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MODERN ELECTRONICS™

OCTOBER 1985 $1.95
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THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

New Technology

- **NEW, QUIETER FM STEREO BROADCAST SYSTEM**

Construction Project

- **ADVANCED FURNACE CONTROLLER BOOSTS HEATING EFFICIENCY**

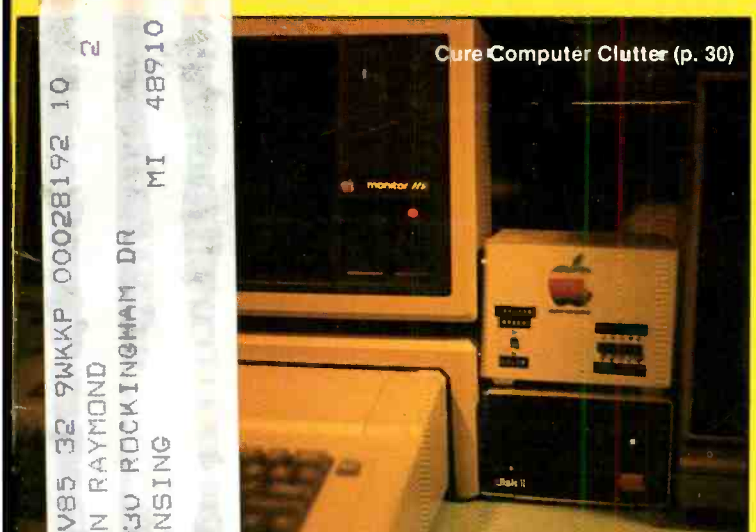
First Impressions

- **Commodore's Wonder Computer: The Amiga**
- **Epson's LX-80 Printer**
- **Ericsson's Portable PC**

Sharp VHS Hi-Fi VCR Evaluated (p. 10)

Projects & Applications

- **Measure Temperature with Any Voltmeter**
- **Practical Op-Amp Circuits**
- **A Testbench Audio Amplifier**
- **Switcher Cures Computer Clutter**
- **Experiment with Sound-Detection Circuits**



Cure Computer Clutter (p. 30)

Project Measures Temperature With Any Voltmeter (p. 50)

Also in this issue: Testing Sharp's Newest Hi-Fi VCR and Juki's $295 Letter-Quality Printer . . . Lancaster Discusses Computerized Cubic Splines for Drawing Freeform Curves . . . Examining DX-Propagation Commodore-64 Software . . . Latest Electronic/Computer Products & News . . . and more.

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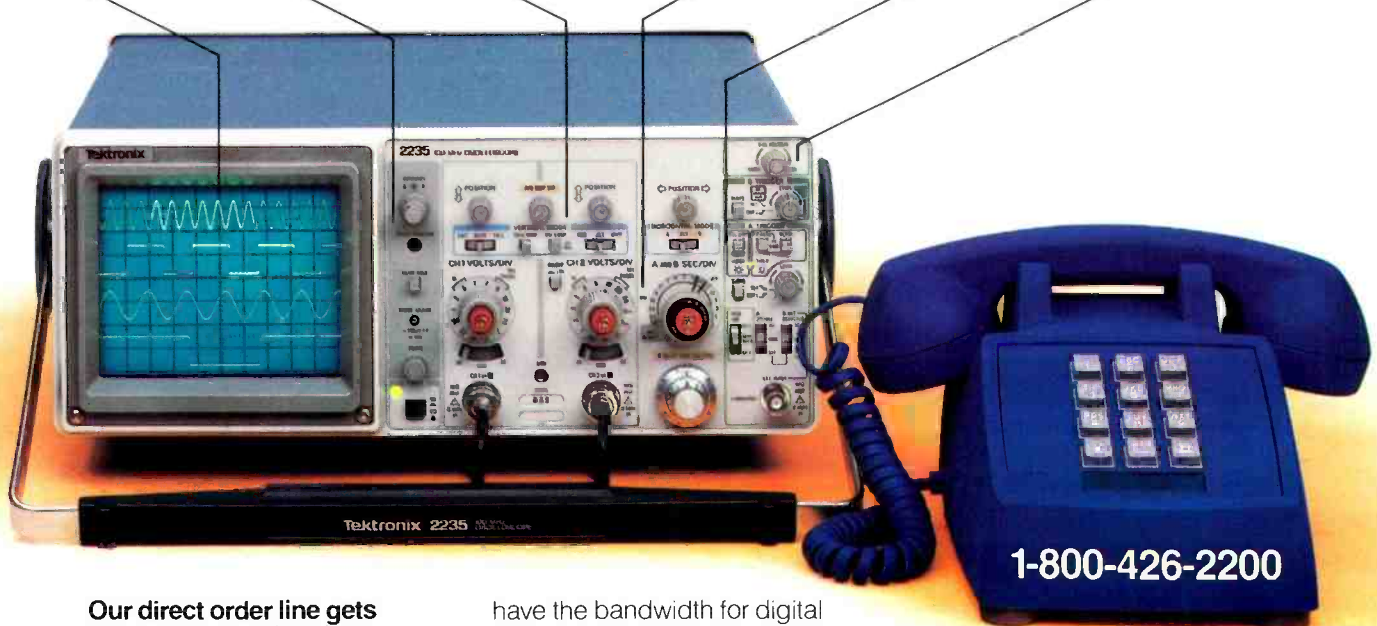

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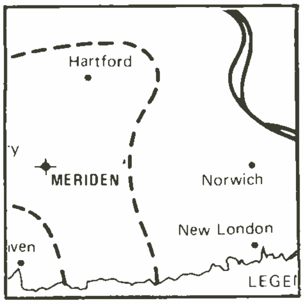
MODERN ELECTRONICS

THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

OCTOBER 1985

VOLUME 2, NUMBER 4



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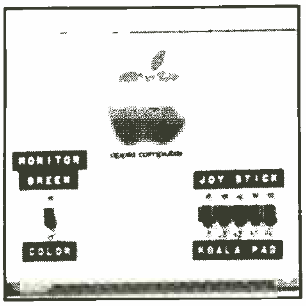

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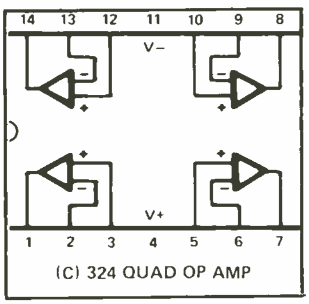

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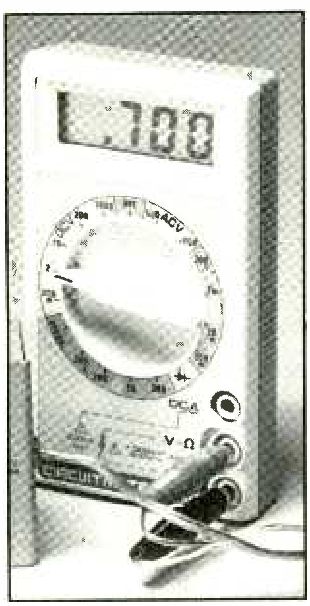
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FEATURES

PRODUCT EVALUATIONS

DEPARTMENTS

Offices: 76 North Broadway, Hicksville, NY 11801. Telephone: (516) 681-2922. Modern Electronics (ISSN 0748-9889) is published monthly by Modern Electronics, Inc. Application to mail at second class rates pending at Hicksville, NY and other points. Subscription prices (payable in US Dollars only): Domestic - one year $16.97, two years $31.00, three years $45.00; Canada/Mexico -one year $19.00, two years $35.00, three years $51.00; Foreign - one year $21.00, two years $39.00, three years $57.00. Foreign Air Mail - one year $74.00, two years $145.00, three years $216.00.

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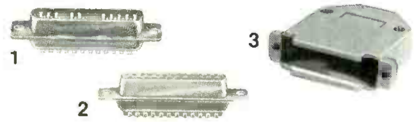

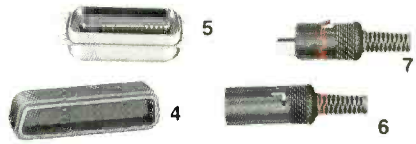

Solder-Type Subminiature "D" Connectors. Ideal for building your own RS-232 cables.

Fig.	Type	Positions	Cat. No.	Each
1	Sub-D Male	25	276-1547	2.99
2	Sub-D Female	25	276-1548	3.99
3	Hood for Above	25	276-1549	1.99

(4) Dustcaps. For Sub-D 25 connectors. Help prevent moisture and dirt contamination. One male and one female. **276-1546** .... **Set 39¢**

(5) Printer Connector. NEW LOW PRICE! 34-position solder-type connector for parallel printers. Heavy-duty metal-shielded construction for trouble-free service. Was $6.99. **276-1534** **4.99**

(6) 6-Position DIN Plug. Fits joystick port of Tandy Color Computer 2. Use with inline jack to build your own joystick extension cord. **274-020** **1.19**

(7) 6-Position Inline DIN Socket. For use with 6-pin DIN plug. **274-021** .... **99¢**

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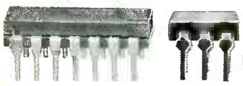
CMOS and TTL Digital ICs



All Include Pin-Out and Specs

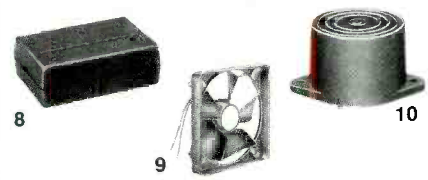
CMOS	Cat. No.	Each
4001	276-2401	.99
4011	276-2411	.99
4013	276-2413	1.19
4017	276-2417	1.49
4049	276-2449	1.19
4066	276-2466	1.19

TTL	Cat. No.	Each
7400	276-1801	.89
7404	276-1802	.99
7408	276-1822	1.29
7447	276-1805	1.69
7490	276-1808	1.19

Computer Interface ICs

Type	Cat. No.	Each
MC1488 RS232 Quad Line Driver	276-2520	1.79
MC1489 RS232 Quad Line Receiver	276-2521	1.79
MOC3010 Triac-Output Optocoupler	276-134	1.99

Check These Super Values!

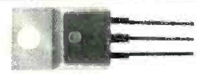


(8) Small Enclosure and PC Board. A real bargain! The $1^3/_{16} \times 3^7/_{16} \times 2^5/_{16}$" enclosure is of rugged, yet easy-to-drill plastic. Internal PC board has 483 DIP-spaced solder-ringed holes. Two labels, hardware, snap-in rubber feet. **270-291** ... **2.99**

(9) 4" 120 VAC Cooling Fan. Whisper quiet and efficient. Moves heat away from computers, ham and hi-fi equipment. Also useful in solar heat systems. 65 CFM. Leads for easy hookup. $4^{11}/_{16} \times 4^{11}/_{16} \times 2^1/_2$". U.L. recognized. **273-241** **15.95**

(10) Electronic "Doorbell" Chime. Gives you the familiar "ding-dong" sound and it operates from one "D" cell. $4^3/_4$" leads. **273-067** ... **6.95**

Voltage Regulator ICs



Type	Function	Cat. No.	Each
7805	5 VDC Fixed	276-1770	1.59
7812	12 VDC Fixed	276-1771	1.59
7815	12 VDC Fixed	276-1772	1.59
LM317T*	1.2 to 27 VDC	276-1778	2.79
LM723	0 to 40 VDC	276-1740	.99

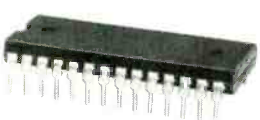
* 14-Pin DIP, others TO-220 case

Switch Values

(11) Rotary Switch. 2-pole, 6-position. Rated 0.3 amp at 125 VAC. Single deck, non-shorting type. $^1/_4$"-diameter shaft. **275-1386** **1.19**

(12) NEW! 120 VAC SPDT Push-On/Push-Off. Round button. Rated 3 amps at 120 VAC. Lamp requires 12 volts, AC or DC. $^1/_2$" mtg. hole. **275-677** **4.95**

Voice Synthesizer IC



Heart of a Rewarding Project!

SPO256-AL2. This MOS LSI device uses a program stored in its built-in 16K ROM to synthesize natural sounding speech. Requires low-cost support components and is easy to interface with most microcomputers. Requires 3.12 MHz clock crystal (available through Radio Shack). 28-pin DIP with detailed specs and programming data. 5 VDC, single supply. **276-1784** **12.95**

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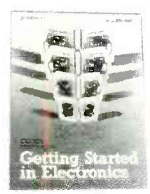
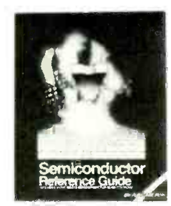


Getting Started in Electronics. By Forrest Mims III. The perfect introduction to the exciting world of ICs and solid-state. It's written in easy-to-understand language by one of America's most popular technical authors. Features large schematic diagrams with clearly labeled component values. 128 pages. **276-5003** **2.49**

Semiconductor Reference

Half Price!

1.75 Reg. 3.49



- 1985 Edition
- 272 Pages
- Illustrated

Exclusive substitution section lists over 80,000 semi types and their low-cost Radio Shack equivalents. Data on Radio Shack ICs, SCRs, LEDs diodes and opto devices. **276-4008** .... **Sale 1.75**

TV RF Modulator

Special Purchase!

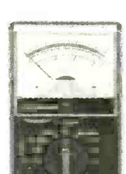
Only **4.95**

Compare our LOW price to mail-order offers on this high-quality device! Originally for TI 99/4 computer, this prewired, metal-cased module provides a superior-quality TV signal on channel 3 or 4. 5-pin DIN plug accepts video, audio and 12 VDC power input. Extra-long cable for easy hookup. With data. **277-1015** **4.95**

Pocket-Size, 8-Range Multitester

Save $2.07

8.88 Reg. 10.95



Switched Ranges

2000 ohms-per-volt sensitivity, yet only $3^1/_2 \times 2^1/_4 \times 1^1/_4$" and super durable. Ranges: AC and DC volts 0-15, 0-150, 0-1000. DC current to 150 milliamps. Resistance to 100,000 ohms. With leads, manual. Requires "AA" battery. **22-212** .... **Sale 8.88**

Digital Logic Probe With Tone Output

19.95

Overload Protected

The fast way to "peek inside" TTL, LS and CMOS digital circuits. Color-coded LEDs indicate high, low or pulsed logic states (up to 10 MHz). The simultaneous tone output frees your eyes for faster testing. With illustrated instructions and user's tips. **22-302** **19.95**

Sale! IC Inserter and Extractor Set

Cut 30%

4.88 Reg. 6.95

Handle DIP ICs The Safe Way

This easy-to-use set helps you remove or install DIP ICs without bending pins. The inserter features a built-in pin straightener. Both of the tools are groundable to protect static-sensitive MOS devices. **276-1574** .... **Sale, Set 4.88**

Over 1000 items in stock: Binding posts, Books, Breadboards, Buzzers, Capacitors, Chokes, Clips, Connectors, Fuses, Hardware, ICs, Jacks, Knobs, Lamps, Multitesters, PC Boards, Plugs, Rectifiers, Relays, Resistors, Switches, Tools, Transformers, Transistors, Wire, Zener Diodes, and more!

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EDITORIAL

Our First Milestone

Starting our second year of publication with this issue gives us some special pleasure. After all, the publishers of *Popular Electronics* had considered active electronics/computer hardware enthusiasts to be virtually an archaic sect. It's clear that this is not so, judging from our responsive readers and growing number of advertisers.

Not that it's been easy, but sweet life is born in pain.

We recently added 37,000 readers who formerly subscribed to defunct *Computers & Electronics*, PE's short-lived later name. They had previously subscribed to PE, so have a strong affinity for electronics. As a result, we've had an opportunity to read some letters from these people that were sent to C&E's circulation department. A sample here captures the essence of many others:

> "I *don't* want more *computer*-only magazines. My original subscription was for *Electronics*. A few months after renewal of *Electronics* you switched to *Computers* & Electronics (a minimum of electronics)!!! I wrote cancelling my subscription, which was ignored. . . ."

Most of these new *Modern Electronics* readers are also into computers, but want electronics as well, with more emphasis on the latter. MODERN ELECTRONICS was conceived to serve such technically oriented people, the majority of whom are involved professionally in some area of electronics.

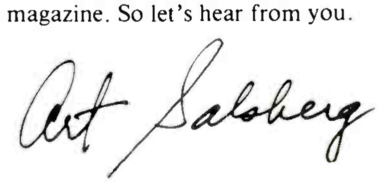
With 12 issues under our belts, we reflected on the past year's publishing effort while working on this one. During our first one-year period we published a total of 747 pages of editorial matter or an average of 62¼ pages per issue plus covers and advertisements. This is a healthy editorial package that compares favorably with that of other technically oriented magazines established many years longer.

Our editorial mix spans the electronics world: Electronic projects and tutorials lead, of course. In the feature article area, it constituted 51.8% of the editorial matter. General technical product articles accounted for another 25.2%, while computers (including computer-oriented projects) garnered 23.1% coverage.

Our columns and departments make up about 40% of the editorial material presented every month. These include Forrest Mims's "Electronics Notebook" electronic experiments, Don Lancaster's "Hardware Hacker," Eric Grevstad's "PC Papers," "New Products," "News," "Product Evaluations," and so on. To distinguish between the two, look for an author's byline or the absence of one. Columnists are identified, and their opinions and conclusions are solely their own; departments such as "New Products" are written in house.

An article index, October 1984 through December 1985, will be included in our year-end December issue. Back copies can be ordered at $2.50 each. Also, should any readers like to write articles for *Modern Electronics*, ask us for our Author's Guide (enclose a stamped, self-addressed envelope).

We try to touch all bases every issue and believe we have a happy mix of electronics and computer information. You're the final arbiter, though. Any suggestions or expressions of likes and dislikes are always most welcome. We'll take them all into account as we continuously fine-tune the magazine. So let's hear from you.



LETTERS

A Happy Discovery

• I was most happy to discover your (relatively) new magazine on the stands. It's good to see all of those familiar names on the masthead and in the table of contents—so good that I've sent in a subscription order.

Jamie E. Hanrahan
San Diego, CA

Correction

• In your July 1985 issue you show a schematic drawing of a portable gas detector. If you look a little closer you'll see that when S1 is closed there is a direct short between V+ and ground.

The foil pattern is correct. Hopefully most of your readers used the PC board and did not wire-wrap this project.

R.D. Payne
Salinas, CA

The V+ line in Fig. 1 should come down the anode side of the LEDs and terminate at pin 9 of IC1. *It should not continue on to the ground connection as shown. The pc guide in Fig. 2 is correct.—Ed.*

Lancaster Booster

• Once again, here's a note to say you folks are right on. Editorial slant is even better than P.E. in its time. Don L. is wonderful—comments on Laserwriter compatibility, etc.

Nicholas Bodley
New York, NY

Down with page 53!

• Here's one vote against the acceptance of future ads such as that on page 53 of the July 1985 issue. One can only assume the "Hacknet" ad is what it purports to be and doesn't represent a "sting" operation. Therefore, this ad for a service ". . . dedicated to computer intrusion . . . and software piracy . . ." isn't the sort of business with which you should associate, regardless of the advertising revenue generated.

Michael Meyers
Montclair, NJ

• I am shocked by the appearance of the ad on p. 53 [Hacknet] of your July issue. Placing an ad for such an organization is nothing short of an endorsement for the illegal and unwanted access they so proudly proclaim.

Ren J. Tescher
Williston, ND

We agree. The ad slid in at the last production moment. It will not be accepted again.—Ed.

Mid-East Video Fan

• Your magazine has more breakthroughs than *Popular Electronics* ever introduced in a single year. I read an article on Videocassettes in your May issue, and there you mentioned the latest play-only VCR made by a South Korean Company, the Goldstar Electronics, the top-loading model VCP-400M, which carries a suggested retail price of $349.95 each. As a consumer I would like to know if there is any local distributor of the above product, including video enhancer, chroma compensator, stabilizer, fader, and modulator, here in SAUDI ARABIA. If there weren't any, I only wish that you would recommend a best selection and the distributor's addresses.

Edgardo P. Generoso
Buraidah Water Treatment Plant
Al-Motta, Buraidah, Gassim
Kingdom of Saudi Arabia

Write to Goldstar Electronics, 1050 Wall St. West, Lyndhurst, NJ 07071.—Ed.

BORLAND SELLS MILLIONTH SOFTWARE PACKAGE. In only about two years since its start, Borland International announced it sold its millionth computer software package. The company's star rose sharply with the introduction of its low-cost desktop utility program, Side-Kick, a set of popup windows that can be called up in the middle of an applications program. As a result, it moved to new, larger facilities; 32,000 sq. ft. compared to its former 8,000 sq. ft.

FLOPPY DISK CAMERA. Konica unveiled a prototype still video system recently with a 2.2 lb. camera that uses a 1.85" floppy disk to store images. A prototype video player was revealed, too, that plays back the disk's recordings, either single or continuous frames, as well as a hard-copy printer.

COMMODORE'S AMIGA COMPUTER BOWS. The Amiga personal computer, a $1295 machine (excluding monitor) that promises to challenge Apple's Macintosh, was demonstrated in all its colorful graphics glory to a large group of press people. Using the same Motorola 68000 CPU, its operation is faster than Mac's and can accommodate more user memory, as well as featuring full color performance. The desktop icons, windows, and mouse are all there. With Digital Research's GEM software giving IBM PC's and compatibles Mac-like operation, there are now three systems in this exciting design area.

SIR CLIVE BITES DUST. Sir Clive Sinclair gave up controlling interest in Sinclair Research as bills piled up during a soft computer-sales market this year. The company's QL computer has not yet been marketed in the U.S. except for one mail-order source. Sir Clive is still with the company, however, as "Lifetime President" and research consultant.

SWITCHING TRANSISTOR SPEED RECORD. Honeywell's Physical Science Center developed what's said to be the fastest semiconductor switching transistor ever made, with current travelling between 25 GaAs transistor gates in a record 11.6 trillionths of a second. A self-aligned gate technique was used, depositing a larger amount of ions into the source and drain regions.

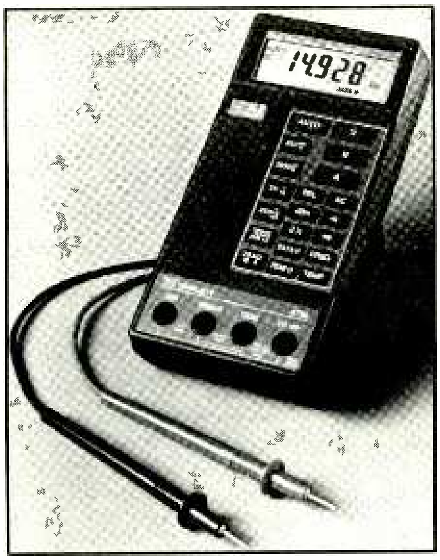
AUTOMATIC VEHICLE LOCATION. A mobile-to-fixed system available from Motorola provides accurate vehicle location up to 1/8th of a mile. It uses the Federal Government's existing LORAN-C network, and a low frequency transmission system infrastructure. The system's database accommodates up to 2,000 street intersections and 200 user-defined sites.

VIDEOCASSETTE MOVIE VENDING MACHINES. Vending machines for videocassette movies have been introduced by Video Vendor, Skokie, IL. The machine underwent tests at a 7-Eleven store, where the maker says hundreds of customers are already using it. The machine takes cash (dollar bills, five-dollar bills or quarters) and can display up to 320 different movie cassettes for rent, virtually a wall of cassettes. Customers fill out an application listing their credit card's information. To rent a movie, a key pad is used to enter an account number and the number of the movie to be rented. After depositing appropriate charge, say, $2, the cassette is said to be "vended" in about 25 seconds. Video Vendor is being sold for $7,500. Might be the Eighties equivalent of the 24-hour laundromat business.

For more information on products described, please circle the appropriate number on the Free Information Card bound into this issue or write to the manufacturer.

"Smart" DMM

Triplett's new Model 4750 4½-decade digital multimeter is claimed to be one of the most advanced DMM's around. Its measuring capabilities include dc/ac voltage, dc/ac current, resistance, frequency, dBm, diode check, continuity check and temperature. Measurements on ac are in true rms, rather than the usual average. In addition, data hold, peak hold, relative display, optional 3½-decade display mode and autoranging are provided. Every function of this "smart" DMM is selectable via a calculator-like keyboard, while a custom LSI chip and CPU provide a 25,000-count resolution.



On power-up, all functions are displayed on the large LCD display and a beep tone is heard. The selected function is displayed and autoranging can be selected. You can then choose manual ranging. In this mode, a relative measurement mode is available in all voltage, current and resistance ranges and the applied input is stored as a zero-reference point. Subsequent measurements are then displayed as deviations from the stored value, making this mode ideal for cancellation of lead wire resistance and for simplified go/no-go deviation measurements.

The peak-hold function is useable on voltage, current and temperature measurements with the positive peak signal value stored for up to 12 hours. The Model 4750 DMM measures 7" × 3½" × 1¾".

CIRCLE NO. 105 ON FREE INFORMATION CARD

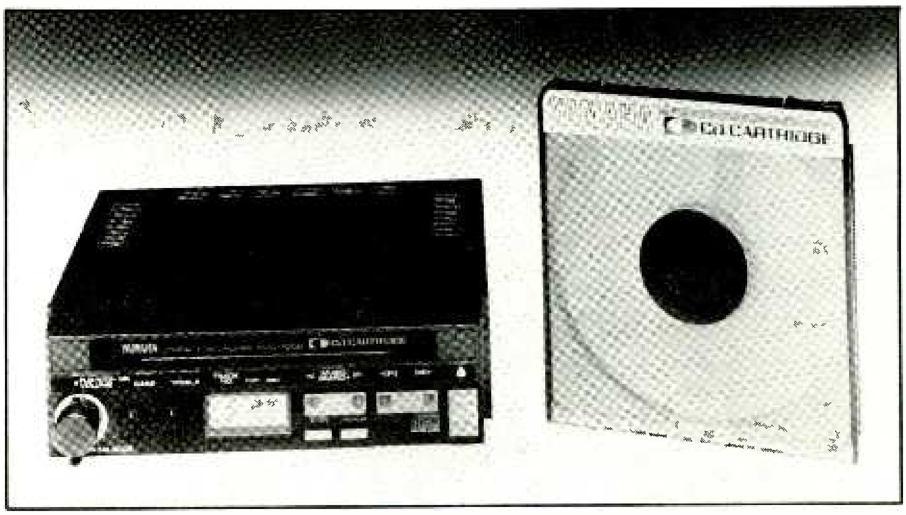
Car CD Player

Yamaha's new Model YCD-1000 car audio compact disc player uses a pair of custom LSI integrated circuits and a new solid-state laser to solve disc-handling, vibration and size problems in the automotive environment. By using a disc cartridge, the player eliminates the handling problem. A floating suspension removes the vibration problem.

One chip is for servo-control, laser focusing and tracking location. The other handles D/A conversion, error correction and filtering. By using LSI devices, Yamaha's new CD player's parts count is dramatically reduced. Additionally, the newly designed three-beam laser, in a down-sized laser heard, helps to reduce size.

When the cartridge containing the disc is loaded into the player, a built-in shutter on the cartridge opens to permit tracking by the laser pickup. Upon ejection, the shutter closes prior to release of the cartridge. The cartridge carrier protects the disc against contamination from dust and dirt, and its ease of handling does not interfere with driver concentration.

CIRCLE NO. 106 ON FREE INFORMATION CARD



EPROM Programmer Kit

Heath's new Model ID-4801 programmer allows you to program, duplicate, verify and simulate EPROMs. The build-it-yourself kit can be used on 2500- and 2700-series EPROMs and other compatible devices with up to 16K bytes of storage and that use a single power supply.

The EPROM programmer can perform 10 functions, some of which require user-wired personality modules supplied with the kit for different EPROM configurations. You

can load an EPROM with data stored in RAM and then verify the transfer. Data can also be loaded from an existing EPROM into the programmer's RAM. Also, the ID-4801 can be used to emulate ROM in an external device with connection of an appropriately wired cable.

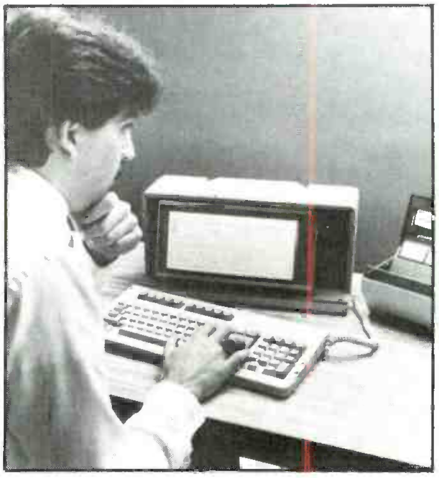
Data can be transmitted and received between the programmer and a computer through an RS-232C serial port equipped with a DB-25 connector. Data (in Intel hex format) transfer rate is 9600 baud. Information and mode entry are performed with a hex keypad that lets you select any memory address to examine, delete, change or enter data. Addresses can also be incremented and decremented, and RAM can be searched to locate one or two data bytes and display data and memory address.

Contained in the ID-4801 are a 2K × 8 system ROM and 2K × 8 RAM, both of which can be expanded to 16K with optional add-ons. $349.95.

CIRCLE NO. 107 ON FREE INFORMATION CARD

IBM-Compatible Laptop Computer

A lightweight computer designed for the business professional has been introduced by Sharp. The compact IBM PC- and PC/XT-compatible Model PC-7000 system measures just 16.1"W × 8.1"H × 6.3"D and weighs only 18¾ lbs. Its 25-line by 80-character (640 × 200-pixel bit-mapped graphics) LCD screen is backlighted with an electroluminescent panel whose display angle can be adjusted for best readability.



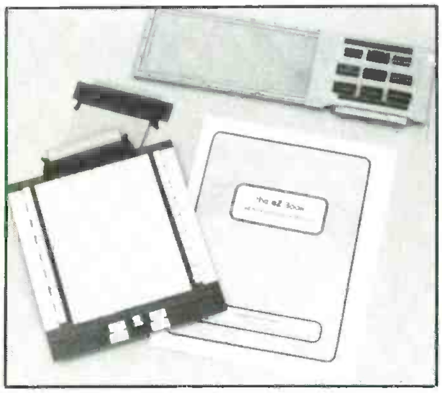
Standard features of the new computer include: an 8086 microprocessor; 320K of RAM (expandable to 704K); 16K of ROM; two 5¼" floppy disk drives; a detached keyboard; RS232 serial and Centronics-compatible parallel ports; and the MS-DOS 2.11 operating system. Options for the computer include an 8087 coprocessor for heavy number crunching with appropriate software; 300/1200-baud Hayes-compatible modem; RGB color monitor controller; and silent transfer printer that uses either plain or thermal paper. Both memory and coprocessor capacity can be upgraded on the motherboard. $2000.

CIRCLE NO. 108 ON FREE INFORMATION CARD

Prototyping System For Personal Computers

"eZ-System" is a complete hardware development system for popular personal computers, available from Sabadia Export Corp. The system consists of an eZ-Board solderless breadboard module and a bus-pluggable eZ-Card buffer I/O module. It provides direct I/O capability in present versions for the IBM PC, XT and AT; Apple II and IIe; and Commodore 64 computers.

eZ Boards, solderless breadboard



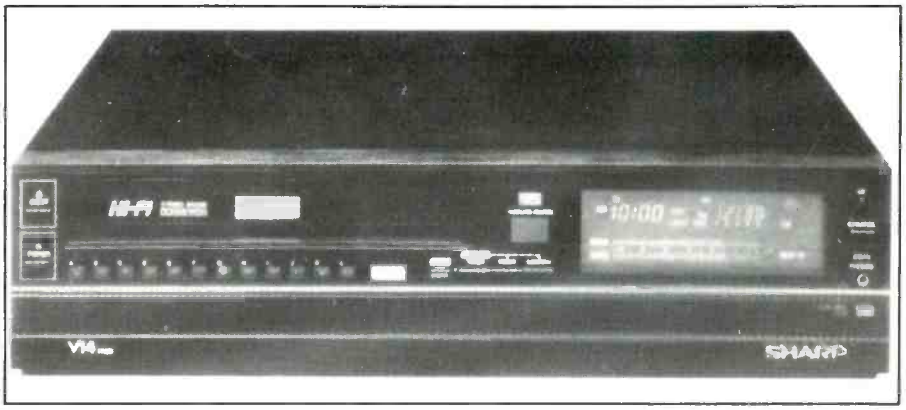
module provides access to bus, power and control signals. It connects via an 18" ribbon cable to eZ-Card to allow you to work freely and without interfering with the system unit. eZ-Card is a protoyping board that accommodates up to 60 16-pin DIP sockets for Wire Wrapping custom logic circuits and also serves

(Continued on page 96)

Video/Audio

Sharp Model VC-5F7U VHS Hi-Fi VCR: Better-Than-Average Video & Great Hi-Fi Sound

Sharp's new Model VC-5F7U VHS Hi-Fi videocassetter recorder combines high-quality video and audio performance, the latter featuring a hi-fi stereo sound mode. The front-loading machine, housed in an attractive charcoal-black enclosure, presents a high-tech appearance.



Its upper front panel is dominated at the left side by the cassette loading slot with a green-illuminated "cassette-in" symbol and at the right by a large fluorescent display window that contains separate time and timer displays, a dual record-level bargraph "meter" and assorted status indicators. Most of the rest of the front panel is surprisingly clean with very few controls visible.

Standard features of this new Sharp VCR include: a double-azimuth four-head drum; 12-preset, 108-channel cable-compatible tuner; 14-day, 5-event timer; Automatic Program Search System (APSS); automatic TV/VTR output signal selection; and a jack for multichannel TV sound (MTS) adapter. Supplied with the VCR is a 14-function wireless remote controller. It measures 16⅞"W × 15"D × 4½"H and weighs 24 lbs. Suggested retail price is $999.95 plus $199 for the optional MTS adapter.

General Description

Sharp has taken a rather unconventional approach to the layout of its front-panel controls. Although the VCR features all of the controls you would normally find on a video/Hi-Fi machine, their locations might lead to a bit of confusion if you've used a VCR before. For example, you have to drop down a door that runs the width of the VCR at the bottom of the front panel to gain access to the transport record, play, stop, etc. controls that are normally out in the open on other VCRs. The same applies to the slide-type audio record level controls. Otherwise, the layout is about standard and arranged in a more or less logical format.

With the door closed, the only items you immediately see on the front panel are the POWER, cassette EJECT, TIMER, COUNTER RESET and MEMORY, and CHANNEL UP and DOWN buttons; the cassette loading slot; a HI-FI indicator that lights up when that function is selected; a PHONES jack; and the comprehensive display window. Within the window area are the separate time and timer displays illuminated in blue and yellow, respectively, accompanied by the appropriate AM and PM and day-of-the-week indicators. Accompanying the timer display are the legends START and LENGTH. Located off to the right are a timer-on symbol, a CH legend and a larger display of the selected channel number, along with a VTR legend. Along the bottom of the window are the channel-identified bargraph record-level "meters" that show up in blue up to the 0-dB level and thereafter are displayed in red. Off to the right of these are the legends APSS, DEW, and DOLBY NR that come on when program search is in progress, the dew level inside the VCR is too high for proper operation and when noise reduction is in force.

Below the cassette slot are 12 small windows behind which are the numerals 2 through 13, corresponding to the number of channels for which the VCR can be programmed. The window for whichever of these channels is selected glows a soft green. The final item on the front panel (still with the door closed) is a timer REC (record) switch that is used independent of the programmable timer. You can use this button to immediately record up to eight times 30-minute periods for a total of four hours.

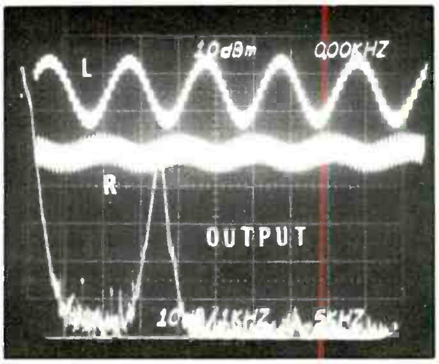
A push on the right side of the front bottom panel drops down the door to reveal an assortment of 31 button-type, slide-switch, slide-type and rotary controls, all arranged more or less according to functions they control. To the left are the usual six transport control buttons, several of which have indicators that light when they are engaged. Next come the Dolby noise-reduction on/off switch and TV/VTR selector. Following this is a cluster of eight pushbuttons and two slide switches that are used to set the time, program the timer and turn on and off the timer. Then come the two clearly identified record-level slide controls, followed by the record speed selector and APSS on/off switches and CUE button. Below these are arranged in a horizontal line the only four rotary controls on the front panel (PICTURE TONE, PLAY and STILL TRACKING and PHONES LEVEL).

On the rear panel are the usual 300-ohm vhf inputs and outputs, channel 3/4 output switch, coaxial uhf inputs and outputs and separate video/stereo inputs and outputs. There is also a camera remote-control connector and the jack into which the optional Model AN-1000U MTS (BTSC/dbx) adapter can be plugged.

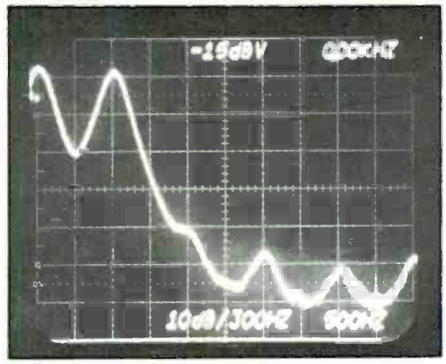
The 14-function wireless remote controller supplied with the VCR duplicates many of the controls on the front panel. These include power on/off, TV/VTR

Testbench Results

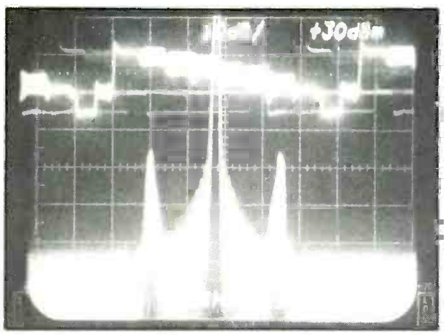
These photos are actual screen shots taken during laboratory testing of the Sharp Model VC-5F7U VHS Hi-Fi videocassette recorder. Oscilloscope and/or spectrum analyzer traces were obtained by recording and playing back selected signals, using Kodak HGX T-120 videocassette tapes.



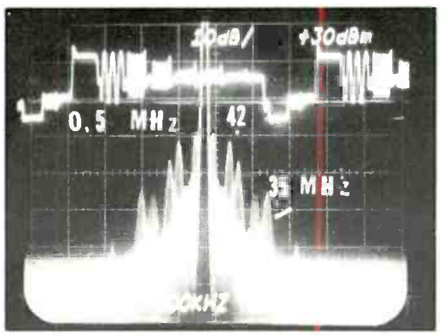
Shown in this display are the left and right stereo outputs with 19-kHz pilot tone, recorded and detected at 17 kHz.



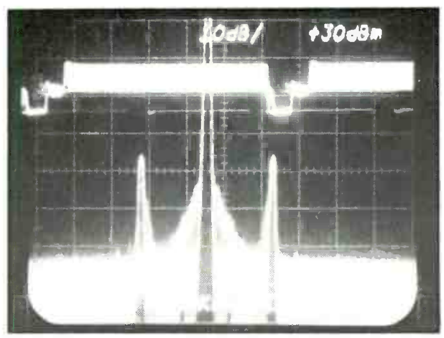
A good approximation of 50-dB difference between fundamental and second harmonic at 1 kHz amounts to 0.3% THD.



Color bars are a bit ragged but usable on scope (upper) but clean on spectrum analyzer (lower) displays, indicating a reasonable overall color response.



Multiburst with low noise is visible beyond 3 MHz in SP mode. In LP and EP, noise and high frequencies are adversely affected, which is normal for VHS.



Saturated red field is used to evaluate the chroma signal-to-noise (S/N) ratio and spectrum response. The display shows nothing wrong in this area.

switching, channel up/down scanning, and record, play, stop, pause, field still, field advance, video search in forward and reverse, fast-forward and rewind.

The V14 double-azimuth four-head system has the usual pair of video heads, plus an extra pair of heads that, Sharp claims, are designed especially for standard play, video search and still operating modes. Mounted at slightly different angles, the extra heads track video signals field by field in still, advance and slow-motion to overcome the usual noise bars and jitters encountered in older VCRs that feature frame-by-frame play.

In audio, basic helical scan video techniques have also been applied, here by positioning two audio heads on the rotating drum ahead of the video heads. As head-to-head tape speed improves, audio head tracking automatically changes from linear to helical to permit slant (diagonal) recording and increase bandwidth. Depth multiplexing is then introduced to further separate video and audio by establishing their positions at different tape depths to prevent interference.

Sharp claims that dynamic range has improved 40 dB (100 times) over that of standard recordings and that wow and flutter are almost unmeasurable. Our laboratory analysis substantiates this claim.

Conventional (linear) sound is also available with fixed audio heads and Dolby noise reduction. This permits you to make recordings from conventional program sources and play them back on the Model VC-5F7U VCR. It also allows you to play back stereo sound tracks recorded on video-taped programs and movies.

To keep everything working smoothly and error-free, Sharp uses a microprocessor-controlled, power-assisted drive system. This is coupled with the usual repeat and programmable timing with reset and memory and a "clean" editing system that can be used to delete undesirable program material while recording.

The APSS feature is an interesting asset of this VCR. It stands for Automatic Program Search System and can be used

Sharp Model VC-5F7U Videocassette Recorder Laboratory Analysis

Tuner sensitivity	
vhf channels 3/10	−6/−8 dBmV
uhf channels 15/30	−7/−5 dBmV
Signal-to-noise ratios (S/N)	
luminance (SP/LP/EP)	41/40 dB
chroma (SP/LP/EP)	40 dB
Audio signal-to-noise ratio (S/N) in Hi-Fi	48 dB
Total Harmonic Distortion (THD) in Hi-FI	0.3%
Audio frequency response max. in Hi-Fi	30 Hz to 20 kHz, −6
Stereo channel L/R separation (sine-wave input)	64 dB
Stereo signal separation (stereo input, Dolby on)	25 dB
Wow and flutter (NAB at 3 kHz/CCIR weighted)	
SP	0.003%
LP	0.003%
EP	0.0035%
Tape speeds	Normal for VHS
Recording/playback times	Up to 8 hours
Ac operating range	100 to 130 V ac
Ac power required at 120V	
record	27.48 W rms
playback	27.12 W rms

NOTES: Dolby engated for audio S/N and stereo.
To convert MHz high frequency luma response to "lines," multiply by 80 lines/MHz for an approximation.

Test equipment: Tektronix Models 7L5, 7L12 spectrum analyzers; Hameg Model HM605 oscilloscope; Sadelco Model FS-3D VU field strength meter; Data Precision Models 945 and 1750 multimeters; B&K-Precision 1260 NTSC color/multiburst and 3020 sweep function generators, 1035 Wow and Flutter meter, and 2007 stereo generator; Sencore VA48 video analyst (modified); a Sultzer resistance-coupled oscillator; Kodak T-120 HGX videocassette; and RCA Model FLR-2622T TV receiver/monitor.

to search out blank spaces on the linear audio track to let you locate the start of a program without having to shuttle the tape back and forth.

Test Results

This VCR gave us some of the best audio and video response results we've found in comparable videocassette recorders. You'll note that our 41- and 40-dB luminance and chroma video signal-to-noise measurements in the SP mode do not agree with the rated 50-dB figure from Sharp. However, audio S/N was a healthy 48 dB, exceeding Sharp's rating of 45 dB, and nominal stereo separation was a good 25 dB.

In 4-head VCRs that use separate sets of heads for the regular and slow speeds, wow and flutter is nominally measured at less than 6 Hz and between 6 Hz and 200 Hz. With this Sharp VCR, we observed greater similarities between measurements at *all* speeds (see Laboratory Analysis table).

Spectrum-analyzer or meter-measuring devices do not produce accurate total harmonic distortion (THD) results unless the signal source being used is a pure sine wave. With our generator being good to −55 dB (less than 0.002% THD), our measurement is very close to Sharp's specified 0.3%.

While we didn't give this VCR a full 3.5-MHz luminance rating in the SP mode, resolution did approach this excellent figure. However, the falloff to 2.8 MHz in the EP mode didn't exactly complement the better SP figure. On the other hand, when tape speed is reduced to one-third of normal, both S/N and rolloff at high frequencies are usually adversely affected in *all* VCRs, though the deterioration is far more pronounced in cheaper machines.

Considering that the Model VC-5F7U is touted as both a video and an audio machine, audio performance in all three available processing modes becomes very important. Unfortunately, we weren't able to check the multichannel sound capability of the system, since the BTSC/dbx decoder wasn't available at the time we performed out tests. Happily, we were able to check the Hi-Fi and linear stereo performance of the VCR. In each case, we used the VCR's outputs to drive external amplifiers and very good speaker systems. The results were very good, as shown in our spectrum-analyzer tests and detailed in the Laboratory Analysis table.

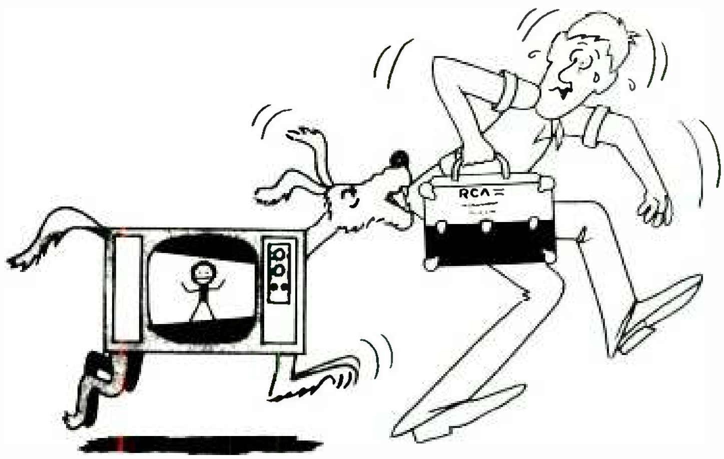
User Comment

This Sharp VCR was a major surprise in more ways than one. From a manufacturer noted for somewhat unexceptional video products, the Model VC-5F7U is an elevating experience. It is a highly flexible videocassette recorder that gives superior pictures and sound and offers a major choice to high-end consumers who want exceptional equipment and are willing to pay the price.

No product on the market is perfect in every way, and the Model VC-5F7U is no exception. For example, its TV channel access is limited to a mix of any 12 stations at any given time. This may not pose a problem if your area is limited in available channels, but if you're in an area where there are dozens of broadcast and cable TV channels available, you'll have to make judicious selections during the programming of the VCR. Also, if you want to plug a camera into the VCR, you can't

(Continued on page 86)

How Many Times Do You Intend To Let "THE SAME DOG" Bite You ?



★ How many times have you worked all day long trying to diagnose the hi-voltage / LV regulator circuit of a set that is in shut down only to eventually find that a **shorted** video, color, vertical, tuner, AGC, or matrix circuit was causing the set to shut down and, to find that the hi-voltage / LV regulator circuit was working flawlessly all the time?

★ How many times have you spent the day looking for a **short** that was causing the set to shut down, only to eventually find that an **open** vertical, video, matrix circuit or, an **open** HV multiplier was to blame?

★ How many times have you worked all day on the same TV set, only to find out that the set's flyback transformer was defective?

★ How many flyback transformers have you replaced only to find that the original flyback was **not** defective?

★ How many horiz output transistors and Sony SG 613 **SCRs** have you destroyed while simply trying to figure out whether the flyback was good or bad?

★ How many times have you been deceived by your flyback "ringer"? Can you even count the number of hours that your "ringer" has caused you to waste?

★ How many times have you condemned a flyback, only to find that a shorted scan derived B+ source was causing the flyback to "appear" as though it were defective?

★ How many hours have you wasted, working on a TV set, only to find that the CRT had a dynamically shorted 2nd anode (to primary element)?

★ How many new sweep transformers have you unknowingly destroyed because a short existed in one of the scan derived B+ sources?

★ How many times have you said to yourself, "I could fix this - - - -thing if I could only get it to fire up long enough to lite the screen? - - - without blowing an output transistor or a fuse."

★ How many additional bench jobs could you have gotten, had you been able to give an accurate, "on the spot" estimate on sets that were either in shut down or, not capable of coming on long enough for you to analyze them?

If you had been using our all new Super Tech HV circuit scanner, you would have had an accurate evaluation concerning all of the above in about one minute, at the push of **just one** single button.

It's true! Push just one test button and our HV circuit scanner will (1) Accurately prove or disprove the flyback, (2) Check for any possible shorts in any circuit that utilizes scan derived B+, (3) Check the scan derived power supplies themselves for shorted diodes and / or electrolytic capacitors, (4) Check for primary B+ collector voltage and, (5) Check the horiz output stage for defects.

Our HV circuit scanner works equally well on sets with integrated or outboard HV multipliers. It will diagnose any brand, any age, solid state TV set including Sony. The only exceptions are sets which use an SCR for trace and, another for retrace (i.e., RCA CTC 40 etc.). Our scanner will not work on these sets.

In plain English, our HV circuit scanner is even easier to operate than a "plain vanilla" voltmeter.

First off, when you're using a scanner, you **do not** remove the flyback in order to check it. In fact, you don't even unhook any of the wires that are connected to the flyback! All you do is:

(1) Remove the set's horiz output device, plug in the scanner's interface plug, then make one single ground connection. That's all you do to hook it up.

(2) If the primary LV supply is functional and, assuming that the emitter circuit of the horiz output stage has continuity, the scanner will tell you that it is ready to "scan" by illuminating the "ready" light, which is the white button on the test / run switch.

(3) Press the spring loaded (test) side of the test / run switch and the scanner will "look" for any type of a **short** that might exist anywhere on the secondary side of the flyback, including the HV multiplier, any circuit that relies on flyback generated B+ and, including the flyback itself (both primary and all secondary windings). It will simultaneously check for a shorted LV regulator device HV multiplier, or an open or "partially" open safety capacitor.

If a short or, an "excessive load" exists on one secondary winding, all other secondary windings will have "normal" output voltage in spite of the short. Only the shorted winding itself will have zero volts on it. This makes shorted scan derived B+ sources incredibly easy to isolate. During this test, the 2nd anode voltage is being limited to approx 5 kv by the scanner.

If a short is present, the red "flyback" light will either lite, or flash (at various speeds), depending on which type of a short exists. If no shorts exist, the "flyback" light will be green.

Assuming that the "flyback" light is green, no **shorts** exist and, it is now time (and safe), to begin looking for **open** circuits which might be causing the set to shut down due to flyback run-a-way. It only stands to reason that if no shorted conditions exist, then one (or more) circuits will have to be open, otherwise, the TV set would be working!

(4) Now that you know that no **shorts** exists, push the "run" side of the test / run switch (the side that latches). Provided all of the other circuits in the TV set are functional, the scanner will now put a picture on the set's CRT screen that has full vertical and horiz deflection, normal audio, video and color.

Keep in mind that during this test, your scanner is:

(1) Circumventing all horiz osc/driver related shut down circuits,

(2) Limiting the set's 2nd anode voltage to approx 20-25 kv,

(3) Substituting the set's horiz osc/driver circuit and, as a result, eliminating any need that the set might have for an initial start up or B+ resupply circuit for the osc/driver.

Wait about 15 seconds for its filaments to warm up, then look at the CRT. Any circuits that are **"open"** will now produce an obvious symptom on the screen. Because the scanner has circumvented all of the set's shut down features, you can now use your old reliable "symptom to circuit analysis" technique to troubleshoot the problem, i.e., if the picture has no blue in it - - - repair the blue video or blue matrix circuit. If the picture has only partial vertical deflection - - - repair the vertical circuit, and so on. The scanner has effectively removed all of the stumbling blocks that would normally prevent you from diagnosing the problem. i.e., start up and shut down features, and allowed you to repair the TV set by using conventional techniques.

When you're using a scanner, all start up, shut down, dead set problems are easy to solve. You don't need anyone to tell you just how difficult these problems can be for those who don't have a scanner!!

Our Super Tech HV circuit scanner normally sells for only $495⁰⁰.

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Stereo FM That's As Quiet As Mono

A new circuit development promises FM stereo reception with greatly improved signal-to-noise performance

By Len Feldman

Back in 1961, when the FCC chose one of five competing systems for broadcasting FM stereo, there were 17,000,000 or so FM monophonic radios in use in this country. There were, obviously, *no* FM stereo radios around then. So, the FCC was more concerned with keeping things sounding good for the *mono* listener than they were for the *future* stereo listeners. Accordingly, they chose a transmission system that degraded the mono signal hardly at all, but one that, under weak signal conditions, degraded stereo signal-to-noise performance by as much as 23 dB. If that number doesn't impress you, consider this: 23 dB represents a change of 200 to 1 in power! In other words, if you try to tune in a distant FM station that sounds perfectly fine in mono, when you switch over to stereo the background noise emanating from your loudspeakers will be 200 times more powerful.

From a broadcaster's point of view, that also means that a station's potential audience for stereo programming is considerably smaller than the size of the audience that can receive the signal in satisfactory monophonic, or single-channel, sound. Tests have shown, in fact, that the area of satisfactory coverage for typical stereo stations is only about one-fourth as great as that same station's mono coverage. Of course, the distant listeners who can't receive their favorite station in stereo can always switch to mono, but studies show that they are not likely to do so. Instead they'll more than likely tune to a stronger, nearby, quieter stereo station.

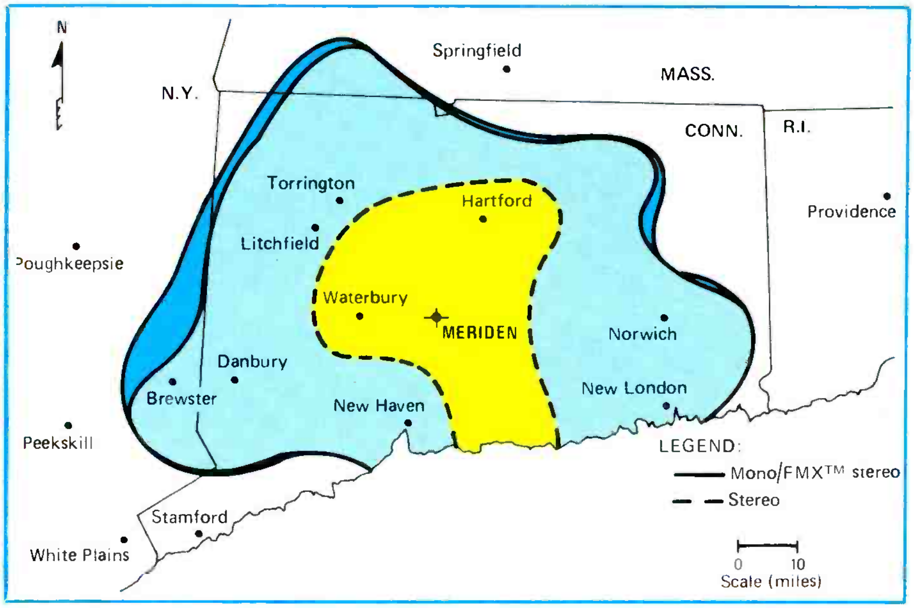


Fig. 1. Map shows effectiveness of FMX (solid contour lines) vs. ordinary stereo (dashed line) in Connecticut tests. Two sets of solid lines show how far out usable 60-dB signal can be received from the transmitting antenna under different reception conditions. Mono and FMX ranges are basically the same.

Increased FM Stereo Coverage

Recently, Emil Torick of the CBS Technology Center revealed details of a new FM stereo transmission system that could provide stereo FM stations with virtually the same extended range of coverage achieved by mono stations having the same transmitter power, or up to a 400% increase. What makes the system particularly attractive is its complete compatibility with existing stereo FM radios. Owners of such radios or FM tuners would continue to get the same kind of stereo FM that they've been getting. Purchasers of new, specially designed tuners or receivers, on the other hand, would benefit from the new broadcast system and would find that even when they tune to stereo stations that were previously too noisy to be enjoyed, those stations will now be as noise-free as they are when their old sets were switched over to mono reception.

Another nice thing about the new system, which CBS calls the "FMX™ Extended Range FM Stereo System," is that no action on the part of the FCC is required for this system to be adopted by FM stations all over the country. If transmitter modification kits were available in sufficient quantity today, your favorite FM station could switch to this new system tomorrow! That's because the FCC has liberalized its rules regarding the use of subcarriers by FM stations. Since this system involves the use of subcarriers within the prescribed frequency baseband authorized by the FCC, stations could begin using the system at once. In fact, one Public Radio station, WPKT, in Meriden, Connecticut has been using the new system on an experimental basis for some time. Field tests have shown that this station's effective stereo coverage using FMX is just about the same as its mono coverage, as shown in Fig. 1. Mr. Torick, ever the precise engineer, told me that if you measure signal strength contour for 55 dB or 50 dB of signal-to-noise ratio instead of 60 dB, you might get "only" three times the area of coverage—and not the 400% increase in coverage which he measured for the station in Connecticut where the first tests were made.

How It Works

The new system, fully developed by CBS, is based upon a broadcasting technique conceived jointly by Emil Torick of CBS and Tom Keller of the National Association of Broadcasters. Figure 2 shows the baseband format of the new composite signal. If you are familiar with how regular stereo FM works you will notice that no alteration has been made to the components that make up present-day stereo FM signals. A monophonic "sum" signal (Left-plus-Right or L + R), extending from 30 Hz to 15 kHz, modulates the main station carrier signal. To this is added a double-sideband suppressed subcarrier (S) at a center frequency of 38 kHz. This subcarrier also modulates the main carrier, but it is, in turn, modulated by the audio "difference" signal, (L − R). A 19 kHz pilot signal (labeled "P" in the diagram) serves to help restore the 38-kHz subcarrier in the receiver and to trigger the familiar LED indicator on the front panels of most FM tuners and receivers when a stereo signal is being received.

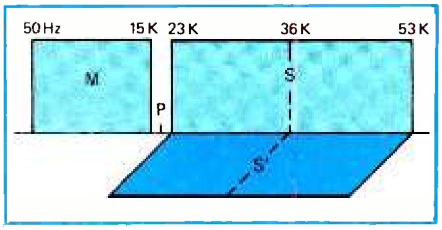


Fig. 2. FMX system uses standard FM stereo format plus new 38-kHz subcarrier in quadrature and 10-Hz tone for automatic receiver operation.

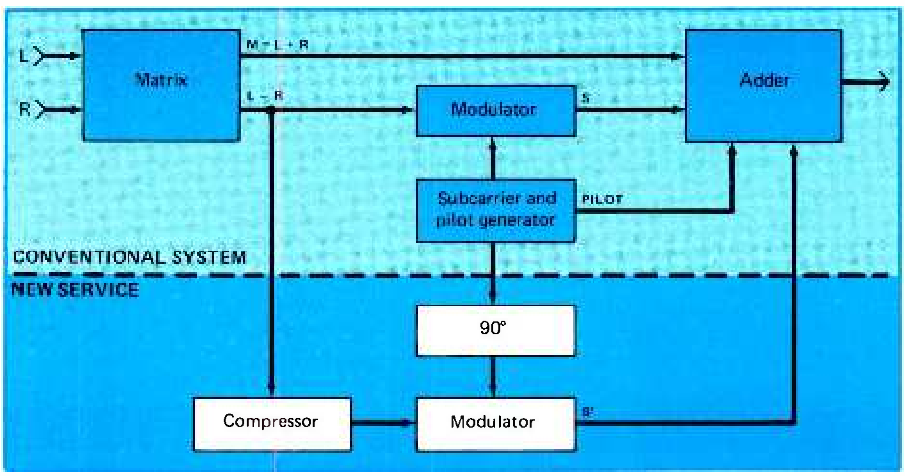
The FMX system adds a second, difference subchannel (S'), also at a center frequency of 38 kHz. This new subcarrier is *in quadrature* with respect to the first subcarrier. That means that it is 90 degrees out of phase with the first subcarrier, S. As such, it will not be detected by ordinary, older FM receivers or tuners.

Most of the noise that is so bothersome when we listen to stereo FM comes from the recovered "difference" (L − R) signal—not from the main channel signal. Accordingly, if there were some way to introduce a noise-reduction technique to this difference signal, overall signal-to-noise ratio of received stereo FM could be significantly improved. The technique that's used in the FMX system to accomplish this is known as reentrant compression. It is applied at the broadcast end of the system, while at the receiver, an adaptive expander takes care of the other half of this companding process.

Figure 3 is a block diagram that illustrates the basic concept of the transmitting system, while Fig. 4 shows a block diagram of an FM receiver that would be needed to receive

(Continued on page 20)

Fig. 3. Broadcaster transmits a compressed audio version of L − R difference signal within new quadrature channel. Reentrant compressor provides optimum modulation without compromising existing broadcast service.



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Back in 1964, great excitement surrounded the launching of Syncom 2, the true forerunner of today's satellites. But not even the most hopeful of scientists believed that in less than 25 years, communications satellites would have such a tremendous impact on the professional and personal lives of millions of people around the globe.

Today, thanks to the rapid development of satellite technology, a call to Paris is as clear and as easy to make as a call to your next door neighbor . . . executives from multi-national corporations and even small businesses use video conferencing to "meet" without leaving their offices . . . simultaneously a billion people witness a single event (a soccer game, an inauguration, a benefit rock concert) . . . global weather maps transmitted from satellites allow meteorologists to forecast weather trends weeks in advance . . . and scientists now explore and investigate the mysteries of outer space without leaving their labs.

And, not surprisingly, these amazing applications of satellite technology have opened up exciting new opportunities for the technician trained to install, maintain, troubleshoot and repair satellite communications equipment.

Home Satellite TV Is Just at the Start of Its Explosive Future

You've seen them in suburban backyards and alongside country farmhouses. Home satellite TV systems are springing up all across the country.

Already there are over a million TVRO (Television Receive-Only) systems in place in the U.S. alone, and experts predict that by 1990, a remarkable 60% of U.S. homes will have a satellite dish. Contributing to the field's phenomenal growth are the support of the FCC and Congress, steady improvement in product quality, the development of smaller dishes, and a growing consumer enthusiasm for satellite TV.

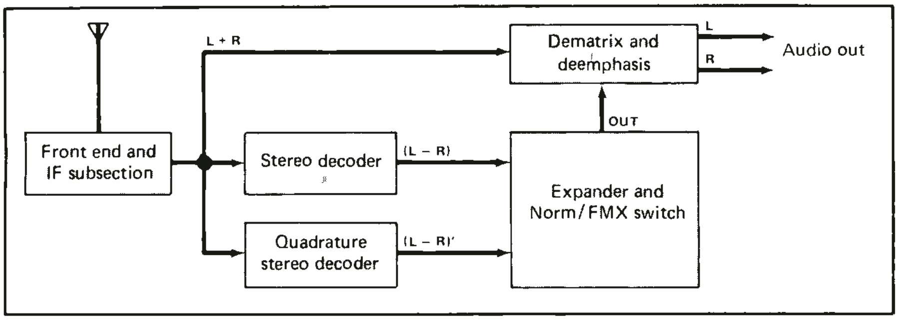

Fig. 4. The FMX receiver decodes the compressed L – R signal in the quadrature channel. Complementary expansion restores the original dynamic range of this signal, providing an improvement in signal-to-noise.

the new FMX transmission. Notice that a selector switch is included so that a listener may choose either conventional stereo FM or FMX "companded" stereo FM reception.

Reentrant Compression

Companding simply means "compression" of a signal at the transmitting end and converse "expansion" of that signal at the receiving end. If you own a cassette recorder that uses Dolby or dbx noise reduction you are probably familiar with the principle of companding used as a means for noise reduction and increased dynamic range. Both Dolby and dbx are companding systems.

There are an almost limitless number of ways in which companding can be accomplished for audio applications. Dolby, for example, compresses and expands only high frequencies, since that's where tape hiss is essentially centered. The dbx noise-reduction system, on the other hand, *linearly* compresses all audio frequencies by a factor of 2:1. Every 2 dB of level change in an audio signal is compressed to a 1-dB change before it is recorded onto a tape. During playback, dbx expands all frequencies in the ratio of 1 to 2. A change of 1 dB of signal levels read during tape playback is expanded to a 2-dB change.

The choice of an optimum companding technique was a very important consideration in developing this new FM broadcasting system. Companding systems can achieve various degrees of noise reduction by raising the modulation level of low-level audio program prior to transmission. In effect, the low-level signals are boosted to get them "up and over" the residual noise level that will be generated during the transmit/receive cycle. At the receiving end, the program is restored to its original dynamic range by *lowering* those previously boosted levels—and with them, lowering the generated background noise as well.

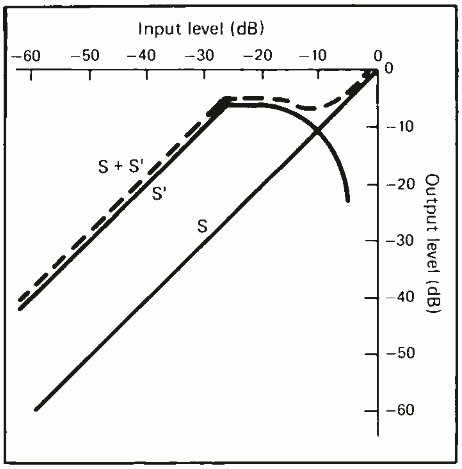

Fig. 5. Response of compressor (upper solid line), uncompressed S channel (lower solid line), and combination of both signals (dashed line).

The compression technique finally chosen for the FMX system has several unique aspects. It is called a reentrant compression system. This compression system is configured to prevent overmodulation by the sum of the S and compressed S' channels at high signal levels and to provide optimum channel loading or utilization at mid-levels with a compression slope that's close to infinite.

Figure 5 shows the response of the compressor (upper solid line), the uncompressed S-channel (lower solid line) and the combination of the two signals (dashed line). At low signal levels the response of the compressor is linear, but with approximately 20 dB more gain than in the uncompressed subchannel. At mid-level inputs the compression characteristic actually exhibits a slightly negative slope, changing at still higher levels to a rapidly changing negative slope. When the compressed and uncompressed characteristics of the two subchannels are combined, the result is as shown by the dashed line in Fig. 5. A block diagram illustrating how the reentrant compressed S' signal is created is shown in Fig. 6.

An Adaptive Expander

Although tests have shown that this rather odd compression characteristic will provide optimum loading of the transmission system and best noise-reduction results at the receiving end, such a compression characteristic cannot be decoded by a traditional expander having fixed slopes or expansion ratios. Fortunately, there is a way out of this dilemma. Remember that the receiver also detects the standard, conventional subcarrier. Though much noise may be present on that original subcarrier, its *audio program* content (L – R) is correct as far as instantaneous amplitudes are concerned.

Therefore, while we don't want to *listen* to the audio information carried by this noise subcarrier, we can use that audio information as a *reference* signal—one that will provide the expander with information it needs to restore audio retrieved from the new, quadrature-related S' subcarri-

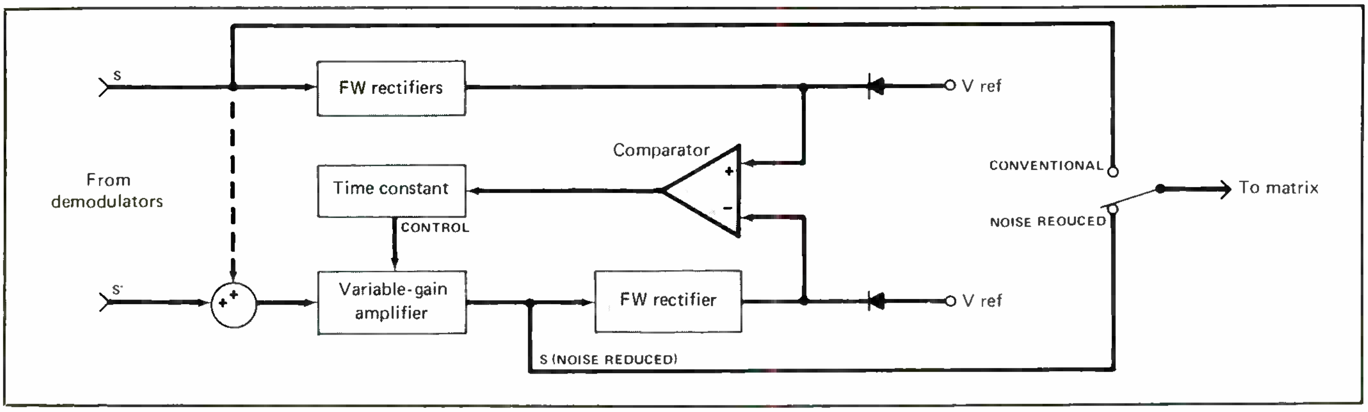

Fig. 6. One possible arrangement for an "adaptive expander." This type of circuitry actually allows encoding of difference audio signals at the transmitter with an arbitrary compression characteristic, no matter how complex.

er to precisely the same correct levels. Failure of the expander to do this would lead to incorrect dematrixing of the (L + R) and (L – R) signals. That, in turn, would result in severely reduced stereo separation.

Figure 6 shows one possible arrangement for an "Adaptive Expander." The conventional recovered "difference" signal, S, is rectified and applied to one input of a comparator circuit. This signal acts as the reference signal in a feedback path. The recovered compressed difference signal, S', is fed to a voltage controlled, variable-gain amplifier. Its output is detected in a rectifier and applied to the other input of the comparator stage. The comparator's output, smoothed by appropriate attack and release time constant circuits, is used to control the voltage controlled Variable Gain Amplifier's gain.

Whenever a difference exists between the level of the expanded signal and the unmodified S signal, the comparator will produce a control signal that causes gain of the voltage controlled Variable Gain Amplifier to change until the comparator's output voltage approaches zero. As a result, the magnitude of the compressed difference-signal audio becomes virtually equal to the level of the conventional difference signal. In this way, the expanded signal "tracks" the conventional signal and is totally

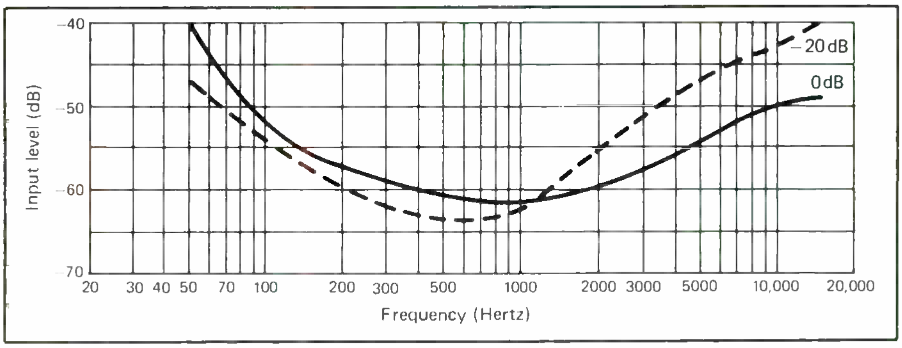

Fig. 7. Curves illustrate separation measured by CBS Technology engineers for an actual decoder using adaptive expander approach. Midband figures as high as 60 dB were obtained in these closed-circuit measurements.

independent of the absolute value of the compressed signal.

The use of this type of "Adaptive Expander" circuitry would actually allow encoding of the difference audio signals at the transmitter end with an arbitrary compression characteristic, no matter how complex. The characteristic of Fig. 5 was selected for the FMX system because, according to Torick, it offers the greatest amount of noise reduction without overmodulation. Figure 7 illustrates the separation measured by the engineers at CBS Technology for an actual decoder using this adaptive expander approach. Notice that midband separation figures as high as 60 dB were measured in these closed-circuit measurements. Even conventional decoders of regular FM stereo rarely are able to achieve such high stereo separation figures.

I had first heard about CBS Technology Center's work on improved FM stereo more than a year ago. As I recall the earliest version fo the system, it did not use this sophisticated kind of adaptive expander. When I asked Emil Torick about that, he agreed. The earliest version of FMX used fixed expansion instead of the adaptive expander technique. "You know how FM stations are," Torick explained. "Our earliest version would have meant that a station might have to give up 1.0 to 1.5 dB of modulation. As small as that number sounds, station managers as a rule want the loudest sounds they can get,

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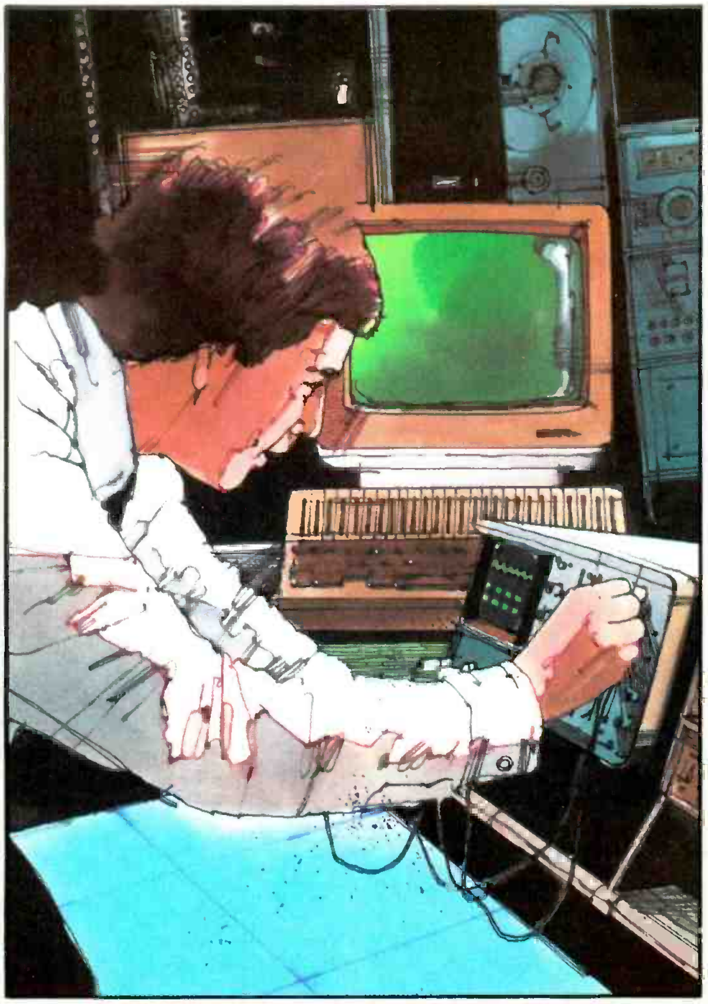
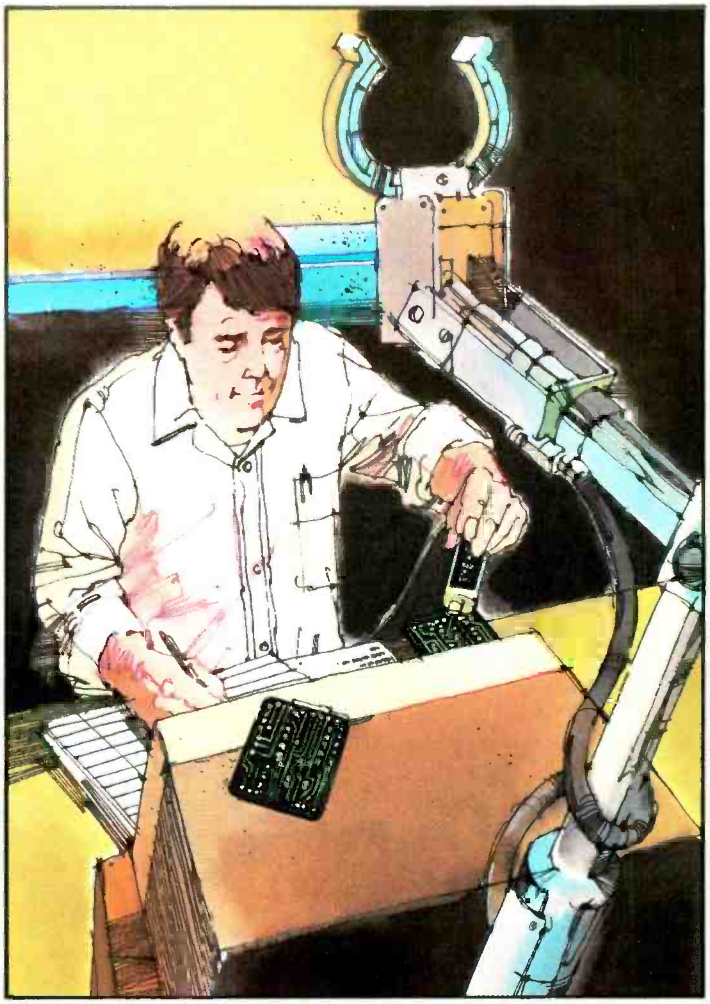

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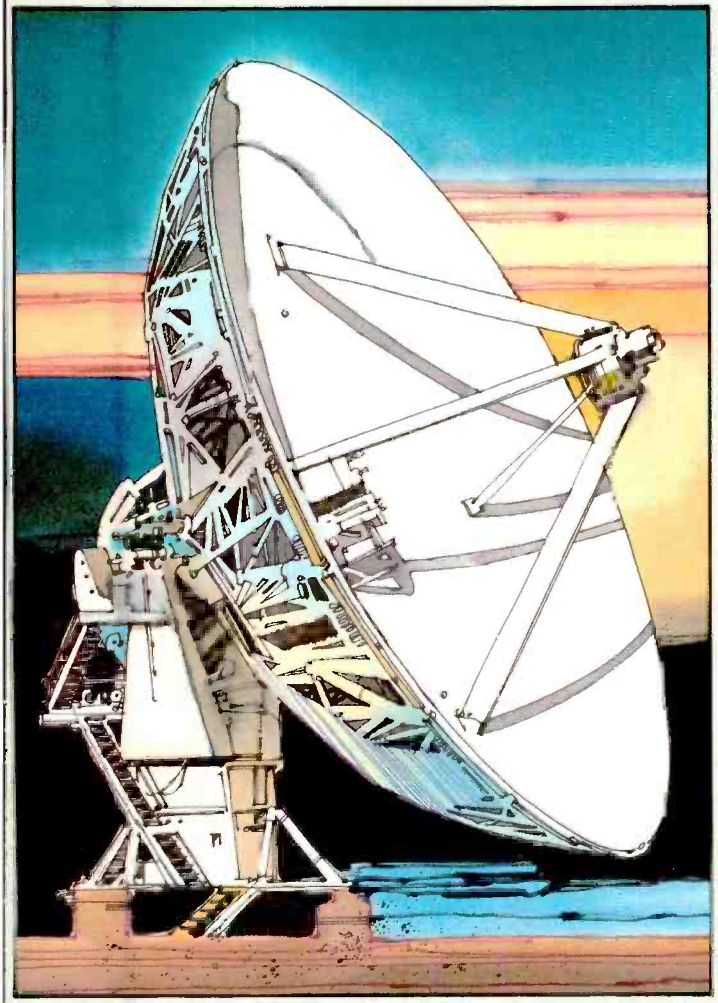

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MO-42

Using Op Amps

Practical applications of the ubiquitous op amp as an amplifier, a filter and a limiter

By Robert A. Witte

New integrated-circuit devices are as universally used as the ubiquitous operational amplifier —or "op amp," as it's affectionately known. It has become firmly established as the workhorse of low-frequency analog circuit design and is frequently found in digital circuits. What makes the op amp so appealing are its standard features: ideally infinite gain, infinite input impedance and zero output impedance.

Op amps usually require a dual power supply, such as +15 and −15 volts, although there are methods for powering them from a single supply (see box). These miniature electronic wonders are available in single, dual and quad chip configurations, with one, two or four op amps in a single IC package, as shown in Fig. 1. In these drawings, note that V+ indicates the positive power supply, V− the negative supply, and NC indicates no connection.

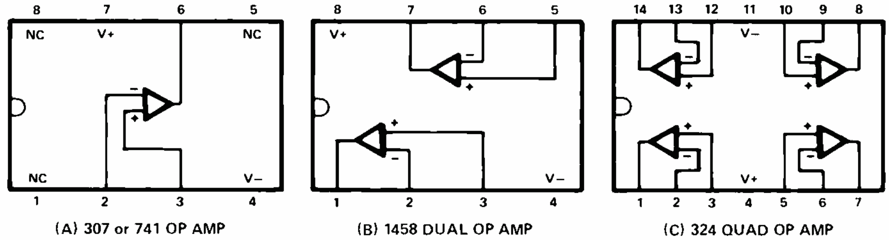


Fig. 1. Connection diagrams for several popular op-amp integrated circuits.

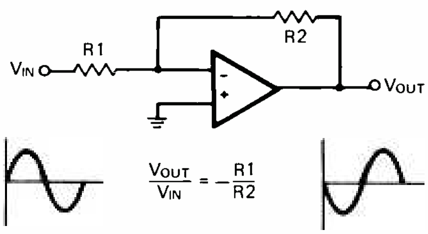


Fig. 2. Voltage gain of inverting amplifier is determined by ratio of the feedback resistor over input resistor.

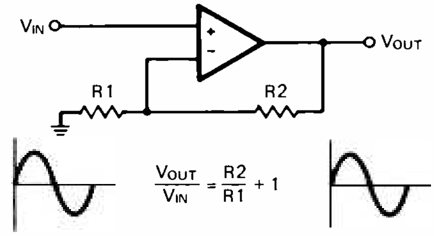


Fig. 3. The noninverting op-amp circuit provides voltage gain without inverting polarity of the input signal.

Inverting & Noninverting Amplifiers

The inverting amplifier configuration shown in Fig. 2 has a voltage gain (ratio of output voltage V_{out} to input voltage V_{in}) that is determined by the ratio of *R1/R2*. The negative sign in the formula indicates that the output is inverted relative to input voltage. If V_{in} is +5 volts dc, V_{out} will be −5 volts dc. If V_{in} is a 5-volt 0-to-peak sine wave, V_{out} will be a 5-volt 0-to-peak sine wave with a 180° phase shift with respect to the input. In many applications, it doesn't matter if the signal is inverted. For instance, a single audio tone will sound the same whether or not it's inverted.

Input impedance of the inverting amplifier is simply the value of *R1*, while output impedance is near zero.

If the polarity of the input signal must be preserved in the output, the noninverting amplifier configuration shown in Fig. 3 can be used. Voltage gain here is *R2/R1* + 1. Operation of this circuit is very similar to that of the Fig. 2 inverting amplifier circuit, except that V_{out} is *not* inverted relative to V_{in}.

Since the input of the Fig. 3 circuit goes directly to the op amp, input impedance is very high. (Ideally, it is infinite. In practice, however, it is limited by the input specifications of the op amp.) Output impedance is very near zero.

Special Amplifiers

One special op-amp configuration is the difference amplifier shown in Fig. 4. Note that this arrangement uses both the inverting and noninverting configurations in a combination that yields a difference signal at the output.

As the difference amplifier's name implies, the output of the circuit is the difference of input voltages V_1 and V_2 multiplied by gain factor *R2/R1*. For example if $R2 = 3R1$, $V_1 = +2$ volts and $V_2 = +5$ volts, $V_{out} = 3(5 - 2) = 9$ volts.

The difference amplifier can be used wherever one signal or voltage must be subtracted from another.

Another special op amp circuit is the summing amplifier shown in Fig. 5. An extension of the inverting amplifier, the summing amplifier permits several different inputs to be added to produce the output. Notice that additional input resistors (*R1*, *R2* and *R3*) have been tacked onto the basic amplifier circuit to obtain this function. Any number of inputs can be accommodated by using the appropriate number of input resistors.

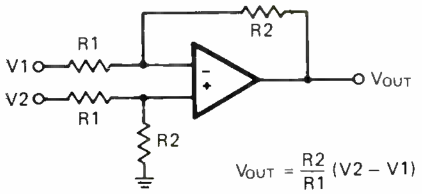


Fig. 4. The difference amplifier subtracts V_1 from V_2, amplifies result.

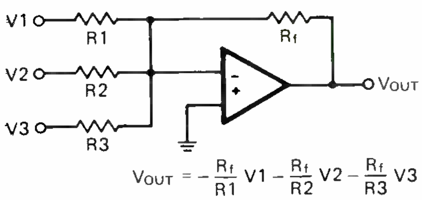


Fig. 5. Summing amplifier configuration adds several voltages. Each input can have different voltage gain.

Since the summing amplifier is based on the inverting amplifier, the output is inverted with respect to the inputs. The voltage gain associated with each input is set independently by the ratio of feedback resistor R_f and the input resistor. If the same gain is desired for each input, just let *R1* = *R2* = *R3*.

The summing amplifier is often used for summing or "mixing" different audio sources into one audio signal, such as in public-address and recording systems.

Op-Amp Filters

The inverting amplifier can also be modified to serve as a low-pass filter simply by adding a capacitor across feedback resistor *R2* in the Fig. 6 circuit. Gain of the inverting amplifier is determined by *R2/R1*. At low frequencies, impedance of the capacitor is very large and, therefore, does not affect voltage gain. At high frequencies, however, capacitor impedance greatly diminishes and virtually shorts out *R2*, causing voltage gain to increase as frequency increases. What results is a low-pass filter in which the exact frequency at which voltage gain begins to noticeably decrease (cutoff frequency f_c) depends on the values of *R2* and *C*.

Usually, f_c is considered to be the frequency at which the output is 3 dB lower than its normal value at low frequencies. For this circuit, $f_c = 1/(2\pi R2C)$. This circuit doesn't have a particularly sharp rolloff beyond f_c, since voltage gain decreases by a relatively gentle 20 dB for every decade (factor of 10) in frequency.

Figure 6 also shows a plot of voltage in decibels versus logarithmic frequency. It's good design practice to provide some controlled rolloff beyond the particular frequency of interest to reduce high-frequency noise and other undesired signals, with cutoff frequency set high enough so that desired signals aren't affected.

If you add a capacitor in series with the input resistor, as shown in Fig. 7, you obtain a high-pass filter. For very low frequencies, capacitor impedance into the inverting amplifier circuit is very large and blocks virtually all of V_{in}, resulting in minuscule output from the op amp. For high frequencies, capacitor impedance becomes very small and passes virtually all of the input signal.

The slope of the high-pass filter below f_c is 20 dB per decade. Here, $f_c = 1/(2\pi R1C)$.

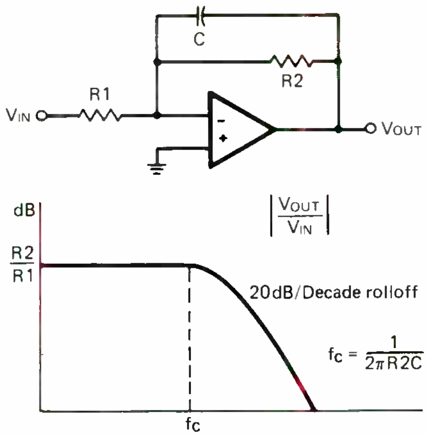


Fig. 6. In this low-pass filter circuit, feedback capacitor C effectively shorts out R2 at high frequencies. Also shown is the frequency-response curve of this filter circuit.

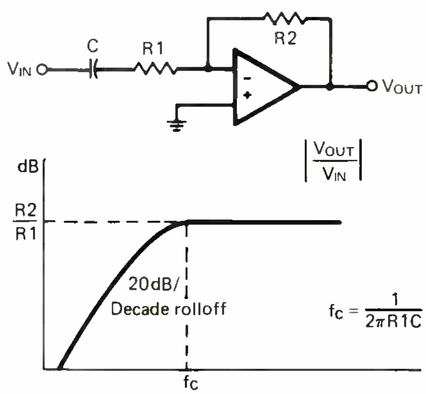


Fig. 7. By adding coupling capacitor C C to the input of the basic inverting amplifier, a high-pass filter is obtained, whose frequency-response characteristic is as shown by the curve.

Single-Supply Operation

Most op amps are designed to be powered by a dual, or "split," power supply. Although you can easily design a split supply, doing so increases the complexity and cost of small electronic projects. However, there are techniques for operating op amps from single supplies that, though they slightly increase circuit complexity, often are well worth eliminating the second supply required.

A very common way of solving the split-supply problem is to use a voltage divider, as shown in Fig. A. The two equal-value resistors divide the supply voltage in half and create a new "ground" at $V_{supply}/2$. The capacitor removes ripple and noise present on the original power supply's output.

When $V_{supply}/2$ is used as ground, V_{supply} becomes V+ and true ground becomes V− for the op-amp circuit. This technique works quite well as long as the current drawn from the $V_{supply}/2$ junction is less than one-tenth of the current through the divider resistors.

For inverting op-amp configurations, the ground connection is the + input of the op amp. This arrangement draws very little current. For circuits that require more current, the values of the 47,000-ohm resistors can be reduced to allow more current to flow through them, though the penalty for doing this is greater power consumption. This technique is shown in Fig. B, using an inverting amplifier.

The capacitor at the input of the Fig. B circuit serves as an ac coupler. This capacitor is usually necessary because the op amp is operating totally above ground potential. If the capacitor weren't included, a negative input signal applied directly to *R1* would be beyond the op amp's ability to handle, since it is outside the range of its V_{supply} and ground power supplies.

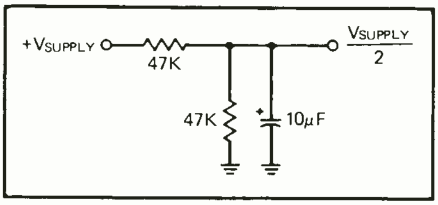


Fig. A. Two series resistors connected across power source creates a new ground for single-supply applications.

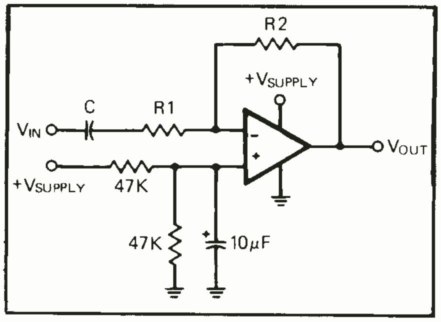


Fig. B. Ac-coupled inverting amplifier biased for single-supply operation.

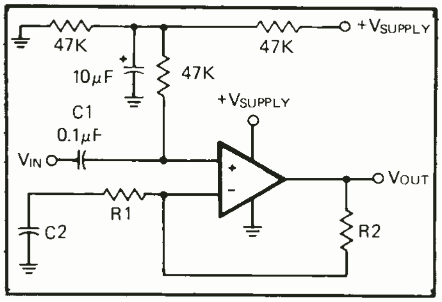


Fig. C. Ac-coupled noninverting amplifier biased for single-supply powering.

If the source of the input signal was another op amp biased for single-supply operation, the input would always be between V+ and ground and ac coupling wouldn't be necessary. However, if the source of the input signal is referenced to ground and has negative voltage swings—such as from a microphone, line output from a tape recorder, etc.—ac coupling is needed. Remember that the values of *R1* and *C1* must be chosen so that the high-pass cutoff frequency will be lower than the frequencies of interest.

Though the same biasing technique can also be used with the noninverting amplifier, the ground connection will no longer be the input of the op amp. Because of this, significant current may be drawn from $V_{supply}/2$, which may require that smaller-value resistors be used in the voltage divider.

An alternative method for the noninverting amplifier is shown in Fig. C. Here, $V_{supply}/2$ is connected to the + input of the op amp, along with small coupling capacitor *C1*. Capacitor *C2* is connected in series with *R1* to allow the op amp to "float" at the proper dc bias level required by $V_{supply}/2$. Also *R1* and *C2* create a high-pass characteristic with a cutoff frequency determined by $f_c = 1/(2\pi R1C2)$.

Choose the values of *R1* and *C2* to obtain the f_c that's below the frequencies of interest. If ac coupling isn't required (V_{in} is always between V_{supply} and ground), *C1* and the 47,000-ohm resistor can be eliminated and V_{in} can be connected directly to the + input.

Some op amps are designed with single-supply operation in mind, while others are designed for split-supply operation. In general, both types can be used for both single- and split-supply operation. The main advantage that single-supply op amps have is that V_{out} can swing all the way to ground. Most split-supply op amp outputs cannot swing all the way to the V+ and V− rails; so when operated with a single supply, their outputs cannot go completely to ground.

This circuit can be used to create a high-pass filter characteristic, or the series capacitor can be used for some other purposes, such as ac coupling. (Since a capacitor blocks dc but passes ac, it's often used to couple together circuits that may have different bias levels.) Regardless of the reason for using the series capacitor, the result will be a high-pass filter characteristic similar to that shown in the graphed plot in Fig. 7. If ac coupling is your goal, select *R1* and *C* so that f_c is sufficiently small for the frequencies of interest.

By combining the high-pass and low-pass circuits, you can produce a bandpass characteristic, the circuit

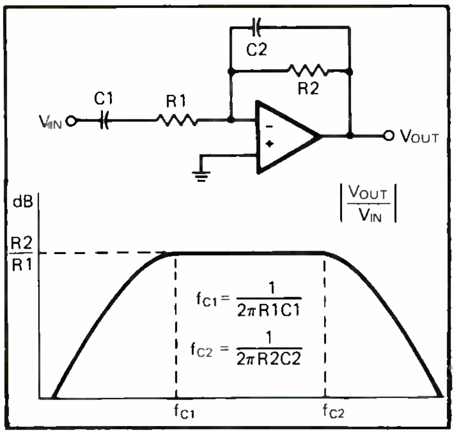


Fig. 8. Combining a feedback capacitor (C2) and input coupling capacitor (C1) with a basic inverting amplifier produces a bandpass filter whose passband is shown by the curve.

and plot for which are shown in Fig. 8. With this configuration, there are two cutoff frequencies—f_{c1} at the low-frequency and f_{c2} at the high-frequency ends of the passband. Frequencies lower than f_{c1} and greater than f_{c2} are attenuated, while those between these two points pass through at full amplitude.

As long as f_{c1} and f_{c2} aren't too close together, they are independent of each other and can be calculated using the same formulas for the high- and low-pass cutoff frequencies. However, if f_{c1} and f_{c2} are separated by less than a factor of 4, they will begin to interact and cause the results obtained from these formulas to be less accurate.

The bandpass circuit is best suited for moderate low- and high-frequency attenuation. It isn't suitable for very steep and narrow bandpass filtering applications.

Advanced Filters

More advanced filters with steeper rolloff characteristics can be designed using op amps. However, choosing component values becomes very complicated. Such parameters as flatness of the filter's frequency response and steepness of rolloff can be traded off to produce the optimum filter for any given application. Either an advanced analysis or a reference manual with a wide range of component values already computed can be used. For less critical applications, you can use the general-purpose filters to be described.

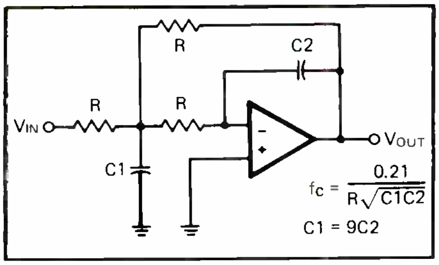


Fig. 9. Shown here is an example of a general-purpose low-pass filter with a 40-dB/decade rolloff characteristic.

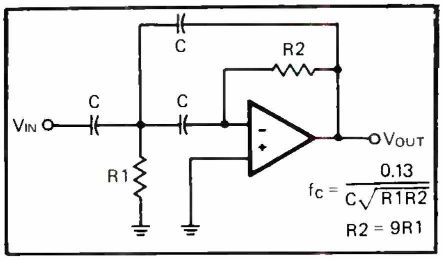


Fig. 10. A general-purpose high-pass filter with a 40-dB/decade rolloff.

Figure 9 shows a low-pass filter with the appropriate design equation for the cutoff frequency. The three resistors all have the same value and *C1* = 9*C2*. This circuit has a fairly flat response below f_c ($Q_{filter} = 1$) and rolls off at a 40-dB-per-frequency-decade rate beyond f_c—twice as steep as the Fig. 6 low-pass filter.

A similar high-pass filter can be constructed, as shown in Fig. 10. All capacitors in this circuit have the same value and *R2* = 9*R1*. Note that the capacitor at the input causes this filter to be inherently ac-coupled. The filter is fairly flat beyond f_c ($Q_{filter} = 1$) and rolls off at a 40-dB-per-decade rate below f_c.

Op-Amp Limiter

There's one more general-purpose op-amp circuit that should prove of interest. That's the op-amp limiter shown in Fig. 11. Operation of this circuit is fairly straightforward.

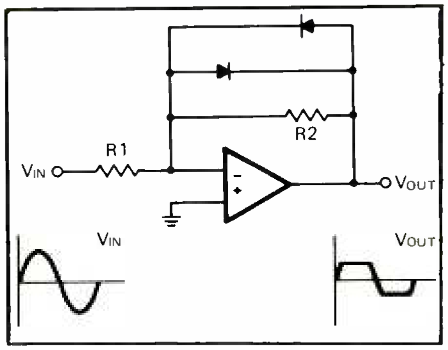


Fig. 11. A pair of diodes across the feedback resistor of the inverting amplifier produces the limiter circuit.

Normally, the inverting amplifier will create an output voltage that is an amplified version of the input. At some V_{out} level, however, the op amp will no longer be able to produce an exact replica of V_{in}. At this point, usually near the V+ of the power supply connected to the circuit, the op-amp's output will clip.

In most cases, the clipping level is too large and uncontrolled to be of use. However, the same type of operation can be deliberately induced by adding a pair of diodes across the feedback resistor, as shown in Fig. 11. With this arrangement, when V_{out} is below the forward voltage drop of the diode, the diode is reverse biased and the circuit acts just like an ordinary inverting amplifier. When V_{out} exceeds the diode's forward voltage drop, the diode becomes forward biased, limiting output at that point. Two diodes, connected in opposition, are used to limit both positive and negative voltages. The diodes effectively reduce the value of *R2*—and thus the voltage gain—to zero when the diode is forward biased.

The forward drop of the diode depends on the type of diode used. It's

(Continued on page 89)

Cure Computer Clutter

"Switcheroo" device lets you switch between color TV and video monitor and between Koala Pad and joystick with an Apple IIe

By Jeffrey I. Lackey

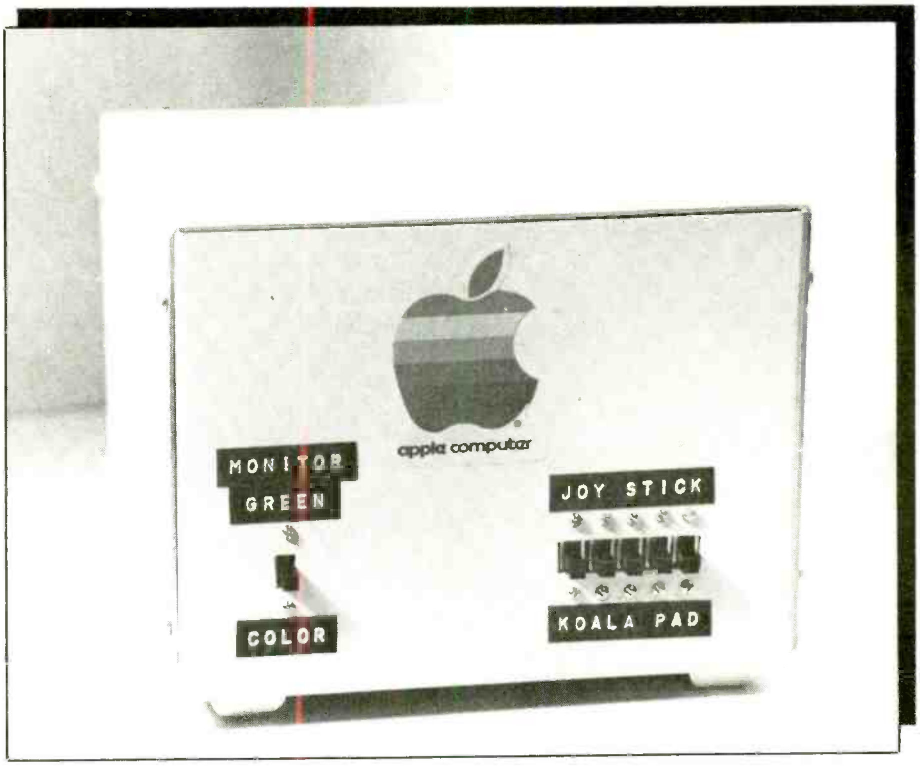
Is the back of your computer all cluttered up with cables, cords and connections? Do you have to switch them around by hand every time you transfer from one chore to another? If so, the "switcheroo" can give you some relief, as it did for me.

When I first bought an Apple IIe and hooked it up to a matching monochrome monitor, I thought green was beautiful. But it wasn't long before I wanted a little more color in my computing life, so I built myself an r-f modulator that enabled me to take advantage of the spare 13" color television receiver we normally keep in the living room.

The advent of color made the two junior members of our family ecstat-

ic. Games that had been merely captivating before were now electrifying. However, my wife missed having a spare TV, and it seemed I was forever reaching around the back of the computer to disconnect the color TV in order to reattach the green monitor for my own programming use.

Christmas came and St. Nick decided that the household needed a Koala Pad and a Commodore 1701 color monitor. We now had our spare TV back, and we all recognized the improvement in color graphics displayed on the Commodore monitor. But now, with the Koala Pad, I had another gadget that needed plugging in whenever the kids wanted to use it to create graphics instead of just playing games with the joystick.



This was especially bothersome since the joystick has a 9-pin D-connector, while the Koala Pad has a 16-pin DIP connector that has to be plugged into the computer I/O game port inside the computer case. There had to be a better way, I thought.

Obviously, I needed a device that could be used to switch not only between the two monitors, but also between the Koala Pad and the joystick. Switching between the two monitors was easy . . . between the Koala Pad and the joystick was just a bit tougher.

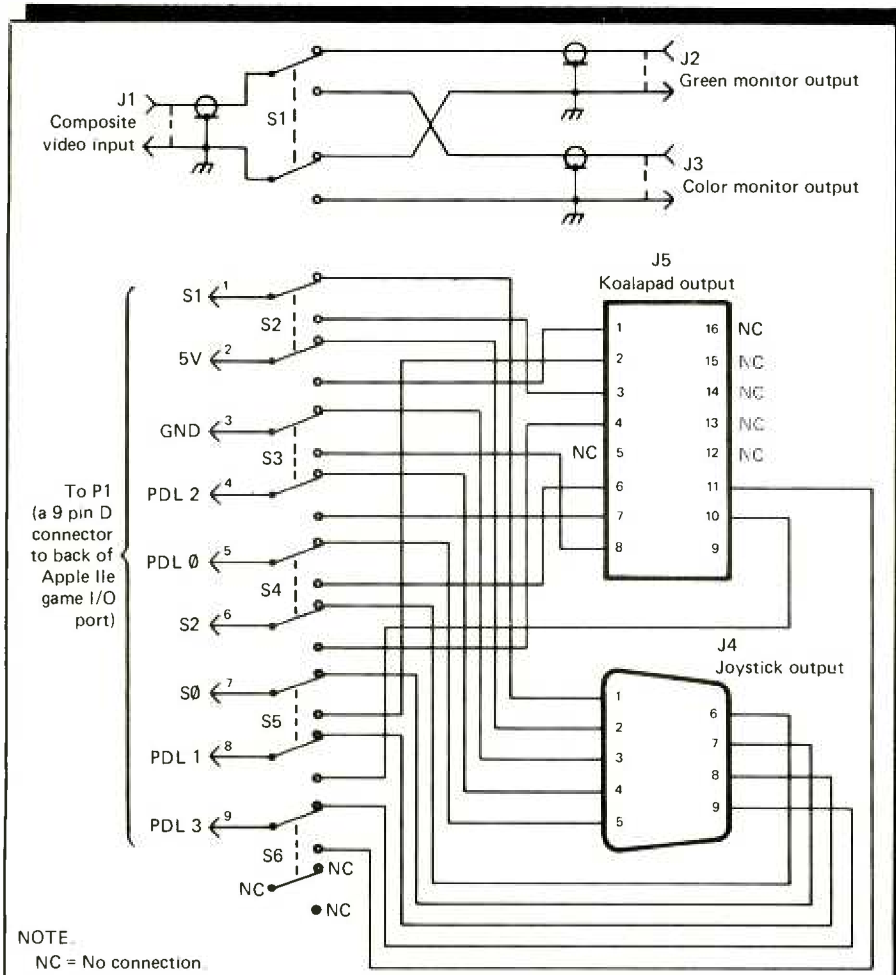
I had determined that nine lines were all that were needed for the Koala Pad to work properly. But how many people have a 9-pole switch in their junk box? I certainly didn't, nor did any of my friends.

But did it have to be one switch? Why not use several switches? Thus was born the "Switcheroo." I used one double-pole switch for the two video monitors and five double-pole switches for the nine lines available at the miniature D connector on the Apple's I/O game port.

Simple slide switches could be perfectly adequate for the game I/O lines. But would they be satisfactory for the composite-video signal needed to drive the monitors? A simple connection was made with a junk box switch and the other family members were polled on the resulting video quality with both monitors. All agreed that degradation in picture quality was unnoticeable.

Circuit Details

As shown in Fig. 1, the circuitry for the Switcheroo is entirely passive, consisting of a battery of switches and connectors and the wiring that ties them all together. A standard



PARTS LIST

J1, J2, J3—Phono jack
J4—9-pin female D connector (DB-9)
J5—16-pin standard or ZIF socket (see test)
P1—9-pin male D connector (DB-9) with 5 ft. of 9-conductor ribbon cable
S1 through S6—Dpdt slide or miniature toggle switch (see text)
Misc.—6″×6″×4½″ aluminum chassis box (see text); rubber feet (4); 6 ft. of miniature 75-ohm coaxial cable; phono plugs (4) for monitor cables; heat-shrinkable tubing or plastic electrical tape; hookup wire; solder; machine hardware; almond spray paint; lettering kit; etc.

Fig. 1. Complete schematic diagram of the "Switcheroo" switching system.

75-ohm coaxial cable with phono plugs brings the composite-video signal from the rear of the Apple computer to the INPUT jack on the rear of the Switcheroo at *J1*. Similar coaxial cables feed the two monitors via GREEN and COLOR output jacks *J2* and *J3*, also on the rear panel of the Switcheroo. The two video outputs are controlled by double-pole, double-throw (dpdt) switch *S1*.

Additional coaxial cable connects the switch with the jacks inside the chassis box. A nine-conductor flat ribbon cable is attached to a DB-9 (9-pin) male connector, *P1*, which plugs directly into the game I/O port on the rear of the computer. The cable enters through the rear wall of the chassis box and is switched by the bank of dpdt switches composed of *S2* through *S6* on the front panel.

The *S2* through *S6* arrangement switches between the connecting jacks for the joystick plugged into *J4* and the Koala Pad plugged into *J5*.

Construction

The Switcheroo is a relatively simple project to build, as illustrated in the photos that accompany this article. The aluminum chassis box I chose for my prototype is rather large, measuring 6″×6″×4½″. It's larger than really necessary for the basic project described above, but I wanted to be able to tie in additional peripherals later on as the need arises. If you don't anticipate this type of expansion, you can use a smaller box.

Perhaps the toughest part of construction is machining the box to accommodate the slide switches. You start off with the usual round holes, made with an electric hand drill, and then carefully use a file to square them off. However, if you prefer not to have to do this, you can substitute miniature toggle switches that neatly slip into round holes and save yourself a lot of time. In either case, your best bet is to arrange *S2* through *S6* in a single row, as shown in Fig. 2 and the lead photo. Plan to put the mounting hole for monochrome/color monitor switch *S1* in a location on the front panel where you won't have a tendency to accidentally flip it when you switch *S2* through *S5* to their alternate positions.

After machining the front panel to accommodate the switches (don't mount the switches just yet), prepare the rear panel to accept the various input and output connectors. Even if you opt for toggle switches for *S1* through *S5*, you can't get completely away from having to use a file (or nibbling tool) to make the cutouts in which to mount the female DB-9 connector and 16-pin socket for the joystick and Koala Pad connections and the slot through which the nine-conductor ribbon cable to which the male DB-9 connector is attached exits the chassis box. The job isn't too

(Continued on page 36)

Fig. 2. Label all switches on the front panel for easy identification.

difficult, however, since the soft aluminum of the box quickly and easily shapes with a file. The holes for the standard audio jacks used for the input from the computer and outputs to the monochrome and color video monitors, of course, are simple ¼"-diameter round holes.

When all machining has been performed and all holes and cutouts have been deburred, thoroughly clean all exterior surfaces of both halves of the chassis box and let dry. Then give each half two or three light coats of almond spray paint, allowing each coat to thoroughly dry before applying the next.

Once the last coat of paint has thoroughly dried (overnight if possible), you can label the various switches and connectors. An adhesive-backed tape-type label maker was used for the prototype, but you might want to use a dry-transfer lettering kit for a more professional appearance.

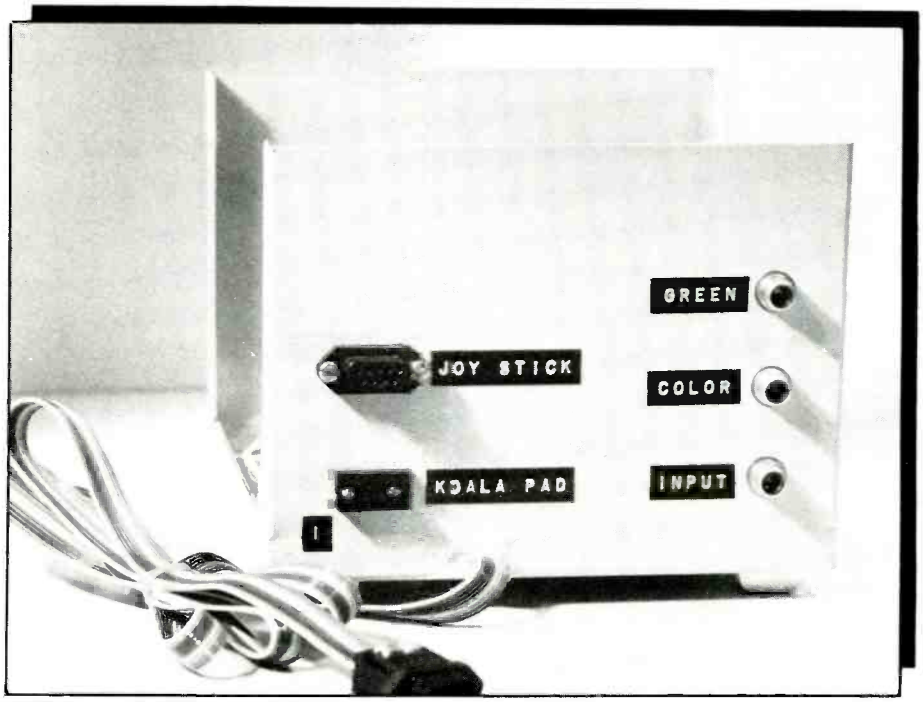
If you decide to use dry-transfer lettering, spray two or three *very light* coats of clear lacquer over the legends to protect them from the inevitable scratches and against flaking off as time goes by. Let each coat dry thoroughly before applying the next. Most importantly, don't try to get away with one thick coat of lacquer. If you do, either the letters will lift off and disolve, the almond paint will soften and run, or both!

You might have noticed in the lead photo and Fig. 2 the Apple Computer logo on my prototype project. I happened to have on hand a stick-on logo, obtained from my friendly Apple dealer, and since I designed the Switcheroo specifically for use with my Apple IIe, I decided to give it an identity with my computer. Use of the Apple logo in no way is meant to imply that the Switcheroo is either an Apple Computer product nor that it has Apple sanction. I just thought it lent a nice touch to the project.

Referring to Fig. 3, mount the switches on the front panel. Then turn around the chassis and mount the various input and output connectors in their respective locations on the rear panel, using Fig. 3 as a guide. Be very careful not to scratch the lettering on both panels with the screwdriver you use to tighten the mounting hardware.

Component mounting done, proceed to wiring everything together according to the diagram in Fig. 1. The

Fig. 3. Clearly label all input and output connectors on the rear panel.



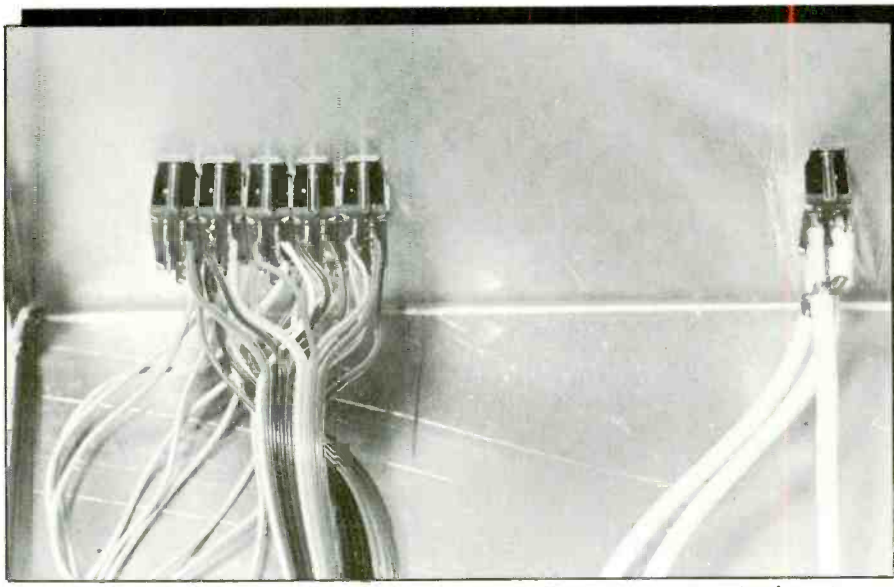
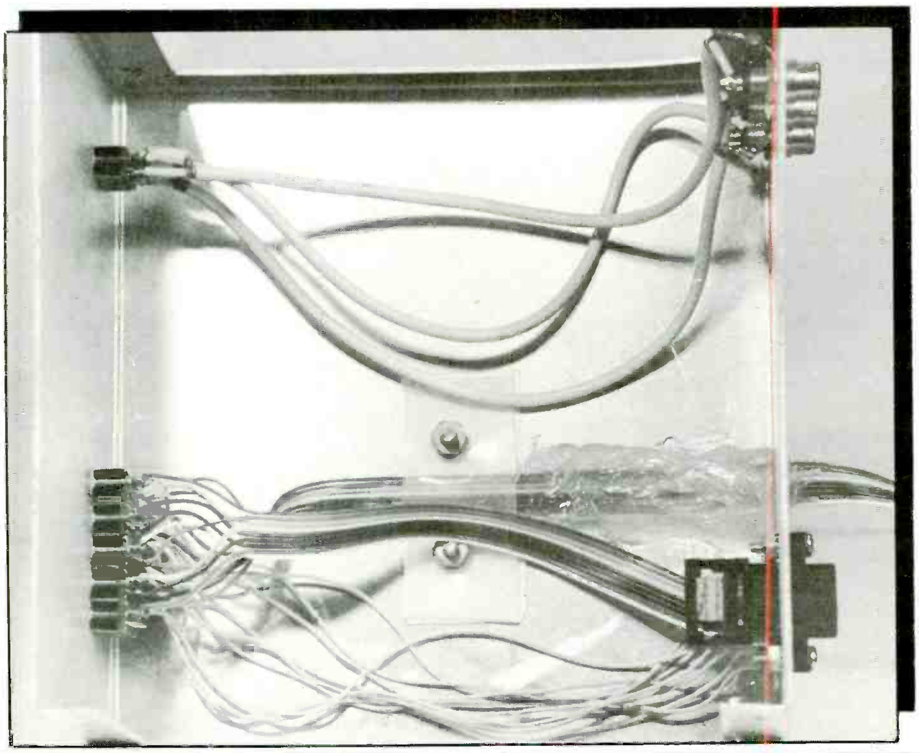


Fig. 4. Close-up view shows wiring to switches on front panel (above).

Finished project blends in with other components in system (right).

photo in Fig. 4 gives a close-up view of the wiring to the switches on the front panel. Note the use of heat-shrinkable tubing on the shield leads of the coaxial cables to *S1* at the far right. This is done to prevent shorts between the conductors wired and soldered to the closely spaced contacts of the switch. If you don't have or can't find heat-shrinkable tubing for the shield leads, use plastic electrical tape to insulate them.

Fig. 5. This overall view shows wiring details for the entire project.



In Fig. 5 is shown an overall view of the wiring for the entire project. In the prototype, I used a pair of stiff plastic sheets, bolted to the floor of the chassis box, to serve as a strain relief for the nine-conductor ribbon cable that exits through the rear wall. It's also a good idea to cement this cable to the floor of the chassis box, as well as line the cable's exit slot, with silicone adhesive as shown.

All wiring and soldering operations complete, carefully inspect each connection for cold soldering and to make sure that no fine conductors bridge the solder lugs on the switches and jacks. Then assemble the chassis box and install the Switcheroo in your computer system.

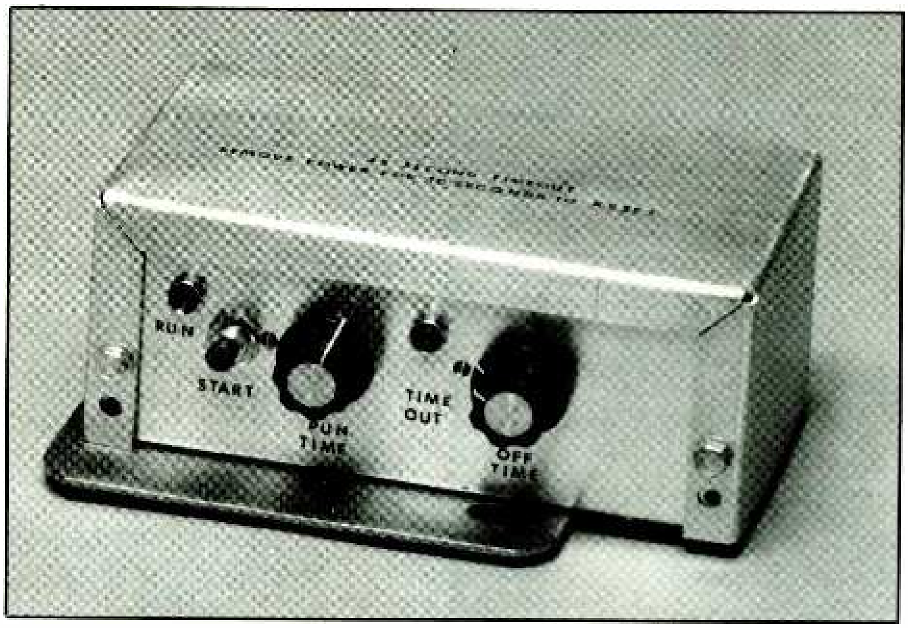
In Closing

Having installed the Switcheroo in my system, life with my Apple IIe is once again simple and hassle-free. No longer do I have to stop in the middle of another job to switch the monitor and game-port cables so that my four-year-old son can use the Koala Pad. For anyone else who is presently facing a similar dilemma, I can't think of anything surer to please than a Switcheroo. **ME**

An Advanced Oil-Furnace Controller

This all-electronic furnace controller replaces the old existing one to conserve fuel and handle timing control

By Duane M. Perkins



You can easily reduce the amount of fuel you use with an oil-fired furnace by replacing the existing unit with the advanced controller to be described. The new all-electronic unit takes command of timing the heating cycle without eliminating existing temperature control. With its shorter burn time and longer interval between burns, the controller can reduce the amount of heat lost up your chimney.

Although this will result in a somewhat longer time to raise the temperature on a cold morning, depending on the timing-cycle setting, you can expect the temperature to be maintained at the thermostat setting once it has been reached. (A fuller explanation of the reasoning behind this improved efficiency was given in "Heating Costs Too High? Try a Fuel Miser," *Modern Electronics*, October 1984. Unlike the Fuel Miser, the controller described here replaces the existing unit on your oil burner and performs all tasks the existing unit performs, plus controlling the timing.)

The Oil Burner

A standard home-heating oil burner has two temperature sensors and one light sensor. The usually low-voltage, low-current thermostat senses ambient room temperature and signals the controller when heat is needed. A similar device (called the "limit control") in the furnace opens a switch when the temperature of the heat exchanger reaches a preset level. This is a high-voltage, high-current switch that controls the 117 volts ac to the burner motor and igniter. When the thermostat calls for heat, the limit control cycles the burner. Another switch, similar to the limit control, turns on and off the blower motor but is independent of the burner itself.

The light sensor is usually a small cadmium-sulphide (CdS) cell mounted in the burner tube, where is can "see" the flame. Its purpose is to signal the controller to shut down after a preset time if the burner does not ignite. Without this very important safeguard, the burner motor would continue to run indefinitely in the event of ignition failure, pumping fuel into the firebox and posing a serious fire hazard.

Figure 1 shows how these components are usually wired. The controller contains a relay with heavy contacts to carry the current required by the burner motor and igniter. The igniter includes a step-up transformer that generates a high voltage to pro-

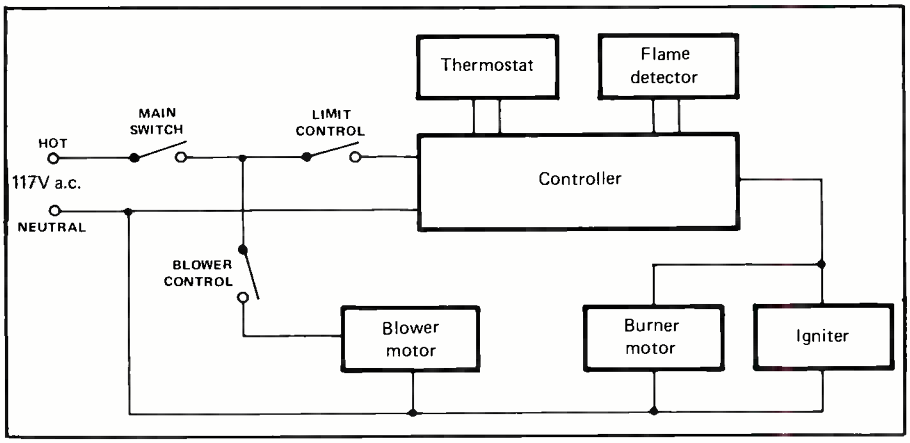


Fig. 1. Hot-air oil furnace components will usually be wired as shown.

duce an arc across the tips of two electrodes at the nozzle of the burner.

Circuit Description

Figure 2 is the schematic diagram of the controller circuit. It uses two timers, both contained in a single 556 IC. One timer, *IC1A*, is held reset by *R7* when the thermostat is open. The low output from *IC1A* holds timer *IC1B* at reset. Relay *K1* is deenergized and the burner does not operate. During this time, *C1* is held discharged by *IC1A*, and *C2* and *C3* will be discharged if *IC1A* has been off long enough for the charges on them to decay through the circuit resistances.

When the thermostat closes, the reset input at pin 4 of *IC1A* goes high through *R11* and causes the output at pin 5 to go high, sending the reset input of *IC1B* at pin 10 to high. With the firebox dark, the flame detector has a very high resistance. The voltage at the anode of *D2* will be at ground potential and this diode will not conduct. Since *C3* is discharged, the trigger input at pin 8 will be held low through *R14*, causing *IC1B* to turn on. The output at pin 9 will then go high, *Q3* will conduct, *LED2* will light, *K1* will energize and the burner will start. Capacitor *C3* will begin to charge through *R3* and *R6*. If the burner ignites, the resistance of *LDR1* will go very low and cause *Q2* to conduct, discharging *C3* and preventing *IC1B* from turning off as long as there is a flame in the firebox and *IC1A* is on.

With *IC1A* on, *Q1* conducts and charges *C2*. Capacitor *C1* begins to charge through *R1* and *R4*; when the charge rises to 8 volts, *IC1A* turns off and resets *IC1B*. At this point, *Q3* will cut off and deenergize *K1*, and the burner will shut down and *C1* will discharge. Also, *C2* will begin to discharge through *R2* and *R5*.

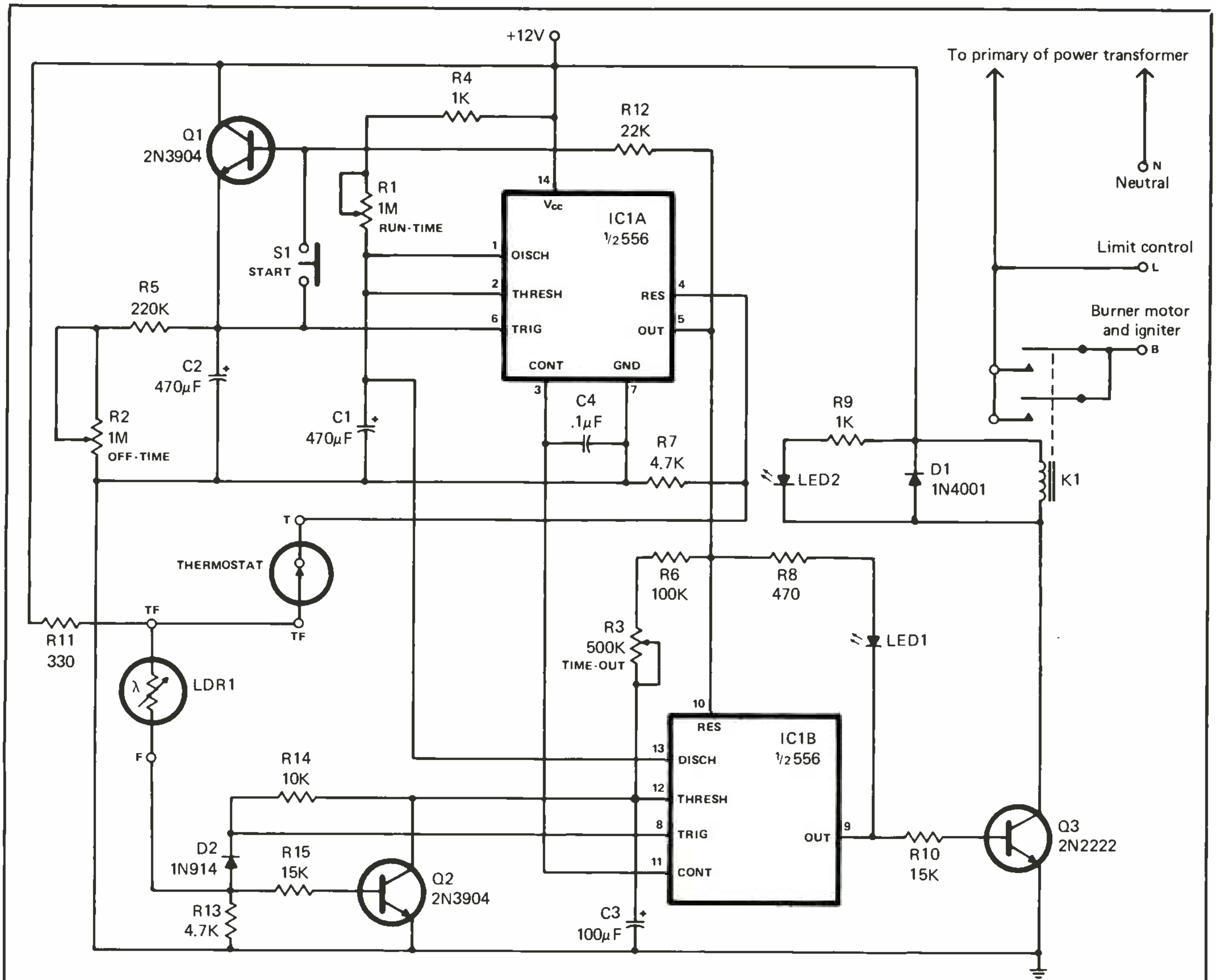
When the charge on *C2* falls to 4 volts, *IC1A* turns on. Since *C3* is discharged, *IC1B* will also turn on and the cycle will repeat indefinitely as long as the thermostat is closed. When room temperature rises above the thermostat setting, it will open and the controller will reset until the temperature drops below the thermostat setting.

In the event of ignition failure, the flame detector will have a very high resistance and *Q2* will not conduct. Capacitor *C3* will charge through *R3* and *R6*. When the charge reaches 8 volts, *IC1B* will turn off, *LED1* lights, *LED2* turns off, *K1* deenergizes and the burner shuts down. Now *IC1B* discharges *C1*, holding *IC1A* on. The controller will remain in this state until either the thermostat is turned down or power is removed. Either of these actions will reset the controller if it remains off for about 10 seconds, but the burner will not start immediately because *C2* will remain charged until the off-time portion of the cycle has elapsed. Pressing START button *S1* will cause *C2* to discharge faster and start the burner in just a few seconds.

The safety feature of the flame detector cannot be foiled by a shorted or open CdS cell, nor will the burner start if for any reason there is a flame in the firebox when *IC1A* turns on. If *LDR1* is shorted or has a low resistance when the burner is off, *D2* will conduct and hold the trigger input at pin 8 high, preventing *IC1B* from turning on. When *IC1A* turns on, *LED1* will light immediately and the circuit locks up until it is reset.

Potentiometers *R1* and *R2* allow you to set the run-time and off-time independently of each other such that changing the setting of one does not affect the other. To be useful, these times should be set so that the burn time is shorter than the time it takes for the limit control to open and the interval between burns is longer than the time it would take for the limit switch to close after the end of a burn. You can time these intervals with RUN-TIME control *R1* set to maximum and OFF-TIME control *R2* set to minimum and then adjusting them to decrease burn time and increase the interval between burns. RUN-TIME control *R1* will have a range of about 0.5 second to 10 minutes, OFF-TIME control *R2* will range from about 1.5 to 7.5 minutes. The timeout interval is adjustable, via TIMEOUT control *R3*, from about 16 seconds to 1.6 minutes but should be set for about 45 seconds.

Relay *K1* should have contacts rated to carry the current specified for your burner. A Radio Shack No. 275-218B with the two sets of contacts in



PARTS LIST

Semiconductors

D1,D2,D3—1N4001 rectifier diode
D4—1N914 switching diode
IC1—556 dual timer
LED1,LED2—Panel-mount light-emitting diode assembly
Q1,Q2—2N3904 transistor
Q3—2N2222 transistor

Capacitors

C1,C2—470-μF, 35-volt electrolytic
C3—100μF, 35-volt electrolytic
C4—0.1-μF disc
C5—4700-μF, 35-volt electrolytic
C6—220-μF, 35-volt electrolytic

Resistors (½-watt, 10%)

R4,R9—1000 ohms
R5—220,000 ohms
R6—100,000 ohms
R7,R13—4700 ohms
R8—470 ohms
R10,R15—15,000 ohms
R11—330 ohms
R12—22,000 ohms
R14—10,000 ohms
R1,R2—1-megohm linear-taper potentiometer
R3—500,000-ohm-flat-mount pc trimmer potentiometer

Miscellaneous

K1—12-volt dc relay with 10-ampere dpdt contacts
PC1—Cadmium-sulphide light-dependent resistor (Radio Shack No. 276-116A or similar)
S1—Normally open momentary-action spst pushbutton switch
T1—25.4-volt, 450-mA transformer
Suitable aluminum utility box (Radio Shack No. 270-238 or similar); electrical box (if needed; see text); pc board; IC socket; two control knobs; 4-lug screw-type terminal strip; rubber grommet; labeler; clear acrylic spray; ¼" spacers (3); 12-gauge stranded wire; 6-32 machine hardware; 1-lb. coffee can; switched ac lamp socket; ac line cord with plug; spst slide or toggle switch; flat black paint; wire nuts (3); solder; electrical tape; etc.

Fig. 2. This is the complete schematic diagram of the oil furnace controller, minus power supply.

parallel will have a rating of 20 amperes, which should be adequate for most burners. The power supply, shown in Fig. 3, uses a center-tapped 25-volt transformer and a 7812 voltage regulator to provide 12 volts.

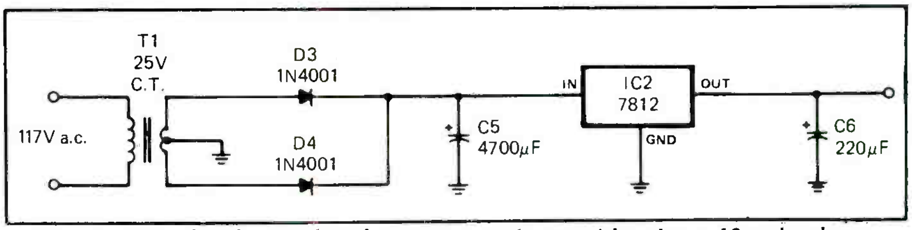


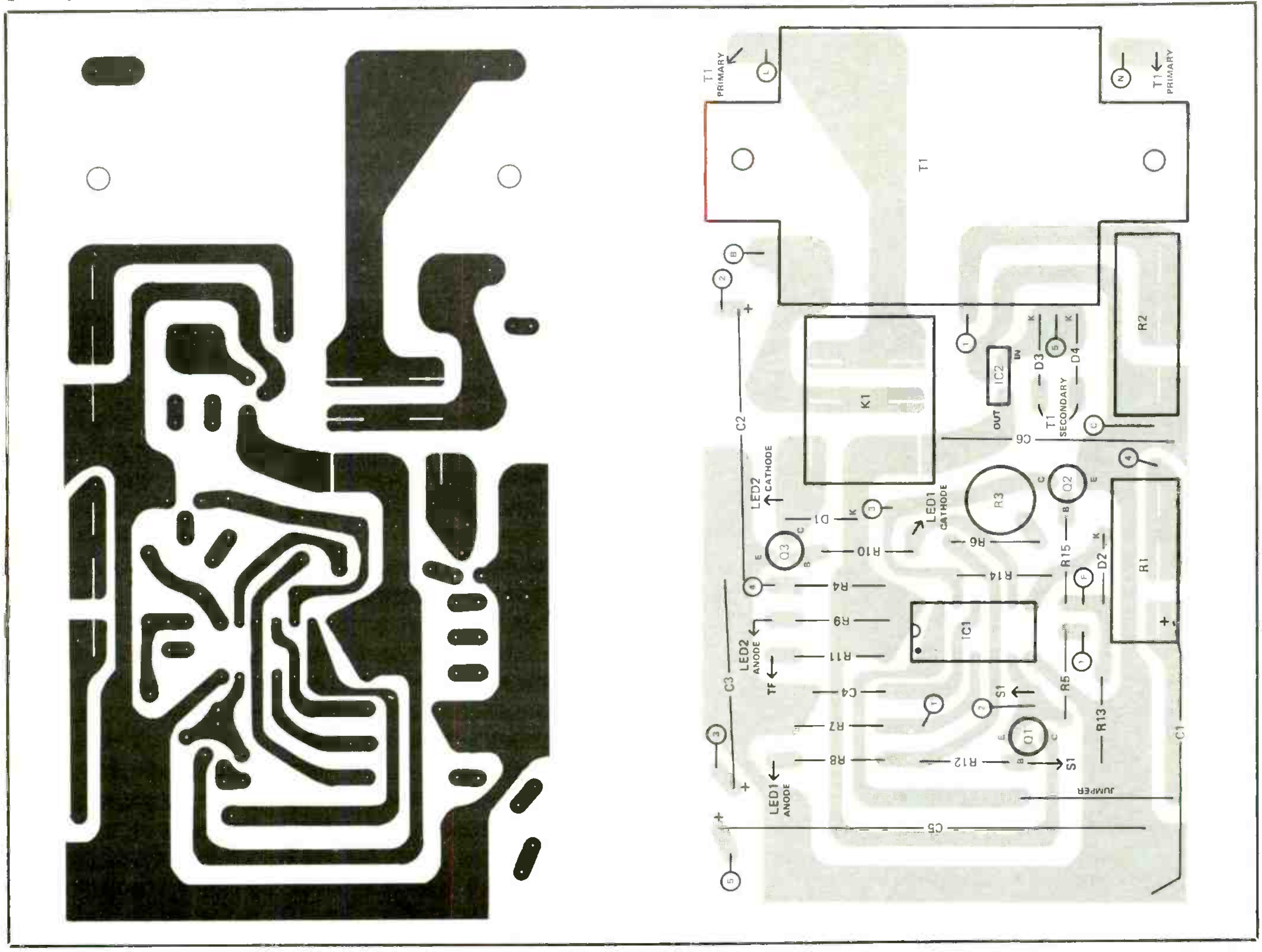
Fig. 3. This simple regulated power supply provides the + 12 volts dc required by the controller. It mounts on the same board as the controller.

Construction

Though you can use traditional point-to-point wiring or Wire Wrap techniques to assemble the controller circuit, a printed-circuit board is much the safer and easier approach. You can fabricate your own pc board with the aid of the actual-size etching-and-drilling guide shown in Fig. 4.

Once the board is etched and drilled, it will be necessary to cut long, narrow slots for the lugs of relay *K1* and potentiometers *R1* and *R2*. If you have a Moto-Tool or similar tool, you can use a thin abrasive wheel to do this. On the other hand, if you don't have such a tool, it will be necessary to drill a hole at each end of each slot and use a coping, jeweler's or keyhole saw fitted with a fine-tooth blade to make the slots.

Fig. 4. Shown at left is the actual-size etching-and-drilling guide for the pc board on which the controller and power supply circuits mount. Wire components to the board as shown in the parts placement/orientation diagram at right.



All components except the LEDs, pushbutton switch and four-screw terminal strip mount on the pc board. The conductors to the relay contacts must be wide and have as much insulation between them and other conductors as possible to safely carry the high current and voltage. Wire the pc board as shown in the components-placement diagram in Fig. 4. Start with the smallest components and work up to the electrolytic capacitors, potentiometers and relay. Do not forget the jumper wire between the *R1/C1* junction and pins 1, 2 and 13 of *IC1*; install this jumper *before* you mount *C1* and *C5*. Also, use a socket for *IC1*.

Before mounting the relay, carefully cut off the lugs to the normally closed contacts (the two nearest the edge opposite the coil connectors) and file them flush with the surface. Cut the potentiometer shafts to ⅜″ before mounting these components on the board. Temporarily mount the transformer with 6-32 hardware. Connect and solder its leads to the indicated points on the board (the center-tap goes to the point labelled C). Use insulated wire to interconnect like-numbered points, leaving these until last so that the wires can be routed around the components.

Use 12-gauge stranded wire for the connections to the points labelled L (limit control) and B (burner). Red insulation for the L and black for the B wires is recommended so that it conforms to the standard color coding for house wiring. The wire used for the N (neutral) lead can be as small as 20 gauge, since it carries only the current to power the controller. Cut all three of these wires to the lengths needed to reach the leads to which they will connect when the controller is installed in your furnace. Drill holes in the pc board adjacent to the connecting points and run these wires through the holes so that they can be routed through a hole in the bottom of the utility box. Cut seven 12″ lengths of stranded hookup wire and solder them to the points labeled F, T, TF, *LED1* and *LED2* (both anode and cathode).

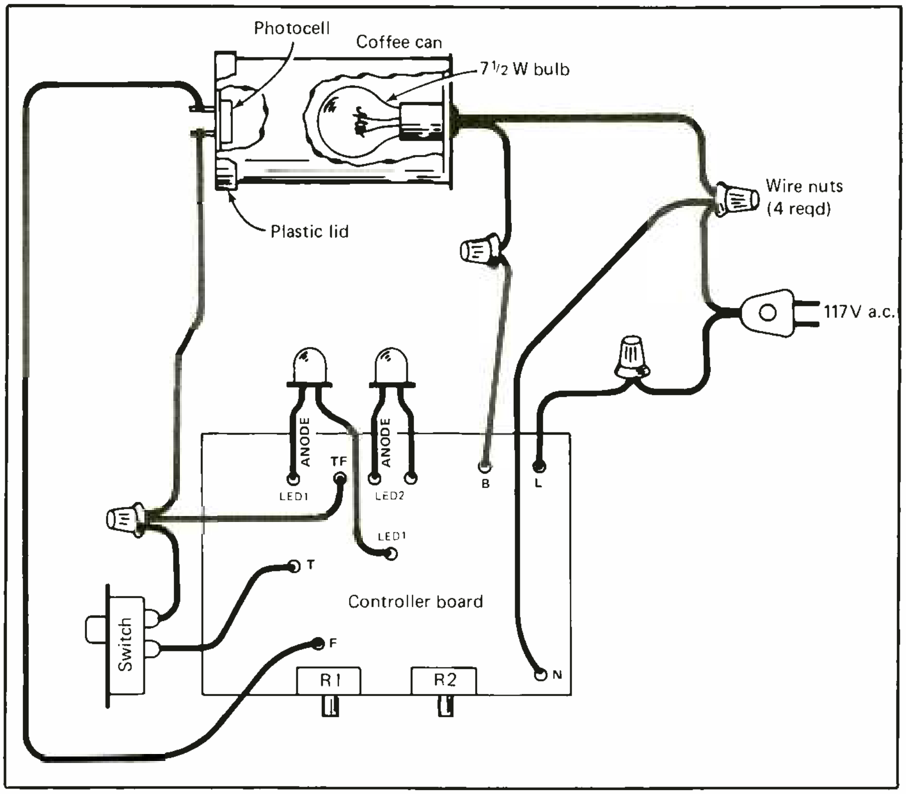


Fig. 5. Before installing your newly wired controller circuit in your oil furnace, wire it as shown here and perform the tests detailed in the text.

Initial Tests

A simple device that simulates the oil burner will greatly simplify testing of the controller. To make it, refer to Fig. 5. Mount a standard 117-volt switched lamp socket in the bottom of a 1-pound coffee can and screw in a 7½- or 15-watt bulb. Spray the inside of the can's plastic cover with a quick-drying flat black paint. When the paint dries, mount a CdS photocell in the center of the cover with its sensing surface facing inward and its leads brought out through the plastic of the cover. The lamp will simulate the flame in the firebox, the CdS cell the flame detector.

Connect the controller to this simulator exactly as shown in Fig. 5. Connect the two LEDs to the leads coming from the points labelled *LED1* and *LED2* on the pc board, making sure the anodes connect to *R8* and *R9*, respectively. Connect an spst switch to the leads from points T and TF. This switch will be used to simulate the thermostat.

Rotate *R1* and *R2* to fully clockwise. With the thermostat switch open, plug the line cord into an ac outlet. Nothing should happen. Use a voltmeter to measure the potentials between pin 14 of *IC1* and ground and between pins 3 and 11 and ground. The measurements should be +12 and +8 volts, respectively. All other pins of *IC1* should be at or near ground potential.

Set the lamp switch and then the thermostat switch to on. The relay should now pull in and the lamp should light. Also, *LED2* should light whenever *K1* is energized. With the photocell conducting, there should be about +8 volts at point F, and the potential at pins 3 and 11 of *IC1* should be near ground, while that at pin 1 should be slowly rising. When the potential at pin 1 of *IC1* reaches 8 volts, *K1* should drop out, turning off the lamp. The voltage at pin 6 should then slowly drop until it reaches 4 volts, at which point, *K1* should energize and the lamp should turn on.

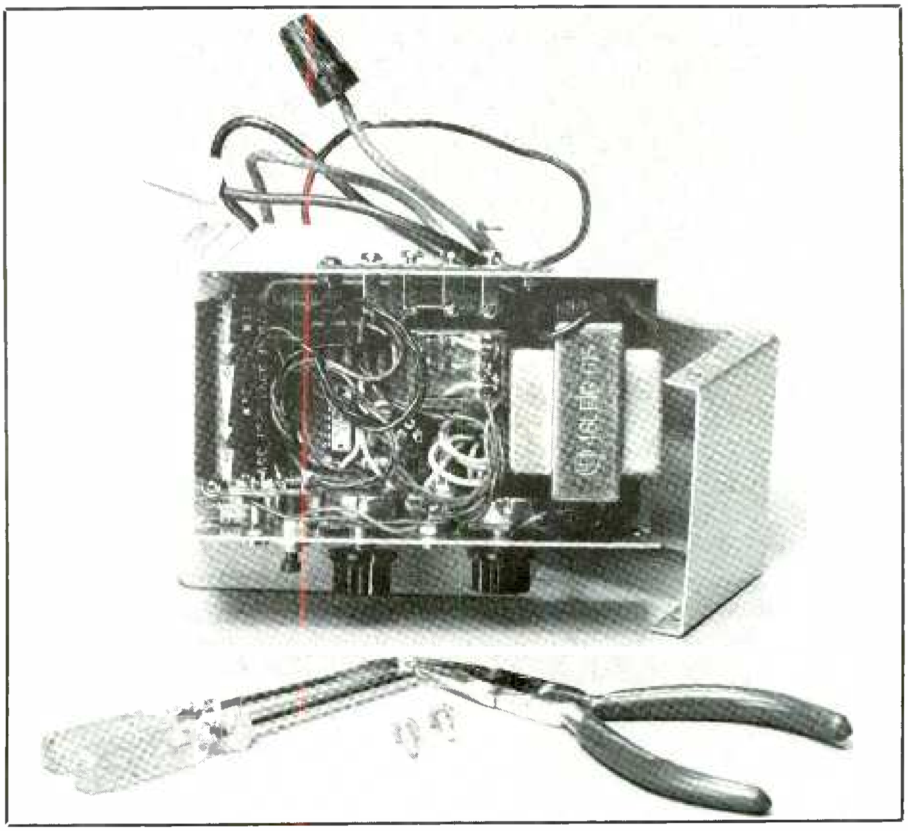
Slowly turn *R1* counterclockwise to decrease run-time. The voltage at pin 1 of *IC1* should rise more rapidly. When the relay drops out, rotate *R2* to maximum counterclockwise. The voltage at pin 6 should drop more rapidly and the "off" time should be about 1.5 minutes. The unit should now cycle continuously with a "run" time set by *R1*.

Set *R3* for minimum resistance. When the relay drops out, turn off the lamp switch and set *R1* maximum clockwise. When the relay energizes, the CdS cell will not conduct. The voltage at pin 12 of *IC1* should rise rapidly. When it reaches 8 volts, *LED1* should light and the relay should not energize. The circuit should remain locked in this state until it is reset. Turn on the lamp switch and then turn off then on the thermostat switch. Normally, cycling should resume beginning with the "off" time portion of the cycle.

When the lamp is off, remove the coffee can cover and expose the CdS cell to bright light. At the end of the "off" time, *LED2* should light immediately. Cover the CdS cell momentarily; at this point, the relay should energize.

Final Assembly

If the controller is working as described above, it is ready for final assembly. Disconnect the leads from the test setup and remove the two LEDs. Solder two short lengths of



An interior view of the controller.

stranded hookup wire to the points labelled S1 on the pc board. The board is to be mounted on ¼" spacers. Measure the height of the centers of the potentiometer shafts from the base of the enclosure (¼" below the bottom of the board). Measure the distance from one edge of the board to the centers of the potentiometer shafts. Marks these dimensions on the front panel of the enclosure and drill the holes for the shafts.

Position the board in the enclosure and check that there is ¼" of clearance for the spacers. Carefully noting the positions of the components, mark the centers for the holes where the two LEDs and the pushbutton switch will be mounted. Remove the board and drill these holes.

Placement of the four-lug screw-type terminal strip on the rear panel of the box is not critical. It can be centered vertically and horizontally. Cut a slot for the strip's lugs and drill the mounting holes.

The positions of the screws that secure the two utility box halves together must be changed because the pc board is now at the height of the original holes. Therefore, drill new holes about ⅜" above the original ones, sizing them the same as the originals to permit use of the self-tapping screws supplied with the box.

The utility box should be mounted on a standard square electrical box cover to keep the ac power connections safely enclosed and to facilitate installation in the furnace. Unless a suitable box is already in place, mount one in a convenient place in the furnace's enclosure. Note how the controller will best fit on the box when installed and mark the box's outline on the cover.

Drill the three mounting holes for the pc board (one for each of the transformer's mounting tabs and a third for the left-front hole in the board) through the bottom of the utility box. Set the bottom half of the box on the electrical box's cover, oriented properly in the drawn outline (the two mounting holes for the board at the *T1* tab locations should overhang the edge of the lid by at least ⅜") and transfer the electrical box lid's outline to the bottom of the utility box. Mark the front-left board mounting hole outline on the top of the electrical box's lid and drill this hole. Fasten the two pieces together with 6-32 machine hardware.

Next, drill two more screw holes through both metal pieces for two more sets of machine hardware. Make sure you position these holes where they will not interfere with either the circuit board assembly or proper mounting of the lid on the electrical box. Secure the two pieces together with 6-32 × ¼" machine screws, lockwashers and nuts. Flip over the assembly and drill a ¼" hole through the bottom of the utility box, centering it within the large hole area of the electrical box lid. Deburr the newly drilled hole and then line it with a rubber grommet.

Thoroughly clean all exterior surfaces of the utility box with fine steel wool. Then use a dry-transfer lettering kit or plastic tape labeler to identify the controls, indicators and connectors. If you use a dry-transfer lettering kit, spray two or three *light* coats of clear acrylic over all exterior surfaces of the box, allowing each coat to dry before applying the next.

When the acrylic has thoroughly dried, mount the terminal strip on the rear wall of the box. Feed three 6-32 × ½" machine screws up through the three holes in the bottom of the utility box. Drop a ¼" spacer onto each screw.

Place electrical tape over the surfaces of the utility box adjacent to the section where the board's conductors carry ac line power. Feed the ac power leads from the board through the rubber grommet and lower the board onto the screws, making sure the shafts of *R1* and *R2* properly seat in their holes in the front panel and that no conductors are caught between the board and spacers. Set *T1* in place over the protruding screws and anchor with lockwashers and nuts. Anchor the front-left corner of the board in place with another lockwasher and nut.

Mount *LED1, LED2* and *S1* on the front panel. Tighten the board-securing hardware and check to make sure that the nut and lockwasher at the left-front corner does not interfere with *C1* or *C5*. Cut all wires on the upper side of the board to the lengths needed to complete the interconnections and, referring back to Fig. 2, connect them to the proper points.

Before you close the utility box, it is a good idea to once again check the project for proper operation. To do this, use the test setup shown in Fig. 5 once again. This time, however, connect the photocell and thermostat switch to the terminal strip. This done, repeat the tests detailed above to be certain that all connections have been made correctly.

When the lamp turns off, press START pushbutton *S1*. In just a few seconds, the lamp should turn on. Adjust *R1* and *R2* for the run and off times you want to initially try when the controller is installed and in control of your furnace. Turn off the lamp switch and adjust *R3* for a 45-second time-out. After each trial, use the thermostat switch to reset and then restart with the START switch.

Installation & Operation

Before you attempt to install the controller in your furnace, make sure all ac power is disabled, preferably at the service box. Use wire nuts to connect the 117-volt ac power leads to existing wiring. Also, ground the controller for safety, using bare 12- or 14-gauge copper wire to connect to the existing ground lead. If it is necessary to extend the connections from the project to the existing wiring, use plastic-insulated three-conductor electrical cable with a ground wire.

Connect the flame-detector and thermostat wires to the contacts on the terminal strip on the rear of the controller and turn the thermostat all the way down. Apply power to the controller. Slowly turn up the thermostat until the burner kicks on. If the thermostat momentarily breaks after it makes, the off-time must elapse before the burner will start—or you can press the START button to get things rolling.

The burner should cycle according to the times previously set. Make any adjustments necessary if the control settings were moved during installation. Remove power, disconnect the black burner lead and replace the wire nut on the lead to prevent grounding. Recheck for a 45-second time-out before *LED2* turns on; readjust if necessary. Reconnect the burner lead and close up the box, using the four self-tapping screws.

In Closing

Experience will tell if the times you set are judicious. If it takes longer than you would like to get the temperature up to the thermostat setting on a cold morning, increase the run-time or decrease the off-time. The limit to which you can go with either control is determined by the limit control cycle time. Economy is achieved by having the controller determine both portions of the cycle. The best compromise will probably be with a setting that runs the burner only long enough for the blower to start and starts the burner shortly after the blower stops. **ME**

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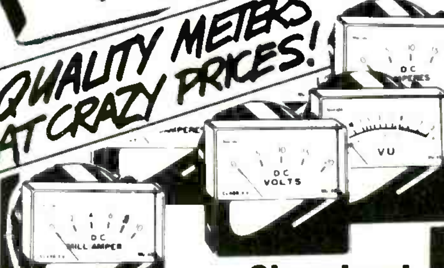

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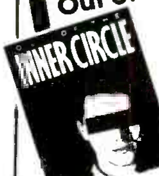

Well I tell you, if you never buy another book on computers, buy this one written by "The Cracker". The 19 year old computer whiz kid apprehended by the FBI and now author of the eye-opening inside story of America's secretive hacking culture. This book will give you heaps of information about "computer hackers" and the art of "hacking". What's more, it even lets you know the secret to keeping potential hackers out of your system. A fantastic hacker's guide to computer security.

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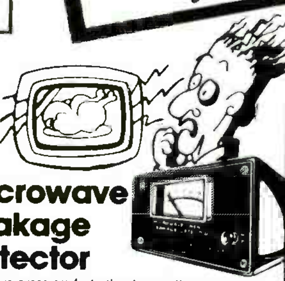

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WHERE THE ELECTRONICS ENTHUSIAST IS #1

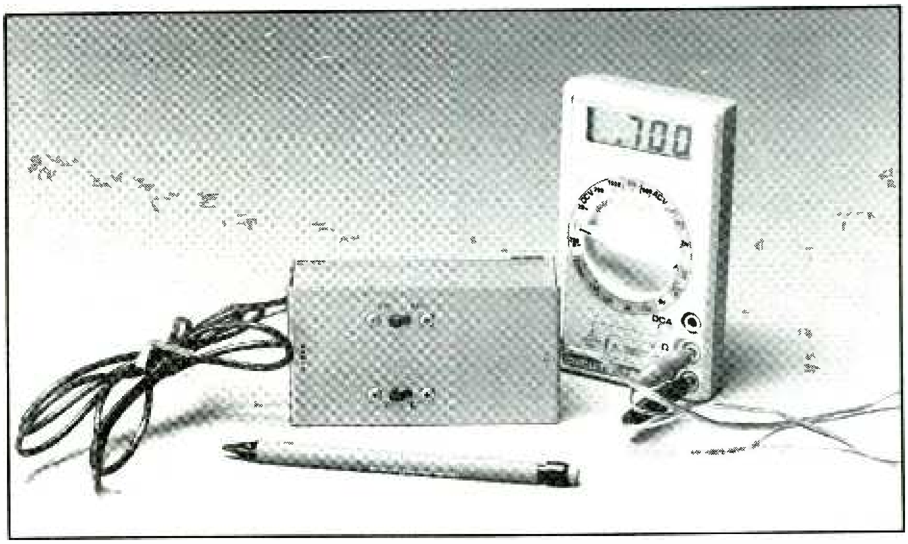
A °C/°F Thermometer Accessory

Simple construction project lets you measure temperatures with any voltmeter

By Bill Owen

An accurate electronic thermometer can be a very useful item, both on your workbench and for general use around your home. It can be used to monitor heat build-up in and around all types of powered equipment and to track down heat-related problems in malfunctioning circuits and systems. Around the home, it can be used to monitor ambient room and outdoor temperatures; keep tabs on air-conditioning and heating systems; monitor refrigerators and freezers; and much more. In fact, once you use an easy-to-read and accurate electronic thermometer, you are likely to find all sorts of uses for it you never considered before.

Our electronic thermometer accessory starts off with the premise that you have on hand an accurate dc voltmeter. A garden-variety DMM will do nicely. Actually, this accessory can be used with any digital or analog multimeter, basic voltmeter or panel meter. The accessory is built around special solid-state circuitry, including the temperature sensor, that provides a linear 10 mV/degree output. It is switch-selectable to allow you to measure temperatures in both °C and °F. Furthermore, its active-circuit design allows the temperature sensor to be located literally thousands of feet away without the attendant problem of noise pickup.



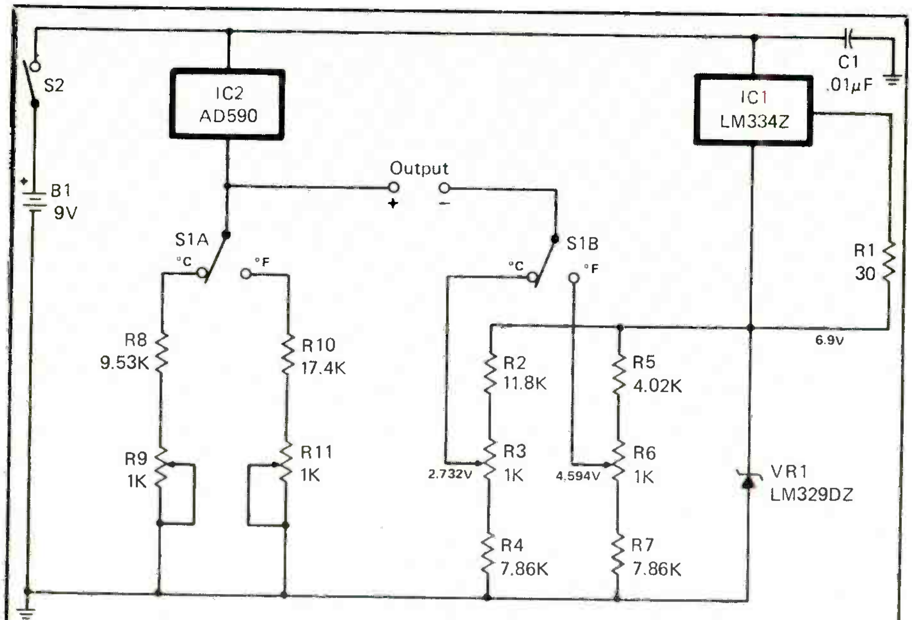
About the Circuit

Though the temperature accessory circuit (Fig. 1) appears to be very simple, it is really quite sophisticated in terms of performance and the technology it uses. The AD590 temperature sensor integrated circuit used for *IC2* produces an output current that is proportional to temperature. The output current produced when the device is connected to a voltage source is equal to 1 μA per degree on the Kelvin temperature scale. The Kelvin degree is equal to the Celsius degree, but the °K temperature scale has its zero at −273.2 °C, or absolute zero. The relationship between Kelvin, Celsius and Fahrenheit temperature scales is as follows:

$$°C = °K - 273.2$$
$$°F = [(9 \times °C)/5] + 32$$
$$°F = [9(°K - 273.2)/5] + 32.$$

It should also be noted that there is a little-used Rankine temperature scale that starts at absolute zero and has Fahrenheit-scaled degrees. Rankine degrees are offset 459.7 higher than Fahrenheit degrees. Rankine to Fahrenheit conversion is as follows: °F = °R − 459.7.

Connecting the sensor's output to a microammeter makes a °K thermometer. The next step, then, is to remove the 273.2 °C or 459.7 °F offset to obtain the more useful °C and °F outputs. To achieve this, sensor



PARTS LIST

Semiconductors
IC1—LM334Z current source
IC2—AD590 sensor
VR1—LM329DZ voltage reference
Capacitors
C1—0.01-µF disc
Resistors (¼-watt, 1%)
R1—30 ohms (2%)
R2—11,800 ohms
R4,R7—7860 ohms
R5—4020 ohms
R8—9530 ohms
R10—17,400 ohms
R3,R6,R9,R11—1000-ohm pc-mount trimmer potentiometers

Miscellaneous
B1—9-volt transistor battery
S1,S2—Dpdt switch
Printed-circuit board; one each red and black banana jacks and plugs; 4″ × 2¼″ × 1¼″ aluminum cabinet; 9-volt battery connector; 4-ft. RG174 coaxial cable; 2-ft. miniature zip cord; dry-transfer lettering kit; clear spray acrylic; ¼″ rubber grommets (2); 4-40 × ⅛″ machine scres (6); solder; etc.
Note: The following is available from NRG Electronics, P.O. Box 24138, Ft. Lauderdale, FL 33037: Complete Model T-100 kit, less battery, for $19.95 + $1.50 P&H + 5% sales tax for Florida residents.

Fig. 1. This overall schematic of the thermometer accessory is deceptively simple. The circuit is actually quite sophisticated. Almost any analog or digital voltmeter or multimeter can be used as the temperature display device. Power for the accessory is provided by a 9-volt transistor battery.

output current is converted to a voltage when passed through a scaling resistor. A voltmeter is then used to measure the difference between the scaled temperature output and an appropriate voltage reference.

The °C scaling resistance is formed by the series network made up of resistor *R8* and trimmer potentiometer *R9*, while °F scaling is accomplished with *R10* and trimmer *R11*. Switch *S1A* routes sensor output current through the appropriate scaling network to select either °C or °F. Switch *S1B* selects either the 2.73- or the 4.59-volt reference so that the differential output is 10 mA per °C or °F.

The two reference voltages are tapped from resistive dividers connected to precision 6.9-volt reference *VR1*. Resistors *R2* and *R4* and trimmer control *R3* make up the °C divider, and resistors *R5* and *R7* and trimmer *R6* make up the °F divider.

Precision reference *VR1* is an LM329DZ, which is biased by the LM334Z current source used for *IC1*. Resistor *R1* sets the current source's output to 2 mA. The combination LM334/LM329 reference is very stable over wide temperature and voltage changes and uses very little current, assuring long battery life.

Construction

To make the thermometer accessory as compact as possible and to facilitate easy assembly, it is suggested that you assemble the circuit on a printed-circuit board. You can purchase a ready-to-go pc board from the source given in the Parts List. Alternatively, you can fabricate your own pc board, using the actual-size etching guide given in Fig. 2.

Wire the circuit board as shown in the components-placement/orientation diagram in Fig. 2. Note that all components except sensor *IC2* and battery *B1* mount directly on the pc board and that controls *R3, R6, R9* and *R11* mount on the *foil* side of the board. When you have finished wiring the pc board, temporarily set it aside and proceed to machining the small metal utility or project box in which the project, with battery, is to be housed. You must drill a hole through each side wall of the box to provide the means for the meter and sensor cables to enter the box.

The only other holes that must be drilled or cut will be in the top of the box, which will serve as the project's front panel. You must cut two rectangular slots, one for each switch's toggle and drill two mounting holes for each switch. When you are finished machining the box, temporarily install the circuit-board assembly to make sure all parts fit as they should. Make whatever adjustments are needed. Then disassemble the

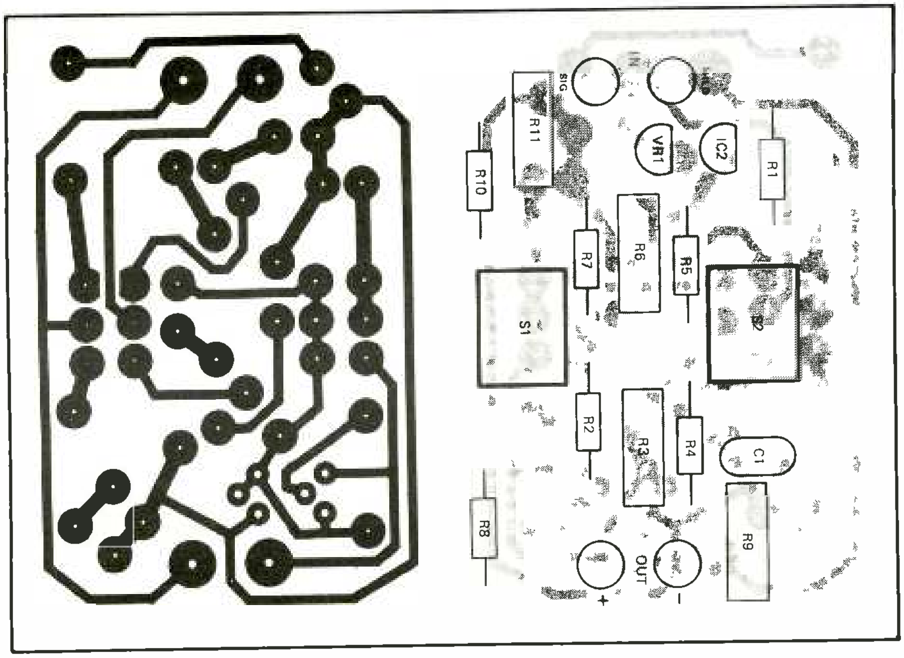


Fig. 2. Fabricate the printed-circuit board for the project using the actual-size etching-and-drilling guide at left. Install the components on the board exactly as shown in the placement/orientation diagram shown at right.

box, remove the pc assembly and clean all exterior surfaces of the metal box with fine steel wool. Using a dry-transfer lettering kit, label (on the top of the box) the legends PROBE and METER just above the entry holes on the left and right sides of the box, respectively. Then label the two switches with the legends °C and °F for the alternate positions of *S1* and ON and OFF for the appropriate positions of *S2*. If you wish, you can also label the legend THERMOMETER ACCESSORY on the top of the box for future identification.

When all lettering is completed, spray two or more *light* coats of clear acrylic on all exterior surfaces of the box to give the project a professional finished appearance and to protect the lettering. Allow each coat to dry before spraying on the next.

Referring to Fig. 3, prepare the probe/cable assembly. Trim the leads of the AD590 so that they are just long enough to permit good electrical and mechanical connection of the coaxial cable. To prepare the ends of the 4-ft. length of coax, first trim away ¼ " and ¾ " of outer insulation from opposite ends. Separate the shield from the inner conductor at both ends back to the outer insulation. Then, making sure not to cut any of the inner-conductor wires, trim ⅛ " of insulation at the ¼ " prepared end and ¼ " of insulation from the ¾ " prepared end. Tightly twist together the shields and inner conductors and lightly tin with solder. Connect and solder the conductors at the ¼ " prepared end of the cable to the shortened pins of the AD590 sensor as shown in Fig. 3. Use heat and solder sparingly and make certain you do not create any solder bridges. When the solder cools, gently separate the connections to obviate any possibility that the two can short together. Then apply 5-minute epoxy cement to the connection, flowing it over only the skirt of the AD590 and about ¼ " beyond the point where the outer insulation was removed from

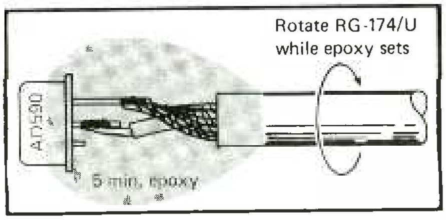


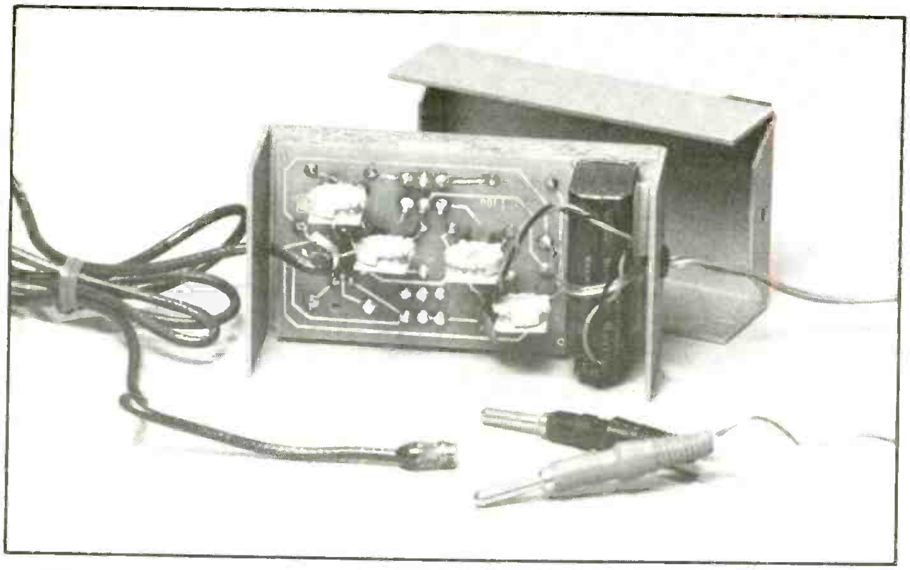
Fig. 3. After tack-soldering a 4-ft. length of coaxial cable to the shortened leads of the AD590 sensor, flow epoxy cement over connections, sensor and cable as shown and slowly rotate the assembly as the cement sets to obtain an air-tight, symmetrical seal.

the coax. As the cement sets, slowly rotate the cable assembly to allow it to assume a symmetrical form. Then allow the cement to set solidly for a couple of hours.

Now prepare the meter cable. For this, you will need a 3-ft. length of miniature zip cord and a pair of red and black color-coded banana jacks. Split the cord apart for a distance of about 5 " at one end and 1 " at the other end. Trim away ¼ " of insulation from all conductors at both ends, taking care to avoid cutting through any fine wires. Tightly twist the wires into neat bundles and sparingly tin with solder. Install a banana jack on each conductor at the long split end.

When the acrylic spray paint on the box has completely dried, place small rubber grommets in the holes in the box's sides. Then feed the free ends of the prepared cables into the box through the grommets and tie a knot in each cable about 3 " from the free ends on the *inside* of the box. Connect and solder these to the appropriate pads on the pc board. Do the same with the battery-connector wires.

Position the pc board assembly in the box and secure it in place with four 4-40 × ¼ " screws via the mounting tabs on *S1* and *S2*. Gently pull on both cables until the knots touch the rubber grommets. Mount



All components except the battery and sensor mount on the pc board.

the battery at one end of the pc assembly inside the cabinet (see photo) and clip on the battery connector.

Calibration

The voltage reference in the thermometer accessory is very stable and will assure linear measurement results in both the °C and °F modes when properly calibrated. It is very important for you to perform calibration with the voltmeter or other readout device that will be used to display temperature.

Connect the negative (COM) lead of the preferably digital voltmeter to the negative (black) battery connector pad and the positive (red) meter lead to the wiper (center) lug of trimmer control *R3*. Turn on the power and adjust the setting of *R3* for a 2.73-volt meter reading. Then connect the voltmeter's positive lead to the wiper lug of *R6* and adjust this control for a 4.59-volt reading.

Accuracy of the accessory is very good when calibration is done around the temperature range where the project is to be most frequently used. For general use, it is convenient to calibrate at the freezing and boiling points of fresh water. To calibrate for the freezing point, place a 50/50 mixture of water and crushed ice in a styrofoam cup and stir for a minute or so to stabilize the temperature; then immerse the probe. To calibrate at the boiling point, bring to a boil fresh water and immerse the sensor probe in this.

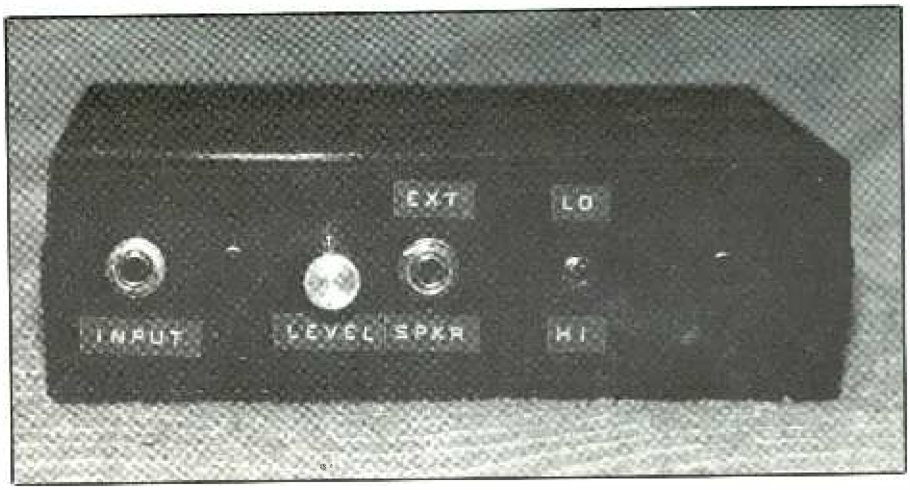
Fresh water freezes at 0° C and boils at 100° C. So, setting the mode switch to °C, first immerse the sensor probe in the ice/water mixture and adjust *R9* to obtain a 0° C reading on the meter when the latter is connected to the METER cable on the accessory. Then immerse the sensor probe in the boiling water and readjust *R9* to obtain a 100° C reading. Repeat this calibration procedure several times to determine which end of the scale is the most accurate.

Once the thermometer accessory is properly calibrated for the °C mode, switch to the °F range and use *R11* to calibrate the scale for the freezing (32° F) and boiling (212° F) points of water. This completes calibration of the accessory. Set the power switch to OFF and assemble the case. **ME**

Testbench Audio Amplifier

A simple, inexpensive amplifier you build for your testbench or modify for other audio needs

By C. R. Fischer



If you do a lot of experimenting with and repairing of audio equipment, as I do, a compact high-quality audio amplifier like the Testbench Audio Amplifier described here can be a real asset. I built this Amplifier specifically for my testbench to help me trace circuits to isolate malfunctioning stages, boost low signals to sufficient levels to hear them through a loudspeaker, and to check out the sonic quality of prospective audio purchases. Other applications will most likely suggest themselves to you. Also, being a musician, I use the Amplifier with headphones to set up and tune my music gear without disturbing anyone else around me.

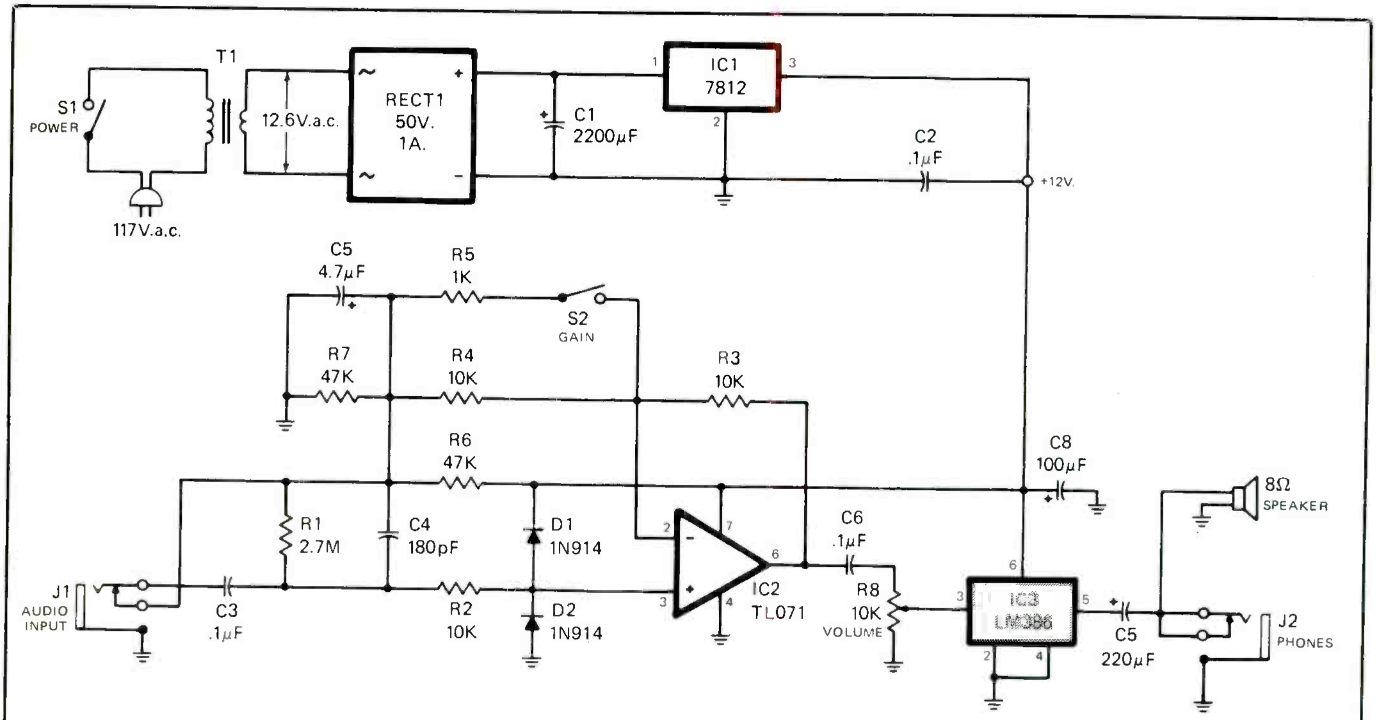
The Testbench Audio Amplifier described here is a very basic audio "instrument." It gives good performance using only inexpensive and readily available components. It delivers roughly 400 mW of power into an 8-ohm speaker, sufficient for listening with a high-efficiency speaker, and is powered by a choice of supply options, including a 117-volt ac line-powered + 12-volt supply and a + 12-volt battery supply. A high-impedance buffer is built in to prevent loading down any signal source to which the project might be connected. And tips are given to help you modify the basic design to suit other applications.

About the Circuit

In Fig. 1 is shown the schematic diagram of the basic Testbench Audio Amplifier. This version includes a suggested ac-line-driven power supply, which is included here mainly because of the amplifier's strictly testbench application. If you prefer, you can eliminate the ac supply and replace it with a different 9- to 12-volt dc source. You could, for example, substitute a 9-volt transistor battery, but a better altenative would be to use eight AA cells in series to obtain a 12-volt supply, which will provide better amplifying headroom and longer operating life. For even greater flexibility, you might even include both an ac-operated and a battery supply, switching in whichever is needed at the time. If you go this route, disconnect the + 12-volt lead coming from the power supply at the point where it joins the positive side of *C8* and install a double-pole, single-throw switch at this point, with the throw lug connected to the vacated *C8* connection and the + 12-volt leads of the battery and ac supplies going to separate pole lugs.

Bi-FET operational amplifier *IC2* serves as a buffer to minimize current drain on the signal source. In addition to providing minimal loading, *IC2* has a high slew rate and generates very little noise.

Audio signals to be amplified are



PARTS LIST

Semiconductors

D1,D2—1N914 or equivalent diode
IC1—7812 +12-volt regulator
IC2—TL071 bi-FET op amp
IC3—LM386 low-voltage audio amplifier
RECT1—50-volt, 1-ampere bridge rectifier

Capacitors

C1—2200-µF, 35-volt electrolytic
C2,C3,C6—0.1-µF, 25-volt disc
C4—180-µF mica
C5—4.7-µF, 25-volt tantalum or electrolytic
C7—220-µF, 25-volt electrolytic
C8—100-µF, 25-volt electrolytic

Resistors (¼-watt, 10%)

R1—2.7 megohms
R2,R3,R4—10,000 ohms
R5—1000 ohms
R6,R7—47,000 ohms
R8—10,000-ohm, audio-taper potentiometer

Miscellaneous

J1,J2—Closed-circuit phone jack
S1,S2—Spst toggle or slide switch
8-ohm speaker; pc board or perforated board and solder posts; sockets for IC2 and IC3; shielded enclosure; control knob for R8; shielded cable; machine hardware; hookup wire; solder; etc.

Fig. 1. This schematic of the Testbench Amplifier includes an optional ac-operated 12-volt power supply (top). You can eliminate it and substitute a 9- or 12-volt battery supply consisting of six or eight AA cells in series.

ac coupled from INPUT jack *J1* through *C3* to the noninverting (+) input of *IC2*. Capacitor *C4* rolls off frequencies beyond 20 kHz to minimize the possibility of demodulation of r-f signals and the passage of noise through the amplifier.

Resistor *R2* and diodes *D1* and *D2* make up a high-voltage protection circuit for those occasions when the amplifier is used with circuits in which the power supply voltage is greater than the amplifier's supply voltage. Resistor *R2* limits input current, and the diodes conduct excess voltages away from *IC2*. If you build this project to amplify an electric guitar or a circuit that shares the same power supply, you can eliminate *R2, D1* and *D2*.

Resistors *R6* and *R7* and capacitor *C5* form a voltage divider that biases *IC2* for symmetrical output. To accomodate a wider range of input signals, GAIN switch *S2* has been included. With *S2* open, the equal values of *R3* and *R4* give *IC2* a unity-gain output. Closing *S2* increases gain to slightly more than 10, allowing the amplifier to boost low-level signals to usable amplitudes.

The output from *IC2* is coupled through *C6* and VOLUME control *R8* into audio amplifier *IC3*. The LM386 low-voltage amplifier used for *IC3* develops sufficient gain to directly

(Continued on page 84)

ELECTRONICS NOTEBOOK

Detecting Sound

By Forrest M. Mims III

Recognition of speech by computers is a topic that has received considerable press over the past few years. Though machine speech recognition is a highly sophisticated technology, the design and construction of electronic circuits that respond to the presence or absence of sounds is very straightforward. In this column I'll describe two such circuits and discuss some of their applications. First, let's review some basics of sound.

Sound

Vibratory movement of air that enters the human ear is perceived as sound. The air movements that cause sounds are pressure waves the fluctuate around the normal atmospheric pressure of about 14.7 pounds per square inch (1013.25 millibars). Sound travels through air at a velocity of 1,128 feet (344 meters) per second when the temperature is 68 degrees F. This is much slower than the speed of light (984,000,000 feet or 299,800,000 meters per second). This, of course, is why the eye perceives a lightning bolt before the ear receives the sound.

The ear, like the eye, possesses an incredibly broad dynamic response. The typical human ear can detect sound pressures ranging from as little as 0.0001 microbar to 1,000 microbars, a pressure range of 1 to 10,000,000.

Because the response of the human ear is so wide, sound is measured on a logarithmic scale. The unit of sound pressure is the decibel (dB). The faintest sound the human ear can discern, which has an intensity of 0.0000000001 microwatt per square centimeter, has been assigned a decibel level of 0. All other sound pressure levels are given relative to the 0-dB level. The intensity in dB of a particular sound is 10 times the logarithm of the ratio of the sound intensity being specified (S1) to the 0-dB reference level (S2) or dB = 10 log (S1/S2).

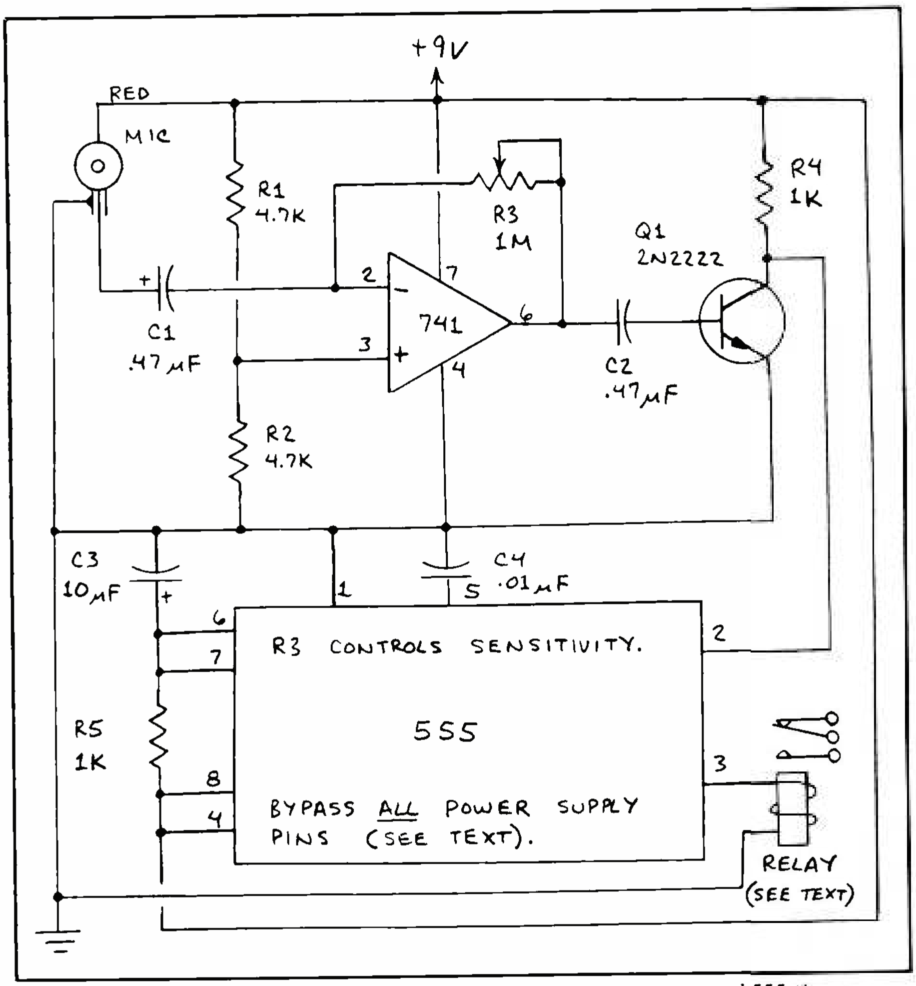


Fig. 1. Simple sound-activated relay uses popular 741 op amp and 555 timer.

A typical conversation yields a sound intensity of 0.001 microwatt per square centimeter at a distance of 3.25 feet. Inserting this value into the formula given above yields a decibel value of 70 [dB = 10 log (10 − 3/10 − 10)]. Here are the decibel levels for some other commonly encountered sounds:

Jet aircraft at 20 feet	140 dB
Threshold of pain	130 dB
Propeller aircraft at 18 feet	121 dB
Passing subway train	102 dB
Niagara Falls	92 dB
Passing truck or bus at 20 feet	80 dB
Average automobile at 15 feet	70 dB
Conversational speech at 3.25 feet	70 dB
Average office	55 dB
Average residence	40 dB
Quiet whisper at 5 feet	18 dB
Threshold of audible sound	0 dB

A person's hearing ability is determined by age, sex and previous exposure to loud sounds. It's well known, for instance, that the ears of older people have a diminished response to higher-frequency sounds. The ears of young children are particularly sensitive, a fact which was clearly in evidence at a recent air show I attended. As the jet aircraft swooped by the spectators, virtually all the children placed their hands over their ears.

Teenagers are often warned about the

hearing loss that will follow long-term exposure to excessively loud music. Experimenters should heed the same warning and practice caution when experimenting with circuits that generate sounds. Years ago I learned to avoid placing an earphone in my ear until the circuit to which is was connected was switched on. On several occasions when I failed to follow this procedure, my reward was a painfully loud tone or noise. Thanks to these mishaps, there is a distinct hearing deficiency in one of my ears.

Sound-Activated Relay

A sensitive sound-triggered relay can be designed around a single operational amplifier and a monostable multivibrator. One such circuit I've recently designed and tested is shown in Fig. 1.

The circuit in Fig. 1 uses a miniature electret condenser microphone that contains a built-in FET amplifier stage. The microphone I used, Radio Shack No. 270-092B, has a sensitivity of −65 dB relative to a reference of 0 dB of 1 volt per microbar at a frequency of 1 kHz. The frequency response of this microphone is nearly flat from 20 Hz to 10 kHz.

Referring to Fig. 1, the microphone's output is coupled through *C1* into the inverting input of a 741 op amp. Feedback resistor *R3* controls the gain of the op amp. The amplified signal is coupled through *C2* to *Q1*, where it is inverted, and from there to the input of a 555 timer configured as a monostable multivibrator or "one-shot." The one-shot issues a pulse at pin 3 that has a duration controlled by *R5* and *C3*. The values given in Fig. 1 give a duration of about 10 seconds. The armature of a relay connected to pin 3 of the 555 is pulled in during this time interval.

The values of nearly all the circuit components in Fig. 1 are noncritical. The sole function of *R1* and *R2* is to act as a voltage divider to bias the noninverting (+ input of the op amp. This permits the op amp to be powered by a single-polarity supply. Though its value can be changed, *C1* must be used for the circuit to function properly (because of the single-polarity supply). Capacitor *C4* helps prevent the one-shot from being false-triggered by stray electrical noise. The relay should be a low-voltage, low-current unit, such as Radio Shack's No. 275-004.

To test the circuit, rotate the shaft of sensitivity control *R3* to its center position, apply power, and speak into the microphone. The relay should pull in and remain pulled in for about 10 seconds. If you continue speaking or if other sounds are present, the relay will remain pulled in. Adjust *R3* to alter circuit sensitivity.

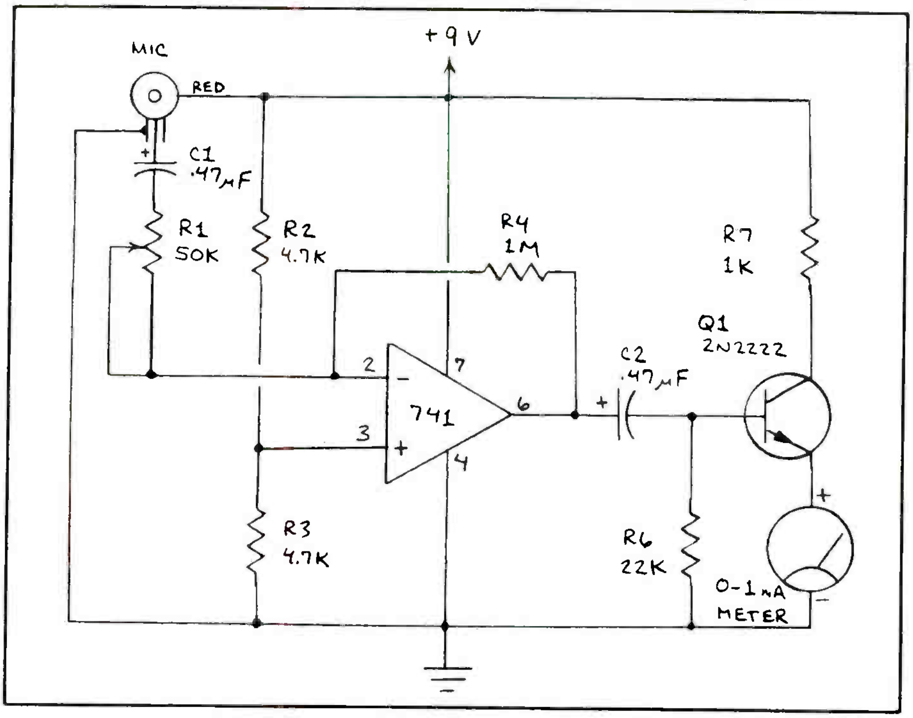
The circuit is very sensitive when *R3* is adjusted for peak amplification (*R3* = 1M). While I was testing the prototype circuit, the relay remained pulled in continuously, even though my workshop was quiet. After spending some time checking and rechecking the circuit for wiring errors, I traced the problem to the air conditioner in the office that adjoins my workshop. The combined sounds of the air conditioner's fan, motor and compressor were retriggering the circuit after each timing interval, thereby causing the relay to appear to be pulled in continuously.

There are many possible applications for sound-activated relays. The circuit in Fig. 1, for instance, can be used to cause a toy car or robot to respond to a hand clap or even a spoken command. The circuit can also be used to switch on a light or other electrically operated device in response to a sound. Finally, the circuit can be used in a sound-activated intrusion alarm. If you try this application, however, it's particularly important to protect the system from both man-made and naturally occurring sounds that might cause false alarms.

Sound-Level Meter

The first sound-level meters (SLMs) were installed in suitcase-size enclosures. However, the batteries required to power their vacuum-tube amplifiers made them much heavier than a conventional suitcase. Despite their bulky size, those early SLMs were used to make many pioneer-

Fig. 2. This sound level meter (SLM) is small enough to fit into a pocket.



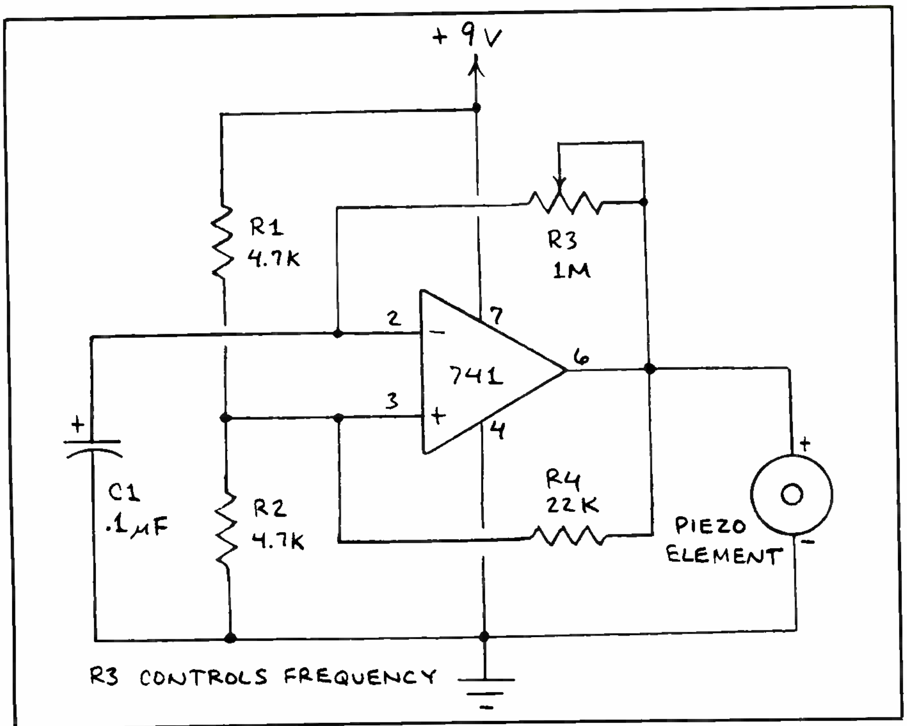


Fig. 3. Here is a simple variable-frequency tone generator you can build.

ing measurements about the intensity of sounds in offices, factories, street corners, train stations and elsewhere.

Modern SLMs can weigh under a pound and fit in a pocket. One such meter sold by Direct Safety Company (7815 South 46 Street, Phoenix, AZ 85040) weighs 4.5 ounces and measures only 5.75 × 1.9 × 1.1 inches. This $149 meter is powered by a single 2.7-volt battery and has a 40-to-120-dB range.

Figure 2 is the circuit for a simple uncalibrated sound-level meter I've recently designed. The circuit is similar to the input stage of Fig. 1.

The microphone is an electret condenser unit such as Radio Shack's No. 270-092B. In operation, signals from the microphone are coupled through *C1* and potentiometer *R1* into the inverting (−) input of a 741 op amp. The amplified signal is then coupled through *C2* to *Q1*, which supplies current to a 0-to-1-milliampere meter. Potentiometer *R1* and resistor *R4* control the gain, hence the sensitivity, of the circuit.

Since the op amp is operated from a single-polarity supply, *C1* is essential for proper operation. Resistors *R2* and *R3* form a divider that biases the noninverting input of the 741 at half the supply voltage. The meter can be a standard panel meter or a digital multimeter set to indicate current.

I tested the SLM with a piezoelectric buzzer that emitted a 6.5-kHz tone at a sound intensity of 90 dB (muRata No. PKB8-4A0 or Radio Shack No. 273-064). When the buzzer was placed 2 inches away from the microphone, the meter indicated an output current of 1 milliampere. Normal speech at a distance of 12 inches gave a current that fluctuated around 10 microamperes.

Adjustable-Frequency Tone Source

While testing the circuits in Figs. 1 and 2, I found that a variable-frequency tone source was a big help. Figure 3 is the circuit for a simple variable-frequency tone source that drives a piezoelectric tone-generator element. The circuit is designed around a 741 op amp configured as an astable multivibrator. Tone frequency is controlled by *C1* and *R3*.

Figure 4 shows how a 555 can be used as a variable frequency tone source. Here, tone frequency is determined by the values of *R1* and *C1*.

Incidentally piezoelectric tone generators produce a very penetrating, even uncomfortable sound. This is why they have become the sound source of choice in alarm devices like smoke detectors. Because their sound intensity can be so loud, use caution when working with them. I usually use ear protectors, especially when working with piezoelectric sound sources operated at high sound levels.

Inverse Square Law

While experimenting with the SLM in Fig. 2 and a piezoelectric sound source, I attempted to verify the inverse square law. Briefly, this law holds that the intensity of a sound wave, like a light wave, is inversely proportional to the square of the distance from the source. In other words, when a sound wave reaches a

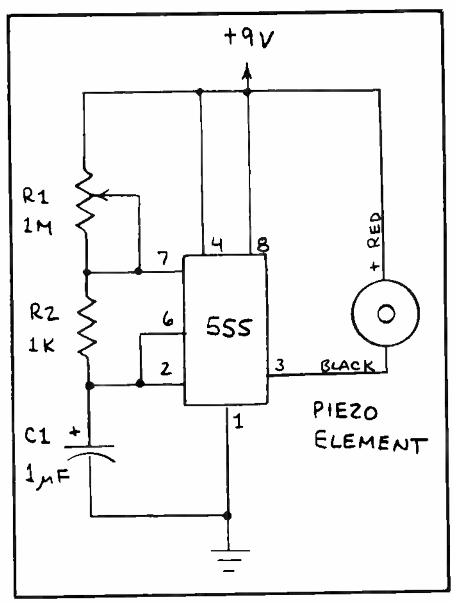


Fig. 4. A variable-frequency tone generator built around the 555 timer IC.

point 3 inches away from its source, its intensity is 1/9 the intensity of the same wave at only 1 inch from the source.

To perform the test, I placed the sound source exactly 1 centimeter away from the microphone and adjusted sound intensity until the meter indicated 250 microamperes. When the sound source was moved 2 centimeters away from the microphone, the meter indicated 60 microamperes. At 3 centimeters the meter indicated 12 microamperes, and at 4 centimeters the meter indicated 1 microampere.

These results differ from those predicted by the inverse square law. Here is a table that compares my results with the predicted results:

Range	Test Results	Square Law Result
1	250	250.00
2	60	62.50
3	12	27.78
4	1	15.63

The square law results are calculated relative to the initial reading of 250 microamperes. When the range was doubled from 1 to 2 centimeters, the test result was in close agreement with the predicted result. However, as the range was increased test results were substantially less than those predicted by the inverse square law.

Several factors can account for the difference between the actual and expected results. For instance, the amplitude response of the microphone might not be linear. In any event, these results illustrate that the measurement of sound, like the measurement of light, requires careful attention to variables that might alter the expected results. In future columns, I'll discuss the topic of measurement in more detail.

Going Further

If you are interested in the general topic of sound-activated devices, you'll want to examine the field of machine speech recognition. One of the most challenging areas of electrical engineering today is machine speech recognition. It's been estimated that a digital computer will have to make some ten billion computations to reliably recognize a 10,000-word vocabulary spoken by a single person. Even then incredibly complex software will be required to enable such a machine to distinguish between such identical sounding words as pail/pale, piece/peace, weather/whether, and so forth.

There now exist many computer-based systems that can reliably recognize from a few dozen to a few hundred words spoken by a single person after a training period in which the person pronounced each word for the benefit of the computer. But these systems are only reliable when the background nosie level is low and the quality of the speaker's voice isn't altered by a cold or sore throat.

Contrast this capability with the incredibly sophisticated speech recognition system possessed by every human being. Most people can understand the same sentence spoken by thousands of persons using scores of dialects and accents. Moreover, people can discern conversations even when they are partially masked by ambient sounds. For example, when the level of the interfering noise matches that of the conversation (signal-to-noise level = 1:1) approximately half the words in the conversation can be understood. Many of the lost words can be filled in by assessing the context of the conversation. Even when the noise level is four times higher than that of the conversation, 25% of the words can still be understood.

Since the speech-recognition capabilities of man-made systems are still rather primitive, there remain opportunities for experimenters to make important contributions. For further information on this fascinating topic, visit a good technical library and review some of the many articles and papers that have been published on speech recognition over the past decade. For starters, see the articles on speech recognition in the September 17, 1984 issue of *Electronic Products*. Also see "Voice Recognition Systems and Strategies" (*Computer Design*, January 1983, pp. 67 through 70) and the special section on voice input and output in the April 21, 1983 issue of *Electronics* (pp. 126 through 143). **ME**

Secrets of cubic splines, world-wide ac power standards, and some details on the Hacker's Mac.

By Don Lancaster

Before getting into this month's column, let me tell you that my brand-new two-volume *Applewriter/Laserwriter Utilities Package* is all ready to go. Its features totally boggle the mind. In fact, *all* of the artwork for this month's column was done using Applewriter on a IIe and this package.

Neat, huh?

On to this months goodies . . . .

Read any good power supply circuit books lately?

The *Lambda* people have a free *Semiconductor Applications Handbook* available that has lots of good information on voltage regulators, switching and linear power supplies, dc motor controls and stuff like that. You can get one by asking for it over their 800 number or by requesting a copy on a business letterhead.

While there's lots of great stuff in this book, note that Lambda tends to be somewhat on the "Baldwin Locomotive Works" side of reality, since they are very much into high-reliability and mil-spec products.

If you happen to be into switching-mode power supplies, *Raytheon* has a data sheet on its 4191/2/3 Micro-Power Switching Regulators that might interest you. Again, there is no charge, and you will find some excellent background tutorial material here.

Finally, if you are at all interested in any "big mutha" semiconductors of any type for use in electric vehicles, robots, steppers, machine tools, giant power supplies, magnetics, super high currents, or whatever, you might want to subscribe to *Powerconversion International.* This trade journal is available free if you meet its qualifications on the bingo card.

What are cubic splines?

Cubic splines are a major breakthrough in computer graphics that let you draw smooth and accurate "freehand" or "freeform" curves as easily as you would draw a plain old box.

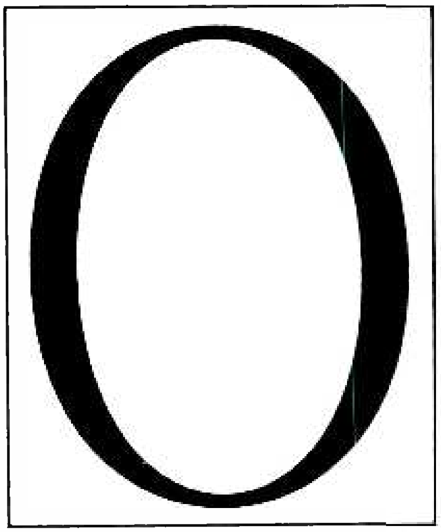


Fig. 1. Only 16 data points are needed to draw this O with cubic splines.

Cubic splines are also a superb way to handle typographic fonts, since the fonts can be stored in an extremely compact form. More importantly, the fonts can be easily scaled to *any* size and *and* shape desired, with resolution and smoothness *increasing* as front size increases. Compare this to scaling a bit-mapped font that gets "chunkier" as the size increases.

The *Laserwriter* uses cubic splines for many of its font characters and for its *curveto* and *rcurveto* operators. This ability places Laserwriter head and shoulders above its "one-size font in an outrageously priced cartridge" shoddy imitators.

Though easily accessible from *Applewriter* on a IIe, cubic splines are conspicuously absent from the Macintosh Quickdraw routines. I'll try to give you some fundamental background here and show you where to go for enough info that you can, with bunches of personal effort, add cubic spline ability to most any graphics program on most any microcomputer of your choice.

First, a plain old spline is a plastic-coated lead ruler that drafting, engineering, and architectural people use to draw a curve that won't "fit" the usual compass or French curve contours. First, you carefully bend the spline to the desired shape. Then you use this shape to draw or ink your line.

Cubic splines use the same general idea. By selecting the right data points, you can force a line to go from its start to its finish by way of a smooth and controllable route. Change the data points, and the shape of the curve changes.

They are called cubic splines because the hairy math behind them involve a pair of polynomials of order three that involve a constant, a linear term, a square term, and a cubic term. Should the curve be too complicated for a single cubic spline to handle, you use as many splines as you need, end to end, to get the job done.

Figure 1 shows a good example. Only four cubic splines having a total of 16 data points are needed to draw this Roman "O," *regardless of font size.* By way of comparison, the Fig. 1 original measured roughly two inches by three inches. At 300 dots-to-the-inch resolution, a bit map of 540,000 pixels would be required!

The first spline covers the top half of the outside edge. The second does the bottom half, while the third does the top inside edge, and the fourth handles the bottom inside edge. A fill routine then uses an "even-odd" rule to blacken the inside of the letter.

You can approach cubic splines from two different ways. Chances are you will like the intuitive or "try it and see" route, instead of the analytical or "mess with all that hairy math" method. Cubic splines lend themselves beautifully to experimenting and playing with them.

Anyway, Fig. 2 shows what is involved in using cubic splines, once the microcomputer or printer is internally set up or programmed to handle them. The object of the game is to build a curve from a point marked START to a point named END. To get from START to END, you go by way of two *influence points.* The positioning of the influence points sets the shape of the curve you will get.

The direction you leave START is set by the first influence point, while the direction you enter END is set by the second influence point. The distance from START to the first influence point, or

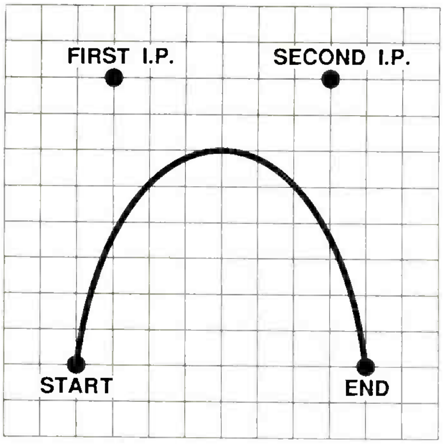


Fig. 2. A cubic spline is drawn via two "influence points" (I.P.s).

from the second influence point to END sets the "enthusiasm" at which the curve moves in the intended direction.

Once you have left START, the smoothest possible curve that can be drawn with a pair of cubic polynomials will then be drawn. One cubic polynomial handles the horizontal motion, while the second takes care of the vertical. The direction you head in is called the *bias* by the computer graphics people, while the enthusiasm is called the *tension*.

The oldest of cubic spline techniques are called *Bezier curves*. Newer and more powerful versions go by the names B-Splines and *Beta-splines*. There are also *conic splines*, available, among lots of others. Many of these fancier splines are more powerful and more flexible, but they are not easily or quickly done on a smaller microcomputer. Some are three dimensional.

One way to get different curves is to move the influence points around and see what happens. Let's see if we can't second-guess what we can or cannot do with a single cubic spline.

First, rotate this page around 360 degrees. Obviously, the same shape curve can be generated in any direction, so long as the relative position of the influence points with regard to START and END does not change.

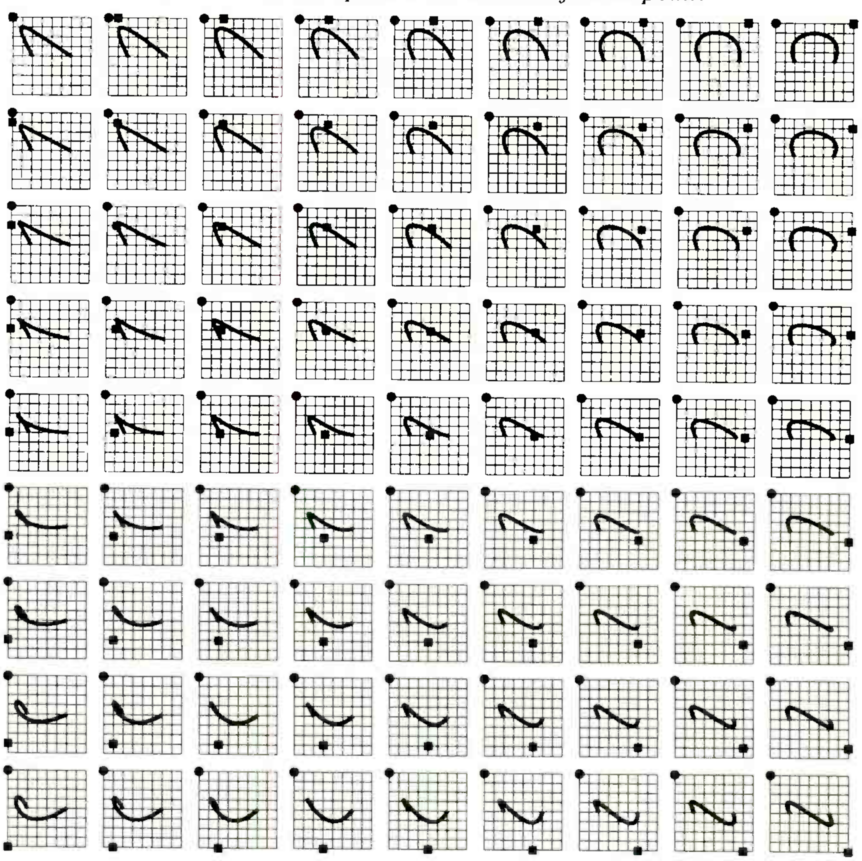
Now, let's get back to Fig. 2 right side up. If both influence points are above START and END, the curve will be above START and END. If both influence points are below START and END, the curve will be below START and END. If both influence points are between START and END, you will get nothing but a straight line. If one or both influence points are on extensions of the straight line between START and END, you will get a straight line that "overshoots" START, END, or both.

If one influence point is above and one is below, you will get a somewhat sine-wave-looking curve that crosses the axis between START and END. You get symmetrical curves if the influence points are related to START and END in the same or mirrored ways. You get asymmetrical curves if one influence point has different bias or tension than the other.

Now for the neat part. If the first influence point is to the right of the second influence point, then the curve may cross, creating a sharp *cusp* or a *loop*. The size and sharpness depends on how far away the influence points are from the START and END points, as well as how far apart they are from each other. You can get an "open" loop if only one of the two influence points is far left or far right of normal. Thus, it seems that you can use one cubic spline to do a smooth symmetric or asymmetric curve, a curve with one change in its curvature direction, a curve with one cusp, or a curve with a loop in it. Anything fancier can be built up with repeated cubic splines.

Sometimes one of the influence points

Fig. 3. This is a sample page from a cubic spline catalog. The dot is the first influence point, while the square is the second influence point.



is placed directly over START or END. This can be used to either sharpen a corner or smooth out a result, depending on the need.

Reviewing, to do a cubic spline on a microcomputer or printer set up to handle them, set a START point, an END point, and two influence points. Then tell the software or firmware to have at it. Once again, the first influence point sets the direction or bias you leave START, while its distance sets up the enthusiasm or tension the curve will head in that direction. The second influence point behaves in a mirror manner with END.

Note that the curve rarely will pass through either influence point. More often that not, it will miss these points by bunches on the "inside," since the smoothest possible curve is being drawn. Many curves will stay inside a "fence" drawn between the four points.

Here's how simple it is to draw the curve of Fig. 2 on a Laserwriter:

```
2 2 moveto
3 10 9 10 10 2 curveto
stroke
```

This says to move two blocks in and two blocks up to set START. Then define the first influence point at three blocks in and ten blocks up. Then define the second influence point at nine blocks in and ten blocks up. Next, set the END point at ten blocks in and two blocks up. Finally, activate *curveto* to draw the curve.

You will also, of course, have to scale and translate the curve to where you want it, as well as set your desired line width and shade of gray.

It turns out that the Fig. 2 curve is actually easier to draw than a plain old box!

Figure 3 is a page out of a spline catalog I worked up. Not too shabby for Applewriter on a IIe is it? At any rate, these cubic spline curves may seem a little dull, because the catalog is based only on a 9 × 9 integer grid. Even at this grid size, there are over 6500 splines in the 81-page catalog! Many of these are rotations or mirror images of each other.

START is always two blocks right and four blocks up. END is always six blocks right and four blocks up. The first influence point is a round dot. The second influence point is a square. In the upper left figure, the dot and square are sitting on top of each other.

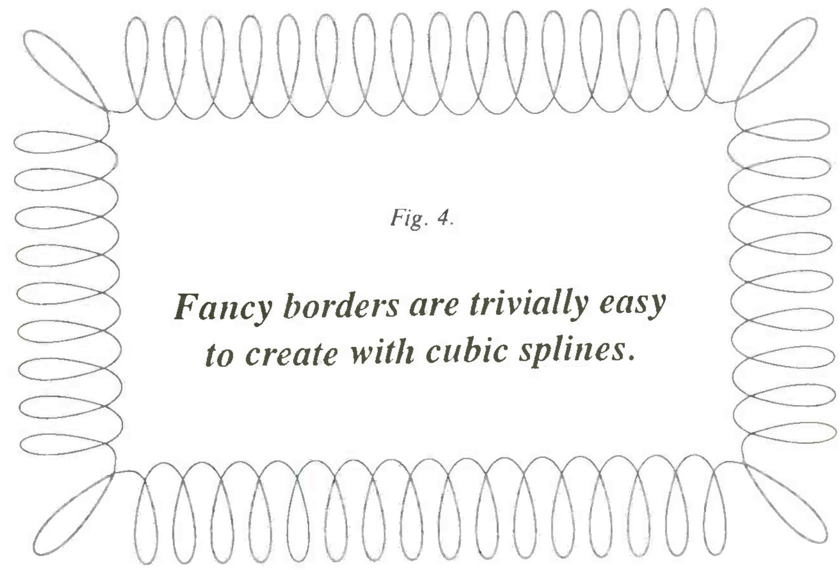


Fig. 4.

Fancy borders are trivially easy to create with cubic splines.

Should you widen the influence points, the curves will gain in impact, grace, and all around impressiveness. As it is, the catalog does show all possible shape families you can get with a single spline. Note that even on one catalog page, you have concave and convex shapes; shapes both symmetrical and asymmetrical; shapes with cusps, loops, open loops; and shapes with or without changes in the direction of curvature.

The number of possible splines you can draw between START and END is nearly infinite. The influence points do *not* have to be integer values.

Figure 4 shows a totally different and totally mind-blowing use for splines. Fancy borders like this are utterly trivial to handle with cubic splines. Only *five* different splines are needed! These are the main side loop from the crossover point, the inner arc, the diagonal end loop, and the two transition arcs connecting the corner loops to the edge loops.

To really get fancy, you can use a double border like this with a slight size difference. This will make the lines fatter in some places and thinner in others, just like "real" engraving. (I have a free *Postscript* listing of Fig. 4 available for you. Just ask for a copy.)

This particular border takes around 20 seconds to create using the Laserwriter's internal computer. All cubic splines need lots of processing time. While ideal for laser printing or creating final bitmaps of fixed visual images, they may not be well suited for real-time animation, unless you have a humongous computer available.

So, how can *you* tap these cubic splines for your own profit and enjoyment? You can do this with or without a Laserwriter. One route is to get yourself a copy of Inside Laserwriter, study it and log some hands-on time on a low-cost rental Laserwriter at your nearby quick copy center.

Otherwise, it is off to the nearest technical library. Bezier's original papers, for some strange reason, are all in French. He is translated in *Numeric Control—Mathematics and Applications,* by A.R. Forrest and A.F. Pankhurst, and published by *Wiley* in 1972. This seems to be out of print, so check a large technical library or a microfilm service.

The best and most consistent source I've found for information on cubic splines, along with excellent bibliographies, are the various *SIGGRAPH* proceedings, available from the *Association*

MICRO MART

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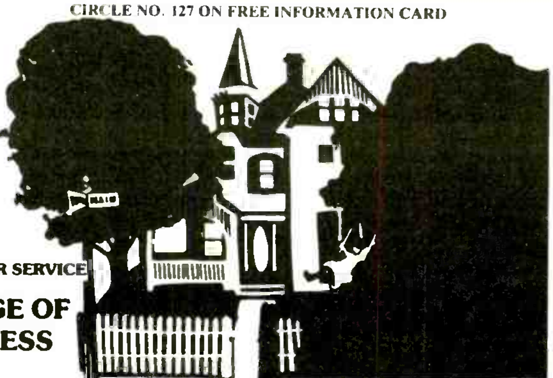

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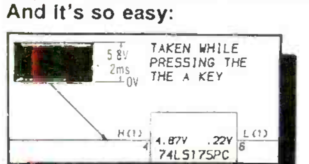

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for Computer Machinery. These usually appear in the number-three issue of each year's *ACM Computer Graphics* quarterly. The 1983 and 1984 proceedings are especially useful. I've yet to see the 1985 SIGGRAPH stuff. The advance promotion promises one paper on conic splines.

An obvious money-making idea that involves splines would be to apply them directly to Apple or other HIRES graphics routines, so that free-form curves can be handled as gracefully as ordinary boxes can. They are also sorely needed by the Mac. What would be really neat is to be able to real-time move the influence points around.

Let me know what you discover in this fascinating new area.

What ac power plugs get used where in the world at what voltage and frequency?

Did you know that the vast majority of countries in the world use 220 volts, 50 Hz as their primary power standard? Or that some buildings in some developing countries actually may have several different power lines connected to several different and totally incompatible power systems?

Did you also know that there are at least 10 different major sizes and shapes of ac power plugs and sockets, all totally incompatible with each other?

This might affect you if you are planning to travel and take a computer or test gear with you, or if you are being assigned to a foreign office, or if you are designing products you want to sell world-wide. You might also be interested in this if you are catering to international tourists.

What is used how and where?

There's a great free book called *International Primary Power Components*. This combined reference and catalog is published by *Panel Components Corp*. It tells you all about all the voltages, frequencies and connectors as they are used everywhere in the world. As usual, you get a copy by way of a request on a business letterhead or by telephone request.

Most electronic equipment these days have a removable cordset that plugs into a standard three-prong socket called an IEC 320 connector. Among countless other places, you'll find these on Hewlett-Packard and Tektronix test equipment and on most personal computers.

All you may have to do to use test equipment in a different country is swap the cordset for the one that fits the ac wall socket and flip a hidden or buried 110/220 switch to the proper position. But this can happen only if your piece of equipment operates either on both 110 and 220 volts or lets you switch between them.

A 110-volt anything could instantly burn out on 220 volts! At the very least, all primary fuses will immediately blow.

While most modern electronic equipment can run at 50 or 60 Hz equally well, many motors may not and could even be damaged. Any motors that are used for timing probably will run at the wrong speed. Certain phonograph turntables and clocks are obvious examples.

Be darn sure you read the label and check the switches before trying to run something at 220 volts or 240 volts. Conversely, most equipment rated at 220 or 240 volts will not work at all on 110 or 120 volts. The extreme "brownout" can damage motors and such if they try to run too slow under too high a load.

Even if there is no 110/220 switch, the internal power supply in your computer or whatever may let you rewire the power transformer primary for 110 or 220. Sometimes a pair of input windings is provided. Wire them in parallel aiding for 110/120 volts or series aiding for 220/240 volts. Details will appear in the tech manual for the instrument or computer in use. As a general rule, if they don't tell you about 220-volt or 50 Hz operation, then you cannot do it.

The final option is to get an external 220/240 to 110/120 step-down transformer big enough to handle the load. Plug the 220 side into the wall outlet and

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the test equipment or computer into the 110 side. Do this only if the equipment will run on *both* 50 or 60 Hz equally well.

Panel Components Corp. sells cordsets for just about every conceivable plug and socket in the world. Typical pricing for a single cordset is around $5 each.

There's lots of other good stuff in the company's catalog, including a complete list of the standards people and their addresses, world maps, and lots more.

Check it out.

What is the Hacker's Mac?

The *real* powers that be in the microcomputer world have decided that Apple can no longer be trusted with the Macintosh design. Apple had their chance and they totally blew it.

Enter the Hacker's Mac, a totally unlocked, totally open, totally expandable Macintosh-like machine, with a public-domain design, a public-domain operating system, public-domain documentation, and ready availability as low-cost kits, using easy-to-get stock parts. Lots of expansion slots, naturally. Everything socketed, naturally. Four channels or more of DMA and full multitasking and coprocessing ability. Full color in various resolutions, naturally.

At this writing, the Hackers Mac is just a dream. But Lee Felsenstein of *Golemics* is rapidly making it happen. And you are invited to participate in any way you feel you are able. Contact Lee directly for information to see how you can help.

NEED HELP?

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First Impressions: Epson's LX-80 Printer, Ericsson's Portable PC & Commodore's Amiga

By Eric Grevstad

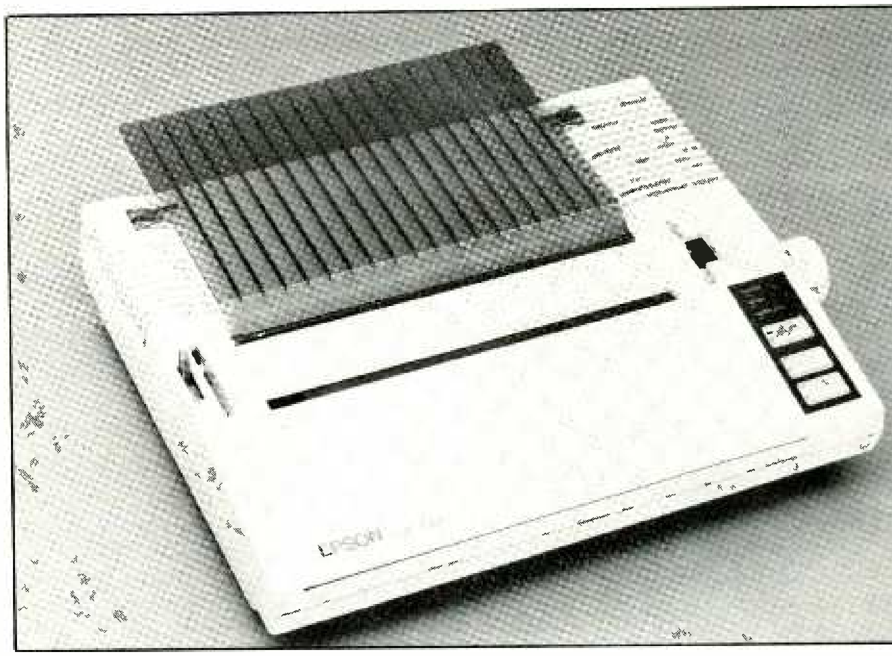
Let me begin by denying the slander my friends say about me: It's not true that I hate Apple Computer Inc. The IIc may be a closed-box bow-wow with no parallel printer port and the world's worst LCD screen option—it was originally advertised as "portable," which is just as true as Apple's claim to have invented the personal computer—but the IIe is a loyal, versatile workhorse for the home and schools.

And the Macintosh, now gaining the hard disks and powerful software it needed a year and a half ago, is finally fulfilling its promise as a brilliant, easy-to-use computer for small businesses and professionals, if never for IBM's corporate office market. With president John Sculley taking over from dreamer Steve Jobs, Apple promises a raft of exciting products (such as a Mac that runs faster and has expansion slots).

No, it's not that I hate Apple—though I admit to showing off with MS-DOS, typing *del *.bak* in one-tenth the time it takes Mac mousers to drag backup files to the trash can icon. It's just that I'd rather focus on the fine products and developments appearing every day in the rest of the computing world, from low-cost printers to exotic display technologies. (Besides, *Modern Electronics* already has Don Lancaster, who's forgotten more about Apples than I'll ever know.)

Good Words Cheap

With laser, ink-jet, and thermal-transfer printers taking the technology spotlight and new 18- and 24-pin dot-matrix models supplying typewriter quality at blazing speeds, it's easy to overlook one trend: old-fashioned dot-matrix printers are getting surprisingly good and amazingly cheap. I just bought Epson's new Spectrum LX-80, which lists for $299 (I paid $229 mail-order), and am delighted. A printer this good would have cost twice as much a year ago.



The Epson Spectrum LX-80 printer.

The LX-80's only shortcoming is speed; its trusty nine-wire printhead generates the familiar Epson Draft Pica at a mediocre 66 characters per second in my tests (Epson advertises 100 cps). Its best feature is its versatility: besides switching to elite or compressed type (or italics, emphasized, double-width or whatever), it can slow to a two-pass, unidirectional 15 cps to produce impressive near-letter-quality type (see print samples).

Besides giving excellent print for the price, the Spectrum frees you from setting DIP switches or sending software codes to change typestyles: the 11 most popular are part of a feature called SelecType, available for use by tapping the on-line, form feed, and line feed buttons a few times in various sequences. (If you prefer software codes or DIP switches, Epson obliges; there's even a switch to select slashed or unslashed zeroes.)

The LX-80's friction feed holds single sheets well, but fanfold paper is best with the optional tractor ($40)—which, to sound like an ad, snaps on in seconds and works like a charm (though it does require you to waste a sheet of paper after each print job). If you need a light- to medium-duty printer and can trade sheer speed for flexibility, ease of use, and text quality that almost matches low-end daisy-wheel printers (which don't offer draft speed or 100-odd typestyles), the "Spectrum" is a

Epson Spectrum LX-80 draft quality pica (10 cpi)

Draft quality pica italics

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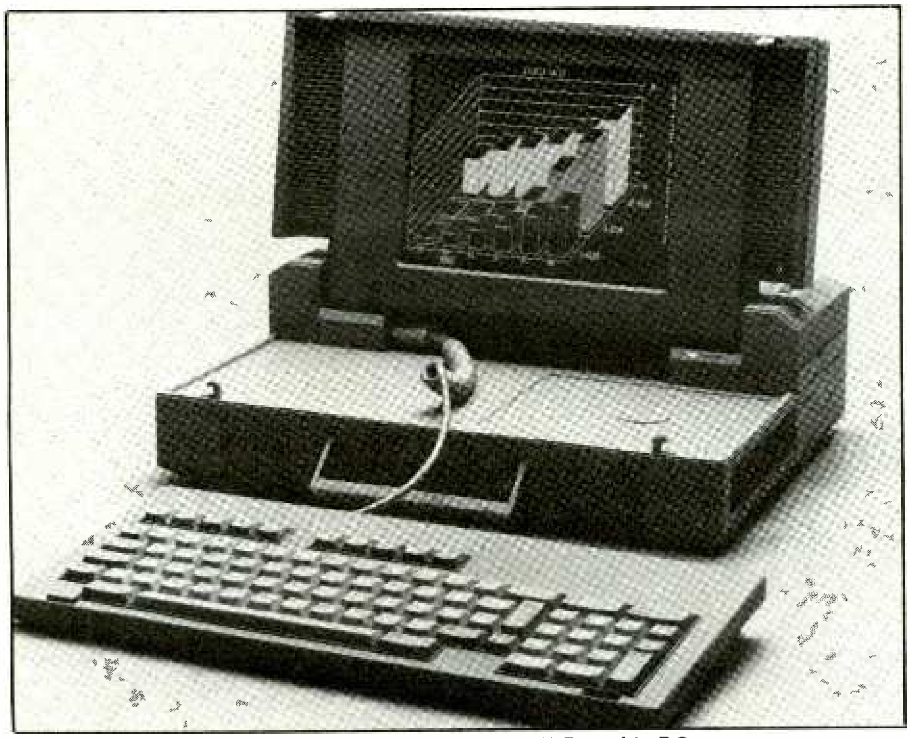


The Ericsson "Screen Machine" Portable PC.

bargain. For my money, it's among the better computer peripherals products I've seen this year.

Ericsson: Screen Machine

In my survey of portable computers (*Modern Electronics,* July and August 1985), I found two obvious trends: the search for clearer alternatives to liquid crystal displays, and the emergence of hybrids between the "portable" and "transportable" catagories, bigger than laptops like the Tandy 100 but smaller than suitcases like the Kapro II. One new micro illustrates both trends perfectly: the Ericsson Portable PC, an IBM compatible from Sweden's leading telecommunications and computer company.

The Ericsson, with onboard 5.25" disk drive and thermal-transfer printer, is about half as bulky as a Compaq: 17 pounds, 12" × 15" × 5". It's a briefcase computer in the sense of being the size of a briefcase, not fitting in a briefcase; it's rather heavy in your lap and needs ac power instead of batteries, but it's a breeze to fold up and tote around. An optional "Ergo-Disk" does a clever job of simulating a two-drive system, quickly copying your program onto a 360K RAM disk, and the Ericsson ran every piece of PC software I tried.

But all that fades beside the main attraction: a 25-line, 80-column bright orange gas plasma display, a flat neon panel that glows like a high-resolution (640 by 400-pixel) CRT. The plasma panel is just the opposite of an LCD, losing contrast in bright sunlight or overhead light, but glorious in dim or even dark rooms. Combined with secret compartments holding everything from parallel, serial, and expansion ports to a voltage selector and spare fuses, the display makes the Ericsson a model of full-powered, no-compromise space efficiency.

The catch? A high price: $2,995 with 256K and one drive, $5,095 with 512K, Ergo-Disk, and printer. The Ericsson's as sleek and high-tech as a top-of-the-line Saab Turbo, but it's probably only for those who need full PC power and travel often. If you just take your machine home once in a while, lug a Compaq.

Amiga: Dream Machine?

By now you'll likely have heard about the Commodore Amiga, a computer I've seen (at this writing) in sneak previews and have mixed feelings about. Viewed one way, the Amiga is the first mass-market supermicro, a desktop that fulfills the Macintosh's promise while quadrupling its power. Its three onboard coprocessors supply dazzling full-color, near-video-quality graphics and animation and symphonic sound; for things like instantaneous scrolling and windowing, they take the easy-to-use concepts of Macintosh software and move them into high-speed hardware, freeing the Motorola 68000 CPU for awesome number-crunching and multitasking. No computer I've seen, IBM's PC AT included, has more superpowered potential.

Viewed another way, the Amiga is the biggest longshot of the decade. What Amiga software will be available, whether there'll be applications programs to go along with the arcade games and MacPaint imitations, is a colossal question mark. So is Commodore's marketing savvy, now that it's out of the Toys-R-Us league: you've seen endless articles about "Can IBM-dominated ofices take Apple seriously?", so imagine the ones about taking Commodore seriously.

There's been nasty gossip about last-minute, past-deadline changes at Commodore headquarters: What software will be bundled with the Amiga? Will the ROM be ready or have to be shipped on floppy disks? Will the extra-cost optional add-on box with 5.25" drive really provide IBM compatibility?

I'm optimistic, because the demonstration I saw looked great and because I'm always happy to see innovations instead of imitations or clones, but the Amiga will have to overcome a sort of specter: the image of a superbly advanced, ultimate Coleco Adam. For now (July 10), all I can say is that I'll be watching very closely. **ME**

SOFTWARE FOCUS

The Computerized DX Edge

The Computerized DX Edge from The DX Edge, New York, NY/For Commodore-64 Computer./Single 5½" Disk./ $34.95.

"The Computerized DX Edge" is a software version of a plastic gadget called "The DX Edge," a slide-rule device for amateur radio and SWL DXers that displays the hourly location of the "Gray Line," the line around our globe where night becomes day and day fades into night. In other words, sunrise and sunset.

The Gray Line is of particular interest to both the amateur radio operator and the SWL because, notwithstanding other conditions such as the sunspot cycle, it sharply determines DX or long-distance communications conditions and openings within a particular band of frequencies. For example, between 10 and 15 meters the best opportunities for DXing exist between stations in daylight. On the other hand, on 20 meters reliable long path ("the long way round") openings exist between stations on the Gray Line; that is, stations going through sunrise to sunset or vice versa. In contrast, from 40 meters down, best DX opportunities usually occur when it is sunset on the western side of the communications path and sunrise on the eastern side.

If the earth stood still, we could show everything we need to know about the Gray Line data on a simple chart or map. But the earth does not stand still. It rotates on a tilted axis, causing monthly variations in its shape and continuous (effectively hourly) displacement of its location. The variations in shape and location are so great that two stations that are in daylight on 15 June will be in darkness at the same time on 15 January.

The slide-rule version of The DX Edge was created in response to the need for reasonably accurate projections on the present and future shape(s) and location(s) of the Gray Line. By juggling a plastic world map slide and monthly inserts, the user can determine shape and location of the Gray Line for any month and time. But there are limitations as to how much data can be crammed onto a plastic slide rule, and as with almost everything else, the same input data can provide much greater and more precise output if the numbers are crunched in a computer. Consequently, the distributors of The DX Edge enhanced its Gray Line projections by computerizing its functions through The Computerized DX Edge.

This computer program integrates data input by the user with the known variations in the shape and location of the Gray Line. The result is a screen display of a world map showing the Gray Line in absolute terms for a given date and time, or for a relative Gray Line. Thus, the line is precisely positioned on one of two possible locations in a communications path.

The program is written specifically for the Commodore-64 equipped with at least one disk drive. Although the program disk is copy protected, it is run the same way as conventional Commodore-64 programs by entering the command:

LOAD "DXEDGE",8 <RETURN>

and then the command:

RUN

The program automatically initializes, first painting a world map on the screen and then loading the rest of the program. The complete initializing process takes several minutes. As soon as the program is finished loading, the screen displays a menu of 16 colors for user selection of the color attributes for color and monochrome monitors. In response to screen prompts the user selects the border, screen and text colors. For monochrome monitors the best results are attained with the recommended white border, black screen and white text because they provide the best grey-tone highlighting and detail of screen data.

The world map first appears with 0 degrees EW longitude centered horizontally. A "rotate" function permits observations to be optimized by rotating the map so a particular country or area is shown in a specific part of the screen. For example, in video-screen photo "A" the display has been rotated 60 degrees east so that the East Coast of the U.S. is horizontally centered. In "B" the display has been rotated 160 degrees east so that Alaska is horizontally centered.

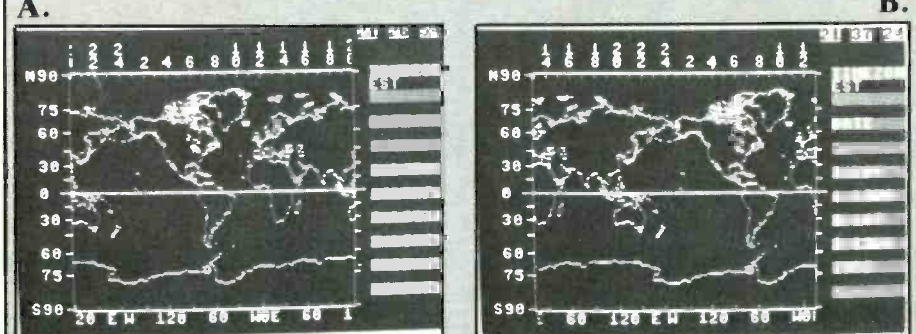
The complete screen display shows the equator, latitude and longitude, local 24-hour standard time across the top of the map, a user-programmed clock in the upper right, and a data column on the right side showing the local time zone selected by the user from a Time Zone Menu (EST, PST, etc.), the date, latitude and longitude for two locations (No. 1 and No. 2), and something called "type." The latter means the kind of data used to enter location No. 2, which we will explain later.

In particular, notice the partial standard time calibrations at the extreme left and right, also the partial meridian value at the lower right of Photo A, where you see the numeral "1" of what is really "120." The partials are created because the local time and the longitude indications are rotated with the map. If the rotation stops before a complete time or longitude value has rotated "behind the screen" from the right side to the left side, part of the value will appear at each side.

Typical of most of the program's functions requiring user input, the map can be rotated by entering more than one kind of value, in this instance either hours or degrees longitude. For other functions, except the home location (No. 1) which

Video Monitor Displays (See text for explanations)

A. **B.**



must be given in latitude and longitude (called a "unique" location), the data can be entered in latitude and longitude, prefix, zone, call area, or country name.

The display shows the shape and position of the Gray Line for either the first or fifteenth of the month, positioned for the specified local time. Alternately, the program can be instructed to automatically update the Gray Line every 15 minutes so it tracks actual conditions throughout the day. As shown in photographs C and D, simply entering the date and local time without locations will superimpose the worldwide Gray Line for that particular date and time.

Photo C shows the Gray Line for 2214 hours on 15 Jan. Notice that the left side of the screen indicates which side of the Gray Line is day and which is night. Photo D shows the Gray Line for 2216 hours on 15 June. You can easily see that both the shape and position of the Gray Line are considerably different from the Gray Line of 15 Jan. In particular, notice the swap of the day/night labels on the left of the screen.

If you need information on a specific location for a particular date and time, as shown in Photo E, you can rotate the map for optimum viewing and/or pinpoint a location with a parallel and meridian crosshair. Either the No. 1 (user) or the No. 2 location, or both, can be marked with a crosshair.

The cross hair for location No. 1 is generated when the location is entered in latitude and longitude. The crosshair for location No.2—which is considered the DX location—is automatically generated when the country name, prefix, call area, zone or longitude and latitude are entered. The box on the right side labeled "TYPE" indicates the location of country name, prefix, etc. The latitude and longitude of the location are automatically calculated and displayed on the screen above the location. If the location No. 2 data is entered in longitude and latitude it is considered a unique "type" and no other information (country, zone, etc.) is displayed on the screen.

As shown in E, The computerized DX Edge can be used to determine in advance when certain Gray Line conditions will exist. In this instance, the desired DX location (No. 2) was Guam. Entering the location "Guam" produced the crosshair made of a thick parallel and a thin meridian, and the latitude and longitude were calculated and displayed on the right side of the screen. The program was then instructed to create a Gray Line passing through location No. 2 as it would exist on 15 April. Notice that the Gray Line passes through the Guam crosshair and that the clock in the upper right indicates that when the Gray Line passes through Guam on 15 April it will be 1511 hours EST at the home location.

Just about any kind of user positioning of the Gray Line is possible: It can be referenced to the home or DX location, to a specific time and date, and to sunrise or sunset at any location even if their times are unknown. The program will even calculate sunrise and sunset times if you have some need for the precise values.

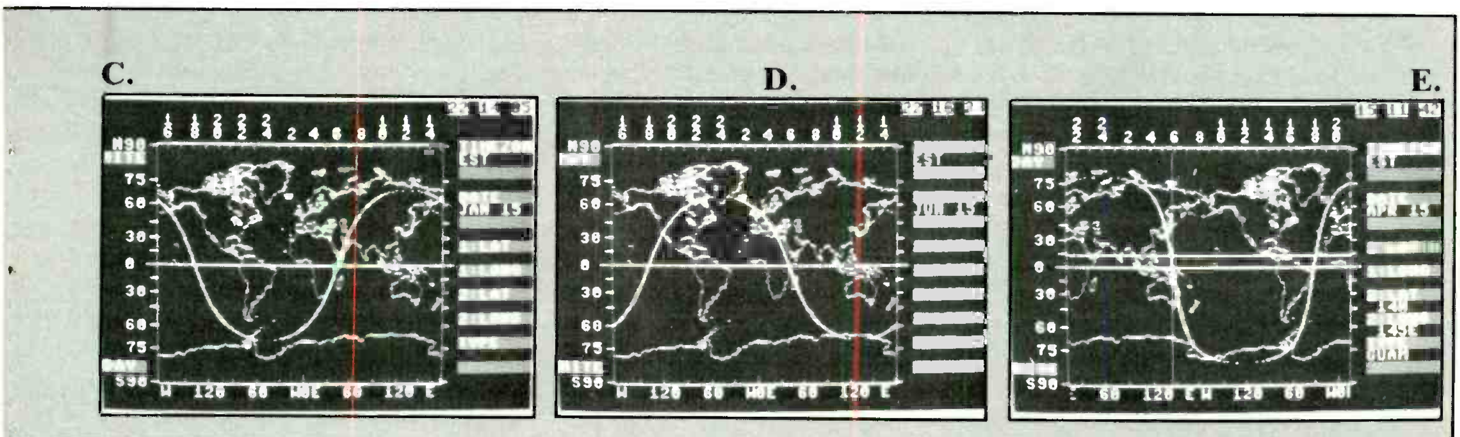
While The Computerized DX Edge provides a lot of valuable information, its real power lies in its ability to project the future. Because the Gray Line can be positioned for specific propagation conditions, the user can predetermine the time and date when a particular communications path should be optimum for DX.

Conclusions

The organization of the screen displays and the menus are exceptionally well thoughtout. It's possible to run the program with nothing more than a cursory read-through of the twelve-page manual.

The program's error trapping is superb and especially deserving of acclaim. One of the difficulties with large programs written in BASIC is the surfacing of unexpected errors for which error trapping wasn't thought necessary or provided; unfortunately, almost any untrapped error during the run of a BASIC program will crash the program. As far as we could determine The Computerized DX Edge is immune to incorrect data entries, sequences, or whatever—the program simply will not crash.

The only difficulty one might have with the software is that, typical of large BASIC programs, it is slow . . . *very* slow. For example, it takes between 8 and 9 minutes to complete a screen rotation and a shade over 4 minutes to erase and then redraw a new Gray Line. Nonetheless, the Computerized DX Edge trades off operating speed deficiencies for accuracy and reliability, positive attributes very difficult to find. In sum, this is a most useful piece of software for ham or SWL enthusiasts who wish to know about propagation conditions.—*John Richardson.*



Shortwave Station News & Schedule Updates

By Glenn Hauser

Here's a roundup of information to help you get the most out of your shortwave listening and DXing this fall. All times are UTC.

Alaska. KNLS finally gave up trying to reach Europe this summer on its planned schedule of 1730-2000 on 7355; a few weeks later it came back to try English at 0500-0600 on 11960. The other English broadcast, beamed due west instead of due north, was planned to be on 9555 in September at 0700-0930 (via Bill Matthews, OH).

Australia. ABC's domestic shortwave stations in Perth, Melbourne, Brisbane, and formerly Sydney have been favorite listening for years, and soon they'll have company from three towns in the Northern Territory, a part of the Outback where shortwave is long overdue as the most efficient way of serving sparsely-settled areas. Existing studios in Darwin and Alice Springs will feed three 50-kW transmitters, in Alice Springs, Tennant Creek and Katherine, using the 6-MHz band in the day, 2-MHz mornings and night (moving up to 9 and 3 MHz when the sunspot count improves), probably making the switch around 0830 and 2230. Target date is before the end of this year (Rodney Norris, Australian DX News).

The Australians also operated Papua New Guinea's domestic shortwave service before independence. Radio Australia still provides a surrogate domestic service to PNG (friendly rather than hostile like Radio Free Europe/Radio Liberty/Radio Marti), in locally-accented "regional English" at 0800-0945 and in Neo-Melanesian (or Pidgin) at 0945-1100 on 5995, 6080, 9760. Night owls such as David Alpert in New York enjoy listening to this service for its local flavor but good rock music and complete news, while other Radio Australia frequencies carry its mainstream service. Meanwhile, PNG is about to enter the television age. After much debate and considerable opposition, a TV network based in Newcastle, Australia, has been authorized to provide television to PNG—not including any foreign advertising. On its independence day, September 16, Papua, New Guinea, planned to change its name following a nationwide competition. See what name you hear on R. Australia, or on PGN's main frequencies of 9520 and 4890 kHz. Regional SW stations have been promised power increases from 2 to 10 kW.

Austria. In our August English schedule, Radio Austria was misidentified as "Radio Australia International." Per Austria's mailbag program, it's far from the first time those two countries with very little in common except a similar name, have been confused.

Brazil. The reorganization of the 49-meter band shown in our June column is scheduled to go into effect October 5 at 0300 (midnight in Brazil), with the following additions: 5980 (ex-5975) Ceara Radio Clube, Fortaleza; 6030 (ex-6105) R. Globo, Rio; 6105 (ex-6030) R. Tupi, Rio; 6160 (ex-5965) R. Pampa, Porto Alegre; 6170 (ex-6165) R. Cultura, Sao Paulo; and 6175-6195, 250 kW R. Nacional, Brasilia (via Antonio R. da Motta and Claudio R. Moraes).

Burkino Faso is the new name of Upper Volta, but at least the remarkably named capitol Ouagadougou has not yet been changed. Once a tough catch on SW, the power on 4815 seems to have been raised. The best time to hear it is 2300-2400, its final hour each day after the even-stronger Africa No. 1, Gabon, closes on 4810. Both are mostly in French. Or you can try again from sign-on around 0530 weekdays; the signal should be fading out by the later weekend sign-on time of 0700.

Canada. Radio Canada International wants to be heard in the Far East. A west coast transmitter site would seem to be the answer, but it's not technically or economically feasible to put one on Vancouver Island. So RCI is trying to work out a deal with some other international broadcaster to build a joint relay station somewhere in the Far East. KYOI, Saipan, says it's not for sale, but does plan to sell two hours of time to RCI each local morning. RCI is already using existing stations in Hong Kong and Japan to broadcast once a week in English and Japanese. You may be able to hear the latter via NSB, Tokyo, Sats. 0830-0900 on 3925, 6055, 9595. Elizabeth Gray, co-host of *As It Happens*, won't be back this fall. Despite critical acclaim, she got a longer vacation than expected last June.

Colombia. Minister of Communications Mrs. Noemi Sanin Posada has warned eleven radio stations to cease broadcasting programs by witches, magicians, sorcerers and fortune-tellers, or else; she's also concerned about over-enthusiastic sports announcers inciting aggression and violence. We dearly wish we could tell you which stations are involved. Perhaps the fortune tellers could move to Radio Marti, which broadcasts horoscopes to Cuba.

Cook Islands. Radio Cook Islands is being heard better in North America now thanks to doubling its power from 500 watts to 1 kilowatt on 11760. Actually, it's always a few hundred Hz on the low side, so look for a tell-tale heterodyne against 11760.0 stations, while hoping the latter will be weak enough not to block RCI. Depending on interference, you might hear it in the 0100-0700 period; a good indicator of South Pacific reception quality is Tahiti on 11825.

Cuba. Here's a frequency to watch for action when Cuba's territory is violated: 5765 kHz SSB (variable). Bob Rankin in Kansas reports in the Ozark Mountain DX Log that a Cuban Frontier Guard Forces net stands by here; he once heard a flurry of contacts during a half-hour period.

Egypt. The clandestine Voice of the Libyan People, mentioned in our September column under Sudan, did make a comeback, this time on 11975 kHz, in Arabic at 1800-2000 and 0400-0600; jamming can be heavy.

Gabon. Africa Number One claims to be reaching a huge audience in French of 15 million; now they're thinking about starting an English service. Several of the French-speaking DJs already throw in brief bits of English, and less than a min-

ute of news headlines in English has been heard around 1200 and 1500 on 15200. Frequencies to check later in the day are 15475 and 4810, each 500 kilowatts.

Guam. KTWR started testing its new antennas for Australia on 11735 kHz before 0900, per Mick Ogrizek in Australian DX news. A new out-of-band frequency has been authorized for US stations in the Pacific, 12025, used initially by KFBS, Saipan and KTWR, in various languages at various times. We expect the new AWR station will use it too. In SPEEDX-GRAM, Mel Hickman reported this plans to be on by year end with four 100-kW transmitters, 16 hours per day in 20 languages to the western Pacific and East Asia.

Hungary. Radio Budapest listings in August should have been bracketed so that all frequencies are used for all broadcasts between 0030 and 0330 (one hour later from late September).

Ireland. Legislation against pirate stations has been pending; a couple to try for if they still exist: Radio Na Gael, 6340 kHz, from 2300 to 0900; Radio Dublin carrying "World Music Radio" (a legal entity in Holland), Sundays 0445-0900; Mondays 0100-0515 on 6910. W.M.R. hopes to gain its own transmitter soon on 9845, location unspecified but our guess is Italy.

Israel. Two frequencies in our August list have been adjusted—9435 instead of 9440, and before 2300, 11658 instead of 11655. Broadcasts should already be one hour later now, as Israel sensibly ends DST September 14, earlier than most other countries. The then 1900 and 2130 broadcasts should have been bracketed to show all four frequencies applying to both.

Italy. Yet another private station has been carrying out shortwave tests. Radio Calabria Interantional, with 200 watts on 13630, Sats. & Suns. 1230-1330. They planned to add a 1 kilowatt unit on 7615, and two more transmissions on 13630, 0900-1030 and 2200-2300. Reports are wanted, and no return postage is necessary (Play-DX).

Kenya. Voice of Kenya registered this schedule for tests of its new 250-kilowatt transmitters at Koma Rock: 1230-1530 and 1930-2130 on 6050, 7225; 1530-1930 on 9655 and 11745; 0600-1600 on 9725 and 9635.

Korea, North. Radio P'yongyang has made several frequency changes for its 110-minute paeans to Kim Il Sung in English: to the Americas, 2300 on 9715, 9555; 1100 on 9977, 9750 (beware: South Korea also uses 9750); to other areas: 0600 on 12000, 11655, 9360; 0800 on 15340, 15245, 11830, 9765; 1300 on 15340, 11880; 1500 on 11880, 9977, 9625; 1700 on the same; 2000 on 11655, 9350, 6576 (Nagoya DX Circle via Australian DX News).

Korea, South. Radio Korea, in contrast, makes few frequency changes but periodically changes times. Bill Matthews in Ohio provides the revised schedule of 1-hour programs: to North America at 0200 on 11810, 15575; 0400 on 9570; 1400 on 9750, 15575. To other areas: 0200 on 7275; 0400 on 11820, 15575; 1100 on 7275, 15575; 1400 on 9570; 1600 on 9870; 1800 on 15575; 2200 on 7550, 6480; and 2300 on 15575. There are also 15-minute English news broadcasts scattered throughout the day on many of the same frequencies.

Mexico. It seems there was no hurry after all to hear Radio Huayacocotla on 2390; Christian Zettl updates his July report with news that for political reasons, the authorities have again denied a mediumwave frequency to the station. So it's been distributing cheap shortwave converters to its listeners.

Mongolia. Radio Ulan Bator made some summer frequency changes, too late for our August listing; whether these will continue into the fall, or again resemble the listing, is unclear. Try all possibilities to be sure, Mon.-Sat. for 35 minutes at: 1200 on 12015, 9615; 1255 and 1940 on 15305, 9575; 1445 on 12015, 9575 (via Joe Talbot, Alberta).

Pakistan. Add these slow-English news quarter-hours from Radio Pakistan: 0230 on 7315, 15175, 17660; 1100 on 15595, 17660; 1600 on 9885, 11675, 15595, 17660 (via Craig Seager, ADXN).

Philippines. Radio Veritas Asia, run by the Catholic church, broadcast a report in July that it might have to close down due to lack of funds to pay maintenance costs of some 4 megapesos this year. Its latest English schedule showed 0200-0225 on 15195, 1500-1530 on 9570. Among the program titles were: "Explore the Philippines" Wed. 0205, "RV Listeners International" Sat. 0200; "Our Asian Memorandum," Mon. 1505; "Women of Asis," Sat. 1517 (via Joe Talbot, Alta.). Several announcers at domestic Philippine stations have been gunned down by terrorists this year.

Puerto Rico. The Voice of America plans to build a major relay facility here, the keystone of its Caribbean network. The San Juan Star reported opposition from some politicians, who felt the U.S. had acted unilaterally without consulting the Puerto Ricans, and there was suspicion that the Cabo Rojo site might also be used for m ilitary training, since the Army Corps of Engineers is designing it. But A.C.E. is routinely responsible for building VOA relay stations. Negative impact on tourism is supposed to be negligible, since it's on *Bahia Sucia*, "dirty bay," where no one wants to go, anyway. There are to be nine 500 kW shortwave, and one 100 kW mediumwave transmitters; 40,000 square feet of buildings, 60-80 personnel; construction cost is $150 million involving some 200 people between 1988 and 1990 (via David Solliday).

Romania. Radio Bucharest has a program on the UTC Monday 0400 broadcast called "Radio Pictures"—we assume mental imagery is involved rather than slow-scan TV. Other topics by UTC day: Tue., "From Romania's Experience,"; Wed., "Romania Today & Tomorrow"; Thu., "Focus on Topical Questions"; Fri., "Listeners' Letterbox"; Sat., "Home News"; Sun., "Tourist News". Check 11940, 11810, 9570, 9510, 6155, 5990 (via Kraig W. Krist).

Sri Lanka. After spending millions of marks to build a new relay station near

Trincomalee, the Voice of Germany temporarily "abandoned" it this summer due to repeated Tamil terrorist attacks on people working at the station, not yet in full operation. Meanwhile, the VOA continues building its new relay station on another part of the island, near Chilaw, to be on the air by 1990 (ADXN).

Syria. Despite announcements that it was on 13700, Damascus Radio's 1200-1300 broadcast in English to North America has been heard on 11625, a frequency really too low this summer, but which should improve in the fall—unless they've changed it again.

Taiwan. Voice of Free China relays by WYFR in Florida on 5985 kHz contain these programs in quarter-hour segments at 0100-0200 and 0500-0600 on the UTC day shown; and the next UTC day (more or less) at 0200-0300. All three move one hour later when DST ends. Daily, News and Comentary first; Let's Learn Chinese, last. The middle half: Sun., "Main Roads & Byways," "Mailbag Time"; Mon., "Journey into Chinese Culture," "Countdown"; Tue., "Spectrum", "Spotlight"; Wed., "Mandarin Kitchen," "Jade Bells & Bamboo Pipes"; Thu., "Chinese Story" "World of Science"; Fri., "Life in ROC," "Chinese Music"; Sat., "People at Work," "Taiwan Economic Report". (via Charles Weiss, OH). There's another broadcast at 0200 on 9680. If you want a greater challenge in hearing VOFC direct, the schedule has changed to: 0200 and 0300 on 15125, 11825, 11745, 9685; 2100 on 11860, 11825, 9765, 9600, 9510; 2200 on 11825, 9600 (via Robert Chester, Australia).

UKOGBANI. BBC dropped its Ascension relay channel of 21660 this summer, intended for South Africa, but a useful off-the-back source for us in the 1330-1600 period. Perhaps it'll be back with the southern spring. "The Last Night of the Proms," that cheerful audience-participation concert, will be broadcast live at 1830 Sat., Sept. 14 when 15400, 15070 or 12095 might be audible here; after 2000, 15260 is definite. BBC ended its "Computer World" series about the time our July column came out, but they do plan to revive it later, not necessarily at the same times.

United Nations. UN Radio has relied on VOA transmitters in the US and abroad but now plans to set up its own relay network of 250-kW transmitters in Chile, Ethiopia, Iraq and Thailand—a motley group of countries; perhaps early this Fall, per ITU registrations uncovered by Bob Padula of ADXM.

U.S.A. Shortwave stations never seem to meet their initial target dates, and KVOH, Simi Valley, CA is no exception. As July 4 approached we found out that the debut had been pushed back to Thanksgiving (it seems a holiday is required), due to problems in getting permits for the antennas from Ventura County; and the transmitter had not yet arrived. KCBI, Dallas, however, was busily testing this summer to Europe on 11790 intermittently between 1400 and 2100 and in August was to go on R. Earth Sundays at 1800-2100. WMLK, Bethel, PA, was also testing on 15110 around 1700-1900, and 15150 at 0400-0600. WRNO New Orleans changed some frequencies to: 2100-2230 on 11705, 2230-0100 on 9852.5. NDXE, Alabama, says it's not for sale, progress is slow.

Radio Marti faces a $2.5-million budget cut for violating separation between church and state, by broadcasting Catholic Mass to Cuba Sunday afternoons.

AFRTS, Los Angeles is useful for carrying some network programs hard to find on local affiliates. "Newsmark," the now weekly CBS documentary, is scheduled UTC Sundays 0230 and 0730, but the first time is subject to sports pre-emption, and the repeat is during the 2-hour break for U.S. transmitters; David Alpert in New York suggests you try an SSB feeder presumably from England on 7572. "Monitoradio" should give us a taste of what the Christian Science Monitor's own shortwave station should be like if and when it goes on the air—AFRTS now carries this on Sundays at 2230, Mondays 0330, again—sports permitting. Pres. Reagan's weekly radio speech and the Democrat response an hour later are scheduled Sats. 1606 and 1706, unless bumped by sports. We scanned the entire AM dial in South Florida during Reagan's talk, and found it carried on only one weak station. (All are one hour later by UTC after DST ends.) Skipper Thurman in Chicago informs us that AFRTS can be heard not only on its usual shortwave frequencies, but also via satellite—Satcom F-1, transponder 20.

U.S.S.R. Radio Moscow made lots of seasonal frequency changes Sept. 1 for the North American Service at 2200-0300, now scheduled on the following, not quite all at once: 15425, 15240, 12050, 11770, 11710, 9880, 9765, 9740, 9720, 9640, 9530, 7400, 7320, 7310, 7195, 7175, 7105, 6170. Radio Kiev at 2330-2400 is on 9685, 11720, 11790, 13605, 15180; 0200-0230 on 7175, 11720, 11790, 13605, 15180. There'll be more changes Oct. 1 as all these move one hour later (via Kraig W. Krist, Joe Talbot, James E. McDonald).

Vietnam. You have until Nov. 30 to enter the Voice of Vietnam's essay contest, "What Do You Know About Vietnam?" which celebrates four different anniversaries this year including the station's 40th. Listen in or write them for the exact questions. They invite not only written entries, but illustrations. Prizes aren't specified, but there's no mention of trips to the country, the grand prize in the Cuban equivalent.

Yugoslavia. R. Yugoslavia's 500-kW transmitter project seems to be nearing completion at Bijcljiva, as a tentative frequency schedule has been registered. Among those planned for use in our evening are 6100, 7240, 9620, 11805 and 11895.

Zaire. Soon after independence 25 years ago, Kinshasa started an external service in English, but it didn't last very long. Finally, they seem to be doing it again. Chris Bagge in Massachusetts caught La Voix du Zaire on 15245 with a program in English about the music of Zaire, around 0130 UTC, but we could not immediately confirm this; Italy and Moscow were also on the frequency.

Good listening! **ME**

drive an 8-ohm speaker that has relatively high efficiency.

Another optional feature shown in Fig. 1 is PHONES jack *J2,* which allows you to use headphones for private listening. Plugging phones into *J2* automatically silences the speaker. If you prefer to omit this feature, simply connect the speaker to the negative lead of *C7*, or install a standard phone jack between this point and ground and a matching phone plug on the speaker cable.

Construction

Almost any method of wiring can be used to build the Testbench Amplifier, including use of a solderless socket breadboard, a small piece of perforated board, or a design-it-yourself printed-circuit board. All basic amplifier components can be arranged to fit on a 2¼ ″ × 2 ″ piece of

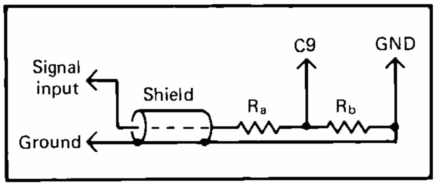


Fig. 2. Distortion caused by an input signal overload can be cured with a simple voltage as shown here. Keep the values of R_a and R_b between 1 and 4.7 megohms to maintain high input impedance and use shielded cable.

perforated board or pc board, with room to spare for the optional ac power supply components (except transformer *T1*).

While the circuit itself is simple, there are several details that cannot be ignored if the amplifier is to operate properly. Keep wire lengths as short as possible, especially in the *IC2* circuit. All audio wiring leaving the circuit board to the input and output jacks, volume control and gain switch, must be shielded cable to minimize hum and noise pickup. Also, *J1* should automatically short out the *R6/R7* junction as shown in Fig. 1 when nothing is plugged into the input to prevent the input circuit's wiring from acting like an antenna for r-f signals. Needles to say, do not substitute a standard phone jack for the shorting type specified in the Parts List. House the project inside a shielded enclosure.

Mount *C8* between *IC2* and *IC3* for greatest stability. If you use the ac supply, keep *T1* as far away as possible from the audio wiring.

The most important decision you have to make is selection of the speaker to use with the Testbench Amplifier. Keep in mind that the amplifier has a wide bandwidth. This being the case, use of a cheap or small speaker will defeat any high-fidelity advantages it provides. If you must keep things small, consider using a set of miniature headphones instead of a speaker. Most modern miniature headphones have very good fidelity for their compact size.

Exercising Options

While the Testbench Amplifier is very useful in its basic form, it can be modified to suit many other uses. For example, you can build a stereo version by using two of the circuits shown in Fig. 1., adding a dual-potentiometer VOLUME control so that you have just one knob to adjust. If you go this route, consider using a TL072 dual op amp in place of the TL071 single op amp specified for *IC2* to minimize parts count.

You can also do a few things to increase the signal-to-noise (S/N) ratio of the system. Metal-film resistors will help a lot here, especially for *R1*. Also, lowering the input impedance of the circuit by changing *R1*'s value can be beneficial. In fact, you could even have several values of resistance on-board for *R1*, switching in whichever one gives the best results from a front-panel rotary switch.

For best results and minimum noise, try to obtain an adequate sound level with the GAIN switch in the ×*1* (open) position. As with any amplifier, increasing gain also increases the noise floor. If you use the amplifier to monitor large enough excursion signals, clipping will result, regardless of how the controls are set. You can eliminate clipping distortion by placing a voltage divider at the input of the buffer to attenuate the signal (see Fig. 2). Use 1-megohm to 4.7-megohm resistors for the attenuator to keep input impedance high. Also, place the divider resistors at the buffer end of the cable to obtain maximum S/N and minimal degradation of the signal.

There are, of course, many other changes that can be made to the basic circuit. The amplifier design presented here will provide reasonably good performance when used as a testbench "instrument." **ME**

BOOKS

The latest technical books and literature in the electronics and computer field.

Complete Guide to Modern VCR Troubleshooting and Repair by John D. Lenk. (Prentice-Hall, Inc. Hard cover. 332 pages. $27.95.)

Modern VCRs may be enormously complex, but if you use a logical approach, you should be able to troubleshoot and repair them with the same facility as you do any other audio/video equipment. This is the premise of this latest book from a long-time master of servicing. Written for the technician who is already familiar with the basics of television and magnetic recording, this book is organized to help him quickly locate the information needed to repair a malfunctioning VCR, regardless of make or model.

Rather than getting you bogged down with details on a specific make or model, however, the author focuses attention on the circuits and secions that are common to *all* VCRs. Each is given a separate chapter of its own and is described in full detail, with each point made being illustrated with drawings and schematic and block diagrams where appropriate.

The opening chapter gives you the basics of Beta and VHS machines, while chapter 2 covers troubleshooting and repair procedures for VCRs. All subsequent chapters are devoted to the common circuits and sections, such as power supplies, remote-control circuits, mechanical sections, video head configurations and so on through audio, video, special features and system control circuits. With the information imparted in these chapters and the manufacturer's service literature, you should have a running start toward repairing just about any videocassette recorder.

Electronics and Microcomputer Circuits by Roger Tokheim. (McGraw-Hill Book Co. Soft cover, 256 pages. $9.95.)

Almost 150 schematic diagrams of useful electronic projects you can build are contained in this book, enough to keep you busy for a long time. The circuits encompass a host of applications ranging from electronic games like digital dice and a slot machine to such practical devices for the home as low- and high-temperature and burglar alarms to computer game-port interface circuits. There are also a number of circuits for automotive, camping and outdoor, meter and test instrument, music/sound-effects, and even timer and thermometer applications. All are arranged by category into 17 distinct chapters for easy lookup. And if you are a newcomer to electronics, there is an appendix that explains the meanings of component symbols used in schematics.

Accompanying each project's schematic diagram is an explanation of how the circuit works and a detailed parts list. Where needed, construction hints and test tips are also supplied.

Most of the circuits in this book have appeared in print elsewhere. Hence, they are tried-and-true designs that you can be sure will work the first time out. None require special tools or skills to build, either, making project assembly a relatively straightforward procedure for even the most complex circuit. If you want to build the circuitry on printed-circuit boards, you'll have to design and fabricate your own since etching-and-drilling guides are not given. You can, however, hand wire on perf board.

The Automotive Security System Design Handbook by J. Daniel Gifford. (Tab Books. Soft cover. 227 pages. $12.95.)

Just about everything you need to know about automotive protection systems and devices is covered in this authoritative book. Early on, you are told about thieves and vandals and what motivates them, to give you an idea of what you are up against. You are then given a rundown of the various electronic and non-electronic vehicle security systems currently in use and told about their strengths and weaknesses. Guiding you through the techniques used in effective security system design, device construction and installation, this book covers such diverse topics as tools needed, sensors required for just about every application you can imagine, and modifications that can improve a basic alarm system to make it more effective.

A section on main control boxes discusses these items in general and provides instructions (including schematics) for a main box that you can build to serve as the core of a sophisticated automotive alarm system. Additional circuits illustrate the add-ons that turn the main box into a complete system. You will find here information on power supplies, power and input conditioning, system controls and sensors, and audible and visible output devices. Assembly and installation instructions emphasize placement, concealment and safety for both commercial and home-build alarm systems.

This is a helpful book if you want to protect your automotive investment.

NEW LITERATURE

Kit & Assembled Products Catalog. A wide variety of kit and assembled electronic products, including the new Personal Loran navigational computer and a 16-bit portable laptop computer, are showcased in the latest Heathkit catalog. Items listed and fully described in the colorful 102-page catalog range from test equipment and ham radio gear to video and hi-fi products to automotive and computer products and much more. All listings are accompanied by full technical specifications and include prices, and most are pictured in photos. For a free copy of the catalog, write to: Heath Co., Dept. 150-585, Benton Harbor, MI 49022.

Full-Line Instrument Catalog. New audio, video and telephone test instruments are featured in B&K-Precision's No. BK-85 full-line catalog. Products are listed according to category for easy lookup. Complete specifications and feature-comparison charts are provided for B&K-Precision oscilloscopes, digital and analog multimeters, function generators, multifunction counters, power supplies, capacitance meters, CRT restorer/analyzers, semiconductor testers, probes and accessories. For a free copy of the Catalog BK-85, write to: B&K-Precision/Dynascan Corp., 6460 W. Cortland St., Chicago, IL 60635; Attn.: Advertising Dept.

Electronics Bench Tools Catalog. A wide array of tools for the electronics workbench are listed and described in a new full-color, 10-page catalog available from OK Industries. The short-form catalog includes complete descriptions and technical information on an array of pneumatic and hand-held screwdrivers, precision pliers, cutters and crimpers, and pc board holders. Also included are electric minidrills and grinders for prototype work, pc board rework, solder removal, lead-hole cleaning, grinding and polishing. For a free copy of the "Bench Tools" catalog, write to: Customer Service, OK Industries, 3455 Conner St., Bronx, NY 10475.

Sharp Model VC-5F7U continued . . .

—there's no connector into which you can plug it.

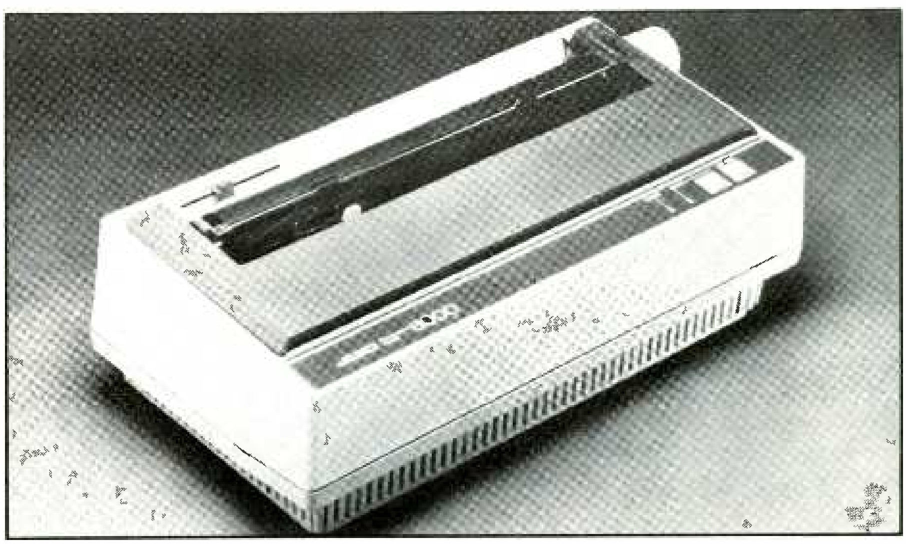
Make no mistake about it, this multifaceted player/recorder is going to take some getting used to. For instance, the AUX designation on the audio source selector must be properly set before auxiliary audio/video inputs can operate. Stereo linear or Hi-Fi are also manual controls, and there are *two* manual tracking controls—one for still, the other for play—that must be adjusted when playing externally recorded tapes to reduce noise bars and picture smearing. And you'll have to get used to the idea that the VCR *automatically* shifts to TV (or cable, whichever is connected) when the VCR stops operating.

Don't let complex and unconventional operating procedures put you off, though. With a little familiarity, you'll master the controls. And your reward for perseverence will be sharp pictures with good color reproduction and super sound. If you plan to use the Model VC5F7U with a common 3-MHz TV receiver and 3" speaker, you've paid a premium price for naught. To really appreciate this VCR's video and audio performance, you'll need an excellent TV receiver/monitor, with good external speakers and a wide-bandpass stereo amplifier.—*Stan Prentiss*

Computer

The Juki 6000: Top-notch print quality in half the space

Daisywheel printers are traditionally the size of large office typewriters that weigh a ton. But Juki's latest product, the model 6000 daisywheel printer, sets a fresh standard for smaller size and weight.



With measurementsof 15¾"W × 9"D × 5½"H, the 6000 is about half the size of an IBM Selectric typewriter. And it weighs just 13 pounds.

The 6000 will not set any speed records, though. At its specified 10 characters per second (cps), it's slow. But bidirectional printing and logic seeking aid the 6000 in the battle against the clock. Like it's weight, the Juki's cost is relatively light, too; suggested retail price is just $295.

About the Printer

The 6000 is housed in a boxy beige case with a gray top cover. The power switch is at the left rear of the machine, right next to the plug for the power cord. There are only two controls, which are at the top of the printer: an on-line and line-feed switch. Unfortunately, there is no way to perform a manual form feed. Two green LEDs next to the switches indicate power on and on-line.

At the right side of the printer is the interface connector, which can be specified at the time of purchase as either Centronics parallel or RS-232 serial. The connector seems to be strangely placed, but it's probably one of the concessions Juki had to make to achieve the machine's small footprint. The platen knob is also on the right side, as is common.

When you lift the printer cover, what you see inside is mostly empty space, except for the printer mechanism. This mechanism holds a standard 100-character daisywheel in place. The wheel is easily

```
This is normal type on the Juki 6000.
This is an example of boldface type.
This is an example of underlined type.
This is a superscript. And this is a subscript.
```

readied for insertion or removal with just the flick of an orange colored lever on the mechanism. The ribbon that the printer uses is a small, non-standard size cartridge type, which is easily installed. The cartridge can be purchased with a fabric, one-time film, or multistrike film ribbon.

The printer handles only up to 8½"-wide paper and uses only a friction feed system. This latter poses a problem when using fanfold paper to print very long documents, since the paper tends to drift in the carriage. But for shorter-length documents the skew is not noticeable.

Printer Performance

Unlike some low-cost daisywheel printers, the Juki 6000 displayed exceptional print quality. Individual characters were equally spaced, with no bunching, and letters did not stray from the horizontal. The type quality is similar to that of a good office electric typewriter.

One of the limitations of the printer is that it can handle just an original and one copy. This may not be sufficient for users such as lawyers who regularly need at least three carbons of their work.

I used the Juki 6000 with an AT&T 6300 computer and XY Write word processor. All that was needed was to connect the printer to the parallel port of the AT&T and configure XY Write for a Diablo 630 daisywheel printer.

I was immediately able to print characters in boldface, underline, superscript and subscript. The default pitch of the printer is 10, but it can be set to 12 or 15 with control codes. The printer is also hardware-ready for proportional spacing, with microjustification in $\frac{1}{60}$" increments, if your software can handle this.

A 17-page manual details installation and removal of the daisywheel and ribbon cartridge. It also includes control codes, interface specifications, and two sample BASIC programs.

Conclusions

I was pleased with the overall performance of the Juki 6000. After trying a few of its low-priced (and higher-priced) competitors, I was expecting to see cramped and twisted letters on the page, but the Juki did not exhibit these problems. On the other hand, I was somewhat disappointed in the speed of the machine. At 10 cps, you can wait a long time for a multi-page document to be printed.

Juki must be commended, though, on the compactness of this printer; it's really a breakthrough in daisywheel printer design. The noise level as it hammers out copy is only moderate and is within the liveable range. And the weight is significantly less than most printers of this type.

On the whole, I would recommend this printer highly to those people who need a low-cost daisywheel, and are willing to trade print wait for low-cost with good-quality output.—*Joseph Peters.*

CIRCLE NO. 128 ON FREE INFORMATION CARD

as a matter of competition, so this new approach doesn't penalize the station in that regard."

"What about reactions of current listeners to WPKT?" I asked. "Has the station received any complaints from listeners who notice that something has changed?" Torick told me that at first, when the FMX system used to modulate the 19 kHz stereo pilot carrier as a way to switch on the FMX decoder at the receiving end, that modulation did affect the sound received by listeners to conventional FM stereo sets. "Now, we've changed that and we simply add a subaudible, 10-Hz signal to provide the switching information and an indicator on the FMX receivers. Since we made that change there hasn't been a single complaint from any listeners to the station. They aren't even aware that the station is using the system experimentally." That speaks well for the compatibility aspect of FMX.

A 25-Year Old "Mistake"

Many audio and FM experts feel that the Federal Communications Commission was short-sighted when they approved the currently used system for FM stereo back in 1961. They provided us (and the rest of the world has since adopted) a transmission system which, while preserving the "status quo" for the mono listener, does not offer the same noise-free reception characteristics for the stereo listeners who, today, constitute a clear majority of all FM listeners. At the time of their decision, the idea of using companding for noise reduction was several years off in the future. (Dolby introduced his famous noise-reduction system for home cassette recorders in 1967 at an Audio Engineering Society Convention in Los Angeles—more than six years after the FCC approval of FM stereo.) Almost twenty years later, when the TV industry was considering how to broadcast stereo over a TV audio channel, the need for companding was realized almost immediately, and the system selected includes a companding approach—in this case one developed by dbx. CBS was one of the proponents for a companding system to be used for stereo TV. Emil Torick tells me that the FMX idea grew out of that related effort.

Since CBS Technology introduced FMX at a professional engineering conference in Chicago last June, the company has been approached by many interested FM broadcasters. Mr. Torick tells me, too, that they've been talking to IC manufacturers who have shown an interest in tooling up appropriate decoder ICs for the FMX system. "You have more than a chicken-and-egg situation here," Torick concluded. "In order to interest FM stations in the idea you've got to be able to assure them that there will be receivers out there that can pick up the improved FM stereo signal. And in order to interest receiver manufacturers in building receivers, there has to be a promise of IC availability so that costs don't become prohibitive."

One thing we can all do to encourage use of this clever system is to make our favorite FM stations aware of its existence. If you tell your favorite local FM station managers that there's a way for them to increase their useful stereo listening area by as much as four to one, just watch how fast they'll be picking up the phone to call CBS Technology Center in Stamford, Connecticut. In case you are an FM station engineer or manager and want to call, the number is (201) 327-2000. Ask for Emil Torick or Eugene Cooper. Maybe, if we all act on this, we can undo a twenty-five year old mistake after all. **ME**

0.6 volt for a silicon diode and 0.3 volt for a germanium diode.

This same concept can be expanded by using zener diodes across the feedback resistor, as shown in Fig. 12. Note how the zener diodes are connected in this circuit. With this arrangement, V_{out} is limited at the zener voltage plus the forward drop of the diodes. Since a wide variety of zener voltages are available with different zener diodes, this circuit is much more versatile than that in Fig. 10.

You can use limiter circuits wherever a signal amplitude must be limited to some maximum value. For example, a limiter is often used in tape recorders to prevent the audio signal from overloading the recording function. Bear in mind, however, that limiting produces distortion. So use this circuit only when the amount of distortion is tolerable compared to the effect being guarded against.

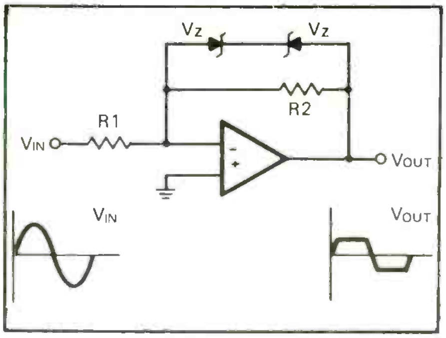


Fig. 12. Using zener diodes in place of ordinary diodes produces a circuit that can limit at almost any voltage.

In Conclusion

From the foregoing, you can readily see that op amps can be used in a variety of applications, some configurations for which we've described here. There are many applications and configurations we haven't covered, particularly in the digital area.

When using the circuits presented here, keep in mind the effects of the capacitors in the circuits. They will introduce high- or low-frequency rolloff, whether you want them to or not. By paying careful attention to component value selection to obtain an appropriate cutoff frequency, you should be able to sidestep potential problems. **ME**

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SN7414N	14	.49	SN7494N	14	.89	SN74176N	14	.79
SN7416N	14	.49	SN7495N	14	.49	SN74177N	14	.79
SN7417N	14	.59	SN7496N	16	.49	SN74179N	16	1.49
SN7420N	14	.19	SN7497N	16	3.25	SN74180N	14	.69
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SN7422N	14	.59	SN74105N	14	1.19	SN74182N	16	1.05
SN7423N	16	.69	SN74107N	14	.29	SN74184N	16	2.29
SN7425N	14	.39	SN74109N	16	.39	SN74185N	16	2.29
SN7426N	14	.39	SN74116N	24	1.49	SN74190N	16	.69
SN7427N	14	.25	SN74121N	14	.45	SN74191N	16	.69
SN7428N	14	.59	SN74122N	14	.69	SN74192N	16	.69
SN7430N	14	.35	SN74123N	16	.55	SN74193N	16	.69
SN7432N	14	.39	SN74125N	14	.49	SN74194N	16	.69
SN7433N	14	.49	SN74126N	14	.49	SN74195N	16	.69
SN7437N	14	.25	SN74128N	14	.69	SN74196N	14	.75
SN7438N	14	.49	SN74132N	14	.59	SN74197N	14	.75
SN7439N	14	.79	SN74136N	14	.69	SN74198N	24	1.19
SN7440N	14	.19	SN74141N	16	.89	SN74199N	24	1.19
SN7441N	16	.89	SN74142N	16	3.95	SN74221N	16	1.19
SN7442N	16	.45	SN74143N	24	3.95	SN74251N	16	.79
SN7443N	16	1.25	SN74144N	24	3.95	SN74273N	20	1.95
SN7444N	16	1.25	SN74145N	16	.65	SN74276N	20	2.49
SN7445N	16	.69	SN74147N	16	1.29	SN74279N	16	.79
SN7446N	16	.75	SN74148N	16	.89	SN74283N	16	1.39
SN7447N	16	.75	SN74150N	24	1.49	SN74284N	16	2.95
SN7448N	16	.75	SN74151N	16	.49	SN74285N	16	2.95
SN7454N	14	.19	SN74152N	14	.49	SN74365N	16	.55
SN7459N	14	.35	SN74153N	16	.99	SN74366N	16	.55
SN7460N	14	.39	SN74154N	24	1.49	SN74367N	16	.55
SN7470N	14	.39	SN74155N	16	.59	SN74368N	16	.55
SN7472N	14	.39	SN74156N	16	.59	SN74390N	16	1.49
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74LS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
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74LS02	14	.35	74LS136	14	.39	74LS251	16	.59
74LS03	14	.29	74LS138	16	.59	74LS253	16	.59
74LS04	14	.39	74LS139	16	.59	74LS257	16	.59
74LS05	14	.35	74LS145	16	1.19	74LS258	16	.59
74LS06	14	.99	74LS147	16	1.95	74LS260	14	.59
74LS07	14	.99	74LS148	16	1.79	74LS266	14	.59
74LS08	14	.35	74LS151	16	.59	74LS273	20	1.49
74LS09	14	.35	74LS153	16	.59	74LS279	16	.49
74LS10	14	.35	74LS154	24	1.49	74LS280	14	1.95
74LS11	14	.35	74LS155	16	.69	74LS283	16	.69
74LS12	14	.35	74LS156	16	.69	74LS290	14	.89
74LS13	14	.59	74LS157	16	.69	74LS293	14	.89
74LS14	14	.59	74LS158	16	.59	74LS299	20	2.95
74LS20	14	.29	74LS160	16	.69	74LS322	20	3.95
74LS21	14	.35	74LS161	16	.69	74LS323	20	3.95
74LS26	14	.29	74LS162	16	.69	74LS347	16	.79
74LS27	14	.35	74LS163	16	.69	74LS353	16	1.09
74LS28	14	.39	74LS164	14	.69	74LS364	20	1.95
74LS30	14	.29	74LS165	16	.89	74LS365	16	.49
74LS32	14	.39	74LS168	16	1.19	74LS366	16	.49
74LS37	14	.35	74LS169	16	1.49	74LS367	16	.49
74LS38	14	.39	74LS170	16	1.49	74LS368	16	.49
74LS42	16	.49	74LS173	16	.69	74LS373	20	1.49
74LS47	16	.89	74LS174	16	.69	74LS374	20	1.49
74LS51	14	.29	74LS175	16	.69	74LS375	16	.69
74LS73	14	.39	74LS181	24	2.49	74LS386	14	.39
74LS74	14	.39	74LS190	16	.79	74LS393	14	1.19
74LS75	16	.45	74LS191	16	.89	74LS399	16	1.49
74LS76	16	.39	74LS192	16	.79	74LS490	16	1.95
74LS85	16	.89	74LS193	16	.89	74LS533	20	1.95
74LS86	14	.39	74LS194	16	.69	74LS534	20	1.95
74LS90	14	.55	74LS195	16	.59	74LS540	20	1.49
74LS92	14	.55	74LS196	14	.89	74LS541	20	1.49
74LS93	14	.59	74LS197	14	.89	74LS640	20	2.19
74LS96	16	.89	74LS221	16	1.09	74LS641	20	2.19
74LS107	14	.39	74LS240	20	1.09	74LS644	20	2.19
74LS109	16	.39	74LS241	20	.99	74LS645	20	2.19
74LS112	16	.45	74LS243	14	1.09	74LS670	16	1.49
74LS122	14	.49				74LS688	20	2.95
74LS123	16	.79				81LS95	20	1.49
74LS125	14	.59				81LS96	20	1.49
74LS126	14	.59				81LS97	20	1.49
						81LS98	20	1.49

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74S04	14	.45	74S135	16	.89	74S244	20	2.19
74S05	14	.35	74S136	14	1.39	74S251	16	.99
74S08	14	.45	74S138	16	.89	74S253	16	.99
74S09	14	.39	74S139	16	.89	74S257	16	.99
74S10	14	.35	74S140	14	.69	74S258	16	.99
74S11	14	.35	74S151	16	.99	74S273	20	2.39
74S15	14	.35	74S153	16	.99	74S280	14	1.89
74S20	14	.35	74S157	16	.99	74S287*	16	1.79
74S22	14	.35	74S158	16	.99	74S288*	16	1.79
74S30	14	.35	74S160	16	2.29	74S299	20	5.95
74S32	14	.45	74S169	16	4.29	74S373	20	2.49
74S37	14	.99	74S174	16	1.09	74S374	20	2.49
74S38	14	.89	74S175	16	1.09	74S387*	16	1.95
74S64	14	.39	74S188*	16	1.75	74S471*	20	4.95
74S65	14	.39	74S189	16	1.49	74S472*	20	4.95
74S74	14	.55	74S195	16	1.49	74S474*	24	4.95
74S85	16	1.99	74S196	14	1.49	74S570*	16	2.95
74S86	14	.55	74S240	20	1.95	74S571*	16	2.95
74S112	16	.55				74S572*	18	4.95
74S124	16	2.75				74S573*	18	4.95

74ALS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74ALS00	14	.59	74ALS32	14	.65	74ALS138	16	1.25
74ALS02	14	.59	74ALS74	14	.79	74ALS240	20	2.25
74ALS04	14	.59	74ALS109	16	.79	74ALS244	20	2.25
74ALS08	14	.59	74ALS112	16	.69	74ALS245	20	2.59
74ALS10	14	.59				74ALS373	20	2.59
74ALS30	14	.59				74ALS374	20	2.59

74F

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74F00	14	.69	74F86	14	1.15	74F240	20	3.75
74F02	14	.75	74F109	16	.95	74F244	20	3.49
74F04	14	.89	74F138	16	1.69	74F253	16	1.79
74F08	14	.75	74F139	16	1.69	74F257	16	1.79
74F10	14	.75	74F157	16	1.69	74F280	14	1.69
74F20	14	.75	74F158	16	1.69	74F283	16	4.89
74F32	14	.79				74F374	20	4.59
74F74	14	.85				74F379	16	1.99

CD—CMOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
CD4000	14	.29	CD4041	14	.69	CD40103	16	2.49
CD4001	14	.29	CD4042	16	.69	CD4503	16	.69
CD4002	14	.29	CD4043	16	.79	CD4506	16	1.29
CD4006	14	.89	CD4044	16	.79	CD4507	14	.59
CD4007	14	.29	CD4046	16	.89	CD4508	24	1.95
CD4008	16	.89	CD4047	14	.89	CD4510	16	.85
CD4009	16	.59	CD4048	16	.59	CD4511	16	.85
CD4010	16	.49	CD4049	16	.39	CD4512	16	.85
CD4011	14	.29	CD4050	16	.39	CD4514	24	1.49
CD4012	14	.29	CD4051	16	.79	CD4515	24	1.49
CD4013	14	.39	CD4052	16	.89	CD4516	16	.89
CD4014	16	.89	CD4053	16	.79	CD4518	16	.89
CD4015	16	.39	CD4056	16	2.95	CD4519	16	.59
CD4016	14	.39	CD4059	24	3.95	CD4520	16	.79
CD4017	16	.79	CD4060	16	.89	CD4522	16	1.69
CD4018	16	.79	CD4066	14	.45	CD4526	16	1.19
CD4019	16	.49	CD4068	14	.39	CD4528	16	1.19
CD4020	16	.75	CD4069	14	.35	CD4529	16	1.69
CD4021	16	.75	CD4070	14	.29	CD4531	16	.89
CD4022	16	.75	CD4071	14	.29	CD4538	16	1.49
CD4023	14	.29	CD4072	14	.29	CD4541	14	1.49
CD4024	14	.69	CD4073	14	.29	CD4543	16	1.19
CD4025	14	.29	CD4075	14	.29	CD4553	16	4.95
CD4026	16	1.59	CD4076	16	.89	CD4566	16	2.95
CD4027	16	.45	CD4077	14	.39	CD4583	16	2.49
CD4028	16	.69	CD4078	14	.29	CD4584	14	.59
CD4029	16	.79	CD4081	14	.29	CD4585	16	1.39
CD4030	14	.39	CD4093	14	.49	CD4723	16	1.19
CD4034	24	1.79	CD4094	16	1.95	CD4724	16	1.19
CD4035	16	.79	CD4098	16	1.95	MC14410	16	8.95
CD4040	16	.75	CD4099	16	1.89	MC14411	24	11.95
						MC14412	16	7.95
						MC14433	24	17.95
						MC14490P	16	3.95
						MC14572	16	1.18

RED-HOT RAM & EPROM PRICES

Part No.	Description	Price
21C14	(200ns) CMOS SRAM — CMOS USES LESS POWER	.99
27C16	(450ns) CMOS EPROM	9.95
4164N-200	(DRAM)	9/9.95
6116P-4	(200ns) SRAM	3.49
6116LP-4	(200ns) L.P. SRAM	3.69
6264LP-15	(150ns) L.P. SRAM	7.49
MC146818	REAL TIME CLOCK & RAM	7.95
27128-25	(250ns) EPROM	5.95
41256-150	(150ns) DRAM	6.49
68764	(450ns) 21V EPROM	12.95
68766	(350ns) 25V EPROM	14.95

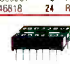
MICROPROCESSOR COMPONENTS

MICROPROCESSOR CHIPS

Part No.	Pins	Function	Price
D765AC	40	Floppy Disk Controller	16.95
D3242	28	Addr. Multiplexer & Refresh Counter	7.95
TMS5501	40	Synchronous Data Interface (SIRC)	14.95
Z80, Z80A, Z80B, Z8000 SERIES			
Z80	40	CPU (MK3880N/780C-1) 2MHz	2.75
Z80-CTC	28	Counter Timer Circuit	3.49
Z80-DART	40	Dual Asynchronous Rec./Trans.	8.95
Z80-DMA	40	Direct Memory Access Circuit	12.49
Z80-P10	40	Parallel I/O Interface Controller	2.95
Z80-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.49
Z80-S10/1	40	Serial I/O (Lacks DTRB)	11.49
Z80-S10/2	40	Serial I/O (Lacks SYNCB)	11.49
Z80-S10/9	40	Serial I/O	11.49
Z80A	40	CPU (MK3880N-4) (780C-1) 4MHz	2.95
Z80A-CTC	28	Counter Timer Circuit	3.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	9.95
Z80A-DMA	40	Direct Memory Access Controller	12.95
Z80A-P10	40	Parallel I/O Interface Controller	3.95
Z80A-S10/0	40	Serial I/O (TxCB and RxCB Bonded)	11.95
Z80A-S10/1	40	Serial I/O (Lacks DTRB)	11.95
Z80A-S10/2	40	Serial I/O (Lacks SYNCB)	11.95
Z80A-S10/9	40	Serial I/O	11.95
Z80B	40	CPU (MK3880N-6) 6MHz	8.95
Z80B-CTC	28	Counter Timer Circuit	11.95
Z80B-DART	40	Dual Asynchronous Rec./Trans.	19.95
Z80B-P10	40	Parallel I/O Interface Controller	10.95
6500/6800/68000 SERIES			
6502	40	MPU with Clock (1MHz)	4.95
6502A	40	MPU with Clock (2MHz)	5.25
6502B	40	MPU with Clock (3MHz)	7.95
6520	40	Peripheral Inter. Adapter	2.75
6522	40	Versatile Inter. Adapter	4.95
6551	28	Async. Comm. Interface Adapt.	6.95
6800	40	MPU	2.95
6802	40	MPU with Clock and RAM	5.95
6809	40	CPU — 8-Bit (On-Chip Oscillator)	6.95
6809E	40	CPU — 8-Bit (External Clocking)	8.49
68B09E	40	CPU — 8-Bit (Ext. Clocking) 2MHz	11.49
6810	24	128x8 Static RAM	2.75
68B10	24	128x8 Static RAM (2MHz)	5.95
6821	40	Peripheral Inter. Adapt. (MC6820)	2.75
68B21	40	Peripheral Interface Adapter (2MHz)	4.95
6845	40	CRT Controller (CRTC)	9.95
68B45	40	CRT Controller (CRTC) 2MHz	14.95
6850	24	Asynchronous Comm. Adapter	2.95
6860	24	0-600bps Digital MODEM	6.95
68000L6	64	MPU 16-Bit (6MHz)	19.95
68488P	40	General Purpose Int. Adapter	9.95
68661	28	Enhanced Prog. Comm. Interface (2661)	8.95
8000/80000 SERIES			
8031	40	Control Oriented CPU w/RAM & I/O	12.95
8035	40	MPU — 8-Bit	4.95
8039	40	CPU — Sgl. Chip 8-Bit (128 Byte RAM)	4.95
8060	40	CPU — 8-Bit NMOS	12.95
8073N	40	CPU w/Basic Micro Interpreter	29.95
8080A	40	CPU	3.95
8085A	40	CPU	3.95
8085A-2	40	CPU 8-Bit N-Channel (5MHz)	10.95
8086-2	40	CPU 16-bit 8MHz	19.95
8087	40	Arithmetic Processor (5MHz)	119.00
8087-2	40	Arithmetic Processor (8MHz)	125.00
8088	40	CPU 8/16 Bit	14.95
8116	18	Dual Baud Rate Generator	9.49
8155	40	HMOS RAM I/O Port-Timer	4.95
8156	40	RAM with I/O Port and Timer	5.95
8202	40	Dynamic RAM Controller	19.95
8203	40	64K Dynamic RAM Controller	29.95
8205	16	Hi Speed 1 out of 8 Binary Decoder	3.95
8212	24	8-Bit Input/Output (74S412)	2.25
8224	16	Clock Generator/Driver	2.19
8228	28	Sys. Cont./Bus Driver (74S428)	3.95
8237-5	40	High Perf. Prog. DMA Cont. (5MHz)	12.95
8238	28	System Controller (74S438)	4.95
8243	24	I/O Expander for 48 Series	3.95
8250A	40	Async. Comm. Element	9.95
8250B	40	ACE (IBM PC or XT Software Compatible)	10.95
8251	28	Prog. Comm. I/O (USART)	3.25
8251A	28	Prog. Comm. Interface (USART)	3.49
8253-5	24	Prog. Interval Timer	6.49
8254	24	Programmable Interval Timer	13.49
8255	40	Prog. Peripheral I/O (PPI)	3.95
8255A-5	40	Prog. Peripheral I/O (PPI) 5MHz	4.25
8257-5	40	Prog. DMA Controller	6.95
8259	28	Prog. Interrupt Control	5.95
8259-5	28	Prog. Interrupt Controller	6.95
8272	40	Sgle/Dble Density Floppy Disk Cont.	16.95
8274	40	Multi-Protocol Serial Cont. (7201)	14.95
8275	40	Prog. CRT Controller	11.95
8279	40	Prog. Keyboard/Display Interface	5.49
8279-5	40	Prog. Keyboard/Display Interface	5.95
8282	20	Octal Latch	6.49
8284	18	Clock Generator/Driver	5.49
8286	20	Octal Bus Transceiver	6.49
8287	20	Octal Bus Transceiver (Inverted)	6.49
8288	20	Bus Controller	13.95
8289	20	Bus Arbiter	24.95
8741	40	8-Bit Univ. Peripheral Interface	19.95
8748	40	HMOS EPROM MPU	19.95
8749	40	MPU 8-Bit (EPROM Version of 8049)	19.95
8751	40	CPU w/4Kx8 EPROM & 128x8 RAM	29.95
8755	40	16K EPROM with I/O	19.95
80186	68	High Integration 16-Bit MPU	19.95
80188	68	High Integra. 16-Bit MPU (8 Bit Data Bus)	49.95
80287	40	Numeric Processor Ext.	195.00
SPECIAL FUNCTION			
MC3470P	18	Floppy Disk Read Amp System	4.95
MM5321N	16	TV Camera Sync. Generator	9.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	8.95
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95
MC146818	24	Real-Time Clock Plus RAM	7.95

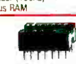
DYNAMIC RAMS

Part No.	Pins	Function	Price
1103	18	1024x1 (300ns)	.99
4027	16	4096x1 (250ns)	1.49
4116N-15	16	16,384x1 (150ns)	1.39 — 8/10.95
4116N-20	16	16,384x1 (200ns)	.79 — 8/5.29
4116N-25	16	16,384x1 (250ns)	.69 — 8/5.49
4164N-150	16	65,536x1 (150ns)	1.22 — 9/10.95
4164N-200	16	65,536x1 (200ns)	1.11 — 9/9.95
MM5261	18	1024x1 (300ns)	.35 — 8/1.95
MM5262	22	2048x1 (365ns)	.35 — 8/1.95
MM5270	18	4096x1 (250ns)	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
MK4108	16	8192x1 (200ns)	.59
8118	16	16,384x1 (120ns)(+5V Only Req.)	.99
41256-150	16	262,144x1 (150ns)	6.49
41256-200	16	262,144x1 (200ns)	5.95
4128	16	131,072x1 (250ns)	8.95
STATIC RAMS			
2101	22	256x4 (450ns) 8101	1.95
2102	16	1024x1 (350ns)	.89
2102-2L	16	1024x1 (250ns) LP (91L02)	1.49
2111	18	256x4 (450ns) 8111	2.49
2112	16	256x4 (450ns) MOS	2.49
2114N	18	1024x4 (450ns)	1.29 — 8/9.95
2114N-L	18	1024x4 (450ns) LP	1.65 — 8/12.95
2114N-2	18	1024x4 (200ns)	1.39 — 8/10.95
2114N-2L	18	1024x4 (200ns) LP	1.69 — 8/13.49
2147HN	18	4096x1 (70ns)	4.49
2148HN	18	1024x4 (70ns)	4.95
TMS4045	18	1024x4 (450ns)	3.95
TMS40L47-45	20	1024x4 (450ns)	1.95
5101	22	256x4 (450ns) CMOS	2.95
MM5257	18	4096x1 (450ns) 4044	4.95
HM6116P-2	24	2048x8 (120ns) CMOS	4.95
HM6116LP-2	24	2048x8 (120ns) LP CMOS	6.49
HM6116P-3	24	2048x8 (150ns) CMOS	3.75
HM6116LP-3	24	2048x8 (150ns) LP CMOS	3.95
HM6116P-4	24	2048x8 (200ns) CMOS	3.49
HM6116LP-4	24	2048x8 (200ns) LP CMOS	3.69
HM6264P-12	28	8192x8 (120ns) CMOS	7.25
HM6264LP-12	28	8192x8 (120ns) LP CMOS	7.95
HM6264P-15	28	8192x8 (150ns) CMOS	6.95
HM6264LP-15	28	8192x8 (150ns) LP CMOS	7.49
27LS00	16	256x1 (80ns) LP	3.95
7489	16	16x4 (50ns) 3101	2.25
74C921	18	256x4 (250ns) CMOS	5.95
74C930	18	1024x1 (250ns) CMOS (6518)	5.95
74S189	16	16x4 (35ns) 93405	2.95
74S289	16	16x4 (35ns) 3101	2.95
82S10	16	1024x1 (50ns) O.C. (93415)	3.95
82S25	16	16x4 (50ns) O.C. (74S289)	2.25
PROMS/EPROMS			
1702A	24	256x8 (1μs)	3.95
TMS2516	24	2048x8 (450ns)	4.95
TMS2532	24	4096x8 (450ns)	5.49
TMS2564	28	8192x8 (450ns)	10.95
2708	24	1024x8 (450ns)	3.95
TMS2716	24	2048x8 (450ns) 3 voltage	7.95
2716	24	2048x8 (450ns)	3.95
27C16	24	2048x8 CMOS	9.95
2716-1	24	2048x8 (350ns)	4.95
27160-5	24	2048x8 (550ns)	3.75
2732	24	4096x8 (450ns)	4.25
2732A-20	24	4096x8 (200ns) 21V	9.95
2732A-25	24	4096x8 (250ns) 21V	4.95
2732A-45	24	4096x8 (450ns) 21V	4.49
27C32	24	4096x8 CMOS	11.95
27C32A-30	24	4096x8 (300ns) 21V (CMOS)	22.95
2764-20	28	8192x8 (200ns) 21V	6.95
2764-25	28	8192x8 (250ns) 21V	5.09
2764A-25	28	8192x8 (250ns) 12.5V	5.95
2764-45	28	8192x8 (450ns) 21V	4.95
27C64	28	8192x8 CMOS 21V	11.95
27128-25	28	16,384x8 (250ns) 128K 21V	5.95
27128A-25	28	16,384x8 (250ns) 128K 12.5V	7.95
27256-25	28	32,768x8 (250ns) 256K (14V)	11.95
68764	24	8192x8 (450ns)	12.95
68766	24	8192x8 (350ns) 25V	14.95
74S188	16	32x8 PROM O.C. (6330-1)	1.75
74S287	16	256x4 PROM TS (6301-1)	1.79
74S288	16	32x8 PROM TS (6331-1)	1.79
74S387	16	256x4 PROM O.C. (6300-1)	1.95
74S471	20	256x8 PROM TS (6309-1)	4.95
74S472	20	512x8 PROM TS (6349-1)	4.95
74S473	20	512x8 PROM O.C. (6348)	4.95
74S474	24	512x8 PROM TS (DM87S296N)	4.95
74S475	24	512x8 PROM O.C. (6340)	4.95
74S476	18	1024x4 PROM TS	6.95
74S478	24	1024x8 PROM TS	9.95
74S570	16	512x4 PROM O.C. (6305)	2.95
74S571	16	512x4 PROM TS (6306)	2.95
74S572	18	1024x4 PROM O.C. (6352)	4.95
74S573	18	1024x4 PROM TS (82S137)	4.95
82S23	16	32x8 PROM O.C. (27S18)	2.95
82S115	24	512x8 PROM TS (27S15)	9.95
82S123	16	32x8 PROM TS (27S19)	2.95
82S126	16	256x4 PROM O.C. (27S20)	2.95
82S129	16	256x4 PROM TS (27S21)	2.95
82S130	16	512x4 PROM O.C. (27S12)	3.95
82S131	16	512x4 PROM TS (27S13)	3.95
82S185	18	2048x4 PROM TS (TBP24S81)	9.95
82S191	24	2048x8 (80ns)	14.95
DM87S181N	24	1024x8 PROM TS (82S181)	9.95
DATA ACQUISITION			
DC10		Mostek DC/DC Converter +5V to -9V	2.95
ADC0801	20	8-Bit A/D Converter (1/4LSB)	14.95
ADC0803	20	8-Bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-Bit A/D Converter (1LSB)	3.49
ADC0808	28	8-Bit A/D Conv. w/8-Channel Analog	9.95
ADC0809	28	8-Bit A/D Converter (8-Ch. Multi.)	4.49
ADC0816	40	8-Bit A/D Conv. w/16-Channel Analog	14.95
ADC0817	40	8-Bit A/D Converter (16-Ch. Multi.)	9.95
DAC0806	16	8-Bit D/A Converter (0.78% Lin.)	1.95
DAC0807	16	8-Bit D/A Converter (MC1408-7)	1.49
DAC0808	16	8-Bit D/A Converter (MC1408-8)	2.25
DAC0830	20	8-Bit Up D/A Conv. (.05% Lin.)	5.95
DAC0831	20	8-Bit Up D/A Conv. (.10% Lin.)	4.49
DAC1000	24	10-Bit D/A Conv. Micro Comp. (0.05%)	7.95
DAC1008	20	10-Bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	16	10-Bit D/A Converter (0.05% Lin.)	7.95
DAC1022	16	10-Bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-Bit D/A Conv. (0.20% Lin.)	6.95
DAC1230	20	12-Bit Up D/A Conv. (.05% Lin.)	14.95
DAC1231	20	12-Bit Up D/A Conv. (.10% Lin.)	13.95
AY-3-1015D	40	25K Baud UART	4.25
AY-5-1013A	40	30K Baud UART (TR1602)	3.95



Low Profile (Tin) Sockets

Part No.	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
40 pin LP	.49	.45	.43



Soldertail (Gold) Standard

Part No.	1-9	10-99	100-up
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.40
16 pin SG	.55	.49	.45
18 pin SG	.65	.59	.51
20 pin SG	.75	.65	.59
22 pin SG	.79	.69	.65
24 pin SG	.79	.69	.65
28 pin SG	.95	.85	.75
36 pin SG	1.25	1.15	.99
40 pin SG	1.39	1.25	1.15

Wire Wrap Sockets (Gold) Level #3

Part No.	1-9	10-99	100-up
8 pin WW	.55	.49	.45
10 pin WW	.69	.65	.59
14 pin WW	.75	.69	.65
16 pin WW	.79	.72	.65
18 pin WW	.95	.85	.75
20 pin WW	1.19	1.09	.95
22 pin WW	1.29	1.15	1.05
24 pin WW	1.35	1.19	1.09
28 pin WW	1.69	1.55	1.39
36 pin WW	1.89	1.79	1.69
40 pin WW	2.29	1.95	1.79

Header Plugs (Gold)

Part No.	1-9	10-99	100-up
14 pin HP	.65	.59	.55
16 pin HP	.69	.65	.59
24 pin HP	1.15	.99	.89

Header Covers

Part No.	1-9	10-99	100-up
14 pin HC	.15	.13	.12
16 pin HC	.17	.15	.12
24 pin HC	.29	.25	.22

NEW EEPROM

Part No.	Pins	Function	Price
2816A	24	2048x8 16K E²PROM 350ns	12.95

Features: • On-board Address/Data Latches • Auto-Timed Byte Write (on chip timer) • 5V Erase/Write/Read • Optional High Voltage Erase/Program (12V-22V) • Power Up/Down Write Protection • Auto Erase before Write. The 2816A is an ideal nonvolatile memory providing in-system alterability with the same ease and with the same features as 2Kx8 Static RAMs.

Digitalker™

DT1050 — Applications: Teaching aids, appliances, clocks, automotive, telecommunications, language translations, etc. The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

DT1050 Digitalker™ . . . . $29.95 ea.
MM54104 Processor Chip . . . . $12.95 ea.

DT1057 — Expands the DT1050 vocabulary from 137 to over 260 words. Incl. 2 ROMs and specs
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INTERSIL

Part No.	Pins	Function	Price
FE0202D	40	4 Digit LCD Display for 7211IPL & 7211MIPL	14.95
FE0203D	40	3½ Digit LCD Display for 7106 & 7116	14.95
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit	28	Stopwatch Chip, XTL (Evaluation Kit)	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	10.49
7106EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7107CPL	40	3½ Digit A/D (LED Drive)	10.95
7107EV/Kit	40	IC, Circuit Board, Display (Evaluation Kit)	46.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD.	10.95
7201IJS		Low Battery Volt. Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	14.95
7205EV/Kit	24	Stopwatch Chip, XTL (Evaluation Kit)	16.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit	16	Tone Generator Chip, XTL (Evaluation Kit)	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit	14	Freq. Counter Chip, XTL (Evaluation Kit)	8.49
7211IPL	40	4 Digit LCD Display Decoder/Driver (TTL compatible)	7.95
7211MIPL	40	4 Digit LCD Display Decoder/Driver (Microproc. compat.)	8.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	15.95
7215EV/Kit	24	4 Func. Stopwatch Chip, XTL (Evaluation Kit)	19.49
7216AIJI	28	8 Digit Univ. Counter C.A.	31.49
7216DIPI	28	8 Digit Freq. Counter C.C.	21.49
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	10.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	9.95
7226AEV/Kit	40	5 Function Counter Chip, XTL (Evaluation Kit)	99.95

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74HC HIGH SPEED CMOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74HC00	14	.59	74HC139	16	1.05	74HC245	20	2.59
74HC02	14	.59	74HC147	16	1.29	74HC251	16	.99
74HC03	14	.59	74HC151	16	.99	74HC253	16	1.09
74HC04	14	.59	74HC153	16	1.09	74HC257	16	.99
74HCU04	14	.69	74HC154	24	2.65	74HC259	16	1.69
74HC08	14	.59	74HC157	16	.99	74HC266	14	.89
74HC10	14	.59	74HC158	16	.99	74HC273	20	2.79
74HC11	14	.59	74HC160	16	1.39	74HC280	14	4.59
74HC14	14	.89	74HC161	16	1.39	74HC299	20	5.59
74HC20	14	.59	74HC162	16	1.39	74HC366	16	2.59
74HC27	14	.59	74HC163	16	1.39	74HC367	16	2.59
74HC30	14	.59	74HC164	14	1.35	74HC373	20	2.69
74HC32	14	.69	74HC165	16	2.15	74HC374	20	2.69
74HC42	16	1.09	74HC166	16	2.49	74HC390	16	1.59
74HC51	14	.79	74HC173	16	1.29	74HC393	14	1.59
74HC58	14	.79	74HC174	16	1.09	74HC533	20	2.69
74HC73	14	.79	74HC175	16	1.09	74HC534	20	2.69
74HC74	14	.79	74HC190	16	1.59	74HC595	16	3.19
74HC75	16	.99	74HC191	16	1.59	74HC688	20	3.59
74HC76	16	.79	74HC192	16	1.49	74HC4024	14	1.75
74HC85	16	1.49	74HC193	16	1.49	74HC4040	16	1.49
74HC86	14	.79	74HC194	16	1.19	74HC4049	16	.89
74HC107	14	.79	74HC195	16	1.19	74HC4050	16	.89
74HC109	16	.79	74HC221	16	2.95	74HC4060	16	1.49
74HC112	16	.79	74HC237	16	1.49	74HC4075	14	.59
74HC123	16	2.29	74HC240	20	2.29	74HC4078	14	.59
74HC125	14	1.75	74HC241	20	2.29	74HC4511	16	1.95
74HC132	14	1.29	74HC242	14	2.15	74HC4514	24	4.19
74HC137	16	1.59	74HC243	14	2.15	74HC4538	16	2.59
74HC138	16	1.19	74HC244	20	2.29	74HC4543	16	3.75

74C—C/MOS

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
74C00	14	.29	74C107	14	.79	74C240	20	1.95
74C02	14	.35	74C151	16	2.19	74C244	20	1.95
74C04	14	.35	74C154	24	3.25	74C373	20	2.29
74C08	14	.35	74C157	16	1.75	74C374	20	2.29
74C10	14	.35	74C160	16	1.19	74C901	14	.59
74C14	14	.59	74C161	16	1.19	74C902	14	.79
74C20	14	.35	74C162	16	1.19	74C903	14	.59
74C30	14	.35	74C163	16	1.19	74C906	14	.59
74C32	14	.39	74C164	14	1.39	74C907	14	.89
74C42	16	1.19	74C165	16	1.29	74C911	28	8.95
74C48	16	1.79	74C173	16	.89	74C912	28	8.95
74C73	14	.69	74C174	16	1.19	74C915	18	1.19
74C74	14	.59	74C175	16	1.19	74C917	28	8.95
74C85	16	1.39	74C192	16	1.39	74C922	18	4.49
74C86	14	.35	74C193	16	1.39	74C923	20	4.95
74C89	18	5.95	74C195	16	1.29	74C925	16	5.95
74C90	14	1.09	74C221	16	1.75	74C926	16	5.95
74C93	14	1.09				80C95	16	.69
74C95	14	1.19				80C97	16	.69

LINEAR

Part No.	Pins	Price	Part No.	Pins	Price	Part No.	Pins	Price
DS0026CN	8	1.95	LF355N	8	1.09	LM747N	14	.69
TL071CP	8	.79	LF356N	8	1.09	LM748N	8	.59
TL072CP	8	1.09	LM358N	8	.59	UA760HC		9.95
TL074CN	14	1.95	LM359N	14	1.79	LM1456V	8	1.95
TL081CP	8	.59	LM370N	14	4.95	LM1458CN	8	.59
TL082CP	8	1.19	LM373N	14	4.95	LM1488N	14	.69
TL084CN	14	1.95	LM377N	14	1.95	LM1489N	14	.69
LM109K		5.95	LM380CN	8	1.09	LM1496N	14	.99
LM301CN	8	.39	LM380N	14	.89	LM1605CK		9.95
LM302H		2.49	LM381N	14	1.79	LM1871N	18	2.95
LM304H		1.95	LM382N	14	1.49	LM1872N	18	3.25
LM305H		.89	LM384N	14	1.95	LM1877N-9	14	2.95
LM307CN	8	.45	LM386N-3	8	.89	LM1889N	18	1.95
LM308CN	8	.69	LM387N	8	1.39	LM1896N	14	1.59
LM309K		1.25	LM389N	18	1.19	LM2002T		1.95
LM310CN	8	1.75	LM391N-80	16	1.19	ULN2003A	16	1.49
LM311CN	8	.59	LM392N	8	.59	XR2206	16	3.95
LM312H		2.79	LM393N	8	.45	XR2207	14	2.49
LM317T		1.19	LF398N	8	3.95	XR2208	16	1.79
LM317K		3.49	LM399H		5.95	XR2211	14	2.95
LM318CN	8	1.59	LF412CN	8	1.95	LM2877P		1.95
LM319N	14	1.49	TL494CN	16	2.79	LM2878P		2.95
LM320K-5		1.35	TL496CP	8	1.59	LM2901N	14	.79
LM320K-12		1.35	TL497	14	1.79	LM2902N	14	.89
LM320K-15		1.35	NE540H (C540H)		2.95	LM2907N	14	2.49
LM320K-24		1.35	NE544N	14	1.95	LM2917N	8	1.95
LM320T-5		.85	NE550A	14	1.95	LM3900N	14	.59
LM320T-12		.85	NE555V	8	.29	LM3905CN	8	1.19
LM320T-15		.85	XR-L555	8	.69	LM3909N	8	.89
LM320T-24		.85	LM556N	14	.79	LM3914N	18	2.39
LM322N	14	1.49	NE558N	16	1.59	LM3915N	18	2.39
LM323K		4.95	NE564N	16	1.95	LM3916N	18	2.39
LM324N	14	.59	LM565N	14	.99	RC4136N	14	1.25
LM329DZ		.65	LM566CN	8	1.49	RC4151NB	8	1.95
LM331N	8	3.95	LM567V	8	.99	RC4193N	8	1.95
LM334Z		1.19	NE570N	16	2.95	RC4195TK		5.95
LM335Z		1.29	NE571N	16	2.49	LM4250CN	8	1.49
LM336Z		1.09	NE592N	14	1.19	NE5532	8	1.69
LM337MP		1.19	LM703CN	8	1.49	NE5534	8	1.39
LM337T		1.89	LM710N	14	.69	78L05A		.39
LM338K		6.95	LM711N	14	.79	78L12A		.39
LM339N	14	.69	LM723N	14	.49	79L05A		.59
LM340K-5		1.35	LM733N	14	.89	79M05AH		1.29
LM340K-12		1.35	LM739N	14	1.95	ICL8038	14	3.95
LM340K-15		1.35	LM741CN	8	.39	LM13080N	8	1.19
LM340K-24		1.35				LM13600N	16	1.19
LM340T-5		.75				75477	8	.99
LM340T-12		.75				75002	14	1.95
LM340T-15		.75				76477	28	3.95
LM340T-24		.75						
LF347N	14	1.49						
LM348N	14	.89						
LM350K		4.79						
LF351N	8	.49						
LF353N	8	.89						

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TRS-80 MODEL I, III

Each Kit comes complete with eight MM5290 (UPD416/4116) 16K Dynamic RAMs and documentation for conversion. Model 1: 16K equipped with Expansion Interface can be expanded to 48K with 2 Kits. Model III: Can be expanded from 16K to 48K using 2 Kits. Each Kit will expand computer by 16K increments.

TRS-16K3	200ns	(Model III)	$6.29
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TRS-80 COLOR AND COLOR II

Easy to install Kit comes complete with 8 each 4164N-20 (200ns) 64K Dynamic RAMs and documentation for conversion. Converts TRS-80 Color Computers with D, E, ET, F and NC circuit boards to 32K. Also converts TRS-80 Color Computer II to 64K. Flex DOS or OS-9 required to utilize full 64K RAM on all computers.

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Easy to install Kits come complete with TRS-64K-2 (8 ea 4164N-20 (200ns) 64K Dynamic RAMs). TRS-64K-2PAL (8 ea 4164's plus PAL chip) and documentation for conversion.

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TRS-64K-2PAL	Expands Model IV (w/Black & White Monitors Only) from 64K to 128K	$29.95

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Easy to install module plugs right into the socket increasing memory in 8K increments. Complete with module and documentation for installation.

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NEC8KR	(NEC PC-8201A & Olivetti M10)	$39.95 ea. or 3 for $99.95

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NEW! Easy to install module plugs right into the socket increasing memory in 24K increments. Complete with module & documentation for installation.

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Intelligent 300/1200 Baud Modem with Real Time Clock/Calendar

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PM1200 RS-232 Stand-Alone Unit **$299.95**

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PMO-64K	(Options Processor Memory – 64K)	$ 8.49
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DATA BOOKS

30009	Intersil Data Book (1984). Complete Line (965 pages)	$9.95
30013	Zilog Data Book (1984). Microprocessors and Support Chips (849 pages)	$9.95
210830	Intel Memory Components Hndbk. (1983/84). Contains all Applications Notes, Article Reprints, Data Sheets & other design information on Intel's RAMs, DRAMs, EPROMs, E²PROMs and Bubble Memories (880 pages)	$14.95
230843	Intel Microsystem Components Hndbk. (1983/84). Contains Data Sheets on all of Intel's Microprocessors & peripherals – 2 volumes (2575 pages)	$19.95
30022	National Logic Data Book Set (1984). Volumes I & II (3485 pages). Contains information on National's TTL product line and CD4000 family. This includes 7400, 74L, S, AS, LS and ALS Series devices, and MM54HC / 74HC / 54HCT / 74HCT High Speed Micro CMOS family, MM54C / 74C family and CMOS LSI / VLSI	$24.95

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Key: a = Apple II or II+ b = Apple //e

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The ARC-16K RAM Card allows the Apple* II and II+ computers to expand from 48K to 64K. Complete with instructions. Key: (a)

ARC-16K **$39.95**

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The AZ80-1 is Soft-card compatible. Used with CP/M related programs. Software not included. Key: (a,b)

AZ80-1 . . . . **$49.95**

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The A80-C is an 80-column card designed for the Apple* II and II+ computers. The card is equipped with a soft switch which allows easy hookup for any monitor. The A80-C also features inverse video capabilities. This card is similar to the Videx*** 80 column card. Complete with instructions. Key: (a)

A80-C **$74.95**

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The ASSC-P is a serial card with a printer mode. It generates standard RS-232C signals and is similar to the Apple* Super Serial Card. Complete with instructions. Key: (a,b)

ASSC-P **$99.95**

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The APC-64K is a parallel graphics printer card with a 64K buffer and graphic dump capabilities. Complete with instructions. Key: (a,b)

APC-64K **$129.95**

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APPLE™ Compatible 5¼" Half-Height Disk Drive

· Uses Chinon Pinch-type mechanics · 143K formatted storage · 35 tracks · Super quiet · Works with Apple Controllers or other compatibles (ACC-1) right · Complete with connector — just plug into your controller · Size: 5¾"W x 1⅝"H x 8"D · Wt.: 4 lbs. Key: (a,b)

ADD-12 . . . . **$129.95**

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ADD-514	(Disk Drive)	$149.95
ACC-1	(Controller Card)	$ 49.95

APPLE™ //c Compatible 5¼" Half-Height Disk Drive

· Same specs as ADD-12 (left) except no controller necessary.

ADD-IIc **$129.95**

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APF-1	Cooling Fan with surge protection · Key: (a,b)	$ 39.95
JE614	Numeric/Aux. Keypad – 23 accessible functions · Key: (b)	$ 49.95
EAEC-1	Expanded Apple Enclosure Case only · Key: (a)	$ 49.95
KHP4007	Switching Power Supply · Key: (a)	$ 59.95
KB-A68	68-Key Apple Keyboard only · Key: (a)	$ 69.95
MON-12G	12" Green Monitor with swivel stand · Key: (a, b & //c)	$ 79.95
JE520AP	Voice Synthesizer – Plug-in, User Ready · Key: (a,b)	$119.95
KB-EA1	Apple Keyboard and Case · Key: (a)	$119.95
PM1200A	Prometheus Internal Modem – 2 cards · Key: (a,b)	$299.95
PM1200M	Prometheus Macintosh Ext. Modem · Key: (Macintosh)	$369.95

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Power/Mate Corp. REGULATED POWER SUPPLY

· Input: 105-125/210-250VAC @ 47-63Hz · Line regulation: ±0.05% · Three mounting surfaces · Overvoltage protection · UL recognized · CSA certified

Part No.	Output	Size	Weight	Price
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· Ideal for disk drive needs of CRT terminals, microcomputers and video games · Input: 115/230VAC, 50/60Hz · Output: +5V @ 5A, +12V @ 1.8A, +12V @ 2A, −12V @ 0.5A · UL recognized · CSA certified · Size: 7⅜"L x 6-3/16"W x 1⅝"H · Weight: 2 lbs.

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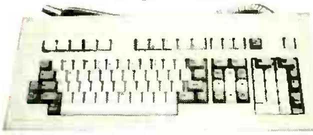

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Additional Add-Ons Available!

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IBM PC AT

Each kit comes complete with nine 128K dynamic RAMs and documentation for conversion.

IBM128K (Nine 250ns 128K RAMs) **$79.95**

IBM PCXT Equivalent 130 Watt Power Supply

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· Input: 110V @ 60Hz · Output: +5VDC @ 15A, −5VDC @ 0.5A, +12VDC @ 4.2A, −12VDC @ 0.5A · Plug compatible connectors · Fits into IBM PC · Weight: 6 lbs.

IBM-PS **$119.95**

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The ProModem 1200B/BS is a 1200/300 baud modem card which plugs into IBM PC and XT. Provides a third serial Comport. Two versions available: 1200B (without software) and 1200BS (with software). The PM1200BS is supplied with powerful MITE communications software from Mycroft labs.

PM1200B	(without Software)	$239.95
PM1200BS	(with MITE Software)	$274.95

IBM Compatible! DISK DRIVES

Documentation Included

RFD480	(Remex 5¼" DS full-ht.)	$ 79.95
FD55B	(Teac 5¼" DS half-ht.)	$119.95
SA455	(Shugart 5¼" DS half-ht.)	$109.95
TM100-2	(Tandon 5¼" DS full-ht.)	$129.95

5¼" DISK DRIVE ENCLOSURES

Complete with power supply, switch, power cord, fuseholder and connectors

DDE-1FH	(Houses 1 full-ht. 5¼" floppy drive)	$ 69.95
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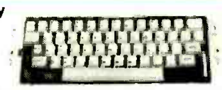
General Application Keyboards

Mitsumi 54-Key Unencoded All-Purpose Keyboard



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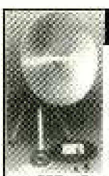

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(from page 9)

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CableMaster controls converter boxes by transmitting infrared commands to converters that have IR control. Also, simply by changing one plug-in "personality module," the same CableMaster unit can be used with many different converters. One module is supplied with the CableMaster; others can be purchased separately.

Currently, CableMaster can be purchased with personality modules for Jerrold, Oak and Zenith converters. Others for Regency, Scientific-Atlanta, Hamlin, Pioneer, Sylvania, Magnavox, Tocom and other converters should be available by the time you read this. $139.90 for CableMaster; $29.95 for each additional personality module.

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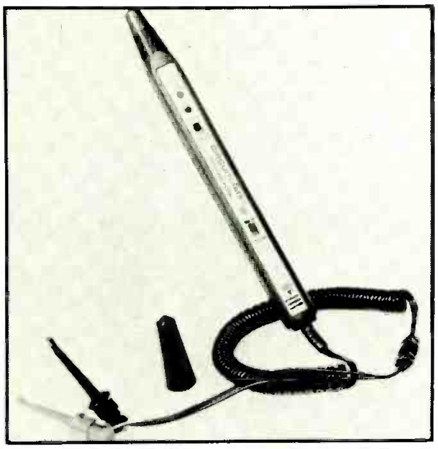

troubleshooting capability for less than traditional 10-MHz probe prices. The LP25 is designed to measure TTL, DTL, RTL, MOS, CMOS and NMOS logic levels at speeds up to 25 MHz. Additionally, it can detect pulses of as small as 30 nanoseconds in duration and has a pulse memory feature to capture single-occurrence pulses for visual indication. A unique LED/tone indicator system makes it easy to discern what the input is doing, and the tone output relieves the user of the necessity of monitoring the LEDs as he is tracing a circuit.

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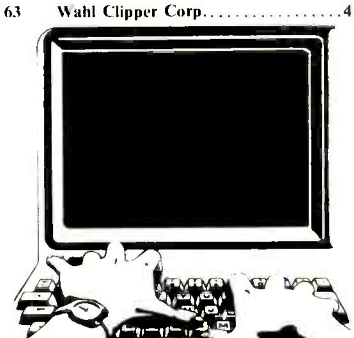

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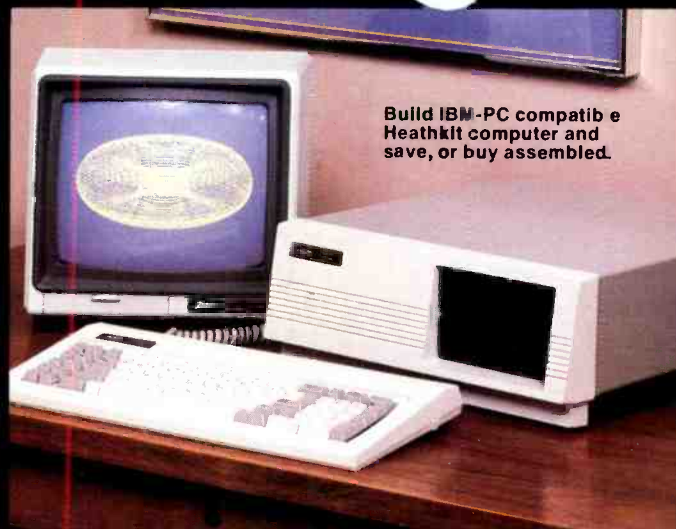

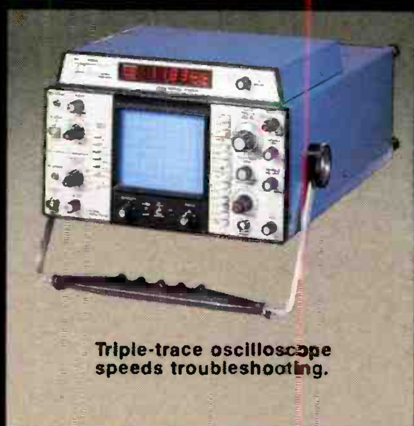

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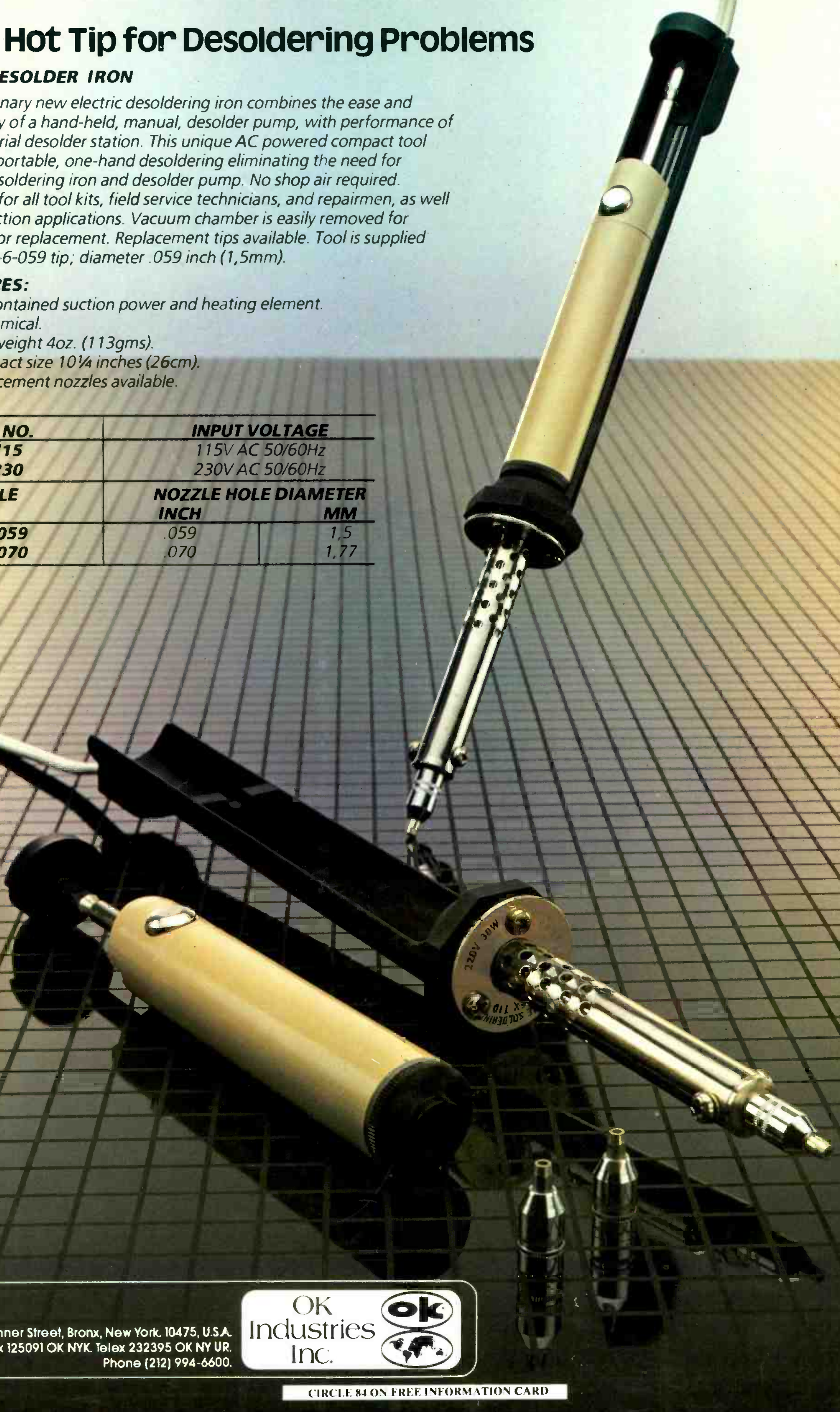

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