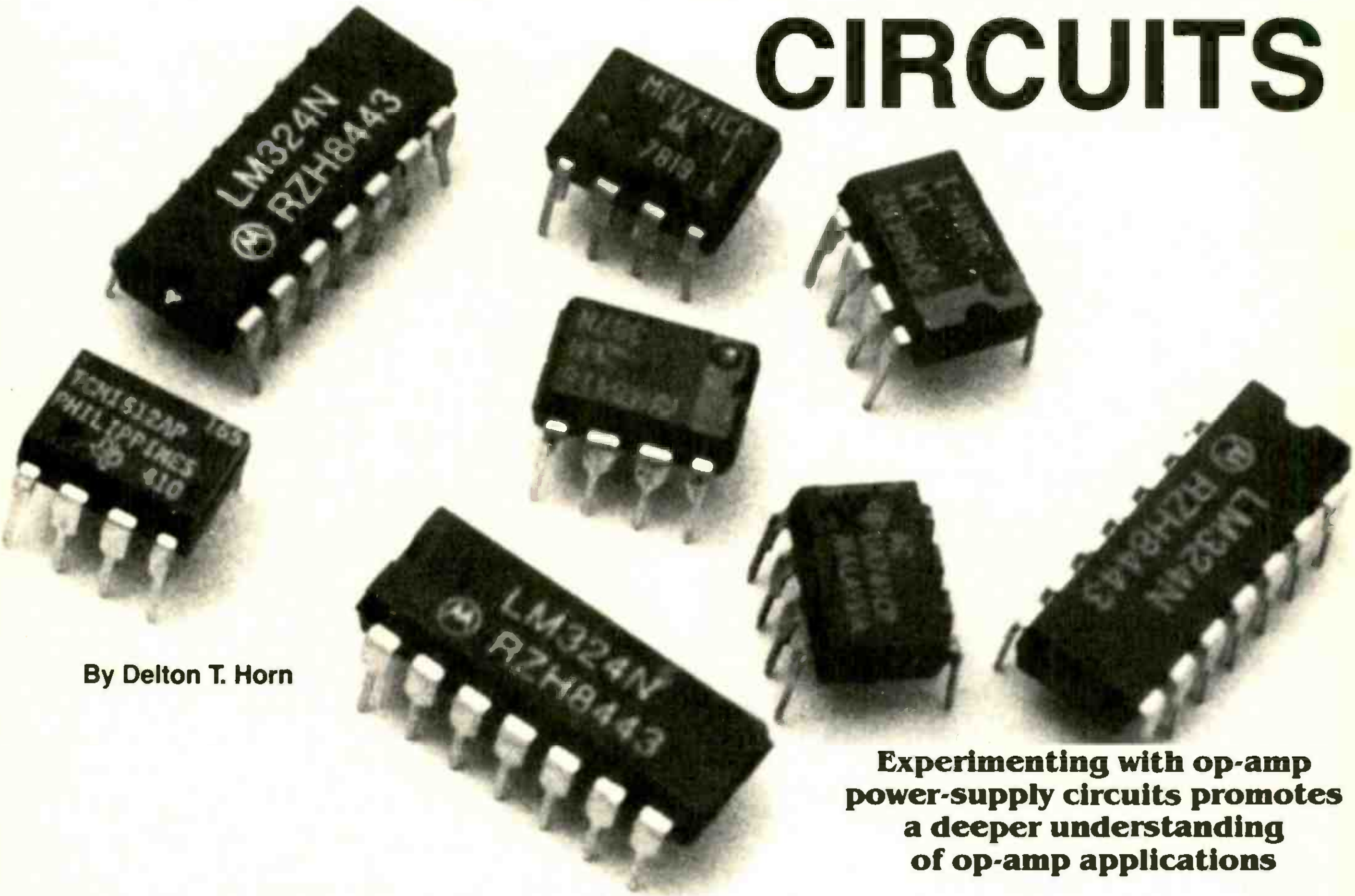
CD Video Disc Cleaner

Announce a new video product and the accessory manufacturers are sure to follow. Although prospects for the new CDV (combining audio and video on a single compact disc) may appear dim, *Discwasher (4309 Transworld Rd., Schiller Park, IL 60176)* didn't hesitate. At this summer's CES, the firm proudly unveiled its **CD Video Disc Cleaner** which uses a "computer-aided design" (no less) to assure "a 'true-radial' cleaning path" so that "the entire surface of the CD is covered." The CDV Video Disc Cleaner uses a special fluid and non-abrasive cleaning pad to "safely remove dust and fingerprints from the disc surface. . . ." Further, the fluid "is totally safe and will not damage the video disc label or surface, prevents dust and dirt from blocking light transmission to the CD player's optical system, therefore eliminating distortions that result in audio drop-out or skips in playback." With the CDV about to be unleashed onto the market, this new Discwasher product appears not a moment too soon. Price: $19.95.

Coming in future issues of GADGET newsletter

- **The "Ultimate Portrait"—Chicago's Holicon has achieved a new level of realism in holography, one which may eventually have important implications for TV, photography and motion pictures. GADGET takes a three-dimensional look into the future.**
- **Precision Workout—Nike calls its new Monitor, "a perfect complement to any fitness program." Besides measuring all sorts of workout variables, the device "talks" to the user.**
- **Good Things in Small Packages—Panasonic's RN-36 Microcassette Recorder is a well-designed, easy-to-use tiny tape recorder. We test the mighty mite and decide that small *is* beautiful.**
- **Photography in the Electronic Era—GADGET tests brand new systems from a trio of well-known camera manufacturers, the Canon Eos 650, The Olympus Infinity and Fuji's HD-M underwater camera.**

USING OP-AMPS IN POWER-SUPPLY CIRCUITS



By Delton T. Horn

Experimenting with op-amp power-supply circuits promotes a deeper understanding of op-amp applications

☐ANYONE WHO READS **Hands-on Electronics** UNDOUBTEDLY knows that the op-amp is one of the most versatile devices in all of electronics. It shows up in countless applications. But there is one application of op-amps that seems to be relatively unfamiliar to most hobbyists and experimenters —the use of op-amps in power-supply circuits.

In this article, we will look at several basic op-amp power-supply circuits, which will be presented primarily as experimental circuits, rather than practical, complete projects. You are strongly encouraged to breadboard and experiment with the circuits yourself, as a way to learn about those versatile globs of silicon. You may even find one or two of them useful in designing your own circuits, or adapting them to your own projects.

No special equipment is needed to build or experiment with any of the circuits: All that's needed is a VOM or DMM and some kind of breadboarding system. If you have an all-in-one designer's breadboard with a built-in power supply, you're practically home free. If not, you can use an inexpensive solderless breadboard and any DC power-supply that can put out about ±9 volts. You might even want to use batteries.

Almost any standard op-amp, such as the 741, may be used in any of the circuits. Although other chips may be used to suit your specific applications, the 741 (which we'll use wherever an op-amp is called for) is cheap enough, so that you can freely experiment with it, without being overly concerned about thermal meltdown. If you blow one, it won't hurt your wallet to simply toss it out and get a new one.

The 741 requires a double-ended (plus and minus) power supply for some of our applications. So if you use the 741, be sure to modify the circuits accordingly. Also, watch out for the pin numbering. Although most op-amp's are pin-compatible with the 741, there are some exceptions.

Basic Voltage Regulator

Figure 1 shows a simple, but effective voltage-regulator circuit built around the 741 op-amp. The op-amp, U1, serves as a reference-voltage source—as set by zener diode D1 and resistor R1—to control the base of Q1 (which, along with

U1, is set up in a feedback-regulator configuration). The reference developed across D1 is fed to the non-inverting input of U1.

At the same time, a voltage (proportional to the output voltage) is tapped off a voltage-divider network, consisting of resistors R2, R3—a 10-turn trimmer potentiometer that's used to calibrate the output voltage—and R4. The 10-turn potentiometer is preferred for the finest adjustment, but an ordinary potentiometer can be used for experimentation or in less-critical applications.

The sampled output voltage taken from the wiper of R3 is fed back into the inverting input of U1. If the voltage appearing at the inverting input equals that at the non-inverting input, the signal at the base of transistor Q1 is $^1/_2V_{in}$. But, if the output voltage is increased or decreased

PARTS LIST FOR THE DUAL-POLARITY VOLTAGE REGULATOR

D1—9.1-volt Zener diode
Q1—TIP3055 or similar NPN silicon transistor (see text)
Q2—MPS2907 or similar PNP silicon transistor (see text)
R1—12,000-ohm, 1/4-watt, 5% resistor
R2, R3—1200-ohm, 1/4-watt, 5% resistor
R4, R6—10,000-ohm, 1/4-watt, 5% resistor
R5, R7—2200-ohm, 1/4-watt, 5% resistor
U1, U2—741 op-amp (or similar), integrated circuit

for any reason, U1's output signal changes, altering the base current to Q1; thereby, maintaining a constant voltage source at the desired level.

With the component values shown (in Fig. 1), the circuit accepts a positive unregulated input of 18 to 20 volts, and provides a well-regulated +9-volt output that's capable of supplying up to 100 mA (0.1A) without any problems. The circuit is not particularly efficient: Half of the input voltage is wasted. And since the full output current passes through Q1, it should be selected accordingly. Once you have the

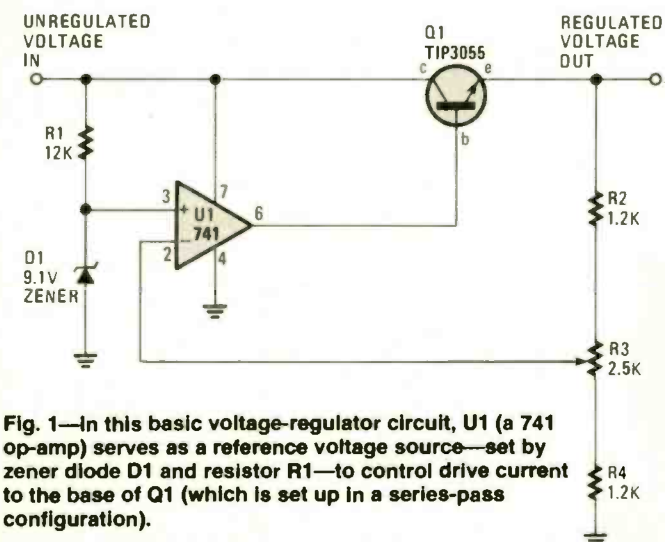


Fig. 1—In this basic voltage-regulator circuit, U1 (a 741 op-amp) serves as a reference voltage source—set by zener diode D1 and resistor R1—to control drive current to the base of Q1 (which is set up in a series-pass configuration).

PARTS LIST FOR THE POSITIVE VOLTAGE REGULATOR

D1—9.1-volt, 1-watt zener diode
Q1—TIP3055 or similar NPN silicon transistor (see text)
R1—12,000-ohm, 1/4-watt, 5% resistor
R2, R4—1200-ohm, 1/4-watt, 5% resistor
R3—2500-ohm, ten-turn trimmer potentiometer
U1—741 op-amp (or similar), integrated circuit

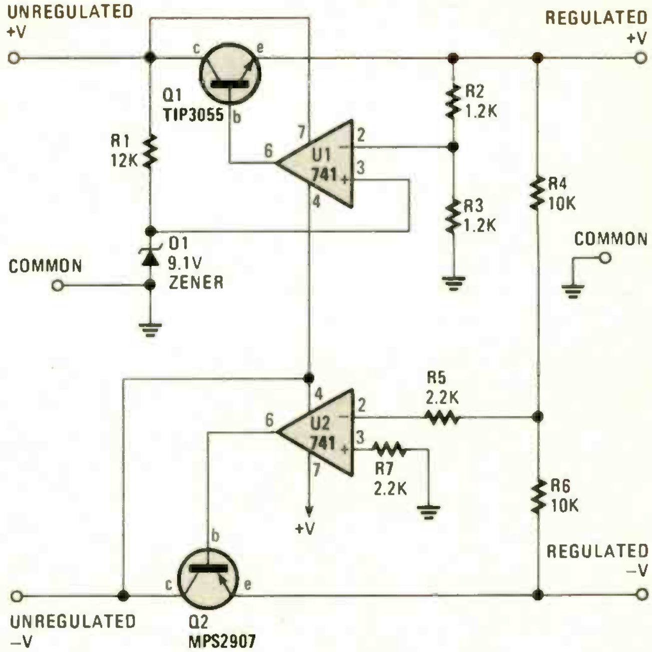


Fig. 2—This circuit is an expansion of the basic regulator circuit, amounting to a dual-polarity, op-amp based, voltage-regulator circuit that's referenced to common ground.

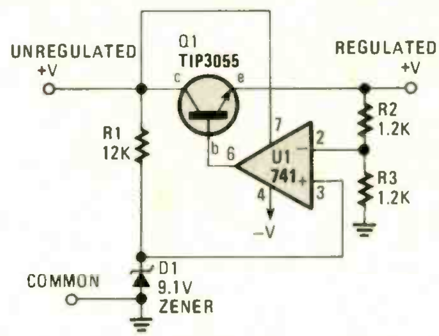


Fig. 3—Transistor Q1 is configured for series-pass operation and is controlled directly by the output of U1. The reference that's applied to the non-inverting input of U1 at pin 3 is determined by resistor R1, and zener diode D1.

have the circuit breadboarded and working, measure the voltage at various points within the circuit, both with and without an output load and adjustment to R3. You might also want to experiment with different values of R1 and D1.

Dual Power Supply

Figure 2 is an expansion of the basic circuit shown in Fig. 1, which amounts to an op-amp based, dual-polarity voltage-regulator circuit that's referenced to common ground. Let's examine the positive portion of the regulator first. The +V regulator circuit (comprised of U1, Q1, D1, R1, R2, and R3) is shown separately in Fig. 3 for convenience.

In Fig. 3. (as in Fig. 1), Q1 is controlled by the output of U1. The reference at the non-inverting input of U1 is determined by resistor R1 and Zener diode D1. A portion of the output voltage is fed back to the op-amp's inverting input through a voltage-divider network made up of resistors R2 and R3. The operation of that circuit is much the same as that of the circuit in Fig. 1.

Now, what about the negative half of the circuit? Actually, the negative voltage regulator is (more or less) a mirror image of the positive regulator with the polarities reversed. To reduce the parts count and to ensure that the dual-polarity outputs are symmetrical, a slight modification to the circuit is in order, as illustrated in Fig. 4 (the negative section of our dual-polarity regulator circuit).

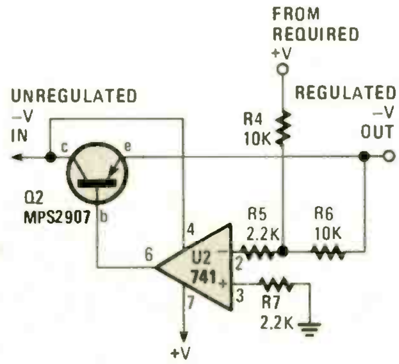


Fig. 4—The negative voltage regulator is (more or less) a mirror image of the positive regulator with polarities reversed. To reduce the parts count and ensure symmetrical dual-polarity outputs, a slight modification to the circuit is necessary.

The negative regulator circuit consists of U2, Q2, R4, R5, R6, and R7. Note that the Zener diode isn't needed to set a reference voltage, because the positive regulated output is used as the reference voltage source for the negative regulator. Also note that Q2 is a PNP transistor to account for the change of polarity. Resistor R7 references the non-inverting input of U2 to ground. Resistors R4 and R6 are equal in value, and for best results, should be matched to minimize differences due to tolerances. You don't need to resort to 1% resistors. The exact value is not as important as close matching between the two resistors.

Because R4 and R6 are equal, the voltage at their junction should be zero if the regulated +V output is equal (except for the inverted polarity) to the regulated –V output. The signal at the R4/R6 junction is fed to the inverting input of U2 through resistor R5. If the two regulated outputs are not equal for any reason (perhaps due to unequal loading), a non-zero signal will appear at the inverting input, causing the U2's output voltage to shift, increasing or decreasing the base current to Q2.

Since +V is regulated by the other half of the circuit, changes in Q2's base current cause it to adjust the –V output in the desired direction. One major advantage of the circuit is that even if the output voltages change momentarily, they'll maintain their symmetrical relationship, because the regulated –V output is referenced to the +V output. Proper symmetry is more important than exact voltage in many circuits, especially those using bipolar op-amps.

The exact component values may vary for specific applications. Experiment to gain familiarity with the circuit. You can try varying the input voltages and the output loads; or experiment with different transistors and resistor values. The exact values of R5 and R7 aren't too important, and changing their values within a reasonable range should have little noticeable affect on the output voltages. You should also try experimenting with different zener diodes (D1).

Voltage regulators are the most obvious power-supply applications, but there are other ways to use op-amps in power-supply circuits.

Voltage/Current Conversion

It is sometimes necessary to convert a current into a voltage, or vice versa—a process that op-amps handle quite well. A simple current-to-voltage converter circuit is illustrated in Fig. 5. If you know anything about op-amps, that circuit should look familiar. The circuit is nothing more than

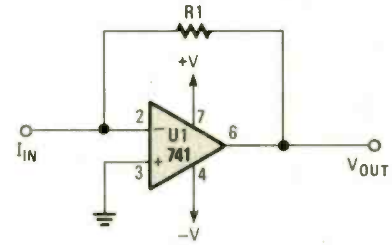


Fig. 5—The current-to-voltage converter is simply an inverting amplifier, minus the input resistor. Output voltage is determined by the input current and feedback resistor.

a simple inverting amplifier, minus an input resistor. The output voltage is determined by the input current and the value of the feedback resistor, and is given by:

$$V_{out} = I \times R1$$

Now, let's say that R1 has a value of 330 ohms, and the input current is 10 mA (0.01A). In this case, the output voltage would be equal to:

$$V_{out} = 0.01 \times 330 = 3.3$$

Raising the input current to 25 mA (0.025A) increases the output voltage:

$$V_{out} = 0.25 \times 330 = 8.25$$

Obviously, the output voltage changes in direct proportion to any changes in the input current. With practical components, the op-amp's input bias current will have an affect on the output. The actual voltage will be equal to the sum of the input and bias currents times the feedback resistance:

$$V_{out} = (I_{in} + I_b) \times R1$$

For obvious reasons, an op-amp with the lowest possible input bias currents should be selected for this application.

Figure 6 shows a circuit for going in the other direction —voltage-to-current conversion. It's typically used to drive relays or analog meters. The feedback resistance is the load being driven, perhaps the coil of the relay or an ammeter. The current flowing through the load is determined by the input voltage and the value of resistor R1, and is given by:

$$I_L = -V_{in}/R1$$

The load current (I_L) is entirely independent of the value of the load resistance, which is usually quite small. A voltage-to-current converter circuit of this type is also known as a transmittance amplifier.

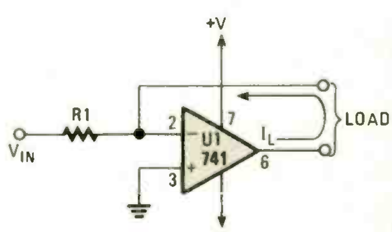


Fig. 6—The voltage-to-current converter—also known as a transmittance amplifier—is typically used to drive relays or analog meters. The load current (I_L) is entirely independent of the load resistance.

The circuit in Fig. 6 uses the inverting input, so the signal polarity is reversed. If that's undesirable in your particular application, the non-inverting, voltage-to-current converter

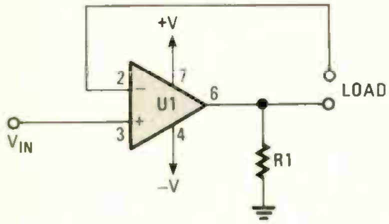


Fig. 7—The non-inverting V-to-C converter is almost identical to the inverting version shown in Fig. 6, other than a simple modification.

shown in Fig. 7 may be used. The load-current equation for the non-inverting version remains unchanged except for the polarity:

$$I_L = V_{in}/R_L$$

Voltage-to-current converters are easy to experiment with. Just connect a milliammeter across the output and watch what happens as the input voltage is varied. You might also want to try using various resistor values for R1. For a practical circuit, just use the equation to find a suitable resistance value for the desired input and output ranges, which is calculated from:

$$R_L = V_{in}/I_L$$

You can also experiment with variable load resistances (R_L). Connect a resistor or potentiometer in series with the meter to raise the load resistance, or in parallel with the meter to lower it.

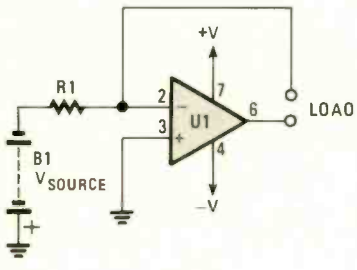
PARTS LIST FOR THE POLARITY SPLITTER

Q1—TIP3055 or similar NPN silicon transistor (see text)
Q2—MPS2907 or similar PNP silicon transistor (see text)
R1, R2—1200-ohm, 1/4-watt, 5% resistor
R3, R4—4700-ohm, 1/4-watt, 5% resistor
U1—741 op-amp (or similar), integrated circuit

Constant Current Source

Some circuit applications require a reference current that does not change with fluctuations in the load. Again the op-amp comes into play. By slightly modifying the basic voltage-to-current converter circuit, we can create a constant-current source, as shown in Fig. 8.

Fig. 8—A constant-current circuit is produced by slightly modifying the basic voltage-to-current converter. The load current (I_L) is determined solely by the input voltage.



The input voltage is a stable DC reference voltage source (shown as a battery in the diagram). As with the conversion circuits discussed above, the load current (I_L) is determined solely by the input voltage (V_{in}) and resistor R1 (R_L has no affect) and is given by:

$$I_L = V_{in}/R1$$

Since both the input voltage and R1 have fixed values in the circuit, I_L also has a constant, unvarying value. Even if the load resistance changes drastically, the current flowing through the load remains virtually unchanged as long as V_{in} and R1 are held constant.

Polarity Splitter

Finally, we will look at an op-amp circuit for splitting a single-ended power supply into a dual-polarity power supply. The value of such a circuit should be obvious to any electronics hobbyist.

The circuit shown in Fig. 9 converts a single-ended power supply into a dual-polarity power source with an artificial (floating) ground. As with any other single-to-dual-polarity converter, the output common (ground) should never be shorted to true Earth ground. That would almost certainly damage the semiconductors in either the converter or load circuit, and it could create a serious shock hazard.

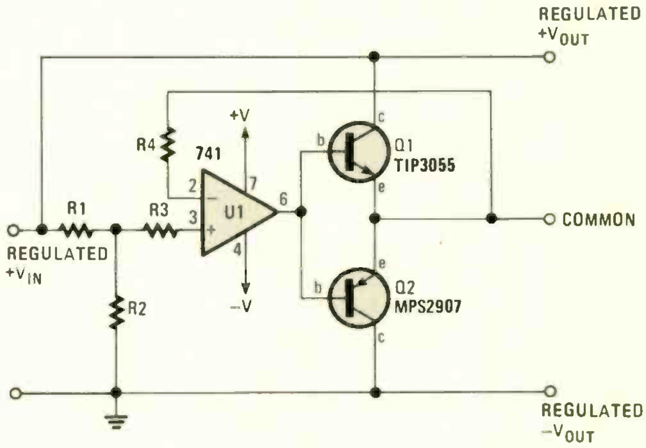


Fig. 9—The polarity splitter allows a single-ended power supply to be used as a dual-polarity power supply, with an artificial (floating) output ground. The artificial ground should never be shorted to true ground to prevent serious shock hazard and certainly damage to semiconductors.

The circuit in Fig. 9 requires a regulated input voltage. You could use an op-amp circuit like the one shown in Fig. 1, or a three-terminal voltage regulator. Since the input voltage is regulated, both halves (positive and negative) of the output will also be automatically regulated without additional circuitry.

Q1 and Q2 are a pair of complementary (opposite polarity, but with the same electrical characteristics) shunt-regulator transistors. They create an artificial ground (sometimes called a floating ground) to be used by the load circuit. Resistor R4 ties the inverting input of U1 to the artificial ground point. The non-inverting input is fed a reference voltage set by a voltage-divider network, consisting of R1 and R2. If the artificial ground level shifts for any reason, U1's output becomes more negative than Q2, causing Q2 to conduct more heavily. On the other hand, if U1's output becomes more positive, Q1 starts to conduct more heavily.

When the output is correctly balanced, the two transistors should conduct equally. The circuit always tries to maintain a balanced condition. The transistors should be selected to dissipate a fairly large amount of power. For the two output voltages to be symmetrical, resistors R1 and R2 should have equal values, and R3 should be equal to R4.

While most electronics hobbyists seldom think of it, the op-amp is quite at home in power-supply circuits. It is truly a general-purpose device. ■

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So don't blow a fuse ... take it easy and enjoy the holidays. Give Christmas gifts of Hands-On Electronics!

By Jack Cunkelman

Fuse Applications and Selection

How often have you wondered if the fuse you are using will save your equipment from the grim reaper?

A FUSE IS, BY DESIGN, THE WEAKEST LINK IN ANY electronic circuit that uses them. When that link lets go and interrupts the supply voltage before the circuit is damaged by an over-current condition, we are given a "second chance". The fault condition is cleared, the fuse is replaced, and life goes on. Circuit designers include fuses in their designs to give us that second chance. (The fact that the Underwriters Laboratories will not allow a manufacturer to sell equipment that does not have some sort of over-current protection may also have something to do with it.)

Consider what happens to a circuit when it is not fused and a fault develops. You might end up with components other than the faulty one destroyed, circuit boards damaged, possibly even a fire caused by overheated components. So the use of some kind of over-current protection is almost mandatory.

At this point it should be acknowledged that a circuit breaker can perform the same duties, but that is another discussion. For now we will concentrate on fuses.

Whether you are buying replacement fuses, or trying to decide what type fuse and fuse rating to use in your next design, a little knowledge of *fuseology* will help, and that is what this article is all about. All fuses have a specific current rating, voltage rating, and fusing characteristic. When those factors are understood and correctly applied the circuit is provided with safe, trouble-free protection.

Physical Size

The fuse industry has always tried to provide some sort of *interlock* so that the correct fuse is always used to replace a blown one. Household screw-in type fuses have a different thread pitch on the base for the various current ratings so only a fuse with the correct current rating can be used. Cartridge-type household fuses come in different lengths and diameters for each current rating. All of that serves to prevent the wrong size (current rating) fuse from being used when replacing a blown fuse. In household applications the fuse size is determined by the gauge of the wire used to wire your house.

The electronics industry developed its own sizing system, although the system actually started with the early automobile industry and the AG series of fuses (AG stands for *A*utomobile *G*lass). The system, however, does not rely on any physical characteristic of the fuse to determine the fuse rating. For example within each series, various amperage ratings are available. Now, care must be taken when replacing fuses to insure you have the correct rating.

Table 1 shows the physical dimensions for the fuses in the AG series along with the range of current ratings that are available. The 3AG series has turned into a sort of generic brand name and is probably the most popular. The major manufacturers however have chosen to apply their own numbers and they are also listed in Table 1. The AB nomenclature indicates that the outer tube of the fuse is made from Bakelite or ceramic materials, and is used where glass type fuses would create a hazard if the glass cartridge should explode.

TABLE 1—FUSE SPECIFICATION CHART

Generic Size	Littlefuse Series	Bussman Series	Characteristics	Amperage Ranges Available
3A (Glass) ¼ × 1¼	312	AGC	Normal Blow	3AG — 1/500 A to 30 A
	313	MDL	Slow Blow	
3AB (Ceramic) ¼ × 1¼	314	ABC	Normal Blow	
	326	MDA	Slow Blow	
5AG (Glass) 13/32 × 1½	KLK	BAF	Normal Blow	1/10 A to 30 A
	FLM	FNM	Slow Blow	
8AG (Glass) ¼ × 1	362	AGX	Normal Blow	
	361	KAW	Fast Blow (Instrument)	1/500 A to 50 A

The Ratings

Stamped on the end cap of the fuse is the voltage and current rating of the fuse. It requires good light and a steady hand to read, but it is usually there. When fuses are discussed the main area of concern is the current rating, yet fuses have voltage ratings; 32, 125, and 250 volts being the most popular ratings. What do they mean? It's the first number we ran into on the end cap.

Fuses are sensitive to changes in current, not voltage. It is not until the fuse element reaches melting temperature and breaks apart that the voltage rating becomes important. The element must be able to break apart cleanly and not continue to arc or, in the worst case, shatter the fuse. The voltage rating stamped on the fuse is the maximum voltage at which the fuse can safely do that. The actual specification reads, for instance, that a 125-volt fuse could safely interrupt a 125-volt, 10000-ampere circuit under a short-circuit fault condition. Fortunately, most of us do not have the kind of power service to test that specification, but the key here is that the fuse used to interrupt a circuit should have a voltage rating equal to or greater than the voltage of the circuit it is protecting. But, you say, " I've seen fuses in the 500-volt supply on my old tube-type TV set—not very safe since the maximum rated fuse I can get is 250 volts." Littlefuse states in their literature - "For secondary-circuit protection where the short-circuit current is known to be not more than 50 amperes, and 10 times the normal load current, fuses rated at 125 and 250 volts may be used at much higher voltage levels." To state it another way: If the short-circuit current will not be excessive, a fuse can be used in a circuit with voltages higher than the fuse rating.

Current Rating

The other number on the fuse cap is the current rating. That rating everybody understands. That is the amount of current that the fuse link can carry almost indefinitely. When the circuit draws more current than the fuse link is rated for, the link melts, the fuse blows and interrupts the supply voltage to the circuit. It's almost that simple, but a few other considerations must enter the mix.

It is considered good practice to only load a fuse to 75% of its current rating. That then takes into account the manufacturing tolerances and eliminates nuisance blowing. Some manufactures derate by as much as 50%. Car radios, for instance, usually draw about 3 or 4 amperes, but are fused at 8 or 10 amps. Under a short-circuit fault condition the fuse will blow, but it will not blow when your favorite song comes on and you *crank it up*.

The ambient temperature also has an effect on the rating. That is shown in Fig. 1. As expected, since the fuse link is a thermal mechanism, as the ambient temperature goes up the fuse must be downrated (i.e. a higher-amperage fuse used). Wide fluctuations in the ambient operating temperature of a piece of gear can cause fuse fatigue and mysterious fuse failures when no fault exists. Fuse fatigue can also be caused by a constant cycling of high currents thru the fuse. Those high currents could very well be normal, but the fuse should be derated to handle that or a different type of fuse used, as we shall see next.

Designers of commercial equipment have taken all of that into consideration, so replacing a fuse in a commercial piece of gear is a matter of replacing a blown fuse with one of equal rating and type.

Fusing Characteristics

The current and voltage rating of a fuse only tell us part of the story. The missing rating is how fast the fuse takes to blow. Since fuses are thermal devices, and thermal characteristics

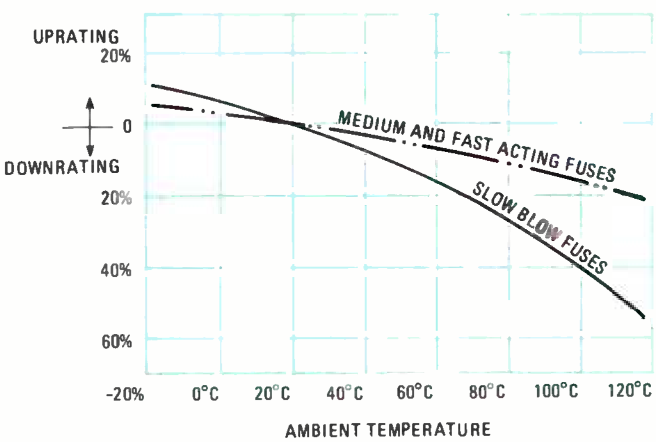


Fig. 1—A most important yet over looked characteristic of fuse operation is the ambient temperature. As you can see, as the temperature increases the rating of a fuse drops.

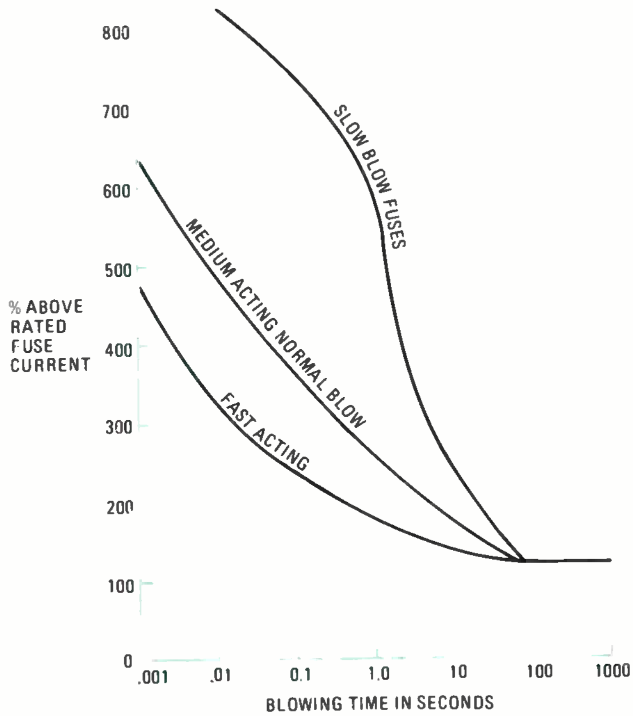


Fig. 2—Sometimes circuits are designed to run "hotter" than they are supposed to for certain applications. For that reason slow-acting fuses are needed since they tolerate overdrawn current for a length of time.

can not change instantaneously, there is a time element involved when discussing fuses.

Generally those time elements are grouped into three categories: fast acting, medium acting, and slow blow. The material used for the fuse link and the construction technique determines what fusing characteristic the fuse will have. A chart showing blowing time vs. current is shown Fig. 2. The proper choice here will also help eliminate nuisance blowing.

The medium acting or normal blow is the most popular and least expensive. The fusible element is made from a medium to high melting temperature material and is made as small as possible to reduce the thermal inertia and speed up the blowing time. There is very little time lag here so circuits that draw high currents when first turned on, will cause that type to blow. That type fuse is typically used in auto applications, smaller appliances, radios, speakers, etc. They can be used very effectively to protect power-supply voltages if placed after the rectifier/filter capacitor assembly. That serves to avoid passing the large surge current that the filter capacitor demands when the circuit is first turned on. That is shown Fig. 3. The transformer rectifier is also protected with a fuse in its primary.

The fast-acting fuse is actually a specially constructed

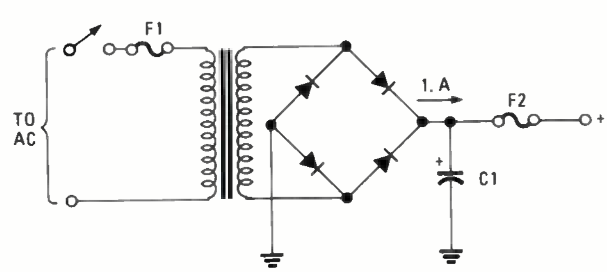


Fig. 3—A medium-acting fuse is used as F2 to provide faster action, while a slow-blow fuse is used as F1 because of the surge current provided to C1 at turn on.

If you look closely at this fuse you can see the spring that keeps the filament in tension. Close inspection of a fuse can often times reveal the source of trouble.

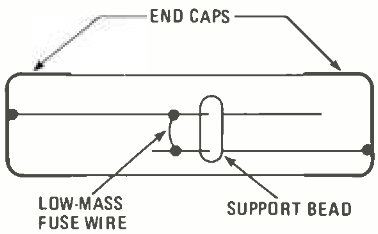


Fig. 4—This is one method of construction used to build a fuse with very-fast blowing characteristics in a 3AG case.

medium-acting fuse. The fuse element is made physically very small so the thermal inertia is very small. Figure 4 shows one method of constructing a fast-acting fuse in standard 3AG series fuse case. Subminiature microfuses and picofuses are usually considered fast acting type fuses because they are physically so small which makes the element small. The fast-acting fuse is used to protect sensitive instruments where even a small amount of overcurrent would damage the device. You are not likely to run across many of those.

The slow-blow or time-delay fuse introduces a special dual construction technique to provide two way protection. Figure 5 illustrates that two way protection. The normal medium-acting link will blow if a short-circuit condition exists. The slow-blow fuse however will stand many current surges and current overloads for a long period of time because of the additional solder junction. The solder joint has a high thermal mass and takes a long time to melt and break loose. A spring attached to the element at the junction assures a clean break when the junction melts. The slow-blow fuse is used in circuits that can tolerate currents 400% above normal for several seconds. They are naturals for use in circuits that have high starting or surge currents such as TV sets, equipment with motors, and high-power audio amplifiers.

The graph in Fig. 2 shows that after 2 minutes or so all the fuse types tend to act the same. The Littlefuse catalog states that both a normal-blow and a slow-blow fuse will blow in 4 hours minimum for a 110% overload and in 1 hour minimum for a 135% overload.

Visual Inspection

Examination of a blown fuse (in the same strong light it took to read the end cap ratings) can tell what circuit condition took the fuse out. A clean break in the fuse element would indicate a simple overload took the fuse out. If the center of the fuse body is coated inside with the metal from the link chances are that a high current short exists that vaporized the fuse element. In low-current fuses, where the fuse element is very thin, sometimes only a quick check with an ohmmeter will tell if the fuse is blown or not. Sometimes a fuse will visually check out okay, but measure open on an ohmmeter. Chances are that the fuse link separated at the joint with the end cap. That is usually a fuse fatigue type of failure and, chances are it was not caused by the circuit it is protecting.

Fuse Holders

It is important that good contact between the fuse and the fuse holder be maintained. The use of spring-temper berylium/copper/silver-plated clips and holders is a must if the currents are above 5 amps. Heating at the fuseholder because of poor contact with the fuse will shorten fuse life. Be sure to remove the fuse from the holder when soldering the wires to the holder to avoid unnecessary heating of the fuse itself.

Home-Brew Projects

The most common use of fuses is in the primary of the power supply of many of our home-built projects. That keeps the house from burning down when one of our pet designs decides it's time to see how fast it can make the power meter spin. Figure 3 is a typical power-transformer wiring diagram. The fuse can be calculated by using the formula:

$$I(fuse) = .013 \times I_o \times V_s$$

where: I_o is the secondary output current: and V_s is the secondary voltage.

Assume that we have a 18-volt transformer that we will be drawing 1 amp from:

$$I(fuse) = .013 \times 1 \times 18 = .234$$

So use a 250 mA fuse.

That assumes a slow-blow type fuse is used. If a regular-blow fuse is used, the rating will have to be increased slightly to prevent the fuse from blowing from the surge of the initial turn on.

Always remember that the fuse in a piece of equipment was put there to protect it and you. Bypassing it or oversizing the fuse may cause another component to fail and that may be more costly than the 50 cents for the correct fuse. ■

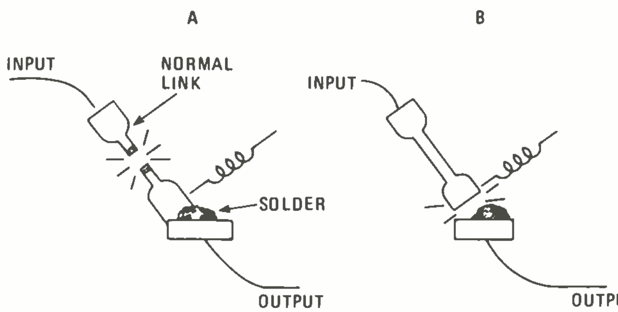
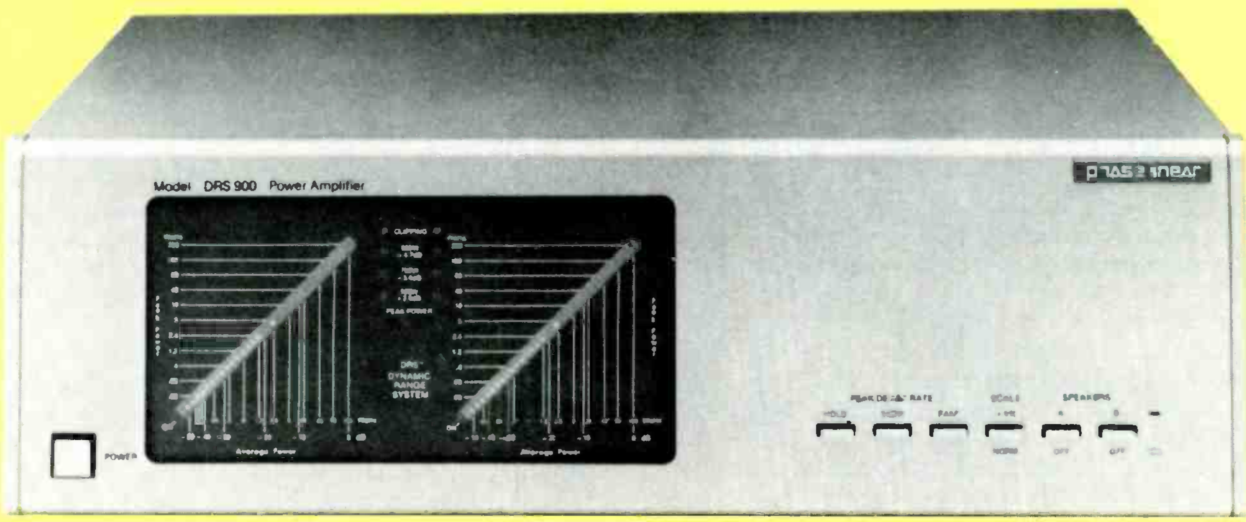


Fig. 5—A dual-action, slow-blow fuse blows in one of two modes: either the link melts under short-circuit conditions (A), or the solder blob melts due to continuous overload.

SERVICING AUDIO AMPLIFIERS



You don't have to be an audio-service technician to troubleshoot and repair malfunctioning audio amplifiers

By Homer L. Davidson

SERVICING HIGH-WATTAGE AMPLIFIERS ISN'T AS DIFFICULT AS ONE might think. Don't let the various components on the printed-circuit board intimidate you; nor should you be dissuaded by expensive test instruments. They're not really a necessity. If you check the right area and know what to look for, you can locate the most-difficult audio problem with nothing more than a pocket VOM or DMM. That's because the symptoms displayed by the amplifier are like a road map. And by following things through, you're bound to get to the root of the problem.

An Ounce of Prevention

As when attempting any repair, it is wise to take a few moments to institute some precautions in preparation of the task at hand. For example, always keep the volume down when making critical voltage measurements. Be extremely careful in measuring voltage on the power-output transistors and IC's, so as not to short out any of the elements.

Be sure to load the speaker terminals: Simply attach a couple of resistors—10- or 20-ohm, 10-watt units—to the speaker terminals as shown in Fig. 1. And let's not forget to remove the power cord from the AC outlet or, at the very least, turn-off the power switch (preferably both) when taking resistance measurements. In addition, when making in-circuit resistance measurements it's necessary to discharge the filter capacitors (by shorting them to ground). If your ohmmeter is connected across a resistor in the circuit while

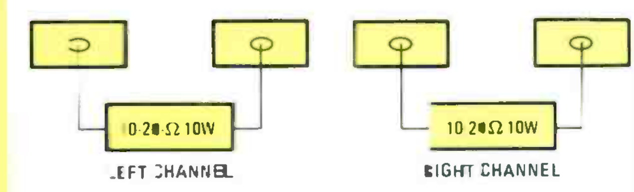
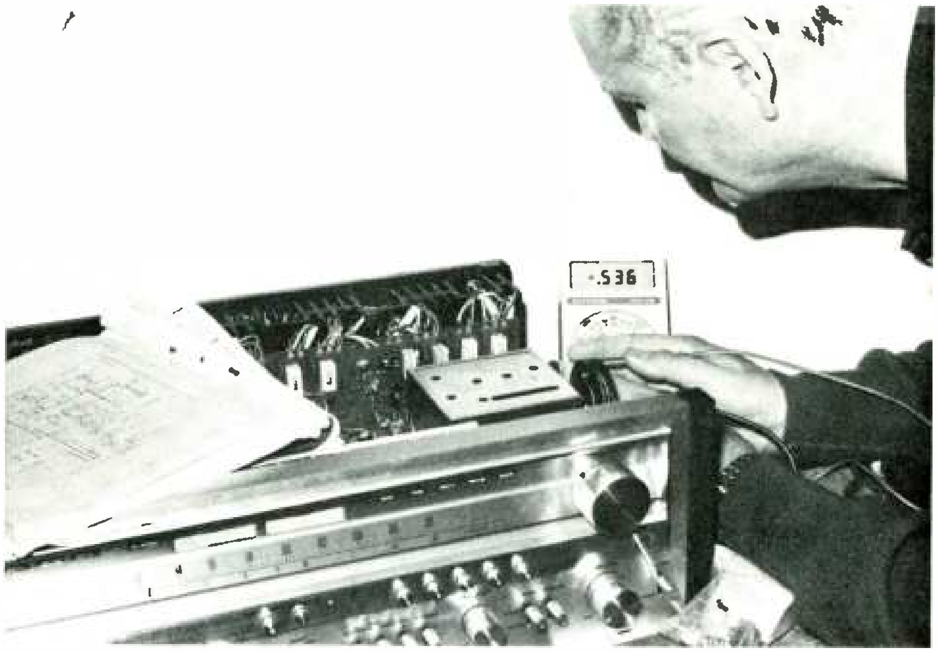


Fig. 1—Always load the speaker terminals with 10- or 20-ohm, 10-watt resistors while servicing high-powered amplifiers. When a high DC voltage is found at the speaker terminal, turn the volume all the way down and do not connect resistor or speaker to the defective channel. Doing so might cause further damage to the amplifier, or destroy the speaker.

The electronic technician is checking bias diodes and output transistors (using the diode test setting of his DMM to make junction transistor measurements) in an attempt to eliminate excessive distortion and hum in a Pioneer model SX-950.



the capacitor is still "loaded," you may damage the meter. I once slapped my digital multimeter (set to read resistance) across a resistor that was near a charged filter capacitor. And what I ended up with is an expensive continuity checker —need I say more?

Relay Problems

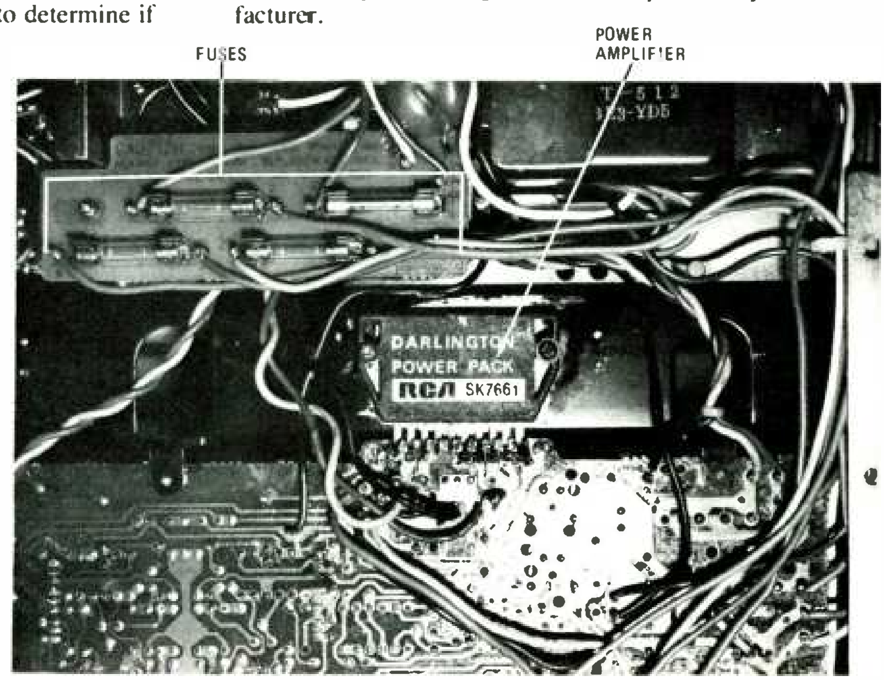
You may find a small relay in the power-supply that channels power to the amplifier circuits. The relay is part of a delay circuit, which provides protection for the power-supply components. Often, you can hear the relay—which might be controlled by power line, DC source, or a transistor —energize when the off/on switch is flipped.

If the unit contains a relay, check to see if the relay contacts close with the wiper (top metal contact) pulled downward. Energize the amplifier, and make a voltage measurement at the output of the transistors or IC's to determine if voltage is present. Low or no voltage at the outputs may indicate poor or open relay contacts, when supply voltage is normal.

The relay can be closed by pushing down on the metal contact with a pencil eraser, and held closed by placing a piece of cardboard between the metal frame and contact assembly. If the contacts close, but the amplifier still doesn't work, inspect the relay contacts and clean them up with a piece of emery board or a finger nail file.

Check the relay's coil windings and control circuits if the amplifier lights up, but does not operate with the application of power. Measure the resistance of the coil winding with an ohmmeter, and replace the relay if the coil winding is open. If the coil is normal, check the bias on the transistors and/or supply voltage to the IC's.

Usually, a leaky or open transistor (like that indicated in Fig. 2) prevents the relay from operating. Make voltage and resistance measurements on the suspected component, noting whether your readings match those specified by the manufacturer.



When attempting to repair stereo amplifiers, note whether each channel is protected by separate fuses. Check speaker fuses when one channel has no output. Suspect a leaky output transistor or IC when a line fuse constantly blows.

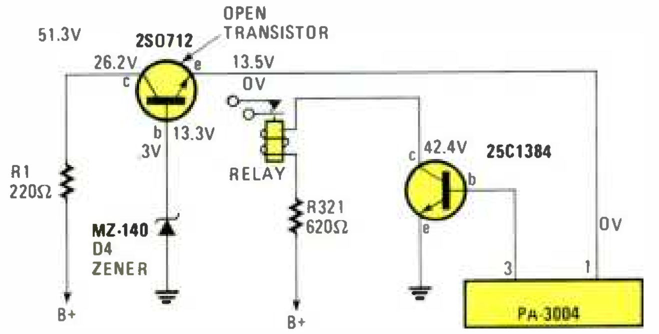


Fig. 2—The relay malfunction may be caused by dirty contacts or an open coil winding. Check transistor and IC-controlled components when the relay itself is operating normally. Should a transistor open up, intermittent operation would result.

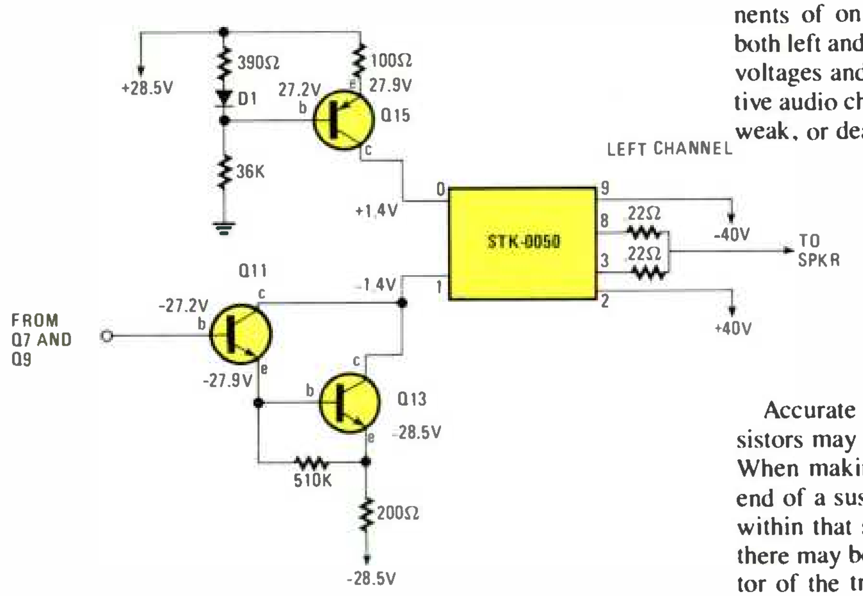
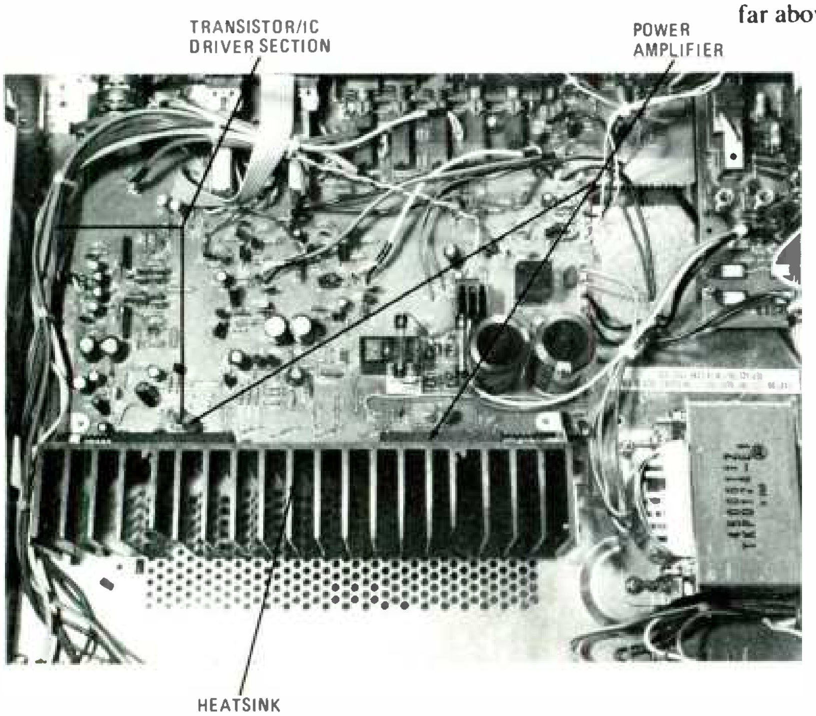


Fig. 3—High B positive and negative voltages are found in high-powered amplifiers. Three or four voltage levels may be fed to high-powered amplifier circuits.



Transistors may be checked in seconds with the diode/transistor test of the DMM. During replacement, put silicone grease on the tabs of transistors or IC's.

Voltage and Resistance Measurements

Most audio transistors and IC's are contained in directly-coupled (DC) circuits. The collector or emitter terminals of a driver transistor may be tied directly to the the output device—another transistor or an IC, as shown in Fig. 3. With a leaky or open transistor, the voltages may be incorrect on the transistors or IC's in that audio channel.

First, make in-circuit transistor tests with the diode/transistor test of the DMM or a transistor tester. A defective IC may be located by using voltage and resistance measurements or through audio signal-tracing methods. Now, take critical voltage and resistance measurements to help locate the defective component.

Always have the correct schematic handy before trying to take critical voltage measurements. It is difficult to take accurate voltage and resistance measurements without a diagram. You may find operating voltages listed on components of only one audio channel of the schematic. Since both left and right channels are identical, the normal channel voltages and components may be compared with the defective audio channel. Improper voltages may cause distortion, weak, or dead conditions in the amplifier circuits.

Accurate resistance measurements of bias and emitter resistors may help to locate a dead, weak, or distorted stage. When making such measurements, it's best to remove one end of a suspected resistor. In that way, other components within that stage will not distort the reading. For instance, there may be another resistor series-connected in the collector of the transistor, which would drive the meter reading far above the actual value of the resistance being measured.

Resistance measurements from each transistor or IC terminal to common ground may help to locate the defective stage. Always, compare each resis-

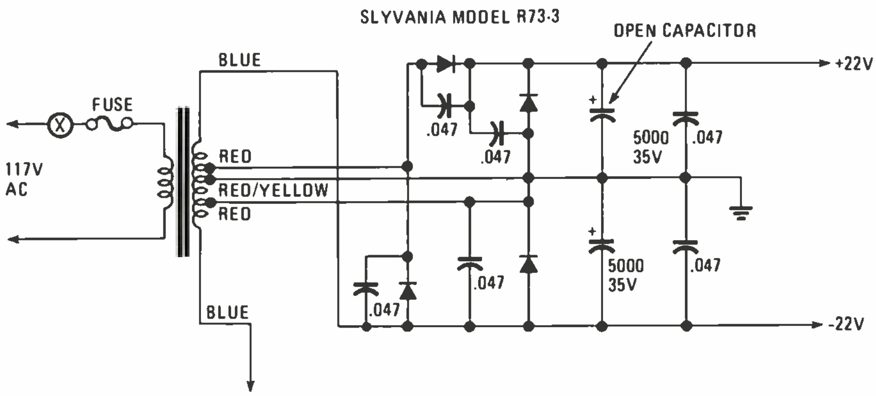


Fig. 4—Excessive hum may be caused by large filter or decoupling capacitors within the low-voltage power supply that may have opened up, or deteriorated. Hum and distortion may result from leaky output transistors or IC components.

tance measurement to the same point in the normal channel.

Blown Fuses

If the fuses in the amplifier continually blow at power up, the first step is to determine which one opens up. Large amplifiers may have separate fuses for power lines, each stereo channel, or speakers, or maybe all three. Suspect a leaky or shorted component in the low-voltage, power-supply or output circuits when the AC power-line fuse keeps blowing. Check the output transistor or IC when the fuse will not hold in a certain stereo channel. Too much volume or DC voltage applied to the speaker fuse may cause the fuse to open up.

Remove the fuses or disconnect the power source from the power-output components when the power line fuse fails. Check each diode (or the bridge rectifier) in the low-voltage power supply for leakage with the diode test of the DMM, again freeing one end of the unit before testing.

Take a resistance measurement across the main filter capacitor to determine if the capacitor or connecting circuits are leaky. Do not overlook a shorted power transformer. Unsolder the secondary leads of the transformer from the circuit for leakage tests. If the fuse opens or transformer appears hot with the secondary wires removed, suspect a shorted transformer. Go directly to the output transistors and IC components and test for leakage when the power supply is overloaded or the channel fuse opens up.

Excessive Hum

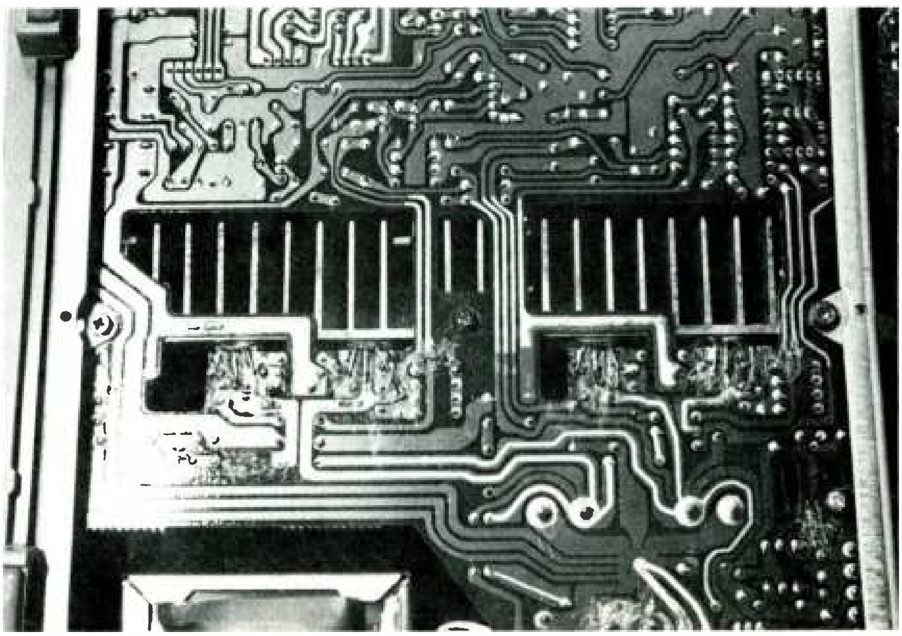
Suspect the main filter capacitor when excessive hum is present in both speakers. A real loud or floating buzz may be caused by a dried-out filter or decoupling capacitor in the low-voltage, power-supply circuit (see Fig. 4). Test for leaky transistors or IC components, and open or burned output bias resistors, when hum and distortion are found in one speaker. Shunt each filter capacitor with the same capacity and voltage with clip wires and the power turned off.

Although most high-powered amplifiers have a separate power IC in each channel, suspect a leaky common power IC when both speakers contain hum and distortion. Hum may be caused in one stereo channel by an oxidized, variable bias-resistor. Slightly rotate the bias resistor and notice if the hum disappears. Spray the resistor with cleaning fluid and return it to it's original position.

Use the other channel for comparison tests when either the right or left channel is dead, weak, or distorted. The dead channel is much easier to locate than a weak stereo channel. Quickly, test each transistor and IC. Now, compare them with the schematic and the good channel. Often, transistor and IC component tests with accurate voltage measurements will locate the defective component.

Single Channel Distortion

Excessive distortion is usually caused by problems in the audio-output circuits. Switch the two speakers to determine whether the speaker or the channel to which it is connected is defective. Take voltage readings of the defective channel and compare your findings to the voltage readings of the normal one.



Bare tie-bar wires may be used on the top of the circuit board to hold the wires together. Inspect and solder tie wires when intermittent and/or DC circuits are encountered.

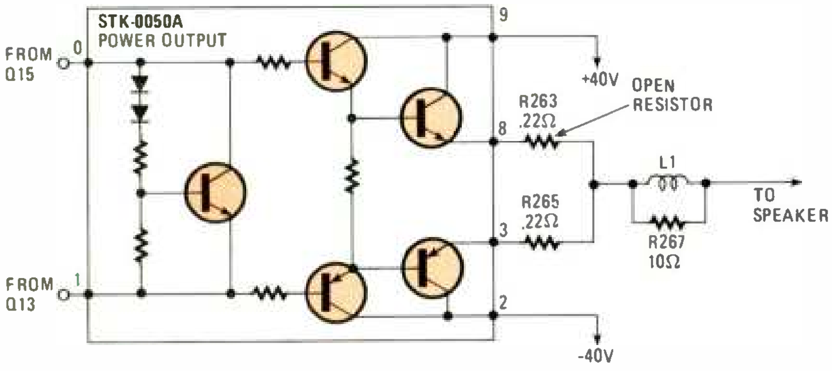


Fig. 5—Check the base/emitter-bias circuits for open or burned resistors in the power output (IC and transistors) section of the amplifier when the output audio is weak and distorted. The open-resistor (R263 shown here) in the power output circuit (from a Pioneer model SX-780) caused excessive distortion.

After locating an open or leaky transistor or IC, check each bias resistor. It's best to check bias resistors while the suspected transistor is out of the circuit. Often, the shorted or leaky transistor may cause the bias resistors to open or burn. An extremely warm transistor or IC may indicate that the component is leaky. Take resistance measurements right across each bias resistor or from one point to common ground (Fig. 5). If both channels are distorted, check the low-voltage power supply, and also check the semiconductors in each channel.

Damaged Speakers

Speakers may be damaged by excessive power or improper speaker matching. Many expensive speaker systems can be damaged by excessively high volume (at or near maximum) or when high-wattage amplifiers are connected to low-wattage speakers. A mid-range speaker or woofer may be damaged by a defective direct-coupled amplifier, because there is no blocking capacitor to prevent the DC component of the audio signal from reaching the speaker.

Suspect too much power has been applied to the speaker when the voice coil is blown loose or frozen against the center magnet. The voice coil can be zapped if a DC voltage is applied to the speaker terminals. Always check for DC at the speaker terminals before replacing a speaker. (It makes no sense to correct the symptom and neglect the cause.)

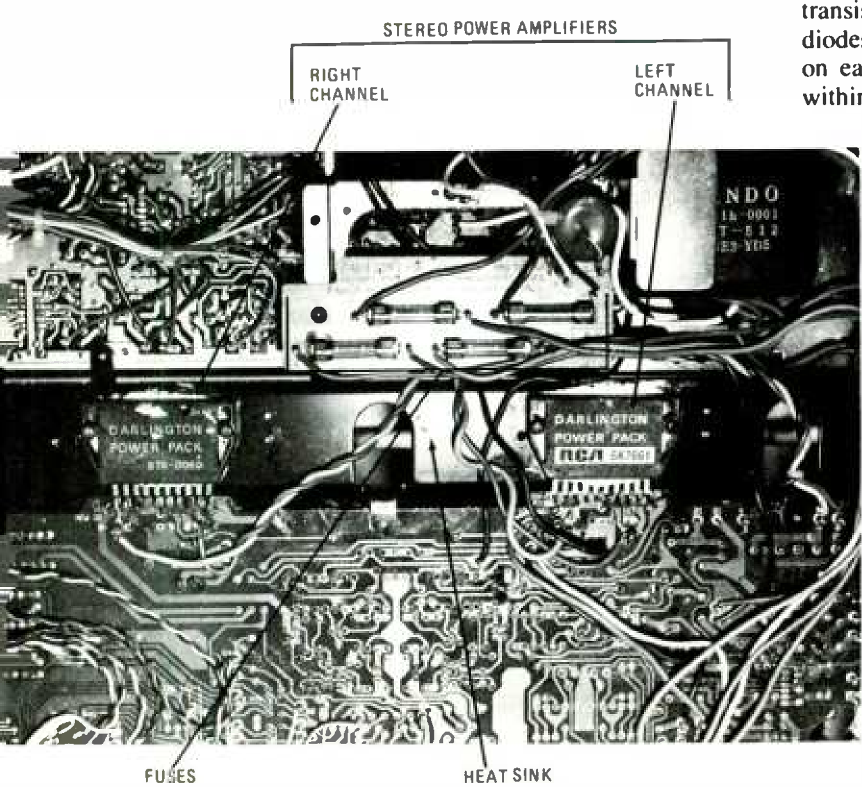
Servicing DC Circuits

Although most speakers are fuse protected, DC voltage found at the speaker terminals may destroy the voice coil. With a 10- or 20-ohm resistor connected across the speaker terminals to simulate the loading effects of a speaker, test for DC voltage at the speaker terminals. The audio output circuits are unbalanced when a high DC voltage is found at the speaker terminals. With normal DC circuits, the voltage is zero at the speaker terminals.

Lower the volume control to zero and keep the 20-ohm resistor connected to the speaker terminals when one channel has high DC voltage at the speaker terminals. Notice if the output transistors or IC's become extremely warm in the defective channel after five minutes of operation.

Next, test each transistor (out of circuit) for leakage or open conditions in the output circuits (see Fig. 6). Replace transistors and IC's that appear excessively warm. While the transistors are out of the circuit, check the bias resistors and diodes with the DMM. Take critical voltage measurements on each transistor and IC. Check each lead and tie wire within the circuit for normal continuity with the low-ohm scale of the DMM. Burned resistors or leaky transistors and IC's can cause numerous DC circuit failures.

Make sure that all voltages of the negative and positive sources are normal. Remember, a broken



Critical voltages on the suspected power IC may indicate a leaky IC component or unbalanced DC circuit. Interchange the two output IC components in both channels to see if it is defective when you do not have a replacement on hand.

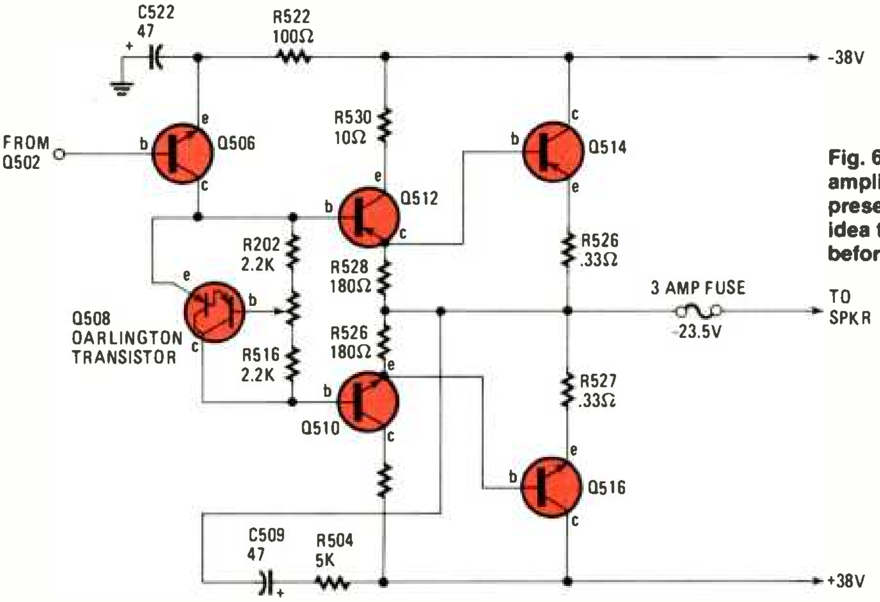


Fig. 6—Any defective component within the DC-amplifier circuits can result in a high DC-voltage presence at the speaker terminals. It's a good idea to check the speaker terminals for DC voltage before connecting a replacement speaker.

printed-circuit trace or poorly soldered connection may cause an imbalance in the amplifier's output at the speaker terminal. Sometimes, the voltage may leak through a good transistor, causing operating voltage to be only a few volts lower than normal. Double check the wiring with the low-resistance scale of the DMM.

Ground Connections

Poor ground connections may cause dead, intermittent and hum pickup noises. Motorboating (a rapid "put-put" sound) may result from poor ground connections in the base circuit of a driver transistor. Improper voltage on the transistors or IC terminal may be caused by faulty ground connections. Improper ground connections in the DC amplifier circuits may place a high DC voltage at the speaker terminals.

Check the circuit for proper ground connections. Most amplifiers use the chassis as common ground, while others may not be grounded to the chassis. Make sure all voltages are taken from a common grounded source. Always, replace metal shields taken from over the amplifier components.

Poor Tie Bars

In many amplifier and TV chassis, wire tie bars or short pieces of wire may connect the printed-circuit wiring together from the top side of the chassis. A poorly-soldered connection at either end of the wiring can result (and often does) in a dead, intermittent, or distorted audio channel.

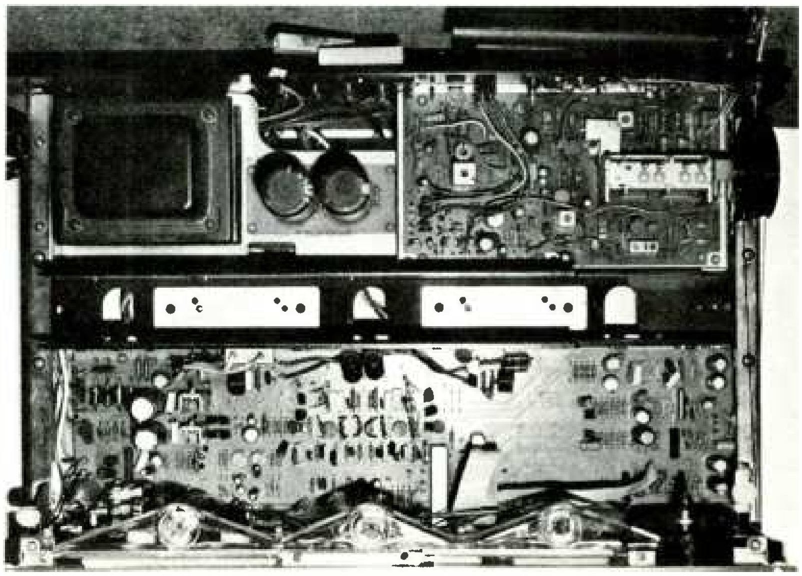
The improper connection of tie-wires in the B voltage source, feeding the various transistors, may cause high voltage at the speaker terminals in a direct-coupled circuit.

Look for a tie wire mounted high at one end. Then check under the chassis for poor solder connections. Check the continuity of the tie wire on the copper side of the board. A poorly soldered tie wire may show a low resistance or open connection. It's wise to automatically touch up the soldering of all tie-wire connections in the intermittent chassis.

Make sure you are in the correct channel when servicing a defective stereo amplifier. Most large amplifiers are laid out with the left channel on the left when facing the amplifier from the front side. Mark the correct terminals of transistors and IC components on the wiring side if not identified.

Darlington transistors may be checked in the same way as any transistor. Individually check each transistor within the same envelope. Be careful when checking voltages on the transistor or IC terminals, so as not to short out an adjacent terminal. Clean out the solder and rosin residue between the soldered terminals with a pocket knife after replacing a defective component; clean the terminals with cleaning fluid and an old tooth brush.

After terminal cleanup, take a low resistance measurement between the transistor or IC terminals. If a short exists, remove the excess solder and take another measurement. Double check each transistor or IC terminal with a resistance measurement to common ground and compare your readings with the good channel. You may locate poorly soldered and shorted connections, open bias resistors and defective new components with resistance measurements after IC or transistor replacement. ■

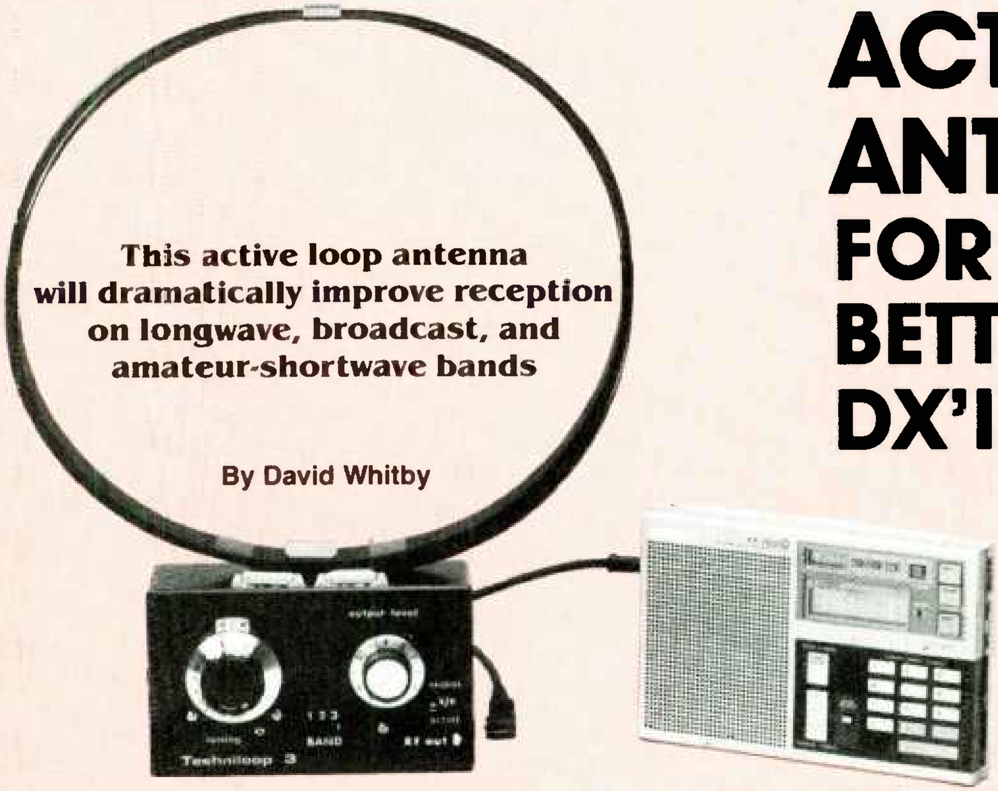


Locate the amplifier's defective channel before testing. In many large amplifiers, the transistors and IC's are layed out in-line when the amplifier is viewed from the front.

ACTIVE ANTENNA FOR BETTER DX'ING

This active loop antenna will dramatically improve reception on longwave, broadcast, and amateur-shortwave bands

By David Whitby



□THE LOOP ANTENNA HAS BEEN AROUND FOR A LONG TIME now. In fact it was one of the earliest forms of receiver antenna used way back in the wireless days.

Over the years loops have been made in various shapes and sizes, the larger ones usually being made in the form of a spiral or solenoid coil wound on a wooden cross or box frame as shown in Fig. 1.

At one time most portable and many domestic sets contained a built-in loop antenna. The introduction of the ferrite-rod, or *loopstick* antenna, as it was first known, soon displaced the loop in portable and domestic radio sets.

The reason for that is not because the ferrite rod was necessarily a better signal-capturing device, but that it was smaller in size and easier to mass-produce.

It can be readily demonstrated that the signal capture of a ferrite rod is approximately equal to that of a loop antenna with a diameter equal to the ferrite rod's length. Thus, an average ferrite rod of say 150-mm length will provide about the same signal to the receiver as a loop antenna with a diameter around 150 mm.

Given that loop-antenna signal pickup is proportional to the square of the diameter, it is easy to see that it does not take a giant loop to outperform even the very largest available ferrite rod.

Added to this, the loop has better efficiency at higher frequencies than the standard ferrite rod, which exhibits increasing losses above 2 to 3 MHz.

The loop antenna is usually tuned by a variable capacitor and its output coupled directly, or inductively, by a second small winding, into the receiver input.

This article originally appeared in Electronics Australia in December of 1986. It has been updated to include changes in pricing of the kits.

The main advantage of a loop antenna over the traditional long wire, is a marked reduction in noise pickup. That reduction is due to the fact that a loop can be tuned. Also, it is directional, and smaller in size. A long wire may pick up more signal, but readability may be worse, especially on weak signals due to broadband noise.

An improvement in signal/noise ratio is the loop's greatest benefit, along with greater selectivity due to the fact that the loop is tuned to the frequency being received.

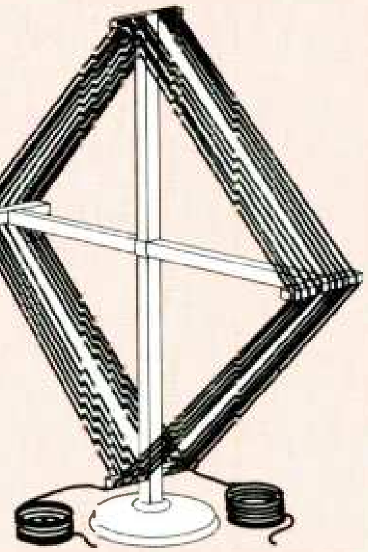


Fig. 1—The conventional loop antenna was large and unsightly. With the advent of the transistor age, miniaturization became all the rage, so the solid core antenna was born putting the air core on the shelf.

Despite its benefits the loop antenna has tended to remain fairly obscure. The reason for this is the cost and difficulty of mass producing wooden frames and coils under tension, and the generally cumbersome and not too attractive appearance of the device.

The Techniloop was designed to overcome those problems. The result is an easy-to-build, efficient loop, that is also reasonably attractive.

Description

As can be seen from the photos, the wooden frame has been eliminated. That is made possible by the use of flat, 16-wire, ribbon cable as the winding of the loop coil.

The coil is formed by connecting the ends of the length of cable back into the starts. That is done by terminating both ends of the cable via IDC (insulation displacement connector) plugs and sockets on a printed circuit which cross-connects the cable ends.

A 3-position, 6-pole switch on the PCB allows three series/parallel cross-coupling combinations to give all, half, or a quarter the number of turns while always using all the wire for maximum efficiency.

The 16-way cable is connected as 8-way cable by paralleling to increase the coil Q and to simplify the PCB track layout. There are actually seven pairs and one single wire used in the main loop, with the remaining single wire being used as the low-impedance, output-coupling turn in the passive loop mode.

The flat cable coil is supported by a 30-mm wide strip of black fiber material formed into a circle. The cable is fastened to it using black plastic tape. That forms a self-supporting, circular loop which is still fairly light.

The loop may be easily plugged (and unplugged) into the housing and is clamped by a right-angle bracket which, in turn, is secured by a thumbscrew on the back of the case.

The printed-circuit board carrying the connectors for the loop, the tuning capacitor, output control, and switches is fastened to the lid of the box which forms the front panel of the unit.

The front panel is silk-screened and carries a precision vernier dial for tuning, a 0-10 indicator output level knob, a 3-position band switch, and a 3-position function switch. A coaxial output socket is mounted on the PCB and protrudes through a hole machined in the side of the case.

How It Works

Figure 2 shows the full circuit diagram. As can be seen, the coil is divided into four equal windings of two turns and one winding of one turn.

Note that there are two turns for each single layer of cable. Where more than one layer of cable is used, the two turns and one turn are multiplied by the number of layers of cable.

Inductors L1 through L4 may be connected in three different configurations by 3-position band switch S1 to give three different inductance values and hence three different tuning ranges. Those are: Band 1 with L1–L4 in series; 8 turns/layer; the highest inductance; and lowest frequency range. Band 2 with L1–L2 in parallel, L3–L4 in parallel, and the two parallel combinations in series; 4 turns/layer; medium inductance; and a medium frequency range. Band 3 with L1-L4 in parallel; 2 turns/layer; lowest inductance; and highest frequency range.

That method provides three inductance values from the coil and always uses all the wire. There are no dead-end turns to absorb energy as with a tapped-coil system.

As distinct from four separate windings, L1–L4 are arranged in a *quadrifilar* pattern. That means that the first four wires at one end of the cable are the L1–L4 *beginnings* and the last four wires at the other end of the cable are the L1–L4 *ends*.

The remaining four wires on either end of the cable are cross-coupled on the PCB to give the two turns per coil (for each cable loop) and the middle strands are routed via band switch S1 (3-pole, 6-position) to give the three different series/parallel turns arrangements previously discussed.

The quadrifilar arrangement of the windings was chosen by experiment. It had little loss and high Q at the high frequencies.

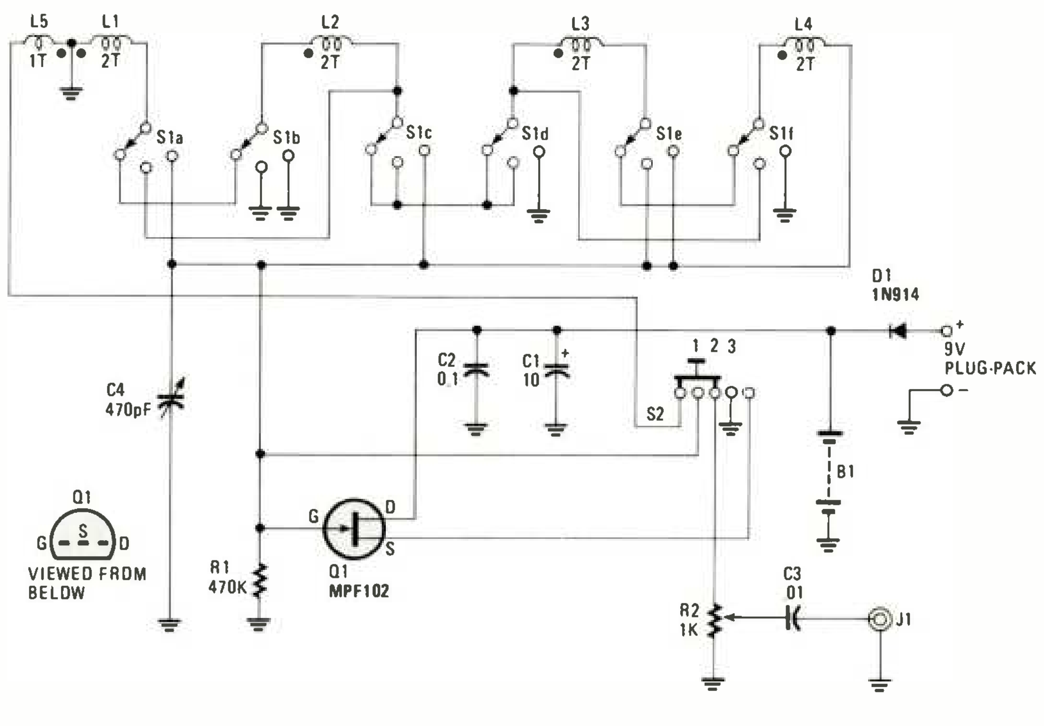


Fig. 2—The circuit uses a FET buffer amplifier (Q1) to provide amplification with high input impedance. The output level control R2 can be used to adjust the output gain so as not to strain your radios AGC on large signals.

Inductor L5 is a single turn (per layer of cable) which is used to provide a low-impedance output in the passive-loop mode. The loop is tuned by C4 which is a polycon variable capacitor.

Most of the small polycons have maximum capacities of around 160pF (antenna section) and 60pF (oscillator section), totaling only 220pF with both sections in parallel. The capacitor used in the Techniloop has a maximum value of 470pF and has been obtained specially for the project.

Unfortunately, the more common, smaller units just do not give enough tuning range for overlap between the three bands for any given loop size.

The Active Circuit

Passive operation (S2 in position 1) gives good results under most conditions and uses no battery or other power. However, for best performance a JFET buffer amplifier is included.

That is simply a source follower which buffers the loop and allows close to the full unloaded-loop output to be delivered into a typical, low-impedance receiver input. Buffering the coil in this way also significantly increases the selectivity.

The effective power gain provided by the buffer is very useful, especially for DX (long distance) work with very weak signals.

Output-Level Control

An output control is used to adjust the loop output in both the passive and active modes, and has proven indispensable in practice.

The AGC (automatic gain control) action of most good receivers tends to mask the tuning and directional maxima of the loop signal by compensating for a wide range of input levels. That is where the level control helps. By initially adjusting the signal to just below the AGC threshold (so that the signal is just audible), both the tuning and the direction of the loop may be accurately adjusted for maximum performance.

After that, it's simply a matter of bringing the output level back up again to apply the full signal to the receiver input.

In cases of very-high field strengths the loop output may also be reduced to prevent receiver overload.

Position 2 of S2 shorts the loop to prevent damage to the FET when the loop is placed in close proximity to a transmitter (as, when the loop is used as the receiving antenna in an amateur station). A relay could be used to perform the same function automatically during transmission if desired.

Power

Power for the JFET buffer is provided either from a 9-volt battery or main power pack. Consumption is 2 to 3.5mA at 9 volts. The power is switched on when the loop is placed in the active mode and off in the passive mode or the short-circuit position. Note that diode D1 is included in the power-pack circuit to prevent damage due to accidental polarity reversal.

Construction

The kit is supplied ready to assemble and no drilling or panel cutting is required. However, if you would rather create your own circuit board, a foil pattern is given in Fig. 3.

Once you have a circuit board, the first job is to fit the components to the printed circuit board as shown in Fig. 4. Fit the components to the top side of the board first. That done, fasten the connectors with the screws provided and insert the switches, making sure that they are pushed right in before soldering.

The tuning capacitor and output-level potentiometer are installed on the track side. Bend the potentiometer lugs 90° towards the shaft before installing it on the board. The tuning capacitor should be secured using the two screws supplied.

The coax output socket is installed directly on the PCB. Locate the central lug squarely over its PCB track and solder it to the board along with the two small outer tags.

Next, anchor the 9-volt battery snap leads through the hole provided near the edge of the board and solder them to their respective pads (red to positive). That done, fit the plugpack wires and solder them to the 3.5 mm socket provided (red to the tip).

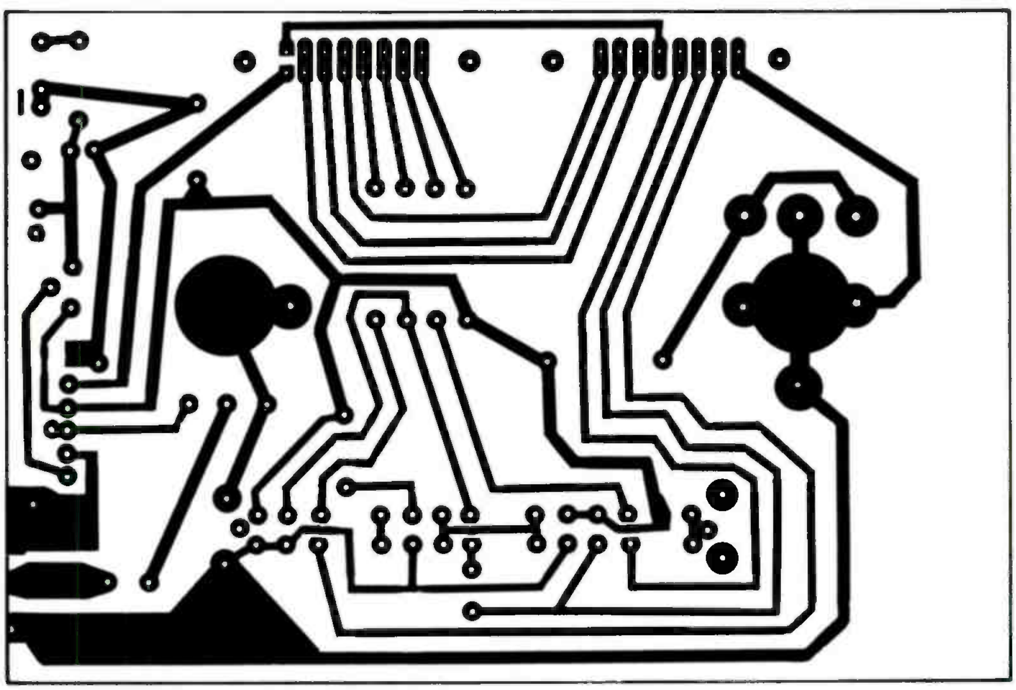
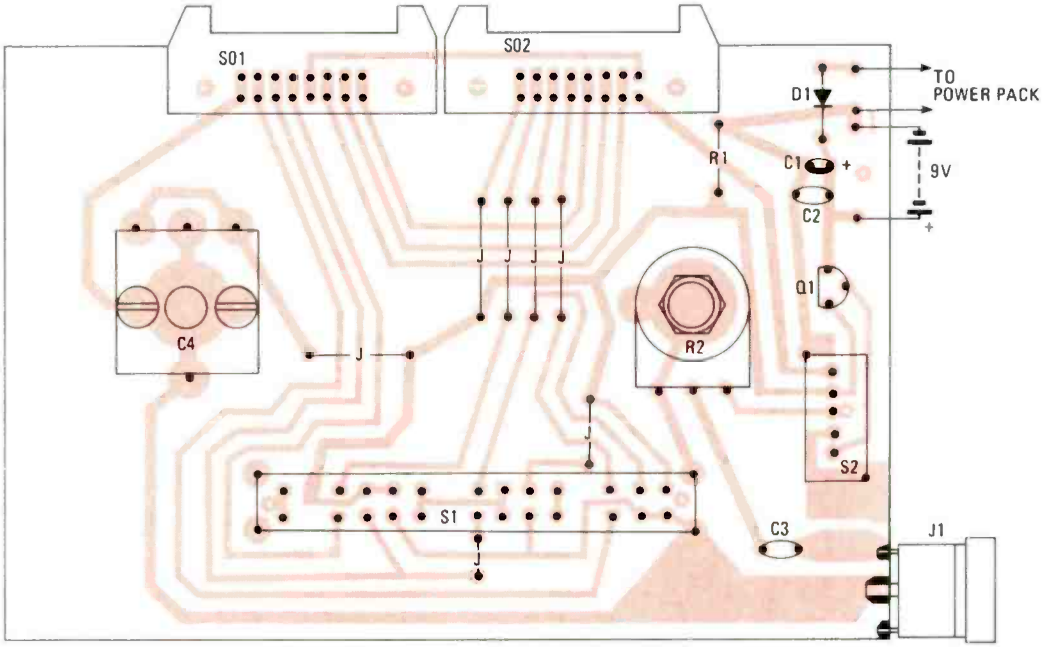


Fig. 3—The circuit-trace pattern shown here is the same size as the circuit board, so you can use this to make your own printed-circuit board using the positive resist method.

Fig. 4—Please take note that in this layout for the PCB, the tuning capacitor and potentiometer are mounted on the reverse (copper) side of the board.



The dial can now be fastened to the panel with the screws provided. Set the dial to read zero, then rotate the tuning capacitor shaft to the fully counterclockwise position. The front panel can then be secured to the band switch by means of two self-tapping screws. Check that the PCB and panel are parallel to each other before tightening the dial fastening-screws.

Finally, fit the output knob and clip on the battery. Wrap the battery in foam before installing the assembly in the case.

The Loop Coils

The basic kit contains one coil-former strip, two cable connectors, and sufficient wire for a one or two-layer loop based on a 300 mm diameter coil.

A one-layer 300 mm loop will tune from 1MHz to 13.5MHz, while a two-layer loop will tune from 500kHz to 5MHz. If you want to go lower down, extra cable, formers, and connectors are available. A five layer loop, for example, will tune from 200kHz to 2MHz.

From that you can see that two coils, one of five layers and one of one layer, will cover 200kHz to 13.5MHz, with a good degree of overlap between coils.

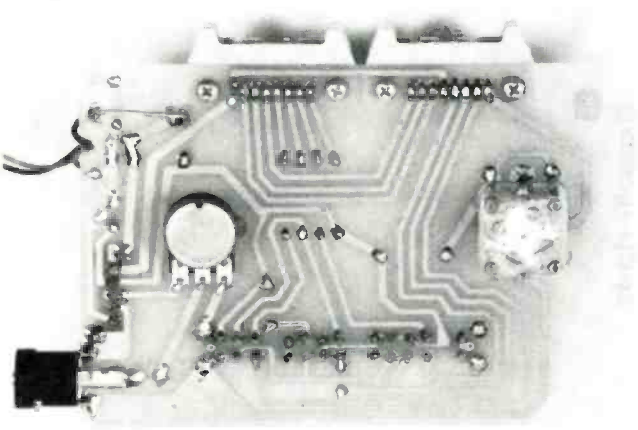
If your main interest is, say, broadcast band DX and/or the 80-meter amateur band, then a two-layer loop will probably be all you'll need.

The one-layer loop is suitable for the top end of the broadcast band right through the 80-meter and 40-meter amateur bands and into the international shortwave bands.

Note that the figures given are for a 300-mm loop. For larger diameter loops, the frequency range for the same turns would be shifted down proportionately. Larger loops will give more signal capture but in practice, the 300 mm size is convenient and quite adequate for most applications, particularly with the FET buffer stage.

The top frequency with a single layer 300-mm loop is 13.5MHz. To go higher with the existing circuit would mean reducing the diameter of the loop which would negate the advantages if taken too far.

Note also that the advantages of a loop tend to diminish with increasing frequency, with directionality becoming vague and the signal falling off.



As you can see the tuning capacitor and potentiometer are mounted on the foil side of the board. Note also how the contact strips on the coaxial connector hold it in place.

The three loops cover the range of frequencies from 200kHz to around 13.5MHz. There is a new design that even covers up to 24 MHz by using eight strands with a 380-mm diameter.

PARTS LIST FOR THE ACTIVE ANTENNA

CAPACITORS
C1—10μF, 16WVDC tantalum
C2—0.1μF, ceramic disc
C3—.01μF, ceramic disc
C4—0–470pF, variable

ADDITIONAL PARTS AND MATERIALS
D1—1N914, small-signal diode
J1—Coaxial jack
PL1, PL2—IDC, 16-conductor connector
Q1—MPF102, N-channel FET
R1—470,000-ohm, ¼-watt resistor
R2—1000-ohm, miniature potentiometer
SO1, SO2—IDC, 16-conductor socket
S1—6-pole, triple-throw, slide switch
S2—2-pole, 3-position, slide switch

Printed circuit board, plastic case (50 × 90 × 150 mm or similar), Sato 10-turn vernier dial, knob for tuner, right-angle bracket with hardware, two 9-volt battery connectors, 380-mm loop-forming plastic strip, 16-conductor ribbon cable (3-meters), piece of foam (to insulate battery), jumper wire, solder, etc.

A full kit of parts (order # TL3/S) for the project is available from: Technikit Electronics, 55 Webber Pde, East Keilor, Victoria 3033, Australia. It comes complete with a pre-punched case, a screen printed front panel, and a single set of loop coil components with sufficient cable for either a one- or two-layer coil.

The price for the kit is $69 ppd. Payment may be made by international money order, bank draft, or Mastercard.

Coil Construction

Begin by shaping the former strip supplied into a circle. To do that, over-lap the ends by exactly 20 mm (mark first with a pencil) and then bind the ends with two or three layers of plastic tape.

Next, fold one end of the cable at 90° (see photograph), leaving at least a 50 mm lead out. Tape that end to the former next to the fold so that the inner edge of the lead out runs along the line of one of the overlapped former ends.

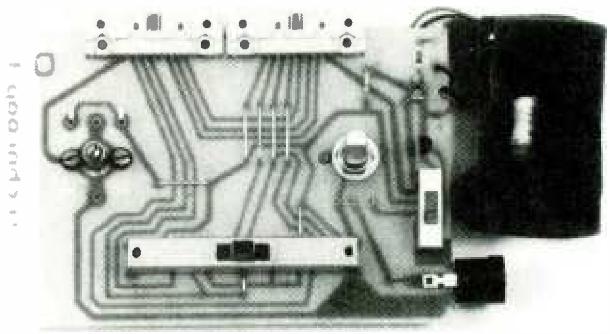
Now rotate the former by hand while feeding the cable centrally on to it until you have the number of layers required. That done, fold the end of the cable in the same way as the start. Note that the inner edge of the lead out should run along the line of the other over-lapped end of the former (i.e., the two inner edges of the cable should finish 20 mm apart).

Bind the end of the winding with two layers of tape and leave the same length of lead out as at the start (50 mm). Once that has been done, tape the cable at the top and sides of the former.

With the loop now completed, it should be clamped onto the top of the control housing using the right-angle clamp supplied with the kit. Adjust the position of the coil so that the two lead outs run centrally through the PCB connector housings.

Next, position a ruler against the front of the connectors and draw a line across both cable lead outs with a ballpoint pen. Remove the coil from the housing and cut the cable carefully along the lines.

The 16-way cable connectors can now be fitted to the leadouts. To do this, locate the connectors over the cable with the keyway (the raised section) towards the front of the coil. With approximately 2 mm of the cable end protruding from the connectors apply pressure using a pair of multigrips or similar until the connector is fully closed. The unit is now ready to be tested.



In this top view of the assembled PCB, notice that the battery is wrapped in foam rubber. That is to insulate it from other components, thus preventing shorts.

Connection to the Receiver

If your receiver has a 50–75-ohm, coaxial input then a cable between the two is all that is needed. A coaxial plug and a length of cable are supplied with the kit.

For receivers with only a telescopic antenna and no external antenna input, a twisted pair from Techniloop with two alligator clips for connection to the antenna and earth will be required. The earth is not strictly necessary but will help on the lower frequencies.

Receivers with existing ferrite-rod antennas for the broadcast and/or LF bands present more of a problem. If there is no provision for an external antenna or Earth, then a two- or three-turn winding may be added to the rod and brought out to a connector or terminals on the back of the set.

Note that when using the loop simultaneously with a ferrite rod you will need to keep both correctly oriented towards the station. The edge of the loop should be pointed in the direction of the station, while the ferrite rod should be broadside to the station for maximum signal pickup.

Small hand-held radios may simply be placed or held near the loop antenna. Orient the radio so that the end of its built-in ferrite-rod antenna points towards the center of the loop. Note that in that case the coupling is inductive and the loop needs only to be set for passive operation.

Tuning the Loop

With the receiver set to a vacant spot around the center of the band of interest, switch the loop to active, and set the output-level control to maximum. When the loop tuning coincides with the receiver tuning, there is an unmistakable increase in activity from the receiver.

Note that the loop tuning is not so sharp as to require constant tracking with the receiver. It is possible to move the receiver tuning a reasonable distance away from the loop resonance without losing reception.

As previously mentioned, to obtain optimum tuning and direction, particularly for weak signals, it helps greatly to reduce the output level of the loop to the point where the AGC action of the receiver begins to drop out (indicated by a sudden increase in background noise and a decrease in signal level). After finding the optimum tuning for the loop, the output level may then be restored to maximum.

(Continued on page 105)

HANDS-ON REPORT

Persoft RAM-Resident Management Program

New utility designed to manage RAM-Resident software

☐YOU REALLY LOADED UP YOUR RAM chips. You packed into resident memory goodies such as keyboard enhancer, word processor, spelling checker, thesaurus, spread sheet, desktop organizer, and more. What convenience! But, then you pressed F3 that activated two or more resident programs causing computer lockup! Too much of a good thing did you in!

Don't despair for there is hope for you in the form of *Referee*, a software manager of RAM-resident programs. Referee was designed to allow microcomputer users to load multiple memory-resident programs without fearing the data loss, malfunctions, and keyboard lockups that sometimes accompany the use of those programs. Referee lets you keep incompatible RAM-resident programs away from each other, while it allows users to customize their computing environments. It alleviates many of the technical-support headaches that RAM-resident incompatibility has caused.

Referee allows users to set up "Ram Teams" in which only pre-specified RAM-resident programs are activated with a particular application program. When a user switches to another application program, Referee will automatically and invisibly disable unnecessary RAM-resident programs and enable the ones that are necessary. For example: In a network situation, the PC users in one department might need ProKey with Lotus 1-2-3, but then need a spelling checker when they switch to word-processing software. Referee can be configured to enable ProKey, but no other RAM-resident programs when the user is in 1-2-3. Then, when the user switches to word processing, Referee will invisibly disable Prokey and enable the spelling checker. Sounds simple? It is and it can do it for the PC XT or AT (or clone).

Installing Referee

Referee is compatible with your IBM, PC XT, AT, and compatible microcomputers that have at least 128K RAM, one disk drive, and PC DOS 2.0 or later.

Begin by using the DOS COPY command to copy all of Referee's files into

(*Continued on page 103*)

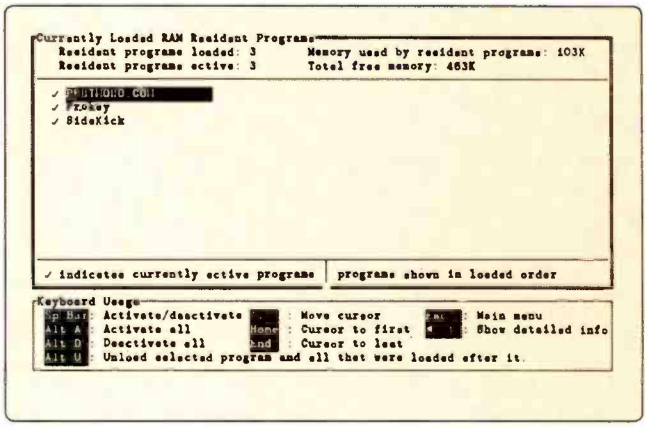


Fig. 1—Referee lets you look at currently-loaded RAM-resident programs. The screen image shows all the resident programs in the order in which they were loaded. Notice that descriptive names as well as file nomenclature appear. Referee lets you designate a descriptive name for each program in place of its filename—it's up to you.

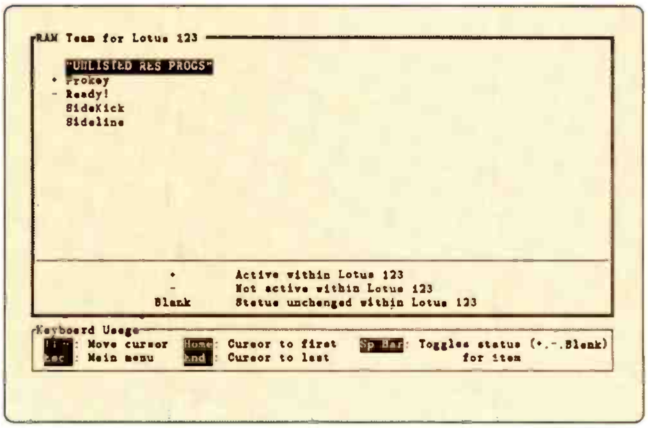


Fig. 2—RAM teams are those RAM-resident programs you would want to use with a particular program. Here, the RAM Team for Lotus 123 are +Prokey, –Ready, Sidekick, and Sideline. The + sign means that the program will be activated; minus, deactivate; and no sign means that the status will remain unchanged. For more information circle no. 81 on Free Information Card.

LEARN BY DOING

OP-AMP APPLICATIONS

By Louis E. Frenzel, Jr.

Op-amps are the most adaptable integrated circuits, but you can't use them unless you're taught how, so here's how

THIS IS THE THIRD IN OUR SERIES OF ARTICLES DESIGNED to teach you the operation and application of some of the more popular and widely used electronic circuits. In this article we will explore some of the more interesting and useful applications for integrated-circuit operational amplifiers (IC op-amps).

This article is written in a unique way. It is not just an article that you read. Instead, it is a lab experiment with step-by-step procedures that you can follow to build and demonstrate op-amp circuits. It will lead you by the hand in circuit construction and operation, explaining each step as you go.

In addition to the specific circuit components listed later, you will need some basic hardware to implement your experiments. The base for the experiment is a breadboard. Any of the various popular commercial types with 0.1-in. spaced holes and room for three or four IC's will do nicely.

You will also need a power supply to run the circuits. For op-amp circuits, two power supplies are needed, both a positive and a negative supply. Any power supply that will furnish ±12 or ±15 volts will work nicely. If you do not have a power supply, you can use two 9-volt transistor-radio batteries to power the circuits described in this article. Simply purchase some connectors with wire leads and connect the batteries as shown in Fig. 1. The batteries have sufficient power to handle the experiments described here. Just be sure to disconnect the batteries after each session so you will not exhaust them prematurely. The .01-µF disc capacitors are used for decoupling to prevent circuit oscillation and instability. You may not actually need them.

Finally, you will need some test equipment. A standard VOM for measuring voltage and resistance will come in handy. Some of the time, voltages will switch from positive to negative which will force you to switch your test leads around if you don't have a DMM. That can be avoided by using the circuit described in the boxed text entitled "Comparator-Output Indicator." An oscilloscope is also a desirable addition. Most of the curcuit you will be able to demonstrate with a voltmeter, but you will get far more out of the experiments if you use an oscilloscope.

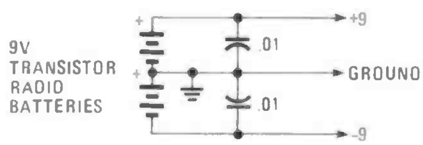


Fig. 1—This simple power-supply circuit is all you'll need to perform all the experiments in this column. Note the use of capacitors to squelch any power surges due to changing load conditions—yes, they're necessary for DC applications.

Learning Objectives

When you complete the experiment, you will be able to:

1 Explain the basic operation of an IC op-amp.

2 Explain the operation of basic op-amp circuits including the inverter, non-inverting amplifier, follower, and differential amplifier.

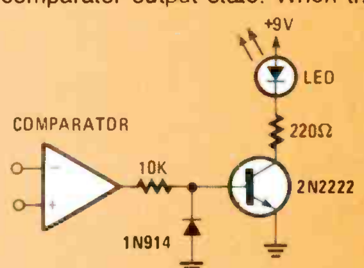
3 Demonstrate the operation of an integrator.

4 Demonstrate the operation of op-amp oscillators and function generators.

5 Demonstrate the operation of an op-amp comparator.

Comparator-Output Indicator

Since the polarity of the op-amp output switches from + to −, it is inconvenient to keep reversing the voltmeter leads to keep the polarity correct. One way to overcome that problem is to use an indicator light to tell the output state. The circuit shown in Fig. A uses a switching transistor to turn an LED off or on depending upon the comparator output state. When the op-amp



output is +8.5 volts, the transistor turns on lighting the LED. When the comparator output is −8.5 volts, the transistor is cut-off, therefore, the LED does not light.

The transistor can be any common NPN unit. A silicon diode of any kind protects the transistor. ■

Background Tutorial

The IC op-amp is one of the most useful electronic components ever designed. Op-amps have done for linear (analog) circuits what logic-gate IC's have done for digital circuits. Op-amps are like logic gates, a basic building block. Virtually any kind of linear circuit can be constructed using op-amps. Because of their flexibility, you can build an amazing variety of precision analog-signal generating and processing circuits.

An op-amp is a high-gain, direct-coupled, differential amplifier. The gain varies depending upon the op-amp, but few ever have a gain of less than 1000. Typically, gains of 10,000 or more are common. Direct coupled means that the internal transistor stages feed one another by direct interconnections rather than passing signals through transformers or capacitors that block DC. In other words, a direct-coupled amplifier will amplify DC as well as AC signals. Also, the op-amp is usually of the differential configuration, meaning that it has two inputs and a single output. The output is the difference between the two inputs multiplied by the gain. In many applications, only one of the inputs is used.

Figure 2 shows the schematic symbol used to represent an op-amp. The inputs are labelled – and +. Those refer respectively to the inverting and non-inverting inputs. A signal applied to the – input will be inverted (shifted by 180°). A signal applied to the + or non-inverting input will not have its polarity or phase changed at the output.

Operation

The thing that makes an op-amp truly useable is feedback. By connecting components such as capacitors and resistors between the output and one or both of the inputs, both positive and negative feedback occur. That greatly changes the characteristics of the circuit and, most important, makes its function mathematically predictable. That is where the term operational comes from as it means some mathematical operation is performed by the op-amp circuit on an input signal.

Most op-amps operate from a pair of power supplies, usually positive and negative supplies of equal voltage. The most common values are ±12 or ±15 volts. Sometimes you will see the connections to the power supply as shown in Fig. 2. In most of our examples here, we will eliminate the power-supply connection to simplify the circuit drawings. Just be sure that when you build the circuits you include the power connections.

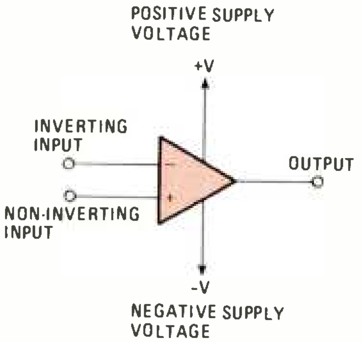


Fig. 2—The power-supply connections will not be shown in the diagrams after this one. You will assume they are used as shown here. Note that neither goes to ground.

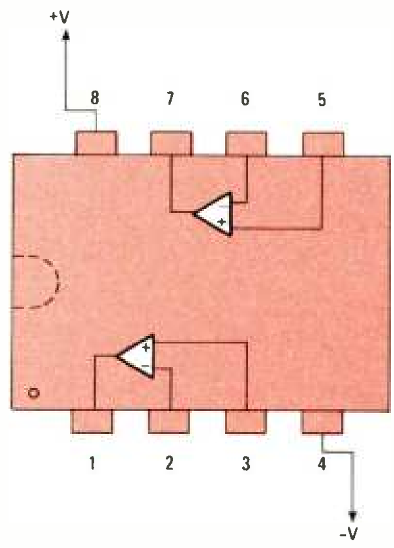


Fig. 3—This top view of the 1458 displays both op-amps in the chip. Note that both the op-amps in the package share the same power-supply pins (pin 8 and pin 4).

There are many different types of op-amp IC's in use. One of the more popular and longest living is the 741. It is packaged in an 8-pin, mini DIP. Amplifiers with similar characteristics are packaged two in a mini DIP. An example is the popular 1458 which contains two op-amps similar to the 741. Its pin configuration is shown in Fig. 3. That is the device we will be using here. Actually, however, almost any other popular low-cost op-amp can be substituted with equally good results.

Circuits

By far the most commonly used op-amp circuit is the inverter, as shown in Fig. 4. It consists of a feedback resistor R_f that connects the output back to the inverting input. The input signal is applied to the input resistor R_i. The non-inverting input is grounded. With that connection, the gain of the circuit is set entirely by the external resistors. The gain value is simply the ratio of the feedback resistor to the input resistor (R_f/R_i). With the values shown in Fig. 4, the gain is 100,000/10,000 = 10. In other words, that circuit multiplies any input signal, AC or DC, by 10 and inverts it. If –2 volts is applied to the input, the op-amp will produce a +20 volts output.

A non-inverting amplifier is shown in Fig. 5. The connections are almost similar except that the input resistor is grounded while the input signal is applied to the non-inverting input. Again, the gain is a function of the feedback and input resistors and can easily be computed with the simple

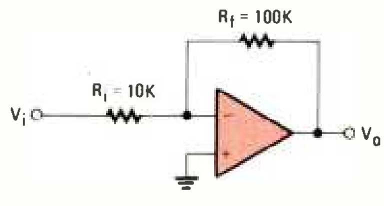


Fig. 4—The inverting amplifier requires a feedback resistor at the inverting input to channel some of the output back. That cancels some of the input signal, cutting down the gain. If one is not used, the output swings wildly.

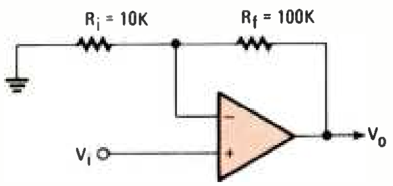


Fig. 5—The non-inverting amplifier requires a feedback resistor at its inverting input, but it accepts input at its non-inverting input, and outputs an in-phase signal.

expression:

$$\text{Gain} = 1 + R_f/R_i$$

Therefore, the output voltage is:

$$V_O = V_i(1 + R_f/R_i)$$

With the values given in Fig. 5, the gain is:

$$\text{Gain} = 1 + 100{,}000/10{,}000 = 11.$$

The third most popular circuit is called a follower. The output is connected directly back to the inverting input while the input signal is applied to the non-inverting input (see Fig. 6). The op-amp follower is like an emitter follower in that it has very-high input impedance, low output impedance, and unity gain. The output voltage is equal to the input voltage in phase and amplitude. The value of the follower is that it is a power amplifier and, therefore, can drive heavy loads. Followers are used as buffers between high impedance and low impedance circuits without affecting the signal, phase or amplitude.

Another common op-amp circuit is the summer shown in Fig. 7. The configuration is the same as that for an inverting amplifier except that multiple input resistors are used. In that way, two or more input signals can be algebraically added together. Each input signal is multiplied by a gain factor that

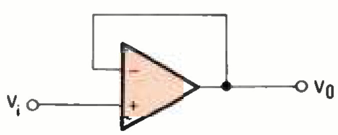


Fig. 6—This simple voltage follower will isolate two circuits to prevent problems with loading and phase shifting of the input signal. Although the circuit doesn't amplify the signal, it is very useful and sometimes a must.

is simply the ratio of the feedback resistor to the input resistor values. The following formula gives the complete output-voltage expression based on the inputs and circuit values:

$$V_O = -[V_1(R_f/R_1) + V_2(R_f/R_2) + V_3(R_f/R_3)]$$

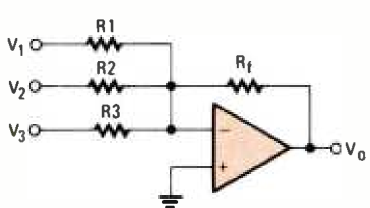


Fig. 7—Signals can be added together using this simple summing circuit. The circuit will not only mix signals, but amplify them as well. That is useful for multi-track audio.

Note that the minus sign means that the circuit inverts. Op-amp summers are used for algebraic addition and subtraction and for linear mixing of signals.

Figure 8 shows another popular op-amp circuit, the integrator. Here the feedback resistor is replaced with a capacitor. With that arrangement, the circuit performs mathematical integration. You don't have to know integral calculus to use an integrator successfully. All you have to know is that when DC voltages are used at the input, such as fixed DC levels or rectangular pulses, the integrator acts as a linear-ramp, or sawtooth, or triangle-wave generator. The formula below gives the output voltage in terms of the input:

$$V_O = -V_i(1/RC)t$$

Where R and C are used as shown, and t is the time over which the circuit operates. When used with sinewave signals, the integrator acts as a low-pass filter. It also provides a 90° phase shift. Integrators are widely used in function generators and wave-shaping circuits.

Figure 9 shows how the op-amp can be used as a comparator. A comparator is a circuit that looks at two input signals and causes the output to switch from one state to the next when the two inputs become equal.

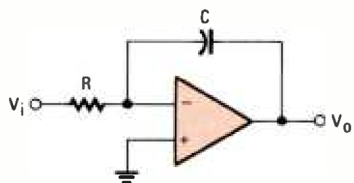


Fig. 8—Operational amplifiers get their name from their ability to perform mathematical operations such as this integrator does. If you give it an input signal it will tell you the area of the curve defined by the input signal.

More On Comparators

To understand the operation of a comparator it is first necessary to understand the output characteristics of an op-amp. The output of the op-amp has voltage swing limits that are equal to approximately a half of a volt less than the values

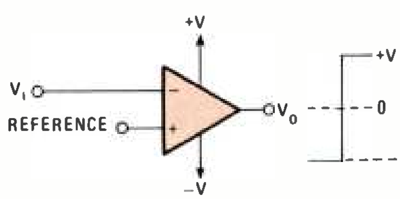


Fig. 9—A comparator is nothing more than an op-amp with its gain wide open. Since it has no feedback resistor the output swings between the power-supply voltages.

of the supply voltages. For example, with ±9-volt power supplies, the output-voltage swing is limited to roughly ±8.5 volts. Any signal that attempts to drive the amplifier beyond those points will simply cause the amplifier to saturate and clip. For that reason, the gains of the circuits discussed previously must all be such that with the input signals provided that the saturation limits are not reached.

The op-amp, when used as a comparator, takes advantage of those two large positive and negative voltage swings. The output is essentially binary in nature for a comparator. One saturation level will be the binary 0 while the other will be the binary 1. In that way, the output can signal when one input signal is larger or smaller than the other.

The two inputs to a comparator are the reference (as marked) and the input signal (V_i). The reference is simply a DC voltage or other level that is used as a standard against which the input signal is compared. When the input signal value is less than the reference value, the comparator output will be one of the two saturated states, depending upon the polarity of the input. As the input signal rises, at some point it will become equal to the reference voltage. At that point, the output voltage will switch to the other saturation level. Increasing the input level beyond the reference level continues to hold the output in that saturated condition.

Note that the comparator is used "open loop," that is, without feedback. That allows the maximum gain of the op-amp to come into play so that precision comparison can take place. In order to cause the amplifier to switch from one state to the other, a small amount of input voltage difference is required. For that reason, the comparator does not switch exactly when the two input signals are equal. But the higher the gain of the amplifier, the smaller the difference in voltage required for output switching and the greater the precision.

Figure 10 shows a variation of an op-amp comparator. Here the non-inverting input is grounded and the two signals to be compared are applied to two equal summing resistors. In order for the circuit to work properly, the polarity of the reference must be opposite to that of the input signal.

Note also that a zener diode is connected as a feedback element. That allows the output voltage to be set to some desired level. With one set of input conditions, the zener diode will be forward biased as any silicon diode and, therefore, the input will be very low, typically –0.7 volts. When the other input condition is reached, the op-amp output switches to the desired voltage level. A common technique is to select a value approximately 5 volts that will allow the op-amp comparator to readily interface with common TTL or CMOS digital circuits.

Virtually all op-amp circuits are some variation of the basic circuits described above. With different arrangements of input and feedback components in those circuits, a literally unlimited number of useful circuits can be created. The circuits to be described here will be described later as you implement each step of the experiment.

Parts Required

In addition to a breadboard, power supply, a VOM and an oscilloscope, you will need the following components: 2, 1458, dual, op-amp IC's (Motorola or TI); 2, .01-µF capacitors; a .1-µF capacitor; a 1-µF capacitor; 2, 3300-ohm, 1/4-watt resistor; a 2,000-ohm, ¼-watt resistor; 2, 22,000-ohm, ¼-watt resistor; 3, 100,000-ohm, ¼-watt resistor; a 220,000-ohm, ¼-watt resistor; a 10,000,000-ohm ¼-watt or ½-watt resistor; a 1000-ohm potentiometer; a 10,000-ohm potentiometer and a pilot bulb type 327, 344, or 1869. You may need 2 silicon diodes (1N914, 1N4148, etc.); 2, 4700-ohm, ¼-watt resistors; 2, 10,000-ohm, ¼-watt resistors; and a 47,000-ohm, ¼-watt resistor if you can't find a suitable bulb. You will need to solder some hookup wire to the potentiometers to use them on the breadboard.

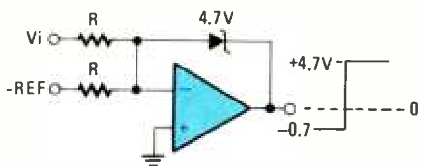


Fig. 10—Using a zener diode as a feedback component causes the output to restrict its excursion, thus outputting clearly defined pulses. That is useful in digital circuits.

Experimental Steps

In these first steps, you will demonstrate an integrator.

1 Construct the circuit shown in Fig. 11. Be sure to connect the + supply voltage to pin 8 and the – supply voltage to pin 4. Note that the input resistor is initially connected to ground.

2 Connect a voltmeter between pin 1 and ground to measure a positive DC output.

3 Apply power to the circuit and note the output. It should be approximately zero volts.

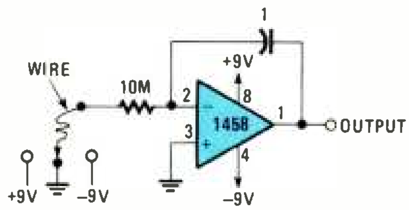


Fig. 11—This integrator takes the flat curve defined by the constant input voltage and outputs a voltage that increases as that area under the input curve increases.

4 Now, remove the input resistor from ground and connect it to the –9-volt power supply. Observe the output. You should note a slow rise in the output voltage. The rise continues until the output limit of the op-amp is reached at approximately 8.5 volts.

5 Now move the input resistor to the +9-volt supply. Again observe the output. It should slowly decline to zero, then switch polarity.

6 Reverse the voltmeter leads and measure the output voltage. It should eventually rise to about –8.5 volts.

7 Connect the input resistor to ground. Take a short piece of hookup wire and touch it to the two leads of the 1-µF capacitor. That will discharge the capacitor.

8 Using a stopwatch or the sweep second hand on your watch, time the next operation. Move the input resistor from ground to the +9-volt supply. At the same instant, start your watch. Let the circuit integrate for 5 seconds, then disconnect the input and connect it to ground. Note the output value and record it below.

V_O (after 5 seconds) = _______________ volts

Now remove power from the circuit.

Review of Steps 1–8

In the above steps, you demonstrated an op-amp integrator. With a fixed DC input, the output is a slow linear ramp as the capacitor charges and discharges. With a negative DC input, the output ramp is positive. With a positive input, the ramp goes negative. That means that the circuit is an inverter. Figure 12 shows typical inputs and outputs. The integrator keeps on integrating until the output limit of the op-amp is reached.

Once the feedback capacitor is charged, it remains charged even if the input voltage is zero. The capacitor stores the last value it sees. That is an advantage in some circuits, but in

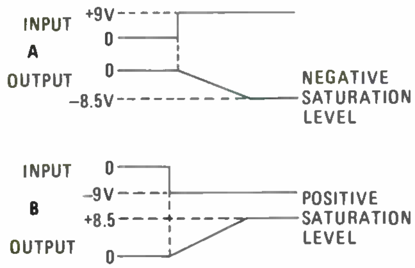


Fig. 12—Of course the output of an integrator can't reach infinity no matter how long the input signal is left on. The output is limited by the negative (A) and positive (B) power-supply values. A perpetual motion machine it's not.

others it is undesirable. A switching transistor is connected across the capacitor to discharge it in some applications.

The output voltage (V_O) at any given time is dependent upon the resistor (R) and capacitor (C) values, the input voltage (V_i) and the time (t) allowed for integration. All that is summed up in the expression:

$$V_O = -V_i(1/RC)t$$

In Step 8, you let the circuit integrate for 5 seconds. The output voltage at that time (assuming a +9-volt input) should have been:

$$V_O = -(9)(1/10{,}000 \times .000001)(5)$$
$$V_O = -(9)(.1)(5) = -4.5 \text{ volts}$$

Because of inaccuracies in your timing, component values, or measurement errors, your value may be different, but it should be close.

Moving On

9 Construct the circuit shown in Fig. 13 using the second op-amp in the 1458 IC. Note that the two 10,000-ohm resistors form a voltage divider to furnish half the supply voltage to the + or reference input at pin 5. The 10,000-ohm potentiometer is connected as a variable voltage divider to supply the other input at pin 6.

10 Apply power to the circuit. Use your VOM to measure the voltage between pin 6 and ground. Adjust the potentiometer for zero volts.

11 Connect your VOM between the op-amp output at pin 7 and ground. Note the output voltage.

V_O = ____________ volts

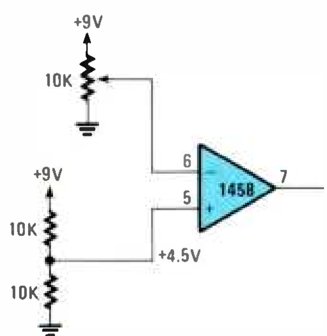


Fig. 13—In this comparator circuit, the non-inverting input is used to receive the reference voltage, and the inverting input as the signal being tested.

12 Next, rotate the potentiometer slowly while observing the output voltage. At some point, the output will switch. Stop turning the potentiometer at that point. Note the output voltage (V_O) and the input voltage (V_i) at pin 6.

V_O = ____________ volts
V_i = ____________ volts

13 Compare the input voltage to the reference voltage at pin 5. Turn the potentiometer above and below the switching point and note how the output swings between the two limits.

14 Remove the potentiometer from the circuit. Connect your integrator output (pin 1) to the comparator input (pin 6). Your circuit should look like that in Fig. 14. Be sure that the 10-megohm input resistor is initially grounded. Short the feedback capacitor to discharge it, and connect your VOM to the comparator output.

15 Now, touch the integrator input resistor to –9 volts. At the same instant, start your stopwatch. Observe the comparator output voltage. As soon as the output voltage switches, stop the stopwatch and note your time below.

Time = ____________ seconds

16 What factors influence the time?

Review of Steps 9–16

In Steps 9–13, you demonstrated the operation of a simple comparator. The reference input is derived from the two 10,000-ohm resistors in a voltage divider that sets the reference input to one-half the supply voltage, or +4.5 volts.

The potentiometer is used to vary the input voltage. You set it to zero initially. The output voltage should have been about +8.5 volts or the saturation level of the op-amp. Here the op-amp is responding to the +4.5 volts applied to the non-inverting input.

Varying the potentiometer to increase the input voltage in a positive direction caused the output to switch from +8.5 to –8.5. Measuring the potentiometer voltage, you should have found it to be about +4.5 volts or slightly higher. Remember that the comparator switches when the two inputs are very nearly equal.

In Steps 14–16, you connected the integrator to the comparator. You let the integrator charge to the negative supply voltage producing a positive output ramp. When the ramp reached 4.5 volts, the comparator switched. The integrator rate and the comparator reference voltage determine the time it takes for the comparator to switch.

Rearranging the integrator formula, we can compute for time instead of voltage.

$$t = V_O/V_i(1/RC)$$

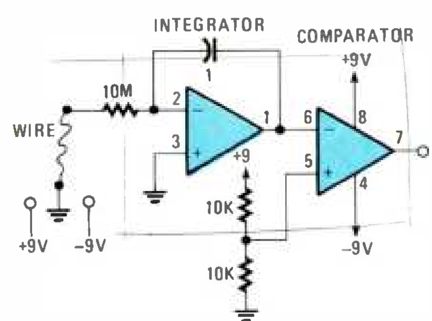


Fig. 14—Connecting the comparator and integrator circuits causes the comparator to switch states when the integrator has been operating for a certain time and reaches 4.5 volts.

We substitute 4.5 volts for V_O because that is the value of output that will cause the comparator to switch.

$$t = 4.5/9(1/10{,}000 \times .000001)$$
$$t = 4.5/.9 = 5 \text{ seconds}$$

Your time value should have been close to that.

Further Steps

You will now use the integrator and comparator to build a signal or function generator.

17 Be sure power is removed. Then disassemble the circuit and build the new circuit shown in Fig. 15. That circuit combines the integrator and comparator circuits to form a function generator that produces square and triangle waveforms.

18 Apply power to the circuit. Monitor the outputs at pins 1 and 7 with your volt meter. Name the output waveforms at each pin.

pin 1 ______________
pin 7 ______________

19 If you have an oscilloscope you can monitor the square and triangle waves. To do that, change the feedback capacitor to .1 μF. Change the 10-megohm integrator-input resistor (R1) to 10,000-ohm. Then, look at the waveforms at pins 1 and 7. You should see near-perfect square and triangle waves occurring at a frequency of approximately 550 Hz.

Review of Steps 17–19

The circuit in Fig. 15 uses an integrator and comparator connected in a feedback loop. The comparator input (pin 6) is connected to ground so that the reference is zero volts. Note that the – input is used for the reference instead of the + input as in the earlier circuit. The integrator output is applied to the other comparator input through the 10,000-ohm comparator input through the 10,000-ohm resistor R2. Along with the 22,000-ohm resistor (R3) it forms a voltage divider that sets the output amplitude of the triangle wave. The integrator charges or discharges until the junction of R1 and R2 is zero, at which point the comparator switches, applying the opposite polarity voltage to the integrator. The integrator output then charges in the opposite direction until the comparator switches again. The cycle continues to repeat. The typical input and output waveforms are shown in Fig. 16.

An Oscillator

In the following steps you will build and test oscillator and mixer circuits. Do **not** disassemble the circuit now wired on your breadboard.

20 Construct the circuit shown in Fig. 17A. Use a second 1458 dual op-amp IC. Be sure to connect the two supply voltages as indicated. That is a Wein bridge oscillator that generates a nearly pure sinewave at a frequency that depends upon values of R1 and C. That frequency (f) is:

$$f = 1/6.28RC$$

If you cannot locate one of the light bulbs indicated in the parts listing, use the alternate circuit in Fig. 17B. In either case, the frequency of oscillation will be the same. The output from the circuit in Fig. 17A will be a cleaner sinewave than that from the circuit in Fig. 17B.

21 Apply power to the circuit. Connect an oscilloscope to the output at pin 1. Adjust the potentiometer in the feedback until the circuit oscillates. Then fine tune it for its best waveform. Set the potentiometer for maximum peak-to-peak amplitude just before clipping begins. Observe the output. It should be a clean sinewave. Measure the frequency by determining the period (t) of one cycle on the calibrated 'scope graticule. Compute the frequency (f) using the expression f = 1/t. Record your value below:

f = ______________ Hz

22 Compute the frequency using the values in Fig. 17 and previously given formula.

f = ______________ Hz

It should be close to the value you measured.

Looking Back On Steps 20–22

The Wein-bridge oscillator is simply a non-inverting op-amp with positive feedback. The resistor network between pin 1 and pin 2 sets the gain of the circuit. The light bulb is used as an automatic gain control (denoted AGC) element. During oscillation, the output amplitude will increase until the saturation limits of the op-amp are reached. Therefore, the output will be a square wave switching between +8.5 and –8.5 volts instead of the desired sinewave. The lamp has a positive temperature coefficient, meaning that its resistance increases with the current through it. If the output voltage rises, the current in the bulb rises increasing its resistance. That decreases circuit gain reducing the output below the point of distortion. The result is a stable output level.

The circuit with the diodes in the feedback circuit of Fig. 17B does essentially the same thing. If the output rises too much, the diodes conduct (one on the positive half cycle, the other on the negative half cycle). That puts the 47,000-ohm resistor in parallel with the feedback resistor thus reducing the gain and lowering the output. The diodes cause some clipping distortion.

The remaining network made up of R1 and C produces positive feedback that sustains oscillation. When the output

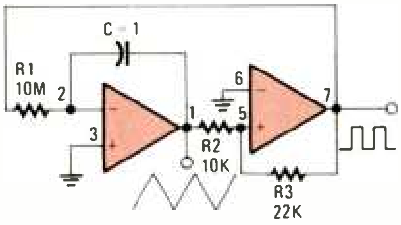


Fig. 15—Cycling the comparator output back into the integrator causes the integrator to alternately charge and discharge. Further, that causes the comparator to swing up and down, and the cycle continues creating a series of triangle and square waves to be output.

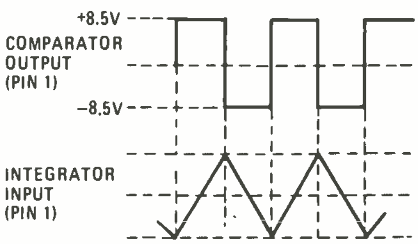


Fig. 16—The output waves from your home-brew function generator should line up like this, with the outputs varying between +8.5 and –8.5 volts. Note the identical frequency.

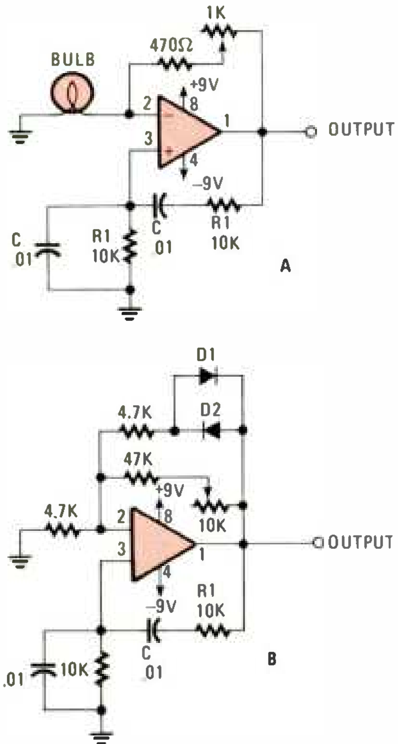


Fig. 17—If you can't get the light bulb needed for the circuit in A, then you can use the circuit in B. Its output will not be as clean, but is good enough here.

is in phase with the input, the circuit will oscillate if the circuit gain is high enough. The R1/C network is a voltage divider so all the output doesn't reach the non-inverting input. The circuit gain offsets that, providing ample input.

In order for the circuit to oscillate, the output must be exactly in phase with the input. Because an RC network is used, the correct phase will occur at only one frequency. That becomes the frequency of oscillation.

Using the formula given earlier, you should have computed a frequency of:

$$f = 1/6.28(10{,}000)(.00000001)$$
$$f = 1592 \text{ Hz}$$

Your measured value of the period should have been about 628 microseconds for one period so the frequency is:

$$f = 1/t = 1/.000628 = 1592 \text{ Hz}$$

Don't be concerned if your value is way off. There are many variables in the circuit to throw it off.

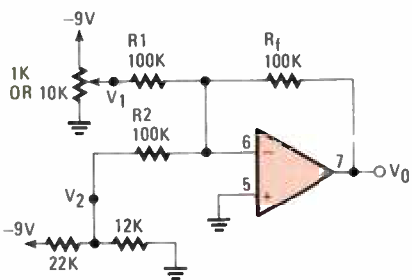


Fig. 18—This summer can actually add two voltages together as long as their sum is less than the supply voltage. The output should equal their sum since no gain is provided.

A Mixer Circuit

23 Remove power temporarily and add the circuit in Fig. 18 to your breadboard. Use the second op-amp in the second 1458 package. Use either the 1,000-ohm or 10,000-ohm potentiometer for one input depending upon which potentiometer you did not use in the Wein bridge circuit. That is an op-amp summer with negative DC input voltages.

24 Apply power to the circuit. Set the potentiometer so that the voltage between ground and its arm (V_1) is –2 volts. Measure the value of V_2 at the junction of the 12,000-ohm and 22,000-ohm resistors. Record it below.

V_2 = ______________ volts

25 Now measure the output at pin 7. Write your value below.

V_O = ______________ volts

26 Using the values for V_1 and V_2 you measured in Step 24, compute the output voltage using the summer formula given earlier. Write in the output you calculate below.

V_O = ______________ volts

How does it compare with your measured value?

Steps 23–26 Revisited

The circuit you built is a two-input summer. Since the input and feedback resistors are all equal (100,000-ohm), the gain is one. You set the V_1 input to –2 volts. The V_2 input comes from a voltage divider that supplies approximately –3 volts. Now, using the formula, you should have computed an output of:

$$V_O = -[(100{,}000/100{,}000)(-2) + (100{,}000/100{,}000)(-3)]$$

$$V_O = -(-2 + -3) = -(-5) = +5 \text{ volts}$$

Your measured value should be the same.

Note that the circuit does perform addition, but its inversion changes the polarity, but not the absolute value of the output.

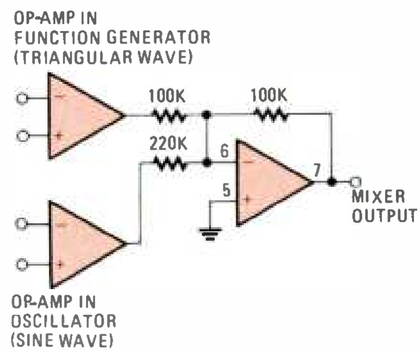


Fig. 19—This circuit not only adds the triangle and sine waveforms together, it amplifies one of them as well.

Signal Mixing

In the following steps, you will demonstrate a linear mixer.

27 Turn off the power and rewire the summer circuit so that it appears as shown in Fig. 19. The only change is the replacement of one 100,000-ohm resistor with a 22,000-ohm unit. One input will come from the triangle output of your function-generator circuit. The other input will come from your Wein-bridge oscillator.

(Continued on page 101)

By Joseph J. Carr, K4IPV

CARR ON HAM RADIO

Basic primer on radio propagation

☐ONE MORNING I GOT UP PARTICULARLY early, and being too lazy to fire up the rig to see what VK/ZL goodies were on 40-meters CW, I flicked on the little B&W TV in our bedroom. A strange test pattern bloomed out at me as the set came to life. Instead of the familiar Channel-5 WTTG test pattern, there was an unfamiliar station on the air with a "C" callsign. Lettering underneath the call letters on that strange pattern indicated that the station was located in Halifax, Nova Scotia—more than a 1200-miles away.

The call crackling out of the speakers of 40 police cruisers was dramatic and frightening: officer in trouble and needs help! A gun battle erupted during a bank robbery in the 8200 block of Main Street. More than three dozen police cars wheeled into action, only to come to a halt at the County Line at 6600 Main ...there was no 8200 block of Main ...and the name of the bank being robbed was unfamiliar to local police.

Investigation revealed that the bank—and 8200 Main—were down in Texas 900-miles away. That Texas police department used the same 38-MHz frequency as our local police department.

If you are a ham operator, then the source of those incidents is obvious: the radio-propagation phenomena called "skip." Because hams use radiowaves to communicate, it is vital that hams understand radio propagation. Whether you use low-HF (160- and 75/80-meters), high-HF (40-10 meters) or VHF/UHF (above 30-MHz), there are critical aspects to radio communications that must be understood to properly use your radio equipment. In this and the next few editions of this column we'll take a quick look at radio-propagation phenomena from DC to daylight (well, the ham bands anyway).

The Electromagnetic Field

Radio and TV waves are electromagnetic (EM) waves exactly like light, infrared, and ultraviolet, except for frequency. The EM wave consists of two mutually-perpendicular oscillating fields (as shown in Fig. 1A) traveling together. One of them is an electric field; the other is a magnetic field.

In dealing with both antenna theory and radiowave propagation, we sometimes make use of a textbook construct called an isotropic source for the sake of comparison and easy arithmetic. An isotropic source assumes that the radiator (i.e., antenna) is a very tiny spherical source that radiates equally well in all directions. The radiation pattern is, therefore, a sphere with the isotropic antenna at the center. As the wave propagates away from the source, that sphere gets ever larger. If, at a great distance from the center, we take a look at a small slice of the advancing wavefront, we can pretend that it's a flat plane, as shown in Fig. 1B. We would be able to *see* the electric and magnetic field vectors at right angles to each other (Fig. 1B).

The polarization of an EM wave is, by definition, the direction of the electric field. Figure 1 illustrates vertical polarization—note that the electric field is vertical with respect to the Earth's surface. If the fields were swapped, then the EM wave would be horizontally polarized.

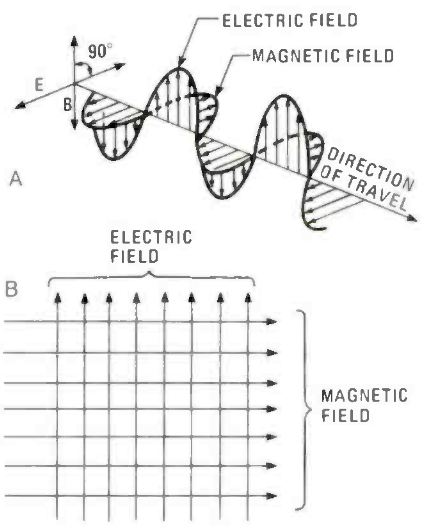


Fig. 1—Radio and TV waves are electromagnetic (EM) waves exactly like light, infrared, and ultraviolet, consisting of two mutually perpendicular oscillating fields (electric and magnetic, shown in "A"). If (as shown in "B"), at a great distance from the center, we take a look at a small slice of the advancing wavefront, we would be able to observe the electric and magnetic field vectors at right angles to each other.

Those designations are especially convenient because they also tell us the type of antenna used: vertical antennas produce vertically polarized signals, while horizontal antennas produce horizontally polarized signals. Some texts erroneously state that antennas will not pick up signals of the opposite polarity. That claim is nonsense, although a 20-dB or so loss might be observed at VHF through microwave frequencies. Although cross polarization might be a factor at VHF, it is not even a consideration in the HF bands.

An EM wave travels at the speed of light (designated by the letter "c"), which is about 186,000 miles per second (or 300,000,000 meters per second if you prefer metric) in a vacuum. To put the velocity in perspective, a radio signal originating on the Sun's surface would reach Earth in about eight minutes. A terrestrial radio signal can travel around the Earth seven times in one second.

The velocity of the wave slows in dense media, but in air the speed is so close to the vacuum or free-space value of "c" that the same figures are used for both air and outerspace.

Propagation Phenomena

Because EM waves are waves, they behave in a wave-like manner. Figure 2 illustrates some of the wave-property phenomena associated with light and radio waves: *reflection*, *refraction*, and *diffraction*. All three play roles in radio propagation. In fact, many propagation cases involve all three in varying combinations.

Reflection and refraction are shown in Fig. 2A. Reflection occurs when a wave strikes a denser medium, as when a light wave strikes a glass mirror. The incident wave (shown as a single ray) strikes the interface between less dense and more dense mediums at a certain angle of incidence (a_i), and is reflected at exactly the same angle (now called the angle of reflection, a_r). Because those angles are equal, we can often trace a reflected radio or TV signal back to its origin.

Refraction occurs when the incident wave enters the different density region and, thereby, undergoes both a velocity and directional change. The amount and

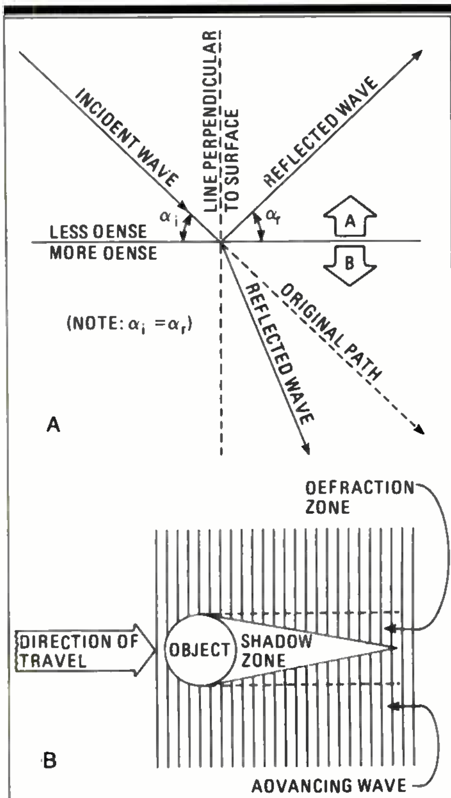


Fig. 2—Reflection, refraction, and diffraction all play roles in radio propagation. Reflection (A) occurs when the incident wave strikes a denser medium. Refraction occurs when the incident wave enters different density region, undergoing both a velocity and directional change, with the amount and direction of change determined by the ratio between the densities of the two media. Diffraction (B) occurs when an advancing wavefront encounters an opaque object. The shadow zone behind the object takes on a cone shape as waves bend around the object. The diffraction zone between the shadow zone and the direct propagation zone is a region of weak signal strength.

direction of that change is determined by the ratio of the densities between the two media. If Zone B is much different from Zone A, then bending is great. In radio systems, the two media might be layers of air with different densities. It is possible for both reflection and refraction to occur in the same system.

Diffraction is shown in Fig. 2B: An advancing wavefront encounters an opaque object (e.g., a steel building). The shadow zone behind the building is not simply perpendicular to the wave, but takes on a cone shape as waves bend around the object. The *umbra region* (or diffraction zone) between the shadow zone ("cone of silence") and the direct propagation zone is a region of weak (but not zero) signal strength. In practical situations the cone of silence is never really zero. A certain amount of reflected signals scattered from other sources will fill in the shadow a little bit.

Propagation Paths

There are four major propagation paths: surface wave, space wave, tropospheric, and ionospheric. The space wave and surface wave are both "ground waves," but behave differently enough to warrant separate consideration. The surface wave travels in direct contact with the Earth's surface. It suffers a frequency, dependent attenuation due to absorption into the ground. Because the absorption increases with frequency, we observe much greater surface-wave distances in the 75/80-meter band (3500-4000 kHz) than in the 10-meter band (29-MHz).

The space wave is also a ground-wave phenomena, but is radiated from an antenna many wavelengths above the surface. No part of the space wave normally travels in contact with the surface; VHF, UHF, and microwave signals are usually space waves. There are, however, two components of the space wave in many cases: direct and reflected (see Fig. 3).

The tropospheric wave is often lumped with the direct space wave in some textbooks, but has properties that actually make it different in practical situations. The troposphere is the region of our atmosphere between the surface and the stratosphere, or about 4 to 7 miles above the surface. Thus, all forms of ground waves propagate in the troposphere. But because certain propagation phenomena—caused mostly by weather conditions—only occur at higher altitudes, we need to consider tropospheric propagation as different from other forms of ground wave.

The ionosphere is the region of Earth's atmosphere that is above the stratosphere, and is located 30 to 300 miles above the surface. The peculiar feature of the ionosphere is that molecules of the air (O_2 and N) can be ionized by stripping away electrons under the influence of solar radiation and certain other sources of energy. The electrons have a negative charge, while the formerly neutral atoms they were removed from are now positive ions.

In the ionosphere, the air density is so low that electrons can travel relatively long distances—richocheting off one another in a domino affect—before recombining with oppositely-charged ions to form electrically neutral atoms. As a result, the ionosphere remains ionized for long periods of the day—even after sunset. At lower altitudes however, air density is greater and recombination, therefore, occurs rapidly. At those altitudes solar ionization diminishes to nearly zero immediately after sunset or never achieves any significant levels even at noon.

Ionospheric propagation is seen in the form of a "sky wave," which is responsible for the so-called *skip phenomena* seen in the MW, HF, and lower VHF-frequency regions. It is skip that makes those signals propagate over long, even intercontinental, distances.

Well, that's about all the space we have for this month. But be with us next time when we'll continue our discussion of radio propagation with a closer look at ground-wave communications—taking a closer look at tropospheric propagation, and then continuing with a look at *skip* (the DX'ers delight). So until then, if you have any questions, comments, or suggestions, write to Joe Carr (K4IPV), PO Box 1099, Falls Church, VA 22041. ■

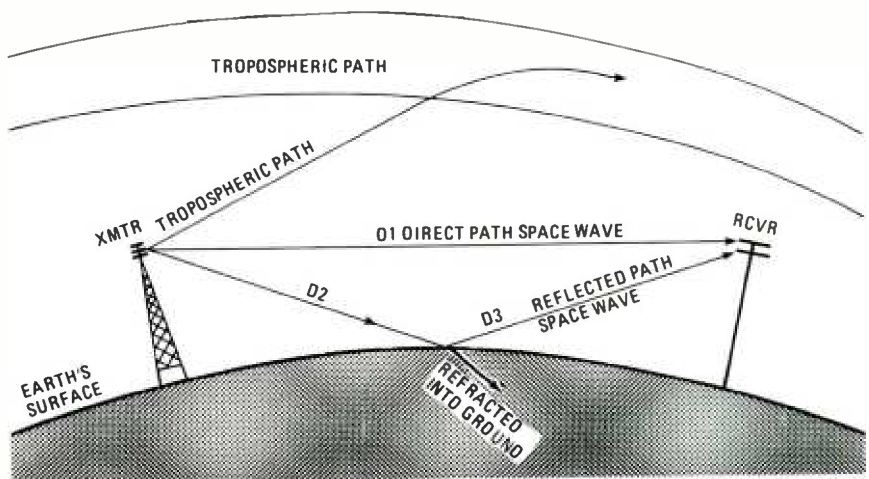


Fig. 3—There are four major propagation paths: surface wave, space wave, tropospheric, and ionospheric. The surface wave (a ground wave) travels in direct contact with the Earth's surface, and suffers a frequency-dependent attenuation due to ground absorption (which increases with frequency). The space wave (also a ground-wave phenomena) is radiated from an antenna many wavelengths above the surface, and no part of the wave normally traveling in contact with the surface. The troposphere is the region of our atmosphere between the surface and the stratosphere, in which all forms of ground waves propagate. The ionosphere is the region of Earth's atmosphere (above the stratosphere) wherein molecules of air (O_2 and N) can be ionized by stripping away electrons under the influence of solar radiation and other sources of energy.

By Marc Ellis

ELLIS ON ANTIQUE RADIO

Echophone EC1—The restoration continues

THOSE OF YOU WHO HAVE BEEN FOLLOWING the last few columns already know about my Echophone restoration project. But here's a little bit of background information for the newcomers. In the July column, I announced that we'd occasionally feature a set for restoration in *Ellis On Antique Radio*. For the first candidate, I selected an Echophone EC1, which I'd recently picked up at a hamfest. Built in the early 1940's, the little Echophone was designed for shortwave listeners with limited budgets. It's a set with a great deal of charm, and its sturdy construction and good looks belie its low original-selling price (about $25.00).

As I received it, the set was relatively intact, and in good cosmetic condition, except for several layers of encrusted grime (especially on the chassis top). It was so dirty that I decided to do some deep cleaning even before trying it out. Last month I reported on the dismantling and cleaning process, as I started to work on the set. This month, only the main tuning/bandspread capacitor (already removed from the chassis) remained to be cleaned.

Reassembling the Set

After some thought, I decided that the best way to get the dust and dirt out of the capacitor would be a good soaking in mineral spirits followed by a compressed-air blow-dry. That worked quite well, but before I could reinstall the unit, I had to solve another small problem. The capacitor's mounting screws had passed through soft rubber vibration-absorbing grommets installed in the chassis. Those were hardened and decomposed, so I needed replacements. I was able to find grommets of the right size in a 99-cent Radio Shack assortment, but I had a heck of a time getting them into the old holes. Modern vinyl is quite a bit stiffer than the old-time soft rubber.

The grimy, main-tuning capacitor was bathed in mineral spirits to loosen up the encrusted dirt and dust, followed by a compressed-air blow-dry.

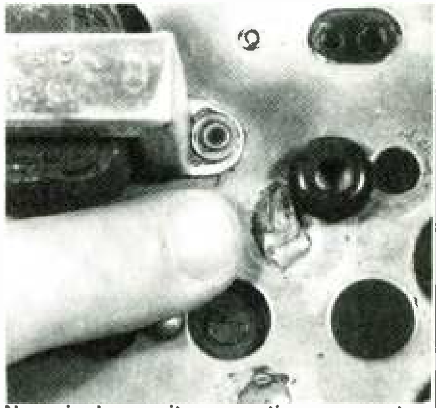
Once the tuning capacitor was remounted on the chassis, I restrung the dial cords for the main tuning and bandspread controls. (I had made a careful reference sketch of the stringing system prior to dismantling it.) After reassembly, everything worked fine, except that one of the cords tended to slip now and then.

Apparently, I had done too good a job of cleaning and polishing one of the control shafts! It was a little too smooth and couldn't get a good enough grip on the cord it was supposed to drive. So, slipping the dial-cord loops temporarily to one side, I rubbed the contact area of the shaft with stick paraffin. That seems to have cleared up the difficulty.

After reinstalling the dial plate and pointers, I was ready to reassemble the chassis to the wrap-around cabinet/front panel. But before doing that—while switches and controls were still easily accessible—I treated them all with a liberal application of contact-cleaner spray, then vigorously operated each one several times through its full range. That treatment effectively removed grime and corrosion, making the old controls operate quietly again.

With the chassis reassembled to the front panel/cabinet assembly, I could now reconnect the wires to the four panel-mounted switches. Since those switches were permanently riveted to the panel, I had to disconnect them earlier (making careful reference sketches of the wiring hookup) in order to separate the chassis and cabinet. Except for installation of tubes and control knobs, the little Echophone was now ready for testing.

In checking the tubes that had come with the Echophone against my Rider service notes, I noticed that—somewhere along the way—a serviceman had replaced with glass types two tubes that had originally been metal. Since I happened to have the metal types on hand, I decided to switch back to the original configuration. The complete tube set was then installed in the radio after having been checked and found to be good. Now the set looks great, and the next step will be to apply power and see what happens! I'll report on the results in the next column.



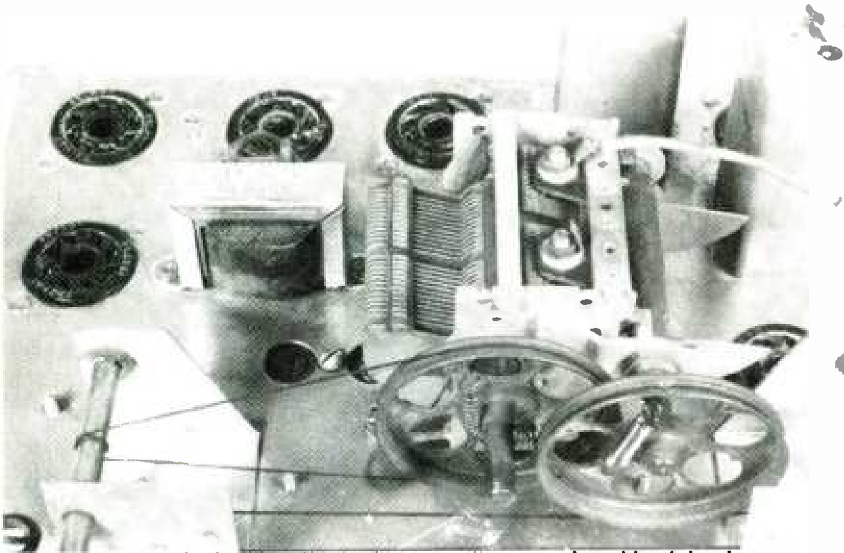
New vinyl capacitor-mounting grommets, which are much more rigid than the rubberized originals, were installed in place of the dried-out rubber ones.

The Echophone in WWII

Recently, two readers wrote in to share memories of their own experience with the Echophone EC1. Both stories are associated with World War II, and both readers still have the EC1's in their possession.

While stationed in England with the Eighth Air Force, George Pearson of Massapequa, NY kept in touch with war news on a variety of home-made regenerative receivers. When the war in Europe ended, he was sent back to the states for redeployment to the Pacific. George decided to take advantage of a short furlough in New York City to find a better radio for the Far East Campaign.

Radios were scarce on the civilian market, but—through a friend—George was able to locate an Echophone EC1. Delighted, he packed it carefully into his duffle bag, leaving behind some clothing to make room. The bag and radio were soon lost, having gone astray on a crowded troop train. George had given up hope of ever seeing his new purchase again. But, amazingly enough, the bag turned up at a lost-and-found office days later.



After a thorough cleaning, the tuning capacitor was placed back in place on the chassis. Note that one of the two dial cord systems has been restrung.

George never made it to the Pacific. The atomic bomb brought the hostilities to a close while he was still on temporary assignment at Charlston Air Force Base. Thanks to the EC1, George was one of the first people on the base to hear about the bomb. Using a bedspring antenna, he picked up the news one morning on an Australian station!

Our other World War II story comes from Dan Scheer, who served as a radio operator with the Marines. He'd been an SWL since the age of 12 or so, and had done his listening on home-made receivers. Just before the war Dan bought himself and EC1, which he used until he was about to be sent overseas. The he shipped it home to his dad and bought himself a Hallicrafters S29 battery-operated portable set.

The Hallicrafters worked for about a year—until mold and rust eventually put it out of action. (Unlike George, Dan must have made it to the Pacific!). The Echophone, however, performed beautifully for Dan's dad all during the war. With his letter, Dan enclosed a Xerox of the original Echophone instruction manual. Needless to say, I was delighted to receive that bit of information, and will be sharing some of its contents with you soon.

My own Echophone shows some interesting internal evidence of having gone through World War II, but I'll need some help from a knowledgeable reader to uncover the whole story. While working under the chassis, I noticed that a wire to one of the oscillator's trimmer capacitors had been disconnected—effectively putting the set out of operation on its highest frequency range (8–30 MHz). That was obviously neither an accident, nor a case of mindless butchery; the wire had been neatly and deliberately-cut and removed.

I've heard that during the war, radio-service technicians were instructed by the government to disable the shortwave bands of all-wave radios that came into their shops. For security reasons, the civilian population wasn't supposed to have access to those bands. I can't imagine any other reason for the wire having been removed, but it's hard to understand how such a policy could have been effective. There must have been many radios that, like Dan Scheer's Echophone, made it through the war without a service call. Would it have been technically illegal to listen to shortwave on those radios?

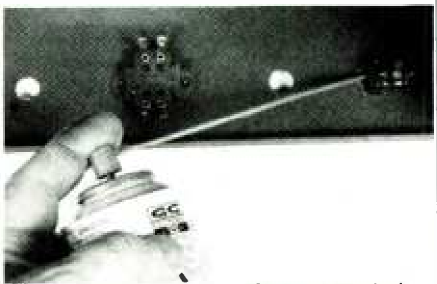
Since the war has been over for some time, I felt I could replace the wire and still be considered a loyal citizen. However, it would be very interesting to learn more about wartime government policy on shortwave listening. Are there any readers with information to share? Please write me C/O **Hands-on Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735.

The Dayton Hamvention

Last month (April) I attended my first Dayton Hamvention—said to be the biggest annual ham radio get-together in the world. I had a super time from a ham radio point-of view, and picked up many items needed for my station. But as an antique-radio collector, I was a bit disappointed.

Only a few sellers at the 1800-table flea market had much in the way of antique gear, and prices seemed to be rather high. The spirit and camaraderie among the participants at the event are great however. And if you'd like to immerse yourself in ham radio for three days, I can't think of a better way to do it. I know that I'll be back next year!

Well, that about does it this time around, but, I hope to "see" you next month. Until then, happy collecting! ■



The switches and controls were treated with contact-cleaner spray, and operated several times to prevent locking prior to reassembling the chassis and panel.

A frontal view of the reassembled Echophone. The top panel (containing the speaker) won't be replaced until the set is operating and needs no adjustment.

By Charles D. Rakes

CIRCUIT CIRCUS

Don't change power supplies—produce what you need from what you have!

☐THE CIRCUS THIS MONTH STARTS OFF with a circuit that goes from positive to negative in a flash, without the aid of that long standing nemesis, Mr. Murphy, and ends up being a working and useful circuit that could fit in your next project.

DC Voltage Inverter/Doubler

The DC Voltage Inverter/Doubler circuit shown in Fig. 1 turns a 12- to 15-volt positive-power source upside down, creating a variable-regulated negative supply. The negative output voltage can be set to any voltage level between 1 and 10-volts when the circuit is operated from a 15-volt power source, and can supply up to 20 mA of operating current to a connected load.

A 555 oscillator/timer, operating as a free running astable oscillator, feeds its output at pin 3 to a voltage-doubler circuit that is connected for a negative output. Without the unusual feedback circuit (components R4 and R5) the DC Inverter will produce a negative output voltage that's about 80% of the positive-power source. The regulator circuit operates best with a load; and when a regulated power source is used, the load/no-load output voltage will only vary a few millivolts.

Voltage Doubler

Have you ever had a favorite circuit or project that you wanted to use in your automobile; but, as fate would have it, a part of the circuit required a slightly higher voltage than the 12-volts offered by the car's battery? If so, take a look at the DC converter circuit in Fig. 2.

A 555 oscillator/timer, configured similarly to the one in Fig. 1, feeds a positive voltage-doubler circuit that produces the higher DC output voltage. Transistors Q1, Q2, and diode D3 add regulation and a variable output function to the circuit. If the regulator circuit is removed and a 12-volt supply is applied directly to the oscillator circuit (top of C1), the output will be over 25 volts and will vary in level with supply voltage changes and load variations. An output current of over 30 mA can be supplied at a regulated output of 6 to 16 volts.

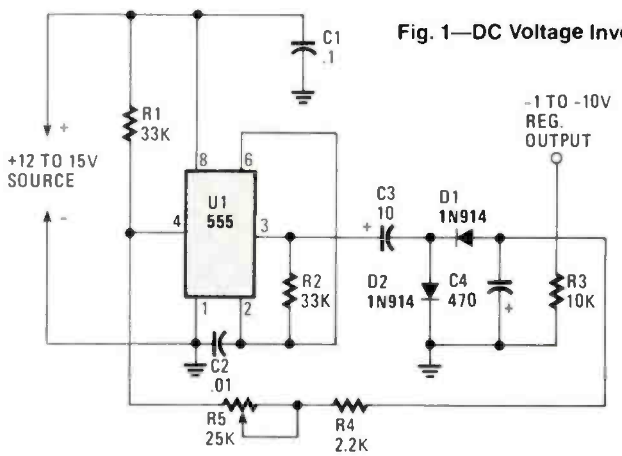


Fig. 1—DC Voltage Inverter/Doubler

C1—.1-µF, 100-WVDC, Mylar capacitor
C2—.01-µF, 100-WVDC, Mylar capacitor
C3—10-µF, 25-WVDC, Electrolytic capacitor
C4—470-µF, 25-WVDC, Electrolytic capacitor
D1, D2—1N914 general-purpose silicon diode
R1, R2—33,000-ohm, ½-watt, 5% resistor
R3—10,000-ohm, ½-watt, 5% resistor
R4—2200-ohm, ½-watt, 5% resistor
R5—25,000-ohm potentiometer
U1—555 oscillator/timer, integrated circuit
Printed-circuit or perfboard materials, etching solution, power supply or battery, enclosure, wire solder, hardware, etc.

Voltage Multiplier

The DC Voltage Multiplier circuit might just tickle your funny bone if you let your fingers do the walking through the circuit—while the power is on—as it steps up the 12-volt supply to over 117-volts. Although the output voltage stands tall, the circuit has very little *umph* in the output-current department; and even a light load drawing, say, 1 mA will drop the output voltage to about half.

The Voltage Multiplier can be used to supply a bias voltage to a high-impedance circuit, to ignite neon lamps, for testing the reverse-breakdown voltage of semiconductors, or for any other application where a high-voltage, low-current power supply is required.

Figure 3 shows the complete high-voltage circuit. Old reliable—the 555 oscillator/timer—is used to generate the switching voltage (AC to those in the know) that feeds the primary of T1. The AC voltage is stepped up by transformer T1 and rectified in a two-diode, voltage-doubler circuit to produce the 117-volts DC at the output. The simplest way to make the output variable is to adjust the input voltage supplying power to the converter circuit to obtain the desired output.

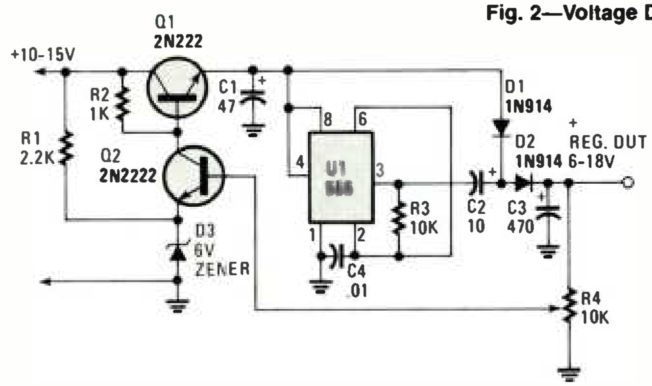
No I don't, unfortunately, own stock in any of the companies that produce the versatile 555, and I didn't start out this month's Circus to feature an old friend in each of the circuits, but experimenting with the device is too much fun to stop now, so here's another 555 circuit.

Electronic Wake-up Call

The first three circuits using the 555 were of the serious type designed to work with, or in, another circuit or project; but the Wake Up circuit is for fun only. A real tomfoolery circuit if ever there was one. No serious stuff with this one folks, so dig in and have a ball.

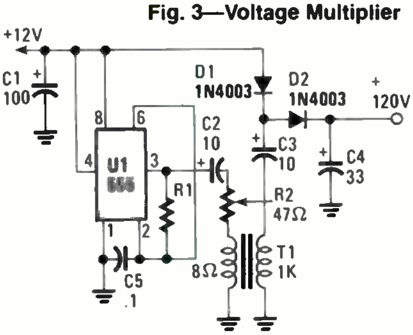
The Electronic Wake-up Call circuit shown in Fig. 4 is designed to help you get moving when sleeping is at its best. Now if you are against having a solar-activated squawk box telling you when it's time to

Fig. 2—Voltage Doubler



C1—47-µF, 25-WVDC, Electrolytic capacitor
C2—10-µF, 35-WVDC, Electrolytic capacitor
C3—470-µF, 35-WVDC, Electrolytic capacitor
C4—.01-µF, 100-WVDC, Mylar capacitor
D1, D2—1N914 silicon signal diode
D3—5 or 6-volt, Zener diode
U1—555 oscillator/timer, integrated circuit
Q1, Q2—2N2222 NPN general-purpose transistor
R1—2200-ohm, ½-watt, 5% resistor
R2—1000-ohm, ½-watt, 5% resistor
R3—10,000-ohm, ½-watt, 5% resistor
R4—10,000-ohm, potentiometer
Printed-circuit or perfboard materials, etching solution, power supply or battery, enclosure, wire solder, hardware, etc.

Fig. 3—Voltage Multiplier



C1—100-µF, 25-WVDC, Electrolytic capacitor
C2, C3—10-µF, 250-WVDC, Electrolytic capacitor
C4—33-µF, 250-WVDC, Electrolytic capacitor
C5—.01-µF, 100-WVDC, Mylar capacitor
D1, D2—1N4003 1-A, 200-PIV rectifier diode
U1—555 oscillator/timer, integrated circuit
R1—10,000-ohm, ½-watt, 5% resistor
R2—47-ohm, ½-watt, 5% resistor
T1—Miniature 8-ohm to 1K audio transformer
Printed-circuit or perfboard materials, etching solution, power supply or battery, enclosure, wire solder, hardware, etc.

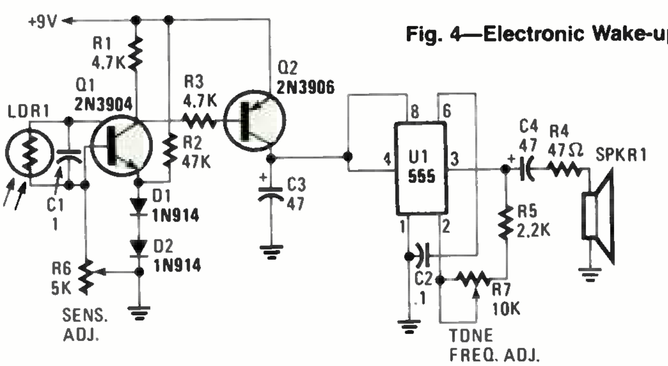
get up, then casually leave it at a friend's house and let him enjoy the benefits of early rising to meet the break of day. A cloudy day might foul up the circuit, but then nobody's perfect anyway. Don't despair, if the Sun *don't* shine where your at, because you can still make friends with the Electronic Wake-up Call circuit by hiding it in a closet, or in a desk, or file cabinet, or? And when the light wakes the circuit up, you will have made another good buddy. Get the picture?

The operation of the Wake-Up circuit in Fig. 4 goes like this. A cadmium sulfide photocell (LDR1, which is a light-dependent resistor) is connected to the base and collector of an NPN transistor, Q1. When light hits LDR1, the internal resistance goes from a very high (dark) value to a low (light) value, supplying base current to Q1, turning it on.

The voltage across R1 produces a bias that turns Q2 on, which in turn, supplies the positive voltage to U1 at pin 8 (the positive-supply input) and pin 4 (the reset input), to operate the 555 audio oscillator circuit. The circuit's sensitivity to light can be set via R6 (a 50,000-ohm potentiometer). R7 sets the audio tone to the most undesirable sound. The squarewave audio tone is fed from U1 pin 3 to a small speaker through coupling capacitor C4 and current limiting resistor R4.

The complete circuit can be built in a light, plastic cabinet with LDR1 facing out through a small hole that will only let light in from a single direction. Other than that, build and use the Wake-Up circuit anyway you please. And until next month help a friend wake up on time. ■

Fig. 4—Electronic Wake-up Call



C1, C2—.1-µF, 100-WVDC, Mylar capacitor
C3, C4—47-µF, 16-WVDC, Electrolytic capacitor
D1, D2—1N914 silicon signal diodes
LDR1—Light-defendent resistor
U1—555 oscillator/timer, integrated circuit
Q1—2N3904 NPN general-purpose transistor
Q2—2N3906 PNP general-purpose transistor
R1, R3—4700 ohm ½-watt, 5% resistor
R2—47,000-ohm, ½-watt, 5% resistor
R4—47-ohm, ½-watt, 5% resistor
R5—2200-ohm, ½-watt, 5% resistor
R6—50,000-ohm potentiometer
R7—10,000-ohm potentiometer
SPKR1—Small 8 or 16-ohm speaker
Printed-circuit or perfboard materials, etching solution, power supply or battery, enclosure, wire solder, hardware, etc.

"Everytime you dial your mother's phone number you erase last month's inventory!"

By Byron G. Wels

WELS' THINK TANK

Reader interactivity continues

THE MAIL HAS BEEN POURING IN, AND the *FIPS* books have been rolling out! Just in case you missed our last column, we've made *Think Tank* interactive. What that means is that from now on, *you* send in your pet circuit, we publish it, along with your name, city and state, and we send you at absolutely *no charge*, a copy of the *Collected Works of Mohammed Ulysses Fips* (a $12.95 value).

Back in the 40's, Hugo Gernsback (our founder) used to write a story for each April issue of *Radio-Craft* Magazine (now *Radio-Electronics*). Each carried the Fips by-line that revealed to regular readers that it was the annual "April's Fool Story." Because Gernsback was skilled in electronics and wrote convincingly, the stories were not only very humorous, but they persuaded many a newcomer into attempting to duplicate those impossible electronic feats. So for some really-great electronics reading, get your copy now!

How? Send us your favorite circuit, along with application, an in-depth description of how it works, and an easy-to-read schematic. Please limit the circuit to no more than two transistors or IC's, because space is limited. When we OK it, we will send you a copy of the *FIPS* book.

Turntable Amplifier

My wife and I, are recently married, and a surplus of money isn't one of the many problems facing this newlywed couple. However, I did manage to save a few pennies out of my lunch money, so that on her birthday I was able to buy her an excellent (and expensive) turntable, complete with tone arm and stylus. Being a music lover, she was thrilled, and I explained that when we could afford it, we'd get her an amplifier and a speaker system, that this was just the start.

I came home the next evening, to see her crouched over the turntable, listening to the stylus tracking in a record groove! I went to my basement workshop after dinner and quickly put together a pair of the amplifiers. Of course, they aren't super-quality—so the big names in audio need not fear competition from this humble hobbyist—but, they did let my wife actually hear the music.—Sam Merchant, Ocean Beach, CA

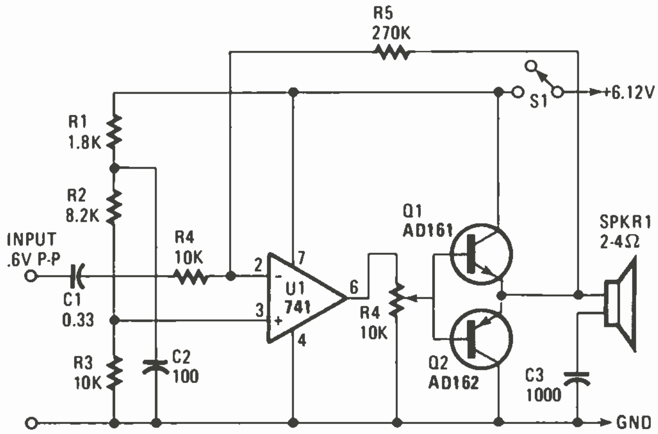


Fig. 1—The input signal is fed to the inverting input of U1 (a 741 op-amp, set up as an amplifier/buffer). U1's output is fed to the common-base leads of Q1 and Q2 (which you'll surely recognize as a push-pull amplifier). The input to the push-pull (feeding SPKR1) is controlled by R4, which serves as a volume control.

Take a look at Fig. 1. Note that only one channel is shown. For stereo operation, two such circuits are required. The applied signal is fed to the inverting input of U1 (a 741 op-amp that's set up as an amplifier/buffer). The output of U1 is fed to the common-base connections of Q1 and Q2 (which you'll surely recognize as a push-pull amplifier). The input to the push-pull (feeding SPKR1) is controlled by R4, which serves as a volume control.

In putting the project together, if stereo operation is desired, we recommend that a dual-gang potentiometer be used for R4 and wire them so that as one side increases, the other decreases. In that way, the volume controls also serve as balance controls, and S1 (which is the on/off switch) can be mounted to the back of the pots.

Well Sam, your copy of the FIPS book is in the mails and I hope that you (and your wife) enjoy it.

Touch Switch

I've derived a good deal of pleasure and satisfaction out of my electronics hobby, so it's indeed a pleasure to give some back. I do remember chuckling over the original FIPS articles when they were published, and it will be a delight to see them again. I do hope this circuit wins me a copy.—writes Ted Welsh, of San Antonio, TX

With no moving parts to wear out, the circuit shown in Fig. 2 gives Ted's rendition of a Touch Switch (which will control 9-volt DC loads of up to 100mA) a great life span. The circuit is built around a 4001 quad two-input NOR gate with all gates connected to act as inverters. U1b to U1d are connected in parallel for a low-impedance output.

Those three gates, along with U1a, form a bistable multivibrator. Touching the two upper contacts (e.g., bridging the contacts) applies a small current to the input of U1a, causing its output at pin 3 to go low. U1a's output is then fed to the bridged inputs of U1b to U1d, forcing its output high. That high, fed to the base of Q1, causes the transistor to conduct, pulling its collector low, completing a path to ground through the load circuit.

To reset (turn off) the circuit, just touch the two lower contacts, applying to the input of U1a, causing its output to go low. The low, in turn, causes the outputs of U1b to U1d to go low, turning off Q1. With Q1 turn off, disrupting current flow in the load circuit, and thus causing the load to cease functioning.

Well Ted, your copy of the FIPS book is on the way. Hope you enjoy it.

Door-Slam Switch!

You want my favorite circuit? You *got* it! I come home at night, walk across the

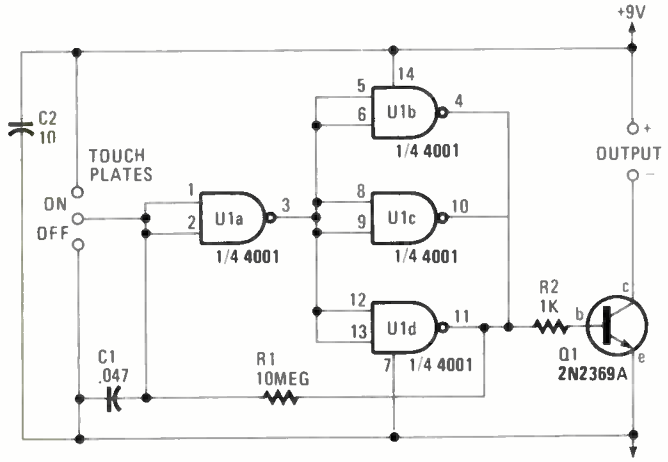


Fig. 2—This Touch Switch (which will control 9-volt DC loads of up to 100mA) is built around a 4001 quad NOR gate. U1b to U1d along with U1a form a bistable multivibrator. Touching the two upper contacts causes Q1 to conduct, pulling its collector low; thereby, completing a path to ground through the load circuit.

carpet, go to turn on the light and I get zapped by a half-inch arc from the static. I tried spray cans but they didn't last long enough and were too expensive. However, this circuit saved me.

When I come in now, all I have to do is slam the front door and the lights come on. Now send me my copy of the Fips book.—Clark Teicher, New Orleans, LA

Clark, it's on the way to you. And I don't mind telling you that I'm in the process of building my own version of this unit, as I suffer the selfsame problem.

Check out Fig. 3. The circuit stays off until a sound (like Clark's door slamming) causes it to activate. The 741 op-amp input stage is hooked up as a non-inverting amplifier with about 100% gain. If you need more sensitivity, raise the resistance of R2. The signal is then rectified and filtered by the diodes, D1 and D2, and capacitors C3 and C4. The signal is applied to the base of transistor Q1, a 2N2222.

R5 sets the desired audio threshold, and the output of the transistor, at its collector, is applied to a relay which activates the output load. Make sure that the relay you choose will have sufficient capability to carry the current you desire at its contacts.

Phone Recorder

If you ever have a need to tape-record telephone conversations, this becomes the handiest gadget in the book. What I particularly like about it, is that it can be connected to the telephone lines just about anyplace, even down in the basement where my workshop is located.—says John Peabody, of Macon, GA

Take a look at Fig. 4. You'll notice that no external power source is needed; the phone company takes care of that. The tape recorder's switch terminals are applied to a pair of transistors connected as Darlingtons that are used to turn the recorder on and off. (All you need is a negative voltage at the base of Q1 to stop the recorder.)

When the telephone is off-hook there's usually about 50 volts DC across the phone that's divided over R1, R2 and R4 so that Q1's base is negative enough to keep the recorder off. Pick up the receiver, voltage drops to 5 volts. That leaves not quite-enough voltage on Q1's base to keep that transistor at cutoff, so the recorder begins. Nice, huh? Just remember to keep your recorder's switch in the ON position, and depending on how many people use the telephone, remember to rewind or change tapes occasionally!

And one more thing to remember John: Remember to watch the mails for your copy of the Fips book.

Light Flasher

My friends and I are all electronics hobbyists, and we're constantly testing each other, just for fun. One of the guys built an R/C circuit using an NE-2 neon lamp, a big battery, a resistor, and a capacitor. The neon lamp blinks happily away, on and

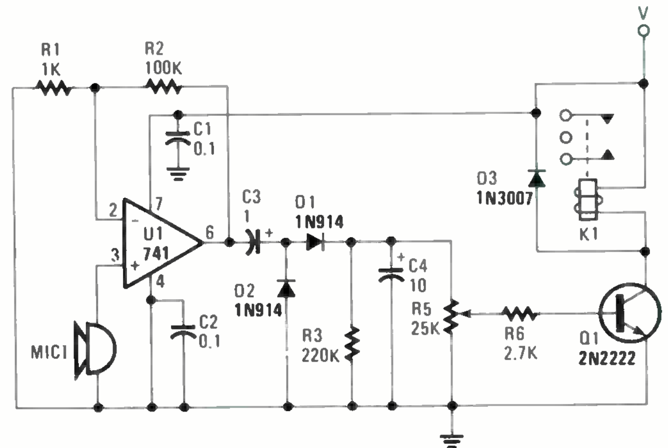


Fig. 3—The op-amp output at pin 6 is rectified by diodes D1 and D2, filtered by capacitors C3 and C4. The resulting DC output is applied to the base of transistor Q1, turning it Q1 on and, thus, the relay, activating the load.

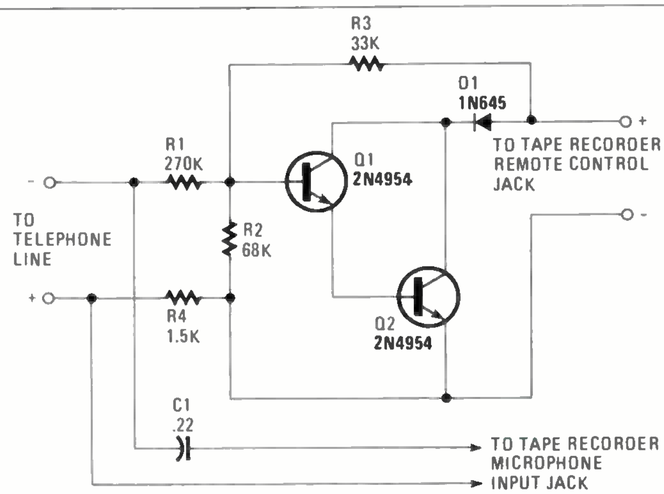


Fig. 4—The tape recorder's switch terminals are connected to a Darlington pair (consisting of Q1 and Q2), which are used to turn the recorder on and off. The telephone's off-hook voltage (about 50-volts DC) is divided over R1, R2, and R4 so that Q1's base is negative enough to keep the recorder off. Lifting the receiver, causes the voltage to drop to 5 volts, biasing the Darlington on, which in turn, activates the recorder.

off, on and off, and will last forever as the drain on the battery is so slight. His parents freaked out when they saw it because they didn't know what it was!

Well, what makes this my favorite circuit, is that it blew them all away. Can you picture an *incandescent* lamp blinking on and off like that?—Fred Conklin, Brooklyn, NY

No way! That's why I recommend that people build this circuit into a little black box, and mount a small pilot lamp, like a GE-47 through a half-inch rubber grommet atop the box.

See Fig. 5. When you press switch S1, a momentary-contact push-to-make switch, the capacitor takes a rapid charge to .7 volts. The transistor is forward-biased allowing collector current to flow and operate the relay which has a 200-ohm coil. When you release switch S1, the capacitor discharges through the 33,000-ohm resistor and when the capacitor voltage is down to about half a volt, the transistor base is no longer forward biased and the transistor stops conducting. As a result, the relay opens.

All you've got to do is wire the contacts of the relay to the small pilot lamp and put the battery contacts in series with them. The other pair of relay contacts are wired so the normally-open contacts are connected in parallel with switch S1.

Sounds like a lot of fun, Fred. I'm sure you've driven them nuts. And talking about fun, wait 'till your friends get a look at the Fips book that's on the way to you.

Code-Practice Oscillator

Byron, I know I've seen schematics for code-practice oscillators in the past, but now I need one in a hurry, as I'm going to be teaching an amateur radio class in my local adult education system. Got anything?—L.B., Kansas City, KS

The circuit shown in Fig. 6 should end your quest. But before we get into the details, understand that if you replace the telegraph key with an ordinary switch, you've also got a signaling device. It also makes a great electronic doorbell. Replace the telegraph key with a pair of test leads, and you've got an audible continuity checker.

The audio tone is generated by a relaxation oscillator (built around a 2N4871 UJT) operating at a frequency of 1.5kHz. If you want a lower tone, simply increase the value of capacitor C1. The sawtooth waveform generated across C1 is coupled through C2 and R4 to the base of Q2, a simple common-emitter, class A output amplifier. Resistor R4 assures that the output stage doesn't overload the oscillator.

Capacitor C3 rolls off the output stage's high-frequency response, reduces the harmonic content, and provides a more pure and pleasing sound that won't tire you after listening for long periods of time.

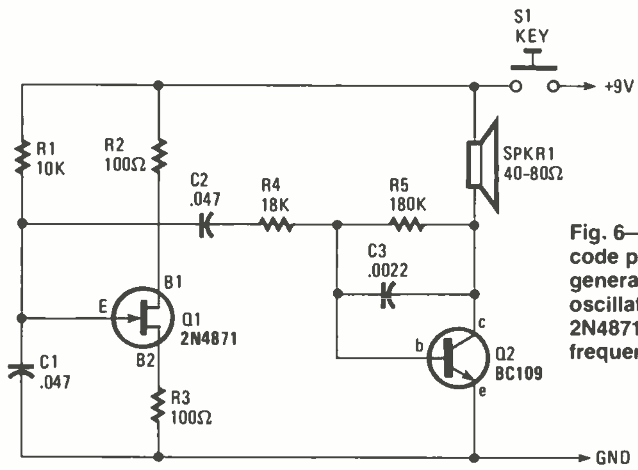


Fig. 6—The audio output of the code practice oscillator is generated by a relaxation oscillator, consisting of a 2N4871 UJT, Q1, operating at a frequency of 1.5 kHz.

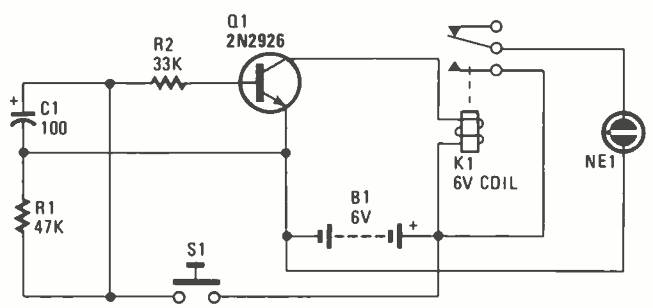


Fig. 5—Pressing switch S1, causes C1 rapidly to .7 volt, biasing Q1, which allows current to flow and operate the relay. Releasing S1 causes C1 to dis- charge through R2. When the charge on C1 reaches about half a volt, Q1 turns off and the relay opens.

Auto-Advance Projector

I'm into photography. And when I do a slide show, I'd like the slides to change automatically, instead of having to push the remote button for each new slide. Got any ideas Byron?—P.G., Neenah, WI.

Sure thing, P.G. Check out Fig. 7. That circuit, built around a 4001 quad two-input NOR gate, even provides switch selectable auto-advance times of 5, 10, 15, 20, 25 or 30 seconds through the remote-control socket of your projector. Three of the NOR gates have both inputs tied together to act as inverters. The remaining gate is used as follows:

U1a and U1b form an astable multivibrator, with its operating frequency dependent on the number of timing resistors switched into the circuit via S2. The frequency is about one cycle for every five seconds with a single timing resistor, one every ten seconds with two resistors, etc. That provides six switched time intervals.

(Continued on page 105)

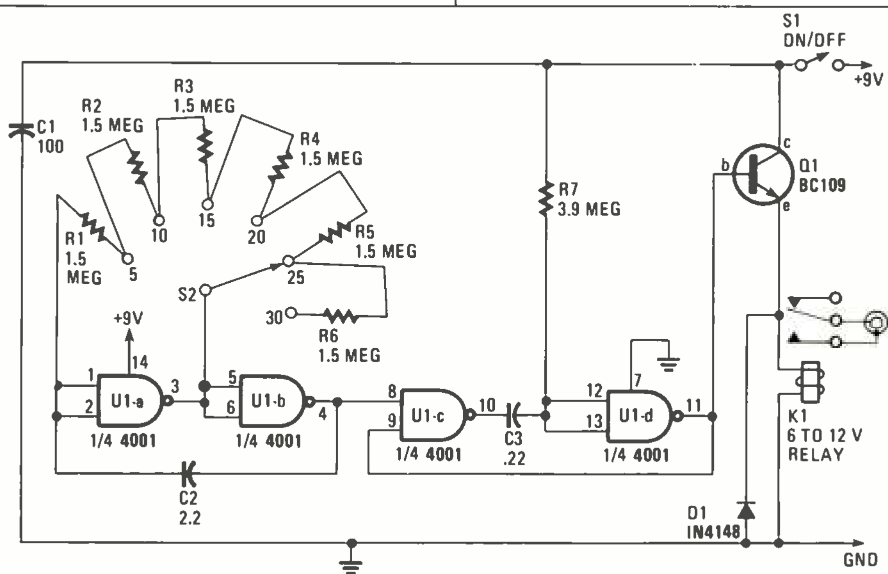


Fig. 7—The auto-advance circuit (using a 4001 CMOS quad, two-input NOR gate configured as inverters) advances the slides at intervals of 5, 10, 15, 20, 25 or 30 seconds, depending on the setting of switch S2.

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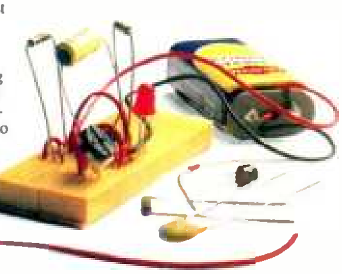

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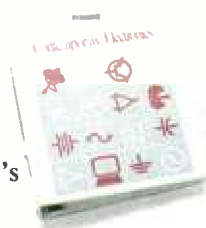

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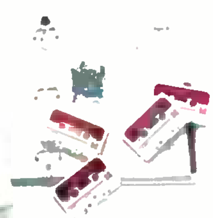

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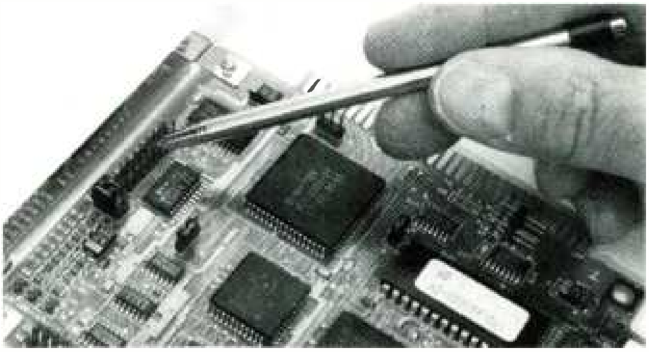
FRIEDMAN ON COMPUTERS

(Continued from page 23)



The pointer indicates one of several sets of jumper pins used to program the controller for specific drive characteristics. The controller usually comes with a data sheet that gives the jumper setting for most drive models.

All the required information is in the data sheet that came with the drive. In fact, if you get one of the commonly-used drives such as a Seagate *225* or a Microscience *612*, the controller data specifically lists the jumper-block connections. (It's always best to use "standard" hardware.)

Low-level Format

Now for the great bugaboo—*low-level formatting* of the hard disk, which in non-technical language means writing magnetic blips on the hard disk as reference marks for the regular format software. Since IBM's DOS was intended for IBM's own hard-disk drives, which are preformatted at the factory, PC-DOS does not contain a low-level format program. Either you must borrow one from a friend or a BBS, get it from the disk supplier (if he has it), or you simply enter a DEBUG routine that's given in the instructions supplied with the Western Digital controllers. In about three to six minutes, the hard disk is low-level formatted and you can then use the regular PC/MS-DOS FDISK and FORMAT software to partition and format the hard disk for use.

Before we close, we should put to rest two myths about hard disks, which are usually used to intimidate hobbyists from saving a bundle of cash by using surplus hard-disk drives. First, you can use more than one hard disk: the *WX-1* and *WX-2* controllers have connectors for two hard-disk drives. Second, the drives need not have the same capacity. If you start out with a 10-megabyte drive to keep costs at rock-bottom, you can add a 20-megabyte drive in the future—it's the assortment of programming pins on the Western Digital controllers that allows you to mix-'n-match. ■

NEW PRODUCTS

(Continued from page 13)

information contact Panasonic, One Panasonic Way, Secaucus, NJ 07094.

Proton Loudspeaker System

Housed in the distinctively-shaped AL-300 cabinet is a one inch polyester, soft-dome fluid-cooled tweeter chosen for it's response capability and high power handling ability.

The midrange driver is a 3.5-in., treated cone mounted in an integral air-suspension sub-enclosure. It incorporates an 11-ounce magnet creating a 12-kilogauss flux density.

The 12-in., air-suspension woofer, operating with a 30-ounce magnet, greatly reduces harmonic and intermodulation distortion, even at high power levels.

The crossover design operates each driver over a relatively small frequency range to reduce system distortion and increase power-handling capability. Extreme off-axis radiation is intentionally limited to reduce unwanted room reflections and stabilize the stereo image.

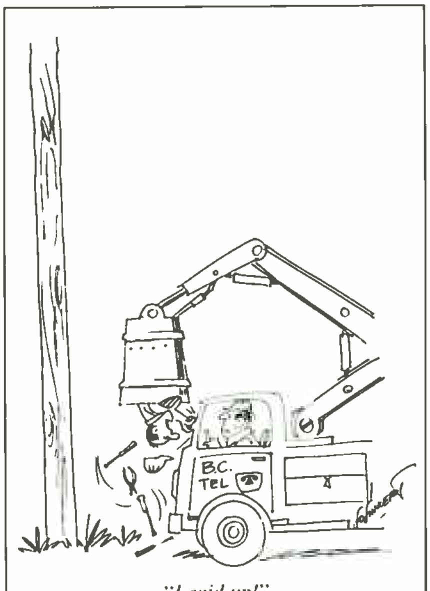
The distinctive angle of the AL-300 front panel aims the axis of radiation directly at the useful listening area in a "real-world" monitoring situation. The panel also helps to integrate the radiation from the individual drivers and limit the amount of midrange and tweeter energy reflection of the floor.

The cabinet is braced to suppress energy storage and superfluous radiation. Acoustically absorbent felt eradicates cabinet diffraction and reflection effects and improves stereo imaging.

System sensitivity runs just over 90 dB at one meter for 2.83 V_{rms} of pink noise (500 Hz to 5 kHz, bandlimited). The input impedance averages 6 ohms (minimum 3.3 ohms) to allow maximum power transfer from contemporary amplifiers.

The Proton AL-300 loudspeaker system has a suggested retail price of $899.00 (pair). The proton D540 amplifier has a suggested retail price of $299.00. The D1200 amplifier has a suggested retail price of $599.00.

For more information contact Proton Corporation, 737 West Artesia Boulevard, Compton, CA 90220.



"I said up!"

OP-AMP APPLICATIONS MADE EASY

(Continued from page 87)

28 Change the values of the 10,000-ohm resistors (R1) in the Wein bridge to 3300-ohm each.

29 Apply power to the circuit. Observe the output of the summer/mixer at pin 7. What do you see?

What You Did

In the demonstration, you mixed the sinewave output with the triangle wave. The result is 550 Hz triangle wave on which is superimposed a 4800 Hz sinewave. The 3300-ohm resistors increased the Wein-bridge output from 1592 Hz to about 4825 Hz. Your waveform should look like that shown in Fig. 20. The mixer/summer input and feedback resistors set the gain or amplitudes of the signals being mixed. Such a circuit is used in audio mixers where sound from one or more musical instruments and voice from microphones are brought together. Potentiometers on each input control the gain of each input. Remove power from the circuit or play with it to your hearts content.

Next month we'll explore the use of high-power semiconductors such as SCR's. So stay tuned, same Hands-on time; same Hands-on channel. ■

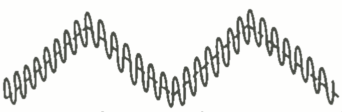


Fig. 20—The sum of the triangle and sine waves should have this appearance. Note the amplitude of the triangle wave after amplification. The sinewave was passed through without any gain, leaving it puny by comparison.

ACNAP: A PROGRAM TO ANALYZE AC NETWORKS

(Continued from page 46)

is equal to the value of the VCCS (in this case V), times the value of the controlling voltage, V_C.

$$I \text{ into node } 1 = V \times V_C$$

The controlling voltage can be equated to the voltage at the positive controlling node, V_3, and at the negative controlling node, V_4, by writing:

$$V_C = V_3 - V_4$$

Therefore, the expression for the current into node 1 is given by the equation:

$$I \text{ into node } 1 = V \times (V_3 - V_4)$$

or,

$$I \text{ into node } 1 = V \times V_3 - V \times V_4 \text{ (Eq. 3)}$$

The effects of the VCCS on node 2 are the same as above, except for a sign change. That is:

$$I \text{ into node } 2 = -V \times V_3 + V \times V_4 \text{ (Eq. 4)}$$

The terms represented by equations 3 and 4 would generally appear on the right side of equation 1. However, because they contain references to other node voltages in the circuit, ACNAP changes their signs and puts them on the left side of equation 1. That accounts for the different signs found in lines 2690 and 2700 of ACNAP.

The A Matrix

As mentioned earlier, nodal analysis requires that one equation be written for each node of the circuit to be analyzed. Now that we know where those equations come from, let's take a brief look at how ACNAP actually handles the KCL equations.

ACNAP enters those equations into an augmented (N row by N + 1 column) matrix. Each row in that matrix represents the KCL equation for the corresponding node of the circuit. That is, row 1 is the KCL equation for node 1, row 2 is the KCL equation for node 2, and so on.

The first N columns of the augmented matrix represent the terms in the KCL equations that are dependent on the corresponding node voltages. The last column represents the constant terms of the KCL equations. The constant terms arise from the current supplied by independent current sources (ICS). IVS's supply a positive current to the node connected to the point of the IVS, while they supply a negative current to the node connected to the tail of the IVS.

An example should help to clarify all of that. Let's write the node equations for the two-node DC circuit of Fig. 7. We will then enter the equations into an augmented matrix.

For node 1, we can write:

$$I_{out} = I_{in}$$

$$(V_1 - V_0)/1 + \text{ohm} + (V_1 - V_2)/2 + \text{ohm} = 0$$

Multiplying by 2, and realizing that $V_0 = 0$, we get:

$$3V_1 - V_2 = 0 \text{ (Eq. 5)}$$

Following the same steps for the KCL equation at node 2, gives:

$$(V_2 - V_1)/2 + \text{ohm} + (V_2 - V_0)/6 + \text{ohm} = 4$$

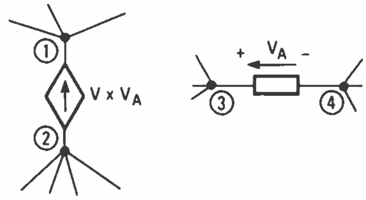


Fig. 6—When analyzing the nodes connected to a voltage-dependent current source (nodes 1 and 2) the nodes it's dependent on (nodes 3 and 4) must be solved for first.

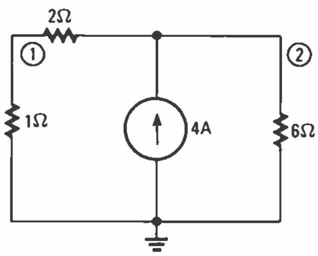


Fig. 7—Going through the trouble of setting up an augmented matrix and going through the math for a circuit as simple as this would be a waste of time for a human.

or,

$$-3V_1 + 4V_2 = 24 \text{ (Eq. 6)}$$

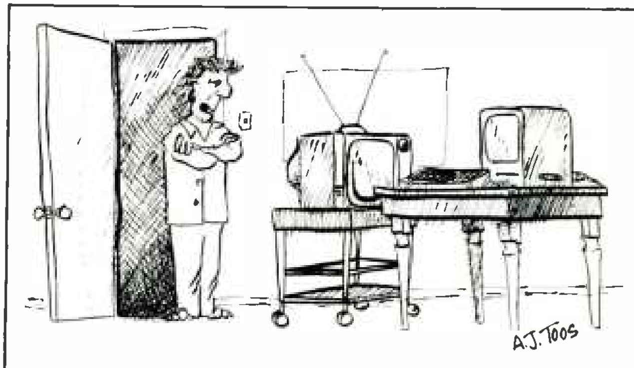
Those two KCL equations (Eq. 5 and Eq. 6) would be entered into an augmented matrix as follows:

$$\begin{bmatrix} 3 & -1 & 0 \\ -3 & 4 & 24 \end{bmatrix}$$

Because ACNAP must deal with complex numbers to perform AC network analysis, its augmented matrix is not just two-dimensional, as is the one shown above. ACNAP uses a three-dimensional matrix the A-matrix. The third dimension allows ACNAP to distinguish between the real and imaginary portions of complex numbers. That is, for elements in the "i"th row and the "j"th column, A(i,j,0) is the real portion of that element and A(i,j,1) is the imaginary portion.

Relating the A-matrix to equation 1, the first N columns of A represent the left side of equation 1, while the last column represents the right side of equation 1.

Needless to say, solving for all the variables in an augmented matrix larger than three rows can become a mathematical nightmare. But ACNAP can make analyzing even more harrowing circuits a snap, so punch in those numbers and good luck. ■



"Am I going to have to put you guys in separate rooms?"

REFEREE

(Continued from page 80)

your working area. Edit your PATH statement to include the subdirectory containing Referee's files (if you are using subdirectories). So far it's simple.

You can then use Referee to manually control your programs. Boot up your PC, but don't load any resident programs. Move to the subdirectory that contains Referee's files, and type REFWATCH at the DOS prompt to load Referee's core program into memory. Then load the rest of your RAM-resident programs.

Type REFEREE at the DOS prompt. You don't need to be in the subdirectory that contains Referee. Just be certain that RAM-resident programs you are planning to use.

Use the third menu "Specify Applications and Their RAM Teams" to enter the names of any application programs you plan to use, and to designate which RAM-resident programs you want active, inactive, or not change with each application program. Now exit to DOS.

As you access each application program, Referee will automatically activate and deactivate the RAM-resident programs according to the RAM Team specified for that application.

What You Get

For the purchase price of $69.95 you teams to watch out for; and Sideline Referee, a RAM-resident option which allows you to enter Referee to make changes from within an applications program. You are provided detailed information about your system. Referee tells you how many programs are loaded into memory, whether they are active or inactive, how much memory is used for each, and how much memory is still available. You can also use Referee to unload programs from memory, even programs that provide no unload option of their own. (The latter is an important feature.)

You can use a TTL, composite, or color monitor to view the menus of Referee, and you can eliminate the color which will

Referee

Quick Start Card

Installing Referee

1. Use the DOS COPY command to copy all of Referee's files into your working area.
2. Edit your PATH statement to include the subdirectory containing Referee's files (if you are using subdirectories).

Using Referee to manually control your programs:

1. Boot up your PC, but don't load any resident programs.
2. Move to the subdirectory that contains Referee's files, and type at the DOS prompt to load Referee's core program into memory.
3. Load the rest of your RAM resident programs.
4. Type at the DOS prompt. You don't need to be in the subdirectory that contains Referee. Just be certain that your PATH statement contains that subdirectory.
5. Use the first menu "Activate/Deactivate RAM resident programs" to manually activate, deactivate, and unload your resident programs. A check mark denotes "active".

Using Referee to automatically control your programs:

1. Follow the directions given above to load and access Referee.
2. Use the second menu "Tell Referee about your RAM resident programs" to enter the names of any RAM resident programs you plan to use.
3. Use the third menu "Specify applications and their RAM Teams™" to enter the names of any application programs you plan to use, and to designate which RAM resident programs you want active, inactive, or unchanged with each application program. A plus sign denotes "active," a minus sign denotes "inactive" and a blank denotes "status unchanged within this application."
4. Exit to DOS.
5. As you access each application program, Referee will automatically activate and deactivate the RAM resident programs according to the RAM Team specified for that application.

Don't forget: Send in your Referee registration card!

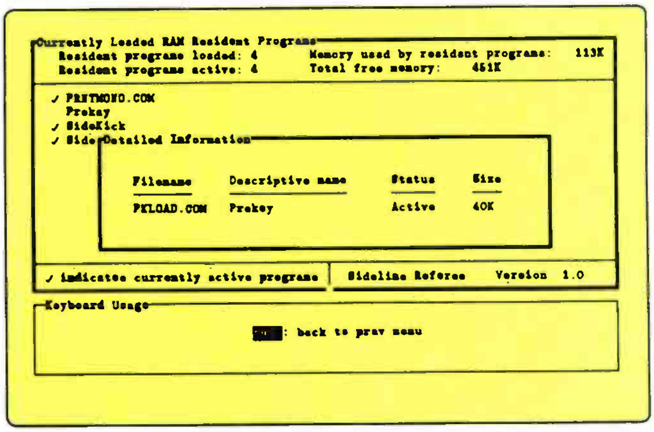


Fig. 3—Sideline Referee informs you of which RAM-resident programs are currently active and inactive, how much RAM space they use, and allows the user to activate or deactivate them.

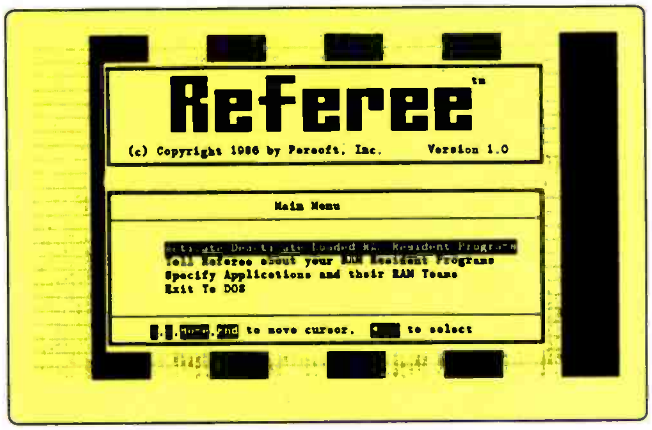


Fig. 4—Here is what the main menu looks like when you first use Referee. Read the excellent manual; however, the menus within the program directs and coaches the user fairly well.

your PATH statement contains that subdirectory. Use the first menu "Activate/Deactivate RAM Resident Programs" to manually activate, deactivate, and unload your resident programs.

Doing It Automatically

You have the option to automatically control your programs with Referee. Just follow the directions given above to load and access Referee. Use the second menu "Tell Referee about Your RAM-Resident Programs" to enter the filenames of any get a user's manual and a packet containing a floppy disk, registration card, and "Referee Quick-Start Card." We used the latter to get started quickly—we are about as impatient as our readers. What the Persoft people claimed for Referee is what we discovered.

Referee can be called a memory-management system comprised of three modules: the core program which watches the activity in the computer's RAM; the applications module which allows you to tell Referee about new applications or RAM make the composite monitor more readable. Should you have some trouble that cannot be cleared up by reading the brief, but comprehensible manual, you can call Presoft's technical support staff during business hours (Central time) on weekdays.

For more information on Referee, and for the name of the dealer nearest you, write to Persoft, Inc., 465 Science Drive, Madison, WI 53711; or telephone 608/273-600. You could also circle No. 81 on the Free Information Card. ■

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ADVERTISING INDEX

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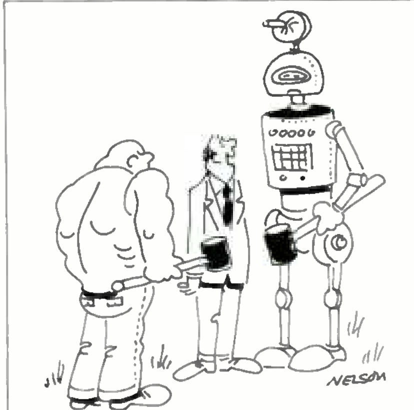
WEL'S THINK TANK

(Continued from page 96)

The output of the astable at pin 4 of U1b is fed to the input of a monostable multivibrator, consisting of the second pair of gates, U1c and U1d. R7 and C3 are the timing components; they set the length of the (positive) output pulse of the monostable at a little more than half a second. The monostable is triggered by each positive-going input it receives from the astable. The output from the monostable therefore, consists of a series of short pulses, the interval between the pulses being controlled using S2.

The output of the monostable (at pin 11) controls a relay by way of Q1, which is configured as an emitter-follower buffer stage. The projector is controlled via the normally-open contacts of relay K1. When the output of the monostable goes positive, the relay contacts close, triggering the slide-change mechanism of the projector. The monostable assures that the power to the relay is applied only briefly by the timer, so that multiple operation of the projector is avoided. ■



"Electrano, meet John Henry!"

ACTIVE ANTENNA

(Continued from page 79)

The Techniloop is not difficult to use, and after a little practice, most people become proficient at getting the most out of it.

Performance

Most of the testing of the loop was carried out using the Sony ICF-7600D, PLL-Synthesized Receiver. The receiver has a low-impedance, antenna-input socket that disables the internal ferrite rod for the BC and LF bands when in use.

Using that receiver, the following points were noted when comparing the Techniloop 3 with the normal antenna arrangement:

LF Band (153-519kHz)—The loop covers that band from 200kHz upwards, which is where most of the activity is in the form of RDF and weather beacons for aircraft, marine, and other use. The Sony receiver normally uses a built-in ferrite rod for this band.

Plugging in the loop dramatically improved the performance, and beacon signals which were barely discernible were brought to useful strength with a significant improvement in signal-to-noise ratio. By comparison, attaching an indoor 10-meter wire antenna to the receiver on this band increased both the signal and the noise, with no real improvement in readability.

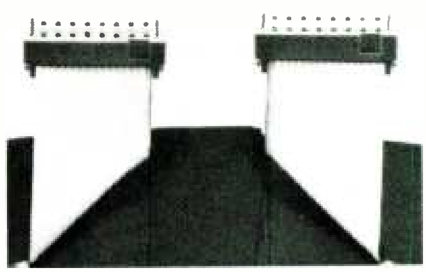
Broadcast Band (531-1602kHz)—During the day-time, country radio stations, that were again just discernible above the noise level were brought to a useful listening level with the loop. For country listeners who want to listen to city stations, or vice versa, the loop will prove a real benefit. And broadcast-band DX fans will not only find a worthwhile improvement in signal-noise ratio, but also a reduction in beat-note interference, which occurs when two stations share the same frequency.

AM Stereo & High Fidelity—Owners of hifi AM stereo receivers will find the improved signal-to-noise ratio of benefit, particularly when the signal quality is only marginal with the normal antenna.

Shortwave Bands—Useful improvements were noted on both the 80-meter and 40-meter bands. The added selectivity and directionality of the loop often helps to reduce or eliminate interfering transmissions on nearby frequencies. A long wire can give more signal strength, but the loop generally gives better signal-to-noise ratio. For international, shortwave transmissions, the loop provides a neat and portable alternative to stringing up a long wire.

Other Receivers

The loop was tried with various receivers, including the Sony ICF-2001D which is a higher performance "big brother" to the ICF-7600D. Improvements were not as marked as with the smaller set, as the ICF-2001D has a larger ferrite rod antenna and a better front-end. Nevertheless, the improvements were significant enough for the owner of the set to consider the loop a worthwhile accessory. ■



This close up view shows how the ends of the loop coil are folded and terminated in the IDC connectors. Note the strips holding the wire in place against the loop.

GRANDPA'S ANTIQUE RADIO

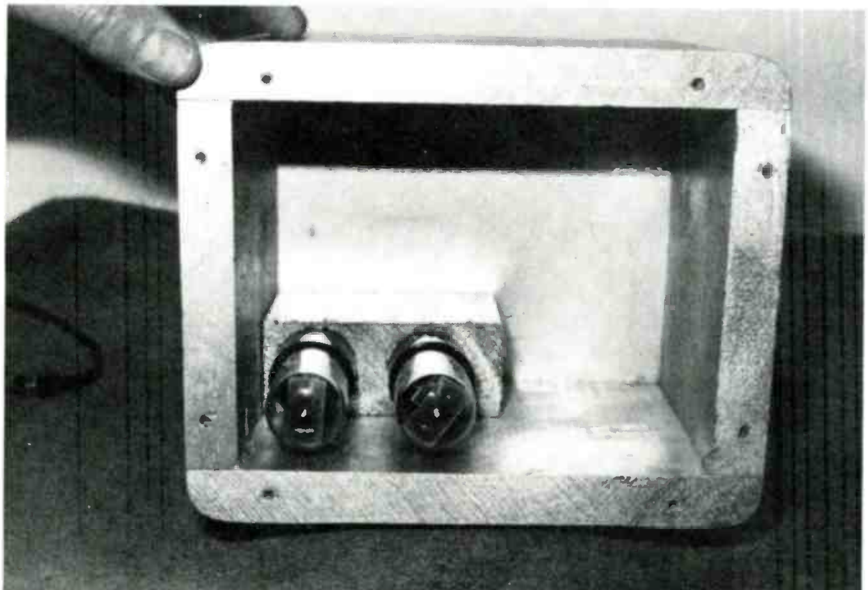
(Continued from page 33)

PARTS LIST FOR GRANDPA'S ANTIQUE RADIO

B1—9-volt, transistor-radio battery
BP1, BP2—Multi-way binding post (one red, one black)
C1, C2, C4—.01-µF, 100-WVDC, ceramic disc capacitor
C3—365-pF, miniature, variable capacitor (Coleco A1-233, Circuit Specialists A1-233, or evivalent.)
C5—.005-µF, 100-WVDC, ceramic disc capacitor
C6—.05-µF, 100-WVDC, ceramic disc capacitor
C7, C8—10-µF, 15-WVDC, electrolytic capacitor
C9—470-µF, 15-WVDC, electrolytic capacitor
C10—47-µF, 15-WVDC, electrolytic capacitor
U1—LM386 low-voltage 7-watt, audio power-amplifier integrated circuit
J1—Earphone jack, miniature-type
Q1, Q2—MPF102 FET transistor (Radio Shack, Circuit Specialist, or evivalent.)
R1—4700-ohm, ½-watt resistor
R2—470-ohm, ½-watt resistor
R3—22,000-ohm, ½-watt resistor
R4—50,000-ohm, potentiometer with SPST switch (S1)
R5—10,000-ohm, audio-taper, potentiometer
R6—10-ohm, ½-watt, resistor
Perfboard (Radio Shack 276-162), 8-pin IC socket, 8- to 30-ohm stereo headphones, 9-volt battery connector, hookup wire, cabinet material, scrap brass, white pine wood, flathead screws, paint, dummy tubes, knobs, etc.

appearance, two dummy tubes are mounted under the slotted area in the front panel. Cut a piece of white pine 2 × 4 inches. Drill two large side-by-side tube mounting holes. The holes should be just large enough so that the prongs of the tubes will fit down inside. Cement the bottom side of the tubes into the mounting holes. Place the tubes directly under the slotted area. Cement the tube board to the bottom panel. If you wish, add a filament transformer to the project and power up the filaments of the vacuum tubes only! The glow from the tubes with the attending heat will add the atmosphere Grandpa enjoyed years ago.

The radio pulls 10 mA with the volume turned down. If the current measurement is over 17—20 mA, suspect incorrect wiring or a leaky transistor or IC. Critical voltage and current measurements should help locate the defective component.


The tubes are dummies in the author's model. If you wish, you can power up the tubes using a filament transformer and nothing else. The tubes will add color and heat like the old sets.

The Final Touches

Nothing can give Grandpa's Antique Radio that old fashioned appearance more than radio knobs. If you can not come up with some antiquated knobs, simply make them. The dial of the main tuning capacitor was constructed of a piece of white plastic. (An aged yellow color would be better.) Lines were drawn within the plastic surface with a flat blade of a soldering iron. Grind the soldering-iron point flat on both sides. Use a metal ruler or straight edge to gouge various lines in the dial assembly. Sand or file down the raised edges. Place black paint in the grooved lines and wipe off the excess paint. Glue the dial in place. (See photos.)

The unique dial-knob assembly was constructed of brass-plated lid support or a flat piece of brass. See Fig. 4. Grind off the hinged support and put a black knob in its place. Select a knob with a brass insert and screw. Break and remove the plastic area of the knob. Epoxy the brass insert to the plated-brass piece. Grind down the end piece to a sharp point. Now, fasten the dial assembly to the shaft of the variable capacitor with the small knob screw.

Not only is Grandpa's Antique Radio easy to build, its just plain fun with the added twist of the *good old days*—some sixty years ago. ■

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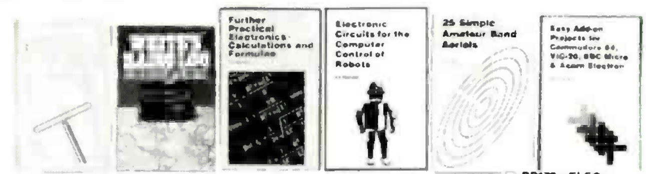

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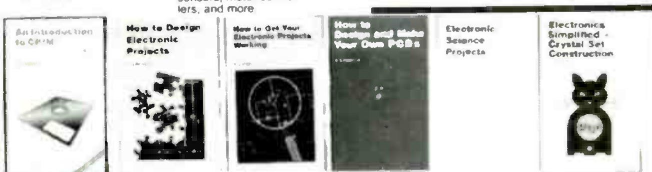

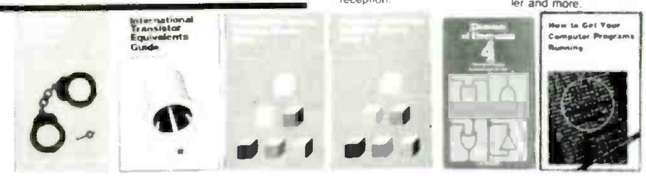

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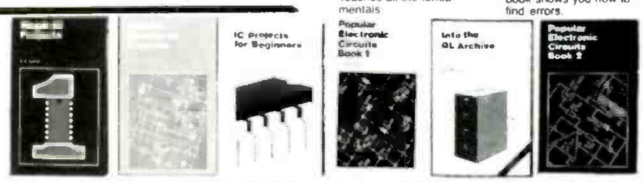

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