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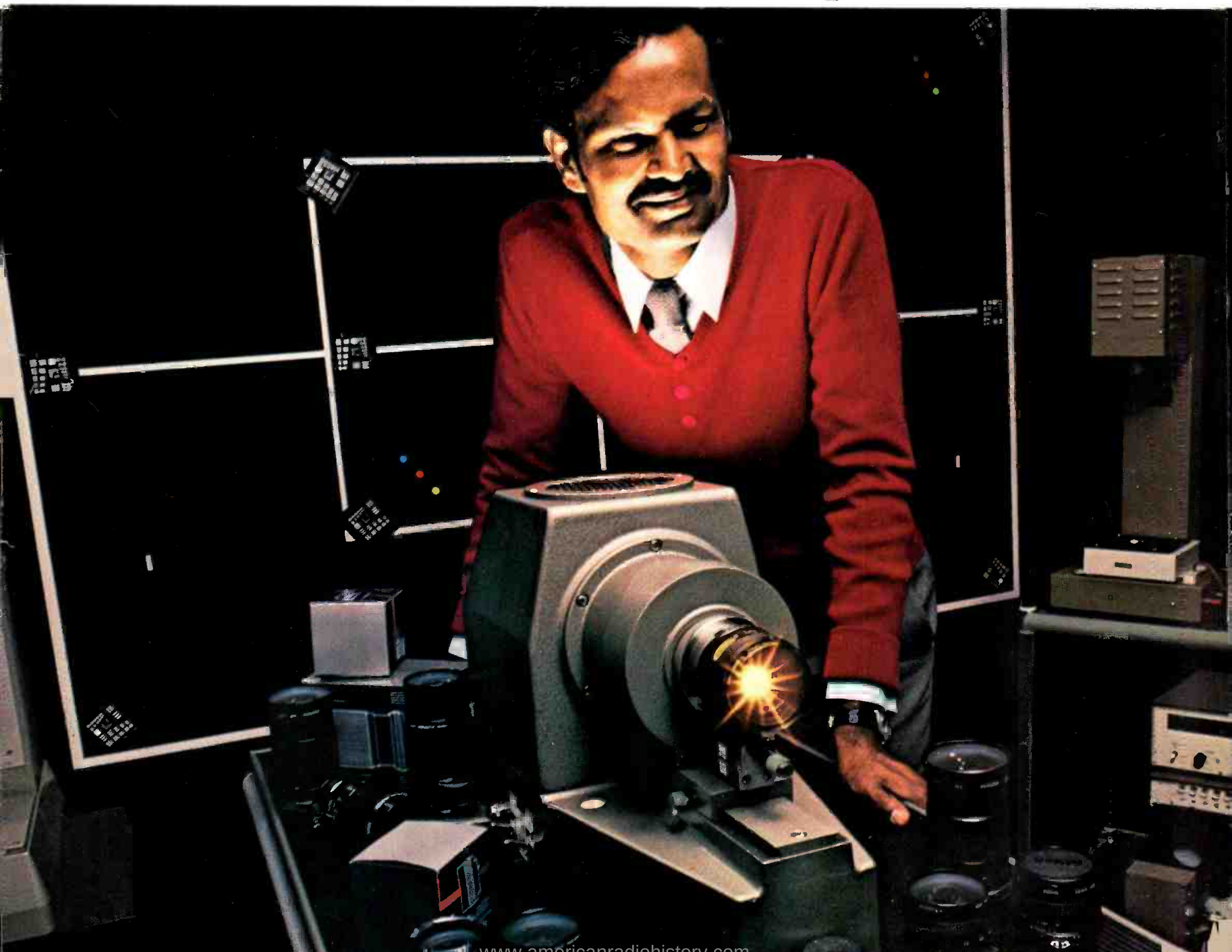
Tested in this Issue:
Technicolor Portable Video Cassette Recorder
dBase II Computer Software
EPI Model A300 Speaker

Reddy Chirra improves his vision with an Apple.

Reddy is an optical engineer who's used to working for big companies and using big mainframes.

But when he started his own consulting business, he soon learned how costly mainframe time can be. So he bought himself a 48K Apple II Personal Computer.

And, like thousands of other engineers and scientists, quickly learned the pleasures of



cutting down on shared time and having his own tamper-proof data base.

His Apple can handle formulas with up to 80 variables and test parameters on 250 different optical glasses.

He can even use BASIC, FORTRAN, Pascal and Assembly languages.

And Apple's HI-RES graphics come in handy for design.

Reddy looked at other microcomputers, but chose Apple for its in-depth documentation, reliability and expandability.

You can get up to 64K RAM in an Apple II. Up to 128K RAM in our new Apple III. And there's a whole family of compatible peripherals, including an IEEE-488 bus for laboratory instrument control.

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The personal computer. apple®

IF YOUR VIDEO INVESTMENT IS SHOWING DIMINISHING RETURNS,

your picture could be suffering from dropouts or bleeding colors. Annoying problems you didn't bargain for when you invested in your video equipment. Before you go out and junk your deck, think about this. The wrong videotape can turn your investment into a loss.

It's just the way the system works. Tape passes along video heads that spin 30 times a second. The resulting friction can cause oxide particles to shed, and drag parts of the picture along with them. You're left with dropouts. Or bleeding colors caused by poor signal-to-noise ratio. Or other video headaches.

THE SOLUTION IS SUPER AVILYN.

For the first few plays, all quality videotapes can perform well. Crisp images. Bright colors. A steady picture. But wait until the tape has been played a few times. That's when one really starts to show its worth. TDK Super Avilyn. It handles the rigors of videotaping, and triumphs.

Super Avilyn high energy tape particles are an optimal size and shape for perfect alignment, giving superb signal-to-noise ratio. They're densely packed and secured on the tape surface, which is polished mirror-smooth. The particles are there to stay, even under their severe working conditions. So your picture is there to stay.

Surrounding the tape is TDK's super precision mechanism. It gives jam-proof performance and excellent tape-to-head contact.

With all this going for us, it should come as no surprise that TDK knows video inside and out. We were involved in the earliest stages of home video, and have participated in every step of its development. Today TDK supplies component parts, including video heads, to major VCR manufacturers. So it stands to reason Super Avilyn is remarkably compatible with just about any VCR you can buy.

Look at it this way. Once you know how your deck works, you'll see that the future of your video investment really depends on the tape. With Super Avilyn, you'll see the dividends, again and again.

TDK®
THE VISION OF THE FUTURE

SUPER AVILYN

JANUARY 1982 VOLUME 20, NUMBER 1

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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EDITORIAL

Mickey Mouse in the Courthouse

In 1976, when about 30,000 video cassette recorders were sold, Walt Disney Productions and Universal City Studios instituted a copyright infringement suit against the maker of Betamax VCRs (the Sony Corporation), as well as a consumer who bought one, and others to prevent taping shows off the air. The U.S. District Court in Los Angeles ruled against the plaintiffs.

Recently, however, the Ninth Circuit Court of Appeals ruled that anyone copying television programs is breaking the law! The 3-0 judges' vote was based on violation of the federal copyright law. But this pronouncement, coming at a time when some 4-million VCRs have been sold, is not the final word, you should know. The defendants can still go back to the lower court or to the Supreme Court or get a rehearing.

Frankly, this latest court ruling strikes me as being sort of Mickey Mouse. Firstly, who will ever be able to police what VCR owners are taping in the privacy of their homes? Ah! But there's a way around this, say our legal minds. An agreement can be reached whereby the tape machine makers or the blank-tape makers can pay royalties to producing companies whose movies are shown on TV. Naturally, this cost would be passed along to the consumer, moving products beyond the reach of more people. Even if this obnoxious "tax" were effected, who would receive what slice of the money among the many who produce films for TV broadcasts?

A Walt Disney spokesman claimed that his company suffers damages if people tape one of its TV shows because it does not make money on the original one, only on repeats or ancillary income from prerecorded cassettes and the like. In response to this, studies have shown that the majority of VCR owners simply do not take this recording route. Rather, they often have timer devices that enable them to record a program when they can't be at home to view it or record a program while they're watching another one that's broadcast at the same time. In effect, viewing can be increased, not decreased, as a result of home VCRs.

Turning to precedents, there's nothing illegal about taping a radio broadcast of a recording. Copyright protection was granted for sound recording in 1971, but Congress specified that this did not restrain home audio recording from broadcasts (or from records or tapes), observing that the practice was "common and unrestrained today . . . "

Clearly, videotaping can be construed simply as an extension of audio taping, and Congress should grant an exception for the newer technology in the same manner as was done for audio. Laws and justice must be rendered with the populace in mind.

Why not write to your congressman, urging him or her to exempt home video recording from the copyright laws, rather than remain mute about the subject and continue to fill the lawyers' coffers needlessly?

Art Salsberg

Popular Electronics

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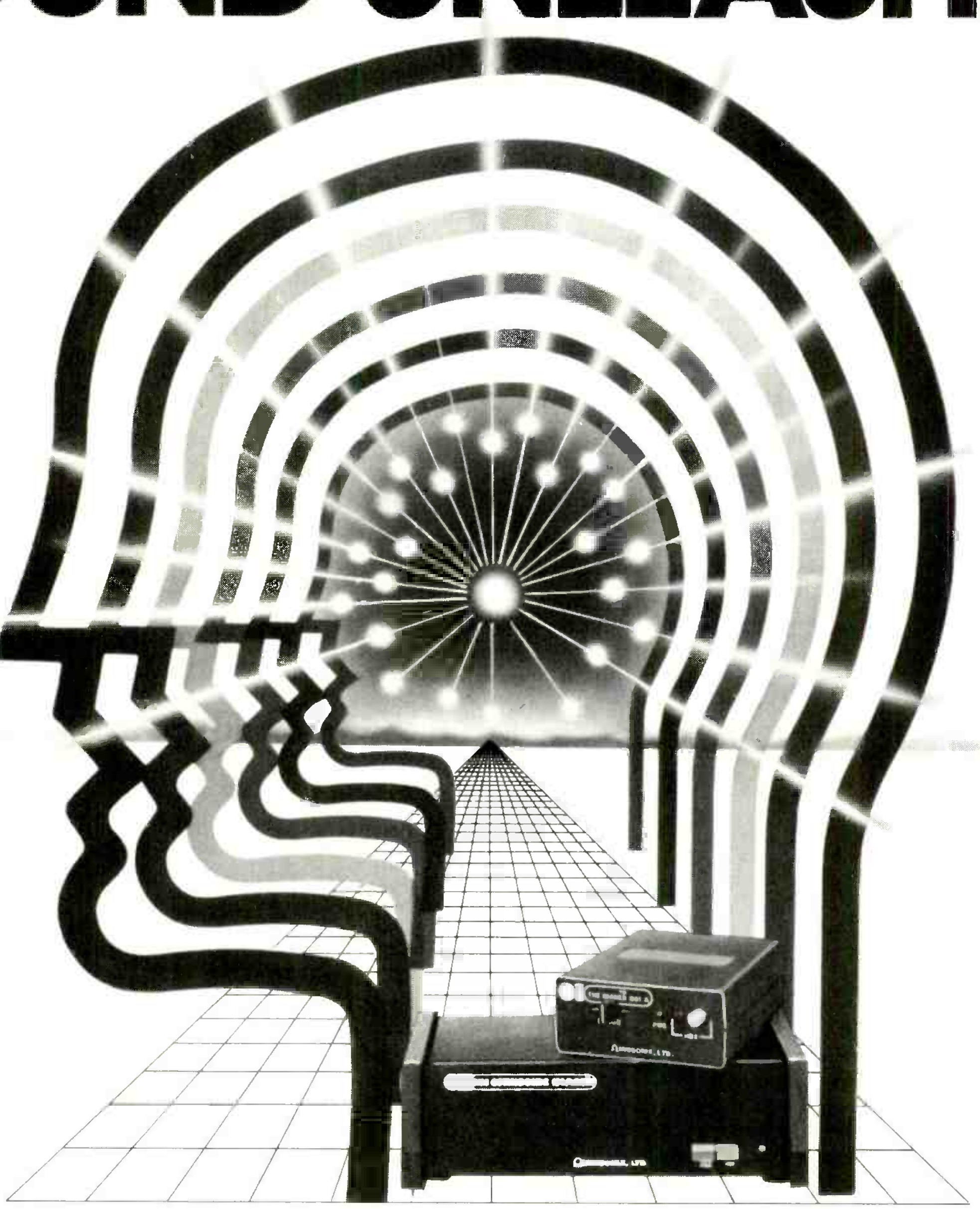

You may not realize it, but you've only been listening to music in two dimensions. In fact, owners of the most sophisticated systems utilizing the latest enhancement techniques are also only hearing two-dimensional sound, totally lacking the missing third dimension, Omnisonic Imagery™. Even owners of the most modest stereo systems will recognize the 801 Omnisonic Imager™ as one of the most significant improvements in music reproduction in years. This advance, available after extensive research by Omnisonix in the field of psychoacoustics, is intended to provide the enjoyment and feeling of live musical performance. To vastly upgrade the performance of your stereo system, simply connect the 801 to the tape or preamp input/output jacks and listen to clear, distinct sound images that seem to surround you, even while moving about. In fact, the impact is so great that the sound seems to come from outside the speaker plane, often overhead and to the rear. Your home virtually becomes a concert hall.

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To experience the dramatic presence and detail that have been missing from your records, digitally recorded discs, and pre-recorded tapes, take a few of your favorites to an Omnisonix dealer for a demonstration; you are in for a musical delight. And amazingly enough, any tape you record through an Omnisonic Imager will retain the Omnisonic quality when it is played back on a conventional stereo system. The 801 Omnisonic Imager also adds a dimension to FM, monophonic AM and TV sound, with a simple adjustment.

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CIRCLE NO. 49 ON FREE INFORMATION CARD

LETTERS

Software Offerings

Having read the article "Word Processing" in the August issue, I would like to point out that Zenith is now selling, through Zenith Data Systems and the Heath Company, CP/M compatible software, including the MicroPro products and Magic Wand. These are in addition to AutoScribe as mentioned.—*Andrew Czernek, Zenith Data System, Glenview, IL.*

Programming the Atari

In your review of the Atari 800 computer (June 1981), you stated, with regard to a program for drawing a three-dimensional polygon, that "Although this program creates a single-view polygon, expanded views, defined by the frame input, weren't possible." This is because the coordinates for the points weren't being incremented.—*J. Becker, Suffern, NY.*

You are right. The array should indeed have been incremented.—Ed.

Reed Relay Substitute

I am building the "Commercial Killer" (June 1981) and have located all the parts except the reed relay (*K1*). Radio Shack offers a switch that would do, but its contacts are normally open instead of closed.—*C. W. McClenahan, Mineral Ridge, OH.*

In his prototype, the author used a surplus reed relay. However, any low-current (around 10 mA), 9-12-volt relay with a normally closed contact should work. Try Radio Shack's miniature spdt relays No. 275-003 (12 V, 10 mA) or 275-004 (6-9 V, 12 mA). The contacts should be rated at 1 A, 125 V. —Ed.

OUT OF TUNE

In "Peak Unlimiter" (September, p 75), the 1N82 diode should have been specified as silicon not germanium.

In "A Battery-Operated Fluorescent Lamp" (August, p 53), in the first step of the adjustment procedure, instead of removing the connection between the rotor of *R6* and the 12-volt end, the instructions should be to disconnect the potentiometer from the 12-volt supply.

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Personal Computer Comparison Chart

Product Features	Commodore VIC-20	Atari 400	TI 99/4A	TRS-80 Color Computer
Price*	$299.95	$399.95	$525.00	$399.50
Total Memory Standard (ROM & RAM)	25K	26K	42K	12K
Memory (RAM) Expansion to...	32K	Not Available	Not Available	32K
Keyboard Style	Full-Size Typewriter Style	Flat Plastic Membrane	Half-size Typewriter	Calculator Style
Programmable Function Keys	4	0	0	0
Basic Language	Microsoft Basic	$59.95 Extra	TI Basic	Radio Shack Basic
Upper/Lower Case Characters	Yes	Yes	No	No
RS232 Interface	$49.95	$219.95	$225.00	$19.95
Number of Keys	66	57	40	53
Graphic Symbols on Keyboard	62	0	0	0
Displayable Characters	512	256	64	256

*Manufacturers suggested retail price September 1, 1981

A computer like this would have been science fiction a few years ago. Now it's a reality. It's the new VIC-20 by Commodore, a full fledged expandable color computer that costs little more than video games. And it's so easy to use you can be writing your first program in 15 minutes!

Everybody loves video games and the Commodore VIC-20 has some of the best. But the VIC-20 can also help children with their homework. Mom can use it for home budgeting. Dad can even take the lightweight, portable VIC-20 to the office for financial and business application.

The Friendly Computer at a Friendly Price: At $299.95 the Commodore VIC-20 is the friendliest way we know to learn computing. It has a full computer keyboard even a small child can operate.

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The VIC-20 can take your children from preschool through post-graduate studies.

Why get just another game that could end up in the closet? Get an honest-to-goodness computer for just $299.95.

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CIRCLE NO. 12 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.

DMM for Home Computers

Sabtronics announces its new Model 2020 DMM with microprocessor interfaces to adapt to the Apple, Atari, PET, and TRS-80 personal computers. The Model 2020 has a basic dc accuracy of 0.1%, with a 3½-digit LED display. It is capable of directly measuring ac and dc voltages up to 1000 V; resistance to 20 megohms; and ac and dc current to 10 A. Optical coupling between the DMM and the computer serves to isolate ground noises. Applications include the ability to make periodic measurements over widely varying intervals, the generation of statistical data for graphic representation, monitoring physical parameters such as stress, strain, temperature, and gas pressure via transducer ICs, etc. The unit is equipped with cabling and I/O support. $299.

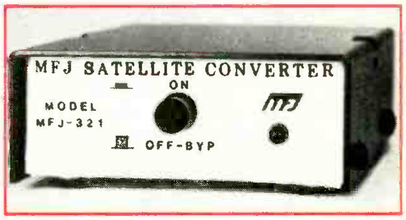
CIRCLE NO. 86 ON FREE INFORMATION CARD

Analog Reverberation System

The ARS-911 from Advanced Analog Systems, Inc. uses a PMOS delay line scheme to enhance the spatial quality of high-fidelity sound. The unit requires a low-level input signal source such as the tape-monitor output from a typical sound system. Left and right channel information is combined in an input-summing amplifier. A portion of the filter output signal is fed back to the input of an anti-aliasing filter via a delay line. The amplitude of the feedback path is controlled by a reverb attenuator, and the feedback delay is adjustable from 2 to 13 ms. The ARS-911 also incorporates a variable-bandwidth noise-reduction filter that senses the high-frequency content of the signal present, thereby controlling active bandwidth of the entire system. This is said to reduce noise by 12-14 dB. A small power amplifier uses four VMOS transistors to directly drive a speaker, permitting use of the unit with systems of up to 50 watts/channel. Available in kit, $150.

CIRCLE NO. 84 ON FREE INFORMATION CARD

Satellite Frequency Converter



The MFJ-321 Scanner Satellite Converter from MFJ Enterprises receives the 130- to 150-MHz satellite band and downconverts it to 30 to 50 MHz. The unit contains a built-in low-noise preamplifier to bring in weak signals. Connecting between the programmable scanner and the antenna of a satellite earth station, it operates on 12 V dc or on ac with an adapter (not included). $100.

CIRCLE NO. 87 ON FREE INFORMATION CARD

Portable Computer

The Osborne 1 computer measures 20.5"W x 13"D x 9"H and weighs 23.5 lb. The main pc board uses the Z80A processor with a 4-MHz clock; memory size is 64K RAM, 4K ROM. Interfaces are RS-232 C and IEEE 488. User controls consist of a 69-key detachable keyboard with a 12-key numeric pad; brightness and contrast controls are on the front panel. The display system uses white video on a dark background; 24 lines of 52 characters are arrayed on a built-in 5"-screen, and 32 lines of 128 characters can be moved with horizontal scrolling. The character set consists of 96 upper- and lower-case characters; and 32 graphics characters. The Osborne 1 uses 5¼" dual-floppy 100K byte diskettes, with storage provided for up to 25 diskettes. Five software packages are included with the unit: WordStar/MailMerge, SuperCalc, CBASIC, MBASIC, and CP/M. Optional extras include a 12" video monitor that reproduces the image on the built-in screen, modem cable, battery pack, and double-density disk drives (200K bytes per drive). Base price is $1795.

CIRCLE NO. 85 ON FREE INFORMATION CARD

Direct-Connect Modem

The AUTO-CAT from Novation is a Bell 103-compatible 300-baud modem that operates over dial-up telephone lines using a standard modular jack. It has three data modes: automatic answer, manual answer, and manual originate. Operating in either full or half-duplex, the AUTO-CAT features local and remote-loopback test functions. LEDs give a constant indication of the unit's operational status. Data can be retrieved unattended by using the automatic answer function. The interface between computer and modem is the EIA RS-232. $249.

CIRCLE NO. 88 ON FREE INFORMATION CARD

Five-Band Equalizer

MXR's new Model 153 offers five bands of discrete (±12 dB) adjustment with

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Flexible Disc 1s	IBM Compatible (128 B/S 26 Sectors)	3060	1.99	473071	53428	800506	2305830	FD1 128	FD 1	740 0	S/A 100	15002	FD34 9000	F111111X	421602
Single Headed Drives	IBM Compatible (128 B/S 26 Sectors) w/ W P N	3062	2.04	—	—	—	—	—	—	740-0	—	—	FD34 9000	—	—
Single Density Media	IBM Compatible (128 B/S 26 Sectors) w/ W P N & Hub Ring	3064	2.39	—	—	—	—	—	—	—	—	—	FD34 9000	—	—
	IBM Compatible (128 B/S 26 Sectors) REVERSIBLE	1729	3 19	473072	54431	—	—	—	FD-2	740/2 0	—	15150	FF34 9000	F171111X	—
	IBM System 6 Compatible	3066	2.04	473077	54561	800509	1669959	—	—	740 0 056	—	15003	FD60 9000	F116111X	—
	IBM Compatible (256 B/S 15 Sectors)	3109	1.99	473073	—	800584	2305845	—	—	740 3600	—	15005	FD36 9000	F112111X	—
	IBM Compatible (512 B S 8 Sectors)	3110	1.99	473074	—	800585	1669954	—	—	—	—	15004	FD60 9000	F113111X	—
	Shugart Compatible 32 Hard Sector	3015	1.99	470901	53802	101/1	—	FH1 32	FD 132	740 32	S/A 101	15025	FD32 9000	—	421322
	Wang Compatible 32 Hard Sector w/Hub Ring	3087	2.49	—	54491	—	—	—	—	740 32RH	—	—	—	F37A411X	—
	CPT 8000 Compatible	3045	2.69	—	—	—	—	—	—	—	—	15226	—	—	—
Flexible Disc 1d	IBM Compatible (128 B/S 26 Sectors)	3090	2.69	474071	54568	3740/1D	—	FD1 128/M2100	FD-1D	741-0	—	—	FD34-8000	F131111X	423002
Single Headed Drives	Soft Sector (128 B/S 26 Sectors) REVERSIBLE	3093	3.69	—	—	—	—	—	—	—	—	—	—	—	—
Double Density Media	Shugart Compatible 32 Hard Sector	3091	2.69	470801	54596	101/1D	—	FH1 32D	—	741-32	S/A 103	15075	FD32 8000	F33A411X	423322
	Wang Compatible 32 Hard Sector w/Hub Ring	3088	3 09	—	—	—	—	—	—	—	—	—	—	—	—
Flexible Disc 2s	Soft Sector (128 B/S 26 Sectors)	3113	3.09	—	54428	800814	1766870	—	—	—	S/A 150	15153	FD10 4026	F121111X	—
Double Headed Drives Single Density Media	Soft Sector (256 B/S 15 Sectors)	3106	3.09	473477	54228	800815	2736700	FD2-256D	—	742.0	—	15154	FD10-4015	F122111X	424612
Flexible Disc 2d	Soft Sector (Unformatted)	3102	3.09	473485	—	DY150	—	FD2 XDM	FD-2D	743 0	—	15103	DD34-4001	—	425002
Double Headed Drives	Soft Sector (128 B/S 26 Sectors)	3115	3.09	—	—	—	—	—	—	—	S/A-150	—	—	—	—
Double Density Media	Soft Sector (256 B/S 26 Sectors)	3103	3.09	473471	54325	800817	1766872	FD2 256D	—	743-0/256	—	15101	DD34-4026	F144111X	425602
	Soft Sector (512 B/S 15 Sectors)	3114	3 09	473472	54479	800818	1669044	—	—	743 0/512	—	15100	DD34 4015	F145111X	425612
	Soft Sector (1024 B/S 8 Sectors)	3104	3 09	473473	54485	800819	1669045	—	—	743-0/1024	—	15102	DD34-4008	F147111X	425622
	32 Hard Sector	3105	3.09	470851	—	101/2D	—	FH2 32D	—	743 32	S/A 151	15125	DD32.4000	F34A411X	425322
	Burroughs B 80 Compatible 32 Hard Sector	3092	3 09	—	—	—	—	—	—	—	—	—	—	F34A611X	—
	Soft Sector (1024 B/S 8 Sectors) w/ Hub Ring	3116	3 49	—	—	—	—	—	—	—	—	—	—	—	—
	Shugart Compatible 32 Hard Sector	3181	3.39	—	—	—	—	—	—	—	—	—	DD32 4000	—	—
Flexible Disc FD Memorex 651 or Equiv Drive Compatible	FD VI (Vinyl Jacket)	30712003	2.69	470851	—	FDIV	—	—	FD-185	511-0	—	15026	FD65 1000	F61A111X	—
Mini Flexible Disc 1s	Soft Sector (Unformatted)	3401	1 94	475001	54256	104/1	—	MD1	MD 1	744 0	S/A-104	15300	MD525-01	M11A211X	441007
5¼" Single Headed Drives	10 Hard Sector	3403	1 94	475010	54257	107/1	—	—	MD 110	744 10	S/A 107	15325	MD525 10	M41A211X	441102
Single Density Media	16 Hard Sector	3405	1 94	475016	54256	105/1	—	MH1	MD 116	744.16	S/A-105	15326	MD525-16	M51A211X	441162
	Soft Sector (Unformatted) w/Hub Ring	3431	2 14	—	—	—	—	—	—	—	—	—	MD525 01	—	—
	10 Hard Sector w/Hub Ring	3433	2 14	—	—	—	—	—	—	—	—	—	MD525 10	—	—
	16 Hard Sector w/Hub Ring	3435	2 14	—	—	—	—	—	—	—	—	—	MD526 16	—	—
Mini Flexible Disc 1d	Soft Sector (Unformatted)	3417	2 14	—	54646	104/1D	—	—	—	—	—	—	MD525-01	—	—
5¼" Single-Headed Drives	10 Hard Sector	3418	2 14	—	54649	107/1D	—	—	—	—	—	—	MD525-10	—	—
Double Density Media	16 Hard Sector	3419	2 14	—	54652	105/1D	—	—	—	—	—	—	MD525-18	—	—
	Soft Sector (Unformatted) w/Hub Ring	3481	2.34	—	—	—	—	—	—	—	—	—	MD525 01	—	—
	10 Hard Sector w/Hub Ring	3483	2.34	—	—	—	—	—	—	—	—	—	MD525-10	—	—
	16 Hard Sector w/Hub Ring	3485	2.34	—	—	—	—	—	—	—	—	—	MD625 16	—	—
Mini Flexible Disc 2d	Soft Sector (Unformatted)	3421	2 59	—	54824	104/2D	—	—	—	—	S/A 154	—	MD550 01	—	—
5¼ Double-Headed Drives	10 Hard Sector	3423	2.59	—	54827	107/2D	—	—	—	—	S/A 157	—	MD550-10	—	—
Double Density Media	16 Hard Sector	3425	2 59	—	54830	105/2D	—	—	—	—	S/A-156	—	MD550-16	—	—
	Soft Sector (Unformatted) w/Hub Ring	3491	2.79	—	—	—	—	—	—	—	—	—	MD550 01	—	—
	10 Hard Sector w/Hub Ring	3493	2.79	—	—	—	—	—	—	—	—	—	MD550-10	—	—
	16 Hard Sector w/Hub Ring	3495	2 79	—	—	—	—	—	—	—	—	—	MD550-16	—	—

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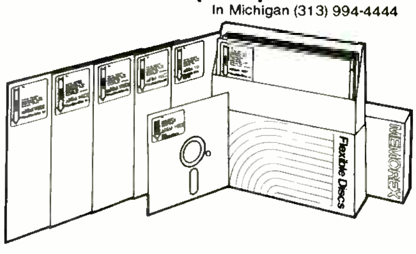

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individual left and right slide controls for a visualized representation of each channel. LEDs associated with each channel permit matching of input-to-output levels. Also featured is an equalizer-bypass switch for comparisons between equalized and non-equalized signals, a tape-monitor switch, and a subsonic filter that removes frequencies below 20 Hz. Specs: equivalent input noise, −95 dBV at 1 V rms (20 Hz to 20 kHz); dynamic range, 108 dB; THD, 0.05% at 0 dBV (20 Hz to 20 kHz); frequency response, 20 Hz to 70 kHz (+0, −3 dB); subsonic filter response, −30 dB at 5 Hz (18 dB per octave slope). $150.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Two-Way Radio

"Talkman," from Standard Communications, is a miniature (2½"W × 4½"H × ¾"D), hands-free two-way radio that will transmit up to ¼ mile. It is available in any one of five channels and features a stowable whip antenna and an adjustable, boom-mounted, voice-activated microphone. Applications include hunting, construction, skiing, security, etc. Its power source is a nine-volt battery. Weight without battery is less than one lb. $125.

CIRCLE NO. 91 ON FREE INFORMATION CARD

Stereo Control Center

The QED Model 7 employs a remote power supply, a BiFET output stage, and passive tone controls to reduce noise and distortion arising from the unit itself. The Model 7 also features a subwoofer output with electronic crossover; loudness boosting for frequencies from 40 to 100 Hz; and an environmental enhancer that is claimed to expand the sonic image when the speakers are closer together than eight feet. A separate input for the audio section of any video source is provided, along with a switching system for other audio sources, e.g., phono, tuner, tape. Specs: frequency response, 10 to 60,000 Hz ±0.5 dB; maximum output, 7 V rms; maximum input, 75 mV at 1 kHz; input impedance, 49 kilohms (MM)/100 ohms (MC); THD, 0.025%; IM, 0.5%; S/N, 77 dB (phono)/87 dB (line); sensitivity, 1.11 mV (phono)/91 mV (line). $415.

CIRCLE NO. 92 ON FREE INFORMATION CARD

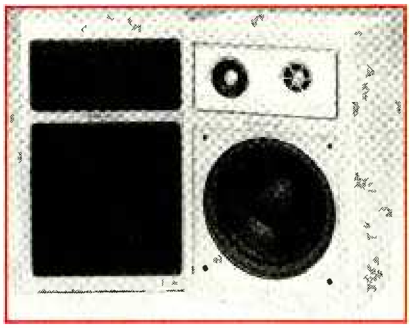
Disk Cleaner

The Verbatim Corporation has introduced its Datalife Head Cleaning Kit that it claims can remove up to 90% of debris contaminating magnetic recording heads in computer and word-processing systems. The kit consists of a reusable Lexan jacket and presaturated, disposable cleaning disks. The disk is removed from its protective cover, inserted into the Lexan jacket, and the whole assembly is put into the drive. A proprietary black ring is said to fool the drive's photosensor into thinking

the cleaning disk is a conventional diskette. The cleaning process takes 60 s. Available in 5¼″ and 8″ sizes, the kit will work with any drive except the Vydec 8″ word processor. $12.50.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Kenwood Speakers



The S-4 is an acoustic-coupled, three-way, floor-standing speaker system with cone-type drivers: an 8″ woofer, a 2⅜″ tweeter, and a 1$^3/_{16}$″ super tweeter. It is said to be able to handle up to 80 W (rated input power is 55 W) and has a frequency range from 50 to 20,000 Hz. Impedance is 8 ohms; sensitivity is 89 dB/W at 1 m. Construction of the enclosure is particle board laminated with polyvinyl finish. Dimensions: 9″W x 14″H x 8″D. $260 a pair.

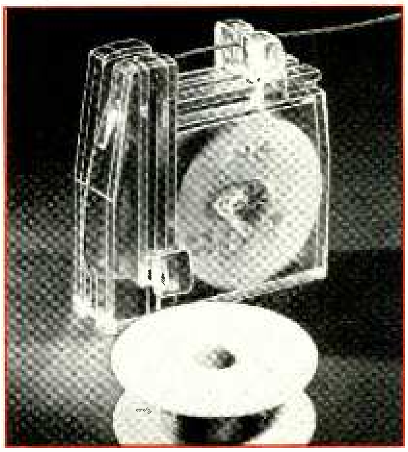
CIRCLE NO. 94 ON FREE INFORMATION CARD

S-100 Capability for the Sorcerer

The new Display/S-100 unit from Exidy Systems is designed to link the Sorcerer computer to all the manufacturers of S-100 bus products. The unit is mounted on a swivel base-stand and includes a 12″ professional CRT with 20-MHz bandwidth and green P31 phosphor. The bus is a self-contained S-100 motherboard with power supply and translation logic for the Sorcerer. The S-100 interface gives Sorcerer computers additional capability, including analysis of scientific data, graphic display, production control, etc. The Display/S-100 comes with cables and installation instructions. $700.

CIRCLE NO. 95 ON FREE INFORMATION CARD

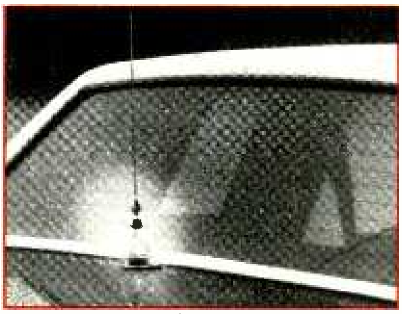
Wire Dispenser



The AD series from O.K. Machine and Tool Corporation is the latest in its line of cutting and stripping-wire dispensers. Featuring ground-steel cutters and a die-stamped stripping blade, the unit permits adjustment of strip length (from ⅜″ to 2″) by loosening the locking cam and sliding the stripping blade to the desired location. Stripping blades are compatible with either 24 AWG or 30 AWG Kynar insulated wire. The 24 AWG version includes 50′ of wire; the 30 AWG version, 100′. Housing is transparent to allow monitoring of wire length. $13.

CIRCLE NO. 96 ON FREE INFORMATION CARD

Light-up Antenna



A new mobile AM-FM/CB antenna has been introduced by Armstrong Industries. Called the "Illuminator" (designated Model TAK-10L), the antenna features a 5000-hour, 0.5-candlepower, 12-V dc, incandescent lamp installed in a clear-molded base, thus illuminating the hollow coil form. The lamp will fail to light unless the antenna is properly grounded. The TAK-10L uses the new Clear-Flex (RG58-AU) coax cable (18′ of which are provided with the antenna). An additional lamp circuit lead attaches to the vehicle's tail or running lights. Hence, the antenna base lights only when the vehicle lights are on. The unit mounts on the trunk of a vehicle; no drill holes are necessary. A Uni-Axis ball joint tilts the whip 45° in all directions. $55.

CIRCLE NO. 98 ON FREE INFORMATION CARD

Your favorite stars are coming off the satellites right now in one of the greatest selections of family and adult entertainment ever offered. And now there's a new satellite receiver system that puts it all within your reach – at a price that's within reach.

The new Heathkit Earth Station

It includes a *3-meter Satellite Antenna* with a single-axis adjustable mount that lets you direct your antenna to receive signals from the entire satellite arc. It's a heavy-duty, commercial-quality antenna, made by Scientific-Atlanta and designed for long, reliable performance.

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Viewing of some satellite TV channels may require the customer to obtain permission from, or make payments to, the programming company. The customer is responsible for compliance with all local, state and federal governmental laws and regulations, including but not limited to construction, placement and use. For use only in Continental U.S.

Heathkit

CIRCLE NO. 21 ON FREE INFORMATION CARD

ENTERTAINMENT ELECTRONICS

By Ivan Berger

CX Noise Reduction in Perspective

FIRST we had noise. Then we had Dolby and less noise. Now, noise-reduction systems are sprouting like dandelions on a country lawn.

The latest, and the one with the biggest push behind it, is CBS's CX system. It may prove the most controversial, and it may bring a bit more breathing space before all-digital discs finally arrive in our living rooms.

There's little controversy over such noise reducers as DNR, the Phase Linear and Carver autocorrelators, or the KLH (originally Burwen) system because they require no changes in the material we play through them. They work after the fact, reducing the noise in whatever program material you pipe through them. If you don't like what they're doing, you don't have to use them.

There is some debate, though, over systems like Dolby, dbx and CX, because they require changes in the software we listen to. If you're going to use any of these "closed-loop" systems, you have to use them both to encode the original broadcast or recording and to decode it in playback. The decoder is useless on unencoded material, while encoded material is somewhat incompatible with playback systems that don't include decoding.

There was some flak over Dolby "B" (the now-universal tape recording noise-reduction system) when it first came out, on just those grounds. But it didn't look, at first, as if the system would catch on enough to be worrisome, which muted the controversy a bit; and, of course, now that virtually every tape deck has Dolby, the subject has cooled entirely. Also, the degree of incompatibility was very small: Dolby tapes played on non-Dolby systems sound a little shrill, but you can correct that to a reasonable degree with your treble control. And now that it has become universal, there's virtually no tape deck around that isn't fully compatible with Dolby, though not all listeners within reach of Dolbyized FM broadcasts are equipped to decode those.

Going Further. The problem with Dolby B was that it didn't do enough. Though the noise was reduced, it could still be heard (as it still can with all the other noise reducers). Why settle for 10 dB or so of high-frequency noise reduction if you could reduce it more and over a wider frequency range?

The first successful attempt to bridge that gap was dbx, one of the most effective and least compatible noise reduction systems I've heard. Basically, it's a 2:1 compression/expansion system, which means it theoretically doubles the dynamic range—and that's about how it sounds in practice. There's a good deal of compatibility between dbx encoders and decoders, too. The dbx system isn't level-dependent like Dolby or CX, so you don't have to calibrate your encoder or decoder to match the signal levels in the rest of your system. But there's virtually no compatibility between dbx-encoded recordings and undecoded playback systems: with 2:1 compression, music sounds not just compressed but squashed flat, like a full-frequency-range version of an acoustically recorded 78-rpm disc.

Dolby C was an attempt to match dbx's noise-reduction capability with greater compatibility. I haven't yet had any home experience with Dolby C so I can't comment. (I will in a month or two.) Since Dolby C can be considered—very loosely—as two Dolby B systems cascaded, I'd assume that there's some compatibility between "C" tapes and "B" playback systems, and that the combination should sound, once more, a bit shrill but more or less adjustable with tone controls. I wouldn't presume to guess what completely undecoded playback of Dolby "C" tapes would sound like, but I'm getting a deck equipped with a C system soon, and then I'll know (and will report).

The Latest Wrinkle. The newest system on the block, though, is CX, which so far has been pushed for disc and video recordings only and not for home tape. (The Dolby systems are for tape only—including videotape, in the new VHS stereo versions—while dbx is available for both tape and disc.) CX has picked up a lot of support quickly. Not only CBS but RCA and the Warner/Elektra/Asylum/Nonesuch group will be offering CX-encoded phonograph discs.

RCA also plans to add CX to its CED videodisc system, while DiscoVision Associates plans to start encoding the sound tracks of its LaserVision video discs, and Pioneer plans to put decoding circuitry in its players. (Magnavox hasn't decided, as of this writing.) There are hints of CX-type CED video discs, too (with RCA already planning to use it on audio discs). Phase Linear, Sound Concepts, MXR, and Audionics are producing CX disc decoders.

One reason for this rapid build-up is that Columbia Records carries clout. If CBS is using it, then there will be some discs worth playing on it; and if that means there will be noticeable numbers of decoders in people's homes, then there will be a good market for other companies' CX-encoded discs. Another reason is that CBS lets other record companies use the system without paying royalties—a shrewd move.

But the main reason for the popularity of CX is CBS's claim of perfect compatibility. They say that, though it increases dynamic range by 20 dB (to as much as 85 dB, in some cases), "CX encoded records can be played on conventional stereo equipment and will sound the same as standard records." A number of recording engineers, however, don't agree.

The CX system works by compressing levels 2:1 in recording and expanding them in playback. However, there are two differences between it and dbx's 2:1 companding system: there's no high-frequency pre-emphasis, and the expansion takes place only for signals from −40 dB up, instead of for all signal levels. That's done so that the compression won't raise the level of any noise already in the signal, which would make the discs noisier on undecoded systems.

Test Results. Press demonstrations of CX were most impressive. Now that I've had a chance to listen to Phase Linear's decoder for a while at home, I'm still impressed. With CX in, I heard no noises I could definitely ascribe to the disc system. (I did hear some noise, but it seemed more like tape hiss from analog masters.) I heard no noise "pumping," either. CX records definitely had more dynamic range and a more "live" and lively sound than regular discs.

Undecoded CX discs did sound a touch compressed, to me, but no more so than many ordinary records do these days. I doubt that many listeners, even among audiophiles, could tell whether they were hearing a CX disc or not, under those circumstances; and I'm sure the average listener would never know. The only difference I heard between the same material in encoded and unencoded form (on two sides of a CBS demonstration disc) was slight compression—about as much as I'd hear if the same disc were played over the average classical FM station.

The system isn't designed for tape recording, mainly because its processing is even at all frequencies, not emphasized at the highs where tape has the most hiss. That being the case, I didn't try any tapes.

Passing ordinary discs and FM broadcasts through the decoder didn't work too well. Some FM broadcasts did sound better with this extra expansion, probably because they're a bit more compressed than discs usually are. But I found no records whose dynamics didn't sound exaggerated when played through the decoder. (Surprisingly, that even applied to LP records from the early Fifties, which were quite compressed.)

For the most part, these exaggerated dynamics didn't sound like bad fidelity but more as if their conductors had worked up to a romantic frenzy. The one acoustically unnatural effect was the over-rapid fall-off of the echoes at the end of musical passages. This was most pronounced on old LPs made in studios that had fairly short reverberation times in any case.

CX decoders aren't intended to be used in playing non-CX recordings, of course, so I can't fault the system or my Phase Linear decoder for that. I haven't yet heard the Sound Concepts SX-80 decoder, which can be switched for upward expansion of non-CX records. The effects might well be worth the price difference (Phase Linear's 220 CX is $99.95, the Sound Concepts model is $119), but I'd have to hear it to be sure. Audionics and MXR also make CX decoders. (*Also, see page 39.—Ed.*)

Calibrating the Phase Linear was easy. It requires a test record, but all CX decoders come with one. My preproduction sample didn't, however, so I used the 3.54 cm/s cut on my CBS STR-100 test record. You'll find the same sort of cut on other test discs, too. On the Phase Linear, you set screwdriver-adjust pots on the back panel until a red LED glows, a point that took 10 seconds or so to find. Some of the other decoders have front-panel controls (handier if you change cartridges a lot, but more easily reset by accident); and the Sound Concepts model has a three-color LED which shows whether your level is too high or low, too.

CX records, properly decoded, sound better than regular records, and give premium-priced audiophile discs (digital, direct-cut, or remastered) a run for their money. For the real audio enthusiast who's likeliest to buy and use decoders, that's a gain. For the average listener, without decoders, CX brings a slight loss of dynamic range—though I think most listeners won't notice it. That leaves some people in the middle, who will find that they hear and dislike the difference between normal and undecoded CX discs, and who may also find it a nuisance to keep switching the decoder in for some discs and out for others. Don't ask me, though, how many listeners are in each group.

The CX system isn't magic, but it does accomplish most of what it was designed for. It gives critical listeners a system with wide dynamic range that average listeners can still enjoy. If CX decoders ever become as universal as Dolby tape decks now are, I could even see it being used to improve further the quality of audiophile discs. But as long as most listeners don't have decoders, I doubt any audiophile disc series (except, possibly, CBS's MasterSound) will compromise their dynamic range by adopting it. ◊

Audio Product of the Month

CHOSEN BY THE EDITORS OF POPULAR ELECTRONICS

EPI Model A300 Speaker

THE EPI A300 speaker system has an improved "Air Spring" concave dome tweeter featuring a modular assembly for easy replacement of its diaphragm and voice coil assembly in the event of damage. The 1" tweeter of this three-way system operates above 3,000 Hz, with a 4" sealed-back midrange cone driver handling frequencies between 700 and 3,000 Hz, and a 10" acoustic-suspension woofer with a "Focused Field" magnetic system taking over below 700 Hz. The rated frequency response of the system is 47 to 20,000 Hz ±3 dB.

The EPI A300 has a rated impedance of 4 ohms. It measures 22½"H x 13½"W x 10¾"D and weighs 37 pounds. The A300 is recommended for use with amplifiers delivering from 25 to 250 watts per channel. The wood cabinet is finished in oiled walnut and has a removable black cloth grille. The suggested retail price is $300.

General Description. EPI's "Air Spring" concave dome tweeters have earned a reputation for excellent dispersion and smooth, extended frequency response.

A resonance test verifies that the moving system resonance occurs between 1,200 and 1,600 Hz, showing that the moving parts of the speaker have been installed and aligned correctly. A harmonic distortion test is made with a 1,000 Hz input signal (well below the tweeter's normal lower operating limits). The acoustic output picked up by the measurement microphone is filtered to pass only 5,500 to 17,000 Hz to the measuring equipment.

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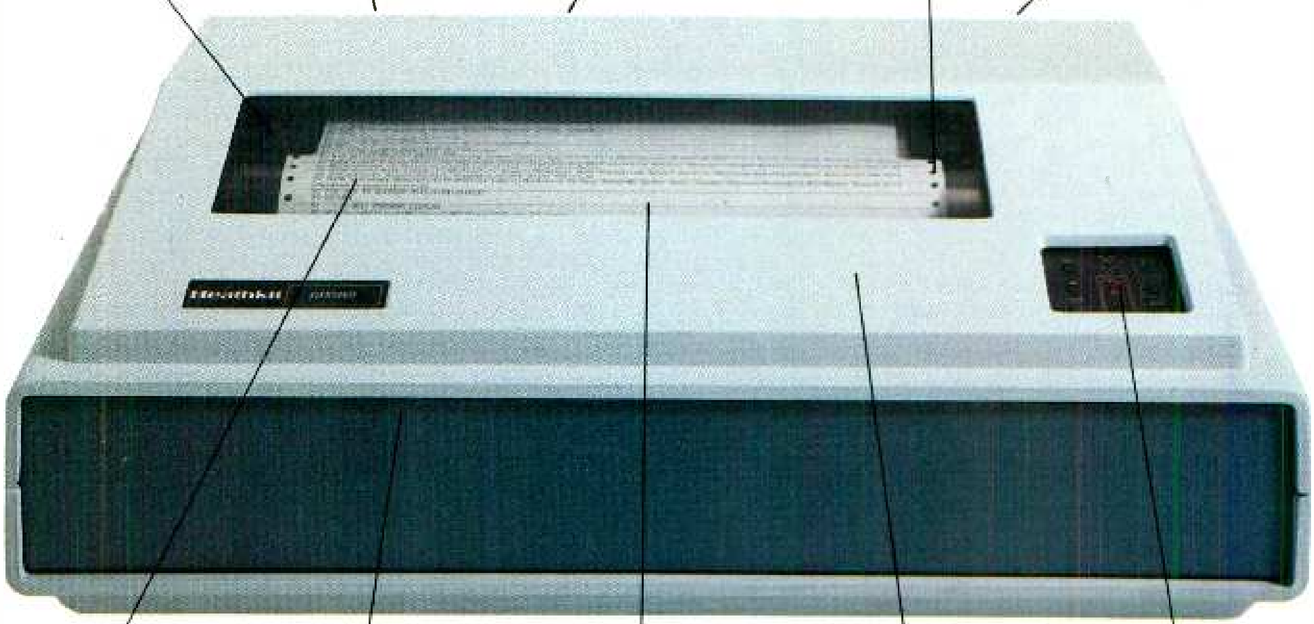

Character set includes 33 block graphic characters for charts and graphs.

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*In kit form, F.O.B. Benton Harbor, MI. Also available completely assembled and tested at $1,595. Prices and specifications are subject to change without notice.

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CP-204C

a harsh or unpleasant sound. EPI considers that the level of the higher-order harmonics (sixth through seventeenth) is a better indicator of such problems. If the total distortion measured in this test exceeds 0.2%, the tweeter is said to be rejected by the manufacturer. This is followed by a conventional frequency-response measurement with a sweeping sine-wave input to confirm that the response of the tweeter is within its design tolerances.

EPI pioneered in the use of "Ferro-Fluid" in tweeter magnetic gaps to conduct heat away from the delicate voice coil rapidly and, thus, minimize the possibility of burning out a tweeter by excessive input (as well as increasing the power-handling capacity of the tweeter). The Ferro-Fluid, a suspension of magnetic particles in a fluid, becomes viscous when placed in a magnetic field and also provides a damping action to reduce the effect of mechanical resonances. It has been used in all EPI tweeters for some years; in the A300 it is employed in both the tweeter and the midrange driver.

The fact that the tweeter resonance is far below the crossover frequency and that it is checked for distortion with an input even lower in frequency than the resonance makes it practical to use simple crossover networks in the A300. This minimizes phase shifts in the crossover region as well as reducing costs. Driver sensitivities have been designed so that no level adjustments or trimming resistors are required in the crossover networks, and the system has no external user-adjustable controls.

The bass driver has a "Focused Field" magnetic circuit for high efficiency and low distortion at high power levels. Its 2-inch voice coil is wound on a high-temperature "Kapton" former.

Laboratory Measurements. Although the EPI A300 can be placed on the floor or on stands, as well as in a typical midwall "bookshelf" placement, we chose the stands for our tests. They were placed against the wall, vertically oriented, with the tweeters about on the ear level of a seated listener.

The averaged, smoothed frequency response in the reverberant field of the room showed the usual minor irregularities (probably the result of room interaction), with peak amplitudes of only 2 to 3 dB. The output was quite uniform from 500 to 3,000 Hz (approximately the operating range of the midrange driver) and then rose about 5 dB to a new plateau between 5,000 and 20,000 Hz. This curve corresponds roughly to the total power response of the speaker into the forward hemisphere, after being corrected for the known absorption characteristics of the room. It is derived by averaging separate curves for the left and right speakers, made with the microphone on the axis of the left speaker and about 30 degrees off the axis of the right speaker. The two curves did not differ significantly over the entire high-frequency range, a clear indication that the tweeter is essentially omni-directional through the forward hemisphere.

Bass response was measured separately with the microphone close to the woofer cone. This gives an equivalent to an anechoic frequency response, unaffected by room boundaries or other surroundings. The woofer output was flat within −1 dB from 100 to 400 Hz, with a rise of about 3 dB in the 55-to-90-Hz range before falling off at 12 dB per octave below 50 Hz. The woofer output rolled off about 5 dB between 400 and 700 Hz and dropped sharply at higher frequencies.

When this curve was spliced to the reverberant field curve, the composite frequency response was within ±4.5 dB from 42 to 20,000 Hz. This curve, being a composite of two very different measurements, cannot be compared directly to any frequency-response rating from the manufacturer or any other source. In our judgment, it confirms the EPI specification.

Having recently acquired a Fast Fourier Transform (FFT) signal analysis system (based on an Apple II computer, with special programs and hardware from Indac Associates), we were able to measure the response of the A300 speaker in our listening room in a quasi-anechoic manner. This system is able to exclude the effects of room resonances or reflections by limiting the analysis time period to that containing only the direct output of the speaker. The speaker is driven with an 18-microsecond pulse, and its output is picked up by our measurement microphone and processed by the computer to generate a frequency-response curve.

This measurement showed the response of the A300 to be even smoother than our reverberant curve, which cannot be completely separated from room resonances and standing-wave effects. From 200 Hz (the lower limit of the FFT analysis in its high-frequency mode) to 17,000 Hz (its upper limit, set by an internal filter) the axial output of the speaker at 1 meter varied only ±3 dB. A separate woofer measurement was made in the low frequency analysis mode, using a pulse 10 times wider and a sampling frequency 10 times lower. The result essentially duplicated our previous close-miked swept frequency measurements.

Woofer distortion, measured with close mike spacing, was determined for frequencies from 100 to 20 Hz, at power inputs of 1 and 10 watts (based on the 4-ohm rating of the system). Second and third harmonics were measured separately and combined for a total harmonic distortion reading. There were no significant distortion components higher than the third.

The EPI A300 was somewhat unusual in this respect since its distortion rose almost exactly linearly with decreasing frequency (the latter being plotted on a logarithmic scale). At 1 watt, it rose from an extremely low 0.2% at 100 Hz to 2.8% at 20 Hz (also an unusually low distortion reading at that frequency). Increasing the drive to 10 watts, more distortion was produced. Furthermore, the speaker displayed a more abrupt rise with decreasing frequency (which is more typical behavior for a speaker). At 10 watts, the distortion was about 1% or less in the 80-to-100-Hz range, climbing to 5% at 40 Hz and 10% at 20 Hz.

The impedance curve of the speaker confirmed the validity of its 4-ohm rating. Starting in the 8-to-10-ohm range between 20 and 35 Hz, impedance reached a maximum of 30 ohms at the bass-resonance frequency of 50 Hz, fell to just under 5 ohms between 100 and 300 Hz, and rose to a broad peak of about 12 ohms around the 700-Hz crossover frequency. It decreased again at higher frequencies to a minimum of about 3.5 ohms from 4,000 to 10,000 Hz and rose to 5.5 ohms at 20,000 Hz. We do not consider that the slightly lower-than-rated impedance in the tweeter range will present any problem for any good amplifier.

Sensitivity of the A300 is unusually high for an acoustic suspension speaker. An input of 2.83 volts of pink noise in an octave band centered at 1,000 Hz created a sound pressure level of 91 dB at a 1-meter distance from the grille. The design of the A300 to favor high efficiency, rather than a maximum bass extension (the two are mutually exclusive "trade-offs" in speaker design), apparently represents the intention of its designers.

User Comment. The sound of the EPI A300 was smooth, balanced, and uncolored. Its bass output was very strong when this was called for, with remarkably low distortion for a 10-inch driver in a cabinet of this size. Listening to the A300, as well as testing it, reinforced our feeling that a speaker that does not have externally accessible balance controls is often a better-sounding product than one which gives the user—informed or otherwise—the opportunity to adjust (or misadjust) the balance to his own taste. Very few people have the hearing acuity and judgment to match the technical expertise of a knowledgeable speaker designer, a description that applies to the creators of the A300.

As we have the opportunity to evaluate more and more speakers in the $200 to $300 price range (in our view, the "optimum" price bracket for sound quality per dollar invested), we have become very aware of the many truly fine products to be found in this group. The EPI A300 is priced near the top of the field, and we would give it very nearly the same rank if it were to be judged only by its sound qualities. Listening rooms differ, as do individual preferences, but the A300 is without question a worthy addition to EPI's distinguished series of speakers systems.

—*Julian D. Hirsch*

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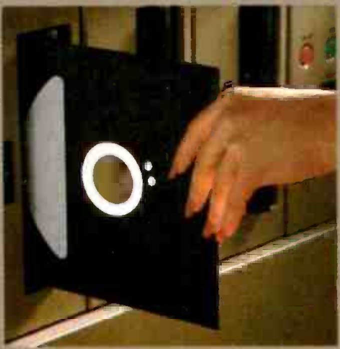

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(Not yet available for Burroughs Mini-Disk II, Vydec or 96 TPI Drive.)

CIRCLE NO. 53 ON FREE INFORMATION CARD

Popular Electronics Tests

Technicolor Model 212 VCR

Unusually lightweight portable uses 1/4" video cassettes

OF THE many adjectives that could be used to describe the Technicolor Model 212 VCR, probably the most important is *portable*. Weighing only 7 lb, including the rechargeable battery, having a volume of less than 300 cubic inches (9.68" x 10.18" x 3.00"), and equipped with a shoulder strap, this VCR is not only easy to carry but also able to power a hand-held color camera. Model 212 will not operate directly from the ac powerline and includes no TV tuner, but these functions are provided by separate modules available from Technicolor. Suggested retail price is $995.00.

General Description. The fundamental difference between the Technicolor VCR and other models is in the width of the tape it uses. Technicolor is the first to use quarter-inch magnetic tape in a specially designed cassette to record color video. Each cassette, about the size of the standard eighth-inch audio cassette, and recording in one direction only, can hold up to 30 minutes of video information.

Basically, the format is VHS, with the familiar M-wrap, twin rotary heads, helical scanning, and FM modulation, and the tape moving at 1.26 inches per second. However, the layout and dimensions of each field track are different from standard VHS. Each track is 25 micrometers wide, with 7.5 micrometers on each edge allowed for overlap, leaving a useful recording track of 10 micrometers per TV field. (Fig. 1.) In standard VHS each head is tilted by 6°, in what is called "azimuth" recording, to allow for overlap cancellation. In the Technicolor version the heads are tilted by 11°, allowing for a wider range of overlap and a smaller useful track. This was done because of the tighter tolerances required on quarter-inch tape.

Power for the unit (consumption is 8 watts) comes from a rechargeable 12-volt battery. When feeding the color camera (Model 412) as well as the VCR, the battery provides up to 40 minutes of operation. Without the camera, the recorder can run for up to 80 minutes on one charge. The plastic carrying case contains a pocket for a spare battery and a spare cassette, permitting about an hour of truly mobile operation. A separate ac supply, which also contains a quick-charge facility, is supplied with the VCR. This module also includes video and audio output, as well as a full r-f-modulated TV and audio signal for connection to the antenna terminals of any color TV receiver. Either channel 3 or 4 can be selected.

Another separate module provides baseband video and audio outputs and a modulated r-f output, all powered by the VCR's 12-volt supply. This is intended for operation in conjunction with a portable TV receiver working either from its own battery or with power drawn from a vehicle or boat. An accessory power cord allows the VCR itself to run from a 12-volt automotive or marine battery.

Still another module contains the TV tuner and i-f amplifier for recording TV broadcasts. An alternate version of this module, which will include a timer, is promised for the future.

All controls and connectors on the unit are clustered around the cassette holder. Five piano-type levers control the basic recorder functions: RECORD, PLAY, STOP/EJECT, FAST FORWARD and REWIND. Near these levers are the battery condition indicator and two warning lights, CONDENSATION and STILL. The cassette holder pops up, allowing the cassette to be inserted without any chance of touching or snagging the tape.

A 7-pin connector to the ac power supply and charger also contains the

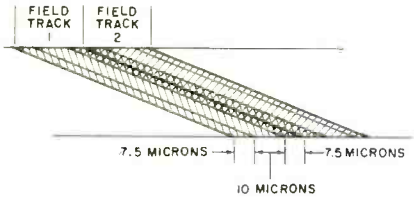

Fig. 1. Tape track layout on ½-inch video tape.

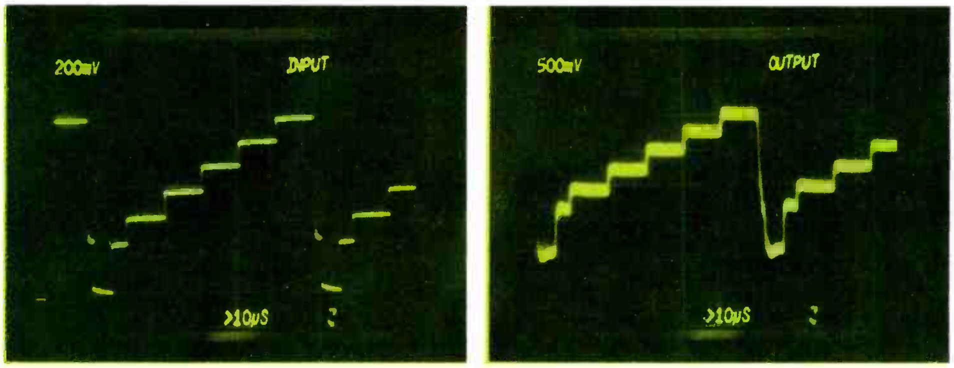

Fig. 2. Results of staircase pattern test. There is some loss of high frequencies, but linearity was quite good.

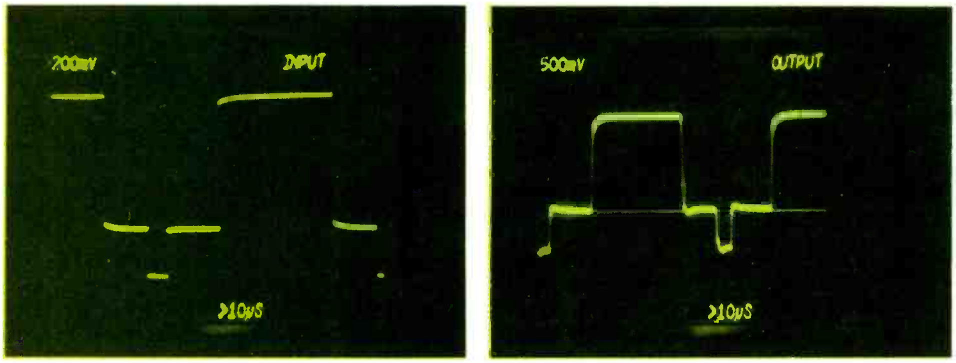

Fig. 3. In the window-pattern test, the scope picture, here, shows loss of high-frequency performances; but the window on the TV set was excellent.

video and audio output. Connections to the camera or to the TV tuner module are made through a 10-pin connector that also contains the remote record command. Thus, either a trigger switch on the camera or a relay contact on the TV tuner timer can start and stop the recording. Also provided is a SOUND DUBBING switch and a coax connector for microphone input. Another connector permits the use of an earphone. A small slide switch near the dubbing pushbutton can be set for still-frame operation, and a subminiature knob nearby is used to optimize tracking.

Next to the cassette holder, is the tape counter and the MEMORY and RESET switch. These controls permit the operator to enter specific counter settings into a memory so that the VCR will automatically stop at these settings on rewind. The battery compartment is accessible from the control side of the VCR and, when the unit is in its plastic carrying case, batteries can be changed and all controls can be conveniently operated. A solid rubber tread protects the bottom of the VCR against shock and abrasion.

Lab Tests. Using the Technicolor Model 412 color camera and a well-adjusted 19-inch color TV set, we recorded and played back a number of different test patterns at different levels of illumination and lens settings. Next we recorded an outdoor scene in full sunlight and in the shade, and finally we recorded a scene in our lab using only existing fluorescent illumination. During all these recordings we operated only with the microphone contained in the camera. Both the camera operator and various subjects, up to 15-feet distant from the camera, spoke in normal voice levels.

Reproduction of the video and audio was excellent. Automatic control circuits in the camera apparently provided excellent compensation and adjustments for the different light levels and for the variations in audio. Color test patterns mounted alongside the 19-inch color TV set provided really surprising color fidelity, even under indoor lighting. Using the standard monochrome wedge pattern, we measured vertical resolution at 220 lines. A slight tendency toward pincushioning was observed, but this was due to the camera's deflection system.

The same quarter-inch cassette was used a total of five times for various recordings. We observed no signs of noise, drop-out or loss of sync, or any of the common color VCR problems.

Next we operated the VCR through the ac power supply and connected our

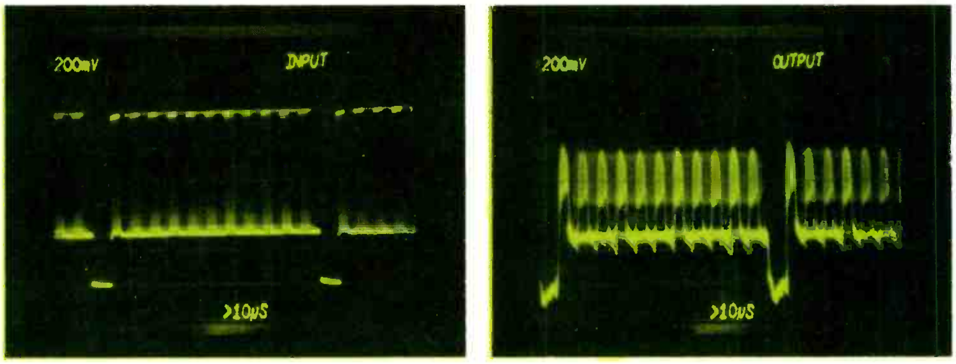

Fig. 4. Color bar pattern test showed good results although the edges of some individual colors lost some sharpness.

oscilloscope to the video and audio outputs, leaving the r-f output connected to the TV set. (We had to rig-up a dummy camera control cable to be able to record video and audio signals from our generators.) First we recorded video from 1 to 4 MHz, then a staircase, window, and color-bar pattern. Video frequency response dropped below −3 dB at 2.7 MHz. The results of the staircase pattern recording are seen in Fig. 2. With a peak-to-peak input of 1 volt, output was about 2 volts. There was some loss of high frequencies, but linearity was quite good. The window pattern—a white window surrounded by a black frame—is normally used to check color temperature adjustments, black level settings, etc., on either a TV receiver or camera system, but we used it to evaluate both high- and low-frequency performance of the VCR. We found a near-perfect window on the TV set, but the oscilloscope picture of Fig. 3 shows the loss of high-frequency performance in the rounding of rise- and fall-time portions of the waveforms.

Color-bar reproduction on the screen was quite good, but, as shown in Fig. 4, the edges of individual color bars lost some sharpness. While the output amplitude for the staircase and window pattern was about twice the input, we found that the color-bar pattern had less output amplitude than the 1-volt input. The reason for this lies in the aforementioned high-frequency response characteristic of the VCR.

We tested the audio response by recording and playing back a series of sine-wave signals at an input level of 1 volt. As claimed by the manufacturer, the audio response was flat up to 8 kHz, but at 100 Hz it was down about 3 dB. In summary, the Technicolor Model 212 VCR we tested met all of the published criteria and performed very well.

Comments. At first, the size of the VCR and, especially, the size of the tape cassette, made us somewhat skeptical about its performance capability, but as testing proceeded, we grew more enthusiastic. Although obviously not designed to compete with the 4-to 6-hour microprocessor-controlled VCRs, the Technicolor Model 212 produces excellent pictures, and is very simple to operate.

We did not evaluate the TV tuner module; but, with it, the recording of TV broadcasts can be achieved. In this application, of course, the 30-minute limit on recording time might be a handicap, though one can switch cassettes during a commercial break for most TV movies. Also, there aren't any prerecorded video tapes for this format, though it is reported that arrangements have been made to produce them.

The main attraction of the unit, of course, is its portability. This gives the user a new dimension of enjoyment—selfmade video recordings with a lightweight easy-to-use machine. Quality of the recording is excellent, which is of high importance. —*Walter Buchsbaum*

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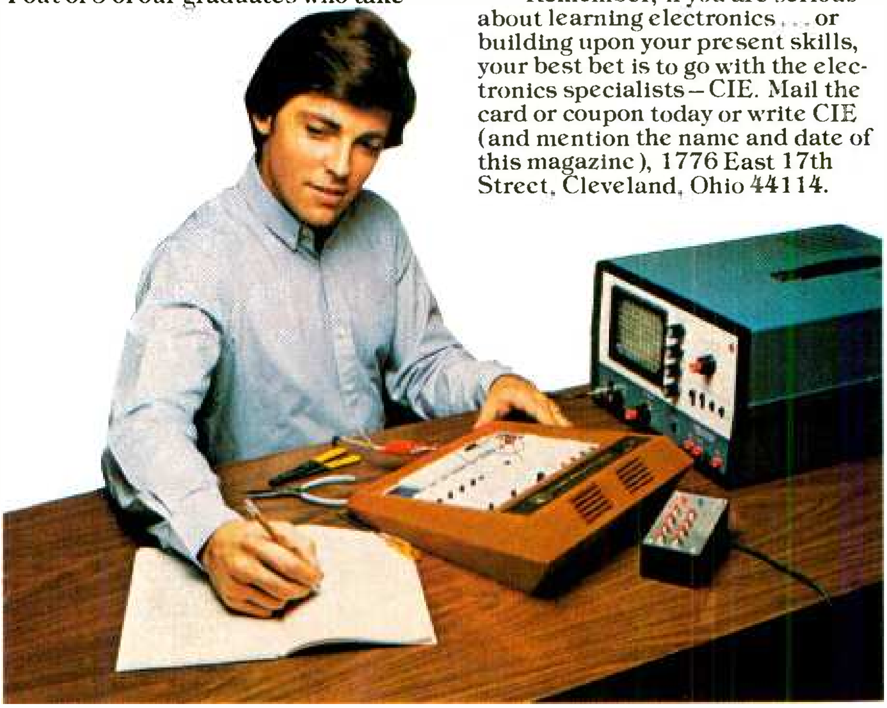

Pattern shown on oscilloscope screen is simulated.

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COMPUTER BITS

By Carl Warren

Another Small Computer

IF you've been considering picking up a small portable microcomputer system, take a look at the Attache from Otrona (2500 Central Ave, Boulder, CO. 303-444-2274).

This classy little system weighs less than 20 lb, fits in a half cubic foot, and offers the following features:

- A Z-80A processor
- A 5-in. CRT, that supports an 80x24 display plus raster-style dot graphics
- Two 180K-byte drives
- A full-sized, flip-down keyboard
- 64K bytes of RAM
- A direct memory processor to relieve the main processor from I/O duties
- Two multi-protocol ports
- CP/M; WordStar; BASIC-80; UCSD Pascal; Valet, an interrupt manager; and Charton, a plotting software package.

If all of that isn't enough, the Otrona folks have also included a clock/calendar and a sound synthesizer.

Should you want to pack it around with you, Otrona offers dc operation with battery and charger option, plus an accessory pouch for all the extra goodies. An optional full-sized video monitor and an Epson MX-80 printer may be attached.

If you're thinking that's a lot of stuff to come in a small box, you are right. More important, however, is that the box is designed right and has upgrade built in. Don't expect to pick this machine up cheap. It's in the under-$4000 bracket, but worth every cent.

Software Tools. If these are in your game plan, contact Microsoft Consumer Products, Bellevue WA, or drop into your local computer store to get information on a program called TASC. This 'tool' will take a source code written in Applesoft BASIC and compile it into machine code. The program not only compiles the code, thus speeding up execution, but uses a compression scheme to eliminate size restrictions usually found with compilers.

And, if you are looking for a documentation tool for your BASIC programs, call Phil Wellhof at BPS (203–853-6880) and ask about BPSXREF. This tidy program will produce a formatted program with an alphabetized list of program variables and functions cross-referenced to the line numbers where they are to be found. This package works with Microsoft's BASIC-80 ver 5.x, requires CP/M, and at least 48K of RAM. It's a $124 package and might be worth the price if you are developing complex programs.

Computer Music? Fans of computer music who happen to own a Heath H-89 or H-8 system should give Skip Barron a yell at Mako Data Products (1441-B N. Red Gum, Anaheim, CA 92806. 714–632-8583) and ask about the PSGx2 Programmable Sound Generator. This board sells for $125 for the H-89 version, $225 for the H-8. Be sure to add $5 for shipping.

The H-89 board fits neatly into one of the open slots on the right side of the motherboard (position P504) and sports four AY3-8910 programmable sound generator chips and a small speaker. Mako has included an extra miniature phono jack if you want to plug in a 6-in. magnet speaker.

Otrona's Attache portable computer system.

There happens to be more to the board than just sound. Included are four 8-bit parallel I/O ports that can be used for adding game paddles or for coupling to a light-bulb system to pulsate in time with the music.

Interestingly, you can program this board with BASIC or assembly code. I recommend a combination of both, since you'll most likely want to change parameters quickly.

To help in getting acquainted with the board's operation quickly, Mako supplies a demo disk that guides you through the programming part, and a diskette of a computer piano.

If you're into writing game software, and want to add that extra touch, then add the sound generator board. If you are unsure of how to create the fancy programs, drop into your local Heath Electronic Center and join a HUG group. Many members have written some great programs that can be found on the HUG bulletin board (which is on MicroNet).

Interactive Data-Processing Systems. Thinking about setting up a complete interactive data-processing system and want everything to be compatible? Then consider the MicroPro International line of generic-type software that is designed for CP/M.

Included in this group are: WordStar 3.0, DataStar, and SuperSort. These packages are all designed to work in concert and provide full data-handling capability. WordStar for example, is the well-known word-processing system that incorporates a spelling dictionary (SpellStar) and merge operations in one package. This means you can develop letters and merge in the address information. In addition, by employing DataStar, which is a unique data-base management system, you can even create detailed reports or your own business journals.

DataStar is designed to function with any terminal employing X-Y addressing, and permits the creation of fill-in formats for data entry. Like WordStar, DataStar uses menus, displayed at the top of the screen, to assist in data entry or form design.

An interesting feature of DataStar is that it allows various data forms to be linked for a full-featured data base. For example, you can create an address file for companies, then a separate file for the products that these companies carry. You do this by defining a field to represent a link to the other data, and when used in conjunction with WordStar, print out the detailed report.

Because data is useless if not ordered in some way, SuperSort can be used to order the data in any useful manner. This program is callable from other languages and can become an integrated part of that super business system you're writing.

Surprisingly, you aren't limited to the MicroPro packages, but can combine them with other CP/M-compatible products such as BASIC, dBase II, or even Sorcim's SuperCalc electronic spread sheet. But MicroPro is offering enough flexibility so that you can stick with just their products if you prefer. Furthering this generic concept, MicroPro is also offering CalcStar, an electronic spread sheet that is fully compatible with other products in the line. This package, which should now be available in most computer stores, is priced at $295, and provides the ability to perform sales forecasts, cash flow analysis, and complete control over complex numerical problems. If you are using an Apple II, the package is priced at $195; the TRS-80 version is $150. Like the rest of the packages, a screen menu is provided to aid in its use.

We've found that all the MicroPro packages are easy to use and quick to install, with the exception of CalcStar, which we haven't had a chance to look at closely. The DataStar program comes with an Install utility that provides a menu selection of various terminal types. Of course, ours, a Heath H-89, wasn't on the list, so we used the alternative method of installation.

The latter is unlike the one found with WordStar. Rather than taking you through each attribute with prompts, it's necessary to employ Digital Research's CP/M Dynamic Debugging Tool (DDT) and "patch" various areas in the code.

Although we were able to do this installation in about an hour, we felt that MicroPro didn't provide enough information on the process. In our case, we happen to be familiar with the operation of DDT and understood what was necessary in performing the changes. However, it appears that the novice user would have some difficulty in getting the package to work.

One way around this is to have the store where you purchase the package install it for you. They supposedly know the machine and should have in-depth knowledge of the software packages they sell.

Because the MicroPro packages do take up a significant amount of room on a diskette, you might find that you don't have enough room for everything. If so, what you might consider doing is creating a diskette with the basics of WordStar, dropping off the messages, and avoid putting on a system. Of course, this means you must have at least a three-disk system for operation, but it is workable.

In respect to the size problem, we found that you can avoid a lot of problems with the H-89 by using the Magnolia Microsystems double-density board reviewed last month in this column. We found that we could put WordStar with MailMerge, and DataStar plus SuperSort on one 5.25-in. diskette, thus freeing up two other 5.25-in drives, and one 8-in. drive for data. ◊

Computer Languages in Public Domain for CP/M

Compiled by Stan Veit

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Popular Electronics Tests

Ashton-Tate dBase II Computer Software

WITH ALL the new computers designed to improve productivity and ease handling of data, there has come a plethora of database managers. One such product is dBase II from Ashton-Tate. Designed to operate with systems employing Digital Research's CP/M, dBase II is referred to as a *relational* database management system.

Relational databases are made up of connections between data elements—a name/address file, for example. It is the job of the management system to recombine these elements in the database to form different relationships, and thus allow greater flexibility in the use of the data. The dBase II system does this in a number of ways.

Supporting the flexibility in handling data is an integral programming language dubbed Application Design Language (ADL), which exhibits many of the properties associated with Pascal and PLI. (It takes about two hours to become practiced in the use of ADL.) It enables you to quickly define input forms and various hardcopy output reports, perform batch operations, and have full control over the data structure. It also allows screen control.

Databases created with dBase II can be used with other languages—BASIC, COBOL, and assembly, for example—without redefinition. In addition, the data can be used in concert with word processors, such as MicroPro's WordStar, for inserting names and addresses in letters. Even more exciting, the data can be shared with such software systems as Sorcim's SuperCalc, an electronic spreadsheet, simply by telling dBase II that the file being created is to be interchangeable.

Although the software package is designed to be compatible with numerous other languages and software systems, it can be used as a stand-alone system to create full business packages.

The Basic Package. The basic dBase package is offered in a variety of diskette sizes and formats, to accommodate the numerous microcomputers using CP/M. You can order the package in standard form on 8-in., single-density IBM-format diskettes, or 5.25-in., 10-sector Heath/Zenith-compatible diskettes. The basic price for dBase II, which includes a two-part user manual and two diskettes, is $700.

Ashton-Tate's two-diskette system is unique in that one diskette is a demo having all the dBase II facilities but supports only 15 records per file and a number of demonstration programs. With this method, you can try the package and return it for a full refund if you don't like it. Moreover, while using this limited version, you can create data structures that best meet your specific needs, all at no cost. If you decide that the product is what you want, you can open the sealed and coded systems diskette—but then the package is yours and cannot be returned.

Although dBase II in the standard version is designed to handle 65,535 records per database, you can purchase a $350 version for the Apple II equipped with Microsoft's softcard that supports 5,000 records. This one is delivered in the same manner as the standard.

If you're thinking it might be wise to buy the less-expensive Apple version and then upload it for use on a larger system, forget it. The Apple dBase has software hooks that rely on the 6502 microprocessor to operate properly.

Installation. Installing dBase II is easy. The first thing to do is make a copy of the software on a diskette that has been SYSGENed (a CP/M system has been placed on the diskette), then bring up the INSTALL program.

If dBase II is operating properly, a menu offering a choice of 10 popular systems is displayed. If your particular terminal isn't shown, you are given the opportunity to enter those characteristics unique to your terminal. In addition, you have the option of choosing whether or not you want full-screen functions, such as highlighting and full cursor movement.

Once dBase is installed, the program is ready to run. The system signs on by asking you to enter the date, which can be ignored by entering a RETURN. The system then prints a period (.) as a prompt and is ready to receive any number of data- and file-handling commands. These commands are broken down into nine groups: file creation, addition of data, editing of data, record positioning, data display, file manipulating, variation by memory, changing files, and controlling devices.

Besides those directly related to data manipulation, in the full-screen mode there are a number of commands that handle the cursor and permit editing. These screen operation controls include functions for moving the pointer when editing or appending.

Evaluation. The version of dBase II that we were supplied was 2.01 configured on a 10-sector, 5.25-in. diskette compatible with a Heath H-89 system. We have our system configured in two ways: standard Heath and Heath disk controller with three 5.25-in. disk drives (90K each), and with a Magnolia double-density controller supporting two 5.25-in. drives (161K each) and one 8-in. drive operating in double density (600K). We have installed dBase on our 20M-byte hard-disk system.

The first part of the evaluation was to install the program, which took only a few seconds. Next, we created a data structure (Fig. 1) that defined 373 bytes per record (up to 1,000 records are permitted with the maximum field being 100 bytes) and 12 fields (32 maximum are allowed). All fields were defined as character fields, but numeric or logical definitions can also be used. With numeric definitions, a decimal point is required; with logical definitions, you can use one of the following values: True, False, Yes, or No.

```
. display structure
STRUCTURE FOR FILE:  C:MAIL.DBF
NUMBER OF RECORDS:   00135
DATE OF LAST UPDATE: 00/00/00
PRIMARY USE DATABASE
FLD        NAME       TYPE WIDTH   DEC
001        CODE        C    002
002        CO:NAME     C    030
003        CONTACT     C    030
004        ADD1        C    030
005        ADD2        C    030
006        CITY        C    030
007        STATE       C    002
008        ZIP         C    006
009        PHONE       C    013
010        EXT         C    005
011        CCT:INFO    C    100
012        PRODUCT     C    100
.
```

Fig. 1. Data structure defining 373 bytes per record.

```
A>type mail.cmd
REMARK WHEN READY, HIT CARRIAGE RETURN
WAIT
SET TALK OFF
SET PRINT ON
GO TOP
DO WHILE .NOT. EOF
        DISP OFF CODE
        DISP OFF CONTACT
        DISP OFF CO:NAME
        DISP OFF ADD1
        DISP OFF ADD2
DISP OFF $(CITY,1,30)-(', '+$(STATE,1,2))-(' '+$(ZIP,1,6))
DISP OFF PHONE
        ? '
      '           SKIP
ENDDO
SET PRINT OFF
SET TALK ON
REMARK ALL DONE
RETURN

A>^F
?
        '
A>^L
```

Fig. 2. Command file to print the index in mail-list form.

Once the structure was created, we used it with no index. Data was entered by pressing the APPEND key, although it is possible to set up a command file to have menus that permit adding, editing, modifying, or deleting (for example). A total of 135 records was entered, with some fields left blank.

With the database created, we entered the EDIT mode to quickly review each file to ensure that no mistakes were entered by us or by dBase. We then sorted the data by company name. Total time for the sort was 5.05 minutes on the Heath standard system, and 1.5 minutes using the double-density controller and 8-in. drive.

We next checked dBase's ability to index data. First we indexed the original file by company name. Since the file was already created, the index function had to look at the file and build the index file for quick access. Surprisingly, even on the standard Heath system this took only a little under a minute, and was just a slight improvement on the 8-in. drive in double density.

The indexing function gives the ability to arrange data on one or more fields in the sequence you would like it to come back. However, remember that data viewed in its indexed form requires that you use the data file with the index file. One problem we encountered in this process was in deleting records while in the INDEX mode. What happens is that, currently, the INDEX function and DELETE are mutually exclusive, so if you delete while indexing, the pointers are lost and dBase gives an error message that the record is too high and thus not locatable. This is easily corrected by going back to the command mode, using the database file without the index file, and packing it. This deletes records where marked and resets pointers. The *index* file, however, is now useless and must be deleted and rebuilt by simply entering the index on command. Regardless of how many times we caused this error, no data was lost or skewed into another record.

Because one of the prime features of dBase II is providing reports, we built a command file (Fig. 2) to print the file in mail-list format for labels. Notice, in the figure, that common English language is used to tell dBase what to do and where to put the data.

In our basic data structure, we created a code that allowed us to define what category the company belonged in. This unique code becomes a key that enables definition in a command file of what records to print, or, using the COPY command, permits building a separate database on the code entry.

With the REPORT command, you can define a report format that is used anytime data must be printed. Some features in the report functions include performing control breaks and the ability to total and subtotal. But even at that, it is not totally functional. The REPORT command asks you the carriage width of your printer, but ignores it if the report file you create sets data widths greater than the defined width. What happens is that data fields longer than the carriage width will be printed on the next line, rather than REPORT performing a dynamic pagination which would permit very wide reports on a narrow printer. Even though this capability doesn't exist in the report generator, you can build a command file using ADL to perform it. Basically, the REPORT function of dBase is good for taking quick snapshots of the data or generating reports with few fields.

One interesting aspect of dBase is its ability to permit exact X-Y cursor addressing by using the SAY function. By specifying the screen location, unique data-entry forms can be created.

Powerful Language. The most striking feature of dBase II is its employment of ADL. This language allows for the creation of command files that perform a host of tasks. For example, a complete

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turnkey business system can be written using the language and CP/M's AUTO command function. So when the computer is turned on, the operator is immediately into the application.

In addition, the files can be so written as to handle batch work and automatic posting from the accounts ledgers to the general ledger. Because ADL has functions similar to BASIC's PEEK and POKE in the form of STORE and RESTORE, functions involving system memory can be established, such as looking at a modem port.

Documentation. The software package comes with a three-ring binder divided into two sections. The first is designed to get the first-time user up and running and give him the basic background to use dBase. Section II goes into more definition of the program and ways to build command files.

Although this attempt to provide a quickly usable manual is laudable, it still has shortcomings. For example, no index is provided for rapid access to the various commands. Furthermore, important functions such as copying specified fields into a new database are buried, as is the information on creating interchangeable CP/M files. But, according to Ashton-Tate, the manual is being rewritten, and functional bugs like the one described in the report generator are being changed in version 2.2.

Comments. In general, dBase II is one of the most powerful software packages we have seen. We found it extremely flexible in data handling, and employment of a command language has made the package a complete stand-alone tool for developing our own business-oriented programs.

Moreover, we were able to easily modify the database structure without destroying previously entered data. And we could automatically create specific databases from one large database. Currently, we have in excess of 3,000 entries of computer and peripheral manufacturers on our hard-disk system, and we've defined specific command files that permit report generation based on product type, company size, projected growth, and many other attributes.

An interesting application that we developed was to put the database on our in-house communication setup and use dBase to create a menu-driven system for accessing various data files we use in our work. This has not only provided us with quick access to important data, it also gave the ability to update the database from virtually anywhere.

There is a problem with dBase which we discussed at length with George Tate, president of Ashton-Tate: dBase is not frugal with disk space, because fields aren't compressed. So, if you define a 100-byte structure but use only 80 bytes on any given entry, 20 are wasted on disk. Tate pointed out that, while nothing can be done to overcome this wastefulness in the current dBase, data in later versions will be compressed to conserve disk space.

Other problems centered around the means of delimiting data. Each field is surrounded by single quotes ('), which is ideal for dBase's purposes, but not for programs such as MicroPro's WordStar. All is not lost, however. You can either change the single quote to a double quote via a simple macrocall, or delete it. While either is acceptable to WordStar if all fields are used, you must use double quotes if some fields are empty.

Although we didn't perform any of our evaluations on the Apple II, we did download a small database from the Heath system just to see if everything worked the same. No problems were encountered. We found that, although we could define the screen on the Apple to work correctly with 40 characters, it was a bit tedious. With an 80-column card installed, dBase worked with no problems at all.

After using dBase II for about three months, we give it a high rating and recommend it to anyone using a CP/M-based system who needs high-level data manipulation. *—Carl Warren*

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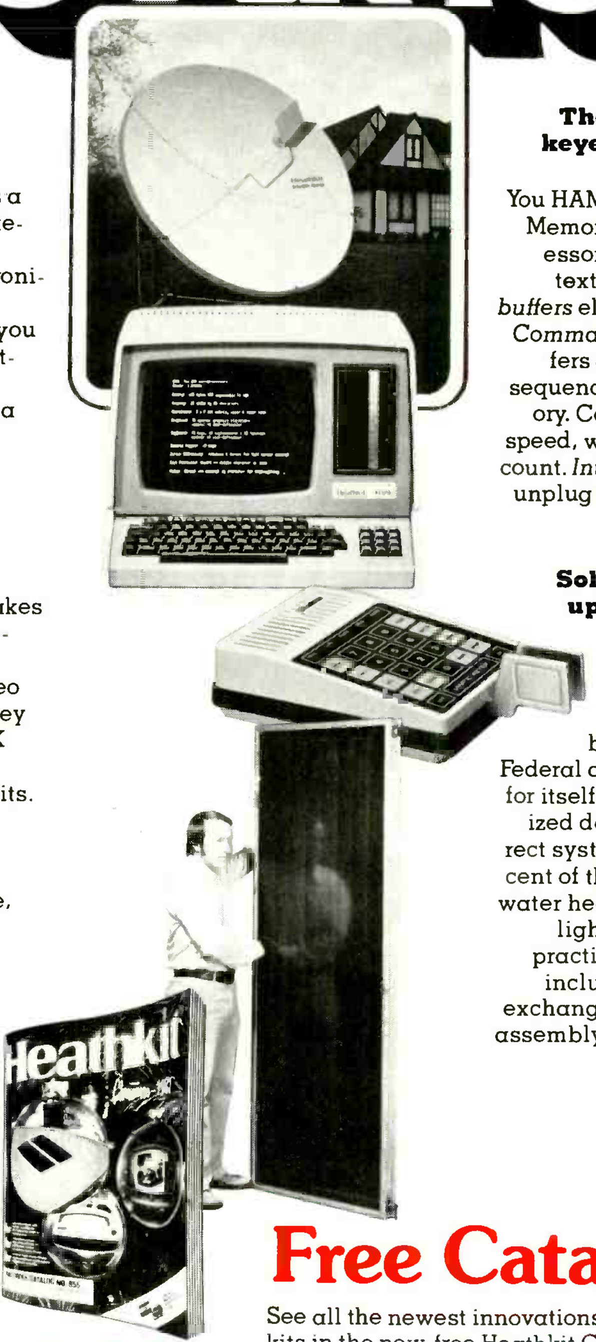

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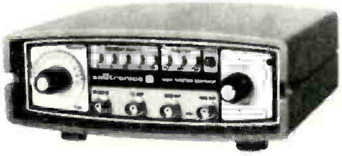

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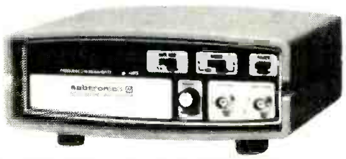

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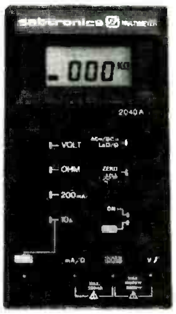

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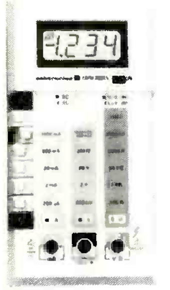

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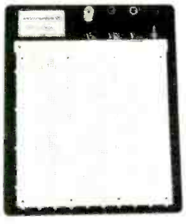

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$70 DECODER FOR NEW CX RECORDS

Provides 20 dB noise reduction when used with CX-encoded records

BY JOHN ROBERTS

HAVE you been wondering about the CX® symbol that's been popping up on record album covers lately? It stands for "compatible expansion," which is a new noise-reduction technique developed by CBS. According to CBS, the CX in-the-groove system increases the dynamic range of records to approximately 80 dB, which is about 20 dB greater than the dynamic range of today's conventional records. But the only way you can enjoy the advantages of this new system is by adding a CX decoder to your stereo system.

The CX-encoded discs are fully compatible with existing stereo equipment. That is, a CX disc sounds the same as a standard LP when played on a system without a decoder. Furthermore, CX discs are priced the same as others.

CX has gained the support of companies like RCA and the Warner/Electra/Asylum group, among others, so it appears to have a bright future. Moreover, RCA recently announced plans to use it for the audio on its new videodiscs.

CX is basically a companding (compression-expansion) noise-reduction system. The dynamic range of the master is compressed to fit the record's limited dynamic range. Upon playback, a complementary expansion restores the original dynamic range, with the added benefit of reducing record-surface noise 20 dB (Fig. 1).

The CX decoder described in this article will expand the compressed audio from a CX-encoded disc. It is a low-cost addition to your stereo system that will enhance your listening pleasure.

How CX Works. A compressor or expander is simply an automatic variable gain device. Compared to agc (automatic gain control), which tries to make all inputs come out at the same level, compressors or expanders vary the gain so that the ratio of the input and output signals remains constant. The most popular ratio for noise-reduction systems is 2:1 for compression and 1:2 for expansion. (See "Build an Audio Compander," PE Nov. 1977.)

With a 2:1 compression ratio, each time the input signal increases or decreases 2 dB, the output signal increases or decreases 1 dB. The CX system encoder is a 2:1 compressor down to a threshold of −40 dBV (reference 3.54 cm/s at 1 kHz), reverting to 1:1 below that. When the master record is made,

everything below −40 dBV is boosted 20 dB. As the signal increases from −40 dBV to 0 dBV, the gain reduces so that by 0 dBV there is 0 dB or unity gain. Above 0 dBV, the gain continues to fall so that a +12-dBV input is reduced by a −6-dB gain for a +6-dBV output.

One of the design goals of the CX system is to produce good sound quality even when a decoder is not being used (however, with no noise reduction). Because of this, compression is limited below −40 dBV. If it weren't, tape hiss boosted by more than +20 dB could become audible above the record-surface noise. Likewise, the circuits that control gain changes must be carefully designed to minimize the perception of those changes. Since both the left and right channels are varied by the same control voltage, the stereo image does not wander about as it would if both were compressed independently.

The CX decoder is a 1:2 expander reverting to 1:1 below −20 dBV. Everything below −20 dBV is reduced 20 dB. As the signal increases to 0 dBV, the gain increases to zero dB until once again a 0-dBV input gives a 0-dBV output. Above 0 dBV the gain continues to increase, restoring the +6 dBV to +12 dBV for an accurate replica of the master recording's dynamic range. In the process of restoring dynamic range, the background "surface" noise of the disc is reduced 20 dB (10 times lower).

Circuit Operation. Since both channels operate the same way, only the left channel is shown in the schematic in Fig. 2. Part numbers for the right channel are the same but in the 200 series—that is, *R1* in the left channel becomes *R201* in the right channel. If no 200-

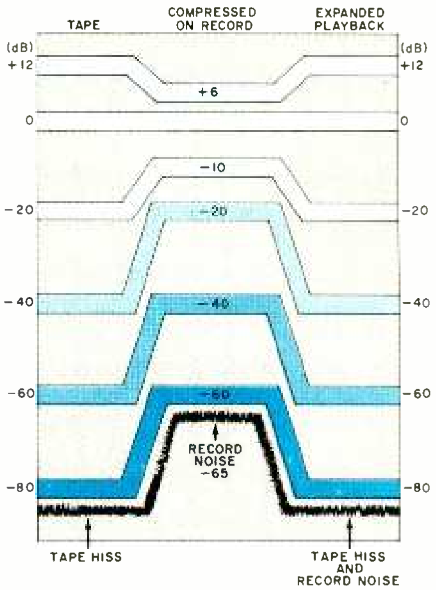
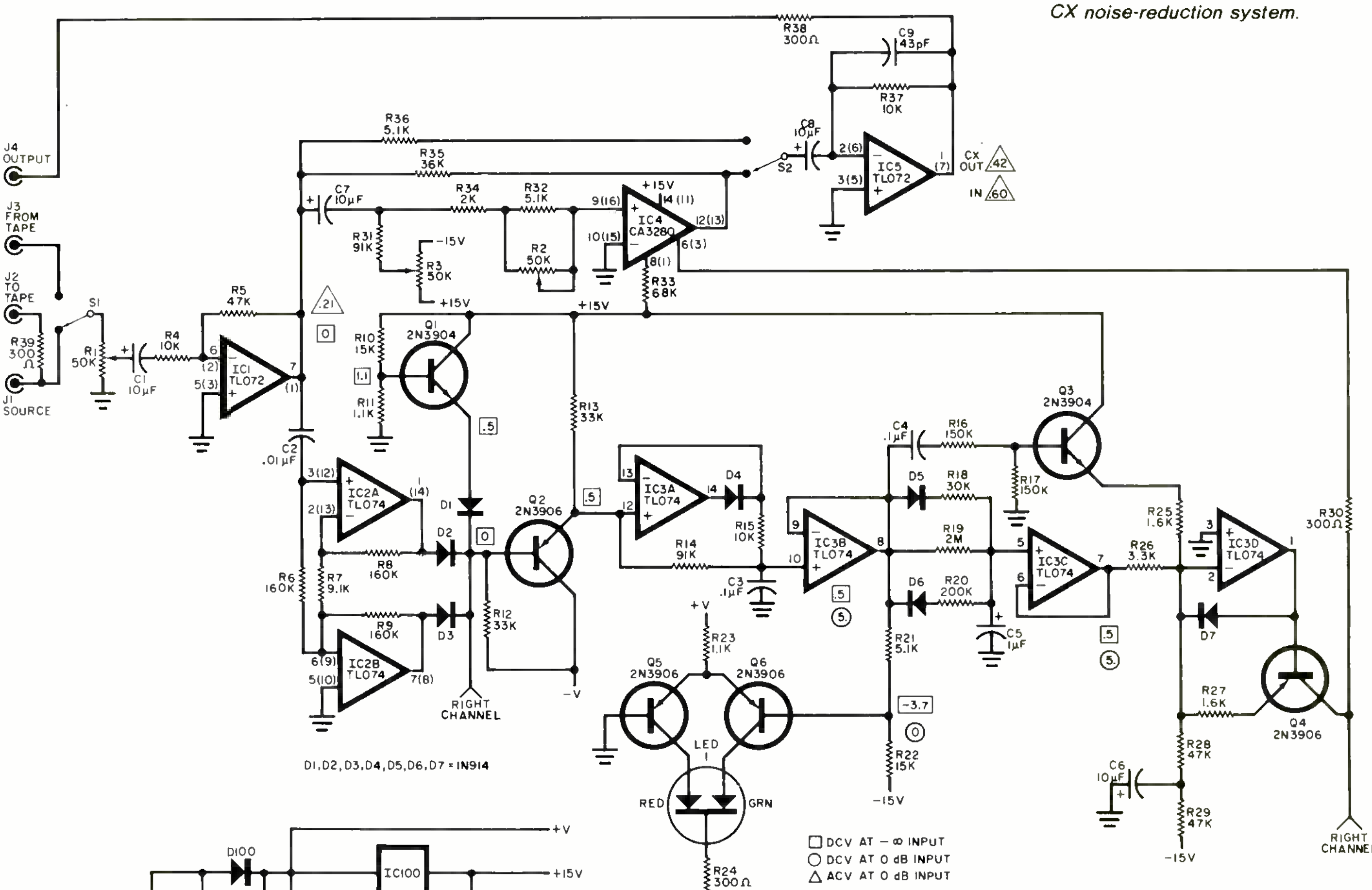


Fig. 1. Waveforms showing the dynamic range of the CX noise-reduction system.



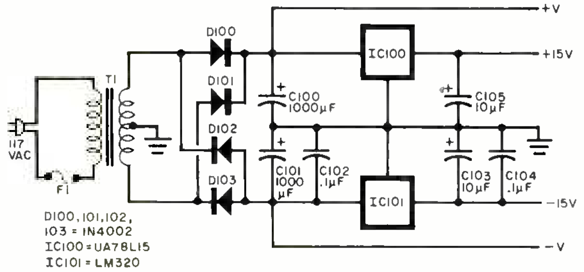


Fig. 2. Schematic diagram of the left channel of the decoder. See text for explanation of part numbers for the two channels. Power supply is at left.

PARTS LIST

C1,C201,C6,C7,C207,C208,C103,C105—10µF, 25-V electrolytic
C2,C202—0.01-µF, 50-V, 5% Mylar capacitor
C3,C4—0.1-µF, 50-V, 5% Mylar capacitor
C5—1-µF, 35-V, 10% tantalum capacitor
C9,C209—43-pF, 160-V, 5% polystyrene capacitor

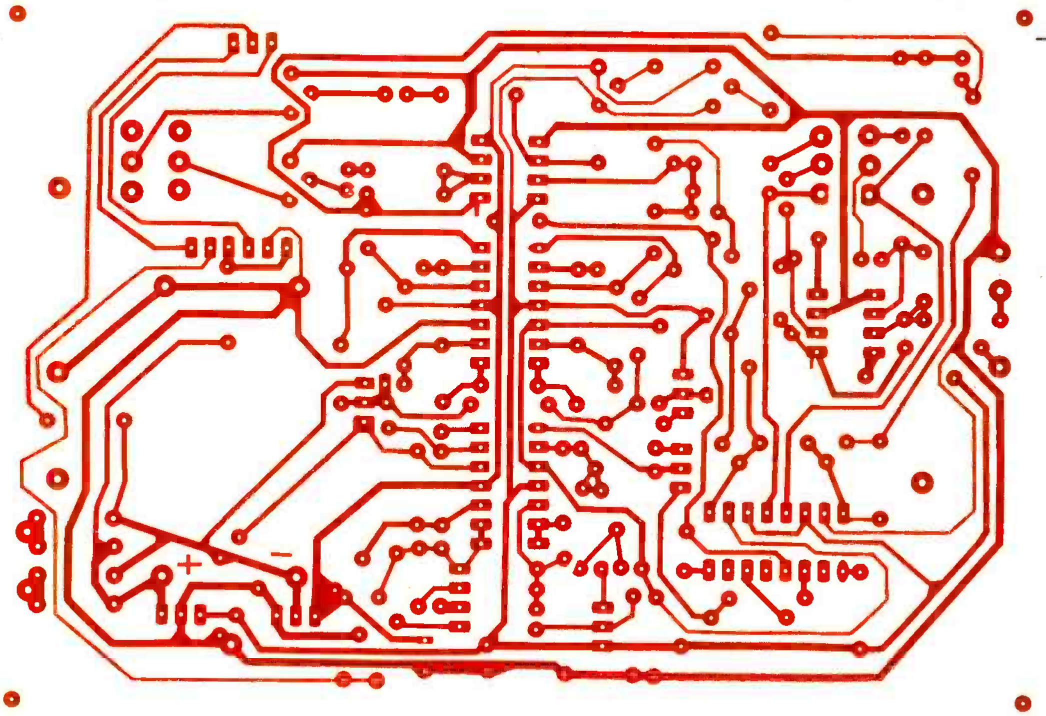
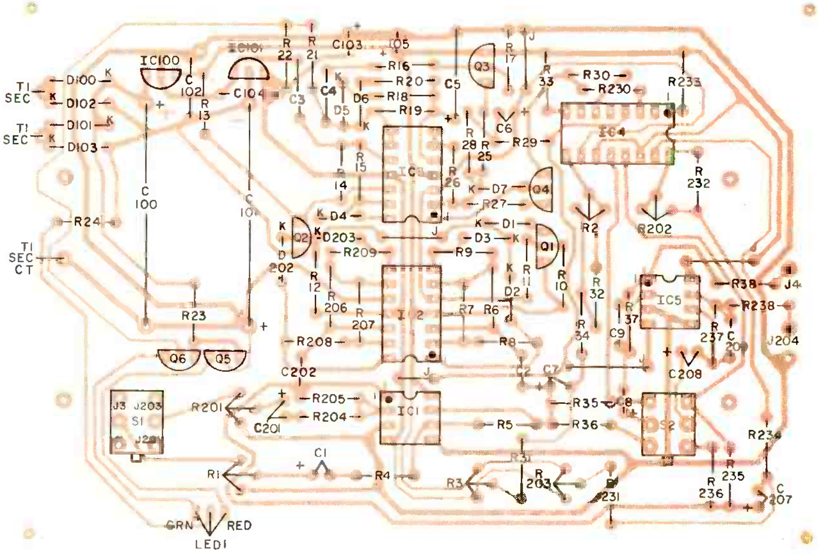
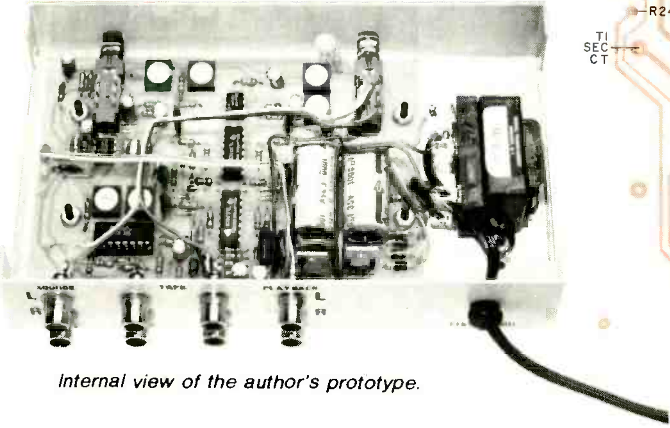


Fig. 3. Actual-size foil pattern for the printed-circuit board is shown above.

Fig. 4. Component layout for the printed-circuit board is at right.





Internal view of the author's prototype.

C100,C101—1000-μF, 35-V electrolytic
C102,C104—0.1-μF, ceramic disc
D1,D2,D202,D3,D203,D4,D5,D6,D7—1N914 signal diode
D100,D101,D102,D103—1N4002 rectifier
F1—¼-A fuse
IC1,IC5—TL072 dual BiFET op amp
IC2,IC3—TL074 quad BiFET op amp
IC4—CA3280 dual operational transconductance amplifier
IC100—μA78L15AWC +15-V regulator
IC101—LM320LZ-15 −15-V regulator
J1,J201,J2,J202,J203,J4,J204—¼" RCA jacks
LED1—Two-color LED (3 lead)
Q1,Q3—2N3904 npn transistor
Q2,Q4,Q5,Q6—2N3906 pnp transistor
R1,R201,R2,R202,R3,R203—50-kΩ trimpot
The following are ¼-W, 5% carbon film resistors:
R4,R204,R15,R37,R237—10-kΩ resistor
R12,R13—33-kΩ resistor
R6,R206,R8,R208,R9,R209—160-kΩ resistor
R7,R207—9.1-kΩ resistor
R10,R22—15-kΩ resistor
R11,R23—1.1-kΩ resistor
R14,R31,R231—91-kΩ resistor
R16,R17—150-kΩ resistor
R18—30-kΩ resistor
R19—2-MΩ resistor
R20—200-kΩ resistor
R21,R32,R232,R36,R236—5.1-kΩ resistor
R24,R30,R230,R38,R39,R239—300 Ω resistor
R25,R27—1.6-kΩ resistor
R26—3.3-kΩ resistor
R5,R205,R28,R29—47-kΩ resistor
R33,R233—68-kΩ resistor
R34,R234—2-kΩ resistor
R35,R235—36-kΩ resistor
S1,S2—2pdt push-push switch
TR1—28-V, CT transformer (SIG 241-3-28)
Misc.—wire, pc board, chassis.

Note: The following is available from Phoenix Systems, 91 Elm Street, Manchester, CT 06040 (Tel: 203-643-4484): complete kit of parts, P-82-CX at $69.00. Also available separately: 28-V CT transformer, P-518-T, $6.00; etched and drilled pc board, P-82-B, $9.00; RCA CA3280 dual OTA, P-CA 3280, $4.00; 2pdt p-p switch, P-2PDT, $1.00; and test record, P-82-TR, $1.00.

Orders less than $10 add $1.00 handling. Connecticut residents please add 7½% sales tax. Foreign residents please add 10% for shipping.

series number is listed for a component, then that component is common to both channels. For op amps, right-channel pin connections are in parentheses.

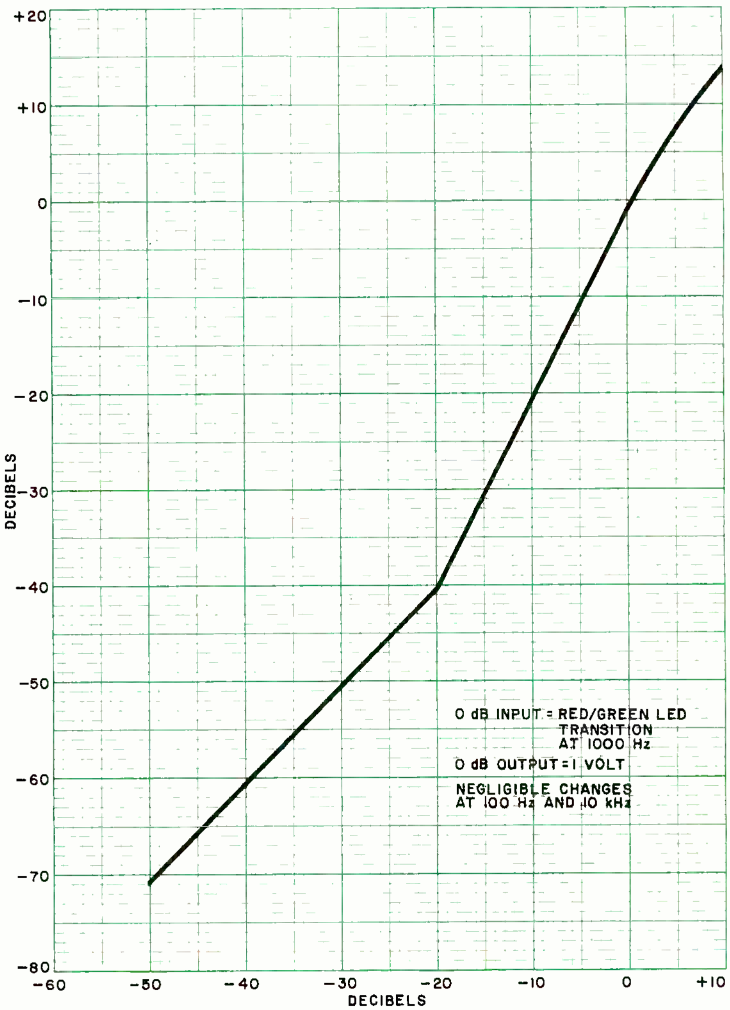
Tape monitor switch *S1* selects either the source or tape output to feed *IC1*, which forms an input buffer, with trimmer *R1* used to set input levels. Capacitor *C2* and resistor *R6* high-pass the signal (−3 dB at 100 Hz) before it is rectified. Op amp *IC2*, with diodes *D2* and *D3*, boosts the signal by a factor of about 20 and then full-wave rectifies it. Transistor *Q1* and diode *D1* set the

HIRSCH-HOUCK TESTS THE PE CX DECODER

THE CX decoder was adjusted for operation in a system using an ADC Astrion cartridge, a Carver C-4000 preamplifier, Phase Linear 400 power amplifier, and several speakers that included a KEF 105.2 and Polk 12A.

None of the signal-processing circuits of the preamplifier were used during our listening tests with the decoder. The source material included about a dozen records (including both classical and popular music, instrumental and vocal) prepared by CBS to demonstrate the system. Several had the same programs on both sides, with one side unprocessed and the other with CX encoding, simplifying the evaluation of the system's performance. Portions of all encoded records were played without decoding to check their compatibility.

The bench measurements made on the CX decoder consisted of its frequency response at several signal levels, harmonic distortion as a function of output level (with the CX function operative and bypassed), and the input/output transfer characteristic at several frequencies (100, 1,000, and 10,000 Hz). The noise reduction of the circuit was measured by driving it with the output of an RIAA-equalized preamplifier whose input was terminated by a 1,000-ohm resistor. Output of the decoder was displayed on our H-P 3580A spectrum analyzer (log sweep mode). The analyzer output was plotted on an H-P X-Y recorder, with the CX decoder both active and bypassed.

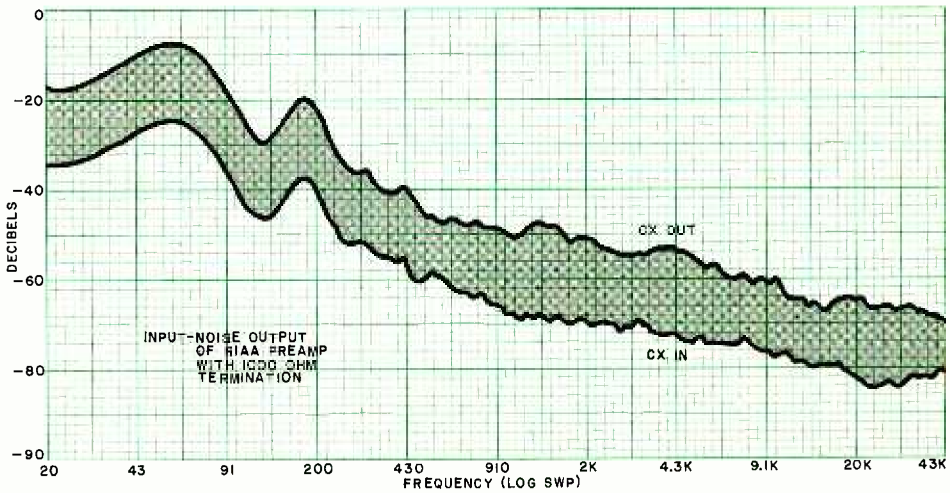


Input/output transfer characteristic.

Test Results. The "0 dB" reference level for our transfer characteristic measurements was the point at which the LED on the panel changed from green to red. As the input signal was decreased, output fell at a doubled rate (20 dB of output change for each 10 dB input change) in the first 20 to 30 dB of signal reduction. Below that, there was a transition to a linear slope that continued down to our lower measurement limit of −50 dB (input) which corresponded to a −70-dB output level. The expansion mode continued above 0 dB, at a slightly reduced slope, so that a +10-dB input produced an output of +15 to +18 dB, depending on the frequency.

Frequency response of the decoder system rolled off at low frequencies to −3 dB at 110 Hz and −15 dB at 20 Hz. This effect could be seen in the action of the LED indicator, which required about 3 dB more input at 100 Hz than at the two higher frequencies for its color transition. The decoder response is built in to complement a boost in the encoding process used on the record.

In the CX mode, the distortion rose smoothly from 0.03% at 0.1 volt output to about 0.5% at the clipping point of 9



Noise reduction using a Hewlett-Packard 3580A spectrum analyzer.

−20-dBV threshold. Transistor *Q2* buffers the full-wave rectified output, while *IC3A* sets the first attack and release time constants at 1 ms and 10 ms, respectively. Op amp *IC3B* buffers this point for the next set of time constants. Small-signal changes are controlled by *R19* and *C5* for a two-second time constant, while large-signal changes cause *D5* or *D6* to conduct for faster response. For large-signal releases, *D6*, with *R20* and *C5* provide a 200-ms time constant. For large attacks, *D5* with *R* provide a 30-ms time constant.

The leading edges of large attack passed by *C4*, *R16*, *R17*, and *Q3*, whi form a 30-ms high-pass. This rather complicated network delivers excellent

---

volts. At normal signal levels of 1 to 2 volts, the distortion was less than 0.2% and consisted entirely of either second or third harmonics. With the CX decoding disabled, the distortion was unmeasurable (less than 0.003%) below 1 volt, reaching a peak of 0.056% between 2 and 3 volts.

The noise-reduction benefits of the CX system are illustrated dramatically by the spectrum analysis. The noise was attenuated by typically 16 to 18 dB over the full frequency range of 20 to 20,000 Hz and beyond. It is noteworthy that the CX system reduces hum and rumble as much as it does higher frequency noises.

User Comment. Some of the demonstration records we used had silent groove sections. Playing those, it was not possible to hear any noise whatsoever with an ear pressed against a speaker, unless the volume was set to an unreasonably high level. In such cases, the first note of the recorded program usually blew our speaker protection fuses. Using the highest practical listening volume setting, the CX system produces a totally silent background from an unmodulated groove.

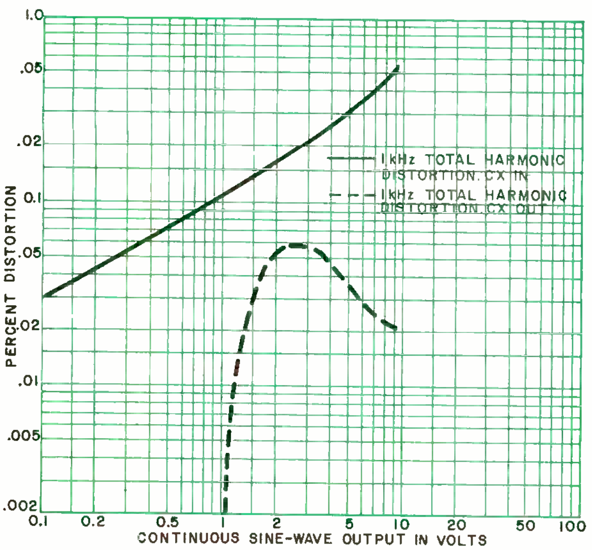
Most criticism of the CX process (from competitors and certain recording engineers) concerns its supposed "compatibility" with undecoded playback. Our listening tests have convinced us that it *is* compatible, in that sense. Listening to any of the CX records at our disposal without decoding (and, of course, without knowing that they were CX-encoded) we doubt that anyone would be able to identify them as being CX-encoded. True, their dynamics are somewhat compressed, but that is true of most standard records as well. Their noise levels are no different from those of ordinary records. The recording quality of the samples we heard varied widely; the CX process has no effect on this. Some of them were superb, others were very mediocre, and most were in between.

Of course, when the CX is turned on, these records all sound better than without decoding. Their more natural dynamics can be especially appreciated by comparison to the compressed sound that is heard without decoding. Since we have all been hearing that compressed sound for years, it seems perfectly normal until the expansion process removes it. We never heard any "pumping" or other signs of incorrect compander operation. The absence of noise is not always immediately obvious due to masking by the program, but during quiet passages it is striking. Unfortunately, there is always the master tape hiss to be heard, since most of the demonstration records were apparently derived from analog tape masters. Unless you play at ear-splitting levels, though, even this is unlikely to be audible in a typical home installation.

We were even more impressed by the almost total elimination of audible rumble, hum, and other low-frequency noises by the CX decoder. To a surprising degree, this can make it possible to get better, quieter sound from an inexpensive turntable than can be realized with a much more expensive turntable and conventional records.

The CX decoder is, in our view, a highly worthwhile addition to any music system. The kit price, not much more than half the cost of many manufactured CX decoders, makes this an even greater bargain. ◇

Frequency responses at 3 input levels.



Distortion with decoder in and out of system. Output is terminated in IHF load (10 kilohms, 1000 pF). Clipping at 9 volts.

transient response with a 1-ms large-signal attack time and low distortion due to a two-second small-signal release time. Op amp *IC3C* buffers the output of this network. Op amp *IC3D* and transistor *Q4* convert the control voltage into a current suitable for varying the gain of *IC4*. *IC4* (RCA CA3280) is an operational transconductance amplifier (OTA). The output current of an OTA is the product of the differential input voltage and the control current, for linear gain control over a wide range. Op amp *IC5* converts the current output of the OTA back into a voltage for interfacing with the final output. Transistors *Q5* and *Q6* form a differential pair and sense the control voltage. Signal levels below 0 dBV will light the two-color LED green; above 0 dBV the LED will flash red. Switch *S2* can be used to bypass the decoder circuitry if desired.

Construction. While pc construction is recommended, satisfactory results can be obtained from other methods, as long as you follow the original layout closely. The finished assembly should be mounted inside a shielded box. A full-size etching and drilling guide is provided in Fig. 3. Its components placement guide appears in Fig. 4.

When mounting the components on the printed circuit board, take note of device orientation. The cathodes of all diodes will be marked by a band, while pin 1 of the ICs will be indicated by a dot. Observe polarity markings on the electrolytic capacitors.

Performance may be degraded if wider tolerance components are substituted; likewise, high-leakage capacitors can alter time constants.

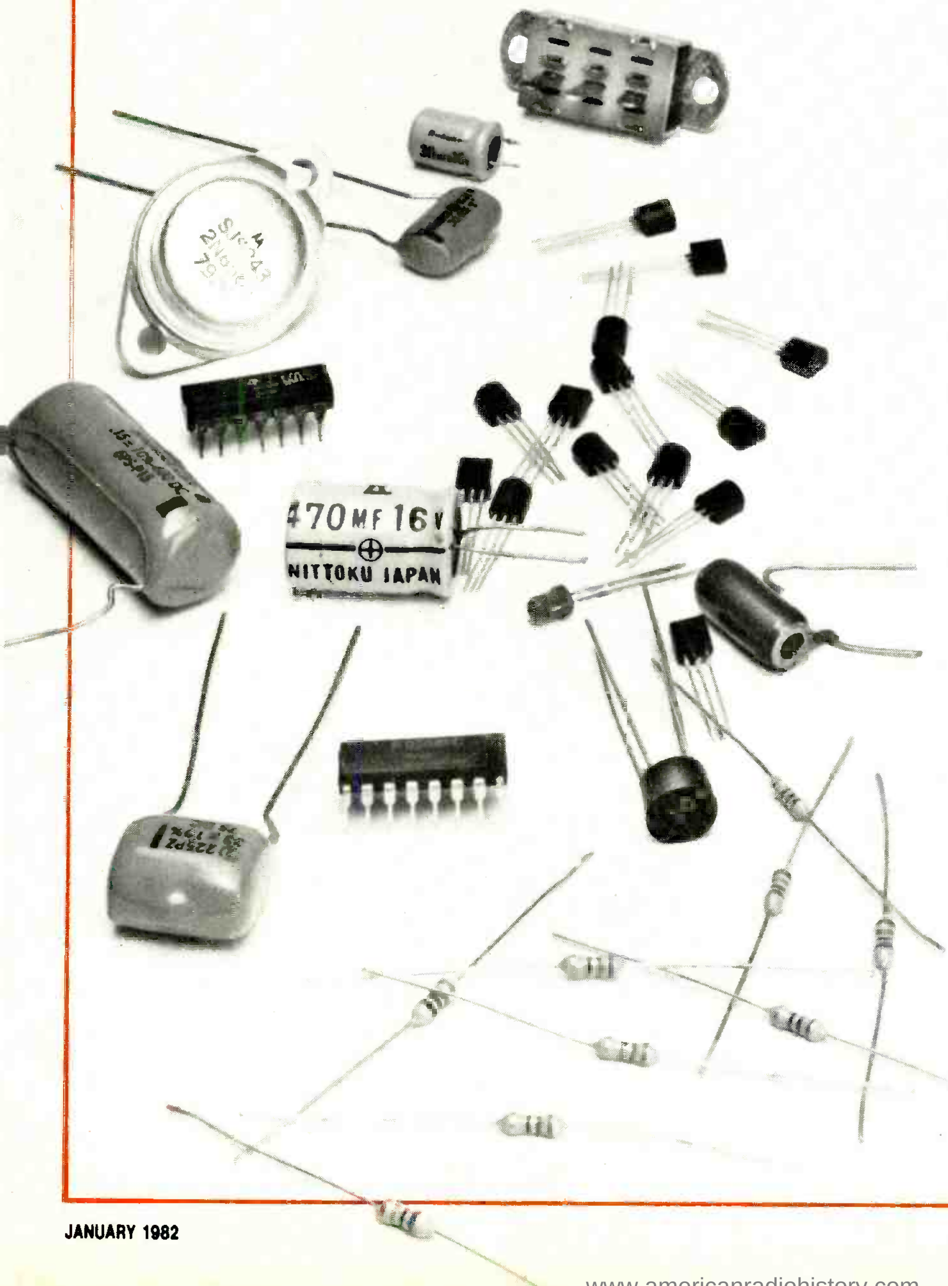
Calibration and Use. For best results, the CX decoder should be calibrated to your cartridge/preamp combination. Center all trimpots and patch the decoder into your tape monitor loop. Plug the power cord into a switched outlet. With a suitable test record, adjust trimmer *R1* so the level LED just turns red for a 3.54-cm/s at 1 kHz test tone. With an ac voltmeter connected to the left output, adjust the output level trimmer, *R2*, so that the signal with CX switched in is 3 dB louder than with CX switched out. Repeat adjustments for the right channel. Connect either a tone-burst generator or a record with high transient information to the right input only. With a sensitive voltmeter connected to the left output, adjust *R3* for minimum feedthrough. Connect the signal source to the left input and adjust *R203*. The input level will only have to be re-calibrated if you change cartridge or preamp.

Cue up a CX record and enjoy. ◇

FOR PROJECTS THAT LAST— DERATE YOUR COMPONENTS

BY CHARLES HANSEN

Running electronic parts at maximum ratings condemns them to short, unhappy lives. Here are recommendations that promote reliability



DERATING electronic components, that is, operating them under electrical and thermal stresses somewhat below maximum ratings, is a good way to promote circuit longevity. The problem is to find a derating factor that gives an acceptable balance between enhanced reliability and escalating cost. Recommendations and procedures based in part on reliability factors and failure rates have been compiled for military applications. Since, however, experimenter applications are not as severe, a more relaxed set of derating procedures is in order.

To derate a component, multiply its maximum rating by the recommended or selected derating factor, which will be a number less than 1. Where a component has multiple ratings (a transistor, say, has voltage, current, and power-dissipation ratings), all derating factors should be applied concurrently. When the various derating factors are applied and the results compared to the parameters of the circuit in which the component is intended to be used, it is easy to tell whether or not the component is suitable for the application.

Figure 1 shows the effects of temperature and voltage on the failure rate of a typical ceramic capacitor. As the operating temperature and the electrical stress (the ratio of the applied voltage to the rated voltage) increase, the failure rate increases exponentially. Thus, above the "knee" of this curve, a small reduction in temperature or electrical stress yields a large increase in device reliability.

For example, applying a derating factor of 0.8 to a capacitor rated to withstand 100 volts dc means that it should not be exposed to more than 80 volts dc. This will double the capacitor's life expectancy. If the operating temperature can be decreased by 20°C (36°F), the expected lifetime doubles again.

Component and circuit reliability can be dramatically enhanced by observation of good design and construction practices in addition to derating. No maximum rating of any component should ever be exceeded, even under worst-case operating conditions. Components that radiate heat should be kept away from other components, especially those that are heat-sensitive. Integrated circuits should be kept at least 20° C (36° F) below their maximum rated temperatures.

Derating factors for common electronic components are given below. More conservative derating factors can be used, but the ones given are effective and economical.

Resistors. Metal-film (1% tolerance) and metal-oxide insulated film (2% tolerance) resistors are used where circuit noise must be kept to a minimum or where tolerances must be kept tight. For such resistors, maximum power dissipation should be no more than 80% of the rated average. The maximum voltage drop across such a resistor should not exceed 250 volts peak for a 1/8-watt rating or 350 volts peak for a 1/4- or 1/2-watt rating.

Carbon-film and carbon-composition resistors should have maximum power ratings derated by a factor of at least 0.8. The maximum voltage drop across a carbon resistor should not exceed 250 volts peak for a 1/4-watt rating, 350 volts peak for a 1/2-watt rating, and 500 volts peak for a 1- or 2-watt capability.

Power-dissipation ratings of wirewound resistors are specified for an ambient operating temperature of 25° C (70°F) and decreases 0.4 percent for each 1°C (1.8°F) increase in temperature. The maximum average power dissipation for a wirewound resistor to dissipate should not exceed 75 percent of rated maximum *at the operating temperature*. Maximum peak (instantaneous) power should not exceed four times the maximum average power. The maximum permissible short-time overload is five times the maximum average power for five seconds. Rheostats and potentiometers should not be called upon to dissipate more than 70 percent of their average rated power.

Capacitors should be derated for ambient temperature and working voltage. Ceramic and mica capacitors should be exposed to no more than 80 percent of their rated working voltage—which is usually specified in dc volts, not ac volts. If the capacitor is to be exposed to ac, keep in mind that ac volts are often expressed in terms of rms, not peak voltage. Plastic-film and paper capacitors should be exposed to no more than 70 percent of their rated dc or ac voltages.

Polarized aluminum electrolytic and tantalum capacitors should not be exposed to appreciable reverse voltages. (Polarities of such capacitors are clearly denoted on their cases by means of symbols or color coding.) A solid tantalum capacitor should be derated to 78 percent of its rated working dc voltage, and should not be subjected to reverse-polarity voltages greater than 10 percent of the rated working dc voltage. The loop of the circuit in which a solid tantalum capacitor is found should contain a minimum series resistance of three ohms per working dc volt to prevent failures induced by excessive surge currents. Aluminum electrolytic capacitors should be derated to 85 percent of their rated working dc voltages and should be exposed to reverse-polarity voltages no greater than 10 percent of their rated working dc voltages. It is preferable not to expose aluminum electrolytics to any reverse voltages at all. Maximum ripple current should be limited to 80 percent of rated current.

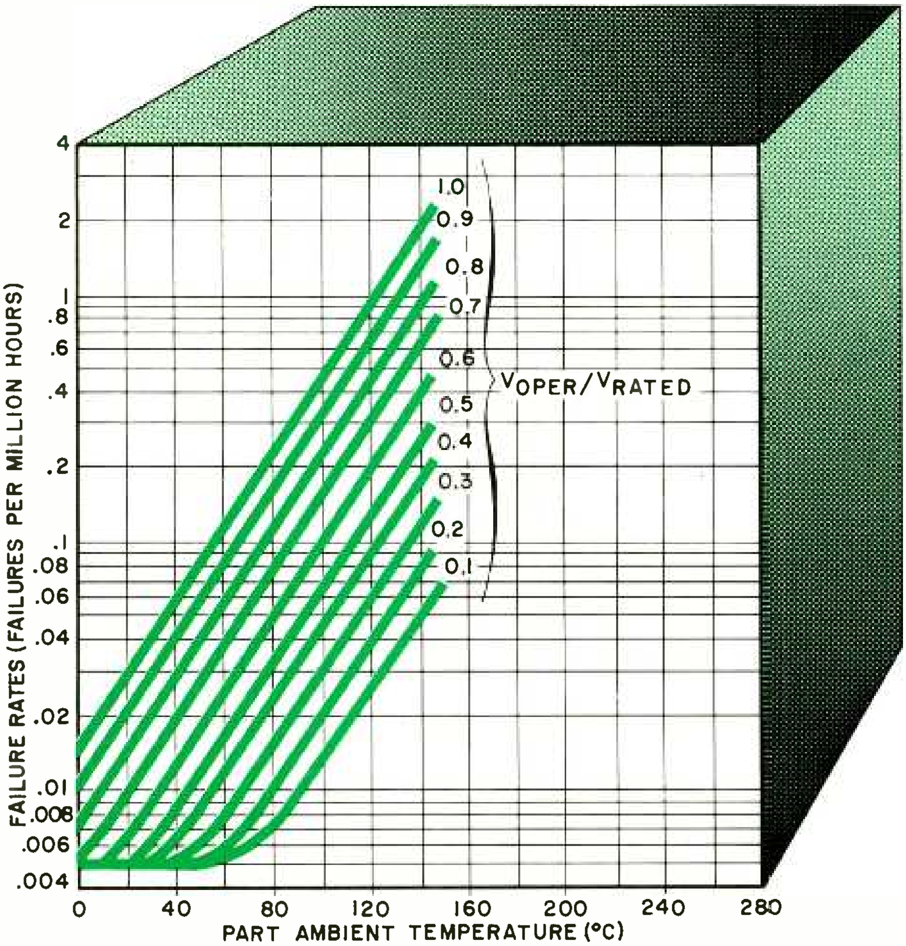


Fig. 1. A typical chart of the effects of temperature on failure rates for general-purpose ceramic capacitors. (MIL-C-11015).

Discrete Semiconductors are very unforgiving of electrical and thermal overloads. Many will be quickly destroyed by reverse-polarity voltages.

Forward currents through a diode should be limited to 87 percent of the rated average and surge currents. Peak inverse voltage should not exceed 80 percent of rating. Current through a zener diode should be limited to 90% of rated value. The power a zener diode is called upon to dissipate should be derated by a factor of 0.7.

Thyristors, including silicon controlled rectifiers and triacs, should handle forward currents no greater than 80 percent of their I_F ratings. They should not be required to handle more than 80 percent of their rated peak blocking voltages.

Small-signal transistors, including BJTs, FETs, and UJTs, should see voltages no higher than 80 percent of their ratings (V_{CE}, V_{BE}, etc.). Similarly, they should handle currents no greater than 80 percent of their ratings (I_B, I_C, etc.). Small-signal transistors should dissipate no more than 50 percent of their rated power dissipations.

Bipolar power transistors should not see more than 90 percent of their V_{CE} ratings nor have to conduct more than 80 percent of their rated collector currents. The maximum power they are called upon to dissipate should not exceed 50 percent of their rated values.

Sufficient heat sinking should be provided to limit junction temperature to 80 percent of the rated maximum T_j or less. When power transistors are employed in switching modes, strict adherence to the manufacturer's safe-operating-area recommendations, forward and reverse secondary breakdown, and thermal-cycling ratings is necessary if the user expects to prevent premature failures.

Digital ICs. The maximum power-supply voltage that should be used with TTL devices is +5.25 volts. A TTL output stage's fanout should be limited to 90 percent of its rating. Each TTL package should be decoupled by a 0.01-to-0.1-μF disc ceramic capacitor connected between $+V_{CC}$ and ground. This capacitor also should be physically near to the IC. If there are unused inputs, follow the manufacturer's recommendations with respect to connecting them to $+V_{CC}$. A 1-kilohm pull-up resistor will be needed in certain cases.

CMOS logic ICs can be used over a wider range of supply voltages than TTL. Supply voltage should be at least 1.5 volts dc greater than the rated minimum and at least 2.5 volts less than the rated maximum. There is no need to derate fanout—the full number of gates that the manufacturer states can be driven is acceptable. For circuit decoupling, at least one 0.1-μF disc ceramic capacitor should be installed across the power-supply bus on each circuit board. *All* unused CMOS logic inputs should be connected to $+V_{DD}$ or $-V_{SS}$, as appropriate. Be sure to observe manufacturers' recommendations in handling CMOS packages to prevent static-discharge damage.

Linear ICs include operational amplifiers, comparators, voltage regulators, etc. The maximum differential supply voltage that should be applied to an op amp or a comparator is 80 percent of the rated value. Differential input voltage should be limited to no more than 60 percent of rated value, and output current to 80 percent of the applicable rating. Specified limits on slew rates and input- and output-voltage swings should be observed, and the circuit layout should be planned to keep inputs and outputs isolated.

A voltage regulator IC should not see input voltages greater than 80 percent of rated value. Differential input-to-output voltage should be between 1.5 times the minimum value recommended and the rated maximum. A regulator should not be called upon to dissipate more than 50 percent of its rated power.

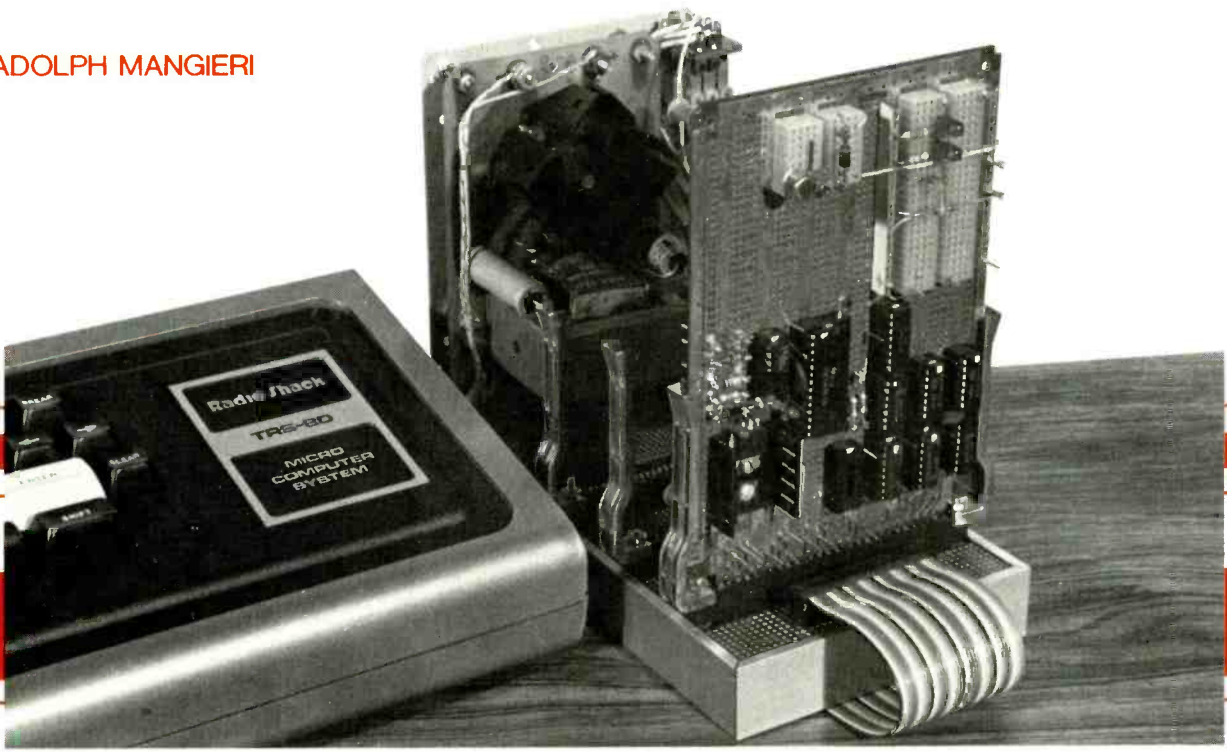
Relays and Switches. The voltage that is applied to energize a relay coil should be within ±10 percent of the rating. (If a transistor is used to switch current through the coil, a reverse-biased diode should be connected across the coil to suppress inductive spikes.) The current that is to be gated by relay or switch contacts should be derated with respect to their current-handling capacity and according to the type of load involved. For a resistive or a capacitive load, relay or switch contacts should have to handle no more than 75 percent of their rated current capacity; for a regular inductive load, no more than 40 percent; for a motor, no more than 20 percent; and for an incandescent lamp, no more than 10 percent.

Following these guidelines will enhance circuit reliability and component lifetimes without unduly increasing the costs of your projects. In addition, when a component in a commercial product is found to have failed, replacing it according to these principles may well avoid the need for future replacements of the same part. ◇

ANALOG-DIGITAL CONVERTER FOR TRS-80 INTERFACING

An 8-bit, 8-channel digital circuit that allows you to connect analog voltages to your TRS-80 microcomputer

BY ADOLPH MANGIERI



DIGITAL computers "speak and understand" only the binary language of electrical ones and zeros. Unfortunately, the binary language is not suitable for direct measuring of physical quantities such as voltage, pressure, temperature, light, or other continuously varying (analog) parameters. To utilize the digital computer in measurement and control systems, an analog-to-digital interface is required. Fortunately, such analog-to-digital converters (ADC) are now available at low cost.

Interfacing with the TRS-80 Model I microcomputer, the 8-bit, 8-channel ADC covered in this article includes a four-bit output port for controlling lamps, relays, and other devices. The output port is readily expandable to eight channels, thus providing 32 channels of control. Running in the TRS-80 TBUG monitor, the accompanying machine language program ANADIG shows how to structure a multichannel data-acquisition system. Several input and output circuits are detailed, including means to quantize the range of an input channel to output multiple decisions controlling a number of output circuit branches. The ADC accepts an input voltage and converts it to binary form for display or further processing by a computer. Common converter types include the costly high-speed 'flash' converter, the inexpensive but slow ramp converter, and the successive-approximation converter that provides excellent speed at relatively low cost. In all cases, the ADC seeks to match the level of an analog input signal with stepped and weighted reference voltages and generate a binary value when the match is found.

Considering first the successive approximation converter, Table I shows conversion of input signal of weight 67 in eight approximations taken in sequence. On the first comparison (bit D7), weight 128 is greater than 67 thus it is discarded by setting output bit D7 to zero. On trial two, weight 64 is less than 67 and is retained as a partial sum by setting bit D6 to one. The following comparisons through bit D2 are discarded because the partial sum would exceed 67. The remaining two trials bring the sum to exactly 67 and the corresponding data bits are set to one causing 67 to be converted to 01000011 or 43 hex. For an input signal of weight 255, the data bits are set to 11111111 yielding FF hex or full-scale. The converter resolves full-scale input of one part in 256.

The block diagram of Fig. 1 shows the internal circuit blocks of the eight-chan-

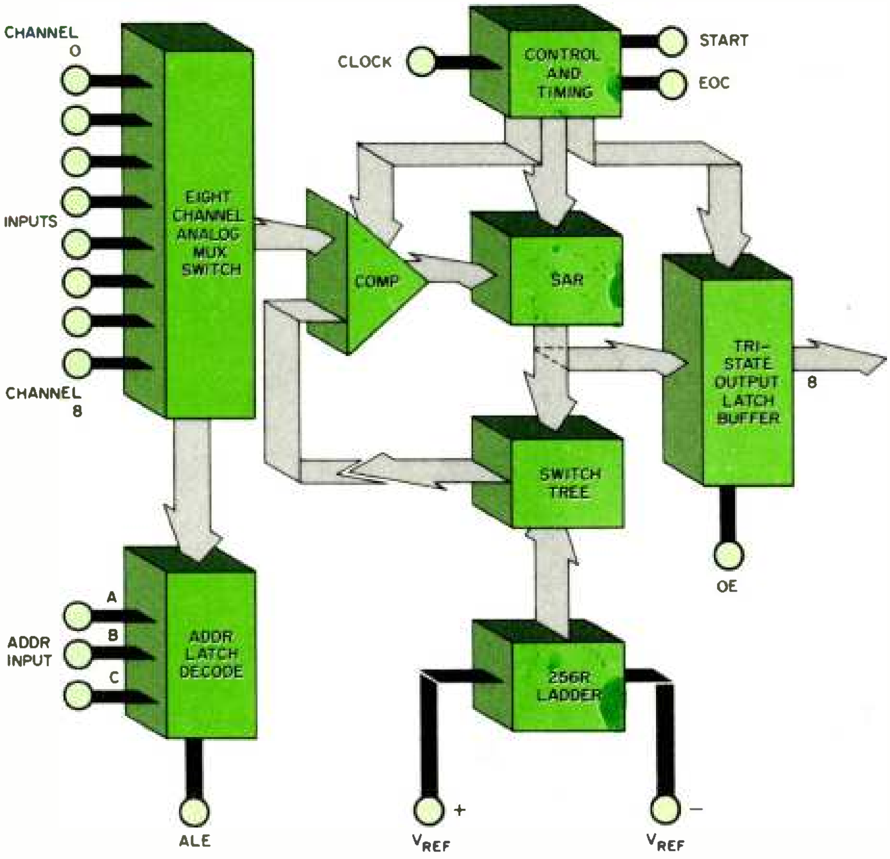


Fig. 1. Block diagram of the circuits contained in the AD0809 analog-to-digital converter used in the project.

nel converter used in this project. One of eight input signals is applied to one input of the comparator through a mux (multiplex) analog switch. The particular channel selected depends on the address bits applied to the address data latch decoder. Bit 000 selects input channel 0, bit 001 selects channel 1, and so forth up to channel 7 by bit 111.

A stable 5-volt reference is applied to a 256R resistor ladder network that supplies weighted reference voltages for comparisons. With the input signal present at one input of the comparator, a switch tree sequentially selects and applies weighted reference voltages to the other comparator input. The comparator output feeds into the successive approximation register (SAR) which performs logical decisions and assembles the binary output data in the Tri-State data-out latch and buffer. The ADC clock and timing and control circuits determine the sequence of events. Using this arrangement, at a clock frequency of 640 kHz, conversion takes place in 116 microseconds.

Figure 2 shows the ADC timing. With address bits and input signal present, address latch enable pulse (ALE) strobes the address bits into the address latch decode circuit. Pulse START initiates conversion and end-of-conversion pulse (EOC) goes low during conversion. Following conversion, pulse EOC goes high and pulse output enable (OE) is applied to enable the data onto the bus for acceptance by the computer.

For comparison, a six-bit parallel flash converter includes a resistor ladder supplying 63 reference voltages each connected to one input of 63 comparators. The input signal connects to the other input of all comparators. Comparisons take place all at once thus the name "flash" converter. The 63 outputs of the comparator string are then decoded by extensive and complex logic to form the equivalent binary output. However, an eight-bit flash converter requires 255 comparators! Costly to manufacture, the flash converter is usually limited to six bits or less.

The ramp ADC technique uses a digital-to-analog converter (DAC) and a computer program to generate a staircase voltage ramp of 256 steps for use by the eight-bit converter. The stepped output of the DAC and the input signal connect to comparator inputs, and on each successive voltage step, the computer program checks comparator output and advances to the next step if the match is not found. Two hundred and fifty-five comparisons are required to reach full-scale for eight-bit conversions. Though relatively slow, ramp-conversion techniques offer advantages through software control.

Table I

EXAMPLE OF SUCCESSIVE APPROXIMATION

Bit	Weight	Comparison	Bit	Sum
D7	128	128>67	0	0
D6	64	64<67	1	64
D5	32	32+64>67	0	64
D4	16	16+64>67	0	64
D3	8	8+64>67	0	64
D2	4	4+64>67	0	64
D1	2	2+64<67	1	66
D0	1	1+66=67	1	67

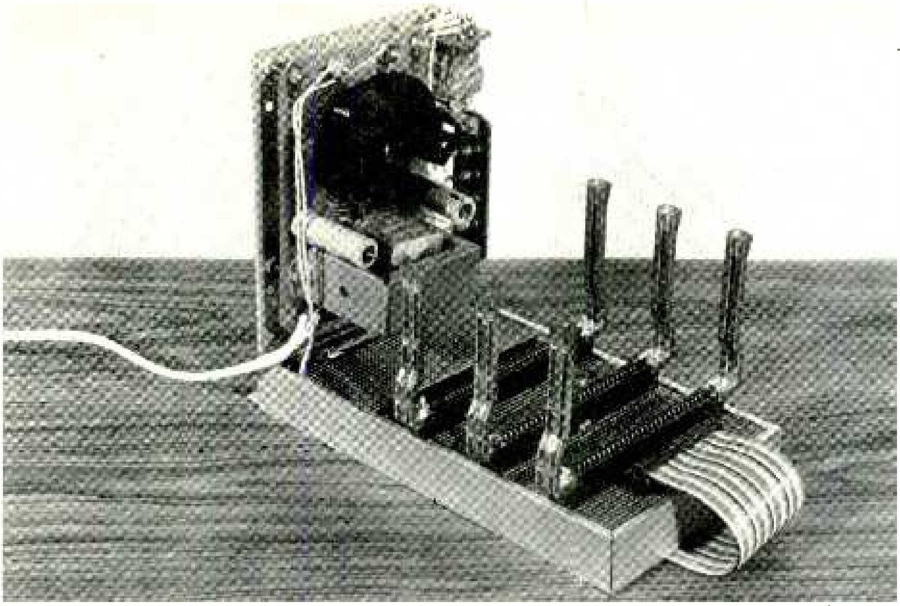
Circuit Operation. As shown in the schematic of Fig. 3, clock generator *IC8* is a 555 timer operating at approximately 100 kHz. Input channels 0 and 1 are the only ones used at this time, with the remaining 6 input channels grounded. A zener diode (*D2, D3*) and a capacitor (C5, C6) protect the active CMOS input channels.

When the program ANADIG issues an $\overline{\text{OUT}}$ instruction to port address FD (decoded by *IC5*), the instruction transmits channel address bits on data lines D0, D1, and D2. Thus *IC5* in conjunction with the $\overline{\text{OUT}}$ signal activates *IC6A* pulsing ALE and START inputs with the address latched into the ADC. A time delay in the program allows time for completion of the conversion. The program then issues an $\overline{\text{IN}}$ instruction to port address FD causing *IC6B* to activate OE (output enable) and placing the converted data on the data bus as input to the computer.

A program task subroutine then processes the data and makes a decision for use by output port, *IC7*. The task decision is output to port address FB decoded by gate *IC4* and enabling *IC7*. Data bits D0 through D3 are transmitted to *IC7* and determine the output of four data latches used to control external indicator lamps or relays.

In the case of an external transistor driver (*Q1*), zener diode *D4* protects the circuit in the event of failure of the transistor. Voltage regulator *IC11* supplies five volts to the circuit.

Additional input channels may be connected to *IC9* as required. Additional output channels are created by adding another 74LS75 (*IC7*) and connecting



The system is assembled on an aluminum frame with power supply and card guides.

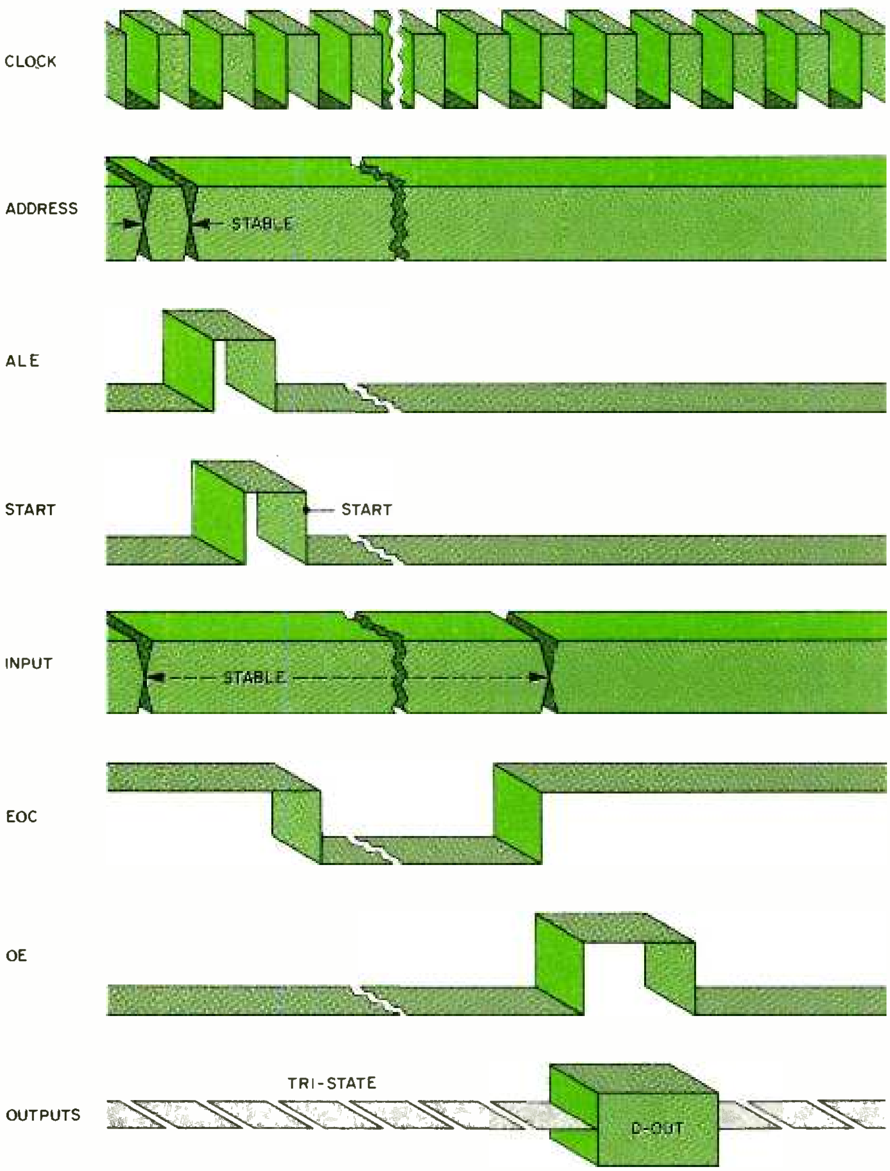


Fig. 2. Timing diagram of the analog-to-digital converter IC.

device pins 4 and 13 to pin 10 of *IC6C*. Data lines D4 through D7 are passed through the spare buffers of *IC3* to the inputs of the second data latch.

Construction. The circuit was assembled on a Vector 4494 ANY-DIP plug card and wire wrapped. Install *IC1*, *IC2*, *IC3*, and *IC10* in the socket row near the card fingers. Install *IC4*, *IC5*, and *IC6* in the second socket row and place *IC7*, *IC8*, and *IC9* in the third row. Experimentation with assorted input and output circuits can be facilitated by installing pairs of Vector T66-96 and T66-32 Klip Bloks and two T45-24 Klip Buses on the upper portion of the card as shown. The plug-board system shown consists of three Vector R644-3 44-contact card receptacles and three pairs of BR27D card guides installed on the 51X aluminum frame. Install two rows of T46-5-9 board pins with pin faces aligned on perfboard at one end forming a male IDC connector. Use a 40-line IDC cable disconnect at the plug board system. A Jameco No. JE210 5-to-15-volt adjustable regulated power supply set for 12-volts powers the circuit. Do not run the TRS-80 5-volt supply to the plug board system. As an alternative to the plug board system, assemble the circuit on Vector 8002 or 8004 Circbords for wire wrapping and install the card in the 51X aluminum frame.

Checkout. With integrated circuits removed and ribbon cable disconnected from the computer, power the voltage regulator and check voltage distribution at the pertinent socket pins. Check voltages at the far end of the cable and be certain that supply voltages do not feed back to the computer. Install the integrated circuits taking usual precautions when handling the CMOS converter chip. Energize the circuit and verify presence of clock pulses at pin 3 of *IC8* using either a counter or oscilloscope. With power off, make connections to the computer and verify proper operation of the computer. Look for shorted bus lines if the computer fails to function.

Connect the input test circuit shown on the schematic diagram to the input of channel zero. Jumper channel-one input to channel-zero input. Enter and load program ANADIG into memory using the TRS-80 T-BUG monitor and break the looping program by inserting STOP code CD 91 40 at address 4A27H. Set test potentiometer *R6* to its ground end, and run the program. Both *LED1* and *LED2* should turn off. Verify that data input buffer memory location 4A00H and 4A01H hold data 00 and that outport buffer 4A08H holds 00. Set the test potentiometer to five volts and observe that both LEDs glow. Verify that chan-

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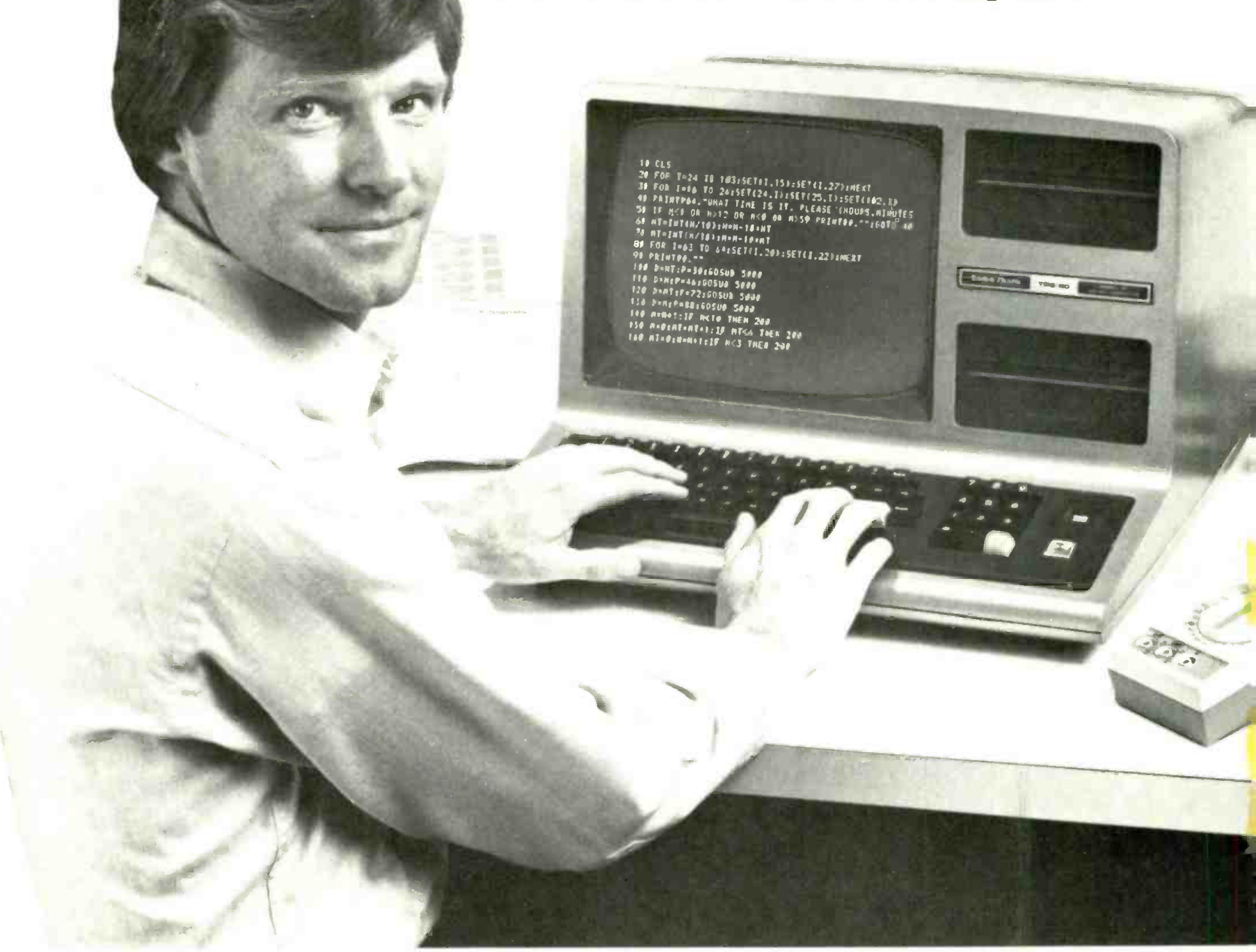

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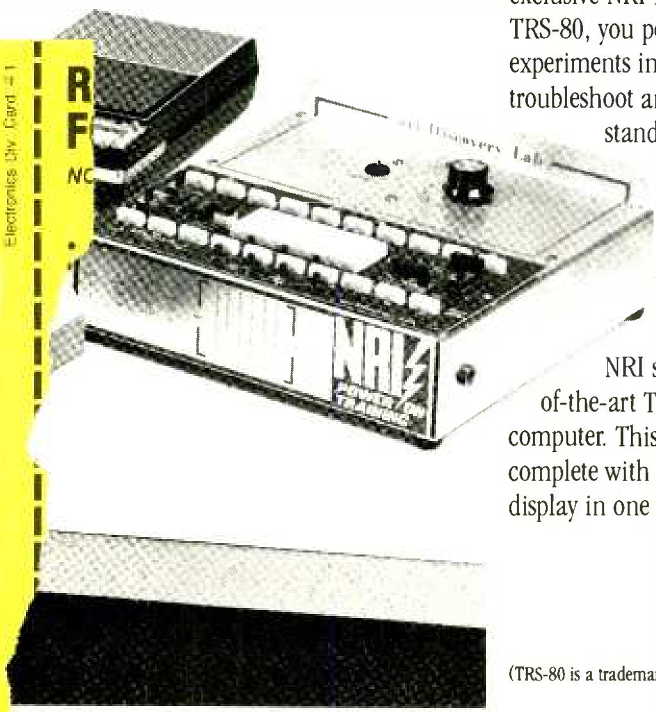

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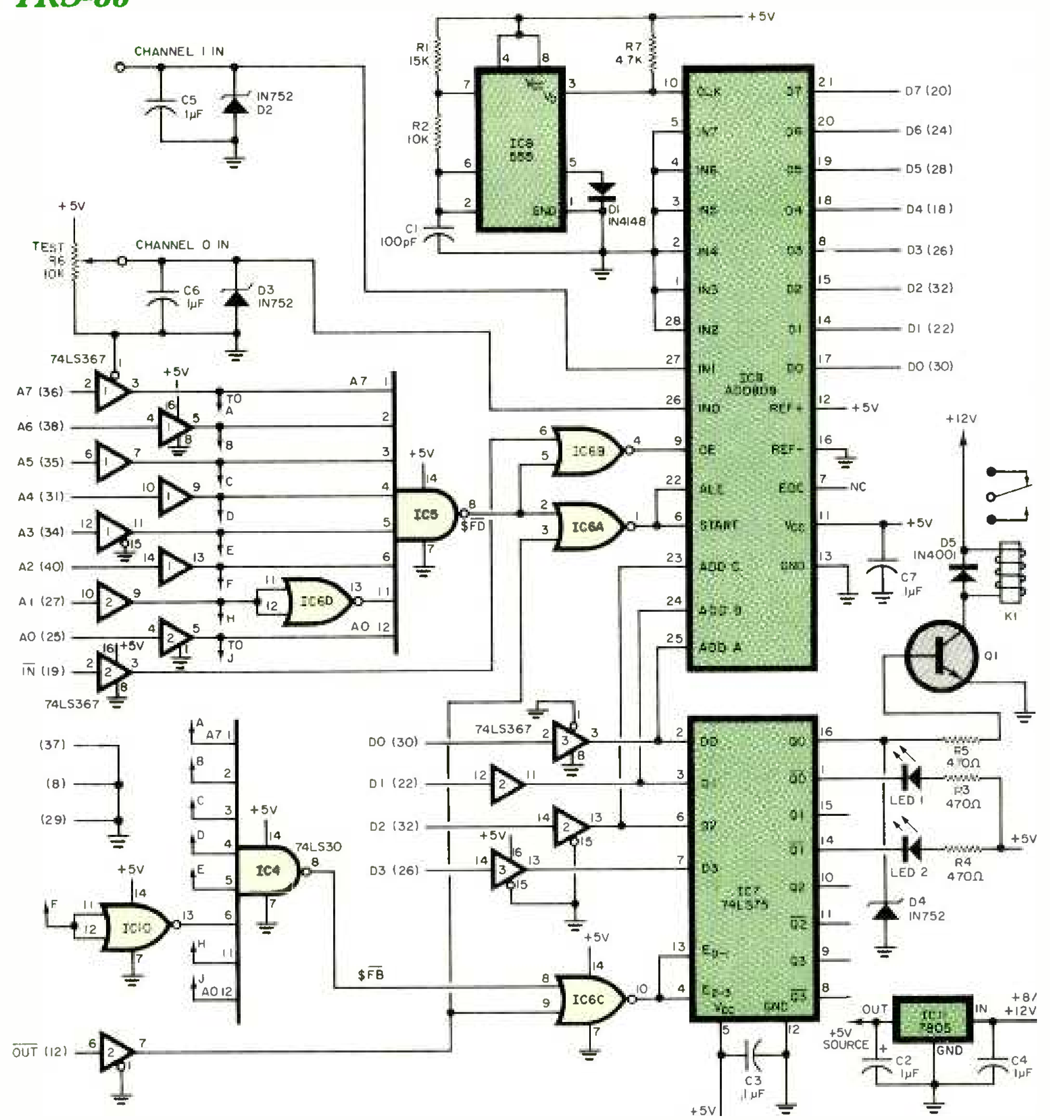


Fig. 3. A 555 clock generator, IC8, operates at approximately 100 kHz. Input channels 0 and 1 are the only ones used in this application.

PARTS LIST

C1—100-pF ceramic capacitor
C2—1.0-μF, 35-V tantalum electrolytic
C3 through C7—0.1-μF, 15-V disc capacitor
D1—1N4148 switching diode
D2,D3,D4—1N752 5.6-V zener diode
D5—1N4001 rectifier
IC1,IC2,IC3—74LS367 three-state hex buffers
IC4,IC5—74LS30 8-input NAND gate
IC6,IC10—74LS02 quad 2-input NOR gate
IC7—74LS75 4-bit data latch
IC8—555 timer
IC9—ADC 0809 eight-bit, eight-channel ADC (available from Jameco Electronics, 1355 Shoreway Rd., Belmont, CA 94002)
IC11—7805 5-V, 1-A voltage regulator
K1—12-V relay
LED1,LED2—Light-emitting diode (XC-526R or equiv.)
Q1—2N3053, RS-276-2030 npn transistor
R1—15-kΩ, ¼-W resistor
R2—10-kΩ, ¼-W resistor
R3,R4,R5—470-Ω, ¼-W resistor
R6—10-kΩ potentiometer
R7—4.7kΩ, ¼-W resistor
Misc: Vector 4494 plug board; 51X aluminum frame; R644-3 44-contact card receptacles (3); BR27D card guides (6); T46-5-9 board pins; perfboard; 28-pin DIP socket; 16-pin DIP sockets (4); 14-pin DIP sockets (4); T49 Klip-Wrap posts; T66-96, T66-32 Klip Bloks (pairs); T45-24 Klip Bus (2); ribbon cable and connectors; wire; etc.

nels zero and one data buffers hold data FF or 255 while outport buffer 4A08H now holds 03. Vary *R6* slowly about the trip points. Notice that LED1 flickers and relay *K1* chatters at the trip point. Notice that the turn-on and turn-off points of *LED2* differ slightly and with no flicker. This is the result of deadband or hysteresis built into the task program of channel one.

Software. Use program ANADIG shown here for initial experiments with multichannel data acquisition and processing and write your own programs for specific applications. The looping main program RUN performs initializations, issues channel addresses, and CALLs subroutine START which initiates A/D conversions followed by subroutines TASK0 and TASK1 which control the relay outport. Memory locations 4A00H through 4A07H respectively store input data for channels zero through seven. Location 4A08H holds the outport byte common to all output channels.

Tracing through a typical program run, index register IX is initialized to point to the input data buffer. The outport byte is arbitrarily cleared to 00. Channel zero address 00 is first loaded

ANADIG TEST PROGRAM

```
                         ;FILENAME - ANADIG
                         ;BY ADOLPH A. MANGIERI 4/81
                         ;CHAN BUFFER - 4A00H THRU 4A07H
                         ;OUTPORT BUFFER - 4A08H
4A00                             ORG     4A00H
0009                             DEFS    9             ;BUFFERS
4A09 DD21004A            RUN     LD      IX,4A00H      ;POINTER
4A0D DD360800                    LD      (IX+8H),00H   ;CLR BUFFER
4A11 3E00                LOOP1   LD      A,00H         ;CHAN 0
4A13 CD7A4A                      CALL    START         ;START A/D
4A16 DD7700                      LD      (IX+0),A      ;SAVE DATA
4A19 CD9D4A                      CALL    TASK0         ;DO TASK 0
4A1C 3E01                        LD      A,01H         ;CHAN 1
4A1E CD7A4A                      CALL    START         ;START A/D
4A21 DD7701                      LD      (IX+1),A      ;SAVE DATA
4A24 CDDB4A                      CALL    TASK1         ;DO TASK 1
4A27 18E8                        JR      LOOP1         ;LOOP
0051                             DEFS    81            ;SPACE
4A7A C5                  START   PUSH    BC            ;SAVE
4A7B D3FD                        OUT     (0FDH),A      ;START A/D
4A7D 062F                        LD      B,2FH         ;TIME DELAY
4A7F 10FE                LOOP2   DJNZ    LOOP2         ;LOOP2
4A81 DBFD                        IN      A,(0FDH)      ;GET DATA
4A83 C1                          POP     BC            ;RESTORE
4A84 C9                          RET                   ;RETURN
0018                             DEFS    24            ;SPACE
4A9D F5                  TASK0   PUSH    AF            ;SAVE
4A9E E5                          PUSH    HL            ;SAVE
4A9F D5                          PUSH    DE            ;SAVE
4AA0 2600                        LD      H,00H         ;CLEAR H
4AA2 1600                        LD      D,00H         ;CLEAR D
4AA4 2E7C                        LD      L,7CH         ;TRIP POINT
4AA6 B7                          OR      A             ;CLEAR CARRY
4AA7 DD5E00                      LD      E,(IX+0)      ;GET DATA
4AAA ED52                        SBC     HL,DE         ;COMPUTE
4AAC FAB54A                      JP      M,SET0        ;GO IF NEG
4AAF DDCB0886                    RES     0,(IX+8)      ;RES BIT 0
4AB3 1804                        JR      LDPORT        ;EXIT
4AB5 DDCB08C6            SET0    SET     0,(IX+8H)     ;SET BIT 0
4AB9 DD7E08              LDPORT  LD      A,(IX+8H)     ;GET DATA
4ABC D3FB                        OUT     (0FBH),A      ;SEND DATA
4ABE D1                          POP     DE            ;RESTORE
4ABF E1                          POP     HL            ;RESTORE
4AC0 F1                          POP     AF            ;RESTORE
4AC1 C9                          RET                   ;RETURN
0019                             DEFS    25            ;SPACE
4ADB F5                  TASK1   PUSH    AF            ;SAVE
4ADC E5                          PUSH    HL            ;SAVE
4ADD D5                          PUSH    DE            ;SAVE
4ADE 2600                        LD      H,00H         ;CLEAR H
4AE0 1600                        LD      D,00H         ;CLEAR D
4AE2 2E7E                        LD      L,7EH         ;HI LIMIT
4AE4 DD5E01                      LD      E,(IX+1H)     ;GET DATA
4AE7 B7                          OR      A             ;CLEAR CARRY
4AE8 ED52                        SBC     HL,DE         ;COMPUTE
4AEA FAF64A                      JP      M,SET1        ;SET BIT 1
4AED 2E7A                        LD      L,7AH         ;LO LIMIT
4AEF ED52                        SBC     HL,DE         ;COMPUTE
4AF1 F2FC4A                      JP      P,RES1        ;JP IF POS
4AF4 180F                        JR      EXIT          ;TO EXIT
4AF6 DDCB08CE            SET1    SET     1,(IX+8H)     ;SET BIT 1
4AFA 1804                        JR      OUTPRT        ;
4AFC DDCB088E            RES1    RES     1,(IX+8H)     ;RES BIT 1
4B00 DD7E08              OUTPRT  LD      A,(IX+8H)     ;GET DATA
4B03 D3FB                        OUT     (0FBH),A      ;SEND DATA
4B05 D1                  EXIT    POP     DE            ;RESTORE
4B06 E1                          POP     HL            ;RESTORE
4B07 F1                          POP     AF            ;RESTORE
4B08 C9                          RET                   ;RETURN
0000                             END
0000  TOTAL ERRORS

OUTPRT   4B00
EXIT     4B05
RES1     4AFC
SET1     4AF6
LDPORT   4AB9
SET0     4AB5
LOOP2    4A7F
TASK1    4ADB
TASK0    4A9D
START    4A7A
LOOP1    4A11
RUN      4A09
```

into register A and subroutine START is CALLed. Routine START loads the address into the converter and starts A/D conversion. After a time delay set by byte 2F at address 4A7EH, the program returns to RUN with converted data in register A. Program RUN stores the data at address 4A00H and CALLS TASK0. Subroutine TASK0 fetches the stored input data and subtracts it from trip point 7C (124) located at address 4AA5H. If the result is negative, bit B0 of the outport byte is set to one or otherwise set to zero. The outport byte is then transmitted to the relay port data latch. Bit B0 now as data bit D0 may alter the status of output channel zero. The next program module of RUN addresses itself to channel one and TASK1 in a similar manner.

Subroutine TASK1 includes an upper trip point 7E (126) at address 4AE3H and a lower trip point 7A at address 4AEEH. When the converted input falls between these limits, bit B1 of the outport data byte is left unchanged. This introduces hysteresis much like a Schmitt trigger and prevents repetitive operation of mechanical relays and solenoids when the input levels hover near the trip points. The trip points and deadband are readily altered to suit the application. Use the TRS-80 TBUG machine language monitor to enter the object code. No changes are required for entry into either Level I or Level II machines. Alternatively, enter the source code or assembly listings using the TRS-80 Editor/Assembler EDTASM. Once the code is entered, make a tape copy using TBUG. Minor program changes are best entered manually using the TBUG. For major alterations, restructuring, or relocation of code, use EDTASM which markedly reduces the effort.

Input and Output Circuits. Input circuit Fig. 4A uses a thermistor for sensing temperature or a light-dependent resistor for sensing light levels. Resistor *Ra* can be a potentiometer for calibration or setting of trip points. The sensor and pot can be interchanged. It is best to include RC filtering in the input circuit to remove noise and ac components which affect conversion. Try 100,000 ohms for *Rb* and 0.1 μF for *Ca* or higher values if the RC time constant is not objectionable. Figure 4B shows two potentiometers of a joystick having two outputs which feed into two channels of the ADC, with the game program processing the converted data.

Low-level voltages from devices such as a photovoltaic cell or thermocouple can be amplified by an op amp such as the LM324 as shown in Fig. 4C. Stage gain or scaling depends on the ratio of

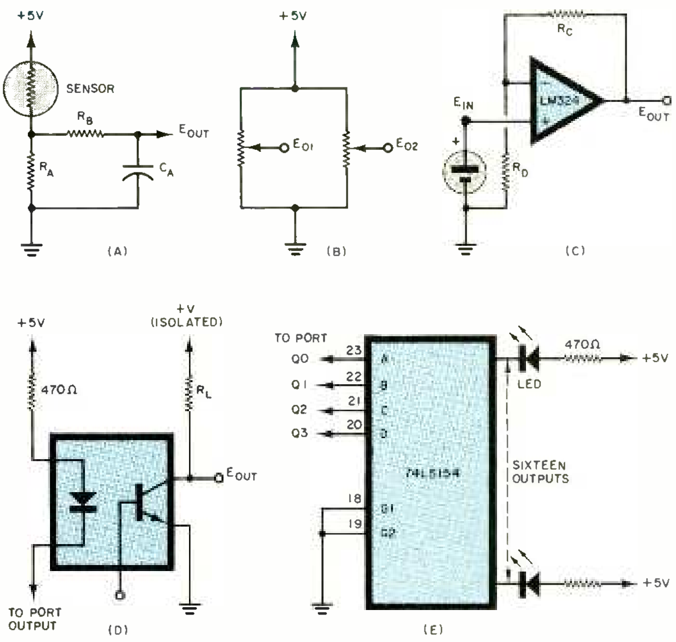


Fig. 4. Inputs: (A) a thermistor or light sensor; (B) two outputs of a joystick; (C) an amplifier to step up low-level signals. An optoisolator (D) is used to drive a triac or SCR. A decoder can be used on the output (E) to drive a display or LED or an alarm.

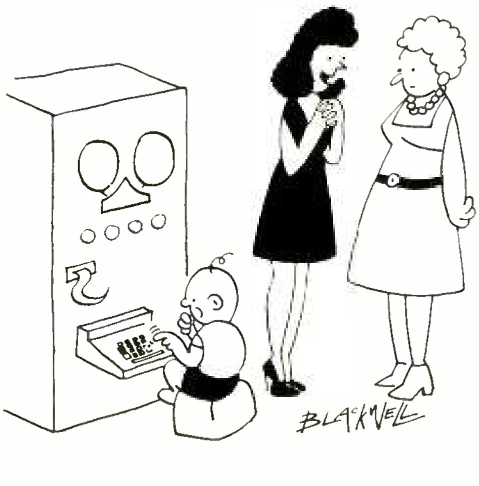
resistors *Rc* and *Rd*. For scaling, use a potentiometer for *Rc*. Higher input voltages can be scaled using a voltage divider string. For low-voltage ranges, scaling is obtained by switching suitable values of resistor *Rc*. If you use 2.55-volts dc for the ADC reference voltage, full-scale or 255 occurs with an input voltage of 2.55 volts. For video display of converted data, include a subroutine which converts binary to ASCII for display in video memory space. This and other useful subroutines such as multiplication and division can be found in manuals on Assembly language programming.

Output circuits include indicator lamps, audible alarms, mechanical and solid-state relays, stepping motors, and similar devices. Mechanical relays provide electrical isolation between the computer circuits and the controlled power circuits. Where triacs or SCRs are used to control power, use an optoisolator as shown in Fig. 4D. Alternatively, install a reed relay on the plug board for control of solid-state or remote-mounted mechanical relays.

Through program subroutines, the full-scale range of the ADC input can be divided into a number of segments each issuing a unique decision to the outport. As an example, the task program can divide full-scale range into sixteen segments with each program segment issuing a unique 4-bit nyble ranging from 0000 to 1111. The nyble is output to the 74LS75 latching port and affects the four outputs.

As shown in Fig. 4E, a 4-to-16-line decoder is connected to the Q outputs and decoded to one of sixteen outputs. The output lines can activate an array of sixteen LEDs arranged as a bar graph (for example), or to activate audible alarms or process controls.

The ADC and the DAC open the door to interfacing the computer with practical tasks in the home and in industry. At far less than the cost of available interfaces, you can begin experimenting with the ADC and put your own ideas to use at home. ◇



"Harold and I are so proud, Mother. Baby encoded his first word today!"

A Science Fair Project for Your Youngster:

THE ELECTRONIC ELECTROSCOPE

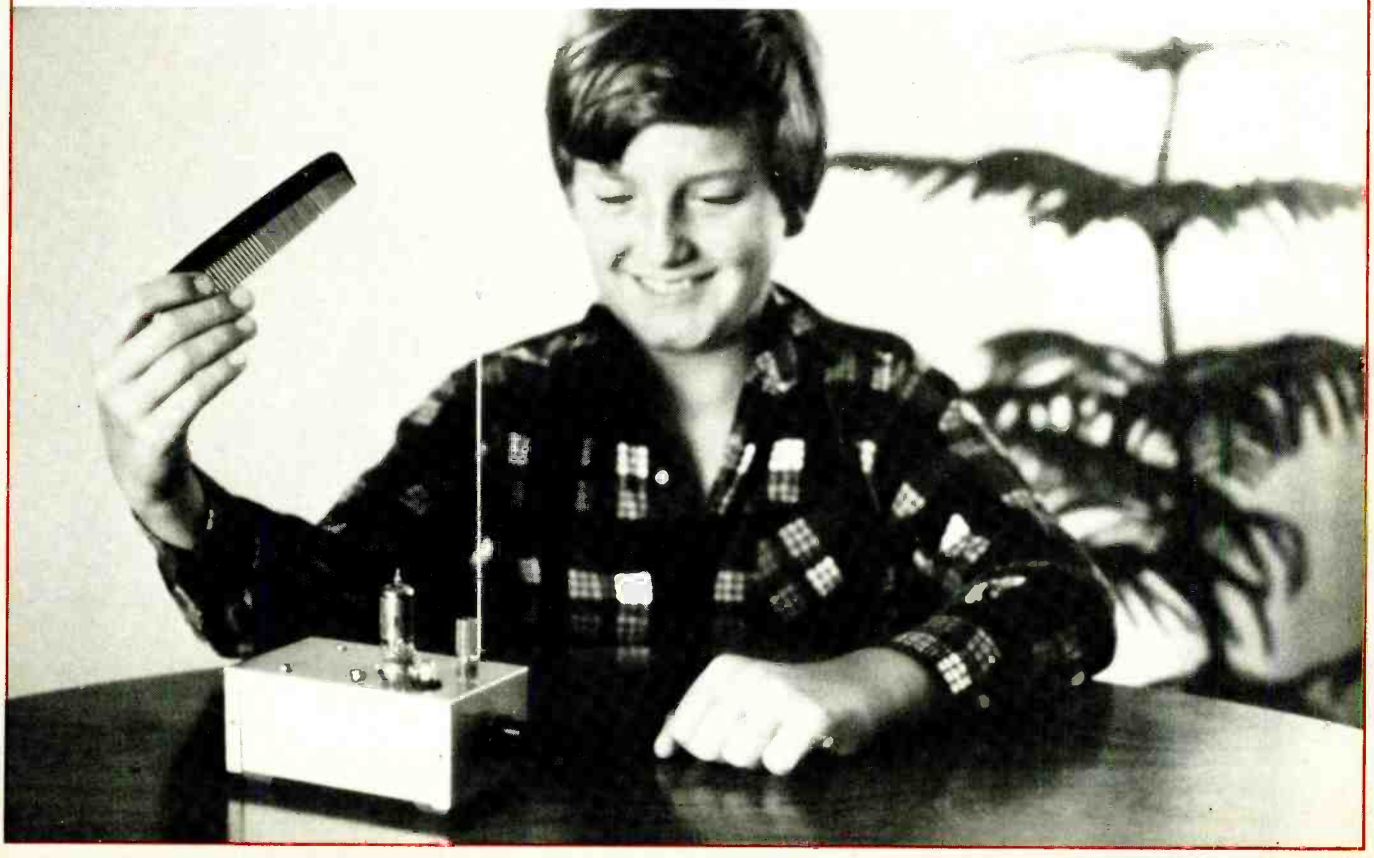
Indicates when strong electrostatic field exists

BY KEITH KUNDE

PRIOR to 1792 and Allesandro Volta's development of the chemical battery, nearly all electrical experimentation and research involved static electricity. Such static charges are generated on many nonconducting materials through friction with a complementary material, with combinations such as glass and silk, sealing wax and wool, and solidified sulfur rubbed by hand, leading the way in early experiments. Of course, the early experimenters had no means for directly measuring their static charges, but they did observe the forces of attraction and repulsion produced by charged objects. These observations led to the introduction late in the 16th century of the earliest form of electroscope by William Gilbert, who used a pivoting metal pointer to demonstrate the presence of static charges.

Another early form of electroscope used small balls of pith or cork suspended by fine insulating threads so that the forces of attraction and repulsion could be observed through the motions of the charged balls. In 1787, Abraham Bennet invented what became the most familiar form of the device—The Gold-Leaf Electroscope, which consisted of a small brass box having glass windows on two opposing sides, inside of which two strips of very thin gold leaf were suspended face-to-face from a metal rod. The rod passed through a cork in the top of the box and was terminated with a brass disk on its outer end.

A charged object near the disk would cause a similar charge to be



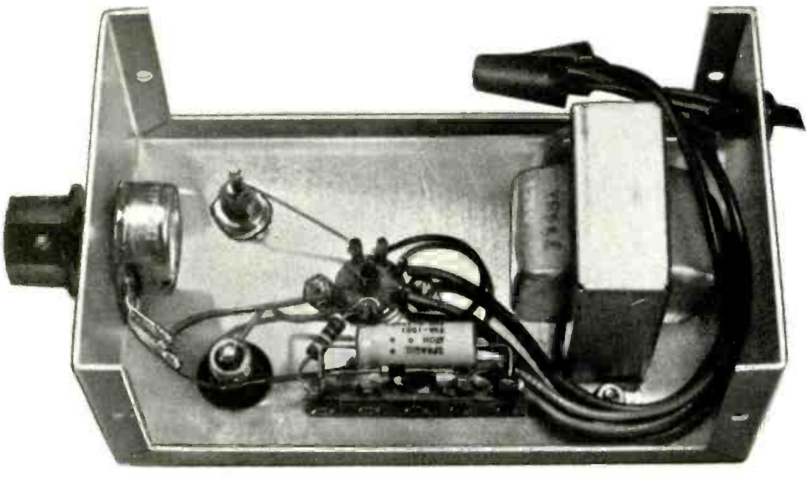


Photo showing how the author assembled his prototype of the electronic electroscope on an aluminum chassis.

induced on the leaves of the electroscope. Since like charges repel, the equally charged gold leaves would repel each other and move apart, with the degree of divergence a function of the strength of the charge. The polarity of a charge could be determined by bringing another charged object near the disk. If the leaves remained diverged, both charges were of the same polarity. However, if the leaves collapsed and then diverged again, the charges were of opposite polarity. External factors such as high humidity and ionizing radiation were observed to cause the rapid dissipation of electrostatic charges as evidenced by the collapse of the leaves of the electroscope when these factors were present.

Later experiments, with so-called "current electricity" from batteries and generators, would reveal responses by the electroscope similar to those produced with static electricity. Eventually, the brass enclosure originally used by Bennet was supplanted by a simple glass jar or flask, and the fragile gold leaves found substitutes in thin foils of tin or aluminum. Since the price of gold prohibits the duplication of the gold-leaf electroscope, we can turn to vacuum-tube technology to create an electronic counterpart of the static electricity detector.

Circuit Operation. As shown in Fig. 1, remote cut-off pentode, *V1*, whose operating bias is set by *R2*, acts as a switch connected across neon lamp *I1*. The control grid of *V1* (pin 1) is floating, thus producing an extremely high input impedance. This makes the circuit very sensitive to electrostatic fields such as those that appear around objects charged with static electricity. These fields are then picked up by a "sense antenna" connected to the control grid.

When the control grid is not under the influence of an electrostatic field, it has little affect on the flow of current through *V1*, thus the tube conducts. The degree of conduction is determined by the setting of bias potentiometer *R2*. When *V1* conducts heavily, it reduces the voltage across *I1*, forcing the lamp to turn off.

If a negative voltage is induced on the control grid by an external negative electrostatic field, *V1*'s conduction is reduced thus allowing more voltage to reach the lamp so that it glows brightly. Since only a small voltage swing on the control grid is required to control the tube, the circuit is quite sensitive. (Note: Although the neon lamp requires about 65 volts to strike, it will remain glowing until the voltage across it falls to less than approximately 50 volts.) The relatively high resistance of *R1* reduces the hysteresis of the circuit, which improves circuit sensitivity.

To detect a positive charge, *R2* is set near maximum resistance. This reduces the shunting affect of *V1* (which is still conducting somewhat) and allows *I1* to glow. When a positive charge is induced on the control grid, *V1*'s conduction increases, dropping the voltage across *I1* and extinguishing the lamp. This reverse operation of the circuit gives a decisive indication of a positive charge.

Transformer *T1* provides filament voltage for *V1*, with *D1* and *C1* forming a halfwave rectifier power supply. Resistor *R1* limits lamp current to a safe level.

Construction. The Electronic Electroscope was built in an aluminum minibox measuring 5¼"L X 3"W X 2⅛"D, but any suitable metal enclosure will do. Arrange the components to fit your enclosure, then mark and drill holes for the *V1* socket, the neon lamp bushing, *J1*, and *R2*. Orient the tube socket so that the lead from pin 1 to *J1* is as short as possible (do not route this wire close to the chassis). If you want the ultimate in sensitivity and low leakage, use a ceramic tube socket and feed-through insulator for the sense antenna connection.

Vacuum tube *V1* should be a remote cut-off or variable-mu pentode for best results. Some representative types are 6BA6, 6BD6, 6SG7, and 6SK7. The 12-volt versions of these tubes will also work if a transformer with a 12.6-volt filament winding is

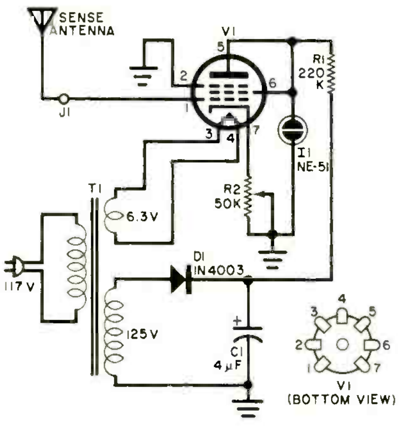


Fig 1. The circuit uses a variable-mu pentode whose operating bias is set to make the control grid extremely sensitive.

PARTS LIST

C1—4-µF, 200-V electrolytic
D1—1N4003 or similar rectifier
I1—NE-51 or NE-2 neon lamp
J1—5-way insulated binding post (see text)
R1—220-kΩ, ½-W resistor
R2—50-kΩ linear-taper potentiometer
T1—125-V, 15-mA; 6.3-V, 0.6-A transformer (Stancor PS-8415, Triad R54X, or similar)
V1—6BA6 or 6BD6 (see text)
Misc.—7-pin tube socket, line cord, terminal strip, knob for R2, neon-lamp rubber grommet, metal enclosure (LMB 780, Radio Shack 270-238, or similar), rubber feet, wire, mounting hardware.

used. The tube socket connections shown in the schematic are for types 6BA6 or 6BD6 or their 12-volt equivalents. Refer to any vacuum-tube manual for information on alternative tube types.

Mount the neon lamp in a snugfitting rubber grommet. Connections to the lamp are made by soldering directly to the base shell or leads, as appropriate. Neon lamp types other than those called out in the parts list can also be used; but they will probably require an adjustment in the value of *R1*. As a starting point, make *R1* equal to the resistor recommended for operation of the lamp on 115 V ac. This information is usually shown in the catalogs. Also, *R1* may have to be adjusted if a transformer supplying other than 125 volts rms is used.

Diode *D1* and capacitor *C1* must both have voltage ratings of at least one and one-half times the transformer rms voltage. Mount them on a terminal strip near the tube socket, being sure to observe correct polarity.

No power switch was felt to be necessary so the line cord was connected directly to the transformer primary leads. You may choose to leave the transformer leads uncut in case you want to use it again.

The sense antenna can be made of a piece of stiff wire about 8″ long. This length has good sensitivity and permits fast response to electrostatic fields. Form the end of the wire into a loop to remove any possible hazard. Longer antennas, or a metal plate mounted just above the chassis, will store a charge for a longer time than a short wire. However, this slows down the response time (which of course, may be desirable).

Operation. Turn the power on and allow the tube to warm up. The neon lamp should light immediately, but it may go out as the tube begins to conduct. Rotating *R2* throughout its range should cause the lamp to turn on and off as you adjust the control. If the neon lamp remains glowing at all settings of *R2*, you may be carrying a static charge caused by rising from a chair or from walking about the room. This may be verified by stepping a few feet away from the sense antenna. If the lamp persists in remaining lighted, try reversing the line cord plug in the socket or connecting the metal chassis to a good earth ground. If the lamp still cannot be controlled by *R2*, increase the resistance of *R1*. When the circuit is operating properly, the lamp will light when *R2* is set toward the high-resistance end of its range and it will go out as *R2* is adjusted downward.

Set *R2* just below the point where the lamp lights. This is the most sensitive position for detecting negative static charges. Pass a plastic comb through your hair and bring it near the sense antenna. The lamp should light, possibly while the comb is still several feet away. If you continue to approach the antenna, the lamp will get brighter, but avoid actually touching the antenna with the comb. Although contact with the antenna does no harm, it may take several minutes for the charge to dissipate from the grid circuit. If this happens, normal operation may be quickly restored by momentarily grounding the antenna to the chassis. Do not touch the antenna with your hands, as you may only add to the charge. Instead, connect a wire to the chassis and touch the antenna with the other end of the wire for a second or two. The circuit should now operate normally again. Alternatively, a 15- or 20-megohm resistor can be connected permanently from the sense antenna to chassis ground allowing rapid dissipation of heavy charges. To experiment with positive electrostatic charges, adjust *R2* just above where the lamp first lights.

A good way to get a positive charge is to vigorously rub a glass rod (or any clean glass object) with a silk cloth. Bring the glass near the Electronic Electroscope and the lamp will go out. Note that, because a positive charge causes grid current to flow in *V1*, the grid impedance is much lower and it will be difficult to keep the lamp turned off using the charge stored on the sense wire. If you want to store a charge for a longer period, try connecting a good-quality capacitor from the antenna to the chassis ground. Polystyrene or mica capacitors have low leakage and should give good results. You can experiment with different values to get the results you want. Of course, the traditional Leyden Jar Capacitor often employed in experiments with static electricity can also be used, but avoid connecting heavily charged capacitors.

If you work with MOS-type semiconductors, or if you are troubled by static sparks zapping your personal computer when you touch it, this gadget can give a warning that you are carrying a static charge. Set the unit up to detect negative charges for this application. Your family and friends will also find it amusing to see who can turn on the lamp at the greatest distance or to test various materials for their static properties. ◊

BY RANDY CARLSTROM

DESIGNING WITH THE 8080 MICROPROCESSOR

Part 5: Morse Code Hardware Interface

THE interface required for the Morse program described in Part 4 of this series consists of one parallel input port and one parallel output port, as shown in Fig. 23. The Morse program was originally written for a system which incorporated a printer or CRT as the output medium. If a printer or CRT is not available, the output display shown in Fig. 24 may be used in conjunction with the necessary program changes given in Table I.

In Fig. 23, *IC2* and *IC3* constitute the Port-Select logic, which decodes I/O port FC. Pin 1 of *IC3B* responds to an IN FCH instruction by going high; pin 4 of *IC3A* goes high in response to an OUT FCH instruction. *IC1* latches the output data during an OUT FCH instruction, the output of which may be connected to a printer, CRT, or the single-character display shown in Fig. 24. *IC4* performs the function of buffering and gating the input data byte onto the CPU Data Bus during an IN FCH instruction. Only bit 0 (pin 2 of *IC4*) is used by the Morse program; the remaining input bits may be used in other applications if desired. *IC5* functions as a form of A/D converter. It has one analog input which accepts audio voltages (such as from a radio receiver's speaker) and one TTL-com-

TABLE I—SUBSTITUTE SUBROUTINE

```
0000                0100 * * * * * * * * * * * * * * * * * * * * * * * * * * *
0000                0105 *
0000                0110 * THIS IS A SUBROUTINE WHICH MAY BE USED IN PLACE OF
0000                0115 * THE ORIGINAL "OUT" SUBROUTINE IN THE MORSE PROGRAM.
0000                0120 * IT WAS WRITTEN PRIMARILY FOR USE WITH THE SINGLE-
0000                0125 * CHARACTER DISPLAY DESCRIBED ELSEWHERE IN THIS ARTICLE.
0000                0130 * THE FIRST LETTER OF EACH RECEIVED WORD IS OUTPUT IN
0000                0135 * UPPER-CASE, WHEREAS THE REMAINING LETTERS OF THE WORD
0000                0140 * ARE OUTPUT IN LOWER-CASE. THIS MAKES IT EASIER TO
0000                0145 * IDENTIFY WORD SPACES WHEN USING THE SINGLE-CHARACTER
0000                0150 * DISPLAY.
0000                0155 *
0000                0160 *
0000                0165       ORG OUT     BEGIN ASSEMBLY AT ORIGINAL "OUT" ADDR
00BB                0170 *
00BB C5             0175 OUT   PUSH B      WANT TO RETURN WITH REG. B UNALTERED
00BC FE 41          0180       CPI 'A'     MODIFY ONLY ALPHABETIC CHARACTERS
00BE DA D1 00       0185       JC DSPLY
00C1 FE 5B          0190       CPI '2'+1
00C3 D2 D1 00       0195       JNC DSPLY
00C6 47             0200       MOV B,A     SAVE ACCUMULATOR TEMPORARILY
00C7 3A FF 0B       0205       LDA PSTN    PUT WORD FLAG INTO ACCUMULATOR
00CA 1F             0210       RAR         ROTATE FLAG BIT INTO CARRY BIT FOR
00CB 78             0215       MOV A,B     TESTING AND RESTORE ACCUMULATOR
00CC DA D1 00       0220       JC DSPLY    SEND LETTER AS UPPER-CASE IF NEW WORD
00CF F6 20          0225       ORI 20H     ELSE CONVERT TO LOWER-CASE
00D1 F6 80          0230 DSPLY ORI 80H     SET DISPLAY ENABLE BIT
00D3 D3 FC          0235       OUT CW      SEND CHARACTER TO LATCH
00D5 AF             0240       XRA A
00D6 32 FF 0B       0245       STA PSTN    CLEAR WORD FLAG
00D9 C1             0250       POP B       RESTORE REG. B TO THE WAY IT WAS PRIOR
00DA C9             0255       RET         TO ENTERING THIS SUBROUTINE AND RETURN
00DB                0260 *
00DB                0265 * * * * * * * * * * * * * * * * * * * * * * * * * * *
00DB                0270 *
00DB                0275 * IF THE ABOVE ROUTINE IS USED IN PLACE OF THE ORIGINAL
00DB                0280 * "OUT" ROUTINE IN THE MORSE PROGRAM, THE FOLLOWING
00DB                0285 * CHANGES MUST ALSO BE MADE:
00DB                0290 *
00DB                0295 *
00DB                0300       ORG CRLF
00AC                0305 *
00AC C9             0310 CRLF  RET         SUPRESS ALL CAR. RET.'S AND LINE FEEDS
00AD                0315 *
00AD                0320 *
00AD                0325       ORG IPSTN
00DB                0330 *
00DB C9             0335 IPSTN RET         DON'T UPDATE PRINTER POSITION COUNTER
00DC                0340 *
00DC                0345 *
00DC                0350       ORG SPOUT
00E3                0355 *
00E3 3E 01          0360 SPOUT MVI A,01    SET WORD FLAG RATHER THAN SENDING
00E5 32 FF 0B       0365       STA PSTN    A SPACE, THEN RETURN
00E8 C9             0370       RET
00E9                0375 *
00E9                0380 * * * * * * * * * * * * * * * * * * * * * * * * * * *

CRLF     00AC     0300
DSPLY    00D1     0185 0195 0220
IPSTN    00DB     0325
OUT      00BB     0165
SPOUT    00E3     0350
```

patible output (pin 5). The output goes low whenever audio of sufficient amplitude (from a received dot or dash) is present at the input, and is high in the absence of audio (spaces).

Turning our attention now to Fig. 24, we find that *IC7* converts the ASCII code latched in *IC1* (which was output by the Morse program) into a multiplexed 5-bit code necessary for driving the alphanumeric display *DIS1*. *IC6*, *IC10*, *IC11*, and buffers *IC8* and *IC9* complete the interface to *DIS1*. Bit 7 of the output latch (the unused parity bit) is used to turn the display on or off; setting this bit to 1 enables the display.

Installation and adjustment of the interface is straightforward. Connect *J1*, *J2*, and *J3* of the interface to *P1*, *P2*, and *P3* of the CPU module using three 16-conductor ribbon cables, and the audio input of the interface to your receiver's speaker. Install the ROM containing the Morse program machine code in the *IC5* socket of the CPU module.

Apply power and adjust the receiver volume to a comfortable listening level. Then tune the receiver to a spot where no signals are present and adjust sensitivity control *R1* until *LED1* lights. Now back off *R1* just past the point where *LED1* extinguishes. This is the point of maximum sensitivity of the detector,

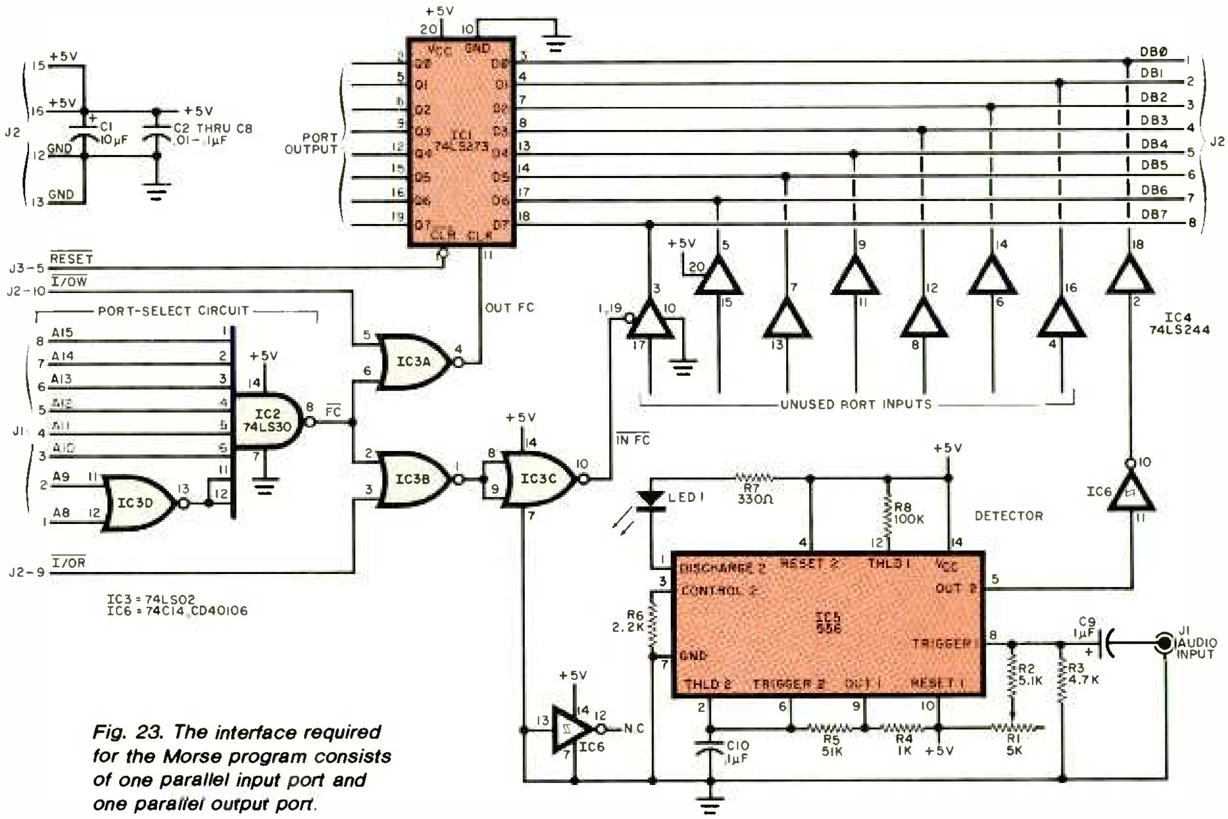


Fig. 23. The interface required for the Morse program consists of one parallel input port and one parallel output port.

TABLE II—MORSE INTERFACE TEST PROGRAM

0000	31 FF OB	LXI SP, OBFFH	(Initialize Stack Pointer to end of RAM area)
0003	CD 00 01	LOOP CALL TEST	(Call the test subroutine)
0006	C3 03 00	JMP LOOP	(Do it again)
0100	3E 41	TEST MVI A,41H	(Load accumulator with the ASCII (character code for "A")
0102	F6 80	ORI 80H	(Set display-enable bit)
0104	D3 FC	OUT FCH	(Sent data byte to the port)
0106	DB FC	IN FCH	(Read the port too)
0108	C9	RET	(and return to main program)

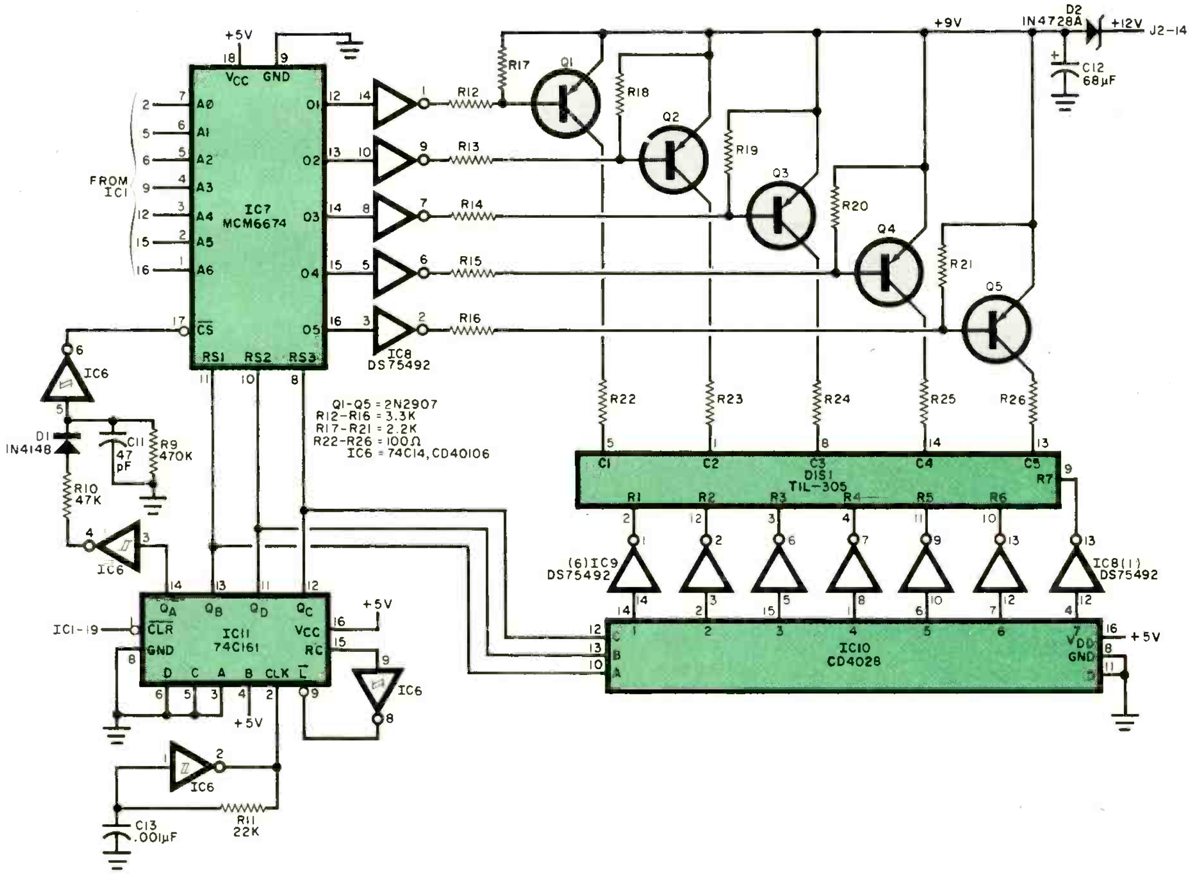


Fig. 24. The output of the interface can be connected to a single-character display as shown here.

PARTS LIST

C1—10-μF, 10-V tantalum capacitor
C2 through C8—0.01-μF or 0.1-μF capacitor distributed near ICs
C9—1-μF, 10-V tantalum capacitor
C10—0.1-μF disc ceramic capacitor
C11—47-pF disc ceramic capacitor
C12—68-μF, 15-V tantalum capacitor
C13—0.001-μF disc ceramic capacitor
D1—1N4148 switching diode
D2—1N4728A 3.3-V Zener diode
DIS1—TIL-305 5×7 alphanumeric LED display
IC1—74LS273 octal D-flip-flop
IC2—74LS30 8-input NAND gate
IC3—74LS02 quad 2-input NOR gates
IC4—74LS244 octal noninverting tristate buffers/receivers
IC5—LM556C dual timer
IC6—74C14 or CD40106 hex Schmitt-trigger inverters
IC7—MCM6674 5×7 character generator (Motorola)
IC8, IC9—DS75492 MOS-to-LED hex digit drivers
IC10—CD4028 BCD-to-Decimal decoder
IC11—74C161 or CD40161 binary counter
J1, J2, J3—16-pin DIP socket
LED1—Red LED
Q1 through Q5—2N2907 or PN2907 transistor
Unless otherwise specified, the following are ¼-watt, 10%-tolerance, fixed carbon-composition resistors:
R1—5-kΩ, PC-mount potentiometer
R2—5.1 kΩ
R3—4.7 kΩ
R4—1 kΩ
R5—51 kΩ
R6, R17 through R21—2.2 kΩ
R7—330 Ω
R8—100 kΩ
R9—470 kΩ
R10—47 kΩ
R11—22 kΩ
R12 through R16—3.3 kΩ
R22 through R26—100 Ω, ½-W
Misc.—IC sockets, Vector board or printed-circuit board, wire-wrap wire or solder, etc.

which is usually a one-time adjustment since various signal strengths and noise conditions may be compensated for by adjustment of the receiver volume level. The interface can be tested by using the program shown in Table II.

The Morse program is now operational. In crowded band conditions, it is especially important that the receiver have adequate selectivity, or the Morse program will not know which signal to lock on to. Code speed variations are automatically tracked and compensated for by the program.

The Morse program may also be used in conjunction with a code-practice oscillator for code practice or troubleshooting of the interface. It has also proven to be a very effective aid in learning the Morse code since each Morse character may be seen immediately after it is heard, making it easier to associate the Morse "sounds" with the characters they represent.

Next month we will discuss programming the CPU ROM. ◇

A SIMPLE SHORTWAVE CONVERTER FOR ANY AM RADIO

Inexpensive device enables AM radios to receive shortwave broadcasts

BY JEFF HIRSCHL

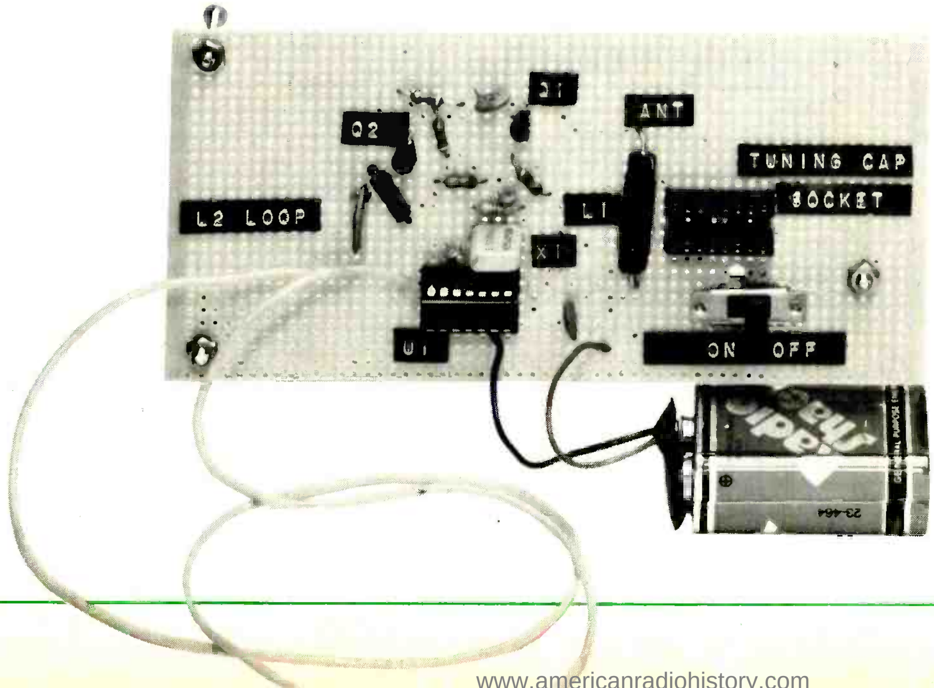
YOU can hear dozens of powerful English-language broadcasts offering news, music, and drama from all parts of the globe night and day—but only if you have a shortwave receiver. If you've never been involved with shortwave and want to see if you'd like to pursue this hobby seriously, without a significant investment, here's a little converter which can be built for about $13. It lets you use an ordinary AM radio to receive broadcasts in the 60-meter tropical band (4750 to 5060 kHz) and the 49-meter band (5950 to 6200 kHz), two of the 11 SW bands available.

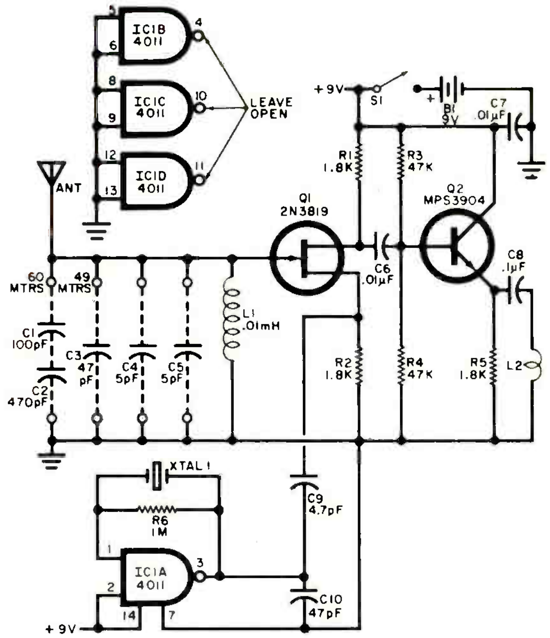
Although performance does not stand up to that of a good shortwave receiver, this converter is more than adequate for an introduction to shortwave listening and at a great deal less money. With the recommended 10-foot antenna, signals from *Radio Nederland*, the *BBC*, *Radio Canada International*, and the *Voice of America* can be easily received on the 49-meter band. On the tropical 60-meter band, so called because of the location of the stations that use it, signals can be received from as far away as Colombia and Venezuela.

About the Circuit. As shown in the schematic, a CMOS NAND gate, *IC1A*, and a TV color-burst crystal, *X1*, form a local oscillator operating at 3579 kHz. The fundamental frequency of this oscillator is used for 60-meter band reception, while the second harmonic is used for the 49-meter band. The oscillator signal is fed to the source of mixer transistor, *Q1*. Meanwhile, the incoming signal from the antenna is tuned by plug-in capacitors, *C1* to *C5*, and is fed to the gate of *Q1*. The two signals "mix" in *Q1* to provide an output in the standard broadcast band, which appears at the drain of *Q1*. This output is coupled by *C6* to amplifier transistor, *Q2*, which boosts it to a level and impedance suitable to drive the broadcast radio's loop antenna. The signal for the broadcast radio is provided by a loop, *L2*, wound around the radio and driven by the emitter of *Q2*.

Construction. The circuit may be built on any circuit board which can accept 14-pin DIP sockets for *IC1* and the input tuning capacitors *C1* to *C5*. Use point-to-point wiring and try to keep lead lengths as short as possible. Use care in soldering to avoid cold solder joints and wiring errors.

To reduce the risk of static damage, use a socket at *IC1* and leave the IC out during assembly. Be careful to wire this socket correctly, avoiding





A local oscillator, which includes a TV color-burst crystal, operates at 3579 kHz. The fundamental of this frequency is used for 60-meter reception and the second harmonic for the 49-meter band.

PARTS LIST

IC1—4011 quad NAND gate
X1—3.579-MHz, color-burst crystal
Q1—Small-signal FET (2N3819, MPF102, or equivalent)
Q2—General-purpose npn transistor (2SC391, 2N3904, or equivalent)
L1—0.01-mH r-f choke
L2—See text
C1—100-pF disc or mica capacitor
C2—470-pF disc or mica capacitor
C3, C10—47-pF disc or mica capacitor
C4, C5—5.0-pF disc or mica capacitor
C6, C7—0.01-µF disc capacitor
C8—0.1-µF disc capacitor
C9—4.7-pF disc or mica capacitor
R1, R2, R5—1.8-kΩ, ¼-W resistor
R3, R4—47-kΩ, ¼-W (or ½-W) resistor
R6—1-MΩ, ¼-W (or ½-W) resistor
S1—Spst subminiature switch
Misc.—Circuit board, IC sockets, battery, battery clips, etc.
Note: All resistors are ±15%; all capacitors are 50-V dc; use a single 82-pF capacitor in place of C1 and C2 if desired.

shorts. It may be helpful to position the leads for pins 1, 2, and 3 alternately toward and away from the center of the socket to reduce the crowding of the pins.

Mount another DIP socket close to *L1*, bus together all of the pins on one side of this socket, and connect to one side of *L1*. Then do the same with the pins on the other side of the socket and connect to the opposite side of *L1*. Try to keep the leads between the socket and *L1* as short as possible. Capacitors *C1* to *C5* will be inserted into and removed from this socket to tune the input circuit to the proper frequencies. Trim the leads on these capacitors to 3/8 inch before inserting into the DIP socket. For the 49-meter band, *C3* and *C4* alone will be used. *C1*, *C2*, *C4*, and *C5* will be used for the 60-meter band. You will add and remove 5-pF capacitors to "peak" shortwave signals.

The output loop, *L2*, should be placed on the AM radio after all other wiring is completed. Set the radio in its normal operating position, then wind the loop vertically around the middle of the radio from front to rear. Do not make any connections or windings inside the radio. You will move the loop on the radio during testing to obtain maximum performance.

The finished converter can be mounted on a small block of wood if you don't need portability. For portable use, enclosing it in a plastic case is ideal. If this is to be done, build the project using as little of the circuit board as possible to minimize the size of case required.

Testing the Converter. Since the bands covered are generally useful only during darkness, make your first test of the converter after sunset. Plug *C3* and *C4* (49-meter band) into the input-capacitor DIP socket, and insert *IC1* into its socket. Wrap *L2* around the AM broadcast radio. Connect about 10 feet of wire to *L1* to serve as the antenna. You can directly solder the antenna wire to *L1* or, preferably, use an alligator clip at the end of the wire to fasten it there. An arrangement using a binding post mounted on the circuit board is all right, too.

The Table shows the portions of the AM broadcast-band dial to which shortwave stations are converted for the two bands. Tune for stations in the 49-meter band first. Connect the battery, switch on the converter, and tune between 960 and 1100 kHz. You should hear shortwave stations interspersed with standard broadcast signals. Removing the antenna or disconnecting power from the converter will make a shortwave station disappear, while a broadcast band signal will stay. Tune in a shortwave signal and move the *L2* loop from side to side on the radio to peak the signal. Then remove and add 5-pF capacitors in the DIP socket until the maximum signal is obtained.

If a signal generator is available, you can use it to test the converter instead of using signals on the air. Set the generator to 6000 kHz with a modulated signal and place its output lead near the converter's antenna. Then tune the broadcast radio around 1158 kHz until the signal is heard. Peak the circuit as described above.

If the converter will not operate, try

CONVERTING SHORTWAVE BANDS TO BROADCAST-BAND FREQUENCIES

Meter Band	Broadcast Dial	Total Capacitance	Conversion Formula
60	1170-1480	87-97	Fb = Fs − 3579
49	960-1200	52-57	Fb = 7158 − Fs
WWV (2500 kHz)	1079	360-380	

Note: The formula converts specific shortwave frequencies to broadcast frequencies. Fb is the standard broadcast frequency in kHz. Fs is the shortwave frequency in kHz. "Total Capacitance" shows the capacitance used in the input circuit to tune the various frequencies.

moving the *L2* loop from side to side. If this doesn't produce results, try winding the loop vertically side to side on the radio instead of front to rear.

In the U.S., almost all of the signals you will receive on the 60-meter band will be low-powered, domestic shortwave stations from Central and South America. Wait until later in the evening to try this band because it doesn't normally stabilize until then, especially in summertime. Plug *C1*, *C2*, *C4*, and *C5* into the DIP socket and try tuning between 1300 and 1470, where the more audible signals will be converted. Station *WWV* has a transmitter in the 60-meter band at 5000 kHz which you should be able to hear (converted to 1421 kHz). You may find that another piece of wire connected to the ground side of *L1* and run in a direction away from the antenna wire improves reception. Try varying its length between 3 and 10 feet. This wire may also provide an improvement in the 49-meter band. Experiment!

Although the converter was not specifically designed for it, reception of *WWV* may also be possible at 2500 kHz. The conversion frequency and capacitance are included in the Table. To achieve the proper capacitance, use any combination of capacitors in the DIP socket which add up to the proper value. During reception of this lower frequency signal, it will be necessary to use the wire connected to the ground side of *L1* that was described earlier. Reception of *WWV* at this frequency will be best during the winter months and in the West.

If you want to try a station listed in a log or magazine article, use the formulas in the Table to convert the listed shortwave frequency to the broadcast-band frequency for each of the covered bands.

Because the broadcast radio's loop antenna still receives the normal AM signals, it is possible that they will interfere with a desired shortwave signal. Rotating the radio may help by nulling out the offending signal. Be sure to keep *L2* in position on the radio while you rotate it.

Shortwave reception varies from season to season and even from night to night. So it is not at all unusual to receive a station as clearly as a local station one night and and not at all the next.

Though this unit is designed for beginners, even experienced listeners may enjoy using it. The unit, if enclosed in a plastic case, is great to take along on camping trips or while travelling. Happy listening! ◇

ADD A SAFE, CONVENIENT SHUTOFF TO SMOKE DETECTORS

Provides a 30-to-45-minute shutoff and restores power automatically

BY PAUL DANZER

SMOKE detectors are a common safety feature in the home nowadays. But when the alarm goes off, it doesn't always mean trouble. If a detector is mounted over a work bench, for example, smoke and fumes from soldering are often enough to set the alarm off. Also, smoke from frying or broiling of meats, such as bacon and lamb chops, can sometimes trigger the alarm. These false alarms are even more of a problem during the winter when windows and doors are sealed against the weather.

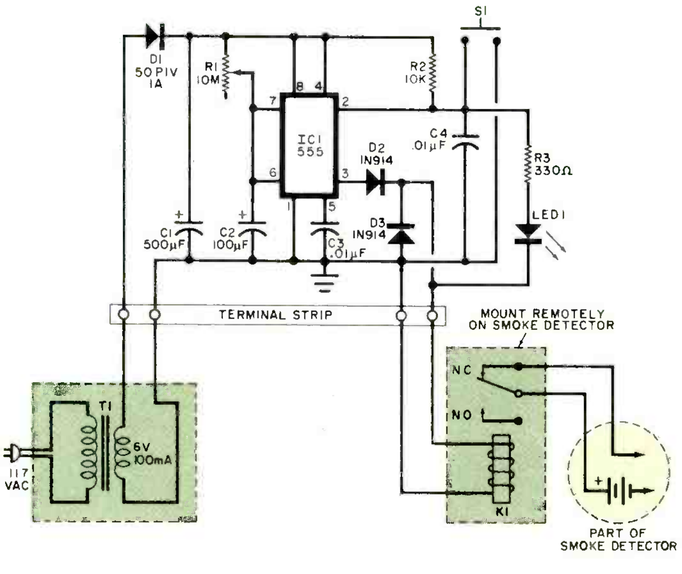
When the alarm goes off accidentally, one approach is to disconnect the smoke detector's battery (not always an easy job) and wait until the smoke has cleared. However, it's very easy to forget to reconnect the battery. The circuit discussed in this article provides a 30-to-45-minute shutoff period for any of the common smoke detectors, after which power is restored automatically.

Circuit Operation. Power is supplied to the circuit from a 120-volt transformer, *T1*. Any small UL-approved transformer, such as one salvaged from an old calculator battery charger, may be used. The transformer must be plugged into the 120-volt wall outlet and left there. The two low-voltage wires from the secondary are run to a small box which contains the circuit.

A 555 timer provides a delay period set by the 10-megohm potentiometer, *R1*, and the 100-µF capacitor, *C2*. When the smoke detector goes off, it can be silenced by pressing *S1*. This energizes relay, *K1*, which is remotely located on the smoke detector case. In addition, the LED goes on, showing that the smoke detector is silenced.

After a period of 30 minutes or so, as set by the potentiometer, the circuit goes off and the relay reconnects the battery to the smoke detector allowing normal operation.

A measure of safety is provided by the LED which indicates that the detector is off in the event of a lockup of the 555 timer (staying in "ON" state). Any other type of failure would not affect normal smoke detector operation because the relay would be in its unenergized state. Place the circuit with pushbutton in a small box at a convenient height. If the detector goes off inadvertently, simply press the button and the circuit will do the rest. It will save you the trouble of finding a chair, climbing up to remove the smoke detector cover, disconnecting the battery, and, hopefully, remembering to reverse the process sometime later. ◇



PARTS LIST

C1—500-µF, 25-V electrolytic
C2—100-µF, 10-V electrolytic
C3,C4—0.01-µF, 25-V capacitor
D1—50-PIV, 1-A rectifier
D2,D3—1N914 diode
IC1—555 timer
K1—Spdt, 5-V dc relay, coil resistance 50-Ω minimum.
LED1—Red light-emitting diode
R1—10-MΩ potentiometer
R2—10-kΩ, ¼-W resistor
R3—330-Ω, ½-W resistor
S1—Spst, momentary-contact, pushbutton switch
T1—6-V, 100-mA transformer (see text)
Misc.—IC socket, perf board, wire, solder, enclosure (approx. 3" x 2" x 2"), terminal strip, etc.

Popular Electronics Tests

Keithley Model 128 DMM

THE Keithley Model 128 Digital Multimeter was designed for the general-purpose service market. It offers 0.5% basic accuracy, 3½-digit, 0.6″ LCD display, resolution to 1 mV/0.1 ohm, 10-ampere ac/dc current capability, and resistance measurements to 20 megohms. One of its interesting features is a presettable "beeper" that operates on all ranges and functions. The beeper functions in conjunction with a set of arrowheads on the LCD readout. When a measurement is above the preset threshold, an arrow pointing up is displayed; and when the reading is below the predetermined level, the arrow points down. The beeper can be turned off if desired without affecting the arrowhead display. It does not affect circuit loading on any range or function.

Model 128 also features a diode test function in which a single junction is tested at 1 mA. This allows testing of LEDs and multiple junction devices such as Darlingtons and eliminates confusion between two forward-biased diode drops and an open junction.

The unit is 7″L x 3″W x 1½″ D and weighs 11 oz. Manufacturer's suggested retail price is $139.

General Description. The instrument features four dc voltage measurement ranges between 2 and 1000 volts with a resolution of 1 mV on the lowest range, and 1 volt on the 1-kV range. The ac function also has four ranges from 2 volts to 750 volts with the same resolution as for dc volts. The frequency range is from 45 to 500 Hz; the voltage reading is an average calibrated in terms of the rms value of a sine wave.

Resistance can be measured in four ranges between 200 ohms and 20 megohms full scale, using an open-circuit voltage of less than 0.4 volt on the two highest ranges.

Model 128 does not have conventional mA current ranges. However, a 10-ampere range is provided for both ac and dc. Accuracy is 1.5% on dc and 2% on ac, with resolution of 10 mA on both functions. Ac current measurements can

MANUFACTURER'S SPECIFICATIONS

DC Volts:
Resolution: 2-V range—1 mV
20-V range—10 mV
200-V range—100 mV
1000-V range—1 V
Accuracy (1 year): ±0.5% of reading + 1 digit (18 - 28°C)
Maximum allowable input: 1000 V dc or peak ac
Input resistance: 10 megohms
Normal-mode rejection ratio: Over 56 dB at 50 or 60 Hz
Common-mode rejection ratio: Over 100 dB at dc, 50 or 60 Hz (1000-ohm unbalance)

AC Volts:
Resolution: 2-V range—1 mV
20-V range—10 mV
200-V range—100 mV
750-V range—1 V
Accuracy (1 year): ±1% of reading + 5 digits (18 - 28°C)
Frequency range: 45 to 500 Hz
Maximum allowable input: 100 V peak
Input impedance: 10 megohms shunted by less than 100 pF
Response: Average responding, calibrated in rms of a sine wave

Resistance:
Range: 200 ohms
Resolution: 100 milliohms
Accuracy: ±0.5% + 3 digits
Full-scale voltage: less than 0.3 V
Range: 20 kilohms
Resolution: 10 ohms
Accuracy: ±0.5% + 1 digit
Full-scale voltage: less than 0.3 V
Range: 2 megohms
Resolution: 1 kilohm
Accuracy: ±0.5% + 1 digit
Full-scale voltage: less than 0.4 V
Range: 20 megohms
Resolution: 10 kilohms
Accuracy: ±2% + 1 digit
Full-scale voltage: less than 0.4 V
Diode test: On-scale reading for 1 or 2 forward-biased silicon diodes (at 1 mA)
Maximum open-circuit voltage: 3.2 V on diode test and 200-ohm ranges, 0.8 V on other ranges
Maximum allowable input: 300 V dc or rms

DC Amperes:
Range: 10 A
Resolution: 10 mA
Accuracy: ±1.5% + 1 digit
Max. full-scale voltage load: 0.3 V
Max. allowable input: 20 A for 15 s (unfused)

AC Amperes
Range: 10 A
Resolution: 10 mA
Accuracy (45-500 Hz): ±2% + 5 digits
Max. full-scale voltage load: 0.3 V
Max. allowable input: 20 A for 15 s (unfused)

be made between 45 and 500 Hz. Voltage burden in either mode is 0.3 volt. Complete specifications are shown in the Table.

The shatterproof ABS plastic case has the LCD panel recessed below a protective rim. The two controls—range and function (which also contains the power on/off switch)—are also recessed below the top plate and have thumbwheel knobs that enable easy setting. The lower portion of the top side is sloped downward and contains five banana jack connectors for ohms, volts, and their common, and the common-high connectors for the 10-ampere ranges. The case and controls are color-coded in shades of brown, with white lettering.

The underside of the case contains the battery (9-volt) holder snap-in cover and a smaller snap-in cover over the threshold detector controls. There are also four skidproof buttons for fret on the bottom of the case. There is no tilt stand. The beeper on/off switch is mounted on the right side.

Optional accessories include Model 1301 Temperature Probe ($89), Model 1304 Soft Carrying Case and Handle ($10), Model 1306 Deluxe Carrying Case ($25), Model 1600A High-Voltage Probe ($79), Model 1681 Clip-On Test Lead Set ($6), Model 1682A R-F Probe ($79), Model 1683 Universal Test Lead Kit ($10), Model 1685 Clamp-On Current Probe ($75), and the Model 1691 General-Purpose Test Leads ($6).

Comments. The Keithley Model 128 Digital Multimeter was tested by the Lockheed Electronics Instrumentation Measurements Laboratory (Plainfield, NJ) against standards traceable to the National Bureau of Standards and met specifications in all respects.

As is usual for these reviews, we used the Model 128 on our workbench for several weeks to get the "feel" of the instrument. During these tests, we try to use any unusual features or functions as much as possible.

The adjustable threshold/beeper combination does a fine job. (The setting of thresholds is covered in the instruction manual.) The beeper, while not too loud, is strong enough to be unmistakeable. We also found the diode test mode excellent for checking single- and multiple-function devices.

The only omission we noted—admittedly a small one—was the lack of a tilt stand. However, even when the instrument is lying flat on the workbench, the large readout remains easily visible.

Model 128 is an excellent low-cost portable digital multimeter. It performed well in the practical phase of our testing and should be at home on almost any test bench. With its beeper, it can be used by blind operators for some go/no-go situations. Having a beeper on all functions, rather than just a few, sets the Model 128 apart from other digital multimeters.— *Les Solomon*

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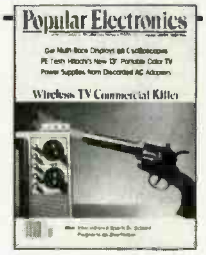

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FUNDAMENTAL FACTS

By Walter Buchsbaum

Noise Fundamentals

THE PRINCIPLES of noise should be understood by anyone in electronics. Equipment and circuit designers strive to minimize noise and most equipment specifications include at least one reference to "noise figure" or "signal-to-noise" ratio.

Definitions. *Noise*: Unwanted disturbances superimposed upon a useful signal that tend to obscure its information content.

Random noise: Transient disturbances occurring at random; spectral characteristics are like those of thermal noise.

White noise: Either random or impulse noise that has a flat frequency spectrum over the range of interest.

Thermal noise: The noise caused by thermal agitation in a dissipative body. (Generally, the result of thermal agitation from electrons in a resistance.)

Types of Noise. All electrical noise can be classified as either external noise, which originates outside the electronic circuit; or internal noise, which is generated by the circuit itself.

Table I lists the four types of external noise, together with their major causes, usual frequency ranges, and typical maximum levels. External noise is of concern in all types of radio communication and in radar operations. Because it is external, it can vary greatly over time and with one's geographic location.

Antennas affect the noise performance of a receiving system by their bandwidth, directivity, location, and inherent noise characteristics. The circuits connecting an antenna to the receiver input also contribute to noise and can be designed to minimize it. Probably the greatest design effort is focused on the receiver front end.

Internal noise is mostly due to thermal effects, originating at the receiver front end and amplified with the desired signal. In systems using FM or various forms of pulse modulation, other undesirable effects such as phase jitter, bounce, and pulse-width variations, are also classified as noise. They require different measurement and reduction techniques than other noise.

Noise Measurement. The mean square value of the thermal noise voltage is

$$E^2 = 4\,R\,kTB$$

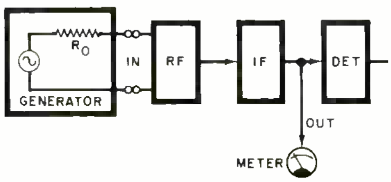
where: R = resistive component of the impedance
k = Boltzmann's constant (1.38×10^{-23} joules/°K)
T = temperature in degrees K
B = bandwidth in Hz (at 3-dB points)

In the temperate climate zone T is set so that 1.38 T = 400, which corresponds to about 17° C or 63° F. This makes $E^2 = 1.6 \times 10^{-20}$ RB

Example: A TV receiver has an input impedance such that R = 300 ohms with a bandwidth of 6 MHz. Then $E^2 = 1.6 \times 10^{-20} \times 300 \times 6 \times 10^6 = 28.8 \times 10^{-12}$. Taking the square root, we get E = 5.37 microvolts. To get a signal-to-noise ratio of 10 we would need a 53.7 microvolt signal from the antenna. In actual fringe area reception we normally expect to receive at least that much signal.

Figure 1 shows the test set-up for a simple noise factor measurement for any type of receiver. Generator resistance R_0 should be the same as the resistive component of the antenna or the transmission line.

With the generator connected but with the signal turned off, we record the reading on the output meter. Next, we turn the generator on at the correct



$$\text{NOISE FACTOR} = F = \frac{\text{NOISE OUT}/\text{NOISE IN}}{\text{SIGNAL OUT}/\text{SIGNAL IN}} = \frac{P_i 1}{KT_0 \Delta f}$$

Where P_i1 is the signal input power required to generate a signal-to-noise output ratio of 1.

k = Boltzmann's constant = 1.38×10^{-23} joules per degree Kelvin
T_0 = Reference temp. = 290° K
Δf = Bandwidth in Hz
($kT_0 = 400 \times 10^{-23}$)

Fig. 1. Setup for making receiver noise-factor measurements.

TABLE I—A SUMMARY OF EXTERNAL NOISE SOURCE

	Major Cause	Usual Frequency Range	Typical Max. Level	Remarks
Atmospheric Noise	Lightning in thunderstorms	Below 20 MHz	+30 to 40 dB	Varies with season and time of day. Worst near the Equator
Galactic Noise	Disturbances at sun and stars. (Sun spots and flares)	15 to 1000 MHz	+25 dB	Antenna's directivity can reduce its effect
Precipitation Noise	Rain, hail, snow or dust storms near antenna	Below 10 MHz	+50 dB	Smooth, rounded corners on an antenna, and proper grounding reduces this kind of interference
Man-made Noise	Anything that creates an arc or corona (neon signs, ignition systems, HV power lines)	Below 20 MHz	+50 dB	Worse in urban areas; varies with time of day

unmodulated carrier frequency, and increase the output until we obtain twice the previous reading on the meter. This gives us P_i1 in the noise-factor equation. If the generator output is indicated in micro or milliwatts we can use this figure, but if it is only available in micro or millivolts we have to convert the reading into power. (Power equals square of voltage, divided by resistance).

More accurate noise measurements involve the use of noise generators, bandwidth-limiting filters and attenuators, as well as dummy antennas and shielded rooms. For most practical applications, however, the method shown in Fig. 1 is adequate.

Example: Using the same TV receiver, we find that we have to increase the generator output to 5.37 microvolts to get twice the meter reading. This corresponds to P_i1. Divided by $kT_0 \times 6$ MHz we get a noise factor of 4.

In some specifications the term "noise factor" is used, while others use the term "noise figure." The "noise figure" is simply the "noise factor" stated in decibels: *Noise Figure (dB) = 10 log Noise Factor.*

SOLID-STATE DEVELOPMENTS

By Forrest M. Mims

Bubble Memory Developments

LESS THAN a year ago this column featured the magnetic bubble memory ("Solid-State Developments," March 1981). At that time bubble memories were very much in the news and at least four major domestic semiconductor companies were making commercial devices. AT&T was making bubble memories for in-house applications and several Japanese and European firms had entered or were preparing to enter the business.

Bubble memories are in the news again, but this time for a very different reason. Instead of announcing new bubble memory products, three of the four major United States bubble memory makers have abandoned the market altogether!

The first company to leave was Rockwell International. The firm will no longer offer commercial bubble memories and will instead concentrate on specialized military applications for the memory devices.

Texas Instruments withdrew from the bubble race shortly after Rockwell International. Prior to the withdrawal, the firm had added a removable bubble cartridge system to its line of bubble memories, support ICs and preassembled bubble memory cards. Like a similar system made by Fujitsu, the big Japanese computer company, only the memory chip itself was housed in the cartridge. All the required support electronics were installed on a board connected to the cartridge socket.

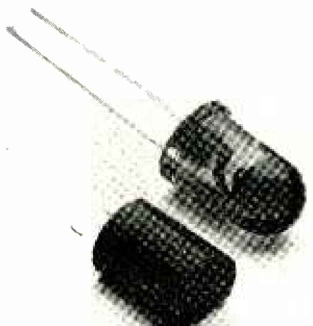
After Texas Instruments dropped out of the bubble market, National Semiconductor issued statements reaffirming its commitment to bubbles and predicting volume shipments of a 1-megabit bubble system by the end of 1981. But by August of last year National became the third bubble maker to bail out. The decision came too fast for the company to cancel upcoming trade magazine advertisements describing its line of bubble products. Some of the ads appeared in print weeks after the cancellation announcement.

The departure of these three firms from the bubble memory business leaves Intel as the only domestic supplier of commercial bubble memories. However, Motorola has announced plans to introduce a line of commercial bubble memories in the near future. Intel and Motorola may soon be joined by a third according to recent news reports. Some former employees from the three cancelled bubble programs have formed a new bubble memory company. But why did three major companies abandon this memory technology?

The high cost of bubble memories appears to be the big reason for companies leaving the business. TI's TM 990/210-3L 69K-byte, bubble memory board, for example, sold for $2,060. Prices were expected to fall as bubble technology was mastered. However, they have been unable to keep up with big price reductions for conventional magnetic disk memories and the new generation of large-capacity RAMs. Consequently, the market for bubbles has been soft.

At last report, Intel and Motorola had both reaffirmed their commitment to bubble memory technology. But the competition from Japan's Fujitsu and the new generation of RAMs will be rough. Already, 64K-bit RAMs are commercially available from many companies and memories with even bigger capacities are being developed.

Consider, for instance, what's happening in Japan. Nippon Electric Company (NEC) has built laboratory versions of a 256K-bit RAM which fits in a 16-pin package! Hitachi and Mitsubishi have also made 256K-bit RAMs and some Japanese firms are working on development of a 1-megabit RAM. To put these memory capacities in perspective, consider that a typical stripped-down home computer system may have only 32K bits of RAM!



A new infrared emitter and detector available from Litronix.

Even though magnetic bubbles have been bursting lately, the 1980's promises to be the decade of the biggest advances yet in solid-state memories. Watch this column for developments.

Miniaturized Core Memory. Remember the magnetic-core memory that once dominated computer memory technology? The Controlex corporation recently announced a product that is probably the world's smallest production-model core memory. Housed in a 14-pin DIP, the Controlex 120 contains a 4-bit core array capable of storing a single 4-bit nybble of data.

Since the device stores data without the need for electrical power, it is ideally suited for saving microprocessor status information during power outages or normal shutdowns. Though the standard model stores information sequentially, a parallel access version is available. Higher storage capacity modules are also available. For more information about this tiny core memory, which is compatible with TTL chips, contact Controlex Corp. (16005 Sherman Way, Van Nuys, CA 91406).

Solid-State Inflation? When someone complains about the high cost of solid-state components, I like to remind them about $18 infrared-emitting diodes (1969), $300 silicon transistors (late 1950's) and $250 microprocessor chips (1974). To realize how inexpensive solid-state components are, just browse through the ads in back issues of *Popular Electronics*.

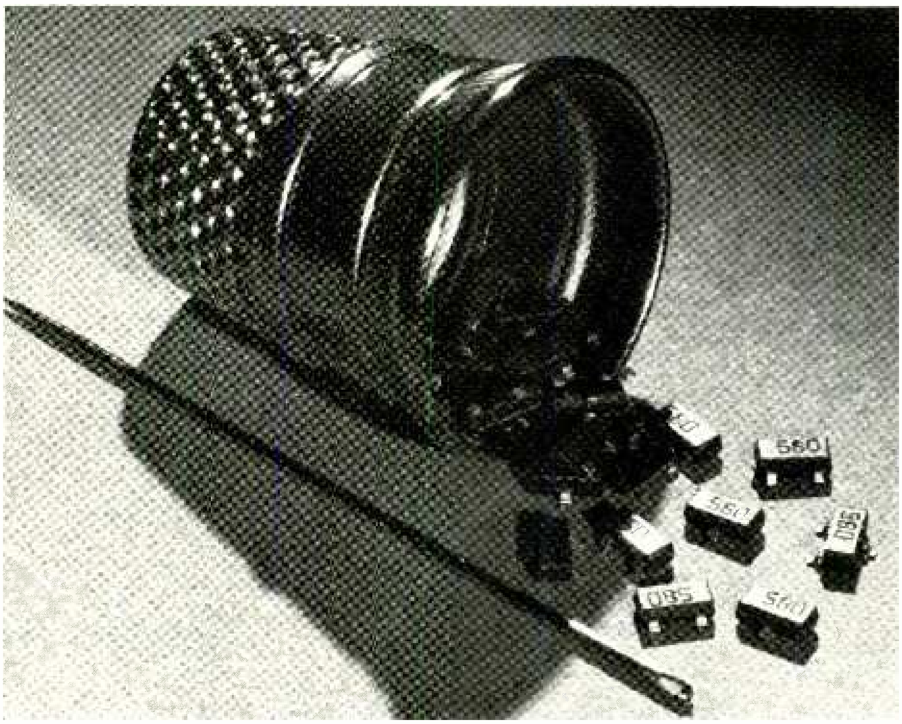
An ad which appeared in May 1970, for example, listed the 7490 decade counter for a whopping $5.50, the 7475 quad latch for $4.50, the 7441 BCD-to-decimal decoder for $6.50 and the 7493 4-bit counter for $4.95. The 709C op amp and the 710C comparator cost $1.69 each.

As you can see, a little over a decade ago even very common ICs, at least by today's standards, were very expensive. Remember also that the value of the dollar was at least twice then what it is now. What's more, the variety of ICs available today is far greater than ten years ago, and they can be conveniently purchased at many local electronics retailers or through mail order suppliers.

Solid-state inflation? Prices may level off and may even begin rising for some components. But those of us who enjoy experimenting with solid-state electronics have never had it so good.

New IR Emitter-Detector Pair. Speaking of inflation, infrared-emitting diodes and detectors have never been cheaper. And many companies are introducing both high-power emitters and fast-risetime photodiodes. The latest IR emitter-detector pair is from Litronix (19000 Homestead Road, Cupertino, CA 95014).

Litronix's new emitter, which is desig-



New temperature-sensing ICs from Motorola offer high accuracy and small size at low cost.

nated the LD-217, generates 10 milliwatts when biased at 100 milliamperes. A 7-milliwatt version (LD-271A) and 16-milliwatt version (LD-271H) are also available.

The photodiode is a fast-risetime pin detector housed in a black encapsulated package similar to the TO-92 transistor package. The black encapsulant acts as a filter that blocks visible radiation while transmitting near-infrared. Two versions of the detector are available, one sensitive on the rounded side (SFH-205) and the other sensitive on the flat side (SFH-206). A clear package version is also available (SFH-206K).

While the press release did not provide single-quantity prices for these devices, the 1,000-unit prices which were given would indicate the LEDs should be available in small quantities for under a dollar each. The pin photodiodes should be priced at about $2 each. These prices are competitive with other recently announced infrared emitting and sensing diodes and reflect the trend toward very low-cost, high-quality optoelectronic components.

Ultra-Small Temperature Sensor. This column has twice covered the increased use of the miniature SO package for integrated circuits (November 1980 and July 1981). Motorola has joined this trend by recently introducing an ultra-miniature, temperature-sensing chip housed in a three-terminal, SOT23 package.

Three versions of the new sensor are available: MMBTS102, 103 and 105. They have temperature accuracies of, respectively, plus or minus 2, 3 and 5 degrees Celsius.

The tiny size of these new sensors greatly speeds up their response to temperature changes. The thermal time constant for liquids is only 400 milliseconds. For air, it is less than 3 seconds. The voltage output as a function of chip temperature is linear within an error band of ±1 percent from −40° C to 150° C. This is comparable to platinum resistance wire, one of the traditional temperature measuring sensors.

Single quantity cost of the MMBTS102 is a surprisingly low $1.10. The 103 and 105 versions are 92¢ and 73¢, respectively. For more information, contact Motorola Sensors Marketing (P.O. Box 20912, Phoenix, AZ 85036). Before purchasing any of these sensors, make sure you are properly equipped to solder them into your circuits. Their small size precludes breadboarding.

CMOS Speeding Up. Experimenters who insist on using TTL or low-power TTL for their projects because of this family's high speed may have to think of a better reason for using it. In a joint effort to overcome the speed limitations of CMOS, National Semiconductor and Motorola have announced plans to make a series of CMOS chips patterned after the low-power Schottky TTL family.

The new series will use a 74HCXX designation. Speeds will be some twenty times faster than standard CMOS at 5 volts. Eventually, at least 100 CMOS equivalents of the LS family will be produced. The new devices will have the same pinouts as standard LS chips and will be rated for use at up to 30 MHz.

Since CMOS is by far my favorite logic family, I can hardly wait for a chance to experiment with some of these new chips. Those of you who are still dedicated TTL users will finally have access to a CMOS family of logic which should meet most of your needs.

An Oscilloscope Breakthrough. The most important piece of test equipment on my workbench is a laboratory-quality, 100-MHz oscilloscope. Until recently, good scopes such as I have cost several thousand dollars. They still do, but the Japanese have made major inroads in this market with comparatively low-priced, high-quality scopes.

Recently, Tektronix turned the tables on the Japanese scope makers by introducing a very high-quality, 60-MHz, dual-trace scope which sells for only $1100 complete with probes. While this price may be well beyond the budget of many hobbyists, serious experimenters should have a look at this new scope's specifications. They are impressive.

For more information, contact Tektronix, Inc. (P.O. Box 4828, Portland, OR 97208) and request literature on the TEK 2200 series of multipurpose oscilloscopes. If the price is too high for your budget or if you aren't satisfied with the scope's specifications, be patient. The very low price tag has already begun rumors about price cuts for competing scopes.

Since oscilloscopes are so important to solid-state electronics experimentation, I'll have much more to say about them in a future column or article in *Popular Electronics*. Many modern, high-speed circuits could not be effectively designed without the help of an oscilloscope. ◇


"I'm sorry, Mr. Cornhuck, but the new video-dish technology is not yet prepared for this type of eventuality."

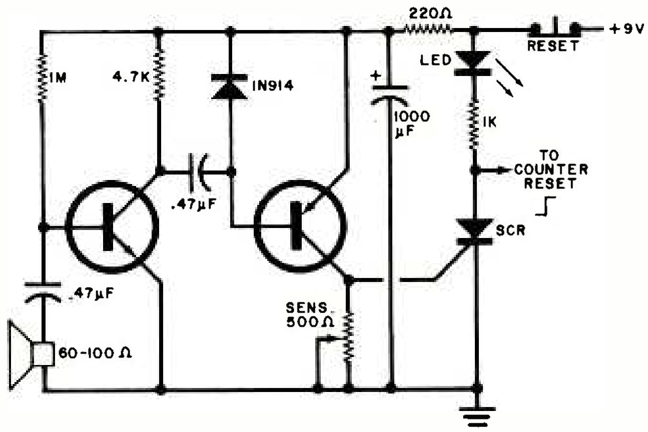
HOBBY SCENE

By Leslie Solomon
Senior Technical Editor

Sound-Activated Timer

Q. *I would like a circuit that will start my battery-operated timer for a race when the starter's pistol is fired. This will enable me to make accurate starting measurements during the races at my school. —David Lopez, Santurce, PR*

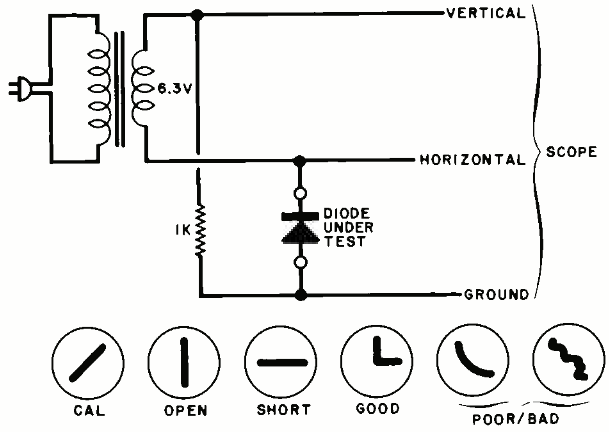
A. The circuit shown here will produce a positive-going pulse when a loud sound (experiment to find out how close to the gun you have to be) reaches the speaker/microphone. The 500-ohm potentiometer controls sensitivity, while the LED acts as the "on" indicator. After timing the race, depress the normally closed RESET pushbutton to reset the SCR (which will remain active since it is powered by a dc source). Any silicon transistors can be used.



Diode Testing

Q. *Other than using a possibly dangerous ohmmeter, is there a simple way that I can test conventional diodes?—Paul Goodbody, Ogden, UT*

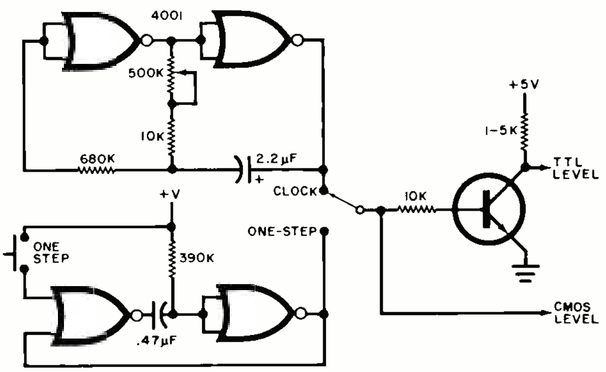
A. The circuit shown here will display curves on a scope, contingent on the state of the diode. To "calibrate," substitiue a 1000-ohm resistor for the diode and adjust the scope gains for a 45-degree line. The other drawings show some expected results. Don't use a higher voltage transformer and expect the diodes to survive the test.



Single Step

Q. *Like most readers, I experiment with various types of digital logic. What I would like is the circuit of a variable "clock" with provisions to stop the clock, and single step the pulses. This will enable me to experiment with various clock rates, and single-step my way through the logic so that I can observe the pulses.—James Flynn, Tenafly, NJ*

A. Since you did not specify CMOS or TTL, the accompanying circuit will do for both. The upper two gates form a variable "clock" oscillator, while the lower two gates form a simple "one-stepper". If you desire TTL output levels, simply feed the switch output to a transistor as shown.

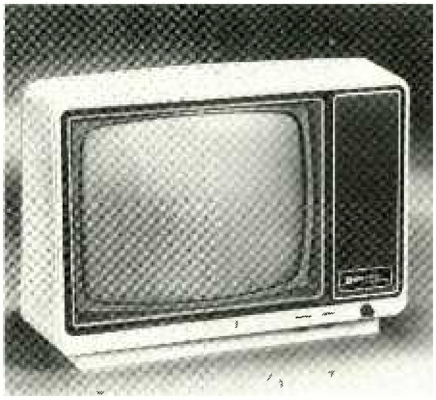


COMPUTER SOURCES

By Leslie Solomon
Senior Technical Editor

Hardware

Video Monitor. The ZVM-121 12" video monitor has a green screen and can be switched to display either a 40- or 80-character line. It uses an 8 × 10 character matrix and up to 24 lines may be displayed. Controls include POWER, BLACK LEVEL, CONTRAST, HORIZONTAL and VERTICAL OSCILLATOR adjustment including vertical size. Bandwidth is greater than 12.5 MHz, and rise-time is about 60 ns. Dc-coupled circuits are used, refresh rate is 60 Hz, and power dissipation is 26 W. It is housed in an orchard brown cabinet and compatible in style with Apple systems. **Address**: Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025 (Tel: 312-391-8181).



HP Memory. Developed for the HP-9845 series, the WMAZ-4 contains 512K of RAM, and features a hardware security system and the ability to add ROM modules. Security is provided by an electronically embedded code that is read by the proprietary program. If the code is missing or incorrect, the program will not run. This feature is not dependent on the HP SECURE utility which prevents the program from being listed. $6500. **Address:** Eventide Clockworks Inc., 265 W. 54th St., New York, NY 10019 (Tel: 212-581-9290).

Apple I/O Board. The OMNI I/O board for the Apple II or II Plus features parallel I/O with handshaking, RS232 software driven, 24-hour real time clock with alarm, and 2K graphic I/O driver EPROM. It enables the full ASCII character set from the keyboard, optional shift key detection, user-definable "soft" keys with screen tables, integrated text line editor with full cursor movement and insertion/deletion modes, key legend stickers, and a demonstration diskette. **Address:** Robert Smith and Assoc., 433 Metairie Rd., Suite 604, Metairie, LA 70005 (Tel: 504-838-8683).

S100 Memory Parity Card. This memory parity card contains parity generation circuity and RAM to store parity information. Each byte of data written into memory is evaluated and a parity bit produced. This bit is written into a location in the parity card RAM that corresponds to the destination address of the data byte. When the data is retrieved, parity is again generated and compared with the previously saved bit. The card does nothing with identical parity. A different parity bit halts the program. Options include interrupt, non-maskable interrupt, infinite wait, reset, and force instruction (requires phantom line). An on-board hex display shows failed memory locations. Full details available from Echo Communications Corp., 1708 Stierlin Rd., Mountain View, CA 94043 (Tel: 415-969-6086 or 415-969-6090).

5M Byte TRS-80. The LS525 uses a Seagate ST506 5" Winchester, LDOS from Logical Systems, a power supply, and an LSI500 Series controller. A separate off-board Host Adaptor allows use with almost all CPU and bus types. Up to three Winchesters may be added with no software modifications. TRS-80 TRSDOS or NEWDOS will run under the LDOS system. It occupies less than half a cubic foot of space. $3750. **Address**: Laredo Systems, Inc., 669 Giraudo Drive, San Jose, CA 95111 (Tel: 408-629-2283).

Disk Head Cleaner. Cleaning and maintenance of the read-write heads of TRS-80 systems are available as 26-0407 for the 5¼" drives, and 26-4909 for the 8" drives. Each kit contains two cleaning diskettes, one bottle of head cleaner, and complete instructions. $29.95. **Address**: Radio Shack Computer Centers and stores.

Apple Lab Package. The Easylab is an automation package for the Apple II that provides real-time data acquisition, experiment control, data analysis, and communications with other computers. Applications require Applesoft BASIC. It is implemented as a superset of Apple DOS 3.3. Hardware features include 16 channels of 12-bit single-ended/differential analog input, 12-bit analog output, and 32-bit I/O. The software allows access to analog input/output, timing, rapid disc storage, recall of data, RS-232 or modem communications. **Address**: Synapse Video, Box 962, New York, NY 10009 (Tel: 212-860-5776).

Interact RAM. Two pc boards, one carrying 16K of RAM and the other a small power supply to absorb the additional RAM can now bring the Interact Computer to 32K. The expansion resides within the main housing. This expansion gives users direct access to over 16K for BASIC programming, plus 4K for machine-language routines accessible from BASIC. More than 28K of contiguous RAM is available for 8080 machine-language programs. $226.50. **Address**: Micro Video, Box 7357, 204 E. Washington St., Ann Arbor, MI 48107 (Tel: 313-996-0626).

Software

Sort/Merge Package. SORT-X is a sort/merge package for the TRSDOS 2.0 (Mod II) and CP/M 2.2. Features include saving up to 90% I/O activity and up to 50% disk work storage; increased throughput; optimization by calculating the sort parameters automatically; high limit on sort keys (set to 10 now); sort both string, numeric, and combinations; and produce accessible key files. For example, it is possible to sort only the first 10 characters of a 50 character field. These can be added to the data base, and merged with the key file created in the last sort session. **Address**: Micro Architect Inc., 96 Dothan St., Arlington, MA 02174 (Tel: 617-643-4713).

Apple Educational. Developed for the Apple II, the educational programs called Fishing for Homonyms, Word-Scramble, Word-Mate, and Preschool Fun are available on cassette and (DOS 3.3) diskettes. Catalog available from THESIS, Box 147, Garden City, MI 48135 (Tel: 313-595-4722).

Application Developer. The FORMULA automatically generates program-like modules. For example, the report generator utilizes a full-screen editor to translate a visual description of a report into an operational module. File maintenance and data entry routines are created from data definitions, and menus and job streams are set up by a parameter driven procedure. Sophisticated systems can be developed using multiple access paths (keys) to data, conditional selection, and/or printing criteria, and algorithmic calculations. It contains an Indexed Sequential Access Method for data retrieval and executes object code modules. Version .93 is available for Z80/8080 systems with CP/M. $595. **Address**: DMA, 545 Fifth Ave., Suite 1400, New York, NY 10017 (Tel: 212- 687-7115).

Electronic Mail. Designed to run on an Apple II or II+ with 48K, one or more disk drives and a Hayes Micro-Modem II, the system allows users to enter and retrieve messages via the conventional telephone line, using a computer and 10 or 30 cps modem. Each new message is "attached" to others in the data base. The "tree" structure makes it easy to locate specific information. Maximum message length is 50 lines of 80 characters, and up to 320 messages. The source code is written in FORTH. Conference tree system is $95, program on 5¼" diskette is $20. **Address**: Communi-Tree Group, 470 Castro St., Suite 207-3002, San Francisco, CA 94114 (Tel: 415-474-0933). For on-line demo, call 415-928-0641 or 526-7733, type two carriage returns. TRS-80 users, type two Enters.

Color/Pocket Computers. This 16-page catalog lists a number of programs for the TRS-80 Color Computer and TRS-80 and Sharp PC-1211 Pocket Computers. **Address:** ARCsoft Publishers, Box 132PE, Woodsboro, MD 21798.

Proofreader. Magic Spell for 6800 or 6809 systems can proofread text files for spelling and typographical errors in just a few minutes. A master dictionary file is used and displays every word not found. The dictionary can be customized with new words. It will operate with 16K or less. It is available for Technical Systems Consultants MiniFlex, Flex 2, and Flex 9 DOS's, as well as for Percom disk systems. $89.29 with source code and dictionary on diskette. OS-9 and SSB versions are upcoming. **Address:** Star Kits, Box 209, Mt. Kisco, NY 10549 (Tel: 914-241-0287). Late evening use modem and LIST MAGIC.DAT).

Business Software. The XtraSoft Point of Sale and Inventory Management package is designed for the Zenith Z89 and allows on-line price, quantity and description lookup, and immediate sales history and inventory adjustment. All functions are menu driven with full-page entry, on-screen instructions, full error detection and recovery, and a 200 page manual. It requires the Z89, CP/M or HDOS, Microsoft BASIC, 64K RAM, one to three 5" disk drives, and a 132-column printer. $295 each. **Address**: XtraSoft Inc., Box 91063, Louisville, KY 40291 (Tel: 502-499-1533).

PET Arcade Games. ASTROIDZS and MUNCHMAN are available for an 8K PET/CBM with old or new ROMs. ASTROIDZ features an invasion of the galaxy and has four levels of play. MUNCHMAN is based on the arcade game Packman and uses a maze. $9.95 each. **Address**: ComputerMat, Box 1664, Dept. P., Lake Havasu City, AZ 86403 (Tel: 602-855-3357).

EXPERIMENTER'S CORNER

By Forrest M. Mims

A Programmable Function Generator

SOMETIMES, when experimenting, I require waveforms other than the simple square, sine and triangle waves provided by most commercial function generators. Unusual or complex waveforms are needed for electronic music applications, sound effects generators, simulations of mathematical functions and imitating the unique signals or signatures emitted by natural phenomena such as the human heart beat, nerve impulses and earthquakes. Another important application for specialized waveforms is the testing of electronic circuits. I've often used hastily breadboarded waveform generators to provide unusual transmitter signals in experimental fiber-optic lightwave communication systems.

Figure 1 is a block diagram of a programmable function generator which will produce customized, stepped waveforms.

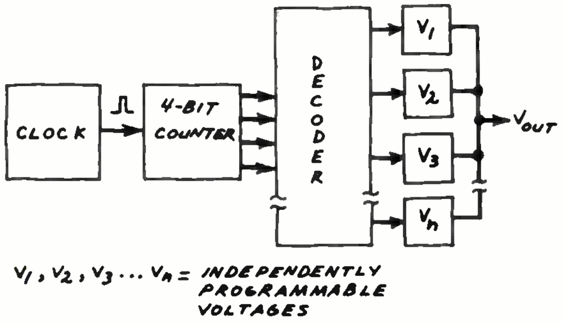


Fig. 1. Block diagram of a basic programmable function generator.

In operation, a variable frequency clock continuously sends pulses to a counter. The binary output from the counter is decoded into 1-of-n outputs by a decoder. In other words, for each state of the counter, one and only one output from the decoder is active.

The decoder outputs are connected to individual switches, each capable of applying a preselected voltage to a common OR-wired output. As the decoder sequentially actuates the switches, a stepped waveform appears at the output.

A Four-Step Programmable Waveform Generator. Figure 2 shows a practical four-step version of the block diagram in Fig. 1. The clock is designed around a 7555, the CMOS version of the 555 timer chip. The output from the clock is fed directly into the clock input of a CMOS 4017, a decade counter with a built-in 1-of-10 decoder. Nine of the ten outputs of the 4017 are normally low while the selected output is always high.

The four lowest-order decoded outputs from the 4017 are connected to the control inputs of each of the four analog switches in a CMOS 4066. The analog inputs of each switch are connected to the wipers of miniature 10-kilohm trimmer resistors which serve as adjustable voltage dividers.

In operation, the first four decoded outputs from the 4017 sequentially actuate each of the analog switches. The voltages appearing at the inputs of each switch are then placed one at a time on the common, OR-wired bus which connects the outputs of the four switches. Then, for the next six clock cycles, the output assumes the high-impedance (open) state. The pattern then repeats, providing a repetitive waveform with a width of four clock cycles separated by intervals of six clock cycles.

Figure 3 shows a typical programmed stepped waveform produced by the circuit in Fig. 2. Simply by changing the adjustment of any or all the trimmer resistors (*R1-R4*), the waveform can be altered in any desired fashion. Th· period of the waveform, hence the duration of each step, controlled by the clock rate.

Since the 4017 incorporates a reset input (pin 15), the dead space between the stepped waveforms can be reduced in increments of one clock cycle or eliminated entirely. This is easily accomplished by connecting one of the six unused decoder outputs to the reset input.

If, for example, the fifth output (pin 10) is connected to the reset input, all the dead space will be eliminated and the stepped waveform will recycle immediately after the fourth step. A typical waveform recycled in this fashion is shown in Fig. 4.

An important operating feature of this circuit is that any desired stepped waveform can be preprogrammed *without* viewing the actual waveform on an oscilloscope screen. All that's necessary is to adjust each trimmer resistor while monitoring the resulting voltage at the trimmer's rotor.

A Programmable Tone Generator. Among the many applications for this function generator is the generation of repetitive sequences of programmable tones. This is readily accomplished by connecting a voltage controlled oscillator (vco) like that shown in Fig. 5 to the generator's output.

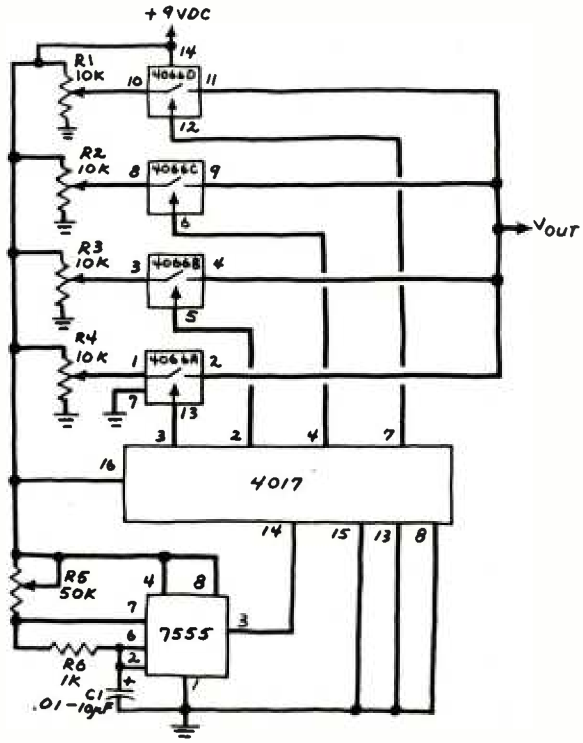


Fig. 2. Programmable four-step function generator.

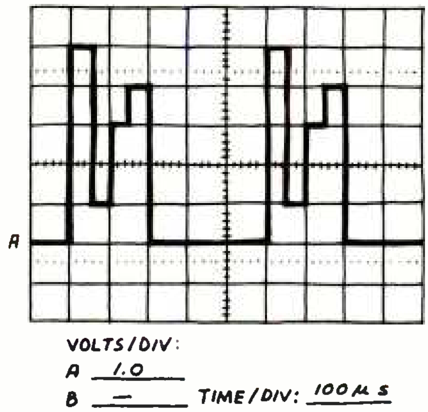


Fig. 3. Typical programmed waveform.

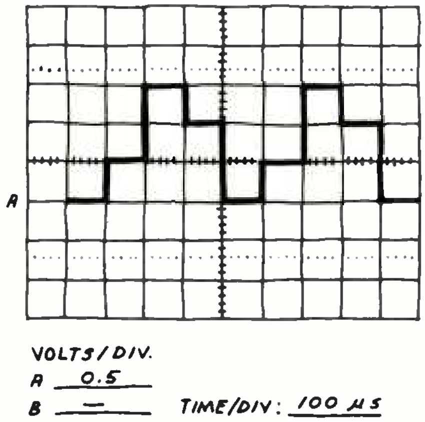


Fig. 4. Standard compressed four-step waveform.

The circuit in Fig. 5 is a straightforward astable multivibrator designed around a CMOS 7555 timer. Normally the 7555 oscillates at a fixed frequency determined by *R1* and *C1*. Variations in the voltage applied to the control voltage input, however, alter the output frequency.

Incidentally, note that Fig. 5 specifies that either the 7555 or the standard 555 can be used in the vco circuit. The 555 produces slightly more volume from the small speaker, but the 7555 has substantially reduced power consumption and a higher operating frequency.

A wide range of unique, attention-getting tone sequences can be programmed with the trimmer resistors. Simulated chirps, stepped tones and sirens are some of the sound sequences I've obtained while experimenting with a breadboard version of the circuit.

For best results, slow the function generator's clock rate to a few tens of hertz by increasing the value of *C1* in Fig. 2 to several microfarads. There's no need to remove the existing capacitor. Just connect the new, larger capacitor directly across the leads of the original capacitor.

If you're using an oscilloscope to program waveforms, you'll need to keep the clock rate high to effectively monitor the waveform. After you program the desired waveform, you can add the new capacitor to slow down the repetition rate. If you build a permanent version of the circuit, add a switch to allow you to increase or decrease *C1* at will.

Expanding the Function Generator. The basic function generator in Fig. 2 can be easily expanded to provide four or six additional output steps per waveform cycle by adding, respectively, one or two 4066 analog switches and their respective trimmer resistors. The switches are actuated by the unused decoded outputs of the 4017.

Figure 6 is the complete circuit diagram of the fully expanded circuit with ten stepped outputs. Despite its apparent complexity, this circuit can be assembled on a solderless breadboard in about fifteen minutes once you've assembled the necessary components and connection wires.

For best results, try to arrange the trimmer resistors in two rows of five each on one side of the board. Also, push the connection wires between the trimmers so they do not protrude above the board. These steps will simplify the programming procedure and encourage you to experiment with the circuit.

Since the 4017 has a carry output (pin 12), expanding the function generator to twenty or more stepped outputs is a straightforward procedure. All that's necessary is to connect the carry output of the first 4017 to the clock input of the second 4017. A twenty-step waveform would require two 4017's, five 4066's and twenty trimmer resistors.

A Programmable Waveform Control Panel. If you build a permanent version of this circuit, consider installing the trimmer resistors on a control panel. For best results, use linear slide potentiometers instead of rotary action trimmers. By installing the slide pots side-by-side, the positions of their control handles will enable you to visualize the approximate shape of the programmed waveform. In addition, you will be able to make virtually instantaneous changes even in very complex waveforms.

Reader's Letters. J.S. Soule of North Vancouver, British Columbia has written "Could you write an "Experimenter's Corner" concerning infrared detectors, especially using them to detect body heat from a distance of up to twenty feet?" I've long been fascinated by the detection of infrared radiation and will definitely plan a column on the topic. There are several ways to detect infrared, some very expensive and others very simple. I'll try to cover them all.

The "Project of the Month" column for May 1981 described a model-railroad crossing light made from integrated circuits, two phototransistors and a dc light source. Model-railroad enthusiast Temple Nieter of Evanston, IL writes: "Good circuit for model-railroad crossing flasher *but* sensors should be well out from the roadway . . . to allow time for flasher to give early warning. This offsets the turn-off, too, making it too long after train has cleared the road. Seems a second set of sensors is needed, gated to work in far/near separate pairs. Maybe one should revert to ancient relay systems to get early flash, immediate off in either direction."

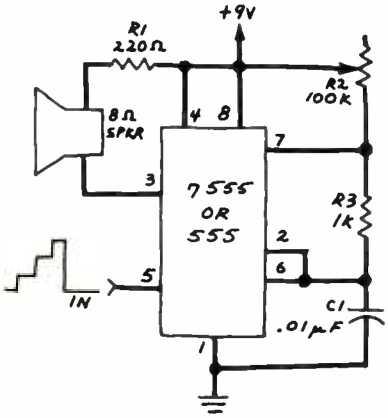


Fig. 5. A simple voltage-controlled oscillator.

I like Temp's first suggestion. If time permits, I'll try to design an early-on/immediate-off flasher system for a future column. Instead of relays, I'll stay with phototransistors.

Jim Kreter of Augusta, GA writes "I am interested in experimenting with underwater voice communication systems, but I am having difficulty in locating information sources. I would greatly appreciate any help that you or your readers could render."

I've informed Jim about my only experience in underwater voice communications. As a senior in high school, I used a crystal microphone and a transistor amplifier to speak to a

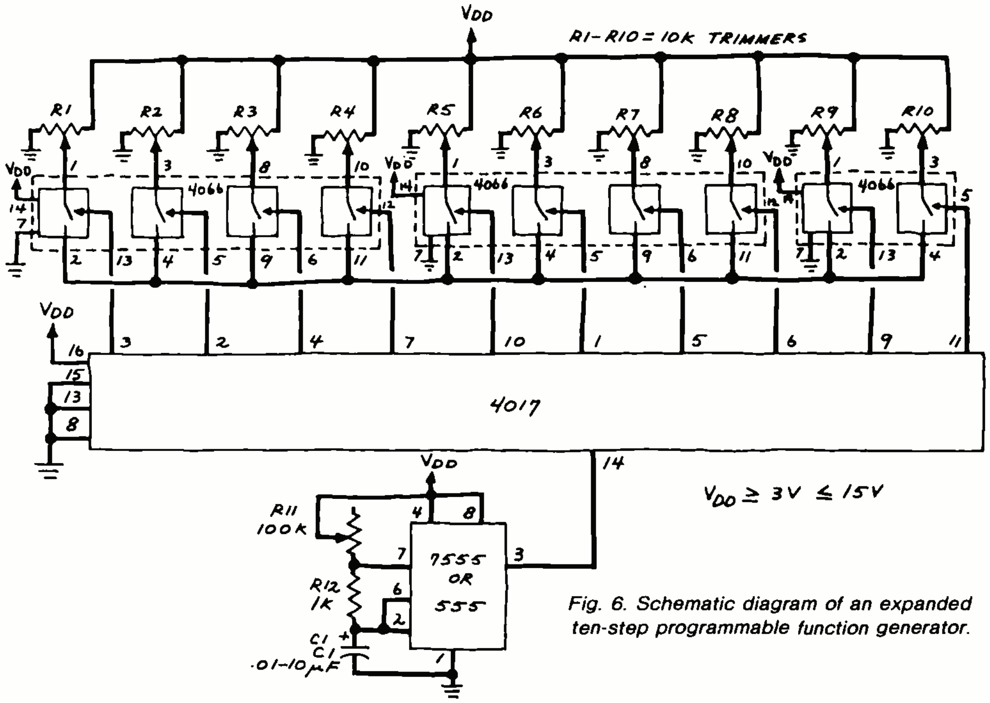


Fig. 6. Schematic diagram of an expanded ten-step programmable function generator.

friend at the surface while I descended to the bottom of a swimming pool. This arrangement actually worked, though the voice was garbled by bubbles.

Those of you who wish to pursue this topic please forward your suggestions to this column and I'll cover them at a later date. In the meantime, readers who experiment with underwater communication should *always* use battery-powered, low-voltage electronics. ◇

English Broadcasts Audible in No. America

by Glenn Hauser

TIME[1] EST	TIME UTC/GMT	STATION	QUAL.[2]	FREQUENCIES, kHz[3]
4:00-4:05 a.m.	0900-0905	UN Radio	B	15250, 9565, 9350-SSB (Sat.)
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	15195, 9505
4:00-5:30 a.m.	0900-1030	R. Australia	B	15115
4:00-5:00 a.m.	0900-1000	AFRTS, Los Angeles	A	9590, 9530, 6030
4:15-4:45 a.m.	0915-0945	UN Radio	B	15290, 9565, 9350-SSB (Sat.)
4:15-6:00 a.m.	0915-1100	BBC	C	17790, 17695, 15070, (21660 Sat. & Sun. and daily from 1030)
4:30-5:00 a.m.	0930-1000	AWR, Portugal	C	9665 (Sun. only)
4:30-5:20 a.m.	0930-1020	V. of Germany	C	17780, 11850
4:30-5:30 a.m.	0930-1030	R. Japan	C	15235, 11875
5:00-5:15 a.m.	1000-1015	R. Japan	B	9505
5:00-5:30 a.m.	1000-1030	V. of Vietnam	C	12036, 10080
5:00-6:00 a.m.	1000-1100	R. Korea	B	11725, 9570
5:00-6:00 a.m.	1000-1100	All India Radio	C	17875
5:00-6:00 a.m.	1000-1100	AFRTS, Los Angeles	A	11805, 9700, 9590, 9530, 6030
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
5:00-11:02 a.m.	1000-1602	ABC, Perth	B	9610, 6140
5:10-12:00 a.m.	1010-1700	V. of Nigeria	C	15120
5:30-6:30 a.m.	1030-1130	Sri Lanka Br. Corp.	C	17850, 15120, 11835 (not all Eng.)
6:00-6:15 a.m.	1100-1115	R. Japan	B	9505
6:00-6:30 a.m.	1100-1130	V. of Vietnam	C	12036, 10080
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 (Sun. 1030-1040)
6:00-7:00 a.m.	1100-1200	AFRTS, Los Angeles	A	6030
6:00-7:50 a.m.	1100-1250	R. Pyongyang	C	11815 (Sat. & Sun. 1100-1330)
6:00-8:00 a.m.	1100-1300	TWR-Bonaire	A	9977
6:00-8:00 a.m.	1100-1300	R. Australia	A	9580, 17795
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
6:00-12:00 a.m.	1100-1700	AFRTS, Los Angeles	A	15430, 15330, 11805, 9700
6:15-6:30 a.m.	1115-1130	Vatican R.	C	21485, 17840 (not Sun.)
6:28-9:00 a.m.	1128-1400	CBC Northern Service	B-C	9625, 6065 (not all Eng.)
6:30-6:55 a.m.	1130-1155	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri.) (irreg.)
6:30-7:30 a.m.	1130-1230	R. Thailand	C	11905, 9655
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.)
7:00-7:30 a.m.	1200-1230	Kol Israel	C	27790, 25640, 21495, 17612.5, 15605
7:00-7:30 a.m.	1200-1230	R. Finland	B	15400, 21475 (not Sun.)
7:00-7:30 a.m.	1200-1230	R. Norway	C	25730, 21730 (Sun.)
7:00-7:30 a.m.	1200-1230	R. Tashkent	C	11785, 9540, 6025, 5945
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
7:00-7:55 a.m.	1200-1255	R. Peking	B	9860
7:00-9:00 a.m.	1200-1400	R. Moscow World Service	B	15150, 15135, 12030, 11720, 9750, 9580
7:00 a.m.-1:00 p.m.	1200-1800	R. Peking	C	11600
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. Bangladesh	D	21670, 15285
7:30-8:15 a.m.	1230-1315	V. of Germany	B	21600
7:30-8:30 a.m.	1230-1330	R. Korea	C	11830, 9570
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, 9720
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
8:00-8:20 a.m.	1300-1320	R. Canada International	A	17820, 15440, 11955, 9575 (Mon.-Fri.)
8:00-8:30 a.m.	1300-1330	R. Bucharest	C	17850, 15250, 11940
8:00-8:30 a.m.	1300-1330	R. Finland	B	21475, 15400
8:00-8:50 a.m.	1300-1350	WYFR, Family Radio	A	11830
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
8:15-8:45 a.m.	1315-1345	Swiss R. International	B	21570, 21520, 17850, 17830
8:30-9:00 a.m.	1330-1400	NYAB, Bhutan	D	4595 (Wed. & Fri.)
8:30-9:20 a.m.	1330-1420	R. Nederland	C	17605
8:30-9:25 a.m.	1330-1425	R. Finland	B	21475, 15400 (Sun.)
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	12036, 10080
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
8:30-11:00 a.m.	1330-1600	R. Malaysia Sabah	C	5980, 4970
8:30 a.m.-fade	1330-	R. Australia	B	6060
8:30 a.m.-5:00 p.m.	1330-2200	R. Moscow World Service (via Cuba)	B	11840
8:35-9:05 a.m.	1335-1405	BRT, Belgium	B	21810, 21525 (Mon.-Fri.)
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, 25615, 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	11785, 9600, 9540, 6025, 5945
9:00-10:00 a.m.	1400-1500	WYFR, Family Radio	A	15215
9:00-10:00 a.m.	1400-1500	R. Moscow World Service	B	30750, 15150, 15135, 12030, 11900, 11720, 9750, 9580
9:00-10:00 a.m.	1400-1500	R. Malaysia Sarawak	C	7160, 4950
9:00-10:00 a.m.	1400-1500	V. of Indonesia	C	15200 or 15150, 11789
9:00-12:00 a.m.	1400-1700	CBC Southern Service	A	17820, 11955 (Sun.)
9:00-12:30 a.m.	1400-1730	R. Australia	C	17795, 9770, 9710
9:30-10:00 a.m.	1430-1500	KTWR, Guam	B	9505

9:30-10:00 a.m.	1430-1500	R. Finland	B	21475, 15400
9:30-10:25 a.m.	1430-1525	R. Nederland	B	21480, 15560, 11740
9:30-10:30 a.m.	1430-1530	HCJB, Ecuador	A	26020, 17890, 15115 (Sat. & Sun.-1600)
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
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 (not Sun.)
10:00-10:50 a.m.	1500-1550	V. of Germany	C	21600
10:00-11:00 a.m.	1500-1600	V. of Rev. Ethiopia	D	9560
10:00-11:00 a.m.	1500-1600	V. of Nigeria	C	11770 (varies)
10:00-11:00 a.m.	1500-1600	BBC	B	17830, 15260 (Sat, Sun)
10:00-11:00 a.m.	1500-1600	R. Moscow World Service	B	30750, 24020, 12050, 12010, 11900, 11720, 9580
10:00-12:00 a.m.	1500-1700	WYFR, Family Radio	A	15365, 15215
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	15415
10:30-11:00 a.m.	1530-1600	Swiss R. International	B	21570, 17830, 15125
10:30-11:30 a.m.	1530-1630	V. of Vietnam	C	11840, 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	21695, (17820 Mon.-Sat.), 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	21757, 21605, 21486, 17910, 17660†
11:00-11:30 a.m.	1600-1630	R. Norway	B	25615, 21730, 21655, 17840 (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
11:00-12:00 a.m.	1600-1700	R. Moscow World Service	B	24020, 15240, 15150, 12050, 12030, 11900, 11720
11:00 a.m.-12:45 p.m.	1600-1745	BBC	B	21710, 17830, 15260
11:00 a.m.-6:00 p.m.	1600-2300	VOA	A	26040, 21660, 21485, 17870, (15250 from 1900) 15445, (15410 to 2200)
-11:30 a.m.	-1630	R. Singapore	C	11940, 5052, 5010 (fade-in time varies)
11:15-12:00 a.m.	1615-1700	UAE Radio, Dubai	B	21695, 21655, 17710
11:45-12:00 a.m.	1645-1700	R. Canada International	A	21695, (17820 Mon.-Sat.) 15325
11:45-12:45 p.m.	1645-1745	R. Pakistan	C	15500, 11672†
12:00-12:15 p.m.	1700-1715	R. Japan	C	9505
12:00-12:45 p.m.	1700-1745	BBC	C	17695, 21470
12:00-1:00 p.m.	1700-1800	R. Moscow World Service	A	15455, 15425, 15240, 15150, 12050, 12030, 11960, 11900
12:00-1:00 p.m.	1700-1800	AFRTS, Los Angeles	A	15430, 15345, 15330, 11805, 9700
12:00-1:00 p.m.	1700-1800	WYFR, Family Radio	A	21615, 17845, 21510, 15440, 15365, 15215
12:00-3:00 p.m.	1700-2000	4VEH, Haiti	C	11835, 9770 (Sun.)
12:00-4:00 p.m.	1700-2100	BSK Saudi Arabia	C	11856 (varies)
12:00-5:00 p.m.	1700-2200	VOA	B	17785, 15205, 11760, 9750, (15140 from 1830)
12:05-12:55 a.m.	1705-1755	R. France International	B	21620, 21580, 21515, 17860
12:10-12:55 p.m.	1710-1755	BRT, Belgium	C	17595
12:30-1:00 p.m.	1730-1800	HCJB, Ecuador	B	26020, 21480, 17790†
12:45-3.00 p.m.	1745-2000	BBC	C	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	17840, 21560 (Sun. only)
1:00-2:00 p.m.	1800-1900	V. of Vietnam	C	10040, 15010
1:00-2:00 p.m.	1800-1900	R. Moscow World Service	A	17700, 15455, 15425, 15240, 15150, 12050, 11960, 11900, 11700
1:00-2:00 p.m.	1800-1900	WYFR, Family Radio	A	21615, 15440, 15365
1:00-2:00 p.m.	1800-1900	V. of Nigeria	C	15120, 17800
1:00-3:00 p.m.	1800-2000	R. Australia	C	17795
1:00-3:00 p.m.	1800-2000	WRNO, New Orleans	A	17895
1:00-4:00 p.m.	1800-2100	R. Kuwait	B	11675
1:00-5:00 p.m.	1800-2200	AFRTS, Los Angeles	A	17765, 15430, 15345, 15330
1:15-1:45 p.m.	1815-1845	Swiss R. International	C	21570 or 21585, 17850, 17830, 15415
1:15-2:15 p.m.	1815-1915	R. Bangladesh	D	15285, 11765 (both vary) †
1:30-1:37 p.m.	1830-1837	UN Radio	A	18782.5-SSB, 15305, 21710, 15410 (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	15309 (varies) 9650 (Mon. Wed. and Fri.) (irregular)
2:00-2:30 p.m.	1900-1930	R. Japan	B	15325
2:00-2:30 p.m.	1900-1930	R. Canada International	A	17875, 15325, 11905 (Sat. & Sun. -2000)
			A	17820, 15260 (Mon.-Fri.)
2:00-2:30 p.m.	1900-1930	R. Afghanistan	C	15079 (varies) or 17742†, 9665
2:00-2:45 p.m.	1900-1945	UN Radio	A	15305, 21710, 15410 (Fri.)
2:00-3:00 p.m.	1900-2000	HCJB, Ecuador	C	26020, 21480, 17790†
2:00-3:00 p.m.	1900-2000	WYFR, Family Radio	A	21615, 15440, 15365, 15215
2:00-3:00 p.m.	1900-2000	R. Moscow World Service	A	17700, 15455, 15150, 12050, 11960
2:30-3:30 p.m.	1930-2030	V. of Iran	C	9022
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	15310
3:00-3:30 p.m.	2000-2030	R. Norway	C	17840, 15135 (Sun.)
3:00-3:30 p.m.	2000-2030	R. Algiers	C	Some of: 25700, 21725, 21635, 17745, 15365, 15307, 15215, 11810 (may be one hour later)
3:00-3:30 p.m.	2000-2030	R. Canada International	A	17875, 17820, 15325, 11905 (Mon.-Fri.)
3:00-3:30 p.m.	2000-2030	Kol Israel	C	21675, 17710, 11638, 15582.6
3:00-4:00 p.m.	2000-2100	R. Moscow World Service	A	17700, 15425, 15150, 15100, 12050, 11960, 7390
3:00-4:00 p.m.	2000-2100	WYFR, Family Radio	A	15215, 21525, 15440, 15365,
3:00-4:15 p.m.	2000-2115	BBC	B	15260, 15070, 11750, 12095, 9410
3:00-5:00 p.m.	2000-2200	WRNO, New Orleans	A	15355
3:00-7:00 p.m.	2000-2400	R. Moscow (via Cuba)	C	600
3:10-4:40 p.m.	2010-2140	R. Habana Cuba	A	15155 or 11920
3:15-3:30 p.m.	2015-2030	Sri Lanka Br. Corp.	C	15120, 15115, 11800
3:15 p.m.-2:15 a.m.	2015-0715	R. New Zealand	C	15485
3:30-4:15 p.m.	2030-2115	Int. Christ. Radio, Malta	C	9510
3:30-4:20 p.m.	2030-2120	R. Nederland	B	21685, 17695, 17605, 15220, 9715
3:30-4:30 p.m.	2030-2100	V. of Vietnam	C	15010, 10040

3:30-4:30 p.m.	2030-2130	V. Turkey	C	9615 or 9725
3:45-12:30 p.m.	2045-0530	R. New Zealand	C	17860
3:50-4:40 p.m.	2050-2140	R. Habana Cuba	C	17750, 11725
4:00-4:15 p.m.	2100-2115	R. Japan	B	15325
4:00-4:15 p.m.	2100-2115	R. TV Benin	C	4870
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	15120, 17800
4:00-5:00 p.m.	2100-2200	R. Moscow World Service	C	17700, 15425, 15240, 15100, 12050, 11960, 11750, 11700, 9700
4:00-5:00 p.m.	2100-2200	WYFR, Family Radio	A	17845, 15440, 15380, 15365,
4:15-5:00 p.m.	2115-2200	BBC	A	15260, 15070, 11750, 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	HCJB Ecuador	C	26020, 21480, 17790†, 15295†
4:30-5:00 p.m.	2130-2200	R. Sofia	B	7115
4:30-5:30 p.m.	2130-2230	R. Baghdad	C	9745
4:31-5:00 p.m.	2131-2200	KGEI, San Francisco	C	15280
4:40-5:40 p.m.	2140-2240	V. of Free China	C	17890, 15270, or 15210, 11825
4:45-5:15 p.m.	2145-2215	Swiss R. International	C	21585, 17830, 17850, 15305
4:50-5:00 p.m.	2150-2200	R. Free Europe	C	17835, 15255, 13690-SSB. 11825, 9725, 9565 (Fri.)
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 11950†)
5:00-5:30 p.m.	2200-2230	R. Argentina	D	11710 (Mon.-Sat.)
5:00-5:30 p.m.	2200-2230	R. Norway	C	17795, 15135, 15175 (Sun. only)
5:00-6:00 p.m.	2200-2300	WYFR, Family Radio	A	17845, 15440, 11805, 15365, 15380
5:00-6:00 p.m.	2200-2300	R. Moscow World Service	A	21565, 17760, 17700, 15425, 12050, 11850, 11770, 11750, 11720, 11700, 9760, 9720, 9685, 9720, 9685, 9685, 9610
5:00-6:00 p.m.	2200-2300	CBC Radio	A	15325, 11925, 9760, 5995 (Mon.-Fri.)
5:00-6:00 p.m.	2200-2300	V. of Turkey	B	9560, 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	15260, 15070, 11750, 9510, 6175, 5975
5:00-7:00 p.m.	2200-2400	WRNO, New Orleans	A	11890
5:00-7:00 p.m.	2200-2400	AFRTS, Los Angeles	A	21570, 17765, 15430, 15330
5:00-11:30 p.m.	2200-0430	VOA	A	21460, 17740
5:15-5:30 p.m.	2215-2230	UN Radio	A	15240, 11830 or 11920 (Fri.)
5:15-5:30 p.m.	2215-2230	R. Yugoslavia	C	9620
5:30-6:00 p.m.	2230-2300	Kol Israel	A	11640, 7412, 9815
5:30-6:00 p.m.	2230-2300	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri.) (Irreg.)
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	15110, 9700
5:45-6:30 p.m.	2245-2330	SODRE, Uruguay	C	11885 (time varies)
6:00-6:30 p.m.	2300-2330	R. Vilnius	B	17870, 17845, 15100, 12060, 11735, 9665
6:00-6:30 p.m.	2300-2330	R. Japan	C	17755
6:00-6:30 p.m.	2300-2330	R. Sweden	C	11705, 9695
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	15365, 17845, 15380
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	15260, 15070, 11910, 9590, 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	CBC Southern Service	A	11850, 5960 (Sat. 2300-2330, Sun. 2300-2400)
6:00-8:00 p.m.	2300-0100	R. Moscow	A	21530, 9800, 7195, 7115
6:00 p.m.-1:07 a.m.	2300-0607	CBC Northern Service	B-C	9625, 6195 (not all English)
6:30-7:00 p.m.	2330-2400	HCJB, Ecuador	B	26020, 15180†
6:30-7:00 p.m.	2330-2400	V. of Vietnam	C	12036, 10080
6:45-7:45 p.m.	2345-2445	R. Japan	C	17825, 15300
7:00-7:25 p.m.	0000-0025	R. Tirana	B	9750, 7065
7:00-7:30 p.m.	0000-0030	Kol Israel	A	11640, 9815, 7412
7:00-7:30 p.m.	0000-0030	R. Norway	C	17795, 15135, 11870 (Mon. only)
7:00-7:55 p.m.	0000-0055	R. Peking	B	15520, 15120, 11650
7:00-8:00 p.m.	0000-0100	WYFR, Family Radio	A	17845, 11720, 5985
7:00-8:00 p.m.	0000-0100	R. Sofia	B	15110, 9700
7:00-8:00 p.m.	0000-0100	AFRTS, Los Angeles	A	21570, 15430, 15330, 11790, 6030
7:00-9:00 p.m.	0000-0200	VOA	A	17885, 17730, 15205, 11740, 9650, 6130, 5995, 1580
7:00-9:00 p.m.	0000-0200	WRNO, New Orleans	A	11965
7:00-9:45 p.m.	0000-0245	R. Luxembourg	C	6090 (Times varies)
7:00-12:00 p.m.	0000-0500	R. Moscow (via Cuba)	A	9600, 600
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	11860, 9515
7:15-8:00 p.m.	0015-0100	SODRE, Uruguay	C	11885 (time varies)
7:30-8:00 p.m.	0030-0100	R. Prague	C	6055
7:30-8:00 p.m.	0030-0100	R. Kiev	B	17870, 17845, 15100, 12060, 11735, 9800, 9750
7:30-8:00 p.m.	0030-0100	La Cruz del Sur, Bolivia	D	4875 (Mon. only)
7:30-8:30 p.m.	0030-0130	HCJB, Ecuador	A	15175
7:30-9:30 p.m.	0030-0230	SLBC, Sri Lanka	C	15425
7:30-9:30 p.m.	0030-0230	BBC	A	15260, 11750, 9410, 7325, 6175, 6120, 5975
7:35-9:30 p.m.	0035-0230	HCJB, Ecuador	B	17875, 15155, 9745
7:55-8:35 p.m.	0055-0135	TWR-Bonaire	B	11755
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	11640, 9815, 7412
8:00-8:30 p.m.	0100-0130	R. Argentina	C	11710 (not Mon.)
8:00-8:30 p.m.	0100-0130	R. Mexico	C	15430 (Sun.)
8:00-8:30 p.m.	0100-0130	La Voz de la Mosquitia, Honduras	C	4910
8:00-8:30 p.m.	0100-0130	R. Canada International	A	11850, 5960
8:00-8:45 p.m.	0100-0145	R. Berlin International	C	11975, 9730
8:00-8:50 p.m.	0100-0150	V. of Germany	A	15105, 11865, 9590, 9565, 9545, 6145, 6085, 6040
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	15520, 15120, 11650
8:00-9:00 p.m.	0100-0200	V. of Free China	C	17890, 15345, 11825
8:00-9:00 p.m.	0100-0200	AFRTS, Los Angeles	A	21570, 15430, 15330, 11790, 6030
8:00-9:00 p.m.	0100-0200	WYFR, Family Radio	B	9715, 5985, 11720
8:00-10:30 p.m.	0100-0330	R. Australia	B	21740, 17795
8:00-11:00 p.m.	0100-0400	R. Moscow	A	21530, 17720, 9800, 9685, 7195, 7115
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
8:30-8:40 p.m.	0130-0140	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
8:30-9:00 p.m.	0130-0200	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6025 (Wed. and Sat.)
8:30-9:30 p.m.	0130-0230	R. Japan	C	21640, 17825, 21610, 15195
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	11640, 9815, 7412
9:00-9:30 p.m.	0200-0230	R. Canada International	A	11845, 5960 (Sat. & Sun. also 11940, 9755, 9535)
9:00-9:30 p.m.	0200-0230	R. Norway	B	11935, 11870, 9610 (Mon. only)
9:00-9:30 p.m.	0200-0230	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6025 (not Mon.)
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	15325, 11800, 9580
9:00-9:55 p.m.	0200-0255	R. Bucharest	C	15380, 11940, 11840, 11725, 9570, 5990
9:00-9:55 p.m.	0200-0255	R. Peking	B	15120, 11650
9:00-10:00 p.m.	0200-0300	R. Nacional, Brazil	A	17830, 15290
9:00-10:00 p.m.	0200-0300	WYFR, Family Radio	A	11720, 9715
9:00-10:30 p.m.	0200-0330	R. Cairo	B	12000, 9475
9:00-11:00 p.m.	0200-0400	VOA	A	17885, 17730, 15205, 9650, 6130, 5995, 1580
9:00-11:30 p.m.	0200-0430	AFRTS, Los Angeles	A	11790, 6030
9:00 p.m.-3:00 a.m.	0200-0700	WRNO, New Orleans	A	6155
9:30-9:45 p.m.	0230-0245	R. Pakistan	C	17840, 21757, 21595
9:30-9:45 p.m.	0230-0245	UN Radio	A	15240, 6035, 15752-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† (time varies)
9:30-10:00 p.m.	0230-0300	R. Sweden	B	11705, 9695
9:30-10:15 p.m.	0230-0315	R. Berlin International	C	11975, 9730
9:30-10:25 p.m.	0230-0325	R. Nederland	A	9590, 6165 (Mon.-0320)
9:30-10:30 p.m.	0230-0330	R. Korea	C	15575, 11810
9:30-10:30 p.m.	0230-0330	BBC	A	11750, 9510, 9410, 7325, 6175, 6120, 5975
9:30-12:00 p.m.	0230-0500	HCJB, Ecuador	A	9745, 15155
10:00-10:15 p.m.	0300-0315	R. Japan	C	17755
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. Budapest	B	17710, 15220, 11910, 9835, 9585, 6025
10:00-10:30 p.m.	0300-0330	R. Kiev	B	17870, 15100, 11735, 9800, 7165
10:00-10:30 p.m.	0300-0330	R. Canada International	A	11940, 11845, 11770, 9535, 5960
10:00-10:30 p.m.	0300-0330	R. Portugal	B	11925, 9765
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	15345, 11825, 17800
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	15520, 15120, 11650
10:00-11:00 p.m.	0300-0400	TIFC Costa Rica	C	5055, (Mon. 0235-0435)
10:00-11:00 p.m.	0300-0400	R. Baghdad	D	21585, 15400, 11935
10:00-11:00 p.m.	0300-0400	WYFR, Family Radio	A	9715, 9660, 5985
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-)
10:00-12:00 p.m.	0300-0500	HRVC, Honduras	B	4820
10:00-12:00 p.m.	0300-0500	AWR Guatemala	C	5980
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
10:30-11:15 p.m.	0330-0415	R. Berlin International	B	11975, 11890, 11840, 9560
10:30-11:23 p.m.	0330-0423	U.A.E. Radio, Dubai	B	17775, 15320 (length varies)
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
10:30-11:00 p.m.	0330-0400	R. Mexico	C	15430
10:30-11:45 p.m.	0330-0445	BBC	A	9410, 6175, 5975 (6120 to 0430)
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	17795, 15330, 11905
10:51-10:58 p.m.	0351-0358	V. of Yerevan	C	17870, 17845, 15100
11:00-11:12 p.m.	0400-0412	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6025 (Wed. & Sat.) (0400-0430 Monday)
11:00-11:15 p.m.	0400-0415	R. Japan	C	17755
11:00-11:30 p.m.	0400-0430	R. Bucharest	C	15380, 11940, 11725 9570, 5990
11:00-11:30 p.m.	0400-0430	R. Canada International	A	11845, 11770, 5960
11:00-11:30 p.m.	0400-0430	R. Norway	C	11935, (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	15120, 11650
11:00-12:00 p.m.	0400-0500	R. Sofia	C	7115
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	9665, 9610
11:00-12:00 p.m.	0400-0500	WYFR, Family Radio	A	9715, 9660, 6070
11:00 p.m.-1:00 a.m.	0400-0600	TWR, Bonaire	A	9700, 800
11:00 p.m.-3:00 a.m.	0400-0800	R. Moscow	A	12050, 9580
11:05-11:50 p.m.	0405-0450	FEBA, Seychelles	C	11810†
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	11790, 9755, 6030
11:45p.m.-12:45a.m.	0445-0545	BBC	A	15070, 9510, 9410, 6175, 5975
11:55 p.m.-3:00 a.m.	0455-0800	V. of Nigeria	B	11770
12:00-12:15 a.m.	0500-0515	Kol Israel	B	11655, 11640, 9009
12:00-12:15 a.m.	0500-0515	R. Japan	C	15325
12:00-12:50 a.m.	0500-0550	V. of Germany	A	11905, 9690, 9545, 5960
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, 9660, 6070
12:00-1:00 a.m.	0500-0600	R. Moscow World Service	C	17880, 12010, 11735, 9530
12:00-2:00 a.m.	0500-0700	HCJB, Ecuador	B	11915, 9745, 6095
12:00-3:00 a.m.	0500-0800	R. Kuwait	C	15345
12:00-3:00 a.m.	0500-0800	R. Nigeria, Kaduna	B	4770 (not all Eng.)
12:00-5:00 a.m.	0500-1000	V. of Cuba	C	550
12:30-12:40 p.m.	0530-0540	R. Garoua, Cameroon	C	5010
12:30-1:00 a.m.	0530-0600	R. Portugal	A	9765, 6185
12:30-fade	0530-	R. Ghana	C	3366, 4915
12:30-1:25 a.m.	0530-0625	R. Nederland	A	9715, 6165 (Mon.-0620)
12:30-1:30 a.m.	0530-0630	Spanish Foreign R.	B	11880, 9630

12:35-1:30 a.m.	0530-0630	R. Korea	C	15575, 11810, 9870
12:40-6:15 a.m.	0540-1115	R. New Zealand	C	11945
12:45-1:00 a.m.	0545-0600	Vatican Radio	C	6210 or 6190
12:45-2:30 a.m.	0545-0730	BBC	B	15070, 11955, 11860, 9640, 9510, 9410, 7150, 6175
12:55-3:55 a.m.	0555-0855	V. of Malaysia	C	15295, 12350, 9750
1:00-1:15 a.m.	0600-0615	R. Japan	C	15325
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. 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
1:00-2:30 a.m.	0600-0730	R. Kiribati	C	16433-SSB (not all English)
1:00-3:00 a.m.	0600-0800	V. of Nigeria	C	15120
1:00-4:00 a.m.	0600-0900	R. Cook Islands	C	11760† or 9695 or 5045 (not all English)
1:15-1:30 a.m.	0615-0630	R. Canada International	B	11960, 11825, 11775, 9760, 9730, 7155, 6140 (Mon-Fri)
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	C	21535, 17780, 15220
1:30-3:00 a.m.	0630-0800	R. Habana Cuba	A	9525
1:45-2:00 a.m.	0645-0700	R. Canada International	B	11960, 11825, 11775, 9760, 9730, 7155, 6140 (Mon-Fri)
1:45-2:00 a.m.	0645-0700	UN Radio	B	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	15325, (15410† via Portugal)
2:00-2:20 a.m.	0700-0720	R. Nederland	C	21480, 17605, 11720, 9895
2:00-2:30 a.m.	0700-0730	Swiss Radio Int.	C	15305, 9560, 9535, 6165
2:00-2:45 a.m.	0700-0745	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	9840
2:00-3:30 a.m.	0700-0830	HCJB, Ecuador	C	11810, 9760
2:00-4:00 a.m.	0700-0900	R. Australia	B	21680, 11725, 15115, 11740, 9570
2:00-6:00 a.m.	0700-1100	HCJB, Ecuador	C	11925, 6130 (9745-1030)
2:07-2:15 a.m.	0707-0715	UN Radio	A	15125, 11735 (Sat.)
2:25-4:00 a.m.	0725-0900	TWR, Monte Carlo	B	9495† (Sun. to 1000)
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, 7150, 9410
2:30-6:15 a.m.	0730-1115	R. New Zealand	C	11960
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, 15125, 11735 (Sat.)
2:45-4:30 a.m.	0745-0930	KTWR, Guam	B	11840
2:55 a.m.-fade	0755-	Action Radio, Guyana	C	5950
3:00-3:15 a.m.	0800-0815	R. Japan	B	9505
3:00-3:30 a.m.	0800-0830	R. Norway	C	11850 (Sun.)
3:00-3:15 a.m.	0800-0815	UN Radio	A	17860, 15235, 15125, 11735 (Sat.)
3:15-3:30 a.m.	0815-0830	R. Vanuatu	D	7260, 3945
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. For AST add 1 hour; CST, subtract 1 hour, MST, subtract 2 hours, PST subtract 3 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 2135; Sunday at 1930; GMT Mondays at 0106 and 0406.
4. R.—Radio; V.—Voice
† = frequent changes

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION (Required by 39 U.S.C. 3685)

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1. Sales through dealers and carriers, street vendors and counter sales	90,828	88,500
2. Mail subscriptions	308,441	288,396
C. Total Paid Circulation (sum of 10B1 and 10B2)	399,269	376,896
D. Free distribution by mail, carrier or other means samples, complimentary and other free copies	10,075	8,074
E. Total Distributions (Sum of C and D)	409,344	384,970
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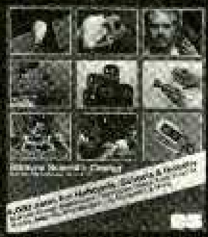
2. Returns from news agents	85,320	88,700
G. Total (sum of E, F1, and 2—should equal net press run shown in A)	496,894	475,111

11.
I certify that the statements made by me above are correct and complete.
William L. Phillips,
Assistant Treasurer



PROJECT OF THE MONTH

By Forrest M. Mims

A Sound-Effects Generator

ONE WAY to produce attention-getting sound effects is to control the frequency of an oscillator by means of periodic impulses from a second oscillator. This is an ideal role for a pair of 555 timers operated in their astable (free-running) mode.

Figure 1 shows how two 555's are connected to provide sound effects. The first 555 (*IC1*) is connected as an oscillator with an adjustable period of a few tens of hertz or less. The second 555 (*IC2*) is connected as a voltage-controlled oscillator (vco) with an adjustable frequency of a few hundred to a few thousand hertz.

Capacitor *C2* is the key to the unique sounds produced by the circuit, so let's assume for a moment that *C2* is not present. Then *IC2* will oscillate at a fixed frequency determined by the voltage at pin 3 of *IC1*. Negative going 10-millisecond pulses from *IC1* will produce brief, click-like interruptions or changes in *IC2*'s frequency of oscillation.

Now let's return *C2* to the circuit. During intervals between negative going pulses from *IC1*, *C2* charges through *R3* to the voltage at pin 3 of *IC1*. The relatively slow charging rate of *C2* produces a gradual *decrease* in *IC2*'s oscillation frequency. When *IC1* switches, *C2* is immediately discharged and the frequency of *IC2* is suddenly *increased*. Capacitor *C2* then begins to recharge, as shown in the oscillogram in Fig. 2, and the cycle repeats. The resulting sounds from the speaker are far more interesting than the rather boring interrupted tone sequence produced when *C2* is not present.

For best results, use potentiometers with knobs for *R1* and *R5*. This will enable you to quickly change the circuit's cycle rate (via *R1*) and its tone frequency (via *R5*). A faster cycle rate resembles the sound of a chirping bird. A slower one makes a good warning alarm.

Be sure to experiment with the values of *R3* and *C2*. Increasing *C2* stretches the time required for *IC2*'s tone to fall from its highest to its lowest frequency. Increasing *R3* has a similar effect. If the values for *C2* or *R3* are too high, *C2* will not fully charge during each cycle, thus reducing the dynamic range of the circuit's tone frequency.

Incidentally, note that Fig. 1 specifies either a 7555 or 555 for *IC1* and *IC2*. The 7555 is the CMOS counterpart of the 555. It consumes much less power and can operate from a lower voltage (less than 3 volts) than the standard 555. It also has a higher oscillation frequency.

I'll have more to say about this important new chip in future columns. In the meantime, this project is an excellent way to become acquainted with either the 555 or the 7555. ◇

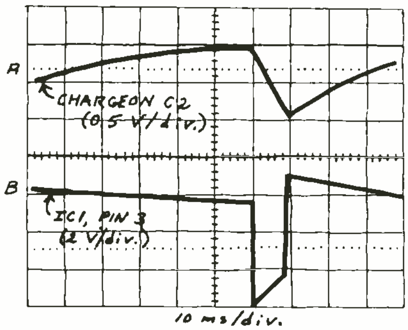


Fig. 2. Oscillogram showing effect of charge on C2 on the output of IC1.

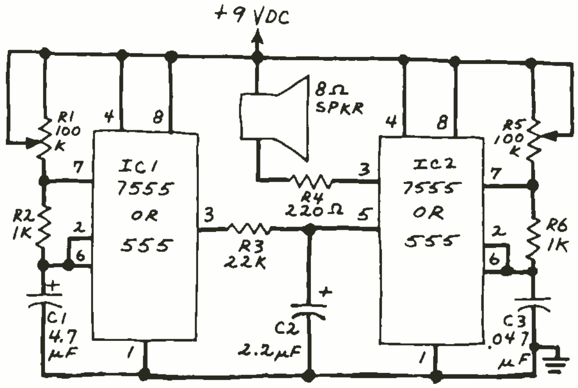


Fig. 1. Sound-effects generator circuit.

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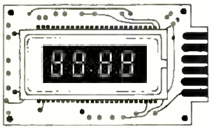
$0.00-$9.99	Add $2.00
$10.00-$24.99	Add $0.75
$25.00-$49.99	Add $0.50
$50.00-$99.99	Add $0.25
$100.00 & Up	No Charge

VOLUME DISCOUNT	
$0.00-$99.99	NET
$100.00-$249.99	Less 10%
$250.00-$499.99	Less 15%
$500.00-$999.99	Less 20%
$1000.00 & Up	Less 25%

CIRCLE NO. 14 ON FREE INFORMATION CARD

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 (3.05"Lx1.75"Hx.98"D) . **$16.95**

CLOCK MODULES

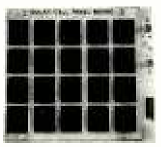
MA1023	.7" Red Digital LED Clock Module	8.95
MA1026	.7" Dig. LED Alarm Clock/Thermometer	18.95
MA5036	.3" Red Digital LED Clock/Timer	6.95
MA1002	.5" Red Digital LED Clock & Xformer	9.95
MA1010	.8" Red Digital LED Clock	7.95
MA1032	CBA .5" Digital LCD Clock	17.95
MA1043	.7" Green Digital LED Clock	8.95

TRANSFORMERS

102-P20	Xformer for MA1023, 1043 & 5036 Mods.	3.49
102-P22	Xformer for MA1026 Clock Modules	3.49
102-P24	Xformer for MA1010 Clock Modules	3.49

NEW!

Sun Power Your Electronics! SOLAR CELL PANEL KIT

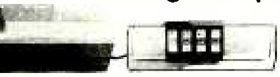


Features:
- **Output: 10VDC, to 100mA in Series 5VDC, to 200mA in Parallel**
- **Panel may be easily connected for Series or Parallel out**
- **Over 11 square inches of active cell surface**
- **Voltage line tap @ 0.5V increments**
- **Provision for charging batteries**
- **Overall panel size: 4¾"L x 4½"H x ½"D**

The JE305 Solar Cell Panel Kit contains 20 each solar cells. On the panel board are power line taps which allow the user to select voltages (one voltage at a time) from 0.5VDC to 10VDC. The applications of each panel can be further expanded by coupling additional panels in series for more voltage or in parallel for more current. The premium grade solar cells provide the current necessary for the operation of most portable transistor radios, small battery powered cassette tape players and unlimited experimental solar projects.

JE305 . . . . $39.95

EPROM Erasing Lamp

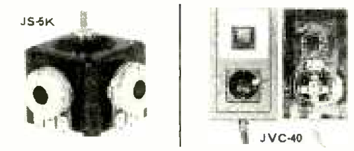


- **Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.**
- **Erases up to 4 chips within 20 minutes.**
- **Maintains constant exposure distance of one inch.**
- **Special conductive foam liner eliminates static build-up.**
- **Built-in safety lock to prevent UV exposure.**
- **Compact — only 7-5/8" x 2-7/8"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

UVS-11EL Replacement Bulb $16.95

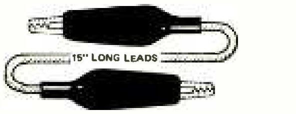
UVS-11E $79.95

JOYSTICKS



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

ALLIGATOR CLIP TEST LEADS



Heavy-duty leads, color coded. Insulated alligator clip on each end. 15" long. Two each black, red, blue, white and yellow.

#ALCP (10 per pack) . . . . $2.95/pkg.

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)	6.95
DP8253	Prog. Interval Timer	8.95
DP8255	Prog. Peripheral I/O (PPI)	5.95
DP8257	Prog. DMA Control	9.95
DP8259	Prog. Interrupt Control	9.95
DP8275	Prog. CRT Controller	39.95
DP8279	Prog. Keyboard/Display Interface	9.95
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
DP8310	Octal Latched Peripheral Driver	5.25
DP8311	Octal Latched Peripheral Driver	5.25

6800/6800 SUPPORT DEVICES

MC6800	MPU	7.95
MC6802CP	MPU with Clock and RAM	14.95
MC6810API	128x8 Static RAM	4.95
MC6821	Peripheral Inter. Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	17.95
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)	11.95
Z80A (780-1)	CPU (MK3880N-4) (4MHz)	13.95
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)	7.95
INS8039N-6	CPU—Sgl. Chip 8-Bit (128 bytes RAM)	9.95
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	9.95
TMS9900JL	MPU—16-Bit	39.95

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
MM1402N	256-Bit Dynamic	2.95
MM5013N	1024-Bit Dynamic/Accumulator	1.95
MM5016H	500/512-Bit Dynamic	1.95
MM5034N	Octal 80-Bit	9.95
MM5035N	Octal 80-Bit	9.95
2504V (1404A)	1024-Bit Dynamic	1.95
2518N	Hex 32-Bit Static	3.95
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 Band Filter	19.95
AF122-1CJ	Touch Tone High Band Filter	19.95
LM308CH	Super Gain Op Amp	1.15
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°)	5.00
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	6.95

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	3.25
2114L	1024x4 Static 450ns Low Power	3.49
2114-2	1024x4 Static 200ns	3.95
2114L-2	1024x4 Static 200ns Low Power	4.95
74S200	256x1 Static	6.95
4116N-4 (UPD416)	16K Dynamic 250ns (MM5290N-4)	2.95
4164N-3	64K Dynamic 200ns	19.95
MM2147J	4096x1 Fast 70ns	7.95
5101	256x4 Static	7.95
MM5261	1024x1 Dynamic Fully Decoded	.99
MM5262	2Kx1 Dynamic	.49
MM5280/2107	4096x1 Dynamic	4.95
MM5290N-2 (4116)	16K Dynamic 150ns (UPD416C-3)	3.95
MM5298J-3A	8K Dyn. 200ns (lower ½ of MM5290J)	1.95
HM6116-4	16K (2Kx8) Static 200ns	14.95
82S25	64 Bit RAM (16x40C)	3.49
UPD414/MK4027	4K Dynamic 16-pin	4.95
TMS4044-45NL	4K Static	9.95
TMS4045	1024x4 Static	9.95

PROMS/EPROMS

1702A	2K UV Erasable PROM	5.95
2708	8K EPROM	4.95
TMS2716	16K EPROM (-5V, +5V, +12V)	9.95
2716 Intel (2516) TI	16K EPROM (Single +5V)	8.95
2732 Intel TI	32K EPROM	17.95
2758	8K EPROM (450ns) (Single +5V)	7.49
2764Q	64K EPROM (Hitachi HN462764)	49.95
5203	2048 PROM	14.95
82S23 (74S188)	32x8 PROM (Open Collector)	3.95
82S115	4096 Bipolar PROM	14.95
82S123 (74S288)	32x8 Tri-State Bipolar PROM	3.95
82S185	8K PROM	16.95

— Over 30 More PROMS Listed In Our Catalog —

ROM'S

2513 (2140)	Character Generator (Upper Case)	9.95
2513 (3021)	Character Generator (Lower Case)	9.95

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

EECO Rocker DIP Switch — "Mini-Dip™" 2400 Series

THE MOST UNIQUE DIP SWITCH AVAILABLE!

MINI-DIP is designed to retrofit all major brands of Dip switches. Unique features include locking rod design to prevent accidental actuation and gold self-wiping contact. One-piece housing and press-fit terminals prevent contamination. 2-10 station Form "A" and 1-5 station Form "C". **• Terminals on .100 x .300 (2.54 x 7.62) centers • PCB or dip socket mountable • Positive cleaning/wiping action with gold contact • Total seal and bottom seal**

Part No.	Pos.	Configuration	Socket	Price	Part No.	Pos.	Configuration	Socket	Price
2400-2	2	12	8 pin	.79 - 10/ 6.95	2400-6	6	123456	14 pin	1.09 - 10/ 9.95
2400-3	3	123	8 pin	.89 - 10/ 7.95	2400-7	7	1234567	14 pin	1.19 - 10/10.95
2400-4	4	1234	8 pin	.99 - 10/ 8.95	2400-8	8	12345678	16 pin	1.29 - 10/11.95
2400-ABCD	4	ABCD	8 pin	.99 - 10/ 8.95	2400-9	9	123456789	18 pin	1.39 - 10/12.95
2400-5C	6	C54321	14 pin	1.09 - 10/ 9.95	2400-10	10	0123456789	20 pin	1.49 - 10/13.95

JE608 PROGRAMMER

2704/2708 EPROM PROGRAMMER

GENERAL APPLICATIONS:
- **To program EPROMS 2704 and 2708.**
- **Developmental system for microcomputer circuits**
- **To read the contents of a pre-programmed EPROM**
- **To compare EPROM(s) for content differences**
- **To emulate a programmed EPROM**
- **To store program in RAMS for alterations**
- **Three separate Display Registers: 8 LED's for Hex Key entries, 10 LED's (2[10]) for Address Register and 8 LED's for Data Memory Register. The Data Memory Register displays the content of the RAMs from the EPROM Chip. Development of microprocessor systems by means of a ribbon cable from the programmer panel test socket to the EPROM socket on the microprocessor board. Rapid checking verification of programmed data changes. User may move data from a master to RAM's or write into RAM's with keyboard entries. Allows manual stepping manipulation (up and down) at any address location. Stand-alone EPROM Programmer consisting of: A 19-key Hexadecimal Keyboard assembly. Programmer Board assembly with 4 power supplies and a LED/Test Socket Panel Board assembly. The Test Socket is zero force insertion type. Power requirements: 115VAC, 60Hz, 6W. Compact desk-top enclosure: Color coordinated designer's case with light tan panels and molded end pieces in mocha brown. Size: 3¼"H x 11"W x 8¾"D. Weight: 5 lbs.**

The JE608 EPROM Programmer is a completely self-contained unit which is independent of computer control and requires no additional systems for its operations. The EPROM can be programmed from the Hexadecimal Keyboard or from a pre-programmed EPROM. The JE608 Programmer can emulate a programmed EPROM by the use of its internal RAM circuits. This will allow the user to test or pretest a program for a system, prior to programming a chip. Any changes in the program can be entered directly into the memory circuits with the Hexadecimal Keyboard so that rewriting the entire program will not be necessary. The JE608 Programmer contains a Programmer/Board w/25 IC's & includes power supplies of: -5V, +5V, +12V and + 26V. The Hexadecimal Keyboard and LED/Test Socket Panel board are separate assemblies within the system.

JE608K Kit $399.95

JE608A Assembled and Tested $499.95

JE608-16K ADAPTER BOARD FOR 2716/2758 EPROMS

GENERAL DESCRIPTION: The JE608-16K Adapter Board allows the JE608 Programmer to be modified for the additional programming of the 2716 and 2758 EPROMS. The adapter provides for adding an address switch for the 2[11] bit and also for selecting the proper power and timing pulses to be applied to the EPROM. Programming and emulating the 2716 (16K) EPROM is done separately to each half (1024x8) of the EPROM because of the existing 8K RAM capacity in the JE608 Programmer.

JE608-16K	Adapter Board Kit	$29.95
JE608-Upgrade	(Send assembled JE608 to factory for adapter installation . . . . . . of the JE608-16K Adapter Board Kit)	$99.95
JE608A-16K Mod.	Assembled JE608 w/Adapter (JE608-16K) Installed	$599.95

BOOKS

National Semiconductor — Intersil — Intel

30001	**National CMOS Data Book** (640 pages) 74C, CD4000, and A/D Converters	$5.95
30002	**National Interface Data Book** (704 pages) DP, DS8000, DS3600, DS75000, etc.	$5.95
30003	**National Linear Data Book** (1376 pages) LM, LF, ADC, DAC, LH Series	$8.95
30004	**National Series 80 — Board Level Computer** (224 pages)	$4.95
30005	**National TTL Logic Data Book** (624 pages) 7400, LS, L, H, S, and DM8000 Series	$8.95
30006	**Buy above (3) 30001, 3, 5 as a set**	**$19.95/lot**
30009	**Intersil Data Book** (1074 pages)	$6.95
010400	**Intel Component Data Catalog** Full data sheets for Intel's products incl. memory devices, microproc., peripherals & indust./mil. products (1328 pages)	$10.00
205610	**Intel Peripheral Design Handbook** Full data sheets, appl. notes for Intel peripheral device components (644 pages)	$7.50

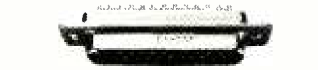
AC and DC Wall Transformers

With Universal Plug and 9V Battery Snap

Selective voltages: 6, 9, 12VDC. Polarity selection (+/-). six-foot line from adapter to plugs — six-inch line from adapter to battery snap. 120V/60Hz, 300mA.

Part No.	Input	Output	Price
AC 250	117V/60Hz	12VAC 250mA	$3.95
AC 500	117V/60Hz	12VAC 500mA	$4.95
AC1000	117V/60Hz	12VAC 1 amp	$5.95
AC1700	117V/60Hz	9VAC 1.7 amp	$3.95
DC6912	120V/60Hz	6,9,12VDC 300mA	$9.95
DV9200	117V/60Hz	9VDC 200mA	$3.25
DC900	120V/60Hz	9VDC 500mA	$3.95

CONNECTORS



DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
D20418-2	Screw Lock Hdwr. (2) DB25S/P	2/$.99
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.

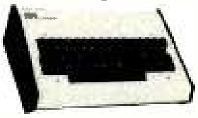
Kit comes complete with:

★ **8 ea. MM5290 (UPD416/4116) 16K Dyn. Rams (*NS)**

★ **Documentation for Conversion**

TRS-16K2	*150NS	$29.95
TRS-16K3	*200NS	$24.95
TRS-16K4	*250NS	$19.95

JE610 ASCII Encoded Keyboard Kit



The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and −12V @ 10 mA for operation. Features: 60 keys generate the 126 characters, upper and lower case ASCII set. Fully buffered. Two user-define keys provided for custom applications. Caps lock for upper-case-only alpha characters. Utilizes a 2376 (40-pin) encoder read-only memory chip. Outputs directly compatible with TTL/DTL or MOS logic arrays. Easy interfacing with a 16-pin dip or 18-pin edge connector. Size: 3½"H x 14½"W x 8¾"D

JE610/DTE-AK (After assembled as pictured above) . . . **$124.95**

JE610 Kit 62-Key Keyboard, PC Board, & Components (no case). . . . **$ 79.95**

K62 62-Key Keyboard (Keyboard only) . . . . **$ 34.95**

DTE-AK (case only — 3¼"Hx11"Wx8¾"D) **$ 49.95**

NEW!

JE212 — Negative 12VDC Adapter Board Kit for JE610 ASCII KEYBOARD KIT
Provides -12VDC from Incoming 5VDC . . **$9.95**

JE600 Hexadecimal Encoder Kit

FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

The JE600 Encoder Keyboard Kit provides two separate hexadecimal digits produced from sequential key entries to allow direct programming for 8-bit microprocessor or 8-bit memory circuits. Three additional keys are provided for user operations with one having a bistable output available. The outputs are latched and monitored with 9 LED readouts. Also included is a key entry strobe. Features: Full 8-bit latched output for microprocessor use. Three user-define keys with one being bistable operation. Debounce circuit provided for all 19 keys. 9 LED readouts to verify entries. Easy interfacing with standard 16-pin IC connector. Only +5VDC required for operation. Size: 3½"H x 8¾"W x 8¾"D

JE600/DTE-HK (After assembled as pictured above) **$99.95**

JE600 Kit 19-Key Hexadec. Keyboard, PC Board & Cmpnts. (no case) . . **$59.95**

K19 19-Key Keyboard (Keyboard only) **$14.95**

DTE-HK (case only — 3½"Hx8¼"Wx8¾"D) **$44.95**

OPERATION ASSIST

If you need information on outdated or rare equipment—a schematic parts list etc —another reader might be able to assist. Simply send a postcard to Operation Assist, Popular Electronics, 1 Park Ave. New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)

Shakespear Model 840 Fortress CB radio. Need operation manual and schematic. Mick C.B. Sales & Service, Box 301, Beloit, OH 44609.

Multi-Products Model CM-1 receiver. Need manual and schematic. James Lincoln, 12 Crestview Terrace, Wallingford, CT 06492.

Roberts Model 770 tape recorder. Need service manual, schematic or any technical information. E.W. Hoffhine, Box 252, Kihei, HI 96753.

MITS 680 I-0 board. Need schematic and owners manual. K. Fisher, Box 268, Bartlesville, OK 74003.

Gertsch Model FM3 vhf frequency meter. Need schematic and instruction manual. Garry Miller, 201 Coral Way, Broomfield, CO 80020.

Concord Model R-1100 tape recorder. Need power transformer and source for other parts. M.L. Smith, Box 15337, Sarasota, FL 33579.

Viking 2 transmitter and **Heath** Model HW-16 transceiver. Need schematics and manuals. E.H. Wilbur, K4FQJ, Box 6678, Lake Worth, FL 33461.

Paratronics Inc. Model LA-100 digital logic analyzer. Need schematic for pc board and horizontal PROM programming information. Mark Heckley, 3733 Lockwood, Toledo, OH 43612.

Fairchild Model 2773 transistor is needed for a Standel guitar amplifier Model SC-12, serial 5521-11. Also need schematics (NPN, Beta of 200+) Chris Howie, Box 675, Vashon, WA 98070.

Elco Model 625 tube tester and Model 427 scope. Need tube chart and operators manual and schematics. R. DesRoches, 171 W. 34 St., Hamilton, Ontario, Can L9C5K4.

Zenith Model R7000 trans-oceanic radio. Need schematic and service manual. Alain M. Butoyi, 308 Westwood Plaza #468, Los Angeles, CA 90024.

Hallicrafters SX99 receiver. Need schematic, operating manual and alignment data. E.C. Ozag, 823 N. Marion, Oak Park, IL 60302.

Akai Model GX-365D tape recorder. Need schematic or operation manual. Earl Kunselman, MacKay Rd 1, Saxonburg, PA 16056.

Amateur Model G-76 transceiver. Need schematic and copy of manual. Keith S. Huie, 240 Willow Rd., Menlo Park, CA 94025.

Burroughs Serial #A60802V. Series B9352 video terminal. Need schematics or service manual. Tony Constantino, 814 Barclay Ave.., Morris Ville, PA 19067.

Hallicrafters Model S-94 shortwave receiver. Need schematic and alignment information. Allen T. Purdy, Fr., 17 Dunwoodie St., Yonkers, NY 10704.

Hallicrafters CB181 Regency MR10, and Heath GC1A transceivers. Need technical data. T.A. Dgogoski, 507 Coal Valley, Clairton, PA 15025.

Heathkit Model IT-3121 curve tracer and **Eico** Model 377 audio signal generator. Need schematics and manuals. Fred Ng, 2230 Jones St., San Francisco, CA 94133.

Bell & Howell Model 10D-4050 oscilloscope. Need schematic and operating manual. John F. Eldredge, 3166 Parthenon Ave., Nashville, TN 37203.

Vu-Data Model PS-940 oscilloscope. Need service manual and schematic. H. Usbeck, 88-41 Ashford St., Queens Village, NY 11427.

Precision Model #10-54 tube tester. Need schematic, operating manual and parts list. Bobby L. Robinson, 75 E. Nelson Point, Indian Head, MD 20640.

Boonton 260-A frequency meter and **Muzak** Model STR-100 tuner. Need schematics and parts lists. Dave Overton, 1709 W. 30, Austin, TX 78703.

Hallicrafters Model S-38B radio. Need schematic. Joseph W. Decker, Box 411, Staten Island, NY 10314.

Grigsby Grunow Co. Model 70, 7 tube radio receiver. Need schematic. Gary Block, Box 357, Lost Nation, IO 52254.

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Lafayette Model LA-224T amplifier. Need schematic. Erique M. Senra, 740 E. 11th Pl, Hialeah, FL 33010.

Dumont Model 2088 oscilloscope. Need instruction book and schematic. Edward Goldman, 27065 Sutherland, Southfield, MI 48076.

General Electronic Equipment Co., Model 555 wide band oscilloscope. Need schematic and handbook. Joseph J. Price, Box 134 Petoskey Rd., Charlevoix, MI 49720.

Pilot Model PMP 2000 AM/FM stereo receiver/turntable. Need schematic. Dale L. Sherwood, 1635 Park Towne Lane, N.E., Suite 1, Cedar Rapids, IA 52402.

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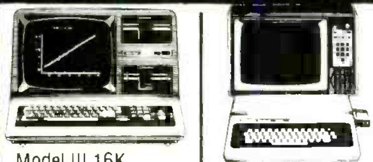

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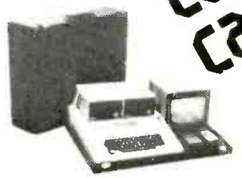

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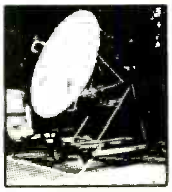

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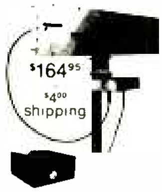

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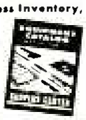

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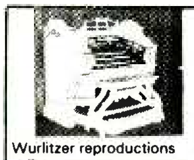

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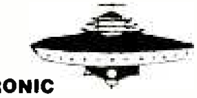

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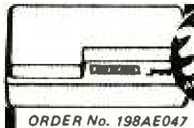

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DATAPOINT COMPUTER NETWORK allows multiple computers to be linked into a larger system by using the Radio Shack TRS-80 Model II. Called ARCNET, the system is based on Datapoint's Attached Resource Computer (ARC), in use since 1977. In the ARCNET scheme, multiple TRS-80 Model II computers can access common data bases such as accounting, word-processing information, or electronic filing systems; as well as share the use of peripherals. An interface card is required in each networked computer; it installs in existing card slots in the rear of the machine. Cost for the card will be around $400. A junction box for four processors will cost about $200, with larger networking capability available for more money. First delivery of ARCNET is forecast for the second quarter of 1982.

FCC KILLS A GROWTH PLAN that would have put hundreds of new AM radio stations on the air by reducing channel spacing from the present 10 kHz to 9 kHz. In a reversal of its previous position, the FCC commissioners overturned their unanimous Dec. 1979 ruling permitting the expansion. The reason given was that the conversion could cost broadcasters up to $40 million to modify their equipment. The National Association of Broadcasters has expressed support of the new FCC ruling.

SONY'S MAVICA VIDEO STILL CAMERA does what no still camera has done before. It eliminates the conventional developing and printing processes by using a CCD imager to record pictures on magnetic disk. (Mavica stands for Magnetic Video Camera.) The disk can record up to 50 still pictures, which can then be played back immediately on your TV receiver through a special playback unit. Each picture can be accessed directly, via a memory function. In addition, the pictures can be dubbed onto a videotape or transmitted to another receiver over the phone lines via a modem. Continuous recording of ten pictures per second can be obtained, and speeds of up to 60 pictures per second are said to be possible in the future. Also in the development stage is a hard-copy printer. The camera itself, including battery, weighs about 1 3/4 lb, and has the dimensions of a standard 35-mm camera. The Mavica should be available in Japan in about 18 months.

'NETWORK OF THE FUTURE' is the trademark of National Entertainment Television's (NET) new service. AT&T will provide the satellite link to regular TV stations, cable TV, and multiple distribution service pay-TV carriers, as well as to apartment complexes and individual homes with earth stations. Scheduled to start in the Spring of 1982 and planned to air 24 hours a day, the programming will include first-run movies, news and entertainment, talk shows, call-in shows, and commercial-free educational programming for college credit. NET has also filed with the FCC to provide teletext electronic newspaper service, with 200 pages of the latest news and information.

INDEPENDENT SOFTWARE WRITERS can now sell their wares, if acceptable, through Hewlett-Packard. A new catalog is promoting software for the HP-41 programmable calculator, and can promote your software if both you and Hewlett-Packard agree.

JAZZ AMERICA, which has been airing on PBS since the fall, is the first TV feature to use digital soundtracks. The series comprises current footage of jazz concerts, as well as rare archival clips, for what will eventually encompass the entire history of jazz. Final mixdown of all audio is done by Master Digital Inc., using the Sony PCM-1610 digital audio processor. The Sony system incorporates automatic SEMPTE time code—permitting extensive video editing and simulcasting of stereo audio.

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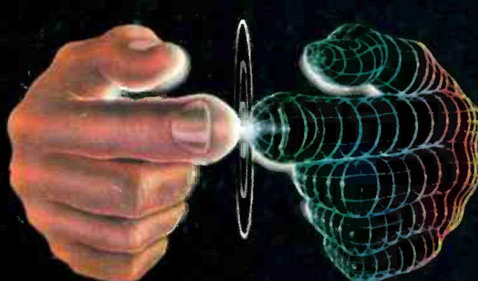

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