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# MODERN ELECTRONICS™

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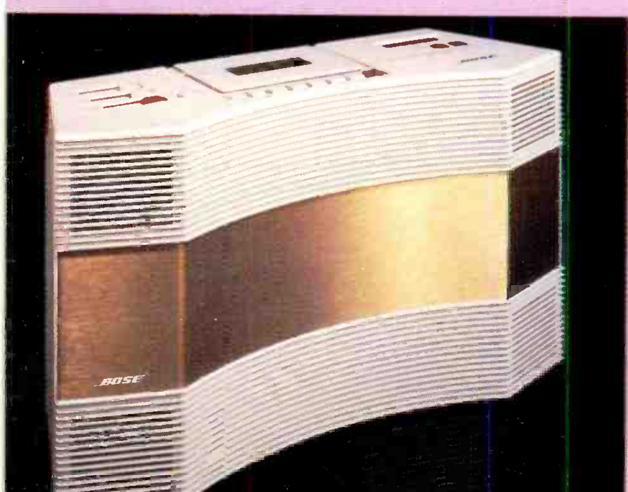
THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

- MAKING PRINTED-CIRCUIT BOARDS . . . THE EASY WAY!
- BOSE'S NEW MINIATURE MUSIC SYSTEM . . . BREAKS SPEAKER-SIZE BARRIER!

Heath's real-time audio spectrum analyzer (p. 18)

- Build an Automatic LED Street-Address Number
- Fine-Tune Your Home/Car Audio System with a Portable Spectrum Analyzer
- Phone Device Thwarts Unwanted Callers
- The Commodore Plus/4 Computer . . . How "Plus" Is It?
- Designing DC Power Supplies




Bose breaks speaker size barrier (p. 26)

Commodore's Plus/4 . . . is it really a "plus"? (p. 36)

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Plus: ● Testing RCA's New VKP900 Videocassette Recorder ● Experimenting with a Universal Active Filter ● Shortwave English-Language Broadcasts ● Don Lancaster's "Hardware Hacker" ● Latest News in Electronics and Computers

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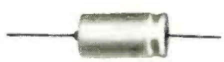

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| 1k | 271-1321 |
| 1.8k | 271-1324 |
| 2.2k | 271-1325 |
| 3.3k | 271-1328 |
| 4.7k | 271-1330 |
| 6.8k | 271-1333 |

| Ohms | Cat. No. |
|---|---|
| 10k | 271-1335 |
| 15k | 271-1337 |
| 22k | 271-1339 |
| 27k | 271-1340 |
| 33k | 271-1341 |
| 47k | 271-1342 |
| 68k | 271-1345 |
| 100k | 271-1347 |
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| 470k | 271-1354 |
| 1 meg | 271-1356 |
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| Type | Volts | Current | Cat. No. | Each |
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| Miniature | 25.2 | 300 mA | 273-1386 | 3.49 |
| Miniature | 12.6 CT | 450 mA | 273-1365 | 3.59 |
| Miniature | 25.2 CT | 450 mA | 273-1366 | 3.99 |
| Standard | 6.3 | 1.2 A | 273-1351 | 3.99 |
| Standard | 12.6 CT | 1.2 A | 273-1352 | 4.99 |
| Standard | 25.2 | 1.2 A | 273-1353 | 5.99 |
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CT = Center Tap

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| 7812 | +12 VDC | 276-1771 | 1.59 |
| 7815 | +15 VDC | 276-1772 | 1.59 |
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| 7912 | −12 VDC | 276-1774 | 1.59 |

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| PN2484 | NPN | 276-2010 | .89 |
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| TIP3055 | NPN | 276-2020 | 1.59 |
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| 2N3053 | NPN | 276-2030 | .99 |
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| TIP120 | NPN | 276-2068 | 1.29 |
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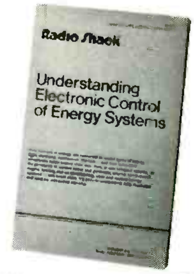
| 2N4401 | NPN | 276-2058 | .59 |
| MPSA06 | NPN | 276-2059 | .59 |
| MPSA13 | NPN | 276-2060 | .59 |
| MPSA42 | NPN | 276-2061 | .69 |
| 2SC945 | NPN | 276-2051 | .79 |
| 2N3819 | N-FET | 276-2035 | .99 |
| MPF102 | N-FET | 276-2062 | .99 |
| IRF511 | V-FET | 276-2072 | 2.59 |
| IRFD1Z3 | V-FET | 276-2073 | 1.49 |
| 2SC1308 | NPN | 276-2055 | 7.95 |

### Understanding Electronic Control of Energy Systems




Learn how modern electronics and computers are used to control electric motors, generators, internal combustion engines, heating and air conditioning, solar systems and nuclear energy. Easy to understand, fully illustrated. 272 pages.
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| DPDT | 275-652 | 2.39 |
| DPDT Center-Off | 275-653 | 2.49 |

### Communication ICs SALE!

| Type | Cat. No. | Reg. | SALE |
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| MC1330 Video Detector | 276-1757 | 1.99 | 1.29 |
| MC1350 IF Amplifier | 276-1758 | 1.99 | 1.29 |
| MC1358/CA3065 FM Detector | 276-1759 | 1.79 | 1.19 |
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### Melody-Maker IC SALE!

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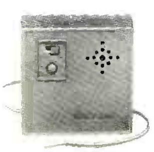

Circuit continuity produces a warbling tone. Possible uses: doorbell, security, capacitor/diode checker, more. Operates from 9V transistor battery. A great experimenter's item at a bargain price!
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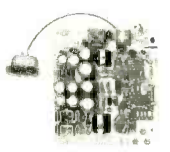

A compact switching power supply for an incredible 44¢ a watt! Input: 18 VAC (use our #273-1515 transformer). Outputs: 12 VDC at 400 mA, +5 VDC at 1.1 amp, −5VDC at 200 mA. Compare our low price! **277-1016** . . . . . . **4.95**

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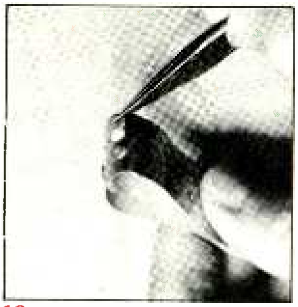
# MODERN ELECTRONICS

THE MAGAZINE FOR ELECTRONICS & COMPUTER ENTHUSIASTS

**MARCH 1985** — **VOLUME 1, NUMBER 6**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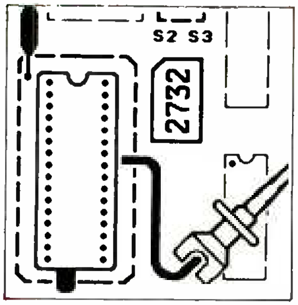

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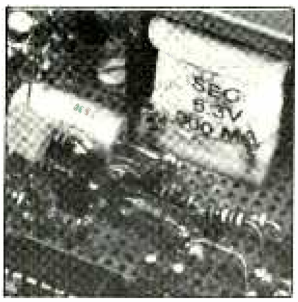
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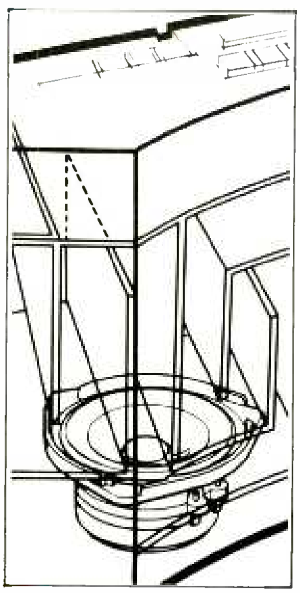
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## FEATURES



## PRODUCT EVALUATIONS



## DEPARTMENTS

# EDITORIAL

## *The Age of Consumer Electronics*

Reflecting on the enormous size and scope of the recent Consumer Electronics Show in Las Vegas, we're surely in a consumer age of electronics now. Whereas one product area or another seemed to be "hot" at these previous trade shows, the sheer volume of brands and models in each product category underscores this.

This winter show, which is followed in June by an even bigger one, featured more than 1,400 exhibitors spread over some 800,000 net square feet of floor space. Too much for any one person to cover and digest, of course. Nevertheless, it was clear that there will be many mid-year introductions of new models.

The Electronic Industries Association Consumer Electronics Group revealed some interesting estimates of household penetration of consumer electronic products. Leading the products that people have in their homes are, not surprisingly, radios (98%), color TV (91%), and audio systems (81%). In the latter category, audio components account for 37%. Home computers are estimated to be in 13% of U.S. homes as of January 1985, while VCRs are in 17% of homes.

Factory sales of consumer electronics products in dollars are expected to increase $2.1 billion in 1985 to $24.9-billion as compared to 1984's projected $22.8-billion. Videocassette recorders are among the rising stars, increasing in dealer sales in units from 1983's 4.09-million units, to 1984's projected 7.3-million, to 1985's estimated 9.5-million. Compact disc player sales are burgeoning, too, with a projected 225-thousand units sold to dealers in 1984 and 400-thousand expected in 1985. Home computers show a steady rise, from 4.8-million units in 1983, to 5.1-million in 1984, to an expected 6-million machines in 1985 with an average factory dollar value of $500 per unit.

There are losers, too, namely programmable video games. They dipped from a high in 1982 of 8.2-million units to anticipated 1985 sales of 2-million. This product area is joined by videodisc players, with an anticipated drop from a 1983 high of 307-thousand to a 1985 estimate of 130-thousand machines.

Next month we'll examine some of the more sparkling new electronic products that will soon be coming up for sale, as well as exploring promising trends in the electronic and consumer marketplace.

Art Salsberg

# LETTERS

### Y Before K Except After . . .

• Your November 1984 issue arrived. In the editorial on "The TV Tube" you made much of Vladimir Zworykyn developing the electronic TV camera for RCA. There is no argument that RCA labs headed by Zworykin had made a lot of progress developing electronic TV, but actually, Philo T. Farnsworth, a brilliant young man with limited formal engineering education and finances, was ahead of RCA and Zworykin in developing all-electronic TV. Farnsworth was granted almost all the basic TV patents and RCA was forced to pay royalties to him.

Also, spell your subject's name correctly, which is Zworykin and not Zworkyn.

Ray L. DeVault
Sacramento, CA

*Farnsworth was indeed a major figure in the development of electronic television. Zworykin's contribution, however, eliminated the need for a mechanical spinning wheel at the broadcast-station end. The accompanying photograph with Dr. Zworykin and myself was taken when he was 92 years old. Your spelling correction is duly noted.—Ed*

### Thanks And Corrections

•Thank you for the great job you did editing my article on constructing a "Digital Humidity Control" that appeared in the January 1985 issue. However, a few errors worked their way into the schematic diagram on page 49. Capacitor *C6* should be listed at *C4*, a 0.15-$\mu$F disc. Also, *C5* connected to pin 12 of *IC4* should be labeled *C6* (its 0.33-$\mu$F value is correct), and *IC3* and *IC4* are incorrectly type labeled on the schematic (they're correctly identified in the Parts List).

Eugene Weber
Hinsdale, IL

### Fan Letters

• I am glad a magazine such as yours "hit the racks." I would like to see more construction articles and less of equipment reviews.

James Mulcahy
Pemberton, NJ

• Please send me one year of *Modern Electronics* at charter member price. I used to enjoy *Popular Electronics*, and your new magazine looks like a good replacement.

Harold D. Somerville
Stow, Ohio

# MODERN ELECTRONICS NEWS

**DISCOURAGING THEFT.** More and more electronic and computer equipment is being stolen from homes and offices than ever before. An interesting concept to discourage this, called the "Kaish Circuit Lockout," is designed for use with microprocessor equipped electronic products. Offered to manufacturers under licensing, it prevents product operation when the power source is removed unless a personally selected code written into a ROM is entered. With about one-trillion possible combinations, the code is unlikely to be broken. The company that holds the patent, International Electronic Technology Corp., Far Rockaway, NY, also markets "K-Safeguard," an expansion board to prevent unauthorized access to IBM PC, PC XT, and PC clones, among other personal computers. A set of switches on the card permits an authorized user or supervisor to set up a code of up to eight digits. After six unsuccesful attempts to break the code are made, a loud alarm sounds for 15 minutes. If power is removed, the alarm resumes upon power up.

**VCR SALES SURGE CONTINUES.** Retailers continue to show great optimisim on sales prospects for VCRs as they continue to set buying records. Units bought by dealers in the first 11 months of '84 hit 6,322,418, which is an 81.2% rise to date as compared to 1983 figures. November's rise was 85.4%.

**THE YEAR OF 32-BIT COMPUTERS.** Will 1985 see home computers with 32-bit CPUs challenge 8- and 16-bitters? Commodore is expected to launch one for less than $1,000, bypassing a step up from 8-bit to 16-bit machines. That is, if Atari doesn't hold them up on an Amigo design that they claim they have some rights to. Atari, too, is readying a 68000-CPU machine, called, tongue-in-cheek, the "Jackintosh." It's said to be a Macintosh-like computer with color, and company president Jack Trameil pins future growth of Atari on the machine's success. Sinclair Research is said to be bringing in its QL machine, so successful in Great Britain, at $500. It uses Motorola's 68008 microprocessor.

**NEW RADIO-SPECTRUM OFFERINGS.** The FCC plans to parcel out parts of the 800-900 MHz frequency spectrum presently reserved. Twelve MHz will go to expand the growing cellular-radio services, while 8 MHz will be going to mobile satellite systems for use in rural areas.

**TESTING STANDARDS BOOK.** ASTM (American Society of Testing and Marterials) has put together more than 200 standard procedures on testing pratices, specifications, and definitions for electronic devices. It's all in Volumes 10.04 and 10.05 of the Annual Book of ASTM Standards, with more than 1,500 pages combined. For ordering, call 215-299-5585.

**CRT BLACK IS BETTER.** So says Sony when it boasts about the new darkened glass of its new Trinitron picture tube. Called the "Microblack" screen, Sony claims it provides better picture contrast. Its new XBR-series color TV sets also incorporate a unique color temperature control that permits users to change from warmer tones, such as reddish whites, to cooler tones, such as bluish whites. The TV receivers come in designer colors, too, including beige or plum. Whatever turns you on. ME

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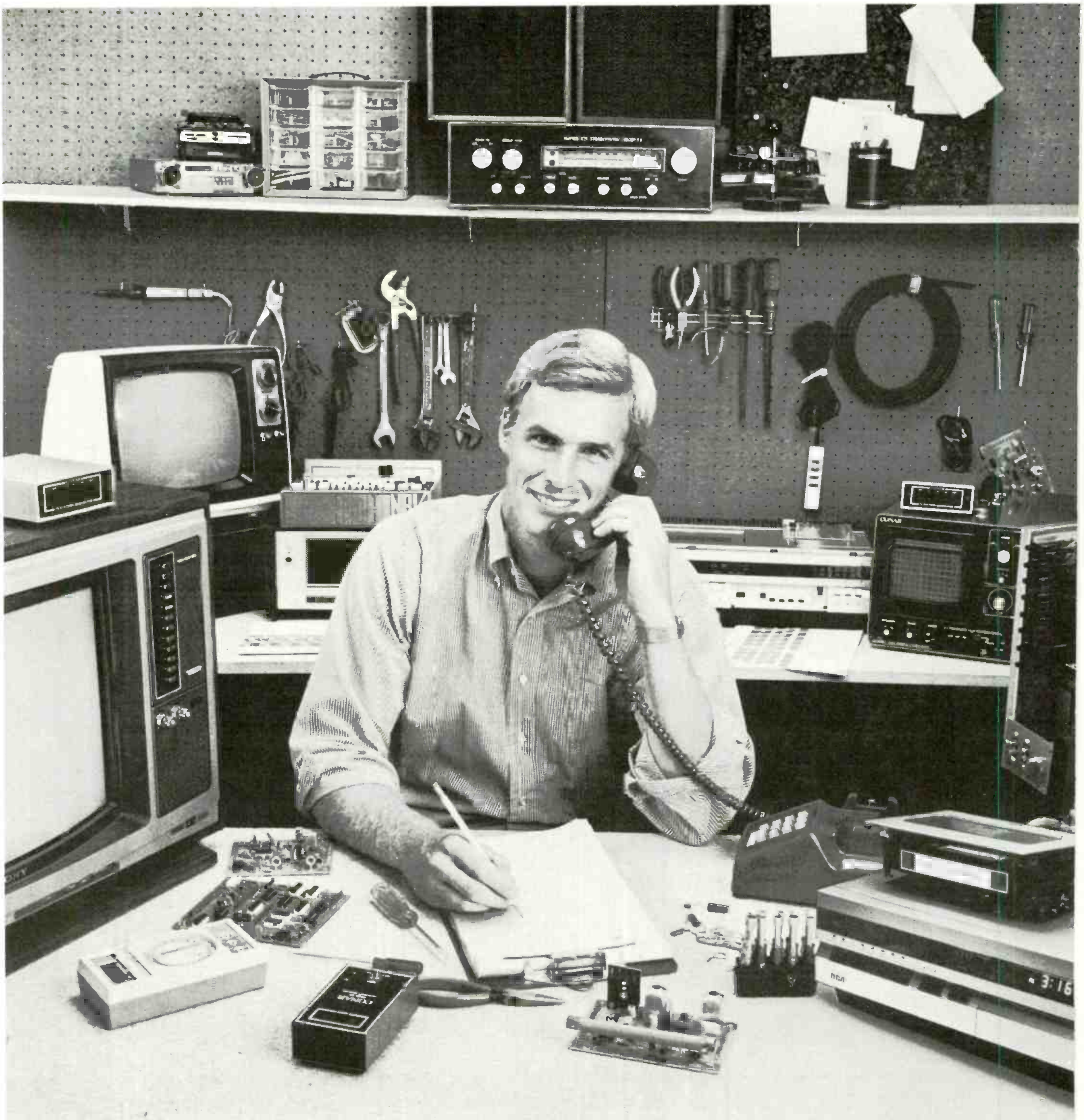

*For more information on products described, please circle the appropriate number on the Free Information Card bound into this issue or write to the manufacturer.*

## *Lap-Size Computer With Desktop Power*

Among the Sord Model IS-11C battery-powered lap computer's desktop-like features is a large 25-line by 80 character LCD screen that offers multi-window, 640 × 200-pixel alpha character display capability. The computer's other standard features include: a Z80A microprocessor operating at 3.4 MHz; 80K of RAM (expandable to 144K with an optional 64K RAM cartridge); 72K of ROM preprogrammed with word-processing and business software; a variety of interfaces; a full-travel keyboard with six function keys; a 128K capacity microcassette deck; and a real-time clock. Interfaces include RS-232C serial, parallel, Centronics-compatible printer, numeric keypad, barcode reader, and ROM cartridge ports. The built-in word processor is said to be a full-featured program that provides 14 advanced commands, including copy, move, search, replace and underline.

Options currently available include both hardware and software. In hardware, there are a 40-character-per-line thermal printer, a numeric keypad with 12 additional function keys, a barcode reader, a 3½", 1M-capacity micro-floppy disk drive, and a mouse. In the software (in ROM cartridge), there are database/spreadsheet/graphics, BASIC interpreter, transfer/format conversion, and time-sharing system packages.

The computer measures 11¹³⁄₁₆"W × 8⁷⁄₁₆"D × 3⅜"H and weighs 6 lbs. 6 ozs. $1495.

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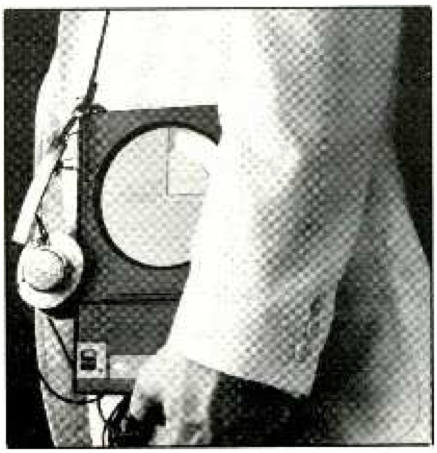
## *Portable CD Player*

Having been a long-time leader in the personal portable tape-player marketplace with its Walkman line of products, Sony has now broken new ground with a personal portable Compact Disc (CD) player. The Model D-5 CD player brings to portable listening the sonic qualities of the tabletop/rack component in a much more compact, lightweight, and battery-powered unit. The player is built around a semiconductor laser pickup and sophisticated mechanical driving system. It features an Automatic Music Sensor that makes it easy to locate and play selections by scanning forward and backward until the desired selection is located. Its Music Search feature provides high-speed sampling of the music at normal pitch to allow you to review a disc's contents and find any portion of the desired selection. An LCD window displays battery condition, track being played, elapsed time, number of tracks remaining, and time remaining on the disc. The Model D-5 player can also be plugged into a home hi-fi system.



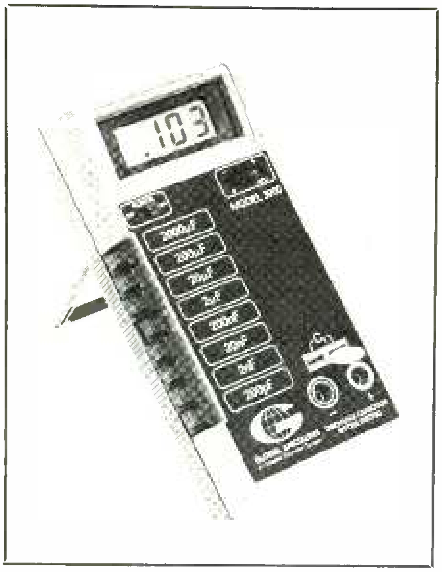
The Model D-5 player delivers a 20-to-20,000-Hz frequency response (−3 dB) at less than 0.008% THD. Dynamic range is rated at more than 90 dB, S/N at more 85 dB, channel separation at more than 85 dB, and below measurable limit wow and flutter. There are both headphones and line outputs, and power can be from six C cells or an ac power adapter supplied with the player. Playing time with fresh alkaline cells is rated at 5 hours. Headphones are optional extras.

The player measures 5¼"D × 5"W × 1½"H and weighs 1 lb. 5 oz. $299.95.

CIRCLE NO. 125 ON FREE INFORMATION CARD

## *Hand-Held Digital Capacitance Meter*

A digital capacitance meter designed to be equally at home on a service bench and in a field-service tool caddy has been introduced by Global Specialties. The Model 3000 is a battery-powered, hand-held portable instrument that can measure capacitances in eight switch-selectable decade ranges from 1 pF to 2000 μF full-scale. Measurement readings appear in a 3½-digit liquid-crystal display (LCD) window. Specified accuracy is up to 0.2% of reading. In addition to the usual 0.5" numeric display, the capacitance meter features annunciators that indicate low-battery and excessive compensation of stray capacitance conditions. A zero-adjust control is provided for nulling stray and incidental capacitance.



Power for the meter is provided by a single 9-volt battery. A collapsable tilt stand swings out from the rear of the instrument to position the display at a comfortable viewing angle on the test/service bench. $139.95.

CIRCLE NO. 126 ON FREE INFORMATION CARD

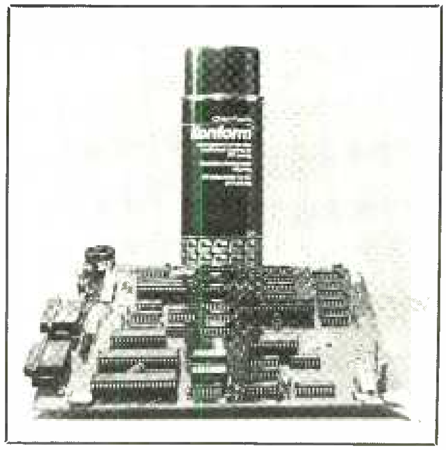
## *Add An Intercom To Your Telephone*

Phone-tercom™ from Ameriphone converts existing single- and two-line home and office telephones into a personal communications network by adding an intercom capability. The device works with both rotary- and pushbutton-dial telephones. It allows you to place calls from one station to another. Incoming calls can be transferred from one extension to another in the network. Additionally, a convenience feature lets you put a call on hold at one telephone so that you can resume a conversation on any other extension. Phone-tercom also lets you set up three-way conference conversations and even silence the telephone when you do not want to be disturbed. Installation is easy. No special wiring or special telephone instruments are needed to install the FCC-approved accessory. You just plug it in and it is ready to use. $34.95.

CIRCLE NO. 127 ON FREE INFORMATION CARD


## *Conformal Aerosol Coating*

Konform from Chemtronics is a clear aerosol silicone/electroplastic-based conformal coating designed to protect rigid and flexible printed-circuit assemblies, thick-film circuits, and individual electronic components. By spraying Konform on a circuit or assembly, you can protect it against such environmental stresses as humidity, salt, sulphur, dust, fuel, corrosive vapors and fungus. The coating remains flexible from $-85°$ to as high as $+390°F$ $(-65°$ to $+200°C)$. It has a dielectric strength of 1100 volts/mil and a water-vapor transmission of 0.013. A 2-mil coating of Konform dries tack-free in about an hour and completely cures in 24 hours. The coating can be removed, totally or partially, with 111 trichlorethane to permit repairs of circuits and assemblies. Availability is in 16-oz. aerosol cans and in 1-gal. (concentrated) size containers.

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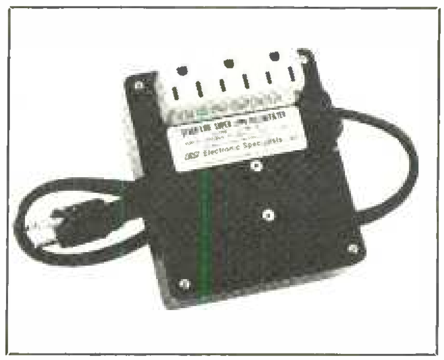


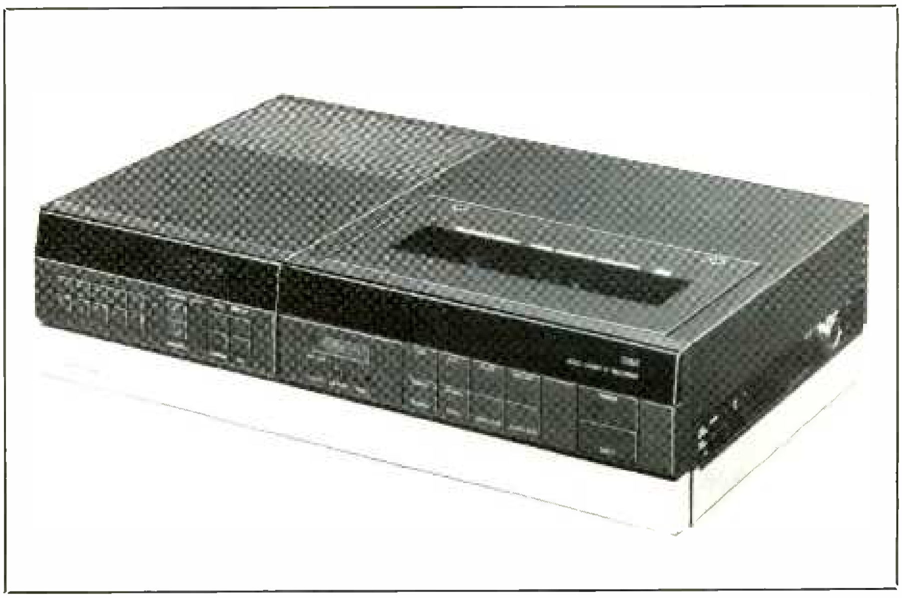
## *Power-Line Filter/Suppressor*

Almost everything electronic, from personal computers to home video systems, requires a clean ac power source nowadays. While it is unfortunate that the modern ac line is electrically noisy, there is something you can do about it. One product de-

*(Continued on page 83)*

**Video**

## *A contemporary ultimate in VHS VCRs:*
# *RCA's VKP900 SelectaVision Convertible*



**Not all VCRs** are created equal. Some are created more equal than others, an example being RCA's new Model VKP900 SelectaVision convertible tested for this report. This exceptional VHS-format videocassette recorder features just about everything currently devised for VCRs, except futuristic BTSC-dbx multichannel TV sound.

Advertised as a "convertible," that's precisely what the VKP900 becomes when the recorder unit is removed from its tuner/timer-connected flatbed docking cradle (no screws or nuts here). Just drop in a battery pack and mate a "Small-Wonder" MOS image-sensor (no tube) video camera to its 9-pin connector, and you're ready to shoot home movies. Battery and recorder together weigh just 7.9 lbs., and the Model CKC020 camera adds another 35 ounces, plus its long tether cable.

The video camera has automatic iris control with manual override, a VHS compatibility switch, automatic white balance, and an illuminated 1" see-through black-and white electronic viewfinder. Displayed in the viewfinder are not only the working image, low light conditions, and battery-charge state, but it also permits quick review of the final three seconds of any recorded scene. It does all this with good effect and without either lag or the high signal whiteout common to most tube-type consumer video cameras.

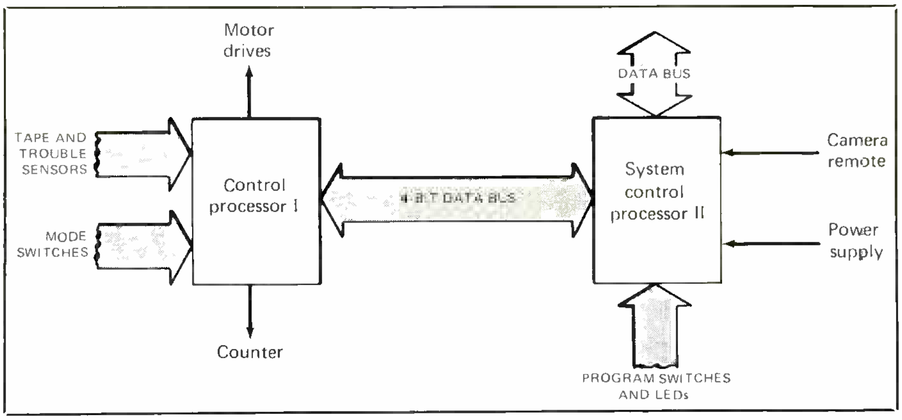
For program scheduling, keeping time, channel selection, infrared remote control, and ac/dc power supply, you need the companion tuner/timer, with its simplified programming and menu display on the receiver's screen. Once you've used the remote-controlled timing and programming functions from the comfort of your easy chair, the pampering process is irreversible, especially since it's completely protected against power outages for up to an hour at a time. What's more, you don't even have to squint to see the programming, especially on large-screen TV receivers.

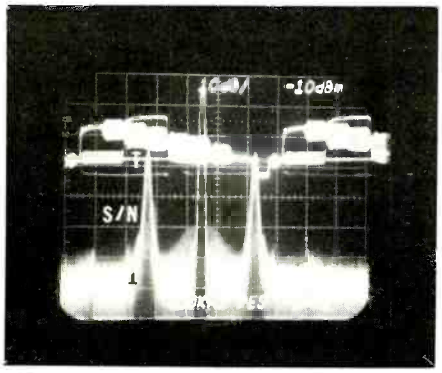
Recorder, tuner/timer and remote-control units have so many outstanding features they'll have to be identified individually before collective examination and performance analysis are undertaken. But be aware that the cost of this system isn't in the "economy" category. Suggested selling price of the Model VKP900 VCR is $1,295. The excellent companion Model CKC020 video camera will cost you an additional $1000.

### *The Recorder Unit*

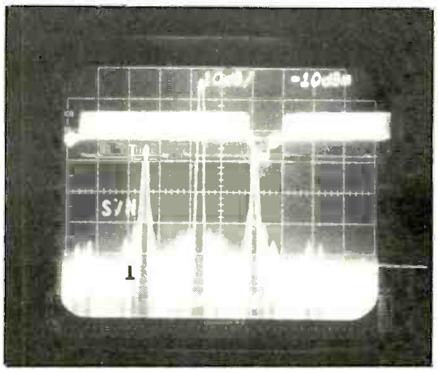
Like other carry-along portables, the Hitachi-made recorder unit can be operated fully independent of the

*The major circuit elements of the RCA VKP900 VCR are the dual microprocessors that control all operating functions under user command.*

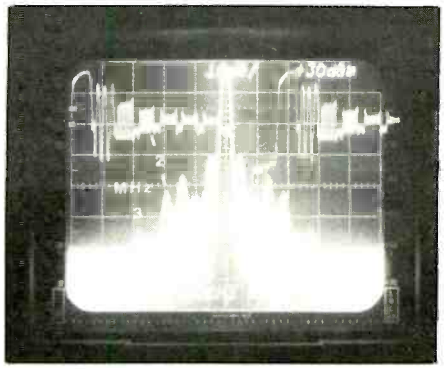




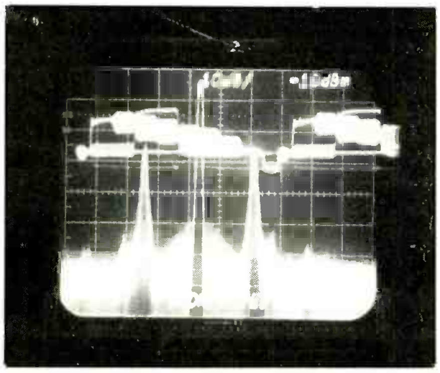

*Fair NTSC color bars and excellent 43 dB S/N ratio are apparent in SP.*



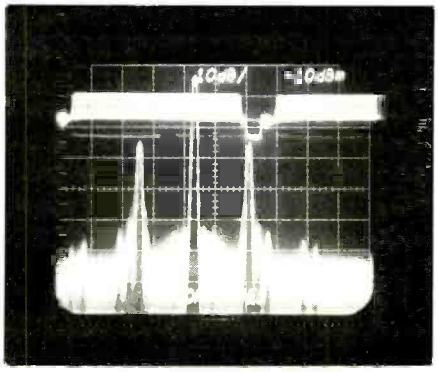

*Analyzer display shows that red field maintains 43 dB S/N ratio in SP.*



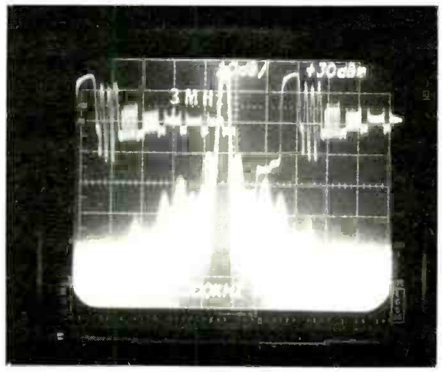

*Multiburst is adequate to 2 MHz but falls off rapidly afterwards in SP.*



*Tests reveal that SLP color bars are little different than those in SP.*

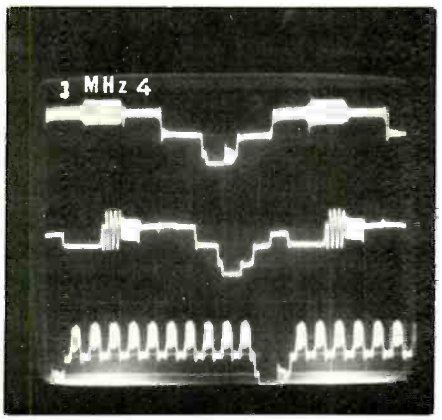



*Almost identical red-field displays were obtained in both SLP and SP.*

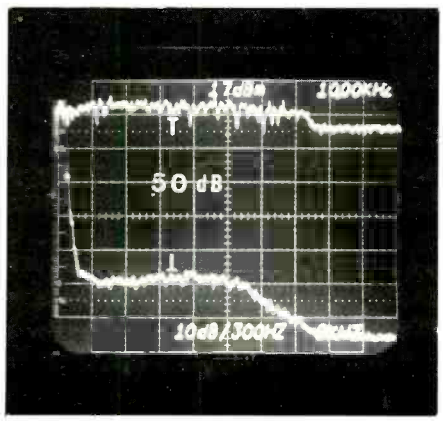



*Low-frequency multiburst is noisier, has less amplitude in SLP than in SP.*

tuner/timer and ac line simply by dropping in a rechargeable battery pack and connecting a video camera. This unit has the usual complement of transport controls, including an SP/LP/SLP (standard play/long play/super-long play) switch, tape speed TRACKING control, cassette EJECT button, and STOP, PLAY, PAUSE, RECORD, REWIND/SEARCH, F FWD/SEARCH keys. Additionally, there are a POWER switch, VIDEO DUB and AUDIO DUB buttons, channels 3/4 input selector switch, 12-volt dc input jack, left and right microphone input jacks, phone jack, noise-reduction switch, and an electronic counter with MEMORY and RESET switches. Rounding out the recorder unit's fea-




*Swept-chroma (top), multiburst (center) and gated-rainbow color-bar (bottom) traces reveal the usual videocassette recorder losses that occur at high frequencies.*




*Mono response (upper trace) continues out to about 80 kHz, while stereo (lower trace) sags a little beyond 12 kHz. L-R separation, however, is enormous.*

tures are four input connectors (not including the 26-pin connector that docks it with the companion tuner/ timer unit), one audio and two tracking and speed selectors, and the battery compartment.

Most of the recorder unit's features are self-explantory. The exceptions are as follows. The VIDEO and AUDIO DUB buttons permit video or audio override of any portions of previously recorded tape. The phone output is for either ear- or headphones, while the microphone inputs are used when audio dubbing. During playback, if you wish, you can engage a noise-reduction system to reduce tape hiss and excessive noise. There are even two hidden but accessible screwdriver controls for adjusting jitter in the pause mode when operating on the SP and SLP speeds.

## *Tuner/Timer Unit*

Virtually all the VKP900's versatility is built into the tuner/timer unit. Front and rear panels are loaded with more than enough bells and whistles to excite the most avid videophile.

On the front panel you'll find the tuner/two-channel audio/camera switch and the programmable add/ erase channel select and up/down channel scan controls. The usual 1 through 0 direct-address channel selector keys; timer lamp; dimmer switch, VCR, display, charge and XPR buttons; and the infrared remote-control receptor are also included here.

On the rear panel are the usual uhf and vhf 75- and 300-ohm r-f inputs and outputs, an auxiliary battery charge input, a 6-pin cable jack, a 300-watt, 120-volt ac accessory receptacle, and paired left and right audio and companion video input and output jacks. Finally, on the recorder's side, you'll find a unified normal/remote switch and a normal/ CATV/H.R. C2 TV cable switch.

The display switch summons up either tuned-channel number or time of day. A nice touch is that the TV/ VCR indicator switch has a LED that glows when the VKP900 is in the VCR mode. Incoming signals are displayed via video or channel 3 or 4 r-f on the TV receiver's screen. A timer indicator also lights in the timed mode. To recharge either the recorder or the auxiliary battery, you simply press a CHARGE switch. The XPR switch handles unattended recordings of certain periods without special programming.

## *Infrared Remote Controller*

Except for channel memory and tuner/audio/camera switching, almost all programming is accomplished with 32 keys on the 4¾"L × 4½"W × 1"D hand-held silver and black plastic and aluminum keypad of the remote-control transmitter. The usual up/down and direct-address channel keys are there, as are the VCR/TV switch and PLAY, PAUSE, STOP, RECORD, REWIND, F FWD, SLOW, VARIABLE SLOW, TRACKING, 2× speed (with audio muted), REVERSE PLAY (for backtracking video), and single FRAME ADVANCE buttons.

## *How It Operates*

It's of more than passing interest to discover how this electromechanical marvel works with its timed events, channel memory, and the lengthy 2.6-, 5.3- and 8-hour playing times for the three speeds with RCA's VK330 cassettes.

To begin with, the VKP900 contains *five* video heads. Two are used for standard play, two more for long and super-long play, and one for special effects. As usual in a two-head helical-scan system, luminance records in FM and color records via rotary phase-converted subcarrier. Measured video impedances are 70 ohms, whereas impedances of the audio inputs and outputs are 47,000 and 1500 ohms, respectively. Total vhf/uhf/CATV receiver tuning range accesses 133 channels via full memory programming and frequency-synthesized tuning.

The system can be programmed for eight events daily or weekly, up to 12 months in advance. A one-hour backup capability retains programming and time in the event a power failure should occur.

Soft-touch keys on both the tuner/ timer and remote controller produce on-screen alphanumeric displays of time, date, day, channel selected, and program modes. When actually programming the system, the remote controller is normally used to set time, normal, daily and weekly programs and for program review. It's all done with easy-to-follow screen displays of step-by-step instructions, all in logical sequence. You simply press the 1 through 5 buttons on the controller to set or remove from memory whatever recording condition is most convenient. Channels are stored in memory only via the tuner/ timer controls.

Inside the VCR are two signal splitters. One routes r-f to the recorder's vhf tuner and TV/VCR switch. The other delivers 470-to-890-MHz carriers to the 14-through-83-channel uhf tuner (even though channels 70 and up have now been assigned by the FCC to land mobile service).

When making normal recordings, an incoming channel is selected, timed and the TV/VCR switch is set to the VCR position with any recording that is to be taped and viewed simultaneously. If you wish to view one channel while recording a different

**RCA Model VKP900 VHS Videocassette Recorder**

| | |
|---|---|
| TV/tuner sensitivity | |
| vhf channels 3/13 | −2/−4 dBmV |
| uhf channel 20 | −1 dBmV |
| Ac operating range | 100 to 130 V |
| Ac power drain | |
| record | 20 W rms |
| playback | 18.6 W rms |
| Tape time | |
| play (on time) | 5 seconds |
| stop (off time) | 3.5 seconds |
| fast-forward & rewind (with VK250 tape) | 5 minutes each |
| Signal-to-noise ratio (S/N) | |
| luminance (SP/LP,SLP) | 43/42 dB |
| chroma (SP/LP,SLP) | 43/42 dB |
| Horizontal resolution (through r-f modulator) | 2.5 MHz |
| Audio response at baseband | |
| left channel | 80 kHz at −6 dB |
| right channel | 12 kHz at −6 dB |
| Stereo separation (sine wave only) | 50 dB |
| Wow/flutter (NAB at 3 kHz) | |
| SP | 0.06%/0.086% |
| LP | 0.06%/0.11% |
| SLP | 0.085%/0.17% |
| Tape speeds SP/LP/SLP (in inches per second) | 1.3/0.65/0.43 |
| Tape playing times (in hours) | |
| VK125 tape (SP/LP/SLP) | 1/2/3 |
| VK250 tape (SP/LP/SLP) | 2/4/6 |
| VK330 tape (SP/LP/SLP) | 2.6/5.3/8 |

**Test equipment:** Tektronix Models 7L5 and 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 Models 1250 and 1260 NTSC color/multiburst and 3020 sweep function generators and 1035 wow and flutter meter; Sencore Models VA48 video analyst (modified) and PR57 ac Powerite; RCA Model VGM2023S TV receiver/monitor.

channel, you simply set the switch to the TV position. If you would like "unattended" entries at the current time, the XPR button offers recordings in 30- and 60-minute increments, up to a total of four hours, with automatic shutdown at the end of the selected time.

For normal, timed and memory programming, changes and error correction can be made by repeatedly pushing the CLEAR button until the offending digit flashes. You then insert amended information via the usual programming keyboard.

To charge the $49.95 optional camera/recorder battery, you must turn off power, connect the recorder to the tuner/timer, and push the latter's CHARGE button. This activates both the charger and a LED to initiate a one-hour charge cycle. A thermostat monitors internal battery temperature in case there is a short circuit. A second thermostat shuts off charging current when internal battery temperature reaches a predetermined temperature.

The main 12-volt dc power supply for the entire system originates from an efficient switch-mode ac-to-dc converter. This converter is isolated from the 117-volt ac power line.

System control principally originates in two microprocessors (see drawing), aided by other ICs that accept digitized instructions and pass them on to main VCR and command circuits. When the tuner has finished selecting all programmed stations, phase-locked-loop (PLL) comparisons center them within frequency tolerance limits and remote or manual keyboard transmits the record or play commands as microprocessors I and II go to work.

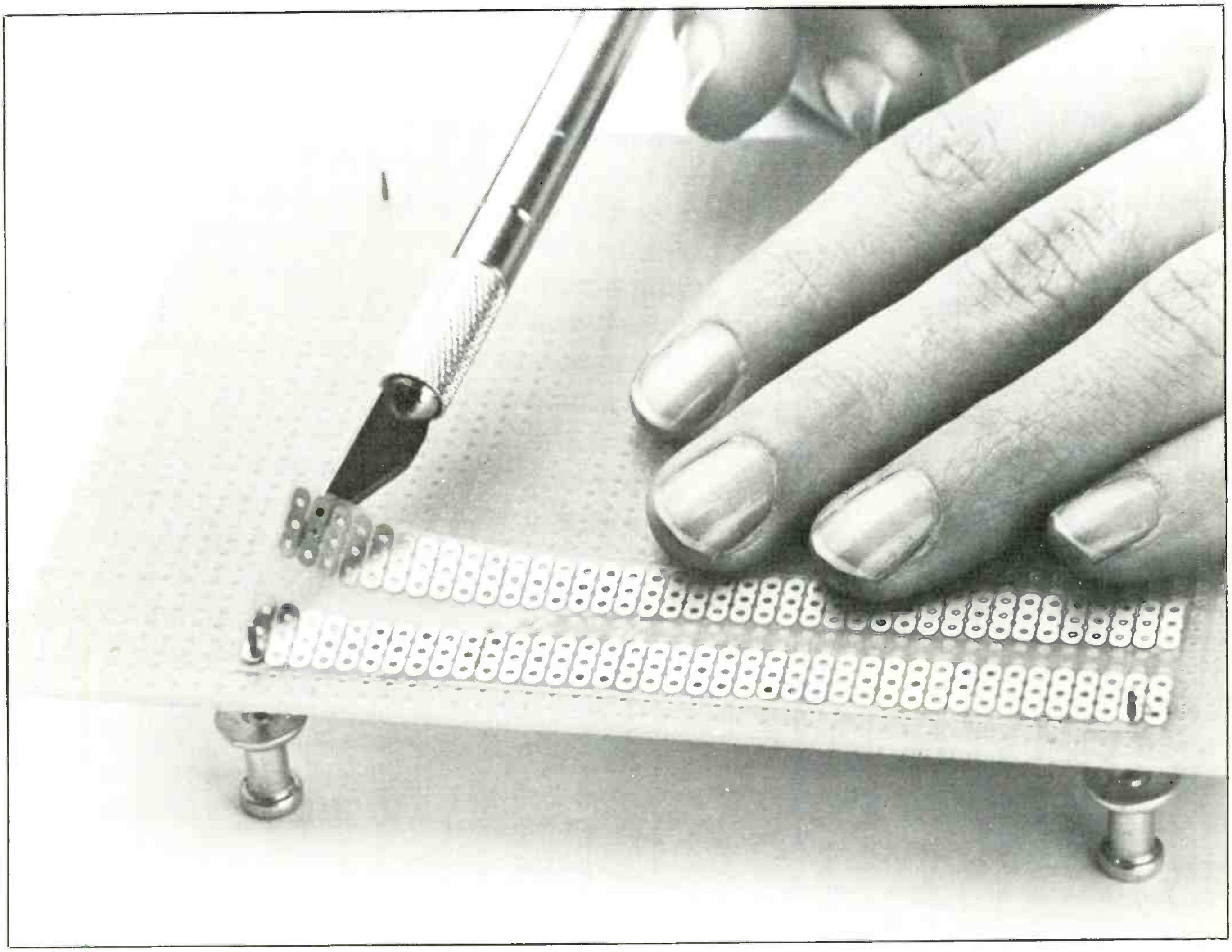
Processor I accepts inputs from the remote tuner/timer/charger microprocessor, camera input, front panel switches, and the deck's power relay. Processor II, programmed by processor I through a 4-bit data bus, then operates VCR deck systems while monitoring them during the entire operation. This includes sampling the trouble sensors, as well as sensing the various mode-switch positions and driving a liquid-crystal display (LCD) counter. Any problem with the unit usually requires replacement of this entire module.

## *Evaluation*

The VKP900 is a technically advanced, multi-mode recorder/player with significant advantages over most other VCRs. In addition to the utility of having an easily disengaged fixed/portable recorder with all functions indicated by LEDs, proven reliability, baseband video/audio, and regular r-f inputs and outputs, the programming flexibility of the two pieces is remarkable. While the 10½"D × 7"H × 6⅝"W measurements for the tuner/timer and 11"D ×9⅞"W×3¼"H measurements for the recorder aren't exactly diminutive, their combined total weight of 17 lbs. is certainly relatively low. Also, all operating abilities are outstanding.

Luminance and chroma S/N figures of 43 dB bear out the outstand-

*(Continued on page 85)*



# The "Easy Circuit" Way To Make Circuit Boards

## *Adhesive-backed materials eliminate photography and chemicals to speed circuit-board fabrication*

**By Harold Wright**

There are a variety of ways to produce printed circuits singly. Typically, photochemical techniques are used on copper-laminated boards. This method enables a builder to accurately replicate printed-circuit foil patterns such as those printed along with construction projects in *Moden Electronics*. To many people this is an odious task, requiring photographic methods, dealing with messy chemicals, drilling component-lead pad holes, and careful monitoring time.

An interesting alternate method, the subject of this article, avoids all this, substituting instead the laying down of pressure-sensitive, copper-clad tape on pre-drilled boards. This E-Z Circuit™ system by Bishop Graphics. Inc., Westlake Village, CA, is examined here.

## *The Materials*

Pressure-sensitive materials used with E-Z Circuit come in the form of copper patterns that are laminated to a thin layer of epoxy-fiberglass substrate. The underside of the substrate is coated with a special adhesive that is protected by a release liner. The adhesive is formulated to provide both good shelf life (as long as the release liner hasn't been disturbed) and good adhesion when the liner is removed and the pattern is placed on an appropriate circuit-board substrate. Patterns can be interconnected with copper tapes of various widths. The tapes have no substrate; instead, the adhesive is applied directly to one side and is protected by a peel-away release liner.

Adhesion of the patterns and tapes increases with time up to about 48 hours after the liner is removed and the materials are placed on the circuit board material. After 48 hours of curing, adhesion is approximately twice as good as it was after one hour. A pattern or tape can be removed and repositioned up to 24 hours after it has been applied to a circuit board. However, patterns removed after about 24 hours are generally no longer reusable, since their adhesion will have diminished to near zero.

Pressure-sensitive patterns and tapes will bond to most epoxy-glass circuit-board materials. However, they will not bond to Teflon or untreated polyolefin boards. So keep this in mind when you're planning to translate a circuit's conductor pattern to a working board design.

Many types of pressure-sensitive patterns are available (see Fig. 1), including pads for ICs and transistors, donuts for terminating a copper-conductor run, and various tapes ranging in width from 0.015" to 0.250". You'll also find circuit board edge-connector patterns for plug-in boards, multiple parallel tapes on a single substrate, power-distribution strips, and many others. If you need a special-purpose pattern that isn't available you can make your own by cutting them from a sheet of cut-and-peel copper, which also has the special adhesive on one side.

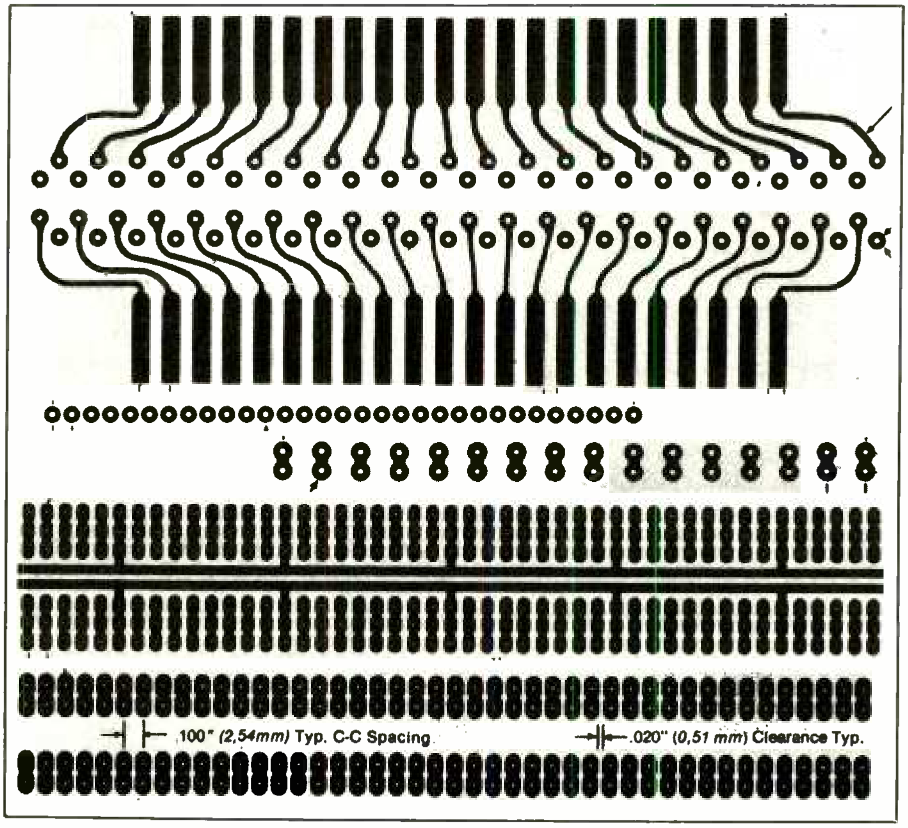


*Fig. 1. Many types of pressure-sensitive patterns are available, as demonstrated by the small sampling shown here.*

Perhaps the most versatile pattern in use today is the DIP strip popularly used for dual in-line package (hence the DIP acronym) integrated circuits. Such strips contain two continuous rows of pads spaced on 0.1" centers and with 0.3" spacing between the rows. Each pad can have two, three or four holes.

DIP strips can be cut to the lengths needed for use with 8-, 14-, 16-, 18-, and 20-pin DIP ICs, as well as for DIP-type bridge rectifier assemblies and optocouplers that require only four pads. They are equally useful for mounting DIP switches and DIP-type resistor arrays. The double- and triple-hole strips can be very useful where two or three components must meet. Also, these strips can be used as termination points where a row of resistors and/or capacitors must mate with wires leaving the board.

For 24- to 40-pin ICs, there are strips available with the 0.6" row spacing required for these devices. However, if you don't anticipate heavy use for these strips and prefer to save the expense of stocking them, the narrower DIP strips can be cut down the center and manually spaced when you do need them.

Even if you're committed to point-to-point wiring, the pads alone will

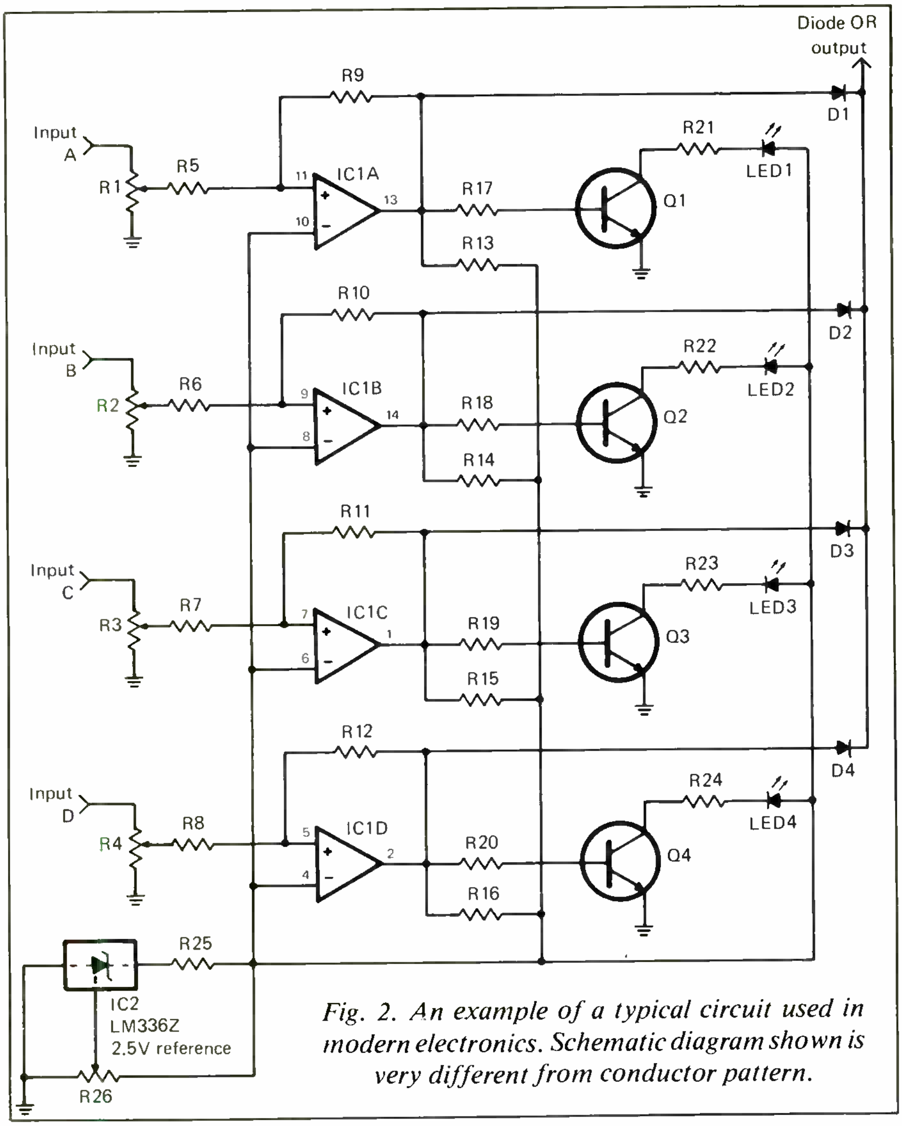



*Fig. 2. An example of a typical circuit used in modern electronics. Schematic diagram shown is very different from conductor pattern.*

greatly simplify the task of obtaining good, reliable connections to IC and socket pins. While it costs more to use self-adhering patterns than to go strictly the point-to-point wiring route, it costs less than going the make-it-yourself printed-circuit board route. As compared to wire-wrapping circuits, it's easier to trace when troubleshooting and much simpler to make making last-minute changes in the circuit.

## Planning The Layout

The procedure for planning the copper tape-and-pattern layout of a given circuit is much the same as that for a printed-circuit layout. If you're laying out a project of your own design, it's a good idea to first assemble the circuit on a solderless socket and check out its operation to be certain it performs as you want it to.

The next step is to redraw the schematic diagram with the ICs and transistors shown as they appear on the conductor side of the board, assuming this is available. Keep in mind that pinout diagrams are invariably top views for ICs and usually bottom views for transistors. Keep in mind when the IC is on the board and is examined from the *conductor* side, its image will be reversed.

Since many circuits use multiple-device ICs nowadays, we'll use one such as our design example. In the schematic diagram, the triangles that represent the single sections of a quad op amp (Fig. 2) are placed to give the simplest, easiest-to-follow circuit. When the circuit is converted to this new format as shown, it may not look simple at all from the circuit board component layout point of view. The schematic layout in Fig. 2 has been planned for maximum simplicity, while Fig. 3 shows a conductor layout for the circuit.

When working out the first crude layout of a circuit's conductor pattern, one of the limitations of the tape system may be encountered—insufficient space to run a trace between two pads. A common practice in photochemically produced pc boards, where the pads are made very narrow, you won't normally be able to do this with pressure-sensitive materials. However, if there's an unused pin on an IC that doesn't have to be grounded or tied to B+ (as in the case with all CMOS and some non-CMOS devices), the pad for that pin can be trimmed away to leave a space wide enough for two narrow tape runs, as shown in Fig. 4. If you should do this, make sure to cut away the corresponding pin from the socket or IC so that it doesn't protrude through the hole and contact the tape.

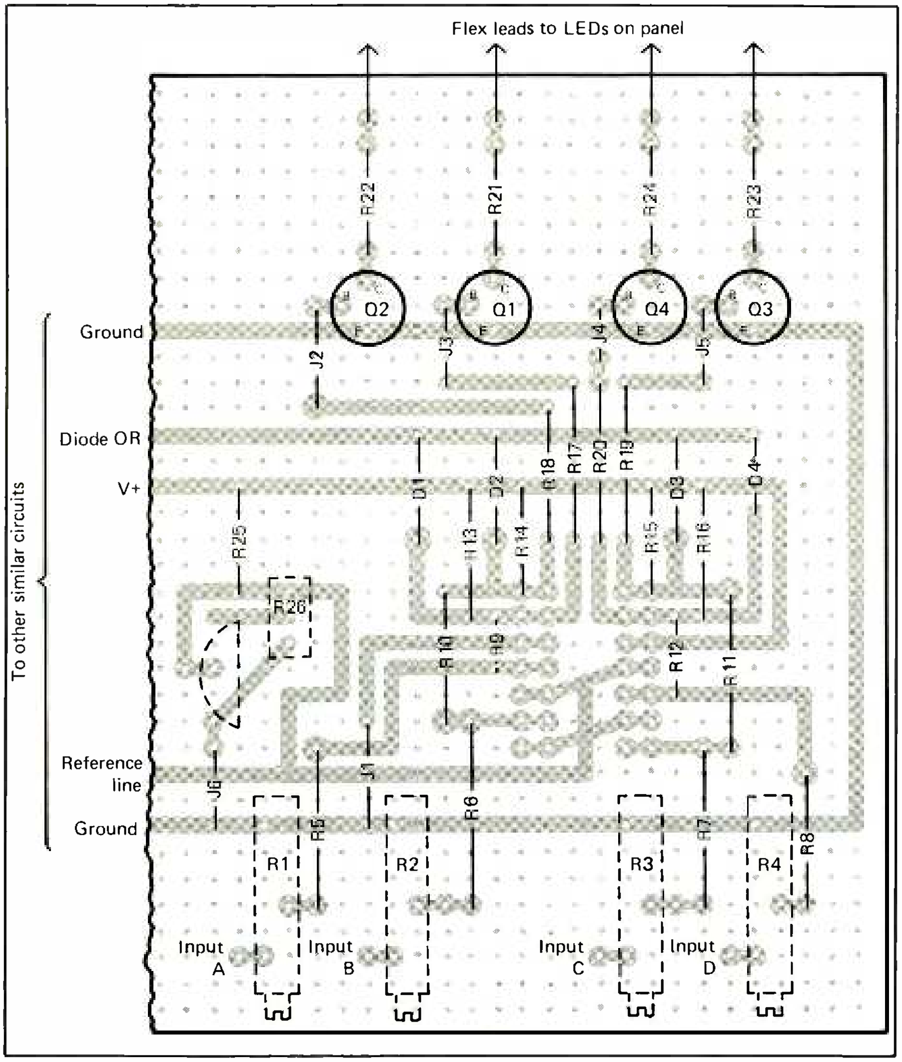
Tape runs down the center between the rows of pads spaced 0.3″ apart are generally limited to three or four, using the narrower tapes. Patterns with 0.6″ spacing between rows of pads have more space and, thus, accommodate a greater number of end runs. Keep these points in mind as the layout develops.

Note in Fig. 3 that many tape runs don't terminate in donut pads. This occurs when several tape runs end side-by-side and are spaced 0.1″ apart. Since only very small donut pads could be used in such a case, soldering is much simpler if you puncture the end runs with a darning needle through the underlying holes. Note also in Fig. 3 that considerable use has been made of two-hole pads snipped from a DIP pattern.

Although Fig. 3 is a view from the conductor side, the components are shown in the positions they would normally occupy on the other side of the board. This has been done here to aid in relating Fig. 2 to Fig. 3. Normal practice when showing component placement gives a component-side view of the board assembly. If such a diagram is needed, it can be derived from the conductor-side pattern simply by laying the latter wrong side up on a piece of glass, shining a light through, and tracing the pattern onto a sheet of paper. Then all you need do is add the components to the tracing.

When you use pressure-sensitive materials, you can frequently avoid the need for jumper wires. Pressure-sensitive tape is available in various widths. When snipped to size and applied over existing conductors, you can bridge the conductors with copper tape to obtain insulated and mechanically stable crossovers (Fig. 5) without having to resort to traditional wire-in jumpers. This technique will usually suffice, except in high-frequency circuits and especially with wider tapes. (Where the tapes cross, a tiny capacitor is formed and at high frequencies could cause unwanted coupling between traces.) If in doubt, use a standard wire jumper on the *component* side of the board. Beneficially, if a wide positive supply tape crosses a wide ground bus tape, a small r-f bypass effect is obtained. Figure 5 shows an insulated crossover.

*Fig. 3. This is the conductor pattern for the partial circuit shown in Fig. 2. Note that IC1 plugs into the double row of pads in the center of the drawing, between resistors R9 and R12. This is not a practical circuit for you to build.*




The final drawing of the scale layout for the patterns and tapes will be easier to draw if the work is done on grid paper, preferably with a 0.1″ spacing. It will be easier still if you work two times actual size. A large-scale equivalent of standard perforated board can be made by placing ink dots every 0.2″ horizontally and vertically on the grid paper. There are also film substrates with grids available from the copper pattern manufacturers and their distributors.

Working on a dotted grid will make it easy to determine if there will be room on the final board for the various components and how much space will be needed between each. For example, a standard ¼-watt resistor will require five holes spaced 0.1″ apart (one hole for each lead and three holes for the resistor body). If the same resistor is mounted on-end, you may need no more than 0.2″ of space. For other components, simply measure their bodies, taking into account lead requirements, and size your layout accordingly.

Projects using this system are easiest to wire if you use perforated board with 0.1″ spacing between holes. Attempts to place a set of patterns and tapes on a nonperforated board blank can be disastrous, since you must drill holes through the holes in the patterns. Unless you use exactly the correct size bit and get the bit exactly on-center, the patterns and tapes will almost invariably "climb" the bit, perhaps even taking with them adjacent tapes and patterns.

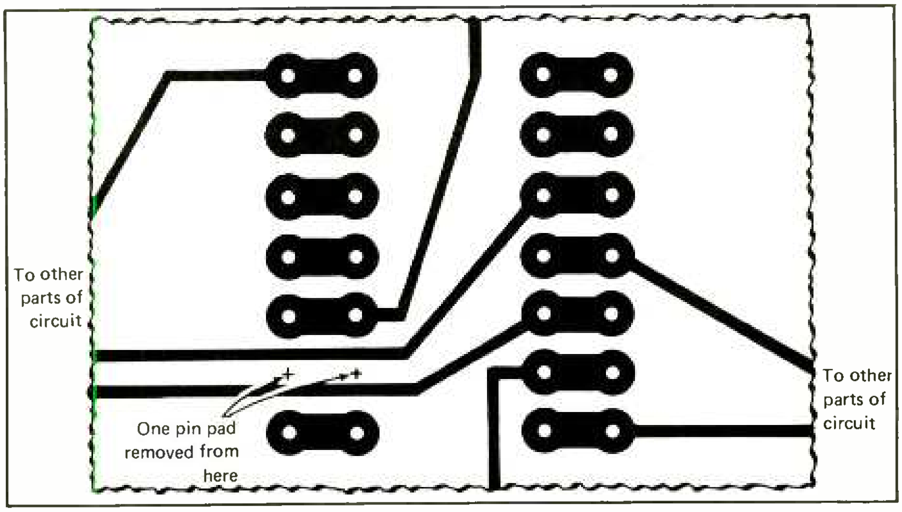



*Fig. 4. How to route one or more conductors between IC pins. Use this technique only if unused IC pins do not have to be tied to B+ or ground.*

When your layout is satisfactorily drawn on grid paper, simply transfer it to the perf board blank by counting holes horizontally and vertically. You will find that your tape layout is equivalent to a printed-circuit pattern. It can, in fact, be used for photochemical pc work at a later time should the need arise. Also printed-circuit layouts provided in electronics magazines can be duplicated using the tape-and-pattern system. If runs are shown between IC pins, however, some modification of the etching-and-drilling guide may be necessary. This could be as simple as using a couple of jumpers. Be aware, however, that where a construction project has a supplier for the pc board, it's simpler, less time-consuming and usually less expensive to purchase the ready-made board, especially if it's very complex.

Another method of board construction uses cut-and-peel copper sheets. Applying a copper sheet to a board blank allows you to draw the conductor pattern directly on the copper and to use an X-acto™ knife to cut away unwanted copper. This method, however, should be confined to simpler circuits, such as a power supply, and be used in conjunction with standard prefabricated patterns.

Tape runs must follow straight lines and various angles—but no curves! Don't attempt to bend a tape into an arc, no matter how narrow the tape or shallow the arc. This isn't really a handicap, because most routing required can be produced with a series of wide angles at the expense of a few extra solder joints. While 90° patterns are available, they do add an extra joint and increase cost.

## Getting It Onto The Board

If you prepared a 1:1 or 2:1 drawing of the required pattern, assembly will go very quickly. The drawing should have a frame around it to define the size and shape of the final board (and that takes into account the needs of mounting hardware). Get the DIP patterns in place first. Count the number of holes from a reference corner in both directions in your diagram to determine where to place the first pattern, aligned with the same hole on the board.

To aid in registering patterns, insert a bulletin-board push-pin into the reference hole from the component side of the board. If you don't have a board-holding jig or vise, push

*(Continued on page 80)*

*Fig. 5. Insulated crossover, shown to right of IC pad, obviates need for a physical wire jumper in many cases.*

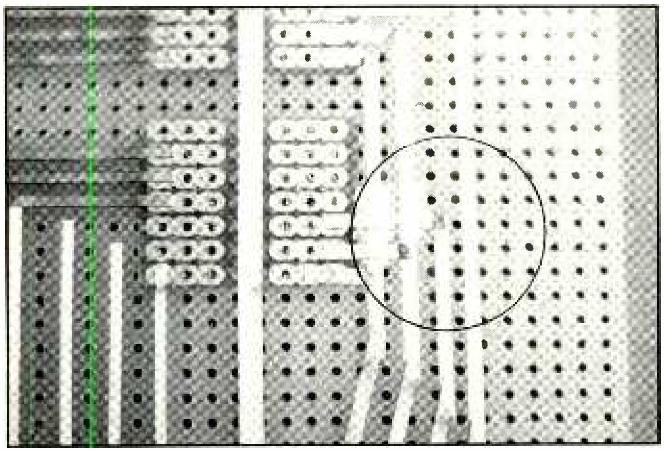
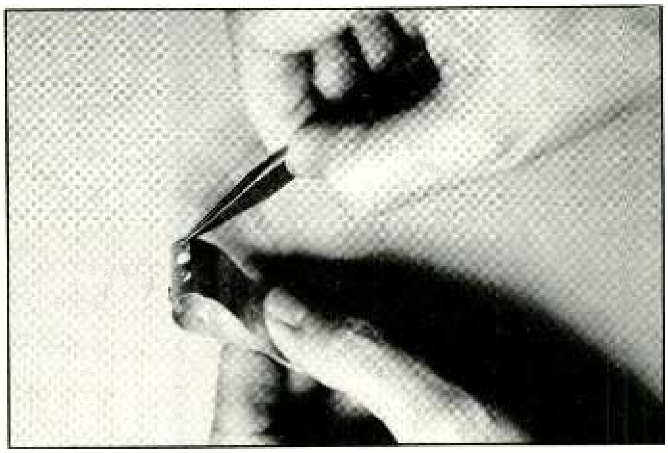


*Fig. 6. Shown here is one way to get the release liner started. Use sharp-pointed tweezers for handling patterns.*



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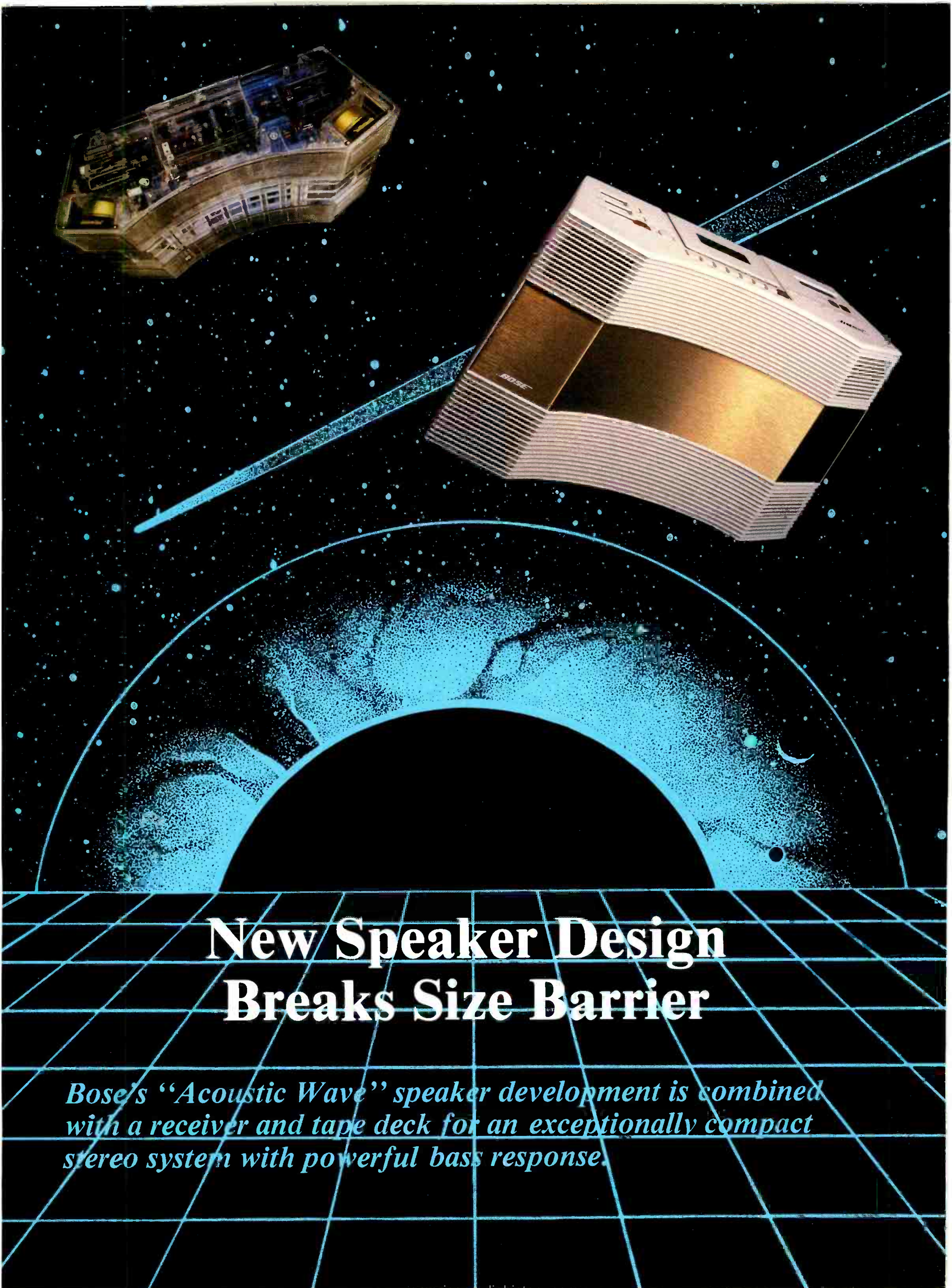



# New Speaker Design Breaks Size Barrier

*Bose's "Acoustic Wave" speaker development is combined with a receiver and tape deck for an exceptionally compact stereo system with powerful bass response.*

By Len Feldman

Until more recent years, speaker-system designing was as much an art as a science. The Bose Corporation was among the pioneer science-ordered speaker developers, led by Dr. Amar Bose, an MIT professor. Moreover, the company has a history of breaking with traditional designs. So it was with a heightened sense of expectation that I traveled to the company's headquarters at the invitation of Dr. Bose to learn about its newest product.

Seated in one of Bose's audio/visual presentation rooms, together with a group of reporters, a spectacular slide-sound show unfolded. The room-filling sound associated with the presentation appeared to be coming from four Bose 901 speakers—no surprise, since these speaker systems, in their latest incarnation, are still the mainstay of the Bose line of direct-reflecting systems. At the conclusion of the meeting, however, hollow covers designed to simulate Model 901 enclosures were lifted away, unmasking an altogether different product—high fidelity component systems packaged in a unitary form.

Each system contained an AM/Stereo FM tuner, a cassette tape deck and the new product development, a speaker system dubbed an "Acoustic Wave Sound System." The entire stereo system surprisingly occupies less space than a single 901 speaker system, measuring only 18"W × 6"D (max.) × 11"H. It weighs around 18 lbs. and, when fitted in an optional carrying case that contains a set of batteries, can be operated solely from this power source. The system carries a suggested retail price of $650.

## Design Philosophy

A thrust of Bose's design quest over the years has been to achieve realistic sound with properly reproduced low bass tones from a small speaker enclosure. Coupled with this, he reasoned that true high-fidelity components hadn't penetrated a high percentage of households due to the large size of such systems on the market. With the advent of integrated-circuit technology, the electronic section of a system no longer posed a problem.

To develop a satisfactory compact system, therefore, only the speaker system stood in the way. To meet this criterion, Dr. Bose and his staff pursued new speaker-design approaches, resulting in the Acoustic Wave™ Music System introduced recently and discussed here. The name of the system is based upon the waveguide technology that it uses. Combined with a receiver and a cassette tape deck, the small system modifies our thinking about the relationship of size to sound-reproduction quality.

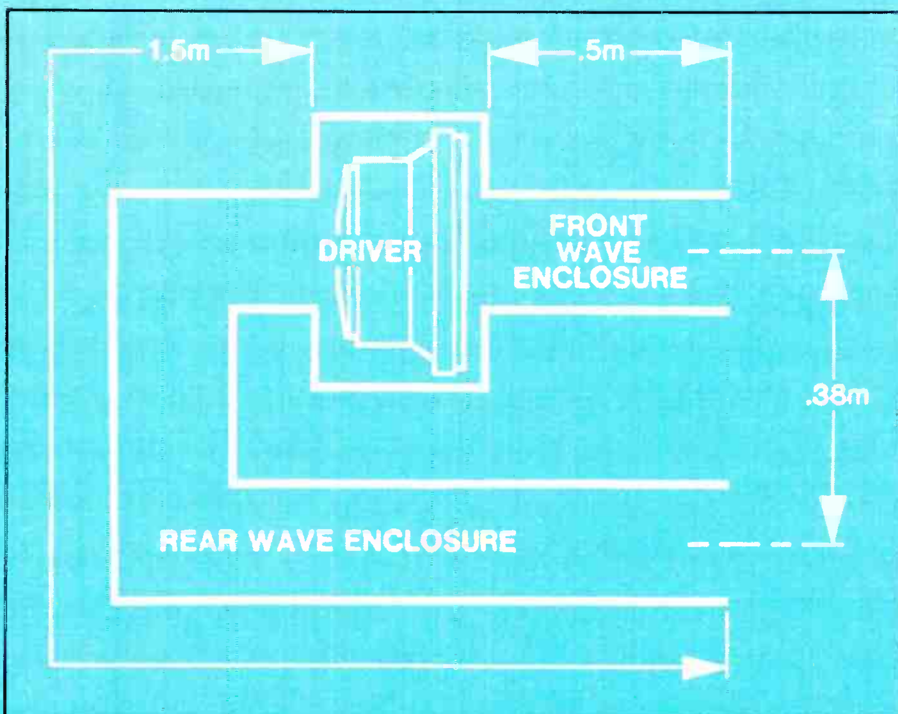
## The Acoustic Wave Principle

Waveguide technology, normally employed for transmission of super-high-frequency radio waves in the Gigahertz frequency region, is fundamentally different from that of "lumped parameter" designs such as those used in the design of bass reflex or acoustic suspension (sealed box) speaker enclosure designs. Inside the waveguide, air does not behave as a single, lumped mass or compliance. Instead, the system is designed so that standing waves are *deliberately* developed.

These standing waves act to improve efficiency and to reduce required speaker cone motion over a wide frequency range. The higher efficiency results in lower amplifier power requirements, while the reduced cone motion results in greater acoustic power output combined with lower distortion.

In its simplest form, a waveguide enclosure consists of two chambers or acoustic "waveguides," with the speaker driver itself located at a precisely calculated point between the two waveguides. The front and rear waveguides operate so that the sys-

*Fig. 1. This is an illustration of the Bose AWMS-1 system enclosure.*



tem can accomplish cone velocity amplification and cone motion reduction over a wide frequency range.

Another way of looking at the principle is to think of a pipe organ. In that instrument, each of the pipes is "tuned" to a specific frequency. When a small volume of air is passed over the opening of each pipe, the resonance effect of that pipe "amplifies" the note to which the pipe is tuned. As a result, a large volume of air (and hence a loud sound) is set in motion at the output of the paper. An electrical analogy is the familiar "resonant circuit" that's used to "tune" radios to incoming r-f signals and to sustain oscillations in oscillator circuits of all kinds. Another familiar analogy, from the world of mechanics, is the clock pendulum. Resonant organ pipes, resonant electrical circuits, and mechanical pendulums all produce a large amount of energy compared with the energy required to *sustain* their oscillation.

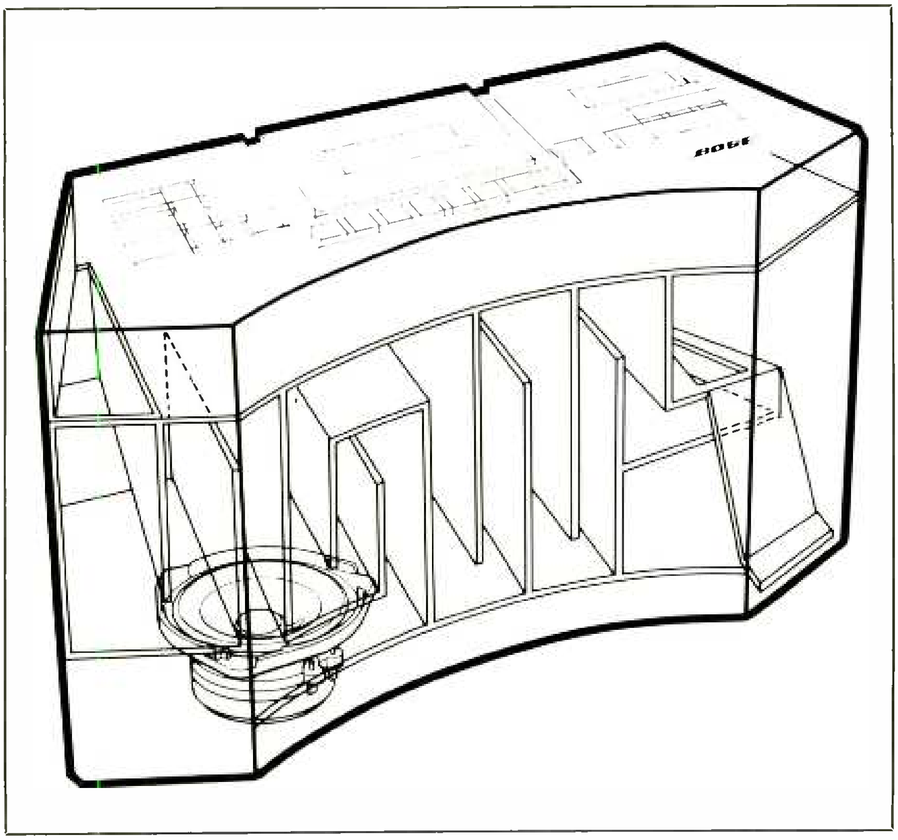
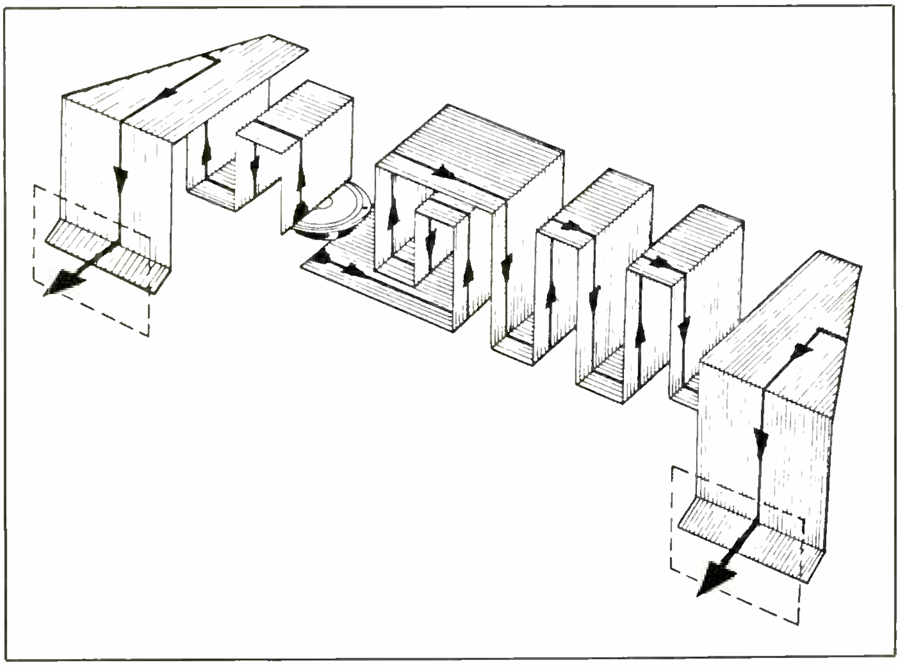


*Fig. 2. This diagram illustrates, in simplified form, the actual waveguide structure used in the Bose Acoustic Wave Music System.*

*Fig. 3. Shown here is the approximate path followed by sound waves in the AWMS-1 as they reflect from each wall of the waveguide structure.*



Unfortunately, each of these devices can produce only *one* frequency. Their "amplification" effect is known, technically, as their "Q," and all of these devices have high "Q" numbers. If you want to have these devices respond to a broader range of frequencies, you would have to lower the Q, thereby losing the amplification effect. What Dr. Bose and his engineers discovered is that, contrary to earlier theory, it is possible to have a "high-Q" pipe that is, at the same time, broadband in its frequency characteristics. In other words, it's like creating a single organ pipe that is responsive not just to one note, but to perhaps as many as three or four octaves worth of frequencies!

The simple waveguide just described requires additional features if it is to be used in music reproduction applications. First, the length of the two waveguides must be in the precise ratio of 3:1. The ends of the two waveguides must be at the proper distance from each other to provide proper radiation impedance at each opening, as illustrated in Fig. 1. Higher-frequency modes must be suppressed by appropriate shaping of the waveguides. Finally, speaker driver parameters must be precisely calculated so that as the waveguides develop "standing waves" that amplify diaphragm or cone velocity, the diaphragm motion itself is automatically and proportionately reduced. This reduced diaphragm motion compensates for the cone velocity amplification, and results in uniform power radiation with changing frequencies.

The actual waveguide structure used in the Acoustic Wave Music System is shown in simplified form in Fig. 2. Each waveguide section has been folded to meet the requirements outlined earlier, and the speaker driver itself has been positioned so that the two waveguide sections are in the required 3:1 length ratio. Figure 3 shows the approximate path followed by sound waves from each side of the following.

In the waveguide system, the wave reflects almost perfectly from the opening and travels back toward the speaker cone. Since there is virtually no damping in the structure, a standing wave is built up. Therefore, what you have are waves in both waveguides traveling in both directions (away from the cone and towards it) at all frequencies at which the system operates. These standing waves provide the velocity gain and the reduction in cone motion that enables the system to perform as it does.

## AN AUDIO PIONEER


The chairman of Bose Corporation, Amar Bose, has set the audio community on its end more than once since he introduced his revolutionary 901 Direct/Reflecting® speaker system in 1968. Around that time I remember being seated next to him at an annual Audio Engineering Society convention dinner (Ray Dolby, inventor of the Dolby noise-reduction system, was at my other side). He told me about his work as a professor at world-famous M.I.T., where he taught acoustics and was involved deeply in psychoacoustics, which he had applied to the design of his new speaker system.

He talked about creativity, inventiveness, and his deep interest in music. Dolby, whose professional noise-reduction system I had just covered editorially in a series of articles in *Audio*, was drawn into the conversation. Both men regaled me with more information than I could ever digest about their products, of course, and I wondered if their enthusiasm would carry over to some degree of business success. As history has shown, it obviously did.

Some years later I visited Bose in his new headquarters atop a high hill called "The Mountain" in Framingham, MA. The facilities were extraordinarily impressive, down to the tranquil, pastoral scene below.

Obviously research-oriented by training (Sc.D. in Electrical Engineering from M.I.T., and supervising graduate and undergraduate thesis students at M.I.T. where he's a Professor of Electrical Engineering and Computer Science) and industry research work (such as for a prosthetics project at Massachusetts General Hospital that led to the Boston Arm), his company gathered one of the most advanced acoustical engineering groups in the world, it is said.

Using electronics to compensate for deficiencies in loudspeakers, he carved out new audio paths. This concept was extended in 1982 when, in a joint effort with General Motors and Delco Electronics, the first automotive sound system where speakers and amplifiers were acoustically customized to individual car models was introduced . . . to critical acclaim.

Bolstering the foregoing, Bose formed the Bose Music Society to offer audiophile-quality prerecorded cassette tapes, which includes a Private Performances Collection for car stereo owners.

Breaking new audio ground once again with the Acoustic Wave™ small music system discussed in the main article, adds another important technical innovation to the credit of this audio industry pioneer.—*Art Salsberg.*

## *The Rest of The System*

Good bass alone does not a high-fidelity system make. The waveguide enclosure in the actual system now being offered by Bose works for frequencies up to 500 Hz. Mid-high frequency drivers are used for the remainder of the audio spectrum, and each of these mid-high frequency drivers is powered by its own small amplifier, separate from the single low-frequency driver. This is shown in the block diagram of Fig. 4. The use of an electronic crossover minimizes phase and amplitude matching problems normally associated with passive crossover networks. The acoustic waveguide functions as a low-pass filter, thereby reducing radiation of distortion by the low-frequency driver, and no low-frequency energy needs to be handled by the high-frequency amps and speakers.

Despite the small size of the system and the use of a single driver for bass frequencies, stereo effect obtained with the AWMS-1 (the model num-

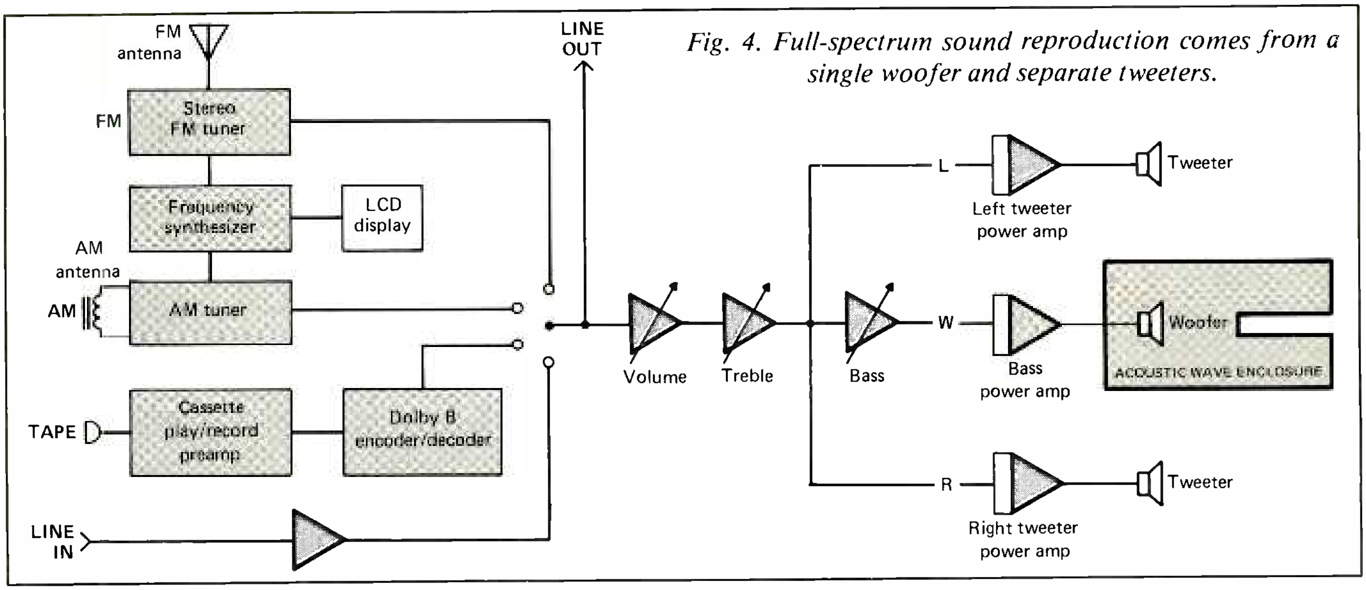



*Fig. 4. Full-spectrum sound reproduction comes from a single woofer and separate tweeters.*

ber given to this first product employing the new principle) is quite satisfactory. This is due in part to the fact that low frequencies are virtually non-directional in any case, and also to the positioning and outboard angling of the mid-high drivers.

Controls have been simplified to the utmost, in keeping with the original goal of creating a system that would not intimidate the typical music lover who wants good sound without complexity of operation. Dynamic equalization provides proper tonal balance at all listening levels. Tape playback equalization is automatic, thanks to internal sensing of tape type being played. The built-in cassette recording capability has been optimized for type II (chrome or chrome equivalent) cassette tape with Dolby noise reduction always active. The tuner is a quartz frequency synthesized type, with provision for presetting 10 favorite station frequencies (5 AM and 5 FM) for recall.

There are auxiliary line input and line output jacks on the unit, for connection of additional program sources such as a Compact Disc player or another tape deck, if desired. In addition to being able to operate the system when it is powered from an optional battery pack, it can also be powered by a car battery. Maximum acoustic output is in excess of 100 dB SPL (Sound Pressure Level)—more than enough to enjoy music at home at lifelike loudness levels.

## Conclusion

The only relevant specifications that Bose reveals concerning the AWMS-1 are its maximum acoustic output (which, as previously stated, is better than 100 dB SPL) and that the system will operate for about 10 hours when it is powered by alkaline flashlight batteries.

The notable absence of technical specifications is consistent with Bose's original goal of creating a music reproducing system that will appeal to non-technical music lovers who have, up to now, resisted buying conventional audio components because the process of purchasing and assembling was overly complex.

Aside from this, Dr. Bose has always decried raw technical specifications as not accurately representing the quality of high-fidelity equipment, to the consternation of many audio equipment reviewers.

Nonetheless, technical tests can be made on any equipment, if numbers are the name of the game. In the case of the new AWMS-1, the speaker system goes very smoothly down to a respectable 50 Hz, which is remarkable for a system its size. The overall sound quality it reproduces is immensely satisfying. Its stereophonic effect is fairly good, given the limits of the speakers' fixed positions.

Aside from its music-reproducing capability, this is a highly versatile product. For example, the integrated entertainment center can be used virtually anywhere one wishes to enjoy high-performance stereo. Since it's about the size of the proverbial breadbox, the modernistic-looking all-in-one system can even fit comfortably on a kitchen counter. It can also be used in a vehicle or boat with an adapter. Furthermore, the AWMS will serve well outdoors when armed with an optional battery pack. And since it can be easily transported, it's inviting to use this portability.

In essence, then, Bose's new Acoustic Wave Sound System may well be the answer to the mass of music lovers who want excellent sound reproduction from a system that occupies little space and who will give up the flexibility of separate components and that extra measure of performance issued by larger, more costly equipment. **ME**

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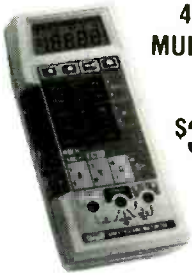

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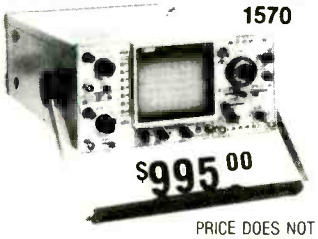

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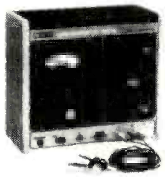

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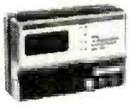

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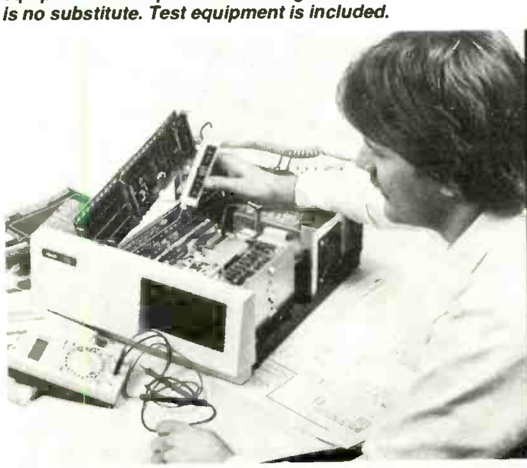

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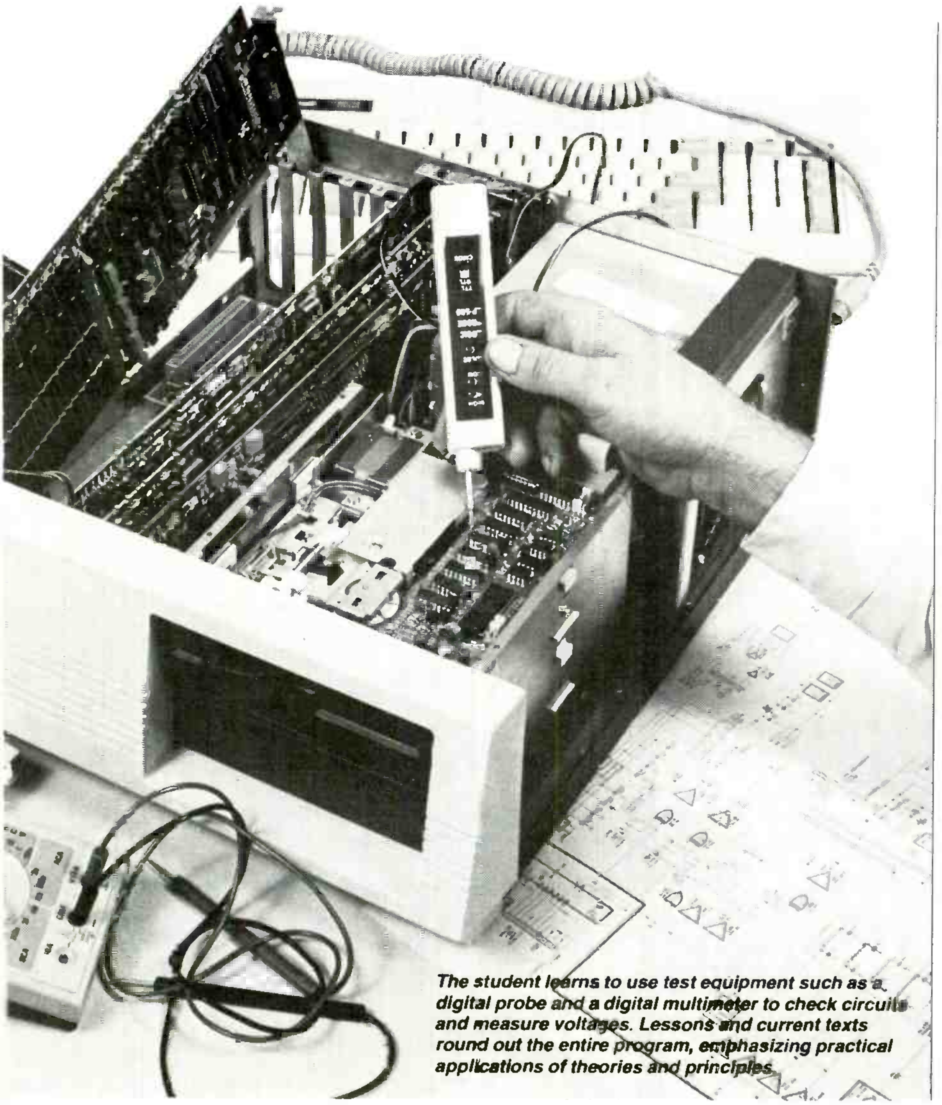

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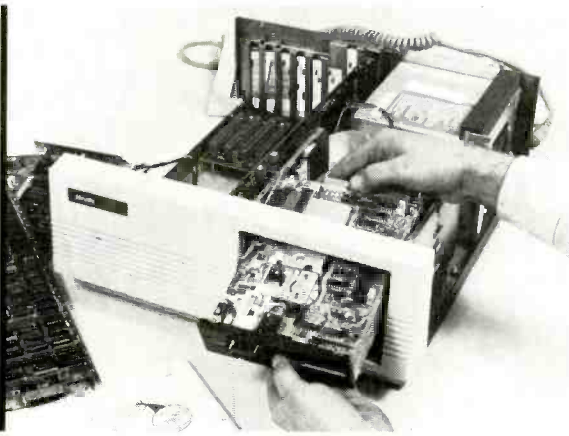

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# The Commodore Plus/4 Computer

# . . . Is It Really A Plus?

***Built-in application programs are a hallmark of Commodore's new Plus/4 computer. The author explores its values, among other features, to a prospective buyer.***

**By Eric Grevstad**

The Commodore Plus/4 is a solid, modest improvement on the best-selling Commodore 64, at a moderate price increase ($229 vs. $199). Its distinguishing external features are a new keyboard, a vastly better BASIC, and a snappy black wedge-case as contrasted to the 64's tan oblong-shaped case.

It also has a few built-in software programs (word processing, database, and spreadsheet programs, with graphics for the latter), accounting for the "4" in its model name.

Since Commodore's 64 computer picked up the company's leadership crown from its low-cost, highly popular VIC-20 model, isn't it natural to look upon the Plus/4 as the 64's successor in an evolutionary chain? Probably so, but at this time it's not clear of this is the case.

There are enough similarities and important differences between the newer Plus/4 and the C64, combined with a blurry market picture, to confuse the most astute buyer of a home computer. Here is a close examination of the Plus/4 that will shed light on where Commodore's new baby fits into the scheme of things. Before doing this, however, let's examine the recent State of the Computer nation that likely influenced the development of the Plus/4.

In the early Eighties home computer buyers were at first content to get a "computer literacy" machine that could be used to play video games at a price not much more than a standalone video game machine. When demand turned to better educational software, modest word processing, and even a disk drive addition, more capable computers such as Commodore's model 64 were developed.

By 1984, however, the home computer had grown from an adolescent into a yuppie. The prospective home micro users became, pundits felt, aspiring professionals eager to join their elders in the business community, as well as professionals who did work at home. Accordingly, a company such as IBM introduced its PC*jr*, a machine for all small computing worlds that itself exhibited an identity crisis —too much for most homes, too little for most offices. This was compounded by some serious shortcomings, most of which have since been corrected.

IBM's stumble gave Commodore an opening, it appears. If the new market resisted entry above (a stripped-down IBM PC), how about a machine coming from below (a souped-up C64)? So now Commodore has a new machine that has yet to find a firm niche for itself.

## *Familiar Hardware*

The two most important specs shared by the Plus/4 and the C64 are unchanged: the same 64K memory and the same 8-bit microprocessor. Though the Plus/4's MOS Technologies CPU is called a 7501, it uses the same instruction set as the 6510 in the C64 (which, in turn, matches the classic VIC-20 and Apple 6502 save for eight extra input/output lines. Interestingly, the Plus/4's manual makes repeated references to 6502 code, and an appendix recommends several books on 6502 programming).

The Plus/4 has some architectural improvements over the C64. For instance, its BASIC can access an extra 21K of RAM that's reserved for machine-language instructions in its cousin (starting in BASIC, there's a spacious 60,671 bytes available to the C-64's 38,911). A new communica-


tions chip governs a *real* RS-232C interface, though Commodore's uses nonstandard voltage levels (0 to +5 rather than −12 to +12 V) for the standard protocol. Like the C64, the Plus/4 won't connect to non-Commodore peripherals such as cassette recorders or printers.

Two changes befitting the Plus/4's more businesslike image actually remove popular C64 features. There's the same 25-line, 40-column display and 320- by 200-pixel resolution, but the Plus/4 has no sprites (movable graphic blocks). This makes game-style animation difficult to achieve. With the C64's eight sprites, you could create a pattern of up to 24 by 21 dots (a spaceship, say) and move it as a whole; with the Plus/4, you'll have to erase and relocate each dot separately.

Similarly, the Plus/4's sound capabilities are comparable to those in other micros: two square-wave voices, with pitch and duration set from BASIC. But the C64's acclaimed SID (Sound Interface Device) chip, a true music synthesizer offering four waveforms, three filters, and attack/delay/sustain/release (ADSR) tone control, is gone in the Plus/4!

## Ports and Peripherals

Both models connect to a wide range of accessorieis and options as long as you stick to the house brand. The Plus/4's right side holds the ON/OFF and RESET switches, while its left has a channel selector and r-f jack for the antenna switchbox used with TV sets; the rear has seven I/O ports plus the power socket. (The computer plugs into an external power supply, the size and weight of a brick, that plugs into your wall outlet.)

Besides the RS-232C port, suitable for a Commodore modem or a voltage adapter, there's a C64-type serial bus for printers or the famously slow 1541 disk drive (around $250). The 1541 stores 170K of data on a 5¼" floppy; C64 owners have learned to be patient about retrieving any. For example, a 6K text file (three double-spaced pages) loaded in 18 seconds, or 338 bytes per second.

Plus/4 owners, however, can hope for faster times from Commodore's forthcoming (early 1985) 1551 parallel drive, which will use the micro's cartridge expansion port. There'll be cartridge software, it's reported, and tape users will find a cassette port. Unfortunately, the latter, like the Plus/4's two joystick ports, is incompatible with its C64 equivalent. Commodore offers a special Plus/4 Datacassette and joystick, about $60 and $20, respectively. (Commodore prices always leave a lot of leeway for dealers).

The final socket on the Plus/4's stern is for a video monitor such as Commodore's popular 1702 or the new, black-cased 1802 (primarily cosmetic differences, at the same $250-$300 price). A monitor will give the sharpest display, but the Plus/4 worked quite well with my color TV after I fiddled with the latter's horizontal hold. Characters on the TV screen looked smaller and squatter, but in fine focus.

**Computing Under $300**

| | Commodore Plus/4 | Commodore 64 | Atari 800XL | Radio Shack Color Computer 2 |
|---|---|---|---|---|
| CPU (all 8-bit) | 750 | 6510 | 6502C | 6809E |
| Total RAM | 64K | 64K | 64K | 64K |
| User RAM | 60K | 39K | 40K | 24-32K* |
| ROM | 32K | 20K | 24K | 16K |
| Display | 25 × 40 | 24 × 40 | 24 × 40 | 16 × 32 |
| Graphics resolution | 200 × 320 | 200 × 320 | 192 × 320 | 192 × 256 |
| Colors × luminances | 16 × 8 | 16 × 8 | 16 × 16 | 9 × 1 |
| Sprites | No | Yes | Yes | No |
| Keys | 67 | 66 | 62 | 53 |
| Sound | 2 voices, 4 octaves | 3 voices, 9 octaves | 4 voices, 3½ octaves | 1 voice, 5 octaves |
| Built-in application software | Yes | No | No | No |
| Price | $299 | $199 | $119 | $199 |

**Depending on graphics mode*

## *A Better Keyboard*

The new machine's keyboard is no match for those of desktop computers (they have real insert keys instead of shift-delete), and a slight toy-piano feel handicaps its otherwise adequate touch typing. Still, it's very good—an improvement on the C64's, already one of the better keyboards in its price range.

The most useful change is the Plus/4's compass of four cursor movement keys, replacing the C64's two (left and up sure beat shift-right and shift-down).

The four function keys are horizontally above the main rows rather than vertically along the right; as on the C64, they serve eight functions (a bit awkwardly, as the unshifted keys are F1, F2, F3, and F8 and the shifted ones are F4 through F7). Pressing F1 starts the built-in software, while F2-F8 are preprogrammed with useful BASIC statements like List and Help (which highlights syntax errors); you can reduce them in your own shorthand, up to an average of 16 characters apiece.

Following Commodore PET and C64 practice, most keys supply four characters (upper- and lower-case letters and two graphics symbols); with the Plus/4 in uppercase/graphics mode, pressing the shift key and a letter produces one symbol, while the Commodore key and the letter supply the other. The number keys work with the control and Commodore keys to change text among 16 colors, if you're too lazy to learn BASIC's Color command (though the latter lets you choose among eight luminances, giving a 128-color total).

## *Basic 3.5 Rates a 10*

The Color command will be a boon to casual programmers; C64 hackers are used to Poke 53280,5 to turn the screen border purple, but Color 4,5 is infinitely easier for the rest of us. It's just one illustration of the Plus/4's built-in Basic 3.5, a splendid extension of the C64's skimpy Basic 2.0 (some of it available in optional C64 expanders). Not only is there more room to write programs, there are over two-dozen new commands to write them with.

It's clear Commodore's paid attention to the two languages currently unsettling BASIC on its throne: some of the new commands make graphics almost as easy as Logo, while others provide structured programming tricks inspired by Pascal.

The former group includes some functions previously relegated to complex Poke commands, such as Sound, Volume, Color, and Graphic (which controls five display modes for text, high-resolution and half-resolution multicolor graphics, and split screens for combinations). Others like Draw, Box, Paint, and Circle (which also creates triangles, ellipses, and octagons) let you sketch and color shapes with ease.

Non-graphics programmers will appreciate 3.5's Pascal-like Do, Loop, Until, While, and Exit statements, along with an Else to simplify If . . . Then constructs. Debuggers will applaud the error-trapping and trace mode routines, and machine-language programmers will be delighted to find a built-in monitor with 15 commands to examine and modify memory contents, and assemble and disassemble 6502 code.

And nearly everyone will benefit from a third group of extra commands, taken from Commodore's CBM desktops and making disk use endlessly easier—commands like Backup, Header (for formatting), Dload (as opposed to specifying the drive device number with Load,8) and Directory (instead of Load "$",8:List).

When you consider that Dload, Dsave, and Directory are preprogrammed on function keys, disk convenience alone is almost worth the $100 extra. With the Model 1551 fast drive, Plus/4 users will leave C64s in the dust.

## *Integrated Applications*

If BASIC 3.5 is good, 3-Plus-1 is less appealing. The latter is Commodore's name for the Plus/4's built-in applications: word processing, database, and spreadsheet programs, with bar-chart graphics for the last. Even as someone used to more costly PC software, I grew to admire the package's versatility. Versatility is not the same as performance, however.

The programs do a first-rate job of sharing data, but only a fair job of getting work done. They're good introductions, but no substitute for separate cartridge or disk programs; if the VIC-20 taught computer literacy, 3-Plus-1 teaches applications literacy. Beginners will learn a lot from the manual's excellent overview of concepts to advanced integrated software maneuvers like swapping spreadsheet rows into a text file. On the other hand, they won't learn about elementary things like word wrap or adequate editing functions.

Running 3-Plus-1 is simplicity itself. From BASIC, pressing F1 and the return key puts you in the word processor; once there (or anywhere in the program), pressing Commodore-C toggles a command mode.

Most commands are simple two-letter ones: entering TC transfers you "To Calculations" (the spreadsheet), TF to the file manager, TW back to your words. The HA and FU commands let you choose half- or full-screen displays for spreadsheets and text, giving a useful split screen or window.

In all applications, the CA command brings a catalog or directory of the current disk. It's a handy feature, but it shows how 3-Plus-1 will disappoint those who thought $299 bought a fully usable system: except for quickly creating and printing short files, the word processor and spreadsheet need a disk drive, and the database won't work without one.

## *The Bad Word*

The word-processor screen shows but 22 lines of 37 characters each, plus a bottom ruler of dots (asterisks show where you've set tabs) and a gauge indicating the cursor's line and column position. That's a small display, but acceptable—or it would be, if text wrapped onto the next line once you've typed a string of more than 37 characters.

Instead, the screen serves as a window, scrolling horizontally like a theatre marquee for up to 77 columns (a document can fill up to 99 of these long lines before exhausting memory). That's unnerving, since each time you do start a new line you can't see the last half of the last one. But even that might be all right if 3-Plus-1 wrapped words as real word processors do. Nope. A line breaks at 77 columns, whether it's the middle of a word or not; the result is as hard to read as anything I've seen. Documents are word-wrapped when printed—even right-justified if you like—and you can set printout margins or line lengths with imbedded commands, typed in reverse video and punctuated with semicolons and colons (lmarg10;:rmarg74;). But on screen, it's a jumble.

As for editing, there's no insert mode; new text writes over old, and carriage returns destroy everything right of the cursor (though Commodore-@ recovers the lost text). You must either insert or delete whole lines or one character at a time—and, unless you go through a tricky rigamarole of inserting pointers to limit the affected area, inserting or deleting anything moves everything below the change, skewing lines from the left margin and hopelessly screwing up you file.

Despite such flaws (the manual boasts "every needed function . . . the essential features found in all word processors"), the rest of the program is passable. The search and replace functions work smartly, and the imbedded commands offer sophisticated printing options, including file merging to overcome the 99-line maximum. Without such fundamental things as word wrap, though, it's best suited for use on desert islands with not other software available

## *To Calculations*

The spreadsheet is a bit slow and clumsy, but hasn't the word processor's glaring faults. It supports 850 cells (50 rows by 17 columns), each shown as 11 characters wide (though a text cell can hold up to 36 characters). Navigating among cells is easy, once you learn that it's the up and down arrows but F1 and F2 for left and right (the left and right arrows move within a cell for editing).

The program assumes all data is numerical, unless you preface each entry with Commodore-T, -F, or -C (for text, formulas, or commands respectively). Number crunchers are limited to one set of parentheses in a cell formula.

Otherwise, there's almost everything found in VisiCalc and its successors: an automatic recalculation mode (though formulas aren't adjusted when you rearrange rows or columns); commands to copy a cell or adapt its formula (such as a sum) to another; and a choice of dollar, integer, or floating numerical formats.

Any copying of a spreadsheet block into the word processor is as easy as putting the cursor on the top left corner, specifying the bottom right, and issuing the cryptic command Blkmap. Up to seven columns by 50 rows can be moved at a time; a similar command, Map, lets you transfer rows manually, one at a time. Of course, keeping the new lines from unraveling in the word processor is a chore, but the transfer is as painless as anything in integrated packages.

The spreadsheet's graphics command is a bare-bones affair, giving a bargraph of all columns in the current cursor row. You'll have to peek at cell 50;16 to find the y-axis scale.

Graphs can be mapped into a blank word processing document, saved, and tidied for printing. They're not made of Commodore graphics characters, but brackets and # signs—ugly, but suited for daisywheel as well as dot-matrix printers.

## *Keeping Records*

Issuing the TF command brings a prompt to issue it again (or NEWTF if creating a database); you must have a disk drive attached and a disk inserted. Database files can't share a disk with texts or spreadsheets, and each database requires a disk of its own. Modestly sized entries will allow up to 999 records per disk, each with a maximum of 17 fields, each containing up to 38 characters.

The database isn't a fancy freeform type; you must plan the number of fields and each field's name and length beforehand, then enter those values during setup. That done, you'll see a minimal display—fields displayed in a column, with two lines at bottom to tell the file's name and the current (cursor) field.

A command such as RC1; or RC27; lets you enter or retrieve a record; UD (update data) and NR (next record) save changes. The RV1; command starts a review with the first record, showing each for about two seconds (and invariably, at the pause or stop command, doing so on the record after the one you wanted).

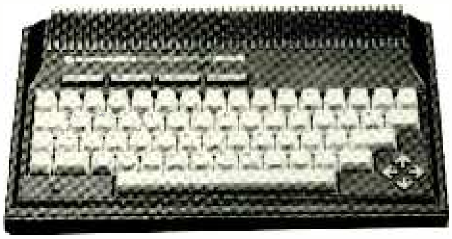
The search command, SR, is utterly simple: it finds records showing the desired data in any field, so a search for John brings John Smith, Alice Johnson, and Fred McKinley of 22 Longjohns Lane. It's possible to narrown the hunt if you've kept track of your fields' numbers. For example, PI6; issues a Pick command on field six, ignoring all records except those, say, with a zip code between 20100 and 20350. Be careful with numbers; the program thinks 545 comes before 62, unless you give the latter its leading zero (062).

Like the spreadsheet, the file manager is slow and sometimes awkward but serviceable; at worst, it's a fair introduction to how databases work. Teamed with the word processor, it can only print lists, but do a fairly advanced job of merging names and addresses into form letters.

## *Conclusions*

The Plus/4 is certainly a reasonably powerful machine, as the product comparison table accompanying this article confirms. Moreover, it has a bevy of enhancements that are attractive, such as a better BASIC. Whether or not it's worth its additional cost among competitive home computers depends on two things: will there be sufficient software support in the future and do your specific wants fall into the machine's capability range?

True, these considerations are the same for any new computer model. On the first, there should be at least a fair amount of software available for the Plus/4 if Commodore lives up to it announcement of producing 40-odd programs that range from its Easy Script and Easy Calc to vertical-market templates and Infocom adventure games. (There's been talk of an adapter to let the Plus/4 run C64 software. I spoke to a Commodore product manager, however, who admitted that it was under consideration, but predicted it was "probably not going to happen.")



For the second consideration, you can speculate about your immediate computing desires and where you might go from there. A plus for the Plus/4 could well be its built-in applications programs, which might be worth the extra money to you. The word processor will at least give novices an idea of what's involved in typing on screen, though I feel it is a horror of a program for reasons cited earlier. The other applications packages are adequate, though.

I would not consider this a business productivity machine by any means. To be fair, though, there are plenty of lesser computers, many of them Commodore 64s, used by people to run little businesses from their home. So the Plus/4's improved keyboard and extra disk-handling convenience might make it a tempting choice once the faster 1551 drive appears.

On the other hand, once you've bought a "system," you've come mighty close to Apple II and MSDOS-machine price-range territory.

Taking everything as a whole, I have to conclude, with hindsight, that it was outragious for Commodore to introduce a new machine so close the the C64 that won't run software in the 64's enormous library. I do like the Plus/4, but I'm not crazy about it. Under present conditions, I suggest that new home-computer buyers go a little lower in price (say, a Commodore 64) or higher, if you're making an immediate purchase. ME

CIRCLE NO. 124 ON FREE INFORMATION CARD

# Designing Dc Power Supplies

*Step-by-step procedure describes how to design the fixed power and adjusted power supplies you need for solid-state applications*

By Joseph J. Carr

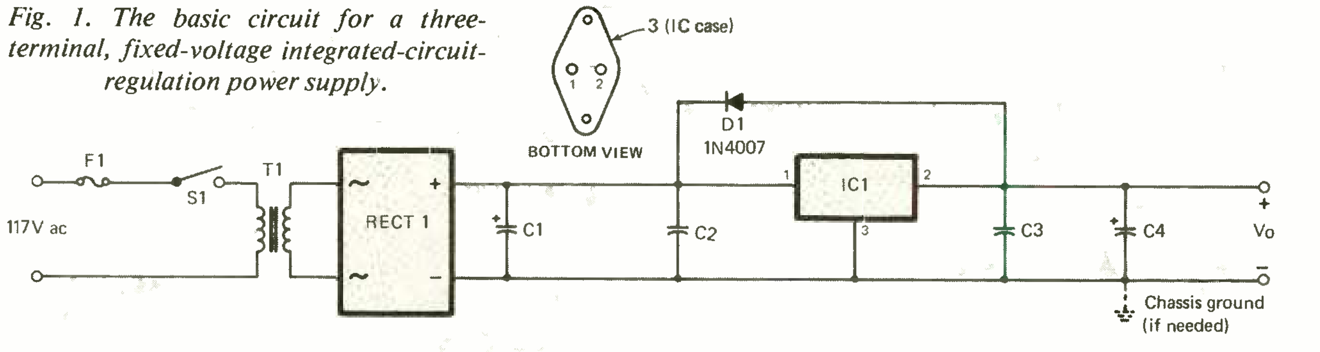
The dc power supply is one of the most important parts of any electronic circuit, yet it is often also the least-considered portion of the design. Dc supplies used by designers and experimenters include both integral power supplies mounted inside a cabinet, and "universal" bench power supplies used for testing, adjusting, troubleshooting, or otherwise experimenting with an electronic circuit. Examined here are methods for "designing" simple dc regulated power supplies, both fixed- and variable-voltage types.

## Fixed-Voltage Types

The task of designing a fixed-output voltage regulator is made much simpler nowadays by three-terminal integrated circuit voltage regulators. There are quite a few of these devices on the market, but they all share certain characteristics. For one thing, their output voltages are fixed at some standard value. The actual value is usually identified from the type number. For example, a 7805 is a 5-volt regulator, while the 7812 is a 12-volt device. There are, of course, exceptions to the numbering rule, but in general there are summarized as follows:

1) LM-309 series are 5-volt, 100-mA or 1-ampere (depending on case style) regulators;
2) LM-323 is a 5-volt, 3-ampere regulator in a "K" package (same as TO3);
3) LM-340n-xx are positive-output voltage regulators. The *n* in the type number denotes package type, the *xx* is the voltage rating. For example, LM-340K-12 is a 12-volt regulator in a "K" package (it passes 1 ampere);
4) 74xx is a family of regulators similar to the LM-340n-xx series. The xx denote output voltage (7812 is a 12-volt regulator). Package style determines output current;
5) LM-320n-xx is a negative-output version of the LM-340n-xx, while 79xx is a negative-output version of the 78xx. (Note: input and ground terminals on the LM-320 and 79xx are reversed from the pinouts of the LM-340 and 78xx. Failure to observe this convention will result in destruction of the regulator!);
6) The package designations are: *H* indicates a TO-5 case, or its

*Fig. 1. The basic circuit for a three-terminal, fixed-voltage integrated-circuit-regulation power supply.*



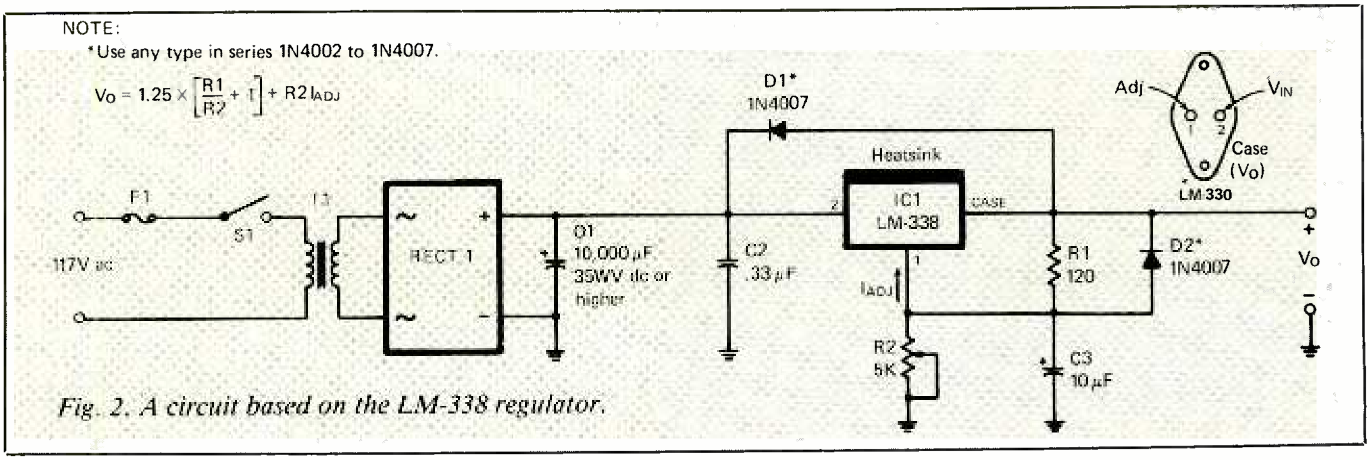



*Fig. 2. A circuit based on the LM-338 regulator.*

plastic equivalent, and a current of 100 mA; *K* indicates a TO-3 case and a current of 1 ampere (1.5 amperes if properly heatsinked); *T* indicates a TO-220 plastic power transistor type case and a current rating of 750 mA in free air or 1 ampere if properly heat sinked.

With regard to current ratings, heat and high currents are the twins that destroy electronic circuits. If these devices are routinely operated at or near maximums, you can expect to experience a higher-than-usual failure rate.

Shown in Fig. 1 is the basic circuit for a three-terminal, fixed-voltage IC regulator. Transformer *T1*, bridge rectifier *RECT1* and filter capacitor *C1* are selected according to the usual rules for any dc power supply. The transformer steps the 117-volt ac line potential down to the level required for the input of the regulator. As a rule, there should be a minimum 2.5-volt difference between the rated regulator output and the minimum allowable input voltage. For a +5-volt regulator, a minimum of +7.5 volts is needed.

With the foregoing in mind, when selecting a transformer, choose one that provides at least the minimum differential. Also, remember that the voltage across the regulartor's input, which is also the voltage across filter capacitor *C1*, will be approximately 0.9 times the peak ac voltage across the transformer secondary. Since the secondary voltage is specified in rms values, you must multiply the rate value by 1.414 to determine the peak voltage. If all terms are accounted for, the output voltage will be approximately $0.9 \times 1.414 \times V_{rms}$, or $1.27 \times V_{rms}$.

The minimum rms value of the secondary voltage should be the minimum value of dc requried to feed the regulator divided by 1.26. For the +7.5 volts required for a +5-volt regulator, then, you need an rms rating of 7.5/1.26, or 5.95 volts. Since 6.3-volts rms is the next highest standard value, you would select a 6.3 volt ac transformer.

Transformer current rating should be no less than the highest expected dc value you expect the load to draw, plus a margin for safety. In addition, keep in mind that most transformers with center-tapped secondaries are rated for regular full-wave rectification, not full-wave bridge rectification. When the bridge circuit is used the current available is one-half the rated value because of the voltage doubling and the fact that you don't want to exceed the volts × amperes rating of the transformer.

Some transformers will bear up when a greater than rated current is drawn, but it isn't good practice to make them work so hard. Transformer current rating, then, must be at least the current rating of the regulator—and preferably more. There's a general design rule that requires us to use only about 75% of capacity on the average.

There are two rectifier ratings that require particular attention. These are forward current and peak inverse voltage (PIV). Forward current is simply the amount of current that the bridge rectifier will normally pass in the forward direction without suffering a heart attack. In most cases, the forward-current rating of the rectifier should be equal to or greater than the regulator's forward current rating. Again, good design practice dictates that you should allow some excess capacity, so that the rectifier is never made to operate for long at its maximum rating. If you observe this simple rule of thumb, your circuit will operate with almost failsafe reliability.

The peak-inverse-voltage rating is the maximum reverse-bias voltage that the rectifier will withstand without breaking down. Exceeding the device's PIV is almost certain to result in destruction of the rectifier. The normal rule of thumb here is to use a minimum PIV of 2.83 times the applied rms. The reason for this is that the normal PIV seen by the rectifier is 1.414 × rms plus the voltage on

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the capacitor (*C1* in Fig. 1), which is also 1.414 × rms. Thus 2 × 1.414 × rms is 2.83 × rms.

This rule doesn't mean much when dealing with 6.3-volt ac transformers, because the minimum available PIV is 25 volts, which is above the maximum reverse voltage generated. But the rule becomes increasingly more important when the voltage increases.

Filter capacitor *C1* in Fig. 1 is selected to provide enough ripple reduction to make the regulator happy. It isn't necessary for *C1* to provide *all* of the ripple reduction needed by the external circuitry powered by the regulator. (The regulator itself adds considerable ripple reduction.) Most authorities recommend a capacitance value of between 1000 and 2000 μF/ampere of current drawn. If you use the 2000-μF/ampere figure, a 1-ampere regulator (the most common type) requries a 2000-μF capacitor. At least 500-μF must be in the circuit, even when the forward current is less than 500 mA.

The working voltage rating (WVDC) of the filter capacitor must be somewhat greater than the maximum expected voltage. Keep in mind that most electrolytic capacitors have a 20% tolerance and that voltages normally vary 15%. Therefore, you require a 35% margin of error on the WVDC rating. For example, if you have 18 volts coming from *RECT1* to regulator *IC1*, this is what will be applied across *C1*. Using the 35% rule, you would specify 18 volts × 1.35, or 24.3 volts (or more). Since 25 WVDC is a standard value, you can use this as the minimum WVDC of *C1*. But to be on the safe side, at only a very small additional cost, you would be much better off using a 35- or 50-WVDC if practical.

Capacitors *C2* and *C3* in Fig. 1 are used for noise immunity/protection. Their values aren't critical. Typically, you would use any value between 0.1 and 1.0-μF. These capacitors are best mounted as close as possible to

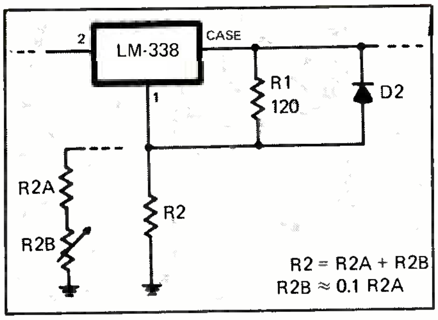


*Fig. 3. Fixed output voltage is initially set with R2A/R2B, which are replaced by same-value resistor.*

the regulator device. In fact, many designers mount them right on the regulator itself.

Output capacitor *C4* is optional. It's included in the circuit to improve the transient response of regulator *IC1*. When external current demand increases very rapidly, it will take a certain amount of time (in microseconds) for the regulator to catch up. During this period, the external circuit will draw current from *C4*, thus preventing a "glitch" in the power supply voltage. The value of *C4* should be determined by assuming that 100 μF/ampere is needed. The WVDC rating shouldn't be less than 1.35 times the rated output voltage of the regulator.

If you do use *C4*, it's a good idea to also use diode *D1* to dump the charge on the capacitor when power is removed from the circuit. Otherwise, the charge can be dumped back into the circuit through and cause damage to the regulator. Any rectifier diode in the 1N4002 through 1N4007 series will suffice here.

## *Adjustable-Voltage Types*

Adjustable-voltage regulators used to be somewhat more difficult to design than fixed types. Today, however, there are several three- and four-terminal devices on the market that greatly simplify the design procedure. To keep this article brief, we'll limit our discussion to the LM-317 and LM-338 devices, since these are readily available to experimenters through mail-order and walk-in retail outlets that sell parts.

The LM-317 and LM-338 are similar to each other in function. They differ in that the LM-317 handles 1.5 amperes, while the LM-338 is rated at 5 amperes. Information given below for the LM-338 is generally usable for the LM-317 as well.

A circuit based on the LM-338K is shown in Fig. 2. Note that the output terminal of this regulator is the case, whereas the case of the fixed-voltage three-terminal regulator in Fig. 1 is the reference terminal for the input

*(Continued on page 96)*

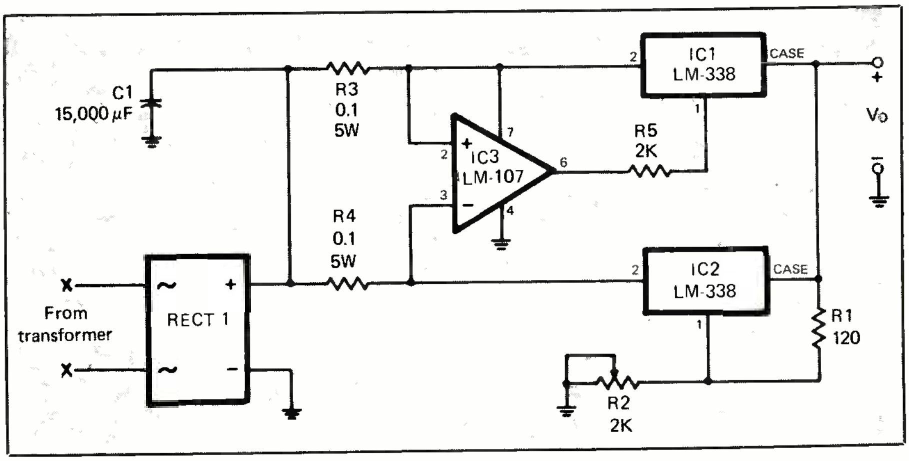


*Fig. 4. In this variable-output-voltage circuit, two LM338K IC voltage regulators are used to provide a 1.2-to-16-volt regulated output with a current-delivery capability of 10 amperes.*

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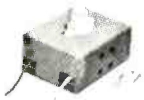

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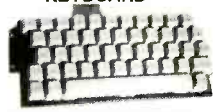

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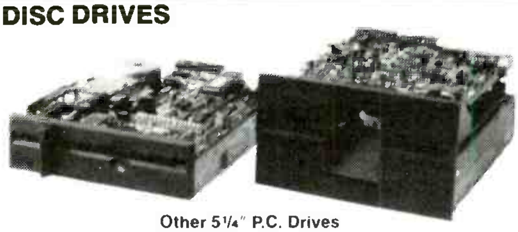

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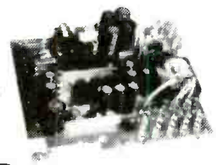

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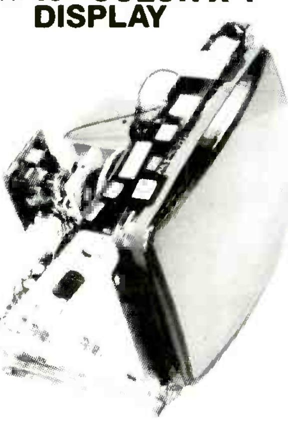

Originally designed for use in Atari coin-operated games. Contains a 19VLUP22 3-gun color tube, focus and brightness controls. Has electromagnetic deflection and solid state circuitry with three "Z" amp inputs (red, green, blue). Ideal for arcade replacement or, with the addition of external circuitry, for color graphics display. Manual included.
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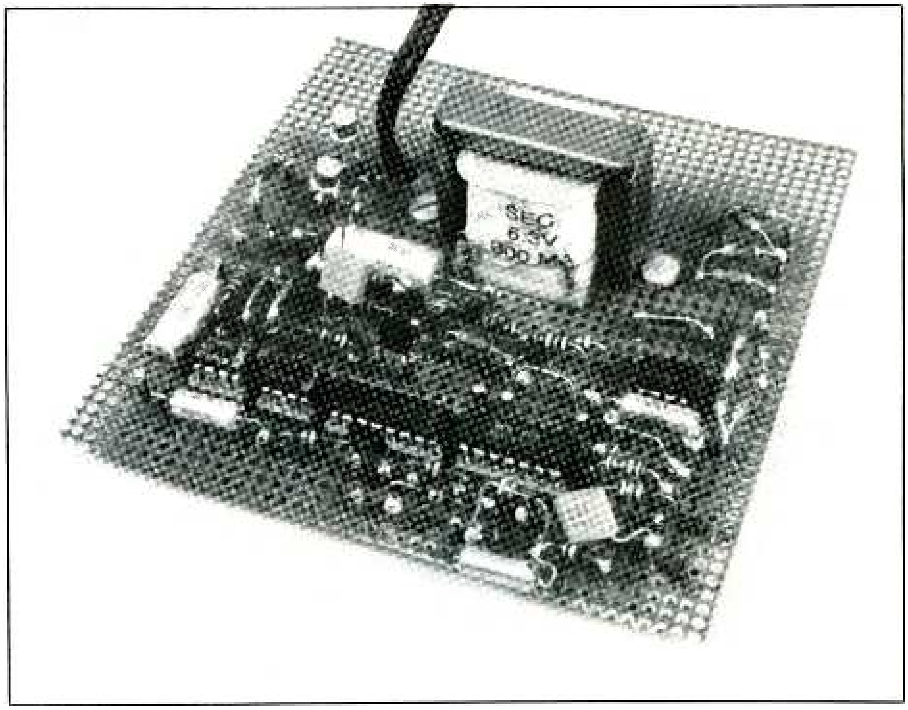
CIRCLE 65 ON FREE INFORMATION CARD

# The Frustrator

## *Phone device thwarts would-be telephone pitchmen and other annoying callers, but lets through calls you want to receive*

**By Anthony J. Caristi**



Annoyed by unwanted telephone calls from people trying to sell you this or that? Are there times when you just don't want to answer your phone but are afraid of missing an important call? If so, the "Frustrator" may be just what the doctor ordered. This project gets its name from its response to anyone who dials your number and doesn't know the secret of getting through to you.

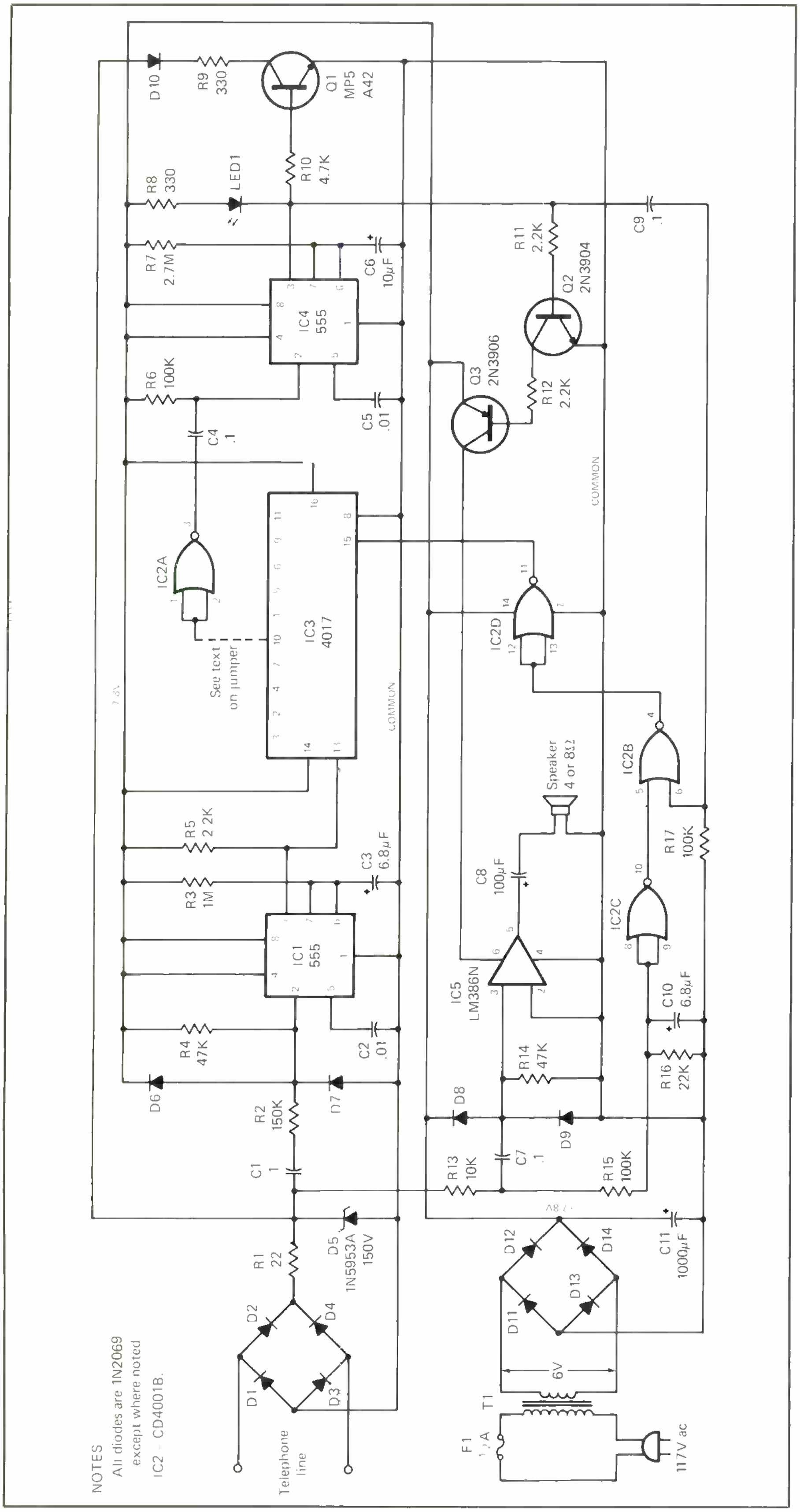
The Frustrator answers your phone, on whatever ring you select, and greets a caller with dead silence. Then, after about 30 seconds, it hangs up (disconnects the line). Repeated calls to your number will result in the same thing happening. Eventually, your unwanted caller will give up in frustration. He'll likely conclude that your phone or the telephone line is defective.

So far, you've succeeded in foiling an unwanted caller. Now for relief from your anxiety about missing important calls. If your caller knows the secret, he or she simply speaks into the mouthpiece or presses one of a series of buttons (in a predetermined code) on a Touch-Tone phone to alert you that a friend or relative is calling. The Frustrator will connect an amplifier and speaker to your line to let you hear voice and Touch-Tone signals. At this point, you have about 30 seconds to pick up the receiver and answer the call; otherwise, the line will be automatically disconnected.

This project can be permanently connected to your telephone line. It won't interfere in any way with normal telephone operation. It always gives you the option of answering your phone before or after it does. Even after you pick up the receiver, it automatically disconnects after about 30 seconds and resets itself to intercept the next call each time you or it anwers your phone, but it lets you continue your conversation for however long you wish.

### *About The Circuit*

Four sections make up the Frustrator's circuit (Fig. 1), each with a specific task. Timer chip *IC1* is configured as a monostable, or one-shot,




## PARTS LIST

**Solid-state devices**

D1 thru D4,D6 thru D14—1N2069 or similar diode

D5—150-volt zener diode (1N5953A or equivalent)

IC1,IC4—555 timer

IC2—CD4001B quad 2-input NAND gate

IC3—CD4017B Johnson decade counter

IC5—LM386N audio power amplifier

LED1—Red light-emitting diode

Q1—MPS-A42 or similar 300-volt npn transistor

Q2—2N3904 or similar npn transistor

Q3—2N3906 or similar pnp transistor

**Capacitors**

C1,C4,C7,C9—0.1-μF, 100-volt disc

C2,C5—0.01-μF disc

C3,C10—6.8-μF electrolytic

C6—10-μF electrolytic

C8—100-μF electrolytic

C11—1000-μF electrolytic

**Resistors** (all ¼-watt, 10% tolerance)

R1—22 ohms

R2—150,000 ohms

R3—1 megohm

R4,R14—47,000 ohms

R5,R11,R12—2200 ohms

R6,R15,R17—100,000 ohms

R7—2.7 megohms

R8,R9—330 ohms

R10—4700 ohms

R13—10,000 ohms

R16—22,000 ohms

**Miscellaneous**

F1—¼-ampere slow-blow fuse

SPKR—Miniature 4- or 8-ohm speaker

T1—6.3 volt, 300-mA transformer

Perforated board and solder posts or printed-circuit board; suitable enclosure; holder for F1; sockets for ICs; ac line cord; machine hardware; hookup wire; solder; etc.

**Note:** The following are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463; etched and drilled pc board, $6.75; LM386N, $3.00; CD4001B, $2.50; CD4017B, $3.25; LM555, $2.50 each; MPS-A42, $3.25. Add 75¢ postage/handling per order.

*Fig. 1. Note in this overall schematic of the Frustrator that power is supplied from the ac line. The project connects to the telephone line via the diode bridge (upper left).*

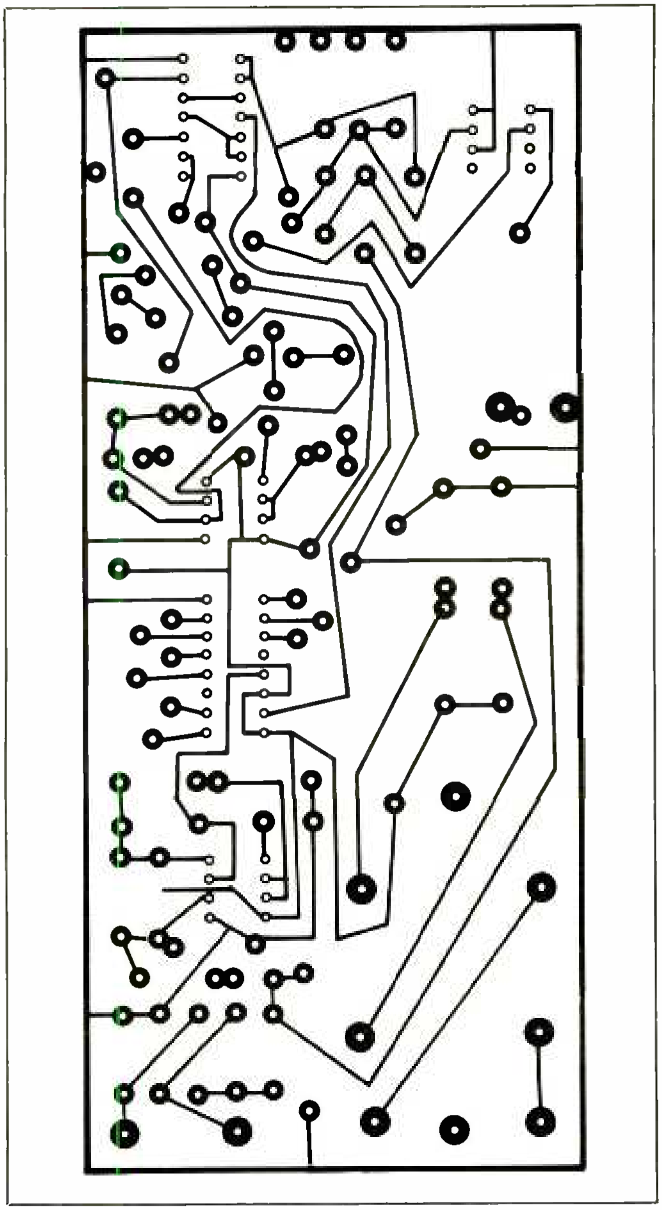


*Fig. 2. This is the actual-size etching-and-drilling guide for the project. A ready-to-use printed-circuit board is available from the source given in the Parts List.*

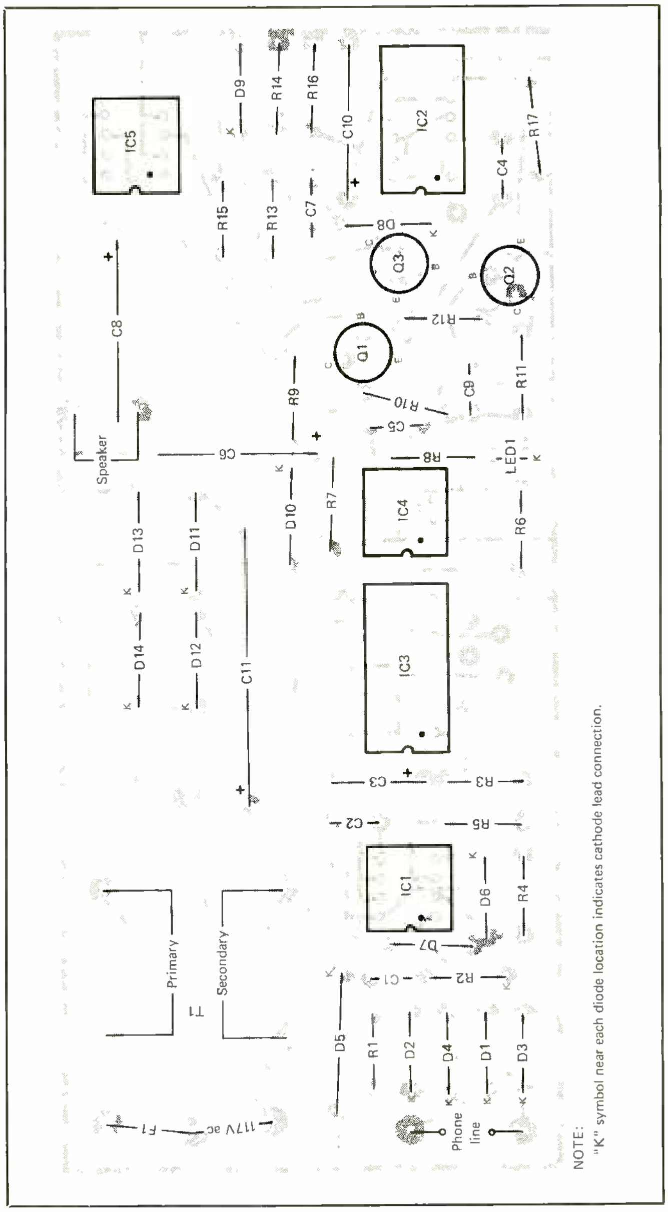



*Fig. 3. This is the component layout diagram for the pc board. Sockets are recommended for installation of the ICs. Be sure to observe component orientations.*

multivibrator. It detects the presence of the ring signal on the telephone line. This signal has an amplitude of 90 volts and a frequency of 20 Hz. Each time the ring signal is detected, *IC1* is triggered and its out-put on pin 3 goes positive for 3 seconds. This converts the 2-second on, 4-second off ring signal into a pulse train of 3 seconds on and 3 seconds off.

The pulse train from *IC1* is used to clock Johnson decade counter *IC3*, which counts from zero to whatever ring you've selected for the Frustrator to answer your phone. When the circuit is at rest, *IC3* is in the normal reset mode, with a zero count obtained from a positive pulse fed to pin 15 from either the last time the Frustrator answered the phone or when the phone was used in the normal manner. As a result, pin 3 of *IC3*, the decoded output for a zero count, is positive (logic 1) and all other outputs are zero.

When your phone rings, each ring causes *IC3* to increment one count. The first ring causes pin 2 to go positive, the second ring pin 4, and so on. When the pin you've selected goes positive, the pulse is inverted by *IC2A*, differentiated by *C4*, and fed to the trigger input of *IC4*, another timer configured as a one-shot multivibrator, with a timing cycle of about 30 seconds.

The positive output of *IC4* (pin 3) is used to forward bias *Q1*. When *Q1* switches on, the current through *D8* and *R7*, supplied by the phone line, causes the caller to hear a click that sounds like your phone's receiver being picked up and then only silence. Then 30 seconds later, pin 3 of *IC4* goes low (0 volt), disconnecting the line, unless you've picked up your telephone's receiver.

The positive output voltage from *IC4* is also used to switch on *Q2* and *Q3*, applying positive supply voltage to pin 6 of the *IC5* power amplifier. This IC amplifies the signal on the phone line only during the on time of *IC4* to let you hear what's happening even though you may not be near your phone. At all other times, *IC5* isn't powered and *SPKR* is silent.

Digital logic fed to *IC2C* or *IC2B* is used to reset *IC3* back to zero count after the Frustrator has done its job. Finally, *IC2C* detects when your telephone's receiver is lifted off the hook, while *IC2B* detects when *IC4* has answered your phone through *Q1*. Under either condition, the circuit is automatically reset to receive the next call.

The LED connected to the output of *IC4* alerts you to the status of the circuit at all times. When the Frustrator is standing by for a call, *LED1* is on. It extinguishes during the 30-second call-answering sequence.

## *Construction*

This is a relatively easy project to build, since there is nothing critical about parts layout nor are there any special assembly techniques that must be followed. Consequently, the project can be assembled on a piece of perforated board, using solder posts, or on a printed-circuit board. You can fabricate your own pc board, using the full-size etching-and-drilling guide shown in Fig. 2, or you can purchase an already etched


## PHONE DIALING BY VOICE

A new home/business telephone device, Command Dialer II™, has been introduced that enables a user to dial a telephone number by voice. Audec Corporation's $199.95 voice-recognition telephone, Model VRT-1150, makes this possible by matching pre-programmed words and telephone numbers.

To set up the machine for voice-recognition/phone dialing, the user stores up to 16 phone numbers in the model's built-in memory, each with as many as 30 digits. Then using your voice, you assign each number an appropriate name, whether it's "police," "Mary," "office," or any other identifiable code. Once programmed in this manner, both numbers and words become part of the device's voice-recognition memory, which is activated by simply lifting the receiver off its hook and voicing the proper code name. The phone does the rest, automatically dialing the proper number, including Sprint, MCI, or another long-distance service number. The system will also adapt to voices of other people—wife, secretary, etc.—according to an Audec Corp. spokesman.

In addition to its voice-recognition function, the VRT-1150 automatically selects pulse or tone dialing, depending on the service you have. Other features abound. For example, a two-way speakerphone can be witched in for hands-free two-way conversation; programmed phone numbers can be checked by visual feedback; an automatic redial function is activated when you hang up the phone while facing a busy signal (the machine calls you back when the number is free); a secret code can be programmed to prevent unauthorized long-distance calls, sounding an alarm when someone makes such an attempt.

Using its built-in memory, there's an instant scratch pad available to enter important numbers during a phone conversation for recall afterwards. Furthermore, there's a mute switch for private speaking and a ringer on-off control so that incoming calls can be indicated only by automatic flashing of a light.

Topping off the foregoing, the telephone device acts as a full-function LED alarm clock with a snooze option. You need not lose your programmed information either since there's a battery-backup. The telephone device measures 11⅞″W × 8¾″D × 3⅞″H.

CIRCLE NO. 120 ON FREE INFORMATION CARD

and drilled board from the source given in the Parts List.

Whichever method of assembly you choose, it's a good idea to have the ICs mount in sockets to permit ease of servicing should this ever become necessary.

Referring to the components layout diagram in Fig. 3, mount the parts as shown. Make sure you orient the electrolytic capacitors, diodes, LED, transistors and ICs according to polarization or pinout. Do not at this time, however, install the ICs in their sockets.

Use only good-quality electrolytic or tantalum capacitors for *C3* and *C6* in the timing circuits and a low-leakage capacitor for *C10*. Also, since it must be able to withstand the high ring-signal voltage on the telephone line, *Q1* must be a high voltage (300-volt) transistor.

You have a circuit option that requires the installation of one jumper on the circuit board. This is the selection of the ring signal (one to nine) on which you want the Frustrator to answer your phone. The Table details how how this jumper is to be installed according to your choice. For example, if you want the Frustrator to answer your phone after the fourth ring, you would connect the jumper between pin 10 of *IC3* and pins 1 and 2 of *IC2*. Be sure to use only *one* jumper.

**JUMPER TABLE**

| Number of rings | Connect IC2A, pins 1 & 2 to IC3 |
|---|---|
| 1 | 2 |
| 2 | 4 |
| 3 | 7 |
| 4 | 10 |
| 5 | 1 |
| 6 | 5 |
| 7 | 6 |
| 8 | 9 |
| 9 | 11 |

## Circuit Checkout

Before you attempt to place the Frustrator into operation, the project must be checked out to ascertain that it is working properly. This can be done very easily with a dc voltmeter.

With no ICs installed in the sockets on the circuit board, plug the Frustrator's line cord into any convenient 117-volt ac outlet. (Be careful to stay away from the wires feeding the primary of *T1*!) Measure the voltage across *C11* while observing the polarity of your meter. You should read about 7.8 volts (+ or − 10%) here if the power supply is operating properly. If the voltage is correct, leave the negative lead of the meter connected to the negative lead of *C11* and measure the voltage at pin 8 of *IC1* and *IC4,* pin 14 of *IC2,* and pin 16 of *IC3.* In all cases, the reading should be the same as that across *C11,* or about 7.8 volts. When you're satisified that all voltages are correct, disconnect power and allow *C11* to completely discharge.

One final check must be made before the Frustrator is put into service. This is the timing of *IC1*. To do this, install only *IC1* in its socket (observe orientation). Connect your voltmeter between pin 3 and circuit common. Plug the Frustrator's line cord into an ac receptacle and use a short length of wire to *momentarily* short pin 2 to circuit common, being very careful not to touch any other part of the circuit. This causes *IC1* to operate as a one-shot multivibrator, which is indicated on the meter as a 7.8-volt (B+) reading for about 3 seconds.

Trigger *IC1* several times with the jumper wire, each time noting the number of seconds the voltage remains high. This time must be more than 2 but less than 4 seconds. If the timing of *IC1* is too short or long, change the value of *R3* to bring it within the 2-to-4-second timing range. Smaller values of *R3* reduce timing, while larger values increase it. When you're satisfied that *IC1's* timing is correct, disconnect the power cord and allow *C11* to fully discharge. Then install the remaining ICs in their respective sockets, taking care to properly orient them.

The circuit-board assembly can be mounted inside a small cabinet that's large enough to also accommodate the speaker. The Frustrator doesn't have to be installed near the telephone. It can be placed anywhere convenient to an ac power receptacle and the telephone line connector. For a professional job, you can terminate the pair of telephone line wires in a modular plug, which will permit you to install the project just as you would any other telephone accessory. Since the Frustrator has a bridge rectifier circuit in the telephone-line input section, the polarity of the connection to the phone line isn't significant. Just be sure to connect to the red and green wires of the existing phone line.

## In Closing

The Frustrator can be placed into service simply by connecting the phone-line input wires to the telephone line and plugging the project's ac line cord into an ac receptacle. If *LED1* doesn't come on when power is first applied to the project, *IC4* has been triggered by the sudden application of power and is in its timing cycle. Allow about 30 seconds for the LED to come on. Reset the circuit to standby mode by lifting the telephone receiver for about 5 seconds and then replacing it.

You can check operation of the circuit by dialing your number from another line (not an extension on the same line!) and observing how many rings it takes for the Frustrator to answer your phone. You might also have a friend dial your number and then signal you with a Touch-Tone rendition of, say, Jingle Bells (999 999 9#789). Once you've established that the Frustrator is working as it should, you're ready to have it thwart all those would-be telephone pitchmen. Be sure, however, that you tell your relatives and friends about your secret, or they'll be frustrated, too! ME

# An Automatic LED Street Number Sign

## *Plug-in-and-forget sign guides visitors to your doorstep in the dark*

**By Hank Olson**

During the daylight hours, anyone walking or driving past your house may not have trouble reading your street number. But it's a different story altogether after the sun goes down and darkness descends. If you don't have a lighted number, it may be impossible for a visitor to find your home in a developed community, especially if you live in a tract community where all homes are built on the same general design. If you have or anticipate having this problem, a solution is the automatic illuminated LED street number sign described here.

This project provides even illumination, unlike signs in which an incandescent lamp supplies backlighting. As a bonus, you don't ever have to remember to turn LEDs on and off. A built-in light detector automatically samples ambient lighting and does the switching for you according light level. Furthermore, the LED sign consumes very little power, even when fully on, making it economical to operate.

### *About The Circuit*

Shown in Fig. 1 is the complete schematic diagram of the automatic LED Street Number sign. Power for the circuit is supplied by the full-wave bridge power supply shown at the upper left. Incoming 117 volts from the ac line is stepped down by transformer *T1*, rectified to pulsating dc by bridge assembly *RECT1*, and filtered to dc by capacitor *C1*.

The dc output at the junction of dropping resistor *R2* and filter capacitor *C1* supplies power to the LED numeral array shown in the dashed-line box at the upper right. Power for the control circuit is picked off the center tap of *T1*, current limited by *R4*, and regulated to +12 volts before delivery to phototransistor *Q1* and comparator *IC1*.

The supply potential delivered to the LED numeral array is intentionally limited to a nominal 30 volts dc, with current limiting, to conform to the National Electrical Code. This permits use of No. 18 bell wire between the control circuit and LED numeral array.

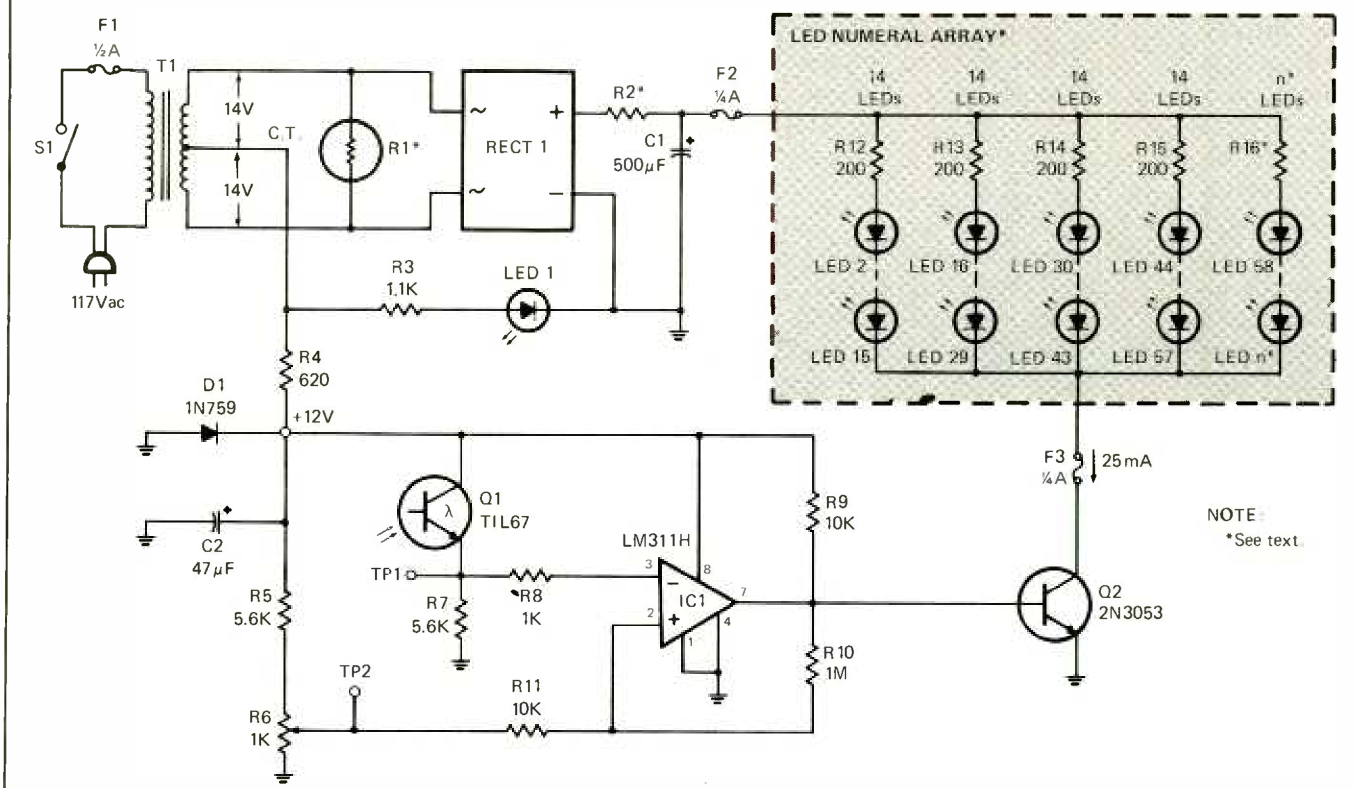
By using only high-efficiency gallium-arsenide-phosphide or gallium-phosphide LEDs, which draw only about 5 mA when conducting, the design procedure can be simplified. With such LEDs, a drop of between 1.8 and 2.0 volts results when a given LED is forward biased by 5 mA. It is a simple matter, therefore, to determine the maximum number of LEDs that can be placed across the nominally 30-volt line.

Taking 1.9 volts as an average forward bias, the maximum number of LEDs that can be placed across the 30-volt line is 30/1.9, or 15. Since some series resistance must be included in any such calculation, this number should be reduced to 14. Therefore, the maximum number of LEDs connected in series across the 30-volt line is 14.

Though you can't construct much of a street-number display from only 14 LEDs, additional series strings of LEDs can be connected in parallel with the first, as shown, until you have all the LEDs you need. The maximum number of series strings of LEDs connected in parallel should be limited to five, giving you a total of 70 LEDs from which to compose your house number.

With 70 possible LEDs, you can figure a minimum of four LEDs per segment per numeral, arranging the numerals in the traditional seven-segment layout, even if your house number is 88888, which represents the most intensive use of LEDs. Figure 2A illustrates the LED count for each numeral. Note here that selected LEDs in certain segments of many of the numbers have been omitted to give the numerals a more rounded appearance, rather than the squared-off boxy look you'll find in traditional LED numeric displays for meters, frequency counters, and other such electronic devices. Coincidentally, this approach reduces the number of LEDs needed to construct numerals with rounded edges, like 2, 5, 6, 8, 9 and 0.

If you have fewer numerals in your street number, or your street number consists of less-intensive segment use numerals (like 1, 4 and 7), you can use




## PARTS LIST

**Solid-state devices**
D1—12-volt zener diode
IC1—LM311H comparator
LED1—Green light-emitting diode
LED2 thru LEDn—Red light-emitting diode (Hewlett-Packard No. 5082-4655 or similar)
Q1—TIL67 phototransistor
Q2—2N3035 transistor
RECT1—50-PIV, 2-ampere bridge rectifier

**Capacitors**
C1—500-µF, 50-volt electrolytic
C2—47-µF, 25-volt electrolytic

**Resistors** (all 10% tolerance)
R1—RY57 thyrite varistor (Automatic Electric)
R2—½-watt (see text)
R3—1100 ohms, ¼-watt
R4—620 ohms, ¼-watt
R5,R7—5600 ohms, ¼-watt
R8—1000 ohms, ¼-watt
R9, R11—10,000 ohms, ¼-watt
R10—1 megohm, ¼-watt
R12 thru R15—200 ohms, ¼-watt
R16—See text
R6—1000-ohm, pc-mount trimmer potentiometer

**Miscellaneous**
F1—½-ampere fuse with pigtail leads
F2,F3—¼-ampere fuse with pigtail leads
S1—Spst power switch
T1—14-volt center-tapped transformer (Triad No. F90X or similar)
Perforated board and solder posts; 8-pin DIP socket for IC1; ac line cord and strain relief; solder-post pins for *TP1* and *TP2*; suitable plastic or metal enclosure; fast-set epoxy cement; silicone adhesive; machine hardware; hookup and bell wire; etc.

*Fig. 1. Overall schematic diagram of the Automatic LED Street Number Sign. The boxed- off section at the upper right is LED array that makes up the sign's LED numerals.*

five and possibly even six LEDs per segment to increase legibility and/or character size, as shown in Figs. 2B and 2C, respectively. Bear in mind that the greater the number of LEDs used per segment, assuming no increase in character size, the greater the legibility of the numeral.

Resistors *R12* through *R16* in Fig. 1 serve as current limiters for the series strings of LEDs. Note that there are five such strings shown connected between the positive bus of the power supply and the collector of driver transistor *Q2*. Each string must contain 14 LEDs or their equivalent. Since not all street numbers will require 70 LEDs, it would be wasteful to include 70 LEDs in your numeral array. It may be possible to reduce the number of series strings required, depending on your LED needs. Also, it will be the rare case in which all series strings will require 14 LEDs, as indicated by *LEDn* in Fig. 1. In a case like this, where there are fewer than 14 LEDs in a series string, the value of the current-limiting resistor (*R16* in Fig. 1), will have to be adjusted to make up for the loss of a LED or LEDs.

Before you can determine what value resistor to use in a string containing less than 14 LEDs, you must know that the potential on the nominally 30-volt positive bus from the power supply is actually 27.6 volts. This potential is fixed by the value of resistance used for *R2* and the current drawn by the series-parallel arrangement of the LED numeric array.

The voltage at the top end of the power supply bus must be adjusted by *R2* (more about this under "Construction") to yield the required 27.6 volts. This resistor dissipates only about 0.1 watt in normal service. However, if the 27.6-volt bus should short to ground, the ½-watt resistor would have to dissipate more than 5 watts and would quickly burn open like a fuse. There are ¼-ampere fuses (*F2* and *F3*) in both LED array lines, but these are to protect the electronics against any possible fault-to-ac-line problems, rather than to protect the circuit from overload damage.

Determining the value of resistance to use for *R2* is complicated somewhat by the rather unorthodox arrangement of the components at the output of the rectifier. Instead of having dropping resistor *R2* follow filter capacitor *C1* in the traditional manner, *R2* precedes *C1*. This arrangement makes determination of *R2's* value more difficult, but it offers the benefit of reduced ripple current in *C1*, resulting in longer life for the capacitor.

In simple terms, the potential at the high end of *R2* will normally be somewhere between +30 and +40 volts. Knowing the number of series strings in the LED numeral array and the current drawn by each (5 mA), you can obtain the approximate value for *R2* and adjust it as needed until the potential at the low end of the resistor measures 27.6 volts.

The values of *R12* through *R15*, all the same in the 14-LED series strings in Fig. 1, have been determined for you and are indicated in both the schematic diagram and the Parts List. The value of *R16*, however, must be calculated separately, depending on the number of LEDs in its series string. Let's assume you need 13 LEDs in the final string. Multiply 13 by 1.9 volts (the average potential dropped across each LED) to obtain 24.7 volts. Subtract 24.7 volts from the actual 27.6 volts on the nominally 30-volt bus to obtain 2.9 volts. Since the current that is to flow through the string is to be 5 mA, use Ohm's Law for resistance to determine the value of the resistor as follows: $R = E/I = 2.9\ \text{volts}/5\ \text{mA} = 580$ ohms.

Similarly, you can calculate the value needed for *R16* for any number of LEDs fewer than 14 in the string. For example, if you need only 10 LEDs, the voltage dropped across them would be 19 volts. Subtracting this from 27.6 volts, you obtain 8.6 volts. Then, using the Ohm's Law formula, you obtain $R = E/I = 8.6\ \text{volts}/5\ \text{mA} = 1720$ ohms.

You can easily determine the number of LEDs needed to make up your street number by adding together the number required for each digit, depending on how many LEDs you want to use for each segment. If your street number is, say, 3456 and you've decided to use four LEDs per segment (Fig. 2A), you would add $12 + 13 + 14 + 14$ to obtain 53 LEDs. This requires three series strings of 14 LEDs each plus a single string of 11 LEDs (with a 1340-ohm resistor in the last string). If you had a less LED-intensive number like 1417 and decided to use six LEDs per segment, your LED count would be 66, requiring four strings of 14 and one string of 10 LEDs, with a 1720-ohm resistor in the last string (Fig. 2C).

The remainder of the electronics are for controlling the LED numeral array. Phototransistor *Q1* serves as an automatic switch that toggles on and off, depending on whether the sun is below or above the horizon. Whichever condition is detected is fed to the inverting (−) input of comparator operational amplifier *IC1*. In turn, *IC1* toggles on and off LED array driver transistor *Q2*.

With a darkness condition, *Q1* conducts very little current, bringing the input at pin 3 of *IC1* to near ground potential. This turns on *Q2*, allowing current to flow through the LED array and light the LED numerals. In daylight, *Q1* triggers into conduction. When the voltage on *TP1* becomes more positive than that on *TP2* (*TP1* and *TP2* are test points), *IC1*'s output changes state and goes to near ground potential. This causes *Q2* to stop conducting and turn off the LED array. Resistor *R10* adds a small amount of hysteresis that prevents *IC1* from being indecisive at or near its on and off levels.

## Construction

This is a relatively simple and straightforward project to build. Its circuitry, excluding the LED numeral array can be assembled on a small piece of perforated board, using solder posts and an IC socket.

The best place to start construction is fabrication of the panel on which the LED numeral array is to be mounted. The panel can be made from 3/16"-thick linen phenolic or other opaque insulating plastic sheet. Preliminary to machining the panel, lay out your numerals on a piece of paper, striving for eye appeal and legibility and sized appropriately for the distances from which your sign must be read. You can use the standard boxy 7-segment layout common to commercial displays, or you can make the numerals more rounded. In either case, give them a slight slant of between 7° and 10°. Mark off the locations where the LEDs are to be located, working actual-size. Try for equal spacing between LEDs, as

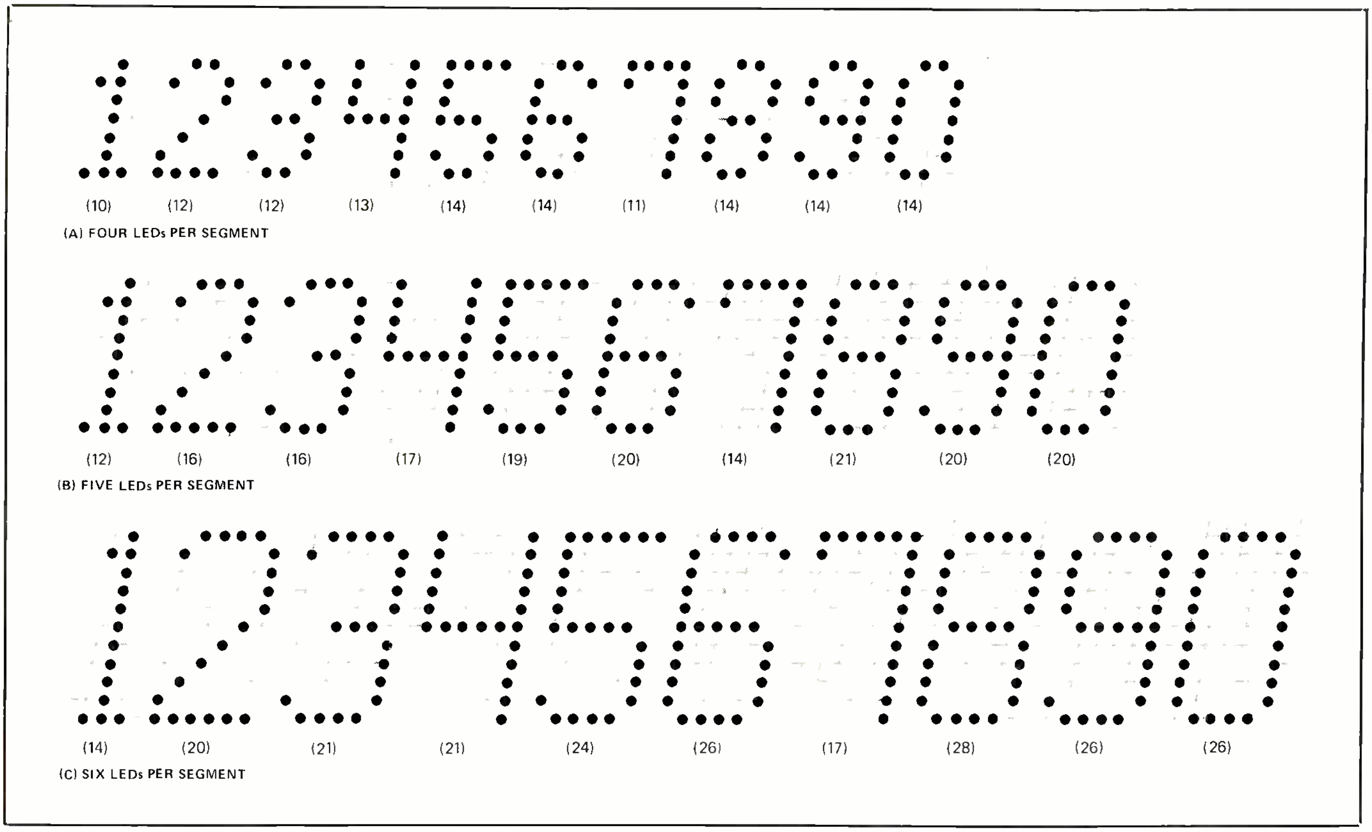



*Fig. 2. Drawings illustrate layouts for numerals composed of four (top), five (center), and six (bottom) LEDS per seg ment. Increase in LED count can increase numeral size, legibility, or both.*

shown in the illustrations in Fig. 2. While you're at it, also indicate where in the layout the current-limiting resistor for each LED series chain is to be.

Tape your template over the LED numeral array panel and use a sharp center punch to transfer the LED pattern to the panel. Tap lightly on the punch to avoid cracking or splitting the panel. (Do *not* at this time transfer the locations for the resistor leads to the panel.) Remove the template.

If you're using the commonest type of LED, the so-called T-1¾, use a 3/16" bit to drill holes through the panel at each center-punched location. If you've decided to use a different type of LED, larger or smaller in diameter, you'll have to select a bit sized accordingly.

Once the holes are drilled, replace the template on the panel and transfer the locations for the current-limiting resistors to the panel with the center punch. Remove the template and use a 1/32" or 3/64" bit to drill the holes.

Push the domed lens end of the LEDs into the holes from the rear of the panel. The lip around the base of the LEDs will prevent them from falling all the way through and will permit the domes to protrude about 3/32" beyond the front surface of the panel. Orient the LEDs for easy interconnection and apply a spot of fast-setting clear epoxy cement on opposite sides to anchor the LEDs to the panel. When the cement sets, wire the series strings of LEDs as shown in Fig. 1, connecting the cathode of the first LED in the string to the anode of the next, and so on to make as many 14-LED strings as needed. Install and wire in the current-limiting resistors.

Now assemble the control-circuit/power-supply board. Keep in mind that phototransistor *Q1* must be located where it can sample ambient light. If you plan to mount this board behind the LED array panel, you'll have to drill two extra holes in the latter, in which to mount *Q1* and *LED1*. *LED1* is used here as a circuit-condition indicator). Run hookup wires from the leads of *Q1* and *LED1* to the appropriate points in the control circuit. If you're using a pc-mount transformer for *T1*, it can mount directly on the circuit board; otherwise, mount *T1* on one of the walls of the box that houses the project.

The only item you won't be able to mount on the circuit board just yet is *R2,* which will have to be selected after the project is powered up. In the meantime, wire into *R2*'s location on

*(Continued on page 84)*

# Upgrading Apple IIe's ROM Monitor

## Part II

*Here are fixes to change this model's restrictive monitor to an absolute old reset one, giving users an opportunity to unleash the computer's real power.*

By Don Lancaster

*Last month in Part I of this article, we discussed Apple IIe firmware, cautioned you about using non-standard ROMs, and began to tell you how to program a 2764 on an old ROM burner. In this concluding part, we continue the burn instructions, tell you how to capture and modify the IIe monitor, and give you a checkout routine for testing your new custom ROM monitor.*

Here are the rules on the slide switch use:

The slide switch points to ground (pin 14) for a low address A12.

It points to +5 volts (pin 28) for a high address A12.

Use the LOW switch position for a C or E monitor burn.

Use the HIGH switch position for a D or F monitor burn.

You might like to mark a 0 on the left switch position and a 1 on the right switch position.

### *Capturing the IIe Monitor*

Catching the D, E, and F segments of the monitor ROM is rather trivial. In fact, some burner-card software will let you simply move their buffer directly to these locations. But the $C000 to $CFFF monitor capture is a bit tricky and non-obvious. So, Program 1 (not shown here due to lack of space, but available free of charge, along with the source code for KREBF SPELL patch by sending a self-addressed legal-size envelope to MODERN ELECTRONICS, Dept. PROG1, 76 N. Broadway, Hicksville, NY 11801) shows you an Applesloth program called SNATCHMON. What SNATCHMON does is grab four 4K segments of the monitor. It places these on disk under IIEMON.C, IIEMON.D, IIEMON.E, and IIEMON.F names.

You then modify these four segments as needed for your custom monitor. These are saved to disk to be BLOADed to a buffer at $8000 to $8FFF. You can relocate these as needed if your EPROM burner card needs a different buffer area. If you have a stand-alone burner, you can use a modem program to send these binary files out as serial text files, and then use them as needed.

SNATCHMON is surprisingly fast, since all of the actual moves are done using the monitor "M" command. Suitable POKEs activate each move as needed. It is absolutely essential that the Y register be zeroed before a monitor move. To do this, any SNATCHMON move CALL first goes to a five-byte machine program at $7FFB that clears the Y register and then jumps to the actual move routine at $FE2C.

Locations $3C (low) and $3D (high) hold the move starting source address. Locations $3E (low) and $3F (high) hold the move ending address. Finally, locations $42 (low) and $43 (high) hold the starting destination address. After these six locations are POKEd with the correct values, the move can be made.

If you're having trouble converting Applesloth decimal into machine hex, check into the *Hexadecimal Chronicles* (SAMS #21802) for instant conversions.

To capture the $C100 to $CFFF monitor as IIEMON.C, you have to flip two pairs of soft switches just right. The magic switches involve $C006, $C007, $C00A, and $C00B. Soft switch $C007 turns on the monitor for the $CX00 access, while $C006 turns on the normal I/O. Soft switch $C00B turns on the monitor for $C300 access, while $C00A turns on the normal slot 3 usage. (Note that these switch flips are *backwards* from page 214 of the *Apple IIe Reference Manual.* Be sure you correct your reference manual. Very ungood things happen if you get these actions mixed up. Note that you must *write* to these locations to activate them, such as with a "C006:00 [cr]" or a

"POKE 49158,0 [cr]". Reads just won't hack it.)

There are a few other soft switches used to control the monitor ROM area, but we need not worry too much about these here. Normally, a cold boot is done before you try running SNATCHMON, which flips the switches into their "normal" positions. You then flip soft switches $C007 and $C008 long enough to move the $C100 to $CFFF monitor image to $8100 to $8FFF, and then flip these switches back to their usual $C006 and $C00A positions.

SNATCHMON assumes you have a single disk drive. A "press the spacebar" prompt lets you change diskettes if you want the images of IIEMON.C, IIEMON.D, IIEMON-.E, and IIEMON.F to end up on a different diskette.

## *Modifying the IIe Monitor*

The IIe monitor is crammed full and has very little in the way of free bytes. There are a few bizarre bugs, such as a programmer's ASCII first name that can get executed as op-codes by certain programs accessing <ctrl>-Y at the old location. The percentage of "compatible" II + programs is far lower than Apple cares to admit, since just about any decent II + program makes use of "illegal" monitor access. As a general rule, schlock II + programs are IIe compatible, while creative and useful ones are not.

Areas available for rewriting are the cassette routines, the screen message, and the above-mentioned "Bryan" code. I urge you not to clobber the cassette routines, since cassettes can often salvage a disaster, even after all else has failed.

About the only monitor area that nobody wants to keep is the hole blaster from $C249 to C260. So, as an example of patching the monitor, we will overwrite this hole blaster with code that accesses the old monitor.

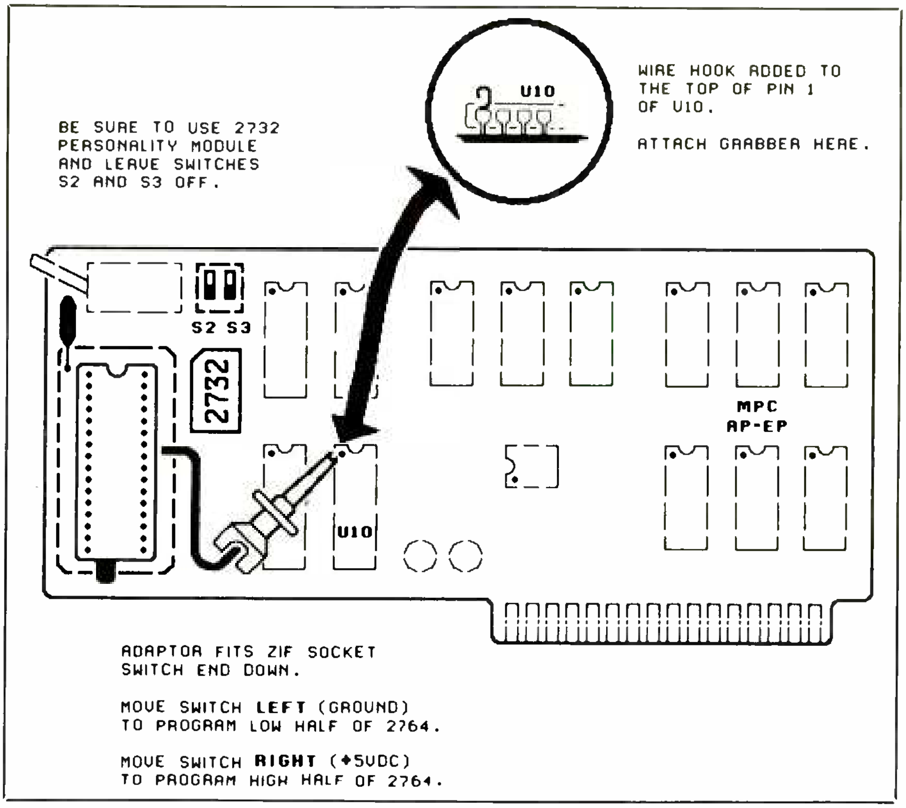



*Fig. 5. This drawing shows how to use the 2764 adapter in the MPC "ap-ep" burner card.*

The source code appears as Program 2 (see above for availability). It is called KREBF SPELL.SOURCE, and assembles into a KREBF SPELL patch. This module is simple enough that we can forego a flowchart. We've used the "new" EDASM format for the source code here.

You can get to location $C249 on a [ctrl] <open-apple dingbat> [reset]. We first blast the warm start location at $03F4 by *incrementing* it. This tells the Apple that we are to do a cold reboot, rather than letting the applications program in use "capture" the reset back to itself.

Then we run through a timing loop 40 times. Each time through, we stall for a tenth of a second via the monitor WAIT routine at $FCA8. We then check to see if the open-apple key is released. If it is released, we continue with a stock cold reboot, sans the hole blasting. If the key is down, we keep on stalling.

If we timeout to a full four seconds, we instead jump directly to the "old" reset code which, thankfully, remains in the monitor at $FF59. The four seconds was selected to be long enough that a child or an unknowing user is unlikely to accidently trip the old monitor access.

There are some undocumented Apple IIe diagnostics stashed at $C400 to $CFFF that will fail the CD ROM if a checksum of all the bits in the entire ROM does not agree with a magic value.

To pass these diagnostics, the checksum of the KREBF SPELL must be the same as that of the hole blaster bytes it replaced. The magic checksum for these $18 bytes of code is $0BA8. The byte at $825E corrects this checksum to let your altered code pass the diagnostics. Note that any

## How to Install Your "Old" Monitor EPROM in an Apple IIe

1. Using the program SNATCHMON, place copies of IIe ROM images onto a work diskette under the filenames of IIEMON.C, IIEMON.D, IIEMON.E, and IIEMON.F.
2. Place a copy of KREBF SPELL onto the same work disk. Do this by copying the companion diskette, assembling from KREBF SPELL.SOURCE, or by simple hand loading.
3. Cast the KREBF spell this way:
   ] BLOAD IIEMON.C <cr>
   ] BLOAD KREBF SPELL <cr>
   ] BSAVE KREBFMON.C, A$8000, L$1000 <cr>
4. If it is needed, plug the 2764 adapter into your EPROM burner. Be sure the notch points to the handle and that the grabber contacts the correct point in the burner. In the MPC ep-ap, the grabber goes to pin #1 of U10.
   WARNING: BE SURE YOUR BURNER IS CONFIGURED FOR AN INTEL 2764 BURN (no adapter) OR A 2732 BURN (with adapter) BEFORE CONTINUING.
   The steps that follow assume you are using the adapter on an older burner, whose 2732 work buffer goes from $8000 to $8FFF.
5. Erase a 28 pin, 250-nanosecond Intel or Hitachi 2764 EPROM using a suitable ultraviolet source.
6. Insert the 2764 EPROM into the adapter socket. Be extra careful not to bend any pins. New 2764s will need all their pins "rocked" inwards to fit.
7. Flip the adapter switch to "0" (towards pin 14). Then arm the EPROM burner and boot the support code.
8. Verify the erasure. Then load, burn and verify KREBFMON.C as if it were intended for a 2732 EPROM.
9. Flip the adapter switch to "1" (towards pin 28). Then load, burn and verify IIEMON.D as if it were intended for a 2732 EPROM. Note that the Krebf spell does *not* get cast on the "D" side.
10. Turn the Apple supply power off and remove *both* ends of the line cord. Carefully remove the CD ROM at E8, using an IC puller, while keeping one wrist on the top of the Apple power supply. Store this ROM in protective foam for possible later warranty repairs.
11. Remove the newly programmed 2764 from the burner and insert it in the newly emptied socket on your IIe, being very careful that the notch goes *towards* the keyboard and no pins are bent or tucked under. Keep your wrist on the power supply as you do this.
12. Apply supply power and run the following checks:
    (a) Normal cold boot of *non-valuable* diskette in drive 1 when power is applied.
    (b) Normal reset to Applesloth or applications program on <ctrl>-<reset>.
    (c) Normal cold reboot on <ctrl>-<open-apple>-<reset>.
    (d) Drop into the monitor on <ctrl>-<open-apple>-<reset> with the <open-apple> key held down for four seconds after release of the reset key. Wait for the beep and the "*" symbol.
    (e) From the monitor, do a C006:00 <cr>, followed by a 6-<ctrl>-P. You should get a standard cold reboot.
    BE SURE TO USE THIS "C006:00 <cr> AT THE START OF EACH MONITOR ACCESS. OTHERWISE, THE I/O SPACE WILL NOT GET PROPERLY ACTIVATED.
    (f) Do a <ctrl>-<closed-apple>-<reset>. After some screen flashing, you should get the "KERNEL OK" message.
13. Put some opaque tape over the lid of your new "old" monitor. Add a bright dot to remind yourself of this change. Save the CD ROM should warranty repairs ever be needed. This completes installation.

changes at all to this code will need a different value for the checksum adjustment byte.

To use your source code, you assemble it into the patch, and then overwrite the patch onto your monitor image. Alternatively, you can hand-load the patch over the monitor code. Details on this appear in the "How To Install Your 'Old' Monitor EPROM In An Apple IIe" box.

Basically, what you do is BLOAD IIEMON.C. Then you BLOAD KREBF SPELL. This patch overwrites the hole blaster with the "old" monitor access timer. Then you BSAVE KREBFMON.C, A$8000, L$1000. All of which casts the Krebf spell on your monitor image.

You then program your 2764, using KREBFMON.C for the low half (switch left) and IIEMON.D for the upper half (switch right). For this particular use, you need only replace the CD ROM with a 2764 EPROM. The EF ROM does not get changed.

Applesloth program SNATCHMON, source code KREBF SPELL.SOURCE, and machine-language binary patch KREBF SPELL are available ready-to-run on a companion diskette. Also included are modules for the IIc and "new" IIe versions. See the box at the end of this article for full details.

Since I cannot legally sell you copies of the IIe monitor image if you do not personally own a IIe on which those images are to be uniquely used, these monitor images are not available from me. You will, instead, have to grab your own with SNATCHMON. The painless and automatic process takes all of half a minute.

It is very interesting to compare Programs 1 and 2. Assembly-language Program 2 was written and debugged much faster than was Applesloth Program 1. Program 2 does more. And its documentation is far more legible.

If you are weak on assembly language programming, check into *Don Lancaster's Assembly Cookbook for the Apple IIe,* (SAMS #22331), for some easy-to-understand text and ready-to-use support modules.

### *Testing and Extending*

Step 12 of the "How To Install" box gives a detailed checkout routine. Be very careful when you swap EPROM for ROM that you bend no pins and that the code dot and notch go towards the keyboard, or front, of your IIe. Save the old CD ROM in protective foam in case warranty repairs are ever needed.

Be sure to turn power off, and remove *both* ends of the Apple IIe line cord. Always lean on the top of the power supply with your wrist before inserting or removing any integrated circuit. Just to be darn sure, hold the Apple end of the line card in your hand as you do this.

It might be best to program your EPROMs on one II + or IIe and test them on a second IIe. This separates programming bugs from strictly operational problems.

Your checkout procedure should include a cold boot, a cold reboot, a cold reboot into the monitor, a cold reboot from the monitor, and a diagnostics pass using the closed-apple key on the IIe's keyboard.

One very important "gotcha": When you drop into the "old" monitor, you do so with the I/O space disabled and the CD ROM enabled. *Always* do a C006:00 <cr> as your very first "old" monitor instruction!

This sounds slightly flakey, but I haven't found a really good way around it. Maybe you can. At any rate, this is no worse than good old CALL -151; in fact, it is one keystroke shorter. Besides, it *always* works—any time, any place, any program, any reason.

If you do not activate the I/O space, all of the usual monitor functions will work in the usual way. The only little problems are that you will have no DOS, printer, or other I/O slot access available. So, be sure to get in the habit of whapping $C006 on each monitor entry.

There are lots of possible things you can do with a custom monitor. For instance, you can rearrange "Applesloth" to suit yourself. You can also do much of what a "snapshot" card can for a tiny fraction of the price. To do this, grab the NMI vector and dump everything in sight to the stack, including all registers, all soft switches, hard-to-read locations such as $0200, and some identifying markers. Then exit to some code that uses none of the usual page-zero or screen-scrolling locations.

Let me know what other monitor mods you would like to see. Use the address or phone number in the box. I'll send a free book and product list to anyone who asks. **ME**

A companion diskette is available that includes the following ready-to-run programs:

SNATCHMON
KREBF SPELL OLD IIE.SOURCE
KREBF SPELL OLD IIE
KREBF SPELL NEW IIE.SOURCE
KREBF SPELL NEW IIE
KREBF SPELL IIC.SOURCE
KREBF SPELL IIC

plus a "must have" bonus book. Price is $19.50 from:

SYNERGETICS
Box 809
Thatcher, AZ 85552
(602) 428-4073

# COMMUNICATIONS

## International Shortwave Program Listings

*(See page 69 for explanation of reception codes in column following broadcast times.)*

**By Glenn Hauser**

**Afghanistan** *R. Afghanistan*
0900-1030 D 15435
1900-1930 C 5905, 7320, 9665, 11805 or 15077

**Alaska** *KNLS*
0700-0930 C 6170
1730-2000 C 7355

**Albania** *R. Tirana*
0000-0030 A 9760, 7065
0130-0200 A 9760, 7120
0230-0300 A 9760, 7120
0330-0400 A 7300, 6200

**Algeria** *R. Algiers*
2000-2030 C 9685, 15215, 17745

**Argentina** *RAE*
0200-0300 B 11710, 15345

**Australia** *R. Australia*
2100-0100 C 17795, 15160
0200-0730 C 17795
0300-0700 C 15320
0600-0840 C 11910
0730-0930 B 11720
0800-1600 B 9580
1100-fade C 5995
1200-fade C 6060

*ABC, Perth*
1000-1600 C 9610

**Austria** *ORF/Austrian Radio*
1200-1230 B 15320 Sun
1230-1255 B 15320
0130-0155 B 5945, 6000
0330-0355 B 5945, 6000
0430-0455 B 5945, 6000
0300-0330 B 9770, 5945 Sun

**Belgium** *BRT*
1910=1930 C 9905 Sun
2200=2255 B 5895, 9905
0030-0125 B 5910, 9925
0800-0855 C 9880 M-F
1300-1355 C 17610, 21810 M-Sat

**Belize** *R. Belize*
0120-0510 C 3285, 830

**Brasil** *RNB - RadioBras*
0200-0300 B 15290

**Bulgaria** *R. Sofia*
2130-2200 A 7115, 9665, 6070
2230-2330 A 9700, 11725 or 11720
0000-0100 A 9700, 11725 or 11720
0400-0500 A 7115

**Burma** *BBS*
1445-1600 D 5985

**Cameroon** *R. Nationale*
0530-0540 C 4000, 5010, 9745
2045-2115 C 9745

**Canada** *CFRX Toronto*
24 hours C 6070

*R. Canada International*
0615-0630 B 11775, 9760, 7155
0645-0700 6140 M-F
1300=1325 A 17820, 15440, 11955, 11855, 9650 M-F
1400=1700 A 17820, 11955 Sun
1537-1545 A 21695, 17820 M-Sat;
1645-1700 15325 daily
1800-1830 A 17820, 15260
S/S-1900
1900-1930 A 17875, 15325, 11905
S/S-2000
1900-1930 A 17820, 15260 M-F
2000-2030 A 17875, 15325, 15140, 11905 M-F
2130-2200 A 17820, 15325, 15150, 11945
2200-2300 A 11925, 9760 M-F
2300-2330 A 11710, 9755
0000=0100 A 11850, 5960
Sun-0030
0100=0130 A 9755, 5960
0200=0300 A 9755,5960 Tue-Sat
0300=0330 A 9755, 5960
0400=0430 A 9755, 5960

*CBC Northern Quebec SW Svc* **NAE**
1158=1359 C 6065
1400=2329 B 11720 (S/S -2359)
2330=0609 C 6195 (Su/M 0000-)

**China** *R. Beijing*
1100-1155 C 9820
1200-1255 B 9820, 6160
0000-0055 C 9880, 11860
0100-0155 C 9880, 11860
0200-0255 C 9880
0300-0355 C 11970, 11860, 9860
0400-0455 C 11970, 9860

**Costa Rica** *TIFC Faro del Caribe*
0300-0400 B 5055 (M 0235-0435)

**Cuba** *R. Habana Cuba*
2010-2140 B 11850
2050-2140 B 17750, 15300, 9550
0100-0600 C 11725
0100-0450 A 6140
0330-0600 B 11760
0630-0800 B 9525

**Czechoslovakia** *R. Prague*
1730-1825 C 15110

0100-0155 B 11990, 9740, 9540
0300-0355 7345, 5930

**Dominican Republic** *R. Earth*
0300-0400 C 11700 Tue-Sun
1600-2200 B 11700 Sun

**Ecuador** *HCJB/V of Andes*
1215-1430 B 11740
1215-1530 A 17890, 15115
1900-2000 B 21477½, 17790
2130-2200 B 21477½, 17790, 15295
0030-0130 A 15250
0030-0200 A 15155
0030-0700 A 9745
0200-0700 A 6095
0500-0700 A 11910
0700-0830 B 5980, 9655
0700-1000 C 9745
0700-1100 C 11925, 6130

**Egypt** *R. Cairo*
2215=2345 C 9805
0200-0330 B 9475, 9675

**Ethiopia** *V of Revolutionary Eth.*
1500-1600 D 9560

**Falkland Islands** *FIBS*
0900/0500 D 3958

**Finland** *R. Finland*
1200=1225 C 15400 Mon-Sat
1300=1325 C 17800 M/W/Th/F/Sa
1400=1425
1504=1528 C 15400, 21475
1330=1525 C 15400 Sun
1330=1455 C 17800 Sun

**France** *R. France International*
1605-1655 B 17795, 17620, 15435, 15315, 11705
0315-0330 B 7135, 9545, 9790, 11670
0345-0400
0415-0430 B 7135, 9535, 9545, 9550
0445-0500 11880

**Germany** *East R. Berlin Int'l*
2315-2400 B 6070, 6125, 6165
0015-0100 C 6080, 9730
0100-0145 C 6080, 9730
0230-0315 C 6080, 9730
0300-0345 B 6125, 6165
0330-0415 B 6010, 6080, 9560
0630-0715 B 6010, 6080

**Germany** *West Deutsche Welle*
1500-1550 C 17800, 15135
1930-2020 C 11785, 9715, 9700
2100-2150 C 9765
0100-0150 A 6040, 6085, 6145, 9545, 9565, 11785
0430-0515 C 7225, 9565

0500-0550 A 5960, 6120, 9545, 9690, 11705
0600-0630 C 9610, 9700

**Ghana** *GBC*
0530-fade 3365, 4915

**Greece** *V of Greece*
1235-1245 C 11645, 15630, 17565
1535-1545 C 11645, 15630, 17565
0130-0140 A 6205, 9420, 11645
0340-0350 A 6205, 9420, 11645

**Guam** *KTWR*
0845-1030 C 11840
1415-1430 C 11920
1500-1600 C 9535

**Guatemala** *AWR/Union Radio*
0300-0400 C 6090.6
*TGNA/R Cultural*
0300-0430 B 3300 (Mon 0045-)
*V of Guatemala*
2130-2330 C 6180 irregular

**Guinea** *R. Guinea*
1830-1900 C 15310v, 11965 Sun irr.

**Guyana** *GBC-2*
0730-fade B 5950

**Haiti** *4VEH*
0000=0030 B 4930

**Honduras** *HRVC*
0300-0400 B 4820 Mon

**Hungary** *R. Budapest*
0130=0200 C 12000 Wed/Sat
0200=0230 9835 exc Mon
0300=0330 9585 daily
0400=0412 9520 Wed/Sat
0400=0430 6110, 6025 Mon

**India** *All India Radio*
1330-1500 C 9545, 11810, 15335
1845-2230 C 11620, 9665, 7170
2000-2230 C 9912
2045-2230 C 9550, 11875
0000-0115 C 15175

**Indonesia** *V of Indonesia*
1500-1600 C 11790

**Iran** *V of Islamic Republic*
1930-2030 C 9022

**Iraq** *R. Baghdad International*
2130=2225 C 9610
0300=0355 D 9745?

**Ireland R. Dublin**
24 hrs. 6910 irreg.

**Israel** *Kol Israel*
0500=0515 B 9009, 9425, 9440, 9815, 11655
1800=1815 C 11585, 9920, 9385
2000=2030 B 9815, 9440, 7412
2230=2300 A 15585, 12025, 9815, 9440, 7412
0000=0030
0100=0125 A 9815, 9440, 7412
0200=0225

**Italy** *RAI*
0100-0120 B 9575, 5990
0350-0410 C 9710, 11905, 15330

**Japan** *NHK/R Japan*
0000-0100 C 11710, 9645
0100-0130 C 17755
0145-0245 C 15195, 17825, 21610, 21640
0300-0330 C 17755
0500-0600 C 9645
0700-0800 C 9505
0900-0930 B 9505
1100-1130 B 9505
1300-1400 B 9505, 11815
1500-1600 B 21695, 11815, 9505
1700-1730 C 9505, 11815
2300-2330 17755, 15210, 15235
*Far East Network, Tokyo*
0900-fade C 6155, 3910

**Kampuchea** *V of Kampuchean People*
1200-1215 C 11938, 9694

**Korea North** *R. Pyongyang*
1100-1250 B 9977, 9745
2300-2450 C 15231, 9745

**Korea South** *R. Korea*
1100-1200 C 15575, 7275
1345-1400 C 15575
1400-1500 C 15575, 9750, 9570
1600-1700 C 11810, 9870, 5975
2200-2300 C 15575, 7550, 6480
0145-0245 C 15575, 11810
0330-0430 C 15575, 11820, 9570

**Kuwait** *R. Kuwait*
1800-2100 C 11675

**Laos** *LNR*
1330-1400 D 7122v

**Libya** *R. Jamahiriyah*
1830-1930 B 15450 time varies
2230=2400 A 11815 or 15450 time varies

**Luxembourg** *RTL*
0000=0200 C 6090

**Malaysia** *V of Malaysia*
0555-0825 C 15295, 12350, 9750

**Malta** *R. Mediterranean*
2230-2330 C 6110

*IBRA Radio North America*
2030-2115 B 6110

**Monaco** *TWR Monte Carlo*
0725=0800 B 7160
0725=1040 B 9493 (Sun=1100)

**Mongolia** *R. Ulan Bator*
1200-1235 D 9615v, 12015? M-Sa
1255-1330 D 19305, 7235 M-Sa
1445-1520 D 9615v, 12019 M-Sa
1940-2015 D 15305, 7235 M-Sa

**Netherlands** *R. Nederland*
0730-0825 B 9770, 9630
1030-1125 B 9650, 6020
1330-1420 C 17605
1430-1520 C 17605
2030-2120 B 17605, 15560, 11740
0230-0325 A 9895, 9590, 6165
0530-0625 A 9895, 9715, 6165

**Netherlands Antilles** *TWR*
1110+1242 A 11815 (Sat-1405, Sun-1337)
0355+0455 A 9535, 800
0605-? A 9535, 800

**New Zealand** *RNZ*
0345-0630 C 17705, 15485
0930-1115 C 15485, 9620

**Nicaragua** *V of Nicaragua*
0100-0200 A 6015
0400-0500 A 6015

**Nigeria** *V of Nigeria*
0455-0800 C 7255, 11770
0500-0600 C 15119v

**Norway** *R. Norway International*
1400-1430 B 15175 Sun
1600-1630 B 11860 Sun
1700-1730 B 11865, 9565 Sun
0000-0030 C 9585 Mon
0400-0430 C 9610 Mon
0500-0530 C 6020 Mon

**Pakistan** *R. Pakistan*
0230-0248 C 7314, 15175, 17660
1100-1115 C 15595, 17660
1600-1615 C 11670, 15580, 15595, 17660, 17890, 21475
1645-1730 C 9432, 12015

**Papua New Guinea** *NBC*
fade-0800 C 9520 NAE
fade-1400 C 4890 NAE

**Philippines** *FEBC Radio Int'l*
0500-1000 C 11890
1300-1500 C 11850
2300-0100 C 15445

*R. Veritas Asia*
0200-0230 C 15195
1500-1530 C 9670

**Poland** *R. Polonia*
0200-0355 C 6095, 6135, 7145, 7270, 9525, 11815, 15120
0630-0700 C 6135, 7270, 9675
2230-2300 C 5995, 6135, 7125, 7270

**Portugal** *R. Portugal*
0300-0330 A 6060, 9560
0530-0600 B 6075, 9575

**Romania** *R. Bucharest*
0200-0300 C 11940, 11810, 9570, 9510
0400-0430 6155, 5990

**Sa'udi Arabia** *BSKSA*
1600-2100 C 11855

**Seychelles** *FEBA*
0400-0500 C 11810, 15200 Sat/Sun
1500-1608 C 15325, 11895

**Singapore** *SBC*
fade-1600 C 11940, 5052, 5010

**Solomon Islands** *SIBC/R Hepi Isles*
0730-1130 C 9545 and/or 5020 NAE

**South Africa** *R RSA*
1100-1156 C 25790, 21535, 15220
1300-1556 C 25790, 15220, 9585
2100-2156 B 15155, 9585
0200-0256 B 9615, 6010, 5980
0300-0426 C 9585, 7270, 5980, 4990, 3230
0630-0730 C 7270, 15220, 11900, 17780

**Spain** *Spanish Foreign Radio*
1930-2030 C 11690, 9780
2300-2400 C 9780, 7105, 5960
0000-0200 A 9630, 11880
0500-0600 A 11880, 9630, 6065

**Sri Lanka** *SLBC*
1030-1130 C 17850, 15120, 11835, NAE
1230-1430 C 15425, 9720
0030-0230 C 15425

**Sweden** *R. Sweden International*
1400-1430 B 17860
2300-2330 C 6045
0230-0300 C 6105, 9695
0330-0400 C 6105

**Switzerland** *Swiss R. International*
0700-0730 C 3985, 6165, 9535, 9560
1315-1345 B 17765
1530-1600 C 17830, 12035
1815-1845 C 12035, 11870, 9885
2145-2215 B 15570, 12035, 9885
0145-0215 A 12035, 9885, 9725, 6135
0430-0500 B 12035, 9725

*Red Cross Broadcasting Service*
1545-1600 C 11870 last Sunday

**Taiwan** *V of Free China via WYFR*
0200-0300 A 5985, 6065
0610-0710 A 5985, 6065

**Thailand** *R. Thailand*
1130-1230 C 9650/9655, 11905

**Turkey** *V of Turkey*
2300 = 2350 B 9560
0400 = 0450 C 9560

**UAE** *UAE Radio, Dubai*
1330-1415 C 21605, 17775, 15320
1600-1700 C 15320, 15300, 11955
0330-0400 B 9565, 11730, 15435 or 7275

**Ukogbani** *BBC World Service*
1100-1300 A 5965
2200-0630 B 5975
2300 = 0430 B 6120
2000-0730 A 6175
0900-0915, 1100-1330 A 6195
0400-0430, 0445-0515, 0600-0630 B 7105
0545-0915 B 7150
2200-0330 B 7325
0300-0430, 0500-2430 C 9410
0430-0915 A 9510
0030-0330, 1600-1745? B 9515
2300-2430, A 9590
0030-0230 C
0400-0430, 0445-0515, 0545-0630, 0700-0815 B 9600
0545-0915 C 9640
0900-1745 C 9740
2200-0330, Tu/F 2130-2200 B 9915
2000-2300, C 11750
2300-0330 A
1500-1615 C
1100-1330, 1600-1745 (Sat/Sun 1500-; or 9515) A 11775
1800-2030, Tu/F 2130-2200 C 11820
0400-0915 A 11860
0600-0915 C 11955
2130-2200 Tu/F C 12040
0600-2030 C 12095
0700-2030 C 15070
1600 A 15260
(Sat/Sun 1500)-1745, 2000-2330
2130-2200 Tu/F A 15390
0615-1130, 1445-2030 C 15400
0900-1615 C 17705
1100-1515 C 17790
1400-1745 B 17885
1500-1530 C 18080
fade-1515 C 21470
fade-1445 C 21550
1030-1615 C 21660
1100-1615, C 21710
1615-1745 A
fade-1515 C 25650

**United Nations** *UN Radio Fri/Sat*
1830-1840 B 21710, 15120
1930-2000 20060-LSB, 18782.5-LSB
2100-2145 B 15120, 17730
0215-0230 B 10454-LSB, 10869-LSB
0545-0600 B 9540, 11740
0710-0715 B 11875, 9565, 7768.5-LSB
0815-0830 B 9680, 11740, 11825
1000-1030 B 9565, 8110-LSB

**USA** *AFRTS*
0900-1100 B 9530, 9590
0900-1300 A 6030
1000-1700 B 11805
1000-1800 B 9700
1100-1700 A 15330
1100-0100 B 15430
1300-0200 A 15330
1700-2300 B 15345
1800-0700 B 17765
2200-0430 C 21570
2300-0700 C 11790, 6030
0330-0700 C 15330

*Voice of America*
0300-0430 B 11720
0300-0800 B 7200
0300-0500 A 6035, 9550, 11835
0300-0600 B 7280
0400-0700 B 6040
0400-0800 B 7170
0500-0800 A 5995, 6060, 7170, 9670
0600-0800 A 3990, 6080, 6095, 6125, 7325, 9530, 9540, 9550, 11840, 11915
0700-0800 A 6035, 7280, 7325, 9650
1100-1500 B 6110, 7230, 9760, 11715
1600-1900 B 11920
1600-2000 B 21485
1600-2200 A 15410
1600-2300 B 15445, 15580, 15600, 17785, 17870
1700-1800 B 17640, 17860, 21545

(first Sun) 21560, 21590, 21840
1700-2200 C 9760, 11760, 15205
2000-2300 C 17715
2200-2300 B 15415
2200-0100 C 17740
0000-0200 C 11740
0000-0400 A 5995, 6130, 9455, 9650, 9690, 11580, 11675, 15205

*WRNO Worldwide, New Orleans NAE*
1600-2100 B 15420
2100-2300 A 11890
2300-0100 A 9852.5
0100-0300 B 7355
0300-0600 A 6185
0600-1200 A 6185 Sun
1200-1400 A 9715 Sun
1400-1600 A 11965 Sun

**USSR** *R. Moscow*
2300-2400 B 17720, 17700, 15455, 15140, 12050, 7440, 7320, 7215, 7185, 7165, 7150, 7115, 7105
0000-0100 A add 6115
0100-0300 B 17720, 17700, 15455, 15140, 12050, 9700, 7440, 7320, 7215, 7185, 7150, 7115, 7105, 6115
0300-0400 B 17700, 15140, 12050, 9700, 7440, 7320, 7185, 7150, 7115, 7105, 6115
0400-0500 B 15140, 9790, 7300, 7260, 7170, 6130, 5980
0500-0700 B 9790, 9505, 7300, 7260, 7170, 6130, 5980
0700-0800 B 9790, 9505, 7300, 7260, 7170, 5980
1000-1300 A 6115
1330-2200 A 11840

*R. Kiev*
0030 = 0100 B 7205, 9685, 9750, 11790, 15240, 15100, 7195
0300 = 0330 B 7195, 7205, 9750, 11790, 15100, 15240

*R. Vilnius*
2300 = 2330 B 7135, 9685, 11790, 15100, 15240

*R. Yerevan*
0351 = 0356 C 15240, 15100, 11790

*R. Tashkent*
1200-1230 C 11785, 9600, 9540
1400-1430 5985, 5945

**Vanuatu** *R. Vanuatu*
0815-0830 D 7260, 3945

**Vatican** *Vatican Radio*
0050-0110 B 11845, 9605, 6015

0600 = 0615 C 9645, 6185

**Vietnam** *V of Vietnam*
1000-1030 C 12035, 9840
1100-1130 C 12020, 9840
1330-1400 C 12020, 10040
1600-1630 C 12020, 10040
1800-1830 C 12020, 10040
1900-1930 C 12020, 10040
2030-2100 C 12020, 10040
2330-2400 C 12035, 9840

**Yugoslavia** *R. Yugoslavia*
1530 = 1600 C 15415
2215 = 2230 B 9620

A - strong & reliable
B - regular
C - occasional
D - difficult
= - one hour earlier during DST



# A Universal Active Filter

**By Forrest M. Mims III**

In electronics, it's often necessary to detect the presence of a fixed-frequency signal immersed in a jumble of other signals and noise. Some of the many applications made possible by this capability include simple remote-control systems, break-beam intrusion alarms, two-frequency digital data recording and telemetry systems and modems.

On the other hand, some applications require that a fixed-frequency signal be *ignored* rather than detected. For instance, 60-Hz hum from the power line is highly annoying when it is amplified along with speech and music.

Circuits that selectivity pass or block fixed-frequency signals are called *filters.* Besides the two roles described above, some filters can block a broad band of frequencies above or beyond a certain point.

Figure 1 classifies the principal kinds of filters by function. The *bandpass* filter is the kind described above that passes a narrow frequency band while blocking frequencies outside the passband. The *notch* filter, which is also described above, rejects a narrow band of frequencies while passing the frequencies on both sides of the notch.

The *low-pass* filter passes a wide band of frequencies below a point called the *cutoff* frequency. The cut-off point is often defined as that frequency where the amplitude of the signal falls to the −3-dB point. In other words, the frequency at which the signal amplitude falls to half its value is the cut-off point. Low-pass filters are used to reject high-frequency noise and in audio equalizers.

The high-pass filter passes a wide band of frequencies above its cutoff point. High-pass filters are used to reject 60-Hz hum, low frequency noise and in audio equalizers.

## Active Filters

Each of the basic filters can be assembled from a network of resistors and capacitors. However, these so-called passive filter networks reduce the overall amplitude of the filtered signal. For this reason, most filters include a built-in operational amplifier (op amp) to restore the signal level that is otherwise attenuated. Such circuits are called *active filters.*

Active filters have served a vital role in analog electronics, but tuning their frequency response requires changing the values of the components in the accompanying network of resistors and capacitors. Books filled with design equations and tables have been written on various ways to design the networks and how to calculate the optimum values for their components. So while active filters using op amps perform many valuable applications, tailoring this kind of active filter for some tasks can be time-consuming.

## Universal Active Filter

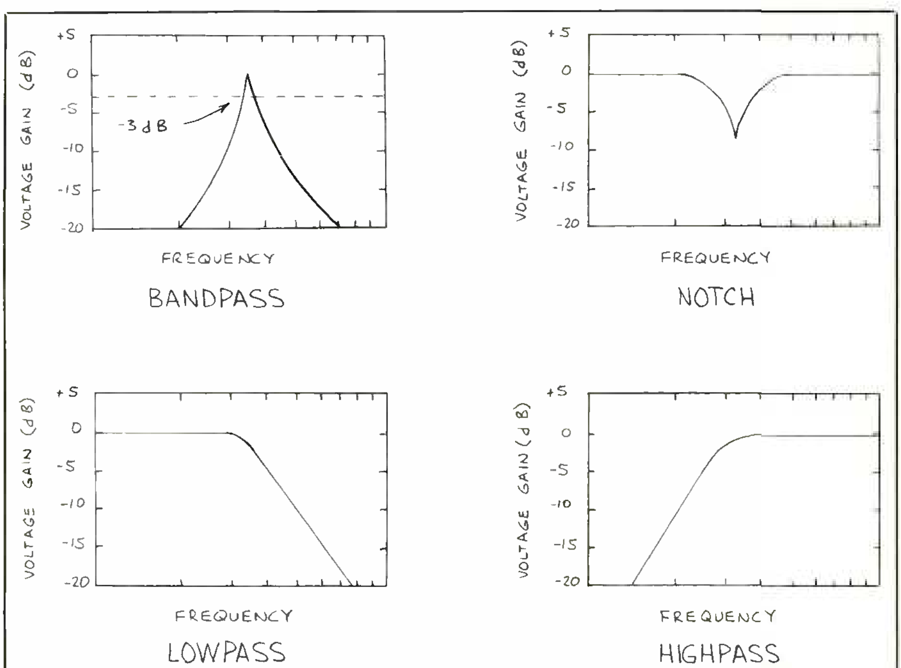
Several years ago a new kind of active filter that can be readily tuned as well as configured to handle any of the four basic filter roles shown in Fig. 1 was introduced. This new kind of active filter, called the *switched-capacitor filter,* can be easily tuned by means of a few external resistors. Note that *No* external tuning capacitors are required in this circuit.

National Semiconductor Corp. (2900 Semiconductor Dr., Santa Clara, CA 95051) makes a family of CMOS switched-capacitor active filters. Included are the MF4, MF5, MF6 and MF10. Of these the MF10 is the most versatile. It includes two separate filters in a single 20-pin DIP and can be operated in any of the classical filter configurations.

Motorola, Inc. (3501 Ed Bluestein Blvd., Austin, TX 78721) also makes a switched-capacitor filter, the MC145415. This device includes a pair of identical filters and is housed in a 16-pin DIP.

Operation of switched-capacitor filters is *very* different from that of traditional passive and active filters that use op amps. Though the MF10 and other members of its family can be used without understanding the details behind its operation, if you want to take full advantage of

*Fig. 1. Frequency responses of the major types of active filters discussed here.*



this chip's flexibility you should understand its basic operating principles.

## Understanding Switched-Capacitor Filters

Figure 2(A) depicts an active integrator made from an operational amplifier and a single capacitor and resistor. The switched-capacitor filter uses an integrator in which the resistor is replaced by a capacitor, as shown in Fig. 2(B).

How a capacitor can perform the job of a resistor is interesting. Referring to Fig. 2(B), note that the input and output of a digital inverter are connected, respectively, to analog switches *S1* and *S2*. When an external clock signal is applied to the input of the inverter, *S1* and *S2* are alternately opened and closed. When *S1* is closed, *C1* charges to the input voltage. When *S2* is closed, the voltage on *C1* is transferred to the input of the operational amplifier. In other words, switching *C1* alternately between the signal input and the amplifier input allows the circuit to function as if a resistor were connected directly between the signal input and the amplifier. It is this switching action that gives the filter its name.

The voltage to which *C1* can be charged and, consequently, the voltage applied to the amplifier is determined by the period of the input clock. Therefore, the effective "resistance" of *C1* is controlled by the frequency of the clock circuit ($F_{clk}$). The time constant of the filter is $C_F/C1F_{clk}$. In other words, the clock frequency determines the filter's resonant frequency.

The filter's resonant frequency can be quickly changed simply by changing the clock frequency. Unlike conventional operational amplifier active filters, absolutely no component changes are required.

The integrators in the MF10 are inverting. Therefore, to preserve the polarity of the input signal as it passes through the filter, it's necessary to add a second pair of analog switches as shown in Fig. 2(C). When *S1* and *S3* are closed, the upper plate of *C1* is positive with respect to the lower plate (ground). When *S2* and *S4* are closed, the upper plate of *C1* is grounded.

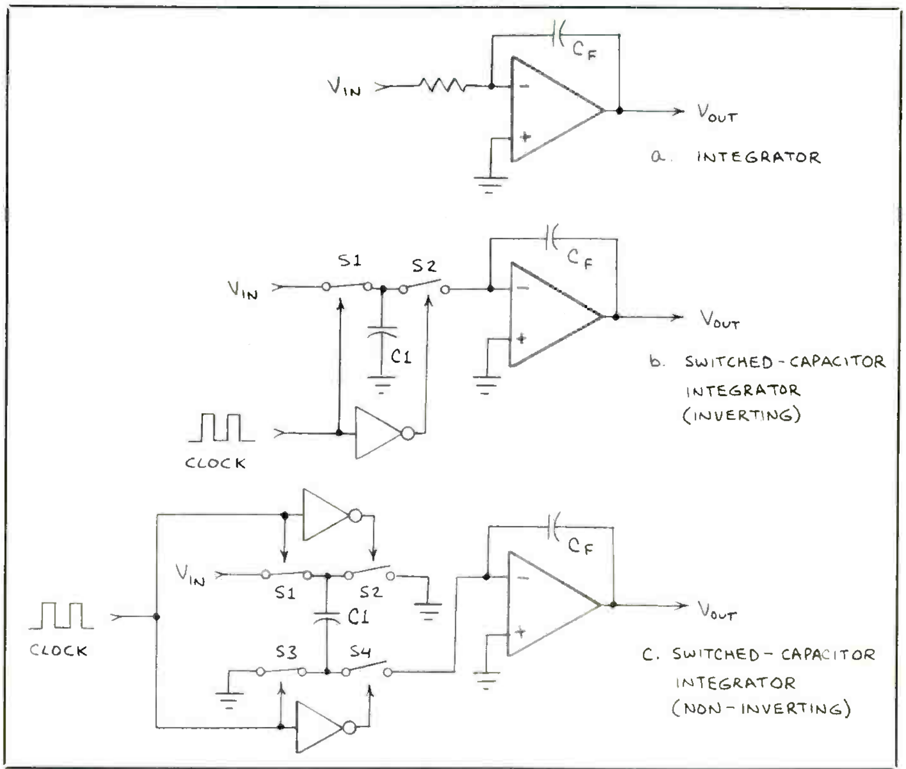



*Fig. 2. Drawings illustrates evolution of the switched-capacitor integrator.*

This reverses the polarity of the charge applied to the amplifier, thereby preserving the polarity of the signal as it passes through the filter.

The external clock circuit connected to the filter that controls the resonant frequency of the filter should have a duty cycle of close to 50%. Either TTL or CMOS clock circuits can be used. Since changing the clock frequency controls the filter's frequency response, the clock frequency should be readily adjustable.

For more details about the operation of switched-capacitor filters, see National Semiconductor Application Note 307. This excellent note was written by Tim Regan. I suggest you also see the data sheet for the MF10 family of filters.

## The MF10

Figure 3 shows the pin outline for the MF10 and Fig. 4 shows the block diagram for one of the chip's two filters. Some of the terms applied to the various terminals of the MF10 and other switched-capacitor filters are different from those applied to conventional active filters. A complete explanation is given in the MF10 data sheet. Here's a brief summary:

INV is the inverting input.

LP is the low-pass output.

BP is the bandpass output.

HP is the high-pass output.

N is the notch output.

AP is the all-pass output.

S1 is the signal input when the filter is used in the AP mode.

$S_{A/B}$ activates an internal switch that connects the input of the filter's second summing amplifier (see Fig. 4) to analog ground AGND ($S_{A/B}$ = low) or the low-pass output ($S_{A/B}$ = high).

$L_{SH}$ is the level shift input. It allows the MF10 to be used at different power-supply and clock voltages. For instance, $L_{SH}$ should be tied to ground, $V_{-A}$ or $V_{-D}$.

$V_{+A}$ and $V_{+D}$ are, respectively, the chip's analog and digital supply inputs.

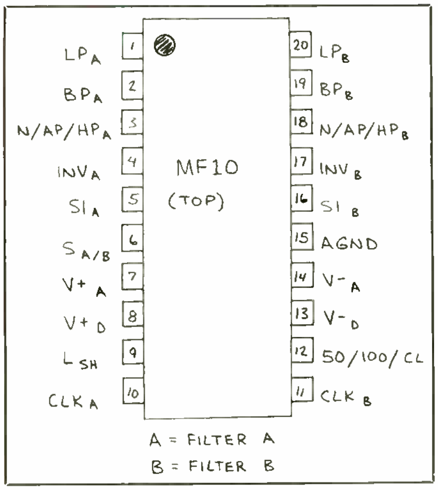



*Fig. 3. Shown here is the pin diagram of the MF10 switched-capacitor filter, a dual filter IC device.*

They may be interconnected and should be bypassed to ground with a capacitor.

$V_{-A}$ and $V_{-D}$ are the analog and digital negative supply inputs.

AGND is the analog ground terminal.

CLK is the clock input terminal.

50/100/CL controls the ratio of the clock frequency to the filter's center frequency (50:1 when high and 100:1 when at analog ground).

Remember, these explanations are condensed from the MF10 data sheet. Refer to the data sheet for more information.

## *MF10 Demonstration Circuit*

The circuit in Fig. 5 shows how the MF10 can be used simultaneously as a tunable low-pass/bandpass/notch filter. No conventional active filter can perform these three tasks as well and with as few components as the MF10.

Two of the six gates in a CMOS 4049 hex inverter, together with *C1, R4* and *R5,* form the clock circuit for the MF10. The oscillation frequency of the clock can be altered via *R5*. Though the 4049 provides a very simple and reliable clock circuit, remember that other clock circuits can also be used. Also remember to ground the unused 4049 inverter inputs.

One of the two filters in the MF10 is configured as a tunable low-pass/bandpass/notch filter. This is referred to as the Mode 1 configuration in the MF10 application note. (At least eight other operating modes are available.)

The circuit is exceptionally easy to breadboard and operate. Be sure to follow CMOS safety procedures when handling both the MF10 and the 4049 to avoid possible damage to the chips. For best results, use a variable-frequency signal generator to supply an input signal and an oscilloscope to monitor the outputs.

The center/cutoff frequency of the MF10 can be quickly tuned to a maximum of about 30 kHz by changing the resistance of *R5*. The LP (low-pass) gain is $-0.1$, the BP (bandpass) gain is $-1$ at $f_O$, and the Q in both the BP and notch modes is 10. The gains and the Q factor can be changed by following the procedures given in the application note.

## *MF10 Tunable Tone Decoder*

Among the many applications for the MF10 is the adjustable-frequency and threshold tone decoder shown in Fig. 6. The circuit is designed to be connected to the bandpass output (pin 2) of the basic MF10 filter circuit shown in Fig. 5.

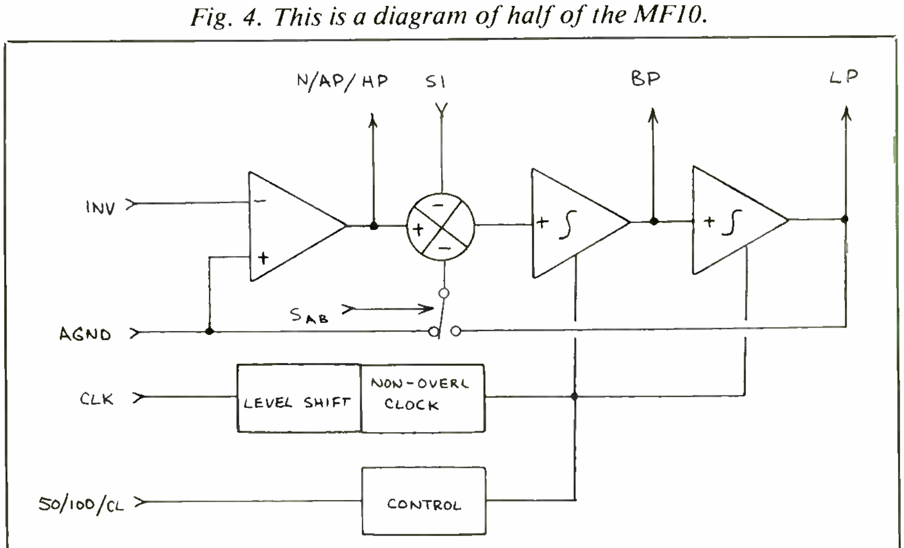
The tone decoder can be used to indicate by means of its LED the presence or absence of a tone whose frequency is determined by *R5* in Fig. 5. The effective bandwidth of the circuit can be quickly reduced from more than 100 Hz to about 20 to 25 Hz simply by adjusting *R6*.

The tone decoder consists of the MF10 and a voltage comparator followed by a missing pulse detector. In operation, the BP output from the MF10 is directly coupled into the inverting input (pin 2) of a 741 operational amplifier configured as a comparator. The switching threshold of the comparator can be altered by changing the resistance of *R5*. This changes the reference voltage at the noninverting input (pin 3) of the 741.

When the threshold of the comparator is properly adjusted, its output is a train of narrow, negative-going pulses when the frequency of the input signal matches the center frequency of the MF10. The switching threshold of the comparator can be adjusted via *R6* to provide the very narrow frequency response mentioned above.

The 555, *Q1, C1* and *R7* form a simple missing pulse detector. When the frequency of the input signal matches the center frequency of the MF10, the comparator emits a train of pulses and the output of the 555 (pin 3) is high. When the signal frequency is above or below the MF10's center frequency, the comparator ceases to generate a pulse train and the output of the 555 then goes low.

*Fig. 4. This is a diagram of half of the MF10.*



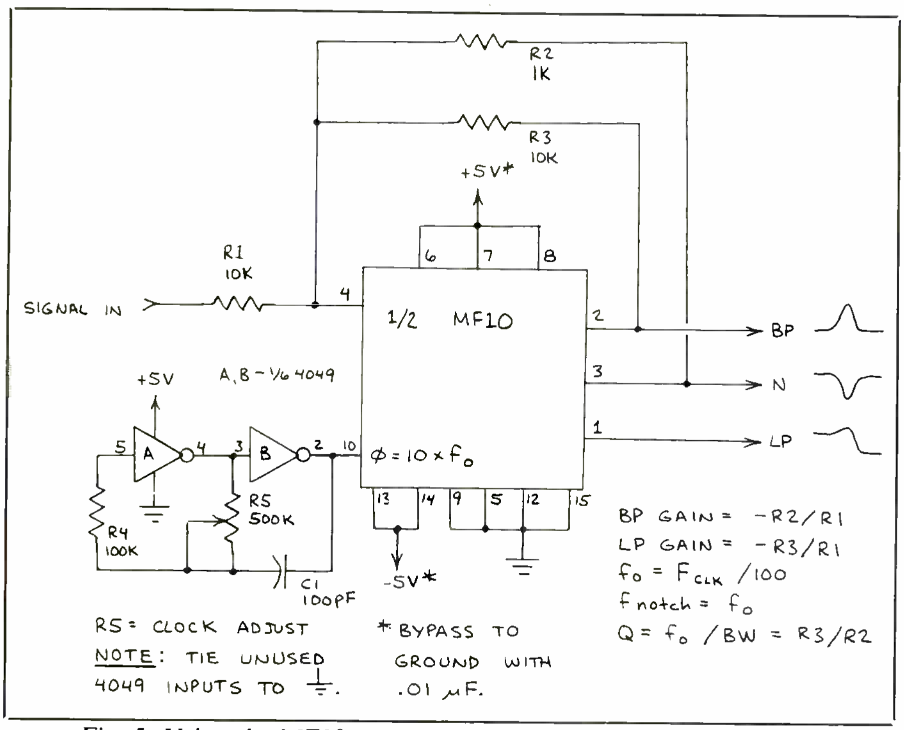



*Fig. 5. Using the MF10, you can build this demonstration circuit.*

The LED can be connected directly to pin 3 of the 555. However, I used one of the spare inverters in the 4049 (see Fig. 5) to cause the LED to glow when the frequency of the signal matches the center frequency of the MF10.

While testing a breadboard version of the tone decoder, I was struck by its precision response. During a typical test, for example, the center frequency of the MF10 was adjusted via *R5* to be exactly 500 Hz. I adjusted *R6* to provide a very narrow but reliable threshold (i.e. no oscillation). For these conditions, the LED glowed when the frequency of the input signal was reduced from 500 to 496 Hz and increased to 518 Hz. This provides an equivalent Q (quality factor) of 500/22 or about 23.

This tone decoder circuit has many possible applications in remote-control, telemetry and intrusion alarms. Since the MF10 includes two separate tunable filters, a Touch-Tone™ decoder can also be designed.

Transistor *Q1* is a 2N2907 or any general-purpose silicon pnp switching device. The values of *R7* and *C1* can be changed to alter the response time of the tone decoder. By increasing the value of either or both *R7* and *C1*, for instance, the time required for the missing pulse detector to respond when a pulse train is not present is increased.

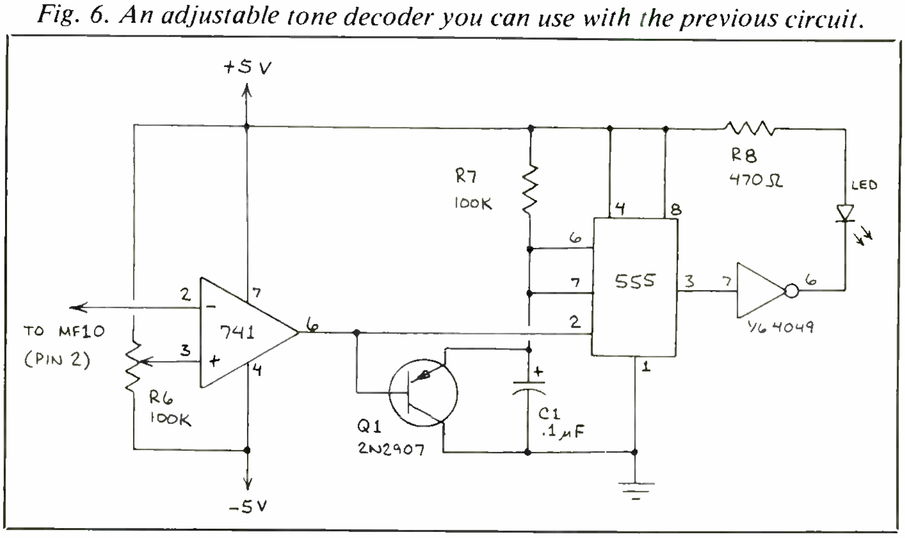
This feature is useful in such applications as break-beam intrusion alarms and moving-object detectors. In the case of outdoor alarms, it permits the system to be adjusted to ignor brief interruptions from falling leaves. In the case of moving object detectors, it enables the system to ignore objects below a certain minimum size.

Incidentally, you can easily modify the basic tone decoder circuit to change its operation. For instance, though I connected the input of the comparator to the bandpass output from the MF10, you might want to experiment with connecting it to the notch output. Many other modifications are also possible.

## Going Further

The MF10 is representative of an important new class of active filter that may ultimately obsolete most conventional kinds of active filters. Whether or not you have used conventional operational-amplifier tuned filters, I urge you to experiment with one or both the circuits presented above. If your experience resembles mine, you will probably think of many applications for the versatile MF10 and other switched-capacitor filters. **ME**

*Fig. 6. An adjustable tone decoder you can use with the previous circuit.*



# HARDWARE HACKER

## Simple square-wave generator, hardware digital divide-by-seven circuit

By Don Lancaster

Let's start off this month's column with some updates. Apparently *Airborne Sales* went belly up, so your best source of three-way EGR valves remains *Jerryco.* The best and cheapest source I've found so far for low-pressure pneumatic robotics air connectors is *Value Plastics.*

There's at least one major manufacturer of stock project cases that have built-in battery compartments. Check out *Pac Tec* on their HPS-9VB, HPL-9VB, and HP-BAT-9V cases, all of which are available in blue, tan and grey. Most cost less than ten bucks.

As usual, all the names and numbers are at the end of this column. By the way, some of these sources are *very* hard to find on your own, so you might want to start your own names and numbers notebook. I subscribe to over 200 technical magazines and scan quite a few more to bring these sources to you.

Also as usual, keep those calls and letters coming. I'll be happy to send some free *Applewriter* patches to anyone who asks for one.

I may be gone next month on a world class tinaja quest, so I've asked Marcia Swampfelder to make one of her rare guest appearances. Don't miss it.

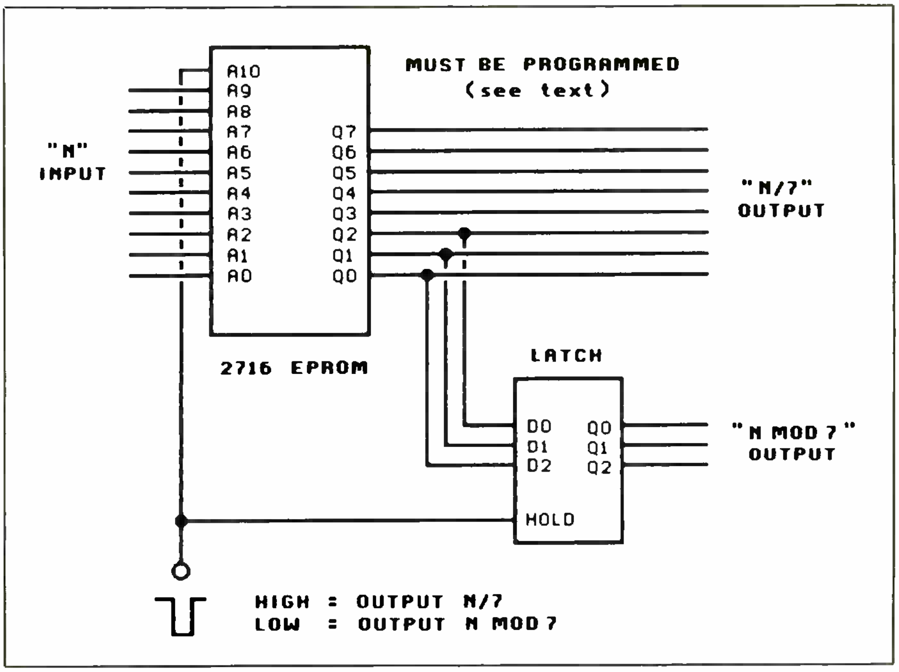



*Fig. 1. This is one way to use an EPROM to do "table lookup" of a fancy math function. The scheme shown time-shares one EPROM to handle both the N/7 result and the N MOD 7 remainder.*

*I need a hardware digital divide-by-seven.*

This is a tad heavy and specialized for this column, but since it shows us some important fundamentals, let's have at it.

Say you want some oddball math function or something else that is complicated but not totally irrational. How do you do it? First, you must ask whether you want to use hardware or software. Software, once developed, is cheap and easy to change for upgrades or customization. It is infinitely duplicated with little or no cost or on-hand inventory. Software, then, is usually far and away your best choice in this case.

On the other hand, hardware is usually much faster and is called for whenever operating speed is super important. Hardware is also needed if your circuit is so simple that it does not already have a CPU/RAM/ROM setup already inside it and ready to go, or if your CPU has better or more important things that you need done right now.

Second, you must ask whether you are going to look up the answer or calculate it. With the *table lookup* method, you simply get the answer out of an exhaustive list of all possible answers. Table lookup is very fast, but needs lots of memory or hardware storage space. Table lookup is usually the best hacker choice, provided the table can be kept reasonably small, say less than 4096 total entries. There are tricks to shorten tables, such as factoring, compression, precoding, interpolation, table pairs, symmetry, partial lookup, and so on.

With the *calculation* method, you actually calculate the result you are after, step by step, using some algorithm that does the job. The calculation method is always much slower, but often will need far less storage space or silicon real estate. Thus, you can look it up or calculate it with software, or you can look it up or calculate it with hardware. Usually, one of the four methods will be far better than the other three. Which one? That depends.

The most likely need for a divide-by-seven is to speed up Apple HIRES graphics animation. This is needed in calculating screen base addresses. A hardware divide-by-seven is the key to a 50 × to 500 × speedup of the best animation available at the present time.

The software solutions to this problem are well known, and appear in my *Enhancing your Apple II,* Volume I (SAMS 21822) and elsewhere in the Apple literature. The original software divide-by-seven was done by actually casting out sevens, painfully one at a time until none were left. The number of sevens cast out was the result, while anything left over was the modulo. While the code was incredibly compact (in those days, a 4K Apple was a really big machine), the result-

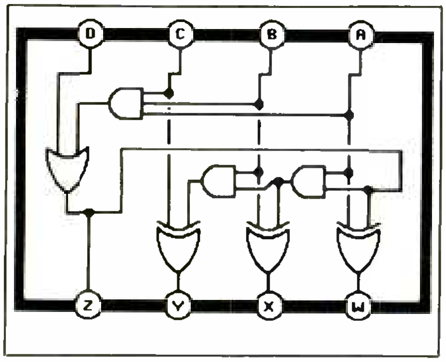



*Fig. 2. Logic can be used to calculate a fancy math function. This module handles one step of a binary ÷ 7.*

ing animation speed was only useful for such things as modeling earth tides, snail geriatrics, congressional reform, or glacial varves. A typical calculation time was 500 microseconds per screen base address.

Modern Apple arcade graphics instead use table lookup to handle the divide-by-seven. The HIRES screen base addresses are gotten out of a table in memory. While the table lookup only takes a few microseconds, a total of 50 microseconds per screen address is involved with the overhead. The tables take some 500 bytes or so of memory, less if you get sneaky.

By using hardware on a plug-in card, you should be able to reduce the divide-by-seven time and its overhead to one or two microseconds at most.

Let's look at two possibilities.

The table lookup can be handled by a pair of 2716 EPROMs. One handles the N/7 result, while the other handles N MOD 7 remainder. When properly programmed, you simply input your straight binary word, and your result or remainder pops out ready to use a few hundred nanoseconds later.

EPROMS work by exhaustively decoding all possible input combinations and then giving you a unique output word of your choice for each and every possible combination.

I have the source code available under EDASM for this N/7 and N MOD 7 EPROM pair. A printed copy is yours free on request, while both the ready-to-change source code and the ready-to burn hex object code costs $9.95 on disk from *Synergetics.*

Pairs of EPROMs are no big deal, but chances are you may need the space or the power consumption elsewhere, particularly if you cannot afford CMOS EPROMs. So Fig. 1 shows a sneaky trick that lets us *time-share* one EPROM for two different tasks.

Essentially, address A10 splits the 2716 EPROM in half. If it is high, you get the N/7 code. If it is low, you get N MOD 7. To separate the two, you catch the N MOD 7 output with a latch and hold it. You look up the N MOD 7 result only as long as you have to per the response time of the EPROM, typically 250 microseconds. Naturally, you look at and use both results only when they are both valid. While only half the speed of two seperate EPROMs, this can be more than fast enough for many needs.

Should you have fancier requirements, you can step up to a 2732, 2764, 27128, 27256, or even a 27512 EPROM. Other times, a second or third 2716 can be used for more than eight different outputs. Often though, it is far better to rethink and compact the stuff needing looking up down to a minimum size.

What about calculating a hardware divide-by-seven?

Almost always, table lookup is simpler and cheaper, particularly for a hacker's budget. A while back, I almost bought a gate array to simplify speedup of Apple graphics. In a gate array, the amount of silicon real estate is super critical, so I had to calculate a divide-by-seven. Let's see how it is done.

You can do a binary long division in pretty much the same way you did decimal long division in the third grade. See if the number will fit. If so, put down how many times it fits and then subtract to get what's left. If not, bring down another place and try again.

With a binary divide-by-seven long division, there are several possible simplifications. For one thing, your answer is always one or zero, meaning "yes it fits," or "no, its too big." Further, your sub-

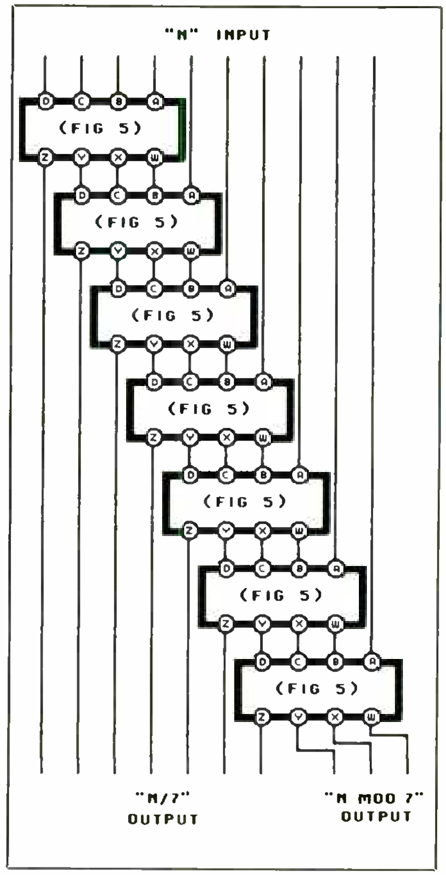



*Fig. 3. By cascading modules like that shown in the previous figure, you can obtain a logic circuit that performs the complete ÷ 7 operation.*

traction is always a three-digit, or *octal* (ugh!) subtraction. But *substracting* binary *seven* in octal is the same as *adding one* in octal. And adding one with hardware is simpler that actually subtracting seven. Two's complement and all that.

At any rate, Fig. 2 shows a module that handles one step of a binary divide-by-seven division. It obeys the rules:

IF D = 1 OR IF C + B + A = 7 THEN Z = 1
IF Z = 0 THEN Y + X + W = C + B + A
IF Z = 1 THEN Y + X + W = C + B + A + 1

Org! What a mess! Let's try it in English instead. Z is the result of the division of this stage. Z is one if what's left over from before is seven or more, since seven fits into seven or more. Z is a zero if what's left over from before is six or less, since seven will not fit into anything smaller than itself. So much for the result.

If seven did not fit, you simply use the three lowest bits of what was left from before over again. Thus A becomes W, B becomes X, and C becomes Y. If seven did fit, you have to subtract seven from the three lowest bits of what was left from before. But, thanks to some hairy two's complement thinking, *subtracting* seven in octal is the same as *adding* one. So, if seven did fit, you add one to the three lowest bits of what was left from before. These become the highest three bits for the next step in the calculation.

Figure 3 shows how you cascade modules for a complete divide-by-seven. The Z output of each module forms part of the N/7 output. The Y, X, and W outputs become the three highest inputs for the next stage. The lowest, or A input of the next stage, drops directly down from the N input.

The result is an N/7 output at the left-bottom and the N MOD 7 remainder at the right-bottom. For more precision, you can add more modules.

Sharp-eyed readers may note a logic error on the first stage for N higher than decimal 959. In the intended use, the maximum possible input N is only decimal 558, and N values starting with four binary ones will not normally occur.

If this bothers you, another module can be added at the top with its D input grounded. Gate array people will go up the wall calculating the worst-case propagation delays on this. But, at worst, it should be faster than an EPROM.

Anyhoo, here is a hardware divide-by-seven. And, if you really wanted to do one this way, a fist full of CMOS jellybeans will do the trick. I count a dozen at fifty cents each. Can you do better?

In fact, let's see your "best" possible hardware or software divide-by-seven. Can you use those new PLA programmable logic arrays now that they are coming down in price? What new software tricks can be done to minimize calculation times or lookup storage area?

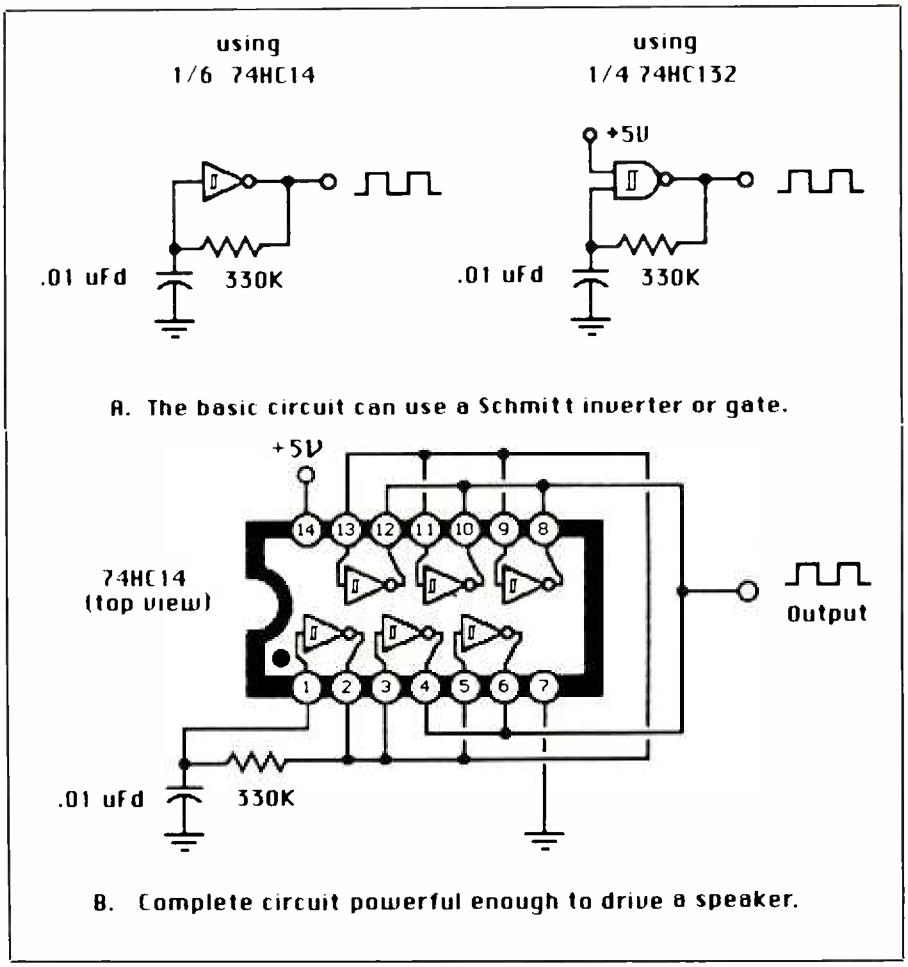



*Fig. 4. Illustrated in these drawings are some square-wave signal generators in which are used CMOS Schmitt-trigger integrated circuit devices.*

You can also combine the best parts of Figs. 1 and 3, using one trip through a 2716 EPROM and three simple gates. Do you see how?

***Show me a simple square-wave generator.***

This is one of my favorite circuit tricks, since it is both elegant and simple. It's also an ideal first project in electronics.

There are several different CMOS Schmitt triggers on the market. These include the 4093, 74C14N, and the newer 74HC14 and 74HC132. The usual sources are *Motorola, National,* and *Texas Instruments,* among dozens of others. Check the ads in the back of *Modern Electronics* for availability.

The 4093, 7314N, and 73HC14N are hex inverters, while the 4584 and 74HC132 are quad NAND gates. Cost is usually under a dollar.

Any of these will make a jim-dandy square-wave generator (Fig. 4). All it takes is one CMOS Schmitt inverter or Schmitt NAND gate, one resistor, and one capacitor.

Here's how it works: The inputs to all CMOS logic are essentially open circuits.

Thus, a CMOS gate or inverter does not significantly load whatever is driving it.

Further, with a CMOS Schmitt trigger, the logic has a built-in *hysteresis*, or snap action. This means that a positive-going waveform will not change the output until it is well over halfway to the positive supply voltage. A negative-going waveform will not change the output until it is well under halfway down to ground. Between the two is a *window* in which the output stays up if it was up and down if it was down.

This snap-action is normally used to clean up a noisy or slowly changing input signal. Thus, the intended use of Schmitt triggers is to detrash sloppy inputs at the front end of your circuitry. We will use this snap-action feature in a slightly different way.

Now, follow the bouncing ball. Assume we first power the circuit. The charge on the capacitor is zero and it cannot be instantly changed. Either the inverter or the NAND gate will have a high (or positive) output, since both of these invert their logic.

A high output slowly charges the capacitor through the high-value charging resistor. The CMOS input does not load the capacitor, so the capacitor starts building up a positive charge.

Eventually, the capacitor passes the lower trip point of the snap-action window, but nothing happens, since the output is already high. The capacitor keeps charging. When it gets to the upper trip point, the output snaps down. The output has now switched from a high state to a low state.

At the same time, the resistor now begins discharging the capacitor, since the capacitor is positive and the other end of the resistor is nearly at ground. The capacitor continues discharging only to the lower trip point, at which time the output goes high and the action repeats.

After the first cycle, the capacitor will saw itself between the upper and lower trip points. Typically you will see a 1-volt sawtooth wave across the capacitor, centered at half the supply voltage. The output will be a clean square wave of nearly perfect symmetry. The frequency is fairly independent of temperature and supply voltage as well.

Resistor values can be into the megohms, and capacitor values can be into the microfarads, letting you time out to minutes or more. Accuracy at extremely long time delays won't be all that great though, so go to the digital counter route if you need extreme accuracy. The highest frequency you can get with this approach is half a megahertz or so.

You can easily vary the frequency by substituting a potentiometer for the charging resistor. If you do this, be sure to add a series 10k resistor to keep the capacitor from shorting the output at the pot's minimum setting. For wide range changes, the capacitor may be switched in decade (10×) steps.

Here's an off-the-wall hint. If you put a dial on the panel behind the pot, the numbers on the dial will end up very cramped and nonlinear. The solution to this is to use an *audio*, or log-taper potentiometer, and then to put the dial on the *shaft* and the marker on the *panel*. The nonlinearity is caused by the frequency being inversely proportional to the pot setting. Reversing dial and marker avoids using an extremely hard-to-find reverse-log-taper pot.

Figure one also shows you a complete square-wave generator test instrument that is powerful enough to directly drive a speaker. All this does is use the remaining five inverters in parallel as an output driver. Total circuit cost is under $2.

The very first cycle on power up will be longer than the others, since the capacitor has to charge all the way from ground, rather than from only the lower trip point. One place this extra delay comes in handy is for an automatic repeat function on a keyboard.

Several gotchas. Do not use TTL or LSTTL Schmitt triggers as they will load the capacitor too heavily and will not work at low frequencies. Use the 74HC14 or 74HC132 only over a +2- to +6-volt supply range. The 4093, 4584, and 74C14 may be used over a +3- to +15-volt range and thus may be powered from a 9-volt transistor battery.

In addition, make sure that *all* unused CMOS inputs go somewhere, such as to ground or the positive supply. Fail to do this, and your package current will dramatically increase, and noise can foul up the works. **ME**

### Names & Numbers

**Apple Computer**
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010

**Jerryco**
601 Linden Pl.
Evanston, IL 60202
(312) 475-8440

**Motorola, Inc.**
Box 20912
Phoenix, AZ 85018
(602) 244-6900

**National Semiconductor Co.**
2900 Semiconductor Dr.
Santa Clara, CA 95051
(408) 721-5000

**Pac Tec**
Enterprise & Executive
Philadelphia, PA 19153
(215) 365-8400

**Howard W. Sams & Co., Inc.**
4300 W. 62 St.
Indianpolis, IN 46206
(800) 428-SAMS

**Synergetics**
Box 809
Thatcher, AZ 85552
(602) 428-4073

**Texas Instruments Inc.**
Box 225012
Dallas, TX 75265
(214) 995-6611

**Value Plastics**
5137 S. College Ave.
Fort Collins, CO 80525
(303) 669-4351

### Need Help?

Phone or write your hardware hacker questions and comments directly to:

Don Lancaster
Synergetics
Box 809
Thatcher, AZ 85552
(602) 428-4073

three or more pins through holes near the corners of the board to keep it level on your work surface.

If a 14-pin pattern is to be positioned, cut off 14 sections in one piece from the DIP strip and peel off the release liner. Figure 6 shows one method for getting the release liner started. The liner can also be started from a corner by using a fingernail to pry it up. Figure 7 shows how to use the push-pin to achieve accurate alignment between patterns and board holes. Alignment is sometimes more easily accomplished with a pair of large darning needles.

Use a fine pointed tweezer to handle the pattern and avoid finger contact with the adhesive side. Slide the pattern's outermost hole over the pin (or spear the hole on one darning needle) and line it up so that the row of holes is in exact registration with the row on the board. A darning needle can be used at the other end of the pattern to further aid in registering the pattern. If the pad is a bit out of line, it can be levered into position with the darning needle.

When the pattern in properly aligned, press it firmly onto the board's surface. Hold the pad down alongside the needle with a fingernail and remove the needle and push-pin. Firmly press the pattern down over its entire surface. However, try to avoid touching the raw copper traces on the pattern and the copper tapes when you use them with your fingers. Place a piece of paper or plastic film over them before you use your fingers to press the patterns and tapes into place.

With all IC and transistor patterns in place, the circuit's conductor pattern can be completed by following your drawing to interconnect the various points with copper tape. Where there's room, terminate the tape ends with donut pads.

A word of caution: When a roll of copper tape is first used, it has a tendency to unravel. If it does this, the tape is almost impossible to roll up again. If you succeed in getting it rolled up again, it will invariably be kinked and wrinkled in places. When this occurs, the release liner is likely to work loose, allowing the adhesive to dry out and rendering those portions of the tape useless. To prevent any of this from happening, it's a good idea to gently press newly opened tape packs onto the adhesive side of a piece of wide masking tape to keep it wound.

Figure 8 shows a short length of tape being positioned on a circuit board. Figure 9 shows a short length of tape positioned to connect with a DIP pad being trimmed to the correct length with an X-acto knife.

There are two methods for making connections between two tapes. The manufacturer recommends butting together the two tapes and then flow-soldering the ends at the joint. If the ends of the tapes don't butt exactly and the cuts aren't precise, you'll have difficulty getting the solder to "take" across the joint. Even a hairline separation between the two butt ends will defeat soldering. Solder will build up on both sides of the joint and refuse to flow together. This is the same action that's so much of an asset when soldering the closely spaced pads on an IC DIP pattern.

The second method requires less precision when cutting the tape. Here, the tapes are overlapped and burnished flat. Figure 10 illustrates good and bad examples for overlap joints. (With both methods of joining tapes and tapes to other patterns, it's essential that the ends be absolutely flat. There must be no curl where they meet or overlap. If any curl is overlooked, the joint, when soldered, might appear to be perfect but will usually be an open circuit.)

It is essential that every soldered junction be checked with a low-range ohmmeter *as soon as it is made!* If you wait until you've finished solder-

*Fig. 7. How to use registration pins to obtain correct alignment between perf board and EZ Circuit pattern holes.*

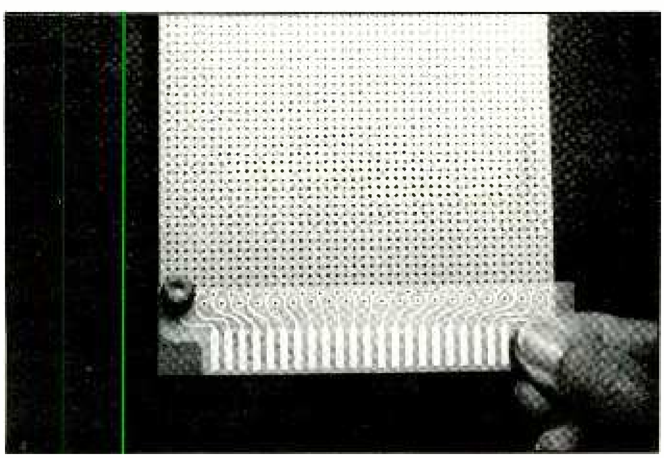
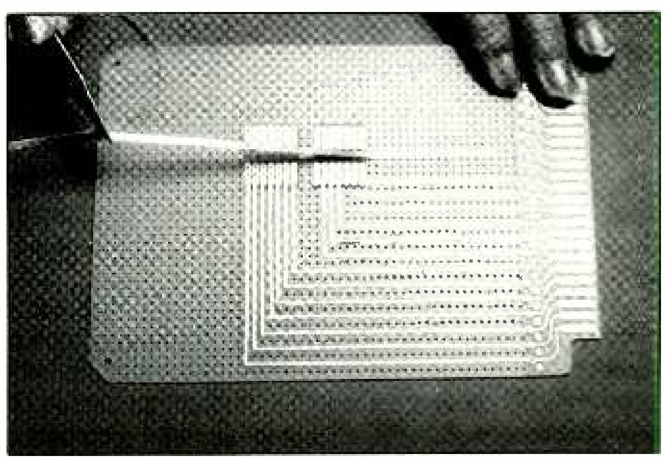


*Fig. 8. Correct method of laying out tape. Use tweezers to avoid unnecessary handling of tape copper and adhesive.*



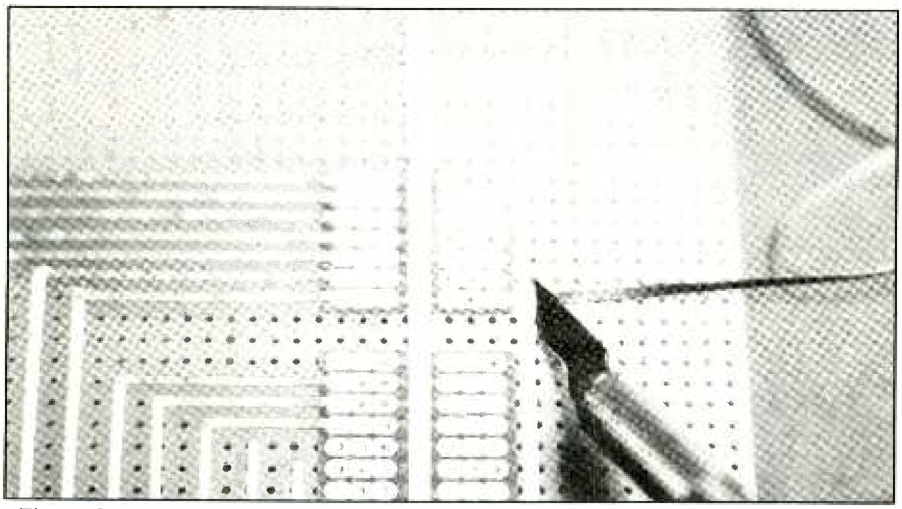


*Fig. 9. Shown here is a short length of adhesive-backed copper tape being positioned to connect to a DIP pad. The terminating end of the tape is best trimmed cleanly and squarely with an X-acto knife or other very sharp cutting tool.*

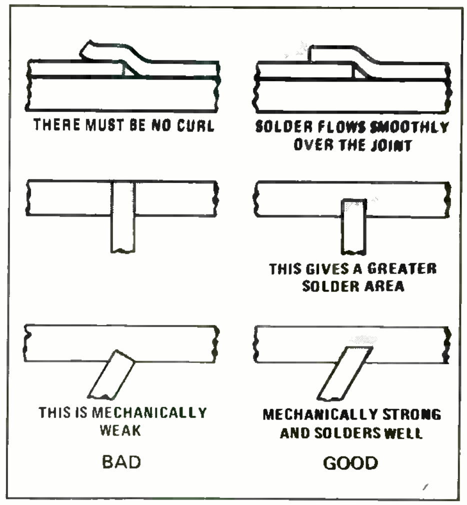



*Fig. 10. Drawings illustrate good and bad tape terminations. Shaded areas show where solder is to be flowed.*

ing all joints, you're likely to miss one or two, each of which is a potential problem.

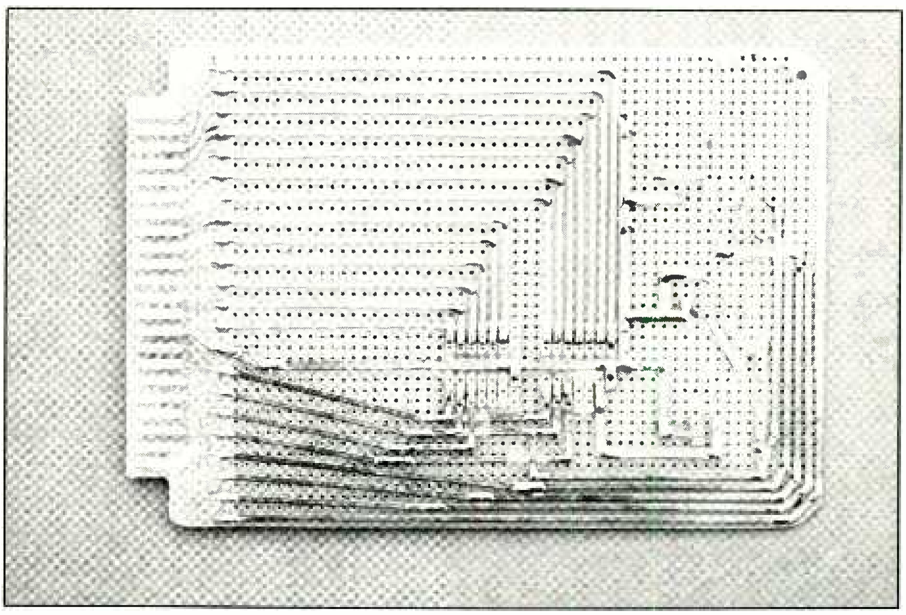
Occasionally, a tape joint will lift when soldering heat is applied. If one does, it may be possible to save the joint by pressing down on the tape with the point of a darning needle while reapplying heat. Solder won't stick to the needle, which can be removed as the solder cools. Very narrow and short pieces of tape must be soldered with care or they may be picked up by the soldering iron. If this happens, the old solder must be heated and wiped off the surface with a cotton cloth. Before you make another try at it, this surface must be free of solder bumps and ridges.

When overlap joints are used, solder bridges the joint more readily if the lower tape is heated and solder is flowed onto it first. Solder can then be flowed over the edge and onto the upper tape to complete the joint. Tape runs that connect to DIP and other patterns should overlap about halfway across pad holes. If a hole is to accommodate a component lead as well as the tape, push a large darning needle through the hole from the conductor side. This forms the tape to the hole contour and permits the component lead to enter the hole without pushing the tape off the pad.

Where tapes are connected to DIP pads at the inner rows of holes, the tape should overlap the hole completely and then be punctured with the needle. This ensures a good soldered joint between IC or socket pin and copper tape.

If you're soldering a component lead to one of the spare holes of a double- or triple-hole DIP pattern, make sure the joint between the IC pin and copper tape is also secure to the copper tape pattern. It's possible to have a good soldered connection between IC pin and tape while having and open circuit between them and

*This is what a completed Easy Circuit board looks like after all connections have been soldered. Notice how turns are made by angling the copper tapes. This photo shows examples of 90° and angled turns and an insulated crossover.*



the pattern pad. Solder must be flowed onto the pattern as well as the tape. However, reserve soldering of connections to DIP pin holes until *after* the socket or IC pin is in place. Otherwise, the solder may prevent entry of the pins.

With tapes and patterns all in place, carefully inspect the circuit to make certain that it agrees with both the conductor pattern drawing *and* the schematic diagram. If inspection discloses an error in the schematic or the pattern drawing, it's much easier to correct before any soldering has been done. You can now solder all connection points, including the pins of ICs or their sockets. Then carefully inspect every solder point, preferably with a jeweler's loupe. Look particularly for poor soldering and possible solder bridges, the latter most likely around IC solder pads. Having done this and corrected any suspicious connection, you can proceed to install and solder into place the remaining components.

When you're done, once again carefully inspect your work. Look for bad solder joints, possible solder bridging between closely spaced conductors and pads, and particularly for *unsoldered* points.

You might be wondering if you can work up a double-sided circuit board using pressure-sensitive materials. The answer is yest—to a limited degree. The main difficulty isn't so much that you must perfectly register the patterns on both sides of the board (this isn't too difficult in any case, considering that you'll be working with perforated board and prepared patterns), but the fact that you can't make plated-through holes. If you're planning to build a project that contains ICs, you won't be able to use sockets, because the sockets will prevent you from gaining access to the patterns on the component side of the board. If you forego sockets and solder the ICs directly onto the board, you run the risk of damaging the ICs with excessive heat. The answer, of course, is to use Molex Soldercon pins, which substitute for sockets and obviate the possibility of causing heat damage.

Where tape runs in double-sided work require interconnection between traces on both sides of the board, you can puncture both and use pretinned hookup wire to form bridges. Insert the wire, solder it to the tapes on both sides of the board, and trim away excess length with flush cutters.

## *Conclusion*

You'll find that you need very few and simple tools to produce printed-circuit boards using the system described. These consist of a fine-point tweezer, an X-acto knife or Gillette "Widget" safety knife, a half-dozen or so bulletin-board push-pins, a couple of large darning needles, and a low-wattage soldering iron and appropriate accessories should do it.

Bear in mind, too, that E-Z Circuit material comes in many sizes and shapes for a variety of applications. For example, edge-connector boards are available for Apple II computer applications, complemented by insertion-type connector patterns. Other bus formats are available, too. Pressure-sensitive insulating tapes can be used to prevent short-circuits should you have any crossover points on your copper circuitry; copper power and ground distribution strips, which are nicely thick and wide, are among the many other adhesive strips and patterns one can use to simplify work.

The attributes provided by this method of making prototype experimental printed-circuit boards and single boards for construction projects should be appealing to many electronics experimenters and professionals who disdain the bother of photochemical work. **ME**

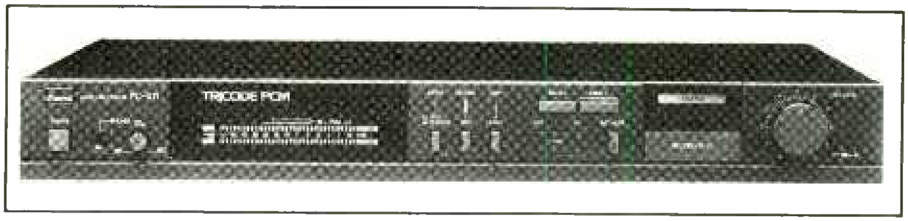
# NEW PRODUCTS ...

(from page 13)

signed to provide interference-free communications equipment operation is the Model AC-SFK-33S Super Filter/Suppressor from Electronic Specialists, Inc. The unit features a dual balanced Pi super filter and a 6500-ampere spike/surge suppressor to deal with stubborn power-line noise, hash and spikes. The Super Filter/Suppressor connects to the ac line via a standard 3-prong plug and provides three 3-prong outlets. It can handle a total load of 1250 watts. $66.95.

CIRCLE NO. 129 ON FREE INFORMATION CARD

## Digital Audio Processor




Sansui's Model PC-X11 Tricode Digital Audio Processor and a VCR are all you need to obtain audio recordings superior to what you can obtain from the very best of open-reel recorders, even those operating at 30 ips. The PC-X11 is designed for digital recording of live music but works equally well when dubbing CD (Compact Disc) programs onto a videocassette.

The processor has a greater than 80-dB dynamic range, flat response from 5 to 20,000 Hz, and distortion figure of less than 0.007%. Sampling frequency is 44.056 kHz; quantization is 14 bits (linear), signal-to-noise ratio is better than 85 dB, wow and flutter is said to be unmeasurable.

Sansui claims the processor's data-reading capability is about 100 times more accurate than that of other PCM processors. Even if a section of the digital information is blurred, Sansui says it can be fully restored to original form. The processor can also deal with variations in signal amplitude, which enables it to make and play back digital audio recordings at the slow EP (extended play) speed on a VCR for more economical use of tapes. Dimensions are 20"W × 15"D × 5"H. $900.

CIRCLE NO. 130 ON FREE INFORMATION CARD

# An Automatic LED Street Number Sign *(from page 59)*

the board a 5000-ohm rheostat and set it for maximum resistance.

When you install polarized components, make certain that you orient them as detailed in Fig. 1. These components include electrolytic capacitors *C1* and *C2*, zener diode *D1*, integrated circuit *IC1*, light-emitting diode *LED1*, and transistors *Q1* and *Q2*. Use a low-wattage soldering iron and only enough solder to assure good electrical and mechanical connections.

Before mounting the electronics in the box you've chosen for your project, wire together the entire circuit and plug it into a convenient ac outlet. Connect a dc voltmeter (or a multimeter set for dc volts) with its common lead going to circuit ground and its "hot" (+) lead going to the junctions between *R2* and *C1* and close *S1*. Slowly adjust the setting of the rheostat for a reading of 27.6 volts. Disconnect the meter and pull the project's plug from the ac outlet.

Now, without touching the setting of the rheostat, remove it from the circuit. Use an ohmmeter to measure the resistance at which the rheostat is set. The reading you obtain is the value of the resistor you must use for *R2*. Select a fixed ½-watt resistor with a value as close as possible to the reading and install it in the *R2* location in the circuit. This completes electronic assembly of the project.

Under normal operating conditions, the potential on the +27.6-volt line to the LED numeral array will go to a level greater than +30 volts when the display is off during daylight hours. It may even go as high as +40 volts above ground. However, it will still be within National Electrical Code limits because current in the circuit is much below the 3.2-ampere NEC specification.

The box you select for your project should easily accommodate the LED numeral array panel and control-circuit/power-supply (and the transformer if it's to be mounted off the board), plus a transparent sheet of red plastic about ¼" in front of the LED display. The plastic sheet serves two purposes: it protects the display from the elements, and it enhances the contrast of the display.

There's only one adjustment to be made to make the project fully operational. That is to set *R6* so that the LED display is off under full daylight conditions.

If you're planning to locate your street number sign outdoors, it's a good idea to completely weather-seal it. To do this, apply about a ⅛" bead of silicone adhesive along all seams of the box and around all hardware that goes through the box.

## In Closing

The automatic LED street number sign described here is a maintenance-free project. It will give you many years of service without the need for attention. The LEDs are rated to deliver a million operating hours, and the circuit has been designed for minimum electrical wear and tear on components. So all you have to do is plug the line cord into an ac outlet and turn on the power. **ME** ing performance of this VCR system. So, too, do channel-pickup, tuning-accuracy, and command-response performance. Dc drive-motor performance appears to be adequate, judging from the low wow and flutter measured. With good-quality tapes, such as RCA's or Kodak's HGX T-120 series, you should obtain excellent mono audio and reasonable stereo, considering that there is no special head for audio reproduction.

About the only thing I'm inclined to criticize is the usual mediocre high-frequency video response. But because of the very high luma/chroma S/N characteristic of this system, this isn't noticeable in either color or fine detail from ordinary viewing distances. In sum, on a scale of 10, I would very conservatively rate the RCA VKP900 a 9+ in comparison with its contemporaries.

—*Stan Prentiss*

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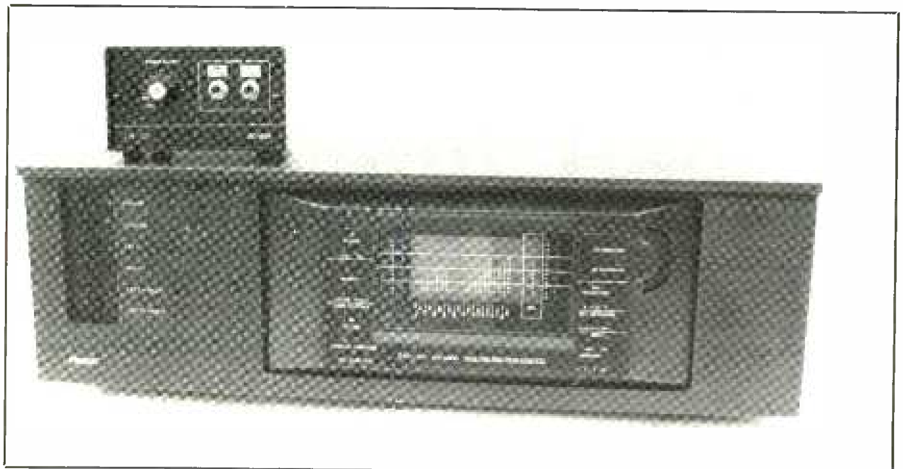
**Audio**

*Lab quality, portability and low price:*

## *Heath's AD-1308 Real-Time Spectrum Analyzer*



Billed as the "world's first hand-held, microprocessor-controlled ½- and 1-octave real-time spectrum analyzer," Heath's Pro-Series Model AD-1308 represents a breakthrough in price that professional sound installers, technicians, recording engineers, and advanced audio enthusiasts only dreamed about—an audio spectrum analyzer, in kit form, that sells for only $279.95! Just add an accurate source of pink/white noise (or buy a $49.95 Heathkit generator kit) and you have a lab-grade instrument to fine-tune any audio system. Being battery-powered extends its capability.

The instrument can be operated by direct connection to an audio amplifier or by using its built-in calibrated microphone. An optional power supply/rack mount is available for $119.95. Though each item—analyzer, generator, and power rack—can be purchased separately, Heath offers a package-deal price of $399.95 if you purchase all three kits at the same time. In effect, you get the pink/white noise generator free.

### *Analyzer Details*

Powered by six C cells (carbon-zinc, alkaline or rechargeable nickel-cadmium types), the analyzer can be operated completely independent of the ac line. Of course, it can also be powered from the ac line when nested in the accessory power supply/rack mount, which also provides the means for recharging the Ni-Cd cells when used.

The instrument is very compact, considering what it's designed to do. It measures 9¼"W × 4¼"H × 3½"D and weighs a surprisingly hefty 3¼ lbs, with C cells installed.

Dominating the front panel is a large window, behind which is a matrix array of 20 columns by 12 rows of fluorescent light squares that selectively glow a soft blue when activated. This arrangement is used for

# PRODUCT EVALUATIONS...

*Heath's AD-1308 continued*

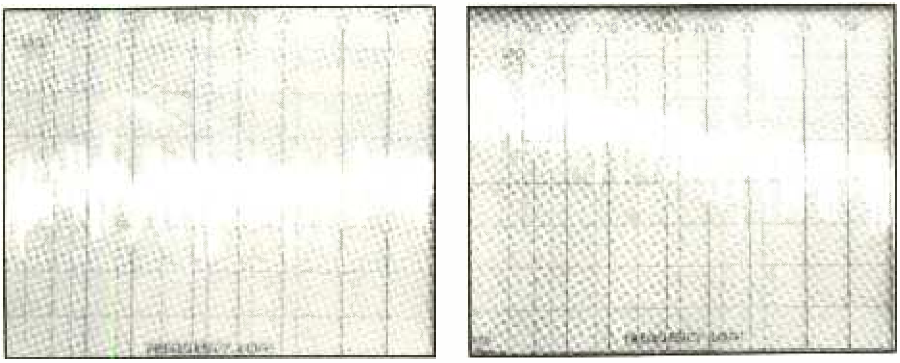


*Fig. 1. The noise generator produced white (left) and pink (right) noise. Photos represent frequency-versus-amplitude plots from 20 Hz to 20 kHz. Frequency plot is logarithmic, vertical calibration is 10 dB per division.*

displaying sound/signal levels in each of 20 half-octave frequency ranges. Located to the far right of the display area is a single isolated column of light squares that indicate overall sound pressure level (SPL).

The display window has scales and base lines printed on it in two colors, keyed to a DISPLAY SCALE switch, with the 1-dB scales in white and the 3-dB scales in red. There are identical vertical scale pairs screened onto the display window on each side of the matrix arrangement. The white scales are calibrated in 1-dB increments from −9 to +2 dB, while the red scales are calibrated in 3-dB increments from −27 to +6 dB.

Along the bottom of the display area are the calibration markings for the frequencies represented by each of the columns of fluorescent light squares. The lowest frequency on this scale is 31.5 Hz, the highest 20 kHz. Depending on the frequency content and amplitude of the signal or sound being tested and the position of an OCTAVE switch, all columns in the ½-octave position or every alternate column in the 1-octave position will light. In either case, there will be a constant indication in the SPL column.

Controls for this sophisticated instrument consist entirely of a combination of slide, pushbutton and rotary type switches. Along the left side of the display window are the POWER, MEMORY 1 and 3 dB DISPLAY SCALE, ½ and 1 OCTAVE, and AVG (average)/PEAK/HOLD DISPLAY RESPONSE switches. Immediately above the POWER switch is a small red LED that comes on whenever this switch is set to the ON postion.

The momentary-action MEMORY pushbutton and slide-type STORE/RECALL switches are used in combination with another slide-type MEMORY switch located on the lower-right of the front panel to store incoming signal waveforms in any of the analyzer's three memory banks and to selectively display any waveforms stored in memory.

To the right of the display window is a large thumb-operated ATTENUATOR for adjusting analyzer sensitivity in 10-dB steps from 50 to 120 dB SPL. Since the maximum range within the display itself extends from −20 to +6 dB, total SPL reading range for the instrument can go from a low of $50-27=-23$ dB to a high of $120+6=126$ dB with this switch.

Below the ATTENUATOR switch are the slide-type A/FLAT/C SPL WEIGHTING, SLOW/FAST/PEAK SPL RESPONSE, MIC/EXT (microphone/external) INPUT, and the aforementioned 1/2/3/DIF MEMORY bank selector switches.

The 1, 2 and 3 positions of the MEMORY switch, when used with the MEMORY switches on the left side of the panel, enables a user to store and display up to three complete frequency-response "curves" in memory and to selectively display each. The DIF position puts the analyzer into a *difference* mode, a feature I have never seen before in any real-time spectrum analyzer. Considering the usefulness of this function, I can't understand why it hasn't been incorporated into these instruments before now.

Using the difference mode, you can compare one of the stored response curves with a current input and then automatically display the difference between the two. For example, if the output waveform of the pink-noise generator were to be used as the stored reference and the output of a loudspeaker as the current input, the difference mode would subtract one response from the other and display the difference. It would then be a simple matter to adjust a graphic equalizer or the tone controls in an audio system for accurate overall frequency response.

The calibrated microphone supplied with the AD-1308 plugs into a connector on the top of the instrument's case. Alternatively, if you wish to keep the mic away from the analyzer's case to eliminate interference effects, you can fabricate a cable with appropriate connectors and coaxial cable to place the mic remote from the instrument.

Normally, a microphone for use with spectrum analyzers can cost as much as or more than the entire system of kits from Heath, ranging from hundreds to even thousands of dollars. How then is Heath able to supply an accurately calibrated microphone as part of its low-cost package? Well, the company starts out with a very good if not altogether "flat-response" mic and then carefully measures its response, including any deviations from flat. By building into the instrument the necessary compensation network which includes a ROM IC to correct any frequency errors, the combination of microphone plus compensated preamplifier yields an overall response that is flat within ±2.0 dB over the entire audio range when used with a pink-noise source in an anechoic (echo-free) environment. (An individual calibration curve response accompanies each instrument.)

Used as-is, the AD-1308 provides test and analysis capabilities only through its microphone. To be able to do in-circuit tests, you must have the instrument docked in the optional power-supply/rack-mount accessory. Docking is accomplished through a miniature 9-pin (DB-9) connector on the rear of the instrument's case.

## *Accessories Details*

The procedure for docking the AD-1308 analyzer in its companion ADA-1308-1 power-supply/rack-mount accessory is simple. You just drop down the latter's front panel, slide the AD-1308 into place until its connector meshes with the connector built into the accessory, and flip the panel back into place. Presented to you then will be what appears to be a single, professional-appearing, unitized piece of test equipment. All AD-1308 controls, plus the switches on the ADA-1308-1, are out in the open for immediate access. The accessory supply/rack measures 17"W (to fit into the standard 19" rack via the supplied rack-mounted brackets) × 8⅝"D × 5½"H.

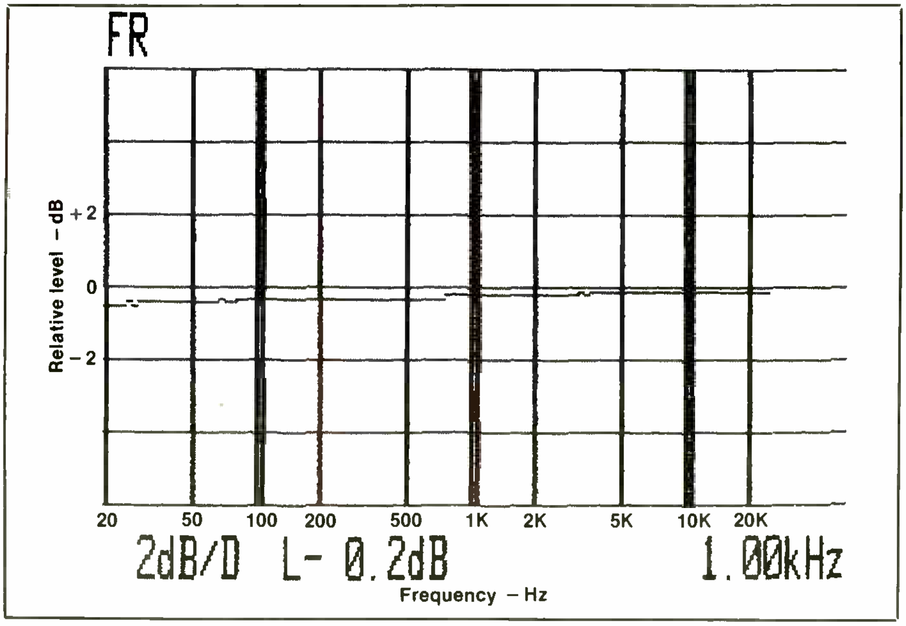



*Fig. 2. Introducing the AD-1308 into the signal path of an audio system does not significatly alter the frequency response of that system.*

When the analyzer is docked in this accessory, power is supplied from an ac source. Additionally, the analyzer's POWER switch is bypassed and replaced by the POWER switch in the accessory. The accessory also allows you to connect external inputs (but not the calibrated microphone) to the analyzer and to access a voltage output from it for connection to an rms voltmeter, chart recorder, or other suitable test instrument. The nice thing about this arrangement is that when you pop the analyzer into the supply/rack mount, you can use standard phono-jack type cables for connecting the analyzer to the outputs of audio equipment.

Another nice thing about the accessory unit is that it is roomy enough to accommodate the calibrated microphone in a pair of retainer clips and the accessory pink/white noise generator, as well as one or more pads of display forms. These items sit nearly out of the way in the same well

*Fig. 3. Analyzer display recalled from memory and frozen for viewing.*

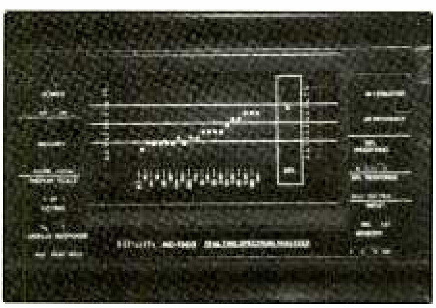
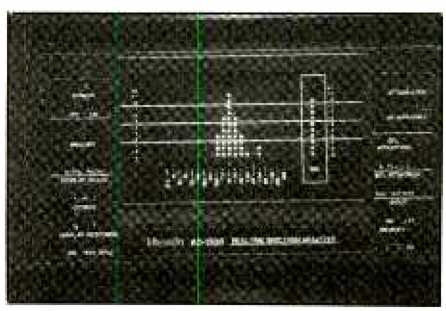


*Fig. 4. Display obtained when single 1-kHz tone was fed into analyzer.*



as the analyzer but are ready for immediate use when needed.

Operation of the power-supply/rack-mount accessory with the analyzer properly docked in it is very simple. There are a total of six push-button-switch controls, arranged in a neat column on the left side of the front panel. From top to bottom, these include the POWER, CHARGE, LEFT, RIGHT, LEFT + RIGHT, and LEFT − RIGHT switches. Immediately to the right of the POWER and CHARGE switches are red and green LEDs, respectively, that come on when these functions are selected. The four lower switches permit independent left and right channel input selections or summed L and R or differenced L and R inputs to the analyzer. All inputs and outputs are via phono jacks located on the rear panel of the accessory.

Housed in a plastic enclosure that measures only 4"W × 3½"D × 2½"H, the very compact and lightweight (1.5 ozs. with battery installed) Model AD-1309 pink/white-noise generator requires only a single 9-volt battery for operation. It's controlled by a combination power switch/POWER OUTPUT (level) potentiometer. Pink or white noise selection is accomplished simply by plugging the feed cable into either the PINK NOISE or WHITE NOISE OUTPUT jack, both located on the instrument's front panel alongside the control.

The white-noise function produces a random-noise signal that has the same voltage amplitude at all frequencies across the audio spectrum. The pink-noise function produces a signal that has the same energy content per unit of frequency spectrum (per octave, half-octave, etc.). Accordingly, white noise plotted on a voltage-versus-frequency graph will yield a "flat" response curve (see slow-sweep spectrum analyzer scope photo in Fig. 1A). Pink noise, on the other hand, will exhibit a downward "tilt" of about 3 dB per octave (Fig. 1B).

The photos in Fig. 1 were taken from the face of a storage oscilloscope that forms a part of our sweep-type spectrum analyzer. Unlike a real-time analyzer (such as Heath's AD-1308), a sweep-type analyzer can display spectral or frequency content of a signal only if that signal is continuous or ongoing. In the case of a musical signal, sounds vary continuously and require a real-time analyzer such as the AD-1308 to show what's happening from moment to moment.

Our own lab is equipped with a real-time analyzer that has most (but not all) of the features as the AD-1308. It was purchased about five years ago and cost four times as much as the AD-1308! This should give you a good idea of where the AD-1308 stands in terms of price and performance.

## *Performance And Comments*

Heath suggests that users may want to connect the AD-1308 into their audio systems so that music being heard will be displayed as a continuously varying set of bargraphs in the analyzer's window. This sounded like a good idea, but before we introduced an "alien" piece of gear into our system we wanted to make sure that it wouldn't alter our ruler-flat response and that it wouldn't introduce any audible harmonic or other distortion. Lab tests showed that we had no cause for concern, as revealed by the analyzer's frequency-response characteristics (Fig. 2), in which the maximum deviation from perfectly flat was less than 0.5 dB, and the measured 0.5% THD.

We had great fun storing instantaneous spectral content of music passing through our audio system. One of our spectrum analysis "instants" of music is shown in Fig. 3, in which can clearly be seen how each half-octave content is individually displayed as an amplitude, while a single light square shows overall SPL.

Curious to find out how sharp the individual half-octave filters in the analyzer were, we fed a pure 1-kHz tone into the system and recorded the display, shown in Fig. 4. Not only is the display completely symmetrical around 1 kHz, indicating the accuracy of the filter's center frequency, but response of adjacent filters, a half octave away from the center frequency used, was down some 12 dB, indicating that the filters are extremely narrow-band in design. We were using the 3-dB per light square for this test.

Removing the analyzer from its supply/rack and using the pink-noise generator allowed us to fine-tune our stereo system with a 10-band graphic equalizer for a flat response in our preferred listening location. The job took only a few minutes, thanks to the high resolution of the analyzer and its ½-octave display. Even though we discovered that maximum system deviation from flat at any half-octave point was no more than 3 dB, we were able to easily correct these minor response deviations.

Aside from the satisfaction of knowing that your sound system is performing with close to flat frequency response, the AD-1308 with its accessories can be put to several other practical uses. For example, we found that the display can be used as an accurate voltmeter once a known voltage is fed into it for initial reference calibration. When fed with 1 volt at 1 kHz, out test unit registered an SPL of exactly 100 dB. We derived a table of decibels-versus-voltage values, after first establishing that a

10-dB change in the display represented a very accurate 10-dB change of input. On that basis, we were able to use the analyzer to read from around 20 volts (126 dB in the display) down to a theoretical low of 0.07 millivolt!

If your audio interests go beyond casual musical enjoyment and extend to professional sound installations and/or consulting, you can easily pay for your investment in the Heath equipment in a very short time. Being portable extends its utility to mobile audio systems. Nor will your initial cost break the bank, as is so often the case with professional and/or laboratory grade instruments nowadays.

—*Len Feldman*

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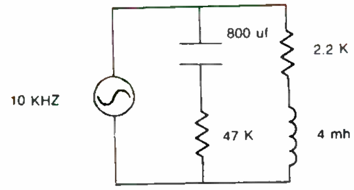


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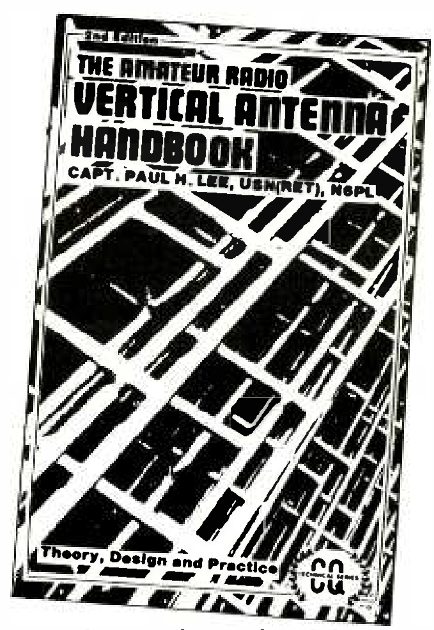


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## Designing Dc Power Supplies *(from page 46)*

and output. Don't forget this important difference! Because of the pin-out arrangement of the LM-338K, you'll have to insultate the case and/or the heat sink it rests on from the chassis, especially if the chassis is used as the common/ground!

The transformer, rectifier and filter capacitor are selected for the Fig. 2 circuit using the same criteria spelled out for Fig. 1.

The LM-338K can accept an input of up to 35 volts. It will produce a maximum output of several volts less than the 35-volt input. The exact output voltage is set by the ratio of *R1* and *R2*. In Fig. 2, *R2* is a variable potentiometer. With the circuit arranged as shown, output voltage $V_o$ will be approximately $1.25V[(R1/R2 + 1 + (R2 \times I_{adj})]$. Normally, the term $(R2 \times I_{adj})$ is so small as to be ignored.

With the values given in Fig. 2, the output can be varied from 1.25 to more than 35 volts (assuming the input would allow it). In some cases, where the voltage is set and then forgotten, *R2* will be a trimmer pot mounted on the power supply board. In other cases, it will be an operator-adjustable front panel control.

Diodes *D1* and *D2* serve the same protection function in this circuit as in Fig. 1. Once again, any 1N4002 through 1N4007 diode will suffice.

If you want to make the LM-338K (or the LM-317) into a fixed-voltage regulator, you can with one of the two modifications shown in Fig. 3. In one case, two fixed resistors are used for *R1* and *R2*. Normally, *R1*'s value will be 120 ohms and *R2* will have a value selected to set the output voltage at the required level. In the other case, *R2* becomes *R2A* and *R2B*, with the value of *R2B* being roughly 10% to 15% of the value of *R2A* and set to trim the output to a precise value. This latter arrangement has the advantages of fixed operation, while allowing trimming of the output to the exact voltage required.

Our final circuit, shown in Fig. 4, has two LM-338K regulators connected together to form a 1.2- to-16-volt dc regulated power supply capable of delivering 10 amperes. Since the cases of the LM-338K devices are connected together, you can use the same heat sink for both. Potentiometer *R2* sets the output voltage and is adjustable to just over 16-volts dc.

The input voltage for the Fig. 4 circuit can be acquired from rectifying a 12.6-volt ac (rms) transformer's output and filtering it with 15,000 $\mu$F, or more, of capacitance.

### *Conclusion*

The dc power supply is very important to the success of any electronic project. Dc supplies are also very important to have on your workbench. With the information presented, you should now be able to design and build most of the elementary supplies needed by hobbyists and experimenters in solid-state electronics. **ME**



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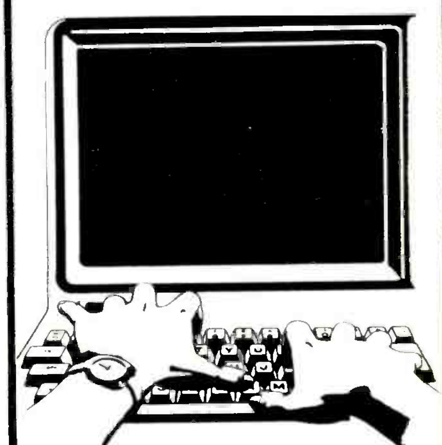

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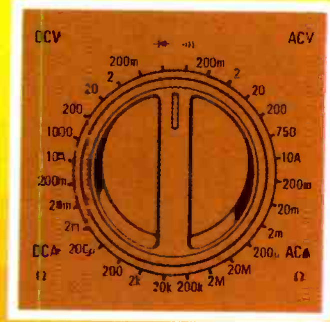


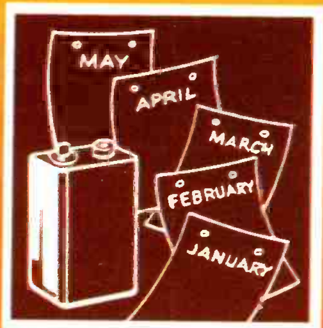


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