Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE
JUNE 1981/95¢

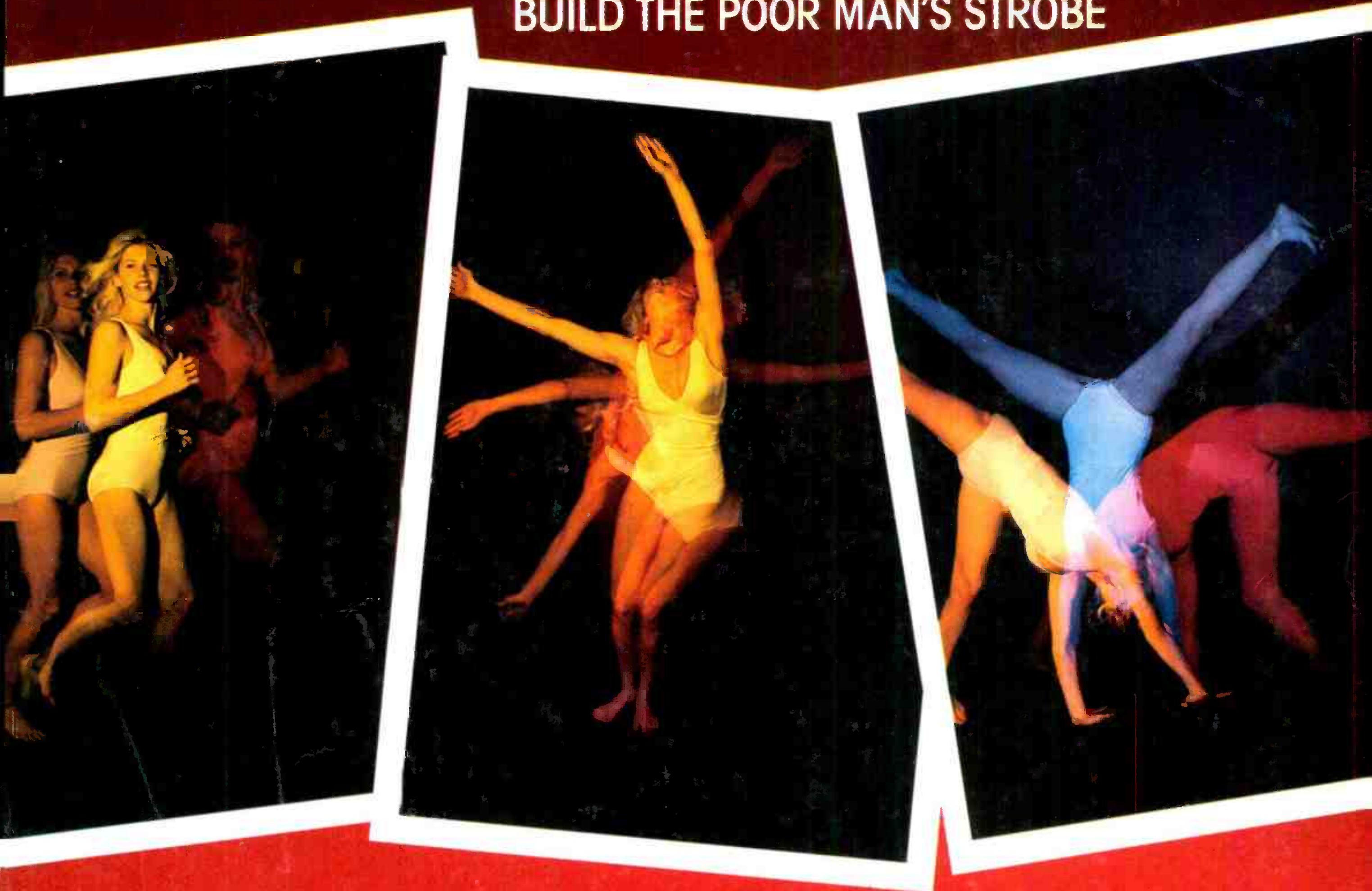
Dolby's New Noise Killer

Multiband Shortwave Antenna

1802 EPROM Programmer

For Special-Effect Photos:

BUILD THE POOR MAN'S STROBE



Tested in this issue:

Atari 800 Microcomputer
Sansui AU-D11 Amplifier
GE 13AC1542W TV Receiver

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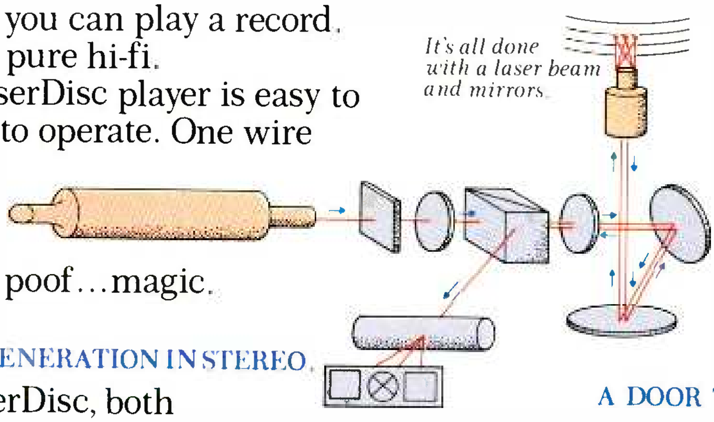
In hi-fi, up until now, sound was the whole picture.

Since the very beginning, hi-fi has appealed to one sense: your hearing. The rest was up to your imagination.

Now Pioneer brings you closer to the reality of performance than you've ever experienced at home: LaserDisc.™

Now you can hear and *see* a concert or a movie as easily as you can play a record. With sound that's pure hi-fi.

The Pioneer LaserDisc player is easy to hook up and easy to operate. One wire to your TV; two to your hi-fi. Then just place a disc on the player, and poof…magic.



It's all done with a laser beam and mirrors.

THE SOUND: A NEW GENERATION IN STEREO.

With Pioneer LaserDisc, both channels are completely discrete from each other. It's stereo in its truest sense. And since the disc is read by a light beam rather than a video head or needle, with normal use, it doesn't wear out from play. In addition, unlike conventional records,

Concerts like Paul Simon.

New movies and classics like Dracula.

Sports like NFL Football.

you can handle the LaserDisc as much as you wish. Even minor surface scratches won't effect the superb audio and video fidelity. You can enjoy the disc forever.

THE PICTURE: BETTER THAN HOME VIDEO TAPE.

The Pioneer LaserDisc player offers a picture with actually 40% better resolution than the picture delivered by a home video tape player. A picture of the highest broadcast quality. For the first time on your television set, video fidelity is matched by audio fidelity.

TRULY PERSONAL HOME ENTERTAINMENT.

Try to imagine what it would be like to sit down in front of your television and see whatever program you wished whenever you wished to see it. With a sense of performance, a feeling of "being there" never before experienced at home: Movies, concerts, sports.

Pioneer Artists and MCA/Discovision discs like Paul Simon, Liza Minelli, Loretta Lynn, Jaws, Animal House, The Blues Brothers, the NFL.

A DOOR TO EDUCATION.

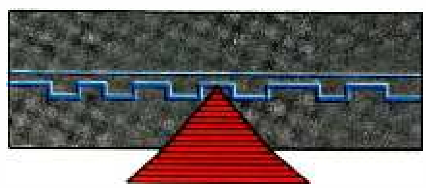
With standard-play discs, you can create your own instant sports replays at home, you can go in fast motion, slow motion, one frame at a time, even stop motion indefinitely. But LaserDisc offers something far more revolutionary. Everyone of the up to 108,000 frames on the disc is coded. And a built in micro-computer lets you access any individual frame at will. This means you can go to your favorite scene in a movie or song in a concert in seconds.

But that's merely the beginning. On one disc you can stroll through the National Gallery and study art masterpieces one masterpiece at a time.

And since play can't wear out the disc, they can be studied forever.

THE FUTURE IS IN REACH.

One of the most surprising parts of this new technology is that it's affordable.



A beam of light instead of a needle.

JUNE 1981 VOLUME 19, NUMBER 6

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

Feature Articles

Construction Articles

Equipment Reviews

Columns

Departments

COVER PHOTOS BY IMRE GORGENYI

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EDITORIAL

By their fruit. . . .

Wolves have been known, at least figuratively, to wear sheep's clothing and while so disguised work considerable mischief. The same ploy has been used by manufacturers who, unwilling to have their products compete on their own merits, dress them in trade styles established by others.

One of the latest victims of this deceptive practice is Pioneer of America, whose car audio speakers are currently being "knocked off" by several sources reportedly based in Taiwan. A knock-off operation consists of manufacturing a product designed to look almost exactly like an established one, except that the name of the manufacturer being copied is not overtly used. Such copies usually imitate not only the styling of the product itself but its packaging as well, right down to details like type style. Needless to say, knock offs are virtually always inferior to the original.

Such practices are distressingly common in the field of consumer electronics. Pioneer is only one of the later victims. TDK and Maxell, in the audio tape market, and Shure Bros. with replacement phonograph styli, have suffered as well (although Shure has made no claim of unfair competition, only that the second-source product is inferior). What is dangerous for the consumer is that a particular instance of knocking off becomes generally known only after it has become fairly widespread. In addition, the pirates have the advantage of taking the initiative. (Are you sure that that balky disk drive is what you thought you were buying?)

Obviously, since the target manufacturers lose sales and profits as a result of these sleazy operators, they take whatever steps are available to suppress these patently unfair business practices. But because of the flexibility with which the perpetrators can operate, changing from product to product and introducing bogus brand after bogus brand, a more flexible line of defense is necessary. That line of defense is you.

If consumers scrutinize what they are buying carefully and make sure that it is what it is said to be, knock-off operators will be out of business. After all, there is no point in their producing what they cannot sell. And, of course, considering the second-rate merchandise that you will not be buying, there is a reward for you here as well. So beware of "bargains" that seem too good to be true—they probably aren't. Remember, the money you save will be your own.

Hal Rodgers

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Radio Shack's TRS-80™ Model III is Your Best Buy in Desktop Computers.

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(Because the "Extras" are Built In!)

With the TRS-80 Model III, you don't pay extra for the features you want. For $2495, you get a *complete*, ready-to-run desktop computer. Go ahead — judge their extras by our standards:

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LETTERS

Preamplifier Performance Specs

Regarding the "High-Performance Phono Preamplifier," described in your March 1981 issue, before I build the unit, I would like to know what I can expect as far as noise and distortion goes.—*Philip A. Wilson, San Jose, CA.*

The author gives the following figures for the moving-magnet preamp: input impedance, 47 kΩ and 100 pF; input overload, 150 mV at 1 kHz; playback equalization, RIAA or IEC ± 1/4 dB; frequency response (AUX), 16 to 100,000 Hz, +0/−3 dB; input sensitivity, 1.5 to 10 mV at 1 kHz; S/N (re 5 mV) 85 dB IHF A wtd.; distortion, less than 0.01%; output clipping, 8 V rms (into 2.2 kΩ); slew rate, ±13 V/µs (AUX), ±2 V/µs (PHONO) (limited by RIAA Eq). For the moving coil preamp: input impedance, 100 Ω; input overload, 5 mV at 1 kHz; input sensitivity, 50 µV to 300 µV at 1 kHz (re 500 mV output); S/N, (re 0.5 mV), 88 dB IHF A wtd.—Ed.

Encouragement from an Author

The "Project of the Month" by Forrest Mims on the Transistorized Light Flasher (March 1981) was most interesting to me because it provided additional insight into the prolific workings of Mr. Mims. I first met Forrest a few years ago and it was he who encouraged me to write my first book (*Listen to Radio Energy, Light, and Sound*, Howard W. Sams). I had had a number of technical articles published but had never ventured into the field of books. With his encouragement and comments, my first effort hit pay dirt. By continuing to publish his articles, which are very innovative and inventive, you are doing a service by providing easy, workable projects for electronics experimenters—the backbone of the electronics community of the future.—*Calvin R. Graf, San Antonio, TX.*

Re Speech-Synthesis ICs

Telesensory Systems, Inc. has been building, since 1975, a talking calculator for the blind with a proprietary speech-synthesis integrated circuit using Dr. Forrest Mozer's waveform encoding technique. National Semiconductor has, as you mentioned in your editorial, recently introduced a chip based on the same techique. In the meantime, our device was selected by Fidelity Electronics for use in their highly successful Voice Chess Challenger, which is now available in four languages. We also introduced an industrial speech board based on this chip, which is used in talking voltmeters, depth sounders, etc.—*David Gilblom, Telesensory Systems, Inc., Palo Alto, CA.*

OUT OF TUNE

In "Power Supplies for Op Amps" (April, p 57), on page 59, column 1, line 14 should read "*C1*, *C2*, and *D1*" instead of "*C1* and *D1*". On page 60, column 3, line 2 should read "*R5* and *R6*" instead of "*R5* and *R7*" and line 3 should read "*R1* and *R7*" instead of "*R1* and *R6*." In Fig. 7, *R4* should be moved so that it is in series with the V+ supply, between the supply and *C1*, *R2*, *C4*, and the V+ terminal of *IC1*.

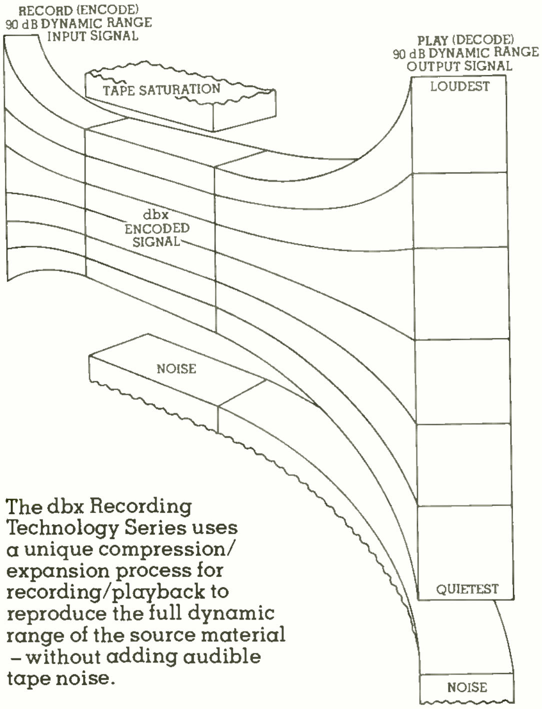
In "Build a High-Performance Phono Preamplifier" (March 1981), there are two *R23*s on the schematic and component layout. The 100-kΩ fixed resistor for *R23* is not included on the Parts List. In the Parts List, *Q1* and *Q2* should be listed as 2SB7375 not 25B7375.

How to master tape.

Eventually, you reach a point with your tape recording system where you realize you just can't make the kind of quality recordings you want.

Even though your equipment may be the very finest.

Because despite Dolby,®* the tape still has too much noise. It doesn't give you enough headroom. And its dynamic range – the range of volume that makes music sound alive and real – is just too restricted.



The dbx Recording Technology Series uses a unique compression/ expansion process for recording/playback to reproduce the full dynamic range of the source material – without adding audible tape noise.

If you've reached that point, you're ready for the dbx Recording Technology Series. Noise reduction systems that eliminate tape hiss and allow you to record with a quality equal to studio master tapes.

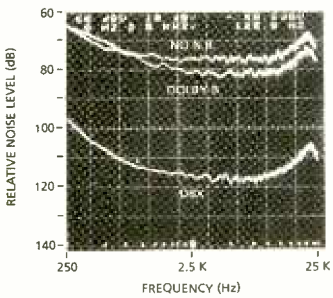
With a dbx Recording Technology Series Model 224 or 222, noise is reduced by 30 dB across the *entire* frequency range. You get 10 dB more headroom. You can even make live recordings with 80 dB or more of dynamic range. Remarkably close to a live performance.

And there's one final touch. The dbx Recording Technology Series includes a built-in dbx Disc Decoder that lets you play the revolutionary dbx Discs and Digital dbx Discs, the world's first Full Dynamic Range Recordings.

See your authorized dbx retailer for a demonstration of the dbx Model 224 and 222 and learn which is best suited for your system.

Short of buying your own recording studio, it's the only way to master tape.

dbx, Inc., 71 Chapel St., Newton, Mass. 02195 U.S.A. Tel. (617) 964-3210. Telex 92-2522. Distributed throughout Canada by BSR (Canada) Ltd., Rexdale, Ontario.



Dolby B reduces noise by only 10 dB in the high frequency range. dbx reduces noise by more than 30 dB across the entire frequency range. (Unretouched laboratory photograph. Data for cassette recorder from "The Importance of Dynamic Range," Audio Magazine, January, 1980. For a copy of the article, write dbx.)

*Dolby is a registered trademark of Dolby Laboratories, Inc.

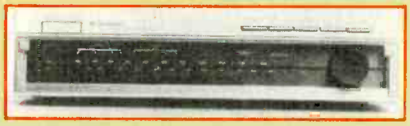
Making good sound better dbx®

CIRCLE NO. 10 ON FREE INFORMATION CARD

NEW PRODUCTS

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

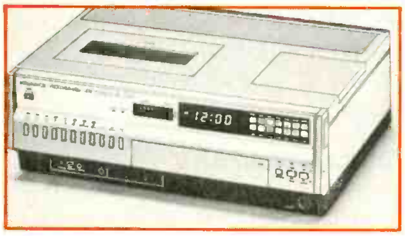
Kenwood Audio Purist AM/FM Tuner



Kenwood's Model KT-1000 AM/FM-stereo tuner features a touch-activated servo-locked tuning system and exclusive pulse-counting detector and sample-and-hold MPX circuits. The tuning system automatically adjusts FM tuning to the center of the i-f bandpass, while the pulse-counting detector digitally recreates the FM signal. Direct r-f conversion prevents interference from strong stations, while normal conversion can be used when greater sensitivity is needed. Other features include: wide/narrow i-f bandpass selector, recording calibration switch, stereo pilot canceller, automatic muting, preselector bypass switch, fixed and variable outputs, and AM i-f output jack (for AM-stereo decoder). Specifications: FM section—usable sensitivity, 10.3 dBf; stereo S/N, 85 dB; stereo THD (1 kHz), 0.04%; alternate-channel selectivity, 45 dB; separation (1 kHz), 60 dB. AM section—usable sensitivity, 10 μV; S/N, 52 dB, image rejection, 70 dB; selectivity, 30 dB (wide i-f). $450.

CIRCLE NO. 89 ON FREE INFORMATION CARD

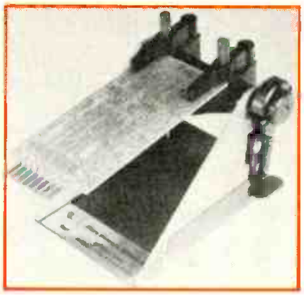
Magnavox Deluxe Video Cassette Recorder



Magnavox's Model 8340 is a VHS-format videocassette recorder that permits unattended recording for up to 6 hours. It has a built-in digital clock/controller and a remote pause control that makes armchair editing possible. Features include search forward and reverse at nine times normal speed, fast motion at two times normal speed, variable slow motion, frame-by-frame advance, and freeze-frame operations, all through the special-effects remote controller. In addition, there is 14-day/seven-event programmability, unattended recording of one additional event at the same time each week, feather-touch controls, automatic rewind, and transitional editing.

CIRCLE NO. 87 ON FREE INFORMATION CARD

Micro Electronic Systems Mini PC Board Holder



Micro Electronic Systems has a new holder that serves as a "third hand" for work on small printed-circuit boards and collapses for easy storage. A pc board is held by two small vise-like grippers that can rotate to provide access to the reverse side. The steel-and-plastic holder (Part No. 1521) sells for $41.40. Address: Mini Electronic Systems, Inc., 159 Main St., Danbury, CT 06810.

Bogen Wireless Intercoms

The new Models WI-1 and WI-3 wireless intercom systems from Bogen require no station-to-station wiring, relying instead on carrier current transmission over the power mains. The WI-1 offers one-channel capability and the WI-3, three-channel capability, both using FM for interference immunity and automatic squelch for minimum noise. A phase-locked loop (PLL) maintains frequency stability. Calls can be announced by tone or voice. A locking button permits continuous transmission for monitoring nurseries, sickrooms, etc. Each system is packaged with one pair of stations, and can be expanded to accommodate more.

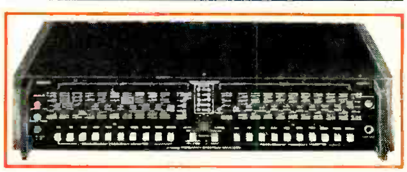
CIRCLE NO. 91 ON FREE INFORMATION CARD

Alphacom Printer/Plotter

The Alphacom Sprinter 40 from Olivetti is a high-speed thermal dot-matrix printer with plotting capability. It prints up to 240 40-character lines per minute on standard thermographic paper, using a 5 x 7 dot matrix to produce 96 upper- and lower-case characters. It requires only 14 seconds to produce a 280-line CRT display in hard copy within a 280 by n-dot matrix. Among the functions available are: automatic carriage return and line feed, reset, right justification, form feed, graphics control, and multiple-line feed. Interface with a computer is user selectable and can be either 7-bit ASCII parallel with STROBE, BUSY, and ACK (Centronics standard) or RS-232 serial with choice of 110, 150, 300, 600, 1200, 2400, 4800, or 9600 baud. The Sprinter 40 is designed to be connected to any computer that uses a standard interface. $390.

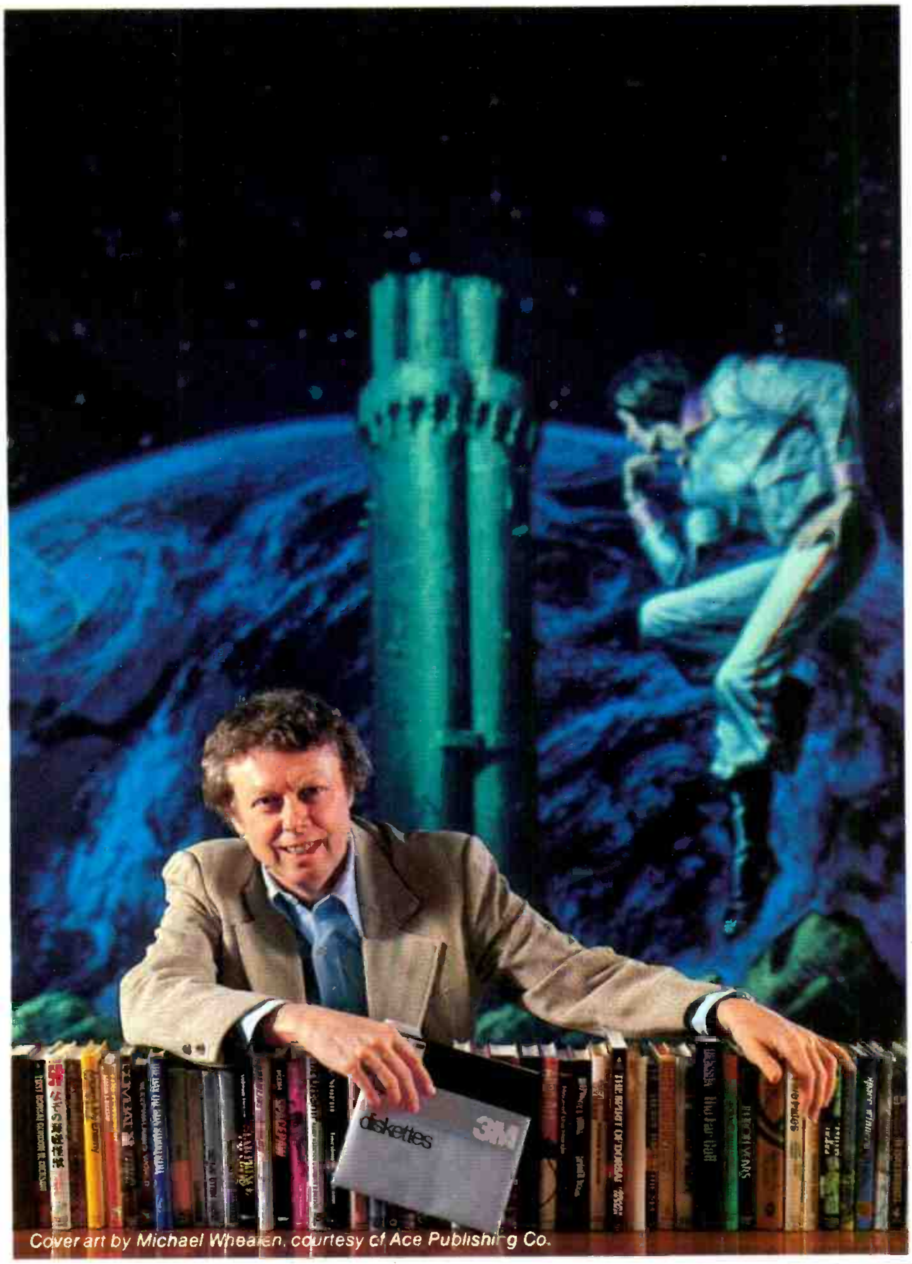
CIRCLE NO. 88 ON FREE INFORMATION CARD

Numark Equalizer/Analyzer



According to Numark, the 10-band Model EQ-2700 computerized equalizer/analyzer permits accurate fine tuning of a hi-

"My computer helped me write The Final Encyclopedia. I wouldn't trust anything less than Scotch® Brand Diskettes to make a long story short."



Cover art by Michael Whealen, courtesy of Ace Publishing Co.

Gordon R. Dickson,
Science Fiction Author,
Minneapolis, Minnesota

Gordon Dickson: a small businessman whose product is his own imagination. He's written more than 40 novels and 150 short stories; his newest work is *The Final Encyclopedia*. He uses his personal computer and word processing software to maximize his production. All his words—his product—are stored on diskettes. He calls up sentences and paragraphs on demand, and gets more rewrite out of the time available. So he depends on Scotch diskettes to save himself production time.

Dependable Scotch media can work just as hard for you. Each Scotch diskette is tested before it leaves our factory, and certified error-free. So you can expect it to perform exactly right.

Scotch 8" and 5¼" diskettes are compatible with computer/diskette systems like TRS-80, Apple, PET, Wang and many others. Get them from your local 3M distributor. For the one nearest you, call toll-free: 800/328-1300. (In Minnesota, call collect: 612/736-9625.) Ask for the Data Recording Products Division. In Canada, contact 3M Canada, Inc., Ontario.

If it's worth remembering, it's worth Scotch Data Recording Products.

3M Hears You...

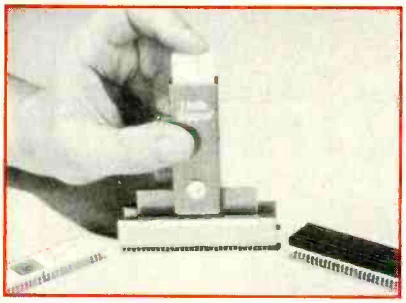
3M

CIRCLE NO. 54 ON FREE INFORMATION CARD

fi system to match the sonic conditions of a listening area. A built-in pink-noise generator permits adjustment in octave bands. An optional measurement microphone (Model STD272) is available. Specifications: frequency response 10 to 100,000 Hz ±1 dB; center frequencies, 60, 120, 240, 480, 960, 1920, 3840, 7680, and 15,360 Hz with a ±15-dB adjustment in each band; IM and THD, 0.02% (0.01% at 1-V output); hum and noise, −102 dB (2-V output, input shorted). Analyzer measurement frequencies are the same as tone-control center frequencies but are selected by pushbutton switch. Price is $450, which includes an optional microphone.

CIRCLE NO. 92 ON FREE INFORMATION CARD

IC Insertion Tool



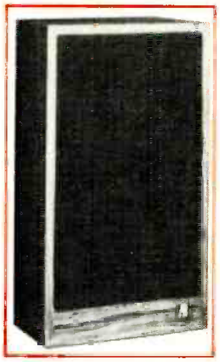
The new "Little Dipper" tools from Techni-Tool permit safe, easy insertion of 64-pin dual in-line package (DIP) ICs with 0.9" pin-row spacing into sockets of printed-circuit boards. One model is for ICs with "radiators" bonded to their surfaces, while a relief-cut model offers protection to delicate hybrid-circuit device top seals. All tools in the Little Dipper line are claimed to be safe for use with MOS and CMOS devices and are adjustable for direct board or socket insertion. Each is made from aluminum and stainless steel. Address: Techni-Tool, Inc., 5 Apollo Rd., Plymouth Meeting, PA 19462.

Orion Emulator/Programmer For TRS-80

Orion Instrument's "Developmate 81" allows a TRS-80 microcomputer to be used as a full development system. It adds both in-circuit Z80 emulation and EPROM/EEPROM programming capability. Developmate 81 plugs into the TRS-80's expansion connector. The PROM programmer has a personality module that defines voltages and connections to the PROM so that devices with up to 28 pins can be accommodated. Software for programming 2758, 2508, 2716, and 2532 EPROMs and 2816 and 48016 EEPROMs is included. Clock speed during emulation is 1.8 MHz. The system comes with power supply, emulation and TRS-80 cables, and a "universal" personality. It's designed to work with any TRS-80 Model I, with or without expansion interface. $329.

CIRCLE NO. 94 ON FREE INFORMATION CARD

Acoustic Research Bookshelf Speaker System



The Model AR28 bookshelf/floor-standing speaker system from Acoustic Research is a two-way design said to deliver 50 to 24,000 Hz, +0, −3 dB frequency response. Crossover from its 8" woofer to 1" dome tweeter is at a nominal 2 kHz. The system requires a minimum input of 15 watts and can accommodate amplifiers rated at 100 watts continuous power per channel, driven to clipping no more than 10% of the time. Sensitivity is rated at 87 dB SPL at 1 meter on-axis for 1 watt input. Nominal impedance is 6.5 ohms, 4.5 ohms minimum. Size is $21\frac{7}{16}$"H x $11\frac{3}{4}$"W x $7\frac{3}{4}$"D and weight is 24 lb. Sold only in pairs, AR28s carry a suggested retail price of $125 each.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Bearcat Synthesizer Scanner

The "Bearcat 150" from Electra is a new low-cost 10-channel synthesized scanning receiver that covers 30 to 512 MHz, including low- and high-band vhf, uhf, and uhf-T land-mobile and public-safety bands and the entire 2-meter and 440-to-450-MHz portion of the 70-cm amateur bands. Among its features are a received-frequency fluorescent display and a "flat-plane" panel that controls all functions including volume via UP and DOWN buttons. Ten memory channels provide automatic scanning of those frequencies of most interest. In addition, direct channel access permits quick recall of individual channels. Also included is an automatic lockout function to suppress any given channel in the scan mode.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Tascam Cassette Recorder

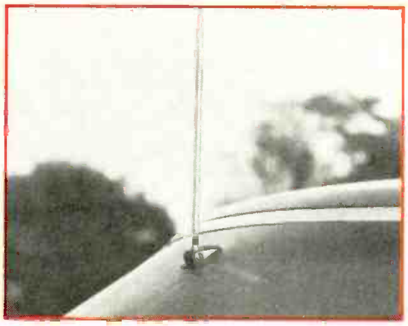
The Tascam Model 122 stereo cassette deck by Teac contains a $1\frac{7}{8}$- and $3\frac{3}{4}$-ips, two-motor transport and three-head record/play capability. A built-in Dolby HX (Headroom Extension) circuit is said to add up to 10 dB of headroom beyond 10 kHz, without sacrificing audible performance. Tapes made with HX can be played on any deck with a Dolby B noise-reduction system. An optional dbx noise-reduction system is also available. All transport functions are LSI logic circuitry controlled and can be operated through an optional remote-control unit (Model RC-90). Three-position switches and screwdriver-adjustable controls permit bias and equalization for any premium tape formulation, including metal. $700.

CIRCLE NO. 96 ON FREE INFORMATION CARD

(Continued on page 16)

(Continued from page 14)

Avanti Autosound Telescoping Antenna



Spirit II is a new autosound antenna from Avanti, designed to be mounted on glass surfaces and telescope to only 18″ from its fully extended 48″. Spirit I is said to reduce noise, static, and "picket fence" fading and to have gain superior to similar antennas. The exclusive on-glass mounting scheme eliminates the need to drill holes in a vehicle's body, and the coupling unit mounts inside the vehicle, where it's protected from the elements. The antenna can be mounted at any angle.

CIRCLE NO. 97 ON FREE INFORMATION CARD

Fisher Direct-Drive Turntable

Model MT6420C is a semiautomatic dc servo-controlled direct-drive turntable. The controls for this 33⅓- and 45-rpm turntable are located on a front panel, where they can be operated with the dust-cover closed. Among the unit's features are an integral tonearm equipped with magnetic cartridge, adjustable calibrated antiskate control, automatic arm return/shutoff system, viscous-damped cueing lever, stylus force adjustment control, strobe light and separate fine speed trim controls, and detachable headshell. $169.95.

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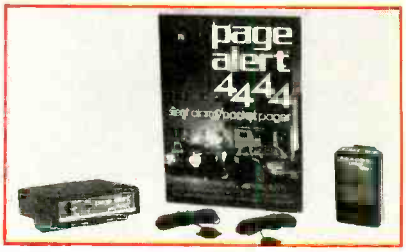
Autotek Premium In-Dash Car Stereo

Autotek's top-of-the-line Model CSR-3300 AM/FM-stereo receiver/cassette car-stereo system is designed for in-dash installation. It has an adjustable voltage at its high-impedance output that is said to assure compatibility with virtually any car-stereo power amplifier. Its auto-reverse cassette deck features a sendust head, Dolby B noise reduction, 31-to-15,000-Hz range with metal tape, and 0.015% wrms wow and flutter. The tuner has a FET front end, LOCAL/DX switch, and FM muting. Amplifier output power is rated at 2.2 watts continuous per channel ±3 dB from 30 to 15,000 Hz with no more than 1% THD. Size is 7″W x 5¼″D x 2″H. $299.95.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Page Alert Vehicle Security & Pocket Pager System



Page Alert Systems recently introduced a deluxe vehicle security system with pocket pager communication facilities. Installed in a vehicle, the Page Alert 4444's 4-watt transmitter sends out an individually coded radio signal to a small pocket pager if a break-in is attempted. Range is said to be 2 miles or more. A switch on the transmitter can be set to PAGE to send a signal to the pager and light its PAGE indicator. Setting the switch to SECURITY causes the pager to beep, but lights the SECURITY indicator. The two-tone sequential coding system used for the 4444 has over 10,000 individual combinations. Address: Page Alert Systems, Inc., 23842 Hawthorne Blvd., Torrance, CA 90505.

Cybernet Wireless Stereo Headphone System

Cybernet's new Model TM-301 "Freedom Stereo" wireless headphone system connects to any line-level (preamp, tape, tuner, headphone output) source and feeds a wire-loop "antenna." Signals radiated from the antenna are said to be receivable anywhere in a home, even on other floors, via the wireless headset. A TALK button and built-in microphone in the transmitter permit paging as well. The phones feature left and right volume controls, frequency range of 50 to 14,000 Hz, and channel separation of 40 dB (frequency not specified). The transmitter measures 7⅞″W x 7¼″D x 2⅝″H and weighs 3 lb. Phones weigh 11 oz and are powered by two AA cells. Price of $199.95 includes 100 feet of antenna wire and one stereo audio cable.

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CIRCLE NO. 6 ON FREE INFORMATION CARD

ENTERTAINMENT ELECTRONICS

By Harold A. Rodgers
Executive Editor

Digital Sturm und Drang

NO SOONER has digital audio begun to mature and come into its own than it has fallen under heavy attack from various critics, some apparently well meaning, some (I suspect) defending their vested interests in older technology, and some just plain ignorant. Naturally, this creates confusion among audio fans, who begin to wonder, "Is this technology all it is said to be?" This is unfortunate, for I have heard samples of digital recording that I would nominate for "best ever," if such a determination could really be made.

The Criticisms. Let's dispose of an ignorant objection first. Consider the notion that "chopping the music into 50,000 or so samples per second irretrievably loses a part of it." On the face of things, this is obviously true—whatever happens between sampling times is not recorded. Yet, it is not too difficult to show that what is lost, if it was there in the first place, is so high in frequency as to be of absolutely no significance to human ears. The problem is that the argument establishing this point is mathematical and a bit subtle. Apparently unable to comprehend it, certain "subjectivists," as they like to call themselves, give their fantasies free rein and decide that they hear what simply isn't there (or hear the lack of what isn't missing). Claiming to have golden ears, they display what might be better called brazen imagination.

Are we to believe that information theory, whose technological fruit are as diverse and extraordinary as high-resolution images of Saturn gleaned via space probe and the packing of literally thousands of simultaneous telephone messages into a single optical fiber is suddenly inadequate for the relatively straightforward task of analyzing a signal whose bandwidth extends only to 20 kHz or so? I think not.

Yet, it is not too hard to see how digital master recordings might well contain objectionable sounds. Such sounds may very well have been in the input signal to the recorder. Though it may come as a surprise to some, including a digital recorder in the signal path is no guarantee of a superior recording. If anything, the greater transparency of the digital recording may well render errors of miking or signal degradation that occurs in the console *more* noticeable than they would be with an analog recorder. Clearly, to blame the digital recorder for this makes about as much sense as chopping off the head of a messenger who brings bad news.

Another point to consider, since few of us are fortunate enough to be listening to actual digital tapes, is that no matter how good the mastering, poor production of the analog disc can render the overall result substandard. All digitally mastered discs are not the same, and finding one or two that are poor does not necessarily reflect on the entire technology.

Much has been made, too, of the idea that, once the parameters of a digital system are set, the level of performance it can deliver is fixed and cannot be improved. This is not entirely true, as it might well be possible at a later time to introduce improved error-correcting systems or slightly more linear analog-to-digital and digital-to-analog conversion. More to the point, however, there are theoretical limits on every recording system—vinyl disc, magnetic tape, or whatever. The difference is that the digital system lets us get close to the limit right away, whereas the vinyl disc, for example, has latent capabilities that we still cannot practically realize.

The Stress Controversy. In the January 1981 installment of this column, I mentioned the findings of Dr. John Diamond concerning the idea that digital recordings produce physiological stress in those who listen to them. At that time I reported the work of Nelson Morgan, who, using methods more conventional than those of Dr. Diamond, came up with sharply conflicting results, namely that digital recordings are biologically innocuous.

Since that time we have received several communications from supporters of Dr. Diamond to the effect that my acceptance of Morgan's findings was premature and might be serving to hinder a legitimate area of scientific inquiry. One of these communications, from Don and Carolyn Davis of Syn Aud Con in California, contained substantial documentation in support of Dr. Diamond's position. Lacking professional expertise in these matters, I referred this material to Dr. Laurence Greenhill, a practicing psychiatrist and sometime contributor to this column. Dr. Greenhill's comments are as follows:

> The definition and concept of stress, as promoted by Dr. Diamond, requires clarification. Contemporary research on stress depends on independent validation using physiological measures with high interest reliability. Such measures have evolved from a sound, published experimental foundation. Changes in blood pressure, heart rate, cortisol and testosterone secretion, and in galvanic skin response are but a few of the respectable documented stress measures. These tests also have validity in linking stress to such consequence as heart disease. The Behavioral Kinesiology (BK) deltoid reflex test, regardless of Dr. Diamond's assertions, has not yet received wide acceptance among respected researchers who publish data in refereed journals. The link between the BK test and stress in human subjects has not been proven experimentally.
>
> The "BK" test, done openly, can be totally explained on the basis of expectation and suggestion effects. Hypnotists routinely demonstrate feats of muscle weakness or strength in naive subjects by manipulating them through prior suggestion. Only double-blind techniques, described below, can remove such biases.
>
> The methodology involved in the BK-deltoid muscle test at present has grave weaknesses; Dr. Diamond's demonstration before the AES was open and uncontrolled and was plainly subject to the researcher's biases. Did Dr. Diamond press down harder on his subject's arms when the digital music was being played? Scientific methodology places the burden of proof on those who made the observation of digital stress. Digitally mastered records will remain innocent until proven guilty.
>
> Double-blind conditions must be used, where neither the tester or testee knows what type of record is being used. A reliable standardized mechanical "arm-displacer" and polygraphic recorder of the displacement and reflex must be used. Multiple baseline runs to establish strength and muscle fatigue decay under no-music conditions must precede the actual experimental run. Time of day and time of month (if the subject is female) must be controlled. Even if these procedures produce positive results, the findings have to be replicated in other laboratories. Such is the tedium of science.

(Continued on page 22)

Charles Santore
1979

(Continued from page 18)

Finally, there is the basic scientific issue. Dr. Diamond has made an observation that fatigue and stress result from listening to digitally encoded analog recordings. Doug Sax and Mark Levinson, among others, have reported similar digital-induced listener fatigue in print. But no one has done the appropriate work to prove or to disprove it. What is required is old-fashioned laboratory stress-research involving time, thought, subjects—and money.

Even if we grant Dr. Diamond his hypothesis, a strong case can be made that it is irrelevant. His control, after all, was not live music, but analog recordings. One could feel justified, therefore, in concluding that music that has not been passed through the analog recording process is stressful. In other words, it may be that *live music* is stressful and digital recording simply *preserves that quality while analog recording does not.*

Moreover, Dr. Diamond discovered the alleged stressfulness of digitally recorded music while using it as a therapeutic agent, something that seems doubtful as the primary purpose of a major composer or, indeed, any of the other artists involved. In fact, if we accept the well-circulated story of why Haydn inserted the sudden, loud chords into the second movement of his "Surprise" Symphony, here is a case in which a composer *deliberately* sought to induce stress in listeners. And does it seem credible that Tchaikovsky included cannons and bells in the score of the 1812 Overture for their restful, soothing quality? Or that Beethoven piled the entire d minor scale into a single chord to produce euphonious harmony, free of conflict? To me it does not, and to the extent analog recording reduces this heavy emotional impact and substitutes restfulness, its own displacement by a more accurate process cannot come too soon.

Doubtless there is some legitimacy to the use of music in therapy, but this must give way to the primary purpose of esthetic expression. (Music I have heard that was written expressly for therapeutic purposes has been pleasing in a bland way, but tends to be supremely boring compared to what I think of as real music.) Nevertheless, it would seem that there is abundant room to live and let live. The vast library of existing analog recordings should prove sufficient for Dr. Diamond and his patients, while those of us who are foolish enough to want all the emotional qualities that great composers put into their music to come through in recordings are free to listen to digital, stress and all. Even if digital recordings were to be imprinted with a health warning similar to that on cigarette packages, I don't think I could give them up. ◇

Audio Product of the Month

CHOSEN BY THE EDITORS OF POPULAR ELECTRONICS

Sansui AU-D11 Integrated Stereo Amplifier

"SUPER feedforward" rather than conventional negative feedback is used to cancel distortion in the Sansui AU-D11 integrated stereo amplifier. The unit is rated to deliver 120 watts per channel to 8-ohm loads between 10 and 20,000 Hz with no more than 0.005% total harmonic distortion. Direct coupled, the amplifier has a specified slew rate of 250 V/μs, and a rise time of 0.8 μs. The amplifier is 17 9/16" W × 17½"D × 6 7/16"H, and weighs 38.5 lb. A black panel and knobs contrast with the rosewood veneer cabinet. The suggested retail price is $1000.

General Description. The control knobs of the Sansui AU-D11 (which incorporate the minimum number of detented positions) include tone and balance controls and a large VOLUME control with a 70-dB calibrated range. The tone controls have selectable turnover frequencies (150 or 300 Hz for the BASS and 3 or 6 Hz for the TREBLE) selected by pushbuttons. The switch labelled SPEAKERS at the upper left of the panel can connect either, both, or neither of two sets of speakers to the power-amplifier outputs.

The pushbutton controls of the AU-D11 are elongated flat bars. One bypasses the tone-control circuits, two others engage 6-dB-per-octave filters with turnover frequencies of 16 Hz and 20 kHz, and a fourth (MUTE) reduces the gain by 20 dB.

On the INPUT SELECTOR, there are positions for two magnetic PHONO cartridges, TUNER, and AUX sources. A separate REC SELECTOR directs signals to the tape output jacks, which can handle two tape decks. With the control in its OFF setting, the tape outputs are completely isolated from the amplifier circuits. The SOURCE position feeds the

source selected by the INPUT SELECTOR to the tape output jacks. A position marked TUNER allows recording from a tuner while listening to another source. There are two DUBBING positions that can be used to record the selected SOURCE on one deck, or for dubbing from either deck to the other.

To hear the playback from either tape deck, or to monitor a program being recorded on a three-head machine, a TAPE PLAY pushbutton next to the REC SELECTOR is engaged. Two smaller buttons select the playback from either machine (playback is independent of the setting of the REC SELECTOR).

The phono section of the AU-D11 includes a built-in head amplifier for moving-coil cartridges. A small button between the INPUT SELECTOR and the REC SELECTOR converts the phono input from MM (moving magnet) to MC (moving coil), simultaneously changing the phono input impedance from 47,000 ohms to 100 ohms. A second button provides a choice of HI or LO gain settings for different moving-coil cartridges.

Activation of the individual pushbuttons, as well as the setting of the INPUT SELECTOR, is indicated by adjoining red LEDs. On initial power-up, the light above the pushbutton blinks for several seconds, until the amplifier's operating voltages have stabilized. Then a relay connects the speaker outputs and the light glows steadily. If the amplifier's overload protection circuit is tripped at any time, the outputs are disconnected immediately, and the POWER pilot light begins to blink. After the fault has been cleared, power must be shut off for a few seconds and then reapplied to restore normal operation.

Phono jacks for all the signal inputs and the tape recorder connections, along with insulated binding posts for the speaker leads, are located on the amplifier's rear apron. Of the three ac convenience outlets in that same general area, one is switched.

Removing the wooden cabinet from the AU-D11 reveals an unusually rugged and well-finished interior, with the metalwork completely copper plated. The massive power supply has more than 65,000 μF of filter capacitance, and the internal connections between the capacitors and from them to the rectifiers use heavy metal bus bars instead of wire. This is apparently meant to reduce the output impedance of the power supply to a minimum.

The output transistors, four in all, are mounted on a metal plate that transfers their heat to an internal sealed convection cooling system. Refrigerant vaporized by the heat circulates through a finned heat exchanger and is cooled by air moving through the chassis by convection. The entire cooling system is contained in the cabinet.

The Sansui "Super Feedforward" circuit is a combination of feedback and feedforward techniques. Negative feedback alone, if used in large amounts, requires careful control of the phase and gain in order to preserve stability. In the large amounts used in most transistorized amplifiers, it has been blamed for transient intermodulation distortion (TIM) when the open-loop bandwidth of the amplifier is too small.

In a typical feedforward system, the error signal sensed by comparing the input and output waveforms is fed to a very-low-distortion error amplifier that inverts it and sums it with the signal at the output, thereby cancelling the distortion at that point.

Negative feedback is applied conventionally, except that less of it is used than would normally be the case. Signal is tapped before the output stage but after the point where the fedback signal has been combined with the input signal and fed forward through a very-low-distortion error amplifier. With appropriate phase corrections, it is summed with the amplifier output.

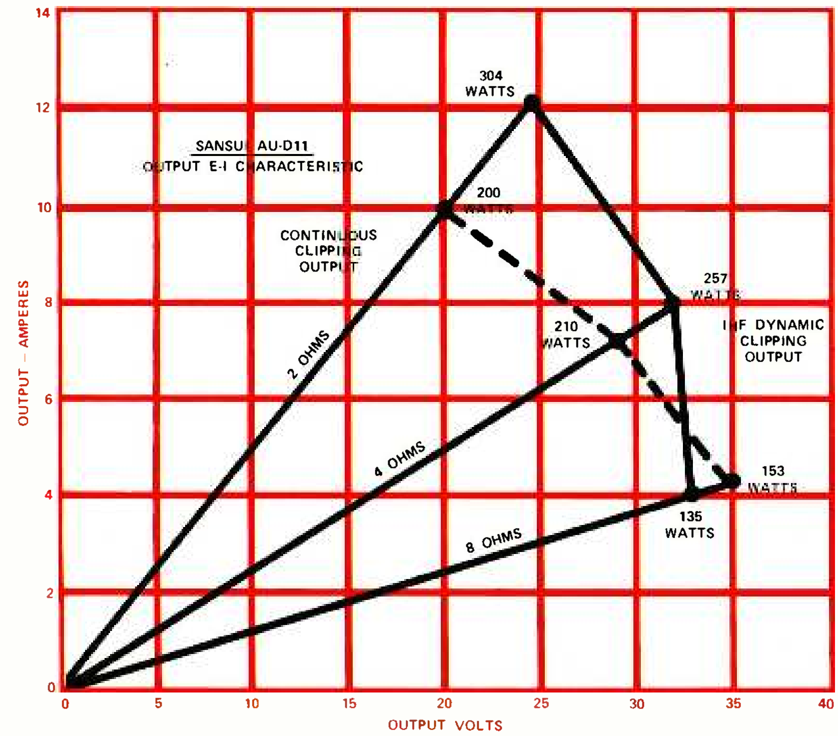
Also incorporated in the AU-D11 are such refinements as symmetrical balanced amplifier stages throughout the unit and direct-coupled signal path. One benefit claimed for this design approach is reduced envelope distortion of low-frequency signals.

Laboratory Measurements. As a rule, we consider distortion of 0.01% or less negligible, and categorize amplifiers having that quality as "nondistorting." The Sansui AU-D11 easily meets that standard; the highest distortion we measured from it was 0.006% at 20,000 Hz. Over much of the audio range, the distortion was well under 0.001% for power outputs from a fraction of a watt to well above rated power.

Even when we drove 4- and 2-ohm loads (operation into 2 ohms is specifically *not* recommended by Sansui) the distortion was negligible until clipping occurred. This happened at 153 watts per channel into 8 ohms (IHF Clipping Headroom = 1.06 dB) and at 210 watts when driving 4-ohm loads. The maximum power into 2 ohms was set by the amplifier's protective circuit, which shut it off at 200 watts—before any waveform distortion was visible.

When we used the 20 millisecond tone-burst signal of the IHF Dynamic Headroom test, the 8-ohm maximum output was actually slightly *less* than its continuous output, measuring 135 watts for a clipping headroom rating of 0.5 dB. However, into a lower load impedance the short-term output was impressively high, 257 watts at 4 ohms and 304 watts at 2 ohms (again, the protective relay intervened before distortion).

Although we do not attempt to measure TIM by any of the several methods that have been proposed for that purpose (there are no current standards for TIM measurements), its absence can be inferred from several of the tests we did make. The two-tone IM distortion with equal amplitude output signals at 19 and 20 kHz having a peak amplitude equal to that of a 120-watt sine-wave signal, was a barely detectable −92 dB for the third-order product at 18 kHz, and the second-order distortion at 1 kHz was our measurement residual of −96 dB. The IHF Slew Factor exceeded our measurement limit of 25, and measured



Power output characteristic of the Sansui AU-D11 with loads of 2,4 and 8 ohms.

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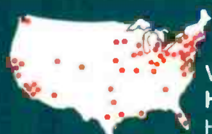

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rise time was about 1 microsecond.

All the preceding tests suggest that the AU-D11 cannot be overloaded at high frequencies any more easily than at low frequencies, and that its exceptional linearity, even at full power, is maintained over the full audio band and well beyond its upper limits. In other words, we would not expect any TIM, no matter how defined or measured, to be induced in this amplifier under any practical conditions. It should be noted, also, that we measured the AU-D11 through its AUX inputs so its preamplifier stages were included in our measurements.

Stability of the amplifier was not impaired when we drove a highly reactive simulated speaker load; and in the IHF overload recovery test, it recovered fully from a 10-dB overload in about 10 microseconds, an inaudibly short interval.

Tone control characteristics were good, with considerable adjustment range available at the frequency extremes with no effect over most of the midrange, especially when using the 150-Hz and 6-kHz turnover frequencies. RIAA phono equalization varied only 0.5 dB overall from 20 to 20,000 Hz. Phono input impedance (MM) could not be modeled as a single parallel R-C combination, but it measured 55,000 ohms at low and middle frequencies. There was some interaction with a high inductance phono cartridge that caused the response to roll off slightly above 15,000 Hz when the equalization was measured with the cartridge coil in series with the input signal. However, this effect was insignificant with most magnetic cartridges. Although we made no measurements through the MC head amplifier, we used it for listening tests and found it to be quite satisfactory in gain and noise characteristics.

Both filters, high and low, were relatively ineffective for attenuating noise. The "16 Hz" filter began to roll off the output slightly below 50 Hz and was down 2 dB at 20 Hz. The "20 kHz" filter effect began at about 4 kHz, and its response was down about 5 dB at 20 kHz. Since the AU-D11 is direct-coupled from its high-level inputs to the speakers, and can be rendered inoperative by even a small dc component in its input signal, some means of blocking dc is clearly desirable. That should have been a capacitor large enough not to affect the audio range. Similarly, since the amplifier's bandwidth extends beyond 300 kHz, exclusion of ultrasonic "garbage" might well be in order. The filter cut-off frequency should have been above the audio band, or a steeper slope should have been used. Sansui chose the mild filter slopes, a company spokesman says, because steeper ones were judged to impair sound quality.

Input sensitivity for a 1-watt reference output was 26 millivolts (AUX) and 0.21 millivolts (PHONO-MM). The respective A-weighted signal-to-noise ratios were 84 and 81 dB referred to 1 watt output, both excellent. The phono input overloaded at 200 millivolts at middle and low frequencies, and at 178 millivolts at 20 kHz (referred to the equivalent 1-kHz level).

User Comment. Although we have made some criticisms of the AU-D11, they apply only to its design features, not to its electrical performance. It is surely one of the most advanced amplifiers we have seen in respect to low distortion and noise, wide bandwidth, and overall stability. Trying to measure its performance limitations was a challenge that made us highly appreciative of our test instruments.

The amplifier can deliver more than ample power for just about any home music installation. Construction is superb, and the protection is impressively effective. Especially noteworthy is the ability of the AU-D11 to drive low-impedance loads with ease (a very unusual characteristic in integrated amplifiers we have seen), yet with no loss of protection.

One oversight that surprised us is the omission of a MONO switch. When playing mono records, it is usually desirable to parallel the signal channels to reduce noise and vertical rumble. We also noted the absence of separate PRE OUT/MAIN IN jacks in the rears of the amplifier. The only rationale we can find for this is that the AU-D11 can be used as a power amplifier without the need to by-pass its preamplifier section, since its performance is so good. Again, Sansui indicates that the additional wiring needed to provide this feature tends to degrade sound quality.

In our listening tests, we did not notice any consistent difference between the sound from the AU-D11 and other high-quality amplifiers and, indeed, Sansui concedes that any difference that might be detectable would be extremely subtle. This is consistent with our past experience—good amplifiers tend to sound very much alike, except for occasional subtle differences that are difficult to prove or classify.

In its electrical performance, the AU-D11 is about as close to ideal as any amplifier we know. As a power amplifier, we would expect it to behave impeccably, especially with highly reactive speakers that many amplifiers find "difficult." Used with premium-grade components having clean outputs, the AU-D11 should give no trouble at all.

Whether the few small omissions in the design of the control section will prove problematic will vary from user to user. Mono records, after all, are virtually antiques, and external signal-processing equipment can easily be patched into a tape monitor loop. As it is, the control section should satisfy the overwhelming majority of listeners, and it would hardly surprise us if a substantial number of audiophiles find the Sansui AU-D11 worth its price for the power-amp section alone. —*Julian D. Hirsch*

CIRCLE NO. 101 ON FREE INFORMATION CARD

Popular Electronics Tests

General Electric 13AC1542W 13" Color TV Receiver

GENERAL ELECTRIC's Model 13AC1542W differs considerably from the deluxe 19" and 25" EC and EM color-TV chassis in the company's 1981 lineup (see review of 19ECO77OW, PE, September 1980). This 13" set has no removable modules and lacks vertical-interval color reference VIR II circuitry. There are also fewer integrated circuits (four total, all in sockets). Even so, the 1542W approaches the performance of a much more expensive color-TV receiver.

A programmable infrared remote-control system is standard in this set. It's a simplified version of the one used in GE's higher-priced sets, offering up/down tuning and volume-control setting but no direct channel addressing. However, all stations are user programmable, and scanning (via either the remote controller or the front-panel keyboard) is very fast. Also provided are the usual CATV midband channels, although there is no manual fine-tuning or extended-range automatic fine tuning (aft) arrangement for capturing non-standard CATV carriers.

The set measures 20½"W x 15¼"D x 14"H and weighs 35¼ lb. Price is about $450, depending on area.

General Description. The LMP-91 four-frequency remote-control transmitter's volume-control and channel-selector buttons generate 41-to-54-kHz signals that modulate the continuous-wave infrared carrier. Channels between 2 and 92 can be initially set numerically or out of sequence, depending on user programming. Buttons for ADD, CLEAR, and PROGRAM are located behind a small door on the front panel. These are used to set up the various channels. A phase-locked-loop (PLL) frequency-synthesizer system automatically locks the frequency and phase of the video and sound for each channel chosen.

Composite video and audio enter the chassis through a network of capacitors and tunable inductors that matches tuner and i-f impedances. One LC network is set to 43.8 MHz for maximum video response, while another tailors the overall response curve so that video and chroma carriers occupy their assigned places (usually 50% on the swept response curve).

Three additional parallel-tuned traps attenuate the 39.75-MHz upper adjacent video, 47.25-MHz lower adjacent sound, and 41.25-MHz sound carriers but permit passage of the audio carrier to its takeoff point in the video i-f IC. Another inductor across the i-f chip input tunes for both maximum bandpass and balanced input.

The complex video chip performs the following functions: i-f amplification; synchronous video demodulation; automatic fine tuning (aft) detection; video amplification; and 4.5-MHz sound take-

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off. There are only three inductors in this circuit, two used for setting the 45.75-MHz synchronous video detector and aft frequency variables. Interstage i-f tuning is nonexistent.

Lacking a comb filter, this receiver has both a conventional delay line and a 3.58-MHz chroma trap in the second (discrete) video amplifier stage. It also has a beam-current limiter and five stages of video amplification that provide more than adequate gain for the final video driver. In addition, it delivers luminance information to the emitters of the red, blue, and green mixer power amplifiers that drive the picture tube.

A very interesting and significant circuit in this set is the color monitor (Fig. 1), which contains only three transistor stages and a few diodes. Dc restorer *Q295* processes horizontal pulses of varying amplitudes from a winding on the primary of the flyback transformer (not illustrated). The R − Y and B − Y sensors *Q282* and *Q284* receive color information from the outputs of chroma demodulators in the chroma processor via pins 7, 8, and 9 of connector *PG5*. With switch *S300* set to AUTO, combined G − Y and B − Y feedback reaches the base of *Q284* through *C284*, while R − Y supplies feedback through *C281* to the base of *Q282*.

As the flyback transformer's current increases and decreases, *Q295* does two things. First, it passes positive spikes of voltage through its emitter to diodes *Y282* and *Y284*, which become bias and dc restorers for the R − Y and B − Y sensors. Secondly, it delivers an inverted pulse that charges *C298*. This pulse is then rectified by *Y295* and becomes a negative clamp for the collectors of *Q282* and *Q284* during retrace. By this means, the average levels of R − Y and B − Y are sensed, G − Y becomes a tint phase shifter, all sensors are brightness and high-voltage controlled, and the common R − Y/B − Y collectors produce a matrixed output. This output then either adds to or subtracts from the chroma signals, ultimately maintaining a relatively constant output under varying color tracking conditions. The heavily filtered outputs from these parallel-connected transistors then supply a control voltage for the color-control portion of the chroma-processor IC. Output from the chroma processor goes to the final RGB amplifiers and cathodes of the picture tube. Color and tint levels are further preset and limited through a resistor that is bypassed during manual chroma control.

Like many other modern table-model color sets, this one has both a bridge rectifier and start-up circuit composed of four diodes and a silicon controlled rectifier (SCR). When power is applied, and after the degaussing coils cut out, the power supply develops an unregulated 145-volt dc source for selected vertical circuits. This 145 volts is also divided and sent to the start-up SCR. When triggered, the SCR's output goes to the scan power source, vertical and horizontal countdown circuits, and horizontal driver. Meanwhile, the +145-volt source furnishes current and voltage to the primary of the flyback transformer to drive the horizontal output. Other operating voltages are derived from various half-wave diodes and a special circuit connected to windings on the flyback transformer.

This circuit is interesting because it operates from the flyback transformer at the 15,734-Hz horizontal rate, through a ferroresonant saturable reactor that regulates the CRT filament voltages and the 35-, 22-, and 12-volt sources. Fully isolated secondaries supply 90% regulation for ICs and various other bias and operating functions.

In addition to a side pincushion trans-

GENERAL ELECTRIC MODEL 13AC1542W RECEIVER LABORATORY DATA

Parameter	Measurement
Tuner/receiver sensitivity (min. signal for snow-free picture):	vhf (Ch. 3): −10 dBmV uhf (Chs. 30, 50): −5 dBmV
Voltage regulation (line varied from 105 to 130 V):	Low voltage: 145-V supply—81% 22-V supply—89% High voltage: 25-kV supply—83%
Luminance bandpass at CRT:	3 MHz
Luminance bandpass at video detector:	4 MHz
S/N at CRT:	41.9 dB
Horizontal overscan:	8%
Agc signal swing (after r-f agc adjust):	51 dB
Audio bandpass (3 dB down):	80 Hz to 6 kHz (usable past 12 kHz)
Dc restoration:	80%
Power requirement (signal applied):	100 W (including remote)

Note: Instruments used in these measurements are: Tektronix/Telequipment D66, D67A oscilloscopes; Sadelco FS-3D VU f/s meter; Data Precision 258, 1350, 1750 multimeters; B&K-Precision 1248, 1250, 3020 color and function generators; Sencore VA48 (modified), CG169, and PR57 video analyst, color and power sources.

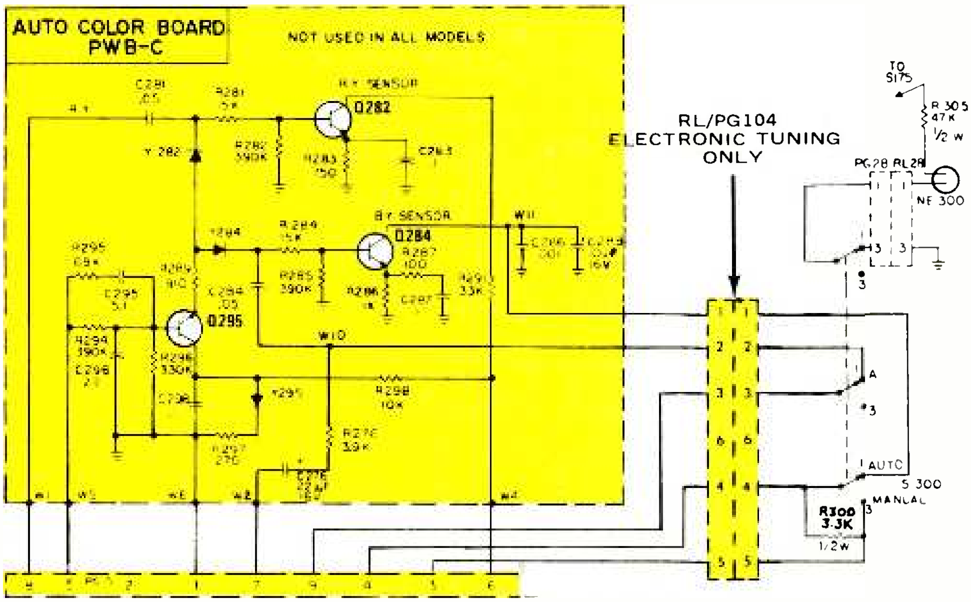

Fig. 1. The color monitor contains only three transistor stages to provide a signal that eventually controls the chroma-processor IC.

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DENVER—The Copley News Service reported that United States Patents have now been issued to Wm. Trevaskis, California veteran electrical engineer, for his Vapor-Jet® brand water vapor injector (Pat. #4,119,062).

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Water injectors were developed to a highly refined state during World War II, to give combat planes increased speed and extended range. However, up to now, the low price of gas and the high cost and extremely difficult installation required for earlier injectors combined to make them unattractive for automobiles and light trucks.

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former and a bridge or ring modulator type of dynamic convergence, this set features dual-diode scan rectification. This involves +13- and −13-volt sources from the secondary of the flyback transformer, developed by oppositely polarized diodes for the collector and emitter of the two vertical-output transistors. Operating during line time forward scan, they supply operating voltages based on conduction time of the horizontal output transformer to the vertical-output stages. This compensates for any changes in the usual 4:3 rectangular aspect raster ratio that might occur due to large beam-current drains or changes in ac supply voltages.

The convergence modulator receives vertical, horizontal, and pincushion inputs and mixes them in a diode bridge. This circuit shapes yoke currents so that red, blue, and green phosphors on the CRT are energized symmetrically and linearly. Dynamic adjustments for left, right, top, and bottom are made by one series inductor and four rheostats connected to the various inputs of the bridge. All are mounted on a separate plug-connected module.

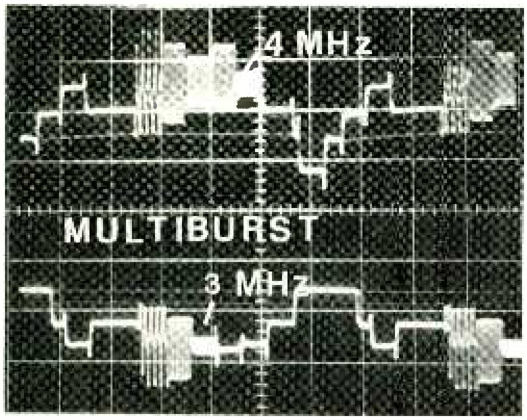

Fig. 2. Multiburst test patterns at video detector and CRT cathodes show 4 MHz and 3 MHz respectively.

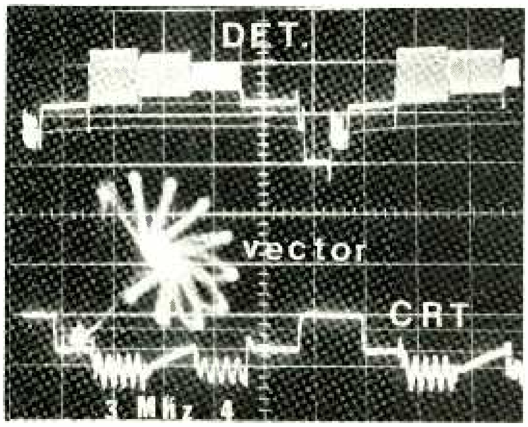

Fig. 3. Swept chroma at video detector and CRT. Normal vector has only slight distortion.

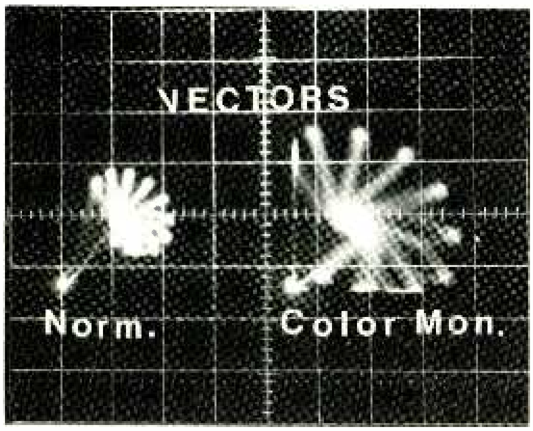

Fig. 4. Normal vector pattern on left, color monitor vector on right.

Test Results. The tuner exhibited better-than-average sensitivity and signal-to-noise ratio (S/N). A full 4 MHz of multiburst was measured at the video detector, while luminance bandpass at the CRT was 3 MHz (Fig. 2.). Swept chroma response was good, as shown in Fig. 3. Agc swing between saturation and cutoff measured 51 dB, which is adequate if the r-f agc potentiometer has been carefully adjusted. With this receiver, you can easily set the r-f agc for greater tuner sensitivity but less agc swing, making the 1542W excellent for long-distance reception. Using only 40 dB of agc swing, we measured vhf and uhf tuner sensitivities before snow of −12 and −20 dBmV, respectively.

Vector differences between manual and color-monitor control are illustrated in Fig. 4. Additional R − Y drive forces enlargement of the vector on the right and produces extra expansion and clipping in the eighth through tenth petals, although not nearly as much as fixed or static circuits that jam oranges and reds together and expand blues, distorting R − Y and B − Y angles of demodulation to 110° or 120°. There is no spreading of fleshtones from their normal hues.

Antiflutter time constants were adequate to prevent or minimize most low-frequency disturbances from aircraft. There was also only slight CB interference on channel 2 at a distance of 60 feet from the transceiver.

Despite somewhat loose voltage regulation, the picture remained stable from 110 to 130 volts ac on the power line. Audio from the 4" Dynapower PM speaker was passable, and light, bright, colorful, pictures with strong contrast reflect the 21-to-26-kV high voltage generated, as well as plenty of video drive from the five luminance amplifiers and 24-pin chroma IC.

User Comment. While some of this set's measurements are a little off target, its color pictures, stylish appointments, and fast responses are pure pleasure. Its hot front end, excellent S/N, and other merits place it a good cut above its competition.

A combination of good luminance/chroma/brightness seems to compensate well for only 3 MHz of bandpass at the CRT. The way this set performs, one could easily be fooled into thinking it had a comb filter. All in all, we'd rate the 13AC1542W the best of the 13" sets available at the time we performed our tests.—*Stan Prentiss.*

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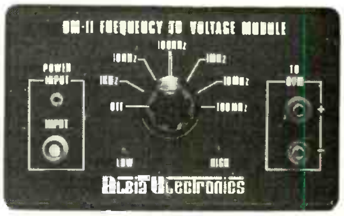

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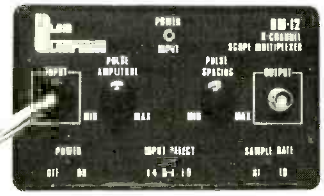

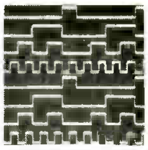

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Popular Electronics Tests
The Hickok Model MX-333 Digital Multimeter

CERTIFICATE OF CALIBRATION

LOCKHEED ELECTRONICS COMPANY, INC.

Plainfield, New Jersey

INSTRUMENT DIGITAL MULTIMETER HICKOK MODEL MX-333 SERIAL NO. 661-00221

PROPERTY OF POPULAR ELECTRONICS WORK ORDER NO. 74-6200-6956

The above instrument has been checked and calibrated against our working standards which are traceable to the National Bureau of Standards. All specifications were found to meet those set forth by the manufacturer. The metrology procedures utilized conform to and satisfy the requirements set forth in MIL-C-45662A.

NBS REPORT NUMBER GMF 9155, s/n 39,362 RB1035 NBS# 219833 Dated 11/27/78

LOCKHEED ELECTRONICS COMPANY, INC. by M. J. Corrigan, Jr. DATE OF TEST 2-25-81

TEST PERFORMED BY B. [illegible] HUMIDITY 47%

TEMPERATURE 73°

THE Hickok MX-333 Universal Digital Multimeter is designed for both bench and field use. It has a 3½-digit, 0.5″ high LCD display and features autodecimal point positioning, autopolarity, and overrange indication. A LOBAT annunciator on the LCD display turns on when the battery is down to the last 15-20% of its life expectancy. The high-impact plastic case is 2.2″ high, 6.7″ wide, and 6″ deep and weighs 22 ounces. The LCD display is mounted in a 45°-tilted front panel to allow the user to see the display clearly when the instrument is on a flat workbench or suspended from the user's belt (via a belt-clip). This also allows the light-reflecting LCD display to use the maximum ambient light. Up to 6-kV transient protection is provided on the ac and dc functions, 500 volts on resistance, and a fuse protects the current functions. Suggested retail price is $249.

General Description. The MX-333 is equipped with four recessed test-lead connectors—COM, V/Ω, 10A, and mA/20Ω. On the straight portion of the front panel are 10 function and range pushbuttons, the power on/off pushbutton, and a control used to null test-lead resistance when using the 20-ohm resistance range. Besides the LCD display, the sloping portion of the front panel also supports an audio tone on/off pushbutton (with associated small speaker hole), and a BNC connector for use with an optional 10:1 probe in what Hickok calls the LOGI-TRAK function. The internal 9-volt battery is accessed via a finger-screw locked sliding panel on the rear.

The audio portion of the MX-333, called VARI-PITCH, is used for "eyes-off" operation. When it is on, an audio tone with a frequency proportional to the LCD display indication is produced.

VARI-PITCH operates on all ranges and functions. In the resistance function, the tone is off at open circuit and increases in frequency with diminishing resistance. On other functions, the tone begins at a display of 40 or less and extends to four times full scale. Response time is less than 100 ms.

The LOGI-TRAK function, which works in conjunction with VARI-PITCH, uses any 10:1 scope-type probe and has an input impedance of 10 megohms/10 pF. It operates when the LOGIC pushbutton is depressed. The minimum pulse width detected is typically 5 ns; pulse indication is a colon on the display and an audio signal. Maximum frequency is 80 MHz. Overload protection extends to 300 V dc or rms continuous.

The *dc voltage* function provides five ranges from 200 mV to 1 kV full scale with an accuracy of ±0.1% reading plus 1 digit. Overload protection extends to 1 kV dc/peak ac, and up to 6-kV for transients. Input resistance is 10 megohms on all ranges. Normal-mode rejection ratio is 50 dB at 60 Hz; common-mode rejection ratio is 100 dB.

The *ac voltage* function provides five ranges from 200 mV to 1 kV full scale with an accuracy of ± 1% reading plus 2 digits between 45 and 1 kHz, and ±5% reading plus 5 digits between 1 kHz and 5 kHz on the 200-mV to 20-V ranges. Overloads up to 1 kV dc or 750 V rms are protected on all except the 200-mV range, which must not be exposed to anything over 200 V rms for more than 15 seconds. Input impedance is 10 megohms on all ranges. Dc blocking voltage is 1 kV dc plus peak ac.

The *resistance* function has seven decade-spaced ranges from 20 ohms to 20 megohms. Accuracy is ±3% on the 20-ohm range; 0.2% on 200 ohms; 0.1% on 2k, 20k, 200k, and 2 megohms; and 1% plus 1 digit on the 20-megohm range. There is overload protection to 500 V dc/rms on all ranges, with a 2-ampere fuse in the 20-ohm range. Voltage dropped across the component under test is 0.25 volt for full scale indication and 3.2 V maximum (open circuit).

The *diode test* range measures the forward drop of a semiconductor junction between 0 and 2 volts dc. The test levels are 2 mA nominal and 2.5 volts open circuit. Overload protection covers 500 V dc or rms.

Both *ac and dc current* functions provide five ranges from 2 mA to 10 amperes. Resolution ranges from 1 μA on the 2-mA range to 10 mA on the 10-ampere range. Dc accuracy is ±1% on the 2-mA, 20-mA, and 200-mA ranges; ±1.5% on the 2-ampere range; and ±1.2% on the 10-ampere range. All are plus 1 digit. The ac current accuracy is ±2.5% on the 2-mA range and ±1.5% on the 20-mA range, both measured between 45 and 65 Hz; and ±1.5% on the upper three ranges, measured between 45 and 400 Hz. All are plus 2 digits. The voltage burden is 0.25 volt on the lower three ranges and 0.5 volt on the 10-ampere range. Overload protection is good for 250 V at 2 amperes except on the 10-ampere range, where it is 15 amperes for one minute maximum.

Packaged with the instrument is a 9-volt battery, a set of safety test leads (red and black), alligator clips, a belt clip and four extra skidproof feet.

Comments. The MX-333 was checked by the Lockheed Electronics Company Instrumentation Measurements Laboratory, against standards traceable to the National Bureau of Standards. After the tests, the IML issued a certificate testifying that the MX-333 met its published specifications in all respects.

The instrument was used on a test bench for several weeks performing conventional functions. The DMM was very easy to use because of the unambiguous pushbuttons for function and range. The positive detenting of the pushbuttons made selection easy. Having the LCD display angled at 45° not only makes the instrument easy to read when placed on a flat surface, but also keeps the display well illuminated when overhead lighting is used. One slight problem was the reflection of overhead fluorescent lights on the front surface of the display.

The VARI-PITCH function takes a little getting used to, but once you do, it is quite handy—especially for making continuity checks. Similarly, LOGI-TRAK is excellent for measurements on high-impedance CMOS circuitry.

If you do much servicing of console equipment, the belt-clip operation of the MX-333 can be very handy. Since the test-lead connectors are mounted on the side of the instrument, the leads do not get in the way. The slope of the display panel, which we found too acute for bench-top operation because of glare, also creates a problem when the instrument is clipped to the belt. The user must bend over slightly in order to see the display.

In conclusion, we find the MX-333 an excellent instrument, quite at home both on the bench and in the field. Although it may cost a little more than other portable DMMs, its versatility provides compensation.—*Leslie Solomon*

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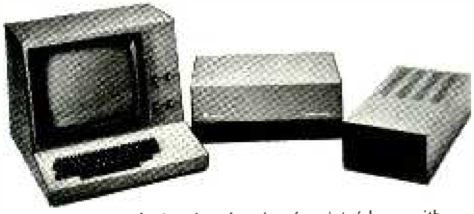

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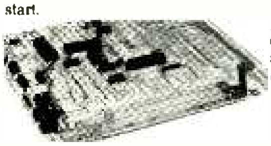

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LEVEL "A" SPECIFICATIONS

Explorer/85's Level "A" system features the advanced Intel 8085 cpu, an 8355 ROM with 2k deluxe monitor/operating system, and an advanced 8155 RAM I/O . . . all on a single motherboard with room for RAM/ROM/PROM/EPROM and S-100 expansion, plus generous prototyping space.

PC Board: Glass epoxy, plated through holes with solder mask. • **I/O:** Provisions for 25-pin (DB25) connector for terminal serial I/O, which can also support a paper tape reader . . . cassette tape recorder input and output . . . cassette tape control output . . . LED output indicator on SOD (serial output) line . . . printer interface (less drivers) . . . total of four 8-bit plus one 6-bit I/O ports. • **Crystal Frequency:** 6.144 MHz. • **Control Switches:** Reset and user (RST 7.5) interrupt . . . additional provisions for RST 5.5, 6.5 and TRAP interrupts onboard. • **Counter/Timer:** Programmable, 14-bit binary. • **System RAM:** 256 bytes located at F800, ideal for smaller systems and for use as an isolated stack area in expanded systems . . . RAM expandable to 64K via S-100 bus or 4k on motherboard.

System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at F000, leaving 0000 free for user RAM/ROM. Features include tape load with labeling . . . examine/change contents of memory . . . insert data . . . warm start . . . examine and change all registers . . . single step with register display at each break point, a debugging/training feature . . . go to execution address . . . move blocks of memory from one location to another . . . fill blocks of memory with a constant . . . display blocks of memory . . . automatic baud rate selection to 9600 baud . . . variable display line length control (1-255 characters/line) . . . channelized I/O monitor routine with 8-bit parallel output for high-speed printer . . . serial console in and console out channel so that monitor can communicate with I/O ports.

System Monitor (Hex Keypad/Display Version): Tape load with labeling . . . tape dump with labeling . . . examine/change contents of memory . . . insert data . . . warm start . . . examine and change all registers . . . single step with register display at each break point . . . go to execution address. Level "A" in this version makes a perfect controller for industrial applications, and is programmed using the Netronics Hex Keypad/Display. It is low cost, perfect for beginners.

HEX KEYPAD/DISPLAY SPECIFICATIONS

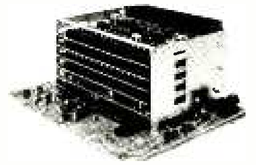
Calculator type keypad with 24 system-defined and 16 user-defined keys. Six digit calculator-type display, that displays full address plus data as well as register and status information.

LEVEL "B" SPECIFICATIONS

Level "B" provides the S-100 signals plus buffers/drivers to support up to six S-100 bus boards, and includes: address decoding for onboard 4k RAM expansion selectable in 4k blocks . . . address decoding for onboard 8k EPROM expansion selectable in 8k blocks . . . address and data bus drivers for onboard expansion . . . wait state generator (jumper selectable), to allow the use of slower memories . . . two separate 5 volt regulators.

LEVEL "C" SPECIFICATIONS

Level "C" expands Explorer/85's motherboard with a card cage, allowing you to plug up to six S-100 cards directly into the motherboard. Both cage and card are neatly contained inside Explorer's deluxe steel cabinet. Level "C" includes a sheet metal superstructure, a 5-card, gold plated S-100 extension PC board that plugs into the motherboard. Just add required number of S-100 connectors.



Explorer/85 With Level "C" Card Cage.

LEVEL "D" SPECIFICATIONS

Level "D" provides 4k of RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original 256 bytes located in the 8155A). The static RAM can be located anywhere from 0000 to EFFF in 4k blocks.

LEVEL "E" SPECIFICATIONS

Level "E" adds sockets for 8k of EPROM to use the popular Intel 2716 or the TI 2516. It includes all sockets, power supply regulator, heat sink, filtering and decoupling components. Sockets may also be used for 2k x 8 RAM IC's (allowing for up to 12k of onboard RAM).

DISK DRIVE SPECIFICATIONS

- 8" CONTROL DATA CORP. professional drive.
- LSI controller.
- Write protect.
- Single or double density.
- Data capacity: 401.016 bytes (SD), 802.032 bytes (DD), unformatted.
- Access time: 25ms (one track).

DISK CONTROLLER/ I/O BOARD SPECIFICATIONS

- Controls up to four 8" drives.
- 1771A LSI (SD) floppy disk controller.
- Onboard data separator (IBM compatible).
- 2 Serial I/O ports
- Autoboot to disk system when system reset.
- 2716 PROM socket included for use in custom applications.
- Onboard crystal controlled.
- Onboard I/O baud rate generators to 9600 baud.
- Double-sided PC board (glass epoxy.)

DISK DRIVE CABINET/POWER SUPPLY

- Deluxe steel cabinet with individual power supply for maximum reliability and stability.

ORDER A COORDINATED EXPLORER/85 APPLICATIONS PAK!

Beginner's Pak (Save $26.00!) — Buy Level "A" (Terminal Version) with Monitor Source Listing and AP-1 5-amp Power Supply: (regular price $199.95), now at SPECIAL PRICE: **$169.95** plus post. & insur.

Experimenter's Pak II (Save $53.40!) — Buy Level "A" (Hex Keypad/Display Version) with Hex Keypad/Display, Intel 8085 User Manual, Level "A" Hex Monitor Source Listing, and AP-1 5-amp Power Supply: (regular price $279.35), all at SPECIAL PRICE: **$219.95** plus post. & insur.

Special Microsoft BASIC Pak (Save $103.00!) — Includes Level "A" (Terminal Version), Level "B", Level "D" (4k RAM), Level "E", 8k Microsoft in ROM, Intel 8085 User Manual, Level "A" Monitor Source Listing, and AP-1 5-amp Power Supply: (regular price $439.70), now yours at SPECIAL PRICE: **$329.95** plus post. & insur.

ADD A TERMINAL WITH CABINET, GET A FREE RF MODULATOR: Save over $114 at this SPECIAL PRICE: **$499.95** plus post. & insur.

Special 8" Disk Edition Explorer/85 (Save over $104!) — Includes disk-version Level "A", Level "B", two S-100 connectors and brackets, disk controller, 64k RAM, AP-1 5-amp power supply, Explorer/85 deluxe steel cabinet, cabinet fan, 8" SD/DD disk drive from famous CONTROL DATA CORP. (not a hobby brand!), drive cabinet with power supply, and drive cable set-up for two drives. This package includes everything but terminal and printers (see coupon for them). Regular price $1630.30, all yours in kit at SPECIAL PRICE: **$1499.95** plus post. & insur. Wired and tested, only **$1799.95**.

Special! Complete Business Software Pak (Save $625.00!) — Includes CP/M 2.0, Microsoft BASIC, General Ledger, Accounts Receivable, Accounts Payable, Payroll Package: (regular price $1325), yours now at SPECIAL PRICE: **$699.95**.

Please send the items checked below:

- ☐ **Explorer/85 Level "A" kit** (Terminal Version) . . . **$129.95** plus $3 post. & insur.
- ☐ **Explorer/85 Level "A" kit** (Hex Keypad/Display Version) . . . **$129.95** plus $3 post. & insur.
- ☐ **8k Microsoft BASIC** on cassette tape, **$64.95** postpaid.
- ☐ **8k Microsoft BASIC in ROM kit** (requires Levels "B", "D" and "E") . . . **$99.95** plus $2 post. & insur.
- ☐ **Level "B" (S-100) kit** . . . **$49.95** plus $2 post. & insur.
- ☐ **Level "C" (S-100 6-card expander) kit** . . . **$39.95** plus $2 post. & insur.
- ☐ **Level "D" (4k RAM) kit** . . . **$69.95** plus $2 post. & insur.
- ☐ **Level "E" (EPROM/ROM) kit** . . . **$5.95** plus 50¢ p&h.
- ☐ **Deluxe Steel Cabinet** for Explorer/85 . . . **$49.95** plus $3 post. & insur.
  - ☐ Fan For Cabinet . . . **$15.00** plus $1.50 post. & insur.
- ☐ **ASCII Keyboard/Computer Terminal kit:** features a full 128 character set, u&l case; full cursor control; 75 ohm video output; convertible to baudot output; selectable baud rate, RS232-C or 20 ma. I/O, 32 or 64 character by 16 line formats, and can be used with either a CRT monitor or a TV set (if you have an RF modulator) . . . **$149.95** plus $3.00 post. & insur.
  - ☐ **DeLuxe Steel Cabinet** for ASCII keyboard/terminal . . . **$19.95** plus $2.50 post. & insur.
- ☐ **New! Terminal/Monitor:** (See photo) Same features as above, except 12" monitor with keyboard and terminal is in deluxe single cabinet: kit . . . **$399.95** plus $7 post. & insur.
- ☐ **Hazeltine terminals:** Our prices too low to quote — **CALL US**
- ☐ **Lear-Sigler terminals/printers:** Our prices too low to quote. **CALL US**
- ☐ **Hex Keypad/Display kit** . . . **$69.95** plus $2 post. & insur.
- ☐ **AP-1 Power Supply Kit** ±8V @ 5 amps) in deluxe steel cabinet . . . **$39.95** plus $2 post. & insur.
- ☐ **Gold Plated S-100 Bus Connectors** . . . **$4.85** each, postpaid.
- ☐ **RF Modulator kit** (allows you to use your TV set as a monitor) . . . $8.95 **postpaid.**
- ☐ **16k RAM kit** (S-100 board expands to 64k) . . . **$199.95** plus $2 post. & insur.
- ☐ **32k RAM kit** . . . **$299.95** plus $2 post. & insur.
- ☐ **48k RAM kit** . . . **$399.95** plus $2 post. & insur.
- ☐ **64k RAM kit** . . . **$499.95** plus $2 post. & insur
- ☐ **16k RAM Expansion kit** (to expand any of the above in 16k blocks up to 64k) . . . **$99.95** plus $2 post. & insur. each.
- ☐ **Intel 8085 cpu Users' Manual** . . . **$7.50** postpaid.
- ☐ **12" Video Monitor** (10MHz bandwidth) . . . **$139.95** plus $5 post. & insur.
- ☐ **Beginner's Pak** (see above) **$169.95** plus $4 post. & insur
- ☐ **Experimenter's Pak** (see above) . . . **$219.95** plus $6 post. & insur.
- ☐ **Special Microsoft BASIC Pak Without Terminal** (see above) . . . **$329.95** plus $7 post. & insur.
- ☐ Same as above, plus **ASCII Keyboard Terminal With Cabinet, Get Free RF Modulator** (see above) . . . **$499.95** plus $10 post. & insur.
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- ☐ **Drive Cable Set-up For Two Drives** . . . **$25** plus $1.50 post. & insur.
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- ☐ **Special: Complete Business Software Pak** (see above) . . . **$699.95** postpaid.

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- ☐ **Microsoft BASIC** . . . **$325** postpaid.
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- ☐ **Level "A" Monitor Source Listing** . . . **$25** postpaid.

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COMPUTER BITS

By Leslie Solomon
Senior Technical Editor

Free Computer Networks

A VIRTUALLY limitless information resource lies almost at your fingertips in the form of some 250 computerized bulletin boards that can be accessed by any microcomputer having a 300-baud, Bell-103 compatible modem. Most use the carriage return as the speed-recognition character and become self-prompting thereafter.

Some systems offer specialized information (medicine, astronomy, photography, ham radio, etc.), while others are more generalized. Most are available evenings or weekends when phone rates are low, while others operate 24 hours a day, 7 days a week. The listing of a telephone number offers no assurance that the system is in operation, as many shut down periodically for maintenance, and others may stop without notice.

Novation, Inc., Tarzana, CA, a modem manufacturers, offers a free dial-up directory with up-to-date listings. Operating 24 hours a day, it can be reached by calling 213-881-6880 and when the message LOGON PLEASE appears, type CAT, then carriage return (or ENTER). An 18-item menu consisting of Novation product information, a glossary of computer terms, and a modem/printer test will appear. Item 18 is the directory of dial-up systems that is updated each month.

As a service to our readers, we would like to be kept up to date on all free bulletin boards, times of operation, and what services are offered. Send all information to this column care of POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016.

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This available software allows you to use and enjoy your computer without becoming an expert. The Challenger, however, is a powerful, general purpose computer which can be programmed in several languages by those who choose to.

Here are just a few of the popular uses of an Ohio Scientific Challenger Computer:

Education

The personal computer is the ultimate educational aid because it can entertain while it educates. Software available ranges from enhancing your children's basic math, reading and spelling ability, through tutoring high school and college subjects, to teaching the fundamentals of computers and computer programming.

Entertainment

Many of the Challenger's games educate while they entertain, from cartoons for preschoolers to games which sharpen mathematical and logical abilities. But, entertainment doesn't stop here. The Challenger's graphics capabilities and fast operation allow it to display action games with much more detail than the best video games, providing spectacular action in games such as Invaders, Space Wars, Tiger Tank and more! All popular sports such as golf, baseball and bowling are available as simulated computer games as well as many conventional games such as chess where the computer plays the role of a formidable opponent.

Accounting

Your Challenger computer can keep track of your checkbook, savings account, loans, expenses, monitor your calorie intake and your biorythms.

If you are involved in a business, you can use it to do word processing; accounting, inventory control, order processing, customer lists, client records, mailing labels and planning.

And more:

This may seem like a lot of uses, but it's only the tip of the iceberg for a general purpose computer. For example, your Challenger can be expanded to control lights and appliances, manage your energy usage and monitor for fire and break-ins. Furthermore, it can communicate with you, with other computers and the new personal computer information services over the telephone.

In fact, the uses of general purpose, personalized computers are expanding daily as more and more people discover the tremendous capabilities of these new technological wonders.

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COMPUTER SOURCES

By Leslie Solomon
Senior Technical Editor

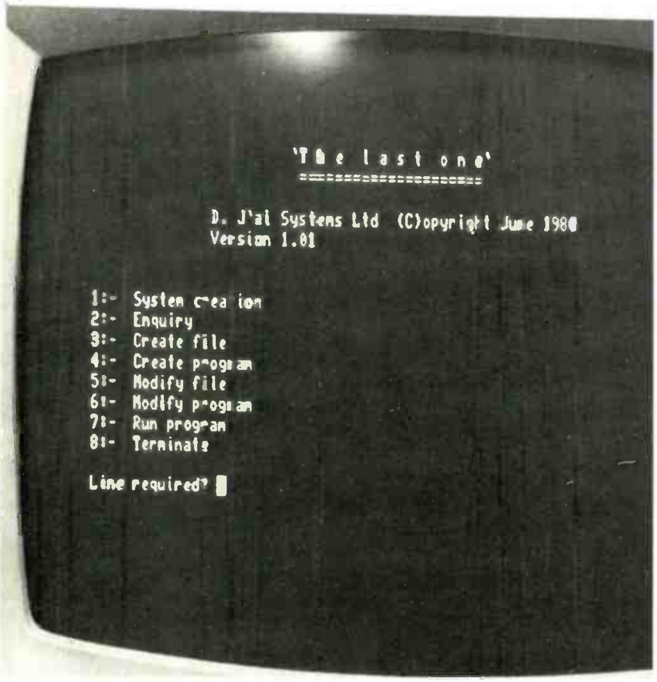
Software

The Last One. The majority of computer users need some "canned" programs to get along because most of them are not too proficient in creating and developing relatively complex programs. Of course, some can (and do) modify existing programs to add or delete certain items if the changes are not complicated. They can also create relatively simple programs in one of the high-level languages. Most shy away from creating large machine-language programs however, simply because they don't fully understand what is really happening at the bit level. In any case, we have had enough of seemingly endless debugging.

A computer, even a simple one, is a marvelous device that can be made to speak, listen, play music, perform all manner of external control tricks, and interact marvelously with the human operator. There are many programs, especially some of the more advanced word processors and statistical packages (WordStar and Visicalc for example) that appear to have some "intelligence"

At (A) is the entry menu into The Last One; (B) creates a flow chart; (C) is enquiry mode; and (D) is modify menu. Once a file has been modified, any program calling that file is also modified.

A



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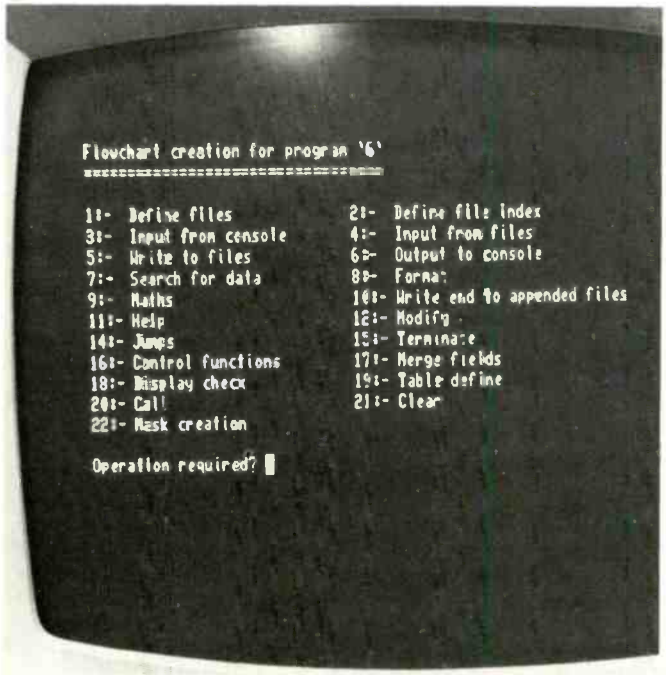

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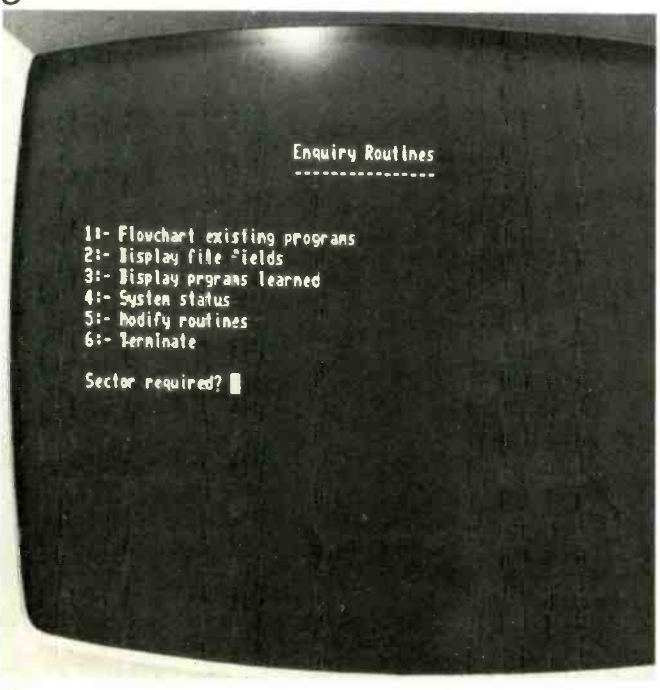


D

and the industry seems to have made some strides in "artificial intelligence." So, why can't a computer be made to create its own programs if the human operator defines just what the program is supposed to do?

This is exactly what has happened in England. Two computer experts, Scotty Bambury and David James, have come up with what they call "The Last One"—a program that interacts with the human operator via a set of menus. The operator need have no knowledge of either the computer or the high-level language being used. He need only have the capability of understanding what the menus are "looking for," and what his program should do. The program originated in connection with work in artificial intelligence.

In use, once the program of interest has been defined by answering the menu questions, the system will produce bug-free(!) code in BASIC (or any other high-level language, and even in machine code). Actual program generation takes very little time—with a couple of hundred BASIC statements requiring only five or six minutes. Since The Last One is presently written in BASIC, once it gets converted to machine code, the generation speed will increase.

The Last One generates two versions of each program, one following the precise structure laid down by the program designer and the other using optimized coding. The system then tests each program, compares the results, and uses the best one. Work is presently being done to allow the user to choose between running speed and memory efficiency.

File design is such that if any file is changed, all programs using that file are also modified and regenerated. If a program is modified, The Last One asks the necessary questions to create its new design and then generates fresh code.

The Last One was designed on an Ohio Scientific system using a hard disk, but is being modified for use with almost any other system.

Marketing decisions for The Last One have not yet been firmed up, but it is hoped that this program will soon be available in the U.S.A.

Atari Screen Print. The Screen Printer Package enables almost anything displayed by the Atari 400 or 800 to be printed on a Trendcom 200 or IDS 440G "Paper Tiger" printer. The image can be printed in gray scale, black-and-white, or reversed (white on black). It also allows LPRINT and LIST P commands. The software is a 3K auto-booting machine-language program supplied on disk or cassette. Examples are provided. $139. Address: Macrotronics, Inc., 1125 N. Golden State Blvd., Turlock, CA 95380 (Tel: 209-667-2888).

BASIC Coding Form. The Pocket BASIC Coding Form can be used to display the computer fixed memories side-by-side with space for program title, programmer's name, date, page number, special notes, and comments. The reverse of the 8½ x 11 inch form contains 30 horizontal program lines divided into 80 columns. Forms can be used with any BASIC programming. 50-sheet pads are $3.95, 100 sheets are $4.95. Address: ARCsoft Publishers, Box 132, Woodsboro, MD 21798 (Tel: 301-845-8856).

Catalog Available. The Winter/Spring Software Catalog for the Apple II, Apple II Plus, TRS-80, and TI-99/4 computers is now available. The catalog features a wide selection of professional, educational, and business software at up to 30% discount. Address: Creative Discount Software, 256 South Robertson Blvd., Suite 2156, Beverly Hills, CA 90211 (Tel: 800-824-7888; in Alaska and Hawaii 800-824-7919; California 800-852-7777. Ask for Operator 831 and catalog 47B).

Accounts Receivable System. Written for TRSDOS 1.2 on a Model II machine, AR is a complete invoicing and monthly statement generating system that keeps track of current and old accounts receivable. It maintains a complete file for each customer consisting of name, address, phone number, type of account, current balance, tax rate, and other account status information. It uses an 80-column screen and requires 64K memory and dual-disk. It is interactive, menu-driven, self-instructing and integrated with the ISAM general ledger system. $129. Address: Micro Architect Inc., 96 Dothan St., Arlington, MA 02174 (Tel: 617-643-4713).

Apple APL. APL/V80 requires an Apple, Z80 Softcard, CP/M, and a 24 x 80 video card. This version uses mnemonic symbols to represent the APL characters. Features include 11 APL arithmetic functions, 11 Boolean and relationship functions, 11 selectional and structural functions, and 9 general functions. It also features canonical representation, function fix, share offer, and share retract. Copy and erase can be executed from functions. It also has disk-based workspace and copy-object libraries, supports arrays to 8 dimensions, and allows booting directly into an application program. $500. Address: Vanguard Systems Corp., 6901 Blanco, San Antonio, TX 78216 (Tel: 512-340-1978).

Small Business Software. Written for the TRS-80, Level II, 16K machine, this four-program package is for the small entrepreneur with no employees, who operates as a home-based business: (1) The 12-Column Ledger prints a ledger of income or expense with page, month, and grand totals; (2) Speed Letter allows formating letters, notes, or forms and is menu oriented; (3) 3-Across Mailing Labels handles up to 220 names and addresses with data sorted on entry by zip code, name, city, etc.; (4) Auto Dialer holds 500 names and phone numbers and requires a phone interface relay. Elapsed timer calculates call costs and redials the last number. $10 each or all four for $25. Address: Blechman Enterprises, Suite H, 7217 Bernadine Ave., Canoga Park, CA 91307 (Tel: 213-346-7024).

Atari Graphics Editor. PLOT & DRAW for the Atari computer allows the user to generate graphics in three colors plus a background. Single keystroke commands and ability to draw pictures allow the user to produce complex drawings. A crosshair coordinate system is used for precision and flexibility. $18. Address: Mosiac Electronics, Box 748, Oregon City, OR 97045.

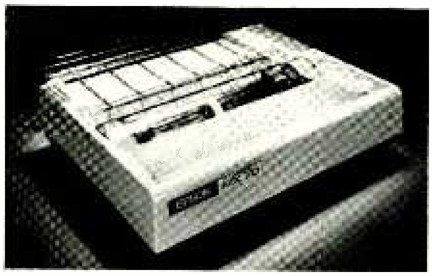
Debugging Program. RAID is a new software debugging tool for 8080/8085 systems using CP/M. It requires 13K of space and uses no overlays. Features multiple breakpoints, with pass count and "snapshot" dumps of memory and registers, symbolic input of arguments, symbolic display and alteration of registers, and a built-in assembler/disassembler. Single-step and multiple-step tracing can be performed. There is also a mixed mode execution, so that some parts of the program can be run in real time, while others are emulated. It has eight input and display formats, memory search, and direct disk access. $250. Address: Lifeboat Associates, 1651 Third Ave., New York, NY 10028 (Tel: 212-860-0300).

Software Library. Contains a number of programs for the Pet and Atari computers. Categories include games, graphics, music, ham radio, astronomy, home use, and utility programs. For more information contact Kinetic Designs, 401 Monument Rd., #171, Jacksonville, FL 32211.

Hardware

5M Byte Disks. The 5M byte series of Winchester disk systems are available for the TRS-80 Models I and II, Apple II, Altos, Alpha Micro, Intertec Superbrain, NEC PC-8001, Ontel, and S-100 bus systems running under CP/M or OASIS. In the near future, TRS-80 Model III, PET, H-89, Atari, and HP-85 machines will be added. The system contains a drive, a Z80-based controller, an interface with firmware and software for the system in use, and a power supply for world-wide power-line standards. Unformatted capacity is 6.9M bytes (5.8M bytes formatted), seek time of 10 ms, average seek and latency times of 50 and 8.3 ms. Power consumption is 120 watts. About $3750. Address: Corvus Systems, 2029 O'Toole Ave., San Jose, CA 95131 (Tel: 408-946-7700).

New Printer. The MX-70 prints unidirectionally at 80 cps with a user-defined choice of 40 (double-width characters), or 80-column printing. It features top-of-form recognition, program-



mable line feed and form length, self test, and adjustable tractor feed. It uses a 5 x 7 matrix. It also has GRAFTRAX II, a high-resolution (60 dots per inch) function. This provides bit images free from jitter, wander, and walk. The replaceable print head has a life expectancy between 50 and 100 million characters. $450. Address: Epson America, Inc., 23844 Hawthorne Blvd., Torrance, CA. 90505 (Tel: 213-378-2220).

Speech Kits. The TMSK101, using the TMS5100 speech-synthesis chip, and the TMSK201 using the TMS5200 chip use linear-predictive coding (LPC). The TMSK101 provides speech synthesis based on 4-bit processors or single-chip computers and includes a ROM having 204 words. The TMSK201 kit can be used with 8- and 16-bit machines. Its EPROM contains 32 words, 2 phrases, and one tone, each individually encoded. LPC provides natural sounding speech and requires 900-1600 bits/second of speech (450-1000 bits per word). $140. Available from Texas Instruments distributers.

Apple Time. TIME II is a real-time clock/calendar for the Apple II. It provides date with year, month, day of week, and leap year. It also provides 24- or 12-hour format with AM/PM indication. Latched I/O enables programming in BASIC. An on-board battery provides 4 months of power when the system is turned off. Selectable interrupt permits foreground/background operation of two simultaneous programs so you can call up schedules, time events, or date listings. $150. Address: Applied Engineering, Box 470301, Dallas, TX 75247.

Dynamic Static RAM. The Z6132 is an NMOS chip organized as 4K x 8. Having the capability of *on-chip* refresh, it combines the convenience of static RAM with the high density and low power consumption of dynamic RAM. The power requirement is 1/16th that of 2114 types, and one Z6132 does the work of eight 2114s. The 28-pin chip operates from a single 5-volt line and has access times of 250, 300, and 350 nanoseconds. Address: Zilog, 10340 Bubb Rd., Cupertino, CA 95014 (Tel: 408-446-4666).

6502 Handbook. The 6502 Instruction Handbook is a 44-page reference containing a synopsis of each instruction for the 6502. Mnemonics and machine codes in hex format are provided. The instruction set is listed alphabetically, by assembler mnemonics, and machine code. It also includes hex-to-decimal conversion chart, chip pin-out, basic timing, and chip architecture. $4.95. Address: Scelbi Publications, 20 Hurlbut St., Elmwood, CT 06110.

Speech Board. The LPC Speech Board has a vocabulary up to 458K bits, typically 200 to 300 seconds of speech. It interfaces with the Multibus, parallel I/O, or RS232 serial I/O. It includes a 40-word vocabulary for time, calculator, frequency counter, and voltmeter applications, an 8085 processor, and a 1.5-watt audio amplifier. The user can enter his own phrases and words to form his own sentences. Words can be randomly accessed to create messages. Linear predictive coding is used. Several other synthetic speech modules are available. Address: Telesensory Speech Systems, 3408 Hillview Ave., Palo Alto, CA 94304 (Tel: 415-493-2626). ◇

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Atari Model 800 Personal Computer

THE Atari Model 800 is a personal computer based on a 6502 microprocessor with color graphics and sound capability. It comes with a TV/GAME isolation switch that allows its use with any TV receiver. Preferably, the 800 can be connected to a high-quality color monitor, using the RGB (*not* composite) video output on the computer's rear panel.

Housed in an attractive plastic case covering an RFI-shielded enclosure, Model 800 features a full-size keyboard with 57 full-stroke and four function typewriter-like keys, four interface connectors for using joystick or paddle controls, an eight-bit parallel interface port, TV channel 2/3 switch, a video monitor connector, 16K bytes of RAM (that can be expanded to 48K), 10K bytes of system ROM (that can be expanded by cartridges), and an Atari BASIC interpreter cartridge. The highest graphics resolution is 320 x 192, and three text modes are provided.

Base price is $1080. Optional items include: Model CX8101 Master Diskette with disk operating system and file manager ($25); Models CX852 and CX853 8K and 16K byte RAM modules ($124.95 and $199.95, respectively); Model 410 cassette program recorder ($89.95); Model 810 5.25-inch single-sided, single-density floppy-disk drive and controller ($599.95); Model 815 double-density, dual-disk drive ($1,499.95); Models 820 and 825 40- and 80-column dot-matrix printers ($449.95 and $999.95, respectively); Model 830 modem ($199.95); Model 850 interface module ($219.95); Model CX40-04 joystick controller package ($19.95); and the CX-70 Light Pen ($74.95). Atari also has a long list of additional useful peripherals, ranging from cables to printer accessories. Software available from Atari includes games, educational courses, and financial programs on cassette tapes ($14.95 to $29.95) and in plug-in ROM cartridges ($24.95 to $39.95). Besides BASIC (CXL4002) included with the machine, there is an assembly editor (CXL4003 at $59.95). Soon to be announced are cartridges for PILOT (CX405 at an as yet unknown price) and PASCAL.

General Description. The Atari 800 doesn't have a user-oriented bus structure. Instead, it uses an r-f system that minimizes radio-frequency (RFI) and electromechanical interference (EMI) with an electrically tight cartridge-slot system for RAM and ROM cartridges. A similar system is used for the BASIC interpreter and game cartridges that slip into one or both of the "game" slots in the console. When the cartridge door is opened, the computer automatically switches off.

The 6502 microprocessor operates with a 0.56-μs cycle at 1.8 MHz. Since the computer is designed to operate with home TV receivers on channel 2 (54 to 60 MHz) or 3 (60 to 66 MHz), the on-screen display is limited to 24 lines of 40 characters because of the available bandwidth in most sets. The TV/GAME isolation switch mounts directly on the TV receiver and connects to the console via a 15-ft cable terminated with a phono plug. Power for the console is supplied by an ac power adapter.

Before turning on the system, you must set the switch on the console and the receiver's tuner to either channel 2 or channel 3, depending on the channel not in use in your viewing area. About 6 seconds after power-up, "ATARI COMPUTER MEMO PAD" will be displayed on the screen in white on a blue background.

Atari's keyboard is designed to generate upper- and lower-case alphabetics, numerals, and graphics and has screen-editing functions. Under software control, each key can also be redefined for special functions. You can move the cursor to any desired location on the screen with the up-, down-, left-, and right-arrow keys. Automatic repeat is possible simply by holding down any desired key for about 5 seconds. The repeat function remains enabled for as long as the key is held down thereafter.

A special key, identified with the Atari symbol, allows entry to and escape from the inverse-video mode. Automatic wraparound immediately drops the cursor to the beginning of the next line once the 38th character is typed in any given line, obviating the need to press RETURN and LINE FEED at the end of each line.

Peripherals can be added to the 800 in two ways. If you have the cassette recorder but no disk drive, you can use the port located on the side of the console. For larger system configurations, however, you'll need the Model 850 interface module, which provides four RS232C serial ports (including one with 20-mA capability), and an 8-bit parallel output port. Serial ports have baud rates to 9600, and Baudot rates to 100 wpm.

Software for the 800 is broken down into two distinct groups—system and applications. The latter is further divided into games, educational, and business programs. Many of the games are in ROM cartridges that plug directly into the console and come up instantly. Other games are on cassette tapes that usually load in about a minute. The game programs let you choose speed, number of players, and how you wish to play, all by pushing one of the function keys.

To use many of the educational cassettes, an Education System Master ROM cartridge ($24.95) is required. This "control" cartridge allows you to carry on a dialogue with the computer. Other educational cassettes are used with BASIC.

The Atari Telelink-1 program is used with the Model 830 modem and can support a printer when connected to the console via the interface module. This ROM-cartridge program slips into the left slot in the console. The software in it is fairly flexible and takes into account the select and option keys that permit setting up a buffer and dumping to the printer. Moreover, it can be configured to allow for automatic dumping to the printer, signalling the host computer to shut off, or sending an X OFF or X ON to control transmission. Since Telelink doesn't support use of a disk drive, you can't save transmit files.

Atari's disk operating system (DOS) is designed to extend the capabilities of the BASIC cartridge. To boot up the system, you turn on the disk drive, insert the diskette, and then turn on the console. Boot-up is then automatic.

The DOS and file manager let you run programs mounted in cartridge

LISTING 1
GRAPHICS TEST PROGRAM FOR DRAWING A TRIANGLE

```
4 GOTO 100
100 CLR
110 GRAPHICS 0
120 PRINT "ENTER NUMBER OF SIDES";
130 INPUT A
140 PRINT "ENTER NUMBER OF FRAMES ";
150 INPUT B
160 DIM C(A,2),D(A,2)
170 REM GENERATE INITIAL COORDINATE ARAY
180 FOR I=1 TO A
190 C(I,1)=RND(-1)*130
200 C(I,2)=RND(-1)*100
210 NEXT I
220 REM GENERATE INCREMENT ARRAY
230 FOR I=1 TO A
240 D(I,1)=(RND(-1)*130-C(I,1))/B
250 D(I,2)=(RND(-1)*100-C(I,2))/B
260 NEXT I
270 GRAPHICS 0
275 GRAPHICS 7
280 FOR J=1 TO B
290 POSITION C(A,1),C(A,2)
300 REM DRAW POLYGON
310 FOR I=1 TO A
320 DRAWTO C(I,1),C(I,2)
330 NEXT I
340 REM ADD INCREMENT ARRAY TO COORDINATE ARRAY
350 C=C+D
360 NEXT J
370 END
```

slots, direct files to either the printer or the screen, and create backup and data diskettes. This is a user-oriented, menu-driven operating system that requires no special setups. Both sequential and random files are supported, and such standard commands as OPEN, CLOSE, READ, and INPUT are employed for ease of developing programs in BASIC. Operating under the Atari DOS, each disk can store up to 73K bytes of data on a system diskette or 84K bytes on a data diskette.

The BASIC interpreter supplied by Atari is designed to support the color graphics and sound functions built into the 800. While it may appear at first glance to be minimal in nature, this BASIC includes such important primitive graphics commands as DRAWTO, POSITION, and PLOT, which are usually found only in more extensive BASICs. The string operators MID$, LEFT$, and RIGHT$ are missing, but string splitting information is provided.

This BASIC is a graphics- and input-oriented language. Consequently, it contains such operators as SOUND, SETCOLOR, and functions that integrate the joystick and paddle controllers for movement on-screen and depression of a firing button.

This computer has facilities for generating 16 colors, each with 8 intensities, that can be called from BASIC using the SETCOLOR command. There are four independent sound synthesizers, in addition to the TV audio, each covering four octaves with variable volume and tone. An internal speaker is provided. The SOUND command permits setting a note on the full musical scale, as well as pitch, volume, and amount of distortion for creating sound effects.

There are nine different graphics modes possible in the 800. The first mode, GRAPHICS 0 permits a 40 x 24 display with two colors without split-screen features. When GRAPHICS 0 is invoked, it clears the screen and places the entire system in its default settings. This mode requires 993 bytes of RAM.

GRAPHICS 1 and 2 are also character/text display modes. In GRAPHICS 1, characters appear on-screen twice normal width but normal height, while in GRAPHICS 2, characters appear double width and double height. Therefore, the displays generated can be either 20 x 24 or 20 x 12, respectively. These two modes permit the use of five colors and provide a split-screen format for mixed graphics and text. Graphics 1 and Graphics 2 require 513 and 261 bytes of RAM respectively.

GRAPHICS 3 through 8 set up additional graphics and screen formats. High-resolution mode GRAPHICS 8, for example, permits creation of a full-screen display consisting of 320 x 192 (61,440) dots. It requires 7.9K bytes of RAM. Graphics 3,4,5,6, and 7 require 273, 537, 1017, 2025, and 3945 bytes of RAM, respectively.

Everything you do in the graphics modes is I/O related. Therefore, all commands result in an output to a text or graphics window or to the basic text screen. Once you've mastered the handling of the graphics functions, you'll find it relatively easy to develop your own on-screen displays in color, including three-dimensional effects.

Evaluation. We tested a fully configured system, including the Model 800 console, interface module, both printer models, two joystick controllers, acoustic modem, program cassette recorder, 5.25-inch floppy-disk drive, and two 16K- and one 8K-byte RAM cartridges. An additional 10K-byte ROM cartridge was used for system control.

LISTING 2
GRAPHICS
TEST PROGRAM
FOR A POLYGON

```
10 GRAPHICS 0
20 GRAPHICS 7
30 PLOT 80,10
40 DRAWTO 40,40
50 DRAWTO 120,40
60 DRAWTO 80,10
70 END
```

Setting up the system is a simple, straightforward procedure. We encountered a minor problem with the TV/GAME switch, which is supposed to mount on the back of the TV set with a self-stick pad. The weight of the switch box and cable appear to be too much for the adhesive. As a result, the switch box can work loose and pull the interconnecting 300-ohm twinlead from the TV set's antenna terminals. Instead of mounting the box on the rear of the set, we recommend that you place it on top and make interconnection by way of a quick clip.

We observed little or no TV interference (TVI) when the console was operating. All in all, this is a very "quiet" console/cable system. The same can't be said about the Model 825 80-column printer, however. With the printer powered and located within 10 feet of the TV set, we observed RFI noise in the display.

While we very much like the "feel" and flexibility of the console's keyboard, we don't care much for the location of CAPS LOCK (just below the RETURN key). This makes it too easy to accidentally switch between upper- and lower-case.

We also have reservations about the use of separate ac adapters for the console and each peripheral instead of a single hefty power supply and bus to feed the peripherals. A fully configured system ties up a multitude of ac outlets. Worse still, you end up with a tangle of trailing wires that can be tripped over or accidentally dislodged.

The floppy-disk drive sample supplied to us proved prone to head misalignment and medium warping, and the controller wasn't exactly bug-free either. Testing the drive with multiple reads and writes produced an error on every fourth entry. When we checked several other samples, we found similar problems, albeit on a random basis. Atari is aware of the difficulty, and the necessary redesign is underway. System hardware operated smoothly in all other respects.

Software supplied by Atari is generally excellent, especially in the area of educational software. While Atari's games software creditably exercises the color-graphics capabilities of the system, two games that give a really rigorous demonstration are "Checker King" and "Microchess" from Personal Software on cassette tape for $19.95 each. The programs are written in machine language to take full advantage of the 6502's speed, displaying a lifelike board and extremely well-defined playing pieces. When a move is made, you actually see motion on the screen.

Since the BASIC interpreter in the Model 800 is unique to this computer, we developed two benchmarks to demonstrate the capabilities of the machine. Listing 1 draws a triangle. Line 10 clears the screen, line 20 sets up a 160-column by 80-row display, line 30 establishes the apex of the triangle, and lines 40 through 60 draw the triangle's sides. The program runs in less than a second and draws fairly smooth lines.

Listing 2 demonstrates the ability of the 800 to draw a multisided polygon by setting up an array using randomly defined points. Although this program readily creates a single-view polygon, expanded views, defined by the frame input, weren't possible. In operation, a 30-sided figure took 11 seconds to format and less than a second to draw. The increment array coordinates remained set at zero, allowing only one view, which demonstrates the inadequacy of the random (RND) statement to correctly generate random numbers that are greater than 1.

Comment. Generally speaking, the Atari Model 800 is a top-notch computer that far surpasses its immediate competition. In addition to its fine assortment of peripherals and software, it incorporates various extra features, such as the music synthesizers and built-in speaker. Its capabilities with respect to graphics seem especially comprehensive. Despite our few minor reservations, the overall system deserves high marks.—*Carl Warren*

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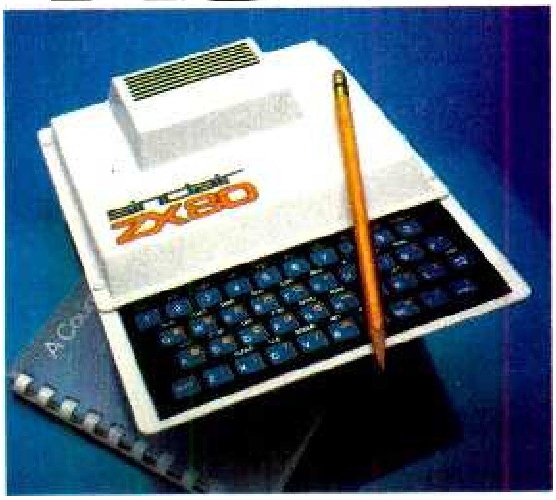

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A MULTIBAND SHORTWAVE ANTENNA FOR SWLs

Transmission-line traps of novel construction allow this antenna to resonate on the 49-, 31-, 25-, 19-, 16-, 13-, and 11-meter shortwave bands

BY ROBERT H. JOHNS

TODAY'S shortwave receivers are so sensitive that simple random-length wire antennas are all that's needed for casual listening. However, serious DXing—picking up signals from distant, low-power stations, for example—calls for a resonant antenna. The classic method of resonating an antenna is cutting it to the appropriate length, but that implies the use of several antennas for multiband reception. A much more convenient approach is possible. The Multiband Shortwave Antenna employs *traps* that automatically adjust its effective length to resonate with the received signal. It can be constructed from

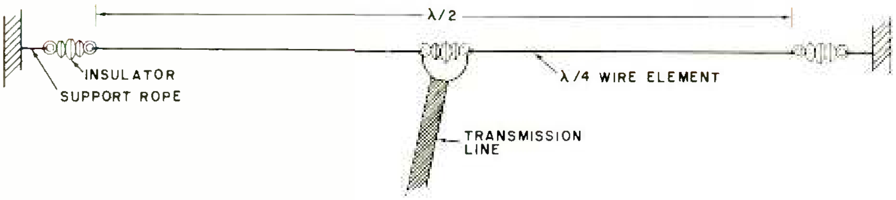

Fig. 1. The basic half-wave dipole antenna.

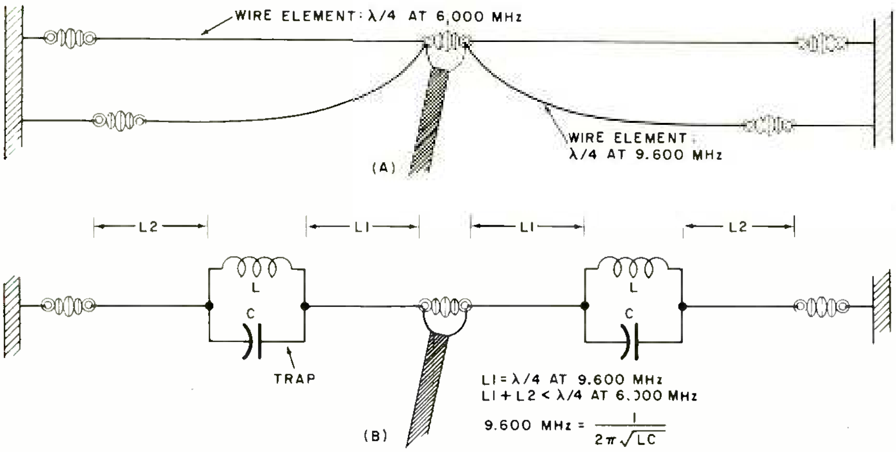

Fig. 2. (A) Two or more half-wave dipoles can be connected in parallel to a single transmission line for dual- or multi-band coverage. (B) A dipole antenna with a single pair of traps can resonate on two different bands.

PARTS LIST

Hard-drawn copper antenna wire; 7/8-inch diameter plastic tubing or PVC pipe; ceramic end insulators; 300-ohm twinlead, ceramic center insulator and silicone weatherproofing compound or 50- or 75-ohm coaxial cable and combination center insulator/4:1 balun transformer (see text); nylon rope; suitable supporting structures; two 35-foot spools of Radio Shack two-conductor Rainbow Wire (Catalog No. 278-755) or equivalent; solder, suitable hardware, in-line lightning arrestor, etc.

Note: A trap antenna for the 11-, 13-, 16-, 19-, 25-, 31-, and 49-meter bands with 50 feet of 72-ohm twinlead transmission line is available for $29.50 from Scientific Instruments, 3379 Papermill Rd., Huntingdon Valley, PA 19006.

readily available, inexpensive materials and can perform well on the major international broadcast bands.

About the Antenna. The basic antenna from which the multiband trap design is derived is the half-wave dipole. As shown in Fig. 1, the dipole consists of two elements and has an effective length of one-half wavelength at the frequency of resonance. Effective length is not necessarily equal to the actual physical length. An antenna can be made to exhibit an effective length greater than its physical length by the introduction of inductive reactance. Similarly, an antenna's effective length can be made less than its physical length by the introduction of capacitive reactance.

An antenna that resonates at 6.000 MHz in the 49-meter international shortwave broadcast band is 77 feet long, and one that resonates at 9.600 MHz in the 31-meter band is 48 feet long. The classic way to construct an antenna that resonates at these two frequencies involves connecting two dipoles, each cut for one of the frequencies of interest, to a common transmission line that feeds signals to the receiver (see Fig. 2A). Each dipole is active at and near its resonant frequency. Its effect on the performance of the other, whose resonant frequency is far removed, is minimal.

The trap approach to the problem of providing a resonant antenna at these two different frequencies is shown in Fig. 2B. It comprises a transmission line, four lengths of wire, and two traps or parallel LC networks that resonate at 9.600 MHz. At resonance, the impedance of the traps is very high and purely resistive. Above resonance, the trap impedance is lower and capacitive. Similarly, below the resonant frequency, the trap impedance is lower and inductive.

The inner wire sections of the antenna comprise a half-wavelength at 9.600 MHz. When the antenna is excited by r-f energy at that frequency, the high resistance of the traps (practically open circuits) decouples the outer wire sections from the inner sections. The antenna thus acts as a half-wave dipole cut for resonance at 9.600 MHz.

At the second, lower frequency of interest (6.000 MHz), the traps are not resonant. Rather, they behave like inductive reactances. When the antenna is excited by a 6.000-MHz r-f signal, the outer wire sections of the antenna are effectively connected to the inner sections through these inductive reactances. The total physical length of the antenna is shorter than would normally be required for resonance at 6.000 MHz. However, the antenna's effective or electrical length is a half-wavelength. The reason for this is that the inductive reactance of the traps supplies the needed electrical length. The traps function as loading coils at this lower frequency and the antenna resonates. This physical shortening of the antenna can be of particular advantage where space is limited.

There is no reason why more than one set of traps cannot be installed in an antenna for operation on more than two bands. That's exactly what's done in the Multiband Shortwave Antenna shown in Fig. 3. Each leg of the antenna contains six traps, allowing the antenna to exhibit resonance on the 49-, 31-, 25-, 19-, 16-, 13- and 11-meter bands. Although it resonates only on those bands, it will offer good performance in other

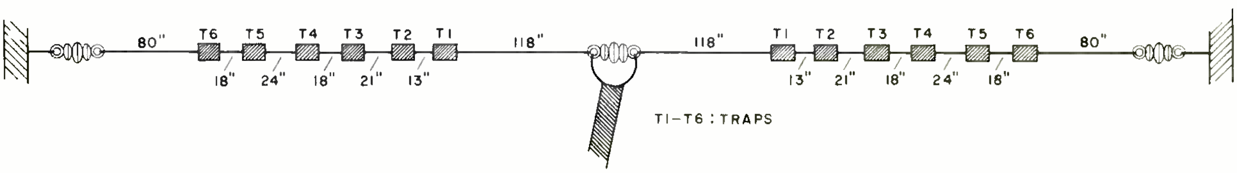

Fig. 3. The Multiband Shortwave Antenna employs six pairs of traps.

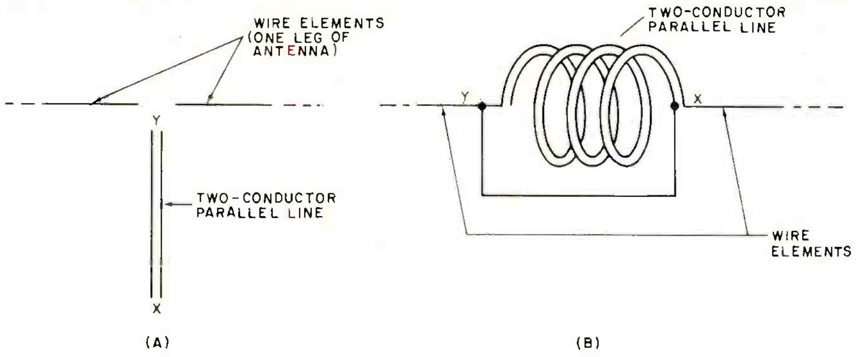

Fig. 4. How a two-conductor parallel transmission line (A) can be made into a trap by coiling it and using its distributed capacitance (B).

or solid, but it should be hard-drawn copper. Soft-drawn copper has a tendency to stretch under load. An antenna made from it will deform and sag, thus detuning itself.

The other end of the "80-inch" wire should be fed through one end of a ceramic antenna end insulator (*not* an "egg" type guy-wire insulator) and wrapped back upon itself for mechanical support. For additional strength, the end of the antenna wire should be soldered where it is wrapped. Feed the other end of the "80-inch" wire through two of the holes at the left end of the 2¾-inch form and wrap it back upon itself, adjusting its length so that the distance between the end of the ceramic insulator and the left end of the trap form is exactly 80 inches. This wrap should not be soldered yet—it will be soldered later, when the assembly of trap *T6* is completed.

Next, slip one end of the "18-inch" wire through two of the holes at the right end of the trap form and wrap it back upon itself. Then separate the conductors at one end of a length of Radio Shack Rainbow Wire for several inches and cut the white wire short by five inches. Remove ¾ inch of insulation from each of the wires. Slip the shortened end of the white wire through one of the two remaining holes on the right side of the trap form and wrap it around the antenna wire. Then slip the end of the black wire through the remaining hole and pass it through the interior of the trap form so that it exits at the left

portions of the hf spectrum. The traps also shorten the antenna considerably compared to a full-size dipole cut for the 49-meter band.

Construction. The traps used in the Multiband Shortwave Antenna are assembled from inexpensive, lightweight, and readily available materials. Two-conductor parallel transmission line—actually, Radio Shack two-conductor Rainbow Wire, Catalog No. 278-755—is employed. It has an interconductor capacitance of approximately 15 pF per foot. Refer to Figs. 4, 5, and 6 for trap details.

To simplify construction, one wire of the pair is employed as the trap's inductor, and the distributed capacitance between it and the other conductor forms the trap's capacitor. A suitable length of two-conductor line with ends *X* and *Y*, as shown in Fig. 4A, is selected. The line is wound into a helix and its conductors connected to two of the wire elements of one leg of the antenna as in Fig. 4B.

One conductor has its *X* and *Y* ends connected to each of the two wire elements. The *Y* end of the other conductor is left floating; the *X* end is connected back to the *Y* end of the other. The result is an LC parallel network whose inductance and capacitance are determined by the pitch of the line's helix, the number of turns comprising the helix, and the length of the line. For mechanical support, the line is wound on an electrically inert, plastic cylindrical form.

The prototype antenna was made using lengths of ⅞-inch outer-diameter polypropylene tubing. This tough, light material was salvaged from a hula hoop that had steel balls inside the tubing. Some other electrically inert material such as PVC pipe can be used as the trap forms, but the coil-winding data in the box, "Details of Trap Construction," is valid only for cylindrical forms with outside diameters of ⅞ inch.

Begin construction by cutting 12 suitable lengths of tubing (two of each length listed in the box for traps *T1* through *T6*). Drill four holes approximately ½ inch from the ends of each length of tubing, using Fig. 5 as a guide. Then take one of the 2¾-inch forms and slip one end of two suitable lengths of antenna wire through two of the holes at each end of the form. The form will support trap *T6* of the left leg of the antenna (see Fig. 3) and the two wire elements will be the "80-inch" and the outer "18-inch" components of that leg.

Note that the wire lengths given in Fig. 3 are those between end insulators and traps, between traps, and between traps and the center insulator. Several extra inches of wire will be needed at each end to form loops and wraps, so make allowances before cutting. The wire can be insulated or bare, stranded

DETAILS OF TRAP CONSTRUCTION

Trap Number	Band (meters)	Resonant Frequency (MHz)	Number of Turns	Length of Trap Form (inches)
T6	31	9.6	18	2.75
T5	25	11.7	15	2.50
T4	19	15.3	11.5	2.00
T3	16	17.7	9.5	1.75
T2	13	21.8	8.5	1.50
T1	11	25.8	7.5	1.50

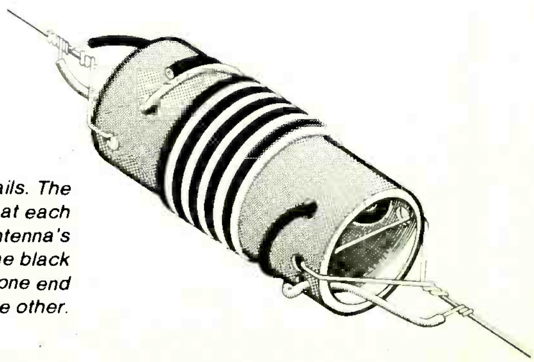

Fig. 5. Trap wiring details. The white wire is connected at each end to one of the antenna's wire elements. The black wire is left floating at one end and cross-connected at the other.

Fig. 6. Two of the antenna's wire elements have been connected to the plastic form and the Rainbow Wire attached.

side. Wrap the exposed conductor of the black wire around the end of the antenna wire.

Next, closely wind 18 turns of the Rainbow Wire around the form from right to left. Cut the wire after the 18th turn, leaving several inches for connection. The black wire should be separated from the white and cut at the completion of the 18th turn. Strip the insulation from the end of the white wire and wrap it over the antenna wire and the black wire that runs from the other end of the trap form. Solder the wires at ends of the form, but do not apply too much heat or the plastic tubing will melt. Trap *T6* of the left leg is now complete, and should resemble the trap that is shown in Fig. 7.

Following the same procedure, assemble the remaining traps and wire elements of the left leg, working in toward the center point of the antenna. The lengths of the trap forms and the number of turns comprising each of the remaining traps are specified in the box. Inter-trap distances that are related to the lengths of the remaining wire elements of the left leg appear in Fig. 3.

When assembly of the left leg of the antenna has been completed, the right leg can be constructed. Follow the same procedure. As before, assembly should begin at the outer extremity and finish with the 118-inch inner section.

If you have access to a grid-dip meter, you can check the resonant frequencies of the traps. They should be close to those listed in the box. If a trap's frequency of resonance is incorrect, it can be adjusted by spacing the turns out somewhat (to raise the frequency) or by squeezing them closer together (to lower the frequency). Larger changes should not be necessary, but can be accomplished by adding or removing turns. When the desired resonant frequencies have been obtained, the trap windings can be secured in place with coil dope or epoxy cement.

When both legs of the antenna have been assembled, they should be connected to a transmission line and a center insulator. To prevent deterioration of the transmission line, a weatherproof center insulator should be used. Alternatively, a ceramic end insulator can be employed, and silicone weatherproofing compound applied after the connections between the inner wire elements of the antenna and the transmission-line conductors have been soldered. Similarly, weatherproofing of the traps is recommended to prevent moisture buildup from detuning the traps. This can be accomplished by enclosing each trap in a cylindrical Plexiglas or PVC form.

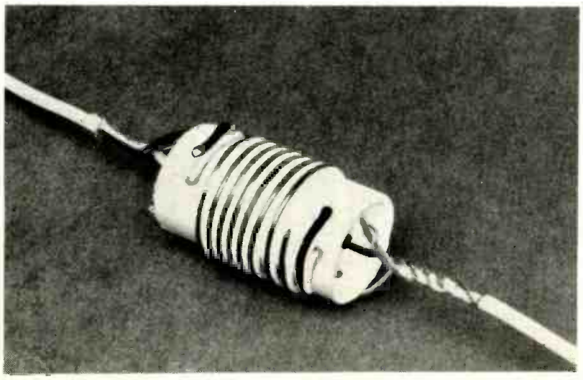

Fig. 7. A completed trap ready to be soldered. Note that the Rainbow Wire has been closely wound around the form.

Two factors influence the choice of transmission line: the impedance of the antenna and its electrically balanced nature. A dipole fed at its center and mounted in free space has an impedance of 72 ohms, but a dipole mounted close to the ground in terms of wavelength will have a different impedance. The impedance plot of the prototype Multiband Shortwave Antenna, which was mounted approximately 20 feet above ground, appears in Fig. 8. It is readily apparent that the impedance of the antenna as measured by the author varies considerably across the hf region of the radio spectrum. At resonance in the 49- and 11-meter bands, the feedpoint impedance is approximately 70 ohms, but it is higher in the other shortwave broadcast bands for which it is designed, even at resonance.

The prototype was fed with 300-ohm twinlead for three reasons. First, its impedance is a good compromise, considering the wide variation in the feedpoint impedance of the antenna. Second, twinlead is a balanced line, making it appropriate for use with the dipole, an electrically balanced antenna, and for use with shortwave receivers that have balanced-input antenna terminals. Finally, twinlead is relatively inexpensive and easy to work with.

If you decide to use 300-ohm twinlead, select a high-quality line. It should be foam-filled to keep signal losses low and to minimize the deleterious effects of dirt and moisture that build up on the line's outer jacket. The best balanced line to use is shielded twinlead. It is the most expensive and is somewhat more difficult to work with than thinner, flatter varieties. However, shielded twinlead has a considerably greater useful lifetime (ordinary twinlead deteriorates rather rapidly outdoors) and its impedance is not disturbed by nearby metallic objects.

Coaxial cable can also be used as the lead-in for the Multiband Shortwave Antenna. A 75-ohm coaxial line such as RG-59/U weathers well and has relatively low losses. The fact that it is shielded means that it can be passed near metallic objects or even buried underground without adverse electrical effects. If 75-ohm coax is to be used, it should be teamed up with a 75-ohm-to-300-ohm balun transformer. The balun will step up the impedance of the line at the antenna's feedpoint and make for a better match between the unbalanced transmission line and the balanced dipole antenna. As a bonus, most baluns

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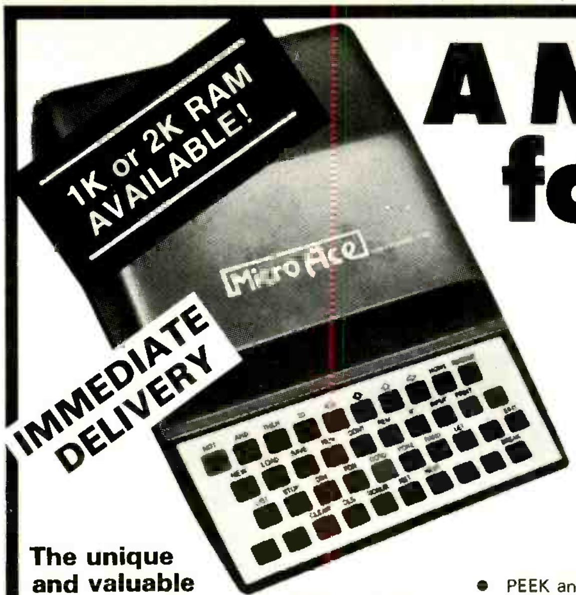

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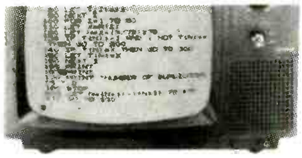

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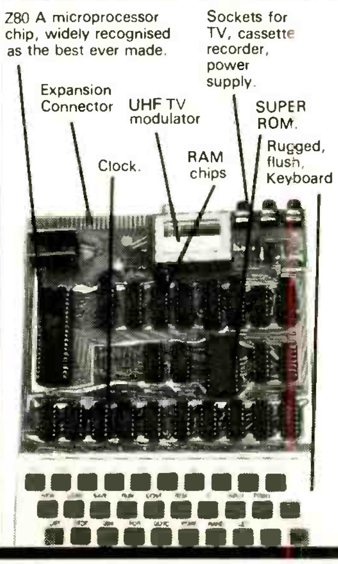

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City ____________ State ____________ Zip ____________ designed for amateur-radio use double as weatherproof center insulators. If you decide to employ coaxial line and a balun, make sure that the balun is of the 4:1, as opposed to the 1:1, variety. Many contemporary shortwave communications receivers have unbalanced, low-impedance antenna inputs, so in most cases a second balun transformer won't be needed at the receiver end of the transmission line.

Installing the Antenna. There are two basic ways that the Multiband Shortwave Antenna can be set up at the receiving site—either as a flattop dipole or as an inverted vee (see Fig. 9). The flattop dipole has a higher feedpoint impedance than an inverted vee and is somewhat directional—it responds best to signals striking it at right angles. It requires two high supports (Fig. 9A), one at each end of the antenna. In most cases, the dipole does not require a center support.

The inverted vee (Fig. 9B) is more omnidirectional and has the advantage of requiring only one high support at the center. This also lessens the stress on the antenna structure. Although the feedpoint impedance of the inverted vee is somewhat lower than that of a flattop dipole, it is still a good match for 300-ohm twinlead or a coax/balun combination, but slightly better results will be obtained with 50-ohm coax than with 75-ohm line.

Nylon rope should be used between the insulators and the antenna supporting structures. In the case of a flattop dipole whose ends are supported by trees, the ropes should pass through halyards attached to the trees and their ends secured to weights. This will allow the antenna to remain stationary even when the supporting structures sway in the wind. If the metallic mast is used to support the center of an inverted vee, tension should be placed on the antenna wires and the feedline to keep them at least several inches away from the mast. In any event, try to keep the feedline at right angles to the antenna for as long a run as possible. The use of an in-line lightning arrestor is also highly recommended for safety's sake.

If only a limited space is available for installation, the ends of the antenna can be bent at right angles. The straight, central portion of the antenna should be as long as possible. The antenna can be installed in an attic, but best results will be obtained if the antenna is mounted straight, in the clear, outdoors, and as high as possible.

For really tight quarters, an excellent performer on the 11-, 13-, 16- and 19-meter bands can be built by eliminating traps *T4*, *T5*, and *T6* and the three outer wire sections of each leg of the antenna. This shortened version has an overall length of approximately 28 feet and will also do a good job, though not as good as a full-size antenna, on the lower-frequency bands. ◇

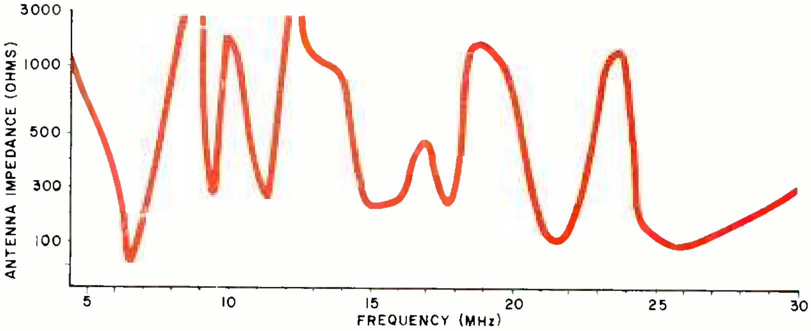


Fig. 8. A impedance plot of the author's prototype installed at a height of 20 feet.

Note—*Readers are encouraged to build the traps described in this article for their own use, but are cautioned that a patent application has been filed on this and other types of transmission-line traps.*

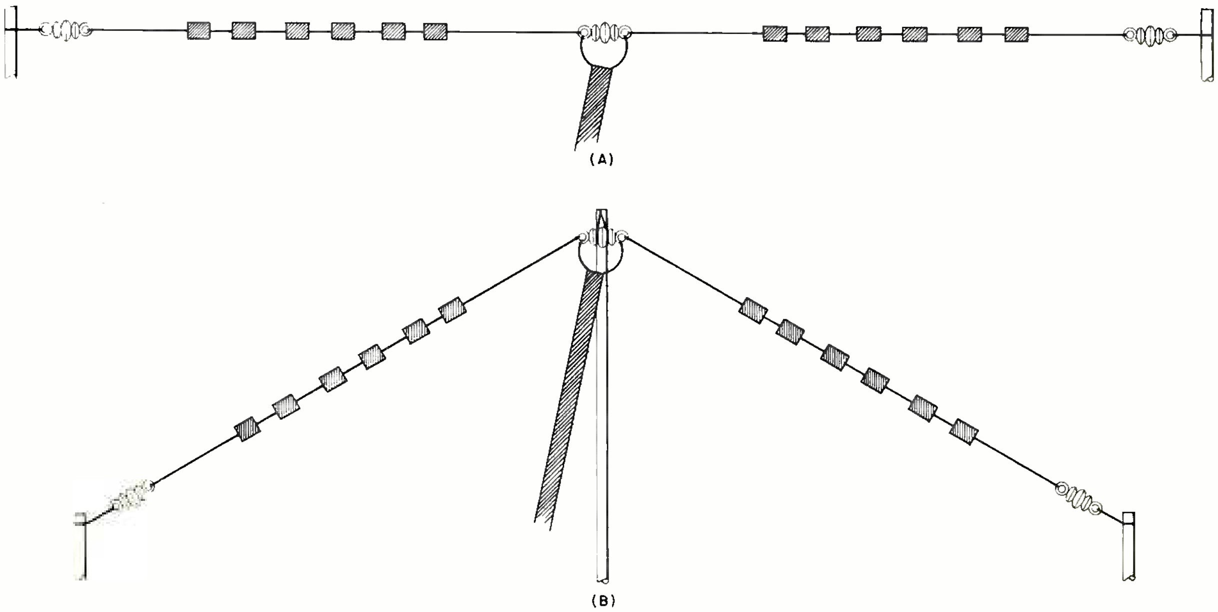


Fig. 9. Two ways to install the Multiband Shortwave Antenna—as a flattop dipole (A) and as an inverted vee (B).

Shhh!

DOLBY DOES IT AGAIN

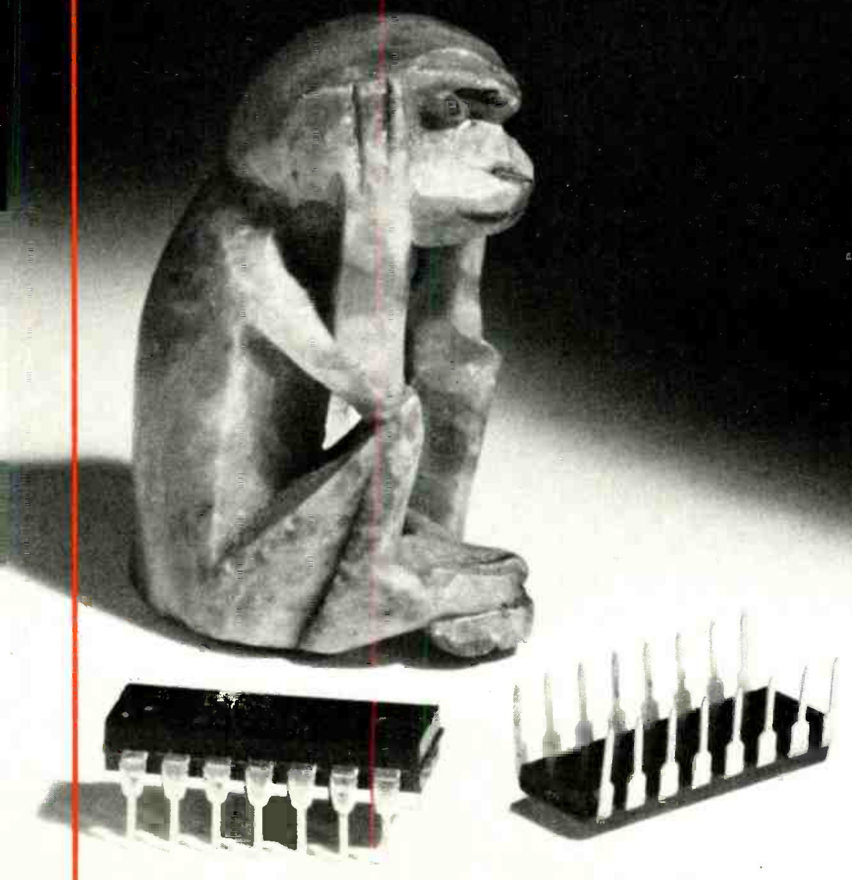
A new noise-reduction system that works twice as well as the ubiquitous Dolby B

BY MARTIN FORREST

IF you ask any audio authority what development of the last 15 years influenced home high-fidelity recording the most, the answer you are likely to hear is: "Dolby B noise reduction." To be sure, the success—not to say dominance—of the stereo cassette recorder is in large measure due to the incorporation of Dolby B encoding and decoding circuitry in all but the very least expensive models.

The Challenges of Noise Reduction. It is generally agreed that in a high-quality sound system, residual noise (in cassette tapes that means largely tape hiss) should be at least 60 dB lower than the peak levels of the program material. But in the late 1960s and early 1970s the best signal-to-noise ratio that could be had from existing cassette tapes and decks was about 42 to 45 dB. The solution to this problem, as almost everyone knows by now, was Dolby B, a compander system that, when properly used, offered as much as 10 dB of tape hiss reduction. Adding this 10 dB to the 42 to 45 dB S/N available from cassette tape systems in 1970 gave 52 to 55 dB. This was hardly total absence of noise, but it could be fairly easily tolerated by those who sought to make high-fidelity music recordings at home.

Over the years, cassette tapes and recorders have improved in small increments, so that now, using premium-quality hardware, it is possible to achieve signal-to-noise ratios in excess of 60 dB. However minute they may seem, such noise levels are nevertheless still audible. Furthermore, program source material has improved too, so that what is available to the home re-



cordist for transcription onto cassettes, (favorite discs, once-in-a-lifetime FM concerts, etc.) is apt to have more dynamic range than when Dolby B was introduced.

Today's direct-to-disc and digitally mastered records can, in some cases, deliver S/N ratios as high as 75 or even 80 dB (measured with an appropriate form of weighting curve). If you tried to transfer such a disc to cassette tape, even with Dolby B, you would either saturate the tape in the loudest passages or "bury" the softest passages below the tape hiss.

Largely for these reasons, several companies other than Dolby have recently developed and marketed compander noise-reduction systems that suppress noise by substantially more than does Dolby B. The dbx linear companding system, for example, can provide up to 30 or 35 dB of noise reduction. Telefunken, of West Germany, developed a noise reduction system, known as High-Com II that is sold in the U.S. in its consumer version by Nakamichi. Sanyo has a system called Super-D (which, like High-Com II provides about 20 dB of noise reduction), while Toshiba markets (in Japan only, thus far) a noise-reduction system known as ADRES, that is similar in concept to the dbx system.

One obvious common characteristic of these new noise-reduction systems is that all can improve S/N by 20 dB or more, compared with the 10-dB maximum of Dolby B. Despite the widespread acceptance that had been achieved, pressure on Dolby began to mount, even to the point where competing noise reducers were finding their way into consumer cassette decks right beside the familiar B system. It began to seem that the sun was setting on the mountain of which Dolby B had been king for so long.

But the limitation to 10 dB of noise reduction for Dolby B had been neither capricious nor abritrary. It is generally conceded that the more compression/expansion there is applied to an audio signal, the more likely it is that modulation of the noise accompanying the signal by the compander will become audible. (This is the source of the much dreaded "breathing" or "pumping" heard in some systems at times.) Furthermore, precisely because Dolby B had been so widely accepted, it was necessary that any new Dolby system be at least reasonably compatible with its predecessor. Finally, it would be desirable that, as is the case with B, a tape encoded in the new system be tolerable to listen to undecoded. At last, early this year, Dolby felt that it had sufficiently met these challenges and introduced a consumer noise-reduction system that offered a 20-dB improvement in S/N for any given recorder or tape. That system, logically enough, was called Dolby C noise reduction.

How Dolby C Works. Dolby C noise reduction lowers the noise inherent in low-speed tape recordings by about 20 dB above 1 kHz. Figure 1 is a multiple plot of noise spectra measured with a constant-bandwidth wave analyzer and weighted using the CCIR/ARM curve to reflect the ear's sensitivity to low-level noise. While Dolby B reaches its greatest effectiveness above approximately 4 kHz and from there upward reduces noise by about 10 dB compared with unprocessed tape recordings, Dolby C reaches full effectiveness at about 1 kHz and offers as much as 20 dB of noise reduction above that frequency. Like the two other Dolby systems (in addition to Dolby B, there is the professional Dolby A system) Dolby C is double-ended. The signal is processed during recording and "deprocessed" in

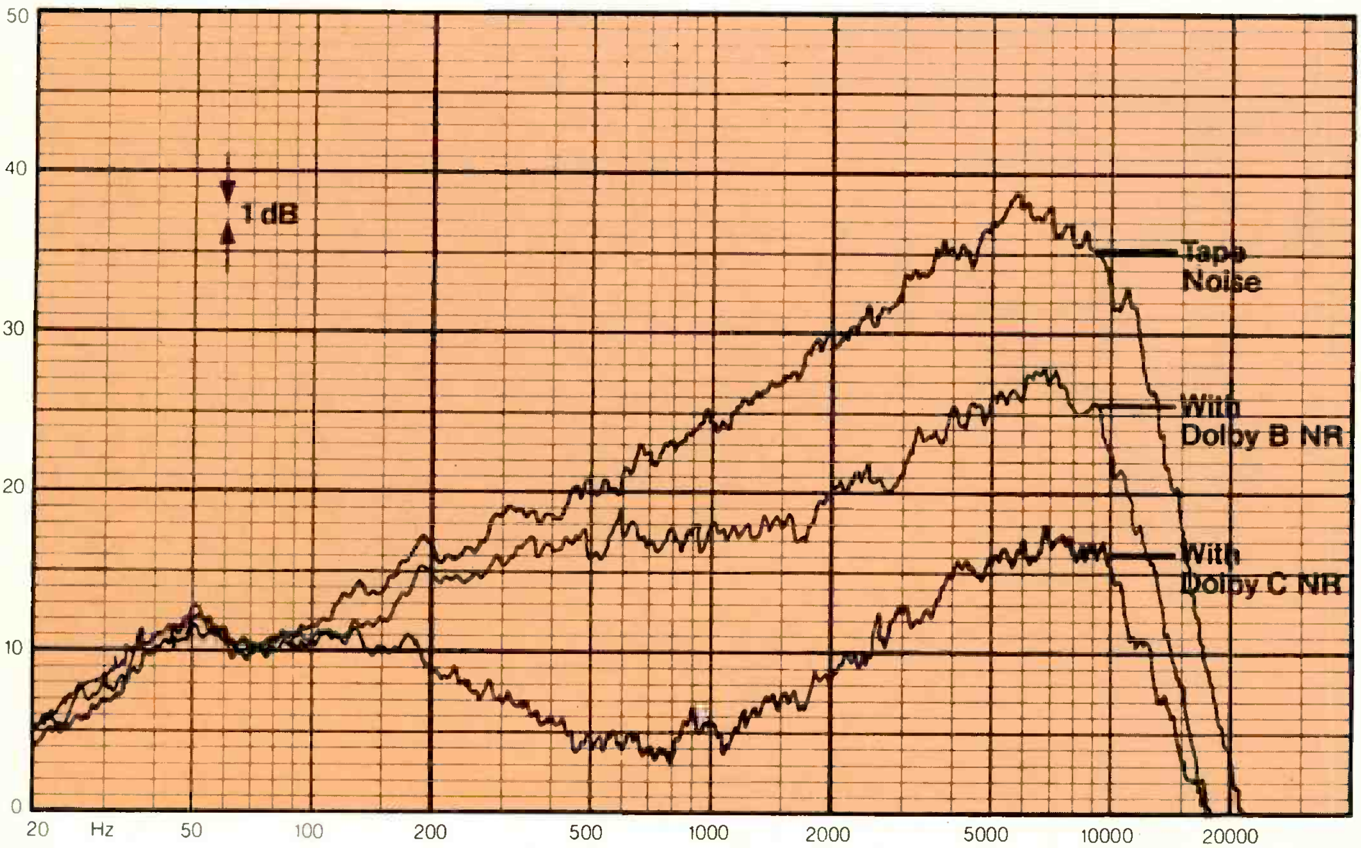


Fig. 1. Comparison of noise (CCIR/ARM weighted) from cassette tapes without noise reduction, with Dolby B, and with Dolby C noise reduction.

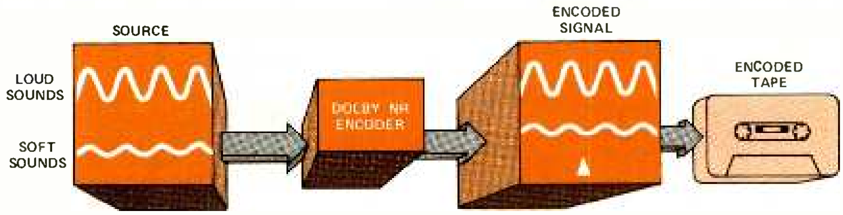


Fig. 2. In encoding, low-level mid- and high-frequency signals are boosted, high-level signals are not altered.

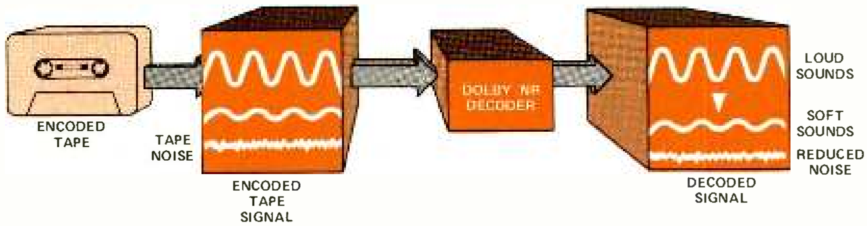


Fig. 3. In Dolby C decoding, low-level signals previously boosted are restored to correct relative amplitudes.

playback. This is illustrated in Figs. 2 and 3. Like Dolby A and B, Dolby C operates only at low program levels, where noise is audible, leaving unaltered high-level sounds that normally can mask tape hiss. Also, like Dolby B, Dolby C is a "sliding band" system. Full noise reduction occurs only in that part of the spectrum where it is most needed.

The chief difference between Dolby C and Dolby B is the *amount* by which signals are boosted during the recording half of the process and attenuated during playback. Dolby C also operates over a greater range of frequencies than did Dolby B, extending noise reduction downward to midrange frequencies, as plotted in Fig. 4. Achieving these new capabilities while satisfying all necessary constraints required several new developments.

A simplified block diagram of the Dolby C encode/decode circuitry is shown in Fig. 5. Each circuit incorporates two sliding-band stages that operate much as does a Dolby B processor. The two operate at different levels, however. Each stage provides 10 dB of compression during recording and the complementary expansion during playback. The high-level stage of Fig. 5 is sensitive to signals at about the same levels as the B-type. Since the two stages operate in tandem, their effect is to successively multiply the signal (or its equivalent, to add or subtract the corresponding number of dB) so that a total of 20 dB of compression/expansion takes place during encode/decode. This, in turn, results in a net reduction in noise of 20 dB. At no time is the program signal subjected to 20 dB of compression or expansion by a *single circuit*. Figure 6 illustrates the principle involved. According to Dolby, the tandem two-stage configuration is much more accurate than a single compander circuit would be.

In addition to the tandem processing, Dolby C incorporates two further developments worth mentioning. One of these, called spectral skewing, reduces the likelihood of encode/decode errors by reducing the sensitivity of the processing circuitry to frequency-response errors above 10 kHz. This allows for the usual variations in high-frequency response often encountered in casual use of a cassette recorder (such as by using a tape for which the deck has not been optimally adjusted). In Fig. 4, the plot shows that the maximum amount of compression in the C-type system diminishes above 10 kHz and crosses the B-type curve at around 20 kHz. This reduction in high-frequency compression results from the spectral-skewing and anti-saturation networks in the C system (Fig. 5). The anti-saturation network, as its name implies, operates at high signal levels to prevent tape saturation. Nakamichi, one of the first manufacturers to introduce Dolby C (albeit as a separate add-on unit), has demonstrated that Dolby C, used with the Model 1000ZXL Cassette Recorder and metal tape, provided a record/play frequency response at 0 dB recording level that was down only 1.0 dB at 20 kHz. Without the anti-saturation networks, record/play response for the same conditions was down some 11 dB at the same frequency.

Recordings made with C-type noise reduction, while not perfectly reproduced, will be listenable when played back on cassette decks equipped with Dolby B decoding. They will even be tolerable with no noise reduction, though purists would say that to call this compatibility is stretching a point.

How Expensive Will It Be? Dolby C-type noise-reduction circuitry is more complex than the B system, and will cost more to incorporate into consumer cassette decks. For the moment, two Dolby-B IC circuits can be configured to carry out C-type noise reduction. Further-

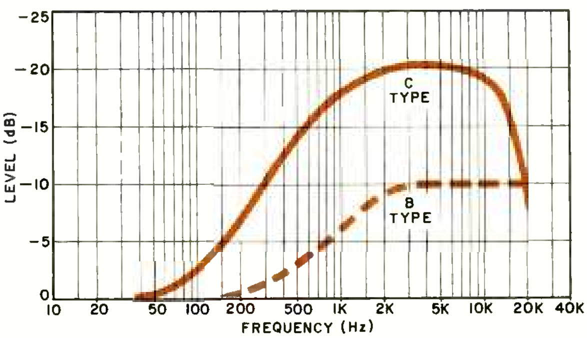


Fig. 4. Comparison of low-level encoding frequency response for Dolby B and Dolby C noise reduction systems.

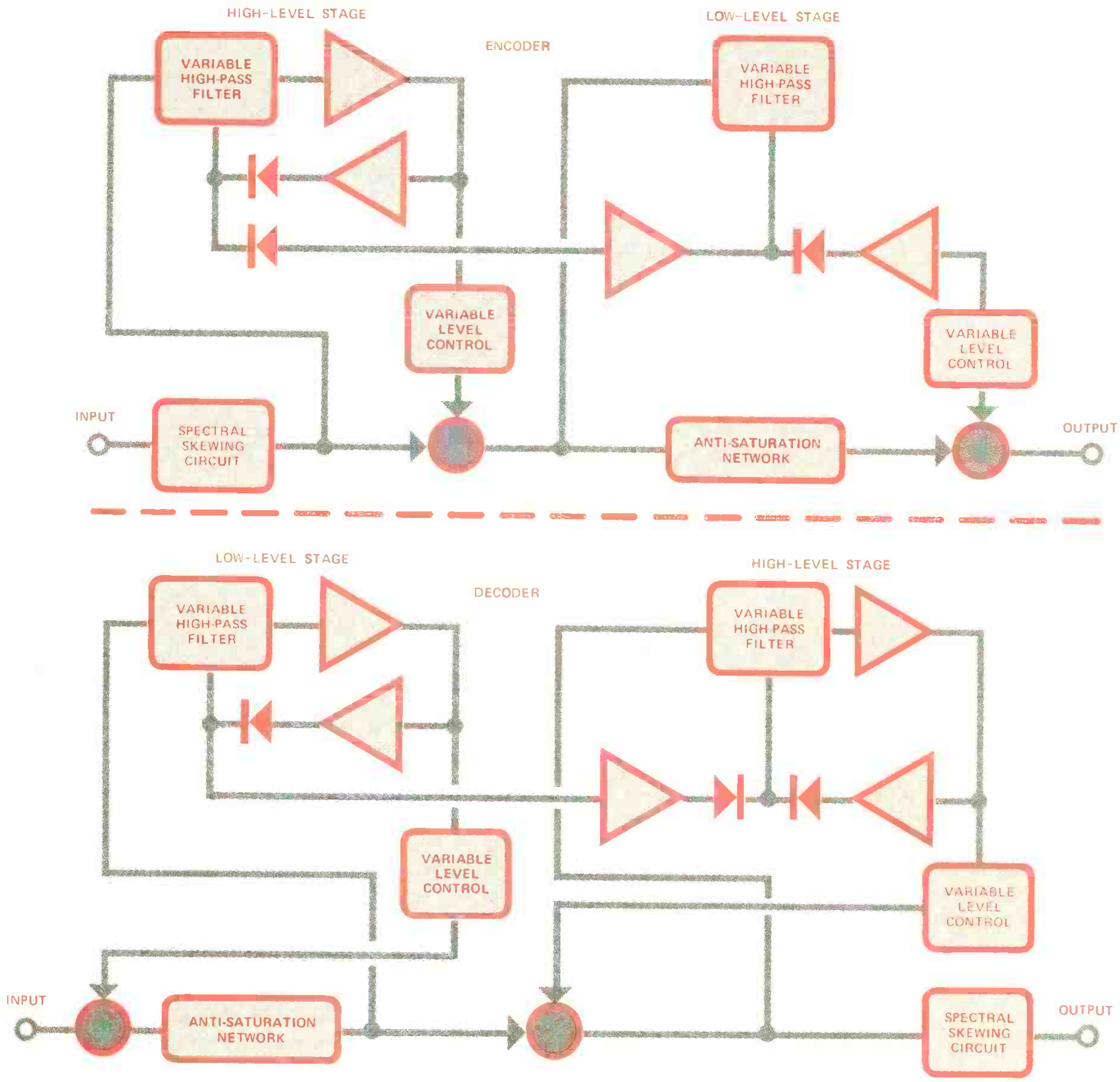


Fig. 5. Simplified block diagram of the encoding and decoding circuitry for a Dolby C noise reduction system.

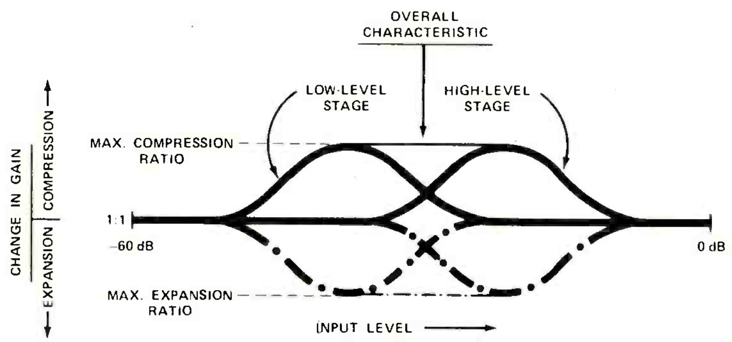


Fig. 6. In the two-level, two-stage Dolby C configuration, effects of the two stages multiply (add in dB) to achieve the full 20 dB of processing required.

more, one of the two stages can be conveniently reconfigured through switching to provide the B-type characteristic as well. It is expected that upcoming development of an IC chip for the C system will reduce costs further yet, but they will always be somewhat higher than those of Dolby B.

On the positive side, Dolby C should not represent a substantially larger fraction of the cost of the cassette decks in which it appears than does Dolby B now. This is because it takes a high-performance recorder to realize the benefits of the new system. Naturally, such machines are expensive to begin with, so it seems reasonable to suppose that the extra cost of Dolby C will not be much more than proportionate, if that. ◇

BUILD THE POOR MAN'S STROBE

Inexpensive circuitry allows timed, sequential flashes for multiple photographic exposures of moving subjects

BY IMRE GORGENYI*

STROBOSCOPIC photography, which exposes a single frame with light from a sequence of timed flashes, is an interesting way to capture a moving subject on film. The result is a series of still images that catch the subject in successive positions along its path, clearly suggesting motion. Stroboscopic photographs of a gymnast working out appear on the cover of this issue.

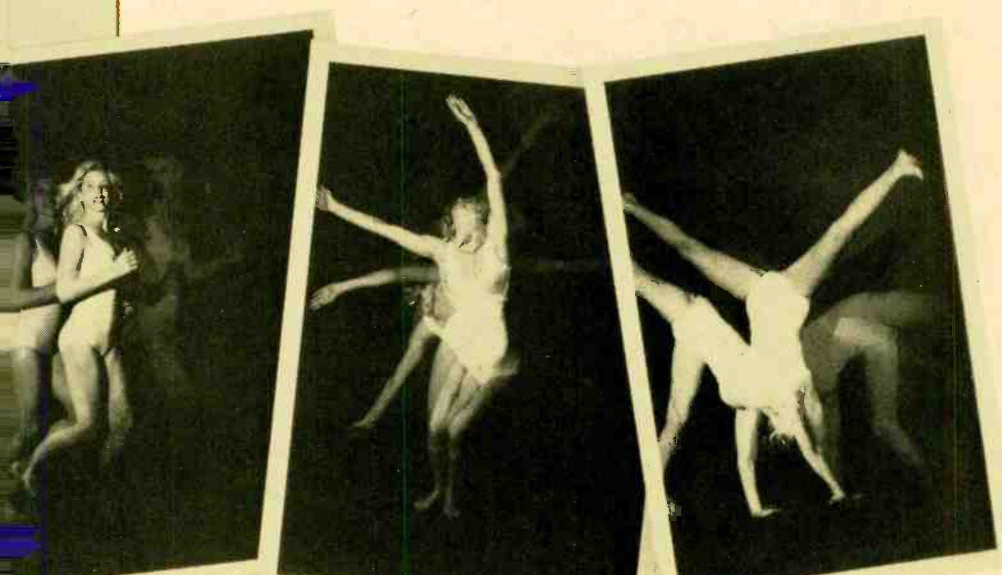
Unfortunately for shutterbugs, commercial equipment for stroboscopic photography is high in price. There are, however, circuits designed around readily available, inexpensive components that are easily built and will enable amateur photographers to experiment with the technique.

*Motorola Semiconductor Group

The Basic Poor Man's Strobe. The circuit (Fig. 1) triggers a flash unit at a predetermined time after the receipt of a light pulse from another flash unit actuated by the camera's flash-sync output. A portion of the light from the camera-triggered flash falls on the window of phototransistor *Q1*, which briefly conducts. The resulting negative voltage pulse at the collector of *Q1* triggers the timing circuit comprising *C1*, *R2* through *R6*, and *Q2*.

At the end of the timing interval, whose duration is adjustable by means of potentiometer *R3*, *Q3* and its associated passive components generate a positive voltage pulse and couple it to the gate of *SCR1*. The SCR breaks into conduction and triggers the flash unit whose sync contacts are connected to jack *J1*. Simultaneously, the timing circuit resets itself by means of *R6* to prepare for the next triggering light pulse. Power for the circuit is provided by a 9-volt alkaline battery via switch *S1*. Quiescent current drain is approximately 1 mA, so long battery life can be expected.

The delay between the arrival of the triggering light pulse and the actuation of the secondary flash can be varied from approximately 0.1 to 1 second. For shorter delays, the value of *C1* can be reduced to 0.1 μF. If this is done and *R3* is set for minimum resistance, the delay is so short that the attached flash unit can be used as a simple slave. Light from the slave will reinforce that from the camera-triggered unit and will yield brighter or more diffuse lighting of the subject. Of course, a number of basic Poor Man's Strobes can be built and each one adjusted for a different delay time to produce multiple images on a single emulsion.



Other Circuits. The slave-trigger circuit in Fig. 2 has practically no delay at all. It is therefore suitable for situations in which the slight delay introduced by the timing circuit of the PMS would cause an undesirable second image or smearing. This circuit has two unusual characteristics—it is not triggered by steady-state ambient light, and it derives its modest operating power from the flash to which it is connected.

Although ambient light would tend to cause phototransistor *Q1* to conduct, inductor *L1* prevents this from happening. Upon receipt of a light pulse, however, a voltage is set up across the inductor and the base-emitter junction of the phototransistor, and the device briefly conducts. This in turn forward-biases the base-emitter junction of switching transistor *Q2*, and a positive voltage appears across *R12*. The SCR breaks into conduction and triggers the flash unit whose sync contacts are connected to jack *J1*. A manual trigger switch (*S1*) is wired in parallel with *SCR1*. Power for *Q1* and *Q2* is derived from the flash unit by means of voltage divider *R3R4* and storage capacitor *C1*, which is wired in parallel with the *R3* leg of the voltage divider. The circuit's power requirements are so modest that almost any flash unit can easily satisfy them.

The circuit shown in Fig. 3 is a sequential flash trigger that can ac-

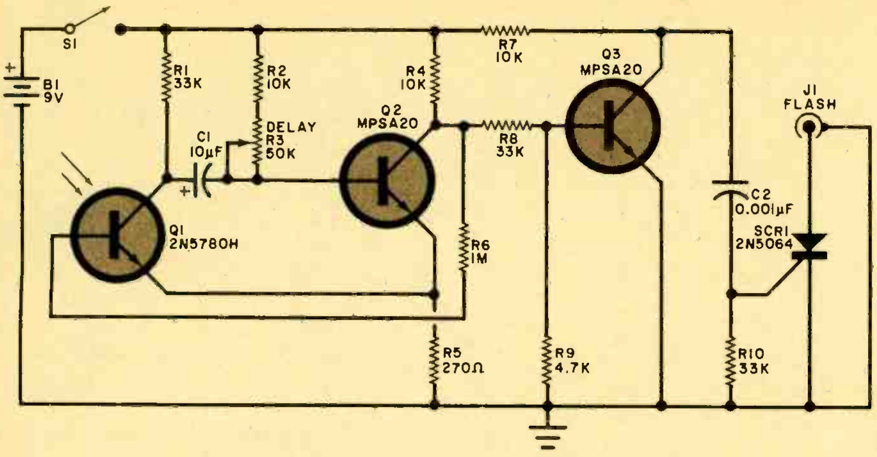
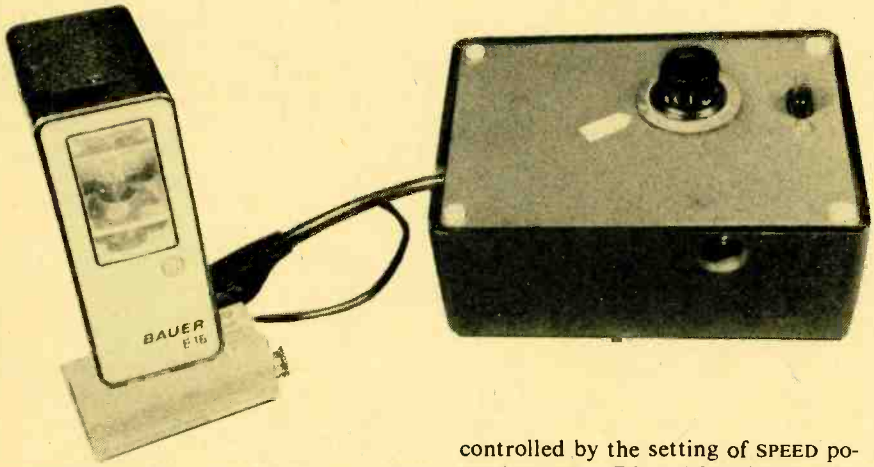


Fig. 1. Schematic diagram (above) of the basic Poor Man's Strobe. Below, a photograph of the author's prototype. The large control knob determines delay between trigger pulse and actuation of flash.

PARTS LIST

B1—9-volt alkaline battery
C1—10-µF, 16-V tantalum capacitor
C2—0.001-µF, 50-V disc ceramic capacitor
J1—Suitable jack (chosen to match the plug of the flash unit's sync extension cord)
Q1—2N5780H npn silicon phototransistor
Q2,Q3—MPSA20 npn silicon transistor
R1,R8,R10—33-kΩ, ¼-W, 10% resistor
R2,R4,R7—10-kΩ, ¼-W, 10% resistor
R3—50-kΩ, linear-taper potentiometer
S1—Spst switch
SCR1—2N5064 or similar silicon controlled rectifier (minimum voltage rating, 200 volts)
Misc.—Perforated board, battery holder, battery clips, sync extension cord, control knob, suitable enclosure, hookup wire, solder, hardware, etc.



tuate as many as five flash units. These units will be triggered at equal intervals after the camera's sync contacts close. The circuit functions as follows: when the sync contacts close, transistor *Q3* cuts off and capacitor *C2* begins to receive charging current from the constant-current source comprising *Q4*, *Q5*, and their associated passive components. The ramp voltage that appears across the capacitor is coupled to position 1 of switch *S2* by Darlington emitter follower *Q6*. If *S2* is in position 1, the ramp voltage is applied to the gates of *SCR2*, *SCR3*, *SCR4*, and *SCR5* through a series of voltage dividers. The gate of *SCR1* receives a separate voltage pulse via a different circuit path almost immediately after the camera's sync contacts close.

As the ramp voltage at the pole of *S2* increases in amplitude, *SCR2*, *SCR3*, *SCR4*, and *SCR5* successively break into conduction and trigger the flash units to whose sync contacts they are connected. The rate at which the SCRs fire is determined by the slope of the ramp, which is ultimately controlled by the setting of SPEED potentiometer *R9*. The lower the resistance of *R9*, the greater the output of the constant-current source. Thus, more current will flow through *LED1*, and the LED will glow more brightly to indicate that the slope of the ramp will be steep and the flash sequence rapid. The total duration of the flash sequence can be adjusted from approximately 50 milliseconds to 3 seconds.

The monostable multivibrator comprising *Q1*, *Q2* and associated passive components performs two functions. First, it triggers *SCR1* when the camera's sync contacts close. Then, after three seconds, it resets the rest of the circuit to prepare for the next flash sequence. When switch *S2* is in position 2, the initial pulse across *R1* is simultaneously applied to the gates of *SCR1* through *SCR5*, triggering all the flash units simultaneously. Power

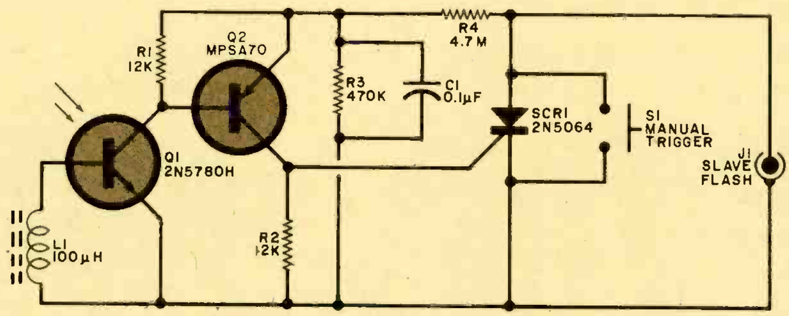


Fig. 2. Circuit for a slave-flash trigger that is not affected by steady-state ambient light.

PARTS LIST

C1—0.1-µF, 250-V Mylar capacitor
J1—Suitable jack (chosen to match the plug of the slave flash unit's sync extension cord)
L1—100-µH choke
Q1—2N5780H npn silicon phototransistor
Q2—MPSA70 pnp silicon transistor
R1,R2—12-kΩ, ¼-W, 10% resistor
R3—470-kΩ, ¼-W, 10% resistor
R4—4.7-MΩ, ¼-W, 10% resistor
S1—Normally open, momentary-contact pushbutton switch
SCR1—2N5064 or similar silicon controlled rectifier (minimum 200-volt rating)
Misc.—Perforated board, sync extension cord, suitable enclosure, hookup wire, solder, hardware, etc.

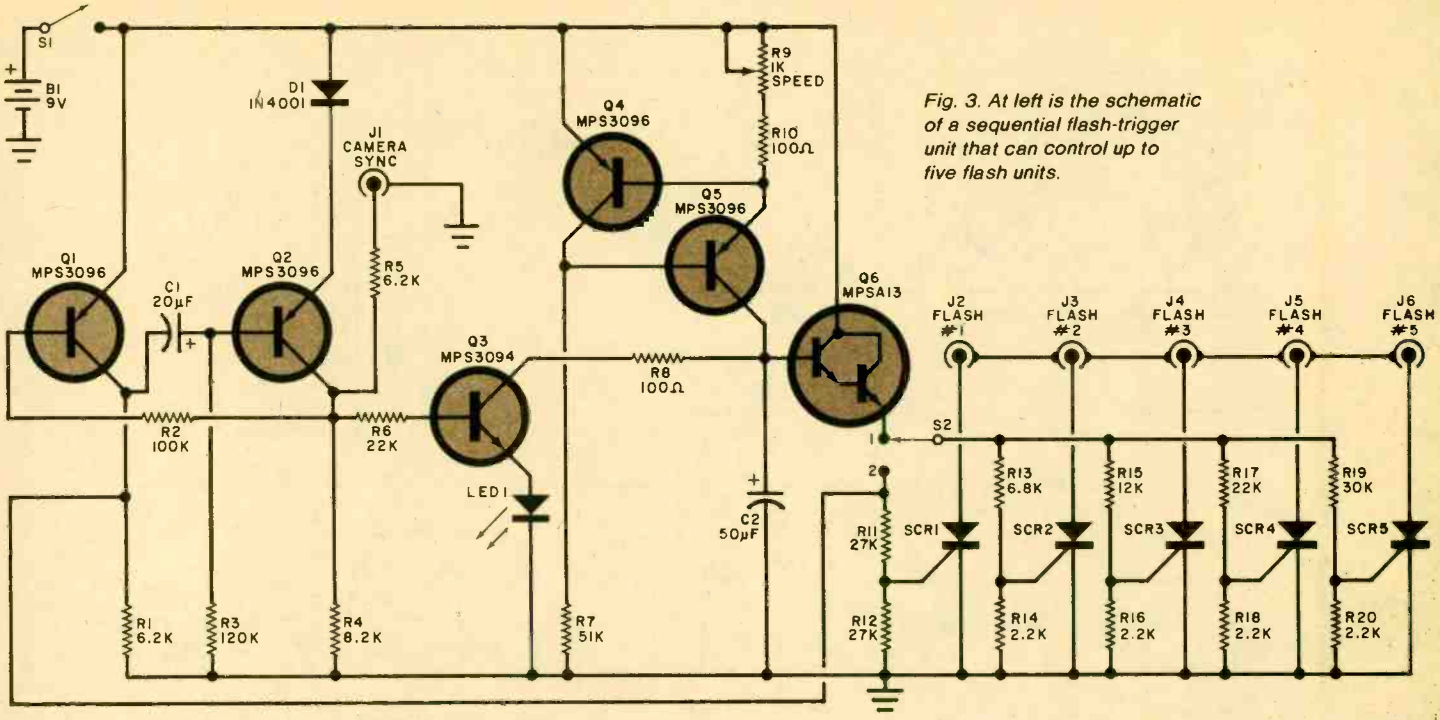


Fig. 3. At left is the schematic of a sequential flash-trigger unit that can control up to five flash units.

PARTS LIST

B1—9-volt akaline battery
C1—20-µF, 25-V aluminum electrolytic
C2—50-µF, 25-V aluminum electrolytic
D1—1N4001 rectifier
J1—Suitable jack (to match the plug of the camera's sync extension cord)
J2 through J6—Suitable jacks to match the plugs of the sync extension cords for Flash #1 through Flash #5)
LED1—Light-emitting diode
Q1,Q2,Q4,Q5—MPS3096 pnp silicon switching transistor
Q3—MPS3094 npn silicon transistor
Q6—MPSA13 npn silicon transistor

The following, unless otherwise specified, are 1/4-W, 10% tolerance, carbon-composition fixed resistors
R1,R5—6.2 kΩ
R2—100 kΩ
R3—120 kΩ
R4—8.2 kΩ
R6,R17—22 kΩ
R7—51 kΩ
R8,R10—100 Ω, 1/2-watt
R9—1-kΩ, linear-taper potentiometer
R11,R12—27 kΩ
R13—6.8 kΩ
R14,R16,R18,R20—2.2 kΩ
R15—12 kΩ
R19—30 kΩ
S1—Spst switch
S2—Spdt switch
SCR1 through SCR5—2N5064 or similar silicon controlled rectifier (minimum voltage rating, 200 volts)
Misc.—Perforated board, sync extension cords, suitable enclosure, battery holder, battery clips, control knob, hookup wire, LED mounting collar, solder, hardware, etc.

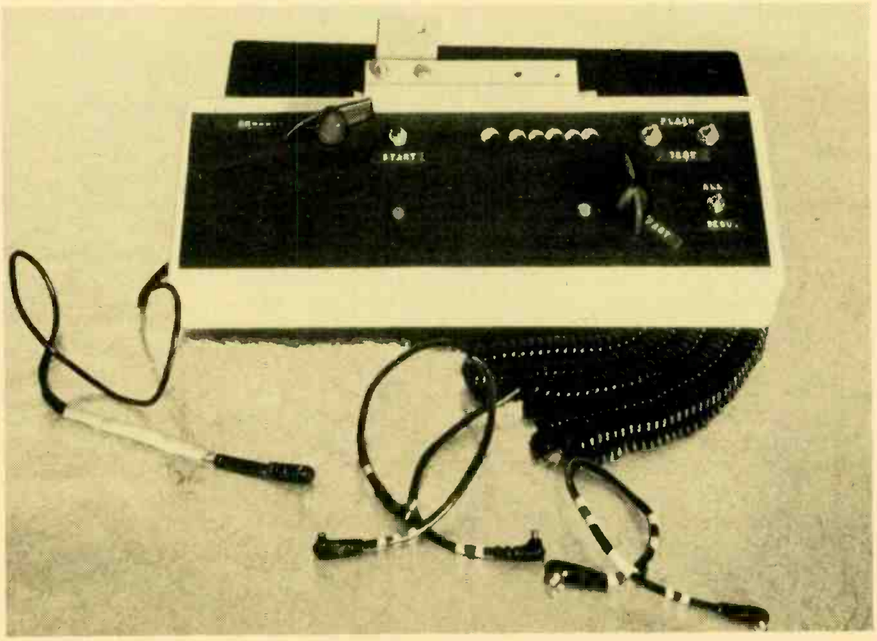


Photo of the prototype sequential flash-trigger unit.

for the circuit is supplied by 9-volt alkaline battery *B1* via switch *S1*.

Another sequential flash trigger circuit is shown schematically in Fig. 4. Here, the trigger pulse from the camera's sync contacts enables unijunction transistor *Q1* to generate clock pulses that drive CMOS decade counter/decoder *IC1*. The rate at which clock pulses are generated is determined by the position of rotary switch *S3*, which selects one of five RC timing networks (*R22C3* through *R26C7*). The gate of *SCR1* is driven by the output pulses of the UJT, but the gates of the other SCRs are driven by various of the counter's decoded output lines. Switch *S1* allows the user to determine whether the gate of *SCR5* will be driven by the Q_4 or Q_6 output line of the counter—that is, whether the flash unit connected to

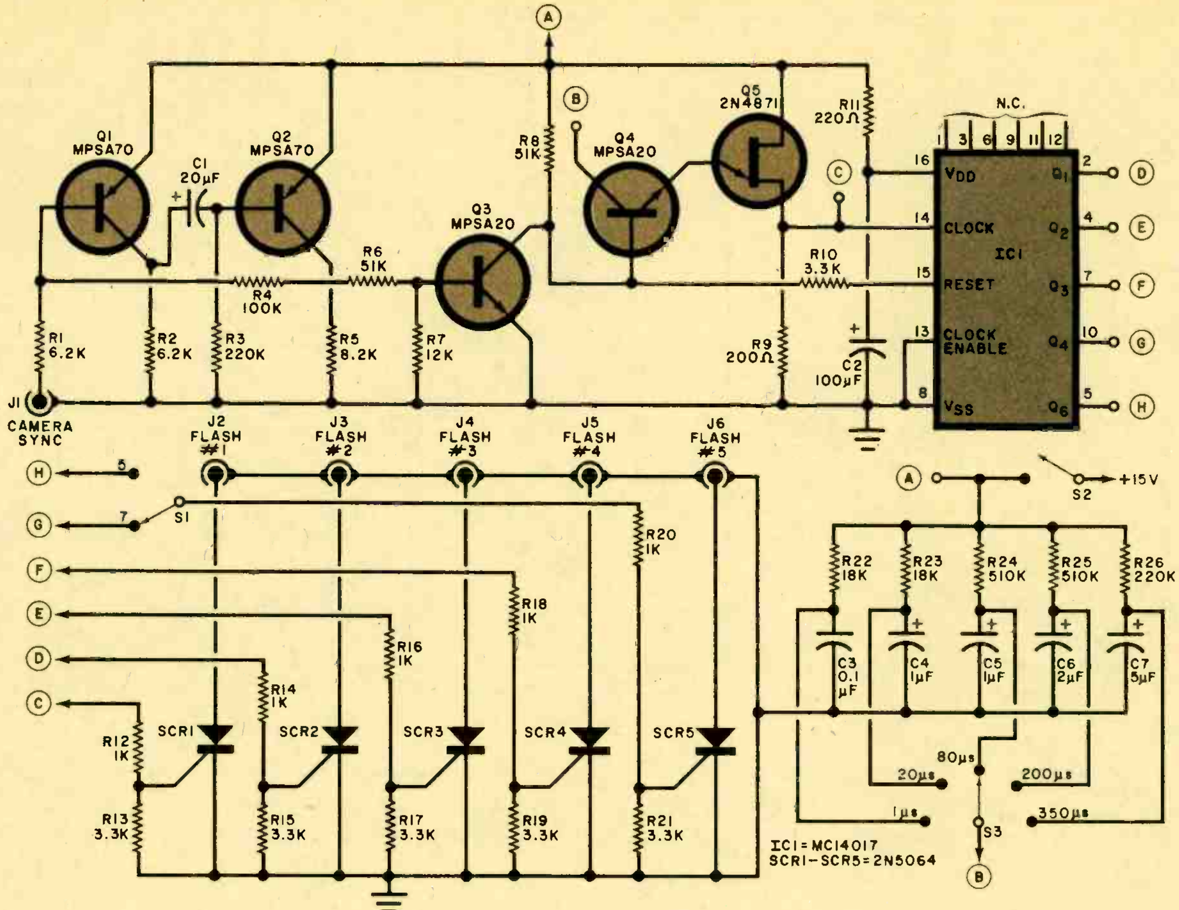


Fig. 4. Another sequential flash-trigger unit. This circuit employs a UJT clock and a CMOS decade counter/decoder.

PARTS LIST

C1—20-μF, 25-V aluminum electrolytic
C2—100-μF, 25-V aluminum electrolytic
C3—0.1-μF, 50-V Mylar capacitor
C4,C5—1-μF, 25-V tantalum capacitor
C6—2-μF, 25-V tantalum capacitor
C7—5-μF, 25-V tantalum capacitor
IC1—MC14017 decade counter/decoder
J1—Suitable jack (to match the plug of the camera's sync extension cord)
J2 through J6—Suitable jacks (to match the plugs of the sync extension cords for Flash #1 through Flash #5)
Q1,Q2—MPSA70 pnp silicon transistor
Q3,Q4—MPSA20 npn silicon transistor
Q5—2N4871 unijunction transistor
The following, unless otherwise specified, are 1/4-W, 10% tolerance, carbon-composition fixed resistors.
R1,R2—6.2 kΩ
R3,R26—220 kΩ
R4—100 kΩ
R5—8.2 kΩ
R6,R8—51 kΩ
R7—12 kΩ
R9—200 Ω
R10,R13,R15,R17,R19,R21—3.3 kΩ
R11—220 Ω
R12,R14,R16,R18,R20—1 kΩ
R22,R23—18 kΩ
R24,R25—510 kΩ
R26—220 kΩ
S1—Spdt switch
S2—Spst switch
S3—Single pole, 5-position nonshorting rotary switch
SCR1 through SCR5—2N5064 or similar silicon controlled rectifier (minimum 200-volt rating)
Misc.—+15-volt power supply or battery, perforated board, sync extension cords, suitable enclosure, IC socket, control knob, hookup wire, solder, hardware, etc.

jack *J6* will fire at the fifth or seventh clock pulse. As in the circuit of Fig.3, a monostable multivibrator built around *Q1* and *Q2* resets the circuit to prepare for the next flash sequence. Power for the circuit is provided by a +15-volt supply (not shown) via switch *S2*.

Construction. The prototype Poor Man's Strobes were assembled using perforated board and point-to-point wiring. However, printed-circuit construction can also be used. Type 2N5064 silicon controlled rectifiers are specified for each of the circuits that have been described. These devices have TO-92 plastic packages and are rated at 200 volts peak blocking voltage, 200 μA gate trigger current, and 6 amperes peak forward surge current. They are compatible with most flash units on the market. However, if you intend to use a flash unit that impresses more than 150 volts or so across its sync terminals, an SCR with a greater peak blocking voltage rating will have to be used.

Circuit layout is not critical, and the projects can be housed in any convenient enclosures. The various input and output jacks should be selected to match the plugs of the sync extension cords that your photographic gear employs. Photographs of the prototypes whose circuits are shown in Figs. 1 and 3 appear with the respective diagrams. In the circuits of Figs. 1, 3 and 4, the use of alkaline cells will extend battery life. Be sure to observe standard CMOS handling procedures for *IC1* of Fig. 4 and to use an IC socket to mount it.

Using the Poor Man's Strobes. As with any photographic hardware, a good deal of experimentation is required to learn how to use the Poor Man's Strobes for the best results.

Start with two flash units in an unlit room with dark walls or wall coverings. If you are using the circuit shown in Fig. 1, connect one flash to the camera's sync contacts and the other to jack *J1*. If you are using one of the circuits shown in Figs. 3 and 4, connect one flash unit to *J2* and the other to *J3*. Run a sync extension cord from the camera to input jack *J1*. Place your camera in its "B" (bulb) exposure mode and either set the object to be photographed in motion or direct your model to move around the room. Trip the shutter and hold it open. One flash will fire immediately, and the other will be triggered after a delay. Release the shutter after the second flash has fired.

This first trial should be a "dry run" with no film in the camera. Your eyes will register the strobed images. Repeat the experiment several times, varying the delay between the triggering of the two flash units and the rate at which the object or model is moving. If you have built several of the basic Poor Man's Strobes or one of the sequential trigger circuits shown in Figs. 3 and 4, add more flash units to see how multiple-flash stroboscopic photographs will look.

Next, determine a sequence of connecting the flash units to the output jacks and applying power that does not result in inadvertent triggering of the units. The proper procedure might be as follows: apply power to the Poor Man's Strobe; connect the flash units to it; and finally apply power to the flash units.

Once you have acquired a feel for the Poor Man's Strobe, you can take real pictures. Here again experimentation is needed. Vary the positions of the flash units, use different levels of light output, and for color work place different color filters on each flash unit. With a bit of experience, you'll be able to turn out interesting and unusual photographs that are as much fun to display as they are to take. ◇

COMMERCIAL KILLER FOR A CLOCK RADIO

Low-cost system cuts off the audio on cue from the listener and restores it after one minute

BY HERBERT L. BRESNICK

DID you ever wish you could eliminate radio commercials and TV commercial sound? My clock radio, tuned to the local news station, is set for 6:00 a.m. This means 5 minutes of news interspersed with 5 minutes of commercials, and I find few things worse than listening to soap or laxative jingles at that hour! Fortunately, most commercials are exactly one minute long—which makes them not too hard to silence.

Basically, the system cuts off the audio on cue from the listener and uses a one-minute delay circuit to restore it—presumably after the commercial is over. Figure 1 shows the schematic diagram of the system, which uses about $3.00 worth of parts, depending upon the size and condition of your parts junkbox. Here's how it works: As soon as the commercial starts, push switch *S1* momentarily. This triggers *IC1*, a 555 IC timer chip, wired as a monostable. Triggering forces pin 3 of the IC high, operating relay *K1*, which pulls in, opening its normally closed contacts. These contacts, in series with the loudspeaker, squelch the audio. After one minute (as set by *C1* and *R1*), pin 3 goes low releasing the relay and restoring the audio—just in time for resumption of the broadcast.

The circuit is easily wired, point-to-point on a 2″ x 2″ piece of perf board. Supply voltage (9 to 12 volts) is tapped from the radio or TV at any convenient point, and one speaker lead is placed in series with the relay contacts. It is recommended that a resistor be placed across the two leads that normally feed the speaker, as most power circuits do not like to be left unloaded. A 10- or 20-ohm resistor will do fine. Wrap the board with tape to protect the wiring and position it in a convenient space inside the receiver. The trigger wires can be brought out through the rear of the set, and connected to a pushbutton switch that can be placed at any convenient location.

Adding the "commercial killer" to my radio, has restored my sanity, and I'm able to face the morning shower, my wife, and the world with a smile. It may do as well for you. ◇

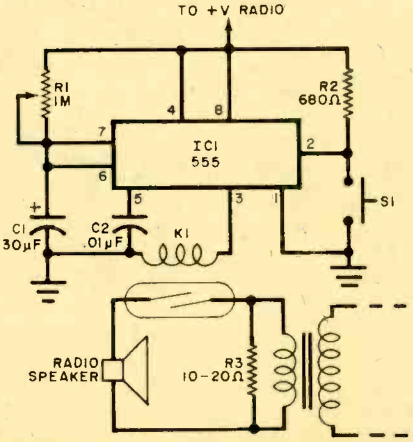


Fig. 1. Duration of silencer period is set by R1 and C1.

PARTS LIST

C1—30-µF, 15-V capacitor
C2—0.01-µF, disc capacitor
IC1—555 timer
K1—9-to-12-V, reed relay
R1—1-M Ω trimpot
R2—680 Ω, ½-W resistor
R3—10-to-20 Ω, ½-W resistor
S1—Momentary-contact pushbutton switch
Misc.—Perf board, wire, solder, etc.

AN 1802-BASED **EPROM PROGRAMMER**

Hardware and software to program, copy, and verify data in a 2708 EPROM, using an 1802 microprocessor

BY LARRY BREGOLI

MOST computer fans have a few favorite programs such as monitors, machine-language utilities, and even high-level languages that are used so often that storing them in ROM would be beneficial. When in this permanent memory, these programs can be accessed at any time, without the often tedious loading procedure. The ROM can even work from a power-up state.

There are numerous ROM programmers available for most systems, but few for those based on the 1802 processor. The programmer described here will help to alleviate this shortage. Although designed for 2708 devices, it can be user modified to accept 2716 devices. This permits doubling the ROM size with no increase in board space.

Circuit Operation. A simplified block diagram of the EPROM programmer is shown in Fig. 1. When the I/O Select Line calls for the programmer, three events occur. In conjunction with the arrival of the $\overline{\mathrm{MWR}}$ (memory write) signal, the Program-Cycle-Latch causes the Address-Latches to: (1) hold the address currently on the address bus; (2) remove the data latches from their three-state mode to allow them to latch and hold the data currently on the data bus; and (3) via the Program-Pulse-Circuit place the 2708 in the write-enable mode so that timing pulses from the CPU will allow a programming pulse to be applied.

The eight Three-State Switches remain in their high-impedance state until the 2708 is read. At this time the $\overline{\mathrm{MRD}}$ (memory read) pulse allows data from the 2708 to be placed on the system data bus. The read function is handled in this manner because it is easier than using the 2708's $\overline{\mathrm{CS}}$ (chip select) circuit that requires three voltage levels. The 2708 data lines go three-state when the $\overline{\mathrm{CS}}$ voltage is at +5 volts, and when the data is read from the 2708, the $\overline{\mathrm{CS}}$ line must be low (the same as ordinary RAM). The 2708 is placed in the write mode by bringing the $\overline{\mathrm{CS}}$ line to +12 volts.

The complete schematic is shown in Fig. 2. Some of the IC grounds shown are functionally necessary while others are required because all unused CMOS inputs must be terminated with either a ground or +5 volts to avoid noise problems. The reset (pin 4) of *IC1*, the program cycle latch, is connected to the system reset line, while the clock input (pin 3) is connected to one of the N lines from the 1802. The Q signal at pin 1 of *IC7A*, is the serial-output line of the 1802 and is set high or low by the system software. Note that the Q pulses cannot get to the pulse circuit unless *IC7A* is enabled by the pin 1 output of *IC1*. The only TTL device used is *IC9*.

The 2708 both sinks and sources current at its programming input (pin 18) during programming and this must be included in the circuitry or the voltage at this pin will be pulled up by the sink current during the low-voltage level of the program pulse. Pin 4 of *IC9* provides this function. Data latches *IC2* and *IC3* may be replaced with 4076's if you want to stick with all 4000-series IC's. The $\overline{\mathrm{MWR}}$ and $\overline{\mathrm{MRD}}$ pulses are both gated by the $\overline{\mathrm{CE}}$ (chip enable) signal from the addressing system. The $\overline{\mathrm{CE}}$ does not have to select the 2708 directly since the EPROM is always in the read mode when not being programmed. There's an additional advantage in this approach, since in the read mode the 2708 uses the minimum standby power without a special power-down circuit. The data-latching-strobe to *IC2* and *IC3* is a function of TPB, a timing pulse which occurs when the data is valid, via *IC7B* and *IC10C*.

The RC network coupled to programming pin 18 of the 2708 shapes the programming pulse so that voltage spikes will not occur inside the 2708 possibly creating an error in the programmed data.

Timing. The 2708 timing must be programmed for a minimum of 100 ms for each bit, and each bit can be programmed only for a maximum of 1 ms at any given time. This means that each bit must be programmed at least 100 times.

Another criterion for programming the 2708 is that, each time a portion of the memory is programmed, the remainder of the bits must also be reprogrammed. This will be described further under "Software." The only other timing consideration to account for is the minimum 10 μs setup time for the address and data information. All of these timing requirements are

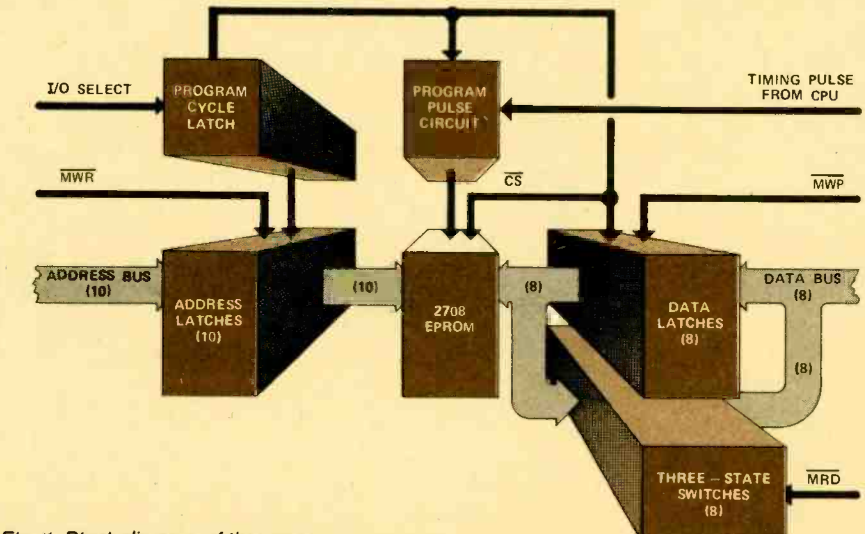


Fig. 1. Block diagram of the programmer.

handled by the programming software to keep the hardware simple.

Software. A fully erased 2708 contains all "ones" and the programmer replaces these with zeros where specified during the programming mode. Once a zero bit is programmed, it cannot be changed back to a one by programming. If you make an error and put a zero in the wrong location, the only way it can be rectified is erasing the EPROM with UV to produce all ones again, and then re-start the programming.

About 1K of RAM is required to assemble and hold the data to be programmed into the EPROM. This RAM space must be initially programmed with all ones to avoid any unwanted zeros from appearing when programming is started. This is accomplished by copying the contents of the erased 2708 in the programming socket into the RAM space.

This method is also convenient for adding data to an EPROM which has been partially programmed. In this case, the existing programs in the EPROM are also copied into RAM

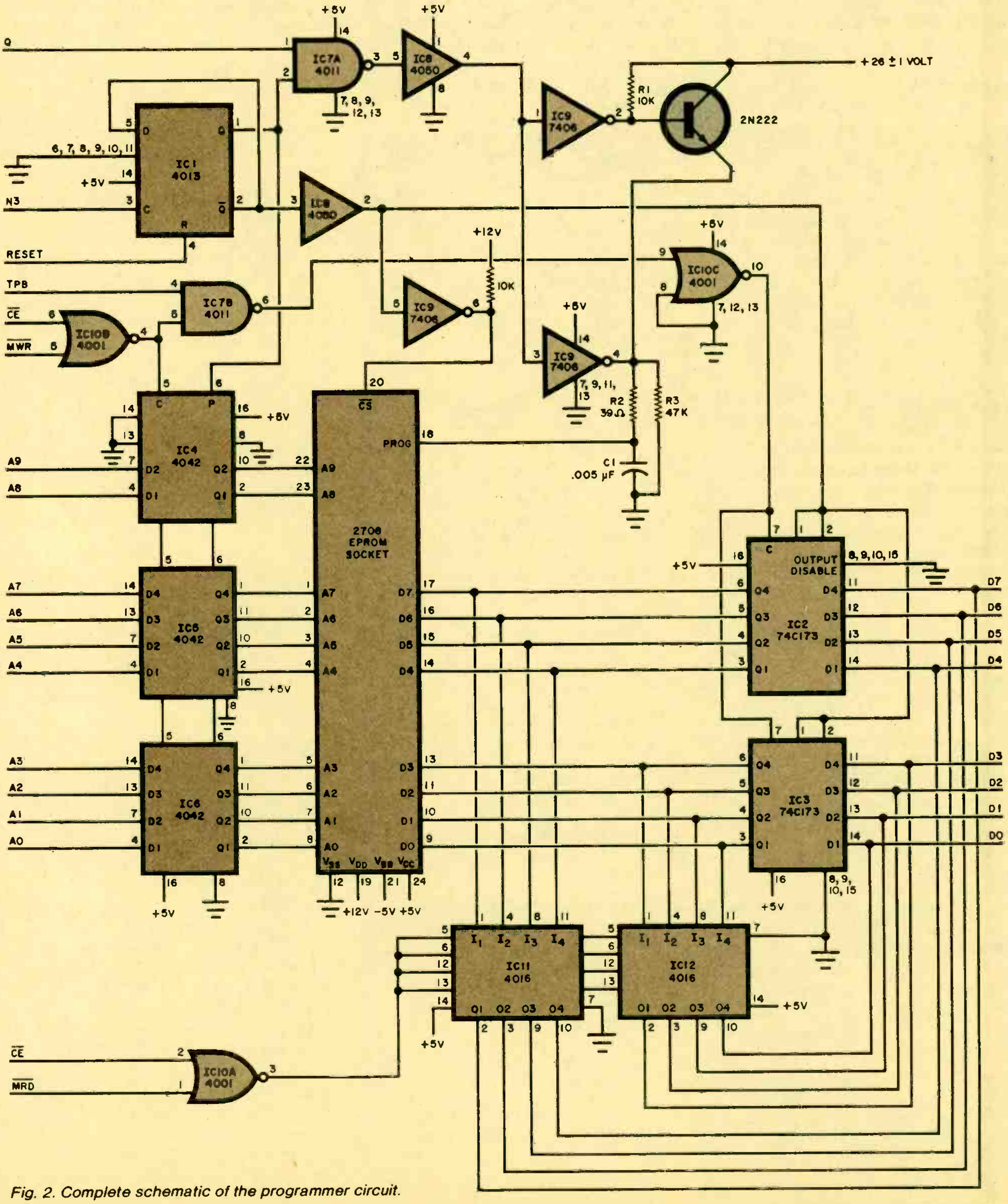


Fig. 2. Complete schematic of the programmer circuit.

and are reprogrammed back into the EPROM along with the added data. Keep in mind that, each time new data is added to the EPROM, all 1024 bytes must be programmed.

The three subroutines to be covered are called using conventional 1802 call and return techniques. The program locations are arbitrarily chosen. The items in parentheses are bytes that would have to be changed if any locations are modified. The COPY subroutine is shown in Listing 1. This is a simple move program of which many versions exist. In this case, the initiating routine sets pointers to the beginning address of the EPROM to be programmed and to the beginning address of the RAM area used to store the program. The bytes are then copied, one by one, from the EPROM into the RAM until all 1024 bytes in the EPROM have been copied.

New data to be programmed into the EPROM is placed in any available RAM space. When the new data has been entered into RAM, the BURN EPROM subroutine of Listing 2 is called to program data into the EPROM.

The BURN EPROM substitute should contain all the timing information needed to properly program a 2708 EPROM including the data and address setup times. When the subroutine is first entered, a counter is loaded with the number of times all 1024 words will be programmed. This number can vary from 100 to 1000 since the width of the programming pulse may be set from 0.1 to 1.0 ms, and the product must always be equal to or greater than 100 ms. An I/O pulse is then sent to the program-cycle-latch by way of line N3 to activate the programmer. Address pointers are then set to point to the starting addresses of both the EPROM to be programmed and RAM area holding the data. A byte, read from the RAM area, is written into the data-input latches, and simultaneously latches the address latches. Before application of the programming pulse, the 2708 needs a minimum of 10 μs to allow for data and address settling times. To accomplish this time delay, simply insert NOP instructions in the program before applying the programming pulse. The pulse-time-counter is then loaded with a number that describes the programming pulse width.

The Q line from the 1802 is then set high causing the programming pulse to begin. Next, the pulse-time-counter is decremented to zero, dictating the width of the programming pulse. The Q line is then set low, ending the pulse. The loop counter is decremented each time all 1024 words have been programmed; then a test for a zero in the loop counter is made. When the loop counter is zero, an I/O pulse is again sent to the programmer to take it out of the programming mode. It requires approximately 103 seconds to program all 1024 words into a 2708.

Some EPROMS may need more programming time to guarantee that all bits are properly burned. To do this, the number in the loop counter must be increased. If you have the BURN EPROM program already in the EPROM, simply burn the new one again using the same program.

To determine if you have burned all the bits properly, they can be tested using the VERIFY program shown in Listing 3. This routine compares each byte in the newly burned EPROM with the original data in RAM. If a mismatch is found, the Q line is set. The erroneous byte location can be shown on a monitor or a hexadecimal display. To determine if the VERIFY program is working properly, inset an intentional error in the RAM area and run the VERIFY program. ◇

LISTING 1—COPY

Location	Code	Comment
E4 1E	F8 (C8) B8	: Point R8 to RAM Area
E4 21	F8 (D0) B9	and
E4 24	F8 (00) A8 A9	R9 to beginning of EPROM
E4 28	09	: Get EPROM byte and
E4 29	58	put it in RAM
E4 2A	19 18	: Increment EPROM & RAM
E4 2C	99 FB (D4)	: If it's not the last
E4 2F	3A (28)	byte, get another
E4 31	D5	: RETURN

LISTING 2—BURN EPROM

Location	Code	Comment
E4 32	F8 65 AA	: Set loop counter to 101
E4 35	EB 63 2B	: Activate Programmer (N lines 3)
E4 38	F8 (C8) B8	: Point to starting locations
E4 3B	F8 (D0) B9	of RAM and EPROM
E4 3E	F8 (00) A9 A8	
E4 42	2A	: Decrement loop counter
E4 43	8A	: If loop counter is
E4 44	32 (5C)	zero then exit
E4 46	08	: Get RAM byte
E4 47	59	: Write byte into latches
E4 48	18 19	: Increment RAM & EPROM
E4 4A	C4 C4	: Waste time for settling data
E4 4C	F8 29 AE	: Load pulse time counter
E4 4F	7B	: Start programming pulse
E4 50	2E 8E	: Pulse width equals
E4 52	3A (50)	approx. 0.1 ms
E4 54	7A	: Stop programming pulse
E4 55	99 FB (D4)	: If it's not last
E4 58	3A (46)	byte get another byte
E4 5A	30 (38)	: Else do another loop
E4 5C	63 2B	: Deactivate EPROM
E4 5E	D5	: RETURN

LISTING 3—VERIFY BURN

Location	Code	Comment
E4 5F	F8 (C8) B8	: Point to start of
E4 62	F8 (D0) B9	RAM & EPROM
E4 65	F8 (00) A8 A9	
E4 69	E8	: Set X R8
E4 6A	99 FB (D4)	: If all bytes O.K.
E4 6D	32 (76)	then exit
E4 6F	09 F3	: Compare RAM byte with
E4 71	19 18	: EPROM and increment both
E4 73	32 (69)	if the same continue
E4 75	7B	: Else set Q
E4 76	D5	: RETURN

BUILD A HEADLIGHT MODULATOR FOR CYCLE SAFETY

Inexpensive circuit pulses the high beam to enhance visibility

BY STAN JONES

AS A safety precaution, riders of motorcycles and mopeds are required to have their headlights on when using public roads. Since even this is not always sufficient to ensure that they will be noticed by other drivers, devices have been developed to modulate the brightness of the headlight, enhancing its visibility. In most cases, the low beam is left on constantly, while the high beam is switched on and off at about a 4-Hz rate. When the headlight is switched to the high beam manually, the modulator is overridden and ceases to operate. In addition, if the circuit should fail to function properly, the normal headlight operation is not affected.

If motorcycles verge on being invisible to drivers of larger vehicles, bicycles are even harder to see. The modulator circuit described here can be easily modified to operate with the type of single-beam headlights commonly used on bicycles.

Circuit Operation. As shown in Fig. 1A, the circuit is based on a 555 timer operating as a slow astable square-wave generator. The ratio of *R1* to *R2* was selected to produce a nearly symmetrical waveform. Effectively, timing capacitors *C1* and *C2* charge through *R1* and *R2* and discharge through *R2* causing the output at pin 3 to be nearly square. The positive-going portion of the pulse turns switching transistor *Q1* on while the zero portion turns it off. When turned on, *Q1* acts as a closed switch to pass filament power from the dim to the bright headlight filament, causing it to glow as long as *Q1* is on. Diode *D1* passes only the positive-going excursions of the pulses.

Alternately, the circuit can be built around a relay as shown in Fig. 2. Just make sure that the selected relay will handle the current.

Power to operate the circuit comes from the low-beam circuit. When the

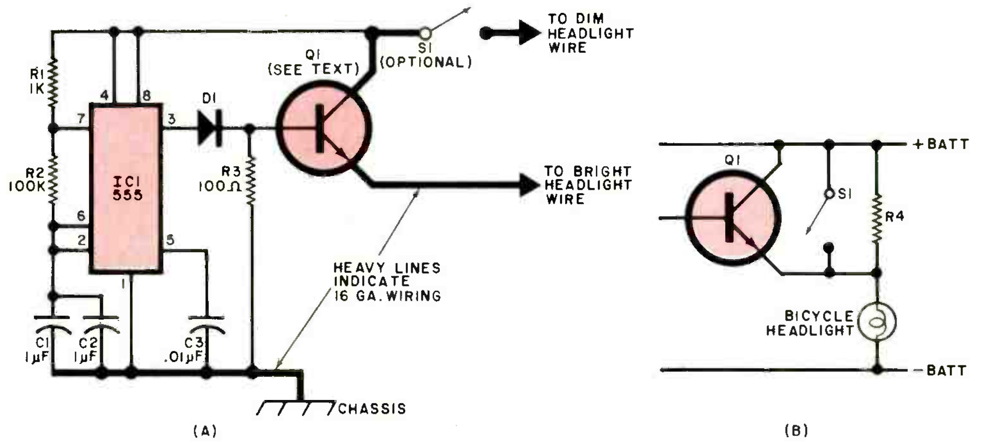


Fig. 1. Basic circuit (A) is based on a 555 timer. It can be modified as shown at (B) for a single-beam bicycle light.

PARTS LIST

C1, C2—1-µF, 34-V tantalum capacitor
C3—0.01-µF, 50-V disc ceramic capacitor
D1—1N914
IC1—NE 555 timer IC
Q1—ECG182 transistor (for 50-watt headlamp) or ECG184 transistor (for 30-watt headlamp)
R1—1-kΩ ½-W resistor
R2—100-kΩ, ½-W resistor
R3—100-Ω, ½-W resistor
S1—Optional spst toggle switch with 5-A contacts
Misc.—1½" × 1½" perf board, wire, solder, 8-pin socket (optional), short length of 16-gauge wire, mounting hardware.

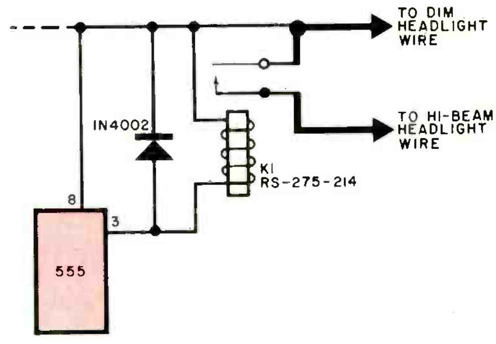


Fig. 2. A relay can be used instead of the output switching transistor.

project is wired to the motorcycle as shown, the high-beam indicator on the instrument panel will flash in-step with the strobe and serve as a visual indicator that it's working. Switch *S1* is an optional bypass switch that turns the entire unit off.

Figure 1B shows how the circuit can be modified to work with a single-beam bicycle headlight. Resistor *R4*, whose value and dissipation rating will depend on the particular headlight, is chosen to give an acceptable level of brightness when *Q1* is off. During the intervals when *Q1* is on, the lamp goes to full brightness. Switch *S1* has been connected to bypass the modulator when normal operation is desired. The additional power drawn by the pulsing circuitry is negligible.

Construction. Wiring of the modulator is not critical and any approach can be used. To allow mounting the finished unit inside the headlight housing, keep its size small. The finished project can be coated with a good silicone sealer, or protected inside a small plastic mini-box. Be sure to use good quality, low-leakage capacitors and test the unit before installation. Almost any npn power transistor will work fine for *Q1* as long as it can handle the required lamp current (5-7 amperes for a moped or small bike and 10 amperes or more for a bike with a 50-watt headlight). A heat sink will be required for *Q1*. Note the wire sizes called out in Fig. 1. As previously mentioned, a relay can be used in place of the transistor and the heat sink will not be needed. The relay drive current can be up to 150 mA and the contacts must, of course, be able to handle the lamp current.

The finished modulator can be mounted within the headlight housing, and all connections can be made without exposed wiring. If optional on/off switch *S1* is used, it can be mounted in a hole drilled in the modulator housing.

Operation. Dimming the headlight automatically starts strobing the high beam. On most motorcycles, the headlight switch can be set in the center position to provide both high and low beam illumination. If this position is used, the modulator is switched off.

Since materials for the unit cost only about $10, what excuse can there be for not building one for yourself? It might well save your life. ◇

Using the 4060 as a Timer

BY T.A.O. GROSS

MENTION timing circuits, and most people tend to think of the ubiquitous 555 IC. While the 555 is excellent for most timing applications, other devices are worthy of consideration. These are the CMOS CD4060A and SCL4060AB 14-stage ripple-carry binary counters from RCA and Solid State Scientific, respectively.

Among other advantages, the 4060-series devices can be less expensive to implement in a given application because they require less critical and less expensive resistors and capacitors. A second advantage is that 4060-series devices can deliver a number of output frequencies from the same RC components; the 555 delivers only one.

Technical Details. In a 555 timer circuit, external frequency-determining resistor and capacitor values must be selected to produce the desired oscillator frequency directly. As a result, in many cases where relatively long time constants (low frequencies) are desired, the RC product requires the use of bulky, expensive electrolytic capacitors with, often, inaccurate values and high losses.

Devices of the 4060-series use oscillator frequencies much higher than what is required at the output. The oscillator frequency goes through a 14-stage binary counter that divides it by as much as 16,384 (2^{14}) before it is used as the final timing frequency.

Using a much higher oscillator frequency than the 555 timer to obtain the same timing frequency the 4060 has a correspondingly smaller RC product. Hence, there is no need to use inaccurate and unstable electrolytic capacitors or humidity-sensitive, very-high-value resistors.

While the CD4060A and SCL-4060AB are interchangeable in most cases, the two are different. In the CD

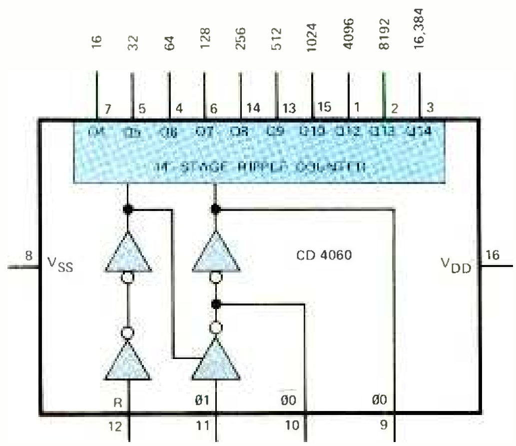


Fig. 1. Internal schematic arrangement of the RCA CD4060 timer integrated circuit.

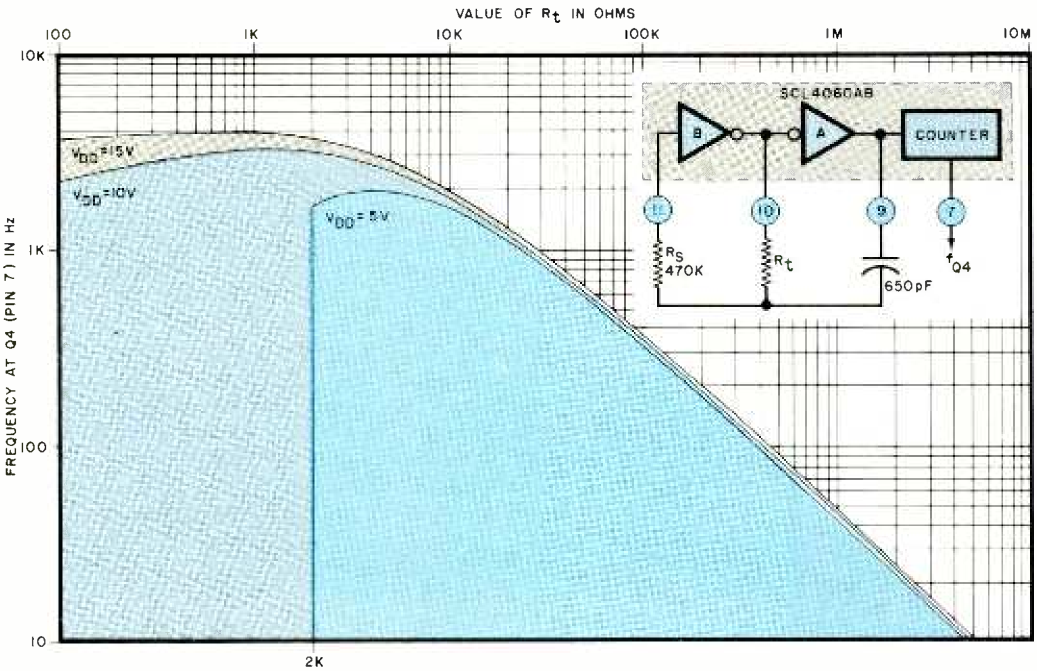


Fig. 2. With low values of timing resistor, R_t, the frequency of the circuit can vary with applied dc operating voltage.

device, the oscillator is keyed by the reset input, whereas in the SCL device, the reset operates on the dividers, leaving the oscillator in continuous operation.

Basic internal logic of the CD4060A is shown in Fig. 1. Two of the four inverters serve as the active elements of the internal oscillator whose output is passed through the 14-stage ripple-carry binary counter. Oscillator frequency is set by an RC network, or an external crystal oscillator can be connected to pin 9 to eliminate the need for the internal oscillator. When the internal oscillator is used, the input at pin 12 is provided to reset the counter to zero and disable the oscillator.

It is not necessary to use all 14 stages of division. As shown in Fig. 1, you can select division factors of 16, 32, 64, 128, 256, 512, 1,024, 4,096, 8,192, or 16,384, simply by picking off the output from the appropriate pin of the IC.

Timing resistance values for 4060-series devices should not be less than 10,000 ohms to avoid changes in frequency with changes in applied dc operating voltages. As can be seen in Fig. 2, the frequency/resistance function reverses at about 4,500 ohms with a 5-volt supply and at 1,300 ohms using 10 volts.

The frequency calculation formula for the 4060 given in manufacturer application notes is $F = 1/(2.2R_tC_t)$, where R_t and C_t are the values of the timing resistor and capacitor. This formula assumes V_{DD} is 10 volts, C_t is greater than 100 pF; R_t is greater than 1000 ohms, and R_s is larger than 10 times R_t. (R_s is the external stabilizing resistor, as shown in the inset schematic diagram in Fig. 2.) In this author's experience, this formula is accurate only when R_t is greater than 50,000 ohms. With values less than 50,000 ohms, observed frequency was lower than predicted by the formula.

Data given in Fig. 2 was obtained at the pin-7 (÷16) output from an SCL4060AB. With time delays of more than a few hours, it was determined that use of R_s is not necessary.

Practical Timer. Shown schematically in Fig. 3 is the circuit for a practical 1-minute timer built around a 4060-series device. A 330,000-ohm resistor and 0.01-μF capacitor are doing a job that would require a 60-megohm/microfarad *RC* product in a 555 circuit.

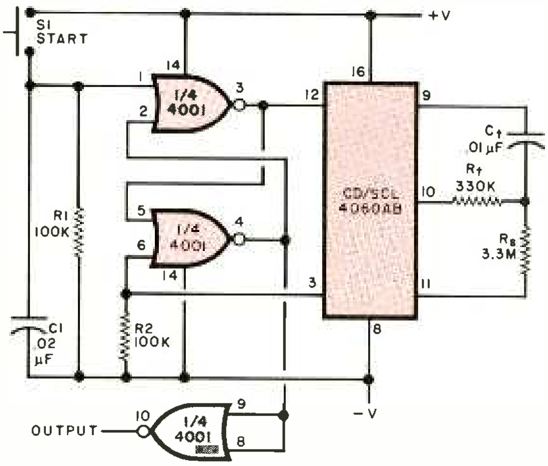


Fig. 3. With the values shown, this circuit has a one-minute delay period. The output strobe goes high after timeout.

Momentary closure of START switch *S1* causes the set-reset flip-flop made up from two gates in a 4001 quad 2-input NAND IC to produce a high output at pin 12 of the 4060. After the timing interval (oscillator frequency) determined by R_t and C_t, pin 3 of the 4060 goes low and toggles the flip-flop to stop the counter. At the same time, the output of the bottom 4001 gate, held low during the timing interval, goes high. (Since the 4001 contains four on-chip gates, the fourth gate can be paralled with the output stage to provide more driving current for an external circuit.)

Much longer timing intervals can be obtained by cascading the pin-3 output of the 4060 with a 4020, a 14-stage counter that is similar to the 4060 but lacks the internal oscillator.

Capacitor *C1* and resistor *R1* improve the circuit's immunity to noise and are optional.

Summing Up. Once you start working with 4060-series devices, you will probably think of them as often as you do the 555 for your timing applications. Their easy implementation into circuit designs and reduced demands on frequency-determining resistors and capacitors make them particularly attractive where costs must be kept down and hardware space is at a premium. And they offer a number of different output frequencies from a given RC network that gives them an important advantage over single-frequency-only timing devices. ◇

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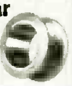

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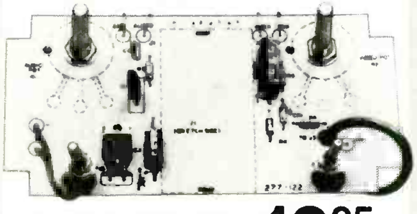

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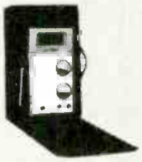

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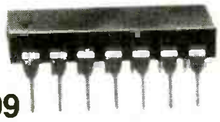

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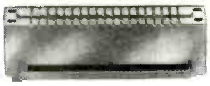

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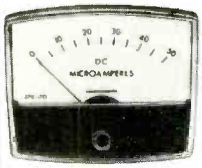

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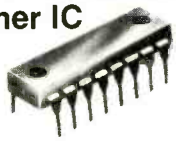

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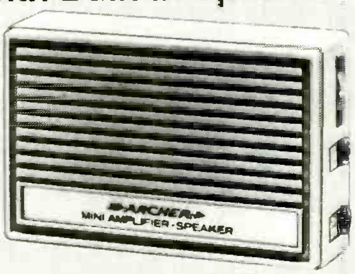

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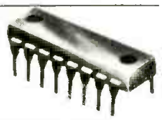

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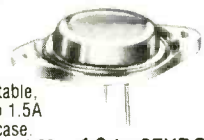

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BY M. T. VALESCU

AN APPLIANCE "OFF" REMINDER

A low-cost project provides an audible alert when an appliance indicator light goes off

IT IS often useful—sometimes vital—for the user of an appliance to know if and when it ceases to operate, whether by design or due to a power failure. Usually, this is not difficult to accomplish, since most appliances are equipped with indicator lights that show when they are working. But if the appliance is not in direct view, keeping track of it can be a great annoyance.

One solution to this problem is to use an electronic "eye" that senses the radiation from the indicator light and sounds an alarm when it is interrupted. For convenience, only the sensor is required to be physically at the monitoring point; the alarm can be located where it is easily heard.

The Lights-Out Alert described here provides the answer. It is battery powered and reliable; can be built from low-cost components; and is usable with almost any sort of power-on light indicator.

Circuit Operation. As shown in Fig. 1, phototransistor *Q1* and Darlington-connected *Q2* form a high-gain optical-to-electrical transducer that drives a charge pump made up of *Q3* and *Q4* and associated components.

When no light strikes *Q1*, its resistance should be high enough so that *Q2* is cut off. Any slight leakage from *Q2* should produce less than 0.7 volt across *R1*—not enough to turn on *Q3*. Assuming that capacitor *C1* has been discharged by the operation of *S1*, *Q4* also lacks the voltage required to turn it on. Thus, all four transistors are off and current from the battery is almost nil.

When light strikes *Q1*, its resistance drops, depending on the illumination level, and *Q2* is turned on. The voltage developed across *R1* turns *Q3* on provided *C1* is discharged. Thus *Q4* is driven deeper into cutoff. Current flows through *Q3* and *R2* to charge *C1*. When the voltage across *C1* rises to within 0.7 volt of that across *R1*, *Q3* is cut off. This condition will last as long as transistor *Q1* is illuminated.

When the illumination ceases, the voltage across *R1* drops. Since *C1* is charged high enough to reverse-bias *Q3*, this transistor cuts off and turns on *Q4*. Discharge current from *C1* now flows through *R2* and *Q4* to drive alarm *A1*.

After some time (about one minute per 10,000 microfarads of *C1*), *C1* becomes discharged and the alarm turns off. The circuit is then ready for the next illumination period, with no current drawn from *B1*. Switch *S1*, in conjunction with *R3*, provides manual silencing of the alarm. This switch should not be operated during the charging cycle of *C1* because this will tend to deplete the battery's charge.

Construction. The circuit consists of two physically independent sections—the light-sensitive portion and the alarm/power package, with the two interconnected by a length of flexible four-conductor cable.

The four transistors and two resistors that form the photosensor can be assembled on a small piece of perforated board or a small printed-circuit board. Make sure that the sensitive face of *Q1* is in the clear so that light can pass through a hole in the case and shine on this surface. Select a low-leakage device for *Q2*. If phototransistor *Q1* is a low-gain device (units vary with manufacturer), increase the value of *R1*. However, to avoid false alarms do not make the circuit too sensitive.

The board can be mounted in a small enclosure having a hole drilled so that external light can fall on the sensitive face of *Q1*. Another small hole can be used for the four-conductor cable. The alarm/power elements are mounted in a separate enclosure with holes near the alarm so that it can be heard.

To test the project, expose the photosensitive surface of *Q1* to an ordinary household light bulb at a distance of about 18 inches. When the light source is removed, the alarm should sound for approximately one minute. Changing the value of *C1* changes the alarm-on time. The alarm can be silenced by operating switch *S1*. ◇

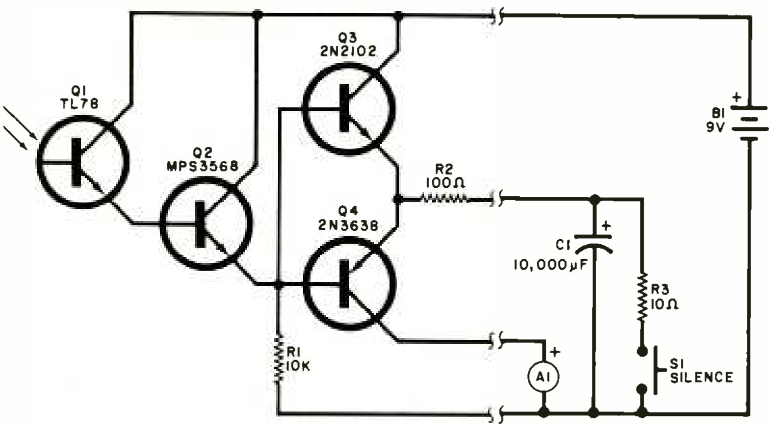

Fig. 1. Phototransistor Q1 senses when the light impinging on it goes off. The signal is then amplified to energize alarm A1.

PARTS LIST

A1—Alarm (Sonalert SC628 or similar)
B1—9-volt battery
C1—10,000-µF, 10-V capacitor (see text)
Q1—TL78 phototransistor (Radio Shack FPR-100)
Q2—MPS3568 transistor (Radio Shack S0015)
Q3—2N2102 transistor (Radio Shack S5026)
Q4—2N3638 transistor (Radio Shack S0029)
R1—10,000-Ω, ¼-W resistor
R2—100-Ω, ¼-W resistor
R3—10-Ω, ¼-W resistor
S1—Normally open pushbutton switch
Misc.—Length of four-conductor cable, suitable enclosures, perf board, printed-circuit board, mounting hardware, etc.

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SOLID-STATE DEVELOPMENTS

By Forrest M. Mims

Jellybean Op Amps

THE semiconductor industry makes many different kinds of operational amplifiers. Those companies that specialize in high performance or precision op amps, however, lump the mass-produced, inexpensive op amps into a catch-all category—*jellybeans.*

One of the most popular jellybean op amps is the 741/741C. This chip was introduced by Fairchild in 1968 as a successor to that company's μA709, the industry's first widely accepted op amp on a chip. The μA741 was also intended to compete with National Semiconductor's entry into the op amp market, the LM301. Unlike the μA709 and the LM301, the μA741 boasted an on-chip compensation capacitor. The other two required the use of external frequency compensation.

When the μA709, LM301 and μA741 were first introduced, they were considered major breakthroughs in semiconductor technology. They quickly became very popular among design engineers, who found that they could replace a number of discrete transistors and their associated passive components with a single chip, and a small handful of external components.

Fairchild's 1965 data sheet for its μA709C, the commercial version of the 709, billed the device as a "High Performance Operational Amplifier." In those days, "high performance" meant a minimum input impedance of 50 kilohms, a minimum open-loop voltage gain of 15,000 and a typical input-offset voltage (V_{os}) of two millivolts.

The μA741C offered even better performance. Its minimum input resistance was 300 kilohms (2 megohms typical), its minimum open-loop voltage gain was 50,000 (200,000 typical) and its typical V_{os} was one millivolt. Like the μA709C, the μA741C was designated a "high performance" operational amplifier.

Both the 709 and 741 (as well as other early op amps) are still in widespread use. They're cheap, readily available, and appear in hundreds of time-tested circuits in the literature

Operational-amplifier technology, however, has hardly stood still in the 13 years since the 741 was introduced. There now exists a wide range of op amps whose specifications are far superior to those of the old standbys.

These new devices are called *precision* or *high-performance* op amps to distinguish them from the 709, 741, 301 and the other general-purpose op amps, all of which now fall into the unglamorous category of jellybeans.

Precision op amps have considerably greater frequency responses than earlier chips. Devices with FET input stages can provide input impedances as great as 10^{12} ohms. Input-offset voltages can be as low as tens of microvolts. Not every op amp offers such exceptional performance in every category, but today's op amps are far more worthy of being termed high-performance devices than were their predecessors.

Experimenters have generally avoided using high-performance or precision op amps because of their cost. Jellybean chips like the 709 and 741 can be purchased for as little as 35 cents each, but precision op amps have sold for as much as $10 or more. Inevitably, however, the superior characteristics of precision and high-performance op amps have stimulated increased demand. More manufacturers have begun making such chips, and prices have begun to fall.

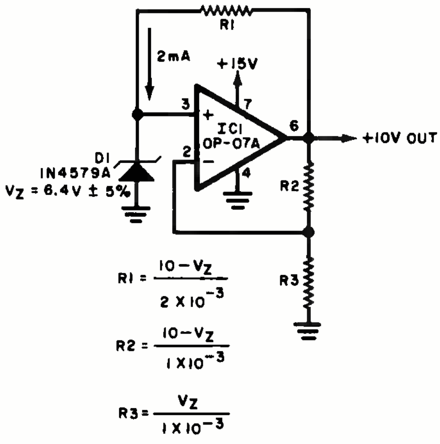


Fig. 1. Accurate 10-volt reference from Precision Monolothic Industries.

When is it worthwhile to select a more costly, precision op amp instead of one of the jellybeans? In many audio applications, the higher bandwidth, lower noise, better noise rejection and greater sensitivity make precision op amps better choices than jellybean chips. All of these advantages are equally desirable in instrumentation-amplifier applications.

Perhaps the best way to appreciate the advantages of precision op amps over the jellybean variety is to see how they are used in actual circuits. Precision Monolithic Industries (PMI), a leading manufacturer of precision analog integrated circuits, has published a number of application notes for its line of precision op amps. Note AN-13, by Donn Soderquist and George Erdi, is a detailed treatment of PMI's OP-07, a bipolar op amp with an input-offset voltage of only 25 microvolts. This ultra-low V_{os}, which eliminates the need for an offset-nulling potentiometer, is achieved during manufacture by a one-time, computer-controlled adjustment of an on-chip trimming network.

The circuit in Fig. 1 is a highly stable 10-volt reference described in AN-13. A 741 could be used in this circuit, but relatively frequent recalibration of an offset trimmer potentiometer would be required because of long-term drift of the 741's V_{os}. Long-term drift of the OP-07 is only about one microvolt per month, about 1% of that of the 741.

The circuit in Fig. 2, which is also from AN-13, is a precision large-signal voltage buffer with a worst-case accuracy of 0.005 percent. This high degree of accuracy is due to the ultra-low V_{os} of the OP-07 and the total absence of external components. See AN-13 for more details.

You can find out more about precision and high-performance op amps by contacting manufacturers. Some of the leading ones are: Advanced Micro Devices (901 Thompson Place, Sunnyvale, CA 94086); Fairchild Semiconductor (464 Ellis St., Mountain View, CA 94042); Harris Corporation (P.O. Box 883, Melbourne, FL 32901); Intersil (10710 N. Tantau Ave., Cupertino, CA 95014); Motorola (Box 20912, Phoenix, AZ 85036); National Semiconductor (2900 Semiconductor Drive, Santa Clara, CA 95051); Precision Monolithic Industries (1500 Space Park Drive, Santa Clara, CA 95050); RCA (Route 202, Somerville, NJ 08876); Raytheon (350 Ellis St., Mountain View, CA 94042); Signetics (P.O. Box 409, Sunnyvale, CA 94086) and Texas Instruments (P.O. Box 5012, Dallas, TX 75222).

Several excellent books on operational amplifiers are also available.

Walter Jung has written two of them. The *IC Op Amp Cookbook* (Sams, 1975) covers just about everything you need to know about op amps in 591 pages. His *Audio IC Op Amp Applications* (Sams, 1978) is limited to audio uses for op amps.

Another excellent all-round book on op amps is David Stout's *Handbook of Operational Amplifier Circuit Design* (McGraw-Hill, 1976). This book is more expensive than the Sams volumes. If it's beyond your budget, you can probably find it at a well-stocked technical or engineering library.

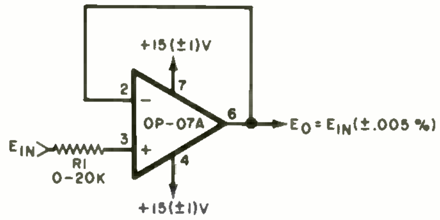


Fig. 2. A precision large-signal voltage buffer using an op amp.

More About Super LEDs. "Solid-State Developments" for February 1981 highlighted the new generation of (AlGa)As super LEDs which have twice the power output of comparable GaAs:Si LEDs. Several such LEDs made by Xciton were described.

I've since heard from Rich Fassler of General Electric that his company was the first to introduce commercial grade (AlGa)As LEDs. According to Rich, ". . . Xciton saw the light and followed *our lead* (please note the 11/78 date on our spec sheet)."

GE's (AlGa)As LEDs come in lensed (D suffix) and flat-window (E suffix) versions. The F5D1 and F5E1 emit at least 12 milliwatts at 100 milliamperes forward current. The power outputs at 100 miliamperes for the F5D2/F5E2 and F5D3/F5E3 are 9 and 10.5 milliwatts, respectively.

Figure 3 compares the optical output from the F5D1/F5E1 LEDs with that from GaAs:Si 1N6264/1N6265 emitters. Xciton's best (AlGa)As LED is the XC-88-FD (flat window) or XC-88-PD (lens). Its output is essentially identical to that of the GE diodes of the same type.

For some information and current pricing, contact a GE electronic-component sales representative or write to General Electric Semiconductor Products, West Genesee Street, Auburn, NY 13201. Xciton's address is Shaker Park, 5 Hemlock Street, Latham, NY 12110.

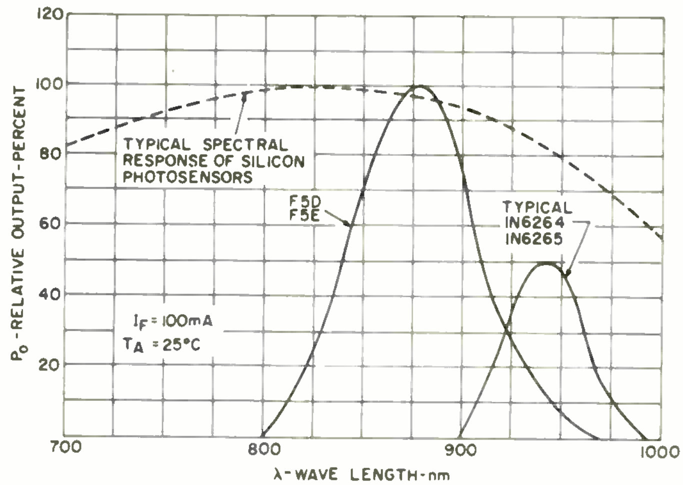


Fig. 3. Power output versus wavelength for General Electric's (AlGa)As LEDs.

Fighting Static Discharge. Regular readers of this column are well aware that certain solid-state devices are susceptible to damage from electrostatic discharge. Particularly vulnerable are CMOS ICs and those components with ultra-small active areas such as double-heterostructure lasers and tunnel diodes.

Manufacturers sometimes ship components and circuit boards that are vulnerable to electrostatic damage in anti-static polyethylene bags known as "pink poly." Ordinary polyethylene bags can develop surface potential gradients of many hundreds of volts from external friction or simply the movement of components inside the bag.

Although antistatic bags do prevent static-charge buildup, they do not prevent external, charged objects from discharging through the bag and across the terminals of sensitive components. Accordingly, last May, the Department of Defense issued a new standard requiring packaging that will not generate static charges *and* will protect against external fields and discharges.

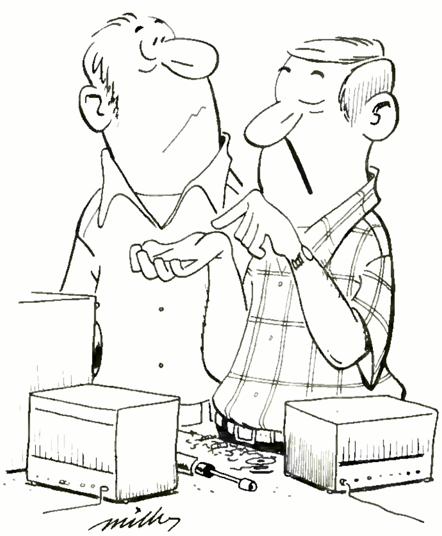
3M Static Control Systems now

makes such a bag. It consists of an inner layer of antistatic polyethylene and a polyester strength layer coated with a 10-micron-thick film of nickel. According to 3M, the nickel film provides "full Faraday cage protection from external static charge." These new bags cost some 15 cents more than ordinary antistatic bags, but 3M claims that one company is already saving some $2500 on each shipment of 100 circuit boards by using the new bags. Previously, as many as half the firm's boards were reportedly damaged by static discharge during shipment!

This new product serves as a reminder of the care one must exercise when working with components vulnerable to static damage. The best protection is to make sure all leads of vulnerable components and chips are shorted together. This can be done by inserting them into foam plastic which is either electrically conductive or covered with one or two layers of aluminum foil.

Even assembled products can be vulnerable to static discharge damage. John Miklosz passed on a warning from Keats Pullen to readers of John's column in *Electronic Engineering Times* (Feb. 16, 1981) that the face of a digital multimeter should be cleaned with a damp cloth to avoid the buildup of a static charge which results from wiping plastic with a dry cloth. As John concluded, "The fact that wiping with a dry cloth can damage an IC *in situ* with at least 1/4 inch between the circuit board and the panel should be of concern to all of your readers."

Indeed it should. I cannot verify the need for this precaution, but will pass along the personal experiences of readers who have damaged instruments by wiping their displays with a dry cloth. My initial reaction is that relatively few instruments are vulnerable to such damage. Otherwise, not many pocket calculators and digital watches would be in working order today. ◇



"Look at this new micro-mini-switch. It's invisible to the naked eye."

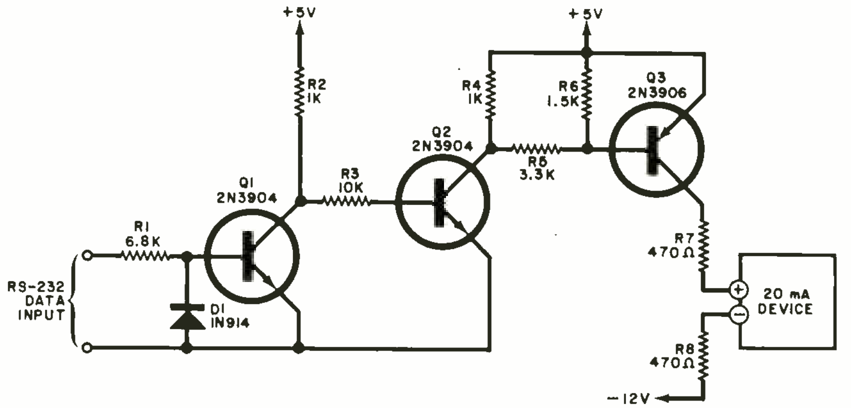
HOBBY SCENE

By John McVeigh, Technical Editor

RS232-to-20-mA Converter

Q. ***Do you have the schematic diagram of a simple circuit that I can use to interface an RS-232 data output port to a 20-mA current-loop printer?—Michael Harbison, Falls Church, VA.***

A. The circuit shown in the figure will allow you to use your 20-mA printer with your output port. It can be assembled for next to nothing if you have a decent junk box. Even if you have to buy all the components at retail, total construction cost will be less than $5.00. Transistor type numbers are not critical—just about any garden-variety npn and pnp silicon devices can be used. Transistor *Q1* and its associated passive components function as an RS-232-to-TTL level converter. Inversion is performed by *Q2*; *Q3* is a keyed 20-mA current source. Power for the circuit can usually be tapped from one of the system components. Current demand is very small.



Open-Collector Logic

Q. ***What is the difference between "normal" TTL gates such as the 7400 or***

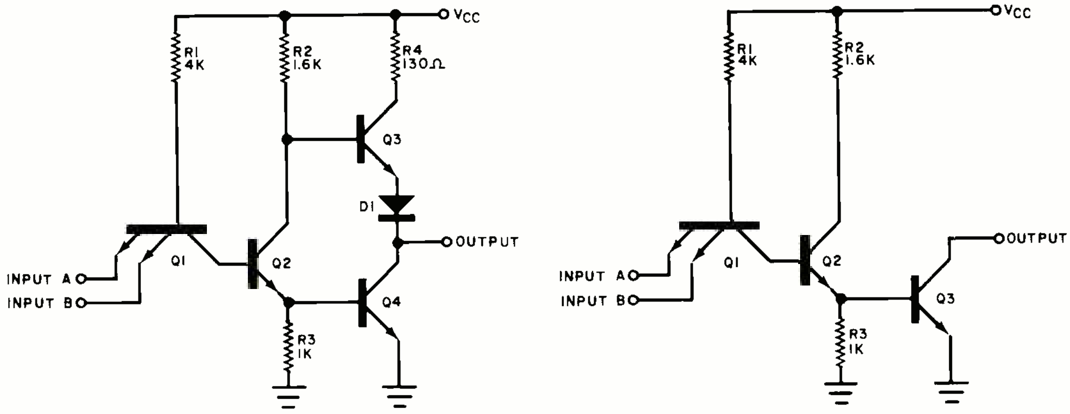
7404 and "open-collector" gates such as the 7401 and the 7405?—Edward Cassidy, Los Angeles

A. Shown at (A) in the figure is the schematic diagram of a standard 2-input TTL NAND gate (type 7400). Two noteworthy characteristics of this gate are *Q1*, the multiple-emitter input transistor, and the *totem pole* output comprising *R4, Q3, D1* and *Q4*. When either input A or B is at logic 0, *Q1* saturates, cutting off *Q2* and *Q4*. Transistor *Q3* acts like an emitter follower and couples a logic 1 to the output. When both inputs are logic 1, forward current through the base/collector diode of *Q1* forces *Q2* and *Q4* into saturation, resulting in a logic-0 output. Diode *D1* prevents *Q3* from conducting when *Q4* is saturated by decreasing the base-to-emitter voltage drop to a value below the turn-on threshold of the transistor.

The major advantage of the totem-pole output is its low output impedance. When *Q3* is conducting, it acts as an emitter follower with an equivalent (Thevenin) output impedance of 70 ohms. When *Q4* is saturated, it has an equivalent (Thevenin) output impedance of approximately 12 ohms. In either case, the output impedance is low. This makes it possible to avoid excessive loading when it is connected to other TTL gates. A low output impedance also keeps switching speeds high. The voltage at the output of the gate cannot change state until all load and stray capacitances have been charged or discharged. Because the gate's output impedance is low in either state, the overall RC time constant is small and the output can change rapidly.

Shown schematically at (B) is an open-collector 2-input TTL NAND gate (type 7401). It lacks a totem-pole output. The gate will not work unless a *pull-up resistor* is connected externally between its output (the collector of *Q3*) and the positive supply voltage. Transistor *Q3* provides active pull-down when its saturates (as *Q4* does in the gate shown at A). However, when it cuts off, there is no upper transistor to pull up the output voltage. Any load and stray capacitances have to charge up through the pull-up resistor. Because the charging occurs through a passive component, the transition from logic 0 to logic 1 is called "passive pull-up." The value of this pull-up resistor is typically hundreds or thousands of ohms, so passive pull-up is considerably slower than active pull-up. This makes passive pull-up unsuitable for certain applications.

There is one principal advantage of open-collector logic. The outputs of a number of similar gates can be tied together through a common pull-up resistor. This direct connection produces the effect of an AND gate and eliminates the need for a separate AND gate. This application is sometimes called *WIRE-AND* logic, or, because of an elementary principle of Boolean algebra (DeMorgan's first theorem), *WIRE-OR* logic. ◇



EXPERIMENTER'S CORNER

By Forrest M. Mims

Do-It-Yourself Batteries

YOU can conduct a fascinating demonstration of electrical power generation by chemical means with a silver coin, a strip of magnesium and a piece of paper towel the size of a postage stamp. Dip the paper in lemon juice, place it over the coin and lay the magnesium strip on the paper. Then touch the cathode lead of a red LED to the magnesium. When the LED's anode lead is touched to the coin as in Fig. 1, the LED will glow brightly.

With the exception of the LED, this simple demonstration would have seemed fairly routine to pre-World War I experimenters. In those days many experimenters constructed their own primary and secondary (storage) cells. Commercial power cells were relatively expensive, and only a few kinds were available.

Today, literally hundreds of different kinds of batteries are available in a wide range of voltages and physical configurations. Nevertheless, for some special-purpose applications, a homemade battery may be more satisfactory than a commercial battery!

One example is powering a telemetry transmitter in an instrumented model rocket. The upward flight of such a rocket might last only a few seconds, yet a commercial battery could supply the necessary power continuously for days or even weeks. The penalty for this unnecessary capacity is excessive size and mass, both of which should be kept to a minimum.

This month, we will experiment with several electrochemical power cells that you can make from readily available materials. These cells are suitable for powering CMOS and other low-power circuits. Whether you assemble any of these cells or not, you may gain a better understanding of how conventional batteries work. If you do build cells of your own, you will certainly gain an appreciation for the convenience and drip-free operation of commercial power cells and batteries.

Some Definitions. Before proceeding any further, it is important to define a few basic terms:

Anode—The negative electrode of a cell.
Battery—Two or more electrically connected cells.
Cathode—The positive electrode of a cell.
Cell—A single two-electrode electrochemical generator.
Electrolyte—An ionized, electrically conductive paste, gel or liquid.
Primary Cell—A nonrechargeable cell.
Secondary Cell—A rechargeable cell.
Storage Cell—A secondary cell.

Electrochemical Generators. Alessandro Volta, an Italian physicist, invented the chemical generator. In March 1800, he demonstrated two of his generators before the Royal Society in London. One, called the Crown of Cups, consisted of a circular pattern of cups containing a solution of water and salt. One strip each of silver and zinc were immersed in each cup, and the zinc strip in one cup was connected to the silver strip in the adjacent cell. This arrangement formed a series connection of *wet cells*.

Volta's second generator was a stack of alternating disks of dissimilar metals separated by disks of paper soaked in brine. This device could produce more electromotive force in a smaller space than the clumsier Crown of Cups arrangement.

The electrochemical generators invented by Volta were used with little variation until about 1860, when other kinds of cells were developed. One such cell, patented by French scientist Georges LeClanche in 1868, was the predecessor of the modern zinc-carbon *dry cell*.

The basic design of the zinc-carbon dry cell (such as those used to power radios, flashlights and toys) has remained largely unchanged for more than sixty years. Each cell consists of a zinc cup or can (the anode) filled with a moist compound whose composition has changed through the years. One 1924 recipe called for a mixture of one ounce each of zinc-chloride and ammonium-chloride, two ounces of water, and three ounces of plaster of paris, which served as a filler. Sawdust was also used as a filler material in some early cells. A

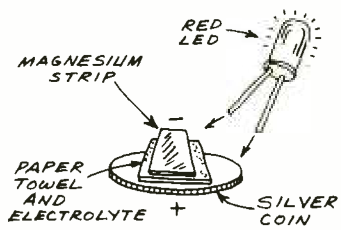


Fig. 1. An ultra-simple homemade power cell.

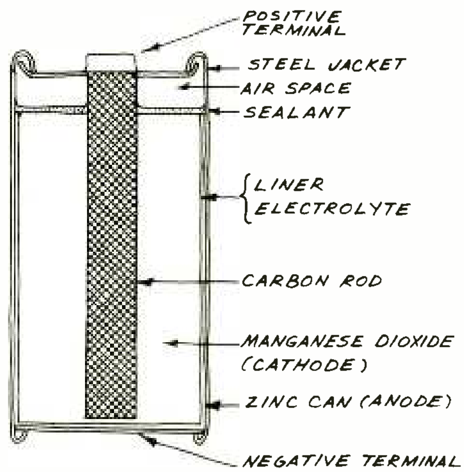


Fig. 2. Simplified internal view of a modern dry cell.

carbon rod inserted into the compound serves as the positive electrode.

The moist compound of the 1924 recipe served as the cell's electrolyte. In today's cells, the electrolyte is a paper liner impregnated with ammonium- or zinc-chloride that slides inside the zinc can. The space between the liner and the cell's carbon rod is packed with a mixture of granulated carbon and manganese dioxide. The latter compound serves as the cell's cathode. It is considered a *depolarizer* because it prevents *polarization*, the formation of an insulating layer of hydrogen bubbles around a cell's positive electrode.

Figure 2 is a pictorial view of the inner construction of a typical zinc-carbon dry cell. Most such cells are well sealed to prevent leakage which might occur should the zinc become corroded. The zinc seal also keeps the electrolyte from drying out. Drying of the electrolyte and subtle chemical reactions at the electrodes over time eventually degrade a cell whether or not it is used.

A Homemade Wet Cell. Figure 3 shows how you can make a simple wet cell from a plastic container such as a 35-mm film holder, a strip of copper and a strip of zinc. The metal strips are inserted through slits cut in the container's cap or lid. The container is then filled with an electrolyte such as salt water or lemon juice, and the cap and the electrodes are installed. This cell will produce about 0.7 volt.

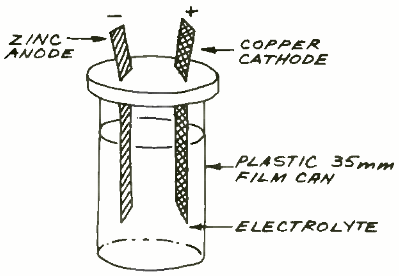


Fig. 3. Sketch of a homemade wet cell.

If you connect a voltmeter to the cell's electrodes and pull the electrodes partially out of the electrolyte, the output voltage will remain unchanged. Even when only a few millimeters of each electrode remain immersed in the electrolyte, the output voltage will remain unchanged. The cell's capacity to deliver current, however, is directly proportional to the area of the electrodes immersed in the electrolyte.

Electrode Materials. Any two dissimilar metals immersed in a suitable electrolyte will generate a voltage. Here are the voltages I measured for all possible pairs selected from the following group: a copper penny, a nickel, a silver dime, a magnesium strip, a zinc strip, and aluminum foil.

Cathode (+)	Anode (−)	Open-Circuit Voltage
Nickel	Copper	0.04
Magnesium	Zinc	0.05
Aluminum	Zinc	0.15
Silver	Nickel	0.19
Silver	Copper	0.20
Copper	Aluminum	0.70
Nickel	Aluminum	0.70
Copper	Zinc	0.72
Aluminum	Magnesium	0.78
Nickel	Zinc	0.81
Silver	Aluminum	0.84
Silver	Zinc	1.01
Nickel	Magnesium	1.44
Copper	Magnesium	1.45
Silver	Magnesium	1.65

(Continued overleaf)

For these measurements, I used as a combined electrolyte and separator several layers of paper towel soaked in salt water. The values you measure may differ slightly from mine, particularly if you use an acid electrolyte, in which case the values will be higher.

Note that the highest voltages are produced by pairing magnesium with nickel, copper or silver. Nickel and copper can be found in pocket change, but silver coins have not been minted in the U.S. since the mid-Sixties and are rarely found in everyday circulation. You can purchase magnesium strips at toy and hobby shops that sell Perfect brand chemicals.

Magnesium is highly reactive. I tried a magnesium strip in a lemon-juice wet cell and found that although the cell could easily power a LED, the magnesium was soon covered by a frothy layer of hydrogen bubbles. The cell functioned well in spite of the bubbles until the reaction with the citric acid in the lemon juice coated the magnesium with a black film.

Zinc is the next-best substitute for magnesium. You can get free zinc by cutting open a discarded zinc-carbon flashlight cell. If the cell is covered by an outer steel jacket, use pliers or diagonal cutters to peel it off. Be careful! The edges of the metal envelope will be very sharp.

When the zinc can has been exposed (it may be covered with a layer of paper or black pitch), secure the cell in a vise and use a hacksaw to remove the top half-inch of the cell. Remove the carbon rod, the filler compound and the electrolyte-impregnated paper liner from inside the can. The carbon in the compound will stain clothing, so be careful. Watch out for the sharp edges of the zinc can and clean any remaining compound from the can with detergent, water and an old toothbrush.

When the zinc is clean, use a file to remove the sharp edges left by the hacksaw. Then cut the can into strips with shears or a nibbling tool. Remove any corrosion from the strips with sandpaper.

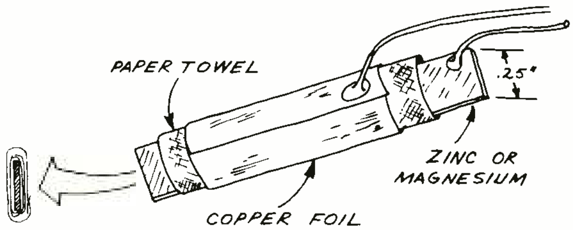


Fig. 4. How to make a simple 1.45-volt "moist" cell.

Homemade "Moist" Cells. Figure 4 shows a simple 1.45-volt cell made from a 1/4-inch wide strip of magnesium or zinc wrapped with two layers of paper towel previously dipped in a solution of salt and water. A piece of copper foil (available at craft and hobby shops) the size of a postage stamp is wrapped over the paper towel.

For best results, the paper towel should be dried before the cell is assembled. When the cell is to be used, it can be activated by dipping it in water. Alternatively, a few drops of water can be applied to the exposed ends of the paper towel.

The cell shown in Fig. 4 is merely one of many possible configurations. You can make round, square or triangular cells. You can even cut the zinc or magnesium anode into long, narrow strips and make ultra-thin, cylindrical cells. You can increase the current capacity of a cell by increasing the area of its electrodes. Two or more cells can be connected in series to achieve higher voltages.

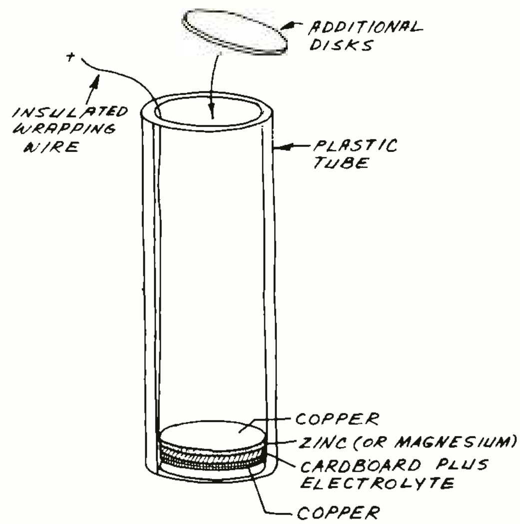


Fig. 5. Construction of a multi-cell stacked battery using zinc or magnesium.

If a discharged cell is disconnected, in time it will gradually recover. Add moisture, and the cell will again deliver power. After several discharge cycles, you can rejuvenate a cell by unwrapping the copper foil and cleaning both the anode and cathode with steel wool. Reassemble the cell with a fresh, salt-impregnated separator layer.

There are two ways to attach wires to the cell. The simplest is to use miniature clip leads. I prefer to solder short lengths of wrapping wire to the electrodes prior to assembly. Copper foil is easily soldered. Zinc must be sanded for best results. Solder will not adhere to magnesium, so you will have to use a clip lead if you use this anode material.

Homemade Stacked Batteries. You can assemble a miniature version of Volta's stacked battery, which was called a *Voltaic pile*, with the help of a $^1/_4$-inch paper punch. Punch a dozen or so holes in a piece of *thin* cardboard like that used for shoe boxes and soak the cardboard disks in salt water or lemon juice. Then punch an identical number of disks out of sheets of copper foil and magnesium or zinc. Solder a six-inch length of wrapping wire to one copper disk and one zinc disk. If you use magnesium, make an extra copper disk and solder a wire to it.

For best results, assemble the cell inside a hollow plastic tube. I used a small tube which originally contained the point of a drafting pen. Flexible tubing can also be used.

Install the copper disk with an attached wire lead first. Then, install alternating disks of cardboard, zinc (or magnesium), copper, cardboard, etc. The final disk should be zinc with an attached wire. If magnesium is used in place of zinc, top off the stack with the other copper disk to which a lead has been attached.

You may need to press the disks lightly against the end of the tube to achieve maximum output from the battery. Too much pressure, however, will squeeze electrolyte from the cardboard disks. Free electrolyte can short adjacent cells and reduce the battery's output voltage.

Incidentally, you will find it very helpful to use pointed tweezers when assembling a battery like this. Also, be sure to blot excess electrolyte from the cardboard disks before installing them in the tube.

Figure 5 shows how a 12-cell stack is assembled. This battery delivers 5.8 volts open circuit and is able to drive a LED with built-in flasher. The load of the LED and flasher circuit drops the voltage from the battery to a few volts, so the LED is not very bright. I used zinc and copper disks and lemon juice electrolyte.

Unfortunately, the battery in Fig. 5 is not suitable for post-assembly water activation. Adding water to the battery would short all the cells together.

Additional Reading. Because of the volume of mail I receive, it will not be possible to answer individual reader's questions about homemade batteries. Fortunately, however, there are many good books on the subject.

For best results, visit a library which has lots of old books. Some large libraries keep such books in a separate section. Small-town libraries tend to keep such books longer than big libraries.

One typical example is *Electricity and Magnetism and Their Applications* by Dugald Jackson and John Jackson. This text was originally published by the Macmillan Company in 1902. It was revised by N. Henry Black in 1919 and republished in 1920. It contains an excellent chapter on early battery technology.

Another old book is *The Amateur Electrician's Handbook* by A. Frederick Collins (Thomas Y. Crowell Company, 1924). It contains instructions for making everything from wet cells to X-ray systems. I would not advise you to try the latter because much has been learned about the hazards of ionizing radiation since 1924.

Many newer books also discuss batteries. One is *Basic Electronics* by Abraham Marcus and Samuel Gendler (Prentice-Hall, 1971). Another is *Handbook for Electronics Engineering Technicians* by Milton Kaufman and Arthur Seidman (McGraw-Hill, 1976). ◇

TO OUR READERS. . .

POPULAR ELECTRONICS does not publicize the home addresses or telephone numbers of its authors, nor can we compel them to reply to inquiries they may receive. Letters to authors sent to the magazine will be forwarded by us, and there is a good chance that those accompanied by a stamped, self-addressed envelope will receive replies.

English Broadcasts Audible in No. America

by Glenn Hauser

TIME EST/CDT	TIME UTC/GMT	STATION	QUAL.[2]	FREQUENCIES, kHz[3]
4:00-4:15 a.m.	0900-0915	BBC	A	15070, 11955, 11750, 9640, 9510, 6195
4:00-4:15 a.m.	0900-0915	R. Japan[4]	B	9505
4:00-4:30 a.m.	0900-0930	UN Radio	B	15250, 9565, 9350-SSB (Sat.)
4:00-5:00 a.m.	0900-1000	R. Andorra	C	15021 (varies) (Sun.)
4:00-5:30 a.m.	0900-1030	R. Australia	B	15115
4:00-6:00 a.m.	0900-1100	AFRTS, Los Angeles	A	11805, 9700, 9590, 9530, 6030
4:15-6:00 a.m.	0915-1100	BBC	C	17790, 17695, 15070, (21660 Sat. & Sun. and daily from 10:30)
4:30-5:15 a.m.	0930-1015	V. of the Malayan Revolution	C	15790, 11830
4:30-5:30 a.m.	0930-1030	V. of Germany	C	17780, 11850
5:00-5:15 a.m.	1000-1015	UN Radio	A	15250, 11090-LSB†, 9565 (Sat.)
5:00-5:15 a.m.	1000-1015	R. Japan	B	9505
5:00-5:30 a.m.	1000-1030	V. of Vietnam	C	12033, 10010
5:00-6:00 a.m.	1000-1100	R. Korea	C	11725, 9570, 9870, 15575
5:00-fade out	1000-	R. Australia	B	6045, 5995
5:00-8:00 a.m.	1000-1300	R. Moscow (via Cuba)	B	9600, 600 (5045 -1100)
5:00-11:02 a.m.	1000-1602	ABC, Perth	B	9610, 6140
5:15-5:55 a.m.	1050-1055	UAE Radio, Dubai	C	21695, 21640, 17775
5:20-5:30 a.m.	1020-1030	V. of Guatemala	B	6180, 640 (time varies widely)
5:28-8:00 a.m.	1028-1300	CBC Northern Service	B-C	9625, 6065 (not all Eng.)
5:30-6:30 a.m.	1030-1130	Sri Lanka Br. Corp.	C	17850, 15120, 11835 (not all Eng.)
5:55-6:55 a.m.	1055-1155	R. Thailand	C	11905, 9655
6:00-6:15 a.m.	1100-1115	R. Japan	B	9505
6:00-6:30 a.m.	1100-1130	V. of Vietnam	C	12035, 10010
6:00-6:30 a.m.	1100-1130	R. Mogadishu	D	9585
6:00-6:56 a.m.	1100-1156	R. RSA	C	25790, 21535
6:00-7:00 a.m.	1100-1200	V. of Asia, Taiwan	C	5980 (not Sun.)
6:00-7:00 a.m.	1100-1200	V. of Nigeria	C	17800, 15120
6:00-7:00 a.m.	1100-1200	AFRTS, Los Angeles	A	6030
6:00-7:30 a.m.	1100-1230	TWR-Bonaire	A	11815 (Sat. 1100-1330; Sun. 1100-1415)
6:00-7:50 a.m.	1100-1250	R. Pyongyang	C	9977
6:00-8:00 a.m.	1100-1300	R. Australia	A	9580
6:00-8:30 a.m.	1100-1330	BBC	A-B	25650, 21710, 21660, 21550, 11775, 11750, 9740, 9510, 6195
6:00-9:00 a.m.	1100-1400	4VEH, Haiti	C	11835, 9770
6:00-10:00 a.m.	1100-1500	VOA	B	11715, 9565
6:00-11:00 a.m.	1100-1600	AFRTS, Los Angeles	A	15430, 15330, 11805, 9700
6:15-6:30 a.m.	1115-1130	Vatican R.	C	21485, 17840 (not Sun.)
6:30-6:55 a.m.	1130-1155	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri.)
7:00-7:15 a.m.	1200-1215	V. of Kampuchean People	C	11938, 9694 (vary)
7:00-7:20 a.m.	1200-1220	Vatican R.	B	21485, 17840 (not Sun.)
7:00-7:20 a.m.	1200-1220	R. Canada International	A	17820, 15440, 11955, 9650 (Mon.-Fri.)
7:00-7:30 a.m.	1200-1230	Kol Israel	C	25640, 17612.5, 21675
7:00-7:30 a.m.	1200-1230	R. Finland	B	15400
7:00-7:30 a.m.	1200-1230	R. Norway	C	21730 (Sun.)
7:00-7:30 a.m.	1200-1230	R. Tashkent	C	15460, 11785, 9750, 9715, 5950
7:00-7:30 a.m.	1200-1230	R. Japan	B	9505
7:00-7:30 a.m.	1200-1230	HCJB, Ecuador	A	26020, 15115, 11740
7:00-7:45 a.m.	1200-1245	V. of Germany	B	21600, 17875, 17765, 15410
7:00-7:55 a.m.	1200-1255	R. Peking	B	15520
7:00-8:00 a.m.	1200-1300	V. of Turkey	D	9560†
7:00-10:00 a.m.	1200-1500	R. Moscow World Service	B	17810, 15490, 12010
7:20-7:50 a.m.	1220-1250	R. Ulan Bator, Mongolia	C	12070 or 11825, 6383 or 4850 or 7235† (not Sun.)
7:30-7:55 a.m.	1230-1255	R. Tirana	D	11960, 9515
7:30-7:57 a.m.	1230-1257	Austrian R.	B	21655†
7:30-8:00 a.m.	1230-1300	R. Sweden	C	21690
7:30-8:00 a.m.	1230-1300	BBC (English by radio)	C	21695
7:30-8:00 a.m.	1230-1300	R. Bangladesh	D	21670, 15285
7:30-8:25 a.m.	1230-1325	R. Finland	B	15400 (Sun.)
7:30-8:30 a.m.	1230-1330	R. Korea	C	11830, 7550
7:30-8:30 a.m.	1230-1330	R. Maldives	D	4754
7:30-9:30 a.m.	1230-1430	HCJB, Ecuador	A	26020, 17890, 15115, 11740
7:30-9:30 a.m.	1230-1430	SLBC, Sri Lanka	C	15425
7:30-10:51 a.m.	1230-1551	WYFR, Family Radio	A	21545, 17785 (Sun. only)
7:35-7:45 a.m.	1235-1245	V. of Greece	C	21455, 17830, 11730 (Mon.-Fri.)
8:00-8:15 a.m.	1300-1315	R. Japan	B	9505
8:00-8:30 a.m.	1300-1330	R. Bucharest	C	17850, 15250, 11940
8:00-8:45 a.m.	1300-1345	R. Berlin International	C	21540, 21465, 17700
8:00-9:00 a.m.	1300-1400	R. Australia	C	11705, 9770, 6080
8:00-10:57 a.m.	1300-1557	R. RSA	B	25790, 21535, 15220
8:00-11:00 a.m.	1300-1600	CBC Southern Service	A	17820, 11955, 9575 (Sun.)
8:00-12:00 a.m.	1300-1700	WYFR, Family Radio	A	11830
8:00 a.m.-6:00 p.m.	1300-2300	CBC Northern Service	B-C	11720, 9625 (not all Eng.)
8:15-8:45 a.m.	1315-1345	Swiss R. International	B	21570, 21520
8:30-9:00 a.m.	1330-1400	R. Finland	B	21475, 15400
8:30-9:05 a.m.	1330-1405	BRT, Belgium	B	21525 (Mon.-Fri.)
8:30-9:00 a.m.	1330-1400	NYAB, Bhutan	D	4692 (Wed. & Fri.)
8:30-9:20 a.m.	1330-1420	R. Nederland	C	17605
8:30-9:30 a.m.	1330-1430	V. of Turkey	C	15125
8:30-9:30 a.m.	1330-1430	V. of Vietnam	C	10010
8:30-10:00 a.m.	1330-1500	All India R.	C	15335, 11810
8:30-11:00 a.m.	1330-1600	BBC	B-C	25650, 21710, 21660, 21550, 21470, 15400 (from 1430), 15070
8:30 a.m.-fade	1330-	R. Australia	C	6060

8:30 a.m.-5:00 p.m.	1330-2200	R. Moscow World Service (via Cuba)	B	11840 or 11860
8:57-11:55 a.m.	1357-1655	V. of Philippines	D	9578 (Sun.-1555) (not all English)
9:00-9:15 a.m.	1400-1415	R. Japan	B	9505
9:00-9:30 a.m.	1400-1430	R. Sweden	B	21615
9:00-9:30 a.m.	1400-1430	R. Norway	B	25730, 21730, 17840 (Sun. only)
9:00-9:30 a.m.	1400-1430	V. Rev. Party, N. Korea	D	4557, 4109
9:00-9:30 a.m.	1400-1430	R. Tashkent	C	15460, 11785, 9750, 9715, 5950
9:00-10:00 a.m.	1400-1500	V. of Indonesia	C	15200 or 15150, 11790
9:00-12:30 a.m.	1400-1730	R. Australia	C	17795, 9770
9:30-10:00 a.m.	1430-1500	KTWR, Guam	B	9510†
9:30-10:25 a.m.	1430-1525	R. Nederland	B	21480, 11735
9:30-11:00 a.m.	1430-1600	HCJB, Ecuador	A	26020, 17890, 15115
9:30 11:00 a.m.	1430-1600	Burma Br. Ser.	D	5985, 5040
9:30 a.m.-5:00 p.m.	1430-2200	UN Radio	A	21670, 15410 (when in session)
9:35-10:20 a.m.	1435-1520	R. Nepal	D	3425 or 7105 or 9589
9:50-10:35 a.m.	1450-1535	V. of the Malayan Revolution	C	15790, 11830
10:00-10:15 a.m.	1500-1515	R. Japan	C	9505
10:00-10:30 a.m.	1500-1530	V. of Asia, Taiwan	D	5980
10:00-11:00 a.m.	1500-1600	V. of Rev. Ethiopia	D	9560
10:00-11:00 a.m.	1500-1600	BBC	B	17830, 15260 (Sat, Sun)
10:00-11:00 a.m.	1500-1600	R. Moscow	B	24020, 12010
10:00-12:30 a.m.	1500-1730	BSHKJ, Jordan	D	9560
10:30 11:00 a.m.	1530-1600	R. Afghanistan	D	4775 or 6230
10:30 11:00 a.m.	1530-1600	R. Yugoslavia	C	15300, 15240
10:30-11:00 a.m.	1530 1600	Swiss R. International	B	21570
10:30-11:30 a.m.	1530 1630	V. of Vietnam	C	15010, 10040
10:35-10:45 a.m.	1535 1545	V. of Greece	C	21455, 17830, 11730 (Mon.-Fri.)
10:45-11:00 a.m.	1545-1600	R. Canada International	A	(17820 Mon. Sat.), 15160, 15325
11:00-11:15 a.m.	1600-1615	R. Japan	C	9505
11:00-11:15 a.m.	1600-1615	Vatican R.	C	17730
11:00-11:15 a.m.	1600-1615	R. Pakistan	C	21755, 21605, 21486, 17910, 17660†
11:00-11:30 a.m.	1600-1630	R. Norway	B	25730, 21730 (Sun. only)
11:00-11:30 a.m.	1600-1630	R. Portugal	C	21530 or 21475 (not Sun.)
11:00-12:00 a.m.	1600-1700	R. Korea	C	11830, 9720
11:00 a.m.-12:09 p.m.	1600-1709	BBC	B	21710, 17830, 15260
11:00 a.m.-1:00 p.m.	1600-1800	AFRTS, Los Angeles	A	17765, 15430, 15330, 11805
11:00 a.m. 4:00 p.m.	1600-2100	R. Moscow World Service	B	24020, 15535, 12010, 11860†
11:00 a.m.-6:00 p.m.	1600-2300	VOA	A	26040, 21660, 21485, 17870, (15250 from 1900) 15445, (15410 to 2200)
11:05-11:55 a.m.	1605-1655	R. France International	B	25820, 21620, 21580, 21515, 17860
11:10-11:55 a.m.	1610-1655	BRT, Belgium	C	21525†
11:30 a.m.	1630	R. Singapore	C	11940, 5052, 5010 (fade-in time varies)
11:30-12:00 a.m.	1630-1700	UAE Radio, Dubai	B	21700, 21655, 21625†
11:45-12:00 a.m.	1645-1700	R. Canada International	A	(17820 Mon.-Sat.), 15325
11:45-12:45 p.m.	1645-1745	R. Pakistan	C	15495, 9460†
12:00-12:15 p.m.	1700-1715	R. Japan	C	9505
12:00-12:30 p.m.	1700-1730	HCJB, Ecuador	B	26020, 21480, 17790†
12:00-12:45 p.m.	1700-1745	BBC	C	18080
12:00-1:00 p.m.	1700-1800	WYFR, Family Radio	A	21615, 21465, 17845, 15440, 11830
12:00-3:00 p.m.	1700-2000	4VEH, Haiti	C	11835, 9770 (Sun.)
12:00-3:00 p.m.	1700-2000	BSK, Saudi Arabia	C	11856 (varies)
12:00-5:00 p.m.	1700-2200	VOA	B	17785, 15205, 11760, 9760, (15140 from 1830)
12:09-12:45 p.m.	1709-1745	BBC	B	17830, 15260 (Sat. & Sun.)
12:15-1:05 p.m.	1715-1805	V. of Germany	C	21600
12:45-3:00 p.m.	1745-2000	BBC	C	(21710 to 1830), 15400, 15070, 12095
12:45-5:30 p.m.	1745-2230	All India R.	C	11620
1:00-1:15 p.m.	1800-1815	R. Japan	C	9505
1:00-1:30 p.m.	1800-1830	R. Canada International	A	17820, 15260 (Sat. & Sun. 1900)
1:00-1:30 p.m.	1800-1830	R. Norway	C	25730, 21730, 17840 (Sun only)
1:00-2:00 p.m.	1800-1900	V. of Vietnam	C	10040, 15010
1:00-2:00 p.m.	1800-1900	WYFR, Family Radio	A	21615, 17845
1:00-2:00 p.m.	1800-1900	V. of Nigeria	C	15120, 15185, 17800
1:00-3:00 p.m.	1800-2000	R. Australia	C	17795
1:00-4:00 p.m.	1800-2100	R. Kuwait	C	11650
1:00-5:00 p.m.	1800-2200	AFRTS, Los Angeles	A	21570, 17765, 15430, 15330, 15345
1:15-1:45 p.m.	1815-1845	Swiss R. International	C	21570, 17830, 17850
1:15-2:15 p.m.	1815-1915	R. Bangladesh	D	15100, 11765 (both vary)†
1:30-1:35 p.m.	1830-1835	UN Radio	A	19505 SSB, 15410, 11960, 17740, 15305 (Mon.-Fri.)
1:30-1:57 p.m.	1830-1857	Austrian Radio	C	15560 (Sun. from 1805)
1:30-2:00 p.m.	1830-1900	V. of Revolution, Guinea	C	15313 (varies) 9650 (Mon. Wed. and Fri.) (irregular)
1:45-2:15 p.m.	1845-1915	Sri Lanka Br. Corp.	C	17850, 15120, 15115, 11870
2:00-2:30 p.m.	1900-1930	R. Japan	B	17755
2:00-2:30 p.m.	1900-1930	R. Canada International	A	21630, 17875, 15325 (Sat. & Sun. -2000)
			A	17820, 15260 (Mon.-Fri.)
2:00-2:30 p.m.	1900-1930	R. Afghanistan	C	15079 (varies) or 17742†
2:00-2:45 p.m.	1900-1945	UN Radio	A	15410, 15305 (Fri.)
2:00-3:00 p.m.	1900-2000	HCJB, Ecuador	C	26020, 21480, 17790†, 15295†
2:00-3:00 p.m.	1900-2000	WYFR, Family Radio	A	21615, 17845, 11830
2:00-3:00 p.m.	1900-2000	R. Nacional, Brazil	C	17810, 15125
2:30-3:30 p.m.	1930-2030	V. of Iran	D	9022
2:35-5:00 p.m.	1935-2200	TIFC, Costa Rica	C	9645 (Sun.)
2:45-4:15 p.m.	1945 2115	R. Free Grenada	C	15104 (time varies and irregular)
3:00-3:15 p.m.	2000-2015	R. Japan	B	17755
3:00-3:30 p.m.	2000-2030	R. Norway	C	25730, 17840 (Sun.)
3:00-3:30 p.m.	2000-2030	R. Algiers	C	Some of: 25700, 25680, 21725, 21635, 17745, 15365, 15307, 11810
3:00-3:30 p.m.	2000-2030	R. Canada International	A	21630, 17875, 17820, 15325 (Mon.-Fri.)
3:00-3:30 p.m.	2000-2030	Kol Israel	C	17685, 17645, 15582.6, 12025, 11637, 9009
3:00-4:00 p.m.	2000-2100	WYFR, Family Radio	A	21615, 21525, 17845, 11830
3:00-4:15 p.m.	2000-2115	BBC	B	21560, 15260, 15070, 11750
3:00-12:00 p.m.	2000-0500	R. Moscow (via Cuba)	C	600

3:10-4:40 p.m.	2010-2140	R. Habana Cuba	A	15155 or 11920
3:30-4:20 p.m.	2030-2120	R. Nederland	B	21685, 17695, 17605, 15220, 9715
3:30-4:30 p.m.	2030-2130	V. of Vietnam	C	15010, 10040
3:30-4:30 p.m.	2030-2130	V. Turkey	C	9615
3:45-5:30 p.m.	2045-2230	All India R.	C	15110
3:50-4:00 p.m.	2050-2100	R. Free Europe	C	21720, 17835, 15255, 15420 or 15290, 11825, 9725, 9565 (Fri.)
3:50-4:40 p.m.	2050-2140	R. Habana Cuba	C	17750, 9770
4:00-4:15 p.m.	2100-2115	R. Japan	B	17755
4:00-4:50 p.m.	2100-2150	R. RSA	B	17780, 15155, 11900
4:00-5:00 p.m.	2100-2200	V. of Nigeria	C	15185, 15120, 17800
4:00-5:00 p.m.	2100-2200	R. Moscow	C	21530, 15455
4:00-5:00 p.m.	2100-2200	WYFR, Family Radio	A	21615, 21525, 17845
4:00-6:00 p.m.	2100-2300	CBC Radio	A	17875, 15325 (Mon.-Fri.)
4:15-5:00 p.m.	2115-2200	BBC	A	21690, 15420, 15260, 15070, 9510, 6175
4:15-7:30 p.m.	2115-2430	R. Free Grenada	B	15045 (time varies)
4:30-5:00 p.m.	2130-2200	R. Canada International	A	17820, 15150, 11945 (17875, 15325
4:30-5:00 p.m.	2130-2200	KGEI, San Francisco	C	15280 Sat. & Sun. only)
4:30-5:00 p.m.	2130-2200	HCJB Ecuador	C	26020, 21480, 17795†, 15295†
4:30-5:00 p.m.	2130-2200	R. Sofia	B	11920, 11860†
4:30-5:30 p.m.	2130-2230	R. Baghdad	C	9745
4:40-5:40 p.m.	2140-2240	V. of Free China	C	17890, 15270, 11825
4:45-5:15 p.m.	2145-2215	Swiss R. International	B	21585
4:55 p.m.-1:30 a.m.	2155-0630	R. New Zealand	C	17860
5:00-5:15 p.m.	2200-2215	R. Japan	B	17755, (via Portugal 11955†)
5:00-5:30 p.m.	2200-2230	R. Argentina	C	11710 (Mon.-Sat.)
5:00-5:30 p.m.	2200-2230	R. Norway	C	17795, 15345, 15175 (Sun. only)
5:00-5:30 p.m.	2200-2230	R. Vilnius	B	17870, 17845, 15100, 11790, 11770
5:00-6:00 p.m.	2200-2300	WYFR, Family Radio	A	21615, 21525, 17845, 9535
5:00-6:00 p.m.	2200-2300	R. Moscow	A	21530, 17720, 15455, 15140, 12050, 12010, 11960, 11920, 11860, 11735, 9765, 9710, 9685, 9610
5:00-6:00 p.m.	2200-2300	V. of Turkey	B	9725, 7215†
5:00-6:00 p.m.	2200-2300	R. Clarin, Dom. Rep.	B	11700 (Sat. & Sun.; irregular)
5:00-6:00 p.m.	2200-2300	BBC	A	21690, 15420, 15260, 15070, 11750, 9590, 9510, 6175, 6120
5:00-7:00 p.m.	2200-2400	CBC Southern Service	A	9755, 5960 (Sat. 2200-2230; Sun. 2200-2300)
5:00-7:00 p.m.	2200-2400	AFRTS, Los Angeles	A	25615, 21570, 15430, 15345, 15330
5:00-11:30 p.m.	2200-0430	VOA	A	21460, 17740, (26000 2400), (17820 0100)
5:15-5:30 p.m.	2215-2230	UN Radio	A	15305, 11830 (Fri.)
5:15-5:30 p.m.	2215-2230	R. Yugoslavia	C	9620
5:30-6:00 p.m.	2230-2300	Kol Israel	A	15583, 12025, 11638, 9815
5:30-6:00 p.m.	2230-2300	R. Nacional, Angola	D	9535 (Mon.-Fri.)
5:30-6:25 p.m.	2230-2325	R. Mexico	B	15430 (Sun., time varies)
5:30-6:30 p.m.	2230-2330	R. Sofia	B	15330, 15110
5:45-6:00 p.m.	2245-2300	SODRE, Uruguay	C	11885, 9515 (time varies)
6:00-6:30 p.m.	2300-2330	R. Japan	C	17755
6:00-6:30 p.m.	2300-2330	R. Sweden	B	15380, 11705
6:00-7:00 p.m.	2300-2400	4VEH, Haiti	B	11835, 9770
6:00-7:00 p.m.	2300-2400	WYFR, Family Radio	A	21525, 9535
6:00-7:00 p.m.	2300-2400	R. Mexico	B	15430 (Thurs., time varies)
6:00-7:30 p.m.	2300-2430	BBC	A	15420, 15260, 15070, 11910, 9590, 9580, 9410, 7325, 6175, 6120, 5975
6:00-7:50 p.m.	2300-2450	R. Pyongyang	C	9977
6:00-8:00 p.m.	2300-0100	R. Moscow	A	21530, 17720, 15455, 15140, 12050, 12010, 11960, 11860, 11780, 11735, 9765, 9710, 9685, 9610
6:00-12:07 p.m.	2300-0507	CBC Northern Service	B-C	9625, 6195 (not all English)
6:25-7:00 p.m.	2325-2400	SODRE, Uruguay	C	11885, 9515 (time varies)
6:30-7:00 p.m.	2330-2400	HCJB, Ecuador	B	26020, 15350
6:30-7:00 p.m.	2330-2400	R. Kiev	B	17870, 17845, 15100, 11790, 11770
6:30-7:00 p.m.	2330-2400	V. of Vietnam	C	12035, 10080, 10040, 10010
6:45-7:45 p.m.	2345-2445	R. Japan	C	17825, 15430
7:00-7:15 p.m.	0000-0015	R. Japan	C	17755
7:00-7:25 p.m.	0000-0025	R. Tirana	B	9750, 7065
7:00-7:30 p.m.	0000-0030	R. Mexico	C	17765, 15430, 11770 (Sat.)
7:00-7:30 p.m.	0000-0030	R. Canada International	A	9755, 5960
7:00-7:30 p.m.	0000-0030	Kol Israel	A	15583, 11638, 9815
7:00-7:30 p.m.	0000-0030	R. Norway	C	15345, 9605 (Mon. only)
7:00-7:45 p.m.	0000-0045	R. Berlin International	C	11970, 9730
7:00-7:55 p.m.	0000-0055	R. Peking	B	17855, 17680, 15125
7:00-8:00 p.m.	0000-0100	WYFR, Family Radio	A	17845, 5985
7:00-8:00 p.m.	0000-0100	R. Sofia	B	15110, 11830
7:00-8:00 p.m.	0000-0100	AFRTS, Los Angeles	A	25615, 21570, 15345, 15330, 11790
7:00-9:00 p.m.	0000-0200	R. Luxembourg	C	6090 (Time varies)
7:00-9:00 p.m.	0000-0200	VOA	A	17730, 15205, 11740, 9650, 6130, 5995
7:00-12:00 p.m.	0000-0500	R. Moscow (via Cuba)	A	9600
7:00 p.m.-4:00 a.m.	0000-0900	UN Radio	A	6055 (when in session)
7:05-8:55 p.m.	0005-0155	Spanish Foreign R.	B	11880, 9630
7:15-8:00 p.m.	0015-0100	BRT, Belgium	C	15385, 15175
7:25-7:40 p.m.	0025-0040	SODRE, Uruguay	C	11885, 9515 (time varies)
7:30-8:00 p.m.	0030-0100	R. Prague	C	6055
7:30-8:00 p.m.	0030-0100	R. Budapest	B	17710, 15220, 11910, 9835, 9585 (Wed. and Fri.)
7:30-8:00 p.m.	0030-0100	La Cruz del Sur, Bolivia	D	4875 (Mon. only)
7:30-9:00 p.m.	0030-0200	HCJB, Ecuador	A	15155
7:30-9:30 p.m.	0030-0230	SLBC, Sri Lanka	C	15425
7:30-9:30 p.m.	0030-0230	BBC	A	15260, 11835, 11750, 9580, 9410, 7325, 6175, 6120, 5975
7:35-9:30 p.m.	0035-0230	HCJB, Ecuador	B	26020, 15360, 9745
7:55-8:35 p.m.	0055-0135	TWR-Bonaire	B	11745
8:00-8:15 p.m.	0100-0115	R. Japan	C	17755
8:00-8:15 p.m.	0100-0115	Vatican R.	B	11845, 9605, 6015
8:00-8:20 p.m.	0100-0120	RAI, Italy	B	11800, 9575
8:00-8:25 p.m.	0100-0125	Kol Israel	A	15583, 11638, 9815

8:00-8:30 p.m.	0100-0130	R. Argentina	B	11710 (not Mon.)
8:00-8:30 p.m.	0100-0130	R. Mexico	B	15430 (Sun.)
8:00-8:30 p.m.	0100-0130	R. Budapest	B	17710, 15220, 11910, 9835, 9585 (not Mon.)
8:00-8:30 p.m.	0100-0130	R. Canada International	A	17820, 9755, 5960
8:00-8:55 p.m.	0100-0155	R. Prague	B	11990, 9740, 9540, 7345, 5930
8:00-8:55 p.m.	0100-0155	R. Peking	B	17855, 17680, 15125
8:00-9:00 p.m.	0100-0200	V. of Free China	C	17890, 15345, 11825
8:00-9:00 p.m.	0100-0200	R. Moscow	A	21530, 17720, 15455, 15140, 12050, 12010, 11960, 11860, 11780, 9765, 9710, 9685, 9610, 9530 (9700 from 0130)
8:00-9:00 p.m.	0100-0200	AFRTS, Los Angeles	A	25615, 21570, 15345, 15330, 11790
8:00-9:00 p.m.	0100-0200	WYFR, Family Radio	B	9715
8:00-10:30 p.m.	0100-0330	R. Australia	B	21740, 17795
8:00-11:50 p.m.	0100-0450	R. Habana Cuba	B	11930, 11725
8:20 p.m.-12:10 a.m.	0120-0510	R. Belize	C	3285, 834
8:20-8:50 p.m.	0120-0150	V. of Germany	A	15105, 11865, 9590, 9565, 9545, 6145, 6085, 6040
8:30-8:45 p.m.	0130-0145	V. of Greece	B	11730, 9655, 9515 (not Sun.)
8:30-8:57 p.m.	0130-0157	Austrian Radio	B	9770, 5945
8:30-8:55 p.m.	0130-0155	R. Tirana	B	9750, 7120
8:30-9:15 p.m.	0130-0215	R. Berlin International	C	11970, 9730
8:30-9:30 p.m.	0130-0230	R. Japan	C	21640, 17825, 17725, 15235
8:45-9:15 p.m.	0145-0215	Swiss R. International	A	15305, 11715, 9725, 6135
9:00-9:15 p.m.	0200-0215	R. Japan	C	17755
9:00-9:25 p.m.	0200-0225	Kol Israel	A	15583, 11638, 9815
9:00-9:30 p.m.	0200-0230	R. Canada International	A	11940, 9755, 5960
9:00-9:30 p.m.	0200-0230	R. Norway	B	11870, 11860, 9610 (Mon. only)
9:00-9:30 p.m.	0200-0230	R. Kiev	B	17870, 15100, 11790, 9665
9:00-9:30 p.m.	0200-0230	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000†
9:00-9:40 p.m.	0200-0240	R. Polonia	B	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
9:00-9:50 p.m.	0200-0250	R. RSA	B	11900, 9585, 5980
9:00-9:55 p.m.	0200-0255	R. Bucharest	C	11940, 11840, 11735, 9690, 9570, 5990
9:00-9:55 p.m.	0200-0255	R. Peking	B	17855, 17680, 15120
9:00-10:00 p.m.	0200-0300	R. Nacional, Brazil	A	15290, 17830
9:00-10:00 p.m.	0200-0300	R. Moscow	A	17720, 15455, 15240, 15140, 12050, 12010, 11960, 11860, 11780, 9710, 9700, 9685, 9610, 9530
9:00-10:30 p.m.	0200-0330	R. Cairo	B	12050, 9475
9:00-11:00 p.m.	0200-0400	VOA	A	15205, 9650, 5995
9:00-11:30 p.m.	0200-0430	AFRTS, Los Angeles	A	21570, 17765, 11790, 9755, 6030
9:00-12:00 p.m.	0200-0500	WYFR, Family Radio	A	9715, 5985
9:30-9:45 p.m.	0230-0245	R. Pakistan	C	21590, 17835, 21745†
9:30-9:45 p.m.	0230-0245	UN Radio	A	15240, 6035, 15685 SSB 10869-SSB (Sat.)
9:30-9:55 p.m.	0230-0255	R. Tirana	B	9750, 7120
9:30-10:00 p.m.	0230-0300	R. Lebanon	C	15170 or 11820† (time varies)
9:30-10:00 p.m.	0230-0300	R. Finland	B	11755, 15400
9:30-10:00 p.m.	0230-0300	R. Sweden	B	15315, 11705
9:30-10:15 p.m.	0230-0315	R. Berlin International	B	11975, 11890, 11840
9:30-10:25 p.m.	0230-0325	R. Nederland	A	9590, 6165
9:30-10:30 p.m.	0230-0330	R. Korea	C	15575, 11810
9:30-10:30 p.m.	0230-0330	BBC	A	11750, 9580, 9510, 9410, 7325, 6175, 6120, 5975
9:30-12:00 p.m.	0230-0500	HCJB, Ecuador	A	15155, 9745
9:51-9:58 p.m.	0351-0358	V. of Yerevan	C	17870, 17845, 15100
10:00-10:15 p.m.	0300-0315	R. Japan	C	17755
10:00-10:15 p.m.	0300-0315	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000† (Wed. & Fri.; Mon. -0330)
10:00-10:25 p.m.	0300-0325	R. Polonia	B	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
10:00-10:30 p.m.	0300-0330	R. Canada International	A	11940, 11845, 9755, 9535, 5960
10:00-10:30 p.m.	0300-0330	R. Portugal	B	11925, 6185 or 15125†
10:00-10:30 p.m.	0300-0330	R. Australia	C	15260 (Fri.)
10:00-10:50 p.m.	0300-0350	V. of Free China	C	17890, 15270, 11825
10:00-10:55 p.m.	0300-0355	R. Prague	B	11990, 9740, 9540, 7345, 5930
10:00-10:55 p.m.	0300-0355	R. Peking	B	17680, 15120
10:00-11:00 p.m.	0300-0400	R. Moscow World Service	A	17765, 15460, 11960, 11860, 11780, 9700, 9610, 9530
10:00-11:00 p.m.	0300-0400	TIFC Costa Rica	C	9645, 5055, (Mon. 0235-0435)
10:00-11:00 p.m.	0300-0400	R. Baghdad	D	11935
10:00-11:15 p.m.	0300-0415	R. Uganda	B	15325 (irregular)
10:00-11:26 p.m.	0300-0426	R. RSA	B	11900, 9585, 7270, 5980
10:00-11:30 p.m.	0300-0430	R. Cultural, Guatemala	B	3300 (Mon. 0030–)
10:00 p.m.-1:00 a.m.	0300-0600	HRVC, Honduras	B	4820
10:00 p.m.-2:00 a.m.	0300-0700	R. Moscow	A	17845, 15470, 15455, 15420, (15140 and 15100 to 0400), 12050, 12010, 9790, 9580
10:00 p.m.-2:30 a.m.	0300-0730	VOA	A	15240, 9670, 6040, 6035, 5995
10:25 p.m.-fade	0325-	R. One, Zimbabwe	C	3396 (exc. Sun.)
10:30-10:55 p.m.	0330-0355	R. Tirana	B	7300, 6200
10:30-10:57 p.m.	0330-0357	U.A.E. Radio, Dubai	B	15320, 11755†
10:30-10:57 p.m.	0330-0357	Austrian Radio	C	9770, 5945
10:30-11:00 p.m.	0330-0400	R. Australia	B	21680, 17890, 17870, 17795, 17725
10:30-11:45 p.m.	0330-0445	BBC	A	15070, 9410, 6175, 5975
10:30-12:00 p.m.	0330-0500	AWR Guatemala	C	5980
10:30 p.m.-1:00 a.m.	0330-0600	R. Habana Cuba	A	11760, 11725
10:40-10:47 p.m.	0340-0347	V. of Greece	B	11730, 9650, 9515 (not Sun.)
10:50-11:10 p.m.	0350-0410	RAI, Italy	C	21560, 17795, 15330
11:00-11:15 p.m.	0400-0415	R. Japan	C	17755
11:00-11:30 p.m.	0400-0430	R. Bucharest	C	11940, 11840, 11735, 9690, 9570, 5990
11:00-11:30 p.m.	0400-0430	R. Canada International	A	11845, 9755, 9535, 5960
11:00-11:30 p.m.	0400-0430	R. Norway	C	21730, 15175, 11860 (Mon. only)

11:00-11:30 p.m.	0400-0430	R. Mozambique	C	4855, 3265
11:00-11:55 p.m.	0400-0455	R. Peking	B	17680, 15120
11:00-12:00 p.m.	0400-0500	R. Sofia	C	11860†
11:00-12:00 p.m.	0400-0500	R. Australia	B	21680, 21650, 21525, 17890, 17870, 17795, 17755, 17725, 15320, 15240, 15160
11:00-12:00 p.m.	0400-0500	R. Moscow World Service	A	17765, 15460, 12055, 11960, 11790, 9610, 9530
11:00 p.m.-1:00 a.m.	0400-0600	TWR, Bonaire	A	9755
11:05-11:50 p.m.	0405-0450	FEBA, Seychelles	C	15400†
11:30-11:57 p.m.	0430-0457	Austrian R.	B	12015
11:30-12:00 p.m.	0430-0500	Swiss R. International	B	11715, 9725
11:30 p.m.-1:00 a.m.	0430-0600	AFRTS, Los Angeles	A	17765, 11790, 15330, 9755, 6030
11:45-12:00 p.m.	0445-0500	Vatican Radio	C	6210 or 6190
11:45 p.m.-12:45 a.m.	0445-0545	BBC	A	15070, 9510, 9410, 6175, 5975
11:55 p.m.-1:00 a.m.	0455-0600	V. of Nigeria	C	7255
12:00-12:15 a.m.	0500-0515	Kol Israel	B	17710, 15105, 15583, 11638
12:00-12:15 a.m.	0500-0515	R. Japan	C	15430
12:00-12:30 a.m.	0500-0530	R. Portugal	B	9575 or 11925, 6185
12:00-1:00 a.m.	0500-0600	R. Australia	C	21680, 17890, 17870, 17725, 15240, 15160
12:00-1:00 a.m.	0500-0600	WYFR, Family Radio	A	9705, 5985
12:00-1:00 a.m.	0500-0600	R. Moscow World Service	B	17730, 15460, 11790
12:00-2:00 a.m.	0500-0700	HCJB, Ecuador	B	9745, 6095, 11915
12:00-3:00 a.m.	0500-0800	R. Kuwait	C	21545 or 15345
2:00-3:00 a.m.	0500-0800	R. Nigeria, Kaduna	B	4770 (not all Eng.)
12:00-5:00 a.m.	0500-1000	V. of Cuba	B	550
12:10-12:45 a.m.	0510-0545	UAE Radio, Dubai	C	17810, 17775†
12:15-1:15 a.m.	0515-0615	Spanish Foreign R.	B	11880, 9630
12:22-12:30 a.m.	0522-0530	UN Radio	A	9540, 6055 (Tue.-Sat.)
12:30-12:40 p.m.	0530-0540	R. Garoua, Cameroon	C	5010
12:30-12:50 a.m.	0530-0550	V. of Germany	A	11905, 9650, 9545, 6100, 5960
12:30-fade	0530	R. Ghana	C	3366, 4915
12:30-1:25 a.m.	0530-0625	R. Nederland	A	9715, 6165
12:45-1:00 a.m.	0545-0600	UN Radio	A	9540, 6055 (Tue.-Sat.)
12:45-1:30 a.m.	0545-0630	R. Berlin Int.	B	17700, 15100
12:45-2:30 a.m.	0545-0730	BBC	B	15070, 11955, 11860, 9640, 9510, 9410, 7150, 6175
1:00-1:15 a.m.	0600-0615	R. Japan	C	15430
1:00-1:30 a.m.	0600-0630	V. of Germany	C	17875, 15275, 11905, 11765, 9700
1:00-1:30 a.m.	0600-0630	R. Norway	B	21655, 15170, 11860 (Mon. only)
1:00-1:30 a.m.	0600-0630	R. Australia	C	21680, 21525, 17870, 17795, 17755, 17725, 15240, 15160
1:00-2:00 a.m.	0600-0700	AFRTS, Los Angeles	B	11790, 9755, 6030
1:00-2:00 a.m.	0600-0730	HCJB, Ecuador	C	11835, 15225
1:00-3:00 a.m.	0600-0800	V. of Nigeria	C	15185, 15120, 17800
1:15-1:30 a.m.	0615-0630	R. Canada International	B	17860, 15325, 11960, 11825, 11775, 9760, 9590, 7135, 6140, 6045 (Mon-Fri)
1:25-3:00 a.m.	0625-0800	TWR, Monte Carlo	B	9495† (Sun. to 1000)
1:25-3:55 a.m.	0625-0855	V. of Malaysia	C	15295, 12350, 9750
1:30-2:00 a.m.	0630-0700	R. Australia	B	21680, 17870, 17725, 15240, 15115
1:30-2:00 a.m.	0630-0700	Radio Polonia	B	9675, 7270
1:30-2:30 a.m.	0630-0730	R. RSA	B	21535, 17780, 15220
1:30-3:00 a.m.	0630-0800	R. Habana Cuba	A	9525
1:40-7:25 a.m.	0640-1225	R. New Zealand	C	11945
1:45-2:00 a.m.	0645-0700	R. Canada International	B	17860, 15325, 11960, 11825, 11775, 9760, 9590, 7135, 6140, 6045 (Mon-Fri)
1:45-2:00 a.m.	0645-0700	UN Radio	A	15125, 11735 (Sat.)
1:57-4:55 a.m.	0657-0955	V. of Philippines	C	9578 (not all English)
2:00-2:15 a.m.	0700-0715	R. Japan	C	15430, (15170† via Portugal)
2:00-2:20 a.m.	0700-0720	R. Nederland	C	25650, 21480, 17605, 11720, 9895
2:00-2:30 a.m.	0700-0730	Swiss Radio Int.	C	21520, 15305, 9535, 9560
2:00-3:00 a.m.	0700-0800	Xandir Malta	C	9670 (Sat.) (irregular)
2:00-3:00 a.m.	0700-0800	ELWA, Liberia	C	11830
2:00-3:00 a.m.	0700-0800	V. of Vietnam	C	7512, 9840, 6383
2:00-4:00 a.m.	0700-0900	R. Australia	B	21680, 17725, 15115, 11740, 9570
2:00-5:30 a.m.	0700-1030	HCJB, Ecuador	C	11900, 9745, 6130
2:07-2:15 a.m.	0707-0715	UN Radio	A	17815, 15195 (Sat.)
2:30-3:25 a.m.	0730-0825	R. Nederland	B	9770, 9715
2:30-4:00 a.m.	0730-0900	BBC	B	15070, 11955, 9640, 9510
2:30-6:30 a.m.	0730-1130	Solomon Isl. Broadcasting	C	9545 or 5020 (Not all Eng.)
2:30-9:00 a.m.	0730-1400	NBC, Papua New Guinea	C	4890, 3925 (not all Eng.)
2:30-9:02 a.m.	0730-1402	ABC Melbourne	C	9680
2:37-2:45 a.m.	0737-0745	UN Radio	A	17815, 15195 (Sat.)
2:45-4:30 a.m.	0745-0930	KTWR, Guam	B	11840
2:55 a.m.-fade	0755-	Action Radio, Guyana	C	5950
2:55-3:05 a.m.	0755-0805	V. of Guatemala	B	6180, 640 (time varies)
3:00-3:15 a.m.	0800-0815	R. Japan	B	9505
3:00-3:30 a.m.	0800-0830	R. Norway	C	15135, 11850 (Sun.)
3:00-315 a.m.	0800-0815	UN Radio	A	17860, 15235, 15125, 11735 (Sat.)
3:00-4:00 a.m.	0800-0900	R. Korea	B	15575, 11810, 9870
3:00-9:00 a.m.	0800-1400	R. East Coast Commercial	D	11578† (Sat.)
3:30-3:35 a.m.	0830-0835	UN Radio	A	15250, 10385, 9565 (Sat.)
3:30-4:25 a.m.	0830-0925	R. Nederland	B	9715
3:30-5:00 a.m.	0830-1000	FEBC, Philippines	C	11890 or 11765
24 Hours	24 Hours	CFRX, Toronto	C	6070

Explanatory Notes.

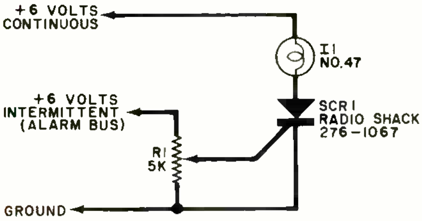
1. Times in first column are EST/CDT. For ADT add 2 hours; EDT add 1 hour; MDT, subtract 1 hour, MST/PDT, subtract 2 hours. Days of week are in GMT.
2. Quality. A—strong signal and very reliable reception. B—regular reception. C—occasional reception under favorable conditions. D—rarely audible. These ratings are for locations in the central USA. European and African stations are in general, more reliably received in eastern North America. Asian and Pacific stations are more reliably received in western North America. North American stations are received well except in areas too close to the transmitter site.
3. The information in this listing is correct to press time. However, frequencies and schedules are constantly changing. Listen to "DX Digest" on R. Canada International for late changes, Saturday at 2130; Sunday at 1930; GMT Mondays at 0100 and 0400.
4. R.—Radio; V.—Voice

† = frequent changes

TIPS & TECHNIQUES

Memory Circuit for Alarm Systems

Many simple alarm systems offer reliable performance but lack one convenience—a memory circuit. Such a memory circuit would alert the owner upon arriving at his premises that the alarm system has been triggered and that he should enter cautiously (if at all). Shown in the figure is a memory circuit

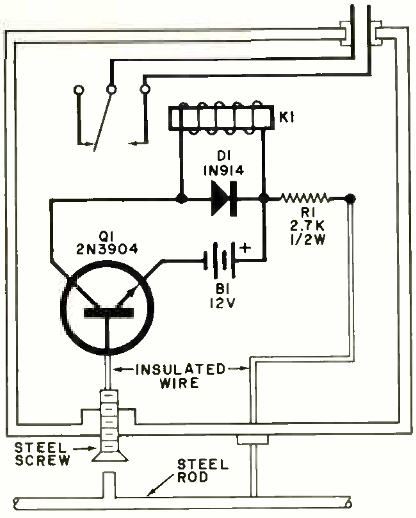


that I added to my alarm system. It takes advantage of the system's continuously available +6-volt supply and the +6 volts that appears on the local-alarm bus during the alerting interval. The 5-kΩ linear-taper potentiometer functions as a voltage divider. It is adjusted to keep the voltage applied to the gate of the SCR within the +1.5-volt maximum rating of the Radio Shack device used. The lamp is installed near the garage door where it is easily checked upon returning home. Although the alarm system resets itself automatically after a fixed time interval, the remote lamp continues to glow until switch *S1* is momentarily opened.—*Edward B. Harris, Spring Valley, NY.*

Perforated Construction Aid

Those who assemble electronic projects using perforated board and point-to-point wiring techniques can obtain more professional results in less time if the board is photocopied before it is wired. Such photocopies will contain arrays of dots corresponding to the board's holes, and the spacing between adjacent dots will be almost exactly the same as that between adjacent board perforations. Prototype component layouts and wiring pictorials can be drawn on photocopies of the board using full-size renditions of the components to be mounted on it.

Working out the "bugs" of a circuit board on paper at the proper scales reduces assembly time and results in improved project appearance. Component spacing on the board will be perfect if the art-work is used as a guide during construction. What's more, a permanent record is generated, simplifying circuit duplication should that be necessary in the future.—*J.C. Smolski, Wilton, NH.*



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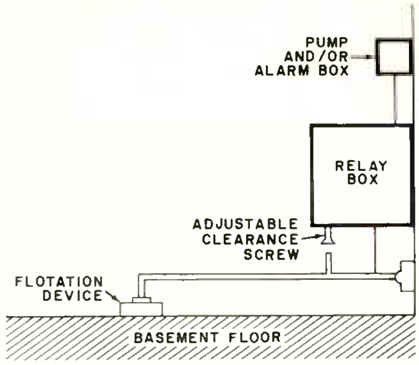

B

Basement Flood Alarm

This circuit is intended for those people who are unlucky enough to have leaky basements. It is designed to give a resident early warning of rising water so that he can take the necessary steps to correct the problem. It is shown schematically in Fig. A. Battery *B1* is a 12-volt power source and can be two 6-volt lantern batteries or 8 D cells connected in series. When the rising water causes the steel rod to contact the screw (by means of a flotation device as shown in Fig. B), base current flows through *Q1*. The transistor then conducts and energizes relay *K1*. The relay contacts can be connected to an alarm, a pump, or any combination of devices.

The only precautions that must be observed are that the relay contacts are rated to handle the current drawn by the load(s) connected to them and that the coil current does not exceed the rated collector current of *Q1* (200 mA). The best location for the flood alarm is either in a corner of the basement or at a low spot where water should most likely collect. The screw is adjustable so that the relay will be energized when the water reaches a predetermined level.—*Donald R. Swenson, Webster, WI.*

ELECTRONICS LIBRARY

Digital Electronics

by Christopher E. Strangio

This book can serve as a comprehensive introduction to digital electronics. It ranges from basic concepts right on up complex to digital computers. Early chapters are devoted to entry-level discussions of logic concepts, boolean algebra, combinational logic circuits and Karnaugh mapping, binary number operations, and the octal and hexa-decimal codes. Details for analyzing and designing flip-flop, counter, and sequential circuits are then discussed, followed by practical digital-circuit fault analysis. *Published by Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Hard cover. 523 pages. $24.95.*

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by Gerry Kane

Here's a reference book for the person who wants to understand design of controller circuits for displaying alphanumerics and graphics on the screen of a cathode ray tube. The first chapter provides general information on the basics of CRT operation. After covering technical details of the CRT itself, it delves into such topics as character-generation logic, screen memory, manipulation of screen data, etc., and finishes up with a section that compares five popular LSI controller chips. Each of the remaining five chapters is devoted to detailed descriptions of one of these controller chips. *Published by Osborne/McGraw-Hill, 630 Bancroft Way, Berkeley, CA 94710. Soft cover. 216 pages. $6.99.*

Pascal

by David L. Heiserman

If you're thinking of moving up to Pascal programming with your microcomputer, this book offers a painless way of learning how to use and manipulate this powerful high-level computer language. The example used in the text is Tiny Pascal written for a TRS-80 II microcomputer. (Tiny Pascal for microcomputers is an abbreviated form of Standard Pascal that can be run only in large computer systems.) Except for a few graphics commands unique to the TRS-80, the material covered in this book is equally applicable to almost any other microcomputer/Pascal system. The text makes no assumption that the reader is conversant with Pascal. To this end, every step is clearly spelled out, from powering up the TRS-80 to running programs written in Pascal. *Published by Tab Books, Blue Ridge Summit, PA 17214. Soft cover. 350 pages. $9.95.*

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PROJECT OF THE MONTH

By Forrest M. Mims

Steam Engine and Whistle Sound Synthesizer

THIS month's project is for model railroaders and anyone else who appreciates the sounds of old-fashioned steam locomotives. A circuit that recreates those nostalgic sounds is shown in Fig. 1.

Originated at Texas Instruments, the circuit is designed around the SN76477 sound-effects chip. In operation, the output of the chip's noise generator is switched on and off by its super-low-frequency (SLF) oscillator. Potentiometer *R2* controls the switching rate, hence the speed of the engine sound.

When *R2*'s resistance is high, the sound resembles that of a stopped train whose engine is idling. As the potentiometer's effective resistance is reduced, the sound speeds up and resembles that produced by an accelerating train.

The sound of the train's whistle is derived from the output of the voltage controlled oscillator (vco) in the SN76477. The values of *C2* and *R3* control the whistle's pitch. Pressing *S1* activates the whistle.

The output of the SN76477 is amplified by *Q1*, which in turn drives a small 8-ohm speaker. Resistor *R11* controls the amplitude of the sound from the speaker. If you prefer, you can drive an external audio power amplifier with the signal voltage appearing between pin 13 of the IC and ground.

For a little more money, you can buy the SN76488. This chip has everything that the SN76477 has, as well as a built-in amplifier, but it has a different pinout. If you use this chip, omit *Q1* from the circuit in Fig. 1 and connect pin 13 directly to one terminal of the speaker. Connect the second speaker terminal to ground through *C4*. Resistors *R10* and *R11* should be omitted.

A drawback of the circuit in Fig. 1 is that the steam-engine sound generator is disabled when the whistle is activated. This problem can be remedied by adding a simple whistle-multiplexer circuit (Fig. 2) and by removing *S1* from the circuit of Fig. 1.

When activated, the whistle multiplexer, which was also suggested by Texas Instruments, switches the whistle on and off at a rate of 26 kHz. Even though the steam-engine sound is turned off when the whistle is on, the switching rate is far too fast for the ear to detect. Consequently, the whistle seems to be superimposed on the sound of the engine. The only audible effect of the whistle multiplexer on the steam-engine sound is a slight reduction in volume when the whistle is activated.

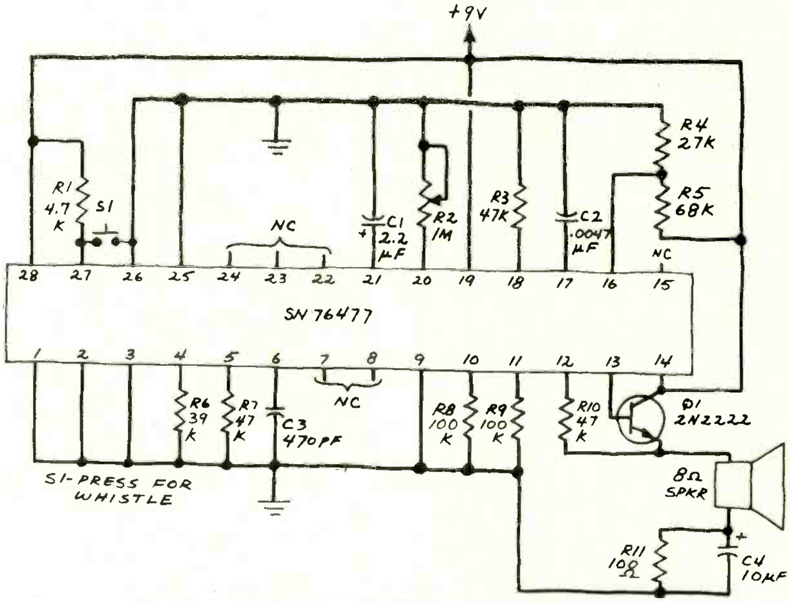

Fig. 1. Schematic using the SN76477 sound-effects chip to generate sounds of a steam locomotive.

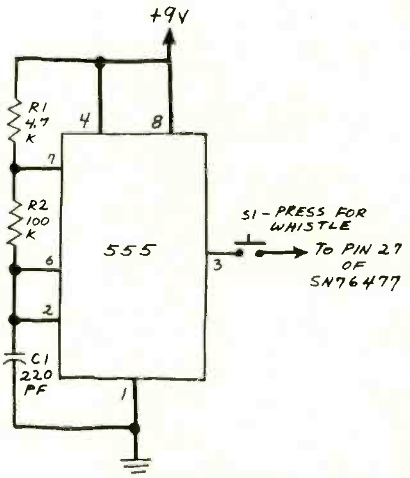

Fig. 2. Whistle multiplexer for steam-engine simulator.

Model railroaders might want to modify this circuit so that the engine sound speeds up *automatically* when a model train is accelerating. This can be done with the help of a homemade optoisolator made from a small lamp and a cadmium-sulfide photocell. Use black electrical tape or heat-shrinkable tubing to mount the lamp adjacent to the photocell and to block ambient light.

Connect the lamp in the optoisolator to the train's transformer. Remove *R2* from the circuit of Fig. 1 and connect the photocell in its place. As the train's speed is increased, the lamp will glow more brightly. This will reduce the resistance of the photocell and increase the rate at which the sound-effects generator is switched on and off by the SLF oscillator.

It might be necessary to add a series resistor between the photocell and the circuit to match the sound of the engine with the speed of the train. You can achieve the same result by blacking out part of the photocell's window. ◇

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SN7437N	.25	SN74125N	.49	SN74194N	.89
SN7438N	.40	SN74126N	.49	SN74195N	.69
SN7439N	.25	SN74132N	.75	SN74196N	.89
SN7440N	.20	SN74136N	.75	SN74197N	.89
SN7441N	.89	SN74141N	.99	SN74198N	1.49
SN7442N	.59	SN74142N	3.25	SN74199N	1.49
SN7443N	1.10	SN74143N	3.49	SN74221N	1.25
SN7444N	1.10	SN74144N	3.49	SN74251N	.99
SN7445N	.89	SN74145N	.79	SN74276N	1.95
SN7446N	.79	SN74147N	1.95	SN74279N	.79
SN7447N	.69	SN74148N	1.29	SN74283N	1.49
SN7448N	.79	SN74150N	1.25	SN74284N	3.95
SN7450N	.20	SN74151N	.69	SN74285N	3.95
SN7451N	.20	SN74152N	.69	SN74365N	.69
SN7453N	.20	SN74153N	.79	SN74366N	.69
SN7454N	.20	SN74154N	1.25	SN74367N	.69
SN7459A	.25	SN74155N	.79	SN74368N	.69
SN7460N	.20			SN74390N	1.49
SN7470N	.29			SN74393N	1.49

74LS

74LS00	.29	74LS92	.75	74LS192	1.15
74LS01	.29	74LS93	.75	74LS193	1.15
74LS02	.29	74LS95	.99	74LS194	1.15
74LS03	.29	74LS96	1.15	74LS195	1.15
74LS04	.35	74LS107	.45	74LS197	1.19
74LS05	.35	74LS109	.45	74LS221	1.19
74LS08	.29	74LS112	.45	74LS240	1.95
74LS09	.35	74LS113	.49	74LS241	1.95
74LS10	.29	74LS114	.49	74LS242	1.95
74LS11	.75	74LS122	.89	74LS243	1.95
74LS12	.35	74LS123	1.25	74LS244	1.95
74LS13	.59	74LS125	.89	74LS245	2.95
74LS14	.99	74LS126	.55	74LS247	1.19
74LS15	.35	74LS132	.99	74LS248	1.19
74LS20	.29	74LS133	.89	74LS249	1.19
74LS21	.35	74LS136	.49	74LS251	1.49
74LS22	.35	74LS138	.89	74LS253	.99
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS151	.89	74LS258	.99
74LS28	.35	74LS153	.89	74LS260	.69
74LS30	.29	74LS154	1.75	74LS266	.69
74LS32	.35	74LS155	1.19	74LS273	1.95
74LS33	.59	74LS156	1.19	74LS279	.75
74LS37	.45	74LS157	.89	74LS283	1.09
74LS38	.49	74LS158	.99	74LS290	.99
74LS40	.35	74LS160	1.15	74LS293	.99
74LS42	.89	74LS161	1.15	74LS298	1.25
74LS47	.89	74LS162	1.15	74LS352	1.29
74LS48	1.15	74LS163	1.15	74LS353	1.29
74LS49	1.15	74LS164	1.25	74LS365	.75
74LS51	.29	74LS165	1.25	74LS366	.75
74LS54	.29	74LS168	1.19	74LS367	.75
74LS55	.29	74LS169	1.19	74LS368	.75
74LS73	.45	74LS170	2.49	74LS373	1.95
74LS74	.45	74LS173	1.39	74LS374	1.95
74LS75	.59	74LS174	.99	74LS375	.89
74LS76	.45	74LS175	.99	74LS386	.69
74LS78	.49	74LS181	2.95	74LS393	2.49
74LS83	.89	74LS190	1.25	74LS399	2.49
74LS85	1.25	74LS191	1.25	74LS670	2.49
74LS86	.45			81LS95	1.95
74LS90	.59			81LS97	1.95

74S

74S00	.50	74S133	.55	74S244	3.25
74S02	.50	74S134	.69	74S251	1.45
74S03	.50	74S135	1.19	74S253	1.45
74S04	.55	74S136	1.75	74S257	1.35
74S05	.55	74S138	1.35	74S258	1.35
74S08	.50	74S139	1.35	74S260	.79
74S09	.50	74S140	1.15	74S280	2.95
74S10	.50	74S151	1.35	74S287*	4.95
74S11	.50	74S153	1.35	74S288*	4.95
74S15	.50	74S157	1.35	74S373	3.49
74S20	.50	74S158	1.35	74S374	3.49
74S22	.50	74S174	1.59	74S387*	5.95
74S30	.50	74S175	1.59	74S471*	19.95
74S32	.55	74S188	4.95	74S472*	19.95
74S40	.55	74S194	1.95	74S473*	19.95
74S51	.50	74S195	1.95	74S474*	21.95
74S64	.50	74S196	3.95	74S475*	21.95
74S65	.50	74S240	2.95	74S570*	7.95
74S74	.79	74S241	2.95	74S571*	7.95
74S86	.79	74S242	3.25	74S572*	19.95
74S112	.79	74S243	3.25	74S573*	19.95
74S113	.79			74S940	3.15
74S114	.79			74S941	3.15

* LIMITED AVAILABILITY ON THESE PROMS

CA—LINEAR

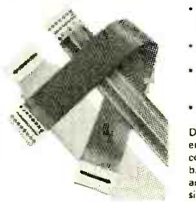
CA3013H	2.15	CA3081N	2.00	CA3089N	3.75
CA3023H	3.25	CA3082N	2.00	CA3096N	3.95
CA3039H	1.35	CA3083N	1.60	CA3130H	1.39
CA3046N	1.30	CA3086N	.85	CA3140H	1.25
CA3059N	3.25			CA3160H	1.25
CA3060N	3.25			CA3401N	.59
CA3080H	1.25			CA3600N	3.50

CD—CMOS

CD4000	.39	CD4041	1.49	CD4082	.39
CD4001	.39	CD4042	.99	CD4093	.99
CD4002	.39	CD4043	.89	CD4098	2.49
CD4006	1.19	CD4044	.89	CD4506	.75
CD4007	.25	CD4046	1.79	CD4507	.99
CD4009	.49	CD4047	2.50	CD4508	3.95
CD4010	.49	CD4048	1.35	CD4510	1.39
CD4011	.39	CD4049	.49	CD4511	1.29
CD4012	.25	CD4050	.69	CD4514	3.95
CD4013	.49	CD4051	1.19	CD4515	2.95
CD4014	1.39	CD4052	1.19	CD4516	1.49
CD4015	1.19	CD4053	1.19	CD4518	1.79
CD4016	.59	CD4056	2.95	CD4519	.89
CD4017	1.19	CD4059	9.95	CD4520	1.29
CD4018	.99	CD4060	1.49	CD4526	1.79
CD4019	.49	CD4066	.79	CD4528	1.79
CD4020	1.19	CD4068	.39	CD4529	1.95
CD4021	1.39	CD4069	.45	CD4543	2.79
CD4022	1.19	CD4070	.55	CD4562	11.95
CD4023	.29	CD4071	.49	CD4566	2.79
CD4024	.79	CD4072	.49	CD4583	2.49
CD4025	.23	CD4073	.39	CD4723	1.95
CD4026	2.95	CD4075	.39	CD4724	1.95
CD4027	.69	CD4076	1.39	MC14409	14.95
CD4028	.89	CD4078	.55	MC14410	14.95
CD4029	1.49	CD4081	.39	MC14411	14.95
CD4030	.49			MC14412	11.95
CD4035	.99			MC14419	4.95
CD4040	1.49			MC14433	13.95

A P PRODUCTS

DIP JUMPERS



- Mate with Standard IC Sockets
- Fully Assembled and Tested
- Integral Molded On Strain Relief
- Line By-Line Probeability

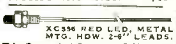
Dip Jumpers are used for jumpering within a PC Board; interconnecting between PC Boards, backplanes and mother boards; and interfacing input/output signals.

Part Number	No. of contacts	Description	Wire Length	Price
924102-12	14	single end	12"	$1.51
924102-24	14	single end	24"	1.92
924102-36	14	single end	36"	2.33
924106-12	14	double end	12"	2.61
924106-24	14	double end	24"	3.02
924106-36	14	double end	36"	3.43
924112-12	16	single end	12"	1.67
924112-24	16	single end	24"	2.13
924112-36	16	single end	36"	2.59
924116-12	16	double end	12"	2.88
924116-24	16	double end	24"	3.34
924116-36	16	double end	36"	3.80
924122-12	24	single end	12"	2.60
924122-24	24	single end	24"	3.30
924122-36	24	single end	36"	4.00
924126-12	24	double end	12"	4.50
924126-24	24	double end	24"	5.20
924126-36	24	double end	36"	5.90
924132-12	40	single end	12"	4.35
924132-24	40	single end	24"	5.53
924132-36	40	single end	36"	6.71

DISCRETE LEDS

XC556R	.200"	red	5/$1	MV50	.085"	red	6/$1	XC111R	.190"	red	5/$1
XC556G	.200"	green	4/$1	XC209R	.125"	red	5/$1	XC111G	.190"	green	4/$1
XC556Y	.200"	yellow	4/$1	XC209G	.125"	green	4/$1	XC111Y	.190"	yellow	4/$1
XC556C	.200"	clear	4/$1	XC209Y	.125"	yellow	4/$1	XC111C	.190"	clear	4/$1
XC22R	.200"	red	5/$1	XC526R	.185"	red	5/$1				
XC22G	.200"	green	4/$1	XC526G	.185"	green	4/$1				
XC22Y	.200"	yellow	4/$1	XC526Y	.185"	yellow	4/$1				
MV10B	.170"	red	4/$1	XC526C	.185"	clear	4/$1				



XC556 RED LED, METAL MTG. HDW. 2-6" LEADS.

RL-2 . . $.39 ea. or 3/$1.00

DISPLAY LEDS

C.A. — Common Anode   C.C. — Common Cathode

Type	Polarity	Ht	Price	Type	Polarity	Ht	Price
MAN 1	C.A.—red	.270	2.95	DLG507	C.A.—green	.500	1.25
MAN 2	5x7 D.M.—red	.300	4.95	DL704	C.C.—red	.300	1.25
MAN 3	C.C.—red	.125	.25	DL707	C.A.—red	.300	1.25
MAN 52	C.A.—green	.300	1.25	DL728	C.C.—red	.500	1.49
MAN 54	C.C.—green	.300	1.25	DL741	C.A.—red	.600	1.25
MAN 71	C.A.—red	.300	.75	DL746	C.A.—red ± 1	.630	1.49
MAN 72	C.A.—red	.300	.75	DL747	C.A.—red	.600	1.49
MAN 74	C.C.—red	.300	1.25	DL750	C.C.—red	.600	1.49
MAN 82	C.A.—yellow	.300	.49	DLO847	C.A.—orange	.800	1.49
MAN 84	C.C.—yellow	.300	.99	DLO850	C.C.—orange	.800	1.49
MAN 3620	C.A.—orange	.300	.49	DL33B	C.C.—red	.110	.35
MAN 3630	C.A.—orange ± 1	.300	.99	FND358	C.C. ± 1	.357	.99
MAN 3640	C.C.—orange	.300	.99	FND359	C.C.	.357	.75
MAN 4610	C.A.—orange	.400	.99	FND503	C.C. (FND500)	.500	.99
MAN 6610	C.A.—orange—DD	.560	.99	FND507	C.A. (FND510)	.500	.99
MAN 6630	C.A.—orange ± 1	.560	.99	HDSP-3401	C.A.—red	.800	1.50
MAN 6640	C.C.—orange—DD	.560	.99	HDSP-3403	C.C.—red	.800	1.50
MAN 6650	C.C.—orange ± 1	.560	.99	5082-7751	C.A., R.H.D.—red	.430	1.25
MAN 6660	C.A.—orange	.560	.99	5082-7760	C.C., R.H.D.—red	.430	1.75
MAN 6710	C.A.—red—DD	.560	.99	5082-7300	4x7 sgl. dig. RHD	.600	22.00
MAN 6750	C.C.—red ± 1	.560	.99	5082-7302	4x7 sgl. dig. LHD	.600	22.00
MAN 6780	C.C.—red	.560	.99	5082-7304	Overnge. char. (±1)	.600	19.95
DLO304	C.C.—orange	.300	1.25	4N28	Photo Xsistor Opto-Isol.		.99
DLO307	C.A.—orange	.300	1.25	LIT-1	Photo Xsistor Opto-Isol.		.69
DLG500	C.C.—green	.500	1.25	MOC3010	Optically Isol. Triac Driver		1.25

SOCKETS — RECEPTACLES

Test TEXTOOL Sockets

ZERO INSERTION FORCE

- Nickel Boron Plating
- G.F. PSF Plastic Body
- For testing IC's

- Nickel Boron Plating
- G.F. PSF Plastic Body
- Wire Wrap Contacts

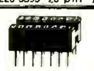
Part No.	Pins	Price	Part No.	Pins	Price
214-3339	14 pin	5.95	222-3343	22 pin	9.95
216-3340	16 pin	6.49	224-3344	24 pin	9.75
218-3341	18 pin	7.95	228-3345	28 pin	11.95
220-3342	20 pin	8.95	240-3346	40 pin	12.95

Part No.	Pins	Price	Part No.	Pins	Price
214-3592	14 pin	9.75	222-3596	22 pin	12.95
216-3593	16 pin	9.95	224-3597	24 pin	12.75
218-3594	18 pin	10.95	228-3598	28 pin	13.95
220-3595	20 pin	11.95	240-3599	40 pin	15.95

LOW PROFILE (TIN) SOCKETS

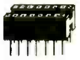
	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)



	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD



	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea.	10 Ohm 12 Ohm 15 Ohm 18 Ohm 22 Ohm 27 Ohm 33 Ohm 39 Ohm 47 Ohm 56 Ohm	50 pcs.	$1.95
ASST. 2	5 ea.	68 Ohm 82 Ohm 100 Ohm 120 Ohm 150 Ohm 180 Ohm 220 Ohm 270 Ohm 330 Ohm 390 Ohm	50 pcs.	$1.95
ASST. 3	5 ea.	470 Ohm 560 Ohm 680 Ohm 820 Ohm 1K 1.2K 1.5K 1.8K 2.2K 2.7K	50 pcs.	$1.95
ASST. 4	5 ea.	3.3K 3.9K 4.7K 5.6K 6.8K 8.2K 10K 12K 15K 18K	50 pcs.	$1.95
ASST. 5	5 ea.	22K 27K 33K 39K 47K 56K 68K 82K 100K 120K	50 pcs.	$1.95
ASST. 6	5 ea.	150K 180K 220K 270K 330K 390K 470K 560K 680K 820K	50 pcs.	$1.95
ASST. 7	5 ea.	1M 1.2M 1.5M 1.8M 2.2M 2.7M 3.3M 3.9M 4.7M 5.6M	50 pcs.	$1.95
ASST. 8R		Includes Resistor Assts. 1-7 (350 pcs.)		$10.95 ea.

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INTERSIL

Part No.	Function	Price
7045IPI	CMOS Precision Timer	14.95
7045EV/Kit*	Stopwatch Chip, XTL	22.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	28.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
7201IDR	Low Battery Volt Indicator	2.25
7205IPG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
7206CEV/Kit*	Tone Generator Chip, XTL	9.95
7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	11.10
7208IPI	Seven Decade Counter	17.95
7209IPA	Clock Generator	3.95
7215IPG	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
7216AIJI	8-Digit Univ. Counter C.A.	32.00
7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter	12.95
7218CIJI	8-Digit Univ. LED Drive	10.95
7224IPL	LCD 4½ Digit Up Counter DRI	11.25
7226AIJL	8-Digit Univ. Counter	31.95
7226AEV/Kit*	5 Function Counter Chip, XTL	74.95
7240IJE	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	5.25
7555IPA	CMOS 555 Timer (8 pin)	1.45
7556IPD	CMOS 556 Timer (14 pin)	2.20
7611BCPA	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.50
8212CPA	Volt Ref/Indicator	2.50

* INTERSIL'S EVALUATION KITS

74C

74C00	.39			74C195	1.59
74C02	.39			74C221	1.95
74C04	.39			74C240	2.25
74C08	.39	74C106	.75	74C244	2.25
74C10	.39	74C107	1.89	74C373	2.49
74C14	.75	74C151	2.95	74C374	2.59
74C20	.39	74C154	3.95	74C901	.89
74C30	.39	74C157	2.25	74C903	1.15
74C42	1.39	74C160	1.69	74C911	10.95
74C48	1.95	74C161	1.69	74C912	10.95
74C73	.79	74C162	1.49	74C915	1.69
74C74	.79	74C163	1.69	74C917	10.95
74C85	1.95	74C164	1.59	74C922	5.49
74C86	.99	74C173	1.39	74C923	5.75
74C89	6.95	74C174	1.39	74C925	7.50
74C90	1.29	74C175	1.39	74C926	7.50
74C93	1.29	74C192	1.69	80C95	.79
74C95	1.59	74C193	1.69	80C97	.79

LINEAR

LH0002CN	6.85			NE570N	4.95
LM10CLH	4.50			LM702H	.79
LM11CLH	4.75			LM703CN	.89
LH0070-OH	6.05	LM340T-5	1.25	LM709N	.49
TL071CP	.79	LM340T-12	1.25	LM710N	.79
TL072CP	1.39	LM340T-15	1.25	LM711N	.79
TL074CN	2.49	LM341P-5	.75	LM723N	.69
LH0082CD	35.80	LM341P-12	.75	LM733N	1.00
TL082CP	1.19	LM341P-15	.75	LM739N	1.19
TL084CN	2.19	LM342P-5	.69	LM741CN	.35
LH0094CD	36.80	LM342P-12	.69	MC1741SCG	3.00
LM300H	.99	LM342P-15	.69	LM747N	.79
LM301CN	.35	LM348N	1.25	LM748N	.59
LM302H	1.95	LM350K	5.75	LM1014N	2.75
LM304H	1.95	LF351N	.60	LM1310N	1.95
LM305H	.99	LF353N	1.00	LM1458CN	.59
LM307CN	.45	LF355N	1.10	LM1488N	1.25
LM308CN	1.00	LF356N	1.10	LM1489N	1.25
LM309H	1.95	LM358N	1.00	LM1496N	1.95
LM309K	1.25	LM359N	1.79	LM1556V	1.75
LM310CN	1.75	LM370N	4.49	LM1800N	2.95
LM311H	.90	LM373N	3.25	LM1877N-9	3.25
LM312H	2.49	LM377N	2.95	LM1889N	3.20
LM317MP	1.15	LM380N	1.25	LM1896N	1.75
LM317T	1.75	LM381N	1.95	LM2002T	1.49
LM317K	3.95	LM382N	1.79	LM2877P	2.05
LM318CN	1.95	LM384N	1.95	LM2878P	2.25
LM319N	1.95	LM386N-3	1.29	LM2896P-1	2.25
LM320K-5	1.35	LM387N	1.45	LM3189N	2.95
LM320K-12	1.35	LM389N	1.35	LM3900N	.69
LM320K-15	1.35	LM392N	.69	LM3905CN	1.25
LM320T-5	1.25	LF398N	4.00	LM3909N	1.15
LM320T-12	1.25	LM399H	5.00	LM3914N	3.95
LM320T-15	1.25	TL494CN	4.49	LM3915N	3.95
LM323K-5	5.95	TL496CP	1.75	LM3916N	3.95
LM324N	.99	NE510A	6.00	RC4136N	1.25
LM329DZ	.65	NE529A	4.95	RC4151NB	3.95
LM331N	3.95	NE531H	3.95	RC4194TK	5.95
LM334Z	1.30	NE536H	6.00	RC4195TK	5.49
LM335Z	1.40	NE540H	6.00	KB4428	4.25
LM336Z	1.75	NE544N	4.95	KB4429	5.95
LM337T	1.95	NE550A	1.30	LM4500A	3.25
LM337MP	1.15	NE555V	.39	ICL8038B	4.95
LM338K	6.95	LM556N	.99	LM13080N	1.29
LM339N	.99	NE564N	3.95	LM13600N	1.49
LM340K-5	1.35	LM565N	1.25	75138N	1.95
LM340K-12	1.35	LM566CN	1.95	75450N	.89
LM340K-15	1.35	LM567V	1.25	75451CN	.39

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.08	.06	.05	.0047µF	.08	.06	.05
47 pf	.08	.06	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

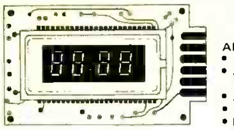
+20% DIPPED TANTALUMS (Solid) CAPACITORS

.1/35V	.39	.34	.29	1.5/35V	.41	.37	.29
.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.19	.16	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

National Semiconductor Clock Modules



12VDC AUTOMOTIVE/ INSTRUMENT CLOCK

APPLICATIONS:
- In-dash autoclocks
- After-market auto/ RV clocks
- Aircraft-marine clks.
- 12VDC oper. instru.
- Portable/battery powered instrumnts.

Features: Bright 0.3" green display. Internal crystal time-base. ± 0.5 sec./day accur. Auto.display brightness control logic. Display color filterable to blue, blue-green, green & yellow. Complete—just add switches and lens.

MA1003 Module $16.95

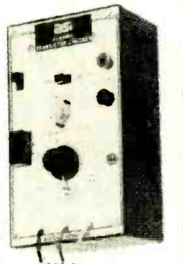
CLOCK MODULES

MA1023	.7"	Low Cost Digital LED Clock Module	8.95
MA1026	.7"	Dig. LED Alarm Clock/Thermometer	18.95
MA5036	.3"	Low Cost Digital LED Clock/Timer	6.95
MA1002	.5"	LED Display Dig. Clock & Xformer	9.95

TRANSFORMERS

XFMR1023	Xformer for MA1023 Clock Modules	3.49
XFMR1026	Xformer for MA1026 Clock Modules	3.49
XFMR5036	Xformer for MA5036 Clock Modules	3.49

Transistor Checker



The *ASI Transistor Checker* is capable of checking a wide range of transistor types, either "in circuit" or out of circuit. It has been specially designed to take advantage of the newest concept of dynamic testing under current amplifier conditions. To operate, simply plug the transistor to be checked into the front panel socket, or connect it with the alligator clip test leads provided. No preliminary set-up is needed. The unit safely and automatically identifies low, medium and high power PNP and NPN transistors. The ASI Transistor Checker also permits matching similar transistors in actual operating circuits, and provides a reliable GO/NO-GO test at practical collector currents (from 5mA on small signal types to 50mA and more on power types.) Match similar type transistors by observing and comparing dial readings: the higher the reading, the higher the gain. Completely assembled — battery operated. ("C" cell battery not included.)

CLOSE-OUT

Trans-Check $9.95

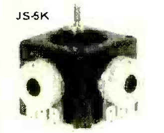
EPROM Erasing Lamp

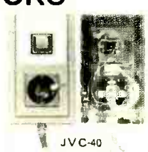
- Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.
- Erases up to 4 chips within 20 minutes.
- Maintains constant exposure distance of one inch.
- Special conductive foam liner eliminates static build-up.
- Built-in safety lock to prevent UV exposure.
- Compact — only 7-5/8" x 2-7/8" x 2"
- Complete with holding tray for 4 chips.

UVS-11E $79.95

JOYSTICKS

JS-5K





JVC-40

JS-5K	5K Linear Taper Pots	$5.25
JS-100K	100K Linear Taper Pots	$4.95
JVC-40	40K (2) Video Controller in case ...	$5.95

6-Digit Clock Kit

- Bright .300 ht. comm. cathode display
- Uses MM5314 clock chip
- Switches for hours, minutes and hold modes
- Hrs. easily viewable to 20 ft.
- Simulated walnut case
- 115 VAC operation
- 12 or 24 hr. operation
- Incl. all components, case & wall transformer
- Size: 6¾" x 3-1/8" x 1¾"

JE701 .... $19.95

NEW! JE215 Adjustable Dual Power Supply

General Description: The JE215 is a Dual Power Supply with independent adjustable positive and negative output voltages. A separate adjustment for each of the supplies provides the user unlimited applications for IC current voltage requirements. The supply can also be used as a general all-purpose variable power supply.

FEATURES:
- Adjustable regulated power supplies, pos. and neg. 1.2VDC to 15VDC.
- Power Output (each supply): 5VDC @ 500mA, 10VDC @ 750mA, 12VDC @ 500mA, and 15VDC @ 175mA.
- Two, 3-terminal adj. IC regulators with thermal overload protection.
- Heat sink regulator cooling
- LED "on" indicator
- Printed Board Construction
- 120VAC input
- Size: 3-1/2"w x 5-1/16"L x 2"H

JE215 Adj. Dual Power Supply Kit (as shown) . . $24.95

(Picture not shown but similar in construction to above)

JE200 Reg. Power Supply Kit (5VDC, 1 amp) . .	$14.95
JE205 Adapter Brd. (to JE200) ±5, ±9 & ±12V.	$12.95
JE210 Var. Pwr. Sply. Kit. 5-15VDC, to 1.5amp.	$19.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES

INS8080A	CPU	4.95
DP8212	8-Bit Input/Output	3.25
DP8214	Priority Interrupt Control	5.95
DP8216	Bi-Directional Bus Driver	3.49
DP8224	Clock Generator/Driver	3.95
DP8226	Bus Driver	3.49
DP8228	System Controller/Bus Driver	4.95
DP8238	System Controller	5.95
INS8243	I/O Expander for 48 Series	9.95
INS8250	Asynchronous Comm. Element	16.95
DP8251	Prog. Comm. I/O (USART)	7.95
DP8253	Prog. Interval Timer	14.95
DP8255	Prog. Peripheral I/O (PPI)	9.95
DP8257	Prog. DMA Control	19.95
DP8259	Prog. Interrupt Control	14.95
DP8275	Prog. CRT Controller	49.95
DP8279	Prog. Keyboard/Display Interface	19.95
DP8300	Octal Bus Receiver	6.95
DP8303	System Timing Element	6.95
DP8304	8-Bit Bi-Directional Receiver	3.95
DP8307	8-Bit Bi-Directional Receiver	3.95
DP8308	8-Bit Bi-Directional Receiver	3.95

6800/6800 SUPPORT DEVICES

MC6800	MPU	14.95
MC6802CP	MPU with Clock and RAM	19.95
MC6810API	128x8 Static RAM	4.95
MC6821	Peripheral Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	10.95
MC6830L8	1024x8-Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	6.95
MC6852	Synchronous Serial Data Adapter	6.95
MC6860	0-600bps Digital MODEM	10.95
MC6862	2400bps Modulator	12.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS

Z80 (780C)	CPU (MK3880N) (2MHz)	13.95
Z80A (780-1)	CPU (MK3880N-4) (4MHz)	15.95
CDP1802	CPU	19.95
2650	MPU	16.95
IDM2901ADC	CPU—4-Bit Slice (Com. Temp. Grade)	19.95
MCS6502	MPU w/Clock (65K Bytes Memory)	11.95
INS8035N-6	MPU—8-Bit (6MHz)	16.95
INS8039N-6	CPU—Sgl. Chip 8-Bit (128 bytes RAM)	19.95
INS8040N-6	CPU (256 Bytes RAM)	24.95
INS8070N	CPU—64 Bytes RAM	24.95
INS8073N	CPU w/Basic Micro Interpreter	29.95
P8085	CPU	19.95
INS8900	CPU—16-Bit	29.95
TMS9900JL	MPU—16-Bit	49.95

SHIFT REGISTERS

MM500H	Dual 25-Bit Dynamic	.50
MM503H	Dual 50-Bit Dynamic	.50
MM506H	Dual 100-Bit Static	.50
MM510H	Dual 64-Bit Accumulator	.50
MM1402	256-Bit Dynamic	3.95
MM5013	1024-Bit Dynamic/Accumulator	1.95
MM5016H	500/512-Bit Dynamic	.89
MM5034N	Octal 80-Bit	9.95
MM5035N	Octal 80-Bit	9.95
2504V (1404A)	1024-Bit Dynamic	3.95
2518N	Hex 32-Bit Static	4.95
2522V	Dual 132-Bit Static	2.95
2524V	512-Bit Dynamic	.99
2525V	1024-Bit Dynamic	2.95
2527V	Dual 256-Bit Static	2.95
2528V	Dual 250-Bit Static	4.00
2529V	Dual 240-Bit Static	4.00
2532N	Quad 80-Bit Static	2.95
3341PC	Fifo (Dual 80)	6.95

DATA ACQUISITION

AF100-1CN	Universal Active Filter 2.5%	5.95
AF121-1CJ	Touch Tone Low Pass Filter	19.95
AF122-1CJ	Touch Tone Low Pass Filter	19.95
LM308AH	Super Gain Op Amp	1.00
LM334Z	Constant Current Source	1.30
LM335Z	Temperature Transducer	1.40
LF356N	JFET Input Op Amp	1.10
LF398N	Sample & Hold Amplifiers	3.95
LM399H	Temp. Comp. Prec. Ref. (.5ppm/C°)	4.95
ADC0804LCN	8-Bit A/D Converter (1 LSB)	4.95
DAC0806LCN	8-Bit D/A Converter (0.78% Lin.)	2.25

DATA ACQUISITION (CONTINUED)

ADC0809CCN	8-Bit A/D Converter (8-Ch. Multi.)	5.25
ADC0817CCN	8-Bit A/D Converter (16-Ch. Multi.)	10.95
DAC1000LCN	10-Bit D/A Conv. Micro. Comp. (0.05%)	13.95
DAC1008LCN	10-Bit D/A Conv. Micro. Comp. (0.20%)	8.95
DAC1020LCN	10-Bit D/A Converter (0.05% Lin.)	8.49
DAC1022LCN	10-Bit D/A Converter (0.20% Lin.)	5.95
DAC1222LCN	12-Bit D/A Converter (0.20% Lin.)	9.95
CD4051N	8-Channel Multiplexer	1.19
AY-5-1013	30K BAUD UART	5.95

RAM'S

1101	256x1 Static	1.49
1103	1024x1 Dynamic	.99
2101 (8101)	256x4 Static	3.95
2102	1024x1 Static	1.75
21L02	1024x1 Static	1.95
2111 (8111)	256x4 Static	3.95
2112	256x4 Static MOS	4.95
2114	1024x4 Static 450ns	3.95
2114L	1024x4 Static 450ns Low Power	4.95
2114-3	1024x4 Static 300ns	4.95
2114L-3	1024x4 Static 300ns Low Power	5.95
2117	16,384x1 Dynamic 550ns (house marked)	4.95
4116 (UPD416)	16K Dynamic 250ns	3.95
4164	64K Dynamic 250ns	49.95
MM2147J	4096x1 Fast 70ns	19.95
5101	256x4 Static	7.95
MM5261	1024x1 Dynamic Fully Decoded	.99
MM5262	2Kx1 Dynamic	.25
MM5280/2107	4096x1 Dynamic	4.95
MM5290J-2(4116)	16K Dynamic 150ns	5.25
MM5298J-3A	8K Dyn. 200ns (lower ½ of MM5290J)	4.95
UPD414/MK4027	4K Dynamic 16-pin	4.95
TMS4044-45NL	4K Static	14.95
TMS4045	1024x4 Static	14.95

PROMS/EPROMS

1702A	2K UV Erasable PROM	5.95
2708	8K EPROM	5.95
TMS2716	16K EPROM (-5V, +5V, +12V)	19.95
2716 Intel (2516) TI	16K EPROM (Single +5V)	10.95
2732 Intel (2532) TI	32K EPROM	19.95
2758	8K EPROM (450ns) (Single +5V)	7.95
5203	2048 PROM	14.95
82S23 (74S188)	32x8 PROM (Open Collector)	4.95
82S115	4096 Bipolar PROM	19.95
82S123 (74S288)	32x8 Tri-State Bipolar PROM	4.95
82S185	8K PROM	29.95

ROM'S

2513 (2140)	Character Generator (Upper Case)	9.95
2513 (3021)	Character Generator (Lower Case)	9.95
2516N	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

NMOS READ ONLY MEMORIES

MCM66710P	128x9x7 ASCII Shifted w/Greek	13.50
MCM66740P	128x9x7 Math Symbol & Pictures	13.50
MCM66750P	128x9x7 Alpha. Control Char. Gen.	13.50

MICROPROCESSOR MANUALS

M-Z80	User Manual	7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

SPECIAL FUNCTION

DS0025CN	Dual MOS Clock Driver (5MZ)	3.50
DS0026CN	Dual MOS Clock Driver (5MZ)	1.95
INS1771N-1	Floppy Disc Controller	24.95
INS2651N	Communication Chip	19.95
MM58167N	Microprocessor Real Time Clock	8.95
MM58174N	Microprocessor Compatible Clock	11.95
COP402N	Microcontroller with 64 Digit RAM and Direct LED Drive	6.95
COP402MN	Microcontroller with 64-Digit RAM & Direct LED Drive w/N Buss Int.	7.49
COP470N	32-Seg. VAC Fluor. Driver (20-pin pkg.)	3.25

TELEPHONE/KEYBOARD CHIPS

AY-5-9100	Push Button Telephone Dialer	14.95
AY-5-9200	Repertory Dialer	14.95
AY-5-9500	CMOS Clock Generator	4.95
AY-5-2376	Keyboard Encoder (88 keys)	11.95
HD0165-5	Keyboard Encoder (16 keys)	7.95
74C922	Keyboard Encoder (16 keys)	5.49
74C923	Keyboard Encoder (20 keys)	5.75
MM53190N	Push Button Pulse Dialer	7.95
MM57499N	96/144 Key Serial Keyboard Encoder	8.95

ELECTRONIC TOY MOTORS

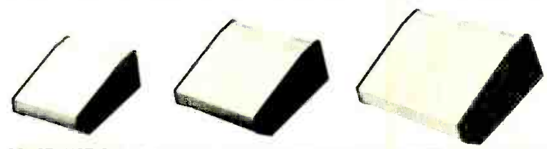
Typical Power Source	Operating Voltage Range	Voltage	NO LOAD Speed RPM	NO LOAD Current AMP	AT MAXIMUM EFFICIENCY Speed RPM	AT MAXIMUM EFFICIENCY Current AMP	AT MAXIMUM EFFICIENCY Torque OZ IN.	AT MAXIMUM EFFICIENCY Output W	AT MAXIMUM EFFICIENCY Eff %	SMALL TORQUE OZ. IN.
DRY CELL	1.5 6.0	3.0	9,200	0.20	6,750	0.90	0.260	1.30	57.0	0.97

(TYPICAL CHARACTERISTICS)

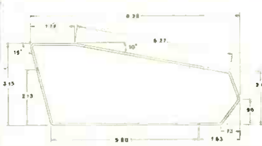
.937 O.D. X 1.201 Length

MABUCHI RE280 $ .99 each . . .10/$7.50 . . .100/$50.00

DESIGNERS' SERIES
Blank Desk-Top Electronic Enclosures



CONSTRUCTION:
The "DTE" Blank Desk Top Electronic Enclosures are designed to blend and complement today's modern computer equipment and can be used in both industrial and home. The end pieces are precision molded with an internal slot (all around) to accept both top and bottom panels. The panels are then fastened to ¼" thick tabs inside the end pieces to provide maximum rigidity to the enclosure. For ease of equipment servicing, the rear/bottom panel slides back on slotted tracks while the rest of the enclosure remains intact. Different panel widths may be used while maintaining a common profile outline. The molded end pieces can also be painted to match any panel color scheme.



Enclosure Model No.	Panel Width	PRICE
DTE-8	8.00"	$29.95
DTE-11	10.65"	$32.95
DTE-14	14.00"	$34.95

$10.00 Min. Order – U.S. Funds Only
Calif. Residents Add 6% Sales Tax
Postage – Add 5% plus $1 Insurance

Spec Sheets – 25¢
Send 52¢ Postage for your FREE 1981 JAMECO CATALOG

NEW 1981 CATALOG

Jameco ELECTRONICS

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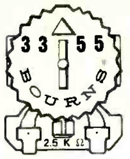
6/81

Bourns Potentiometer



3/4 Watt Single Turn
(TOP ADJUSTMENT)

Values: 500Ω 1K 2.5K 5K 10K 25K 50K 100K 250K 500K 5Meg

INDIVIDUAL PRICING:

1-49	50-99	100-999	1K-up
.19	.17	.15	.12

GB174 ...... $1.95/lot
(25 pieces all 11 asst. values)

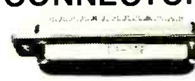
To order: Specify Bourns 3355 – (Value desired)

AC and DC Wall Transformers

Ideal for use with clocks, games, power supplies or any other type of AC or DC application

Part No.	Input	Output	Price
AC 250	117V/60Hz	12 VAC 250mA	$3.95
AC 500	117V/60Hz	12 VAC 500mA	$4.95
AC1000	117V/60Hz	12 VAC 1 amp	$5.95
AC1700	117V/60Hz	9 VAC 1.7 amp	$6.95
DV 9200	117V/60Hz	9 VDC 200mA	$3.25
DC 900	120V/60Hz	9 VDC 500mA	$3.95

CONNECTORS



DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
DB51226	Cover for DB25P/S	$1.75
22/44SE	P.C. Edge (22/44 Pin)	$2.95
UG88/U	BNC Plug	$1.79
UG89/U	BNC Jack	$3.79
UG175/U	UHF Adapter	$ .49
SO239	UHF Panel Recp.	$1.29
PL258	UHF Adapter	$1.60
PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
UG1094/U	BNC Bulkhead Recp.	$1.29

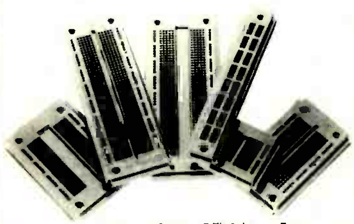
TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
★ 8 ea. MM5290 (UPD416/4116) 16K Dyn. Rams (*NS)
★ Documentation for Conversion

TRS-16K2 *150NS $39.95
TRS-16K4 *250NS $29.95

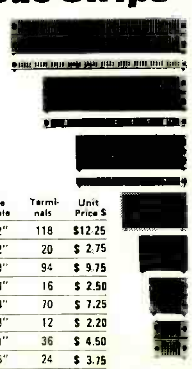
GLOBAL SPECIALTIES

EXPERIMENTOR SOCKETS



Model	Length	Width	Center Channel	5 Tie Point Terminals	Bus Strips	Price
EXP4B	6.0"	1.0"	n/a	n/a	4(160)	$ 4.75
EXP300	6.0"	2.1"	.3"	94(470)	2(80)	$12.00
EXP325	1.8"	2.1"	.3"	22(110)	2(20)	$ 3.50
EXP350	3.6"	2.1"	.3"	46(230)	2(40)	$ 6.75
EXP600	6.0"	2.4"	.6"	94(470)	2(80)	$14.75
EXP650	3.6"	2.4"	.6"	46(230)	2(40)	$ 8.75

Quick Test Sockets & Bus Strips



MANY OTHER GLOBAL ITEMS

	Length	Hole to-hole	Terminals	Unit Price $
QT-59S	6.5"	6.2"	118	$12.25
QT-59B	6.5"	6.2"	20	$ 2.75
QT-47S	5.3"	5.0"	94	$ 9.75
QT-47B	5.3"	5.0"	16	$ 2.50
QT-35S	4.1"	3.8"	70	$ 7.25
QT-35B	4.1"	3.8"	12	$ 2.20
QT-18S	2.4"	2.1"	36	$ 4.50
QT-12S	1.8"	1.5"	24	$ 3.75
QT-8S	1.4"	1.1"	16	$ 3.00
QT-7S	1.3"	1.0"	14	$ 2.75

NEW LITERATURE

Transistor Catalog

A 52-page booklet from TRW describes its family of 15 small-signal, low-noise transistors, complete with specifications, performance graphs, photographs, circuit diagrams, and dimensions. All devices are npn silicon bipolar transistors with gold metallization. Address: TRW RF Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260.

Word Processing Booklet

"CPT Takes the Mystery Out of Word Processing" is a 20-page booklet explaining what word processors do—and how they do it. Helps the reader decide whether he needs word processing and lists criteria for prospective buyers of equipment such as screen size, memory capacity, etc. Address: CPT Corp., Box 17, Minneapolis, MN 55440.

Test Probe Catalog

A new catalog from Test Probes, Inc. describes 16 models of probe kits and test lead sets. Specifications and applications are given for probes for scopes, DVMs, DMMs, VOMs, and special meters. Address: Test Probes, Inc., Box 2113, La Jolla, CA 92038.

Digital Switches

Ordering instructions, option information, truth tables to illustrate circuit connections, and prices are given on 16 series of digital switches in two six-page brochures. No. 1-0071C covers commercial and industrial switches. No. 1-0072C is for sealed, QPL, and general-purpose units. Address: Digitran Co., 855 S. Arroyo Pkwy., Pasadena, CA 91105.

Acoustic-Coupled Modems

Bulletin 5273 describes two new acoustic-coupled modems (ACM300 and ACM300/1200) which operate asynchronously over the DDD network. The publications contains photographs, a system diagram and technical notes. Address: Rixon Inc., 2120 Industrial Pkwy., Silver Spring, MD 20904.

Software Catalog

"Micro Yellow Pages" is a 20-page newsletter and catalog describing Micro Architect software. It describes software packages for the Model I, Model II, and Model III TRS-80*, CP/M, and Heath HDOS. Send long, SASE (30 cents) to: Micro Architect Inc., 96 Dothan St., Arlington, MA 02174.

DIODES/ZENERS

QTY			
1N914	100v	10mA	.05
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N4733	5.1v	1 W Zener	.25
1N4749	24v		.25
1N753A	6.2v	500 mW Zener	.25
1N758A	10v		.25
1N759A	12v		.25
1N5243	13v		.25
1N5244B	14v		.25
1N5245B	15v		.25
1N5349	12v	3W Zener	.25

SOCKETS/BRIDGES

QTY				
8-pin	pcb .20		ww	.40
14-pin	pcb .25		ww	.60
16-pin	pcb .30		ww	.70
18-pin	pcb .35		ww	.95
20-pin	pcb .45		ww	1.05
22-pin	pcb .50		ww	1.15
24-pin	pcb .55		ww	1.25
28-pin	pcb .60		ww	1.45
40-pin	pcb .70		ww	1.75
Molex pins .01		To-3 Sockets		.35
2 Amp Bridge		200-prv		1.35
25 Amp Bridge		200-prv		2.25

TRANSISTORS, LEDS, etc.

QTY		
2N2222M (Metal)	.25	(2N2222 Plastic .20)
2N2222A	NPN	.35
2N2907A	PNP	.35
2N3906	PNP (Plastic)	.25
2N3904	NPN (Plastic)	.25
2N3054	NPN 4A 90v	.60
2N3055	NPN 15A 60v	.75
TIP125	PNP Darlington	1.95
LED	Green Red Clear Yellow	.19
DL747	7 seg 5/8" High com-anode	2.25
DL 728B	doub 7 seg 5" com-cathode	2.50
MA6740	doub 7 seg 5" com-cathode	2.50
MAN72	7 seg com-anode (Red)	1.50
MAN3630	7 seg com-anode ÷1	1.00
MAN82A	7 seg com-anode (Yellow)	1.50
MAN74	7 seg com-cathode (Red)	1.50
FND359	7 seg com-cathode (Red)	1.50

9000 SERIES

QTY		QTY	
9301	1.95	9322	.65
9309	1.25	9601	.40
9316	1.50	9602	1.35

MICROs, RAMS CPUs, E-PROMS

1771 Disc Controller	$29.50
8T13	1.50
8T23	2.50
8T24	3.00
8T97	1.50
74S188	6.50
1488	1.75
1489	1.75
1702A	8.50
AM9050/TMS4050	5.00
ICM7207	6.95
ICM7208	13.95
MM5314	4.50
MM5311	4.50
MM5316	4.50
MM5387	4.50
MM5369	3.95
TR1602B/6011	4.95
UPD414/TMS4027	3.50
Z80A	15.00
Z80	9.50
Z80PIO(A)	10.50
2102	1.45
2102L	1.75
2107B-4	5.95
2114	5.00
2513 (5V) Up/Lo	9.50
2708	6.95
2716TI	9.00
2716(5V)	12.00
TMS2532/2732	35.00
3242	12.50
4116	6.50
6800	11.50
6802	15.50
6820/6520	8.00
6850	9.95
8080	5.50
8085	14.50
8212	3.50
8214	4.95
8216	4.50
8224	4.25
8228	5.95
8251	9.50
8253	14.50
8255	9.50
TMS4044	9.95

— T T L — 4/1/81

QTY		QTY		QTY		QTY	
7400	.35	7493	.60	74H11	.45	74LS74	.95
7401	.25	7494	.75	74H15	.45	74LS75	.95
7402	.35	7495	.60	74H20	.35	74LS76	.90
7403	.35	7496	.55	74H21	.35	74LS86	.95
7404	.45	74100	2.75	74H22	.40	74LS90	1.85
7405	.35	74107	.55	74H30	.40	74LS93	1.00
7406	.55	74121	.55	74H40	.45	74LS107	.90
7407	.65	74122	.55	74H50	.40	74LS109	1.00
7408	.50	74123	.70	74H51	.40	74LS123	1.20
7409	.35	74125	.75	74H52	.40	74LS138	1.00
7410	.35	74126	.75	74H53	.45	74LS151	1.00
7411	.35	74132	.75	74H55	.45	74LS153	1.15
7412	.35	74141	.90	74H72	.45	74LS154	2.00
7413	.45	74145	1.35	74H74	1.50	74LS157	1.75
7414	.65	74150	1.15	74H101	.95	74LS160	1.65
7416	.35	74151	.95	74H103	.55	74LS161	1.50
7417	.40	74153	.95	74L00	.30	74LS164	1.90
7420	.45	74154	1.40	74L02	.75	74LS193	2.00
7426	.35	74156	.70	74L03	.35	74LS195	2.00
7427	.40	74157	.95	74L04	.90	74LS196	2.50
7430	.40	74161	1.50	74L10	.30	74LS244	1.50
7432	.65	74163	1.50	74L20	.45	74LS245	3.50
7437	.55	74164	1.50	74L30	.55	74LS253	1.95
7438	.70	74165	1.10	74L47	1.95	74LS298	1.50
7440	.40	74166	1.10	74L51	.65	74LS367	1.50
7441	.95	74175	.95	74L55	.85	74LS368	1.95
7442	.95	74176	1.15	74L72	.65	74LS373	1.50
7443	.75	74177	1.10	74L73	.70	74S00	.70
7444	.75	74180	1.10	74L74	1.95	74S02	.90
7445	.75	74181	2.25	74L75	1.05	74S03	.45
7446	.90	74182	.75	74L85	3.00	74S04	.70
7447	1.50	74190	1.25	74L93	2.95	74S05	.65
7448	1.50	74191	1.25	74L123	2.95	74S08	1.80
7450	.35	74192	1.50	74LS00	.50	74S10	.95
7451	.25	74193	1.50	74LS01	.60	74S11	.75
7453	.25	74194	.95	74LS02	.50	74S20	.75
7454	.35	74195	.95	74LS03	.60	74S22	.75
7460	.40	74196	1.75	74LS04	.60	74S40	.70
7470	.35	74197	.95	74LS05	.60	74S50	.70
7472	.40	74198	1.50	74LS08	.60	74S51	.75
7473	.40	74221	1.50	74LS09	.60	74S64	.35
7474	.45	74298	2.50	74LS10	.60	74S74	1.50
7475	.45	74367	1.15	74LS11	.60	74S86	1.25
7476	.95	75107A	1.50	74LS20	.65	74S112	1.90
7480	.60	75451	.85	74LS21	.50	74S114	.85
7481	.95	75452	.85	74LS22	.45	74S133	.85
7482	.95	75491	1.50	74LS27	.60	74S140	.95
7483	.75	75492	1.50	74LS32	.80	74S151	1.50
7485	.95	74H00	.50	74LS37	.60	74S153	2.25
7486	.55	74H01	.50	74LS38	.95	74S157	2.95
7489	1.95	74H04	.90	74LS40	.70	74S158	1.75
7490	.75	74H05	.55	74LS42	.75	74S194	1.75
7491	.60	74H08	.90	74LS47	1.95	74S196	2.00
7492	.50	74H10	.45	74LS51	.95	74S257(8123)	1.95
						74S287	5.95
						8131	2.75

C MOS

QTY		QTY		QTY		QTY	
4000	.40	4019	1.15	4041	1.15	4081	.55
4001	.35	4020	.95	4042	.65	4082	.60
4002	.35	4021	.75	4043	.90	4093	.90
4006	1.50	4022	.75	4044	.90	4098	2.25
4007	.30	4023	.35	4046	1.50	4507	.95
4008	.75	4024	.95	4047	2.50	4511	1.50
4009	.40	4025	.35	4048	2.50	4512	1.25
4010	.35	4026	1.95	4049	.50	4515	2.95
4011	.65	4027	.65	4050	.65	4519	.85
4012	.25	4028	.95	4052	.75	4522	1.10
4013	.65	4029	1.50	4053	1.50	4526	.95
4014	.75	4030	.45	4066	.75	4528	1.50
4015	.75	4033	1.50	4069/74C04	.45	4529	.95
4016	.55	4034	2.75	4070	.60	MC14409	14.50
4017	1.50	4035	.95	4071	.40	MC14419	4.85
4018	.95	4040	1.50	4072	.50	74C151	2.50

I^2L, LINEARS, REGULATORS, etc.

QTY		QTY		QTY	
MCT2(E)	1.25	LM320K24	1.65	LM373	3.95
8038	4.50	LM320T5(7905)	1.65	LM377	2.95
LM201	2.00	LM320T12	1.65	78L05	.95
LM301	.95	LM320T15	1.65	78L12	.95
LM308	1.25	LM323K	7.95	78L15	.95
LM309H	1.50	LM324	1.00	78M05	.95
LM309(340K-5)	1.50	LM337T	2.25	LM380(8-14Pin) 386N	1.19
LM310	.85	LM339	.95	LM709(8-14Pin)	.75
LM311(8-14Pin)	1.50	7805(340T5)	1.50	LM711	.45
LM317T	2.25	LM340T12	1.50	LM723	.75
LM318N	2.15	LM340T15	1.50	LM725	3.95
LM320H6	.89	LM340T18	1.50	LM739	1.50
LM320H15	.89	LM340T24	1.50	LM741(8-14)	.75
LM320H24	.89	LM340K12	1.50	LM747	1.25
LM320K5	1.65	LM340K15	1.50	LM1307	1.75
LM320K12	1.65	LM340K18	1.50	LM1458	.65
LM320K15	1.65	LM340K24	1.50	LM3900	.75
				LM3909	1.50
				NE555	.50
				NE556	1.00
				NE565	1.50
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74LS03	.32	74LS158	.82
74LS04	.35	74LS160	.94
74LS05	.28	74LS161	.99
74LS08	.38	74LS162	.99
74LS09	.38	74LS163	.99
74LS10	.32	74LS164	.99
74LS11	.29	74LS165	.99
74LS12	.29	74LS166	2.40
74LS13	.38	74LS168	1.79
74LS14	.99	74LS169	1.79
74LS15	.35	74LS170	1.89
74LS20	.26	74LS173	.82
74LS21	.30	74LS174	1.19
74LS22	.34	74LS175	1.09
74LS26	.40	74LS181	2.19
74LS27	.35	74LS190	1.15
74LS28	.39	74LS191	1.31
74LS30	.35	74LS192	.88
74LS32	.39	74LS193	98
74LS33	.54	74LS194	1.80
74LS37	.78	74LS195	1.39
74LS38	.39	74LS196	.82
74LS40	.25	74LS197	82
74LS42	.79	74LS221	1.28
74LS47	.78	74LS240	1.89
74LS48	.78	74LS241	1.89
74LS51	.35	74LS242	1.89
74LS54	.35	74LS243	1.89
74LS55	32	74LS244	1.79
74LS73	.44	74LS245	2.89
74LS74	.48	74LS251	1.32
74LS75	58	74LS253	.89
74LS76	.50	74LS257	.89
74LS78	.59	74LS258	.89
74LS83	.90	74LS259	2.89
74LS85	1.23	74LS260	.68
74LS86	.45	74LS266	.68
74LS90	.70	74LS273	1.69
74LS92	.82	74LS275	3.39
74LS93	.71	74LS279	.59
74LS95	1.11	74LS283	1.03
74LS96	.86	74LS290	1.25
74LS107	.43	74LS293	1.89
74LS109	.49	74LS295	1.09
74LS112	.48	74LS298	1.24
74LS113	.48	74LS352	1.59
74LS114	.55	74LS353	1.59
74LS122	.55	74LS363	1.39
74LS123	.99	74LS365	.99
74LS124	2.99	74LS366	.99
74LS125	.99	74LS367	.99
74LS126	.88	74LS368	.99
74LS132	.69	74LS373	1.85
74LS136	.58	74LS374	1.81
74LS138	.79	74LS377	1.48
74LS139	.79	74LS385	1.90
74LS145	1.19	74LS386	.65
74LS148	1.39	74LS390	1.90
74LS151	.79	74LS393	1.90
74LS153	.79	74LS395	1.69
74LS154	2.39	74LS670	2.20

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2114	(450ns)	2.95	2.85	2716-1(5v)	(350ns)	12.95	10.95
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4116-20	(200ns)	8/19.95	2.35	TMS25L32	(450ns)	29.95	Call
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8224	2.95
8226	3.49
8228	4.95
8238	5.50
8251	6.95
8253	12.95
8255	6.50
8257	16.95
8259	14.95
8275	49.95
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7400	.19	7450	.19	74123	.59
7402	.19	7472	.29	74151	.69
7404	.24	7473	.34	74153	.59
7406	.29	7474	.35	74154	1.49
7407	.29	7475	.49	74156	.69
7408	.24	7476	.35	74157	.69
7410	.19	7483	.65	74161	.79
7420	.19	7486	.35	74163	.89
7430	.19	7490	.49	74164	.89
7432	.29	7491	.69	74173	1.39
7440	.19	7492	.59	74174	.89
7442	.49	7493	.49	74175	.89
7445	.69	7496	.74	74176	.89
7446	.69	74100	1.19	74192	.79
7447	.59	74107	.34	74193	.79
7448	.69	74121	.34	74196	.79

74S00 SERIES

74S00	.50	74S124	3.95	74S288	4.75
74S02	.50	74S174	1.49	74S387	5.75
74S04	.50	74S188	4.75	74S471	18.75
74S08	.50	74S195	1.95	74S472	18.75
74S37	.55	74S240	2.95	74S474	19.95
74S74	.80	74S260	1.80	74S570	7.80
74S113	.79	74S287	4.75	74S571	7.80

IC SOCKETS

8 pin ST	10/1.29	8 pin WW	.59
14 pin ST	10/1.49	14 pin WW	.69
16 pin ST	10/1.69	16 pin WW	.69
18 pin ST	10/1.99	18 pin WW	.99
20 pin ST	10/2.89	20 pin WW	1.09
22 pin ST	10/2.99	22 pin WW	1.39
24 pin ST	10/2.99	24 pin WW	1.49
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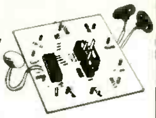

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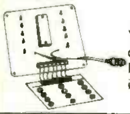

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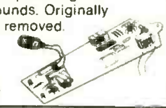

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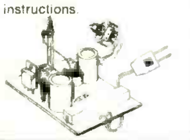

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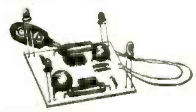

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8097	65
8098	65
8T09	1 25
8T10	4 50
8T13	3 00
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2 level 14 pin ww 20

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16	49	28	1 00
18	67	40	1 23

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5 MHz	4 25
10 MHz	4 25
18 MHz	3 90
20 MHz	3 90
32 MHz	3 90
32768 Hz	4 00
1 8432 MHz	4 50
3 5795 MHz	1 20
2 0100 MHz	1 95
2 097152 MHz	4 50
2 4576 MHz	4 50
3 2768 MHz	4 50
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FND500 507	CC CA	500	1 35
FND503 510	CC CA	500	90
FND800 807	CC CA	800	2 20
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10 digit display			1 25
7520 Clairex photocells			39
TIL311 Hex			9 50
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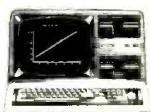

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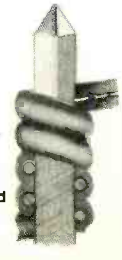

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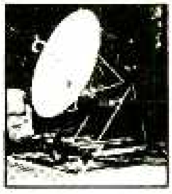

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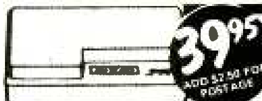

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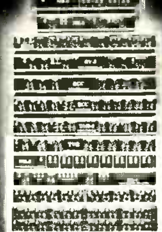

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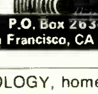

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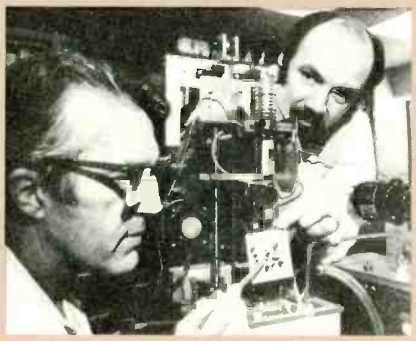
COMMERCIALLY PRACTICAL SOLAR CONCENTRATOR CELLS are the goal of a contract awarded Photowatt International, Inc. (Tempe, AZ) by the Sandia National Laboratories. Using silicon solar cells mated with acrylic Fresnel lenses that concentrate sunlight by a factor of 400, giving efficiencies on the order of 20%, the systems can achieve an overall sunlight-to-electricity conversion efficiency of 14% to 15%. Sandia is also working with Varian Associates (Palo Alto, CA) to develop GaAs cells that produce higher overall system efficiencies (16.4% has been measured) but these are not yet ready for commercialization.

TALKING BACK TO YOUR TV is the most important aspect of cable television now confronting cable companies and government entities responsible for their enfranchisement. Warner Amex, for example, has recently won two large franchises on the strength of QUBE, its two-way cable system. Local governments all over the country are demanding such two-way services as opinion polling, fire protection, and news-wire stories. However, fewer than 1% of the 4,150 cable systems in place now are interactive, and refurbishing older systems to make them so will cost $1000 to $1500 per mile. The problem appears to be to find the two-way services that will justify making the investment. Most people in the industry seem to agree that home-security services may be one answer.



CIRCUIT BOARDS OF PORCELAIN OVER STEEL have been developed by RCA. Said to have improved electrical and heat-resistance characteristics, the new boards offer promise of improved ruggedness and reliability, as well as the capability of accommodating many types of components and circuits. The highly crystallized porcelain can be repeatedly heated to high temperatures without deforming so that many electronic components can be formed directly on the boards.

PRICE DOESN'T TELL ALL—at least not about uhf antenna equipment. That's the conclusion of a study conducted by Georgia Tech and funded by the FCC. The important things to look for are: uhf-only preamps providing approximately 20 dB gain with noise figure of 2 to 5 dB; a match between preamp input and antenna terminal; and RG-6/U coax transmission lines. These requirements should be met with an outlay of about $70 ($10 for antenna, $45 for preamp, and $15 for coax). For the antenna, a 4-bay, bow-tie with screen reflector was found to be the best.

AN ELECTRONICS HALL OF FAME CENTER has been proposed by officials of the National Electronic Service Dealers Association as a tribute to people who have made significant contributions to the electronic industry or its trade associations. Already elected to the Hall of Fame are Dr. Lee de Forest, Thomas A. Edison, Hugo Gernsback, and David Sarnoff. The Hall of Fame Center would include a museum, technical library, and exhibits. Inquiries should be sent to NESDA, Attn: J. W. Williams, 2708 W. Berry St., Fort Worth, TX 76109.

COMPUTING DEVICES MUST HAVE FCC CERTIFICATION if they are manufactured after Jan. 1, 1981 and intended for use in residential areas. If the devices are not certified, they must be labeled as marketed under a temporary waiver of the FCC rules. The required label states that the device can cause objectionable interference to radio and TV reception and, if such interference occurs, the user must take steps to correct the interference. One of the first devices to obtain the FCC certification was Centronics' Models 730 and 737 dot-matrix printers.

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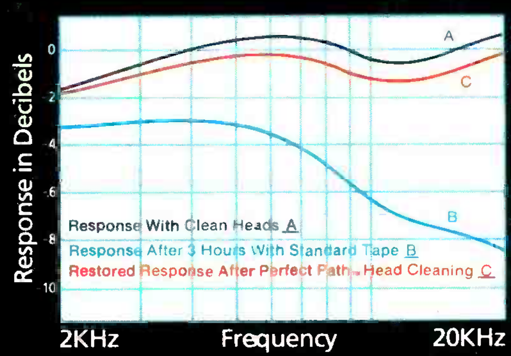

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