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Hands-on Electronics

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NOVEMBER, 1986

THE MAGAZINE FOR THE ELECTRONICS ACTIVIST!

Lightning

How it can
be tamed!

Super Buffered Breakout Box—

End those printer nightmares!

How to Repair Damaged Speakers

Build a Musical Doorbell



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Build this...

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from our complete plans!

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Hobby News, and much, much more!

New GPS Series: Tek sets the pace with SmartCursors™ and push-button ease.

Work faster, smarter, with two new general purpose scopes from Tektronix. The four-channel, 100 MHz 2246 and 2245 set the new, fast pace for measurements at the bench or in the field. They're easy to use and afford, by design.

On top: the 2246 with exclusive integrated push-button measurements. Measurements are accessed through easy, pop-up menus and implemented at the touch of a button. Measure peak volts, peak-to-peak, \pm peak, dc volts and gated volts with new hands-off convenience and on-screen readout of values.

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Features	2246	2245
Bandwidth	100 MHz	100 MHz
No. of Channels	4	4
Scale Factor Readout	Yes	Yes
SmartCursors™	Yes	No
Volts Cursors	Yes	No
Time Cursors	Yes	No
Voltmeter	Yes	No
Vertical Sensitivity	2 mV/div	2 mV/div
Max. Sweep Speed	2 ns/div	2 ns/div
Vert/Hor Accuracy	2%	2%
Trigger Modes	Auto Level, Auto, Norm, TV Field, TV Line, Single Sweep	
Trigger Level Readout	Yes	No
Weight	6.1 kg	6.1 kg
Warranty	3-year on parts and labor including CRT	
Price	\$2400	\$1875

sensitivity to 0.25 div at 50 MHz, to 0.5 div at 150 MHz.

Accuracy is excellent: 2% at vertical, 2% at horizontal. And four-channel capability includes two channels optimized for logic signals.

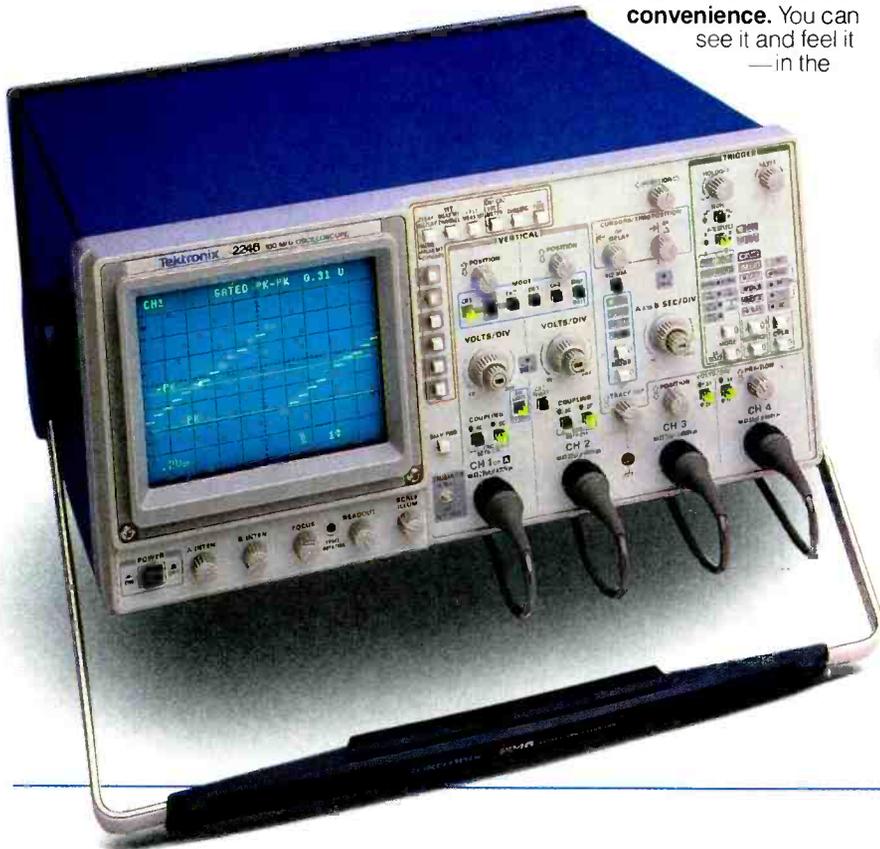
Best of all, high performance comes with unmatched convenience. You can see it and feel it — in the

responsive controls and simple front-panel design, in extensive on-screen scale factor readouts, and in simplified trigger operation that includes Tek's Auto Level mode for automatic triggering on any signal. Start to finish, the GPS Series saves steps and simplifies tasks.

Get out in front! Call toll-free today to order, to get more details or a videotape demonstration.

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In Oregon, call collect 1-627-9000



Featuring four channels, flexible triggering, extensive CRT readouts and push-button ease of use, the new Tek 2246 (left) and 2245 (above) bring high-quality, low-cost analysis to diverse applications in digital design, field service and manufacturing.

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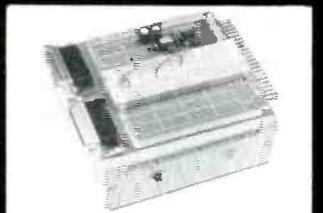
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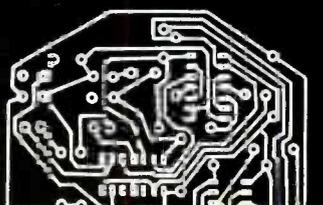
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A story is generated! like a flash

Although we generally have a specific idea or plan for the topics selected for each issue, we leave room for concepts and ideas inspired by reader mail, a word dropped in conversation, even Divine Inspiration. The stories that develop from those seemingly unrelated thought-processes turn out to be tomorrow's technology, or at the least, tomorrow's TV news. This month's feature on lightning is a good example of how a fleeting thought turns into a TV *newsbreak*.

It all started with a photograph of a powerful stroke of lightning hitting the ground. The editorial staff wondered just how much energy was packed into that stroke, and how much damage it would do. Later, a reader's letter revived our interest in that topic. Our interest blossomed into this issue's in-depth feature on lightning: what it is, how much damage it can do, and how to protect your family and property against lightning damage.

Our story became TV news when six people in a nearby park took shelter during a storm under a large tree. Just as our article explains, lightning looked for the highest and *zapped* the tree and injured the six who sought refuge from the storm. We wonder—was it some higher power, a sixth sense, or clairvoyance that inspired us to do the story on lightning? We'll never know for certain.

Last, but not most important, John Yacono has joined our editorial staff. John is a graduate electrical engineer and an avid electronics experimenter. His resume included the plans for a project he was building (Smart move!) Welcome to the staff of Hands-on Electronics, John.

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NATIONAL ADVERTISING SALES

(For Advertising Inquiries Only)

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714/760-8697

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500-B Bi-County Boulevard
Farmingdale, NY 11735
516-293-3000



Hands-on Electronics, (ISSN 0743-2968) Published monthly by Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735. Second-Class postage paid at Farmingdale, NY and at additional mailing offices. One-year, twelve issues, subscription rate U.S. and possessions \$28.00, Canada \$33.00, all other countries \$35.50. Subscription orders payable in U.S. funds only, International Postal Money order or check drawn on a U.S. bank. U.S. single copy price \$2.50. © 1986 by Gernsback Publications, Inc. All rights reserved. Printed in U.S.A.

Postmaster: Please send address changes to **Hands-On Electronics**, Subscription Dept., P.O. Box 338, Mount Morris, IL 61054-9932.

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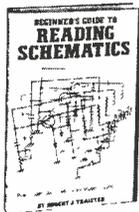
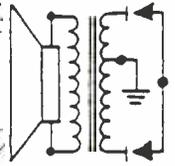
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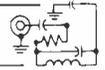
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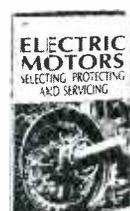
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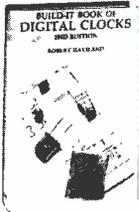
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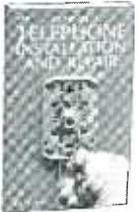
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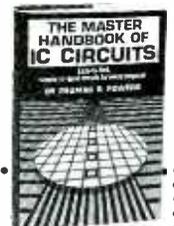
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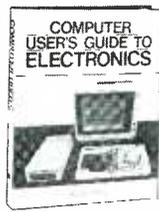
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NEW PRODUCTS SHOWCASE

Pocket-size Autoranging DMM

Mercer Electronics introduces a newcomer to its line of compact autoranging digital multimeter. Priced at \$59, the Model 9370 offers autoranging or manual selection of voltage and resistance ranges. It measures up to 1000-volts DC in 5



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ranges; 750-volts AC in 4 ranges; 10-amps AC and DC in 2 ranges, and up to 2-megohms in 5 high-power and 4 low-power ranges.

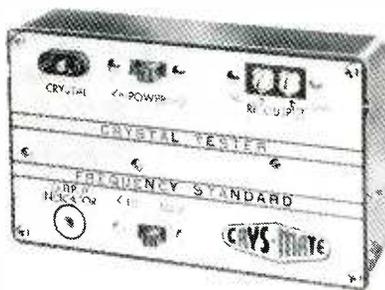
The 9370 has a memory mode that provides up to 99 counts of zero offset. Also included is an audible continuity indication. Its basic DC volts accuracy is 0.5%. Low and high energy fusing are provided.

Housed in a 5.9" x 2.95" x 1.34" high-impact case and weighing 3/4 lb, the unit comes with a 9-volt battery, color-coded test leads with screw-on alligator clips, and an operator's manual.

Mercer's product line, available from electronics and electrical distributors nationwide, consists of DMM's, digital capacitance testers, digital amp-clamps and hand-held analog multimeters. For more information, contact Mercer Electronics (a division of Simpson Electric Company) at 859 Dundee Ave., Elgin, Illinois 60120; Tel. 312/697-2265.

Crystal Checker/Frequency Standard

The Crys-mate Model KC-720B is ideal for testing the operational condition of crystals, for generating fundamental frequencies, and as a marker for calibrating equipment. Powered by a 9-volt tran-



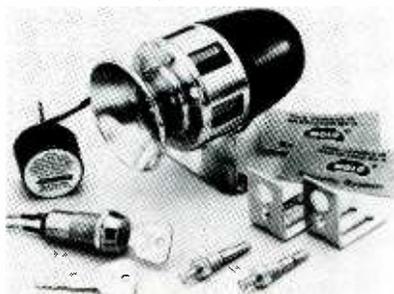
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sistor battery and housed in a compact (6" x 3 1/2" x 1 1/4") case, the Crys-mate is equally suitable for bench and field work. Special features include a unique indicator lamp which shows instantly whether the operational condition of a crystal is good or bad, and a special powersaver switch that protects against excessive battery drain when the unit is being used as a frequency standard or as a TV, FM, or CB channel marker. Shipping weight: 1 lb, Dealer cost: \$26.90. Manufactured by Polaris, div of UXL Corp, 108-02 Otis Ave., Corona, NY 11368; Tel. 718/271-5200.

Current-Monitor Alarm Kit

Advanced Wolo technology made the Mighty Mo the first of its kind in size and sound. The small size of the Mo makes it quick and easy to install in all American and foreign vehicles. A transistorized sensor activates a powerful siren when current is drawn by a light bulb when the door, trunk, or hood is opened. Mo's sensor is programmed not to be false triggered by electric cooling fans. All electronic parts are sealed in rock-hard epoxy assuring years of dependable service.

The Alarm Kit comes with a high-security switch lock that features a double-bitted, pick-resistant key, and a stainless-steel spring closing shutter that protects



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against dust, dirt, and weather. The 3002 Kit comes complete—there is nothing else to buy.

For more information, contact Wolo Manufacturing Corp. One Saxwood Street, Deer Park, NY 11729.

Programmable CD Players

Marantz is debuting two compact-disc players with sophisticated digital filtering to ensure perfect playback. The fully programmable CD30 and CD50 allow the user to listen only to certain tracks, if desired, and in any preferred order. The CD30 and CD50 have 16 programmable tracks. And a wireless infrared remote-control is included with the CD50.

Forward and reverse track, skip, forward and reverse search, and track side repeat for listening again to a single track or an entire disc, are incorporated in the CD30 and CD50. A special three-way digital display serves as a guide, showing track number, elapsed time, and remaining time.

The CD30 and CD50 each have a 16-bit digital/analog converter with 2 x oversampling, frequency response of



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5Hz-20kHz, total harmonic distortion of 0.005%, and a signal-to-noise ratio of 96dB. The CD30 and CD50 will be available at suggested retail prices of \$329.95 and \$399.95, respectively.

NLQ Printer for Commodore Computer

The OKIDATA 120 dot-matrix printer now offers near-letter-quality (NLQ) capabilities to Commodore home computer users, Okidata announced at the Consumer Electronics Show (CES) in Chicago.

Compatible with several Commodore computers, including the 64, 128, SX64, Plus/4, 16, and VIC 20, the OKIDATA 120 has a suggested retail price of \$269.

The OKIDATA 120 prints bidirectionally in the draft mode with short line-seeking logic at 120 cps. It is rated at 60 cps in the enhanced mode and produces excellent near-letter-quality (NLQ) text at 30 cps. (Continued on page 6)

cable tv

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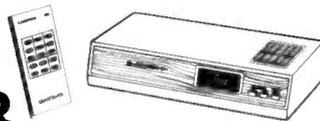
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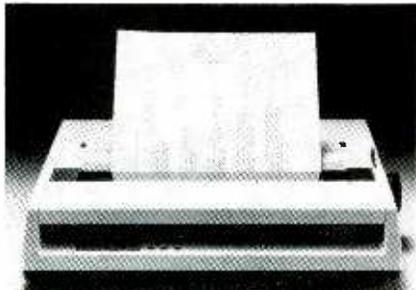
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NEW PRODUCT SHOWCASE

(Continued from page 4)

The OKIDATA 120's "long life" nine-pin printhead—capable of printing 200-million characters—is among the most durable in the industry. It prints 80 columns with standard characters and 137 columns with condensed characters.

Its standard features include a Commodore character set (upper and lower case), characters with true descenders, double-width characters, condensed characters, vertical spacing at six and



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eight lines per inch, and a Commodore graphics character set.

The OKIDATA 120 also offers friction and pin-feed paper-handling capabilities, all-points addressable graphics, Commodore block graphics, emphasized and enhanced print, superscripts, subscripts, and underlining.

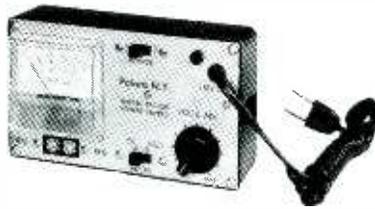
The mean time between failure rating of the OKIDATA 120 is 4,000 hours, while the mean time to repair is 15 minutes. The printer comes with a supply of computer paper and an interface cable.

All of those big-printer capabilities are packed into a sleek, 8.8-pound printer taking up just one square foot of desk or printer-stand space. The OKIDATA 120 offers a one year warranty on parts, labor, and printhead.

The OKIDATA 120 is available through most popular retail outlets. Commodore users can locate the nearest Okidata retailer by calling Okidata's toll-free hotline, 1-800-OKIDATA.

DC Power Supply

The multi-functional Polaris DC Power Supply Model TPS-225 is suited for service work, industrial and educational applications, and circuit designing. It has an adjustable range of from 0–25 volts DC. The TPS-225 incorporates the latest voltage-regulator and short-circuit protection. Full 250-mA current-carrying capacity. And its meter monitors both voltage and current. The extremely low ripples make the Polaris DC Power Supply ideal for radios, phonos, tape machines, transistor, and IC circuits. It can



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serve as a battery eliminator and charger; it may be used as a negative or positive power supply, and is indispensable as an adjustable bias supply. It measures only 6 × 3 × 1½", and operates on 105 to 125-volts 60Hz. Shipping weight 2 lbs. Dealer cost: \$34.95. Manufactured by Polaris, div of UXL Corp, 108-02 Otis Avenue, Corona, NY 11368; Tel. 718/271-5200.

Radar Detector

The first "personalized" radar detector has been introduced by B.E.L.-Tronics Limited, the world's largest maker of radar detectors. Called the Micro Eye Quantum, the new model can be programmed by the driver to match performance to driving environments. Programming is quickly and easily accomplished using the Quantum's digital-readout, signal-strength display.

The Quantum's two user programmable modes each affect the audio-alert sequence and levels. Both can be set by the driver to match actual driving situations and limit annoying audio alerts to extraneous signals while maintaining the full value of the detection circuitry and visual alerts.

The first programmable mode allows a driver to change the X-band audio-alert threshold to an optimal level for the particular mix of urban/suburban driving done. In a city situation, for instance, there may be many X-band sources to set off the detector, while the likelihood of police radar is relatively small. In a subur-



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ban environment, those factors shift, with greater distances between other X-band sources and a greater likelihood of police radar. The Quantum's audio-alert threshold can be adjusted to sound an alert at readings of 2, 4, and 6. B.E.L.-Tronics calls this user adjustable sensitivity circuit

C/PAS, which stands for City/Programmable Alert Sequence.

The Quantum's second programmable feature is called FSR, which stands for False Signal Recognition. As with the C/PAS mode, the visual alerts of X-band signals are unaffected, but the audio alert is adjustable. FSR uses a programmable time-delay circuit, so that a driver can set the audio alert to sound 3, 5, 7, or 9 seconds after the Quantum detects a radar signal and has given a visual alert.

Regardless of the C/PAS and FSR settings programmed into the unit, override circuitry built-into the new Quantum will sound an alert if the detector senses either Instant On or K-band radar. K-band is used only by the police.

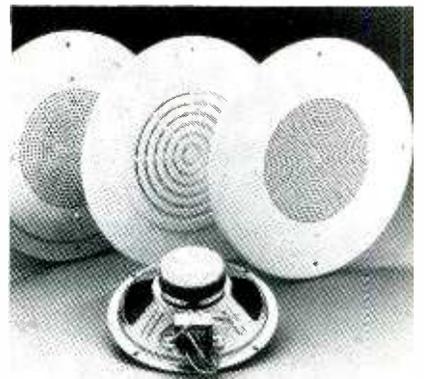
The Micro Eye Quantum comes complete with travel case, 9-foot straight power-cord, 6-foot coiled power-cord, visor bracket, and Velcro strips. It has a suggested retail price of \$329.95.

For further information, contact Chris Fuhrmann, Sales Manager for Eastern U.S.A., 800/341-1401, (800/845-4525, NY only), or Donal Rich, Sales Manager for Western U.S.A., 800/835-4054.

10-ounce Magnet Speakers

3M's line of 8-inch standard and coaxial speakers have 10-ounce magnets for increased sound-system efficiency. The standard speaker offers quality sound at an economical price for many user applications. A whizzer cone helps extend the speaker response to an excellent 70 to 15,000 Hz.

The coaxial model has a piezo, solid-state ceramic tweeter, center-mounted



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without a structural bridge, to provide crisp high frequencies without blocking the low-frequency sound from the woofer. Frequency response is an outstanding 70 to 20,000 Hz. The 70-volt speaker transformers have color-coded, stripped and tinned leads for easy installation.

Speakers are available with transformers or assembled to steel, plastic and aluminum grilles for ceiling installations. They are also available in Slimline and

Slantline wall cabinets with a durable, walnut-grained vinyl finish.

Suggested end-user list prices for the standard and coaxial speakers are \$13.90 and \$21.00, respectively, with volume discounts available. For additional information about 3M's line of 10 oz. magnet speakers, contact 3M Sound Products, Broadcasting and Related Products Division, Dept. SP86-17, P.O. Box 3360, St. Paul, MN 55133-3600.

Linear-Phase Speaker System

The SB-L95 linear-phase speaker system from Technics offers the listener wide dynamic range with high efficiency by handling input power of up to 200-watts (music). The highly-sensitive speaker system—93dB at 1 watt at 1 meter—allows for high-volume levels with relatively low-power amplifiers or receivers.

The system's linear-phase design puts the acoustic center of the woofer, mid-



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range, and treble frequencies in alignment so that all are radiated with the same relationship that they had in the original music signal. Linear phase response helps reduce time lag and phase distortion.

The SB-L95 uses a large (15-inch) woofer. Aluminum bobbins and heat resistant voice coils enable high-power handling, and select diaphragm materials contribute to the computer-designed cone's performance. For smooth crossover, the dust cap uses a non-resonant fabric.

A precision dynamic tweeter helps to smooth out the upper midrange and treble frequencies. Select voice coil and diaphragm materials help reduce undesirable resonances, and feature a computer-designed diffuser to help achieve consistent stereo imaging.

For midrange coverage, the speaker system uses a 4-inch dynamic driver with a large magnet for high efficiency and low distortion. The bass-reflex design results in powerful bass response. Precision join-

ing and internal reinforcements aid in preventing undesirable resonances and vibrations. The cabinet features an attractive simulated woodgrain finish and removable grilles.

The SB-L95 speakers are currently available at the suggested retail price of \$350/pair.

Voice Recognition System

Voice Master (from Covox), a half-card board for the IBM and work-alikes, provides the foundation of a complete voice-development system. High-quality digital speech is also supported through



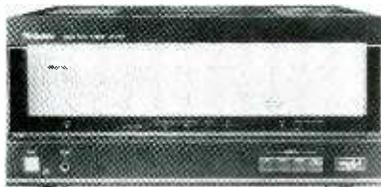
CIRCLE 84 ON FREE INFORMATION CARD

optional software to deliver the greatest flexibility and functionality coupled with manufacturing economy.

More information on Voice Master and other Covox products may be obtained from the company directly; VAR, OEM, distributor and dealer inquiries are welcomed and encouraged. Contact Covox, Inc., 675-D Conger Street, Eugene, OR 97402; Tel. 503/342-1271.

Stereo Power Amplifier

Technics' newly-developed Class AA circuit is being put to use in the SE-A100 stereo power amplifier. The Class AA VC-4 amplifier system delivers 170-watts per channel of stable power with 0.0007% distortion (at 20Hz-20kHz into an 8-ohm load). The VC-4 amplifier uses four circuits (two for each channel), a voltage-controlled amplifier, and a current drive-amp, which takes the voltage across both ends of a network bridge as its input signal, and outputs a proportional current. In turn, the pure Class A voltage-controlled amplifier connects to a corner of the Class AA bridge and NFB is applied from the speaker's output terminals, to help ensure a stable voltage supply.



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NEW PRODUCT SHOWCASE

(Continued from previous page)

Each channel's current-drive amplifier has its own transformer. A third transformer is used for the left- and right-channel, voltage-controlled amps. The symmetrical arrangement helps eliminate left/right channel interference via the power supply. Total capacitance of the large electrolytic capacitors is 91,200- μ F.

Magnetic flux and physical vibrations are reduced by the 3mm-thick, 2.3kg heavy top plate, a 2mm-thick rigid chassis, and a 2mm-thick rubber insulator-pad for the transformers.

The SE-A100 has large power meters to give direct readings from 0.0001 to 300-watts, and a 10-mm thick metalized-glass front. A 2mm-thick, 10-mm-wide bus bar is used as the common ground. Other features include: oxygen-free copper bus ground and LF-OFC wiring; two-way DC/normal input jacks; oxygen-free copper connection cord with gold-plated jacks; and a 50-strand, 7.4mm diameter AC power cord.

Electronic speaker switching is provided to remember which speakers were being used when the AC was shut off. When the AC is turned on again, the same speakers will automatically be selected.

The SE-A100 carries a suggested retail price of \$1,500.

Portable PC

Dual disk drives, faster-computing, performance, and more memory mark the T1100 PLUS, an enhanced version of the T1100 portable personal computer. The fully IBM-compatible laptop is equipped with two 3.5-inch, 720K disk drives, 256K (\$1999) or 640K (\$2399) of memory, parallel and serial ports, optional 300/1200-baud modem, and a new keyboard layout.

Running on an 80C86 16-bit processor at 7.16 MHz clock speed, the PLUS runs programs up to twice as fast as IBM's PC Convertible. The PLUS features 256K RAM with an optional 384K memory card (\$499), or 640K standard memory. An I/O bus is included for an optional external expansion chassis (\$999) with slots for five IBM PC/XT-type cards to support additions.

Built into the unit are a clock/calendar and interfaces for an RGB color-monitor, monochrome composite-monitor, external 5.25-inch diskette drive, parallel printer and serial communications. An optional internal 300/1200 bit-per-second Hayes-compatible modem card (\$399) is available.

The PLUS features a high-contrast (640 by 200 pixels), 80-character by 25-line



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liquid-crystal display (fully adjustable for ease in reading). Weighing under 10 pounds, the PLUS measures 12.1-inches wide, 2.6-inches high and 12-inches deep.

Included with the laptop is an internal Ni-Cad battery, and an AC adapter for recharging and/or line power. Also offered is an external 5.25-inch disk drive (\$499) for compatibility with standard PC diskettes, and a universal Floppy Link (\$199), allowing use of the 5.25-inch drive in IBM PC, PC/XT, PC AT, or Compaq, AT&T, Leading Edge, and other PC's.

The T1100 PLUS is packaged with MS-DOS 2.11, documentation, and AC adapter. A one-year warranty is also included. Like Toshiba's T3100 portable PC, the T1100 PLUS is backed by the Exceptional Care service program, which provides overnight replacement of a failed unit.

Toshiba America, Inc. (based in Tustin, CA) a leader in the sales and service of industrial and consumer electronics also markets portable personal computers, three-in-one dot-matrix printers, and related peripherals throughout North America.

Ultra-high-speed Printer

The EX-800—a high-speed, 80-column, dot-matrix printer from Epson America, featuring a color option for added flexibility is designed to meet the needs of corporate and business users.

Retailing at \$749, the EX-800 prints at speeds of up to 300 cps in the draft mode and 54 cps in the near-letter-quality (NLQ) mode at 12 characters-per-inch (CPI). In pica (10 CPI), the draft speed is 250 cps and NLQ speed is 45 cps.

This easy-to-use printer also offers an eight-button, type-style selection panel with improved paper-feeding features. It also includes an IBM printer emulation for use with software written for IBM dot-matrix printers.

The SelecType II control panel allows users to quickly and easily choose from among eight different type-styles by simply pushing the appropriate button. That

eliminates the need to memorize complicated control codes or tamper with dip switches. The buttons, clearly labeled "draft," "pica," "elite," "normal," "NLQ roman," "NLQ sans serif," "proportional," and "condensed" light up when a particular mode is in use. In addition, all available typestyles can also be printed in italics, super and subscripts by using control codes.

In addition, the EX-800 includes an automatic sheet-load feature that enables users to simply insert a sheet of paper, pull a lever and wait for the printer to line up the paper. Users who require a color output can add an inexpensive, easy-to-install, color option, allowing the EX-800 to produce seven colors—black, red, blue, violet, yellow, orange, and green—as well as print full-color business graphics including graphs and charts.

The EX-800 features bi-directional printing in both text and graphics for maximum throughput, and has built-in parallel and serial interfaces to connect to most popular computers. It also offers dual identity, enabling it either to execute Epson's ESC/P standard printer codes (which have been extended to include



CIRCLE 91 ON FREE INFORMATION CARD

IBM graphic-style characters) or to select IBM printer emulation and a 8K buffer. An optional 32K buffer is also available. Epson America's EX-800 comes with a one-year warranty.

For more information, contact Epson America (Computer Products Division, 2780 Lomita Blvd., Torrance, CA 90505) at 213/539-9140; consumers outside California can also call Epson's consumer hotline, 800/421-5426.

Canon Personal Computer

Canon, looking to enhancing its personal-computer line with a second generation, has introduced the A-200II Series, delivering performance that goes beyond mere compatibility—yet it is more affordable. The A-200II Series comes in both floppy-disk and hard-disk models.

The A-200II floppy-disk model, available at a suggested retail price of \$1,995,

(Continued on page 12)

Train for the Fastest Growing Job Skill in America

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Now that computers are firmly established in offices—and in homes, too—the demand for trained computer service technicians surges forward. The Department of Labor estimates that computer service jobs will actually *double* in the next ten years—a faster growth rate than any other occupation.

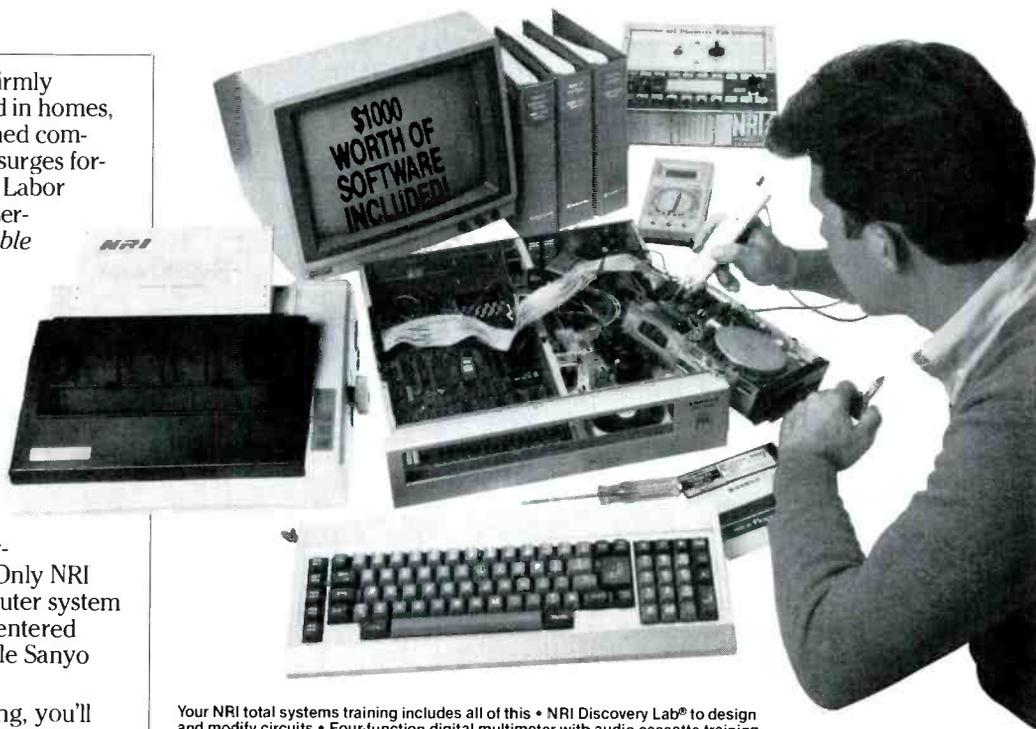
Total systems training

No computer stands alone... it's part of a total system. And if you want to learn to service and repair computers, you have to understand computer *systems*. Only NRI includes a powerful computer system as part of your training, centered around the IBM-compatible Sanyo 550 Series computer.

As part of your training, you'll build this highly rated, 16-bit IBM compatible computer system, assemble Sanyo's "intelligent" keyboard, install the power supply and disk drive, interface the high-resolution monitor and dot matrix printer, even expand the memory from 128K to 256K RAM. It's confidence-building, real-world experience that includes training in programming, circuit design, and peripheral maintenance.

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Even if you've never had any previous training in electronics, you can succeed with NRI training. You'll start with the basics, then rapidly build on them to master such concepts as digital logic, microprocessor design, and computer memory. You'll build and test advanced electronic circuits using the exclusive NRI Discovery Lab®, professional digital multimeter, and logic probe. Like your computer system, they're all yours to keep as part of your training. You even get over \$1,000 worth of software, including the popular WordStar and CalcStar.



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NEW PRODUCT SHOWCASE

(Continued from page 8)

includes a monochrome CRT, 256K of standard memory, two 5¼-inch floppy-disk drives, Centronics-type parallel interface, serial data interface, six expansion slots, and a standard PC-compatible keyboard. The A-200II hard-disk model, with its suggested retail price of \$3,595, includes the same specifications as the floppy-disk model, but combines one 5¼" floppy-disk drive with a 20M-byte hard-disk drive.

The A-200II, using the 8086 16-bit CPU, is compatible with the IBM PC and has a variety of features for fast speed and greater storage capacity. As an extra feature, Canon has added a choice of CPU clock rates: either the standard 4.77-MHz for normal usage, or an ultra-fast 7.16-MHz for high-speed data processing, which can be selected with the turn of a switch or by the software. It has a standard memory capacity of 256K that can be expanded to 640K for heavy-duty operations.

The A-200II is available with a choice of either a color/graphic monitor or monochrome monitor. The monitors feature highly-legible screens that can be tilted or swiveled for easy viewing at any angle. Canon will also offer a dual CRT adapter, to allow the unit to be used with both the color/graphic and monochrome monitors. The CRT adapter provides high resolution in mono-graphics.

In developing the A-200II, Canon con-



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sidered the requirements of different operators, which resulted in a choice of two different keyboards: a standard keyboard with the traditional layout, and a second keyboard, designed for word processing applications. A mouse can be connected directly to either of the keyboards, without an extra card.

The floppy-disk model has two 360K 5¼" disk drives. The hard-disk model has one floppy-disk drive and a built-in, hard-disk drive (360K and 20M, respectively) for the convenience of massive storage without changing disks. With built-in par-

allel and serial interface ports, the A-200II also has six PC-compatible expansion slots; three of which are 16-bit data-bus slots for high-speed processing, while the remaining three are 8-bit data-bus slots.

The A-200IIA works with variety of software from various suppliers, in addition to MS-DOS and GW-BASIC, CanonWriter II plus word-processing software and Canon BASIC programming language software.

For further information, contact Canon U.S.A., Systems Division, One Canon Plaza, Lake Success, NY 11042, Attn: Ms. Shirley Lacy.

Wattmeters

VIZ Test Equipment has announced the development of two wattmeters capable of measuring true RMS voltage, true RMS



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current, and true power. Each model features exceptional measuring accuracy in a compact, low-cost instrument. The 1-kilowatt WD-766A features a three-digit LED display; while the 2-kilowatt WD-767 features a three-and-a-half digit display. Both feature front and rear outlets; discrete, flush-mounted, touch-activated switches to select display of volts, amps, or watts, and are designed to meet the UL and CSA safety specifications.

The compact, rugged instruments are ideal for a wide range of applications, including production-line testing, design and development labs, incoming and final quality control, service/maintenance/repair, manufacturing, educational/instructional applications, and general and diagnostic testing.

The VIZ wattmeters are available locally from any of VIZ Test Equipment's more than 300 distributor branches throughout the United States and Canada.

Full details and specifications on the WD-766A and WD-767 wattmeters are given in Data Sheet 9167 available upon request from VIZ Test Equipment, 335 East Price St., Philadelphia, PA 19144-5782; or call 800/523-3696 or 215/844-2626.

Back-up Power Supplies

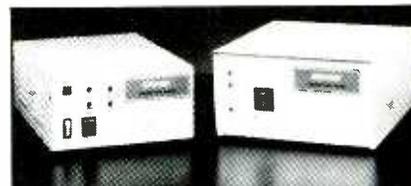
Ohm/Electronics recently introduced a new line of affordable, top-quality, Scooter standby power supplies. Model SPS 250XT (with 250-watts of back-up power) and Model SPS 500XT (with 500-watts) keep IBM PC or PC/XT, Apple, Macintosh, and compatible PC's running under full-load from 10-15 minutes after loss of primary power. The Model SPS 500AT, also rated at 500 watts, acts as a comforting Guard Robot™ for safe emergency operation of an IBM PC/AT or compatibles.

Designed to meet the more demanding needs of the IBM PC/AT, the model SPS 500AT has an extremely fast transfer time—less than three milliseconds. Models SPS 250XT and SPS 500XT act within four milliseconds of line-power failure, or minute interruptions. The completely automatic system immediately switches over to emergency inverter power as an instant audible alarm and flashing indicator alert the user to the condition. Thus, ample time is provided to preserve data and use normal shutdown procedures. If primary power returns, the system immediately switches back to standby. In addition, the system features built-in noise and surge protection against voltage transients and spikes.

At the heart of the system is a sealed, rechargeable, maintenance-free lead-acid battery that's mated to an electronic circuit, which monitors line voltage and senses any disturbance. A regulated charger maintains the battery at full power during normal operation.

Other features include three AC outlets (rear-mounted) for easy connection to a computer, printer, modem, outlet strip, or other computer accessory. A front-panel reset switch turns off the audible alarm at the discretion of the user, with system on/off and test on/off switches completing the front panel controls. Other indicators on XT models are: low battery (LED and audible alarm), AC power on, inverter power on, and overload.

Suggested retail price for the model SPS 250XT is \$389.95; the SPS 500XT retails for \$689.95, and the SPS 500AT retails for \$729.95. For additional information write: Ohm/Electronics, 746 Vermont St., Palatine, IL 60067; or call toll-free 800/323-2727 (Illinois, call 312/359-6040).



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Long-range Night Viewer

Designed for serious night-time surveillance work by government investigators, the ZA211 infrared night-scope from Crosley Electronics lets you make facial identification in total darkness from up to 135' away or detect and recognize objects, people, and animals up to 300' away. The low-cost ZA211 can be used for a multitude of applications by photographers, nature lovers, lab workers, and CCTV and video operators. Fascinating applications are to be found in animal observation, IR CCTV, IR photography, darkroom work, audience observation, eye examination, sleep monitoring, haze and fog penetration, laser observation, fiberoptic work, IR astronomy, and microscopy.

The viewer can be used to observe the thermal scene above 600°F, to check on furnaces, heaters, flames, and arcs. Intriguing observations can be made of invisible markings on currency, stamps,



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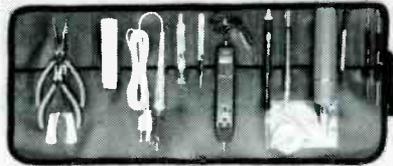
and paintings, and faded, worn, or charred documents.

The ZA211 camera operates on 12-volt DC power supply and uses a premium-grade 6032 IR tube coupled with a 50-watt halogen IR source to achieve its remarkable performance. The camera comes with a 16X eyepiece and a 265mm *f*:4.1 fixed-focus lens. Available accessories include a binocular eyepiece and a relay lens for SLR and CCTV use.

Priced at \$750, the ZA211 is available from Crosley Electronics, Box 840, Champlain, N.Y. 12919; 514/739-9328. Dealer inquiries are invited.

PC-Board Repair Kit

Jensen Tools Inc. has introduced a compact kit of essential tools for circuit-board technicians. Recommended for easy in-the-field CB troubleshooting and repair, the kit contains a cordless mini-drill with half-moon bit for fine circuit-board drilling; a miniature 12-watt soldering iron; a pocket pack of 60/40 solder;



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two soldering aids; spring-loaded piston-type solder remover; DIP insertion and extraction tools; wire stripper/cutters; needle-nose pliers; miniature diagonal

cutters, and more. An optional 50-MHz digital probe that displays pulse presence and logic states for quick, accurate analysis of digital circuits (compatible with TTL, DTL, RTL, HTL, CMOS, MOS, and HiNil) is also available.

All components are contained in a 10 × 22" vinyl-covered, roll pouch with tie band that stores easily in limited space, such as a tool case or desk drawer. For more information or free catalog of components
(Continued on page 103)

★ CABLE TV SPECIALS ★

CONVERTERS

- JERROLD:** DRZ-3DIC105—66 Channel Wireless \$199.⁹⁵
 JRX-3 DIC—36 Channel Corded Remote..... \$149.⁹⁵
 JSX-3 DIC—36 Channel Set Top..... \$129.⁹⁵
 SB-3—'The Real Thing' \$119.⁹⁵

- MAGNAVOX:** 6400—60 Channel Wireless w/Parental Lockout for Jerrold systems..... \$199.⁹⁵

- ZENITH:** Z-TAC Cable Add-On..... \$225.⁰⁰

- VIEW STAR:** EVSC-2000—60 Channel Wireless— with Parental Lockout..... \$ 99.⁹⁵

- EVSC-2000A-B—Same as above with A-B Switch \$109.⁹⁵

- View Star 1000—60 Channel Wireless— with Volume \$119.⁹⁵

MISCELLANEOUS

- OAK:** N-12 Mini-Code \$ 89.⁹⁵
 N-12 Mini-Code Vari-Sync \$109.⁹⁵
 N-12 Mini-Code Vari-Sync Plus Auto On-Off .. \$165.⁰⁰

- JERROLD:** 400 & 450 Handheld Transmitters..... \$ 29.⁹⁵

- HAMLIN:** MLD-1200 \$ 99.⁹⁵

- NEW ITEMS:** Standard Components—66 Channel Wireless— with Parental Lockout \$ 99.⁹⁵

- Scientific Atlanta **Call for Price**

- Power Zapper Stun Gun, 46, 000V..... \$ 59.⁹⁵

- K-40 Radar Detector—Dash Model \$199.⁹⁵

- K-40 Radar Detector—Remote..... \$229.⁹⁵

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ICD Assemblies

Socket Connector (Style S)

PCB Connector (Style P)

Card Edge Connector (Style K)

Beater / Air / Dash / Cable Length in Feet

Part No.	Beater	Air	Dash	Cable Length	Price
10	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00
14	1.00	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	1.00	1.00
16	1.00	1.00	1.00	1.00	1.00
17	1.00	1.00	1.00	1.00	1.00
18	1.00	1.00	1.00	1.00	1.00
19	1.00	1.00	1.00	1.00	1.00
20	1.00	1.00	1.00	1.00	1.00
21	1.00	1.00	1.00	1.00	1.00
22	1.00	1.00	1.00	1.00	1.00
23	1.00	1.00	1.00	1.00	1.00
24	1.00	1.00	1.00	1.00	1.00
25	1.00	1.00	1.00	1.00	1.00
26	1.00	1.00	1.00	1.00	1.00
27	1.00	1.00	1.00	1.00	1.00
28	1.00	1.00	1.00	1.00	1.00
29	1.00	1.00	1.00	1.00	1.00
30	1.00	1.00	1.00	1.00	1.00
31	1.00	1.00	1.00	1.00	1.00
32	1.00	1.00	1.00	1.00	1.00
33	1.00	1.00	1.00	1.00	1.00
34	1.00	1.00	1.00	1.00	1.00
35	1.00	1.00	1.00	1.00	1.00
36	1.00	1.00	1.00	1.00	1.00
37	1.00	1.00	1.00	1.00	1.00
38	1.00	1.00	1.00	1.00	1.00
39	1.00	1.00	1.00	1.00	1.00
40	1.00	1.00	1.00	1.00	1.00
41	1.00	1.00	1.00	1.00	1.00
42	1.00	1.00	1.00	1.00	1.00
43	1.00	1.00	1.00	1.00	1.00
44	1.00	1.00	1.00	1.00	1.00
45	1.00	1.00	1.00	1.00	1.00
46	1.00	1.00	1.00	1.00	1.00
47	1.00	1.00	1.00	1.00	1.00
48	1.00	1.00	1.00	1.00	1.00
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56	1.00	1.00	1.00	1.00	1.00
57	1.00	1.00	1.00	1.00	1.00
58	1.00	1.00	1.00	1.00	1.00
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61	1.00	1.00	1.00	1.00	1.00
62	1.00	1.00	1.00	1.00	1.00
63	1.00	1.00	1.00	1.00	1.00
64	1.00	1.00	1.00	1.00	1.00
65	1.00	1.00	1.00	1.00	1.00
66	1.00	1.00	1.00	1.00	1.00
67	1.00	1.00	1.00	1.00	1.00
68	1.00	1.00	1.00	1.00	1.00
69	1.00	1.00	1.00	1.00	1.00
70	1.00	1.00	1.00	1.00	1.00
71	1.00	1.00	1.00	1.00	1.00
72	1.00	1.00	1.00	1.00	1.00
73	1.00	1.00	1.00	1.00	1.00
74	1.00	1.00	1.00	1.00	1.00
75	1.00	1.00	1.00	1.00	1.00
76	1.00	1.00	1.00	1.00	1.00
77	1.00	1.00	1.00	1.00	1.00
78	1.00	1.00	1.00	1.00	1.00
79	1.00	1.00	1.00	1.00	1.00
80	1.00	1.00	1.00	1.00	1.00
81	1.00	1.00	1.00	1.00	1.00
82	1.00	1.00	1.00	1.00	1.00
83	1.00	1.00	1.00	1.00	1.00
84	1.00	1.00	1.00	1.00	1.00
85	1.00	1.00	1.00	1.00	1.00
86	1.00	1.00	1.00	1.00	1.00
87	1.00	1.00	1.00	1.00	1.00
88	1.00	1.00	1.00	1.00	1.00
89	1.00	1.00	1.00	1.00	1.00
90	1.00	1.00	1.00	1.00	1.00
91	1.00	1.00	1.00	1.00	1.00
92	1.00	1.00	1.00	1.00	1.00
93	1.00	1.00	1.00	1.00	1.00
94	1.00	1.00	1.00	1.00	1.00
95	1.00	1.00	1.00	1.00	1.00
96	1.00	1.00	1.00	1.00	1.00
97	1.00	1.00	1.00	1.00	1.00
98	1.00	1.00	1.00	1.00	1.00
99	1.00	1.00	1.00	1.00	1.00
100	1.00	1.00	1.00	1.00	1.00

D-SUBMINIATURE ASSEMBLIES

MALE FEMALE

Single Ended with Female Connector
Double Ended with Male Connector
Double Ended with Female Connector
Double Ended with Male and Female Connector

Number after dash in Part No. is length in feet

1 Pin D-Subminiature Assemblies

Style Part No.	Price
R065-10-6	5.17
R065-10-8	5.17
R065-10-10	5.17
R065-10-12	5.17
R065-10-14	5.17
R065-10-16	5.17
R065-10-18	5.17
R065-10-20	5.17
R065-10-22	5.17
R065-10-24	5.17
R065-10-26	5.17
R065-10-28	5.17
R065-10-30	5.17
R065-10-32	5.17
R065-10-34	5.17
R065-10-36	5.17
R065-10-38	5.17
R065-10-40	5.17
R065-10-42	5.17
R065-10-44	5.17
R065-10-46	5.17
R065-10-48	5.17
R065-10-50	5.17
R065-10-52	5.17
R065-10-54	5.17
R065-10-56	5.17
R065-10-58	5.17
R065-10-60	5.17
R065-10-62	5.17
R065-10-64	5.17
R065-10-66	5.17
R065-10-68	5.17
R065-10-70	5.17
R065-10-72	5.17
R065-10-74	5.17
R065-10-76	5.17
R065-10-78	5.17
R065-10-80	5.17
R065-10-82	5.17
R065-10-84	5.17
R065-10-86	5.17
R065-10-88	5.17
R065-10-90	5.17
R065-10-92	5.17
R065-10-94	5.17
R065-10-96	5.17
R065-10-98	5.17
R065-10-100	5.17

TI EDGEBOARD CONNECTORS

16 Wire Wrap to 50 (Socket Tall) micro-inches gold plated over a nickel/olfin barrier
Operational on CA 75 alloy
Infrared contact points
Preconditioned continuous spring design
Contacts are user removable

MA SERIES 100 x 200" EDGEBOARD CONNECTORS

Part No.	Price
MA100-100-200-1	1.00
MA100-100-200-2	1.00
MA100-100-200-3	1.00
MA100-100-200-4	1.00
MA100-100-200-5	1.00
MA100-100-200-6	1.00
MA100-100-200-7	1.00
MA100-100-200-8	1.00
MA100-100-200-9	1.00
MA100-100-200-10	1.00
MA100-100-200-11	1.00
MA100-100-200-12	1.00
MA100-100-200-13	1.00
MA100-100-200-14	1.00
MA100-100-200-15	1.00
MA100-100-200-16	1.00
MA100-100-200-17	1.00
MA100-100-200-18	1.00
MA100-100-200-19	1.00
MA100-100-200-20	1.00
MA100-100-200-21	1.00
MA100-100-200-22	1.00
MA100-100-200-23	1.00
MA100-100-200-24	1.00
MA100-100-200-25	1.00
MA100-100-200-26	1.00
MA100-100-200-27	1.00
MA100-100-200-28	1.00
MA100-100-200-29	1.00
MA100-100-200-30	1.00
MA100-100-200-31	1.00
MA100-100-200-32	1.00
MA100-100-200-33	1.00
MA100-100-200-34	1.00
MA100-100-200-35	1.00
MA100-100-200-36	1.00
MA100-100-200-37	1.00
MA100-100-200-38	1.00
MA100-100-200-39	1.00
MA100-100-200-40	1.00
MA100-100-200-41	1.00
MA100-100-200-42	1.00
MA100-100-200-43	1.00
MA100-100-200-44	1.00
MA100-100-200-45	1.00
MA100-100-200-46	1.00
MA100-100-200-47	1.00
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MA100-100-200-49	1.00
MA100-100-200-50	1.00

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P104	1.00
P105	1.00
P106	1.00
P107	1.00
P108	1.00
P109	1.00
P110	1.00
P111	1.00
P112	1.00
P113	1.00
P114	1.00
P115	1.00
P116	1.00
P117	1.00
P118	1.00
P119	1.00
P120	1.00
P121	1.00
P122	1.00
P123	1.00
P124	1.00
P125	1.00
P126	1.00
P127	1.00
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P139	1.00
P140	1.00
P141	1.00
P142	1.00
P143	1.00
P144	1.00
P145	1.00
P146	1.00
P147	1.00
P148	1.00
P149	1.00
P150	1.00

LED'S - Red, Green, Amber, Orange

Color Part Price Size Shape

Color	Part No.	Price	Size	Shape
Red	LED100	2.20	150 x 5	Round
Green	LED101	2.20	150 x 5	Round
Amber	LED102	2.20	150 x 5	Round
Orange	LED103	2.20	150 x 5	Round
Red	LED104	2.20	150 x 5	Round
Green	LED105	2.20	150 x 5	Round
Amber	LED106	2.20	150 x 5	Round
Orange	LED107	2.20	150 x 5	Round
Red	LED108	2.20	150 x 5	Round
Green	LED109	2.20	150 x 5	Round
Amber	LED110	2.20	150 x 5	Round
Orange	LED111	2.20	150 x 5	Round
Red	LED112	2.20	150 x 5	Round
Green	LED113	2.20	150 x 5	Round
Amber	LED114	2.20	150 x 5	Round
Orange	LED115	2.20	150 x 5	Round
Red	LED116	2.20	150 x 5	Round
Green	LED117	2.20	150 x 5	Round
Amber	LED118	2.20	150 x 5	Round
Orange	LED119	2.20	150 x 5	Round
Red	LED120	2.20	150 x 5	Round
Green	LED121	2.20	150 x 5	Round
Amber	LED122	2.20	150 x 5	Round
Orange	LED123	2.20	150 x 5	Round
Red	LED124	2.20	150 x 5	Round
Green	LED125	2.20	150 x 5	Round
Amber	LED126	2.20	150 x 5	Round
Orange	LED127	2.20	150 x 5	Round
Red	LED128	2.20	150 x 5	Round
Green	LED129	2.20	150 x 5	Round
Amber	LED130	2.20	150 x 5	Round
Orange	LED131	2.20	150 x 5	Round
Red	LED132	2.20	150 x 5	Round
Green	LED133	2.20	150 x 5	Round
Amber	LED134	2.20	150 x 5	Round
Orange	LED135	2.20	150 x 5	Round
Red	LED136	2.20	150 x 5	Round
Green	LED137	2.20	150 x 5	Round
Amber	LED138	2.20	150 x 5	Round
Orange	LED1			

LETTER BOX



Computer Maven

I have just finished "Digital Fundamentals—Lesson 8." While Mr. Frenzel's presentation is largely correct, it is not true that the 6502 microprocessor has 16-bit Index Registers and Stack Pointer. The Index Registers and Stack Pointer are all 8-bit registers; the 8-bit Stack Pointer is supplemented by a fixed logic 1 on address line 8. That forces the stack to be confined to page 1 (addresses \$100 to \$1FF). A limited stack pointer is seldom a disadvantage, and it prevents a runaway stack from overwriting all of memory—which can happen with 16-bit stack pointers.

Two other problems arise with this presentation. First, the Register Indirect addressing mode is not available on either the 6800 or 6502 microprocessors. That was implied rather than implicitly stated, but can possibly cause a misunderstanding. Finally—nit-picking: the Commodore 64/128 computers use 6510 and 8502 microprocessor respectively; those are code-compatible with the 6502 but have enhanced hardware capability.

Ralph Tenny
P.O. Box 830545
Richardson, TX 75083

On Our Survey

Enclosed is the *Hands-On Electronics Reader Survey* that I really enjoyed filling out. That is my second copy of **Hands-on Electronics** (July/August 1986). I picked it up at a local Osco Drug Store. Also, I mailed a subscription form in, in order to receive uninterrupted copies of this fine magazine. The reason I am interested in your magazine is that it has something for everyone—such as SWL and amateur radio. I've been a licensed ham for sixteen years, with the call of WB0QPL, Advanced Class. I am sort of inactive in ham radio since last year, because I was living in Grand Jct., CO; but due to the poor job situation I had to move back to the Denver area and start from scratch (jobwise, that is). My wife and I live in a mobile home park here in Aurora; so the only ham antenna I can put up is a 10 through 80-meter vertical antenna on the roof of the mobile home. I am in hopes that I will be active in the HF spectrum before this Fall.

In your survey I am glad that you included questions regarding us hams

and SWL's. But I know that you could only make the survey just so big because of space problems. However, I hope your editors and associate editors Julian S. Martin, KA2GUN, Herb Friedman, W2ZLF, and Byron G. Wels, K2AVB will include more articles to the interest of us hams, like material on packet radio, ham satellite communications, EME, DX news, etc.—and I hope that you will include projects that hams can build from novice to holders of Extra Class tickets, too. For the SWL's, I think that articles not only on where to find the hard-to-get DX stations but also kit projects for antennas, how to filter out the Russian Woodpecker, and a review of SW receivers to fit everyone's pocket.

I hope my comments will be of some value to your magazine. I feel very excited about this magazine as I do about QST, CQ, 73's etc. I am looking forward to receiving my first copy in the mail. I think you have a winner. Keep up the good work. 73's.

L.D.—Aurora, CO

Glad you like our magazine. You're in for even more enjoyment because, thanks to people like you, we're now a monthly magazine.

Did He Say, "Baffles?"

I enjoyed the reprint of Neville Williams article, "Baffles, Boffles, Boxes and Vents" in your May/June issue. However, his closing comments to the effect that the hobbyist should not attempt reflex enclosure designs was of great concern to me. With the availability of several good books and computer-aided design programs costing a small fraction of the cost of a single pair of speakers, your magazine should encourage the audio hobbyist searching for the needed information. Because my company has developed and markets such a computer program, I am, naturally, biased. Still, the design of such enclosures is not beyond the reach and capability of even the modest speaker-system builder. A friend with an Apple computer is all that he needs.

The program described below is complete with a manual that is easy enough for the serious hobbyist, yet technically sophisticated for the design engineer. The package retails for about \$40.

The enclosed printouts are from the program that DCL Company developed

specifically for designing low-frequency enclosures (ported and closed) by evaluating any given driver's performance in any given enclosure. Using graphic display of response curves and continuous screen report of all design choices and their immediate results, the user is led through orderly design-sequences. Or, the user can allow complete computer-generated designs. The flexibility of design-sequence alternatives ranges from all trial-and-error routines to totally automatic generation, while letting the user change between the two at will.

The eight Main Menu selections lead to more than twenty-two user-driven, computer-prompted, design-sequence alternatives for accomplishing the specific driver/enclosure performance desired (or at least as nearly as a given driver is capable). The attached *Review* printouts reflect the same driver in: 1) A standard design alignment for that driver, 2) An improperly conceived *Custom* use of the driver, 3) A *Custom* design to extend the low-frequency utilization of the driver and 4) A completely computer *Generated* model.

Although all design sequences allow immediate graph and table printouts, only copies of the *Reviews* are enclosed because they reflect the culmination of specific design sequences. The acceptable alternative designs took about four minutes, while the computer *Generated* design took about two minutes. The *Fast Start Align* segment alone can analyze several enclosures per second out of the hundreds possible. It is initiated by a single user-input defining a response decrease allowed (-db) at a given frequency.

The program is for Apple II series computers with 64K memory, 80-column card and single disk drive. All graphic, line-print and design-segment programs are loaded at system initialization to allow fast response. It is compatible (terminology and process) with several books written on enclosure design for the hobbyist. Obviously, it is geared for the hobbyist speaker builder.

If your magazine wishes further information to pass along to your readers, please contact me personally.

Daniel Longest
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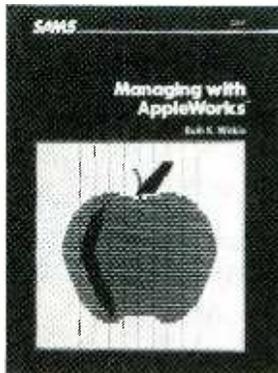
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nations in order to insert bogus traffic.

The book also provides a nation-by-nation directory of the latest information on worldwide embassy communications stations and networks—callsigns, tactical ID's, operating modes, locations, etc. It also includes the U.N. networks, Interpol, "spy numbers" station listings, long-distance telephone terrestrial microwave relay and satellite terminal frequencies in the New York/Washington communications areas (these are reported to be heavily monitored by many nations for the governmental messages they carry), the International Committee for The Red Cross, as well as the huge U.S. State Department (some claim C.I.A.) shortwave communications network, as well as their VHF/UHF scanner-band operations frequencies within the U.S.A. Terrorist communications are also covered.

**Guide To Embassy
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Tom Kneittel, K2AES



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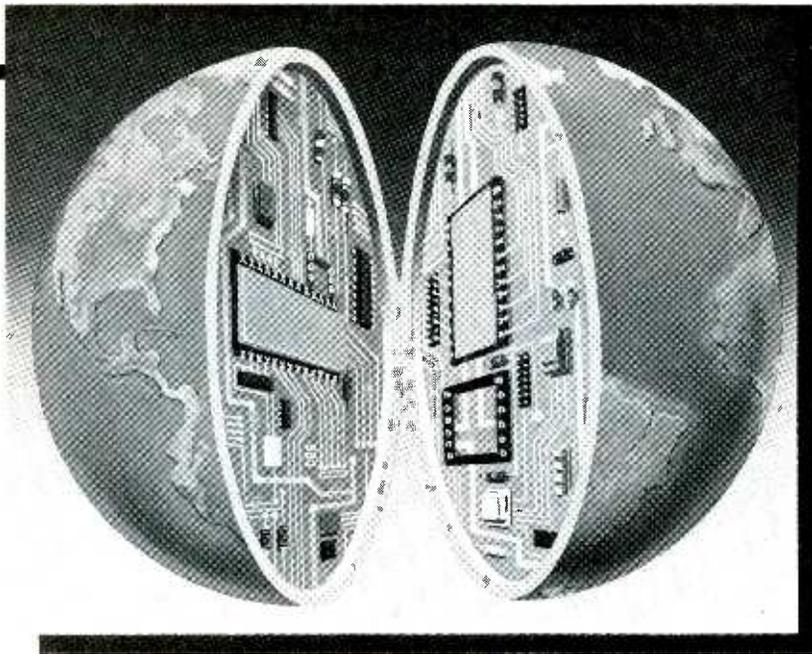
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(Continued on page 22)

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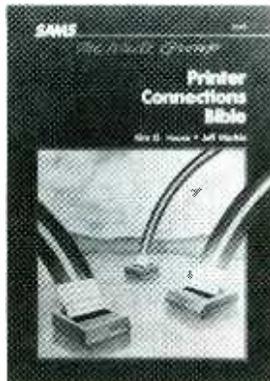
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BOOKSHELF

(Continued from page 18)

unnecessary costs when attempting to connect your model "X" printer to a model "Y" computer by using the Sams *Printer Connection Bible*.

The book contains all the



CIRCLE 80 ON FREE INFORMATION CARD

information necessary to make the proper connections to get a printer printing. It focuses on the hardware side of connecting printers and computers, particularly the main interface—the cable itself. Included are tables and diagrams, information about various printers, computers and software, printer technology, and cables and connectors. This softcover text sells for \$16.95.

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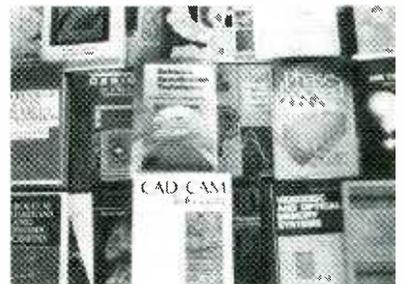


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(Continued on page 24)

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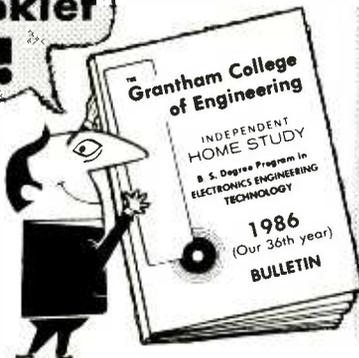
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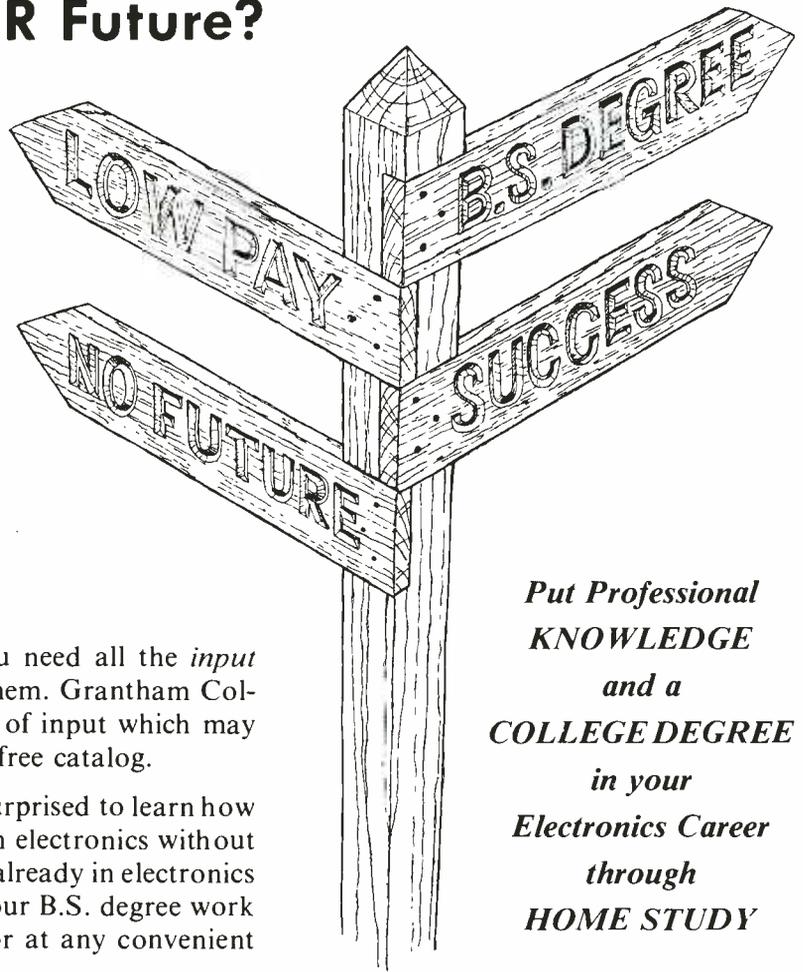
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BOOKSHELF

(Continued from page 22)

He to produce hard copy that's almost as good as typeset copy, and eliminate the Wolfenstein SS using six new and easy-to-build playing aids. In addition, you can capture your own source code for custom modification using the "tearing method," and use software to create an exact and jitter-free screen lock. Author Don Lancaster's writing style is light and informative, offering invaluable tips for the Apple II and Apple IIe.

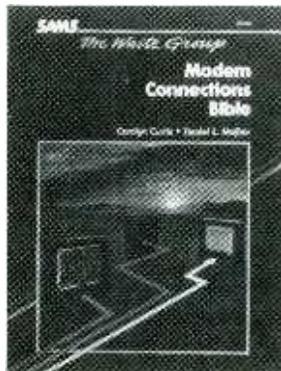


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The book is available from book shops and computer stores. For more information write to Howard W. Sams & Co., Dept. R41, 4300 W. 62nd St., Indianapolis, IN, or call toll-free, 800/428-SAMS.

Modem Connections Bible By Carolyn Curtis and Daniel Majhor

The *Modem Connections Bible*, by Howard W. Sams & Co., is a companion to their *Printer Connections Bible*.



CIRCLE 77 ON FREE INFORMATION CARD

The book provides an introduction to the world of computerized communications, and thereafter serves as a reference source.

The heart of the book is a collection of drawings of the RS-232-C interfaces on a number of popular microcomputers, the interfaces on the modems, and the cables that connect the two. The softcover text sells for \$16.75.

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Testing Electrical Systems

The 16-page brochure *Electrical Troubleshooting with Fluke Multimeters* describes how to use digital multimeters (DMMs) for a wide



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variety of troubleshooting and repair procedures for electrical systems.

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Electrical Troubleshooting with Fluke Multimeters is available from Fluke distributor locations throughout the United States, and through Fluke's worldwide sales network. For more information write John Fluke Mfg. Co. Inc., P. O. Box C9090, Everett, WA 98206, or call toll-free, 800/426-0361.

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JENSEN ON DX'ING

It takes a relay to put a signal where it's needed

□ RELAYING SHORTWAVE PROGRAMS ISN'T new. The British Broadcasting Corporation has been doing it for decades; so has the Voice of America.

In recent years, though, they have been joined by a growing number of international broadcasters who have learned that they can deliver more bang for the buck, providing stronger, more reliable signals to distant listeners through relay transmitters closer to the target areas.

The technique works well. Shortwave listeners usually get better reception of the relayed programs. But sometimes the whole business of *who* is transmitting from *where* can get a bit confusing. Because of shortwave relays, things are not always what they may seem.

The Radio Nederland shortwave signal you hear may be transmitted from a station in Holland, but more likely it is really coming from a station on the island of Bonaire in the Netherlands Antilles, an island off the coast of South America. BBC programming could really be coming from another West Indian island, Antigua, or perhaps from Ascension Island in the South Atlantic.

Deutsche Welle, the Voice of Germany? It also uses the Antigua facilities, but has a relay transmitter in Rwanda in central Africa as well. Radio Japan's programs could be coming from Gabon in West Africa, or Portugal. Radio France International has a shortwave relay station in French Guiana. And there are more broadcasters either in the relay race or planning to start soon.

Years ago, the BBC determined that it could better reach Asian audiences if the programs originating in London were retransmitted by stations in Singapore. Today, it has four 250-kilowatt and four 100-kilowatt relay stations there.

In the past, special point-to-point transmitting facilities—usually making use of the single-sideband (SSB) transmission mode—were used to get the programming from the point of origin to the SW relay station for rebroadcast. SSB is still used for that purpose today, but in other cases, the programming is sent out to the distant relaying point by communications satellite.

Besides Singapore, Ascension, and Antigua, BBC programs are relayed on

shortwave from transmitters in Lesotho in southern Africa, Cyprus, Masirah Island off Oman, and from the U.S. and Canada.

Cooperation

Reciprocal arrangements with the Americans and Canadians are typical of the way a number of major international broadcasters are dealing with the high costs of building their own shortwave relay facilities.

In return for air time to relay BBC broadcasts from Canadian transmitters at Sackville, New Brunswick, and American stations at Delano, California, and Greenville, North Carolina, Radio Canada International and the Voice of America can air their programs from British SW stations. That allows each to put better signals into target zones than they otherwise could.

One of the most recent reciprocal broadcasting agreements involves Radio Beijing, China's international voice, and Radio France International. RFI's programs to the Orient are being relayed by the Chinese transmitters, while Radio Beijing broadcasts are relayed, with real punch, to the Western Hemisphere from the RFI facilities at Montsinery, French Guiana.

The France-China deal followed an air time trade-off pact involving the Taiwan government's Voice of Free China and a private religious broadcaster, WYFR, Family Radio, which has its shortwave transmitters in Florida.

The VOA, like the BBC, owns some relay stations of its own and makes other arrangements, such as the Anglo-American reciprocity deal, for the rest of its rebroadcasts.

VOA also has shortwave relay operations from such places as Monrovia, Liberia; Tangier, Morocco; Rhodes and Kavala, Greece; Munich, Germany; Sri Lanka, and the Philippines.

Radio Nederland, besides its own pair of 300-kilowatt shortwave relays on Bonaire, has two more of the powerful transmitters at Talata, Madagascar, off Africa's Indian Ocean coast.

In recent years, the world's major broadcasters have found that building your own relay station overseas had two drawbacks: cost and finding a suitable site.

Political instability in the world caused the second problem. After you invest millions of dollars in building, equipping and staffing a powerful shortwave rebroad-

(Continued on page 105)



Tom Gravaras, Minnetonka, MN, brings in a lot of shortwave DX signals with his ICOM R-70 receiver. Tom's interest in radio dates back to 1969. He has heard and confirmed stations from more than 200 countries.



WELS' THINK TANK

Introducing the best of Wels!

□ HOW MANY TIMES HAVE YOU WISHED there was somebody close at hand to answer some of the questions that keep coming up? And how often have you been stopped in the middle of a thought to wonder just "how do you do that?"

We hope that this column will do exactly that for you. Probably, the biggest advantage that we have, is that we're here, surrounded by electronics experts in just about every discipline. In addition to that, we have scores of books available to us, and if all of these sources don't provide suitable answers to your questions, know that we have other sources from a long list of contributors to our magazine, who most-assuredly will have the answers.

This will not be a "letters" column to which you can write to comment on articles or ask about general electronics facts—our purpose here is restricted to electronic circuitry and electronic circuitry only. But in that area, we're here to help as problem solvers, regardless of how big or little the problem might be.

Bike Speedometer

R.K., of Waukesha, WI asks if he can build a speedometer for his bicycle. He's

found that the commercial units available are a bit expensive. Yes, R.K., we've found a schematic diagram that should work for you. (See Fig. 1.) This unit needs only 3 volts at 6 mA and we use six small solar cells for power. Chances are that you have spoke-mounted reflectors on your wheels, and all we do is reflect the light from that reflector to a phototransistor mounted on the bicycle's front fork.

Mount the TIL414 in a black-painted

tube to eliminate extraneous light.

The 2N577 has a built-in amplifier stage which feeds op-amp U1, a 741 connected as a differential amplifier. Setting the level at R3 causes a rise in voltage when the reflector passes the TIL414. This (through capacitor C1) is fed to the timer, U2, a 555, wired as a monostable multivibrator.

With each rotation of the wheel, a pulse of fixed length is pumped through D1 into C3. The charge on C3 bleeds into the meter (M1) and the faster the wheel is going, the more charge there will be. Use a 30- μ A full-scale deflection meter for this.

After assembling the unit, all you have to do is calibrate it, and this is most-easily done by having a friend in a car maintain a constant speed while riding alongside you.

Metronome

L.B. of Santa Fe, NM asks if there isn't an electronic—and silent—metronome. His daughter is taking piano lessons, and he bought her an electronic keyboard that she can use with earphones, but the metronome ticking is driving him *nutso*.

Take a look at Fig. 2, L.B. Timing is a function of the 555 timer, U1. C1 and C2 are charged through R1, R2 and R3, but are discharged through R2 and R3 only. The discharge rate is faster than the charge rate, so the output of the 555 doesn't have

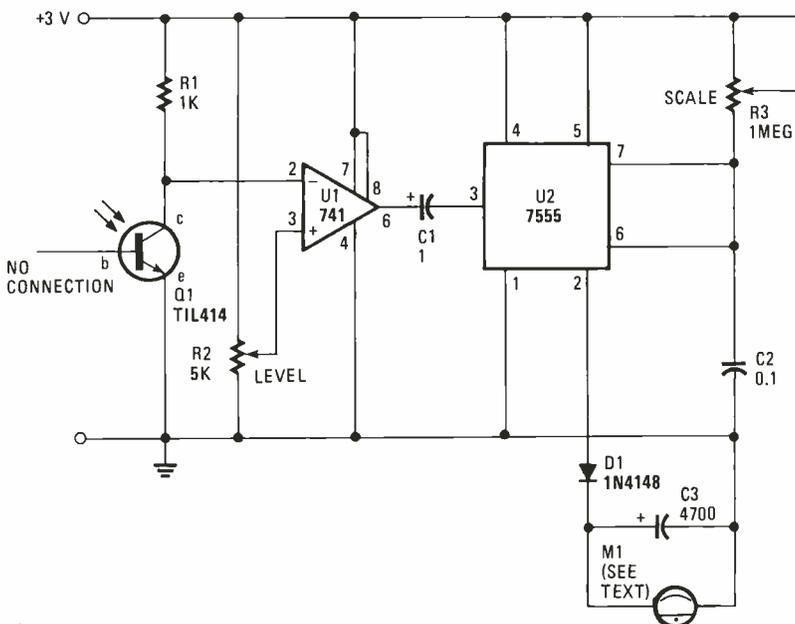


Fig. 1

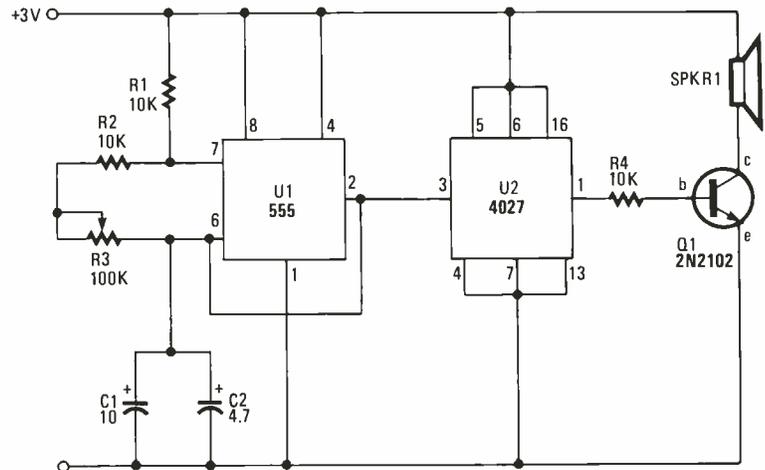


Fig. 2

a 1:1 mark-space ratio. That 1:1 ratio is needed for a regular beat, so we feed the output to a J-K flip-flop, U2, a 4027. The J and K inputs are both held high so the output changes state when the clock input changes from low to high. The output of the flip-flop is amplified by transistor Q1, a 2N2102 and at each state change, a sharp "click" is heard in the crystal earphone.

Calibrate the knob of R3 for the various tempos that are required, and relax as peace once again descends on your household.

Code Practice Oscillator

In a letter from B.J., of Enid, OK, we're asked for a schematic diagram for a simple code practice oscillator. Figure 3 shows a pretty-basic model that should serve well right now for learning the code, and can easily be adapted as a monitor to hook up to a receiver later on.

The 7611, U1, feeds its output from pin 6 to voltage divider R4-R5. Half of it is fed back to the non-inverting input, and this positive feedback causes instability and therefore, oscillations. The frequency is determined by R3 and C2. When the output is high, the input at pin 3 is high. Current flows from pin 6, through R3 to charge C2. As the voltage on pin 2 reaches the level at pin 3, the output falls. It goes negative, and C2 gradually discharges through R3 to the negative voltage at pin 6. This unit provides a tone of a few thousand hertz, adequate for the purpose. Use a high-impedance speaker of about 80 ohms, and operate the system with a 1½-V. battery.

Exposure Meter

"I don't need a fancy (and expensive) exposure meter for taking photographs," writes L.D. of Lubbock, TX. "Keep all the bells and whistles. Just give me as basic an exposure meter as I can build."

Take a look at Fig. 4, L.D. I think this

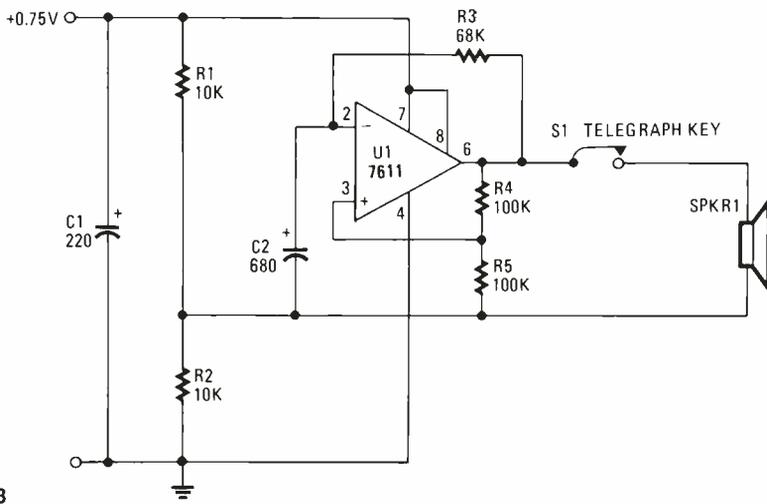


Fig. 3

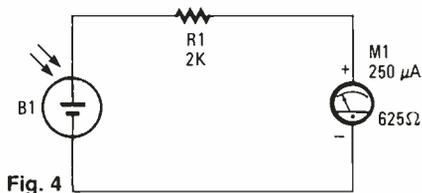


Fig. 4

will strike your fancy, if not your pocket-book. B1 is a silicon solar cell, which uses R1 to set the sensitivity. You might want to add a switch and a second resistor to give you two sensitivity ranges, but that's getting a little fancy. Use a microammeter with a full-scale deflection of 250 μA. and a resistance of 625 ohms. Of course, you're going to have to calibrate this against a known-accuracy light meter.

Enlarger Timer

G. T., of Ft. Lauderdale, FL, asks for an enlarger timer that he can build. Nothing to it, G.T., check the schematic diagram in Fig. 5. Naturally, we're going to be using a 555 timer for this circuit. It radiates a light pulse from an LED at one-second intervals. What could be better in the darkroom?

To use the unit, turn it on and as soon as the LED flashes, start to count the flashes. If you want a ten-second interval, for example, count ten flashes and turn the enlarger off. Use a watch with a second hand, simply set the flashes for one-second intervals using potentiometer R4.

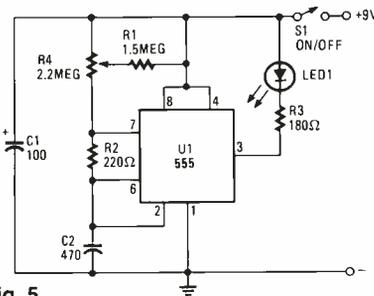


Fig. 5

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WELS' THINK TANK

Automatic Parking Light

M.F. of Ogdensburg, UT, wants to update his car by adding an automatic parking light that will come on when dusk falls. Figure 6 is just such a circuit.

In this circuit, the familiar 555, U1, is not used as a timer, but rather, as a comparator. With pin 6 connected to the positive line, the output of the IC goes high whenever pin 2 is at less than one third of the supply voltage, or low if pin 2 is higher. The IC drives the parking lamp(s) L1 through common-emitter driver transistor Q1, an NPS222A. R2 limits the base current safely, and Q1 will be biased on when the output of U1 is high and will then supply power to the lamp.

The photocell, an ORP12 light dependent resistor, has a resistance of over 10 megohms in total darkness, and only 20 ohms when brightly lit.

Adjust potentiometer R3 for proper operation. Make sure in assembling the unit,

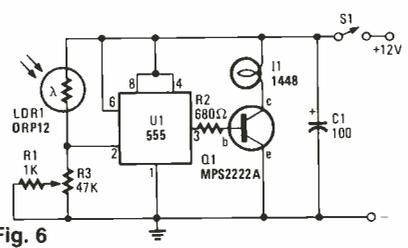


Fig. 6

that you use a suitable heatsink on the transistor, and don't place the LDR where it will be affected by the car's lighting.

One final word of warning. Make certain that you connect to the car's supply *downstream* of the ignition switch, or you'll have the parking lights coming on even when you aren't using the car!

Weak Battery Indicator

The letter from J.O., Houston, TX, indicates that he's had some problems with his car battery. He writes to ask if there isn't some way to warn him when the battery needs recharging. Such a circuit is shown in Fig. 9.

When the voltage drops below a predetermined level, the LED comes on to let you know. The circuit uses an 8211, U1. R1 provides a controlled portion of the supply voltage to one input of a voltage comparator inside the IC. The other input gets a precision 1.5 volts from a voltage source. You adjust R1 so that if the voltage drops, the voltage at R1's wiper will drop below 1.5 V. When this happens, the hysteresis output starts to go low and because of the coupling through R2, you get a regenerative action which causes the hysteresis to go fully negative. This pulls the voltage at R1's wiper well-below the trigger level.

In this state, the output at pin 4 of U1 goes low, and turns on the LED (D1) from a constant-current source.

This unit will operate over a supply range of 3—30 volts.

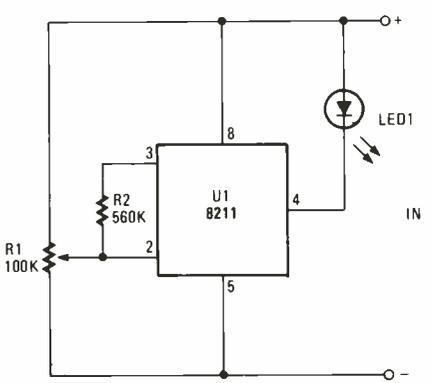


Fig. 7

Flashlight Finder

N.L. of Philadelphia, PA, tells an amusing little story: His main fuse went out and he knew he had a flashlight in the basement workshop. He wanted the flashlight to change the fuse, but since all the lights were out, he couldn't find the flashlight! He wound up lighting a candle (his wife knew where the candles were) to find the ding-dong flashlight.

Here's a way to solve that problem. Figure 8 shows a circuit for a constantly-flashing LED. Drain is so very low that

(Continued on page 32)



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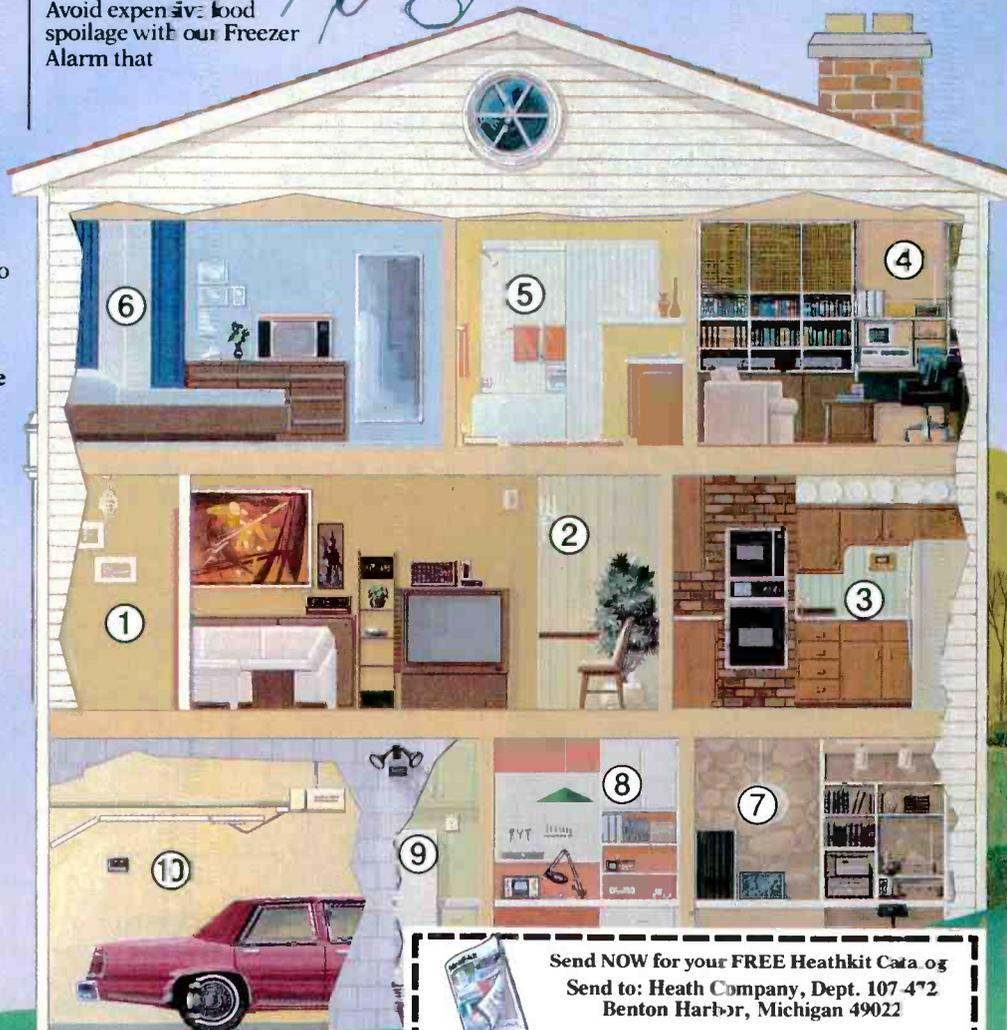
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WELS' THINK TANK

(Continued from page 28)

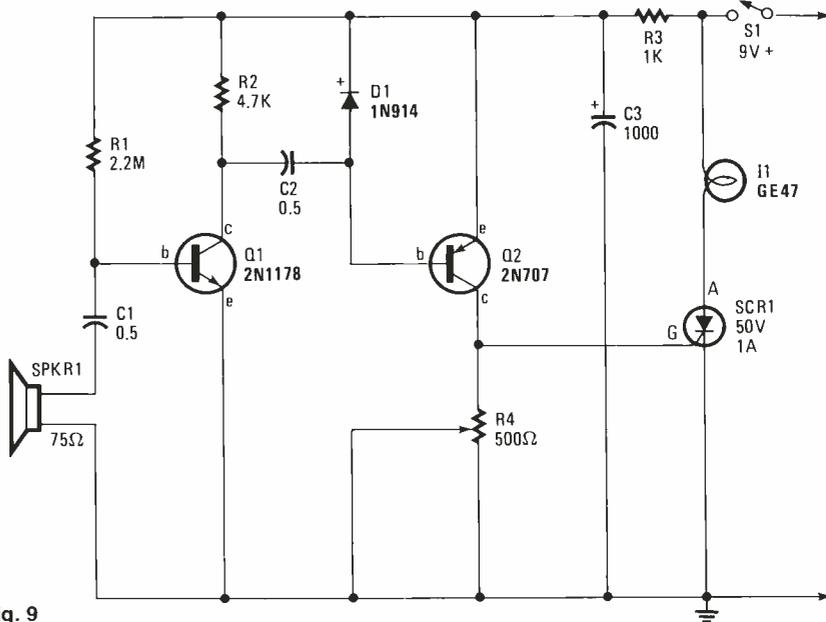


Fig. 9

battery depletion is no problem.

This is basically a relaxation oscillator in which C1 is charged to almost the full supply voltage, and then added to the supply, yielding over 2 volts. This is then connected across the LED until C1 has mostly discharged. Now the circuit returns to its original state and C1 begins to recharge. An internal resistor in U1, a 3909, prevents too-large a current from flowing through the LED when C1 discharges.

The slow flashing rate should keep the batteries going for quite some time, and all you'll have to do is mount this circuit on your flashlight. No matter how dark things get, you'll always find the light.

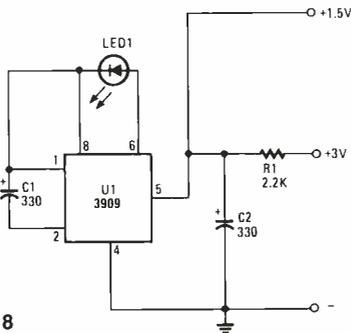


Fig. 8

Sound-Operated Switch

F.K., of Greenfield, MA has a father who is deaf and doesn't always hear the phone ringing. He wants a sound-operated switch that will sense the ring of the phone and translate this to a lamp that will go on and off. The schematic diagram in Fig. 9 should do the job nicely. The sound is picked up by the small loudspeaker,

perhaps a three-inch type, with a high impedance rating. Capacitor C1 is used to keep from upsetting the bias for Q1, obtained through R1.

The amplified signal across R2 reaches Diode D1 through capacitor C2. The rectified audio signals provide a negative bias for Q2, a PNP transistor. This causes Q2 to conduct so current that triggers SCR1 is provided at the gate. Potentiometer R4 sets the sensitivity. R3 and C3 offer a delay in operating voltage for Q1 so the circuit will not be triggered on by the sound of the on-off switch, S1 or by the current surge.

Set the lamp atop a TV receiver, turn it on and set the potentiometer so that a finger snap at two feet will trigger the lamp on. Place the speaker close to the telephone and give it a try.

That's about all the space we have for this month, so do write if you have any specific problems. We're here to help. Write to By Wels, Hands-On Electronics Magazine, 500-B Bi-County Blvd., Farmingdale, NY 11735.

The circuits contained in this column are taken from the following books:

Projects in Opto-Electronics by R. A. Penfold; 50 Projects Using Relays, SCR's and Triacs, by F. G. Rayer, T. Eng; Electronic Security Devices, by R. A. Penfold; Electronic Projects Using Solar Cells, by Owen Bishop; 52 Projects Using IC741, by Rudi & Uwe Redmer; and Popular Electronic Circuits, Book 1, by R. A. Penfold. All are available from Electronic Technology Today Inc., P. O. Box 240, Massapequa Park, NY 11762-0240.

AUDIO FUNCTION GENERATOR

**You can build an audio function generator
that rivals the commercial stuff!**

By TJ Byers

□ WHEN IT COMES TO FUNDAMENTAL TEST EQUIPMENT, IT'S hard to beat the basic audio oscillator. The most used audio oscillator is undoubtedly the function generator. Function generators are an important signal source, because they provide a wide variety of wave shapes—triangular wave, squarewave, sinewave, and pulsed outputs—over a wide range of frequencies. Recognizing the need for a quality audio generator at an affordable price, **Hands-On Electronics** presents a sophisticated function generator that is well within the budget of any hobbyist, experimenter, or audiophile.

How It Works

A key element in the realization of this project is the development of the single-chip function generator. Until the advent of large-scale integration, function generators were very expensive and difficult to maintain. Today, a four-dollar chip—the XR2206, a single-chip monolithic function generator from EXAR—provides the same performance as did a five-hundred dollar laboratory generator some ten years ago. The XR2206 is capable of producing quality sine, square, triangle, ramp, and pulse waveforms of high stability and accuracy over a range of 0.01 Hz to more than 1 MHz.

In addition, its outputs may be externally amplitude modulated (AM) or frequency modulated (FM) with virtually no effect on the quality of the output signal. The XR2206 accomplishes that feat through only four basic building blocks. A functional block/pinout diagram of the chip is shown in Fig. 1. At the heart of the unit is a voltage-controlled oscillator (VCO); an astable multivibrator that produces an output frequency that's proportional to the control current.



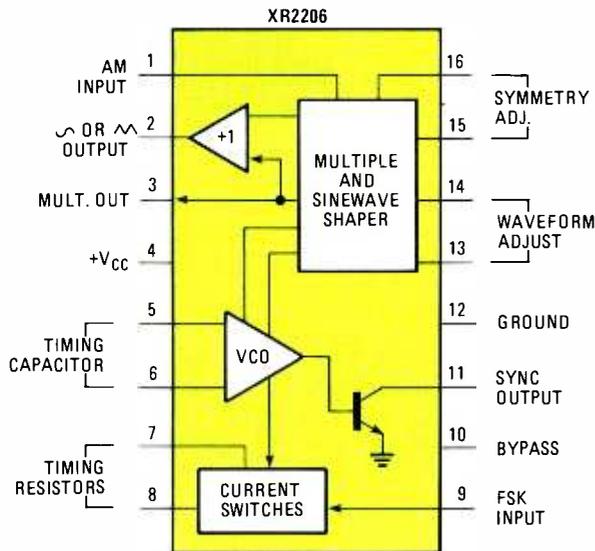


Fig 1—Functional block diagram of XR2206 single-chip function generator. The chip, along with a few support components, is all that's needed to produce a reliable test instrument.

The control current is generated internally within the XR2206 and its magnitude is determined by an external resistor connected between pin 7 and ground.

The center frequency of the VCO is set by a timing capacitor connected between pins 5 and 6. The output frequency of the VCO is inversely proportional to the size of the timing capacitor. That is, the smaller the capacitance, the higher the frequency.

Taken together, the capacitor/resistor combination determines the operating frequency of the generator. By varying the values of the timing resistor and capacitor, it is possible to adjust the VCO frequency output over several octaves.

Generating Squarewaves

The fundamental output waveform of the VCO is a squarewave, which is buffered through an open-collector transistor and output at pin 11. The voltage swing of the squarewave is from ground to very nearly the supply rail (V_{CC}). Our generator uses that output to feed more than one application. In all, the VCO output is presented in three different forms: as a 600-ohm, 6-volt squarewave; a TTL driver; and a 10-microsecond sync pulse.

First, our function generator takes the squarewave, reduces its voltage swing to 6 volts, and directs it to the function-mode switching circuit. When that mode is selected, the squarewave is available at the main output terminals at a standard output impedance of 600 ohms. Next, the squarewave signal is buffered through a TTL driver for selection as a TTL output.

Finally, the squarewave is passed through a monostable multivibrator, which transforms the signal into a 10-microsecond-wide timing pulse that is output through a separate pair of terminals labeled SYNC. The SYNC output is intended for triggering a scope or synchronizing another oscillator.

Squarewave-to-Sinewave Conversion

The squarewave output of the VCO also feeds another function block—the multiplier/sinewave shaper—inside the XR-2206. It is within that circuit that the other two waveforms are generated. First the multiplier generates the triangular wave by tapping a linear ramp-voltage inside the

VCO. That ramp voltage is the result of the timing capacitor charging and discharging through a constant-current source and is an excellent triangular voltage source. The multiplier circuit simply amplifies and buffers the signal to provide the triangular output.

The sinewave is created by internally routing the triangular waveform through a sinewave shaper. Basically, the shaper is a logarithmic amplifier whose amplification factor is dependent on the input signal. As the input voltage to the amplifier increases, its gain decreases. That creates a compression effect (as illustrated in Fig. 2) that rounds-off the sharp peaks of the triangular wave and gives the output a sinewave appearance.

Logarithmic amplifiers are preferred over filters, because they are not frequency-sensitive. The shaping process is totally dependent on the *amplitude* of the input signal and not its frequency. As you might suspect, the output voltage of the sinewave is less than the triangular wave, because of the compression factor. Typically, the sinewave has about one-third the amplitude of the triangular wave for the same amplitude setting.

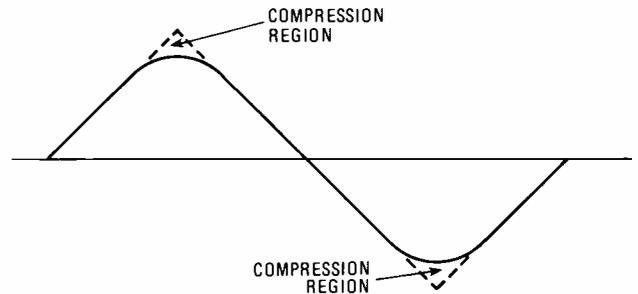


Fig. 2—A triangular wave is fed to a sinewave-shaper circuit, which clips and rounds off the peaks (shown as a dashed line curve) of the input waveform to provide a sinewave output.

The multiplier/sinewave shaper has only one output: pin 2. Selection of the waveform is made by a resistor placed across pins 13 and 14. With no resistance between those points, the logarithmic amplifier is disabled and the triangular waveform passes through the sinewave shaper unaltered. A resistance of about 200 ohms, however, engages the amplifier, reshaping the input triangle wave for sinewave output. In either mode, the output is buffered before it is sent to pin 2.

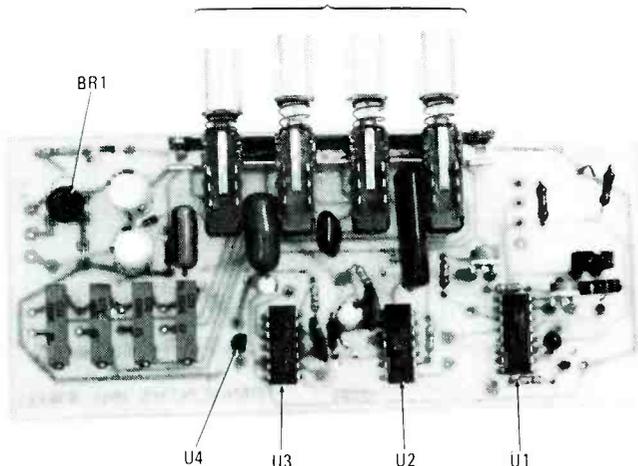
About Our Circuit

Now that we have generated our waveforms, we need to get a handle on them. Refer to Fig. 3. The various output configurations are controlled by a switching network (S1–S4). The switches are uncommon, in that they are of locking, double-pole double-throw (DPDT) pushbutton type. As one switch is pressed, the other switch is released. The desired waveform is made available by engaging the proper switch.

The amplitude of both the sine- and triangular-wave outputs is controlled by a potentiometer (R2) connected to pin 3 of U1, which varies the gain of the multiplier/sinewave shaper inside the chip. The squarewave output, however, does not pass through the multiplier circuit and, therefore, remains at a fixed level. Consequently, neither the squarewave nor the sync-pulse outputs are adjustable with the AMPLITUDE control.

The frequency of the output waveform is controlled by half of a second bank of locking DPDT pushbutton switches (S5a–S8a) wired to four capacitors. The capacitors dictate the instrument's frequency range, which spans 10 Hz to 100 kHz

RANGE-SWITCH ASSEMBLY
(S5-S8)



The Function-Generator circuit uses two switch assemblies, one of which is circuit-board mounted to provide support for the board when installed in its enclosure.

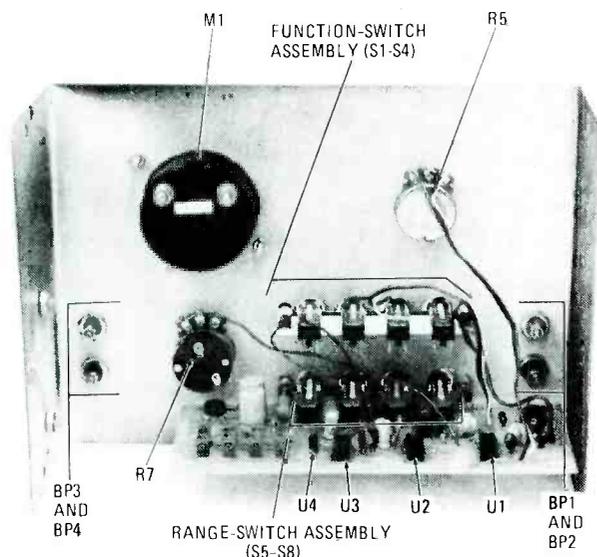
in four steps. A potentiometer—R7, configured as a rheostat—connected to the current switch input (pin 7) smoothly sweeps the selected frequency band over a 10 to 1 ratio.

The output frequency is read directly on a panel meter. The meter is driven by another rather uncommon integrated circuit, the LM2917, which is a *frequency-to-voltage* converter. That chip accurately translates an input frequency to a voltage that is displayed on the meter. That arrangement provides a more precise method for setting the output frequency than could be obtained using a calibrated dial, and is less expensive than a digital display.

Construction

Construction of the function generator is fairly straightforward. With the exception of the panel controls and meter display, all components mount on a printed-circuit board. A foil pattern of the board is shown in Fig. 4.

To reduce construction costs and simplify board duplication, the printed-circuit board was designed single-sided



All off-board components are mounted to the front panel of the enclosure, along with the circuit board, which is held in place by the switch-assembly's mounting hardware. Connections between the circuit board and the off-board components are then completed through hookup wire.

PARTS LIST FOR THE AUDIO FUNCTION GENERATOR

SEMICONDUCTORS

- BR1—50-PIV, 1-A bridge rectifier
- D1, D2—6.0-volt Zener diode
- U1—XR2206 function generator integrated circuit
- U2—LM2917 voltage-to-frequency converter integrated circuit
- U3—CD4001 quad 2-input NOR gate, integrated circuit
- U4—78L05 5-volt regulator integrated circuit

RESISTORS

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

- R1—1-Megohm, trimmer potentiometer
- R2—100,000-ohm
- R3—1,000-ohm
- R4—20,000-ohm, trimmer potentiometer
- R5—50,000-ohm, audio-taper potentiometer with on/off switch S9
- R6—4,700-ohm
- R7—100,000-ohm, audio-taper potentiometer
- R8, R9—600-ohm
- R10, R18—1,000-ohm, trimmer potentiometer
- R11—330-ohm
- R12, R21—10,000-ohm
- R13—470-ohm
- R14—47,000-ohm
- R15, R16—47-ohm
- R17—10,000-ohm, trimmer potentiometer
- R19, R20—100-ohm, trimmer potentiometer

CAPACITORS

- C1—10- μ F, 16-WVDC, electrolytic
- C2—1000-pF, ceramic disc
- C3—1.0- μ F, mylar
- C4—0.1- μ F, mylar
- C5—0.01- μ F, mylar
- C6—0.001- μ F, mylar
- C7—1- μ F, 25-WVDC, electrolytic
- C8—120-pF, ceramic disc
- C9—33- μ F, 16-WVDC, electrolytic
- C10—2.2- μ F, 16-WVDC, electrolytic
- C11, C12—470- μ F, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

- M1—0–1-mA analog panel ammeter
- S1–S8—Pushbutton switch assembly (Dick Smith Cat. S-1906)
- S9—Part of R5
- T1—Stepdown power transformer: 117-volt primary, 12-volt, center-tapped 1-A secondary
- Printed-circuit materials, 3-wire AC line cord with molded plug, metal enclosure, hook-up wire or ribbon cable, banana jacks, solder, hardware, decals, etc.

Note: An etched and pre-drilled printed-circuit board for the Audio Function Generator is available from Danocinths, Inc., PO Box 261, Westland, MI 48185 for \$21.00 (postpaid). Request part RW-133; Michigan residents add local sales tax. Please allow 6–8 weeks for delivery.

rather than double-sided. That decision led to the unavoidable placement of jumper wires on the board—altogether, five jumper connections—between the positions labeled V through Z, which are shown in Fig. 5. The jumper connections can be placed on the component side of the board prior

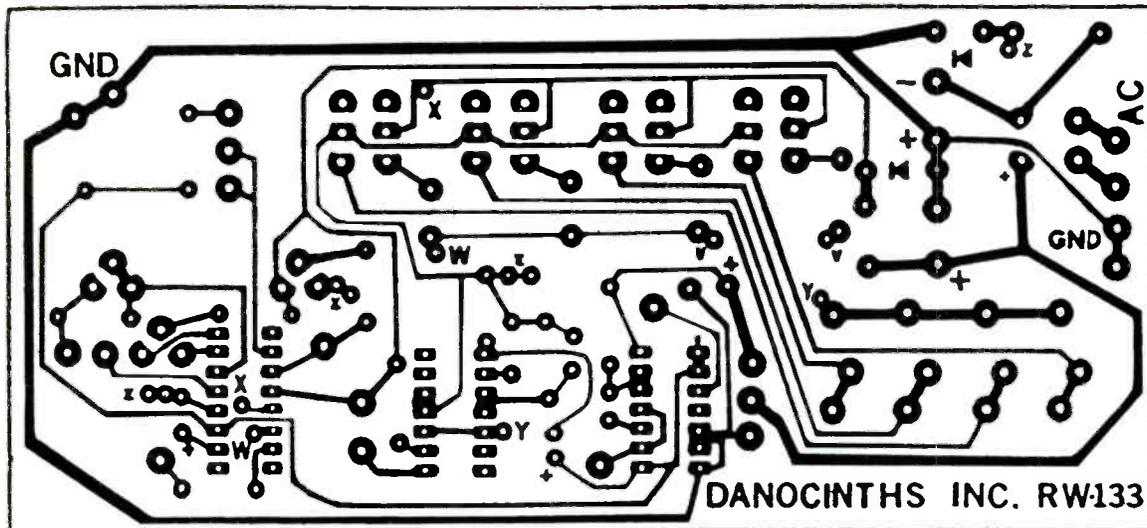


Fig. 4—This full-scale template of the Audio Function Generator can be copied from the page and used to etch your own printed-circuit board.

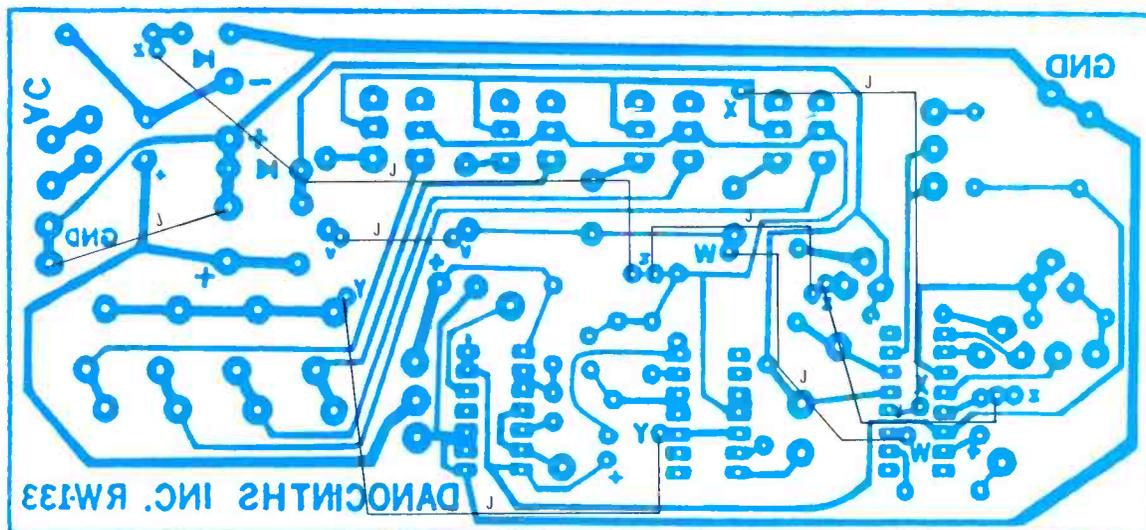


Fig. 5—The five jumper connections can be made on the unclad side of the board prior to component installation or after installation on the copper side of the board as the author did.

TABLE 1
TYPICAL PERFORMANCE SPECIFICATIONS

FREQUENCY RANGE

10 Hz to 100 Hz
100 Hz to 1 kHz
1 kHz to 10 kHz
10 kHz to 100 kHz

SINEWAVE OUTPUT

Amplitude: 0–6 volts peak-to-peak
Output Impedance: 600 ohms
Distortion:
3% at 100 kHz

SQUAREWAVE OUTPUT

Amplitude: 6 volts peak-to-peak
Output Impedance: 600 ohms
Duty Cycle: 50%
Rise Time: 250 ns
Fall Time: 50 ns

SYNC OUTPUT

Amplitude: 5 volts, TTL drive
Pulse Width: 10 μ s

TRIANGLE WAVE OUTPUT

Amplitude: 0–6 volts peak-to-peak
Output Impedance: 600 ohms
Linearity: 1% typical

TTL OUTPUT

Amplitude: 5 volts, TTL drive
Duty Cycle: 50%

to installing the parts or on the copper side after the components have been mounted. If you have any trouble, simply match the letters on the board. Note that Z has four locations and requires three jumpers in daisy-chain fashion. A parts-placement diagram is shown in Fig. 6.

Note that the *range* switches, S5 to S8, are attached directly to the circuit board, providing a handy way of mounting the circuit board inside the cabinet with a minimum of

hardware. Once the components are soldered in place, the panel-mounted components must be positioned on the front panel of your enclosure. Mount the panel meter, control potentiometers (R5 and R7), binding posts, FUNCTION-switch set, and circuit board to the front panel as illustrated.

Install the switch assemblies into the cabinet using 1/2-inch spacers. Then wire the various front-panel components to their respective circuit-board pads using color-coded ribbon

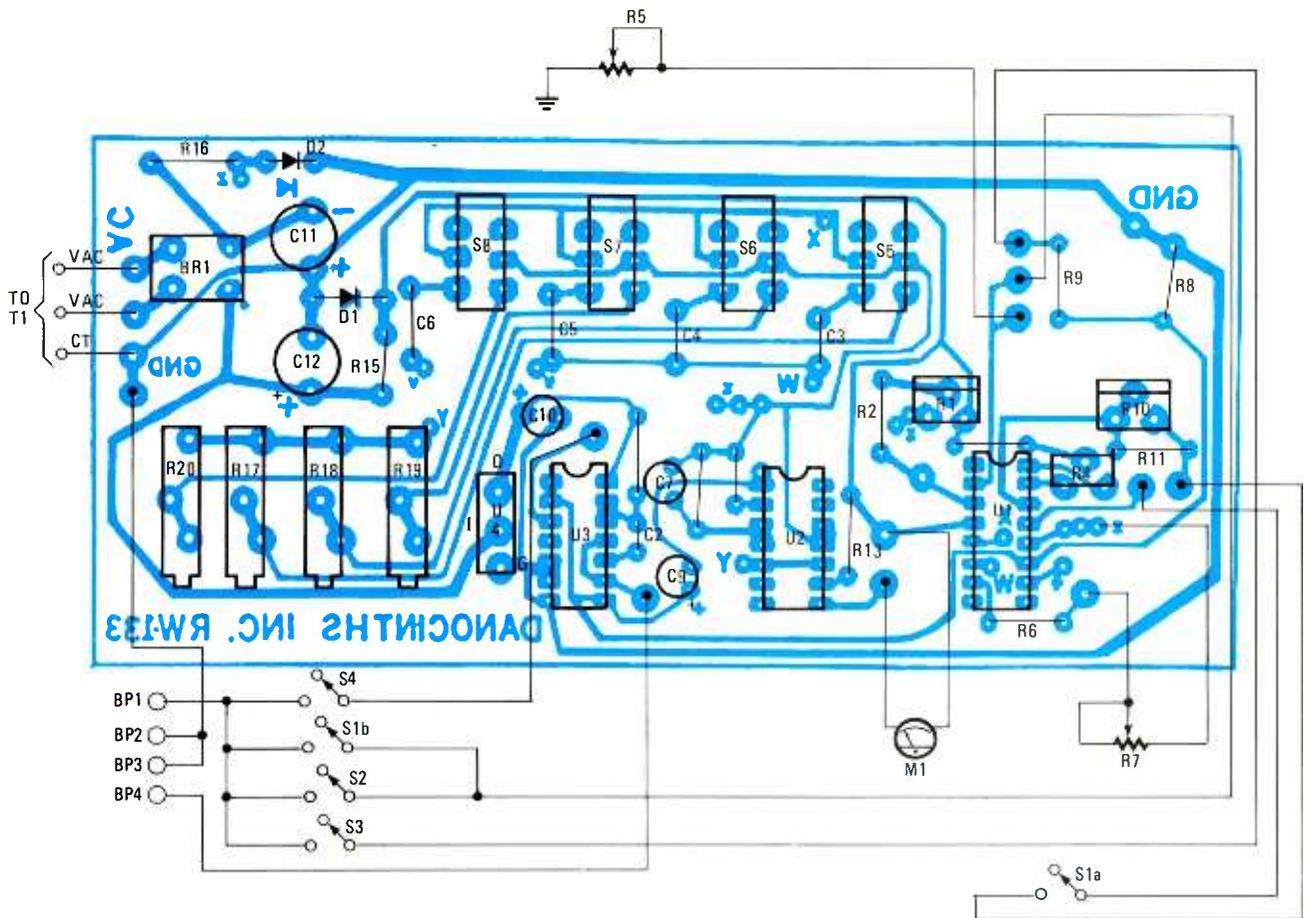


Fig. 6—When used in conjunction with the template in Fig. 4, plus the jumper-positioning guide in Fig. 5, this layout makes putting the circuit together a simple task.

cable, which makes things neater and offers less chance for error. Attach five short wires to the FUNCTION-switch set, S1 to S4, as indicated and solder them to their respective solder pads.

Finally, install and wire the power transformer. The primary of the transformer is connected to the AC line through a switch located on the back of the AMPLITUDE control. That switch serves as the power OFF/ON control. Although not shown, it is recommended that a pigtail fuse be series-connected to the line cord for safety reasons. The three secondary windings are hooked up by soldering their leads to the circuit board as indicated.

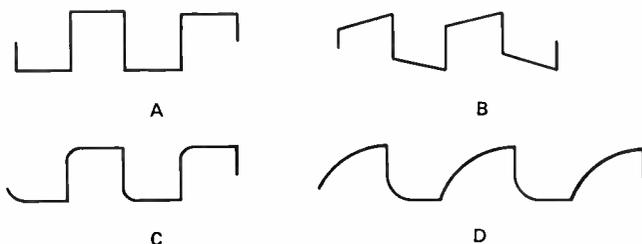


Fig. 7—Amplifier response can be judged by applying a squarewave to the input of the amplifier tested and monitoring its output with an oscilloscope. The trace in A shows the results of an amplifier with perfect frequency response; B is the output of amplifier with poor low-frequency response, showing the characteristic sloping of the waveform. Poor high-frequency response is characterized by a rounding of the corners, as shown in C, which contains the highest frequency components. Another fairly common defect, phase shift with frequency, may be identified from the sloping sides of the distorted waveform as shown in D.

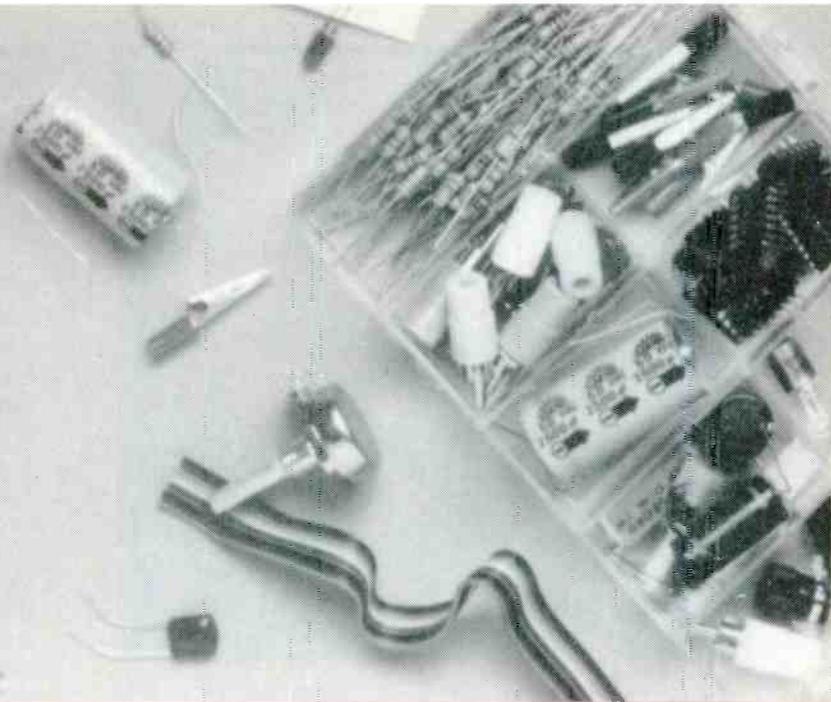
Calibration

After you've assembled your function generator and checked it out, it is ready to be calibrated. Calibration can be done in more than one way, depending on how exacting you want your instrument to be. First, adjust the offset voltage. That's done by connecting a DC voltmeter between the pin-2 output and ground. With the AMPLITUDE control (R5) turned fully counterclockwise, adjust R1 (OFFSET) until the meter registers zero volts. That references the DC component of the output signal to ground.

Next, with an oscilloscope connected across the output terminals, set the XR2206's oscillator to approximately 1 kHz and adjust the AMPLITUDE control for maximum swing without clipping. Now alternately adjust R4 (SYMMETRY) and R5 (AMPLITUDE), while observing the waveform on the scope. Choose a setting that results in the best waveshape with minimal distortion. If a scope is not available for that step, you needn't worry. Simply set the two controls to their midpoint and leave it at that. The latter results in about 3 percent harmonic distortion, as opposed to less than 0.5 percent resulting from the former.

The final step is to calibrate the frequency meter. Using a frequency counter, adjust R18 through R21 stepping through the ranges 10 Hz to 100 kHz, respectively, until the meter indicates the frequency displayed by the counter. If a counter is not available, you can use Lissajous patterns (see *Understanding and Using Lissajous Figures* in the Sept./Oct., 1986 issue of *Hands-on Electronics*) on an oscilloscope to determine the output frequency of the generator, and set your meter resistors accordingly. (Continued on page 102)

PICKING PARTS FOR YOUR PROJECTS



...or one from column A and two from column B

By Robert Grossblatt

□ NO MATTER WHAT AREA OF ELECTRONICS YOU'RE INTERESTED in, there's no thrill as great as building something of your own. Taking an idea from drawing board to breadboard to printed-circuit board is definitely the ultimate high in electronics. But whatever form your brainstorm happens to take, from a light dimmer to a home-made Univac, there's one problem everybody faces sooner or later—getting parts. As we all know, finding the exact part needed to complete a project is often harder than building the project in the first place.

How hard it is to get parts depends on what you're building. If you've designed from the ground up, you have a good understanding of the circuit parameters; so being forced to substitute one part for another isn't too much of a problem. If you're putting together a circuit from a magazine, part-substitution can be a gigantic headache. Subtle differences in part ratings or characteristics can make even the most well thought-out circuit do nothing more exciting than drain the battery.

There are no hard and fast rules to follow when you're forced to substitute parts, other than trying to avoid doing it in the first place. But since we all have to do it sooner or later, there are a few things to keep in mind to make the substitution successful.

1. Know what the component does and know why it's there.
2. Understand the parameters in that part of the circuit.
3. Breadboard the circuit first.
4. Identify suitable circuit test points.
5. Power the circuit with a variable supply.
6. Substitute with worst-case conditions in mind.
7. Keep all your data books handy.

Even if you have a lot of experience in electronics, your chances of making a successful component substitution will drop if you don't keep those things in mind. Before we look at

individual components, let's go through those general points one at a time.

Know What the Component Does and Know Why It's There

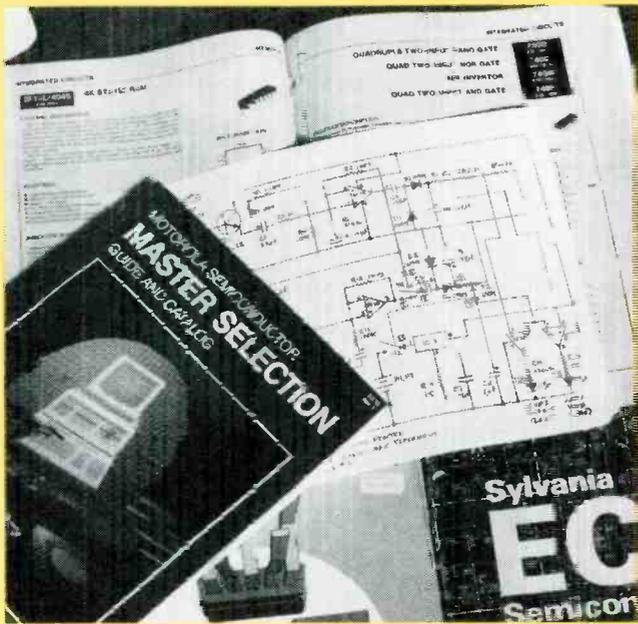
Before you can even think about substituting one component for another, you have to understand why it's there and what job it's doing. Keep in mind that just because two components have the same rating is no guarantee that they'll behave the same way in a given circuit. What the part is made of, how it's constructed, and even how it's packaged will give it certain characteristics that aren't immediately obvious from knowing its value. Thermal stability, linearity, and charge retention are only a few of the factors that are affected by how a part is constructed. The bottom line here is that *all* the device characteristics have to be considered whenever you're faced with the necessity of part replacement.

Understand the Parameters in that Part of the Circuit

How well one component can do the work of another depends on what you're asking the component to do. In electronics terms, that means that you have to know what's going on in that part of the circuit. And remember that there's more to that than an examination of the static DC parameters. Take a good look at the circuit and see whether the component you want to replace is subject to unusual AC transients, a lot of heat buildup, physical stress, and so on. Basing your choice of replacement on static-circuit measurements is a very good way to increase the probability of ultimate circuit failure. The circuit may be fine under test but the part you've substituted may degrade quickly when it's faced with real-world conditions.

Breadboard the Circuit First

Sticking a substitute part in the final version of the circuit is



just asking for trouble. PC-board copper traces are fragile things and you can bet that repeated soldering and desoldering will lift them from the board and destroy them no matter how careful you are. And there is no better way to bugger a screw head than to open a case time and time again. Just as with a lot of other things in life, if you mess with something long enough, you'll break it—guaranteed. If it's not practical to breadboard the circuit, breadboard the relevant part of it. Most circuits can be broken down into individual parts; and as long as you know what that part of the circuit is supposed to do, you can duplicate it on the breadboard and experiment with substitutions there. The extra time it takes to set up the circuit will be a lot less than the time used soldering and unsoldering one substitution after another.

Identify Suitable Circuit Test Points

A replacement component may seem like the perfect candidate for a substitute. All the values may be right and every other factor can be well within circuit specifications, but the end product may still be a circuit that sits there and refuses to work. As someone once said, "No part is an island unto itself." In electronic terms, that means that each component in a circuit has an effect on the whole circuit. One key element in substituting parts is to know where to look to measure the effect of the substitution. And knowing where to look means that you need a good understanding of how the circuit works. Go through the schematic and see what other components are affected by the one you want to replace. Track down clock circuits, trace the ins and outs of amplifiers, find the best places to take your voltage and current measurements. Once you've found those, label them on the schematic and, if possible, write down the calculated values. Make yourself a checklist. Knowing whether a circuit works means knowing where to look.

Particularly with integrated circuits, make certain a substitute is a pin-for-pin replacement, because you can't deform the terminals to fit a mismatched socket. Also, be sure the replacement works with the other parts.

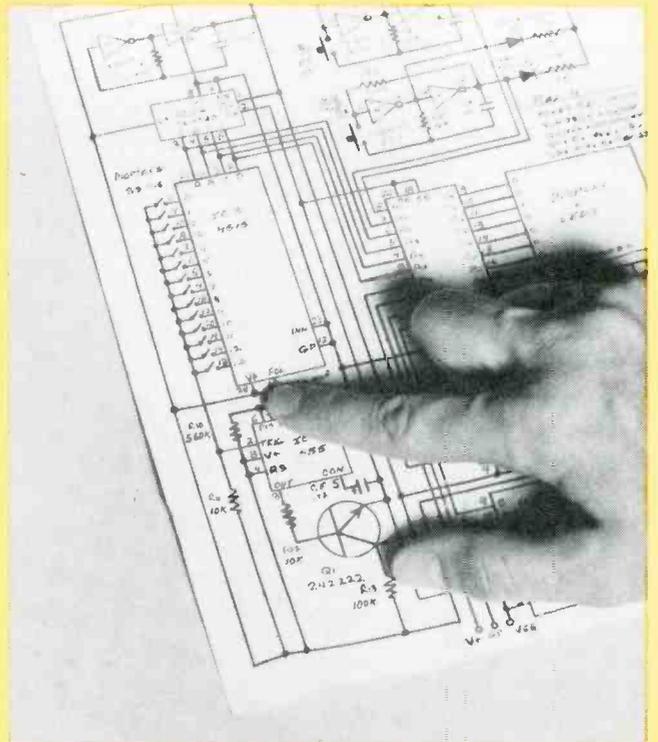
General replacements are available for most commonly-used solid-state devices. If you can't get an exact substitute, make certain the device will work in the intended circuit.

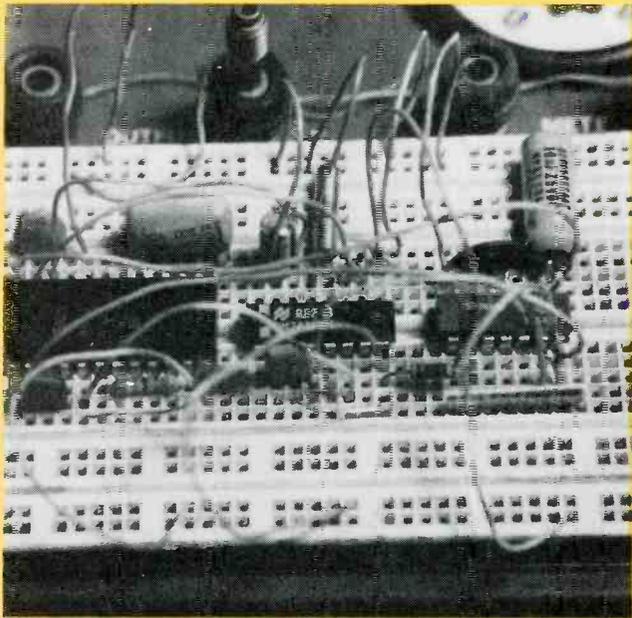
Power the Circuit With a Variable Supply.

Although it's more than likely that the circuit was designed to be powered with a fixed voltage, it's always a good idea to use a variable supply when you're trying substitute parts. A project that is supposed to be battery-powered has to take into account the drop in supply voltage as the battery ages. That means that you should test your replacement component across the complete range of voltages that you can expect from the battery. Components that work well at 9 volts may be unreliable at less than 7 volts. And if you're powering your circuit with a 9-volt transistor-radio battery that could cause you a lot of problems later on. The opposite is also true. A variable supply can test a circuit under overvoltage conditions. A fast turn of the dial can approximate power-supply spikes and transients. In the last analysis, a variable supply is as much a test instrument as a multimeter or an oscilloscope and the possible problems it can let you identify just can't be spotted with anything else.

Substitute with Worst-case Conditions in Mind

It's always better to be safe than sorry. When you're trying to substitute parts, keep the superlatives in mind. The most suitable replacements are going to be those with higher voltage ratings, more power-handling ability, and greater current capacities. Even exact replacements have differences so you should understand what all the outside values are for circuit parameters. The substitutes you pick should be able to survive under worst-case conditions. Check the results of various circuit catastrophes—thermal runaway, short circuits, voltage-regulation failure, and so on—on the components you're replacing. If it was a well-designed circuit to start





with, those are the kinds of considerations that went through the mind of the person who originally designed it. Since substitution of parts is basically a redesign of part of the circuit, you should keep the same thoughts in mind.

Keep Your Data Books Handy

There's absolutely no way that you can safely substitute one part for another without knowing all there is to know about the original part, and the replacement that you're considering. And the only way to have that data at your fingertips is to have specification sheets and data books. You can bet your new pair of white tennis shoes that the original design was done with a data book, and you're kidding yourself if you think that redesign is possible without one. A careful thumbing of a data book can help you identify unmarked or house-numbered parts. Once you know the parameters of the circuit, paperwork can provide you with a starting list of possible replacements. Doing circuit work without a good library at hand is like navigating without a map. You might finally end up where you want to be, but you'll probably make a lot of expensive mistakes before you get there.

Now that we know the things you should keep in mind when you're trying to do part substitution, (or original design), we can look at the differences in the various types of components. Not all diodes, resistors, capacitors, and so on, behave the same. Each family of components is made up of members with a different set of operating characteristics. As a result, although two components may have the same value, a particular circuit might work perfectly with one and grind to a halt with the other.

Capacitors

With the exception of semiconductors, no family of components has more members than capacitors. That variety can be a bit bewildering but in actual fact, unless you're talking about circuits performing critical timing, filtering, or those

There is a multitude of capacitor types and styles, but unless you're talking about critical timing, filtering or high frequency circuits, one capacitor is pretty much the same as any other.

If you have any doubts about a component, in the long run it's easier to breadboard the circuit to test the questionable parts than it is to debug a circuit that's been wire-wrapped or soldered.

designed to handle very high frequencies, one capacitor is pretty much the same as another. And you can be just as tolerant about capacitance as well. The common disc capacitor usually has a tolerance of +100% to -30% of the value printed on it, so you can be fairly cavalier choosing the replacement part in most applications.

In general, the best rule to follow is to make your substitution the same type as the original. Capacitors can be combined in series or parallel if you can't find one with the right value. You can get the relevant formulas from just about any book on electronics. The only restriction to watch in combining capacitors is to be sure that there's enough room on the board to replace one capacitor with two or more.

If you're looking for a replacement with a value of more than one microfarad, your choices are pretty much limited to two—aluminum electrolytics or tantalums. The same guidelines mentioned above are applicable here as well. Tantalums are better capacitors and that is reflected in their price—they're usually more expensive than electrolytics. The characteristics that make them better however, such as lower leakage and tighter tolerances, are only important in a few applications.

If it's absolutely impossible to find a replacement part with the needed rating, use a capacitor with a higher value. In 99% of all circuit applications you can safely use a replacement that's as much as 20% higher than the original part without any difficulty at all. Tolerances however, are another story. If the original design calls for a 10% part, you're best off using a substitute with a tolerance of at least 10%. If you can't find one, try for 5%.

The last consideration for capacitors is their voltage rating. A replacement should have a rating at least as great as the original part—preferably much greater. If no voltage is specified in the original circuit, use twice the power-supply voltage as a starting point. If you're using a bipolar supply, make it twice the maximum voltage—±15 volts would mean a replacement capacitor that has a voltage rating of at least 60



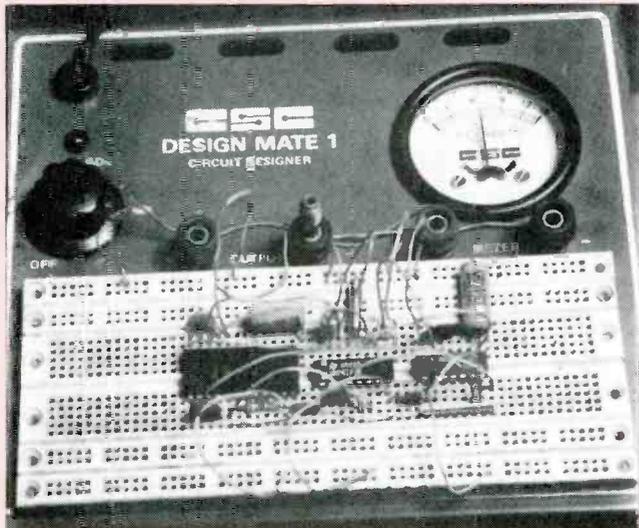
volts. It may be overkill, but you'll at least be sure it won't blow up.

If you're replacing capacitors in timing, RF, or tuning circuits, you should get a part that's as close as possible to the original. And check the operation of the circuit after the substitution to be sure that the parameters, like frequency or bandwidth, are still within specification.

Resistors

Resistors are the easiest parts to substitute. Although there are several kinds, the only important difference is between carbon types and wirewound. If you observe power ratings, you can usually put a carbon resistor in place of a wirewound one, but not the other way around. Wirewound resistors, as their name implies, are lengths of special wire wound around a core, so they also have a certain amount of inductance. If they're used in a circuit that does any critical timing or RF operations they can change the characteristics of the circuit. Just as we saw with capacitors, the best rule is simply to make your replacement the same type as the original.

Besides the resistance value, you also have to pay attention to the power rating and tolerance. The former should be at least as large as the original and the latter should be at least as



If you're substituting parts, make certain they aren't working in a very narrow voltage range. For battery-powered circuits, use a variable supply to test the complete range of voltages expected as the battery ages.

small. A few circuits will use precision metal film resistors with tolerances of 1% or less and you should use the same type as a replacement. Of course, you can put two or more resistors in series or parallel to get the value you need. The best all-around choice for replacement parts is a carbon resistor with a 5% tolerance. That type will be suitable for the majority of circuits and they're easy to find.

Diodes

Finding replacements for diodes is generally simple. There are two kinds—rectifier and small signal type. The two parameters to watch out for here are the maximum current and PIV (Peak Inverse Voltage) ratings. Make sure that the replacement part you choose has ratings equal to or greater than those of the original part. If you're replacing a small signal germanium diode, (the glass ones), it's often just about impossible to read the number off the original part. In that case,

a good general replacement is the 1N4148.

Transistors

The number of transistors available on the market is absolutely staggering and trying to find an exact replacement for some of the more exotic ones usually involves more luck than hard work. If the truth be known however, the differences between the majority of them exists nowhere but in the minds of the manufacturers. Once you have the relevant parameters, you'll find that there are lots of easily available parts with specifications that are close enough to the original for them to be perfectly suitable replacements. A good data book will tell you everything you want to know about the original part. Once you've nailed down the number of the substitute, check to see if you can find it at a place like Radio Shack. Blister packed parts are a lot cheaper than buying mail order.

If you look through a transistor data book, you'll see that there are a whole slew of specifications for each part. When you're looking for a replacement, there are really only a few that are important.

1. Collector Current
2. Reverse Breakdown Voltage
3. Power Rating
4. Frequency (F_T)
5. Gain (Beta or H_{FE})

All of those figures should be at least as great as those listed for the original part. Of course, you have to match type as well. A PNP replacement must be a PNP and an NPN can only be used in place of an NPN. If your original transistor is unmarked, the first thing to do is determine whether it's an NPN or PNP type—you can't even think about finding a replacement until you know the original type. And the case style can be important as well. Some styles, such as a TO-92+ or a TO-220, have tabs on them to help dissipate heat and your replacement should be the same. If you can't find a replacement with a tab, try to find one in a metal can or, failing that, put a heatsink on the replacement.

Integrated Circuits

There's not much room to move around in when you're trying to find a replacement for an IC. If a circuit calls for a particular part, it's a pretty safe bet that you have to use that part. TTL stuff can stand a little bit of substitution, but you have to know what you're doing. A 7400, 74S00, and 74LS00 are functional pin-for-pin equivalents, but each of them have their own unique operating characteristics in terms of fanout, speed, current requirements, and so on. You can try substituting one TTL family for another, but your chances of success are directly proportional to how well you really understand the way that the circuit operates.

Inductors

The two parameters to be concerned about when you're replacing an inductor are the inductance and the current rating. The inductance of the replacement should be within 20% of the original part and the current rating should be as great or greater than the original. Pay attention to the size and shape of the replacement. Inductors come in a wide variety of packages and even an exact replacement won't do you much good if you can't fit it on the board.

Transformers

The guidelines for replacing transformers are much the



same as for inductors. Power-handling capability and physical size are two of the specifications you have to watch, but there are a few added things you have to keep in mind as well—gain and rated duty cycle. If your substitute has slightly different voltage ratings for the primary and secondary (the gain), you can add some circuitry to cut the voltages down to match those of the original transformer. That can be anything from a simple series resistor to a more complex voltage-divider circuit. Make sure that there's room on the board to add those additional parts before you sit down and design the extra circuit.

It's generally best to try to match the power-handling capacity of the original transformer. The replacement's specifications should be at least as large as the original part. The only time that you can use a replacement with less capacity is when the original part was rated for intermittent duty and the substitute is rated for continuous duty. If that is true, then you can use a substitute rated as much as 20% less than the original.

Miscellaneous

The guidelines for substituting switches, sockets, LED's, jacks, and other hardware have more to do with physical considerations than electronic ones. They have to be the right size, the correct power rating, and have an adequate number of pins, poles, or positions to get the job done. If you're replacing a rotary switch, find out if the original is a "make before break" or "break before make" type and make sure that your replacement is the same.

Getting Parts

Once upon a time, just about every city had a few stores that sold electronics parts, but it seems that those days are gone. Even Radio Shack has been reducing the number of components that they carry and concentrating more on consumer-electronic products. The best way to buy parts is mail order, and the hassles of minimum orders are more than offset by the large variety of available parts being sold by huge numbers of suppliers. Buying mail order, however, is a bit different than walking into a store. There are a few things you can do to make the process easier.

1. Get the catalog. Most mail-order houses carry a much larger inventory than they show in their advertisements.
2. Find out what the minimum order is and what the charges are for shipping and handling.

Although the number of transistor types is staggering, many can be replaced by a handful of substitutes. Often, the worst of the problem is to match the heat dissipation rating, or the particular lead arrangement.

Resistors are the easiest parts to substitute. Except for certain precision types, as a general rule the only major difference is between carbon and wirewound types. Often, you can substitute carbon types for wirewounds.

3. Be sure you know how they want to be paid. Some companies will take personal checks, but they'll delay shipment until your check has cleared their bank. The most common method of payment is by credit card or money order.

4. Some companies are willing to ship COD, but find out whether there's an extra charge for that service.

5. See if you can specify the way that the company will ship. Most companies use UPS, but will do overnight service for an extra charge.

6. Check into the return policy. Although nobody plans on it, some parts reach your front door DOA.

7. When you place your order, there's much less of a chance of confusion if you use the company part number rather than the actual generic part number.

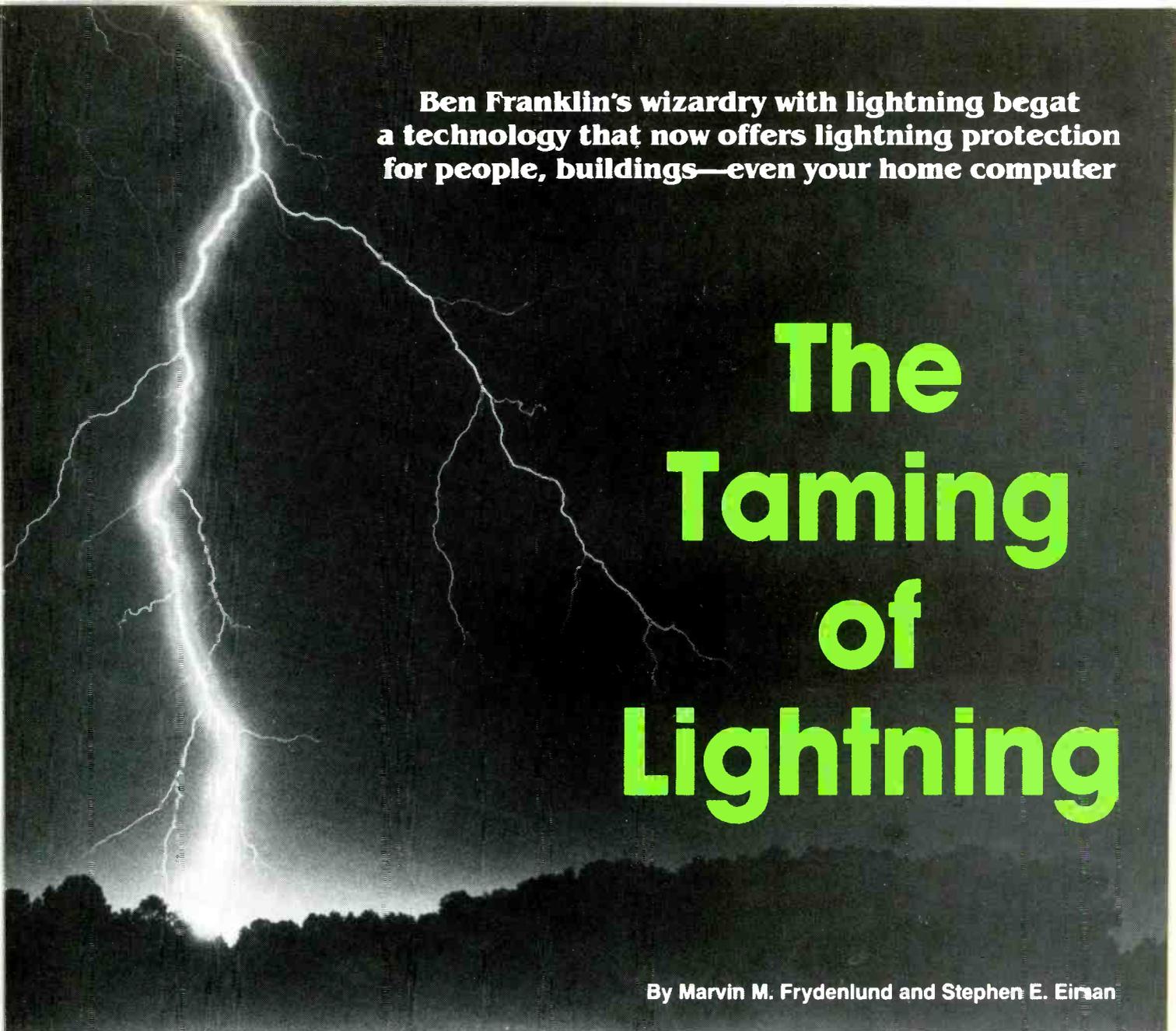
8. Make sure to find out what policy the company has for dealing with orders for parts that are out of stock. Some suppliers will bill you and put the part on backorder, while others will just drop the part from your order.

All those points, and others as well, can be answered by reading the ordering information in the company catalog. You should write or call the mail-order houses and get them to send you their catalogs well before you plan on ordering.

It's just not possible to have a parts supply of your own that's extensive enough to cover everything, but it's a good idea to keep your bench stocked with a good variety of common parts. Those would include resistors, capacitors, a bunch of standard transistors, and a few of the most common logic and analog IC's. Since those parts are generally inexpensive, you can include some of them when you're ordering from a mail-order house. Most companies offer packages of resistors, etc. in a variety of values, packs of general-purpose transistors, etc. If all you need is one TTL IC, you can pad the order with those other things to meet their minimum. And it's a very good idea to get in the habit of keeping your junkbox filled with prime parts rather than junk.

Most of the mail-order houses are run by people who really want to fill your order with maximum speed and minimum annoyances. If you get in the habit of dealing with one supplier, you'll be able to build up a relationship that will make ordering almost as convenient as dealing with a local store.

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Ben Franklin's wizardry with lightning begat a technology that now offers lightning protection for people, buildings—even your home computer

The Taming of Lightning

By Marvin M. Frydenlund and Stephen E. Eiman

IT ALL BEGAN IN PHILADELPHIA WHEN BEN FRANKLIN introduced the concept of lightning-rod protection in the 1753 edition of his *Poor Richard's Almanack*. In that edition, Ben described three basic lightning-protection components:

1. "A small iron rod, but of such length that one end being three or four feet in the moist ground, the other may be six or eight feet above the highest part of the building," and

2. "To the upper end of the rod fasten about a foot of brass wire, the size of a common knitting needle, sharpened to a fine point."

3. "If the house or barn be long, there may be a rod or point at each end, and a middling wire along the ridge from one to the other."

For scores of years such primitive *Franklin rods* protected houses and barns, churches, schools, stores, statehouses, and other structures as well. During that early time, a single rod could constitute the entire lightning-protection scheme. But as buildings came to be built longer, taller, wider, and more complex, the lone rod (or two rods and middle wire) gave way to an expanded system of lightning rods, conductors, and ground rods. Later, the advent of wiring and electrical

appliances, telephones, and radios added a need for devices to protect against high peaks of static-generated current induced over electric power lines and telephone wires. Even the mighty computer bows to the whims of Thor.

Computers, microprocessors, robotics, and other electronic equipment have created a new need—to protect such equipment against tiny transient voltages from distant lightning flashes, as well as induced charges from direct or nearby strikes.

Today, lightning rods are more often called *air terminals*, and they constitute only the roof-mounted portion of a total system made up of five sub-systems that (1) intercept any lightning current; (2) conduct the current to ground; (3) prevent sideflashes to nearby grounded objects; (4) provide a dissipation area for the current; and (5) shield electrical and electronic equipment from the harmful effects of conducted or induced currents.

To appreciate total lightning protection and the need for it, it is necessary first to consider what lightning is and does.

The Lightning Flash

A typical destructive lightning flash contains three elec-

Metropolitan areas receive more than their share of lightning strikes, because buildings serve as man's tallest air terminals. In this instance, the strike caused little damage, due to the internal steel frame of the building. Some mortar was damaged.

trical pulses. Each pulse consists of a *downward negative* and *upward positive stroke*. Typically, a stroke occurs in about *four-tenths of a second*. Peak current flow during a typical stroke is *25,000 amperes* at *30 million volts* of potential (Fig. 1).

The range of electrical magnitude varies from a few hundred to hundreds of thousands of amperes, and voltages vary from a few million to 100 million volts. A *cold bolt* is a faint zap, containing only strokes whose current flows endure for microseconds. A *hot bolt* is one that includes at least one stroke of low-amperage current of long duration (up to a full second or more). Those facts are presented so that the reader will realize that lightning bolts may appear to be alike, but in actuality they are as different as bugs on a June day.

Destructive Effects

Lightning's destructive effects take many forms. They are:

Thermal—Fire may result from heat up to 50,000 degrees generated in the ionized lightning channel. Or, lightning's heat may convert moisture in building materials to high-pressure steam, spalling or cracking concrete or mortar, and splintering lumber or fiberglass. It is also heat that vaporizes, melts, or welds electrical or electronics components. Even transient currents from distant strikes can break down insulation protecting circuit components—especially integrated circuits and other semiconductors.

Electrical—Lightning sideflashes are electrical sparks between conductors and nearby unconnected, grounded conductive bodies such as soil or vent stacks. Sideflash current



can cause the same kinds of damage as the main current stream.

Mechanical Effect—Lightning's current flow attempts to straighten a conductor in the same way that high-pressure water straightens a fireman's hose. And the large pressure wave (created as current that superheats non-conductive air around the ionized channel) can cause severe structural damage.

Structural Design Factors

Lightning-protection design factors include a building's height, configuration, and construction materials.

The tallest building in the immediate area of a lightning strike is the likeliest target. Conversely, comparative height determines the degree of shielding a protected roof provides to a lower roof or an adjacent lower structure.

The protected zone of a building up to 25-ft. high is

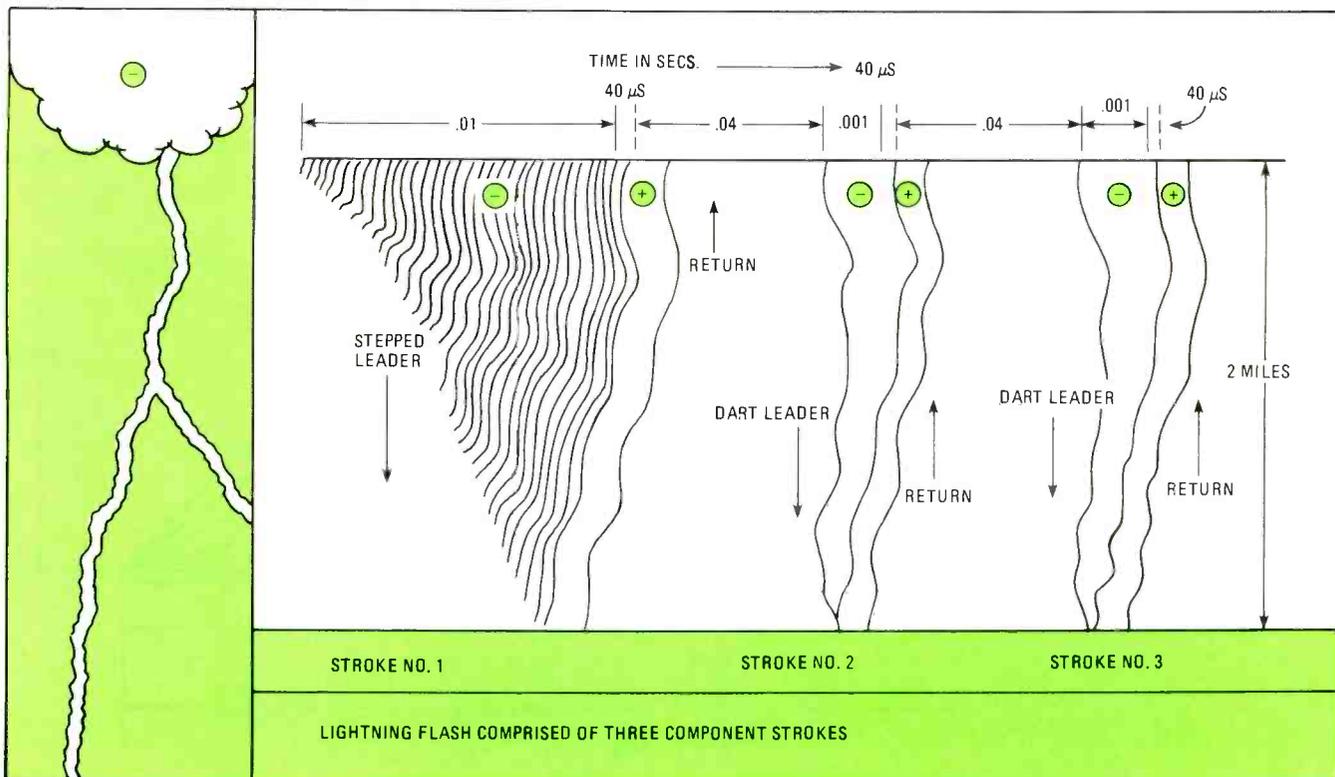


Fig. 1—Although a lightning strike appears to be a single flash, in actual fact it consists of three individual strokes, each having a *leader*—a downward negative stroke—and a *return*—a positive upward stroke.



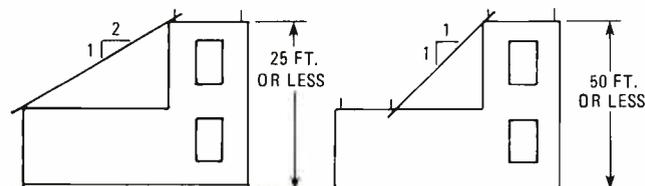
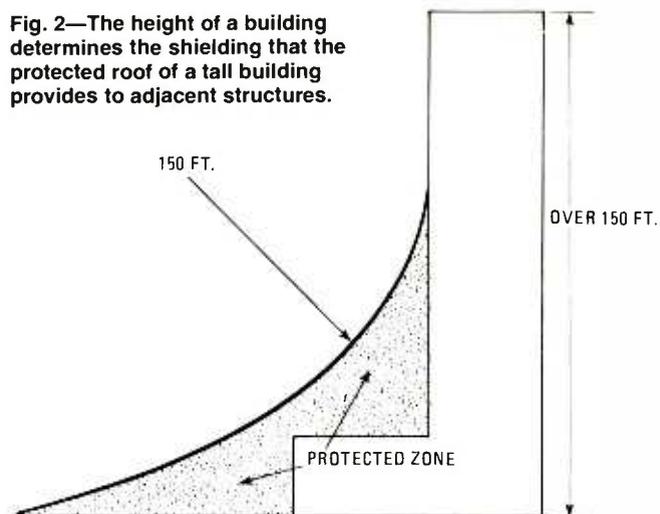
It was a good thing that lightning toppled this tree at night. It was situated in a popular spot in South City Park in Brookfield, MO. The force of the lightning's impact split the tree and stripped bark from the trunk.

contained within a line struck at a 1 to 2 angle. A building 25-ft. to 50-ft. high offers a 1 to 1 protected zone. Buildings taller than 50-ft. provide protection to ordinary structures within an arc of 150-ft. radius. Fig. 2 provides a good visual explanation. Those rules are design parameters assigned after many years of recorded experience and accident reports in lightning incidents.

A gable roof with a span of less than 40-ft. and rise of 1/8th or more only needs air terminals atop the ridge. So does a gable roof with a span of more than 40-ft. and rise of 1/4th or more. However, buildings with flat roofs or low-slope roofs that do not meet the rise/span ratios cited require air terminals along their edges, at all corners and at 50-ft. grid spacings in mid-roof areas (Fig. 3).

Framing and cladding materials affect lightning-protection design. For example: Copper components cannot be installed

Fig. 2—The height of a building determines the shielding that the protected roof of a tall building provides to adjacent structures.



on aluminum-clad structures because of harmful electrolytic action between dissimilar metals that will occur. Electrically continuous steel columns may be substituted for lightning-protection system downconductors. A bimetal connector must be used when an aluminum conductive body is bonded to a copper conductor system, or vice versa (Fig. 4).

Occupancy and Contents

In the "Occupancy and Contents" risk-index table of the

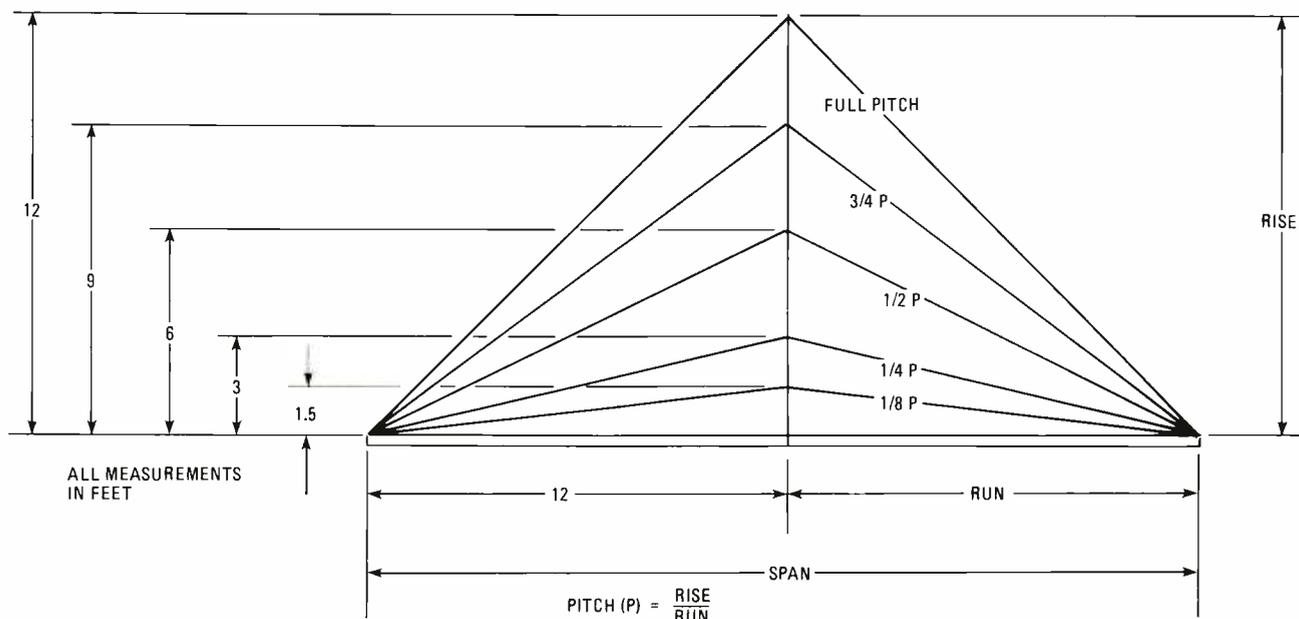


Fig. 3—The span of a roof and its rise determines the location and number of air terminals needed. Flat roofs require air terminals along the edges, and at the corners.

Lightning Protection Code, NFPA 78, it is stated that the index (risk) value rises from "4" for an assembly of less than 50 people to "6" for an assembly of more than 50 and to "5" for combustible materials, then jumps to "10" for explosives and explosive ingredients.

As you can surmise, a building housing explosive materials has a much higher index value, for the risk zooms to multi-digits. Buildings housing explosives are usually protected with grounded overhead cable systems that shield the structures from sideflash current and from any contact with the main stream of lightning current (Fig. 5).

System Design and Inspection

The best time to design a lightning-protection system is when the building is on the drawing boards. There are two options at that stage. They are: (1) adopt a standard specification, leaving system layout to the successful installation bidder; (2) can contact one of a growing number of professionals, particularly electrical engineers, who are adding lightning-protection system design and inspection to their portfolios. Study programs and testing for LPI certification of "Professional Designer/Inspectors" are available. System-design assistance is available from manufacturers of lightning-protection components.

To better understand the design of an excellent lightning-protection system for a building, we'll present some of the details here. Refer to Fig. 6 throughout this discussion.

Let's begin at the top with the roof system. Air terminals (Fig. 6-1) that extend at least 10-in. above protected objects are located at a maximum spacing of 20-ft. (or 25-ft., if rods exceed 24-in. in height) on high points of the roof, along flat roof edges, within 2-ft. of corners, gable ends and other sharp building features and at 50-ft. grid spacings in mid-roof area. Braided copper or aluminum conductors are laid out to interconnect all air terminals and form a closed loop on flat roofs. On large roofs, cross-run cables are located at 150-ft. intervals to provide shortened paths to ground.

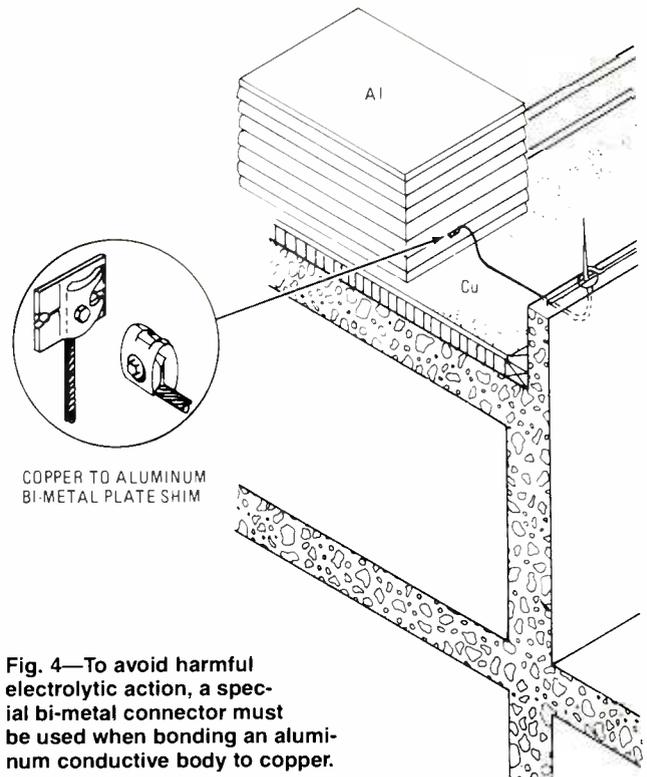


Fig. 4—To avoid harmful electrolytic action, a special bi-metal connector must be used when bonding an aluminum conductive body to copper.

Conductors (Fig. 6-2) are sized by weight, according to height of the structure to be protected. For structures 75-ft. high or less (Class I), copper conductors must weigh at least 187.5 lbs. per 1,000-ft. and aluminum conductors 90 lbs. per 1,000 ft. For structures over 75-ft. high (Class II), conductors must weigh at least 375 lbs. per 1,000-ft. for copper and 190 lbs. per 1,000-ft. for aluminum. Most homes fall into the Class-I category.

Two downconductors at diagonally opposite corners are required on any building with a perimeter up to 250-ft. An

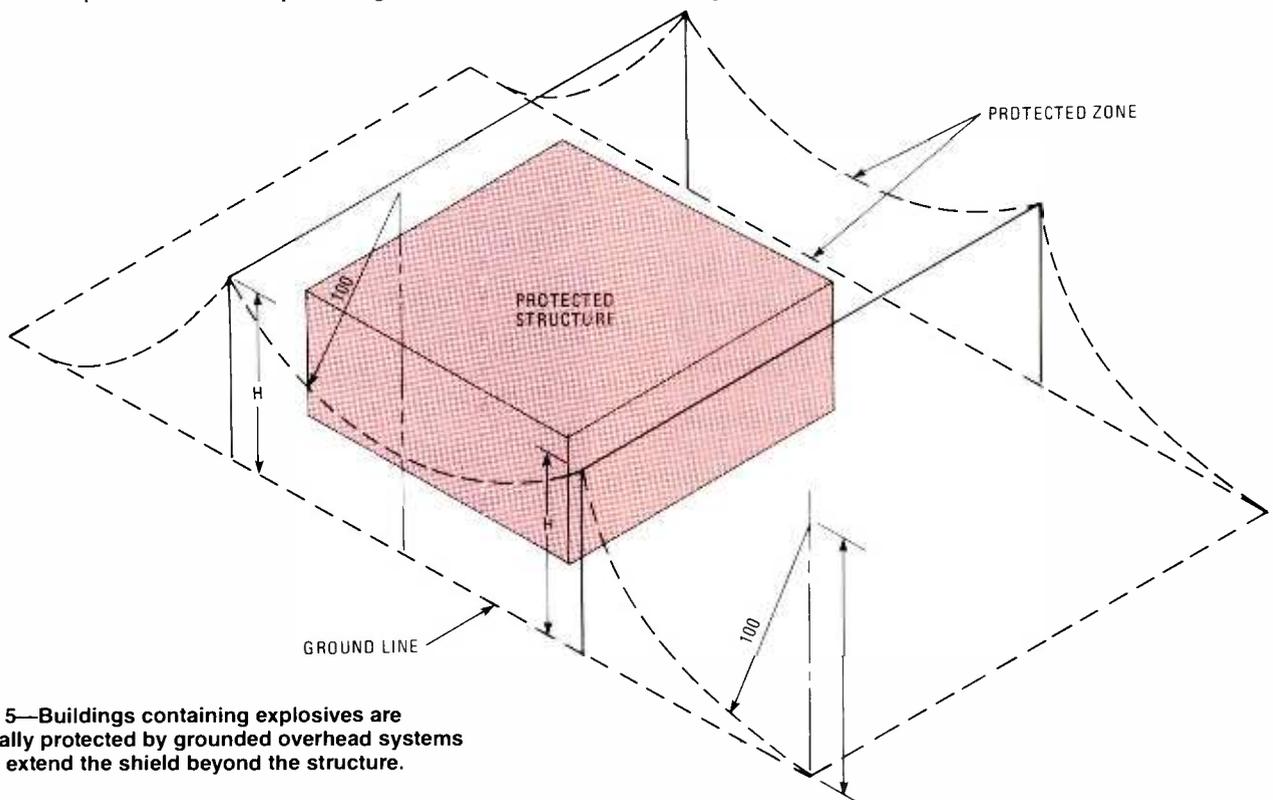


Fig. 5—Buildings containing explosives are usually protected by grounded overhead systems that extend the shield beyond the structure.

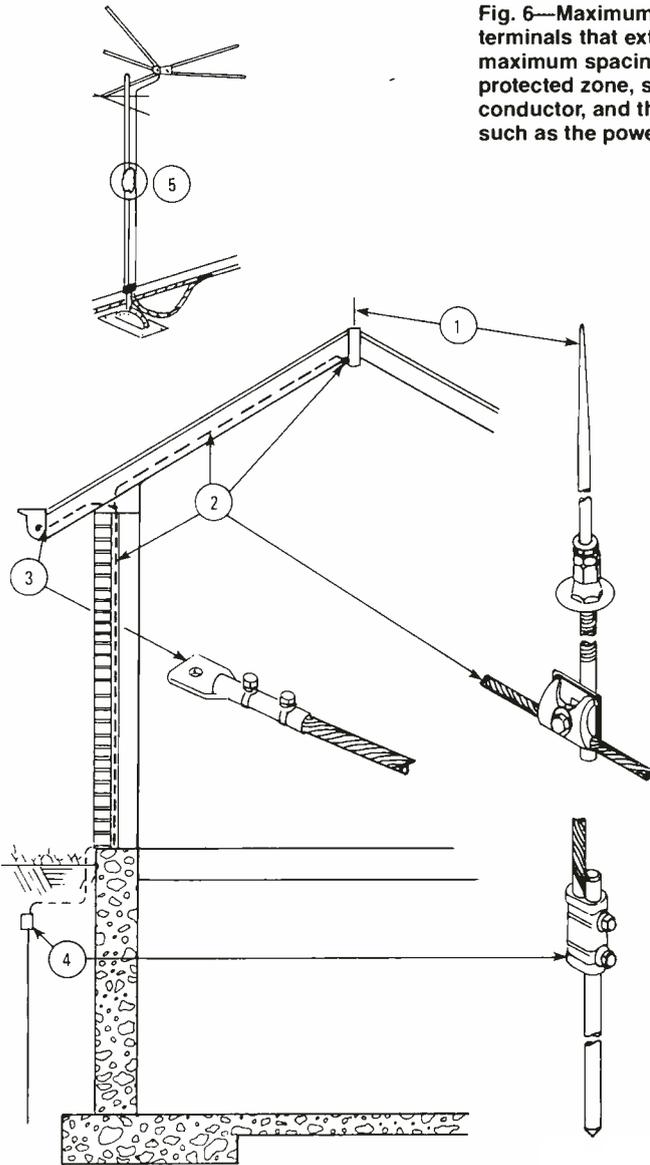


Fig. 6—Maximum lightning protection involves: 1) Spacing of the air terminals: air terminals that extend at least 10-in. above the protected object are located at a maximum spacing of 20-ft. 2) Conductor size; 3) Bonding of metal bodies not within the protected zone, such as rain gutters; 4) A grounding system connection at each downconductor, and the interconnection with utility grounds; 5) Protected external wiring, such as the powerline, TV antenna cable, and telephone and data wires.

may be ignited. Therefore, air terminals must be mounted on thin metal-clad buildings. Backyard sheet-metal sheds, considered to be fireproof, often have their contents go up in flames after a strike.

A grounding-system connection (Fig. 6-4) is located at each downconductor, and the system is interconnected with utility grounds. The type and configuration of a grounding system depends on the electrical resistivity, moisture content, and penetrability of the soil.

Extremely low ground resistance may be needed for a structure housing volatile substances or fragile electronic equipment (your home-computer system). In moist, highly conductive soil like gumbo, clay, or loam, 8-ft. or 9-ft. copper, copper-clad or stainless steel ground rods driven to at least 10-ft. depths (tops are below the surface) are acceptable. Class I buildings require 1/2-in. diameter rods, Class II structures, 5/8-in. diameter rods.

Sandy or gravelly soil require additional ground rods driven to 10-ft. minimum spacings in-line or triangularly.

Where bedrock near the surface prohibits driven rods, copper conductors should be laid in 12-ft. long 1-ft. minimum depth trenches extending out from the wall in clay soil and in 24-ft. long trenches in sandy or gravelly soil. Amateur radio operators and shortwave listeners can take advantage of that counterpoise when considering their antenna installation.

In shallow soil, a copper Class I or larger counterpoise cable should be laid in trenches, rock crevices, or directly on the bedrock to encircle the building. Extra copper or stainless-steel ground plates or a reservoir filled with a moisture retaining material may be used to enhance grounding.

additional downconductor is required for each additional 100-ft. of perimeter. The average home has a perimeter of under 150 feet. Preferred downconductor locations are at roof corners, which are most often struck by lightning.

Rooftop vents and stacks, and below-roof air-handling units are examples respectively of primary and secondary metal bodies which contribute to lightning hazards, because they are grounded or assist in providing a path to ground for lightning currents.

Primary metal bodies (Fig. 6-3), which are objects located at or above roof level and not within the protective zone of an air terminal, may be struck directly and must therefore be bonded with a main-size conductor. Vent fans and air ducts fall into that group. If such an object has a metal skin less than 3/16-in. thick, a hole can be melted by a long-duration stroke's tremendous heat, and flammable material beneath

Woodframe homes are not spared by the damage of lightning even though many people believe that wood structures are insulated against nature's rampages. Boyd Dilworth of Goldmine Community in Hart County stands in front of his home, which was damaged when lightning struck a nearby power line.





Interior damage can be severe even though almost no trace of a lightning strike can be found on the outside of a structure. This home in Concord, NC was spared destruction by flames, but interior repair costs were considerable and costly.

A properly installed lightning protection system for a structure confines direct current flows to the system's conductors and any grounded metal objects, such as plumbing stacks and water lines, that are bonded to the protection system. In addition to preventing fire, structural and contents damage and injury, such a system reduces the strength of the electric field induced inside the building during a lightning strike. But some induction, enough to harm fragile electronic equipment, may be inevitable.

Lightning surges also often find their way into a structure's interior via power lines, telephone lines, data-transmission lines, or television cables (Fig. 6-5). Moreover, airborne transient currents from distant lightning flashes may cause damage to highly sensitive microprocessors and other electronic equipment.

A lightning surge is a higher than tolerable wave of current flowing along a conductor or through the air. Its destructive effect depends on the voltage involved and the varying tolerances of the electrical or electronic equipment affected. Because surges can originate from so many sources, and because modern buildings house more and more fragile electrical and electronic equipment, a total lightning-protection system should include surge suppression equipment. Computer stores offer several types of multiple-outlet, surge-

protected line cords, some of which have power-switching capabilities for turning on all or part of the system. They are inexpensive and usually cost less than one repair bill for damage caused by lightning.

Residential Surge Suppression

In a typical residential installation, a lightning-protection contractor will install a surge suppresser on the power entrance side of the circuit breaker or fuse/breaker box. Such a device may *clamp* at 600 volts for example; that is, it will create a temporary path to ground, shunting the surge current into the lightning-protection grounding system.

Telephone equipment is commonly equipped with a modular plug-type arrester installed between the phone and its wall outlet and grounded to the nearest electrical outlet.

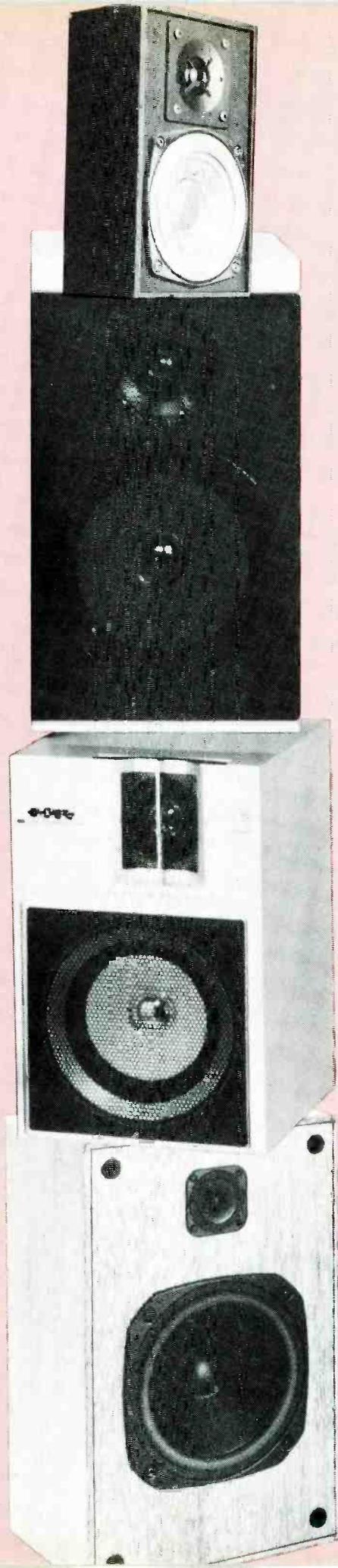
A burglar-alarm system may require a fast clamping, low-voltage suppresser, as will any other sensitive electronic device. Such units are grounded to the electrical outlet used to power the equipment.

You have just had a rundown on basic lightning technology and the protection steps necessary to limit the possible harm that can damage your home. You have just the basics here. If you want to learn more about about lightning protection, send \$1.00 and a stamped, self-addressed #10-sized envelope to

LPI Booklets, P.O. Box 458, Harvard, IL 60033. Lightning protection is the umbrella your home needs *before* lightning strikes. ■



Firemen could do little to save this industrial building in Morristown, TN. Thunderstorms passed overhead in the night and early morning hours when the building was unattended.



How to Prevent and Repair Speaker Damage

Sometimes, loudspeaker repairs are easy

By Homer L. Davidson

THE SPEAKERS ARE THE MOST IMPORTANT COMPONENT IN music reproduction, because the reproduction of sound from even the most expensive amplifier can be no better than that of the speaker system. Yet, no two persons can agree on what is the best speaker design—or even what is the best design for the enclosure—and so, speakers come in many different sizes and shapes. For example, the speakers in your own hi-fi system might use acoustic-suspension, or bass-reflex, or passive-radiator enclosures.

An expensive speaker system might contain from two to four different speakers, while a low-cost system might have only one or two speakers. For example, an acoustic-suspension speaker might have a 1-inch dome or cone tweeter, a 4-inch to 5-inch cone midrange, and a 6-inch to 10-inch woofer. A 3-way linear-phase or bass-reflex speaker may have a cone or dome-type tweeter, a cone-type midrange, and a 15-inch woofer with sealed-tuned or multiple-tuned ports. A passive-radiator cabinet might have two woofer-type speakers, one connected to the speaker system and the other functioning as a *drone*—with no signal passing through it.

Speaker Damage

Regardless of the individual design concept, most speakers are damaged when too much power is applied to them, because excessive volume can damage the speaker's voice coil. (Unfortunately, today, music is generally played loud or not at all.) Then there are times when low-wattage speakers are found damaged, because a person has upgraded to a high-

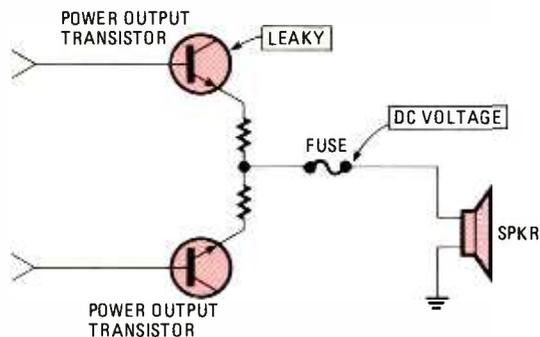


Fig. 1—The speaker's voice coil can be damaged by a leaky power-output transistor (or integrated circuit) if the speaker isn't properly fused. Keep in mind that replacing the speaker fuse with another unit having a larger ampere rating might offer no protection to the speaker at all.

powered amplifier or receiver. Exactly what causes the damage? The usual cause is in overheating the voice coil so that it either "opens," causing the speaker to be "dead;" or the excessive heat warps the voice-coil so that it rubs against the metal pole-piece (magnet) and the listening pleasure of the audiophile.

The total output-power of a stereo amplifier should never exceed the total power-rating of the stereo speakers. Likewise, the amplifier's maximum output power should never be less than the minimum power recommended for the speakers, because excessive distortion may result when the output-power rating of either the amplifier(s) or the speaker(s) is outside the equipment's recommended operating limits.

Physical damage to the speaker can occur if a DC voltage is somehow applied directly to a speaker's voice coil, because of a leaky output transistor (or an integrated circuit) that is directly-coupled to a speaker. As shown in Fig. 1, in some amplifiers the output signal to the speaker directly from the output circuit originates at a point of zero DC voltage. But if one of the power-output transistors (or an integrated circuit) becomes leaky, a high DC voltage might be applied to the speaker's voice coil, and the speaker may be damaged if not properly fused (as shown in Fig. 1).

When one channel of a stereo amplifier is dead, suspect a blown speaker fuse. Often, the top or back cover must be removed from the amplifier to get at the fuse(s). Always replace the fuse with its exact rating. Don't substitute a larger fuse, and don't place tin-foil around the fuse—or wire across it—as a temporary repair.

As shown in Fig. 2, in some low-powered amplifiers a large electrolytic coupling-capacitor may be found between the output semiconductor(s) and the speaker. Here, the speaker is protected from a DC voltage, but not from excessive power

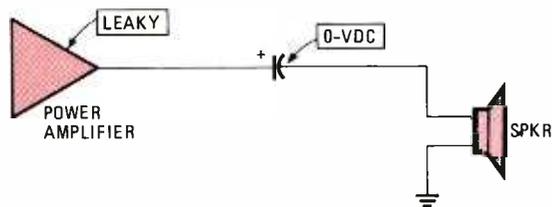


Fig. 2—Amplifiers having a large coupling capacitor between the power output stage and the speaker will not place a DC voltage on the speaker if the amplifier is leaky; however, excessive high volume or abnormal sounds (filed with sharp peaks) may still destroy the speaker's voice coil.



Accidentally stepping into, or large articles falling into the speaker area, may damage large, unprotected speakers

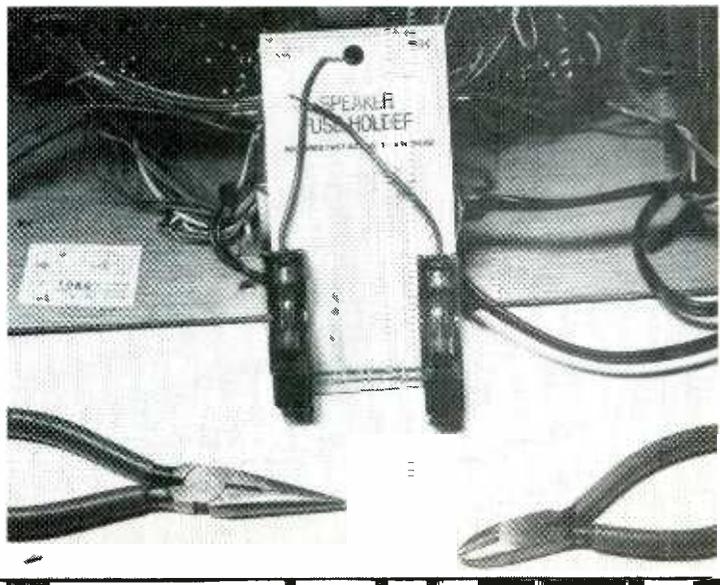
output. Of course, one can check the schematic diagram to determine if there is a capacitor between the speaker and amplifier components.

Speakers may also be damaged by water or other liquids spilled into the cone; or, as shown in the photograph, a party can get *out of control* and someone literally puts a foot through the speaker; or children playing near the speaker enclosure may accidentally stick a toy through the grille into the speaker cone (most grille cloths don't give adequate protection to the woofer).

Excessive Equalization

Higher than normal power, having greater than normal bass and treble sounds may also injure the speaker system. When servicing the amplifier using continuous tone from a test oscillator or a test record, keep the volume at a low level to avoid speaker damage.

If the amplifier doesn't have speaker fuses, you can install external fuse holders at each speaker. Either solder the fuse holder onto the speaker's positive terminal (indicated by a + or red dot) wire or clip it to the amp's output terminal.





Most speakers can be inspected by removing the large woofer from the front panel after removal of the grille cloth cover.

The sound level developed by acoustic feedback from a microphone or electronic musical instrument can also damage a speaker, as can abnormal *pop* noises generated when input or output cables are connected or disconnected. The primary rule when working around an amplifier is: **Keep the volume low.**"

Thermal Protection

Although conventional fuses are usually used to protect speakers against DC and volume overload, Fig. 3 shows how speakers can be protected from electrical damage by a thermal breaker or a thermal relay that's connected in series with the amplifier and speaker.

You may find a thermal-reset relay or breaker in series with the various speakers. Two different thermal units are used in Fig. 3: a thermal breaker for the tweeter, and a thermal relay for the woofer and mid-range speakers. Simply reset the thermal relay or breaker if you find one of the speakers dead. You may find those protection devices behind a speaker's removable front grille, or at the back of the speaker enclosure. (Sometimes they are bumped and broken loose when mounted on the back panel.)

The tweeter or mid-range speaker may be protected by a level control inserted in the line just ahead of the speaker (see Fig. 4). The controls protect against excessive power being fed to the speakers, and they also provide a way to conveniently balance the midrange and tweeter sound with the woofer.

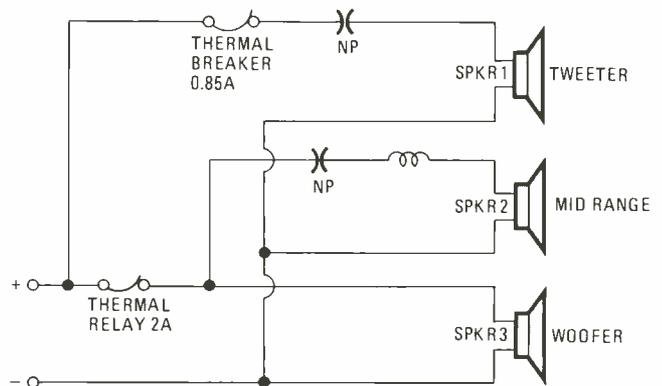


Fig. 3—Many expensive speaker systems use thermal relays or circuit breakers to protect the various speakers. Reduce the volume and wait thirty seconds—with no sound coming from the amplifier—before resetting the overload buttons.

If the amplifier doesn't provide speaker protection of some kind, you can protect the speakers by adding a pair of stereo fuses between the amplifier and the speakers. Even if the amplifier has internal speaker fuses, it's often difficult and bothersome to replace a fuse that is mounted under the top cover; so move the fuse. Solder a wire across the existing fuse clips and locate the protective fuses outside the amplifier cabinet for easy replacement. Simply epoxy-cement a fuse block to the rear panel as shown in the photograph, or insert separate fuse holders into each stereo channel.

In the event that the amplifier does not have fuse protection for the speakers, the correct fuse may be determined by the formula:

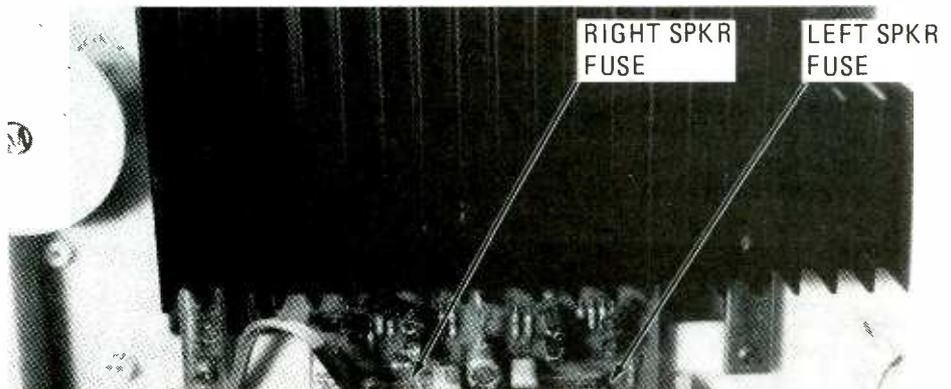
$$A = \sqrt{P/Z}$$

where A is the current rating in amperes, P is the rated capacity of speakers in watts, and Z is the impedance of speakers in ohms. For example: A 50-watt, 8-ohm speaker system requires a 2.5-A fuse, while a 75-watt, 8-ohm speaker system is protected with a 3-A fuse.

Correct Wiring of Speakers

It's best never to splice a speaker cable to the existing wires when moving or extending the speaker cable, because the wires often short together—causing damage to the amplifier's output transistors. If possible, always run a new set of speaker cables, but make sure that you choose proper size cable wires for long cables runs.

Most speaker-connecting cable of less than twenty feet may be #22 or #24 stranded wire; however, if a speaker requires 40 feet of cable, the total resistance of the #22



Many amplifiers have a speaker fuse built into in each output channel. Don't replace them with a larger fuse, or wrap tin-foil around the fuse to just "get by" until the store opens.

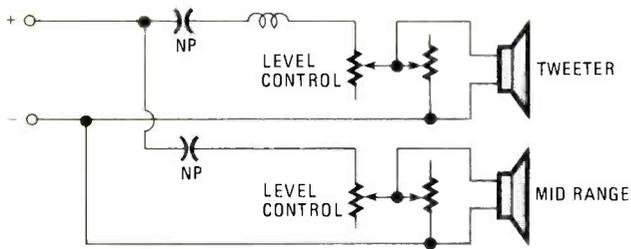


Fig. 4—Mid-range and tweeter speakers in multi-speaker systems may be protected with level controls located on the front or rear panels. The right amount of high and mid-range level balance can be attained using those controls.

speaker wire will represent 1.3 ohms. If the speaker were 4 ohms, 25 percent of the output power from the amplifier would be absorbed by the wiring between the amplifier and the speaker. (If the speaker impedance is 8 ohms, at least 10 percent of the applied power would be consumed in the wiring.) As a general rule—to keep *copper loss* (wire resistance loss) at a minimum—for any substantial distance the use of #16 or #18 gauge 2-conductor stranded wire is suggested.

Conventional #18 gauge 2-conductor zip or lamp cord is ideal for speaker cable. Often, zip cord is available with clear, white, black, or brown plastic insulation.

If the speaker wiring must be spliced, stagger each splice so that there's no possibility that they can short together—no matter how much traffic walks upon or pulls the speaker cable. To ensure reliability, solder each splice and cover the splice with plastic electrical (insulating) tape.

Multiple Speakers

When several speakers are connected to a stereo channel it's possible for the impedance to represent less than 1 ohm, which can cause damage to the audio-output transistors or integrated circuits within the amplifier. Normally, something

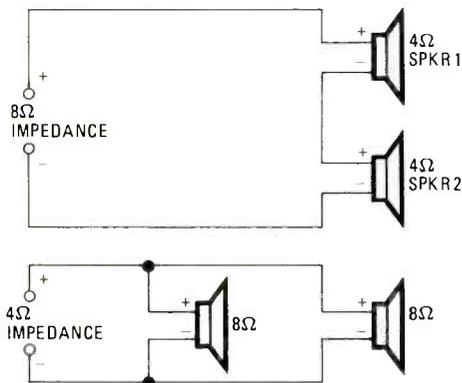


Fig. 5—The total speaker impedance is 4 ohms when two 8-ohm speakers are connected in parallel. The total impedance is 8 ohms when two 4-ohm speakers are connected in series.

Many amplifiers, such as this Sansui 2000X, allow two different speaker systems to be connected through A and B output terminals. The systems are selected by a front-panel switch.



An intermittent or mushy speaker can be located by gently pressing your fingers on the cone when music is playing.

must give if 80 watts is fed into a 1-ohm load: the amplifier may run hot, and within a few minutes blow the speaker's fuse or the solid-state output devices. At the very least, too many speakers connected to a low-powered amplifier will result in excessive distortion and weak volume. (Connect only one set of speaker units to an amplifier rated under 10 watts.)

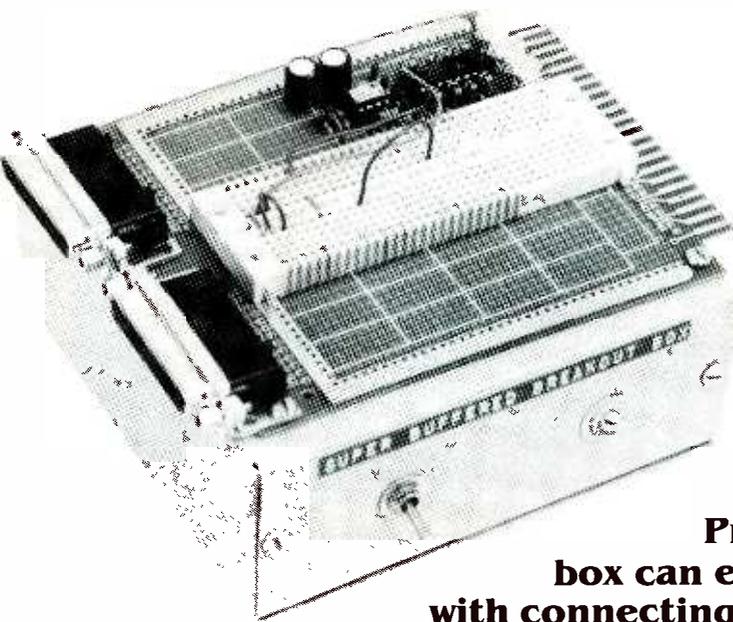
However, as shown in the photograph, most quality amplifiers provide for two speaker systems—A and B—which can be switched either in series or parallel to maintain proper impedance matching to the amplifier.

If the amplifier doesn't provide for automatic impedance matching (when necessary), you'll have to do it yourself. As shown in Fig. 5, if two 8-ohm speakers are connected in parallel the total impedance is 4 ohms. On the other hand, if two 4-ohm speakers are connected in series the total impedance is 8 ohms. Use the series or parallel arrangement needed for the specific speakers and amplifier you're using. Normally, for best music reproduction most speakers are connected in parallel; speakers seem to *fight* one another when connected in series.

How to Locate a Defective Speaker

A defective speaker may be dead, intermittent, or may
(Continued on page 102)





SUPER BUFFERED BREAKOUT BOX

Printer cable nightmares? A breakout box can eliminate the frustrations associated with connecting peripherals to personal computers!

By Jeff Holtzman*

YOU'VE JUST BOUGHT A NEW PRINTER FROM THE Chop Stix Printer Company of Hong Kong. You remove it from its box and prepare to hook it up, expecting to dazzle family and friends with the latest in low-cost, high-tech printer technology. But panic sets in when you realize that no manual is included, just a sheet of paper proclaiming that the Chop Stix is fully compatible with Brand X. How can you get it to work with your personal computer?

Or consider this scenario: You're a technician for the U-Break-Em-We-Fix-Em Computer Service Company. The *honcho-in-charge* sends you out on a call to the Ladies Better Quilting Society of America, where you find that a member's three-year-old son has unhooked every interconnecting cable of the Society's office computer. Then comes the clincher: The Ladies tell that you that they threw away all the manuals that came with the hardware because they considered them unimportant.

In spite of that, you have no trouble hooking up the keyboard and the monitor, since their connectors are unique. However, the parallel printer uses a DB-25 connector, and there are two identical DB-25's on the rear of the computer. You know that the computer has both serial and parallel outputs, but you don't remember which is which. What do you do? Scenes like those illustrate the fact that poor (or absent!) documentation is very common in the computer industry. So we must be prepared to figure things out for ourselves, without benefit of wiring diagrams and other installation documents.

The Easy Way

One extremely useful device used by every computer professional is called a breakout box. Breakout boxes come in varying degrees of sophistication. The simplest might consist of several connectors, test-leads with sub-miniature, hook-on clips, and an LED (with current-limiting resistor). The clip

leads allow you to connect various pins to each other, and the LED allows you to monitor the status of one signal line. More complex breakout boxes include some other, more convenient means of connecting various pins, an LED for each and

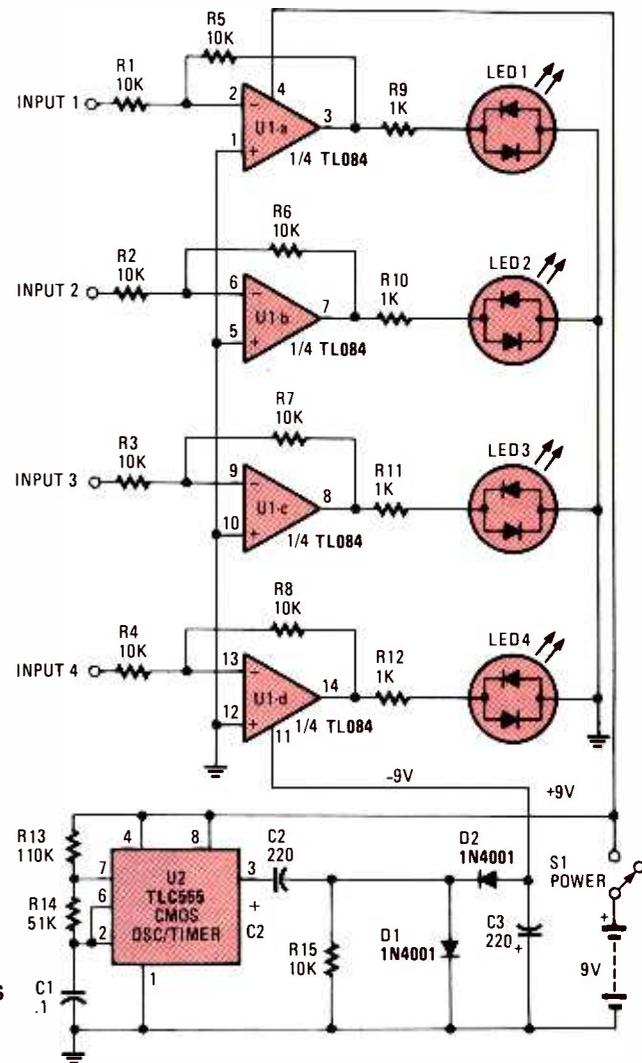


Fig. 1—Four buffered tri-color LED's provide high/low indication of RS-232 signal lines, while the TLC555 CMOS timer/oscillator circuit provides a -9-volt DC source.

*Assistant Technical Editor, *Radio-Electronics Magazine*

every signal line, and perhaps a test-data generator that continuously outputs streams of ASCII characters.

The problem with the connector and clip-lead approach is that it can be more trouble than it's worth. You never have enough clip leads, which often fall off the connectors, and it's easy for the leads and the clips to become separated from one another. Connectors and clip leads have a couple of advantages, though: they're inexpensive and easily replaced. On the other hand, test-data generators can be extremely useful—if your pocketbook can stand the investment they require.

One option that may not have crossed your mind is to build your own *Super Buffered Breakout Box*. In that way, you can get just the features you need, without paying extra for ones that you don't. By building your own, you can make it as simple or as complex as you want. And if your junkbox is even moderately well stocked, the cost can be very little indeed. (The author built his for about \$10; but using all new parts the circuit costs less than \$30—about a third of what a comparable commercial unit would cost.)

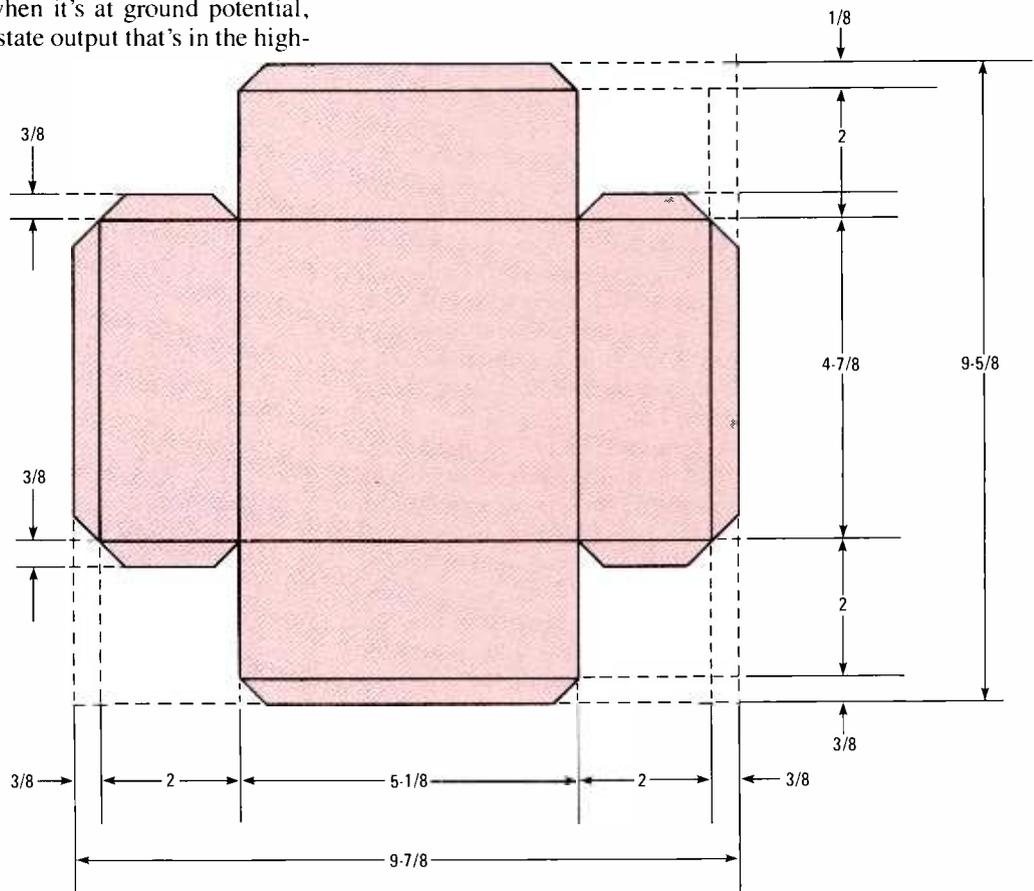
About the Circuit

The heart of the Super Buffered Breakout Box (see photos) is a 35-conductor solderless breadboard. All pins of two 25-pin D-type connectors are connected to opposite sides of the breadboard, with corresponding pins of each connector opposite each other. As shown in Fig. 1 the monitoring circuit consists of four tri-color LED's, which are driven by an equal number of op-amps that are configured as gain-of-one inverting amplifiers. Each LED is wired in the circuit so that it glows red when the input to the op-amp is high, and green when the input is low. The LED remains off when the input is disconnected from a circuit, when it's at ground potential, and when it's connected to a 3-state output that's in the high-impedance state.

Each input has an impedance of 10,000 ohms (due to the series resistor), preventing the circuit from loading communication lines. For local printer runs and the like, loading is seldom a problem. But a long cable run can heavily load a line by itself; the addition of a bare LED/resistor combination can be enough to totally disrupt communications. So, we chose to be safe rather than sorry.

The op-amp requires both positive and negative supply voltages to properly drive the LED's. Both voltages are supplied by a single, nine-volt battery. The battery supplies the positive source directly. The negative source is sup-

Fig. 2—Bend a thin piece of aluminum to provide a case for the circuit. Cut a hole in the top to match the circuit board, and then cut an additional plate to close up the bottom.



PARTS LIST FOR THE SUPER BUFFERED BREAKOUT BOX

SEMICONDUCTORS

- D1, D2—1N4001 100-PIV, 1-ampere silicon rectifier diode
- LED1-LED4—Tri-color LED (Radio Shack #276-035)
- U1—TL084CN, quad operational amplifier, integrated circuit
- U2—TLC555 CMOS oscillator/timer, integrated circuit

RESISTORS

- (All resistors are 1/4-watt, 5% fixed units.)
- R1-R8, R15—10,000-ohm
- R9-R12—1000-ohm
- R13—110,000-ohm
- R14—51,000-ohm

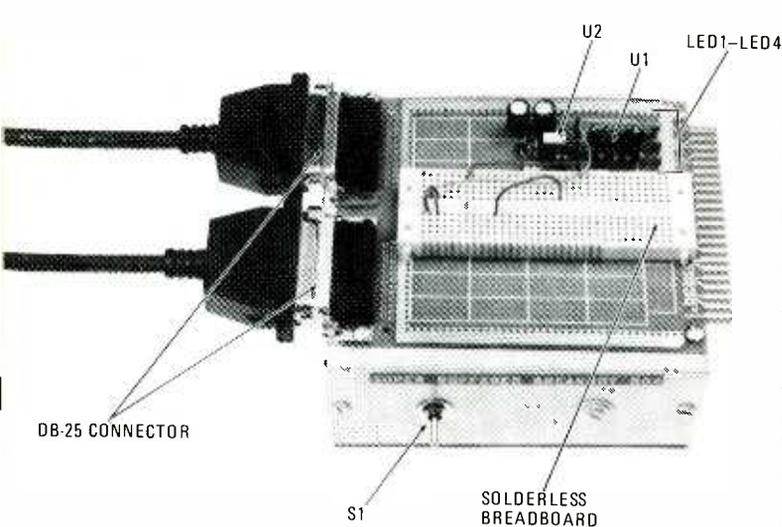
CAPACITORS

- C1—0.1- μ F, mylar
- C2, C3—220- μ F, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

- B1—9-volt, transistor-radio battery
- S1—Single-pole, single-throw (SPST) miniature-toggle switch
- Solderless breadboard, printed-circuit board (Radio Shack #276-187), two 25-pin D-type connectors (Radio Shack #276-1521), enclosure (see text), solder, wire, etc.

plied via a CMOS 555 oscillator/timer that's configured as an astable oscillator, which is used to drive a standard diode/capacitor voltage doubler. When the 555 is connected to the monitoring circuit, the output voltage is not 18 volts (2×9),



Two female DB-25 connectors mount on the PC board in pre-etched and pre-drilled pads. The solderless breadboard is held in place by 50 J-type wirewrap pins.

specifications shown in Fig. 2. A hole was then cut in the top of the box and the printed-circuit board fitted over that hole, as shown in the photos. Two holes are then drilled in the front panel, through which switch S1 and the battery holder for B1 are mounted. A matching bottom plate is then screwed to the bottom.

Testing the Breakout Box

After you've completed all the wiring, check the circuit carefully. Fix any mistakes, and then insert U2 (the 555) into its socket. Connect a nine-volt battery, and then turn S1 on. Measure the voltage at the negative side of C3. If you don't measure a negative voltage, connect a scope to the output (pin 3) of U2. You should see a rectangular wave (an AC signal having steep sides and a flat top, but not square) with a frequency of about 70 Hz. If not, the 555 is not oscillating, so track down the source of error before continuing.

Connect a jumper wire to LED1's input terminal. Connect the opposite end of that wire to the +9-volt terminal. LED1 should glow red. Then connect the wire to the negative nine-volt terminal. The LED should turn green. Repeat that test for each LED, correcting all wiring errors as they are encountered.

Using Your Creation

Debugging serial interfaces is a subject unto itself. However, a few general rules can be stated: The input of one device must be connected to the output of another device. You can usually—but not always—tell if a terminal is an output by an illuminated LED. An LED that doesn't light indicates either an input or no connection. Also, busy lines are often a source of trouble. For testing purposes, you can fake a busy output by connecting either the positive or the negative nine-volt output terminal to the busy input. That should allow you to establish basic communications. After the basic link is established, you can worry about the actual hookup of the busy line.

There is both an art and a science to debugging computer interfaces. Most knowledge about the subject can only be obtained through direct hands-on experience. And that's what we're all about. Build the Super Buffered Breakout Box, and your next debugging session should go much easier. ■

but a little under nine volts, due to loading. The circuit draws about 16 mA with all LED's off; with all four on, it draws between 20 and 30 mA, depending on how many LED's are high, and how many are low. The use of CMOS op-amps reduces quiescent current drain considerably.

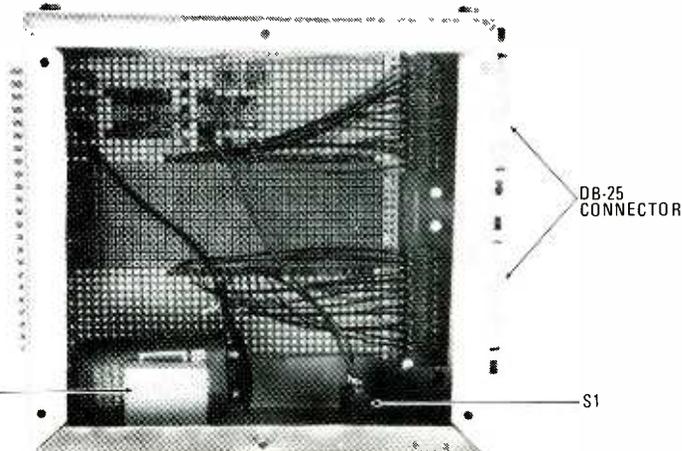
Construction

The author built the Super Breakout Box from readily available parts on a special prefabricated circuit board (sold by Radio Shack). However, any similar circuit board can be used. The printed-circuit board has pre-etched pads laid out to accept two 25-pin printed-circuit-mountable, D-type connectors; the opposite edge of the board also accepts a standard 44-pin edge-card connector (which is unused in this project).

Fifty J-type wirewrap terminals are used to attach the solderless breadboard to the printed-circuit board. The hook end of the J-pin is inserted in the breadboard; the long part then extends through the printed-circuit board. The J-pins provide a neat assembly, but solid 20-gauge or smaller solid hookup wire might just as well be used. Each J-pin is soldered to a pad on the copper side of the printed-circuit board, and small lengths of pre-cut wirewrap wire connect each pin of each D-type connector to the appropriate pin. The author used a strip of rubber cement to attach a thin sliver of paper down the center trough of the breadboard—indicating pins 1 through 25 and spaced every 0.1 inch. Be careful to keep the sequence of pin numbers straight; an error here could lead to a very hard-to-debug problem later on!

The remainder of the components (except B1 and S1) are soldered to the printed-circuit board and interconnected with short lengths of wirewrap wire. IC sockets are provided for U1 and U2. Seven pins of the type found in machined IC sockets (which are also sold separately) are used to provide the four LED inputs, ground, and ± 9 -volt connections. Small-gauge solid hookup wire can be inserted in the pins and then run to the appropriate breadboard holes. Using the machined pins leaves ten rows of holes free on the solderless breadboard for experimental interface circuits, etc.

The board was then mounted on a custom-made box, which was cut from aluminum sheeting and bent to the



All of the electronic components mount in the upper left corner of the circuit board; then they're interconnected with wirewrap wire.

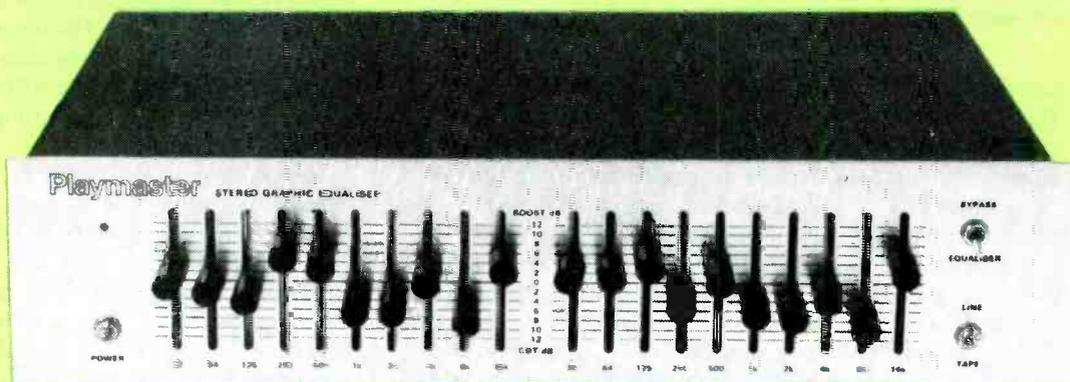
BATTERY & HOLDER

DB-25 CONNECTOR

S1

Playmaster

GRAPHIC EQUALIZER



Improve the sound quality of your stereo system with an inexpensive equalizer—You put it together and pocket the difference!

By Patrick Eunker

□ TODAY'S AUDIO ENTHUSIASTS DEMAND MORE FROM STEREO equipment than did their counterparts of a decade ago. And the manufacturers seeking to satisfy the audiophile's every whim have flooded the marketplace with all sorts of audio-enhancement devices. Of the devices that have been widely accepted, the equalizer is probably the most popular.

There are two basic uses for an equalizer. The first is to smooth out lumps in a system's frequency response caused by room acoustics (which play a major role in the way sound is perceived) and limitations in the stereo equipment itself. The second is to deliberately alter the tone of the audio to minimize noise, emphasize particular instruments, or simply to change the tonal balance to suit one's own taste.

The price of equalizers varies widely, depending on the number of features incorporated into the unit. For instance, some units might contain an audio spectrum analyzer to aid in adjusting the unit for the best response in a given listening area. However, if your needs run toward the very basic, or if you just want to try one out to see what it can do for your listening pleasure and you don't mind a little work, then the *Playmaster Equalizer Kit* may be just the thing for you.

The *Playmaster Equalizer Kit* (from Dick Smith Electronics) comes with all the components, wire, solder, hardware, and instruction booklets necessary to build the complete unit. But before we let you in on what the assembly procedure involves, let's review some of the theory behind its operation.

In The Beginning

The first generation of equalizers used inductors in the circuit design. Although they worked well, the inductors were expensive, tedious to wind, and prone to inductive hum. Early equalizers—based on the simple principle illustrated in Fig. 1, representing a single band—used op-amps connected in the non-inverting mode, with negative feedback supplied to the inverting input. (Twenty such circuits are needed for a two-channel, 10-band unit.)

With the slider control (wiper) of the potentiometer centered, the op-amp provides unity gain and the tuned LC circuit has little effect. But, as the wiper is moved toward the BOOST end, the negative feedback is gradually shunted to ground through the tuned LC circuit, thereby, increasing the circuit's gain at the resonant frequency. Conversely, as the wiper is moved toward the CUT end, negative feedback is increased to maximum, thereby providing minimum gain at the resonant frequency. As one might expect, the multiple-tuned LC circuits had a tendency to interact with each other.

Enter the Gyrotor

Later, in more modern designs, a circuit called a *gyrotor*—like that shown in Fig. 2—replaced the inductive coils in some equalizer circuits. The gyrotor, as used here, refers to an op-amp circuit that effectively transforms a capacitor into an inductor in an AC circuit.

To understand its operation, first consider the input signal

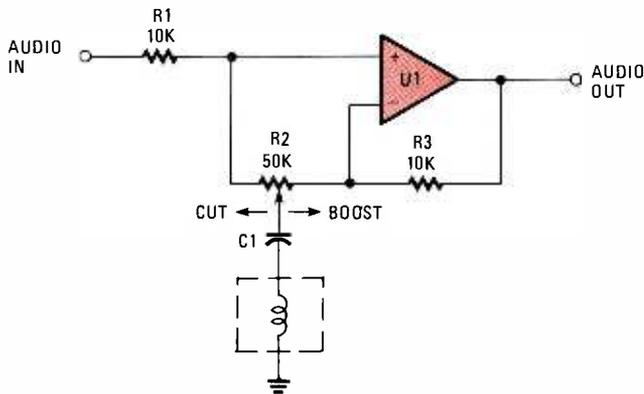
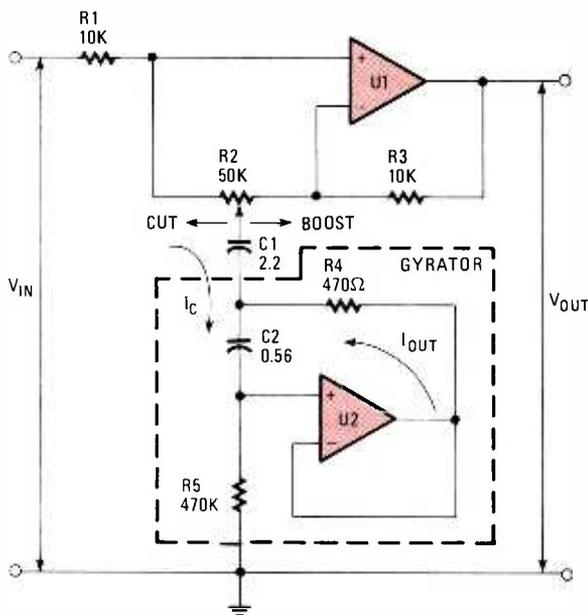


Fig. 1—Early equalizers used inductors in the circuit's design. The inductors were expensive, bulky, tedious to wind, and the multiple-tuned circuits had a tendency to interact with each other.

source (V_{in}), which forces current, I_c , through capacitor C2. That causes a proportional voltage to be developed across R5, which is then input to the op-amp and reproduced at its output. The feedback voltage developed across R2 (the difference between V_{in} and V_{out}) causes current to flow through R2 to the op-amp's non-inverting input.

As the waveforms in Fig. 2 illustrate, while I_c leads V_{in} (as would be expected for a capacitive circuit), the net input current (which is the vector sum of I_c and I_{out}) actually lags V_{in} . So, capacitor C2 (as far as the circuit is concerned) has effectively been transformed into an inductor by the op-amp. And since several op-amps can be fitted into a single IC package, the gyrator circuit lends itself nicely to equalizer applications, thus, allowing bulky inductors to be replaced by compact circuitry.



A Look at the Circuit

The schematic diagram in Fig. 3 is an extension of the concept outlined for Fig. 2, showing one complete channel (left or right) of the Playmaster Equalizer. The circuit is built around six μ A4136 quad op-amps, which provide the entire active device complement for the Playmaster Equalizer. The μ A4136 can be regarded as upgraded 741 with superior noise characteristics. Its noise characteristic allows the Playmaster to be used in the *tape monitor* circuit of amplifiers where signal levels are normally between 100 and 200 millivolts. And because the μ A4136 op-amp has a good ripple-rejection ratio, the power supply can be simple and inexpensive.

The incoming audio signal is routed through the series combination of C1/R1 to U1b, which functions as an input buffer to match the output impedance of the signal source to that of the Equalizer. Its output is fed to U1a (which performs as outlined for Fig. 1). The ten gyrator circuits—each covering a specific band of frequencies—are connected in the feedback loop of U1a (the position that an inductive coil once occupied)—determine the composition of the signal at the output of U1a.

For instance, let's say that the output audio is rich in mid-to-high-frequency components, but is somewhat lacking in bass (the range between 20 and 300 Hz). Sliding the wipers of potentiometers R9 to R14 (see Fig. 3) into the CUT region increases in negative feedback in the gyrator circuit to which they are connected. That, in turn, reduces the output level for the band frequencies associated with those potentiometers, resulting in an apparent increase in bass. If that still doesn't suit your taste, you can increase the bass component of the audio by sliding the controls for the 20–300 Hz bands into the BOOST position. What's left of the input audio after increasing and decreasing the various bands is then routed back to the non-inverting input of U1a.

The signal is then fed through your amplifier to your speakers with the desired mix of bass, treble, and mid-range audio.

The power supply for the circuit is made up of two half-wave rectifiers, D1 and D2, to provide positive and negative supply voltages. The two supply voltages are filtered by C26 to C29 and decoupled via R40 and R41.

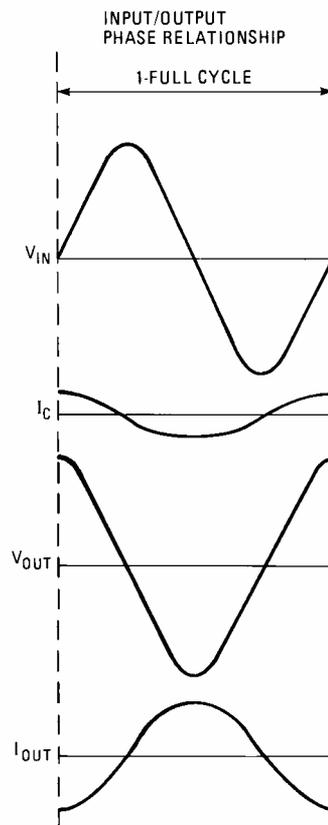
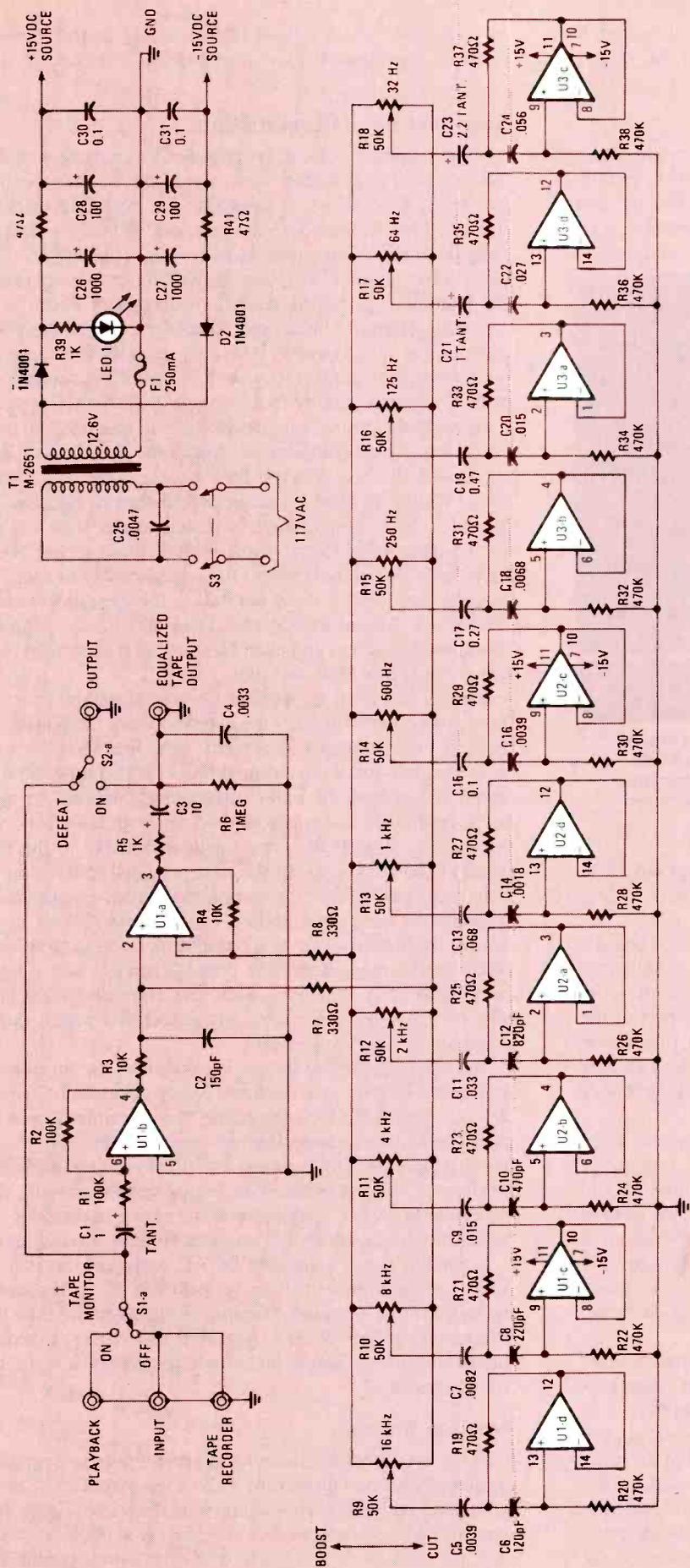


Fig. 2—Some of the more modern equalizer designs replaced the inductive coils with gyrator circuits, which effectively transformed a capacitor into an inductor.



A light-emitting diode (LED1) fed from the positive supply rail via a 1000-ohm resistor functions as the front-panel pilot lamp. Fuse F1 provides protection for the power-supply circuit. A 0.0047- μ F capacitor, C25, connected across the transformer's primary suppresses transients that may be generated during power up or power down. The chassis, grounded through the mains, does not connect to any part of the signal circuitry to avoid earth loops.

Putting It Together

The Playmaster Equalizer is assembled on three printed-circuit boards (see photos)—the main circuit board, which carries all the equalizer circuitry; the control board, supporting 20 slide potentiometers that connect to the active circuitry on the main board, and the power-supply board—which are interconnected to form the completed unit with a minimum of point-to-point wiring.

Prior to starting assembly, it is strongly recommended that you go over the construction techniques section outlined in the *Guide to Kit Construction*. The booklet will help to acquaint you with proven assembly techniques. It's also a good idea to read each step in the *Assembly Manual* before you start, and to make sure that you understand the instructions completely. And once assembly begins, check off each step in the boxes provided as they are completed. Start with the control board: It's fairly straightforward, requiring only that you place and solder 20 slide-control potentiometers onto the board. Concentrating on the control board first, allows you to get in some good soldering practice to prepare you for the boards to come.

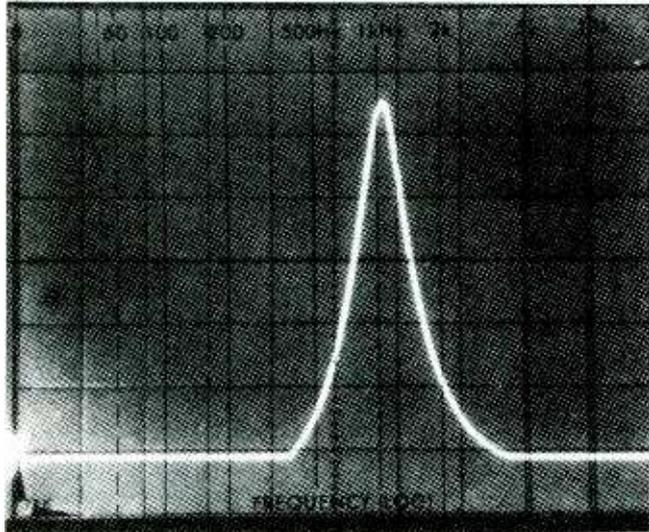
Each potentiometer has a short tab on the underside (not to be confused with the solder lugs) that must be bent flush to the unit's body before it's placed and soldered into position. Install the potentiometers on the non-copper side, flush to the board (they'll only go in one

Fig. 3—The schematic diagram—illustrating one channel (either left or right) of the Playmaster ten-band, graphic equalizer—reveals that the circuit is merely an extension of the concept outlined in Fig. 2. Several gyrators have been connected in parallel with each other, but given separate controls, as would be the case where inductive coils are used.

way). Bend one or two of the lugs on each unit to secure it in place. Once all are in position—parallel to the board and each other—solder them securely in place.

Check Your Work

When finished, check for solder bridges and/or cold solder joints. If you're satisfied that your work is error-free, put the board aside and move on to the remaining two boards, and assemble them according to the instructions, beginning with the resistors, then the capacitors, and finally the semiconduc-



The Playmaster Equalizer is capable of boosting or cutting the frequency in any of its 10 bands by as much as 12 dB. Note that maximum gain is centered around the resonant frequency; in this case, the 1-kHz band. Gain is decreased as the signal moves away from resonance.

tors. Once all the printed-circuit boards are assembled, double check your work; looking for cold solder joints, solder bridges, misoriented components, etc.

The next step is to interconnect the three individual boards. Start by laying the control board down on its face and aligning the pads on the edge of the main circuit board with those on the control board at right angles. Caution: This part of the assembly is a little deceptive, and the photo illustration provides little or no help. The *Assembly Manual* does include a notation referring to the fact that the production kit has been modified, but it's a little vague.

In the *Assembly Manual* photos, the boards appear to be lined up perpendicular and edge-to-edge—well, one out of two *ain't* bad; they are perpendicular! However, they should be lined up so that the edge-connector pattern (on the edge of the main board) and the one on the control board (located at the center) are perpendicular to each other. Also, be sure when joining the boards that the edge of the control board with the logo (an encircled E_A) shows at the top, with the main circuit board component side down.

Line up the copper traces at either end of the boards, making sure the edge-connector pads do the same. Then *tack* the boards together with a blob of solder at the ends.

Once the two large boards are joined, the power-supply board is connected with the three pads on the end of the main board aligned with those on the power-supply board, as per the instructions. Then solder the end of the control board to the large pad on the power-supply board, and compare the finished assembly to the photograph. (The capacitors on the

bottom of the main circuit board, shown in the *Assembly Manual*, have been deleted from the final version.)

Near the End of Construction

With the printed-circuit board assembly complete, make a final check that all components are in the correct locations and that all polarized components are correctly oriented. Because Playmaster is a stereo unit, the two halves (left and right channels) of the main board are almost identical. Compare each channel; if there are any differences, double check the assembly against the complete component layout in the *Assembly Manual*. Install the 10 solder pins (at the points indicated in the *Assembly Manual*) on both the main and power-supply boards. They will be used to connect the printed-circuit assembly to the controls and the RCA jacks.

Now put the printed-circuit assembly to one side and begin fitting the chassis components. Install the two six-way RCA sockets on the inside of the back panel, using 12×10 mm bolts. The bolts need a fair bit of pressure to bite into the bakelite. Cut a 7-inch length of tinned copper wire and join all the outer conductors (short ground lugs) of the twelve RCA sockets together. Solder the wire securely to each lug, making sure that it does not touch the chassis or center conductors. Mount transformer T1 to the chassis using two 10mm bolts, washers and nuts. Next install the terminal block using two 12mm bolts and nuts.

Place a grommet in the chassis hole through which the units power cord will enter the cabinet. Work the power cord through the grommet (it's a pretty tight fit), allowing sufficient length to reach the terminal block, with a little left over. Strip off some of the outer insulation to expose the three inner, insulated conductors, and secure with the plastic wiring harness. Install the three switches loosely in the front panel of the chassis using the nuts provided. *Do not* fit the front panel yet. Mount the completed printed-circuit assembly, with the main circuit board's component-side up, on the front of the chassis using six countersunk screws and spacers. Once done, interconnect the controls, jacks, and printed-circuit assembly, following each step carefully. It's a good idea to trace over each wire with a colored pencil during assembly to avoid confusion.

The final step before testing is to connect the transformer secondary. Clip the transformer's center-tap close to its body (It's not used.) Tin the ends of the two remaining leads and solder them to the appropriate pins on the power-supply board as outlined. Check all the main's wiring to ensure that there's no chance of shorts between the wiring and the chassis. Turn the entire assembly upside down and shake to dislodge any pieces of wire or solder that might be floating around inside.

Insert the power plug into an AC outlet and switch the power on. Measure the voltage on each IC at the points indicated in the *Assembly Manual*. If there is more than 10% difference between what's measured and what's specified, turn off the power switch, and turn to the manual's section on troubleshooting.

Problem Solving

In the event that the completed project fails to operate as expected, your first move is to make a few visual tests. Begin by rechecking your wiring against the diagrams. Trace each wire in colored pencil as it is checked. It is often helpful to have a friend check your work. Someone who is not familiar

with the unit may spot something that you've consistently overlooked.

Installation

Playmaster may be connected to a stereo amplifier in two ways. The better method is to connect it between the preamp and the power amplifier. To do so, simply connect the *preamp out* and the *power-amp in* sockets, respectively, to the Equalizer's *INPUT* and *OUTPUT*. However, that's not possible with many amplifiers, known as *integrated amplifiers* or *integrated receivers*, where the power amplifier and preamp are packaged as a single unit.

In such cases, the usual way is to connect the equalizer in the tape monitor loop. Connect the amplifier's *tape out* (record) and *TAPE MONITOR* (playback) sockets to the Playmaster's *INPUT* and *OUTPUT* jacks, respectively. The Playmaster's *RECORD* and *PLAYBACK* sockets now substitute for those on the amplifier. Connect your tape recorder to those sockets as normal and use the *TAPE MONITOR* switch on the Playmaster when you wish to play a tape. The amplifier's *tape monitor* switch now switches the equalizer (and tape recorder) in and out of the circuit.

The *EQUALIZED TAPE OUTPUT* is used when you wish to equalize a signal before recording. To use that feature, connect the tape recorder's *input* to those sockets instead of the *RECORD* sockets. With the unit connected, set all sliders to their center ("0") position, switch on the Playmaster, the amplifier, and the signal source. Flip Playmaster's *BYPASS/EQUALIZED* output switch to bypass, and check the function of each slider. There should be a noticeable tone change as each slider is moved from minimum to maximum, and *visa versa*. If any do not work, turn to the troubleshooting instructions.

Finishing Touches

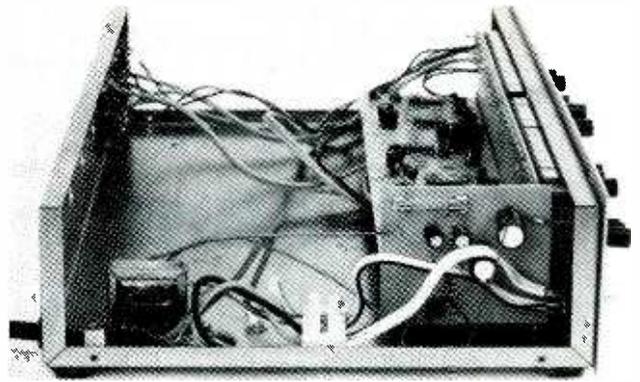
If all the checks are satisfactory, turn off power to the equipment and disconnect the amplifier and from the Playmaster. Take the nuts off the switches and mount the front panel, which is held in place with the switch nuts. Push the knobs onto the slider shafts. They are a tight fit, so support the slider control board firmly while pushing them on. Connect the LED to the power supply using a 4-inch length of red and black hookup wire as shown. Make sure that the correct terminals are connected or LED will not light. Push the LED into the hole in the front panel. You may need to use a little glue to hold it in place.

Again flip the chassis over and shake to remove any wire or solder. Slide the cover onto the chassis, securing it in place with four self-tapping screws. Attach the four rubber feet to the corners of the chassis base. Cut the back-panel label from the Assembly Manual, and glue it to the back panel.

System Setup

As stated earlier, there are two basic uses for an equalizer: To flatten the system's frequency response for a given room, or to alter the tonal balance to suit your own individual taste. To *flatten* the system's frequency response, some kind of reference is needed. The best reference is a *real-time spectrum analyzer*, which gives a direct readout of a room's or system's frequency response. But, if such an instrument is not available, a good alternative is to use a pink-noise generator and microphone.

To use the latter method, a microphone must be connected



The main circuit board, the power-supply board, and the control board are held together by nothing more than a few blobs of solder, so be very careful once they are joined. The assembly is then mounted with spacers and held in place by six screws and nuts.

to a level meter of some kind. (A tape deck's level meter is ideal.) All the slide controls are set to the maximum *CUT* (bottom) position with the pink noise fed into the auxiliary input of the amplifier. Make sure that the bass and treble controls on the amplifier are set for a flat response (where the input signal is output without modification other than amplification). Position the microphone close to your normal listening position. Since pink noise has equal energy in all octaves, if each of the Playmaster's slide controls are adjusted until the microphone level is equal, the frequency response will be close to flat.

Start by setting the 1-kHz potentiometer to its center ("0") position and adjusting the level meter to read 0 dB. Return the slider (potentiometer) to maximum *CUT* and do the same for the others. Note each knob position before returning the slider to maximum *CUT*. Once all have been checked (do each channel separately), set them to the levels noted and your frequency response should be essentially flat. This technique relies on the microphone having a reasonably flat response. Most electret condenser microphones should be satisfactory.

Avoid switching the Playmaster on or off while the amplifier volume control is set at a high level; otherwise there will be quite a loud turn-on thump from the loudspeakers and not as loud, but more disconcerting, a *chirp* from the loudspeakers about two seconds after turn-off (which, by the way, is quite normal). Also when the amplifier's volume control is fully advanced, a noticeable difference in hum may be detected when the Playmaster is switched into circuit.

That effect—which should not be detectable at normal listening levels—is actually a fault or characteristic of the amplifier concerned: It's due to the amplifier's input being connected to its common ground point via a low impedance (e.g., the source impedance of the Playmaster). The same effect may be produced by shorting the high-level inputs of the amplifier; or mitigated by connecting a 10,000-ohm resistor in series with the inputs of the amplifier or more conveniently, in series with the output of the Playmaster. However, most people find that modification unnecessary. ■

Note: The Graphic Equalizer Kit K3500 is available by mail order from Dick Smith Electronics, Inc., P.O. Box 8021, Redwood City, CA 94063. Orders: 800/332-5373; inquiries: 415/368-8844. Price: \$79.95 plus \$6.00 for shipping. California residents add 6-1/2% sales tax. Orders outside U.S. must include U.S. funds and add 20% of total price for shipping.

Make Your Own Calendar

A great personalized gift idea!

BY JEFF HOLTZMAN

□ HAPPY NEW YEAR! TO HELP YOU KEEP TRACK OF YOUR year a little better, here's a BASIC program that will print a yearly calendar like the one shown to the right. The program will print a calendar for any year you like, and the year headline can contain your name, your wife's name, your girl friend's name, or anything else you type at the keyboard. You can print trial versions to screen, and when you have a format you like, you can print the final copy on paper.

The program will run as is (in BASICA) on any IBM-PC or compatible, and (in MBASIC) on any CP/M machine. The program uses no special graphics characters, and no special BASIC statements, so it should run on Apples, Commodores, etc. with no difficulty. The program assumes you have an 80-column output device—screen and printer.

How to Use It

When you run the program, it will ask for a year. Type in four digits corresponding to the year you want. For example, type 1987, not 87. Press the RETURN (or ENTER) key. Then the program will ask you to enter a name. You can enter any combination of letters, numbers, and symbols. The only limitation is that the length of the line must be less than 256 characters. Press RETURN after typing in your headline.

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							31															

JULY							AUGUST							SEPTEMBER									
SU	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA			
				1	2	3						1	1	2	3	4	5						
5	6	7	8	9	10	11	2	3	4	5	6	7	8	6	7	8	9	10	11	12			
12	13	14	15	16	17	18	9	10	11	12	13	14	15	13	14	15	16	17	18	19			
19	20	21	22	23	24	25	16	17	18	19	20	21	22	20	21	22	23	24	25	26			
26	27	28	29	30	31	23	24	25	26	27	28	29	27	28	29	30							
							30	31															

OCTOBER							NOVEMBER							DECEMBER										
SU	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA	SU	MO	TU	WE	TH	FR	SA				
				1	2	3	1	2	3	4	5	6	7	1	2	3	4	5						
4	5	6	7	8	9	10	8	9	10	11	12	13	14	6	7	8	9	10	11	12				
11	12	13	14	15	16	17	15	16	17	18	19	20	21	13	14	15	16	17	18	19				
18	19	20	21	22	23	24	22	23	24	25	26	27	28	20	21	22	23	24	25	26				
25	26	27	28	29	30	31	29	30						27	28	29	30	31						

```

10 '-----
20 ' PERPETUAL PRINTING CALENDAR !
30 ' WITH FORMATTED HEADER !
40 ' WRITTEN BY: FRED KEMPLER !
50 ' MODIFIED FOR MBASIC 5 BY STAN MISEL 3/81 !
60 ' Modified for HOE by jkh 7/86 !
70 '-----
80 'clear 6000 :rem remove the ' if you get an out of space error message
90 PA=128
100 D1$=STRING$(21, 32)
110 DIM M(12), Q$(6), H$(25), C$(24)
120 PRINT TAB(21);"PERPETUAL CALENDAR"
130 PRINT
140 FOR I=1 TO 12
150 READ M(I)
160 NEXT
170 READ DS
180 FOR I=1 TO 4
190 READ MS(I)
200 NEXT
210 READ QS
220 READ RS
230 INPUT"ENTER YEAR";Y$
240 Y=VAL(Y$)
250 M1=1
260 FOR I=1 TO 4
270 Y(I)=VAL(MID$(Y$, I, 1))
280 NEXT
290 GOSUB 710
300 PRINT"ENTER NAME: ";
310 LINE INPUT N$
320 GOSUB 550
330 PRINT"FORMULATING CALENDAR"
340 GOSUB 980
350 PRINT"FORMATTING NAME"
360 GOSUB 630
370 GOSUB 780
380 PRINT"PRINTING CALENDAR"
390 GOSUB 1340
400 END
410 DATA 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31
420 DATA" SU MO TU WE TH FR SA SU MO TU WE TH FR SA SU MO TU WE TH FR SA"
430 DATA" JANUARY FEBRUARY MARCH"
440 DATA" APRIL MAY JUNE"
450 DATA" JULY AUGUST SEPTEMBER"
460 DATA" OCTOBER NOVEMBER DECEMBER"
470 DATA" 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 "
480 DATA" " :REM WAS STARS
490 ' 0 1 2 3 4 5 6 7 8 9
500 DATA"1111010111111111011111111111111111"
510 DATA"101110001001101100100001101101"

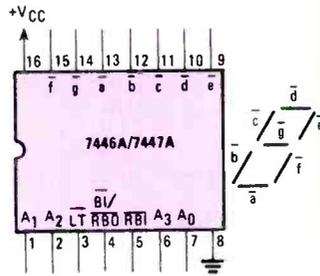
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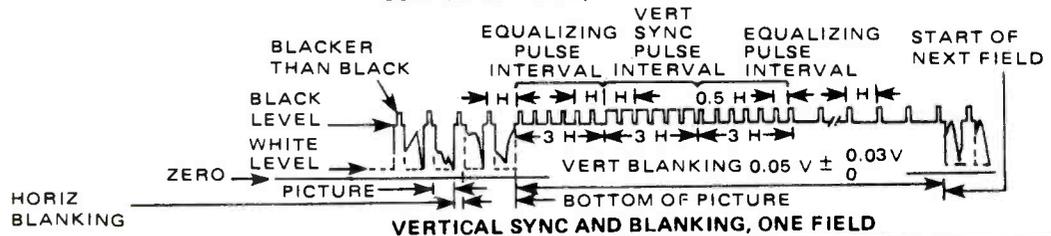
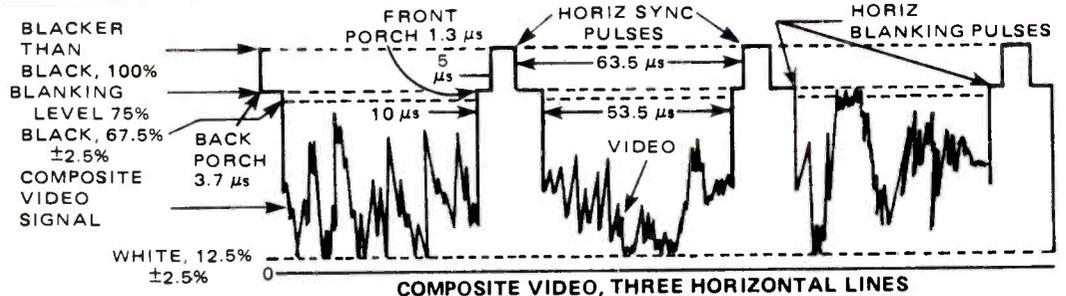
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Each issue, Hands-On-Electronics will present 3 new FactCards, each dealing with one of a variety of electronics topics. Some will deal with electronics basics, some will deal with discrete components, some will deal with IC's, and some will deal with circuits and applications.

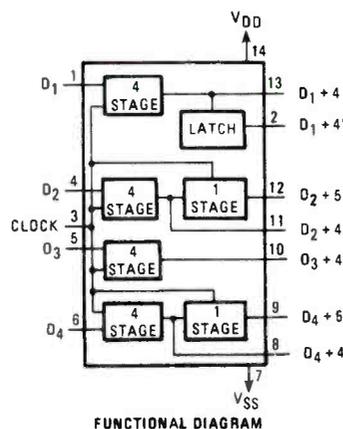
All will contain the type of information electronics hobbyists need, but sometimes must search to find. With FactCards, you can find that information in a hurry.



DECIMAL OR FUNCTION	INPUTS						OUTPUTS							
	LT	RBI	A ₃	A ₂	A ₁	A ₀	BI/RBD	a	b	c	d	e	f	g
0	H	H	L	L	L	L	H	L	L	L	L	L	L	H
1	H	X	L	L	L	H	H	L	L	L	L	L	L	L
2	H	X	L	L	H	L	H	L	L	L	L	L	L	L
3	H	X	L	H	L	L	H	L	L	L	L	L	L	L
4	H	X	L	H	H	L	H	L	L	L	L	L	L	L
5	H	X	L	H	H	H	H	L	L	L	L	L	L	L
6	H	X	L	H	H	L	H	L	L	L	L	L	L	L
7	H	X	L	H	L	L	H	L	L	L	L	L	L	L
8	H	X	H	L	L	L	H	L	L	L	L	L	L	L
9	H	X	H	L	L	L	H	L	L	L	L	L	L	L
10	H	X	H	L	L	L	H	H	L	L	L	L	L	L
11	H	X	H	L	L	L	H	H	L	L	L	L	L	L
12	H	X	H	H	L	L	H	H	L	L	L	L	L	L
13	H	X	H	H	L	L	H	H	L	L	L	L	L	L
14	H	X	H	H	H	L	H	H	L	L	L	L	L	L
15	H	X	H	H	H	H	H	H	L	L	L	L	L	L
BI	X	X	X	X	X	X	L	H	H	H	H	H	H	H
RBI	H	L	L	L	L	L	L	H	H	H	H	H	H	H
LT	L	X	X	X	X	X	H	L	L	L	L	L	L	L

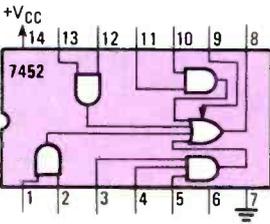
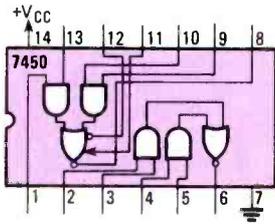
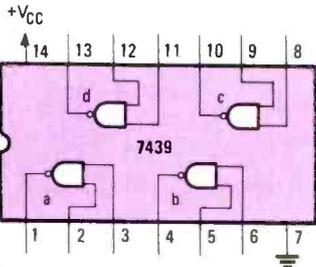
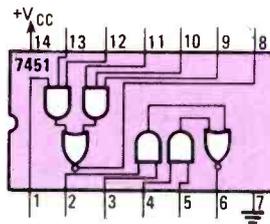
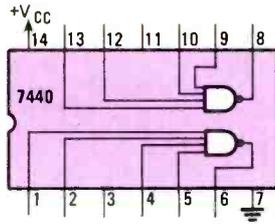
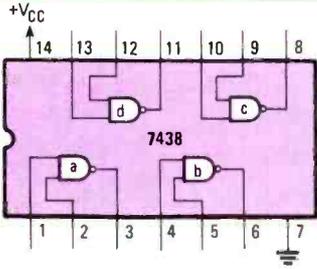


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RECOMMENDED OPERATING CONDITIONS

CHARACTERISTIC	V _{DD} (V)	LIMITS		UNITS
		Min.	Max.	
Supply-Voltage Range (For T _A = Full Package Temperature Range)	—	3	18	V
Clock Pulse Width, t _w	5	180	—	ns
	10	80	—	
Data Setup Time, t _s	5	100	—	ns
	10	50	—	
Data Hold Time, t _h	5	60	—	ns
	10	40	—	
Clock Rise or Fall Time: t _r , t _f	5, 10, 15	—	15	μs
	5, 10, 15	—	2.5	MHz
Clock Input Frequency, f _{CL}	5	—	5	
	10	—	7	



VIDEO SIGNAL COMPONENTS		
Signal	Frequency	Purpose
1. Black & white video signal	0—4.2 MHz	Represents the black & white picture information
2. Color signal	3.58 MHz + 0.5 MHz — 1.5 MHz	Represents the color picture information
3. Horizontal blanking pulses	15,750-Hz B&W, 15,734-Hz color	Turns off picture tube during horizontal retrace
4. Vertical blanking pulses	60-Hz B&W, 59.94-Hz color	Turns off picture tube during vertical retrace
5. Horizontal sync pulses	15,750-Hz B&W, 15,734-Hz color	Forces the receiver's horizontal oscillator to be in step with the transmitter's
6. Vertical sync pulses	60-Hz B&W, 59.94-Hz color	Forces the receiver's vertical oscillator to be in step with the transmitter's
7. Equalizing pulses	Twice the horizontal frequency	Prevents the loss of interface scanning
8. Color burst	3.58 MHz	Synchronizes the receiver color circuits with the transmitter's
9. VITS	Various frequencies	Studio test signals

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C)

CHARACTERISTIC	CONDITIONS			Typ.	UNITS
	V _O (V)	V _{IN} (V)	V _{DD} (V)		
Quiescent Device Current, I _{DD} Max.	—	0.5	5	0.04	μA
	—	0.10	10	0.04	
	—	0.15	15	0.04	
	—	0.20	20	0.08	
Output Low (Sink) Current, I _{OL} Min.	0.4	0.5	5	1	mA
	0.5	0.10	10	2.6	
	1.5	0.15	15	6.8	
Output High (Source) Current, I _{OH} Min.	4.6	0.5	5	-1	mA
	2.5	0.5	5	-3.2	
	9.5	0.10	10	-2.6	
	13.5	0.15	15	-6.8	
Input Current, I _{IN} Max.	—	0.18	18	± 10 ⁻⁵	μA

CHARACTERISTIC	CONDITIONS			Typ.	UNITS
	V _O (V)	V _{IN} (V)	V _{DD} (V)		
Output Voltage Low-Level, V _{OL} Max.	—	0.5	5	0	V
	—	0.10	10	0	
	—	0.15	15	0	
	—	0.20	20	0	
Output Voltage High-Level, V _{OH} Min.	—	0.5	5	5	V
	—	0.10	10	10	
	—	0.15	15	15	
	—	0.20	20	15	
Input Low Voltage, V _{IL} Max.	0.5, 4.5	—	5	—	V
	1.9	—	10	—	
	1.5, 13.5	—	15	—	
Input High Voltage, V _{IH} Min.	0.5, 4.5	—	5	—	V
	1.9	—	10	—	
	1.5, 13.5	—	15	—	

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```

520 DATA"1010101110111111111001111111"
530 DATA"101010100001001001101001101001"
540 DATA"1111111111001111110011111111"
550 INPUT "HARDCOPY ? (Y/N)";XS
560 IF XS="Y" OR XS="y" THEN 570 ELSE 620
570 PRFLAG%=1
580 PRINT:PRINT"PLEASE READY PRINTER"
590 PRINT"* ENTER 'R' WHEN PRINTER AT TOP OF PAGE";
600 INPUT XS
610 IF XS<>"R" THEN 590
620 RETURN
630 '----- EXTEND NAME -----
640 X=LEN(NS)+1
650 X=INT(255/X)
660 AA$=""
670 FOR I=1 TO X
680 AA$=AA$+NS+"_"
690 NEXT I
700 RETURN
710 '----- FORMAT HEADER -----
720 FOR I=0 TO 4
730 READ F$
740 FOR J=1 TO 4
750 A$(I)=A$(I)+MID$(F$(Y(J)*3)+1, 3)
760 NEXT J, I
770 RETURN
780 '----- FORMAT NAME -----
790 FOR I=0 TO 4
800 FOR J=1 TO 5
810 Q=(I*5)+J
820 H$(Q)=" "
830 PRINT 26-Q;
840 FOR K=1 TO 12
850 P=(K-1)*5
860 IF MID$(A$(I), K, 1)="0" THEN 890
870 H$(Q)=H$(Q)+MID$(AA$, Q+P, 5)
880 GOTO 900
890 H$(Q)=H$(Q)+" "
900 NEXT K
910 T$=""
920 FOR L=0 TO 3
930 T$=T$+MID$(H$(Q), (L*15)+1, 15)+" "
940 NEXT L
950 H$(Q)=T$
960 NEXT J, I
970 RETURN
980 '----- FORMULATE CALENDAR -----
990 L1=-6
1000 FOR I=1 TO 10 STEP 3
1010 L1=L1+6
1020 FOR J=I TO I+2
1030 FOR JJ=1 TO 6

```

```

1040 QS(JJ)=D1$
1050 NEXT JJ
1060 M=M1
1070 D=M(M)+(1-SGN(Y/4-INT(Y/4)))*(1-ABS(SGN(M-2)))
1080 L=L0
1090 Y1=Y
1100 IF M>2 THEN 1130
1110 M=M+12
1120 Y1=Y-1
1130 M=M+1
1140 Z=INT(365.25*Y1)+INT(30.6*M)-1
1150 Z=Z-7*INT(Z/7)
1160 M=M1
1170 QS(1)=LEFT$(R$, 3*Z)+QS
1180 QS(1)=MID$(QS(1), 1, 21)
1190 L=L-Z
1200 L0=L
1210 A1=0
1220 L0=L0+1
1230 A=(L+7+D-ABS(L+7-D))/2
1240 QS(L0)=LEFT$(MID$(QS, 3*L+1, 3*(A-A1))+R$, 21)
1250 L=L+7
1260 A1=A
1270 IF A<D THEN 1220
1280 FOR K=1 TO 6
1290 C$(K+L1)=C$(K+L1)+" " +QS(K)
1300 NEXT K
1310 M1=M1+1
1320 NEXT J, I
1330 RETURN
1340 '----- PRINT CALENDAR -----
1350 FOR H=1 TO 25
1360 OUTPUT$=H$(H):GOSUB 1530
1370 NEXT H
1380 OUTPUT$=" " :GOSUB 1530
1390 L=25
1400 M=0
1410 FOR CC=1 TO 24 STEP 6
1420 M=M+1
1430 OUTPUT$=M$(M) :GOSUB 1530
1440 OUTPUT$=" " :GOSUB 1530
1450 OUTPUT$=D$ :GOSUB 1530
1460 L=L+3
1470 FOR C=0 TO 5
1480 OUTPUT$=C$(C+CC) :GOSUB 1530
1490 L=L+1
1500 NEXT C, CC
1510 'LPRINT CHR$(12) 'FORM FEED
1520 RETURN
1530 'added printer output subroutine-----
1540 IF PRFLAG%=1 THEN LPRINT OUTPUT$ ELSE PRINT OUTPUT$
1550 RETURN

```

Next the program will ask whether you want "hardcopy" output—output on paper. Type "Y" or "y" if you do, any other character if you don't. If you choose hardcopy output, the program then gives you a chance to get your printer ready. You should align the paper so that the printhead is on line one. Type an "R" (upper case only) when you're ready.

Now the program takes a few seconds to format the header and the calendar; while it's doing that, it prints a series of messages on the screen to keep you informed. Then the image starts rolling up your screen (or printer). When the program finishes, you can run it again if you like.

Getting It Running

Type the program in exactly as shown. Be careful not to confuse "L" with "I" with "1." Some lines begin with an apostrophe('); if your BASIC objects to it, just type the word REM in its place. Some dialects of BASIC (Radio Shack's, in particular) require that space be set aside for string operations. If you get an "Out of String Space" error message when you run the program, remove the apostrophe at the beginning of line 80.

After you've typed the program in, check it against our printed listing—you'll save a great deal of debugging time. Correct any errors that you find, and then try running the

program. Don't worry if there are any errors—the program doesn't write to disk, so it can't hurt anything. If the program stops at an error, just correct the error against our listing and run the program again.

Customizing the Program

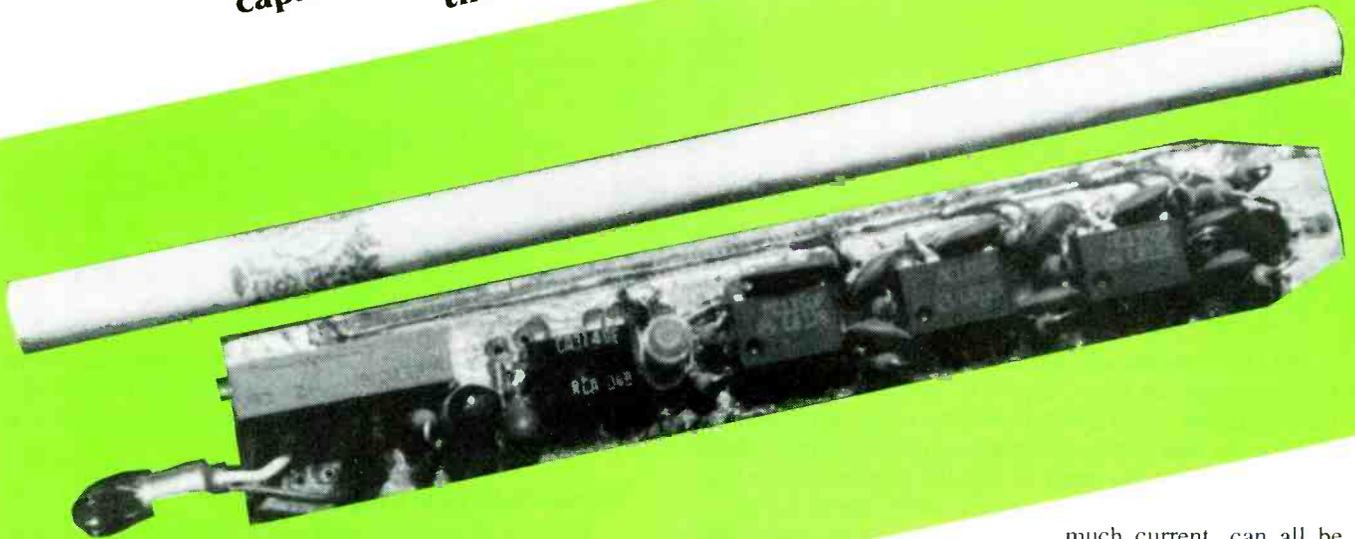
There are a couple of ways you could modify the program to make it more useful. First, you could check that the year input to variable Y\$ is valid. Second the program simply ends after printing a calendar. You could allow the program to reprint the same calendar, or to create a new one. Third, you could add a print-to-disk function, so that you could get a calendar that you could manipulate or print with your word processor. That might be useful, for example, if you wanted holidays to print in boldface or italic type. Or you could modify the calendar program itself to provide the fancy print function.

If you enjoyed this program and would like to see more like it, let the editorial staff know. They enjoy playing with computers and they would be happy to share some of the tricks and techniques all computer buffs picked up along the way.

Thanks to Long Island Computer Club, whose electronic bulletin board provided us with this program. ■

BUILD AN INDUCTIVE CURRENT PROBE

An inductive current probe can improve your troubleshooting capabilities by allowing you to follow current flow through the circuit, even between IC pins!



□ USING THE ELECTROMAGNETIC field generated by a signal and an inductive current-pickup signal tracer, you can find an IC shorting a bus or circuit node; trace signals through insulated cables and around coated or multi-level circuit boards, find shorts, solder bridges, etc; troubleshoot a three-state bus, track down "bus fights" (where two drivers battle for control over the same bus), and stuck wired-AND nodes, where several open collector gates are tied together. What's more, troubleshooting a clamped circuit node (exhibiting virtually no detectable voltage change), determining whether a logic circuit feeding a gate input is failing to source enough current, or if the gate's input is sinking too

much current, can all be accomplished.

Voltage-sensing instruments, including oscilloscopes, digital voltmeters, logic probes, computer-controlled auto testers, and so on often only track a failure down to a faulty circuit node, such as the connecting point for several IC's. But, a current-pickup signal tracer can determine precisely which IC or gate therein has failed or, if the problem is in the interconnection, where an open or short circuit may exist. That is, a special shielded coil (inductive pickup) senses current in a conductive path via inductive coupling to determine the precise location of a fault, such as a short, as opposed to checking voltages.

General Outline

Now, there are many ways of building a fast pickup probe, but most of them *ain't* cheap. Many inductive pickups provide low-level detection, which requires the use of op-

amps with slew rates from 600V/ μ s all the way up to 3000V/ μ s with equally fast settling times. In fact, such devices (which include some high speed op-amps, peak detectors, peak-to-peak detectors, sample-holds, precision rectifiers) can cost more than the entire project.

One way around the horns of the dilemma is to sidestep low-level detection all together. That is, amplify the signal until we can use a (not so fancy) full-wave rectifier made from inexpensive signal diodes and some equally cheap capacitors to store the charge long enough to be displayed on a scope or via an incandescent bulb. By the same token, we can dodge the gain-control problem by using an inexpensive RF/IF amp with a 60-dB minimum AGC range and capable of operating from DC to 60MHz, such as Motorola's MC1350.

Getting Down to Basics

Before we take a closer look at shielded-pickup coils (which are usable with digital and pulse circuits), consider a simple unshielded pickup coil application. An audio signal generator is capacitively coupled to a node suspected of being shorted. Then, an unshielded search coil (like the Nytronics DD-100, ETC PU-1000, and others capable of going between the pins of a standard dual in-line package, DIP) is used to track the the flow of current.

A low-noise amplifier, with a cut-off frequency of around 10 kHz, boosts the low-level output of the coil, giving a gain of 1000 or 60dB. Thus, tracing current and/or finding a short is made to look easy. Variations of that technique include the use of filtering, additional amplification to produce a stand-alone pickup, using a squarewave signal source, etc. Such a technique or its variations might be used by power and/or telephone companies to "ring out cables."

But, as with so many other things, the procedure does have its drawbacks: When unshielded coils are used in digital or pulse circuit troubleshooting, they have a tendency to respond to voltage as well as current steps. Thus, you can't dynamically test digital circuits with sinewaves, and static testing (where the circuit under test is powered down) doesn't allow the use of a circuit's own signals. Further, when such procedures are applied to circuit-boards, shorts not going to ground or supply rails make determining the return point a nightmare. And the use of low pass, bandpass, and similar filtering techniques, as in setting the amplifier cut-off frequency at 10 kHz, limits usable bandwidth.

A Closer Look

To increase dynamic range, sensitivity, selectivity, and still end up with a small, hand-held pickup probe usually requires the use of a more selective and sensitive pickup coil. Generally, selectivity is increased by the use of shielding; the shielding reduces extraneous high-frequency pickup, response to voltage steps, eddy currents, electrostatic fields, etc. Sensitivity is increased by the use of a ferrite core, which both limits response to something less than 20 MHz, and makes pulse-pickup coils act like transformers, giving a spiked output when working into a low impedance.

Although sensitivity and selectivity can be increased via coil construction, commercial pickup probes include several stages of wide bandwidth, controllable-gain and peak detection, which is then used to drive an analog display, like an incandescent lamp. The gain of the amplifier, which is adjusted to illuminate an incandescent lamp at half brightness under normal signal conditions, determines the circuit's sensitivity to a given input. Thus, brightness remains unchanged

as long as the same current is present.

But, abnormally high current levels, such as might be caused by a low impedance on a node, increases the brightness of the lamp. Moving the pickup along the conducting path, causes the display to become less bright where current is diverted to another path. The information provided isn't quantitative in nature; however, it is sufficient to find a large number of faults.

Since there's no need to make physical contact with the conducting path, signals may be traced through insulated wires, inner traces of multilevel PC boards, etc. That usually gives the user enough information to track the actual signal path as it flows up to a fault, without having to cut-traces, pull IC's, or make other non-productive troubleshooting moves.

Step changes in current are coupled via mutual inductance, converted to a proportional amplitude voltage spike, and then amplified. The amplified signal is then stretched by peak detectors to produce a pulse of sufficient duration to light an incandescent lamp, while a display driver provides the drive for the lamp.

Even though we have a shielded pickup, with reasonable sensitivity and selectivity, like the ETC-PU-5000 (some disc tape heads will also work) or equivalent, designing the electronics still takes some doing. Depending on the pickup coil used, we need around 100 dB of stable gain with a bandwidth of 15 to 20 MHz on a PC board .5 to .75 inches wide and 4 to 6 inches in length. However, many inexpensive scopes don't have 20-MHz bandwidths. Measuring current from, say, 1 mA to 1A requires a gain of 1000 or 60dB, which can be tricky to attain given the size, bandwidth, and linearity requirements.

After the input is amplified, we are still left with a signal that might be 150 to 200 nanoseconds wide and of either polarity (positive or negative) depending on the polarity of the current step and random orientation of the pickup coil to the current path. Therefore, we need to process a 150-nanosecond pulse of constant polarity and stretched in duration to around 200 milliseconds with sufficient amplitude and drive to power an incandescent lamp.

The current spikes driving the lamp must be decoupled from the input, and all electronics should be shielded from extraneous pickup. Further, the unit must run off the available power, or have a self-contained power source.

A Look at the Circuit

In Fig. 1, the pickup coil or transducer is capacitively coupled to Q1, which acts as a phase splitter, providing a coupled differential input to U1, an MC1350 video IF amplifier. U1's output is capacitively coupled to the U2 and its output is, in turn, capacitively coupled to U3 to provide a total gain, possibly, well in excess of 120dB. The output of U3 feeds D1 and D2, which provide full-wave rectification.

C11, which we assume has charged via R12, discharges via D1, D2, and the output transistors in U3, providing a fast-rise time incoming wavefront. Conversely, when D1 and D2 are reverse-biased, the fall time is increased as C11 attempts to charge up through R12. Thus, the signal stored in C11 may be seen (stretched out) on a scope, allowing both a stable baseline and large output to easily be detected. Further, increasing R12's value, increases the charge time of C11, while decreasing its value and/or that of C11 reduces the charge time of C11. R12 and C11 could even be made variable to provide an adjustable rise/fall time, thus, allowing the probe to be used with a reasonably fast-rise time oscilloscope.

PARTS LIST FOR THE INDUCTIVE CURRENT PROBE

SEMICONDUCTORS

- D1-D3—1N914 small signal, silicon diode
 Q1, Q3—2N3904, general purpose NPN, bipolar transistor
 Q2—E304 (or SK3116) N-channel JFET
 U1-U3—MC1350 video RF/IF amplifier, integrated circuit
 U4—CA3140 video IF amplifier, integrated circuit

RESISTORS

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

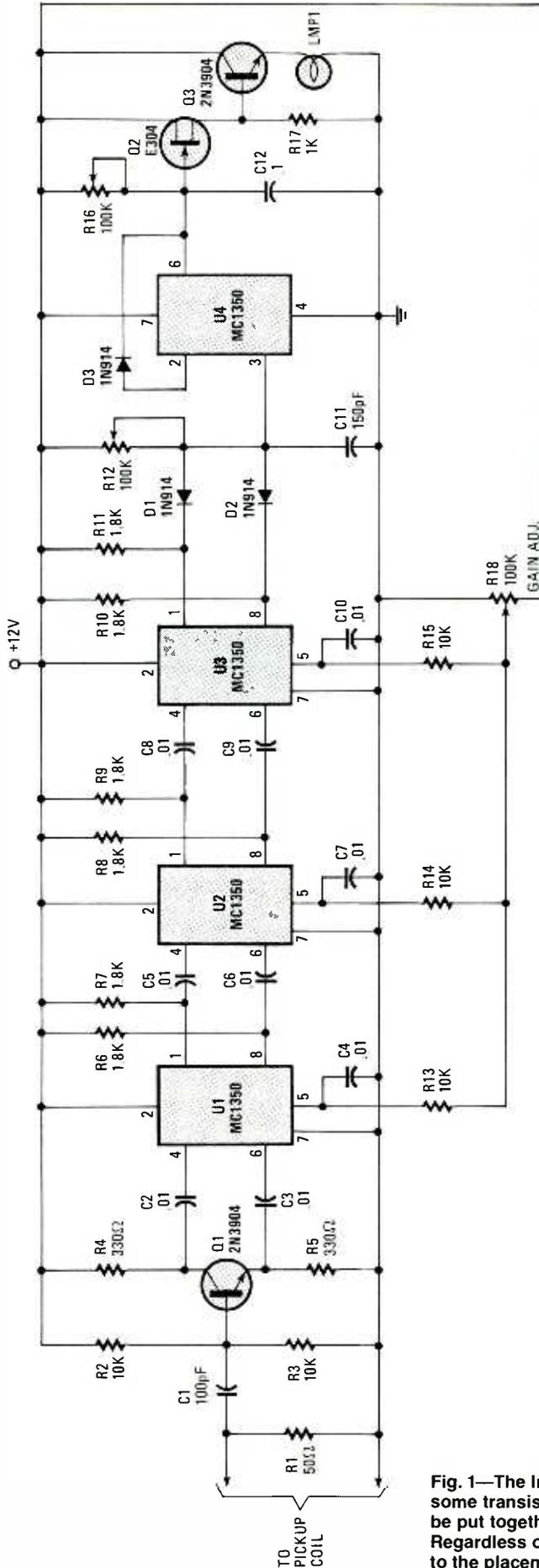
- R1—50-ohm
 R2, R3, R13-R15—10,000-ohm
 R4, R5—330-ohm
 R6-R11—1800-ohm
 R12, R16, R18—100,000-ohm linear-taper potentiometer
 R17—1000-ohm

CAPACITORS

- C1—100-pF, ceramic disc
 C2-C10—0.01- μ F, ceramic disc
 C11—150-pF, ceramic disc
 C12—0.1- μ F, ceramic disc

ADDITIONAL PARTS AND MATERIALS

Printed-circuit materials, pickup coil, enclosure, solder, etc.



However, for stand-alone operation (using an incandescent lamp), a second peak detector or storage circuit is necessary; thus the addition of U4 (a 3140 video IF amplifier capable of single-supply operation) to the circuit. U4's output at pin 6 causes C12 to charge to peak value. The charge is then buffered by Q2 (a source follower) and Q3 (an emitter follower), and used to drive an incandescent lamp. With large signal levels, the voltage drop (0.6-0.7-volt) across diodes D1 and D2 is of little consequence.

The master gain control (R18) adjusts the gain of U1, U2, and U3, via R13, R14, and R15, respectively (which are bypassed by C4, C7, and C10, respectively). An I_{AGC} variation of 0.1 to 0.2 mA typically provides a gain reduction from 0 to -60dB per amp, while the distributed gain control scheme prevents many problems.

R12 and R16 both can be made variable (as shown), or R12 may be a fixed unit with only R16 variable. That would give the user the ability to adjust charging and discharging times, which in turn provides for adjustable scope or incandescent lamp-display hold times.

Construction

There is nothing particularly critical about the circuit. It might even be built on perfboard using point-to-point wiring; but for the best results, it is recommended that it be built on

(continued on page 108)

Fig. 1—The Inductive Current Probe, made up of a four IC's, some transistors, and a handful of additional components, can be put together using the construction method of your choice. Regardless of how the circuit is built, pay strict attention to the placement of the components and their orientation.

Just a little electronic magic allows you to maintain signal levels throughout the audio-component chain.

UNITY-VAC

By Robert Grossblatt



THERE'S A STORY THAT SOMEONE once asked Thomas Edison what he thought about Alexander Graham Bell's new telephone; Edison said that "it's great but the audio quality stinks." Even if the story isn't true, it's a fact that nobody is ever satisfied with audio quality.

The days are long past when audio went straight from the preamp to the main amplifier. Equalizers, companders, limiters, and noise-reduction circuits are only a few of the things that, sooner or later, get stuck in the audio chain.

The longer the audio chain, the more difficult it becomes to maintain audio levels. No matter what the manufacturer claims, each piece of gear adds its own change to the overall strength of the audio signal. If you do a lot of audio processing, you'll find it difficult to keep a constant level throughout the chain. *Unity-Vac*, however, can let you maintain audio levels to within half a dB so you don't have to worry about

overdriving, clipping, and all the other *nasty* things that can happen when you don't keep an eye on signal levels in the audio chain.

The General Idea

Figure 1 is a block diagram of *Unity-Vac*. It produces a close approximation of white noise (more on that when we look at the circuit in detail) to determine the overall gain of the device under test. As you can see, the noise is fed both to the input of your audio gear as well as *Unity-Vac*'s final comparator. The output of your equipment drives the other half of the comparator. The two LED's indicate whether there's more than half a dB of gain or loss in the signal going through your equipment.

Once you've connected your equipment to *Unity-Vac*, switch S1 is put in the CAL position and potentiometer R17 (ADJ.) is adjusted until both LED's flicker. When you've got that done, flip S1 to TEST and adjust the output on your equipment. When both LED's start to flicker, you've achieved unity gain. It's really that easy.

The Big Picture

The complete schematic diagram for *Unity-Vac* is shown in Fig. 2. The white noise is generated by reverse-biasing Q1. The signal produced isn't exactly the same as real white noise, but it's close enough to do the job. White noise has to be used for gain measurements because we need a signal that contains all of the frequencies found within the audio spectrum. If you're really a purist, you can use a real noise-generator like the MM5837, but the voltage requirements for the chip are a pain in the neck. The bottom line is that it's more expensive.

The output signal level of the transistor is very low so it's fed to U1A (half an LF353 dual op-amp), which is set up as a non-inverting amplifier, to boost the signal to 1-volt AC. The output signal is rectified by D1 and D2, and the resulting DC across R8 and R9 is fed to U2, a 1458 dual op-amp, which is

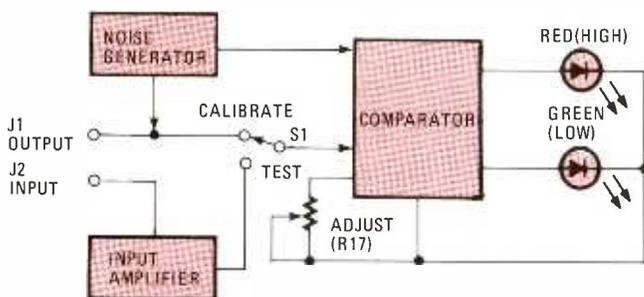


Fig. 1—This block illustration demonstrates *Unity-Vac*'s operation. As shown, the output of the noise generator is fed to one side of the comparator circuit as a reference. The other side is fed either from the unit-under-test, or when in the CAL mode (as shown), from the noise generator. When the two input signals are equal, the two LED's will flicker. However, when there is an imbalance between the two inputs, one LED extinguishes and the other remains illuminated, depending on whether there is a gain or loss in signal level.

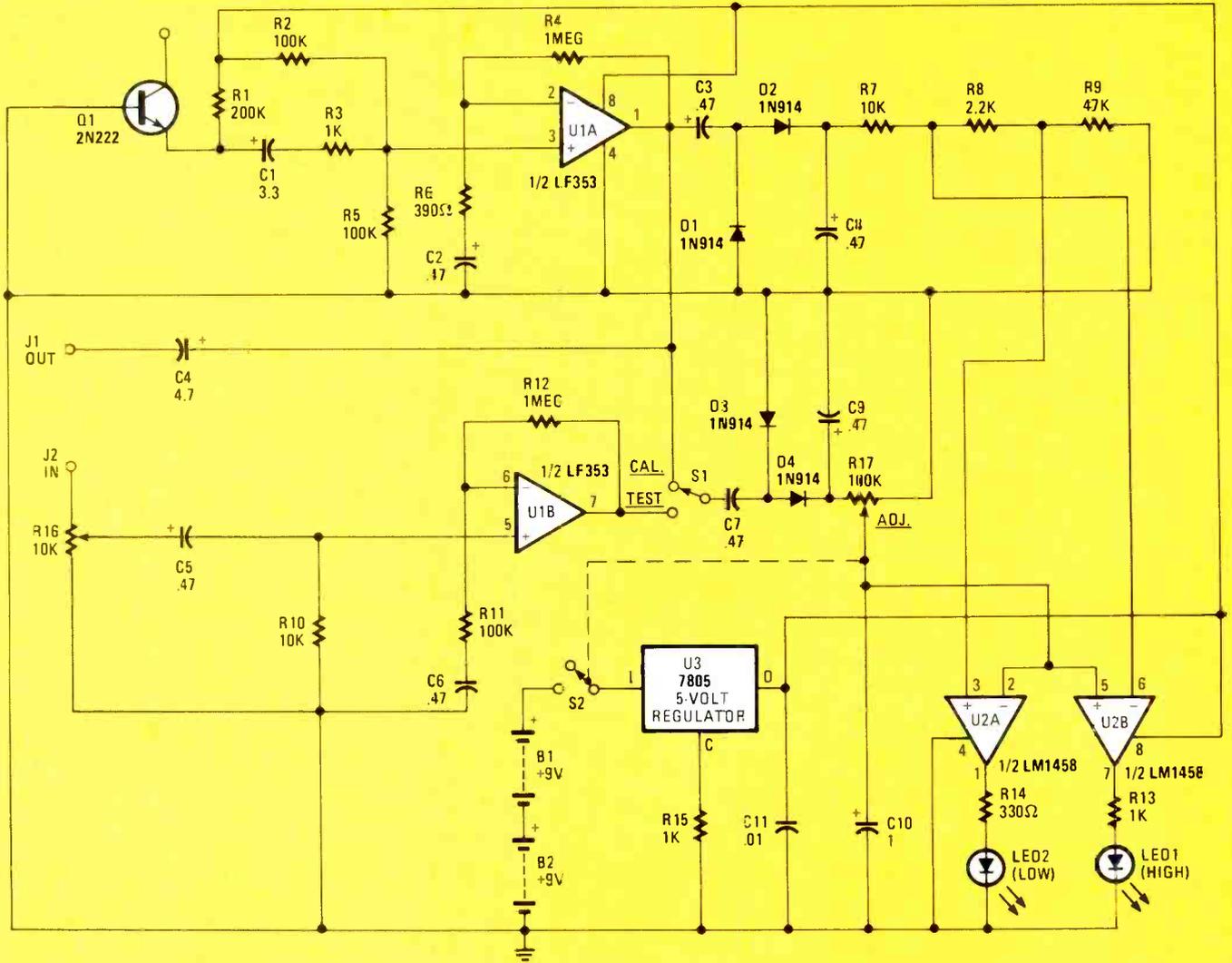


Fig. 2—The schematic diagram reveals that the noise-generator portion of the circuit is really nothing more than a reverse-biased general-purpose, Q1. You'll also note that our comparator circuit is actually two comparators: one configured as negative signal and the other as a positive one. Each comparator drives an LED to indicate the condition of the input signal.

used in a dual-comparator configuration. Half of the chip, U2A, is configured as a non-inverting comparator and uses the voltage across R9 as a reference. U2B, on the other hand, is an inverting comparator with a reference determined by the voltage across R8 and R9. The values chosen for the resistors cause the thresholds of the comparators to differ by slightly less than 1 dB.

When S1 is in the CAL position, the output of U1A is rectified by D3 and D4 and fed to the other side of the comparators. By adjusting R17, you can set the level so that it falls within the upper and lower limits of the comparators. If the signal is too high, the red LED lights; but if it's too low, the green LED lights. As soon as the incoming signal on pins 2 (U2A) and pin 5 (U2B) falls inside the window set by the two comparators, both LEDs begin to flicker and Unity-Vac is calibrated. Calibrating Unity-Vac is really a very simple procedure and takes only a few seconds.

When S1 is set to the TEST position, D3 and D4 are connected to the output of U1B (which is configured for non-inverting operation), and the circuit is ready to perform gain measurements. Figure 3 shows how Unity-Vac is connected to

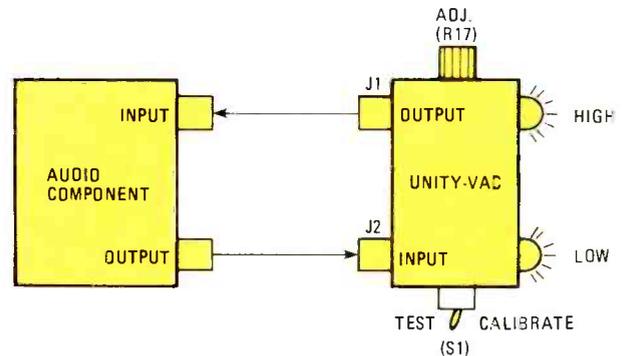


Fig. 3—After calibration, Unity-Vac is connected to the unit-under-test as shown. Unity-Vac's signal from the noise generator is then fed as a reference to the comparator circuit. That signal is also routed through J1 to the audio component and back to Unity-Vac. Depending on the condition of the returning signal, one or the other LED will be on while one is off, or both will flicker.

your equipment. The output at J1 connects to the input of whatever device you're testing and Unity-Vac's input is fed by the device's output. What you're basically doing is con-

necting Unity-Vac across the tape loop. All that you have to do to set your equipment for unity gain is to adjust its level control until both LED's flicker.

Power for the circuit is supplied by two nine-volt batteries and regulated by U3, a standard 7805. The ground leg on the 7805 is lifted with a 1000-ohm resistor to raise the regulated potential up to 11 volts. Q1, the reverse-biased transistor, needs that much voltage to start generating noise. Since we're using the transistor in a non-standard way, different transistors will want different voltages before they'll work in the circuit. Eleven volts should work in the majority of cases; but if more is needed, you can increase the value of R15 in 50-ohm increments. Keep an eye on the voltage as you do so, because there's a good chance that you'll fry the op-amps if the regulated voltage gets above 15 volts.

Construction

Because the circuit is so simple, you can use just about any kind of construction. It's always best to use a printed-circuit board, but you can build it on perfboard or wirewrap it if you like doing things that way.

For the most part, the values given for the components are flexible, too. If you plan on building Unity-Vac from your junkbox, feel free to substitute parts. Even the op-amps can be changed if you happen to have some others on hand. The

only word of caution relates to R8 and R9, which are used to set the comparator thresholds. The values given are the result of a compromise between a lot of *hairy* math and practical resistor values.

If you do have to substitute for those parts, stick with five percenters, stay within about twenty percent of the values listed and *above all*, keep the same ratio between them. A change in the ratio has a greater effect on the circuit parameters than does a change in the values. R9 has to be twenty times greater than R8. You can vary that by about five percent, but any more than that will have a significant effect on Unity-Vac's accuracy.

Building the circuit is straightforward. You can use the printed-circuit pattern shown in Fig. 4, and then stuff it according to the parts-placement diagram shown in Fig. 5. If you go that route, all the necessary off-board connections are brought to the edge so it's really simple to wire the circuit to the off-board components—the LED's, switches, and so on. You should do the same thing regardless of the method you use to assemble the circuit. By doing things that way, the connections are much easier to make and, more important, the circuit is much easier to troubleshoot. Note that the parts-placement diagram does not show capacitor C11 mounted on the board; it can be tack-soldered to the under-side of the board between the regulator output and the ground trace. (Leaving it out may cause the circuit to break into oscillation.)

Once the circuit is assembled and you're confident that there are no construction errors—solder bridges, misoriented components, etc.—put S1 in the CAL position and apply power. One of the LED's should light and, as R17 is rotated, you should reach a point at which both LED's begin to flicker. Turning R17 past that point causes the first LED to go out and the second one to stay on. If that happens, the circuit is working correctly and ready to be calibrated.

Problem Solving

Troubleshooting Unity-Vac is not too difficult since the circuit is very simple. The first thing to do is to check all of the usual things—solder bridges, broken traces, orientation of polarized components, and so on. If you're absolutely sure

PARTS LIST FOR THE UNITY-VAC

SEMICONDUCTORS

- D1-D4—1N914 silicon small-signal diode
- LED1—Jumbo red light-emitting diode, 20 mA
- LED2—Jumbo green light-emitting diode, 20 mA
- Q1—2N2222 NPN silicon transistor (see text)
- U1—LF353 dual operational amplifier, integrated circuit
- U2—LM1458 dual operational amplifier, integrated circuit
- U3—LM7805 5-volt 1-A regulator, integrated circuit

RESISTORS

- (All resistors ¼-watt, 5% fixed units unless otherwise noted)
- R1—220,000-ohm
 - R2, R5, R11—100,000-ohm
 - R3, R13—1000-ohm
 - R4, R12—1-Megohm
 - R6—390-ohm
 - R7, R10—10,000-ohm
 - R8—2,200-ohm
 - R9—47,000-ohm
 - R14—330-ohm
 - R15—1,000-ohm (see text)
 - R16—10,000-ohm trimmer potentiometer
 - R17—100,000-ohm potentiometer with SPST switch S1

CAPACITORS

- C1—3.3- μ F, 16-WVDC Tantalum
- C2, C3, C5-C9—.47- μ F, 16-WVDC Tantalum
- C4—4.7- μ F, 16-WVDC electrolytic
- C10—1- μ F, 16-WVDC electrolytic
- C11—.01- μ F, 16-WVDC Tantalum

ADDITIONAL PARTS AND MATERIALS

- B1, B2—9-volt DC transistor radio battery
- J1, J2—Phono jack, RCA-type, female chassis-mount
- S1—SPST
- S2—SPST toggle switch (Part of R17)
- Printed-circuit materials, battery clips (2), enclosure, wire, solder, etc.

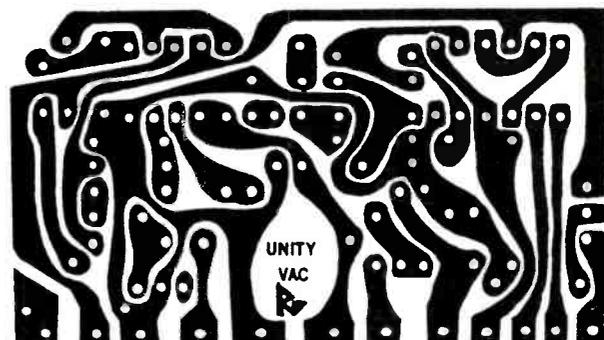
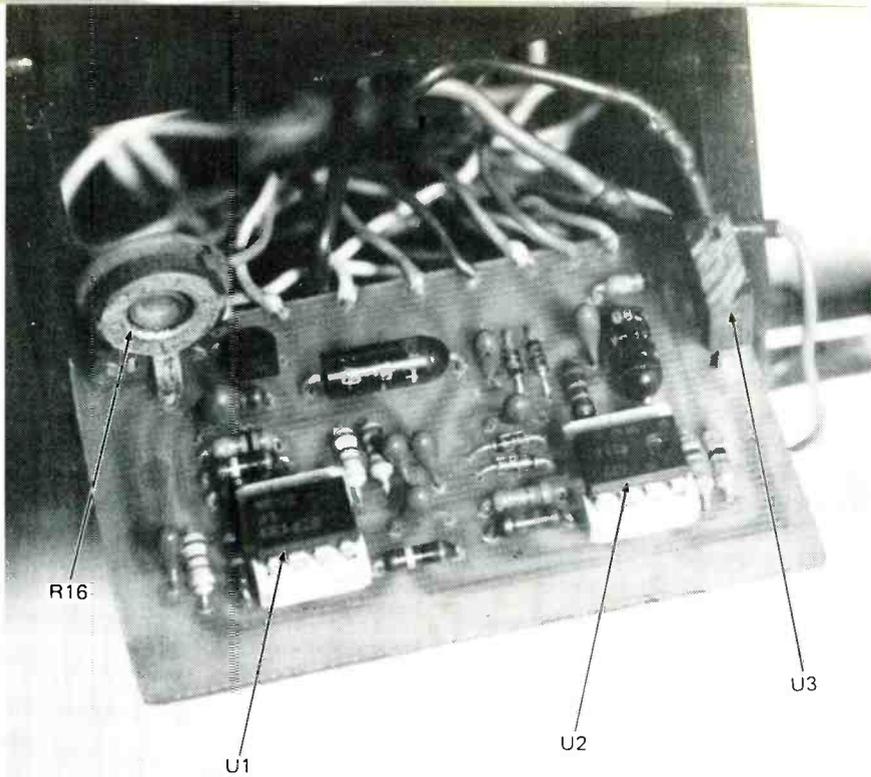


Fig. 4—The author built Unity-Vac on a small piece of printed-circuit board, for which a template is shown. It may be copied or lifted from the page to produce your own circuit board.

The following is available from Mao Electronics Company, P.O. Box 6871, Alexandria, VA 22306:
Printed-circuit board, \$7.50
Complete kit of parts (excluding the case), \$20.00
Please allow 6-8 weeks for delivery

Note that all the capacitors in the circuit, except two, are Tantalum units. But, because the circuit is forgiving of substitutions, electrolytic units may be used. In fact, the only critical part of the circuit is the ratio between and not the values of, R8 and R9. If those parts are substituted, it is essential the the same ratio is maintained.



By connecting Unity-Vac to individual components in the audio chain, signal levels throughout the system can be maintained.

that the circuit is mechanically OK, the next step is to check the noise generator.

The audio level at the output of U1A is high enough to drive a line input so you can connect it to your amplifier and listen. If it's working, you'll hear a hiss. If you don't hear anything, try changing Q1. If that doesn't work, make sure that the 7805 is putting out 11 volts. The last thing to do is increment the value of R15 as described earlier.

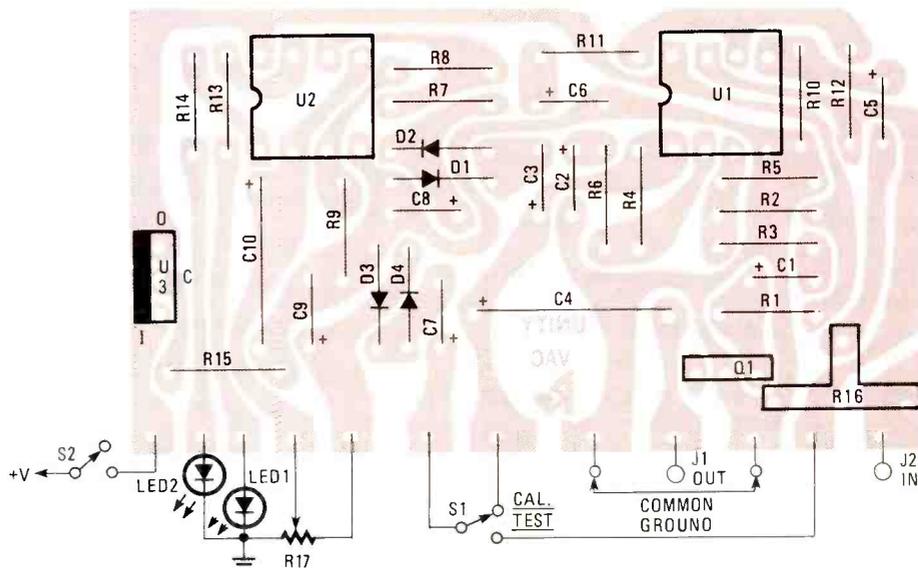
Before Unity-Vac can be used, there's an internal calibration that has to be done. If you look at the schematic diagram in Fig. 2, you'll see that U1B is really more than just a buffer—it actually amplifies the input signal. Therefore, potentiometer R16 has to be set to offset the gain on the op-amp. Power up Unity-Vac, flip S1 to the CAL position, and turn R17 until both LED's are flickering.

When that's done, connect J1 and J2 together and flip S1 to the TEST position. One of the LED's will more than likely go out since there's some gain or loss through U1B and R16.

When you have J1 and J2 connected, slowly rotate R16 until both of the LED's flicker. And that, as someone once said, is that. You've just adjusted the circuit so that there's zero gain through the op-amp. If you flip S1 between TEST and CAL, you'll see that both of the LED's continue to flicker. One consequence of designing U1B with gain is that you can use Unity-Vac to test for any amount of gain or loss. You'll have to use an external VU meter to set signal levels, but you can adjust R16 to compensate for any amount of signal loss or gain. If, for example, you set R16 for a 3-dB loss through U1B, Unity-Vac will test for a 3 dB gain in your equipment.

Once you have Unity-Vac up and running, you'll wonder how you ever managed to do without it. If you're really into audio, setting gain is an important part of producing good fidelity. Unity-Vac makes the job so easy and painless that you'll probably make it a regular part of your setup procedure. ■

Fig. 5—This parts-placement diagram makes putting Unity-Vac together a snap. Note that C11 is not shown in the placement diagram; it is easily tack-soldered to the copper side of the board. When installing the parts, make sure that they are in the right place, properly oriented, and that there are no solder bridges.



RETROFITTING THE COMMODORE DISK DRIVE

A simple retrofit makes it easy to select
Commodore 1541 disk drives.

By Lou Hinshaw

□WHEN MY WIFE AND I TIRED OF ARGUING OVER WHO HAD *dibs* on our Commodore 64, we added a second complete C64 system: because we wanted to be able to use two disk drives with either computer, or one drive with each. That arrangement ruled out conventional drive-select programming, because Commodore's model 1541 disk drive requires removal of the cabinet to change its programming.

The solution to the drive-selection problem was to install selection switches on the side of the cabinet. In that way, we could easily make the drive function as any of the four available device numbers, and we would not be bothered with the problem again.

Although modifying the circuitry that determines a disk drive's selection might sound complex, for the Commodore 1541 it's a very inexpensive and simple task: All it takes is three short wires, two switches, the usual hand tools, and lots of extra care. Yet, even with the extra care, the whole job took only about 30 minutes.

Let the Warranty Expire

The first thing you should keep in mind is that any retrofit will void the disk-drive's warranty, so don't make any changes until after the drive has had a "full shakedown"—meaning, the entire warranty period.

The next thing is not to do the job when the relative humidity favors the generation of static electricity: That is, if you're shocking yourself getting in and out of your car or when walking across the carpet, leave the project for a day when the air is more humid. Also, prior to the actual soldering, touch the tip of the soldering iron and a finger to the metal chassis to equalize potentials between the iron, and the drive's printed-circuit board.

When you're ready to work, gather your tools, clear a place to work, and find a plastic buttermilk tub for screws. You'll need a Phillips screwdriver, a 10-to-20-watt soldering iron, needle-nose pliers, wire cutters, a pocket or utility knife, a way to cut a notch in the side of the disk drive's case, and a way to drill four holes in the case (for the switches' mounting screws).

For materials, you'll need some scrap wire, solder, screws and nuts, and two miniature SPST slide switches (such as the Radio Shack 275-408).

Installing the Retrofit

Turn the disk drive upside down and loosen the four screws located in the deep holes in the bottom of the case. When you're certain that the screws are loose, place a small length of tape over each hole so that the screws can't fall out. Then hold the case together and turn the drive upright.

Next, carefully lift the top of the cabinet off the drive and set it aside. That will reveal the perforated metal cover of the circuit board. Turn the drive so that the front is toward you, as if ready for use. Then look on the left side of the drive. You will see two screws that hold the perforated metal lid on the drive's electronics. Remove the two screws.

Lift the metal lid up from the left side where the screws

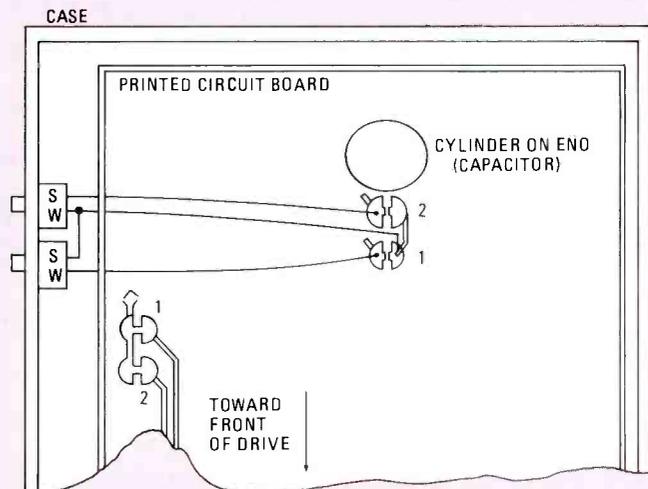


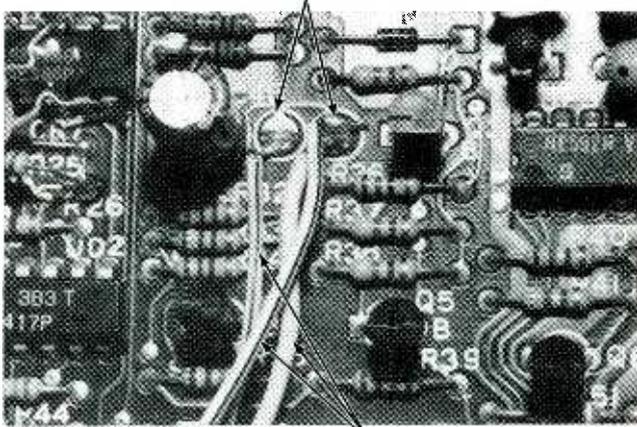
Fig.1—This figure is not to scale and not proportional. It is specifically intended to help you locate the drive-select solder pads by showing only their shape and relative location.

were. The opposite side is secured by only a pair of dimples in the lid: remove the lid and set it aside. You will see the printed-circuit board. You must tack-solder three wires to numbered solder pads located on the board.

Two different locations were used for the solder pads—depending on the particular production run. Figure 1 shows the two locations of the solder pads (only one of which will be in your disk drive), their individual shape, and their relative location. The older drives will have the pads located on the edge of the board; the newer drives have the pads near the center of the board.

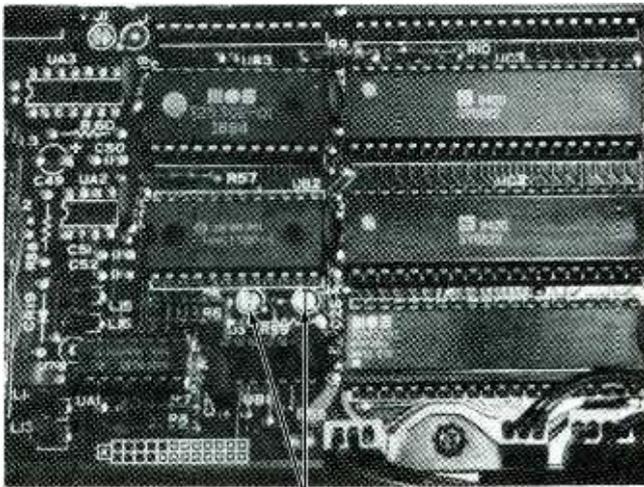
But a note of caution! The latest drives may have another set of pads, located toward the rear of the board. Unlike the numbered solder pads, the “extra” pads will not be connected together on the ground side, and they will be spaced farther apart. Do not disturb them.

DRIVE SELECT SOLDER PADS



WIRES TO SWITCHES

Install the wires on the solder-pads before connecting them to the switches. Simple tack-soldering is sufficient



FALSE SOLDER PADS

Be careful not to use the “false” solder pads, which appear very similar to disk-select solder pads. The false solder pads are located near resistors R5, R6, and R59.

Install the Switches

Find a place for the switches on the left side of the case that is as close as possible to the pads. Cut a notch in the case to accommodate the switches and drill holes for the mounting screws. Be certain that you can mount the switches so they will not wiggle around, and that you can close the case.

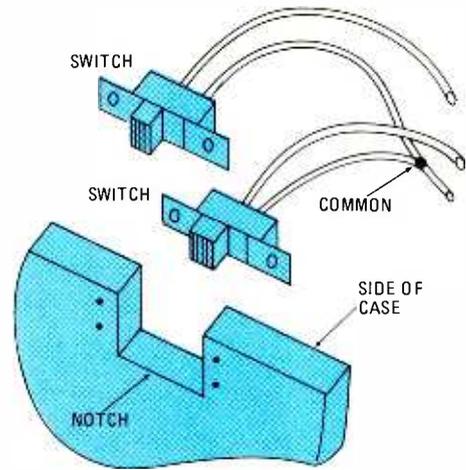
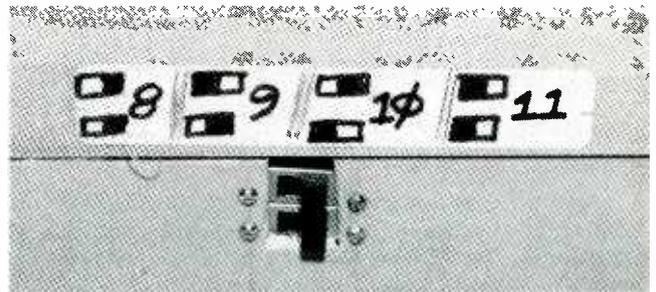


Fig.2—Cut individual notches for each switch in the side of the case. Don't attempt to gang the switches in a single notch because the switches must be rigidly mounted.



Apply a small drawing directly above the switches indicating the correct setting for the various drive assignments.

Ascertain that by bolting the switches in place and putting the top on the drive. If the top fits correctly, set it aside and proceed with the retrofit.

Notice, from Fig. 1, that each pad is divided into two half-circles connected to each other by a thin foil between the adjacent straight edges. Carefully cut and remove the foil.

Also, as shown in Fig. 1, a foil leaves one half of each pad and goes somewhere else. The other half of each pad is joined by another foil. *Do not cut the foils that lead away from the round edges of the pads.* Cut only the foils inside the pad itself—the one that connects the two halves of the pad.

Cut three wires just long enough to reach easily from the solder pads to the switches when they are mounted on the case. Solder a wire from either one of the pad sides that share a common trace; then solder a wire to each of the pad halves that has its own trace; that will give you three switch leads. The one connected to two pads is the common wire; the other two are *number wires*.

Next, solder one *number wire* to one contact on one switch. Solder the other *number wire* to the other switch the same way. Then solder the common wire to the other free contact on both switches. Doublecheck the connections.

Finally, mount the switches in their notches. (Be certain that the black and red wires to the disk drive's LED indicator—which pass near the switches—aren't damaged.)

Final Checkout

Make a diagram of the switches like the one in the photograph. Connect the open drive to the computer, turn the drive and the computer *on*, type: LOAD "\$", 8 and press RETURN. If the screen says *searching*, then *load-*

(Continued on page 103)

ZX-81 PARALLEL PRINTER INTERFACE

□ ONE OF THE MOST PRACTICAL ACCESSORIES FOR ANY COMPUTER is a conventional printer, but some computers were not initially designed to work with a standard "Centronics-type" parallel printer—which is the kind that's usually available at low to moderate cost.

The Sinclair ZX-81 was among those personal computers that made no provision for interfacing with conventional printers. But if you're into a ZX-81, and have looked longingly at those \$100 standard-paper printers, here's your chance to upgrade your computer with a standard printer interface.

Centronics Compatible

The interface shown in the photographs—and its driver program—allows the ZX-81 to operate any printer that is "Centronics-compatible." In keeping with the Sinclair philosophy of making it small, simple and inexpensive, the interface uses five commonly available integrated circuits and a few capacitors. The most expensive parts are the connectors. If you have a well-stocked junkbox, or the extreme patience to solder ribbon cables, the project will cost you under \$20.

How It Works

To understand a parallel interface, let's look at what the printer expects and what it does in response. The important

parallel printer connections are eight (sometimes seven) data lines that input character codes, a STROBE connection, and the BUSY and/or the ACK *handshake*. Other connections might be provided for control purposes, but those are absolutely required.)

The computer tells the printer that new data is available through a short negative pulse on the STROBE connection. The printer reacts by bringing the BUSY connection high to stop output from the computer, and then processes the character (it may print it immediately or store it in an internal buffer memory and print later.) When the printer is finished processing, it produces an ACK (knowledge) pulse similar to the STROBE and brings the BUSY low. Obviously, ACK and BUSY convey similar information so only one need be monitored. (Most personal computers recognize the BUSY rather than the ACK.)

The ZX-81 printer interface shown in Fig. 1 has this general design: It uses 8 data lines for the character code (Centronics connector pins 2-9), produces a STROBE pulse (pin 1), and monitors BUSY (pin 11) to determine when to send the next character. ACK (pin 10) isn't used. Those connector pins are "standard" and should be compatible with virtually all parallel printers; but just to be safe, check your printer's manual for unusual pinouts.

The output port is a 74LS374 octal dual flip-flop which will latch the data from the computer on the printer data lines



By Rudy Massey

**Now you can use any
standard parallel printer
with your ZX-81 home computer.**

Fig. 1—Some Centronics-type printers need only the SO1, pin 16 signal ground connection; others require all the data-line returns on pins 19-23. If your printer doesn't work with only pin 16 grounded, all other grounds must be made on SO1, or on its matching plug (the one from the printer).

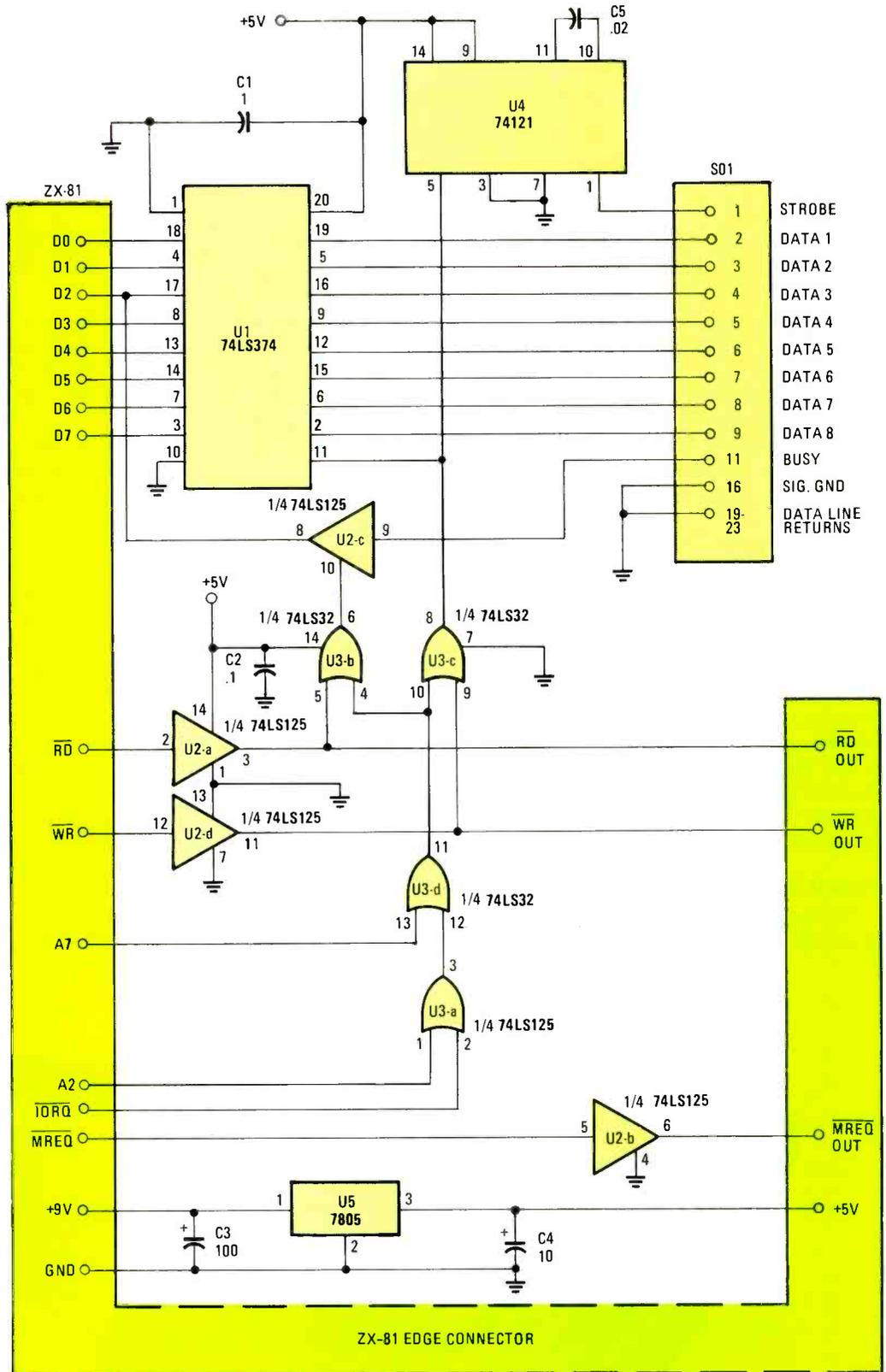
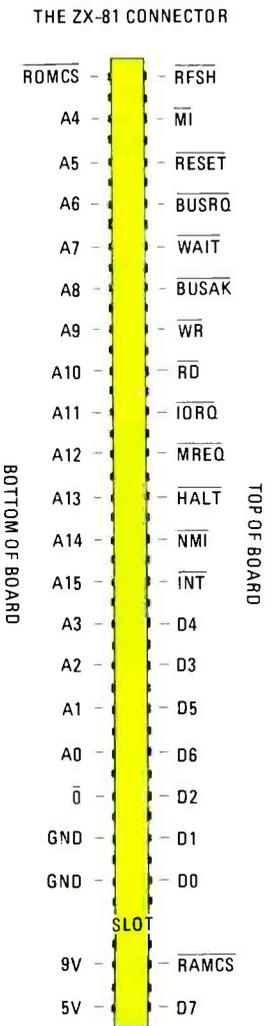


Fig. 2—The ZX-81's connections on the top and bottom of the system connector are different. Make certain that you get them right the first time—you might not get a second chance.



**PARTS LIST FOR
ZX-81 PARALLEL PRINTER INTERFACE
SEMICONDUCTORS**

U1—74LS374 octal dual flip-flop integrated circuit
U2—74LS125 three-state quad buffer integrated circuit
U3—74LS32 quad 2-in OR gate integrated circuit
U4—74121 monostable multivibrator integrated circuit
U5—7805 5-volt regulator

CAPACITORS

C1, C2—0.1- μ F, 50-WVDC disc capacitor
C3—100- μ F, 16-WVDC electrolytic capacitor
C4—10- μ F, 16-WVDC tantalum capacitor
C5—0.02- μ F disc capacitor

ADDITIONAL PARTS AND MATERIALS

SO1—Centronics-type connector, solder type
Enclosure/PC Board (Radio Shack 270-291)
50 pin card edge connector
12-inches 50-conductor ribbon cable
6-10 feet 20-conductor ribbon cable
46 pin section of 0.1" spaced double row header
1½" wide section of double-sided 0.1" spaced card edge
Wire-wrap materials, bus wire, solder

OPTIONAL PARTS AND MATERIALS

20-pin header connector 50 pin header connector
20-pin double-row right angle wire-wrap header
50-pin double-row wire-wrap header
The following are available from Zebra Systems, 78-06
Jamaica
Ave., Woodhaven, NY 11421.
C110 Edge connector—\$5.95
C111 Protocard—\$9.95
C112 Extension connection—\$2.50
Please add \$3 per total order for shipping and handling
(only via UPS). Additional \$3 for COD via UPS.

when a falling pulse is sensed on its control line. A STROBE pulse is produced by a 74121 monostable multivibrator set up to trigger on a rising edge (note only one capacitor is needed with this IC to set the duration). By using the same negative going pulse to trigger both, an output to this port signals the printer automatically. The BUSY line is monitored by a one bit input port formed by a 74LS125 quad buffer. This IC has three-state outputs that isolate the gate from data line D2 when the control line is high. To define these ports as in/out, RD and WR are OR'ed to the enable lines (after buffering to reduce loading due to the piggy-backed memory) via a 74LS32 quad OR gate. One of the remaining gates must be used for IORQ (to differentiate from memory operations) and the other two are for address-line decoding. Both input and output can use the same address.

Port Usage

Here we must pause to mention the port usage of the ZX-81. Although the Z-80A microprocessor inside can address any of 256 input/output ports defined by decoding lines A0 through A7, eight ports can be had with no decoding: just activate one device off each line. Sinclair completely decoded only one address, FF(hex) or all lines high. That, plus FE(hex) and FD(hex), which correspond to A0=low and A1=low respectively, are used internally. FB(hex) is used for the output to the Timex/Sinclair printer, decoded by the printer as A2=low and A7=high. That leaves available A2=low and A7=low, which is appealing in our case be-

cause there are just enough inputs to decode A2 and A7 low. Thus, 7B(hex) will avoid all "taboo" ports and still leave plenty available for other devices.

It will be apparent if you look closely that it doesn't matter which input A2, A7, or IORQ use since they all must be low. But if A2 and A7 occupied the same gate, it would change states much more often than necessary. Using A2 and IOREQ together eliminates that. It might be nit-picking, but if the choice is ours—why not? MREQ was buffered with the one remaining gate but any choice is fine.

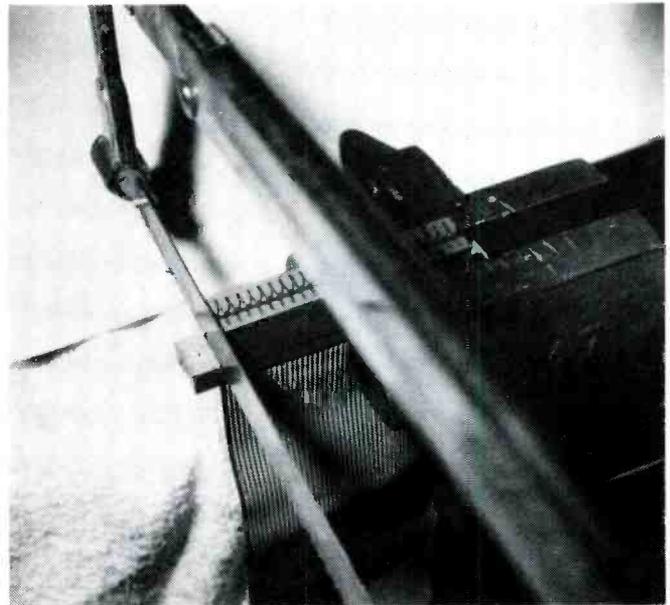
That's all there is to the circuit! Outputting a character code to port 7B(hex) will send it to the printer. Input on the same address; and if bit 2 is high, the printer is busy.

Construction

Because the ZX-81 is almost certain to have a memory pack attached, and Sinclair's own pack—the one often supplied with the computer—has no output to allow piggybacking peripherals, it seemed necessary to provide one in the interface's design. That probably doubles the complexity of construction; so if you have no need of an output, do yourself a favor and eliminate it (and all those connections). Likewise there is a 5-VDC line available on the ZX-81's output which will power the device (the interface is only 50 ma. or so), but tests showed a great increase in TV interference when it was used. If TVI is of no concern, you should be able to eliminate the regulator circuit (keep the 10- μ F Tantalum capacitor on the 5-volt line).

Initially, a small perfboard/box combination from Radio Shack seemed perfect: All hardware is included and the board's holes are copper ringed, so point-to-point or wire-wrapped connections are possible. But solder the connections when strength or reliability is important.

(The space gets tight when the output connector is installed, so if you have trouble working in close places you might want to use a "protocard" and connector set specifically intended for homebrew ZX-81 projects. The parts are available from Zebra Systems, 78-06 Jamaica Ave., Woodhaven, NY 11421. See the parts list for additional details.)



If you make your own edge connectors, use a hacksaw to cut a standard connector down to size.

Let's start with the input connector. As shown in Fig. 2, the ZX-81 requires a non-standard card-edge connector that can be made from a 50 pin type. Before you clamp it on the ribbon cable, use needle-nose pliers to push out the two metal displacement pins on each end, then the third set in from what is to be the right side. (That is where the "key" will be.) Then use a small vise to evenly clamp the connector on a short piece of 50-wire ribbon cable.

Make a deep cut with a hacksaw on each end through the area where the pins were removed, then cut in from the side to provide clearance for the computer's cabinet. A small file can enlarge the space for the "key"—the key being a piece of plastic or circuit board that fits into the slot on the ZX-81's connector. The other end of the cable is soldered to the interface board, but a wire-wrap header would be easier (if you don't mind spending a few extra dollars). Keep in mind that the two wires on each edge aren't connected.

The output connection for the printer uses a 20 pin header, but direct soldering can be used. Since the BUSY line is needed—which is pin 11 on the Centronics connector—a 20 wire cable can't be used with an insulation displacement connector because only the first 10 pins would be used—the connection on pin 11 would be missed. A solder-type Centronics connector allows skipping pin 10 and using pin 11. (That's just one of many solutions. Use what you have so long as the necessary connections are made.)

Install the wire-wrap sockets with solder or glue in the positions shown (not much deviation is possible.) The output board can be cut from an old printed-circuit board or etched

TABLE 1—LOADER PROGRAM

```

10 REM ... (200 CHRS) .....
.....
20 LET A=16514
30 SCROLL
40 FOR B=1 TO 8
50 INPUT A$
60 IF A$="" THEN STOP
70 IF LEN A$<>2 THEN GOTO 50
80 POKE A,16*CODE A$(1)+CODE A
$(2)-476
90 PRINT A$+ " ";
100 LET A=A+1
110 NEXT B
120 IF A>=16699 THEN STOP
130 GOTO 30
140 REM RUN THIS FOR PRINTER
TEST
150 LET A=16514
160 LET A$=STR$ A+ " "
170 FOR Z=1 TO 8
180 LET B=PEEK A
190 LET C=INT (B/16)
200 LET D=B-(C*16)
210 LET A$=A$+CHR$ (C+28)+CHR$
(D+28)+ " "
220 LET A=A+1
230 NEXT Z
240 IF A>16713 THEN STOP
250 LET A$=A$+CHR$ 8
260 RAND USR 16529
270 GOTO 160

```

TABLE 2—HEX CODE TO ENTER

21	D1	40	7E	EE	20	77	21
DF	40	7E	EE	20	77	C9	2A
10	40	EB	2A	14	40	E5	A7
ED	52	44	4D	E1	2B	2B	3E
46	ED	B9	E0	23	23	7E	A7
C8	47	23	23	7E	E5	CD	B7
40	E1	10	F7	C9	FE	80	20
04	D6	60	18	2E	A7	FE	1C
38	20	FE	26	30	04	C6	14
18	21	FE	40	30	04	C6	1B
18	19	FE	9C	D8	FE	A6	38
07	FE	C0	D0	D6	45	18	0B
D6	80	21	16	41	5F	AF	57
ED	5A	7E	FE	0D	20	05	CD
F6	40	3E	0A	F5	DB	7B	E6
04	20	FA	F1	D3	7B	C9	06
03	21	12	41	7E	A7	C8	CD
F6	40	AF	77	23	10	F5	C9
00	00	00	00	20	09	0E	14
0F	12	1B	08	0D	0A	0C	22
23	24	3A	3F	28	29	3E	3C
3D	2B	2D	2A	2F	3B	2C	40
27	5F	26	21	22	7C	25	5B
5D	25	00	00	00	00	00	00

from scratch. Sandwich it between a section of dual header pins (it just fits) and solder. After trimming for proper fit on a connector or *rampack*, solder it to the board (there's a lot of stress here, so do a good job.) Next, install U5, the voltage regulator.

Begin making the connections with the ground and power wires. Those lines are direct-soldered where possible, using bus wire. Next, connect all the capacitors (check polarity). At this point, it's a good idea to use a bench power supply to locate any problems while they can be easily fixed. Input about 8-VDC to the regulator and check for proper voltage at the sockets.

The wire-wrap pins are too long to fit inside the case so they must be trimmed to less than half their normal length. That doesn't leave much for multiple connections, so take extra care. Make the connections to the integrated circuit sockets first, using the schematic to identify the pins. Next, wire the output board to the input, and finally, the printer cable connector. Take your time; use a continuity tester to TRIPLE check your work, and *never* take any connection for granted. The ZX-81 is relatively tolerant of shorts but its output bus isn't buffered and major damage can occur. When it's all wired and you are sure it's correct, insert the integrated-circuits. Then connect the remaining components and power up the computer.

If you don't get a cursor on the screen in a reasonable amount of time, turn the power off and check your work. If there is a cursor, congratulations! Now you can fit the case.

The main cable enters through a small slot easily cut in the bottom case half. Likewise, the printer cable slot is totally in the bottom half.

The output board requires a hole in the top of the cabinet. (The plastic cabinet is soft and easily cut and filed.) Drill a few holes in the bottom of the cabinet for ventilation. If you have been careful, the interface will resemble a commercial product.

It's a tight fit, but the interface will fit into a combination perfboard/box sold by Radio Shack. But you'll have to cut slots in the case for the connectors.

The Software

The program (listing in Table 1) searches the variable storage area for "A\$" (any string can be substituted, more on that later) and outputs the whole string (256 bytes maximum) to the printer port. The graphics characters (Sinclair character codes 1-10) and the inverse numbers can be defined any way you want: as control codes, special characters, or whatever the printer will accept. This allows you to take advantage of the ZX-81's excellent string handling to do much of the work arranging and imbedding characters. Just define the string (no arrays, DIM A\$ is out!), and use "RAND USR 16529" to print it.

To create the program, copy the program listing in Table 1 and use it to load the actual code given in Table 2. You will be left with a first line that looks like gibberish but actually contains the machine code. Now all lines except the first can be deleted. That *must* appear as the first line of any program using the interface.

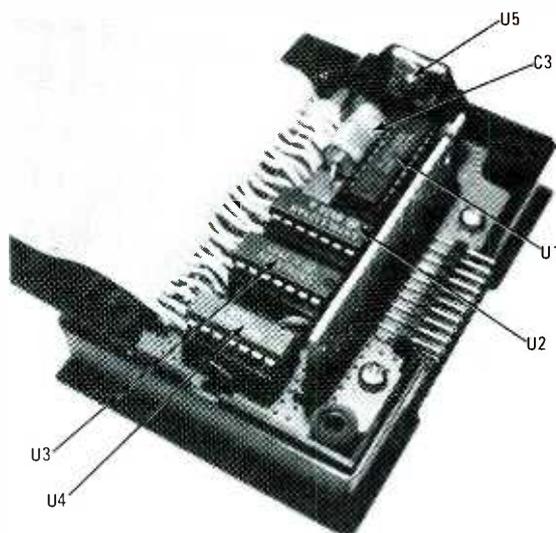
A couple of utilities, that are also included for convenience, should be explained. As loaded, the program prints all "normal" ZX-81 characters as upper case, and all inverse characters as lower case that seems to work out best overall, but some programs need just the reverse. That is easily done by RAND USR 16514. The program is a toggle: Each time it is called it reverses the cases. Also included is a "just in case" program that outputs up to three bytes—starting at address 16658—directly to the printer. (It could be convenient if you don't want to redefine any characters for one-time use.) RAND USR 16641 calls it after you have POKED the codes in the addresses; those addresses are cleared after each use.

Address 16546 holds the code of the string printed; "A\$" is 70(decimal), "B\$" would be 71, "C\$" 72, and so on. Just POKE the code you need here to change the string printed.

While most printers use ASCII character codes and will respond properly, there are always some individual control

TABLE 3—CHARACTER CONVERSION

Sinclair CHRS Code	Output to Printer		Output Address
	Hex	Decimal	
Graphics			
1	09	9	16663
2	0E	14	16664
3	14	20	16665
4	0F	15	16666
5	12	18	16667
6	1B	27	16668
7	08	8	16669
8	0D	13	16670
9	0A	10	16671
10	0C	12	16672
Inverse #'s			
156	40	64	16689
157	27	39	16690
158	5F	95	16691
159	26	38	16692
160	21	33	16693
161	22	34	16694
162	7C	124	16695
163	25	37	16696
164	5B	91	16697
165	5D	93	16698



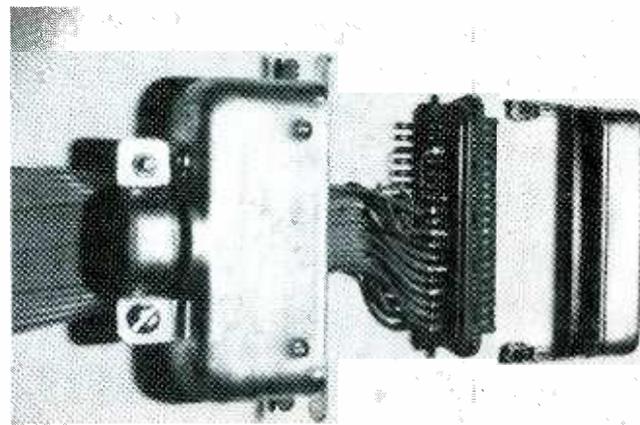
and character codes. The program will probably need customizing to allow their use. The codes output in response to Sinclair graphic characters (Sinclair codes 1-10) are held in sequence beginning at address 16663. Those resident are all control codes. Inverse number codes are in sequence from address 16690. Those are set up to print characters not on the ZX-81 keyboard. (See Table 3 for conversions.) To add codes for your printer, just POKE the decimal value you want output to the address required (avoid POKES outside those two areas).

One last possible modification: The program automatically outputs a "linefeed" after a "carriage return." If your printer is set up to require just the "carriage return," it will print double-spaced lines. To correct that in the program, POKE 16623,24.

As you can see, that is something different from the LPRINT command, and although not as simple as LPRINT to use, the program is far more versatile.

Existing programs should be easily modified once the code is resident in the first line. Just replace the LPRINT statements with a string definition (don't forget to use control codes, particularly a carriage return): the RAND USR 16529.

The first time you see the printer busy taking orders from this "toy" computer could be slightly shocking. You won't believe that something so small can tell a big printer what to do. It gives you a new respect for the power of those little marvels. ■

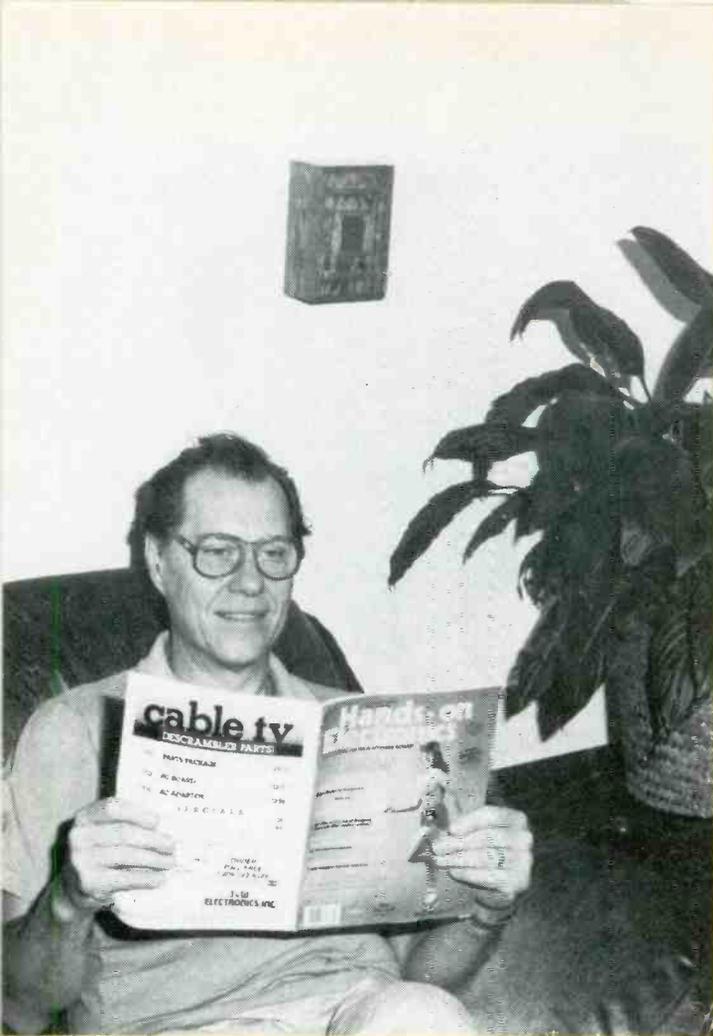


Although ribbon cable is used for the printer output wires, use a solder-type Centronics connector.

MUSICAL DOORBELL

Greet visitors to
your home with a song

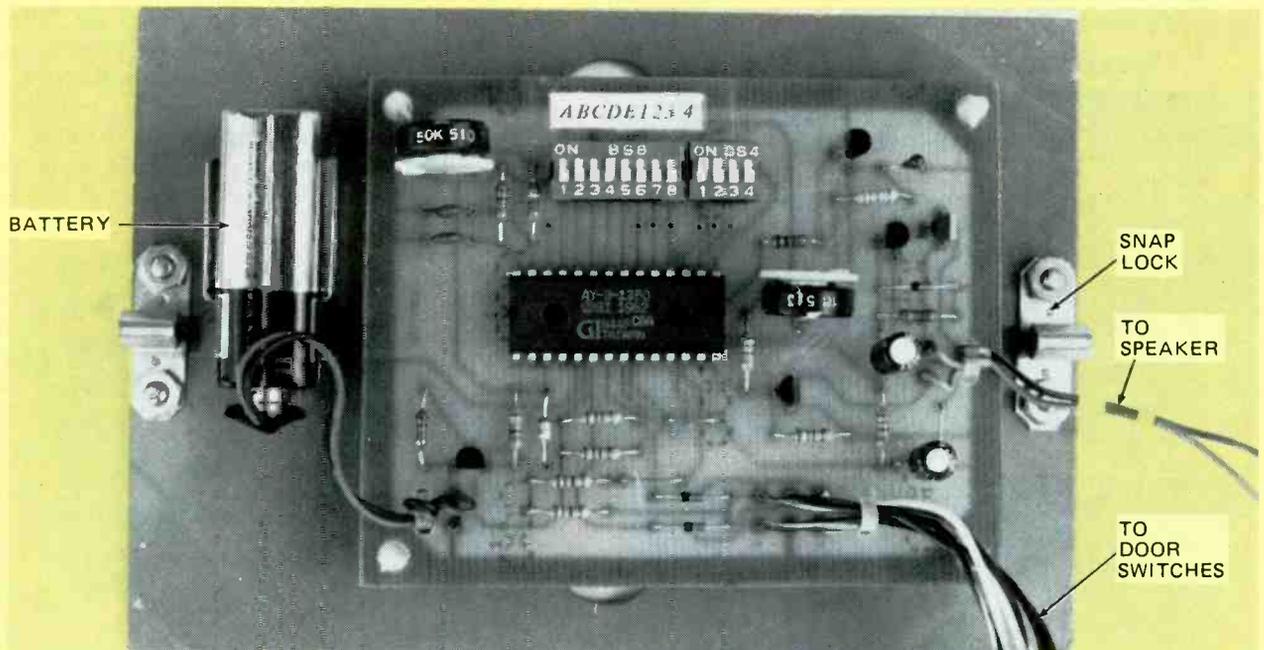
By Davis A. Ward



THE MUSICAL DOORBELL IS A PROJECT CERTAIN TO IMPRESS your friends, your neighbors (or anyone else who comes to your door) because instead of hearing a *ding-dong*, or *buzz-buzz* when they press the bell switch, they'll be welcomed by a recognizable melody, or a musical chime.

The project is built around integrated circuit U1, a General Instrument AY-3-1350 melody-synthesizer chip that is factory-programmed to play 25 melodies and three kinds of chimes. (A complete list of melodies and chimes is shown in the table.) Two DIP switches, S1 and S2, permit you to select the desired melody or chime.

Three door-switch circuits are provided so that the *Musical Doorbell* can service up to three separate entrances. Depending on the setting of S1 and S2, each door-switch will cause the *Musical Doorbell* to play a different melody, making it easy to determine which door needs your attention. The *Musical Doorbell* is powered by a 9-volt DC battery so that it can be located even where there is no AC power available. The circuitry contains a power-down feature that turns off U1 when it's not in use. A 9-volt transistor-radio battery will



The printed-circuit assembly is installed on the cabinet's rear panel using stand-off insulators at each corner. The battery is held in place by a small clamp. The cabinet latch at each end of the panel will secure the panel to the cabinet.

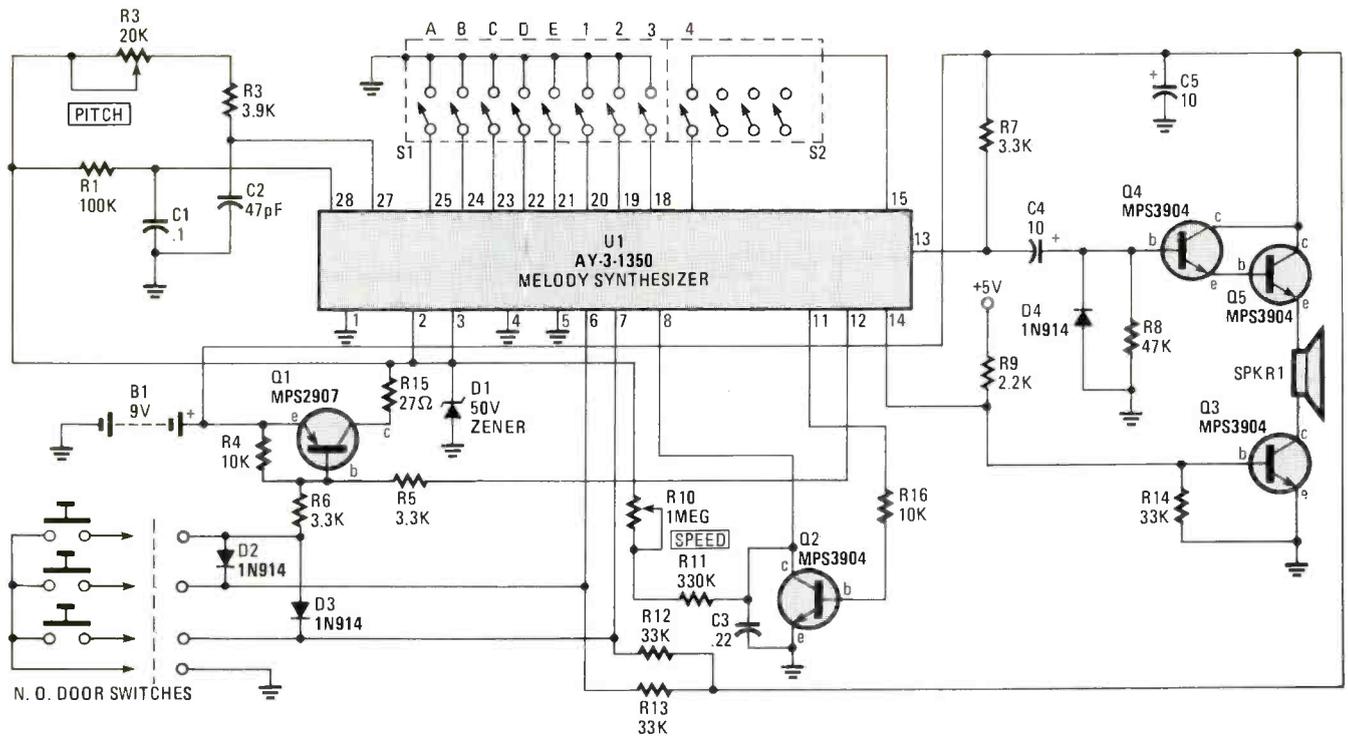


Fig. 1—Both the melodies and the chime effects are generated by integrated-circuit U1. However, potentiometers R3 and R10 determine the pitch and the speed of the melody.

PARTS LIST FOR THE MUSICAL DOORBELL

SEMICONDUCTORS

- D1—Zener diode, 50-volt, 1-watt
- D2—D4—1N914 silicon signal diode
- Q1—MPS2907 PNP transistor
- Q2—Q5—MPS3904 (2N3904) NPN transistor
- U1—General Instrument AY-3-1350 melody synthesizer

RESISTORS

- (All resistors are 1/4-watt, 10% fixed units unless otherwise noted)
- R1—100,000-ohm
 - R2—20,000-ohm potentiometer
 - R3—3900-ohm

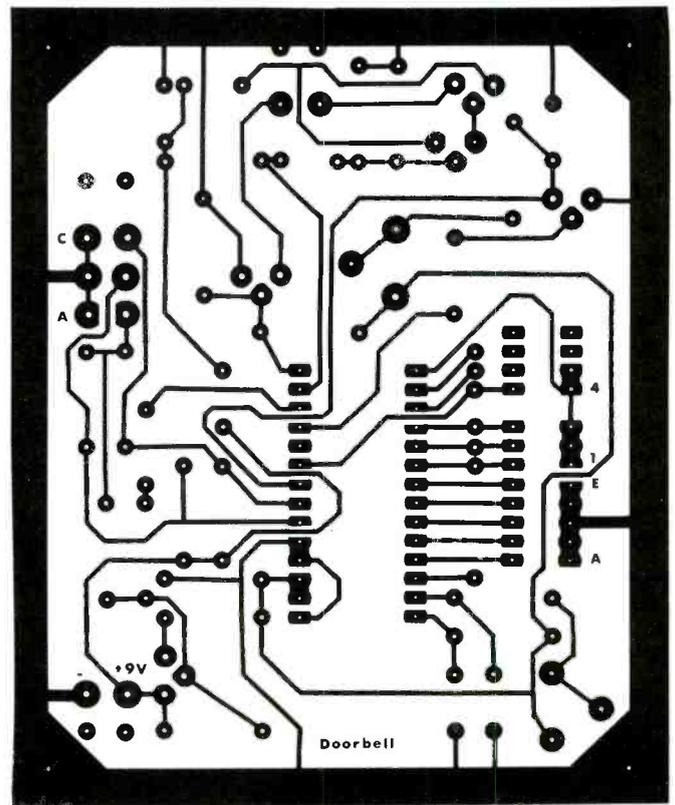


Fig. 2—In addition to holes for the components, the printed-circuit board contains larger openings for the plastic ties used to secure the wires from the door switches.

provide at least six months of service in normal use.

The circuit also provides *one-shot* operation so that if the door-switch is held down, the doorbell will only play one time, and will not repeat a melody until the switch is released and then pushed again. That feature can save your sanity

hard-

25 TUNE DOORBELL COMPONENT PLACEMENT DIAGRAM

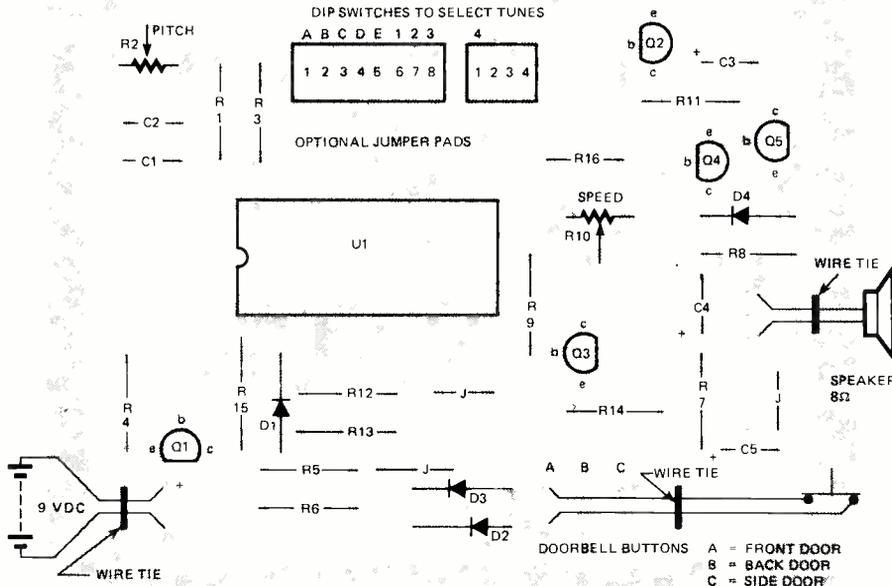


Fig. 3—Be very careful, when installing the components on the printed-circuit board that you position U1's "notch" correctly. The notch should point toward the nearest edge of the printed-circuit board; away from speed potentiometer R10.

the printed-circuit board with plastic wire ties, you'll reduce the possibility of the external connections breaking if you frequently disturb the *Musical Doorbell* to reprogram the melodies or chimes.

Reprogramming the Switches

The melody programming requires a 9-section DIP switch, something impossible to obtain in the conventional marketplace. We *synthesize* the required switch by using conventional 8-section (S1) and 4-section (S2) switches.

Switch S1 provides the "ABCDE123" programming; switch S2 provides the "4" programming. The remaining three sections of S2 are unused (you can use them for experimentation).

Because switch S1 is usually supplied with its sections marked 12345678, we avoided confusion by pasting a label on the printed-circuit board—directly above S1-S2—that is marked "ABCDE123 4". The space between the "3" and "4" is needed to compensate for the physical space between S1 and S2 when the switches are mounted end on end.

The *Musical Doorbell* shown in the photographs was installed in a home-brew wood cabinet made to replace the existing wall-mounted door chime. The rear panel of the cabinet, on which the printed-circuit assembly and the battery holder are mounted, is secured with cabinet latches so that the cabinet can be easily opened for reprogramming—resetting the DIP switches.

Although the melodies are preselected by the DIP switches, both their pitch and speed can be tailored to your preference by adjusting R3 (PITCH) and R10 (SPEED). Turning R3 to a lower pitch also controls the loudness of the melodies.

MELODY SYNTHESIZER TUNING

Set the DIP switches S1 and S2 to the ON position to select the melody you want. There should be no more than one letter switch and one number switch set to ON at one time. The DIP switch numbers do not correspond to the tune setting numbers and letters, see the example below.

DIP switch number -- 1 2 3 4 5 6 7 8 1 2 3 4
 Actual value = A B C D E 1 2 3 4 * * *
 *Not used!

A0	Toreador	C2	Wedding March
B0	William Tell	D2	Beethoven's 5th
C0	Hallelujah Chorus	E2	Augustine
D0	Star Spangled Banner	A3	O' Sole Mio
E0	Yankee Doodle	B3	Santa Lucia
A1	John Brown's Body	C4	The End
B1	Clementine	D3	Brahms' Lullaby
C1	God Save the Queen	A4	Hell's Bells
D1	Colonel Bogey	B4	Jingle Bells
E1	Marseillaise	C4	La Vie en Rose
A2	America, America	D4	Star Wars
B2	Deutschland	E4	Beethoven's 9th

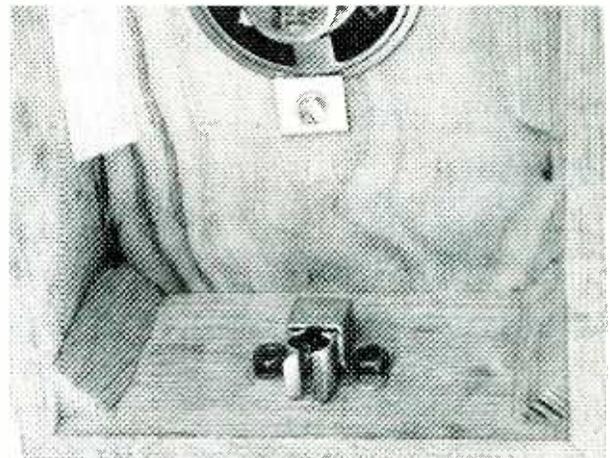
With no switches set to "ON" pressing the 3 doorbell switches will produce the following tunes:

A	Westminster Chime	C	Descending Octave Chime
B	Simple Chime		

when the neighborhood prankster finds out about the doorbell at your house. (In a future issue, we may run a combination doorbutton/Tesla-coil project for such situations.)

Construction

Except for SPKR1, the loudspeaker, the entire project is assembled on a 3 1/8-in. x 4 1/4-in. printed-circuit board for which we provide a full-scale template. (See Fig. 2) If you examine the template, you'll find that six unused solder-pads are provided: The pads may be used when you experiment with the various "options" discussed in the literature usually supplied with U1. You will also notice that the component-placement pictorial diagram (Fig. 3) shows 6 holes labeled "WIRE TIE," which are intended for plastic wire ties. If the connecting wires to external equipment(s) are tied down to



Conventional cabinet-latch hardware installed on the sides of the cabinet will secure the rear panel to the cabinet.

DIGITAL FUNDAMENTALS

**Microcomputers don't do
anything until they are programmed**

LESSON 10: Programming Microcomputers

By Louis E. Frenzel, Jr

□ MICROCOMPUTERS BY THEMSELVES DON'T DO VERY MUCH. They are simply a collection of electronics circuits and other hardware that are waiting for *directions* that tell them what to do. Those directions come from the *programs* that cause the microcomputer circuits to perform in a specific way. Once given a program, the microcomputer will accomplish some useful work. All of the programs that computers use are referred to as *software*.

In this final lesson, we discuss the basic process of creating the software that will make the microcomputer do something worthwhile. More specifically, we will show you how to write some simple programs using the microcomputer's instruction set.

Microcomputers have, for the most part, replaced large complex collections of smaller SSI and MSI integrated circuits. By programming a microprocessor, you can cause it to perform all of those basic operations which are usually carried out by individual gates and flip-flops wired in many different configurations. Microprocessors can be programmed to perform arithmetic operations, logical operations such as AND, OR, and NOT, counting, shifting, comparing, and many other standard digital functions. We will show you how to accomplish many of those basic operations in this lesson.

Introduction to Programming

Programming is the process of converting a *problem* to be solved into a form that the microcomputer can interpret. During that process, a program is created. Recall that a program is a sequential list of microcomputer instructions that tell how to accomplish some specific thing.

Programming is basically a two-step process. The first step is *problem solving* where you define the work to be done and develop a solution. The second step is called *coding*. That is the process of converting your problem into a specific computer *language*. In this case, that language is the specific instruction set of the microcomputer. You will hear it called *machine language*. Following the work we started in Lesson 9, we will use the instruction set of the type 6800/6502 microprocessors.

Problem Solving

The first step in programming is to clearly define the problem. That is where you ask yourself what it is that you are

trying to do. The best way to begin the process is to write down a general statement of what you are trying to accomplish. Anything else you can do to explain or illustrate the problem will also be helpful to you in coming up with a solution. For example, draw yourself a picture using blocks that might show the flow of the problem from one step to the next. If necessary, make charts and tables or lists that specifically state what needs to be done. Keep in mind a picture of the basic computing process, which involves input data of some kind that is then processed to create new useful output data. Defining the available inputs and the desired outputs will help you understand exactly what processing must take place.

Next, analyze all of the material you have collected. That will result in your coming up with an *algorithm*. An algorithm is a detailed step-by-step procedure for solving the problem. It could be a basic algebra statement or formula to compute. Otherwise, it might be more like a recipe with individual steps to be accomplished one after another.

One way to illustrate the problem you are trying to solve and test your algorithm is to draw yourself a *flow chart*. That is a graphical description of your problem using standard symbols. Figure 1 illustrates the solving of a typical problem. The *oval* symbols represent start and stop conditions. The *rectangular* boxes state specific processing operations to be carried out on your data. The *diamond-shaped* figure represents a decision, which usually asks a question with a "yes" or "no" answer. Work your way through the problem in Fig. 1 to be sure that you understand how it works.

Coding

Once your problem is well-defined and your algorithm is available, you can begin writing the program. That is the process of creating a sequential list of the microprocessor's instructions that will do the job.

When you have finished coding the program, you should check it over carefully for errors. Programming is a very time-consuming and tedious process and it is extremely easy to make a mistake. You may goof in thinking through your algorithm and there may be some faulty logic that you will not discover until you test the program. Or you may simply make a coding error, leaving out an instruction or entering an incorrect *op* code or address. In any case, attempt to get out all the bugs.

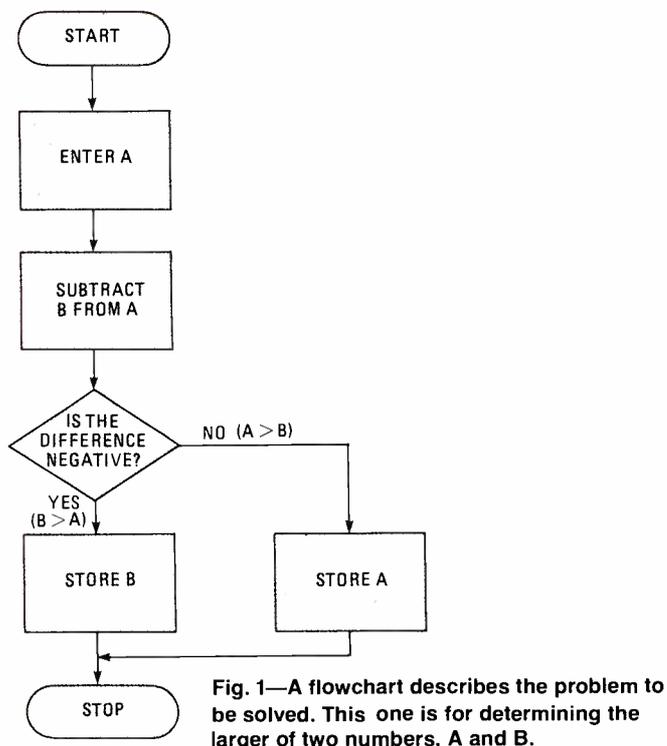


Fig. 1—A flowchart describes the problem to be solved. This one is for determining the larger of two numbers, A and B.

Next, you will load the program into the microcomputer and test it. If everything is satisfactory, the computer will run the program and you will get the desired results. If not, you will need to do some *debugging*. Debugging is typically standard procedure, particularly for large, complex programs. Short programs can usually be written and run the first time without error. But big programs, those using hundreds or even thousands of instructions, generally require hours of debugging to make them work properly. With the bugs eliminated, your microcomputer now performs some useful function.

The Microprocessor and Its Instructions

As stated earlier, we will use the architecture and instructions of the 6800 and 6502 microprocessors. But to refresh your memory quickly, let's take a brief look at the architecture of the device and the formats of the instructions.

Architecture

Figure 2 shows the general layout of the 6800 microprocessor. Note that it has two 8-bit *accumulators* labelled ACC A and ACC B. An 8-bit *instruction register* holds the op code, and an 8-bit *condition code register (CCR)* indicates CPU status. Also included is a *program counter*, a *stack pointer*, and an *index register*. Those are 16-bit registers.

We won't show the block diagram of the 6502 since it is basically similar in its organization. The main difference is that the 6502 has only a single *accumulator (A)*, but it does have two *index registers* labelled X and Y. The instruction sets are also similar and we will use those instructions that are common to both.

In operation, the microprocessor fetches instructions which are shown in the memory, puts them into the instruction register, then decodes and interprets them. The logic in the microprocessor then causes the circuitry to carry out the designated operations. Most of those operations take place on data that is in the accumulator. Data may be brought in

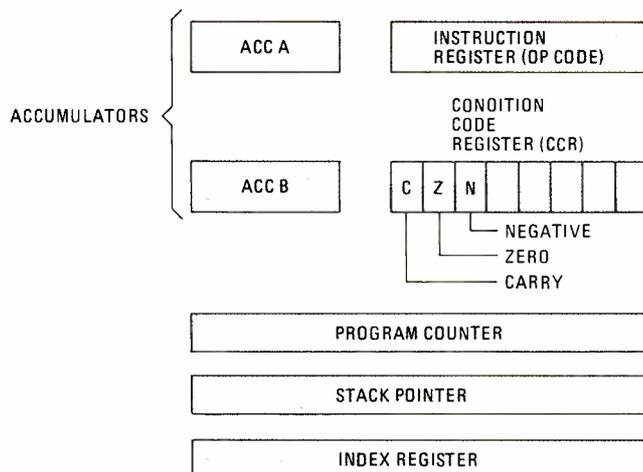


Fig. 2—This is the basic register organization in the 6800 microprocessor. Note that there are two accumulators.

from the memory and stored in the accumulator, then used in some arithmetic or logic operation with the result stored in the accumulator. That result can then be transferred to a storage location in memory. Once an instruction is executed, the next instruction in sequence in memory is then fetched and executed. The process continues until the end of the program is reached.

Condition Codes

As the program instructions are executed, various conditions are monitored and the results are stored in the flip-flops of the condition-code register (CCR). Those flip-flops are also known as status flags. Some of the more common conditions monitored include *carry (C)*, *zero (Z)*, and *negative (N)*. For example, the carry bit is set to binary 1 in the condition-code register if the result of an addition in the accumulator causes a carry to be generated out of the *most-significant-bit (MSB)* position.

The zero bit in the condition-code register is set if the result of some operation in the accumulator is zero. Should some arithmetic, logic, or other operation result in the accumulator containing all zeros, the zero flip-flop is set to binary 1.

In a similar way, the negative or N flag of the condition-code register will be set to binary 1 if the result of an arithmetic operation produces a negative result. A negative result is indicated by the most significant bit of the accumulator (bit 7) being a binary 1.

The condition-code bits can then be monitored so that decisions can be made. Special jump and branch instructions which make those decisions rely on those conditions for determining which direction to take in the program. We will illustrate them in the programs to come.

Instruction Format

An instruction for the microprocessor consists of one, two, or three bytes stored in memory. Some simple instructions contain only an 8-bit op code that designates an operation to be performed.

Some instructions require two bytes, as shown in Fig. 3A. The first byte is the op code that tells the microprocessor what is to be done. The second byte usually contains an address that designates where the data to be operated upon is stored. Alternately the second byte may also contain the data itself to be used in the operation.

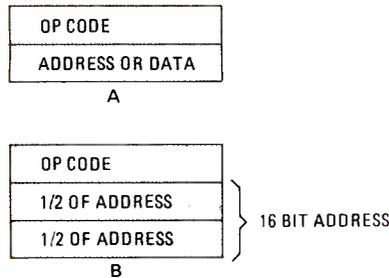


Fig. 3—A 2-byte instruction puts the complete address or data in one memory location. A 3-byte instruction puts only half the address in a memory location.

Memory Location	Instruction Address, or Data
0	LDAA
1	7
2	ADD
3	8
4	STAA
5	9
6	HALT
7	25
8	19
9	44 (sum)

BINARY	HEXADECIMAL
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	A
1011	B
1100	C
1101	D
1110	E
1111	F

Fig. 4—Binary to hexadecimal conversion. The binary number 10001011 is the equivalent of hex 8B.

A three-byte instruction (shown in Fig. 3B) contains an op code in the first byte; the remaining two bytes contain the upper and lower halves of a 16-bit address, which usually designates the location where the data to be operated on is stored.

The instructions, of course, are nothing more than binary numbers. However, programmers never work with binary. It is simply too difficult to remember all those 1's and 0's. Therefore, most programmers who write programs in machine language typically use the *hexadecimal* (hex) notation. Recall that that is the process of replacing each four-bit binary group of numbers with its equivalent *hexadecimal symbol*. The hexadecimal symbols include the digits 0 through 9 and the letters A through F. Figure 4 shows the designations. To express a given binary number in hex, simply replace each 4-bit group with its equivalent hex digit. For example, the binary number 10001011 in hexadecimal is 8B. This happens to be the op code for the ADD instruction in the 6800. All of the instruction op codes have a specific hexadecimal designation. In addition, the addresses are also expressed in hex notation.

To keep things simple in this lesson, we are going to use our own special notation. We will use a simple three- or four-letter mnemonic designation for each instruction and express memory locations and data in terms of decimal numbers. We will also limit ourselves to the use of two-byte instructions.

Simple Example

The simple program listed shown at the top of the next column is designed to add two numbers together and store the sum. Let's step through the program one instruction at a time so that you can see how to read such a program.

The first instruction in location 0, LDAA, loads accumulator A with the number stored in memory location 7. That is designated by the second byte of the instruction in

location 1. Looking down the program, you can see that in memory location 7 is the number 25. That first instruction brings the number 25 into accumulator A.

The next instruction in location 2 is ADD. That instruction tells the computer to add the number stored at the memory location designated by the second byte of the instruction (in location 3) to the number contained in accumulator A. As you can see, the number 19 is stored in location 8. The sum, 44, will be stored in the accumulator.

The third instruction in location 4, STAA, says to store the accumulator in location 9. That is, the sum in the accumulator will now be stored in the memory location designated by the second byte of the instruction in memory location 5. The address stored there is 9. Therefore, the sum will be stored in that location. The program ends at that point.

Now that you have the format in mind, let's take a look at a number of sample programs that show how to do useful functions. In each example we will show a program listing and explain what is happening. We will introduce new instructions in each sample, but those will be explained as we go along.

Arithmetic Operations

Let's code the program described by the flow chart in Fig. 1. The purpose of the program is to determine which of two numbers, A and B, is larger. Our algorithm is to subtract B from A, then to test to see if the difference is positive or negative. If the difference is positive, then A is larger than B. If the difference is negative, B is larger than A. The program concludes by storing the larger of the two numbers in a designated memory location.

The program for solving the problem is illustrated at the top of the next page.

The first instruction, LDAA, loads the first number A stored in memory location 18 into accumulator A. The second instruction subtracts number B stored in location 19 from number A. The difference between the two numbers is stored back in the accumulator. If A is 14 and B is 17, the result in the accumulator is -3.

The next instruction is a *branch-if-minus* (BMI) instruction. That is a decision-making instruction that may change the sequence of program execution if a certain condition occurs. In this case, the instruction tests the negative flip-flop in the condition code register. Recall that various flip-flops in the condition code register are set or reset depending upon the outcome of the execution of the various instructions. If the subtraction results in a positive result in the accumulator, then the negative flip-flop in the condition code register is set to binary 0. If the subtraction operation results in a negative value, then the negative flip-flop is set to binary 1.

The branch of minus instruction looks at the negative flip-

Memory Location	Instruction Address, or Data
0	LDAA
1	18
2	SUBA
3	19
4	BMI
5	12
6	LDAA
7	18
8	STAA
9	20
10	JMP
11	22
12	LDAA
13	19
14	STAA
15	20
16	JMP
17	22
18	A = 14
19	B = 17
20	Larger = 17
21	
22	HALT

flop to determine what action to take. If the subtraction operation results in a positive value, no branch occurs. The next instruction in sequence after the BMI instruction is executed as would normally be the case. Therefore, A is the larger of the two numbers. The LDAA instruction in location 6 causes that number to be loaded into the accumulator. The next instruction STAA stores that number in the designated memory location. Next, the JMP instruction causes an unconditional jump to occur. The program counter is loaded with the address part of the JMP instruction in location 11. Therefore, the CPU resumes executing at location 22. A HALT at that location ends the program.

If the result of the subtraction is a negative number, as it is in this example, then the BMI instruction detects it and causes the program to branch to a memory address designated in the second byte of the BMI instruction in location 6. In other words, the usual next instruction in sequence is not executed. The BMI instruction causes the program counter to be loaded with the address designated in the BMI instruction, in this case 12. That indicates that the larger of the two numbers is B. Therefore, the instruction at 12, an LDAA, causes the B to be loaded into the accumulator. The STAA instruction stores the result in the memory location designated for the larger number. The JMP instruction then causes the program to jump to the designated memory location, in this case 22. At that point, the program ends.

Subroutines

Most simple 8-bit microprocessors such as the 6800 and 6502 can only perform simple arithmetic operations such as add and subtract. But many times the problem to be solved requires more complex math, such as multiplication, division, square root or some other operation. The microprocessor can perform these operations, but they must be programmed to do so. A special program is written to perform one of these math operations.

Whenever the main program needs to perform say a multiplication, it will branch to or call this special multiplication program, perform the desired operation, and then return to the main program sequence. That is illustrated in Fig. 5. Such programs, which may be referenced several times by the main

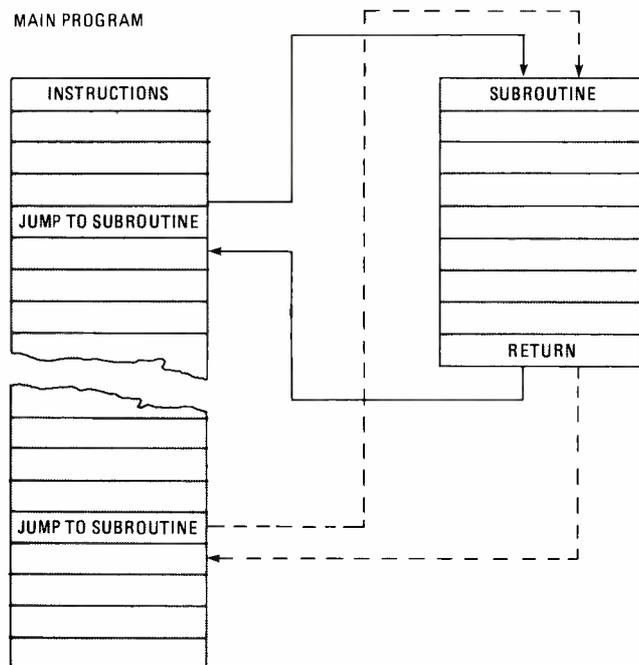


Fig. 5—A small program which will be used many times by the main program can be stored as a subroutine, to which the main program jumps (and returns) when it's needed.

program, are called *subroutines*. A subroutine is simply a specialized segment of computer code that does some specific thing. Rather than write that sequence of code each time it is needed, the code is written once. Then, special instructions are used by the main program to call the subroutine, use it, then return to the main program. A jump to *subroutine instruction* (JSR) calls up the subroutine. That instruction's address tells where the subroutine is located. When a JSR is executed, the contents of the program counter is stored in the stack. That allows the CPU to pick up where it left off when the subroutine has been executed.

At the end of the subroutine is a *return-from-subroutine* instruction (RTS). It retrieves the address in the stack and loads it in the program counter. The main program resumes executing.

The program we want to illustrate here is a subroutine for performing multiplication. It will illustrate the concept of a subroutine and how higher-level math functions are programmed using the microprocessor instruction set.

There are a number of ways to produce multiplication in a microprocessor. The algorithm we have chosen here is simple, because it is easy to understand. Since the microprocessor can add and subtract, naturally the subroutine must use these instructions. One way to perform multiplication is by repeated addition. For example, if you wish to multiply 5 by 3, you can accomplish it by simply adding 5 three times. That is what our program will do.

Add to Multiply

Recall that in multiplication, there are usually two quantities involved. One of those numbers to be multiplied is called the multiplicand. The number we multiply it by is called the multiplier. Of course, the answer or solution to the multiplication results in a new value called the product. In the microprocessor we will set aside three memory locations to store those three values.

The flow chart outlining the multiplication algorithm is

shown in Fig. 6. Basically, the process is to add the multiplicand the number of times specified by the multiplier. In the program, we designate the location where the final product will be stored. During the multiplication process we will call that the *partial product* because each time the multiplicand is added, it is restored in that location. Initially, the partial product is zero. Then, each time we pass through the program, the multiplicand is added to it and then restored.

Each time the multiplicand is added, the multiplier is loaded into the accumulator and one is subtracted from it. That tells us that the multiplicand has been added one time. We then reduce the multiplier by 1 and restore it. We then check to see if the multiplier is zero. Naturally, if it is zero, then the multiplicand has been added the correct number of times. If not, then the program should go back and repeat the same sequence. Note in the flow chart the use of a decision block designated "Is multiplier zero?". If the answer is yes, then the correct product is available for use. If the multiplier is not zero, the answer is no and the procedure begins again. That forms a program loop. A loop in programming terms simply means that a particular sequence of instructions is repeated a number of times as required by the algorithm. A loop is implemented with a decision making branch or jump instruction.

The code for the problem is given below. Let's walk through it step-by-step to be sure you understand the process.

Memory Location	Instruction Address, or Data
0	
1	CLR
2	20
3	LDAA
4	20
5	ADD
6	18
7	STAA
8	20
9	LDAA
10	19
11	DECA
12	STAA
13	19
14	BNE
15	3
16	RTS
17	
18	MULTIPLICAND
19	MULTIPLIER
20	PRODUCT (partial product)

The first instruction CLR causes the memory location designated by the second byte to be cleared to zero. As you can see, that clears memory location 20 where the partial product is to be stored.

The next instruction LDAA causes the partial product to be loaded into the accumulator. Of course, it is zero at this time. The next instruction ADD causes the multiplicand in location 18 to be added to the accumulator. The result in this case is simply the multiplicand itself. The next instruction STAA causes the content of the accumulator to be stored back into location 20, the partial product.

Next, the LDAA instruction in location 9 causes the multiplier in location 19 to be loaded into the accumulator. The DECA instruction then decrements it. That instruction simply causes 1 to be subtracted from the contents of the accumulator. To *decrement* means to subtract one.

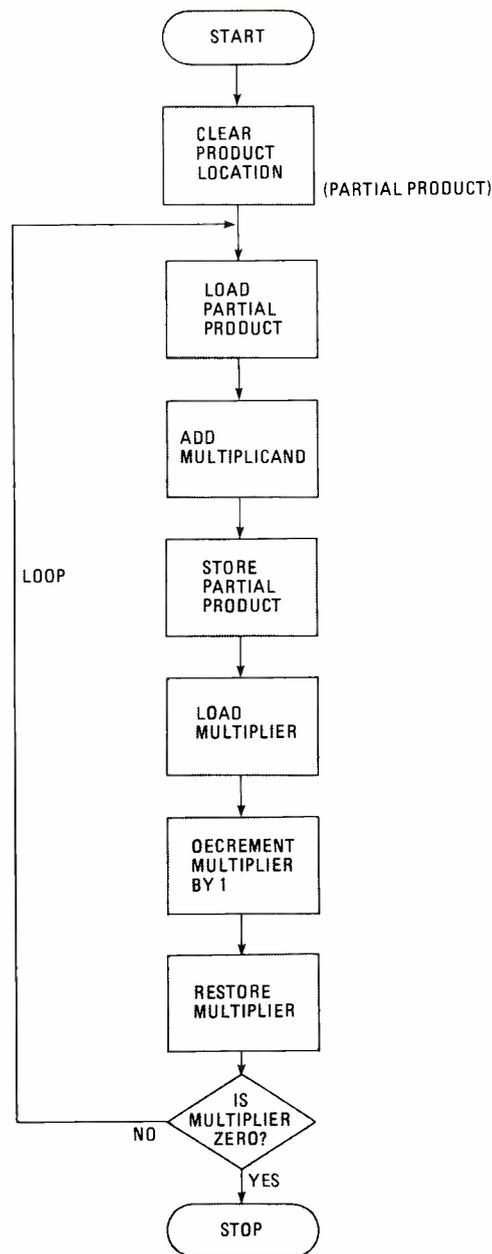


Fig. 6—A flowchart shows that multiplication is actually done by repeated addition.

The multiplier has now been reduced by 1, indicating that the multiplicand has been added once. We restore the reduced multiplier in location 19. Next, a BNE or branch if not equal to zero, instruction is executed. That instruction looks at the decremented multiplier in the accumulator and attempts to determine if its value is equal to zero. If it is not equal to zero, then it causes the normal program sequence to be abandoned. A branch occurs to the memory location designated in the second byte of the BNE instruction. In this case, the branch occurs back to memory location 3. That causes the instructions stored between locations 3 and 13 to be re-executed. The process, therefore, is repeated. The multiplicand is added again to the partial product and the result restored. The multiplier is loaded and decremented by 1 and restored. Again, the BNE checks for any zero result. If none occurs, then a backwards loop is again performed.

At some point, however, the multiplier will be reduced to zero. At that point the BNE instruction detects the zero so no branch or loop occurs. The next instruction in sequence at location 16 is executed. That is a return from subroutine (RTS) instruction. In a subroutine, the final instruction is called a return from subroutine. The instruction simply retrieves the content of the program counter which was previously stored in the stack by the jump to subroutine instruction that caused the subroutine to be called. At that point, the main program resumes.

Logical Operations

As we indicated earlier, a microprocessor can also perform logical operations such as AND, OR, and NOT. It can even perform more complex operations such as EXCLUSIVE OR. The 6800 and 6502 microprocessors, for example, have instructions for those operations. The instructions operate on all of the bits in the accumulator rather than one bit at a time.

For example, to perform an AND operation between two binary numbers, one of them is stored in the accumulator while the other is stored in a memory location that will be referenced by the AND instruction. The AND instruction is designated ANDA which means to AND the contents of accumulator A with the contents of the memory location designated in the instruction. The corresponding bits in the two 8-bit words will be ANDed together with the logical result being stored back in that same bit position in the accumulator. See Fig. 7. The individual bits being operated on are independent of one another and do not affect adjacent bits. Because of that, you can perform various individual bit manipulations within a word if desired.

OR operations can also be performed with the ORA instruction. The EXCLUSIVE OR function is performed with the EORA instruction.

As for performing the NOT function, a special instruction called *complement* (COM) is used. Here, a word is loaded into the accumulator and the COM instruction is executed. The result is that each bit in the word is complimented, that is, 1's changed to 0's and 0's changed to 1's. With those basic logic functions, virtually any Boolean operation can be implemented with short subroutines.

An example of a useful logical operation is to use the AND instruction to perform masking. Masking is the process of blocking out or eliminating a bit or groups of bits from a binary word. When the bits are eliminated, they are effectively set to or replaced by binary 0's. To mask bits from a given word, that word is first stored in the accumulator. Then, a special mask word in some memory location is ANDed with it. To eliminate the desired bits from the word, the corresponding bits in the mask word are set to binary 0. Those bits to be retained are ANDed with binary 1's in the mask word.

Here's an example:

A - binary word	11001100
B - mask word	00111100
C - result of ANDing	00001100

The truth table for the basic AND function is given below as a refresher.

A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

The simple program below illustrates the use of the AND instruction for masking. The purpose of the program is to convert ASCII characters into standard BCD numbers.

Memory Location	Instruction Address, or Data
0	LDA
1	8
2	ANDA
3	9
4	STAA
5	10
6	HALT
7	
8	00111001 (ASCII code for 9)
9	00001111 (mask word)
10	00001001 (BCD result)

(NOTE: In this article, a HALT instruction is used to stop a program. In truth, there is no such instruction in the 6800 or 6502. It is used here to simplify the discussion. In practice, other more complex techniques, beyond the scope of this article, are used.)

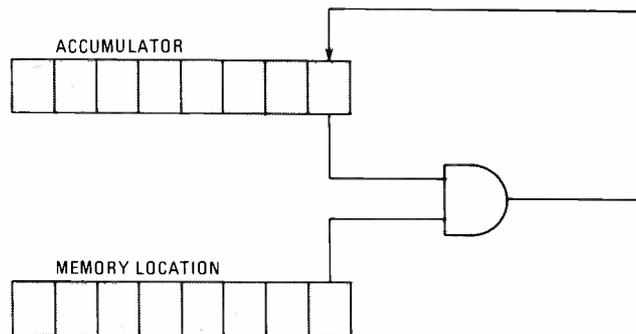


Fig. 7—The AND instruction is designated ANDA which means to AND the contents of accumulator A with the contents of the memory location designated in the instruction.

ASCII Code

Recall that ASCII is the 8-bit code widely used for communications between computers and peripheral devices or in data communications. A special 8-bit code is given to upper and lower case letters of the alphabet, numbers, punctuation marks, and special symbols. The ASCII code for the numbers 0 through 9 turns out to be the standard 4-bit BCD codes for those numbers plus a special 4-bit code preceding it, in this case, 0011. For example, the BCD number for 5 is 0101. The ASCII version, therefore, is 00110101.

In order to use ASCII numbers in arithmetic operations, they must first be converted into their BCD equivalents. A simple way of doing that is to strip off the first four bits leaving the 4-bit BCD code. That can be done with a masking code of 00001111. The first four zero bits will be ANDed with the 0011 portion of the ASCII we wish to eliminate. ANDING those digits with zero will cause the logical result to be 0000. The four bit BCD portion of the code we wish to be retained will be ANDed with the 1111 portion of the mask word. ANDING bits with binary 1 will simply reproduce those bits.

In the program above, the ASCII number has been previously stored in memory location 8. That number is now brought into the accumulator with the first instruction, LDA.

Next, the ANDA instruction is executed. The mask word is stored in location 9. That number is ANDed with the contents of the accumulator. The result appears in the accumulator. In this case, the ASCII number 9 is converted to its BCD equivalent, 00001001. That number is then stored in location 10 by the STAA instruction. Then the program halts.

Implementing Counters

A microprocessor can also be used to perform counting functions. For example, by using the interrupt feature of a microprocessor, external pulse trains can be counted. The pulses to be counted are simply applied to the interrupt input of the microprocessor. Then, each time the interrupt occurs, the microprocessor will complete the current instruction in process of the main program, then jump to a subroutine for the count operation. The simple program shown below is the subroutine that performs the counting operation.

Memory Location	Instruction Address, or Data
-----------------	------------------------------

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
100

Memory Location	Instruction, Address, or Data
52	LDAA
53	64
54	DECA
55	STAA
56	64
57	BNE
58	52
59	LDAA
60	65
61	STAA
62	100
63	RTS
64	COUNT VALUE
65	00000001
100	OUTPUT PORT

Memory location 53 is assigned a count value. Next, that count number which is proportional to the length of the delay is loaded into the accumulator by the LDAA instruction. For short delays, a low value number will be used. For long delays, a high value will be used. The decrement instruction (DECA) subtracts one from it. It is then restored by the STAA.

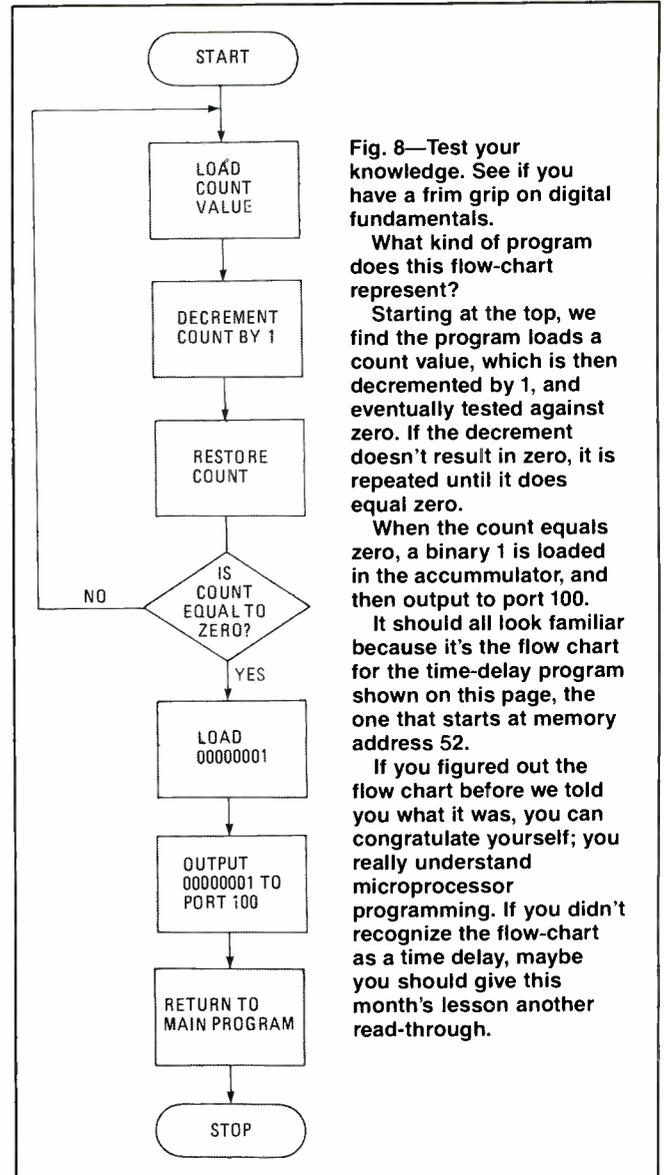


Fig. 8—Test your knowledge. See if you have a firm grip on digital fundamentals.

What kind of program does this flow-chart represent?

Starting at the top, we find the program loads a count value, which is then decremented by 1, and eventually tested against zero. If the decrement doesn't result in zero, it is repeated until it does equal zero.

When the count equals zero, a binary 1 is loaded in the accumulator, and then output to port 100.

It should all look familiar because it's the flow chart for the time-delay program shown on this page, the one that starts at memory address 52.

If you figured out the flow chart before we told you what it was, you can congratulate yourself; you really understand microprocessor programming. If you didn't recognize the flow-chart as a time delay, maybe you should give this month's lesson another read-through.

Next, the BNE or branch if not equal to zero instruction is executed. That checks to see if the count value has been decremented to zero. If it hasn't, the program loops back to location 52 for additional decrementing. The process repeats as the counter is decremented once each pass through the loop. When the count value reaches zero, the BNE instruction detects it. It then executes the LDAA instruction in location 59. That loads the number 00000001 in to the accumulator. Then, the STAA instruction outputs this value (00000001) to the address designated (100).

In this program, the length of the delay is determined by the time it takes for the various instructions to be executed. Most of the time involved is that time required to load, decrement and store the count value. Since most microprocessors are controlled by a crystal clock oscillator, the clock cycle time is precisely known. With that information then, the time it takes to execute various instructions can also be determined. The information is usually available. Knowing the amount of time it takes for each instruction to be executed, the delay count value can be determined to create a delay of a specific duration.

This program ends with the RTS, which was triggered by an interrupt.



By Charles D. Rakes

CIRCUIT CIRCUS

Putting digital devices into the "Twilight Zone"

THIS MONTH OUR *CIRCUIT CIRCUS* TAKES you to a three-ring event that places a couple of digital CMOS IC's in circuits that operate in the "Twilight Zone,"—somewhere between the norm and extra-terrestrial. (It's always more fun to experiment with a circuit that doesn't flow down the middle of the road.)

The first project, shown in Fig. 1, places one-quarter of a CMOS quad 2-input NOR gate, a 4001A, in the heart of our *Super-Simple-Dyne* broadcast receiver circuit. Don't let the simplicity of the circuit discourage you from building the receiver; its performance will rival the best of the one or two transistor-radio circuits. Even in my remote rural area, by using a short 33-inch telescopic antenna we received four stations loud and clear during daylight hours. Connecting 10 feet of hookup wire to C1 brought in several additional stations.

Since the component layout isn't critical you can build the receiver on a 5- × 5-in. section of perforated wiring board (*perfboard*).

Almost any kind or quality of ferrite loop-stick antenna coil will work for L1, but the small adjustable type is best. L2 is a secondary winding added to L1 by winding 10-turns of #26 enameled copper wire, in a solenoid fashion, around the center of the loopstick. Make certain that you leave the leads at least 3-in. long.

Tape the secondary in place with ordinary plastic electrical tape.

Use a 14-pin integrated-circuit socket

PARTS LIST FOR FIGURE 1

SEMICONDUCTORS

D1, D2—Silicon diode, 1N914, or equivalent

U1—4001A, CMOS quad 2-input NOR gate integrated circuit

CAPACITORS

C1—22-pf, 50-WVDC ceramic disc

C2—365- μ F tuning capacitor

C3, C4—0.1- μ F, 50-WVDC Mylar

C5—0.02- μ F, 50-WVDC Mylar

C6—100- μ F, 16-WVDC electrolytic

C7—39-pF, 50-WVDC electrolytic

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor-radio battery

J1—Phone jack

L1—Ferrite loopstick antenna, see text

R1—10,000-ohm, 1/4-watt, 10%, resistor

R2—50,000-ohm, miniature potentiometer, see text

S1—SPST switch

Misc.—2000-ohm headphones, perfboard, IC socket, hardware, wire, solder, etc.

for the 4001A, and tie all unused gates to battery negative, as shown in Fig. 1.

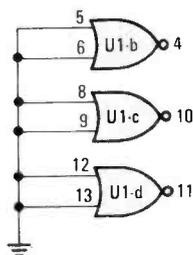
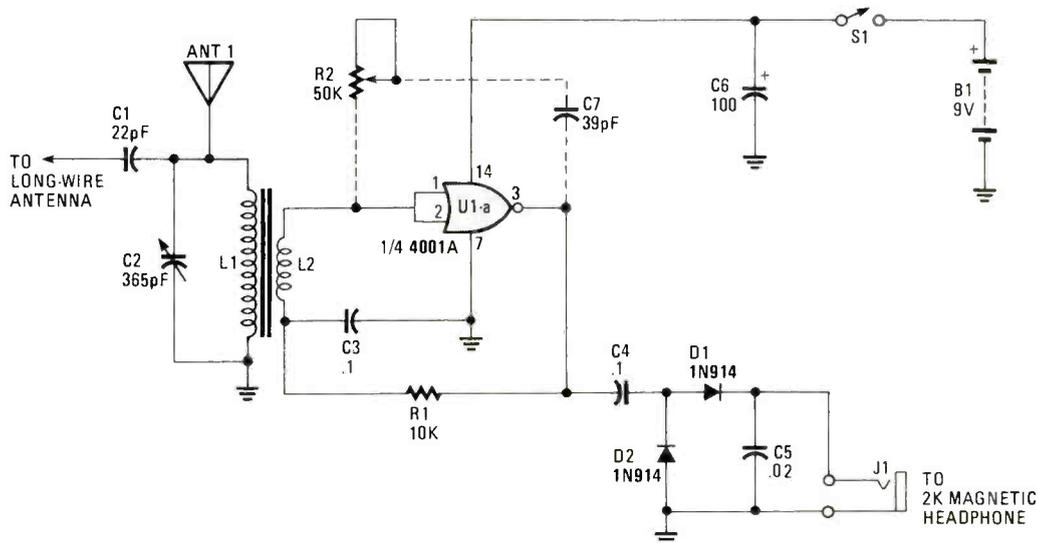
If the receiver doesn't work and the wiring checks out OK, try reversing the leads on L1's 10-turn secondary. Also, make certain that the headphones are 2000 ohms or higher; the low impedance "hi-fi" type won't work.

The receiver circuit is operating at a very high level of gain and may tend to go into oscillation. If it does, add the components indicated by the dotted lines—C7 and R2—and adjust R2 for the best reception. You can experiment by: changing the number of turns on the secondary of L1; making C1 a variable capacitor to match a much longer antenna for receiving DX; using a 4001B in the circuit; adding an audio amplifier to the receiver.

Don't Get too Close

The second "not-by-the-book" circuit, shown in Fig. 2, places a CMOS hex inverting buffer (a 4049) in the middle of a sensitive proximity-alarm project. Inverters U1a and U1b are connected in a simple RC oscillator circuit. The frequency is determined by the values of R1, C1, C2, and the internal characteristics of the integrated circuit. As long as the circuit is oscillating, a positive DC voltage is developed at the output of the voltage-doubler circuit: C3, D1, D2, and C4. That DC voltage is applied to the input of U1c—the

Fig. 1—Just one digital integrated circuit is all that's needed to make a really sensitive broadcast receiver.



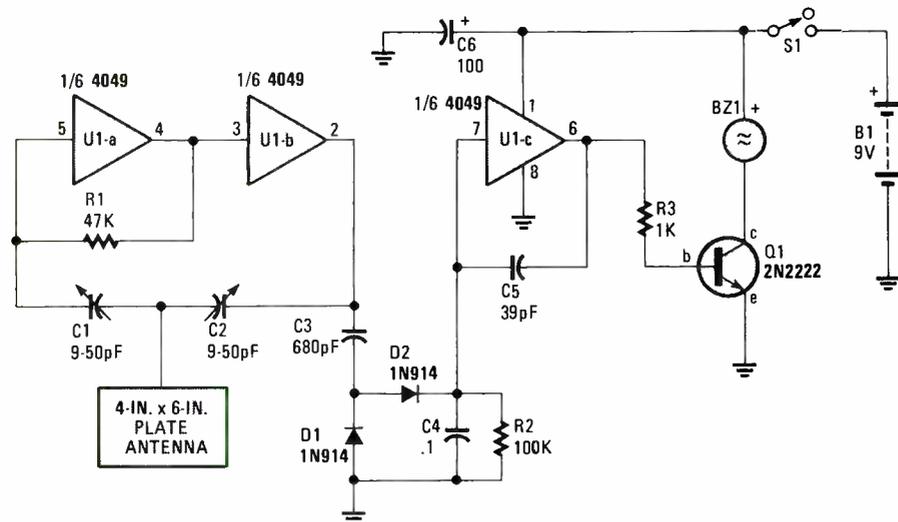


Fig.2—Wave your hand, a finger, or any part of your body to set off this simplified proximity alarm.

third inverter amplifier—keeping its output in a low state, which keeps Q1 turned off so that no sound is produced by BZ1. With C1 and C2 adjusted to the most sensitive point, the pickup plate will detect a hand 3 to 5-inches away and sound an alert.

Any handy construction method can be used in building the proximity circuit, but try to keep C1 and C2 close to the IC and away from metal objects. A small section of perfboard would be an excellent choice.

Set C1 and C2 to approximately one-half of their maximum value and apply power to the circuit. The circuit should oscillate and no sound should be heard. Using a non-metallic screwdriver, carefully adjust C1 and C2, one at a time, to a lower value until the circuit just ceases oscillation: Buzzer BZ1 should sound off. Back off either C1 or C2 just a smidgen until the oscillator starts up again—that is the most sensitive setting of the circuit.

As an experiment, you might try several different metal objects (in size and shape) for the pickup plate. You might also try replacing BZ1 with a small relay and use the circuit with an existing burglar-alarm system.

An Electronic Theremin

The electronic Theremin circuit shown in Fig. 3 has the CMOS IC from Fig. 2 doing double-duty performance. The first two inverters operate as a digital audio

PARTS LIST FOR FIGURE 3

SEMICONDUCTORS

LDR1, LDR2—Light dependent resistor, Clairex CL603A
U1—4049 CMOS inverting hex buffer integrated circuit

CAPACITORS

C1—0.02- μ F, 100-WVDC Mylar
C2—0.1- μ F, 100-WVDC Mylar
C3, C4—100- μ F, 16-WVDC electrolytic

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor-radio battery
R1—100,000-ohm, 1/4-watt, 10%, resistor
S1—SPST switch
SPKR1—Speaker, 8-ohms
T1—Transformer, audio output, 1000- μ m primary, 8-ohm secondary
Perfboard, pins, wire, solder, light source, etc.

PARTS LIST FOR FIGURE 2

SEMICONDUCTORS

D1, D2—Silicon diode, 1N914, or equivalent
Q1—NPN transistor, 2N2222, or equivalent
U1—4049 CMOS inverting hex buffer integrated circuit

CAPACITORS

C1, C2—9-50-pF ceramic trimmer
C3—680-pF, 50-WVDC ceramic disk
C4—0.1- μ F, 50-WVDC ceramic disc
C5—39-pF, 50-WVDC ceramic disc
C6—100- μ F, 16-WVDC electrolytic

RESISTORS

R1—47,000-ohm, 1/4-watt, 10%, resistor
R2—100,000-ohm, 1/4-watt, 10%, resistor
R3—1000-ohm, 1/4-watt, 10%, resistor

ADDITIONAL PARTS AND MATERIALS

B1—9-volt transistor-radio battery
BZ1—Piezo-electric audio sounder
S1—SPST switch
Misc.—Perfboard, pins, wire, solder, metal plate, etc.

oscillator; the third operates as a low-gain linear audio amplifier. As the intensity of the light falling on photoresistor LDR1 increases the oscillator's frequency increases; Similarly, the illumination falling on photoresistor LDR2 determines the volume level from the loudspeaker: The more illumination the more volume.

If you flop and wave your hands between the two photocells and a light source, a special kind of electronic music will be produced.

The Theremin can be built on a small section of perfboard and housed in an opaque plastic case. Locate the photocells at opposite ends of the case so that light can only hit the cells from above.

Experimenting with the musical circuit offers a number of possibilities. For example, changing C1's value will change the basic tone frequency. Or, you can reverse the effect of the illumination on the sound level by disconnecting LDR2 from U1 pin 2, connecting the free end to ground, and then connecting a 100,000 ohm 1/4-watt resistor (experiment with the value) between U1 pin 2 and the junction of LDR1 and C2. That circuit-change will reverse the volume-control action of the Theremin. More light hitting P2 less output; and with less light, more output.

The more time that you spend working on the three circuits the greater number of ideas and changes that will occur to you, so have fun until next month. Oh! By the way, be extra careful when handling the CMOS integrated circuits. Like me, they are very voltage conscious. So no static, please!

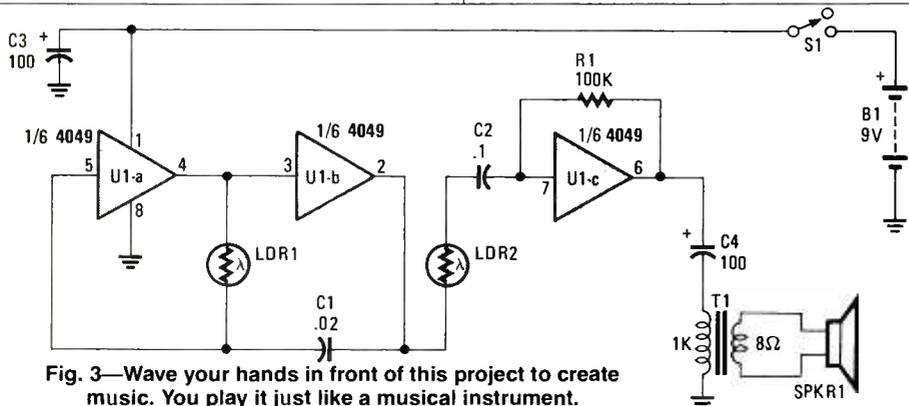


Fig. 3—Wave your hands in front of this project to create music. You play it just like a musical instrument.

□ELECTRONICS JUNKBOXES seem innocuous at the beginning. Someone who knows you're into electronics gives you an old TV or a nonworking radio. It's not fixable, but it seems a waste to toss out all those perfectly good (probably) components. An hour later, you have a pile of rubble and a quantity of resistors and capacitors with short legs, tubes that nobody uses any more, colorful coils of unknown value, a tangle of hook-up wire that will fall apart in your hands when you try to use it, and various bits and pieces that look as if they ought to be worth something if you could just figure out what.

I warn you, though, junkboxes have imperial aspirations. They grow like *The Blob*, and take over first your storage space, then the dining room, and finally the whole house. My son cleaned out three junkboxes and discarded a large quantity of material. He put the sorted remainder back and found he needed four boxes. And that was over just a couple of hours.

Valuable Stuff

Junkboxes are full of white elephants. No real use, but much too valuable to consign to the round file. An antiquated DIP chip can't be thrown out because it was once worth \$20—back when \$20 was a chunk of money. Twenty-watt resistors, high-voltage electrolytics of undetermined age, or 1X8 EPROMS that would cost a bundle to replace, and you never know when you might need one. Never mind that you've had them for ten years and have never done anything but admire them.

Electronics junk has disgusting habits. Microfarads leak, although picofarads usually behave—unless they're the old wax-dipped kind that melts in the heat. Wires tangle not only with each other and with adjacent components, but in the carpet, on your favorite sweater, and on the parts of your anatomy most embarrassing to have people pulling at.

Nuts and bolts are quite unstable. Those you reclaim from an unwanted chassis roll around in the bottom of your boxes and make alarming noises. Once you separate them from their original connections you can seldom mate a nut or bolt again. When you find a pair the same size, they have incompatible threads.

Bolts and screws removed from something you're working on right now will try their best to escape. If you don't confine them in a margarine or butter tub, at least some of them will make it to the carpet, and disappear forever. Springs and washers are even harder to keep track of.

Connectors are the worst, though. Old connectors oxidize to an icky green fuzz, which must be removed before they will conduct properly. Connectors also breed and mutate

Junkbox Blues

**Little jars of caps,
little cans of ohms
fill the mighty junkbox,
and swell the pleasant homes**

By Annette Hinshaw

shamelessly: No matter what you build, you need more connectors than you have.

Despite the fact that every time you check your junkbox you have more connectors, you never have the ones you need at the moment. Buying spares of the most popular configurations doesn't help. By the time you need them, they have disguised themselves or otherwise gone west. They will not turn up until you go searching for some other type—which you also bought spares of—and which you presently cannot find.

I Can't Read The Markings

Small components are manageable. You can stick them in old coffee cans or jars to keep like kinds together. However, a true junkbox is not content with mere resistors and capacitors. It craves boxes and chassis and transformers. Small, elegant transformers seldom have values on them, and are

best suited for making unique earrings or one-of-a-kind pendants. Useful transformers, the kind that are just right for that heavy power supply you might build some day, all weigh at least five pounds. When your spouse puts his/her foot down, you may have to pretend that you meant them for doorstops all along.

Recycled chassis are the most difficult junkbox components to store. They are invariably odd shapes that will not reduce to any useful configuration. They peek out of boxes and dribble off workshop shelves like gawky children. Each piece has holes already drilled and tapped, a solid place to mount a transformer, tube sockets already in place, or some other virtue which makes it essential for that halcyon future day when you will actually build whatever it is that you saved the chassis for in the first place.

Most households have natural attenuators of junkbox imperialism in the form of spouses and children who are not into electronics. My family has no such component. There are three of us, all *hams*. When we moved to Tulsa, we left furniture and household goods behind. For weeks we sat on boxes of books and ate off boxes of junk. As we settled in and acquired more conventional furniture, we had to rent storage space to hold the electronics parts overflow. We could hardly refuse an opportunity like the offer of two old ASR-33 teletypewriters that some poor fellow's wife was hounding him to get rid of.

And so it goes. Garage sales and thrift shops almost always have some arcane electronics goodie offered for a pittance: worth the price just for the chassis. The siren call of components that were high-tech, state-of-the-art twenty or thirty years ago draws us relentlessly. And the junkbox grows inexorably. My husband has a natural attraction for the con-

(Continued on page 108)



SAXON ON SCANNERS

Finally, a continuously tuneable scanner that can handle anything between .905 and 60 MHz.

□ YAESU, LONG A LEADING MANUFACTURER of precision communications equipment, has burst onto the scene with the latest addition to its line of scanners: the FRG-9600. The unit takes in all of the action between .905 and 60 MHz—picking up wide- and narrow-band FM, CW, AM and SSB. And with an optional plug-in video monitor, you can even watch TV on the set! This scanner we like in a BIG way.

The FRG-9600 scans in steps of 5, 10, 12.5, 25 and 100 kHz, or you can *dial up* the desired frequency using the set's tuning-control knob. The variable-tuning feature lets you zero-in on frequencies in-between the standard channel spacings (usually 5 kHz on the VHF high band and 15 kHz on the UHF bands). You can also enter frequencies via the FRG-9600's microprocessor pushbuttons.

Another novel feature is a signal-strength readout, making the FRG-9600 a first cousin to the type of equipment that has previously been designed for hobby listening below 30 MHz on the international shortwave-broadcast and communications bands. It's about time that someone finally brought something like this onto the market—a fully versatile piece of gear that's a true communications receiver capable of covering the public service bands.

By the way, the FRG-9600 has 99 memory frequencies and can scan through them with all of the amenities of other scanners. The FRG-9600's entry upon the scanner scene is a welcome addition. For more information, contact Yaesu USA, 17210 Edwards Road, Cerritos, CA 90701. Be sure to mention that you read about it here!

Air Force 1 and 2

OK, you *inside information* fans, here's a tidbit sent in by reader Stan (*The Man*) Manchester of Cleveland, Ohio. The Man says that on 415.70 MHz he's heard telephone calls (*phone patches*) from Air Force 1 and Air Force 2 when those aircraft are flying in his area.

As you know, they're the aircraft usually used to transport the President and the Vice President; so we'd say that such sta-

tions would be an interesting catch for any enthusiast who has a scanner that will cover frequencies in the 406- to 420-MHz range.

They Just Vanished

Harold Finkel (Chicago) reports that he has long listened to the U.S. Postal Service Inspectors on their *red* and *blue* channels of 169.85 and 169.65 MHz. Problem is that the channels seem to have gone dead on him. It doesn't appear to be a malfunction of his equipment so he assumes that, as he puts it, *The red and the blue, they've picked up and flew*. The question is, where have they gone?

Our information has it that the new red and blue channels in Chicago are 414.75 and 415.05 MHz. Try that on *yer* scanning machine, Harold!

Monitoring Base Security

An anonymous sailor from the Pensacola Naval Air Station in Florida, wants to know how to monitor the base-security frequency at his station.

Well, we think you'll be all set if you punch up 140.04 MHz.

Cops and Robbers In Tia Juana

"What frequency do I monitor for the

police in Tia Juana," is the question put to us by Pepe Montez of San Luis Rey, CA. He notes that Mexican frequencies aren't generally covered in scanner-frequency guides and wonders if we can help.

Well, Pepe, there may be additional channels in use, but at least one of them is supposed to be on 172.00 MHz.

I Spy?

A.J. Moody, who monitors from Washington, DC, says that he wonders how he can monitor the CIA HQ at Langley, VA.

Why not? They're probably monitoring you, A.J.! Rumor has it that Langley may be operating on 165.825 MHz.

Help!!

A reader in Kansas City, MO, reports that he had his scanner in the search mode when it locked onto 163.375 MHz around noon one day. That produced for him a simulated hostage exercise, complete with building evacuations, preparation of vehicles, and ransom money, etc. He goes on to say that the frequency hasn't produced any results upon further monitoring, and asks if we can offer any thoughts.

Well, we think we can safely guess that it was a federal agency, but that's about as
(Continued on page 102)



The Yaesu FRG-9600 communications receiver does the work of a scanner and is tuneable from .905 to 60 MHz. It detects both narrow- and wide-band FM, CW, AM, and SSB.



ELLIS ON ANTIQUE RADIO

Introducing our column that looks back into our archives!

WELCOME TO THE VERY FIRST **HANDS-ON Electronics** antique radio column. In the months to come, we're going to touch on almost every topic of interest to the serious (and even not so serious) antique radio collector. If you're new to the hobby, you'll find information to help you get oriented. And whether you're new or experienced, you'll enjoy our restoration tips, photos of interesting sets and glimpses of radio history.

Let's kick things off with a feature for the newcomer. In this issue and the next one, we'll take a quick tour through the world of radio collectibles and look over some of the old sets and other items you might want to watch for in flea markets, antique stores, and house sales. I'll make a point of avoiding the extremely rare pieces found only in museums, or traded among advanced collectors at high prices. Instead, I'll try to concentrate on the ones that you still have a good chance of finding on your own—with persistence and maybe a bit of luck.

Old Sets You Might Find

Prior to the widespread availability of affordable vacuum tubes (beginning about 1923), radio listeners heard their favorite programs by making use of the radio-detection properties of a common mineral called *galena* (lead ore). A small piece of the ore (the "crystal") was

mounted in a metal cup and placed in contact with a fine piece of springy wire (the "cat's whisker"). The surface of the crystal was probed with the wire until a spot was found that provided good reception. Crystal sets had limited sensitivity and provided only earphone volume. But they remained extremely popular—even during the vacuum-tube era—because of their simplicity and maintenance-free (no expensive batteries required) operation.

One and Two-Tube Sets

In the early 1920's, sets using vacuum tubes began to appear in the marketplace. The simplest of those employed one or two-tube circuits. The one-tubers, like the crystal sets, provided only earphone reception—though they offered increased volume and sensitivity. Many used a "regenerative" detection circuit, in which a portion of the tube's output was fed back into the input—a process that would cause the set to oscillate and squeal if not carefully controlled. Kept just below the point of oscillation, however, the tube became an extremely sensitive detector of radio signals. In two-tube circuits, the extra



The RCA Radiola III is a good example of an early 2-tuber. It has a regenerative detector and a one-stage audio amplifier.

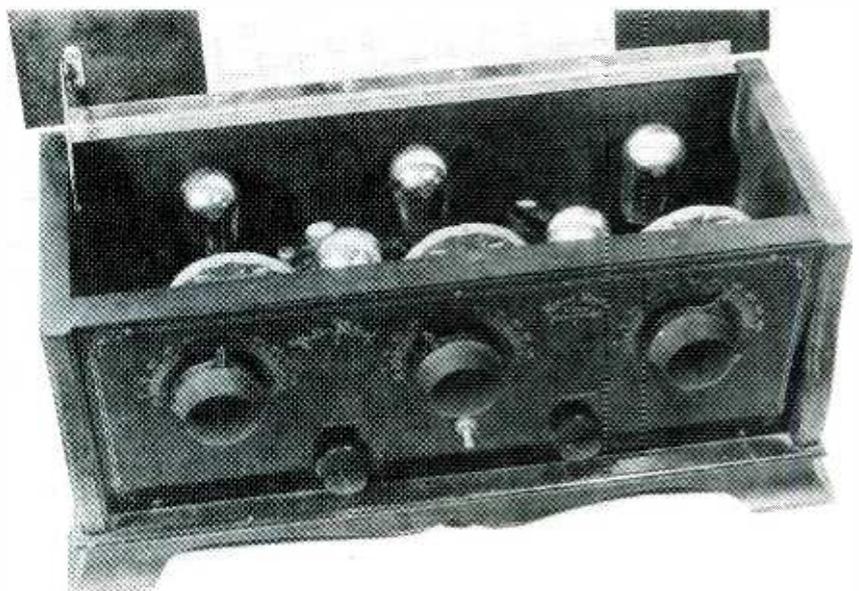
tube was most frequently used as an audio amplifier—providing enough extra volume (if signals were strong) to operate a small loudspeaker. Those simple sets were powered by relatively inexpensive, lightweight dry batteries.

Multiple-Tube Sets (Battery)

The mid-1920's radio buyer who was looking for something a little more power-



The Mengel Ehtherion Type M.R. 101 was a novelty crystal radio built into a small jewel-box-like case.



The Polle Royale is a 5-tube battery set of about the same era as the Radiola III. A staggered tube arrangement gave it an unusually compact "footprint" for its type.

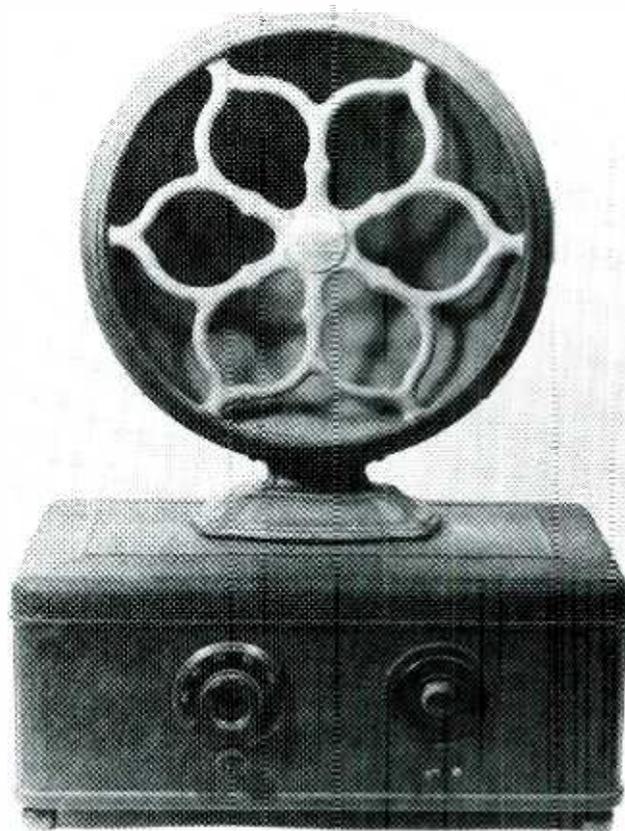
ful would probably buy a five-tuber. Those sets usually came in long, narrow cabinets to accommodate the straight-line tube arrangement generally in use. The typical set's tube complement included two R.F. amplifiers, a detector and two audio amplifiers. They could pull in a lot of signals and comfortably drive a loud-speaker. They were also tricky to operate (most had three separate tuning knobs as well as rheostats to adjust tube filament voltage) and required a lot of battery power. An automobile-type storage battery was used to light the tube, and one or more bulky dry batteries provided the other operating voltages.

Early AC Sets

By the late 1920's, radio designers had found a way to obtain necessary operating voltages from the 117-VAC power line. Batteries disappeared, but sets became bigger and heavier to accommodate the additional power-supply components. While the inside of the set was definitely more complicated, the front panel had become amazingly simplified. Filament rheostats (which had been provided to compensate for declining voltage as batteries aged) were no longer needed. During that era, methods were also worked out for ganging a receiver's tuned-circuit controls—so a single knob replaced the three previously needed for station selection. Separate speakers (housed in their own enclosures) were still used, but they were bigger and heavier to handle the greater available audio output.



A good example of an elegant console is the RCA Victor Radiola 66, shown in the pages of *Radio Craft* magazine for October, 1929. An early Gernsback magazine, *Radio Craft* was a direct ancestor of *Hands-on Electronics*.



The Atwater Kent Model 52 represents the first generation of "plug-in" sets. Most sets of this era were purchased with the manufacturer's matching speaker.

Later AC Sets

During the early 1930's, two distinct styles of radio cabinetry began to emerge. The console, an imposing piece of furniture usually enshrined in the living room, housed the larger chassis and the bigger speaker required to provide state-of-the-art reception and audio fidelity. At the same time, the development of more efficient tubes and circuits—as well as more numerous and powerful stations—made it possible to build very satisfactory radio reception into a much smaller package. That gave rise to the "table model" cabinet. The new table models were much more compact and lightweight than the earlier 117-VAC powered table radios and came with built-in, rather than separate speakers. While outperformed by the big consoles, they could easily be moved from room to room—allowing the family to enjoy radio entertainment anywhere in the home.

Plans for Next Month

I hope you're enjoying this quick trip through the land of vintage radio. In the next issue, we'll pick up our overview of old sets by looking at some of the dramatic changes in radio design that occurred as a result of the 1930's depression. After wrapping up the sets, we'll discuss other

types of radio collectibles—including radio tubes and parts, reproducing equipment, test equipment, literature and advertising. In the meantime, how about letting me hear from you? Contact me care of **Hands-on Electronics**, Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, N. Y. 11735. See you next time! ■



The Balkeit Model 55 typifies the downsized AC sets made possible by more efficient tubes and more powerful radio stations. Its "gothic cathedral" case houses a 5-tube (with rectifier) circuit.



By Herb Friedman

FRIEDMAN ON COMPUTERS

Software gets very expensive when all of it has to be replaced!

□ALTHOUGH MANY EARLY USERS OF PERSONAL computers still plug along with their 8-bit CP/M computers, when it comes time to replace *ol' reliable*, the computer of choice is most often an IBM-compatible. While the initial cost of an IBM-compatible computer rarely perturbs the buyer, the software-replacement costs have been known to drive people speechless: That's when users discover that the software can easily represent several times the cost of the new computer—that it's possible to pay well under \$1000 for a fully-loaded IBM-compatible, and several thousand dollars for replacement software.

Yet the truth of the matter is that much, if not all, of the old 8-bit software would be functionally adequate if you could figure out how to run it on the new 16-bit computer. In fact, many 8-bit programs are easier to use and somewhat more convenient than their 16-bit counterparts.

Because there is so much good 8-bit software still in use, there have been frequent attempts at using both software and hardware to provide an 8-bit environment on 16-bit computers.

Software Emulation

The pure software approach provides a software emulation of the 8080 microprocessor, which is the device for which CP/M was intended. As you might imagine, because it is an *emulation*, CP/M programs run somewhat slower—about 50% slower—on a 16-bit computer.

The best-known emulator is a program called "ZP/EM," which is available from the same folks that gave us *Media Master*, the disk-format converter. In fact, the two programs go together because *Media Master* is needed in order to move a program or data from a CP/M-formatted disk to an MS-DOS disk. *Media Master* sets up one MS-DOS disk drive to emulate just about any CP/M disk format. The user then uses the CP/M drive to copy the desired program(s) to an MS-DOS formatted disk on another drive, changing the diskfile's extension from .COM to .CPM during the copy process. The reason for the extension change is so that the MS-DOS computer doesn't confuse the CP/M program with one of the conventional MS-DOS .COM files, and vice versa.

Hardware Emulation

But as we said earlier, software emulation is very slow, even if it works. A far superior method is to use hardware emulation via a microprocessor known as a V-20 (for PC/XT computers; a V-30 for AT computers). The V-20 microprocessor is a pin-for-pin substitute for the an 8088 microprocessor. It can directly execute either 16-bit 8088 instructions or 8-bit 8080 instructions. In practice, CP/M hardware emulation runs at least as fast, and sometimes faster, than a *true* CP/M computer.

The best-known hardware emulators are Intersecting Concepts's "Acceler8/16," and the Micro Interfaces Corporation's "RUN/CPM." Both attempt to accomplish the same thing through differential application of the V-20. *Acceler8/16* is somewhat unusual in that it can also function as a CP/M software emulator (it appears to be a modified version of ZP/EM), but as a software emulator it suffers the typical 50% processing-speed loss, so we will concentrate on its use as a CP/M hardware emulator (in conjunction with the V-20).

To run a CP/M program using *Acceler8/16*, you first use its *Media Master* function to copy CP/M programs to an MS-DOS disk (changing the program's extension from .COM to .CPM). When you run the *Acceler8/16* software, the MS-DOS computer will automatically recognize the CP/M programs, automat-

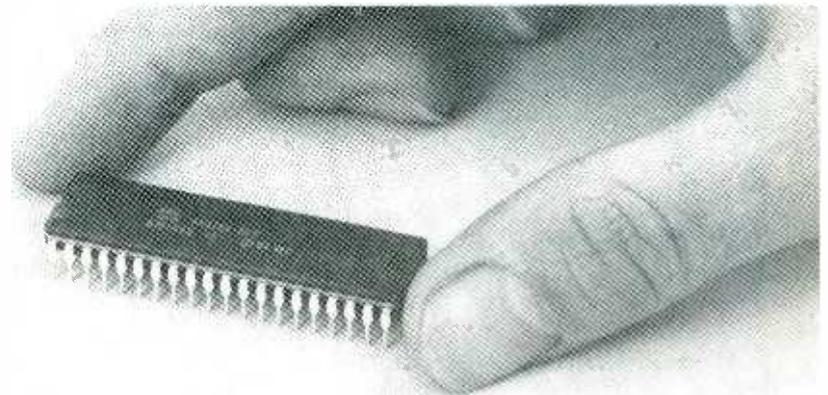
ically switch to hardware emulation if you're using a V-20, and respond to CP/M commands such as ERA, DIR, REN, etc.

An inconvenience with that method is that every program must be copied from a CP/M disk to an MS-DOS disk. But although the CP/M to MS-DOS transfer is slow, the total emulation is quite reliable.

In Real Time

A much more convenient CP/M emulation is provided by RUN/CPM, because it doesn't require copying of the CP/M programs to an MS-DOS disk. Like *Media Master*, RUN/CPM can also match virtually any CP/M disk format, but unlike other programs, which only provide a copy function for the *foreign* disk format, RUN/CPM sets up either the MS-DOS A: or B: drive—possibly both—to actually function as a foreign drive. For example, you can put an Osborne-format disk with a book-keeping program in the A: drive and an Osborne format data disk in the B: drive and run both directly on the MS-DOS computer; or, you could run an Osborne program disk in the B: drive and record the data to an MS-DOS disk in the A: drive.

Yes, you read that correctly. You can intermix CP/M and MS-DOS data, because the CP/M programs run under MS-DOS control, using MS-DOS commands. (If that appears confusing, read it through a few more times—it might be difficult to
(Continued on page 107)



The V-20 microprocessor looks exactly like the 8080. It will function as an 8088 unless specifically software-instructed to emulate an 8080. The software toggles the operating modes.

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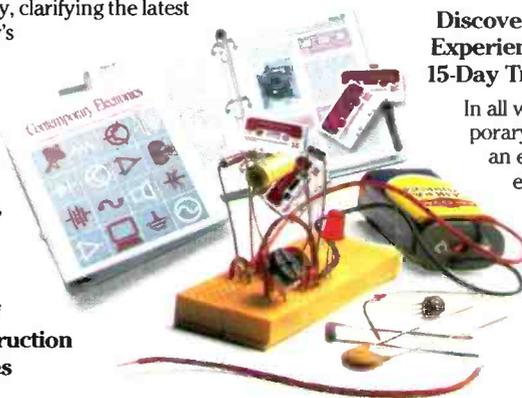
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With your first module, you'll build this solderless breadboarding system. As you add additional boards, you create increasingly complex circuits easily and quickly, bringing today's electronics concepts to life.

AUDIO FUNCTION GENERATOR

(Continued from page 38)

ready for service.

It doesn't take long to discover the advantages of a function generator and you'll soon wonder how you ever got along without one.

Testing Amplifier Frequency Response

One of the best uses for a function generator is testing the frequency response of an audio amplifier. Contrary to first impressions, it is not necessary to sweep the entire audio-frequency range to get an indication of an amplifier's performance. Precise response measurements can be made using two or three selected squarewave frequencies. Although simple in appearance, the squarewave actually consists of an infinite number of odd-harmonic sinewave components su-

perimposed on each other. Since the component sinewaves contain a balanced mixture of both low and high frequencies, faithful reproduction of a squarewave by an amplifier is a reliable indication of overall frequency response.

The test is performed by applying a squarewave to the input of the amplifier to be tested, and monitoring its output with an oscilloscope. Figure 7A shows the results of an amplifier with perfect frequency response. The display of an amplifier with poor low-frequency response is shown in Fig. 7B. Notice the characteristic sloping of the waveform. Poor high-frequency response is characterized by a rounding of the corners, as shown in Fig. 7C, which contains the highest frequency components. Another fairly common defect, phase shift with frequency, may be identified from the sloping sides of the distorted waveform as shown in Fig. 7D.

For best analysis, the test results should be evaluated at three frequencies: 50 Hz, 500 Hz, and 5000 Hz. ■

REPAIR SPEAKER DAMAGE

(Continued from page 55)

sound *mushy*. A dead speaker is caused by an open voice coil. A mushy sound is created when the speaker's cone rubs against the metal pole-piece. Also, if excessive volume has caused the cone to heat and warp it might *freeze* against the center magnet—the voice coil cannot move.

An intermittent speaker—one that cuts in and out—might have a poor connection at the flexible voice coil-leads. Also, check the speaker terminals for poor solder connections or a break in the speaker cable.

A noisy speaker may have small holes or tears in the cone area; or, the cone's rim might be loose. Very small holes can be repaired with regular speaker dope. If the cone is loose around the rim, try to cement it back on the metal rim. (I say "try," because sometimes it can't be done.)

A *blatting* noise may be caused by a loose cone spider or spacer close to the magnet area. Sometimes the blatting-type noise is heard when the voice-coil assembly has been damaged by excessive volume. Speakers with voice-coil damage or large torn cone areas should be replaced.

If you suspect that one or more speakers in a multi-speaker enclosure or system is open, locate the defective speaker by pressing your ear close to each speaker while music is playing.

If a woofer is open, most of the volume will be missing; if a tweeter is open the music will sound *dull*. If you can't be certain which speaker is open, simply measure each voice coil for continuity; remove one lead wire from the suspected speaker and test the voice coil with an ohmmeter.

A normal speaker will show continuity when using the

RX1 range of the VOM or DMM. Keep in mind that measured resistance might vary from the rated speaker impedance; for example, an 8-ohm speaker may have a resistance of 7.9 ohms while a 4-ohm voice coil may indicate only a few ohms. No measurement (infinity resistance) means that the speaker is open. If the tweeter and mid-range speakers test normal without any sound, suspect a defective capacitor or an open coil in the crossover network.

Replacing the Speaker

Try to replace the defective speaker with an exact replacement, because it will fit into the same hole, have the same magnet, and its sound quality will match up with the other speakers.

To ensure a correct replacement, go to the dealer where the speaker component was purchased or to the manufacturer's servicing depot. Make sure that you take along the speaker-enclosure model number and, if possible, the speaker itself.

If it is impossible to obtain an original speaker, try to select a comparable replacement. Select the right size, same weight of magnet, wattage, and voice-coil impedance of the new replacements. Small, inexpensive speakers are easy to obtain and may match up perfectly with the original speaker; they can be picked up at most electronics parts stores.

Today, most speaker enclosures have a removable front grille cloth or panel to get at the various speakers. Simply removing the screws from the large woofer speaker may provide enough room to check and test the other speakers. Front-mounted speakers are fastened to the plywood panel with wood screws. The rear panel may be sawed out with a saber saw to get at the defective speaker in a sealed baffle or enclosure. ■

SAXON ON SCANNERS

(Continued from page 95)

far as we are willing to speculate based upon the information available. If any readers can speculate further, please step forward and make yourselves known!

Are They Worth It?

Raymond L. Crandall, Glenwood, WA, asks if scanner preamps and pre-selectors are of any significant value in improving reception. Ray says that some-

times he can get 100-mile DX reception and therefore he wonders if such an add-on accessory would be of any real value.

Sure, it will bring in many additional stations, especially mobile units and base stations that don't have the *punch* that those you normally hear have. We have found that UHF monitoring has been substantially enhanced by adding a pre-amplifier to the station.

Such devices are simple to use: You just insert one where the antenna cable enters the scanner. No internal connections are

required, although you'll probably have to supply external power to the preamp. Ask your nearest scanner dealer to show you what he has available in the way of scanner signal boosters.

Scanner-Frequency Guides

One of the most commonly asked questions here is for information on where to obtain a selection of scanner-frequency guides.

We suggest that you request the latest (free) catalog from CRB Research, P.O.



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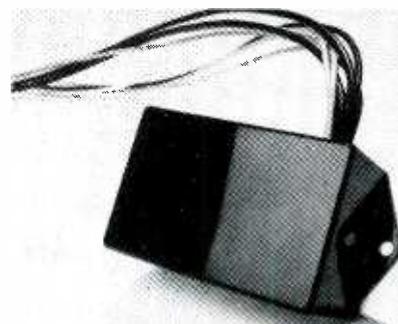
NEW PRODUCT SHOWCASE

(Continued from page 13)

puter tools, kits and accessories, write or call Jensen Tools Inc., 7815 S. 46th Street, Phoenix, AZ 85044; Tel. 602/968-6241.

Glass Break Protector

Audiovox Corporation has introduced an automobile glass-breakage protection device that triggers an alarm when an intruder attempts to forcibly enter an automobile through the glass windows, windshields, sunroof or T-top. The glass-



CIRCLE 70 ON FREE INFORMATION CARD

break protector is an easy-to-install system that is compatible with all types and brands of auto security products.

The latest Audiovox product (model number AA-9092) contains a wide-range sensitivity control, LED sensitivity indicator, and a dynamic microphone. The AA-9092 has a suggested retail price of \$59.95. For more information, contact Audiovox Corporation, 150 Marcus Blvd., Hauppauge, NY 11788; Tel. 516/231-7750.

COMMODORE DISK DRIVE

(Continued from page 76)

and press RETURN. If the screen says *searching*, then *loading*, mark the correct arrangement of the switches with an 8. If the screen says *drive not found*, change the 8 on the load command to a 9 and hit RETURN again. If necessary, try 10, and 11; and one of them will respond with *loading*. Mark that number on the switch diagram. If none of them loads, remove the disk and replace it between tries. If there is still no load, recheck your work.

If the load works OK, turn off the drive, change one switch

and turn the drive back on. Repeat the routine again until all four drive-select numbers are in their proper place in the diagram.

Reassemble the case in the reverse order of disassembly.

Selecting the Drives

Always make certain that you have the drive-select switches set the way you want them before you turn on the drive. Switching after power is applied might cause damage to the drive. Similarly, do not either connect or disconnect a drive with any power turned on. ■

Box 56-GP, Commack, NY 11725. They have a huge assortment of scanner directories covering police, fire, federal, aeronautical, railroad, emergency, and many other services.

FAA (Federal Aviation Administration) communications are often quite interesting: 135.85 and 135.95 MHz can produce FAA Flight Check stations testing the accuracy of airport navigational aids.

FAA Communications

Arthur Buckland, of South San Fran-

cisco, CA, writes to say that in the Bay Area the FAA has also been monitored on 172.95 and 172.975 MHz. Monitors in other areas of the nation might find that those two channels produce activity. Let us know and we'll pass it along to our readers.

I've Been Working on the Railroad

Ed Randazzo, Nashville, TN, would like us to publish the road frequency used by the Birmingham Southern Railroad.

Easy, Ed, that would be 160.29 MHz,

and quite active, too.

Gee, we're just barely got into the stack of mail and already we've used up this month's allotment of space. But don't be bashful; keep in touch and let us know what you're hearing on your scanner.

You might even want to pass along a photo of your station. ■

Let us know your comments by sending a letter to Saxon on Scanners, **Hands-on Electronics**, 500-B Bi-County Blvd., Farmingdale, N.Y. 11735.

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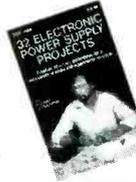


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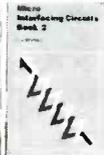
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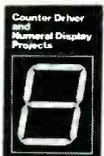
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JENSEN ON DX'ing
(Continued from page 25)

casting station in an overseas location, you run the chance of losing the whole investment should the government in the host nation change, either by democratic means or by coup.

That, of course, is not a major concern in cases involving territories actually governed by the mother country, such as Radio Nederlands's Bonaire site; Radio France International's Montsinery relay, or Spain's Radio Exterior de Espana operation at Tererife, Canary Islands. In most cases, though, it can be difficult to locate a relay station on a long term basis.

One answer for the big international stations is cooperative agreements with host governments, giving them a stake in the broadcasting facilities. Typically, in return for permission to put up a relay transmitter complex, the host country gets use of some of the broadcasting facilities for their own purposes.

The Moroccan and Greek government SW'ers, for instance, have access to some of the powerful VOA transmitters at Tanger and Kavala, respectively. Spain has reached a similar arrangement with the government of Costa Rica to establish a shared transmitting facility.

Another solution for cutting costs is to lease time from private—or nominally private—shortwave stations.

One of the first of those was Radio Trans Europe at Sines, Portugal, which operates a pair of 250-kW shortwave-transmitters-for-hire.

Among the international broadcasters who lease time from that relay facility are Deutsche Welle, Radio Canada International, and Radio Japan.

Japan's shortwave voice also buys air time from a station called Africa Number 1 at Moyabi in the West African nation of Gabon. Radio France International also uses the Moyabi outlet for its program relays to African audiences.

Relayed programs, of course, are the same as those aired by transmitters located in the "home" country. So how can you tell if its a relay or not?

Often, it is hard to tell if a program is relayed, without a station's schedule of programs, hours and transmitters at hand. Most stations, though, do announce actual transmitter sites at least at the beginning and end of programming blocks.

Here are some relay transmissions by major international broadcasting stations:

British Broadcasting Corp—via Antigua, West Indies, World Service in English, from 0000 UTC on 6,175 and 7325 kHz—via Ascension Island, in English, from 2130 UTC on 11,820 and 15,260 kHz—via Singapore, in English, from 0000 UTC on 17,710 kHz—via Sackville, Canada, in English, from 1700 UTC on 11,775 kHz.

Voice of America—via Great Britain, in various European languages, from 1600 UTC, on 11,855 kHz—via Monrovia, Liberia, in English from 0300 UTC, on 6,035 and 11,720 kHz.

Radio Moscow—via Cuba, World Service in English, from 0000 UTC, on 6,000 kHz.

Radio France International—via French Guiana, in French and English, from 0300 UTC, on 6,055 and 9,800 kHz—via Gabon, in French and English, from 1700 UTC, on 9,790 kHz.

Deutsche Welle—via Antigua, in English, from 0100 UTC, on 6,040 kHz.

Radio Nederland—via Bonaire, Netherlands Antilles, in English, from 0230 UTC, on 6,065 kHz—via Madagascar, in English, from 0700 UTC, on 21,485 kHz; and from 1430, on 11,735 kHz.

Voice of Free China—via WYFR, Florida, in Chinese and English, from 0030 UTC, on 5,985 and 6,065 kHz.

Family Radio, WYFR—via Taiwan, in English, from 1500 UTC, on 6,015 and 9,635 kHz.

Radio Beijing—via French Guiana, from 0200 UTC, on 6,015 and 9,635 kHz.
(Continued on page 107)

Hands-on Electronics

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SEE in complete darkness with amazing new infrared night viewers. Kit \$189. Factory assembled \$295. Super long range model \$750. (Dealers wanted). Catalog \$1. **CROSLEY (F)**, Box 840, Champlain, NY 12919. (514) 739-9328.

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BUY BONDS

JENSEN ON DX'ing

(Continued from page 105)

Down The Dial

Here are other stations and programs being logged by some of our SWL friends. Let me know what you're tuning on shortwave these days. If you have any questions about shortwave DX listening, send them along to: Jensen on DX'ing, **Hands-on Electronics**, Gernsback Publications Inc., 500-B Bi-County Blvd., Farmingdale, NY 11735.

Iran—5,084 kHz. *Voice of the Islamic Republic of Iran* from Teheran can be heard beginning its English language programming at 1112 UTC, with its tuning signal and opening announcements.

Iraq—9,565 kHz. Iran's mortal enemy, Iraq broadcasts its English programming on 9,565 and 11,750 kHz.

Falkland Islands—3,958 kHz. Falkland Islands Broadcasting Service, from the far South Atlantic, is a very nice

DX catch on shortwave about 0430 UTC.

Clandestine—5,015 kHz. *Radio Truth* broadcasts, allegedly from South Africa, although it does not announce its location to Zimbabwe, in English from 0430 UTC.

Yugoslavia—7,240 kHz. *Radio Yugoslavia* in Belgrade can be heard with its English programming from 2200 to 2230 UTC.

Brazil—11,745 kHz. Radiobras' "Tourism" English language program, 0225 UTC every other Monday, offers a brief glimpse of some of the highlights for travelers in Brazil.

Norway—15,305 kHz. Radio Norway offers only one English program a week on shortwave. "Norway Today" can be heard at 1300, 1400 and 1700 UTC.

Credits: Richard D'Angelo, PA; Sheryl Paszkeiwicz, WI; Norman Bobb, MN; Gladys Martin, Brooklyn, NY; Alex Batman, LA; North American SW Association, 45 Wildflower Road, Levittown, PA 19057. Byron Wels, Farmingdale, NY. ■

FRIEDMAN ON COMPUTERS

(Continued from page 98)

digest at once.) When running from a CP/M disk, you use the programs *as is*. When the CP/M program is running from an MS-DOS disk, the extension must be changed from .COM to .CPM to avoid confusing the MS-DOS operating system.

A Hair Trigger

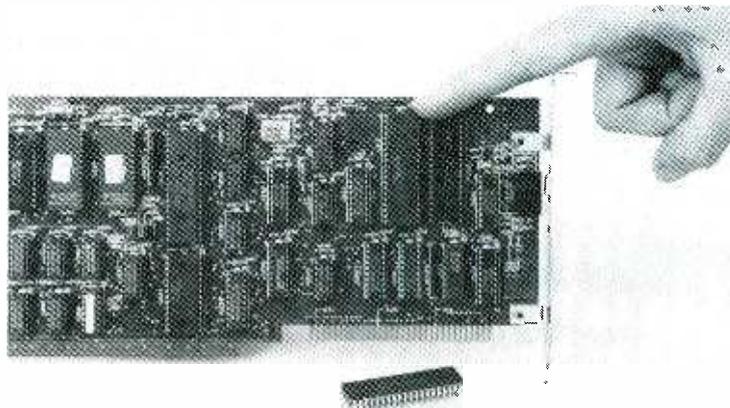
Although RUN/CPM is the most convenient hardware method for running CP/M programs on an MS-DOS machine, its operation is best described as *hairly*. We had a chance to try two different updated versions of the program and both tended to lock-up the computer if anything whatsoever went wrong; so a user must pay strict attention to details in order to get it to run correctly. Also, the manual is unclear: It appears to have been written by *hackers*, for *hackers*, leaving much to intuition or experimentation. (Just make certain that you don't use any valuable or

important disks when experimenting).

One final difficulty we had with RUN/CPM is that it requires a computer having at least two floppy-disk drives. We used it on an IBM having two floppies and a hard disk and it worked just fine, although we had considerable difficulty in using the hard disk because we simply couldn't decipher the section in the manual on how to do it. (Or the program was defective and we didn't know it because of the manual.)

No Z-80 Code

If you have any problems with any of the CP/M emulators, it will be with programs that are system or disk utilities, hardware dependent, or which contain Z-80 instructions. Presently, all emulators are intended for the 8080, the microprocessor for which CP/M was originally intended. If your particular CP/M program(s) uses instructions for the Z-80 microprocessor the emulators won't run them. Unfortunately, you rarely know in advance whether a program was written in 8080 or Z-80 code. ■



To retrofit consists of simply locating your computer's 8088 and then substituting the V-20 microprocessor.

JUNKBOX BLUES

(Continued from page 94)

sumer-electronics store that wants to throw out its warehouse full of non-working trade-ins. Once he brought home three truckloads of old TVs. I couldn't find any better place for that last box of computer boards than hanging them on the wall—my friends who are not into electronics think I am a daring decorator with sophisticated taste.

Of course, our madness has moments of clarity. Once in a blue moon we all shake our heads clear of miasma, look around in surprise and horror, and gird our loins for trimming the junkbox back to size. We throw out circuit boards having 98 non-removable, unidentified integrated circuits. We discard leaking electrolytics, hoary connectors, odd lengths of ancient coax, ungainly chassis, plus all the resistors, capacitors, and inductors whose values cannot be identified and whose legs are too short to hook up.

We give up on the transformers that might or might not have a shorted coil, and sort all the components we plan to

keep into neat, well-marked boxes and cans. We squeal in delight as we uncover the photocell we couldn't find last month after hours of searching. We welcome the discovery of a box that's perfect for the project we hope to get to next week.

In a cathartic paroxysm of organization, we pile the discards higher and higher. The most impossible make it to the garbage can. Those pieces that we cannot reasonably ever expect to use, but which are too wonderful to part with, we try to foist on other hams. My husband and son rescue some of my rejects as soon as I turn my back, while I thriftily save some of the components they so cavalierly threw away.

Finally, we reach a day where all the excess junk has been hauled away. We no longer risk stubbed toes and barked shins from protruding chassis and odd transformers if we get up at night for a drink of water. We can again invite our friends who are not into electronics to visit without shame. We revel in self-congratulation and feelings of virtue. We swear we will never again let the junkbox get out of hand.

On that day, inevitably, we need something, desperately, that we threw out the day before. ■

INDUCTIVE CURRENT PROBE

(Continued from page 70)

printed-circuit board. Regardless of the construction used, make sure that the components are in the correct place with the proper orientation. A misplaced or misoriented component will result in an inoperative circuit, not to mention burned-out parts. So save yourself some time and irritation.

If you decide to go the printed-circuit route and a nice tight package is your goal, it is best to do the layout on a 2-to-1 scale and then reduce it to 1-to-1. Doing so provides a comfortable work area and allows the circuit traces to be easily routed between IC pins and component pads. Plus, the final layout (when reduced) will have a more professional appearance. But, let's not lose sight of the negative side of that procedure: Because of the tight spacing that will result, be careful not to overheat the semiconductors when solder-

ing—excessive heat is the enemy of all semiconductor components.

For stand-alone operation, it will be necessary to build a power supply into the circuit. A common three-terminal regulator, such as a 7812 12-volt unit, and a couple of filtering capacitors (for example, a 100 μ F electrolytic and a 0.1 μ F ceramic disc) is all that's required—one at the regulator input and the other at the output. ■

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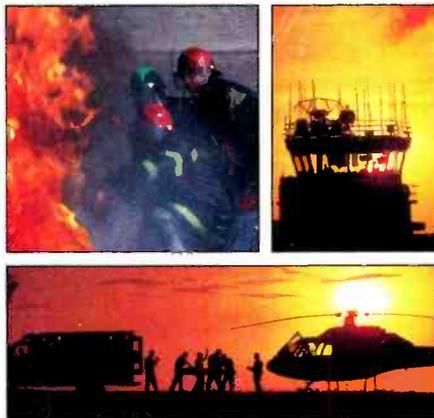


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