Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

FEBRUARY 1980/95¢

Audio Noise Source For Testing Hi-Fi
How a Car "Econometer" Can Save Gas
A Mastermind Controller for Photo Labs

The New Digital Multimeters

How to Make the Right Buying Judgments

| 2100 FM Tuner

500 Speaker System

RG Dynamics PRO-20 Dynamic Processor

Issue

FIRST OF A SERIES

FTC Revolt

You've heard of the tax revolt. It's about time for an FTC revolt. Here's my story and why we've got to stop federal bureaucratic regulation.

My story is only one example of how the FTC is harassing small businesses but I'm not going to sit back and take it.

By Joseph Sugarman, President, JS&A Group, Inc.

I'm pretty lucky. When I started my business in my basement eight years ago, I had little more than an idea and a product.

The product was the pocket calculator. The idea was to sell it through advertisements in national magazines and newspapers.

Those first years in the basement weren't easy. But, we worked hard and through imaginative advertising and a dedicated staff, JS&A grew rapidly to become well recognized as an innovator in electronics and marketing.

THREE BLIZZARDS

In January of 1979, three major blizzards struck the Chicago area. The heaviest snowfall hit Northbrook, our village—just 20 miles north of Chicago.

Many of our employees were stranded—unable to get to our office where huge drifts made travel impossible. Not only were we unable to reach our office, but our computer totally broke down leaving us in even deeper trouble.

But we fought back. Our staff worked around the clock and on weekends. First, we processed orders manually. We also hired a group of computer specialists, rented outside computer time, employed a computer service bureau, and hired temporary help to feed this new computer network. We never gave up. Our totally dedicated staff and the patience of many of our customers helped us through the worst few months in our history. Although there were many customers who had to wait over 30 days for their parcels, every package was eventually shipped.

WE OPENED OUR DOORS

During this period, some of our customers called the FTC (Federal Trade Commission) to complain. We couldn't blame them. Despite our efforts to manually notify our customers of our delays, our computer was not functioning making the task extremely difficult.

The FTC advised JS&A of these complaints. To assure the FTC that we were a responsible company, we invited them to visit us. During their visit we showed them our computerized microfilm system which we use to back up every transaction. We showed them our new dual computer system (our main system and a backup system in case our main system ever failed again). And, we demonstrated how we were able to locate and trace every order. We were very cooperative, allowing them to look at every document they requested.

The FTC left. About one week later, they called and told us that they wanted us to pay a $100,000 penalty for not shipping our products within their 30-day rule. (The FTC rule states that anyone paying by check is entitled to have their purchase shipped within 30 days or they must be notified and given the option to cancel.)

NOT BY CONGRESS

The FTC rule is not a law nor a statute passed by Congress, but rather a rule created by the FTC to strengthen their enforcement powers. I always felt that the rule was intended to be used against companies that purposely took advantage of the consumer. Instead, it appears that the real violators, who often are too difficult to prosecute, get away while JS&A, a visible and highly respected company that pays taxes and has contributed to our free enterprise system, is singled out. I don't think that was the intent of the rule.

And when the FTC goes to court, they have the full resources of the US Government. Small, legitimate businesses haven't got a chance.

We're not perfect. We do make mistakes. But if we do make a mistake, we admit it, accept the responsibility, and then take whatever measures necessary to correct it. That's how we've built our reputation.

BLOW YOUR KNEE CAPS OFF

Our attorneys advised us to settle. As one attorney said, "It's like a bully pulling out a gun and saying, 'If you don't give me a nickel, I'll blow your knee caps off.'" They advised us that the government will subpoena thousands of documents to harass us and cause us great inconvenience. They warned us that even if we went to court and won, we would end up spending more in legal fees than if we settled.

To settle would mean to negotiate a fine and sign a consent decree. The FTC would then issue a press release publicizing their victory.

At first we tried to settle. We met with two young FTC attorneys and agreed in principle to pay consumers for any damages caused them. But there were practically no damages, just a temporary computer problem, some late shipments, and some bad weather. The FTC then issued a massive subpoena requesting documents that will take us months to gather and which we feel was designed to harass or force us to accept their original $100,000 settlement request.

Remember, the FTC publicizes their actions. And the higher the fine, the more the publicity and the more stature these two attorneys will have at the FTC.

If this all sounds like blackmail—that's just what it appeared to be to us.

We did ship our products late—something we've admitted to them and which we publicly admit here, but we refuse to be blackmailed into paying a huge fine at the expense of our company's reputation—something we've worked hard eight years to build.

We're not a big company and we realize it would be easier to settle now at any cost. But we're not. If this advertisement can attract the attention of Congressmen and Senators who have the power to stop the harassment of Americans by the FTC, then our efforts will be well spent.

ALL AMERICANS AFFECTED

Federal regulation and the whims of a few career-building bureaucrats is costing taxpayers millions, destroying our free enterprise system, affecting our productivity as a nation and as a result is lowering everybody's standard of living.

I urge Congressmen, Senators, businessmen and above all, the consumer to support legislation to take the powers of the FTC from the hands of a few unelected officials and bring them back to Congress and the people.

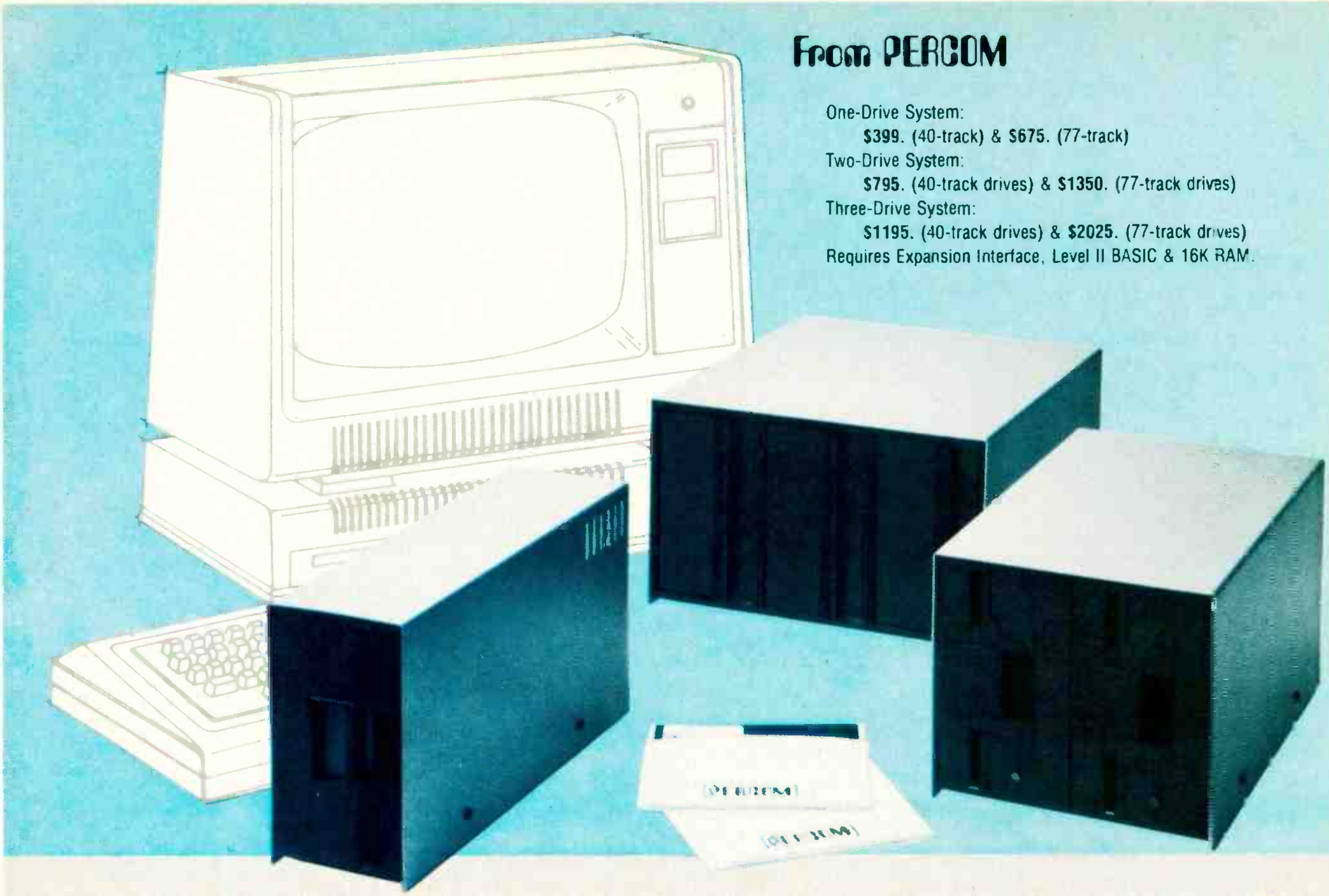
I will be running this advertisement in hundreds of magazines and newspapers during the coming months. I'm not asking for contributions to support my effort as this is my battle, but I do urge you to send this advertisement to your Congressmen and Senators. That's how you can help.

America was built on the free enterprise system. Today, the FTC is undermining this system. Freedom is not something that can be taken for granted and you often must fight for what you believe. I'm prepared to lead that fight. Please help me.

Note: To find out the complete story and for a guide on what action you can take, write me personally for my free booklet, "Blow your knee caps off."

JS&A PRODUCTS THAT THINK®

One JS&A Plaza, Northbrook, Ill. 60062



Low Cost Add-On Storage for Your TRS-80*. In the Size You Want.

When you're ready for add-on disk storage, we're ready for you. Ready with six mini-disk storage systems — 102K bytes to 591K bytes of additional *on-line* storage for your TRS-80*.

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- TFD-100™ drives accommodate "flippy disks." Store 205K bytes per mini-disk.
- Low prices. A single-drive TFD-100™ costs just $399. Price includes PATCH PAK #1™ disk.
- Enclosures are finished in system-compatible "Tandy-silver" enamel.

Whether you need a single, 40-track TFD-100™ add-on or a three-drive add-on with 77-track TFD-200™s, you get more data storage for less money from Percom.

Our TFD-100™ drive, for example, lets you store 102.4K bytes of data on one side of a disk — compared to 80K bytes on a TRS-80* mini-disk drive — and 102.4K bytes on the other side, too. Something you can't do with a TRS-80* drive. That's almost 205K bytes per mini-disk.

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PATCH PAK #1™, our upgrade program for your TRSDOS*, not only extends TRSDOS* to accommodate 40- and 77-track drives, it enhances TRSDOS* in other ways as well. PATCH PAK #1™ is supplied with each drive system at no additional charge.

The reason you get more for less from Percom is simple. Peripherals are not a sideline at Percom. Selling disk systems and other peripherals is our main business — the reason you get more engineering, more reliability and more back up support for less money.

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To order add-on mini-disk storage for your TRS-80*, or request additional literature, call Percom's toll-free number: 1-800-527-1592. For detailed Technical information call (214) 272-3421.

Orders may be paid by check or money order, or charged to Visa or Master Charge credit accounts. Texas residents must add 5% sales tax.

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CIRCLE NO. 55 ON FREE INFORMATION CARD

FEBRUARY 1980 25TH ANNIVERSARY

Popular Electronics®

VOLUME 17, NUMBER 2

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

About the cover:

Sampling of portable digital multimeter models, all of which feature LCD readouts.

Photo by Don Carrol

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Editorial

CB RADIO—A PHOENIXLIKE FUTURE?

There were 980,253 CB license applications in the month of January 1977, 453,811 in January 1978, and 164,400 in January 1979. That's quite a downward slide, but it certainly does not spell the death of CB as so many people have surmised.

With ten month's worth of 1979 figures in hand, CB license applications reached 777,393. By year's end, it'll edge close to one million, with total active CB licenses numbering almost 15 million! Moreover, the cumulative percentage change in application rate has moved very slightly up over the months.

Will we ever again see the stunning growth exhibited by CB radios in the mid '70s? Perhaps, if a severe auto gasoline shortage develops once more and many service stations close early. Or will the creation of an additional Personal Radio Service, as outlined in the FCC's June 1979 Notice of Inquiry (PR Docket No. 79-140), spur consumer purchasing?

This latest step would create a new service in the 900-MHz band (Hams rejoice, since 220 MHz is not in the picture). The proposal has many enticing attributes that are not practical at 27 MHz. These include the use of FM, selective signalling, extended CB range through use of repeaters, equipping new transceivers with an automatic transmitter identification system (ATIS) to simplify rules enforcement, and placing of telephone calls in the Public Switched Telephone Network (PSTN).

Initial price of 900-MHz equipment is expected to be in the $300 to $500 range as contrasted to the $50 to $500 range of 27-MHz transceivers today. So one of the answers sought by the FCC in its Notice of Inquiry is how many people (CB licensed or not) would give serious consideration to buying equipment for operation at 900 MHz, understanding that the price will likely decline as demand grows?

I, for one, would welcome such two-way radio facilities for the general public. However, it would likely be a few years before such a private radio service is implemented. Better late than never, though.

Art Salsberg

Step up to your next computer.

STEP UP TO A C4P FROM OHIO SCIENTIFIC

You know about computers. In fact, you probably own one now. One that you might be thinking of expanding. We have a better idea. Take a giant step into the personal computing future with an amazing, new C4P from Ohio Scientific.

SPEED SEPARATES THE COMPUTERS FROM THE TOYS

The C4P MF has execution speed that is twice as fast as Apple II or Commodore PET and over THREE times as fast as TRS-80. They are many times faster than the recently introduced flock of video game type computers. And, as if that weren't fast enough, the C4P nearly doubles its speed when equipped with the GT option.

Just look at the back panel of the C4P MF.

All the I/O you'll ever need!

Apple II, Commodore PET, TRS-80, and Atari 800 are registered trade names of Apple Computer Inc., Commodore Business Machines Ltd., Radio Shack, Atari, respectively.

SOUND

1—programmable tone generator 200 — 20 KHz
1—8 bit companding digital to analog converter for music and voice output.

HUMAN INPUT EXPANSION

2—8 axis joystick interfaces
2—10 key pad interfaces

HOME INTERFACE

1—AC-12 AC remote control interface

DISPLAY

32 x 64 with upper and lower case
2048 Characters.
256 x 512 effective Graphic Points
16 Colors

SOFTWARE

Ohio Scientific offers a comprehensive library of both systems and applications software for the C4P.

The C4P is an outstanding premium computer — years ahead of the market. We know because there's nothing quite like it for the price, anywhere. And probably won't be for a very long time.

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C4P $698

8K BASIC-in-ROM, 8K of static RAM and audio cassette interface. Can be directly expanded to 32K static RAM and two mini-floppy disks.

C4P MF $1695

All the features of the C4P plus real time clock, home security system interface, modem interface, printer interface, 16 parallel lines and an accessory BUS. The C4P MF starts with 24K RAM and a single mini-floppy and can be directly expanded to 48K and two mini-floppies. Over 45 diskettes now available including games, personal, business, educational and home control applications programs as well as a real time operating system, word processor and a data base management system.

Computers come with keyboards and floppies where specified. Other equipment shown is optional.

For literature and the name of your local dealer, CALL 1-800-321-6850 TOLL FREE.

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Letters

FAX—THE QUIET GIANT

In "FAX—The Quiet Giant" (December 1979), Fig. 4 was intended strictly to describe a 2:1 bandwidth compression technique popularly applied to *analog* fax systems, which is where the illustration was referenced in my manuscript. Except for the depiction of black-white thresholding, the diagram has nothing whatever to do with the concept of digital data compression, where the figure number was incorrectly transferred.—*Daniel M. Costigan.*

NOTES ON HUMIDITY CONTROL

Regarding the "Solid-State Humidity Control" (November 1979), I believe you should make your readers aware of . . . deficiencies of the design. . . . The owners manual for my commercial humidifier states that the maximum safe level of humidity in a house varies with the outside temperature because of moisture problems above these humidity levels. However, the range shown is 20-35% RH. The article apparently recommends 30-50% RH, which probably will cause moisture problems and will be a major problem if it goes undetected inside the walls.—*Edward J. Canton, Library, PA.*

Depending on outside temperature, you can only get a certain amount of relative humidity in your home. Beyond that point, condensation will appear on the windows. Such condensation may, of course, not be beneficial to the walls so, when it starts to occur, it is wise to cut back on the humidity as instructed in the article.—Ed.

W. W. Grainger does not sell water solenoids to individuals. Also, I cannot find a telephone number for Wm. Stein Mfg. Co.—*F. S. Colligan, Sumner, MD.*

The water solenoid or a similar one that will do the job can be obtained from most plumbing supply houses. The source for the spray nozzle was unfortunately misspelled in the article. It is Wm. Steinen Mfg. Co. The address (29 E. Halsey Rd., Parsipanny, NJ 07054) was correct, and the phone number is 201-887-6400.—Ed.

It has been my experience that water used in any furnace humidity system is more efficient if taken from the hot water line. Warm water spray is much easier for the furnace's warm air to evaporate.—*Dennis Ghorf, Weston, Ont., Can.*

IMPROVING "SUPER DISCS"

Your article on "Super Discs" (December 1979) fails to mention that most modern recordings also go through a lot of overdubbing, equalization, compression, and other processing. Furthermore, much of the equipment used by studios is not really state of the art. Therefore, would not the quality of recordings improve if such processing were eliminated or minimized and engineers demanded better equipment, even if tape were still used for recording the original performance?—*Michael Kiley, Palos Heights, IL.*

Yes. The article did note that some super discs are careful analog tape transfers.—Ed.

SIMPLIFYING JOGGING TOTALS

In "Electronic Pedometer for Joggers" (August 1979), it would simplify the final determining of the total number of strides if, instead of keying in 1, +, 1, =, = to initialize the system and then subtracting 1 from the answer, the user keys in 0, +, 1, =, = initially. The answer he gets is then in finished form.—*Duncan Wier, San Francisco, CA.*

Out of Tune

In "NASA Motor-Control Circuit Cuts Electric Cost" (October 1979), the length of No. 22 wire necessary to fabricate *R1* (under "Construction" on page 43) should be 15 inches, not 9 inches. (This is in correction to the "Out of Tune" that appeared in the December issue.)

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.

Tangent-Tracking Turntable

The Phase Linear 8000 turntable uses a tangent-tracking tonearm driven by a linear induction motor that's controlled by an optoelectronic position detector. The platter, which operates at 33 or 45 rpm, is driven by a high-torque, quartz-lock dc motor, to which it is directly coupled. Signal-to-noise ratio is rated at 78 dB (DIN B)., with wow and flutter at 0.013% rms. By virtue of the tangential arm configuration, tracking error and skating force are both specified at zero. Capable of fully automatic or manual operation, the unit measures 23" W x 10" H x 17½" D and weighs 26½ lb (12 kg). $750.

CIRCLE NO. 82 ON FREE INFORMATION CARD

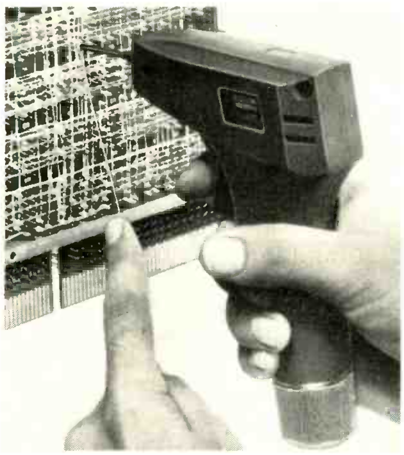
Collins Amateur Radio Transceiver

The Collins KWM-380 transceiver is a self-contained, solid-state amateur station including an ac/dc power supply and speaker. In RECEIVE, it provides general frequency coverage between 0.5 and 30 MHz. Transmit output power is 100 W PEP for SSB, down-rated for CW and RTTY if optional blower is not installed. A microprocessor controlled frequency synthesizer is said to give high stability and accuracy and offers a choice of four tuning rates—1-MHz, 1-kHz, 100-Hz and 10-Hz increments. The microprocessor also controls the LED frequency display, band selection and 2-register memory which allows split-frequency (even cross-band) operation. The operator can transmit immediately upon dialing a frequency because there are no bandswitch or tuning controls. Transmit low-pass filters are automatically selected by relays. A front panel meter measures signal strength in receive. In transmit, it measures alc, supply voltage, or forward or reflected power. Options include a noise blanker and a choice of i-f filters.

CIRCLE NO. 83 ON FREE INFORMATION CARD

Battery-Powered Wire-Wrap Tool

The BW-2630 wire-wrapping tool from OK Machine and Tool Corp. operates on two standard C-size NiCd batteries (not included) and accepts either of two bits. Bit BT-30 is for wrapping 30 AWG wire onto 0.025 sq in. pins; BT-2628 wraps 26-28 AWG wire. The tool, with both positive indexing and anti-overwrapping mechanisms is $19.75; the BT-30 is $3.95 and the BT-2628 is $7.95.



CIRCLE NO. 84 ON FREE INFORMATION CARD

Visonik Tiny Car Preamp

Visonik's new PA-1 Auto Stereo Preamplifier measures only 7b K 1rb K 4b (178 K 38 K 102 mm) and will handle signals from two sources, such as radio and tape. It has three tone controls—bass, mid, and treble—and a volume control. High input impedance of the preamp allows a tape deck or radio to act as a signal source without delivering power. It can be switched to a lower value for use with components that need more loading. Specifications include: frequency response 20-20,000 Hz, ± 0.1 dB; THD less than 0.01%; S/N 70 dB; and output impedance 150 ohms.

CIRCLE NO. 85 ON FREE INFORMATION CARD

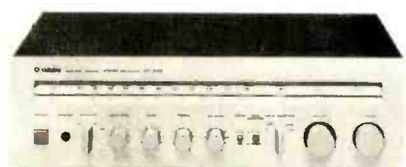
Tarbell Dual-Disk Drive System

Tarbell offers a new dual-disk system built around two Siemens 8" (203-mm) drives. The Model VDS-II Vertical Disk Subsystem also features a Tarbell floppy-disk interface, CP/M DOS, Tarbell BASIC, cabinet with fan and power supply, all cables and connectors, and full hardware and software documentation. This Shugart-compatible, single-density, single-sided dual-drive system employs standard IBM-compatible soft-sectored diskettes and has a 256K capacity per side and a transfer rate of 250K bits. Interfaces with S-100 bus and has 32-byte ROM bootstrap that is automatically implemented after RESET. Four extra IC slots are provided, and on-board circuitry permits up to four disk drives to be added. $1888.

CIRCLE NO. 86 ON FREE INFORMATION CARD

Budget-Priced Receiver

Yamaha's new model CR-240 is rated to deliver 20 watts continuous power, 20-20,000 Hz to an 8-ohm load, with no more than 0.02% THD. In the FM section, a pair of LED displays show signal strength and indicate accurate tuning. In addition to dc amplification, the receiver incorporates a variable loudness control and provisions for connecting and switching two pairs of loudspeakers. $250.



CIRCLE NO. 87 ON FREE INFORMATION CARD

Schober "Fun" Organ Kit

The new Schober Showman Automatic Electronic Organ was designed to permit players with little or no musical training to produce highly varied and complicated musical effects. These include automatic chords and rhythms, alternating and walking bass, harmonic memory, multiple arpeggios, and space-age musical effects. The organ has two keyboards, one for melody and automatic or manual operation

for harmony. Three pedals modify one-finger-selected automatic chords to produce 60 different harmonies. Five melody voices, including a wah-wah, can be used

alone or mixed, and there are eight automatic rythm patterns with controllable tempo. The console is walnut veneer and solids. $650 including bench.

CIRCLE NO. 88 ON FREE INFORMATION CARD

Remote Radar Detector

Comradar's second-generation "SuperFox" is a remote radar-warning, all-band device that features a superheterodyne design. it has a high-concentration focus-

ing lens to expand signal gathering. The SuperFox mounts in the vehicle's grille, eliminating the need for dashboard mounting, while a small remote control box mounts under the dash. Signal tone increases in frequency as distance to radar source is decreased. Can detect X, K, and pulsed-K band signals. $299.95.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Hybrid Frequency Equalizer

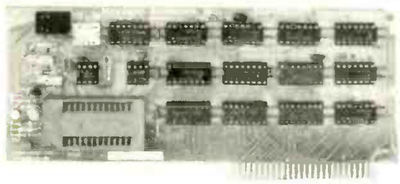
The ADC Sound Shaper Three "Paragraphic" frequency equalizer is said to combine many of the advantages of both parametric and graphic equalizers without the limitations of either. The unit offers a control range of ±12 dB in 12 frequency bands with centers ranging from 32 to

18,000 Hz. Each center frequency can be shifted by ±20% using switches located below the respective slide controls. A pair of LED signal-level meters are provided to facilitate balancing the two channels and for monitoring. THD at 1-volt output is rated at 0.018%, 20-20,000 Hz, with SMPTE IM at 0.02% and noise 90 dB below a 2.45-volt output. $500.

CIRCLE NO. 91 ON FREE INFORMATION CARD

EPROM Programmer for Apple Computers

RomWriter™ is an EPROM programmer made by Mountain Hardware to permit Apple computer users to program 2K 2716 (5V) EPROMs. The programmer can be situated in any peripheral slot, except #0.



EPROMs to be programmed mount in a zero-insertion force socket, and all or part of the EPROM can be programmed and contents verified without moving the PROM to another location. A write protect switch is provided for programmed EPROMs while running from the ROM-Writer board. Diskette-based software included with the RomWriter permits the user to specify a start and end address in the EPROM and either a Disk File name or a starting address in memory. $159, including software.

CIRCLE NO. 92 ON FREE INFORMATION CARD

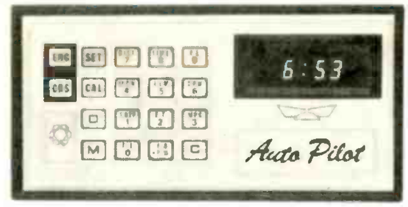
Fuji Videocassettes

A new line of VHS- and Beta-format videocassettes designed to provide maximum performance in standard-, long-, and the new extended-play recorders has been announced by Fuji Magnetic Tapes. The tapes are said to give improved video characteristics and increased durability through an improved binder and smoothly polished tape surface. The tapes have been reformulated for improved sensitivity and S/N, lower dropouts, and better chroma characteristics. A BERIDOX (berthollide iron oxide) formulation was designed to provide excellent performance at all speeds, even on slow- and stop-motion. $17.50 for Beta 60/120-min. $25.50 for VHS 120/240-min.

CIRCLE NO. 93 ON FREE INFORMATION CARD

A.R.A. Vehicle Computer

Developed to meet the increasing need for maximum fuel efficiency, A.R.A. Manufacturing's Auto Pilot® is a universal accessory for domestic and imported internal-combustion-engine vehicles. One model is a 36-function computer, the other a 39-func-



tion computer with speed control. Programmed for maximum efficiency in fuel management, the computer monitors fuel supply and helps determine the vehicle's most effective driving speed, effects of tire air pressures, and fuel-consumption data. Trip-computer functions indicate distance, fuel, and time elapsed or to arrival. A built-in quartz clock has a reminder alarm and nighttime display dimming.

CIRCLE NO. 94 ON FREE INFORMATION CARD

Shure V-15 III Upgraded

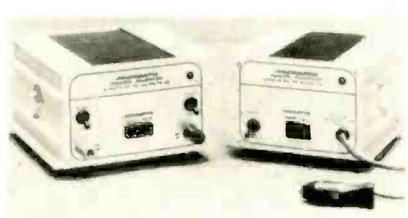
Shure has added a new variant of the V-15 III phono cartridge to its line. The new model, designated V-15 III-HE, uses the same hyperelliptical geometry as that

found in the top-of-the-line V-15 IV. This configuration gives a vertically elongated contact area that is said to produce a significant reduction in intermodulation and second-harmonic distortion. The new stylus may be retrofitted into any V-15 III cartridge. $115 complete cartridge; $38 stylus assembly only.

CIRCLE NO. 95 ON FREE INFORMATION CARD

12-Vdc to 120-Vac Power Inverters

Radio Shack introduces two new Micronta Power Inverters for converting 12 Vdc to 120 Vac to power ac appliances from the



battery of a car, boat or other vehicle. The 300-watt inverter is said to be capable of *(Continued on page 14)*

Facts from Fluke on low-

cost digital multimeters.

When you're looking for genuine value in a low-cost DMM you have a lot more to consider than price. You need information about ruggedness, reliability and ease of operation. Accuracy is important. And so are special measurement capabilities. But above all, you must consider the source, and that company's reputation for service and support.

Fact is, as electronics become more a part of our daily lives, dozens of new manufacturers are rushing to market their "new" DMM's. In theory, this is healthy; but in practice, crowding is confusion.

To help you deal with this flood of new products, here are some facts you should know about low-cost DMM's.

The economics of endurance.

Even the least expensive DMM isn't disposable. Accidents happen, and test instruments should be built to take the abuses of life as we live it.

Look for a DMM with a low parts count for reliability, and rugged internal construction protected by a high-impact shell. Make sure the unit meets severe military tests for shock and vibration.

Another feature to check out is protection against overloading, whether from unexpected inputs, transients, or human errors.

Just for the record, all Fluke low-cost DMM's meet or exceed military specs, and feature extensive overload protection.

The importance of being honest.

Just because a multimeter is digital doesn't mean it's automatically more *accurate* than a VOM – even though the LCD might give you that impression. The benchmark for accuracy in DMM's is *basic dc accuracy*. The specs will list it as a percentage of the reading for various dc voltage ranges.

Of course accuracy is more critical in some applications than others, and increasing precision and resolution in a DMM usually means increasing price. In the Fluke line, you can choose a model with a basic accuracy of 0.25% (the 8022A), others rated at 0.1%, or the new 8050A bench/portable at 0.03%.

Special measurements: getting more from your DMM.

Actually, for all the variations in size, shape and semantics, most DMM's perform five basic measurements: ac and dc voltage and current, and resistance. Prices vary according to the number of ranges and functions a DMM delivers.

	Product	Functions	Ranges	Digits	Basic DC Accuracy	Conductance	Other Special Features	U.S. Price
Handheld Models	8022A	6	24	3½	0.25%		Basic six-function DMM; lowest-priced	$129
	8020A	7	26	3½	0.1%	X	High accuracy; pioneer in conductance; exclusive two year warranty.	$169
	8024A	9	26	3½	0.1%	X	Direct temperature readings; continuity/input level detector with selectable audible signal; peak hold capability.	$199
Bench/Portables	8010A	7	31	3½	0.1%	X	True RMS; extra 10A range.	$239
	8012A	7	31	3½	0.1%	X	True RMS; two extra low resistance ranges.	$299
	8050A	9	39	4½	0.03%	X	True RMS; selectable reference impedances with direct readouts in dBm; offset feature.	$329

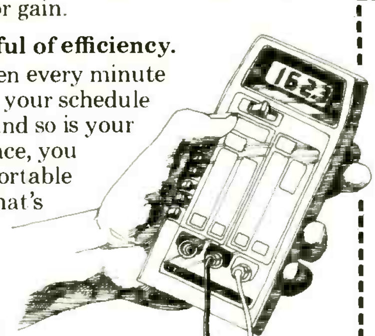
The Fluke line includes DMM's with from 24 to 39 ranges, 3½ and 4½-digit resolution, and some unique functions you won't find in any other DMM. Additional measurement capabilities like temperature, dB, conductance and circuit level detection.

If your work involves temperature measurements, the new 8024A delivers direct temperature readings via any K-type thermocouple. This is especially useful in testing component heat rise and checking refrigeration systems.

Another talented instrument is our new 8050A bench/portable. The microprocessor-based 8050A features a self-calculating dB mode in which dBm readings are displayed automatically referenced to one of 16 selectable impedance ranges – a real timesaver when servicing audio equipment.

And of course no discussion of DMM's is complete without considering conductance – a Fluke exclusive featured on five of our low-cost DMM's – which allows you to make accurate resistance measurements to 100,000 Megohms. You can't do that with any ordinary multimeter, but it's a must for checking leakage in capacitors and measuring transistor gain.

A handful of efficiency.



When every minute matters, your schedule is tight and so is your work space, you need a portable DMM that's fast and easy to operate. We designed our handheld DMM's with color-coded in-line pushbuttons for true one-hand operation: no need to hang onto the meter with one hand while twisting a rotary dial with the other.

But there's more to convenience than fingertip control. The 8024A, for example, is also designed to function as an instant continuity tester, with a selectable audio tone to indicate shorts or opens. It also has a peak hold feature to capture transients.

A word about warranties.

Last but not least, look closely at the company that manufactures a low-cost DMM. Their service is just as important as their product. Look for no-nonsense warranties, a large family of accessories, an established network of service centers and technical experts you can rely on.

ANCRONA

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Portland, OR 97220
(503) 254-5541

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Santa Ana, CA 92705
(714) 547-8424

Sunnyvale
1054 E. El Camino Real
Sunnyvale, CA 94087
(408) 243-4121

Tucson
4518 E. Broadway
Tucson, AZ 85711
(602) 881-2348

QTY	P/N	PRICE EA.	TOTAL
	8010A	$239.00	
	8012A	$299.00	
	8020A	$169.00	
	8022A	$129.00	
	8024A	$199.00	
	8050A	$329.00	
		Sub Total	
		Tax(Cal Res. Add 6%)	
		TOTAL	

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EEP EEP CORPORATION

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Los Angeles, Calif. 90045
Phone (213) 670-7880
TWX 910-328-6161

CIRCLE NO. 5 ON FREE INFORMATION CARD

powering color TV's, electric typewriters and many other items requiring no more than 300 watts continuous power. Full load input current is 25 amps. The smaller 100-watt inverter is reported suitable for powering small TV sets, electric razors, CB two-way radio equipment and other small appliances. Full-load input current is 12 amps. Both inverters feature a Normal/Boost switch to provide extra power to compensate for low battery input voltage. Automatic overload protection turns off the inverters if overloaded and a circuit breaker automatically resets 3-4 seconds after the overload has been removed. 300-watt Power Inverter, $79.95; 100-watt Inverter (with cigar lighter plug), $39.95.

CIRCLE NO. 96 ON FREE INFORMATION CARD

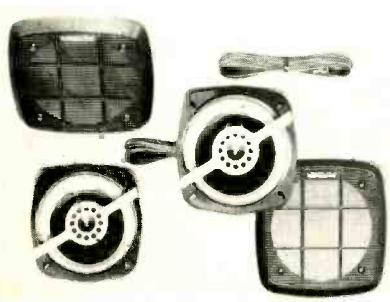
Colby Precision Pulser

The Model P5A tunnel-diode step generator is said to produce a very precise pulse with total transient aberration of less than

1% peak-to-peak. Pulse output is 50 ohms reverse terminated, and rise time is rated at 250 ps or less. Output amplitude into 50 ohms is rated at 200 mV minimum positive-going, and pulse duration is 1 microsecond minimum, while period is typically 15 microseconds. Suitable for calibrating oscilloscopes and other instruments, the pulser can also be used to drive very fast amplifiers. Requires two 9-volt batteries (not included). $149. Colby Instruments, Inc., P.O. Box 84379, V.A. Branch, Los Angeles, CA 90073.

New Car Speaker

As part of its "Series I," Jensen has introduced a coaxial speaker with a 4½"



(114 mm) woofer. The new size has 17% more radiating area than the usual 4" size and promises increased efficiency. Despite the increased cone size, the unit will mount in conventional cutouts. With a nominal impedance of 4 ohms, it is said to have a frequency response of 65-18,000 Hz ±3 dB, deliver 97 dB SPL at 1 meter from a 4-watt input, and accept the full undistorted output of an amplifier rated at 40 watts continuous. The tweeter is a 2" (51 mm) piezoelectric device. $65 per pair.

CIRCLE NO. 97 ON FREE INFORMATION CARD

Real-Time Analyzer

Eventide Clockworks has introduced a real-time audio spectrum analyzer module designed to mate with a Commodore PET

computer. The analyzer fits on a single circuit board that installs inside the PET and draws power from the computer's transformer. It divides the audio spectrum into 31 bands ⅓ octave wide and displays their relative amplitudes on the PET screen on either a linear or logarithmic scale. In addition, a PEAK HOLD feature freezes the display at the highest indication given in any band. Three BASIC programs to access the analyzer are provided in the package: Interactive operation, Self-Test, Minimal Operation. $595. Address: Eventide Clockworks, Inc., 265 W. 54th St., New York, NY 10019.

Lightweight Color Video Camera

Panasonic Video Systems is offering Model WV-3320, a lightweight color video camera designed for use with the company's VHS recorders. Although the unit is meant mainly for outdoor applications in conjunction with a portable recorder, an optional ac adaptor permits it to be used

indoors as well. The camera has a 1" (25.4 mm) vidicon tube in conjunction with a 17-102 mm f/2 6:1 zoom lens. Iris adjustment is automatic or manual depending on setting of a switch. Another switch provides four settings of color-temperature correction to allow for various light sources. At the recommended illumination of 140 footcandles for f/4, the WV-3320 is said to yield a luminance signal with an S/N ratio of 45 dB. $1345.

CIRCLE NO. 98 ON FREE INFORMATION CARD

Magnetic Mount for CB Antennas

Shakespeare Co. claims to have developed a new magnetic mount for mobile CB antennas which increases the holding power over previous designs by 400%. The gripping surface (17 sq. in. on some models) is said to align the magnet flush with the mounting surface with a retaining

shoulder preventing air pressure from countering the grip. The new mounts are available for the Two Load™, Mighty Mite™, White Knight™, and Shadow™ Shakespeare antennas.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Computer Phone Modem

Designed specifically for the personal and small-computer market, the CAT™ telephone modem from Novation, Inc. enables computers to exchange data via phone

lines. It operates at 300 baud via a standard RS232C port. It is Bell-103 compatible and comes with a wall-mount ac transformer that is said to reduce heat and voltage hazard inside the modem itself. Switches and LEDs are provided for mode selection, operation and displaying operating status. Acoustic self-test is standard. $199.

CIRCLE NO. 100 ON FREE INFORMATION CARD

Attractive Air Alive unit measures only 4½" x 4" x 1¾" and cleans a 20' x 15' x 8' room in up to 15 minutes.

AIR ALIVE

Uses "Nature's Air Cleaners" to electronically destroy odor, smoke, dust, and pollen. Now research shows it may do more!

Little-understood particles, called negative ions, are said to be nature's best air cleaners. They attach themselves to dust, smoke, pollen or anything else floating in the air, and cause it to fall harmlessly to the ground. Now there is growing proof that negative ions may affect your moods, health and sense of well being.

THE ION CONTROVERSY

For the past 20 years, scientists and scholars - world wide have been studying the effects of electronically charged particles in the air called negative ions.

Russian scientists have recently proven that the presence of ions in the air is essential to animal life. Research conducted at the University of California has shown that plant growth is stunted when the ion content in the air is decreased.

Some researchers claim there's evidence that negative ions can relieve allergic ailments and headaches, help control virus, retard the growth of bacteria, increase mental alertness and energy, reduce pain, tension, fatigue and depression and produce sound sleep.

Interestingly, while the number of those who believe that negative ions do, in fact, produce these benefits, has grown, the number of doubters has decreased over the years.

THE ION IMBALANCE

The air is made up of molecules that contain either a majority of electrons, making them negative particles, or a majority of protons, making them positive particles.

Although nature produces a nearly equal number of positive and negative ions, there are a number of reasons why we are surrounded by an over abundance of protons: air pollution depletes the number of negative ions in the air, the static charge from synthetic fibers produces positive ions and natural earth radiation, that would normally produce negative ions, is retarded by concrete and asphalt covering the land.

In effect, we are breathing air that nature never intended us to breathe ... air that has been depleted of negative ions. What is needed is a way to correct this ion imbalance.

NATURE'S AIR CLEANERS

There is almost no disagreement among scientists that negative ions are unmatched in their ability to cleanse the air of impurities. This is how they do it: negative ions attach themselves to dust, smoke and pollen, neutralize them and cause them to fall harmlessly from the air.

Engineers and doctors have recently recognized this benefit and have begun to take advantage of it. Many now use commercial units that emit negative ions and effectively destroy odors and pollutants in the air.

It has only been during the last year that technology has developed an affordable consumer model. These units were first introduced in Europe where there is a high level of interest in the benefits of negative ions.

Now we are introducing one of the first consumer units to be sold in this country!

ONE OF THE FIRST UNITS UNDER $100

When we were offered the opportunity to introduce Air Alive to the American market, we jumped at the chance! Why? Because it's one of the first consumer models in this country to be sold for under $100. And because it's manufactured by Western Systems, Inc., a pioneer in the ion generation field.

MOST COMPACT UNIT ON THE MARKET TODAY

Air Alive measures only 4½" x 4" x 1¾" and puts out 3 trillion negative ions per second per cubic centimeter. That's as many or more than larger, more expensive units now on the market. It is so powerful that it cleans a 15' x 20' x 8' room in up to 15 minutes. Air Alive brings you more cleansing power in its compact size.

WARRANTED FOR TWO FULL YEARS

Air Alive is an all solid state unit ... it has no moving parts. The unit is so trouble free that it is warranted by Western Systems, Inc. for two full years, in the unlikely event that anything should go wrong.

FREE BOOK JUST FOR TRYING AIR ALIVE

Just for trying the Air Alive unit, we are offering a 160 page book entitled "The Ion Effect"

Absolutely Free!

It is yours at no additional charge. It's yours to keep even if you should return the Air Alive unit during our 30 day trial period. "The Ion Effect" traces one man's 10 year effort to discover the truth about the effects of ions. Judge for yourself the benefits of negative ions.

OPTIONAL AUTO ADAPTER

Now Western Systems, Inc. brings something new to the American market that Europeans have used for years ... an optional auto adapter that allows you to use your Air Alive home model in your car, truck, van or RV. Hardware included for mounting under your dashboard and adapter plugs into your cigarette lighter.

30 DAY NO-RISK TRIAL

We believe Air Alive to be the most compact negative ion generator on the market today. It will destroy the dust, smoke, pollen and odors in the air in your home, office or car.

And we want you to decide for yourself whether or not you can benefit from the effects scientists are claiming that negative ions can have on your health and sense of well being.

We offer you a 30 day, no risk trial period on every Air Alive unit you order. If during that time you decide the Air Alive unit does not meet your expectations, for any reason, you can return it for a prompt refund of the purchase price.

TO ORDER YOUR AIR ALIVE

Simply fill out the coupon and send it, along with your check or money order, to the address below. For even faster service, call Toll Free: **1-800-527-7066.** In Texas call **(214) 349-3120.**

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Yes! Send me _____ Air Alive units at $79.95 ea. and _____ Auto Adapters at $8.95 ea. Add $3.50 postage, handling and insurance charge. Texas residents add 5% sales tax.

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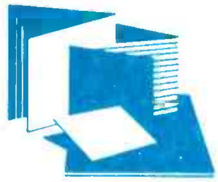

New Literature

CATALOG OF ELECTRONICS BOOKS

8A catalog of new electronics titles from Parker Publishing Co. includes books on digital test equipment, troubleshooting of various electronic equipment, home electrical repairs, ICs, microelectronics, solar energy, and computer technology. Ask for Book News Catalog h9 and include stamped, self-addressed envelope. Address: J. Schaumburger, Parker Publishing Co., Inc., West Nyack, NY 10994.

COMPUTER EQUIPMENT CATALOG

The Newman Computer Exchange has published a catalog of the line of mini- and microcomputers, terminals and peripherals. One section is devoted particularly to personal computing including the latest manufacturers' information and specs. Featured are the Apple II and PET. Instructions on leasing and buying terminals are provided. Address: Newman Computer Exchange, Inc., Box 8610, Dept. LBUP, Ann Arbor, MI 48107.

ANTENNA ACCESSORIES CATALOG

Catalog PC-80 lists antenna accessories for ham, CB and TV, including baluns, traps, insulators, CB invisible antennas, filters, and home TV hook-up accessories. Address: Unadilla/Reyco Div., Microwave Filter Co., Inc., 6743 Kinne St., East Syracuse, NY 13057.

AUDIO/VIDEO INTERFERENCE

Catalog 971 from Electronic Specialists describes its line of products for control of interference in audio and video systems. Protective devices are included and application sections outline particular problems and their solutions. Address: Electronic Specialists, Inc., 171 S. Main St., Natick, MA 01760.

POWER BASIC REFERENCE GUIDE

A 15-page selection guide (MP713 Rev.) covers Texas Instruments' products for use with POWER BASIC language. Described are evaluation (TM990/450), development (TM990/451), development enhancement (TM990/452), and configurable (TMSW510-FO) packages. Also included are POWER BASIC statements, commands and functions. The guide provides a reference to TI's 16-bit TMS9900 family of TM990 Series modules and components. Address: Inquiry Answering Service, Text Instruments Inc., Box 1443, M/S 6404, (Attn: MP713), Houston, TX 77001.

EQUIPMENT RENTAL CATALOG

Leasametric's new catalog contains model numbers, descriptions and rental rates on more than 4000 pieces of equipment from over 300 manufacturers. Long- and short-term leases on telecommunications and general-purpose test equipment, I/O terminals, and microprocessor development systems are given. Address: Leasametric, 1164 Triton Dr., Foster City, CA 94404.

SHORTWAVE NEWS BULLETIN

A bi-monthly news bulletin devoted to the DX listening hobby, containing technical and general-interest articles is available for six dollars per year (sample copy, one dollar). Address: World Shortwave Listeners Club, 80 Hartsdale Ave., White Plains, NY 10605.

FUJI VIDEOCASSETTE BROCHURE

A brochure entitled "Everything you always wanted to know about videocassettes, but didn't know who to ask" is available from Fuji Magnetic Tapes. The 8-page booklet discusses the difference between audio and videocassettes, videocassette recording methods, dropout and tape-wear problems, and freeze frame and rapid-search capabilities. Address: Gary Conway, Sales Magr. Fuji Magnetic Tape Div., 350 Fifth Ave., New York, NY 10001.

SAMS COMPUTER BOOK CATALOG

Spanning the range of requirements from the hobbyist to the professional technician, books listed in Sams' new catalog include works in five areas: Basics, Programming, Computer Technology, Reference, and Computer-Related. Books are written by professionals, in easy-to-understand language, and have many photos and illustrations. Titles include *Microcomputer Primer*, *How to Program Microcomputers*, and *Computer Dictionary and Handbook*. Address: R.W. Soel, Advt. Coordinator, Howard W. Sams & Co., Inc., 4300 W. 62 St., P.O. Box 558, Indianapolis, IN 46206.

TUCKER TEST EQUIPMENT

A 104-page catalog from Tucker Electronics Co. lists approximately 2100 different pieces of reconditioned electronic test equipment and microwave components. Included are amplifiers, analyzers, bridges, frequency meters, signal generators, power supply, recorders, etc. All units are reconditioned and calibrated to manufacturer's specs. Address: Tucker Electronics Co., 1717 S. Jupiter Rd., Garland, TX 75042.

THE "PA BIBLE"

A new guide to public-address speaker systems, intended for the musician as well as the dealer in contract sound installations, has been issued by Electro-Voice. The *PA Bible* is applicable to any manufacturer's equipment and describes PA installations and step-by-step from problem through solution—using single-enclosure systems or many components. Send $1.00 to: PA Bible, Electro-Voice, Inc., 600 Cecil St., Buchanan, MI 49107.

AMATEUR AND COMMERCIAL ANTENNAS

A new 22-page catalog from Hustler features its line of ham antennas and includes models for 80 meters through 435 MHz. Also shown is a line of business-band antennas for 30–50, 148–174 and 450–512 MHz. Address: Hustler Inc., 3375 North B Ave., Kissimmee, FL 32741.


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AUDIO MUTING
VOLUME
TONE
LEFT
RIGHT

THE COMPANY THAT VIRTUALLY INVENTED TRANSISTORIZED HIGH FIDELITY HAS JUST REINVENTED THE RECEIVER.

For three decades the engineers at Sony have been behind not just one or two, but eighteen major technological innovations in high fidelity. One of our engineers even won a Nobel Prize.

The fact is, much of the hi-fi equipment made today is based on technology developed at the audio labs of Sony.

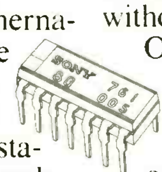
And now Sony introduces the new STR-V55. The receiver that, we assure you, will send the competition reeling back to their drawing boards. Especially when they note its list price.

A COMPUTER FINDS YOUR STATION.

Unlike other hi-fi companies, we didn't just make a few improvements in an ordinary receiver and call it "new."

We actually reinvented it.

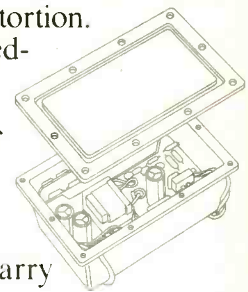
Instead of using the same basic tuning mechanism that's been found in radios since the days of Marconi, the new V55 uses microprocessor tuning to insure crisp, clear, perfect sound. We call this "quartz frequency synthesized tuning." It's totally computerized. So there are no strings, pulleys, flywheels, or other mechanical parapherna-lia that can wear out and become less accurate as the years go by.



Equally innovative is a memory feature that lets you preselect up to eight AM or FM stations for instant push-button tuning. Use our exclusive "memory scan" device and you automatically hear 3.5 seconds of each. And there's a three-position muting level switch that enables you to hear only the stations you want to hear—and never the noise in between.

PULSE POWER: ANOTHER SONY FIRST.

Even the most sophisticated ear will have trouble hearing any distortion in the new Sony V55 receiver. That's because, statistically, the V55 puts out 55 watts per channel from 20 to 20,000 hertz with less than 0.02% total harmonic distortion.



One of the reasons: an incredibly advanced, Sony developed "Pulse Power Supply." It not only completely eliminates any trace of audible distortion, but it's a fraction of the size and weight of conventional power supplies. So it doesn't require a forklift truck to carry it home from the store.

All this adds up to the elimination of hum and noise and, when combined with the V55's DC power configuration, delivers richer, cleaner bass response.

ADVANCEMENTS, MORE ADVANCEMENTS AND STILL MORE ADVANCEMENTS.

Naturally, we could go on and on about such things as the V55's new transistor design which greatly extends the high-frequency range for more accurate sound reproduction.

Or about our switches that allow you to record automatically from one tape deck to another—without spending half your time rearranging wires.

Or about our special low filter device that lets you remove subsonic noise from your records without removing music.

Or about how the V55 is the one state-of-the-art receiver that won't require you to get a second mortgage to purchase it. And we at Sony confidently state it's by far the best investment you can make in hi-fi this year.

For more information on the complete line of new Sony receivers and the name of your nearest Sony dealer write: Sony, P.O. Box CN-04050, Trenton, New Jersey 08650.

SONY® AUDIO

It's all you need to know about high fidelity.

FEATURES AND SPECIFICATIONS: 55 watts per channel with 0.02% distortion/Quartz freq. synthesis AM-FM/8 station memory IC (nonvolatile)/4 way tuning system/3 position tuning level/Pulse Power Supply/Hi-f_T output transistors/M/C cartridge capability/Dual tape monitoring and dubbing controls/Subsonic Filter (15 Hz-12 dB per oct)/Gold-plated phono input.

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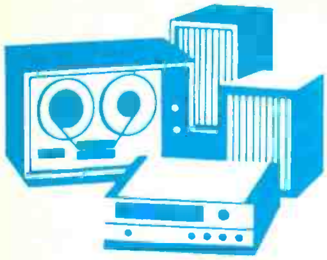

Stereo Scene

By Harold A. Rodgers
Senior Editor

WHITHER DIGITAL AUDIO?

AT THE annual New York Convention of the Audio Engineering Society last November, a colleague that I usually run into once or twice at events of this kind confessed: "I had expected digital hardware to be taking shape by now, but they are still fighting it out over standards." This gentleman, I believe, qualifies as an insider in the audio industry and is, moreover, usually perceptive in his view of unfolding events. It was a bit surprising, therefore, to see him nonplussed about the way developments were going—or not going.

On reflection, it appears that those of us who have been bullish and optimistic about digital audio as the way of the future have been overlooking one inconvenient fact: digital technology is facing the audio industry with a set of problems unlike any that it has faced in the past. Worse yet, the problems are not involved with overcoming technological shortcomings. In fact, although there are limits to what can be done, they seem, at least for now, to lie well beyond what is necessary. The difficulty is more in determining what is really necessary.

Redefining High Fidelity. When the audio industry had its beginnings, it was virtually inconceivable that electronic equipment would ever become equal to the task of adequate music reproduction. At each stage, designers produced the best gear they knew how, only to find that each step forward exposed faults elsewhere in the signal chain and that new models from their competitors rendered what they had worked so hard to achieve obsolete in a distressingly short time. Accordingly, the watchword became: "Every piece of equipment must be as good as it can be, at its price point, of course, and in every possible way."

Even in the analog domain, this point of view seems already dated. (Is a THD rating of 0.001% any meaningful improvement over 0.003%? Must an amplifier accept signal slopes of 200 V/μs without slewing?) It has persisted through inertia, largely, I suspect, because these little exercises in overkill don't really add significantly to the cost of the product, and better specs give marketing people something to talk about. In the digital hardware domain, however, overkill rapidly turns into overprice.

It has been pointed out that in going from a 12-bit digital audio system to one that uses 16 bits, one is likely to incur a tenfold cost penalty, a notion that the price differential between Sony consumer and professional systems seems to just about confirm. Therefore, the general concensus seems to be that if the digital product is to be marketable, the signal-to-noise ratio (the parameter most closely connected to the number of bits comprising the digital word) should not exceed that which the ear can appreciate. Actually, the problem is somewhat more complex than this. Coding schemes designed to exploit the nonrandom nature of music may lead to ways of using fewer bits and maintaining very wide dynamic range, at least in a subjective sense.

The other parameter in which savings can be made, according to some, is bandwidth. Since sampling must be done at a rate somewhat in excess of twice the highest audio frequency present if alias distortion is to be avoided, every bandwidth reduction significantly eases the demands on the A/D and D/A converters. A paper presented by Muraoka, Iwahara, and Yamada of JVC at this very convention examined bandwidth requirements for optimum sound-signal transmission and concluded that a high-frequency limit of 15 kHz would be acceptable for consumer use. Similar tests made by AKG and others in Europe tend to support this idea, but there seems to be a fairly large number of individuals who can reliably determine when frequencies above 15 kHz have been removed. Whether or not these people are so disturbed by this absence to pay the cost of having it corrected is, of course, another matter. The gentlemen from JVC, incidentally, state further that professional equipment should have a bandwidth to 20 kHz so that problems that might complicate later stages of software manufacture can be identified and corrected. Purists then might all covet professional systems.

One other scheme for economizing on digital hardware is the use of delta modulation. This technique operates on changes in the signal, rather than encoding the signal directly. For equal bandwidth and dynamic range, the system uses fewer bits per second than conventional PCM. In addition, it does not require an antialias filter (expensive and hard to align correctly) and is, in principle, at least relatively insensitive to tape dropouts.

On the debit side, adaptive delta modulation, the only type suitable for high-grade music signals, behaves as though a compander is included in the system. It is thus subject to modulation noise. Delta code is also not as readily handled by computer hardware, making signal processing and electronic editing less easy to perform.

Double Standards. This brings us to the general question of whether or not double standards should be applied to digital audio. Will the public settle for "as good as it needs to be" or will it demand "the best that can be done"? For example, although the disc system that Philips proposes to introduce is based on a 14-bit digital word and will have a signal-to-noise ratio of about 84 dB, the company indicates that original recordings will be done in a 16-bit system with an S/N of 96 dB. This, it is explained, leaves extra dynamic range and headroom to allow for the fact that the recording engineer is not always certain what levels his equipment must tolerate. Critics of this viewpoint counter, "Fine, but once you have a 16-bit recording, why not release that without transferring it to an inferior 14-bit format?" Some even go so far as to hint that the extra bits are part of some devious means of protecting against piracy. (Defending software against unauthorized copying and distribution is a legitimate concern, however.) The counterquestion these critics should face is: "Will the consumer, listening in his home environment, derive any audible benefit from those costly extra two bits?" Right now, that is not easily answered.

Hardware Developments. In the meantime, hardware is beginning to proliferate at the professional level. Sony has made major additions to its line, including more sophisticated electronic editing. 3M has added a preview system for disc cutting, and adopted a more flexible marketing stance overall.

Mitsubishi's X-80 PCM unit is rated at better than 90 dB S/N, frequency response of 20 to 20,000 Hz ±0.3 dB, and distortion less than 0.02% at peak levels. The unit allows tape-cut editing, or electronic editing referenced to SMPTE time code can be used by adding an accessory.

Most interesting from the consumer point of view is Pioneer's PCM "box" (for want of a more formal name) that does for the DiscoVision system what devices like the Sony PCM-1 do for video tape recorders. Actually, the Pioneer is somewhat more advanced in that it is a 16-bit system with linear coding. Dynamic range is said to exceed 90 dB, with frequency response of 2 to 20,000 Hz ±0.5 dB, harmonic distortion of less than 0.03%, and unmeasurable wow and flutter. Playing time is 30 or 60 minutes per side. Try as I might, I could get no information about prices for either hardware or software.

The Future. Where the digital bandwagon will eventually end up is anyone's guess at this point. But frankly, I do not see any standard format or set of formats being established very soon.

The key question, as I see it, is: "What do consumers want and what are they willing to pay?" If this means that the battle must be waged by systems, mutually compatible or not, competing in the marketplace (and the Federal Trade Commission has apparently decreed that this shall be the case), it may be all for the best. Such a development may prove costly at first, but it may be the only way to give consumers best value in the long run. Anything else may well lead to widespread conviction that performance has been compromised excessively, costs have been allowed to get out of hand, or both. If the market makes the decision, the guy who

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pays the bills has no one to blame for the ultimate choice but himself and his peers.

Audiophile Recordings

HOLST: THE PLANETS, **St. Louis Symphony Orchestra, Walter Susskind conducting.** (Vox Turnabout QTV-S 34598) dbx encoded disc SS-3002. Given the vast dynamic range provided by the dbx system, the heavily scored bravura passages of this suite really come off well. (The original unencoded disc is pale by comparison.) Delicate passages do not come off quite as well, however, probably more because of the extremely reverberant recorded perspective than any inattention by the conductor and performers. That the recording has been QS processed seems to exaggerate the reverberation all the more. Still, despite a mildly distracting level of hiss that seems to come from the master tape, the overall result shows some of the advantages of the dbx system and is musically very enjoyable.

RUGGLES: MEN AND MOUNTAINS, **New Hampshire Music Festival Orchestra, Thomas Nee conducting.** Hammar SD 150. There is nothing particularly exotic about the way this disc is made; it's a standard analog tape transfer. The transfer has been carefully done, and the pressing is up to snuff, with a clean, quiet record as the ultimate result. Fans of Carl Ruggles (I'll admit to being one) will find this disc noteworthy—and not just because recordings of his works are so rare. From what I hear, the conductor and ensemble really get into the spirit of the music. What comes out is a marvelous series of orchestral textures ranging from hard and angular to delicate and subdued, all nicely captured by the recording. The rendition of Mozart's Symphony No. 35, seems less inspired, although there are no obvious grounds on which I can fault it. Side 2 is taken up by concertos by Telemann and Vivaldi, both of which come off with appropriate elegance and sparkle.

TAJ MAHAL AND THE INTERNATIONAL RHYTHM BAND LIVE & DIRECT. Crystal Clear CCX-5011. If a direct mastering session is close in concept to a live performance, why not include a live audience? Why not, indeed? This is the premise behind a new series of recordings that Crystal Clear has decided to release. In this case, the experiment is at least partly successful in that the players seem to loosen up a bit in the presence of the audience. Fans of Taj Mahal who are used to his fairly cool, laid-back style will probably enjoy this disc, but the overall impression is expression through understatement. The recording seems to be well-produced, giving clear sonics and self-effacing surfaces, which does let the subtleties come through. This one is more for listening than showing off your hardware to friends. ◇

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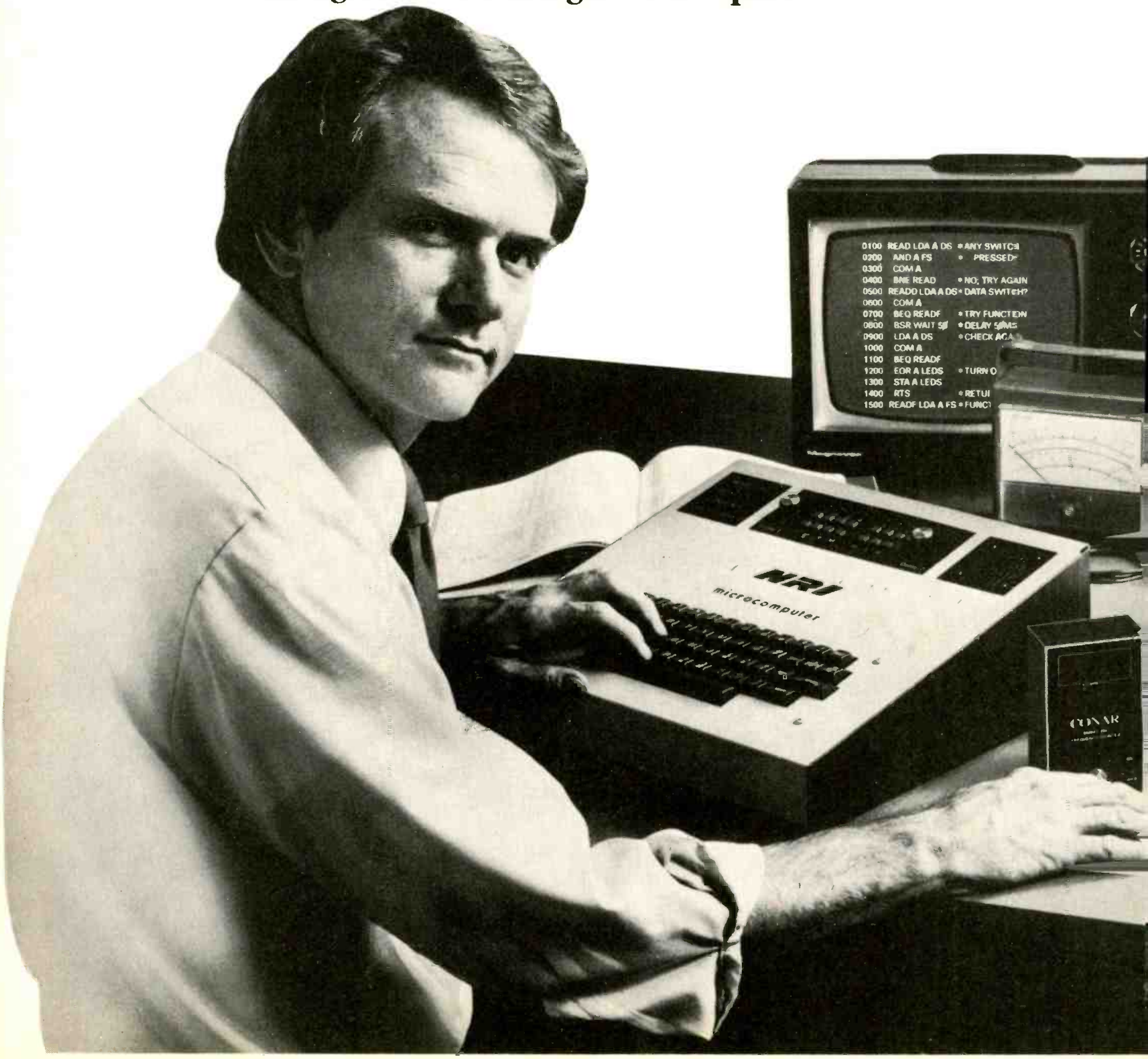

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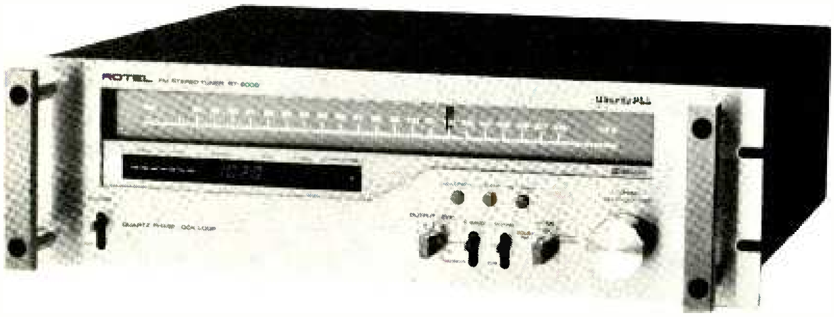


Rotel Model RT-2100 FM tuner features quartz-lock tuning and Dolby decoder

HIRSCH-HOUCK LABS REPORT

The Model RT-2100 is Rotel's finest FM-only tuner. It employs a quartz-lock tuning system that combines the stability and frequency accuracy of a synthesized tuner with the moderate cost and continuously variable tuning of a conventional tuner's free-running local oscillator. Both analog and digital frequency displays are provided, and LEDs are used instead of meters for tuning, signal strength, and multipath-distortion indicators.

The tuner has dual i-f amplifiers with narrow and wide bandwidths that can be selected either by a switch or automatically according to the received signal strength. Also built in is a decoding system for Dolby-encoded broadcasts.

Styled to match other deluxe Rotel audio components, the RT-2100 has a panel slotted for mounting in a standard 19" (483-mm) rack and is fitted with rugged handles. The tuner measures 19"W x 13"D x 5⅝"H (483 x 330 x 143 mm) and weighs 16.5 lb (7.5 kg). Price is $640.

General Description. With power off, the tuner has a conventional appearance. The long tuning dial has linearly spaced markings for the FM band at 1-MHz intervals. A bank of lever switches labeled IF BANDWIDTH, MUTING LOCK, OUTPUT LEVEL, and MODE, plus a larger tuning knob permit total control over the tuner's operation.

The IF BANDWIDTH switch has WIDE and NARROW positions, the former offering reduced distortion when signal conditions permit its use. The MUTING LOCK switch ties together the operation of the interstation noise muting circuit and the quartz-lock frequency control, both of which are either on or off simultaneously. The MODE switch permits selection of MONO, STEREO, AUTO, or DOLBY FM. In the STEREO position, the tuner is muted until a stereo broadcast is received while in the AUTO position, the tuner itself switches automatically between stereo and mono according to received program format. In the DOLBY FM position, the Dolby circuits are switched in, the tuner's deemphasis time constant is switched from 75 to 25 μs, and the tuner is placed in its AUTO mode. The OUTPUT LEVEL control affects one of the two pairs of audio outputs on the rear of the tuner. (The other output is at a fixed level.)

Three pushbutton switches are also provided. MULTIPATH allows the signal-strength display to indicate multipath distortion. HI BLEND reduces noise on weak stereo signals by partially blending the higher audio frequencies. REC CHECK replaces the program outputs with an internally generated 400-Hz tone at a level equivalent to 50% FM modulation for setting tape-recorder gains in advance of recording FM programs.

Within a black window are the tuning, signal, and frequency displays. The large ⅜" (9.5-mm) numeric frequency display supplements the more conventional "slide-rule" FM logging scale. The signal strength indicator consists of seven discrete red LEDs arranged in a horizontal line whose length is proportional to signal strength. When the MULTIPATH button is engaged, this display blanks out and flashes with program modulation according to the amount of multipath-distortion present in the received signal.

Three LEDs replace the usual center-channel tuning meter. A green TUNED light is flanked by two red arrows that indicate which way the tuning knob should be moved to reach channel center. The arrows light up within 60 kHz of a signal and the TUNED indicator comes on when tuning is within 8 kHz of channel center. Then, if MUTING LOCK is switched on, releasing the tuning knob activates the quartz-lock circuit and a green LOCK indicator comes on. Finally, there is the usual red STEREO indicator to inform you when a stereo broadcast is being received.

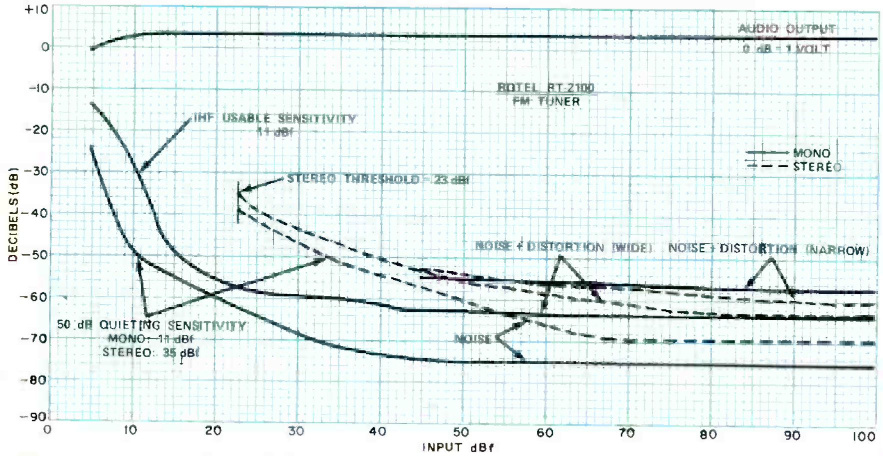
Laboratory Measurements. So far as possible, measurements were obtained using both the wide and narrow i-f bandwidths, since these can affect some performance characteristics. We found that the i-f bandwidth automatically switched to NARROW when the input signal level was less than about 38 dBf (45 μV), regardless of the setting of the bandwidth switch. Only above that threshold does the switch offer a choice of WIDE or NARROW band.

IHF usable sensitivity was 11 dBf (2 μV) in mono. In stereo, it was determined by the automatic switching threshold of 23 dBf (7.5 μV), which was also the muting threshold. Since the THD at the usable sensitivity point (3.2%) accounts for most of the "garbage" in the output, noise suppression is sufficient that the same 11.2 dBf represents 50-dB quieting in mono. In

LEDs proved to be a sensitive multipath indicator

stereo, 50-dB quieting (and 0.5% THD+N requires 35 dBf (30 μV). The ultimate distortion, at a 65-dBf (1000-μV) input, was affected by the i-f bandwidth. It was 0.07% (WIDE) and 0.165% (NARROW) in mono, while in stereo, it was 0.11% (WIDE) and 0.17% (NARROW). The S/N was not affected by the bandwidth; it measured 74.5 dB in mono and 68 dB in stereo.

The two r-f stages and multiple tuned circuits in the front end gave the tuner an exceptional 109-dB image rejection (barely within the measuring range of our instruments). AM rejection was a very good 70 dB. Capture ratio at a 65-dBf input was 1.22 dB in WIDE and 1.33 dB in NARROW bandwidth modes. We could not measure the alternate-channel selectivity with wide bandwidth, because the tuner would not switch to WIDE at the low signal levels necessary for this measurement. In NARROW, the selectivity was a very good 87 dB. Adjacent-channel selectivity was 9.5 dB (NARROW) and 4.9 dB (WIDE). Hum level was −68 dB, and 19-kHz pilot carrier



Tuner noise and sensitivity curves.

leakage was −80 dB with respect to 100% modulation.

The stereo frequency response was +0.7/−0.2 dB from 30 to 15,000 Hz. Channel separation ranged from 45 to 47 dB through the midrange in WIDE and about 40 dB in NARROW. It reduced to about 35 dB at the extremes of 30 and 15,000 Hz in WIDE and to about 32 dB in NARROW.

The REC CHECK signal level corresponded to a 57% modulated FM signal. Its level is determined by an internal adjustment, which was evidently set incorrectly. The instruction manual was also incorrect or misleading in its description of this signal, its function, and its level. However, the service manual indicated that it should have been set at 50% modulation. The signal strength indicator was also incorrectly adjusted on our test tuner. According to the service manual, all seven LEDs should come on at a 65-dBf (1000-μV) input. On our sample, this indicator had a very limited operating range, with the first LED coming on at 32 and the last at 43 dBf. Practically every signal we received lit up all LEDs, making them useless for antenna orientation. However, with the MULTIPATH switch engaged, the LEDs proved to be a sensitive multipath reception indicator.

We recommend leaving the switch in the MULTIPATH position and orienting the antenna, if possible, for minimum or no indication in the display. The tuning LEDs are clear and easy to interpret, and the numeric frequency display leaves no doubt as to which station the tuner is set. Calibration of the "slide-rule" dial scale, though only present at 1-MHz intervals, was very accurate and could be used successfully to preset the tuner to a desired frequency.

User Comment. The measured performance of the RT-2100 places it in an elite group of FM tuners. While its distortion, channel separation, and a few other performance characteristics are not unsurpassed, they are usually very close to the best, and in aggregate they show the RT-2100 to be well worth its fairly considerable cost.

The quartz-lock system works so smoothly that one is not really aware of its presence, except when the signal light display comes on. Muting (which uses reed relays) is completely positive and noise-free. Although we did not make any measurements on the Dolby system, our use tests confirmed that it was functioning properly. However, we would have appreciated a LED to show when the Dolby system was on. (It is easy to overlook the setting of the small MODE knob.)

Performance Specifications

Specification	Rating	Measured
Usable sensitivity (MONO)	9.3 dBf (1.6 μV)	11 dBf (2 V)
50-dB quieting sensitivity		
MONO	14.7 dBf (3 μV)	11 dBf (2 μV)
STEREO	36 dBf (35 μV)	35 dBf (30 μV)
S/N ratio (65 dBf)		
MONO:	80 dB	74.5 dB
STEREO:	75 dB	68 dB
Distortion (65 dBf)		
MONO:	0.05% (W), 0.15% (N)	0.07% (W), 0.165% (N)
STEREO:	0.07% (W), 0.2% (N)	0.11% (W), 0.17% (N)
Frequency response	30–15,000 Hz (+0.3/−1 dB)	+0.7/−0.2 dB
Capture ratio	1 dB	1.22 dB (WIDE, 65 dBf)
Alternate-channel selectivity		
WIDE:	45 dB	Not measurable
NARROW:	80 dB	87 dB
Adjacent-channel selectivity		
WIDE:	NA	4.9 dB
NARROW:	NA	9.5 dB
Spurious-response ratio	90 dB	NA
Image-response ratio	115 dB	109 dB
I-f response ratio	115 dB	NA
AM suppression ratio	65 dB	70 dB
Muting threshold	15 μV	7.5 μV
Stereo separation:		
1 kHz	45 dB (W or N)	47.5 dB (W), 39.5 dB (N)
30–15,000 Hz	40 dB (W or N)	34 dB (W), 32 dB (N)
Subcarrier product ratio	65 dB	80 dB
SCA rejection ratio	65 dB	NA
Antenna input	300 ohms BAL 75 ohms UNBAL	confirmed
Output level	0.775 V (FIXED) 0–1.5 V (VAR)	NA 0–1.55 V

tasteful styling and fine performance . . . an excellent choice for a deluxe hi-fi system

The couple of minor discrepancies we found in performance (the level of REC CHECK tone and the miscalibration of the signal strength display, for example) were obviously due to misadjustment in our test sample, which was an early production unit. Our other criticisms principally relate to the literature for the tuner, rather than to its actual performance. For example, nowhere is it mentioned that IF BANDWIDTH selection is automatic for signals of less than 38 dBf.

All things considered, the Rotel RT-2100 is a remarkably complete FM tuner, with more operating flexibility than one will normally find in most competitive models. Its performance, well beyond the requirements of the FM medium, approaches the point where broadcast quality is usually the limiting factor. Together with its handsome, tasteful styling and fine performance, these qualities contribute to making it an excellent choice for a deluxe hi-fi system.

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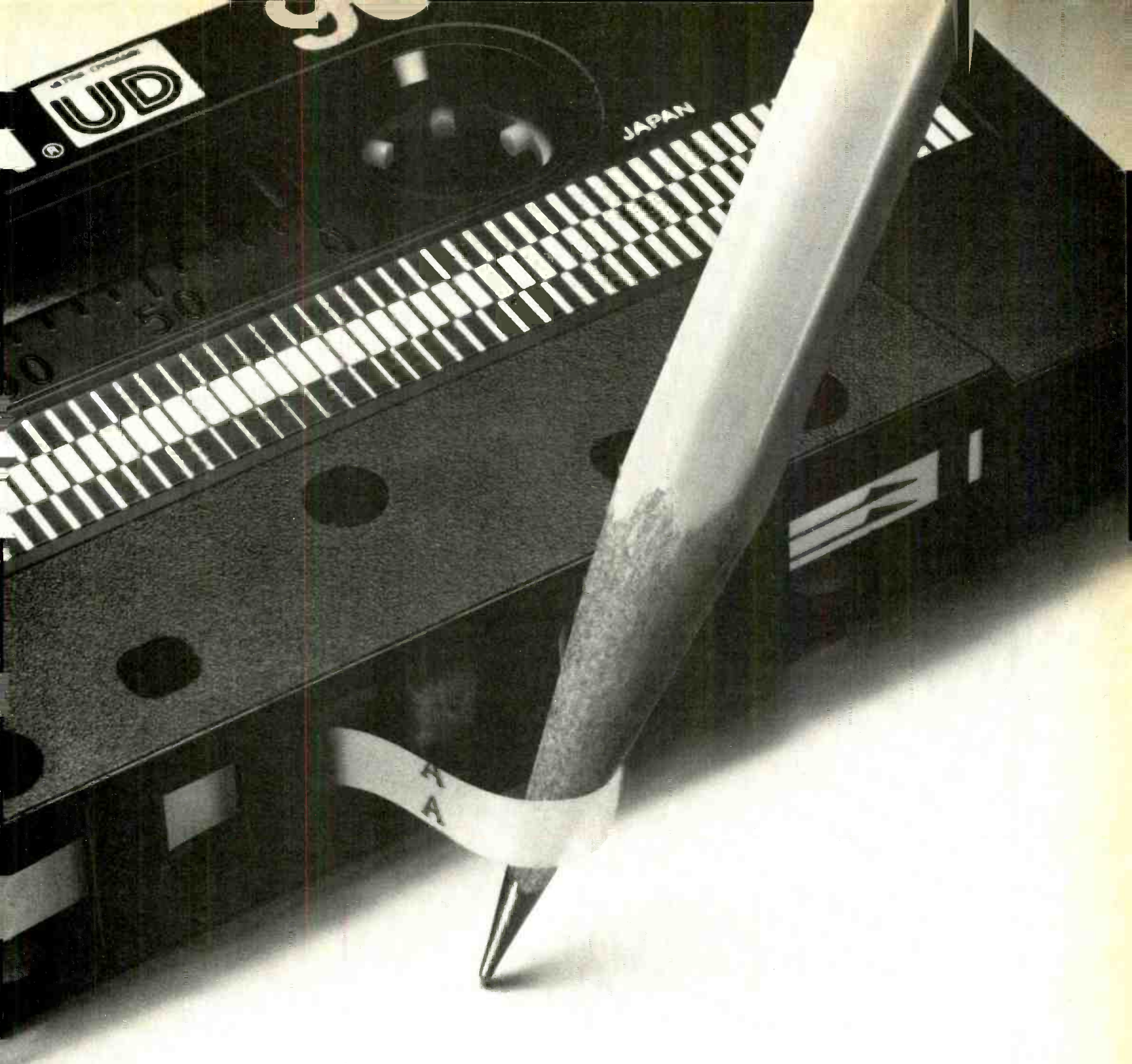
(Reports continue on page 32)



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CIRCLE NO. 40 ON FREE INFORMATION CARD

Maxell Corporation of America, 60 Oxford Drive, Moonachie, N. J. 07074.

EPI Model 500 three-way speaker system features two passive radiators

The new Model 500 is the first three-way speaker system from EPI. This top-of-the-line system is built with the axes of its three active drivers aligned vertically on the front panel. Augmenting the low-bass output are two 12" (305-mm) passive radiators, one at the bottom of each side panel of the cabinet. A 10" (254-mm) woofer crosses over to a 4" (102-mm) midrange driver at 750 Hz, while the second crossover, to a 1" (25.4-mm) concave dome tweeter, occurs at 3 kHz.

The speaker system measures 39"H × 14¾"D × 12"W (990 × 375 × 305 mm) and weighs 50 lb (22.7 kg). Suggested retail price is $400.

General Description. The 500's newly developed woofer has been designed for minimum internal inductance and a minimum dynamic variation of that inductance. EPI investigations showed that conventional woofers usually have a "driver offset", or a mechanical phase shift, so that the voice coil is not at its neutral position when the electrical drive signal is zero. This is related to the voice coil inductance. Furthermore, the inductance changes as the voice coil nears the end of the magnetic gap, distorting the acoustic output.

To minimize static inductance, EPI uses a two-layer voice coil in the new woofer, instead of the common four-layer design. To reduce dynamic inductance change, a shaped magnetic pole piece focuses the magnetic field into a thin disc, so the voice coil is subject to a constant flux.

The passive radiators appear from the outside as flat pistons of hard plastic, with compliant edge surrounds. However, these are merely the exteriors of deep foam plastic plugs supported inside the speaker by second suspensions. The plugs block midfrequency sounds, and the dual suspension makes them act as pistons.

The midrange driver, also specially designed for the 500, is fully sealed to prevent interaction with the woofer. Its voice coil is immersed in ferrofluid to provide damping and cooling. The high-frequency driver is the EPI "air-spring" tweeter whose voice coil is also surrounded by ferrofluid. Maximum power-handling ability of the system is 100 watts continuous, 500 watts peak.

a flat, neutral-sounding speaker

The cabinet of the EPI 500, made of particle board, is veneered in ebony (vinyl) on the top and sides, and in walnut on the front and rear surfaces. A snap-on black cloth grille, held by plastic pegs, covers the upper part of the front panel. The input terminals are multi-way binding posts, underneath the speaker, that accept the standard ¾" (19-mm) spaced dual banana plug connectors. There are no user-accessible level or frequency-balance controls.

Laboratory Measurements. Reverberant-field frequency-response measurements revealed variations of only ± 2.5 dB, from 1100 to 20,000 Hz, with a slight midrange depression and a gently rising high end. There was also a small bump, of about 3 dB, in the response at 1600 Hz. Bass response, measured with close microphone spacing, was flat within ± 2.5 dB from 55 to 750 Hz. When we combined the outputs of the three bass radiators (after allowing for their relative areas) it appeared that there was a modest peak of 2.5 dB in the response at 75 Hz, below which was a slightly uneven drop-off in output. Overall frequency response, relative to the 1000-Hz level, was ±5 dB from 33 to 20,000 Hz.

Bass distortion was very low with 1 watt delivered to the speaker's nominal 4-ohm impedance, measuring about 0.15% at 100 Hz, and increasing very gradually to about 1% at 40 Hz and 3.2% at 30 Hz. A 10-dB power increase raised the distortion to between 1 and 1.5% near 50 Hz, and 7% at 30 Hz. Sensitivity was moderate, as indicated by an 88-dB sound pressure level 1 meter from an input of 2.83 volts of random noise in a midrange octave.

Tone-burst response was good at most frequencies. Near 1000 Hz, there were start-up and decay lags of about 2 ms. Tweeter dispersion was good, with a difference of 3 to 4 dB between the outputs measured from the left and right speakers between 10 and 20 kHz with the microphone on the axis of the left speaker and about 30° off the axis of the right. Although EPI claims that the impedance of the 500 is exceptionally uniform, it varied substantially over the total range. It fell to just below 4 ohms between 3.5 and 15 kHz, justifying the 4-ohm rating even though its behavior elsewhere is characteristic of an 8-ohm speaker.

User Comment. In most respects, our subjective impressions of the 500 coincided with our measurements. In general, it is a flat, neutral-sounding speaker, with slightly bright, crisp character. The measured bass rise, which might have been expected to add coloration to the midbass, was not audible. For our listening tests, the speakers were located about 6" to 12" (152 to 305 mm) from the wall.

The only identifiable sound coloration was a slight emphasis in the upper midrange. We suspected that it was connected with the measured peak at 1600 Hz; some experimenting with a parametric equalizer confirmed this.

The sound stage formed by the pair of 500s was, for the most part, confined to the space between them. The sound was highly detailed, and the vantage point seemed close. It was as though the instruments were lined up across the room, with no apparent extension outside of the plane of the speakers.

The speaker put out highly impressive bass when called for, yet it gave no gratuitous hints of this capability by adding boominess or heaviness to voices. Likewise, only when there were cymbals, triangles, or other instruments with extended spectra in the program was the excellent high-frequency performance evident. Never was there any accentuation of record hiss or any other sign of a treble peak.

The EPI 500 might be described as a "comfortable" loudspeaker. It is a fine reproducer of music that will fit into all but the most confined listening rooms without strain or inconvenience. Tastefully styled as it is, it won't upset your decor either. Perhaps the nicest part is that it gives you all this without sending shock waves through your budget.

CIRCLE NO. 102 ON FREE INFORMATION CARD

(Reports continue on page 34)

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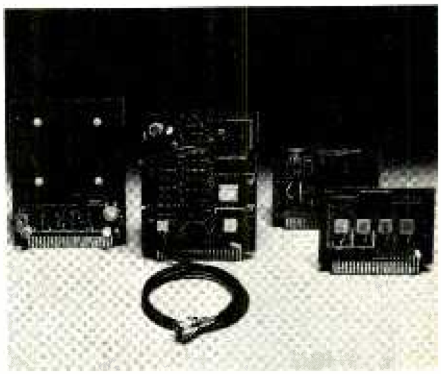
RCA



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Type	Description	Price
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☐ VP-114	Expansion Kit for VP-111—Includes 3K RAM, I/O Port and connectors	$ 76
☐ VP-711	VIP—The original VIP Microcomputer (See description above)	$199
☐ VP-44	RAM On-Board Expansion Kit—Four 2114 RAM IC's. Expands VP 711 memory to 4K bytes	$ 36
☐ VP-590	VIP Color Board—Converts VIP to color. Four background and eight foreground colors	$ 69
☐ VP-595	VIP Simple Sound Board—Provides 256 programmable frequencies. For simple music or sound effects. Includes speaker	$ 30
☐ VP-550	VIP Super Sound Board—Turns your VIP into a music synthesizer! Two independent sound channels. On-board tempo control. Outputs to audio system	$ 49
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CIRCLE NO. 58 ON FREE INFORMATION CARD

RG Dynamics Model PRO-20 signal processor provides expansion and noise reduction

HIRSCH-HOUCK LABS REPORT

The Model PRO-20 heads up a new line of dynamic signal processors from RG Dynamics. The characteristics of this new "volume expander" have been optimized for use in home-music playback systems to compensate for the dynamic compression present in virtually all recorded and broadcast programs. It normally connects to the tape-recording monitoring loop of an amplifier and duplicates the amplifier's tape input/output jacks on its rear panel.

The expansion circuits can be switched into the system ahead of the tape-recorder outputs to permit the PRO-20's noise-reducing properties to be used on a signal before it is recorded. Degree of expansion (from −8 to +12 dB) and noise reduction are adjustable, and no critical level adjustments are required. Instantaneous expander status is displayed on two columns of LEDs on the control panel.

The PRO-20W has walnut-finished wood side panels and a silver-finished control panel. Overall size is 18″W × 12″D × 3½″H (475 × 304 × 89 mm). Suggested retail price is $395. The processor is also available with a black panel (Model PRO-20BW) or with a black standard rack-mount panel (Model PRO-20B).

General Description. The DYNAMIC EXPANSION control permits continuous adjustment of expansion between the limits of 4 and 20 dB at 4-dB calibration intervals. Normally, about 4 to 8 dB of the total expansion is downward, corresponding to gain reduction for low-level signals. The rest is upward expansion, an increase in gain with increasing signal strength, to a maximum of +12 dB. Instantaneous expansion, based on comparison of input and output levels of each channel, reads out on two columns of LEDs that light successively at 4-dB intervals. Processing is separate and independent for each channel. A NOISE REDUCTION red LED at the bottom of each column comes on when downward expansion occurs.

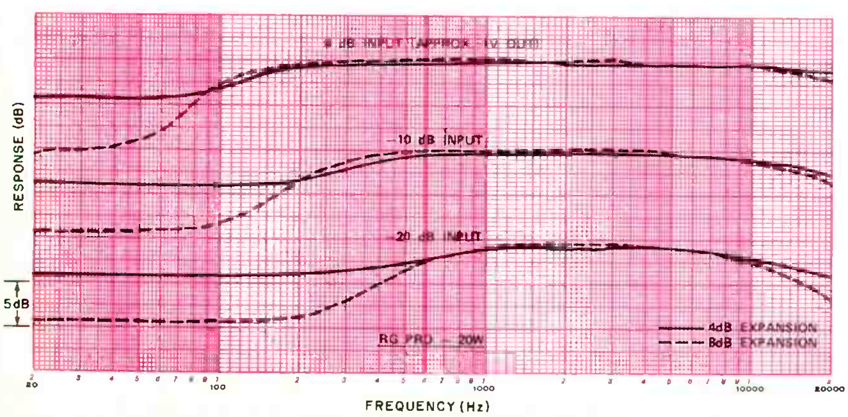
Four lever switches control basic expander operation. Set to MIN, the NOISE REDUCTION switch limits downward expansion to 4 dB. The TAPE MONITOR switch replaces the similar switch on the amplifier to which the PRO-20 is connected. There are two DYNAMIC PROCESSOR switches: MAIN bypasses the expander circuits when set to OFF, and TAPE inserts the expander ahead of the tape-recorder outputs when set to ON. The PROCESSOR LEVEL PRESET control permits adjustment of input sensitivity for operation with any input signal between 80 mV and 10 volts.

Expansion attack time is rated at 0.6 ms and decay at 80 ms. Nominal output in 1 volt, with a maximum of 7 volts available into 50,000 ohms. Input impedance is 80,000 ohms and output impedance is 300 ohms, both compatible with tape-monitoring circuits. The PRO-20, which draws only 3 watts from a 120-volt 60-Hz power line, is designed to be left on continuously or, if desired, it can be controlled via a switched accessory outlet.

no unwanted side effects . . . the best device of its type we have used

Laboratory Measurements. It is difficult to make conventional electrical performance measurements on a device like the PRO-20, since the test signal modifies the performance of the device being tested. Even when measurements are possible, they rarely convey a useful impression of performance, which is usually dependent on unmeasurable psychoacoustic phenomena. The only valid criterion for judging the operation of a dynamic signal processor of any type is its subjective performance. As a rule, if you can detect its action by ear, the processor is not doing its job properly or is being operated incorrectly. A successful dynamic range expander, noise reducer, or other signal processor will never give a positive indication of its presence in the system.

We did make some electrical measurements on the PRO-20 to assess its effect, if any, on overall signal quality. Although the clipping output level at 1000 Hz was approximately 7 volts into 50,000 ohms as rated, using the standard 10,000-ohm IHF



Response curves for three input levels at 4 and 8 dB expansion.

load in parallel with 1000 pF reduced clipping output to 3.1 volts, which is still more than sufficient for use in any home music system. At 1000 Hz, total harmonic distortion (THD) was less than 0.03% for outputs between 0.1 and 0.35 volt, with the maximum 20-dB expansion, and rose to 1% at 2.8 volts. Distortion measured less than 0.1% at 20 kHz for 0.1-to-0.5-volt outputs and 1% at 2.1 volts.

At very low frequencies, distortion rose appreciably. In a processor of this type, there is a tradeoff between low-frequency distortion and response time. A fast attack is psychoacoustically desirable, but it can also cause the expander to partially track low-frequency waveforms, resulting in distortion. This was illustrated by the 20-Hz distortion data, which were 0.35% at a 0.1-volt output, about 3% at 0.4 volt and 20% at 1 volt. With strong expansion, a sudden reduction in input signal level resulted in a much slower "settling period" at the expanded output. Several seconds were required for the output to fall to its final level.

When we attempted to measure frequency response under different operating conditions, we were actually measuring only the frequency response of the control circuits, not the expander's signal path. Expansion is controlled largely by midfrequency content of the program, which resulted in a "peaked" response, with the difference between the middle- and low-frequency portions being the setting of the DYNAMIC EXPANSION control. Turnover frequency varied considerably with signal level and expansion setting, from below 100 to above 1 kHz. Control circuit response peaked at 2 to 3 kHz. When we attempted to measure the noise of the RG PRO-20, we could only confirm (as the rating of 88 dB below 1 volt suggests) that it was below the range of our test instruments.

User Comment. Subjectively, this is about the least obtrusive consumer-type expander we have ever heard. It can, of course, be set to give too much expansion, and will then sound unpleasant, producing an unnatural surging as the gain goes up and down. Using expansion of 12 dB or less, we found the results close to ideal. The presence of the PRO-20 in the circuit was never audibly betrayed.

When the noise floor of the incoming program is not too high, the expander works well to lower it yet further. We could hear almost no tendency for the noise to be modulated by the changes in gain, which is a usual fault of expanders acting as noise reducers. Nevertheless, the quieter the original program was, the more effective the device. The switch to limit noise reduction struck us as a curious inclusion, as there is no reason why limiting downward expansion to 3 dB would make modulation of the noise, if it did occur, less severe. Furthermore, we found no situation in which we preferred the lower level of noise reduction.

Overall effectiveness and freedom from unwanted side effects make this, perhaps, the best device of its type we have used. Ease of adjustment and use are also among its virtues.

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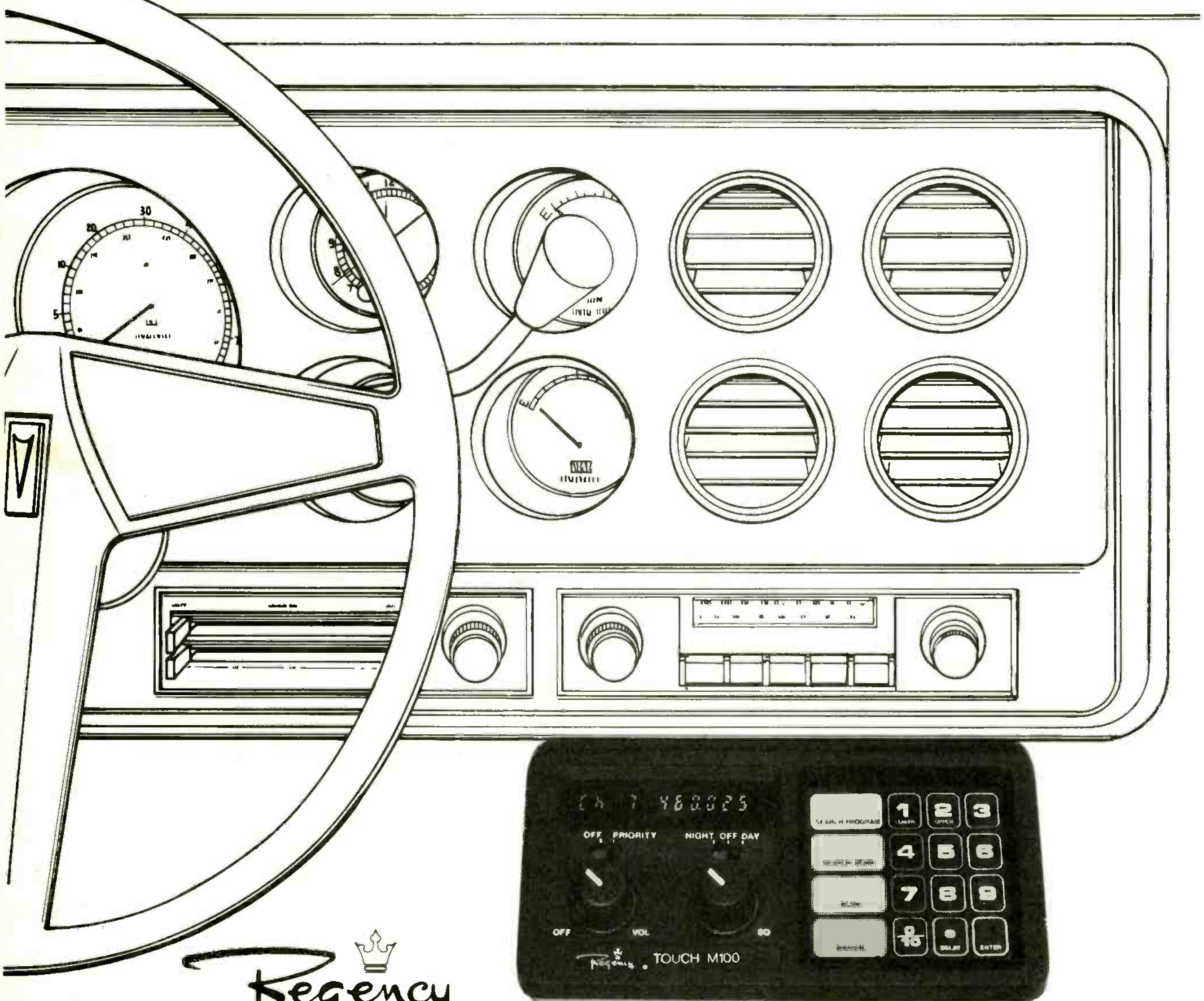

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CIRCLE NO. 59 ON FREE INFORMATION CARD

Popular Electronics
FEBRUARY 1980

Buying the Right Digital Multimeter

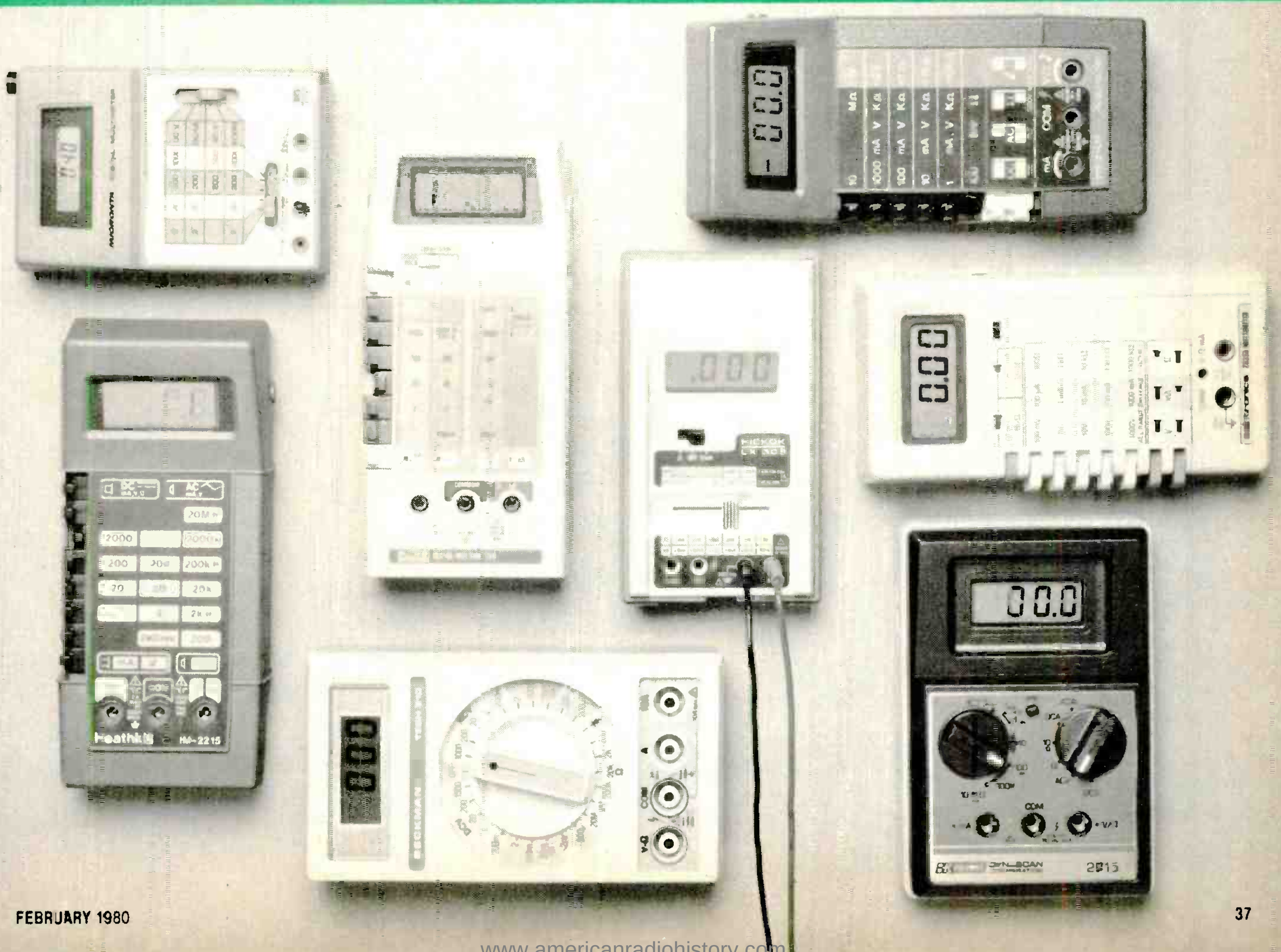
PE STAFF REPORT

Understanding the specifications, operating characteristics, and special features of DMMs will help you avoid pitfalls and match the instrument to the job

IN THE relatively short time that digital multimeters have been widely available they have attained great popularity. By reputation, DMMs offer better accuracy and resolution than analog types, while also being more reliable and easier to use. These virtues, and more, are available to the purchaser of a DMM—if he can intelligently evaluate the instrument's capabilities and match it to his needs.

There are available on today's market more than a hundred DMMs from dozens of different manufacturers, ranging from inexpensive hand-held kit models to costly and sophisticated laboratory instruments. Not only must you choose between portable and bench types, you must also decide how many and what kind of display digits you need, the features and functions that meet your requirements, and whether or not you need certain optional accessories.

One ready source of information is the manufacturer's specification sheet; but it must be examined carefully and critically. Specs that are not understood can confound rather than inform.



the Right Digital Multimeter

continued

General Information. Basically, DMMs consist of two sections. One is a voltage-sensitive display system that accepts a low-level dc input (usually 2 volts maximum) and flashes the measured value on a multiple-digit numeric display. The other is a signal conditioner or "front end" that converts and scales the input signal into a dc voltage proportional to its magnitude and within the range of the measuring system.

DMMs can be portable, bench-type, or both. Portable instruments dominate today's market and are available in a variety of sizes. They offer about the same basic features and functions in each price category. As a general rule, portable DMMs are the lowest-priced models, selling for as little as $75 in kit form. Since they are extremely compact, portable DMMs provide fewer features than larger bench-only types.

Human engineering is extremely important in the design and layout of a portable DMM, especially for hand-held models. Display, range and function selectors, and input connectors must be easy to use. A potential purchaser should be concerned with the visibility of the display. Is it large enough? (Most displays are at least 0.5 inch—or 12.7 mm—high.) Can it be read in bright surroundings? In the dark? Liquid-crystal displays (LCDs) depend on ambient light. LED displays are self-illuminating, but may wash out in bright light.

Range and function selection can be accomplished in any of a number of ways. These may involve a pair of rotary switches, one for range, the second for function; a single rotary switch that selects both; or a single rotary for one and a series of input jacks for the other. Whatever the geometry, the thing to look for in your DMM is convenient operation that does not trick you into making errors or demand a fatiguing level of concentration.

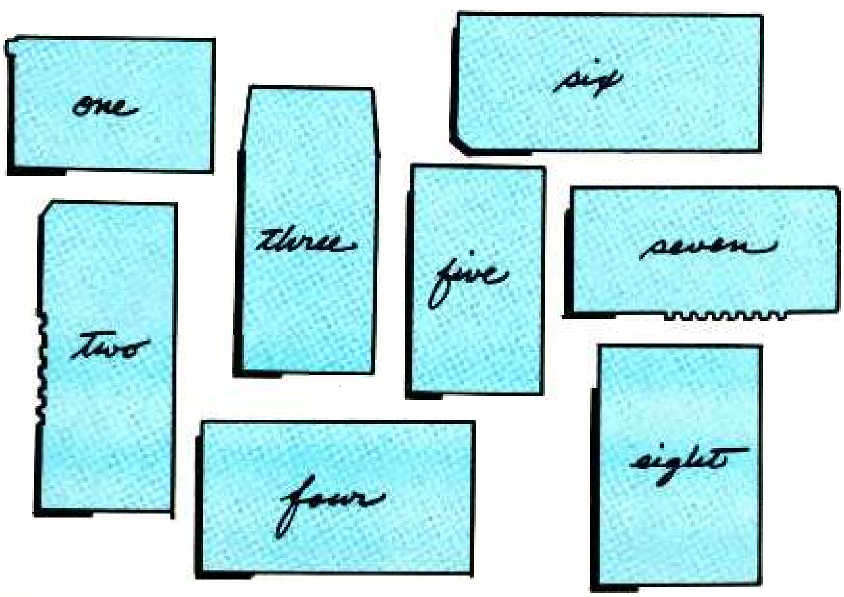
Most "portable" DMMs that are not designed to be hand-held are really bench-type instruments that offer the flexibility of battery operation. These instruments sometimes provide functions not found in hand-held DMMs. Bench-only DMMs are invariably powered from an ac line. Range and function can be selected via rotary or pushbutton switches, the latter predominating. These instruments frequently have special features and/or functions that are built in or can be added as desired. One such built-in feature is an auxiliary analog meter movement, as in Simpson's Model 460-3A, that simplifies the task of making peaking and nulling adjustments. Some portable DMMs can operate for hours on one battery, a consideration that may be important for field work.

Even low-priced DMMs today offer 3½ digits of display, which is sufficient for most normal purposes. Critical applications may demand more digits, but these are only useful if the rest of the instrument is up to snuff. A 5½-digit display doesn't offer anything more than a 3½ if the two low-order digits are in error or "bobbling" indecipherably. Note also that a 4½-digit instrument whose most sensitive scale reads to 1.9999 V gives no more sensitivity than a 3½-digit type that reads 1.999 mV on its most sensitive range.

The half digit is, of course, the 1 in a display that goes to, say, 1.999. It is turned on by overflow of the last full digit and sometimes called the overrange indicator. Note that the instrument may not read to the limit implied by the overrange indicator. A 3½-digit meter that goes to 1.999 has 100% overranging. A rating of 50% for this parameter would imply measurement capability to 1.499. Don't be confused by the fact that the range selector switch is marked "2", "20", or "200". The maximum is 1.9, 19.9, 199.9 regardless.

Among the available special features, one of the more popular options is a low-ohms function that permits resistance measurements to be made with test potentials lower than the turn-on voltages of semiconductor devices. Besides safeguarding the semiconductors, this feature prevents them from upsetting in-circuit resistance checks. Another useful function is an alarm that indicates when continuity exists during a test. Beckman uses a flashing omega (Ω) in the display to indicate when continuity occurs. Weston, Fluke, and Data Precision feature a beeper that sounds when test leads are shorted together. Weston's Roadrunner goes a step further, creating a beep to mark two different voltage levels and three different resistances.

Some of the more expensive bench-type DMMs come with BCD (binary-coded-decimal) digital outputs for driving hard-copy printers to provide permanent records of tests and measurements. Others provide a computer bus (usually IEEE-488 format) to permit the



Which Ones Are They?

(Key to photo on previous page)

one *Micronta 22-197*
two *Heathkit IM-2215*
three *Fluke 8024A*
four *Beckman Tech 310*
five *Hickok LX303*
six *Weston Roadrunner*
seven *Sabtronics 2035A*
eight *B&K 2815*

instrument to be controlled by an external computer.

There are still a few DMMs on the market that feature built-in capacitance-measuring circuitry. And some of the more critical-application DMMs feature very stable temperature-compensated crystal time bases for conducting ultraprecise measurements.

By the Numbers. Like all test instruments, DMMs can be technically described by ratings listed as "technical specifications." In general, looking for prospects to buy, specs are the first things you should study. To do so, however, you must know how to interpret each specification. Here is a brief rundown on the more commonly published specifications:

Accuracy. For most people, this is the single most important DMM parameter. To be meaningful, accuracy should be stated with reference to time, ambient temperature, power-line variations, and other measurement conditions. The period of time over which the accuracy holds to its specified value is important because it indicates an instrument's stability and how often recalibration is required. Accuracy is usually expressed as a percentage of *full-scale* or percentage of *reading*, both plus and minus some number of digits. Typical examples are 0.1% full-scale ±1 digit and 0.1% of reading ±1 digit, respectively.

The full-scale spec found generally in older material, means that the DMM is accurate within 0.1% of its *full-scale* value over the entire selected range. For example, if the range is 199.9 V full-scale, maximum error at any point will be 0.19 V (0.1% of 199.9). At 80 volts, the error approaches 0.25%; at 20 volts, 1%; and so on. At the low end of the range, then, the instrument can have a fairly large error and meet its spec.

The newer percent-of-reading spec means that the displayed number represents the maximum error. For example, using the 1.999-V range and 0.1% accuracy, maximum error will be 0.19 V at 1.999 V and only 0.02 V (20 mV) at 20 V. Needless to say, this is a much "tighter" spec than full-scale-referenced specs.

In essence, the ±1-digit portion of the accuracy spec accounts for least-significant-digit "bobble." If the correct display should be, say, 0.795, the least-significant digit could be a 4, a 5, or a 6 and still be within spec. For low readings, this makes the achievable accuracy far less than that promised by even a percent-of-reading spec. If low-level accuracy is a critical concern, calculate the ±1-digit tolerance in percentage to be sure of what you are getting.

Accuracy of resistance, current, and ac voltage measurement is usually not as good as it is for basic dc measurements. This is due to errors in the signal conditioners used to make the necessary signal-to-dc-voltage conversion. Measurements of ac in particular suffer from the input capacitance of the instrument and are good only up to some frequency (which should be stated). A spec stated at some spot frequency cannot be considered complete.

Remember too that ac calibration holds only for sine waves, with no harmonics present. If you need to be able to read peak voltages, look for a DMM offering that feature. To determine rms values for nonsinusoidal waveforms requires conversion circuitry. Lab-grade meters respond to the equivalent heating value of the signal; more modestly priced DMMs use circuitry that squares the signal, averages it, and extracts the square root.

Resolution. The ratio of the least number of counts that can be displayed to the maximum is known as the instrument's resolution. Full-scale resolution in a 3-digit DMM is 1:1000, or 0.1%. Overranging is generally ignored in the resolution spec.

Sensitivity. Another of the specs you should examine closely, sensitivity refers to the smallest incremental voltage change the instrument is able to detect. In mathematical terms, it is the lowest full-scale range multiplied by the resolution. Sensitivity of a 3-digit DMM with a 0.1% resolution and 100-mV lowest full-scale range (overranging is again ignored) is 0.1% of 100 mV, or 0.1 mV. If the lowest full-scale range is 1 volt, sensitivity becomes 1 mV.

Loading. An ideal voltmeter would have infinite impedance and thus present no load to a circuit to which it is connected. Real voltmeters always draw some current, however small, and therefore appear to the circuit as an additional element in parallel with the one across which voltage is being measured. This parallel combination, of course, has a lower impedance than either element alone, so the voltage developed with the meter connected is lower than it would otherwise be. Voltage measurements, therefore, are *always in error*, but if the meter's impedance is high enough compared to that of the element across which voltage is being measured, then the error will be negligible.

For a DMM to give rated sensitivity, its impedance should exceed source impedance by a factor of at least 10^N, where N is the number of digits in the display. For example, a 3-digit, 1-megohm input DMM cannot measure voltage across a resistance much above 1000 ohms without excessive loading. In contrast, a 3-digit, 10-megohm DMM will not excessively load a circuit whose resistance is 10,000 ohms or less. A 15-megohm DMM will reduce loading further, enhancing accuracy. Don't forget, however, that ac input impedance of a DMM is lower than for dc and varies with frequency. A maximum frequency limit should accompany the ac impedance specification.

Voltage Burden. This is a current-measuring phenomenon analogous to loading in voltage measurements. Most current-measuring instruments operate by inserting a very low resistance in series with the circuit being measured and reading the voltage developed across that. In most cases, the voltage drop across the sensing resistor is negligible in comparison with those elsewhere and can be ignored insofar as circuit operation is concerned. But in a low-voltage, high-current circuit, the voltage drop can be significant. This is usually specified by a DMM manufacturer as a maximum voltage drop for each current range of the instrument. Also, bear in mind that the current-sensing resistor is common to all circuits following it and that "glitches" generated by any one stage may have an effect on all following stages with the current-measuring device connected.

Noise. There are two types of electrical noise that can have a significant effect on the accuracy and sensitivity of a DMM (or any digital instrument, for that matter). They are commonly referred to as "normal" and "common-mode" noise signals.

Normal noise signals are unwanted components that enter the DMM riding on the signal being measured. They can be picked up by the test leads or be a component of the signal itself, such as power-supply ripple. The degree of error caused by noise is proportional to the amount of noise present on the input signal; this is shown somewhat exaggeratedly in Fig. 1. The true value of the dc component can be hidden within the noise, especially when the voltage being measured is very low.

The usual solution to this problem (other than eliminating the noise at its source) is to use a low-pass filter in the voltmeter input. Although the filter reduces the effect of high-frequency noise, it also increases the response time of the following circuitry.

A DMM's ability to reject normal-mode noise is specified as NMR (normal mode rejection) and is expressed in decibels at a specific frequency. A NMR of 60 dB at powerline frequency (50 or 60 Hz) will keep hum-induced error below 1 count in a 3½-digit DMM with a 100-mV scale.

Common-mode noise is an undesired signal that can occur between the instrument's input terminals and common ground used during measurement. It is generally caused by unwanted current flowing as a result of the potential difference between the input terminals and common ground and is sometimes called a "ground loop."

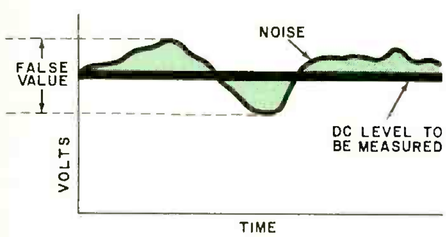


Fig. 1. Noise (boundary of shaded area) added to dc level can give an erroneous, fluctuating reading.

A typical input for a DMM is shown in Fig. 2. In most measuring situations, the impedance of the high-side leakage components (usually the red, or +, lead plus *Z2*) is much greater at all frequencies than the impedance of low-side leakage components *Z1*. This is because the high side consists of short wiring and a printed-circuit foil trace, while the low side is the instrument's ground foil, which can be relatively large in area. Because of its rather high impedance, the current path through *Z2* can be disregarded.

As shown in Fig. 2, common-mode noise is essentially in series with the desired signal. The worst path is through low-side leakage components *Z1*. Thus, common-mode rejection is related to the ability to reduce the unwanted voltage generated across *Z1*. The best way to increase rejection is to increase the impedance of the low-side leakage components. In a well-designed DMM, the low-side leakage resistance can approach 10^9 ohms, with an associated capacitance as high as 2500 pF. These values give a −120-dB dc CMR and a −60-dB ac CMR determined as follows: dc CMR= −20 log $(10^9/10^3)$ and ac CMR= −20 log $[(1/2\pi fC)/10^3]$.

In the example just given, a dc common-mode noise signal of 100 volts would develop 100 μV across the low-side resistance, while an ac common-mode signal of 20 volts at 60 Hz would develop 20 mV across this resistor. You can think of CMR as a reduction in the amount of common-mode signal converted into normal-mode across the low-side resistance.

Errors caused by common-mode noise can be reduced by a technique called "guarding," in which a metal enclosure surrounds the circuitry associated with the low input and is insulated from both this lead and ground. A connector on the front panel of the DMM makes the guard available to the user. In use, the guard connects to the low side of the circuit under test.

With the guard, the resulting low-side leakage components are changed to, say, a leakage resistance of 10^{11} ohms and a capacitance of less than 2.5 pF. Since the guard is driven by the same common-mode signal as the low input, virtually no current flows through the guard impedance. This reduces the dc CMR to about −160 dB and the ac CMR to about −120 dB at 60 Hz. Now, the 100-volt dc common-mode signal generates only 1 μV of normal-mode and the 20-volt ac common-mode signal generates only 20 μV of ac normal-mode.

Effective common-mode rejection is a specification that often appears on data sheets. Effective CMR is a combination of "pure" CMR due to guarding and normal-mode rejection.

Another form of noise that can give false readings in a DMM results from induced r-f energy from radio and radar gear. In an r-f environment, false displays of measured parameters result from rectification of the r-f by dissimilar junctions inside and outside the DMM. A common way to reduce the effects of stray r-f is to shield the DMM. Ballantine, B & K, and other manufacturers are offering instruments with this feature.

Settling Time. A DMM measures steady-state values only. However, the application of the probes to an input signal represents a transient. The time the instrument needs to recover from this transient and give a steady reading is the settling time. This time varies depending on the input waveform. Find out if this reference steady reading has rated accuracy.

Overload Protection. Overload protection should be given careful attention, as it can be critical. Remember that a sudden overload may cause catastrophic destruction of an internal IC or the entire front end. Pay particular attention to the protection provided for the resistance-measuring function, as the scaling network here is particularly vulnerable if a voltage source is erroneously applied. If fuses are used, find out how hard they are to replace. And after they are replaced, is it necessary for the meter to be recalibrated?

(Continued on page 47)

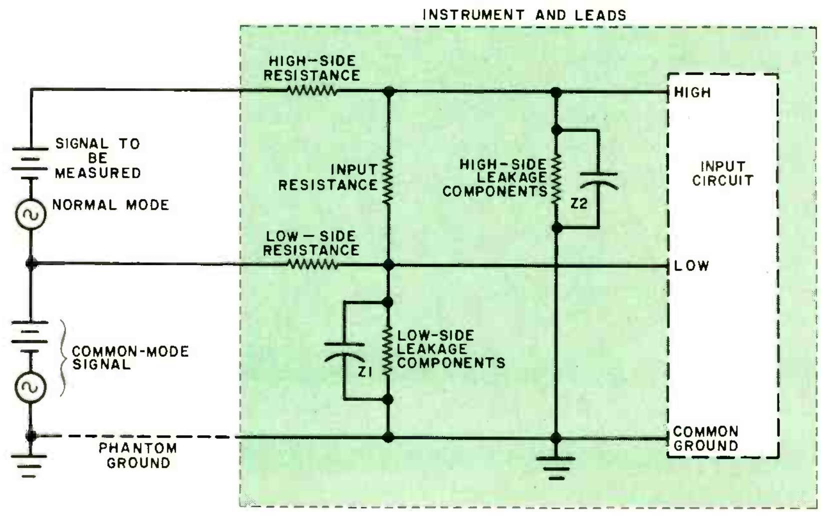


Fig. 2. Common-mode noise, applied to both meter terminals, may develop false voltages due to imbalance of leakage paths Z1, Z2.

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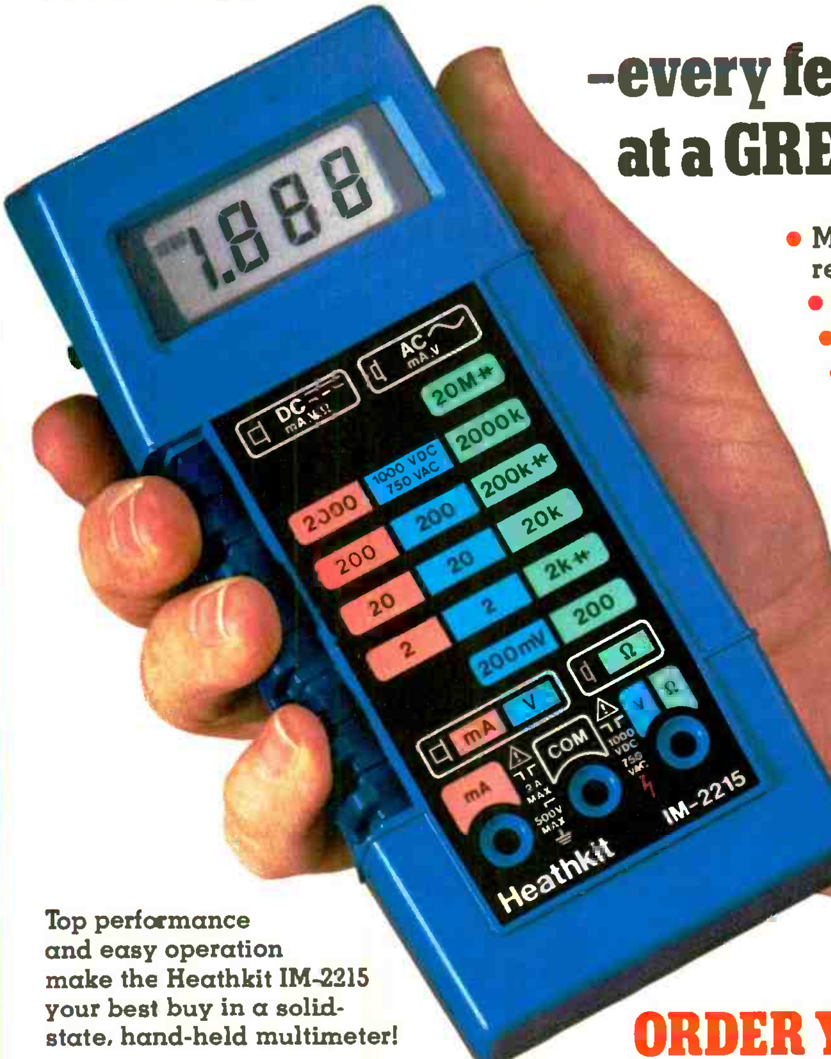

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STA-2200 is 599.95, at participating stores and dealers, price may vary. *TM Dolby Laboratories.

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(Continued from page 40)

Beyond the Basics. Most DMMs are similar in terms of voltage-, current-, and resistance-measuring capabilities. They differ in these areas chiefly by offering greater or lesser accuracy, greater or lesser selection of ranges, and different ac bandwidths, all of which determine price. In general, a "basic" DMM comes with only a user's manual and a pair of general-purpose test leads. Some inexpensive models even omit the leads.

Most manufacturers offer a variety of optional accessories for their instruments. Among these are soft and hard carrying and storage cases, rechargeable-battery packs, battery eliminators/chargers, and special-purpose probes. The probes either extend existing ranges or the utility of the DMM. Among the more or less standard probes and accessories available as options are high-voltage probes that permit measurements up to and beyond 30 kV, temperature-measuring attachments, current-measuring clamp-ons, and light-sensitive devices.

Choice of accessories depends on the uses to which you intend to put your DMM. In making your choices, consider your present needs and future applications for the instrument. For example, if you intend to perform appliance repairs, you'll need at least one relatively high-current clamp-on. (Most DMMs can measure up to only 2 amperes, while appliances often draw 10 or more amperes.) Temperature probes are good for the heating/air-conditioning specialist and for monitoring the operating temperatures of power transistors. For example, TV-radio technicians may elect to use Sencore's "Transient Protector Probe," which extends a 15-megohm-input meter to 10,000-V dc operation for checking horizontal output stages. Its high input impedance of 150 megohms also reduces loading in critical oscillator power and i-f stages.

In Conclusion. Choosing a DMM can be greatly simplified if you approach the problem intelligently. Know what your needs are to start, what to look for in terms of performance, and what a multimeter is capable of doing. Though LCD-display types appear to be most popular of late, a field TV service technician might find a LED display more useful when working on TV receivers in a subdued-lighting area or inside the TV's cabinet. If you have special needs beyond the abilities of the basic DMM, check out the optional extras. You are almost certain to find at least one suitable model at a price you can afford. ◇

DMM MANUFACTURERS SAMPLER

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B & K Precision
Dynascan Corporation
6460 W. Cortland Ave.
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Mountlake Terrace, WA 98043

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Benton Harbor, MI 49022

Hewlett-Packard
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Palo Alto, CA 94304

Hickok Elect. Inst. Co.
10514 DuPont Ave.
Cleveland, OH 44108

International Technology
3828 Woodcliff Rd., Box 5127
Sherman Oaks, CA 91403

Keithley Instr. Inc.
28775 Aurora Rd.
Cleveland, OH 44139

Leader Instruments
151 Dupont St.
Plainview, NY 11803

Micronta (see Radio Shack)

Non-Linear Systems
533 Stevens Ave.
Solana Beach, CA 92075

Philips Test & Measuring Inst. Co.
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Racal-Dana Instruments
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Irvine, CA 92713

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Sabtronics Internat. Inc.
13426 Floyd Cr.(M/S24)
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Sencore
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Sioux Falls, SD 57107

Simpson Electric
853 Dundee Ave.
Elgin, IL 60120

Sinclair Radionics
66 Mount Prospect Ave.
Clifton, NJ 07015

Soar Electronics Corp.
200 13th Ave.
Ronkonkoma, NY 11779

Systron-Donner
Instrument Div.
10 Systron Dr.
Concord, CA 94518

Triplett Corp
286 Harmon Rd.
Bluffton, OH 45817

Viz Manufacturing
335 E Price St.
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Weston Instruments
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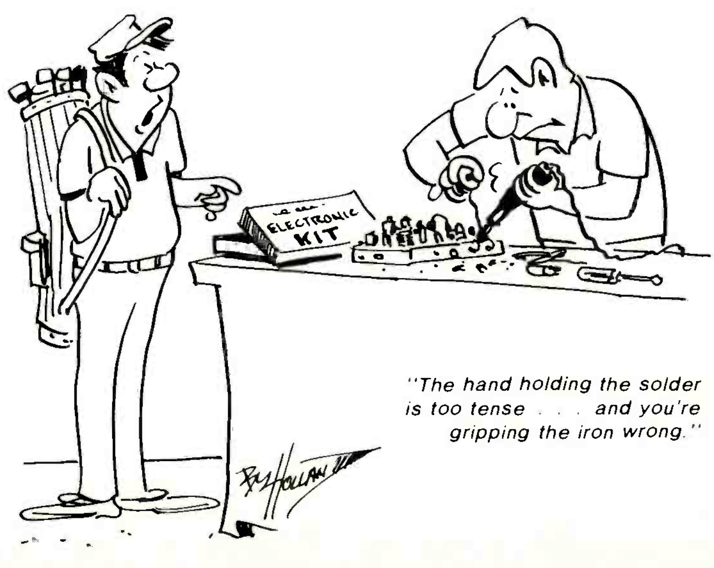
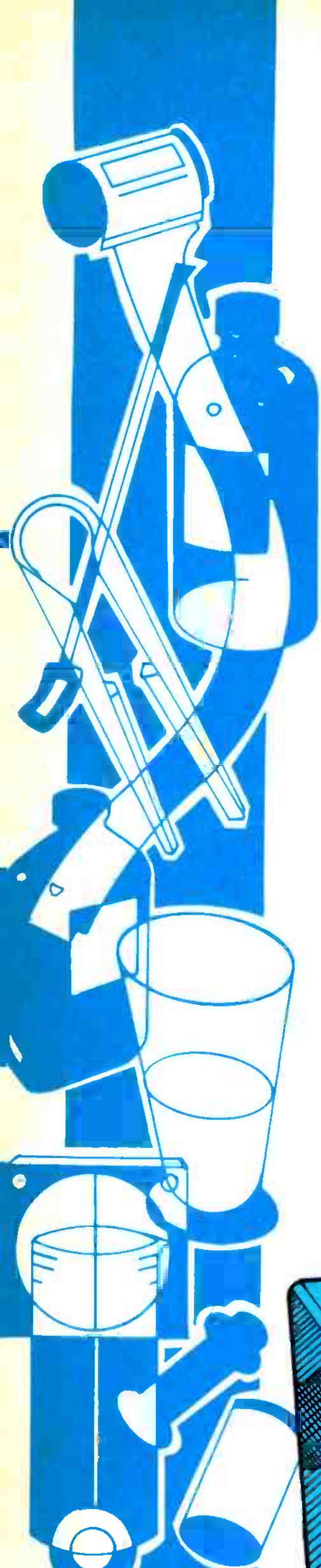


"The hand holding the solder is too tense . . . and you're gripping the iron wrong."

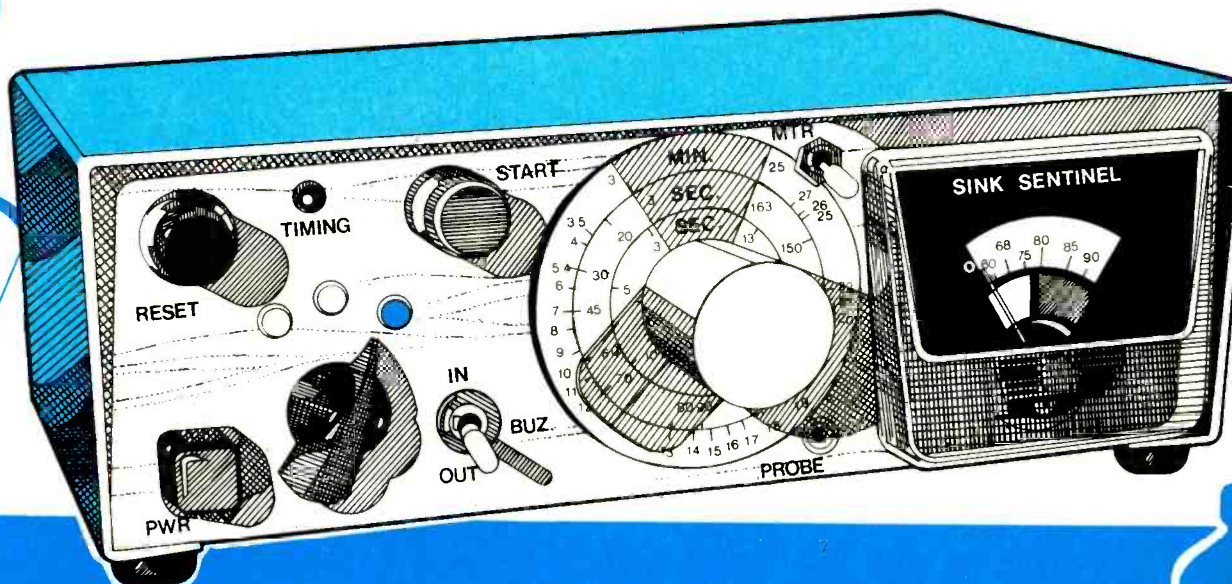


BUILD A PHOTO SINK

THERE are many reliable timers, thermometers, and quality-control devices to aid the photographer. Unfortunately, most of these commercial devices are expensive. You can, however, build the "Sink Sentinel," which serves as a photo-lab timer, thermometer, and conductivity tester, at a fraction of the cost you would expect to pay for a similar commercial device. The Sink Sentinel accurately monitors the temperature of film-processing chemicals, times film processing, and tells you when your film or paper can come out of the hypo.

About the Circuit. The timer portion of the Sink Sentinel is shown in Fig. 1. It is based on a conventional 555 timing circuit (*IC1*). TIME SET potentiometer *R2* and RANGE switch *S3*, the latter selecting the appropriate range capacitor (*C1* and *C2* shown, but more capacitors can be added, as desired), determine the timing range.

Timing is initiated by pressing START switch *S4*, which places pin 2 of *IC1* at ground potential. Pin 2 is normally held high by *R3*. The timing interval in seconds is approximately equal to 1.5 times the value of *R2* in megohms times the value of the capacitor (selected by *S3*) in microfarads. The timing values for the R



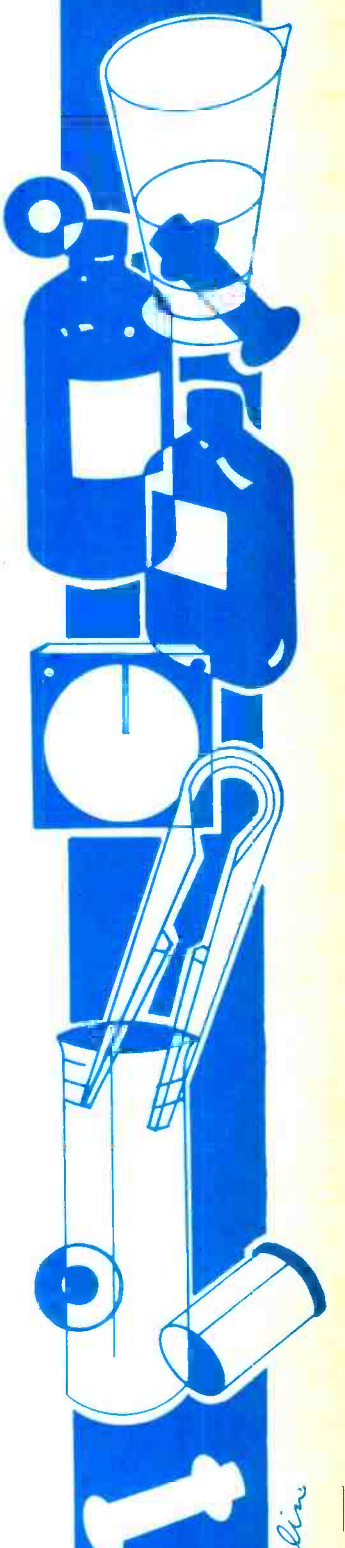
and C values shown in Fig. 1 were set in three ranges. The first and most commonly used for photographic printing and enlarging is from about 3 to 23 seconds; the second from 20 seconds to nearly 3 minutes; and the last from 3 to almost 30 minutes. If desired, the R and C values can be changed to produce any desired timing interval.

During the timing interval, the output of *IC1* at pin 3 is high and lamp *I1* and alarm *A1* (if the latter is switched in via *S5*) will not operate, but *LED1* will be on. At the end of the timing cycle, the output of *IC1* goes low to allow *A1* and *I1* to operate. At this point, *LED1* extinguishes.

If at any time you wish to terminate the timing cycle, you simply press RESET switch *S2*.

An optional enlarger/safelight powering arrangement is provided by sockets *SO1* and *SO2* and relay *K1*, as shown in Fig. 1. If you prefer not to have this option, you can eliminate *K1* and *SO1* and *SO2*. Assuming you decide to keep this option, when *K1* is not energized at the end of a timing cycle, *SO2* is powered and can be used to power your safelight. During the timing cycle, *K1* is energized, connecting *SO1* to the power line for powering an enlarger.

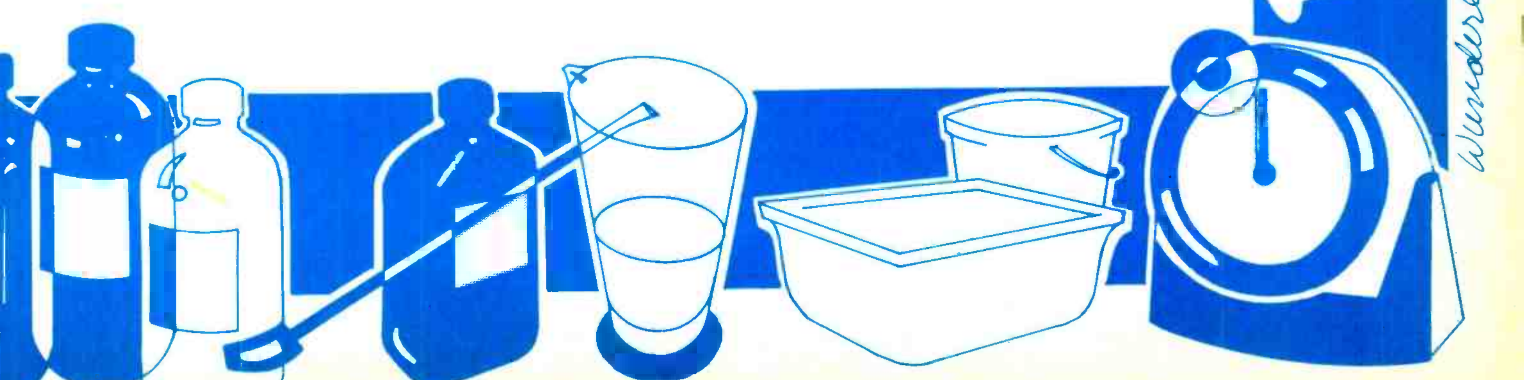
The temperature/conductivity section



DARKROOM SENTINEL

Moderately priced system monitors temperatures and film process time of photographic chemicals, and alerts user when film or paper processing is completed

BY FRANK I. GILPIN



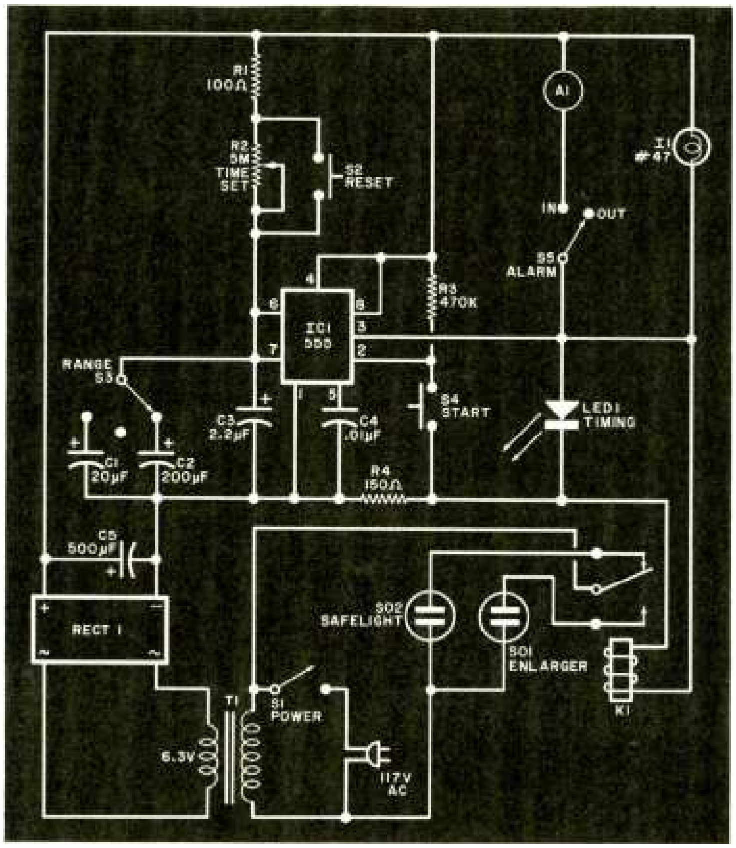


Fig. 1. Basic 555 timer can be adjusted for almost any desired timing ranges. The relay circuit allows timing an enlarger then turning on safelight.

PARTS LIST

A1—6-volt dc alarm or buzzer (Mallory Sonalert No. SC628, Radio Shack No. 273-049, or similar)
B1—9-volt battery
C1—20-µF, 20-volt electrolytic
C2—200-µF, 20-volt electrolytic
C3—2.2-µF, 20-volt electrolytic
C4—0.01-µF disc
C5—500-µF, 20-volt electrolytic
I1—6-volt lamp (No. 47 or similar)
J1—Subminiature phone jack
K1—6-volt, low-current relay (Radio Shack No. 275-004 or similar)
LED1—Red discrete light-emitting diode
M1—0-to-50-µA dc meter movement (Radio Shack No. 22-051 or similar)
P1, P2—Subminiature phone plug
Q1—Pnp germanium transistor in T01 or T04 metal case (see text)
The following resistors are ½ - watt, 10%:
R1—100 ohms
R3—470,000 ohms
R4—150 ohms
R5,R6—3000 ohms
R8—3600 ohms
R2—5-megohm linear-taper potentiometer
R7—100,000-ohm miniature potentiometer
RECT1—Rectifier (Radio Shack No. 276-1626)
S1—Spst switch
S2,S4—Normally open spst pushbutton switch
S3—Single-pole, three-position nonshorting rotary switch
S5,S6—Spdt switch
SO1,SO2—Chassis-mounting ac receptacle
T1—6.3-volt, 300-mA transformer
Misc—9" × 6" × 3½" (22.9 × 15.2 × 8.9 cm) aluminum cabinet; holder for B1; ac line cord with plug; pointer knob; plain pressfit control knob; 2" × 2" (10.8 × 10.8 cm) perforated board; 36" (about 1 m) stranded two-conductor speaker cable; 1/16" clear plastic sheet; quick-set epoxy; plastic cement; silicone-rubber cement; 4" (21.6 cm) chrome or stainless-steel wire (see text); dry-transfer lettering kit; rubber grommets (2); hookup wire; machine hardware; etc.

of the Sink Sentinel is shown in Fig. 2. It is based on the Wheatstone bridge principle. The circuit measures the relative resistance of either a plug-in temperature or conductivity probe.

The temperature probe is made up of an ordinary pnp germanium transistor with a metal TO1 or TO4 case. Sensing is performed in the emitter-collector junctions. Although such a temperature probe is limited in range, it will suffice for the 60° to 90° F (15.6° to 20° C) range required in most photographic developing situations.

Construction. The timer circuit can be assembled on a small perforated board, or you can use a printed-circuit board of your own design. A socket is recommended for *IC1* in either case.

Mount the various switches, control, indicators, and meter on the front panel of the enclosure in which the system is to be housed. This done, secure the power supply in place on the bottom of the enclosure. Pass the prepared end of the line cord into the box through a rubber-grommet-lined hole in the rear panel. Then, before connecting and soldering the line cord to the appropriate points in the circuit, tie a knot about 4" (10.2 cm) from the prepared end on the inside of the box to prevent the cord from being torn loose.

Light-emitting diode *LED1 mounts* on the front panel via a rubber-grommet-lined hole. Note that a separate lamp and switch can be used for *I1* and *S1*, or you can use a switch with built-in lamp.

Use a dry-transfer lettering kit to label the front panel with the appropriate legends. With an ink compass, draw four concentric circles on medium-weight white cardboard. Make the circles ⅝", 2", 2½", and 3" (15.9, 51, 63.5, and 76.2 mm) in diameter. Cut a disc from the cardboard, using the 3" circle as a guide. Next, cut a hole in the center of the disc, using the ⅝" circle as a guide. Rubber cement the disc to the front panel, with the shaft of *R2* centered in the hole. (This "dial plate" will be inscribed later during the timer calibration procedure.)

Slip a pointer knob onto the shaft of *S3*. Properly index the pointer and tighten the setscrew.

Next, cut a 3" disc from 1/16" (1.6-mm) thick sheet of clear plastic. Using a metal straightedge and a sharp needle, firmly scribe a line from the center to the edge of the disc. Fill the scribed line with india ink and wipe off the excess, leaving behind a fine scribed cursor. Drill a ⅜" (9.5-mm) hole through the center of the plastic disc.

Temporarily place a knob with a pointer on the shaft of *R2* and rotate it to locate the two stops on the pot. Locate this angular gap at the top of the cardboard disc (lightly pencil marking the two points on the cardboard disc) equidistant to both sides of an invisible vertical axis with the pot's shaft. Remove the pointer knob.

Now place the plastic disc over the pot's shaft, scribed cursor line toward

(Continued on page 56)

SINK SENTINEL

(Continued from page 52)

the cardboard disc. Center the plastic disc over the cardboard disc and line up the cursor line with the *right* pencilled stop mark on the cardboard disc. Temporarily tape the plastic disc in place. Rotate the pot's shaft fully counterclockwise. Apply a thin bead of plastic cement to the back of a plain plastic friction-fit control knob. Slide the knob onto *R2*'s shaft and gently press it against the plastic disc. Allow the cement to set for at least 8 hours before removing tape.

Meanwhile, fabricate the conductivity probe as follows. The probe itself (see Fig. 2) consists of a pair of closely-spaced conductors, with a limiting resistor, that can be plugged into *J1*. The probe elements can be made from two 2″ (5.1-cm) lengths of chrome or stainless-steel 12-gauge rod. A bicycle spoke or a length of stainless-steel antenna rod will do.

Solder *R8* to one end of one of the rods. Then trim away 1″ (25.4 mm) of one of the conductors at one end of a 36″ (about 1-meter) length of speaker cable. Strip away the insulation from both conductors of this end of the cable, twist together the wires and tin them lightly with solder. Connect and solder the shorter conductor to the free end of *R8* and the other conductor to one end of the remaining rod.

Now, cut two 1″ × ⅜″ (25.4 × 9.5 mm) strips from a sheet of 1/16″ thick sheet of plastic. Drill two ⅛″ (3.2-mm) holes ⅛″ apart in the center of both strips of plastic. Slip the free ends of the rods through one hole in each strip of plastic and apply a drop of fast-setting epoxy cement at each hole to secure the strips to the rods.

While the cement is setting, drill a ½″ hole through the center of the bottom of a plastic film or pill container. Drill eight or more ⅛″ holes around this hole and 25 or more ¼″ holes through the body of the container. Assuming the epoxy cement has set, slightly bend the tops of the rods apart to obviate any possibility of the two touching each other.

Pass the free end of the speaker cord through the ½″ hole from the *inside* of the container and pull it through until the tips of the rods are just slightly recessed from the open end of the container. Then liberally apply silicone-rubber cement over the resistor and the three soldered connections. Just fill the space around and between the tops of the rods to fill the ½″ hole. This will provide a mechanically secure mount for the conductivity probe's elements and a seal against the caustic solutions into which it will be immersed. Allow the cement to set for at least 24 hours.

To one end of a 36″ length of speaker twin-lead cord, connect and solder a subminiature phone plug. Separate the cord at the other end for a distance of about 4″ (10.2 cm). Strip away about ⅜″ of insulation, twist together the wires, and lightly tin the conductors with solder. Plug in and turn on the Sink Sentinel. Then, making sure to prevent the tinned conductors from contacting each other, insert the phone plug into *J1*.

Temporarily connect the collector and emitter leads of a pnp germanium transistor to the tinned conductors. Make sure that the emitter connects to the *R5* junction and the collector connects to the *R7/M1* junction. Note that the meter's pointer swings upscale. In a typical 68° F (20° C) ambient room, adjust *R7* for about a one-quarter-scale pointer swing.

Bring the transistor close to a turned-on light bulb; the meter's pointer should swing to full-scale. If this does not occur, repeat the procedure with a different germanium transistor until you locate one that is relatively heat sensitive. Put a kink or other identifying mark on the transistor lead connected to the speaker cable conductor with ribbed insulation. Then disconnect the cable from the circuit and turn off the power.

Once you have your heat sensitive transistor, clip away its base lead close to the metal case that houses it. Connect and solder the emitter and collector leads of the transistor to the cable's conductors, making sure that the identified transistor lead goes to the cable conductor with ribbed insulation. This done, pack silicone rubber cement over the exposed metal connections and down to the case of the transistor. Do *NOT* coat the sides or top of the transistor's case with the cement. Put this cable assembly aside to allow the cement to set for at least 24 hours.

Calibration. The timer section can be calibrated with the aid of a stopwatch, digital watch with seconds display, or an ordinary analog watch with a sweep second hand. Plug the Sink Sentinel into the power line and turn on the power. Lamp *I1* should come on and the alarm will sound if ALARM switch *S5* is on.

Set the RANGE switch to the maximum time (*C2* in Fig. 1) and the pointer knob for minimum resistance (fully counterclockwise). Carefully mark with an awl or the point of a pin, on the plastic disc over the potentiometer dial, the points where the cursor line crosses the circles on the cardboard disc. Remove the cursor knob and drill a 1/16″ hole at the two points marked. Then slip the knob back on the pot's shaft.

With the knob fully counterclockwise, push the point of a pin through both holes in the cursor disc to lightly detent the cardboard disc. Turn the knob fully clockwise and repeat the procedure. Return the pot fully counterclockwise.

Now calibrate the minutes range on the inner circle of the dial plate as follows. Simultaneously start your stopwatch (or wait for your watch to reach the zero seconds mark) and press START switch *S4*. The LED should come on, *I1* should extinguish, and the alarm should cease to sound (assuming it is switched in). When the countdown is completed by the timer, *I1* will come on, the LED will extinguish, and the alarm will sound. Note how long this took on a sheet of paper under the heading "MIN." Adjust *R2*'s cursor slightly clockwise and repeat this procedure. At the end of the countdown, note the time elapsed and slightly detent the inner circle on the cardboard with a pin. Repeat this procedure until the pot is at its fully clockwise stop. Then repeat this procedure for the

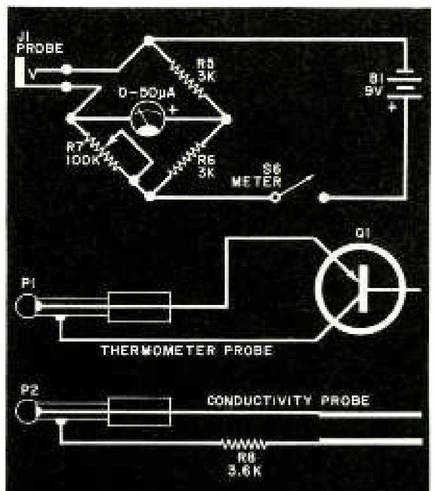


Fig. 2. Temperature/conductivity is measured on conventional Wheatstone bridge. Both probes are also shown. Temperature probe uses standard germanium transistor, while resistivity probe has stainless steel rods.

other two positions of the RANGE switch and the two SEC circles on the cardboard disc. (If you prefer, you can adjust the pot's setting to coincide with exact seconds and minutes to obtain a neater dial plate. This is time-consuming but well worth the effort.)

When you have completed calibration, turn off the Sink Sentinel and remove the cursor knob from the shaft of the pot. Mark three or four points on the perimeter of the cardboard disc and on the front panel exactly in line with them. Then lift off the cardboard disc. Using a dry-transfer lettering kit (or working with a pen), place tick marks at each detented point on the circles on the disc and label each with the appropriate time in your calibration listing. Then rubber cement the disc back in place, using the marks on it and the front panel as a guide. Slip back onto the shaft of the pot the cursor knob. (A typical finished dial is shown in the lead photo.)

The temperature probe can be calibrated with the aid of an accurate mercury-column thermometer. Since the most used range will be between 60° and 90° F, leave the probe in ambient room air (about 68° F) until the meter's pointer deflection stabilizes. Then adjust *R7* for a pointer deflection of about one-quarter scale. Carefully place a pencil mark on the scale at this point. Place both the mercury thermometer and temperature probe in water and adjust the temperature for an indicated reading of 95° F on the mercury thermometer. Again, place a pencil mark on the meter's scale at this point. Reduce the temperature of the bath by 2.5° F and again make a pencil mark on the scale. Repeat reducing the bath's temperature by 2.5° F and indicating each point on the scale until you reach 60° F. Turn off the power and remove the line cord from the ac power line.

Carefully remove the dial-scale card from the meter and relabel it with a dry-transfer lettering kit for each of the pencil marks. Start with 60° F and label only in 5° F increments, placing a small but easily legible tick at the 2.5° locations on the scale. Then replace the scale card. Plug in and turn on the Sink Sentinel and replace the temperature probe with the conductivity probe.

Calibration of the meter scale for conductivity is simple. Allow a cold water tap to run for awhile. Then fill a clean container with water. Place the conductivity probe in the water and mark the meter pointer's deflection on the scale with a pencil. Add some hypo to the water and wait a few seconds; the meter's pointer should swing upscale, the amount of deflection determined by the concentration of the hypo in the water. No further marks need be made on the meter's scale. Run cold water in the container while observing the pointer deflection. As the concentration of hypo diminishes and finally is all gone, the meter's pointer will swing down-scale and ultimately come to rest at the mark you made on the scale.

Turn off the power and, using a black felt marker, place an easily legible dot at the point pencilled in just below the arc of the scale. Then replace the protective cover on the meter and assemble the project's case.

Use. When you start your film-washing cycle, set the timer for a period of slightly less than the time recommended by the chemical manufacturer. Insert the conductivity probe into the wash water. Then when the timer's alarm sounds (or *I1* lights), note the position of the meter's pointer with respect to the mark made below the scale arc. If it is at the mark, it is safe to stop the wash cycle. However, if the pointer is above the mark, continue to wash until it gets there.

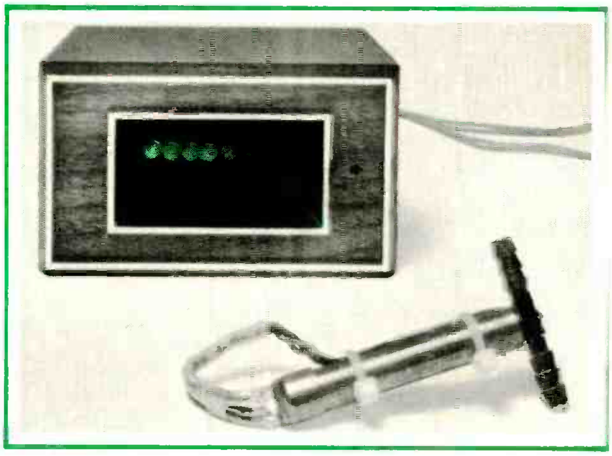
To operate the complete system, turn on the METER switch (*S6*), plug in the temperature probe, and place the probe in the chemical bath. When the proper temperature is reached, set RANGE switch *S3* to the appropriate range and TIME SET control *R2* to the desired interval. Start the developing cycle and press START switch *S4*. (If you desire visual signals only, switch off the alarm with *S5*.)

When the programmed-in developing time is completed, the timer will signal with both *I1* and the alarm (if the latter is switched in). Set the time for the correct fixing period and press START switch *S6* to start the timing cycle.

During the fixing cycle, you replace the temperature probe with the conductivity probe. When the timer's alarm sounds, end the fixing and start the washing cycle. Set the timer just short of the recommended period and, when the timer signals again, immerse the conductivity probe into the wash water. Continue washing until the meter's pointer drops to the mark on the scale.

You will find that, once you become familiar with its operation, the Sink Sentinel will take the guesswork out of your photographic lab processing. It will insure accuracy and let you turn out more professional negatives and prints. ◇

CURB "FUELISHNESS"
with the
Automotive Econometer



Solid-state vacuum gauge monitors gas consumption and driving habits

BY BILL GREEN

POOR DRIVING habits can reduce fuel economy by up to 50% regardless of how well-tuned and maintained the vehicle. In the era of high-cost energy and shortages, you want to get as much as possible from every drop of fuel your car burns. One good way to do this is by using a device such as the Econometer described here. It constantly and accurately monitors the relative fuel consumption of your car so that you can adjust your driving technique accordingly.

The Econometer is an electronic device that keeps tabs on intake-manifold vacuum. It has a display consisting of a row of eight LEDs. At idle, four or five LEDs normally glow. With your vehicle in motion, more or fewer LEDs glow, the maximum number (high vacuum) corresponding to high engine rpm and a small throttle opening and the minimum indicating low rpm and open throttle. High vacuum conditions give maximum fuel economy.

You will not be able to maintain high vacuum under all driving conditions. Naturally, accelerating from a standing start, driving up a steep grade, or hauling a heavy load all take more fuel than cruising on a level surface with a light load. But by observing the Econometer, you will be able to avoid using more throttle than necessary for any conditions, thereby saving fuel.

About the Circuit. The simple circuit of the Econometer is shown schematically in Fig. 1. The vacuum transducer, a proprietary device manufactured by Alpha Electronics, receives power from 5-volt regulator *IC2* through current-limiting resistor *R1*. The output signal from the transducer is developed across *R2*, which is also connected to the stable 5-volt source.

The transducer mounts in the vacuum line from the carburetor. Its electrical output across *R2* varies from 0.3 to 1 volt, depending on instantaneous manifold pressure. This voltage is applied to 10-step analog detector *IC1*.

The new integrated circuit used for *IC1* contains 10 comparators and a reference-voltage network that detects the level of the analog signal at the input. Each comparator drives an open-collector transistor that is capable of sinking 40 mA at 32 volts. Since the comparators are arranged in a "totem pole," as input signal level increases, the LEDs light in succession. Potentiometer *R3* provides a means for setting the operating thresholds.

Construction. Because of the simplicity and noncritical demands of the circuit, any convenient board-type method of assembly—Wire Wrap, point-to-point on perforated board, or printed-circuit board—can be used. An actual-size etching-and-drilling guide for a pc board is shown in Fig. 2.

Mount the LEDs with their tops flush and their bottoms about ¼" (6.2 mm) above the surface of the board, carefully observing polarity during installation. Then install the single jumper and two ICs, again taking care to properly orient them. Use of a socket for *IC1* is optional, but if you do use a socket, try to find a means of securing the IC (a daub of silicone rubber cement will do) so it will not vibrate loose.

Before mounting it in an enclosure, test the circuit board assembly. To do this, temporarily connect a jumper wire between the SNS (sense) point and GND (ground) in the circuit, apply 12 volts dc to the circuit, and check for a 5-volt dc reading between the junction formed by *R1* and *R2* and the ground bus. With *R3* fully clockwise, all LEDs should light; turning the pot fully counterclockwise should extinguish all LEDs. Disconnect the dc power and remove the temporary jumper from the circuit.

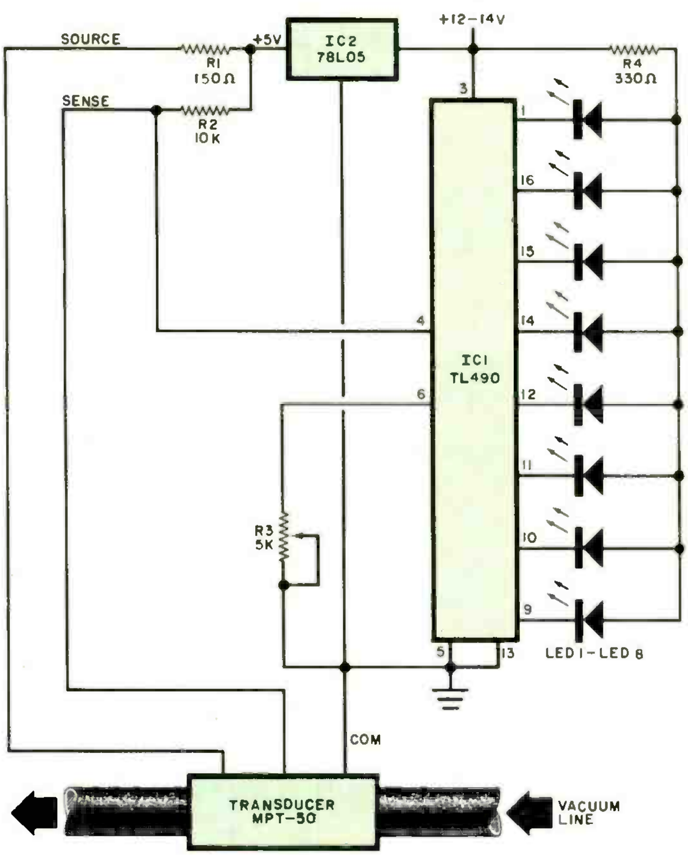
Temporarily mount the circuit-board assembly in the enclosure in which it is to be housed. Carefully determine and mark the locations of the display and adjustment slot of *R3* on the enclosure. Remove and temporarily set aside the circuit assembly. Then cut the display-window slot and drill a screwdriver access hole for *R3*. Drill another hole through the side or rear of the enclosure to provide entry for the wires that will interconnect the circuit with its transducer and the vehicle's electrical system. Deburr all holes and glue a red plastic filter over the display window. Line the wire-entry hole with a rubber grommet if you are using a metal enclosure.

Installation. Five well-insulated color-coded wires, preferably 18-gauge stranded, are required to interconnect the Econometer with its transducer and the vehicle's electrical system. Lengths of the wires are determined by the mounting location of the Econometer where it will be easily visible at a glance and the location of the engine's vacuum hose. Starting from where the Econometer will be positioned and leaving several extra inches, route a black-insulated wire to a metal chassis connection or screw that is at chassis ground. Repeat this procedure with a red-insulated wire, this time terminating it at a source of fused +12 volts that is "live" only when the ignition is on. Connect and solder the free ends of the black and red wires to the GND and POS pads, respectively, on the circuit-board assembly. Identify on your schematic diagram the colors used for each function for future reference.

Locate a source of intake-manifold vacuum (usually a rubber hose near or on the carburetor) so that the transducer and its leads will not be near a moving part or engine heat. Using this as your reference point, route three wires with different color insulation (not red or black) back along the chassis, through the firewall, and into the passenger compartment under the dashboard. Continue routing to the Econometer's case location, leaving several inches of slack at both ends of the wires before cutting to final length.

Now, working with only one wire at a time, strip away 1/4" of insulation from the first selected, slip on a 3/4" (19-mm) length of insulated tubing, and solder the wire to the terminal closest to the black dot on the transducer. Solder the other end of this same wire to the SNS pad on the circuit board.

Remove 3/4" of insulation from the second selected wire and connect and solder it to *both* center lugs on the transducer. Solder the other end of this wire to the GND pad on the board. Then, prepare the last wire in the same manner as for the first, including the insulated tubing, and solder it at one end to the remaining lug on the transducer (push the tubing down over both connections) and to the SRCE pad on the circuit board at the other end. Indicate your wire colors on your schematic.



PARTS LIST

IC1—TL490 10-step adjustable analog level detector (Texas Instruments)
IC2—78L05 5-volt regulator
LED1 thru LED8—Red light-emitting diode
R1—150-ohm, 1/4-watt resistor
R2—10,000-ohm, 1/4-watt resistor
R3—5000-ohm pc-type potentiometer
R4—330-ohm, 1/4-watt resistor
Transducer—MPT-50 (see Note below)
Misc.—Enclosure (Radio Shack No. 270-303 or similar); red plastic filter; color-coded stranded insulated wire (see text); insulated tubing; machine hardware; solder; etc.

Note: The following items are available from Alpha Electronics, P.O. Box 1005, Merritt Island, FL 32952 (Tel: 305-453-3534): Complete kit of parts, less case and wire, for $18 plus $2 in US, $4 in Canada, $8 all other countries for postage and handling. Included in kit, but also available separately: No. PC179 etched and drilled printed-circuit board for $5.50 in US (add $2 for Canada, $4 for all other countries); No. MPT-50 transducer for $11 in US (add $2 for Canada, $4 for all other countries); TL-490 for $4.50 in US (add $2 for Canada, $4 for all other countries). Florida residents, please add 4% sales tax.

Fig. 1. The transducer converts vacuum level to a dc voltage. This is measured by level detector IC1 and displayed on a series of LEDs. More LEDs glow as the vacuum increases.

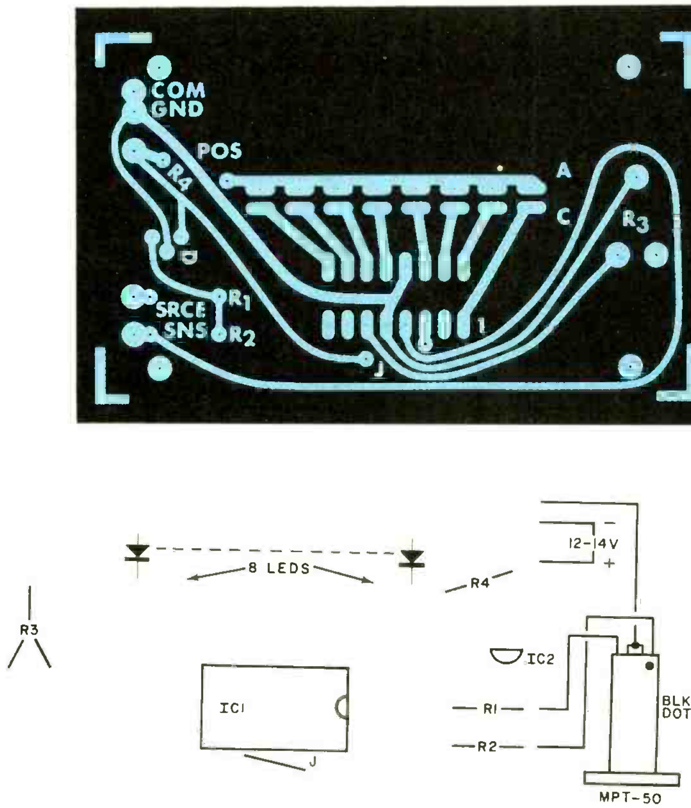


Fig. 2. Same-size etching and drilling guide for pc board is at top. Component placement directly above.

Bend the three-wire cable over the side of the transducer's case, taking care to avoid obstructing the small hole in the case, and secure with a cable tie. Now, cut the vacuum hose and install the transducer in series with the cut ends. (You can install the transducer in either direction.) After installation, make sure the connections to the transducer are airtight.

Position the three-wire cable so that it and the transducer do not contact any moving parts and are away from engine heat. Bundle the cable conductors together with cable ties and secure the assembly to the vehicle's chassis. Then assemble the project's enclosure.

Checkout and Calibration. Start your vehicle's engine and allow it to idle in neutral. Using a small screwdriver, adjust *R3*, through the small hole in the front of the enclosure, until four or five LEDs are on. Still in neutral, slowly press the accelerator and note that the display changes by one LED. Release and then quickly press and release the accelerator. At first, only one LED should be on for a second or so, four or five as the engine returns to idle.

In some vehicles, the vacuum connection is located above the throttle butterfly valves. If this is the case, slightly press the accelerator and adjust *R3* to turn on only three LEDs. Completely releasing the accelerator should cause the display to have only one of the LED indicators lighted.

In Use. A quick glance at the Econometer's display will suffice to keep you informed of your driving efficiency. The idea is to drive so that the maximum number of LEDS is glowing, indicating the highest vacuum and, consequently, the least fuel/burned. As you become familiar with the glowing display and accelerator position during driving, any marked change that persists in the display may indicate a problem in the operation of your engine.

One final note: "right foot awareness" has a great effect on driving efficiency and, thus, fuel economy. Using the Econometer (or any other vacuum-measuring device) reveals how little accelerator pressure is needed to keep a vehicle moving at cruising speed with maximum vacuum. You may be surprised at how far you can back off the gas pedal before your vehicle slows down. So, when you get your vehicle up to the desired speed use a feather touch instead of a lead foot. ◇

Simulated TV Reception 4.

3.

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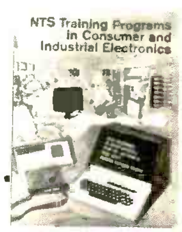

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A valuable audio analysis tool

BUILD A LOW-COST WHITE/PINK NOISE GENERATOR

BY JOHN E. PFEIFER AND WILLIAM EPPLER

A NOISE SOURCE that has predictable amplitude and frequency characteristics is a valuable tool for making real-time audio spectral analyses. For flexibility, it should have two different noise signals—white and pink. A commercial noise source with these characteristics would probably be too expensive for the home user, but you can build the instrument described here at only nominal cost.

This Audio Noise Source was designed as a companion to the "Hand-Held LED Spectrum Analyzer" (PE September 1979). However, it can also be used with any other constant-Q analyzer or any other multiple fixed-bandpass filter real-time device that requires a noise source to provide equal power in each of the measurement bands.

White and Pink Noise. White noise, so called because of an analogy to white light, contains all frequencies within a specified bandwidth at equal energy. Since white noise contains equal noise energy per hertz, it is most compatible with constant-bandwidth analyzers, such as the heterodyne, swept-filter, and digital fast-Fourier-transform (FFT) types.

Since the bandwidth of a filter with given Q is proportional to the center frequency of the filter, a 10,000-Hz filter has 10,000 times as many hertz in its bandpass as does a 1000-Hz filter. A complementary noise characteristic can be derived from white noise by using a 1/f *energy* filter in which energy must decrease at a 6-dB/octave rate.

Since the voltage of an electrical signal is proportional to the square root of the power, the noise voltage must decrease at a square-root of 1/f rate or 3 dB/octave. With a similar analogy to white light filtered in this manner, the resulting signal is called "pink" noise.

The frequency characteristics of both white and pink noise are shown in graph form in Fig. 1.

Noise Generation. Among the various methods of generating white noise, the most common employs the avalanche or reverse-breakdown characteristics of a pn junction. The "Surfer" (June 1979) is a good example of this type of circuit. In measurement-quality systems, the noise junction must be selected, operating-current trimmed, and gain adjusted to yield the required noise quality and amplitude uniformity. For highest accuracy, junction temperature should be stabilized or compensated. Even with these restraints, this technique is widely used in r-f and very broadband applications.

A wholly different approach is the use of a random digital number generator as a noise source. If the bandwidth of interest is sufficiently restricted, a digital technique used in many computer programs to generate a pseudorandom sequence can be applied. In this form, a pattern of 1's and 0's statistically uniform in character will be produced. The sequence generated is stable and repeatable in both amplitude and character to within a small fraction of a decibel. General implementation of this approach (Fig. 2) consists of an N-stage shift register with a tap at stage M. Both M and N are inputs to a modulo-2 adder (exclusive-OR gate) that feeds the shift register input clocked by an oscillator. Proper choice of M and N will produce a maximum sequence length of $2^N - 1$ clock pulses.

About the Circuit. The schematic diagram of the Audio Noise Source is shown in Fig. 3. The N-stage shift register is divided into M-stage register *IC2* and (N−M)-stage register *IC3*. Both *IC2* and *IC3* are CMOS shift registers.

The *IC1D* section of the quad XOR gate performs the modulo-2 addition function. The remaining three sections of *IC1* are connected as inverters in a standard CMOS oscillator configuration. Oscillation frequency is determined by *R1* and *C1* and, with the values specified, is about 300 kHz.

Both *IC2* and *IC3* can be wired to be 4, 5, 8, 9, 10, 12, 13, 14, 16, 17, or 18 stages in length. With these available lengths, two ICs can be cascaded for an M of 13 and an N of 31 to produce a length of $2^{31} - 1$ clock periods—almost 2 hours in duration. This is the longest sequence that can be generated with two 4006 shift registers and the elementary two-input feedback mechanism. The noise half-power frequency exceeds 100 kHz, and the output can be from any point along the register.

In *S1*'s WHITE position, the register's output passes through a one-pole low-pass filter consisting of *R8, R9, R10,* and *C8* at about 72 kHz and is buffered by *Q1*. The white-noise spectrum available at *J1* is flat to within ±0.33 dB from 10 to 20,000 Hz.

To obtain pink noise, a 3-dB/octave low-pass filter must be synthesized. Since a simple pole or zero filter has a 6-dB/octave slope, several lag networks can be cascaded so that the zeros of one section partially cancel the poles of the next. The network consisting of *R4* through *R7* and *C3* through *C7* exhibits a −3-dB/octave slope ±0.5 dB from 10 to 40,000 Hz. To maintain the high accuracy inherent in the design, the capacitors and resistors that make up the network should have 5% tolerances. Amplitudes of the white and pink noises are dependent on the supply voltage and measurement bandwidth. The rms potential is roughly 0.01 volt from 20 to 20,000 Hz. With a 9-volt supply, the output potential of either white or pink noise is 90 mV. (Current consumption with a 9-volt battery is less than 8 mA.) As shown in Fig. 1, the white-noise voltage is adjusted to be equal to the pink-noise voltage at 2870 Hz.

The circuit is designed to function properly from a 3-to-15-volt dc power source. Current consumption is very low, owing to the use of CMOS devices.

Construction. This is a relatively easy project to build, thanks to its limited number of components. Since there are no restraints on component layout and wire routing, just about any wiring technique can be employed. However, to make the project as compact as possible, it is best to use a printed circuit board, an etching-and-drilling guide and components-placement diagram for which are shown in Fig. 4.

If you use a pc board, wire it as shown. You can use sockets for the ICs if desired, and do not forget to install the three jumpers. Be sure to properly orient the ICs, *Q1*, and *C9*.

Mount the finished circuit-board assembly and *B1* and its battery holder in a small box. Function switch *S1* and output jack *J1* can be mounted on the front of the box and connected to the circuit board assembly with short lengths of hookup wire. Finally, use a dry-transfer lettering kit to label the positions of *S1* and identify *J1*.

Applications. Since both pink and white noise are statistically random quantities, characterizing them by a single voltage or power specification is difficult at best. Special sampling techniques using a specified time and frequency "window" coupled with a true-rms detector are required.

When the noise source is applied to a spectrum analyzer, the slowest sweep speed or longest averaging time consistent with a reasonable measurement should be selected. If you use the companion LED Spectrum Analyzer in our September issue, set the DECAY switch to SLOW when performing noise analyses. Even in this condition, the

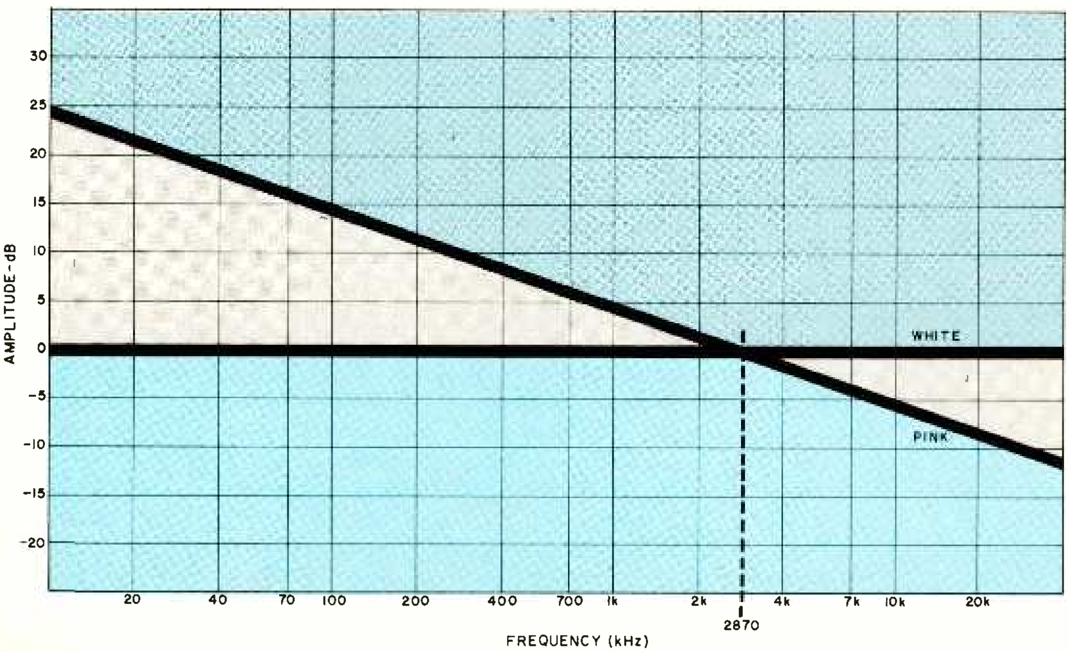


Fig. 1. Noise spectra of white and pink noise. In the generator described here, the two amplitudes are similar at 2870 kHz.

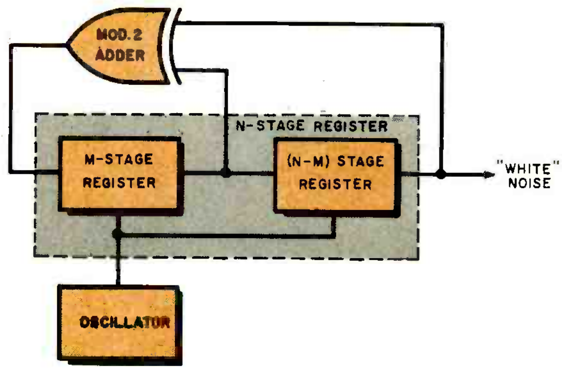


Fig. 2. Block diagram of a pseudo-random noise generator used to create white noise.

lower-frequency channels might exhibit some amplitude flicker. However, high-accuracy measurements are still possible if you mentally average the display reading. Simply note which particular channel LED is on most of the time.

The microphone in the LED Spectrum Analyzer is a free-field type, which should be pointed directly at the sound source. To avoid substantial errors in the middle-frequency region, caused by reflections and absorptions of your body, stay as far from the pickup as practical when making measurements.

Positioning the analyzer a proper distance from the source is also of critical importance for accurate measurements. Data taken too near the source will display wide variations with small changes in analyzer position due to diffraction and dispersion irregularities. Readings taken too far from the source are prone to environmental reflections and noise.

In the optimum free-field area, the inverse square, law relating sound intensity to changes in distance from the source, applies. Thus, if the distance from the source to the analyzer is increased by a factor of 1.33, the sound level should decrease by 2.5 dB. This distance is usually greater than one wavelength of the lowest frequency to be measured. At 63 Hz, about 18′ (5.5 m) may be adequate. The microphone should be no closer than twice the largest dimension of the source.

Loudspeaker Evaluation. Figure 5 illustrates a typical system interconnection for loudspeaker testing and evalua-

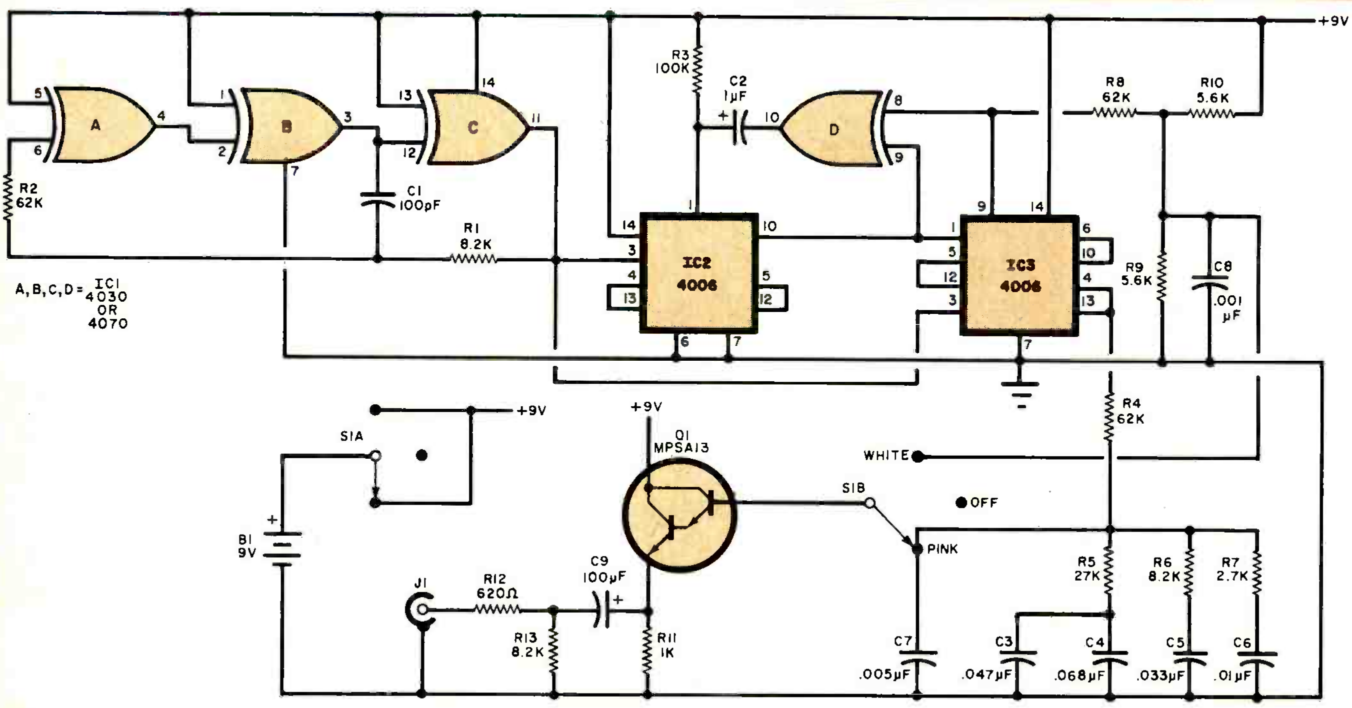


Fig. 3. Noise generator consists of two 18-stage shift registers with an adder.

PARTS LIST

B1—9-volt battery
C1—100-pF, low-temperature-coefficient
C2—1-µF, 16-volt electrolytic
C3—0.047-µF, 100-volt 5% Mylar
C4—0.068-µF, 100-volt 5% Mylar
C5—0.033-µF, 100-volt 5% Mylar
C6—0.01-µF, 100-volt 5% Mylar
C7—0.005-µF, 100-volt 5% Mylar
C8—0.001-µF, 100-volt 10% Mylar
C9—100-µF, 10-volt electrolytic
IC1—CD4030AE quad XOR gate (or similar)
IC2,IC3—CD4006AE 18-stage shift register (or similar)
J1—Phono jack
Q1—MPSA13 Darlington transistor
The following are ¼-watt, 5% resistors:
R1,R6,R13—8200 ohms
R2,R4,R8—62,000 ohms
R3—100,000 ohms
R5—27,000 ohms
R7—2700 ohms
R9,R10—5600 ohms
R11—1000 ohms
R12—620 ohms
S1—Dp3t switch
Misc.—Suitable enclosure; battery holder; hookup wire; etc.

Note—The following are available from Gold Line Inc., P.O. Box 20, Redding, CT 06875 (Tel: 203-938-2588): Complete kit including case for $39.95. + $1.50 for shipping and handling. Also available separately: etched, drilled, and screened pc board for $7.95. The companion ASA-10 hand-held LED audio analyzer kit (POPULAR ELECTRONICS, September 1979) is available for $139.00 ($199.95, wired and tested). Connecticut residents, please add 7% sales tax.

tion. The pink-noise source can be either the noise generator described above or a pink-noise record or tape. All tone controls and equalizer settings should be defeated or set flat.

Adjust amplifier level for moderate volume and adjust analyzer gain for the flattest display near the 0-dB level with the DECAY switch on the LED Spectrum Analyzer set to SLOW. The spectrum analyzer will then display the combined response of the speaker, room and electrical signal path.

By connecting the amplifier's speaker terminals to the analyzer's external input, the electrical signal conditions can

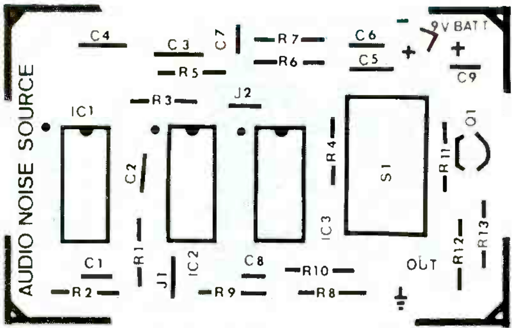
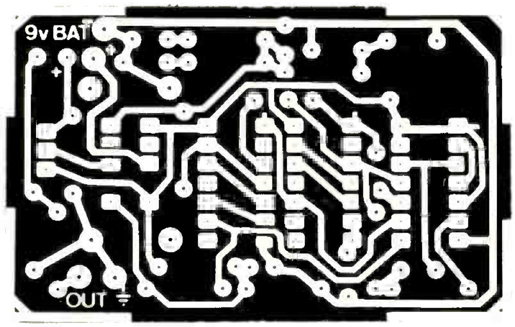


Fig. 4. Actual-size foil pattern (above) and component installation for noise generator.



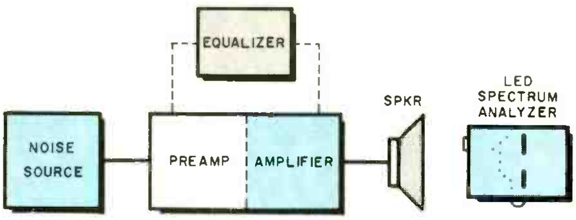


Fig. 5. To test a speaker, use noise generator to drive audio system and hold LED spectrum analyzer at various points in sonic field.

be determined and subtracted from the combined response. Moving the analyzer with its built-in microphone around the test area will provide an indication of the speaker's directional characteristics. On the other hand, leaving the analyzer stationary and moving the speaker around will demonstrate the importance of proper speaker placement in optimizing frequency response.

Environment Equalization. If a sound system has suitable tone-control flexibility or a graphic or parametric equalizer, a typical listening environment can be considerably improved, using the setup shown in Fig. 5. Real-time analysis (RTA) has been successfully applied to living rooms, concert halls, discos, and even to vehicles. In the last case, the advent of autosound systems with equalizers and high-quality amplifiers and speakers makes RTA an exciting prospect in achieving realistic mobile sound.

With the analyzer placed in the anticipated normal listening position and all frequency balance controls set flat (or switched out), apply pink noise at a moderate level. In stereo or quad systems, apply the signal to only one channel at a time. Make small changes in speaker system position and orientation, if possible, to optimize the frequency response displayed on the analyzer. Any crossover controls can now be

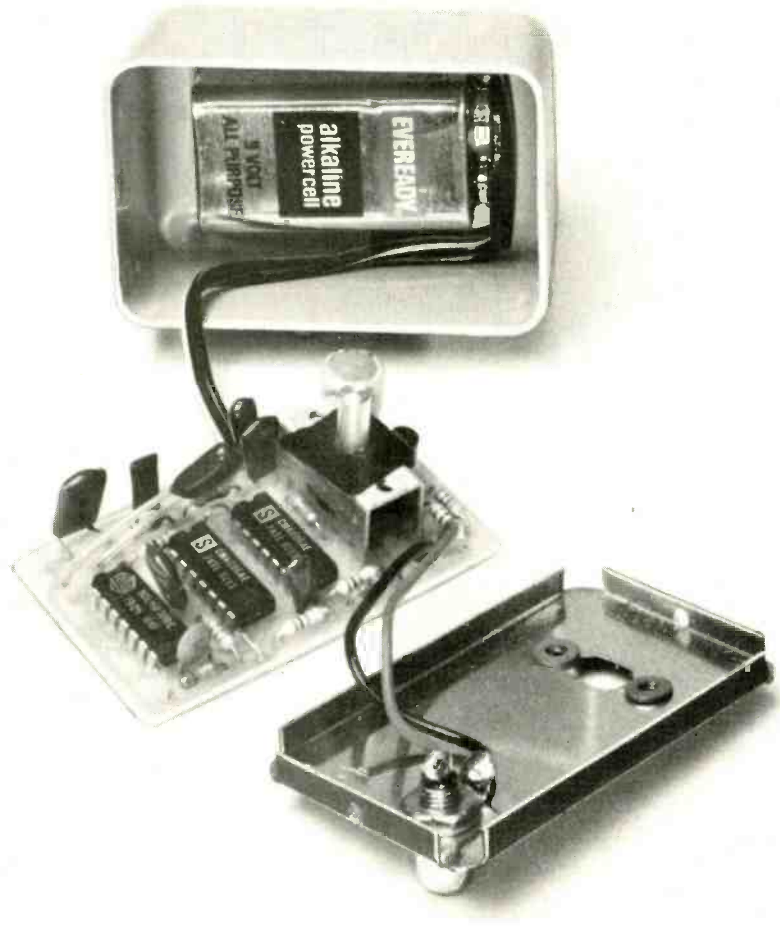


Photo shows construction of author's prototype generator. Use of printed circuit board makes the unit as compact as possible.

adjusted. Finally, tone and equalizer settings can be optimized to flatten overall frequency response to within a couple of decibels.

Do not assume that the settings developed for one channel can be applied to other channels. Each speaker system should be equalized separately.

Tape-Recorder Alignment. Play a high-accuracy prerecorded pink-noise tape with the analyzer connected to the tape recorder's output. (The internal microphone is not used.) Adjust playback-head azimuth for maximum output in the 16-kHz channel. The oscilloscope output of the Hand-Held LED Spectrum Analyzer can be useful for highest resolution. Complete the play alignment by adjusting the reproduce equalization controls for a flat spectral display.

Begin record alignment with the tape you normally use and pink noise fed to the recorder's input. Assuming you have a three-head recorder capable of simultaneous recording and *tape* monitoring, connect the analyzer to the deck's output. Adjust record-head azimuth for a maximum 16-kHz output. Then adjust record bias (if accessible) for maximum at 1 kHz. Increase bias current until a 2-dB drop in the 16-kHz response is obtained. Finally, trim the record equalization controls for flattest displayed frequency response.

Aligning two-head tape decks is more time consuming. Each time an adjustment is made during record, the tape must be rewound and played to determine the effects of the adjustment.

In either case, tape-recorder alignment using RTA is much easier and faster than conventional methods.

Noise Abatement. The Walsh-Healy Public Contracts Act and OSHA have set standards for permissible noise-exposure levels to avoid hearing damage. Noise-abatement procedures are often required to comply with these standards. The techniques are well documented and can be extremely effective, provided the noise-frequency spectrum is known.

Enter RTA! When the noise frequencies to be attenuated are known, the characteristics of damping materials and their placement can be determined and dimensions of required resonant cavities can be calculated. Time-consuming "cut-and-try" procedures can be kept at a minimum, and the results of abatement engineering can be easily documented. ◇

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There are only three functional requirements for a frequency counter: 1. Good accuracy over temperature 2. Resolution 3. Sensitivity

Good accuracy over temperature. Crystal oscillators drift with temperature changes. This change is specified in parts per million (PPM). The 5500 TCXO (temperature compensated crystal oscillator) holds an accuracy of 1 PPM from 17° to 40° C. This corresponds to ± 450 Hz at 450 MHz. Counters with 2 PPM accuracy would read to ± 900 Hz at 450 MHz. Counters with 10 PPM accuracy would read to ± 4500 Hz and so on.

Resolution. What is the value of the least significant digit displayed? A counter with 10 Hz resolution would display 146.52000 MHz as 146.52000 i.e. with the last digit left off. A counter with 100 Hz resolution would display 146.5200. The 5500 with *8 Digits* is capable of resolving 1 Hz from 50 Hz to 50 MHz and 10 Hz from 50 MHz to 500 MHz. Counters with only 7 digits usually can only resolve 10 Hz to 50 MHz and 100 Hz to 500 MHz. The above effects, accuracy and resolution are cumulative. Example; a seven-digit counter with 1.5 PPM accuracy reading 450 MHz would only be accurate to ± 675 Hz ± 100 Hz (last digit error) or ± 775 Hz. The 5500 with eight full digits and 1 PPM accuracy would be accurate to ± 450 Hz ± 10 Hz (last digit error) or ± 460 Hz maximum. Not bad for $99.95. You really need that eighth digit to achieve real accuracy.

Sensitivity. The 5500 requires only 10-15 mv of signal to stabilize and achieve an accurate reading. A one watt hand-held can be read with accuracy at a distance of 15-20 ft. from the counter using the T600 antenna. Counters with 150 mv sensitivity will only stabilize at distances of less than a foot.

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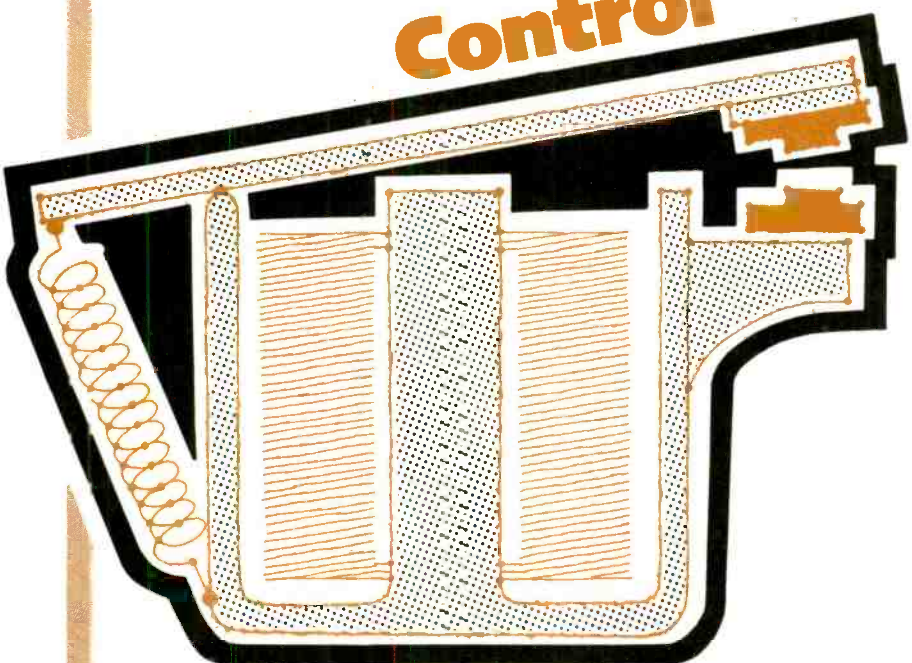
BY AL SYDNOR

How to use solid-state circuits to obtain predictable performance from electromechanical relays

An Experimenter's Guide to Relay Control



BECAUSE OF their simplicity and low cost, electromagnetic relays are widely used in control applications. Unfortunately, some experimenters and designers do not fully understand how to interface relays with electronic circuitry. As a result, their circuits frequently operate erratically, and outright failure of either the relay or the components associated with it is far more common than necessary. Moreover, many possible functions that relays can perform with appropriate drive circuitry are often overlooked. A knowledgeable approach, such as that presented here, should enable one to use relays with confidence and without hesitation.

What is a Relay. An electromagnetic relay, regardless of details of construction, is basically a mechanical switch operated by electric power. Its contacts are coupled to an armature of magnetic material held in proximity to a coil. When current passes through the coil, the resulting magnetic field attracts the armature toward the coil to close or open one or more sets of contacts. When the current stops, the magnetic attraction ceases, and a spring returns the contacts to their former positions.

Available in both ac and dc versions, relays have rated coil energizing potentials usually ranging from 1 to 250 volts with 6-, 12-, 24-, 48-, 117-, and 240-volt designs the most common. There are also relays that operate at energizing potentials as low as 25 millivolts for special applications. You should keep the voltages within ±20% of ratings. Too much voltage may burn out the coil; too little may cause erratic operation. Operating power ranges from a few milliwatts to about 20 watts, which should be borne in mind when you are designing the drive circuits. Operating current can be determined by measuring or looking up coil resistance.

Looked at from the point of view of the drive circuit, a relay has the following parameters:

Operating voltage (current). The value that closes the contacts reliably.

Pull-in voltage (current). The value that just barely closes (opens) the contacts.

(continued from page 75)

Drop-out voltage (current). The value that barely lets the contacts open (close).

The limits on current or voltage the relay can switch are also important. Contacts are commonly rated either according to current capacity or by a maximum number of volt-amperes (VA), the product of current and voltage. If a relay that must handle heavy current cannot be driven from a low-power circuit, it can, in turn, be driven by a relay the circuit can handle.

Contact Protection. When a switch in series with an inductive circuit (such as a relay coil) is opened, the magnetic field in the coil collapses and a voltage proportional to the rate of change of current is generated. This high voltage across the switch contacts can eventually cause damage or failure.

Semiconductors can be used to suppress these voltage transients, as in Fig. 1A, where a diode is connected across the load as shown. When a positive spike appears across the switch contacts, the diode clamps it to the positive power-supply voltage. The diode's reverse-voltage rating must exceed the power-supply voltage, and its current rating must be at least 25 times the load operating current. A varistor, or voltage-dependent resistor, can be substituted for the diode. Its resistance should be more than 10 times the dc resistance of the coil at 20°C.

Sometimes, when a relay coil appears to have shorted for no reason, an inductive spike that exceeds its insulation ratings may be at fault. A diode can be used as in Fig. 1B to protect a relay coil if a longer release time can be tolerated. An improvement over this method is to use a transistor circuit as in Fig. 1C. When the switch in Fig. 1C is closed, the capacitor discharges. Opening the switch causes the capacitor to keep the transistor conducting until the capacitor has charged up through the base-emitter junction and resistor enough to cut off the transistor. This is equivalent to opening the switch slowly to lengthen the decay rate of the current and keep the induced voltage smaller.

Linear-Amplifier Driver. To drive high-current relays from low-current sources you can use a transistor amplifier such as that shown in Fig. 2A. When *S1* is set to OFF (ground), no base current is supplied, the transistor is cut off, and the relay is deenergized. Setting *S1* to its ON position sends the transistor into saturation and energizes the relay.

More sensitivity can be had simply by adding amplifier stages, as shown in Fig. 2B. If no input is applied to *Q1*, it is cut off and *Q2* is saturated energizing the relay. Application of bias to *Q1* saturates it, and *Q2* cuts off, deenergizing the relay.

Another two-stage transistor relay driver is shown in Fig. 2C. In this case, the circuit is noninverting and is controlled by a photocell. The photocell controls *Q1*, which in turn controls *Q2*, whose collector current energizes the relay. The potentiometer permits adjustment of threshold voltage for the particular photocell being used and prevents leakage current from operating the relay under high-temperature conditions.

A single-power-supply, three-stage driving amplifier is shown in Fig. 2D. Once again, illuminating the photocell energizes the relay, with the potentio-

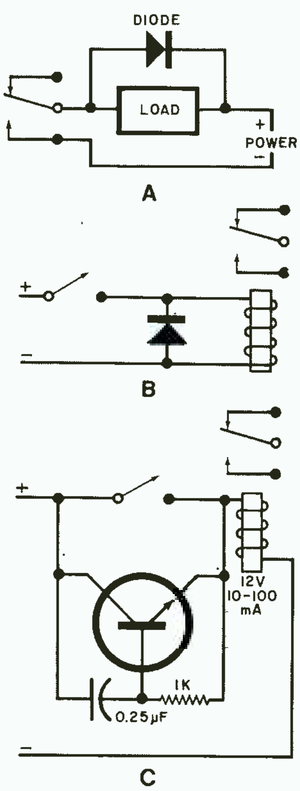


Fig. 1. Switching-transient suppression: diode across inductive load (A) or relay coil (B); transistor circuit across switch contacts (C).

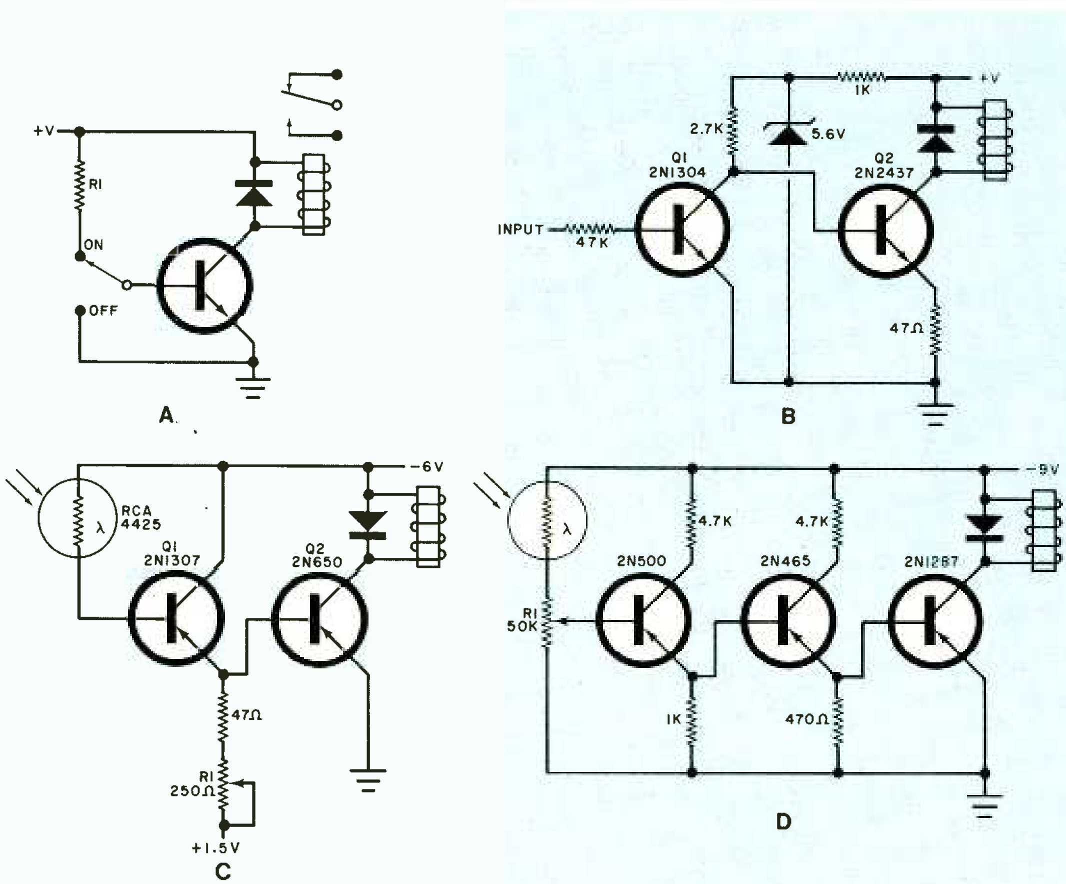


Fig. 2. Linear amplifiers as relay drivers: (A) single-stage; (B) two-stage inverting; (C) two-stage noninverting; (D) three-stage noninverting.

meter permitting adjustment of the relay's operating threshold. In the off state, all transistors are cut off and current consumption is negligible, which makes this circuit suitable for operation from a battery.

Regenerative-Amplifier Driver. The relay drivers discussed above have a serious disadvantage in that a borderline threshold input can cause the relay to alternate rapidly between on and off, producing "chatter." Also, the energizing threshold can vary with temperature. A regenerative amplifier can be used to keep the relay energized or deenergized with no in-between state.

A Schmitt trigger with a relay coil as the load is shown in Fig. 3A. As long as the input level is less than 6 volts, *Q1* is cut off, *Q2* is saturated, and the relay is energized. When the input exceeds 6 volts, *Q1* rapidly saturates and cuts off *Q2* to positively deenergize the relay. The potentiometer permits precise setting of the operating threshold.

Another regenerative-amplifier circuit is shown in Fig. 3B. Here, the relay's coil is the load for one side of an Eccles-Jordan bistable multivibrator. This is a conventional design except for *C1* and *R1*, which are used to ensure that *Q1* will be driven into saturation and *Q2* will be cut off when power is first turned on to prevent the relay from energizing on power-up.

A positive signal on the RESET line to the base of *Q2* activates the relay solidly, while a positive signal on the SET line to the base of *Q1* deactivates the relay just as solidly.

When using high-power relays, it is usually necessary to add a buffer stage between the relay and regenerative circuit. A typical arrangement is illustrated in Fig. 3C. Here, Schmitt trigger *Q1*/*Q2* is coupled to *Q3* via 12-volt zener diode *D1*. When a negative control signal of sufficient amplitude is applied to the input of this circuit, *Q1* conducts and *Q2* cuts off. Current through the *Q2* collector load resistor and *D1* to the base of *Q3* causes it to conduct and energize the relay.

Because *Q3*'s bottom potential at 1.5 amperes is less than 0.5 volt and this transistor's rated free-air dissipation is less than 1 watt, *Q3* can be operated without a heat sink. If *Q3* is to be operated at high ambient temperatures, however, it should be mounted on a 2" (50.8-mm) square sheet of No. 16 aluminum.

A regenerative relay driver that uses an SCR is shown in Fig. 3D. Initially, *S1* and *S2* are both open and no trigger voltage is applied to the gate of the SCR, which remains cut off. Closing *S1* applies a positive voltage to the SCR's gate, triggering the SCR and energizing the relay.

Opening *S1* does not turn off the SCR. It does, however, allow the voltage across capacitor *C1* to approach that of the supply. Then, closing *S2* applies a negative pulse to the anode of the SCR to stop conduction. An alternative to using *S2* to turn off the SCR is to connect a transistor from the anode to the cathode, as shown by the phantomed circuit in Fig. 3D. When the transistor turns on, it diverts current from the SCR. As soon as the SCR's current falls below its holding value, the device turns off. The relay coil is deenergized when the voltage to the base of the transistor is removed.

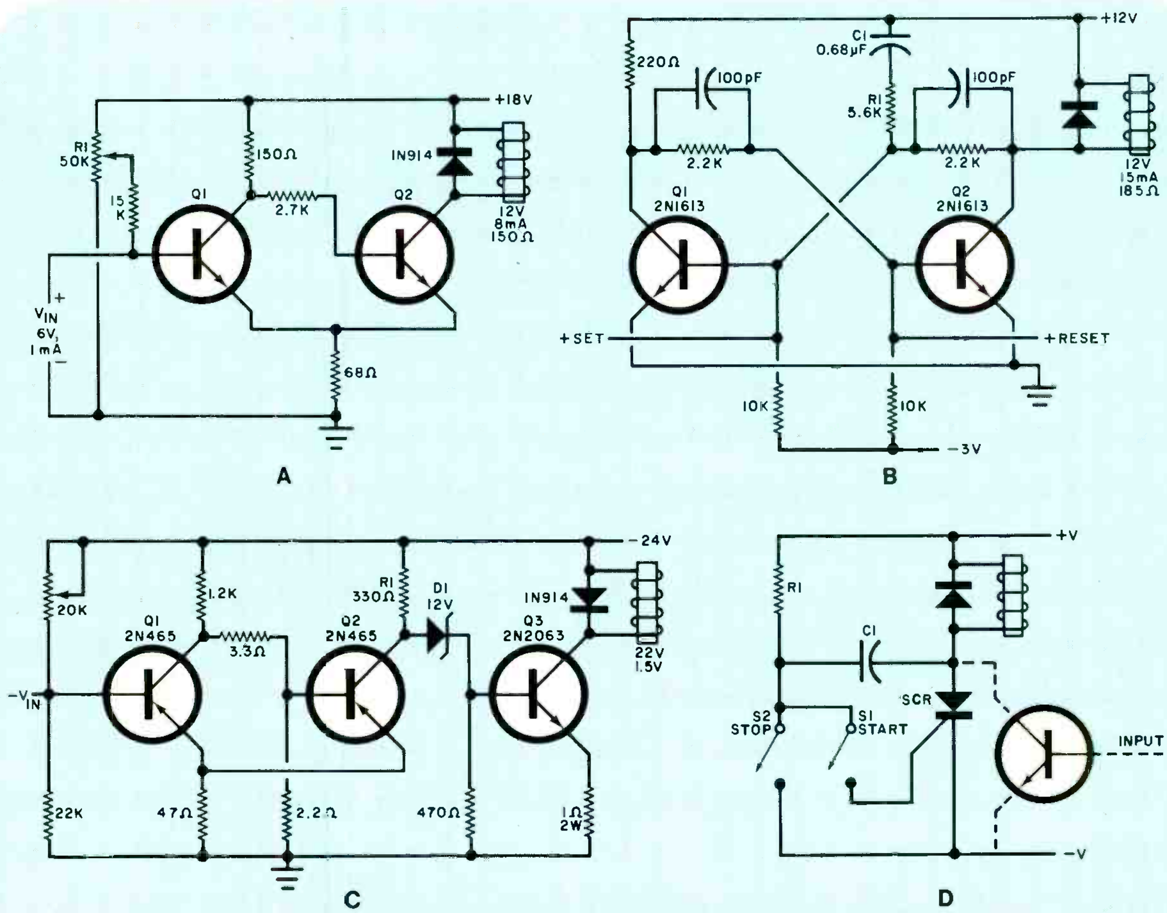


Fig. 3. Relay-driver regenerative amplifiers: (A) single-stage Schmitt trigger; (B) single-stage bistable; (C) Schmitt trigger with relay driver; (D) latching SCR control.

Time-Delay Circuits. Semiconductors are commonly used to provide time-delay periods for operating electromagnetic relays. An example of this is the delayed application of supply voltage to the power stages in a hi-fi amplifier to prevent the power-on transient from being heard in and possibly damaging the speaker systems. One simple way to delay energizing a relay is to place a thermistor in series with the coil, as shown in Fig. 4A. When the switch is closed, current flowing through the thermistor causes it to heat up, resulting in a decrease in resistance from its normally high cold resistance. As resistance drops, more current flows until the current through the relay coil is sufficient for energization. A series potentiometer can be used to permit adjustment of delay time.

At room temperature, the thermistor should have a resistance three to five times that of the relay's dc coil. For example, a thermistor with a cold resistance of about 400 ohms that drops to 25 ohms at 400 mA can be used with a conventional 12-volt, 80-mA relay.

The circuit in Fig. 4A is for slow energization and fast deenergization. For applications where fast turn-on and a slightly delayed turn-off are required, a shunt thermistor can be used, as illustrated in Fig. 4B. Again, the thermistor's cold resistance should be 3 to 5 times the relay's dc coil resistance.

Another circuit that gives slow turn-on and fast turn-off relay operation is shown in Fig. 4C. When *S1* is closed, the base of the transistor is grounded and *Q1* is cut off, resulting in a deenergized relay. Opening *S1* allows *C1* to be charged at a rate determined by the *C1* (*R1* + *R2*) time constant until the base potential of *Q1* is sufficient to turn on the transistor and energize the relay. Closing *S1* causes *C1* to discharge rapidly and cut off *Q1* practically at once.

A rearrangement of the Fig. 4C circuit, shown in Fig. 4D, gives a fast turn-on and slow turn-off action. With the switch closed, the capacitor discharges and base current through the resistors from the supply line sends the transistor into saturation and rapidly energizes the relay. Reopening *S1* allows the capacitor to continue to supply base current until it is charged up enough to cut off the transistor. The result is a slow turn-off for the relay.

Many variations of the above circuits are possible, such as the very slow turn-on circuit shown in Fig. 4E. With *S1* open, all capacitors are discharged. Closing *S1* allows *C1* to be charged up via *R1* until the voltage on the gate of *Q1* rises above firing potential. At this time, *Q1* becomes a low resistance and applies a firing pulse to the gate of the SCR, which energizes the relay.

When *S1* is opened, supply voltage is removed, the SCR stops conducting, and the relay deenergizes. This circuit has been used to provide a 40-second (±1 second) delay over a −25° to +75°C temperature range.

Differential Drivers. Many of the relay-driver circuits shown above are limited by the fact that control-signal operation is uncertain and may have considerable backlash. (The relay may not deenergize until the voltage across its coil is well below the energizing potential.) One way to obtain close differential operation with the deenergizing and energizing voltages roughly equal is to use a Schmitt-trigger circuit with a small hysteresis (backlash), such as shown in Figs. 3A and 3C. Simply replace the common-emitter resistor of the Schmitt trigger with a zener diode whose voltage rating is the same as the potential required at the emitters to energize the relay.

As the input to the close-differential

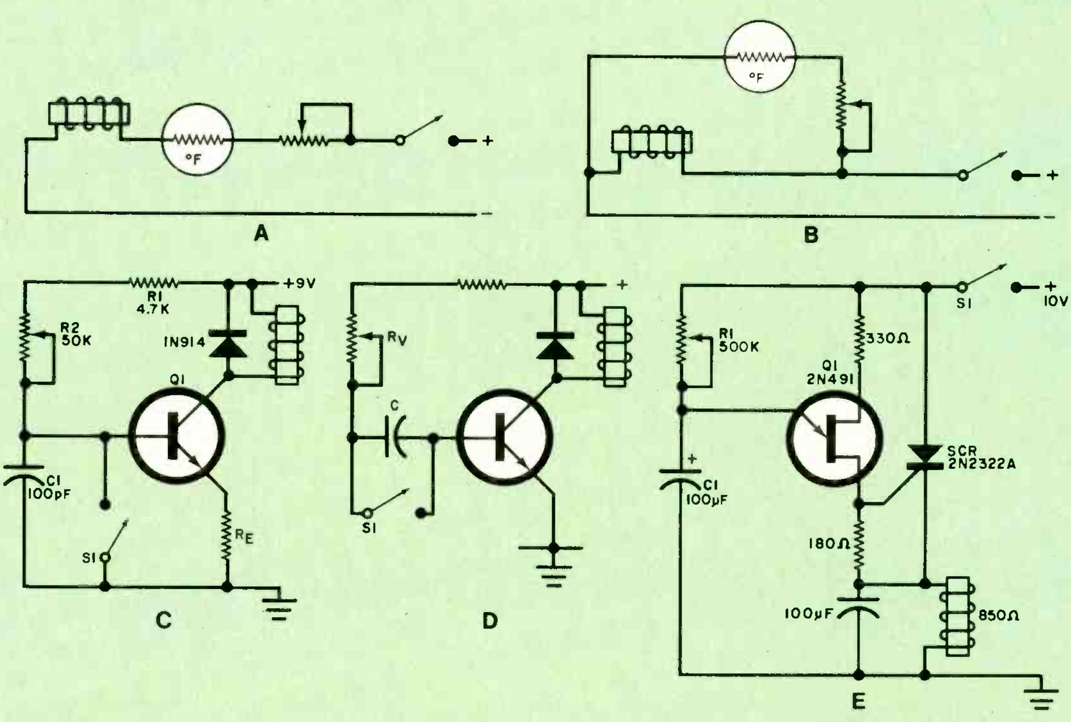


Fig. 4. Relay time-delay circuits: (A) thermistor-controlled slow-on/fast-off; (B) thermistor fast-on/slow-off; (C) transistor-controlled slow-on/fast-off; (D) transistor fast-on/slow-off; (E) unijunction transistor circuit with very slow on.

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circuit shown in Fig. 5A is increased in the negative direction, no base current flows through *Q1* until V_{IN} exceeds the 10-volt breakdown potential of the zener diode plus the base-emitter forward voltage drop required for *Q1* to conduct (about 0.3 to 0.5 volt). When V_{IN} reaches about 11 volts, *Q1* saturates and collector current energizes the relay.

The silicon diode across the base-emitter junction of *Q1* prevents it from being overdriven. With up to 0.6 volt on the transistor's base, the diode does not conduct. Beyond this point, it conducts and shunts excess current away from the transistor's base. Because of the sharp breakdown characteristics of the zener diode, drop-out signal potential of this circuit is within a few hundred millivolts of relay energizing voltage.

Use of a p-channel MOSFET with a threshold potential of about 5 volts to yield close differential relay operation is shown in Fig. 5B. When V_{IN} is greater than 6 volts, the zener diode conducts through *R1*, but as long as the input is less than 11 volts, the drop across *R1* is less than 5 volts and *Q1* is off.

As long as *Q1* is cut off, *Q2* is also cut off and the relay is deenergized. When the input exceeds 11 volts, *Q1* conducts and current through *R2* to *Q2*'s base causes the relay to energize. When V_{IN} is less than 11 volts, the relay is deenergized, while it energizes with positive action when V_{IN} exceeds 12 volts. By cascading a second FET after the first, it is possible to reduce the difference between energizing and deenergizing potentials to 0.1 volt.

AC Drive Circuits. Any dc relay can be adapted to work from an ac source by combining it with rectifiers. In Fig. 6A, *D1* permits only positive current to pass through the relay and should have a current-carrying capacity several times the operating current of the relay. Clamping diode *D2* is optional and is used for surge suppression. It not only protects the relay contacts, but prevents high reverse voltage on *D1*.

Another diode arrangement is shown in Fig. 6B. Here, four diodes are used in a full-wave bridge circuit. Note that the bridge circuit inherently provides protection from inductive spikes.

The circuit in Fig. 6C allows a true ac relay to be operated electronically through an SCR. When *S1* is open, the SCR has no potential applied to its gate and does not conduct. Meanwhile, current from *T1* is rectified by *D1* and generates a dc voltage that is stored in *C1*. When *S1* is closed, the positive voltage across *C1* is applied to the gate, causing the SCR to conduct and remain on as long as *S1* is closed. Opening *S1* causes the SCR to cut off when the ac cycle passes through zero, causing the relay to be deenergized.

Op Amp Relay Drivers. Contingent on the type and level of the input signal, relay amplifiers can be built up with op amps whose extremely high (open-loop) gain is sufficient to allow operation with minute input levels. The op amp also allows for differential operation where an input signal can be compared with a known reference so that the relay pulls in (or drops out) only when the desired voltage differential exists.

In addition, the op amp, with its very high gain, can be used with reactive feedback to form filters that produce relay operation only at certain input frequencies (assuming an ac input). A phase-locked-loop (PLL) using a 567 for instance, can also be a frequency-sensitive driver for a relay amplifier. Since many op amps do not have sufficient output current to drive a relay directly, a transistor power stage will often be required between the op amp and the relay. ◇

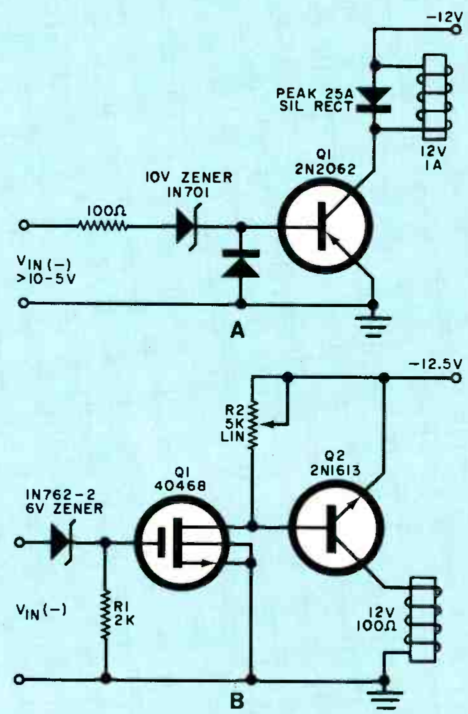

Fig. 5. Driver circuits with close differential operation: (A) single-stage transistor with zener; (B) two-stage FET and bipolar transistor.

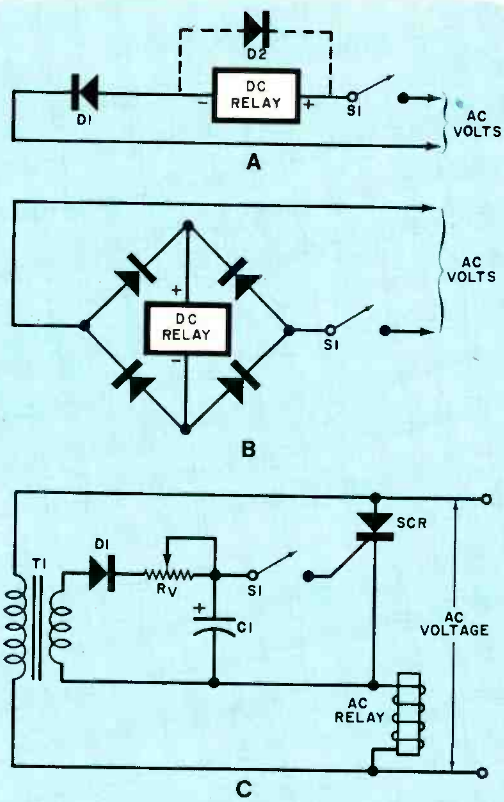

Fig. 6. Ac drive circuits: (A) single diode; (B) diode bridge; (C) thyristor.

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Get consistent cassette data loading with this Peak-Reading Meter

BY EMORY COOK

Eliminates azimuth and level problems in transferring computer digital information when using inexpensive cassette recorders

AN INEXPENSIVE cassette recorder makes a pretty nifty data storage medium, but getting the computer to accept the data when it is transferred can often be a problem. Generally, what is involved is setting the playback level and the azimuth adjustment just right. Most of these little recorders don't have VU meters, and even if they did, the meters would not be of great use. The rms/average reading given by a VU meter doesn't much count to a computer; it is the peak level that matters.

The project described here, a peak-reading meter that connects between the cassette recorder output jack and the computer port input plug, will be a great help in solving both azimuth and level problems. It follows both positive and negative peaks and responds to whichever is greater in magnitude. The scale is arbitrarily calibrated from 0 to 10 with 2 volts (which is where most computers want to load) falling in a highly expanded region at midscale. A 1-volt signal, therefore, will hardly show, but the 1.23 volts rms of the +4-dBm audio standard level will be easy to see. Current drain is a mere 500 μA under quiescent conditions, so the 9-volt battery that powers the meter will last for about its shelf life if you switch the device off when it is not in use. Frequency response, which extends to 20 kHz, is somewhat better than needed for computer work.

Circuit Operation. One half of *IC1* responds to positive swings of the input signal, and its output charges *C2* through *D2*. The other half of *IC1* responds to the negative swings and charges *C2* through diode *D3*. When *S2* is in the ON position, the voltage developed across *C2* is measured by meter *M1*, which has a resistance of about 2300 ohms. When *S2* is placed in the TEST position, the meter is connected across the 9-volt battery. The value of *R7* is selected so that the meter indicates full scale.

As the battery runs down, the meter will indicate further down scale. The battery should be replaced at an indication of about 5 volts. Any meter can be substituted for the one called for in the Parts List, provided its resistance (with

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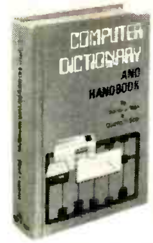

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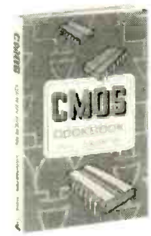

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PEAK READING METER *continued*

an external series resistor if necessary) is about 2300 ohms.

Diode *D1* protects the noninverting input of the upper op amp from damaging negative-going signals (the inverting input of the lower op amp is self-protecting), while *D4* prevents damage to the circuit if the battery is connected backwards. If one wishes to raise the input resistance, the value of *R1* can be as much as 100,000-ohms, which gives about 30,000 ohms of input resistance.

Construction. The meter can be assembled in any desired fashion; the use of the pc board shown in Fig. 2 is optional. When installing components, observe the polarity of the four diodes and the two polarized capacitors. A socket for *IC1* can be used if desired. Any type of enclosure can be used to mount the project provided it has enough room for the pc board, the battery and its connector and holder, and a front panel large enough to hold the meter, two jacks, and two switches.

To determine where the 1.5-volt peak appears on the meter face, connect a fresh 1.5-volt cell between the input (top of *R1*) and ground, and set *S1, S2* to ON. Note the meter indication. Double check by reversing the battery connections—the meter should give approximately the same reading.

Make up two patch cords: one to plug into *J1* and the cassette player's ouput jack; and the other from the computer cassette input part to *J2*.

Azimuth Adjustment. Conventional cassette data storage should have a very low error rate—statistically the equal of a 5¼" floppy disk. However, many cassettes "seem to load better" than others. Usually this can be traced to differences in playback-head azimuth adjustment.

Azimuth is the angle that the tape makes as it crosses the gap of record or playback head. If a recorded tape does not pass across the playback-head gap at the same angle that it passed across the record-head gap there is a loss in amplitude. The problem does not exist for cassettes recorded and played back on the same machine, but in other cases, there is the possibility of azimuth

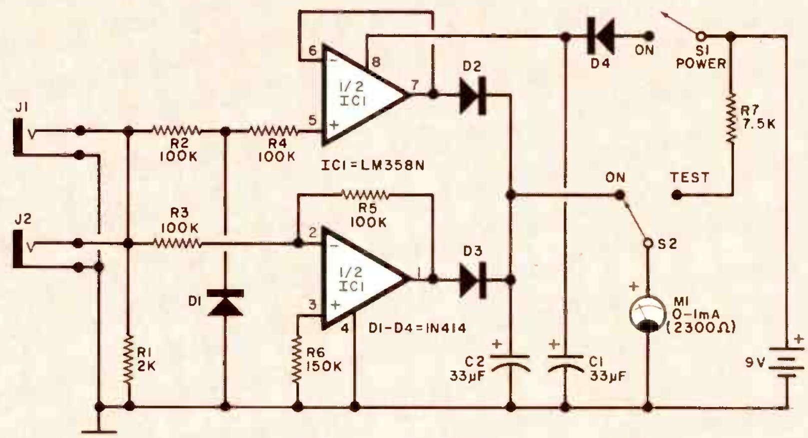


Fig. 1. Both positive and negative signals are used to indicate peak signal level on the meter.

PARTS LIST

B1—9-V battery, connector and holder
C1,C2—33-µF, 10-V tantalum
D1 through D4—1N4148
IC1—LM358N dual op amp (National)
J1,J2—Miniature phone connectors (Switchcraft 41 or similar)
M1—1-mA meter (Modutec MD-DMA-001-CC2 or similar)
P1,P2—Miniature phone jack (Switchcraft 750 or similar)
The following are ¼-watt, 5% resistors:
R1—2000 ohms (see text)
R2 through R5—100,000 ohms
R6—150,000 ohms
R7—7500 ohms
S1—Spst switch
S2—Dpst switch
Misc.—Suitable enclosure and panel (H.H. Smith 2377/78 or similar), IC socket (optional), audio cable for interconnect, mounting hardware.

Note: The following is available from Cook Labs., 375 Ely Ave., Norwalk, CT 06854: Complete kit including case and litho panel, less battery (#PK-80), $25.90; azimuth test cassette (#AZ-80), $14.95. Also available separately: etched and drilled pc board (#AZ-B1), $2.50. Add $2 for handling/shipping. Connecticut residents please add 7% sales tax.

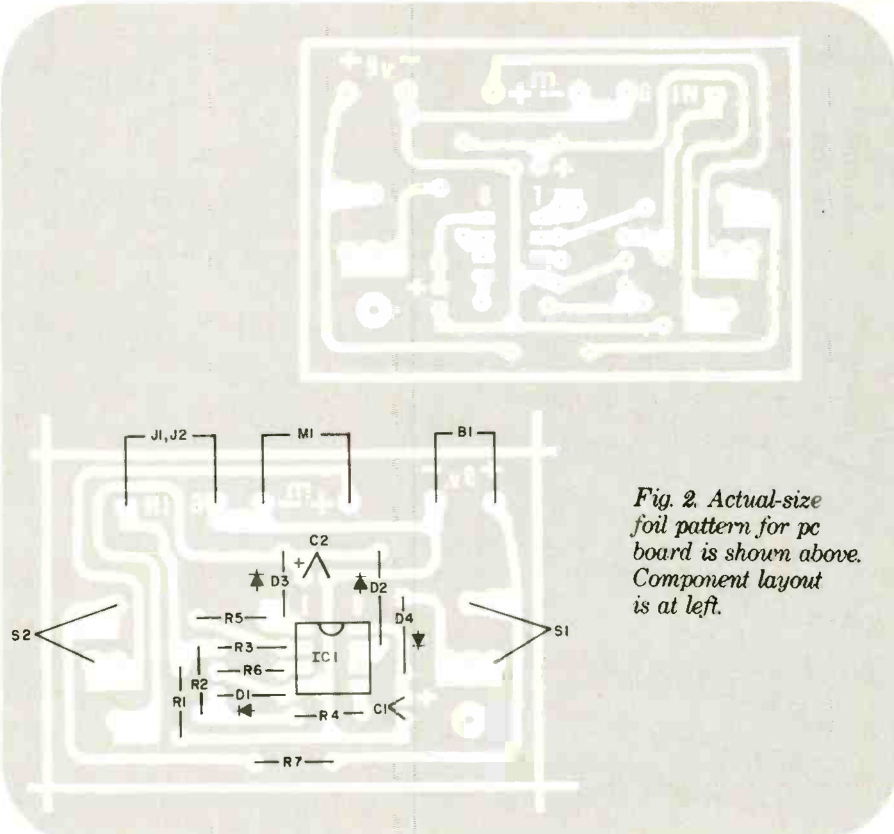


Fig. 2. Actual-size foil pattern for pc board is shown above. Component layout is at left.

mismatch. Or, if the machine used to create "homebrew" tapes has independent record and playback heads, that also can cause an azimuth mismatch.

To check playback-head azimuth, connect the level meter to the audio output of your cassette recorder, play an azimuth calibration tape (see Parts List), and use the cassette recorder volume control to bring the meter indicator to a low- to medium-scale range. Very carefully, adjust the playback-head azimuth to move the meter indicator as far upscale as possible.

Azimuth mechanical adjustment is a function of the particular cassette player you are using, so you will have to search for the mechanical element (usually a screw) that raises or lowers one side of the head. Often, this screw is positioned where it cannot be reached from outside the case. In this event, you will have to (carefully) drill a small hole to gain access to it. (Drill chips in the transport mechanism will *definitely* not enhance the recorder's operation.)

If you are willing to assume that a purchased program tape was made on a professional recorder whose azimuth was correct, then play this instead of the calibration tape and adjust the recorder playback azimuth for maximum meter indication. When you have an important program that was recorded on a machine whose record-head azimuth was slightly askew, you can repeak your machine's playback azimuth for this particular tape, and record it on your machine for future use. If you do this, don't forget to correct the azimuth of your playback head afterwards.

Tape Considerations. Setting correct playback azimuth will correct one problem, and keeping the heads clean and de-gaussed will remove another major cassette-load problem. A commercial tape-head de-gausser, available at most electronic and audio shops, can be used to remove the magnetic fields that are created around tape heads. Commercial head cleaners can be used to remove residue from the heads. Once a head is clean, use only good tapes, especially those marked "drop-out proof." Some general-purpose low-cost audio cassettes may have a dropout here and there, and although these will not greatly affect an audio recording, they could lose a data bit, which is a catastrophe in computer work. In general, good-quality chromium-dioxide *computer* cassettes of C-60 length or shorter will give the best results.

In Conclusion. The meter described in this article is simple and relatively inexpensive to build. Nonetheless, it can prove invaluable as a cassette recorder accessory handling digital data. ◇

BY KARL THURBER, JR. W8FX/4

WHAT'S ON THE AIR BELOW 500 kHz?

Part 1

How long waves (600 meters and below) propagate and what can be heard below the AM broadcast band

TO MOST of us, that portion of the radio spectrum below the bottom of the AM broadcast band is unknown territory. One major reason for this has been the lack (until recent years) of commercially available, high-performance receiving gear capable of covering these frequencies. Now, however, a number of manufacturers are producing receivers, receiving converters, and compact antennas that make it possible to explore the lower reaches of the spectrum, where wavelengths are often measured in *kilometers*. This, together with the proselytizing efforts of a relatively small group of hobbyists, has stimulated new interest in the long waves.

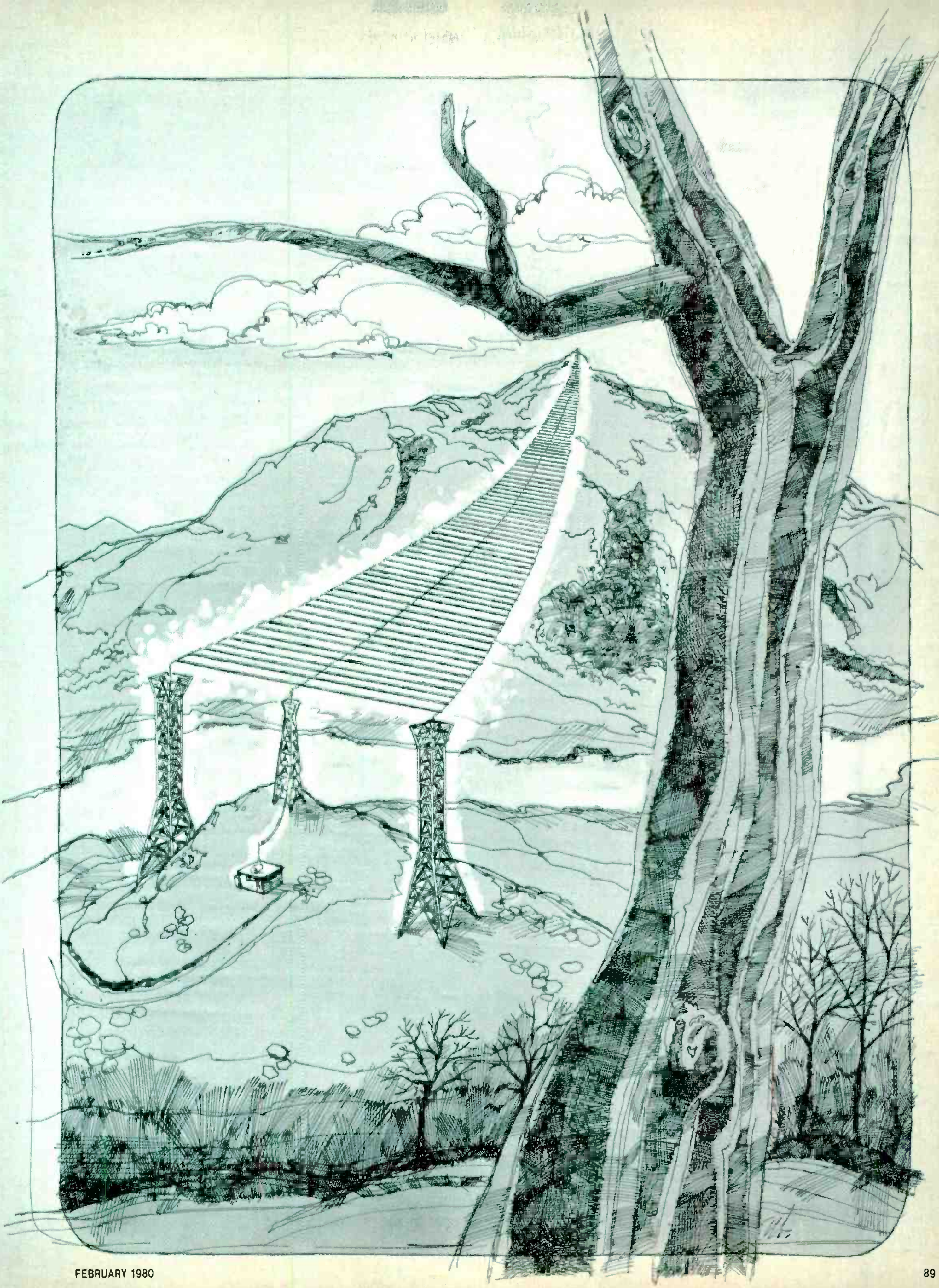
In this two-part article, we will tour the radio world below 600 meters (500 kHz). It's populated by signals from time and standard-frequency stations, foreign broadcasters, military installations, unlicensed (but legal) experimenters, weather and navigation beacons, radioteletype stations, pulsed radiolocation systems, and a host of other unusual signals. We'll also examine how long-wave radio signals propagate, present a sampler of commercially available receiving equipment, and give details of the relatively unknown license-free "1750-meter" experimenters band.

Nomenclature. Before embarking on our tour, let's see just where these frequencies fit in the scheme of things and eliminate some of the confusion that has arisen from the use of different words to mean the same things and the use of the same words to mean different things. As you know, the total usable radio spectrum is presently considered to extend from a few hertz to approximately 300 gigahertz (300×10^9 Hz). This immense range of frequencies is broken up into smaller groupings that are easier to deal with. The lowest range, called the extremely low frequencies (elf), has an upper limit of 3 kHz. Above that, extending from 3 to 30 kHz, are the very low frequencies (vlf). Next come the low frequencies (lf), from 30 to 300 kHz). The medium frequencies (mf) extend from 300 to 3000 kHz or 3 MHz. From 3 MHz to 30 MHz are the high frequencies (hf). Above them are the very high frequencies (vhf) from 30 to 300 MHz. The ultra high frequencies (uhf) extend from 300 to 3000 MHz or 3 GHz. From 3 GHz to 30 GHz are the super high frequencies (shf), and from 30 GHz to 300 GHz, the extremely high frequencies (ehf).

Some people refer to the AM broadcast band as the medium frequencies. Because radio signals can be described by reference to their wavelength as well as by their frequencies, AM broadcast frequencies are also referred to as the medium waves. Actually, the medium frequencies extend above and below the domestic AM broadcast band, so you might come across references to the region between 300 kHz and the bottom of the AM band as medium frequencies or medium waves. Some characterize everything below the AM broadcast band as "low frequencies." For the purpose of this article, we will designate 500 kHz and below (600 meters and down) the *long waves*.

Having agreed on terminology, let's now start our tour of the long wave with a look at their history, which in large part is synonymous with the early history of radio communications in general.

'Way Back When. Much of the pioneering work in the field of radio communications was performed on the long waves. In fact, for a long time, the popular view was that the higher frequencies were essentially useless. The intensive use of the long waves during the infancy of radio communications can in large part be explained by the technology of the times. It was much easier to generate substantial amounts of r-f



energy at such wavelengths than at higher frequencies and shorter wavelengths.

The spark gap was the principal means of generating r-f. Designed at the peak of spark-gap technology, the original *NAA* was the world's first high-power longwave radio station. It was erected in Arlington, Virginia by the U.S. Navy as a 1913 experiment to determine the feasibility of long-distance wireless communications. This station employed a Fessenden synchronous rotary spark transmitter. In the following decade, many government and commercial radio stations were constructed, some on ships and some on shore. They operated on frequencies ranging from several tens of kilohertz to a few hundred kilohertz. At the time, these frequencies were hardly considered *low*!

Such stations were characterized by high-power spark-gap transmitters, very large and costly antennas, and operating wavelengths that measured not feet or meters but miles or kilometers. In those days, most stations communicated on wavelengths of 1000 meters or longer. "Rock-crusher" *NAA* transmitted on the then relatively short wavelength of 2500 meters. French station *YN* was heard by many old-timers listening on this side of the Atlantic on the respectably long wavelength of 15,000 meters—20 kHz! Later, the American Telephone and Telegraph Company scored a longwave first by establishing a reliable transatlantic voice circuit as early as 1923. The company employed an operating frequency of 55 kHz.

The long waves remained in vogue until the early Twenties, at which time radio amateurs went to higher frequencies to escape the murderous interference from the high-power commercial point-to-point and broadcast stations. These hams made an amazing discovery—the higher the operating frequency, the greater the communications range. When word got out, almost everyone joined the exodus to higher frequencies. The long waves went into a decline that only began to be reversed after the Second World War. Their renaissance in recent years is due in large part to important propagation characteristics that make them superior to the higher frequencies for a number of applications such as radiolocation, certain types of communications, and very precise timekeeping and frequency measurements.

We'll next examine what types of signals you'll find on the long waves and the services that employ them. It's important to note that a given frequency or band of frequencies is not necessarily allocated to the same service on a worldwide basis. For the purposes of frequency allocation, the International Telecommunications Union (ITU), the organization charged with the responsibility of overseeing the use of the radio spectrum, has divided the globe into three regions. Europe and Africa comprise Region I; the Americas, Region II; and Australasia, Region III. Also, because propagation in the tropics differs considerably from that in other areas, there are tropical "subregions" where frequency allocations may vary to take these differences into account.

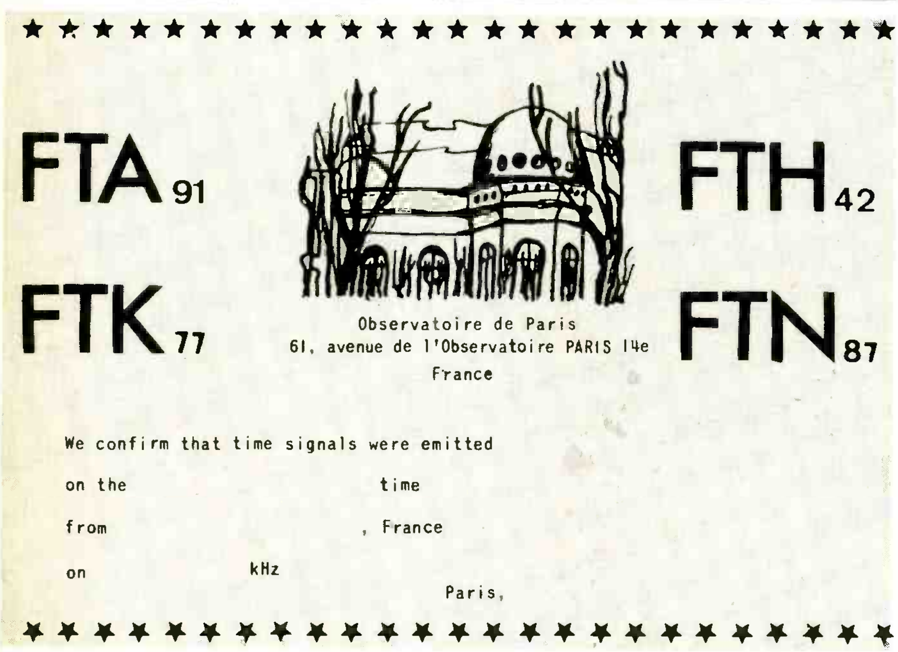


Fig. 1. This QSL card was received from the French time station FTA91, which transmits Coordinated Universal Time (UTC) in Morse code on 91.15 kHz.

Beacons and Weather Stations. In years past, the mainstay of aeronavigation was a longwave system called the *radio range*. Although the radio range is somewhat obsolete today, the 200-to-400-kHz radio-range band is still used for aircraft direction-finding. Small, low-power transmitters located at or near airports form a network of electronic range patterns enabling aircraft to home in on them. These stations are being replaced by elements of the more sophisticated *VOR* and *TACAN* systems which operate on vhf and uhf. They are still important navigation aids, however, in remote areas of the United States and Canada, and in other parts of the world. In fact, there are still over 3000 beacons of various kinds around the globe!

A list of selected beacons appears in Table I. You should be able to hear at least one or two beacons if you live anywhere in the United States or southern Canada. Note that these stations use "identifiers" rather than regular call letters to help tie in the ID with station location. Most operate between 190 and 400 kHz at relatively low power. They make for some interesting and challenging DX "catches".

Some stations also transmit continuous aviation and marine weather broadcasts using amplitude modulation. These transmitters can be heard out to approximately 100 miles during the day and 1000 miles or more at night. You'll also find that the frequencies around 500 kHz are active with marine radio traffic. Exactly 500 kHz is an international calling and distress frequency.

Time and Frequency Standards. Over the past few years, the long waves have become a popular source of channels for accurate time and frequency standards. Approximately twelve stations around the world now broadcast highly accurate marker signals 24 hours a day; mostly on frequencies below 100 kHz. Why are the long waves especially well suited for this application? They are to a large extent free of the small but, to some users, important errors that result from the variations in signal propagation which affect reception of regular ("shortwave") transmissions of time and frequency stations. The hf signals from such familiar stations as *WWV, WWVH* and the Canadian *CHU* are affected by fading, multiple-path reception, and propagation which either make them difficult to receive or unsuitable for use when high accuracy is demanded.

Because the long waves are much less affected by propagation irregularities and thus make steady, reliable reception possible, many of the agencies that provide such services have set up longwave installations. Much of this interest is new-found, but not all. One of the first broadcast time services, provided by British station GBR, was instituted in 1926. At the time it first went on the air, it was reported to be the world's most powerful radio station. Even today, its 16-kHz signal is widely received in the United States. The station boasts a frequency accuracy of better than 5 parts in 10^{10}, or 5 parts in 10,000,000,000! Table II lists the world's major low-band standard time and frequency stations, including WWVR, the National Bureau of Standards station transmitting on 60 kHz.

Shown in Fig. I is a QSL card from French Station FTA91, which is operated by the Paris Observatory. Its frequency is 91.15 kHz and transmitter power is 45 kilowatts. This station is heard all over Europe broadcasting Coordinated Universal Time (UTC, the successor to Greenwich Mean Time or GMT) in Morse Code.

Radio location. The stability of propagation phenomena on the long waves, coupled with the fact that such signals tend to cover vast areas by following the curvature of the earth, has made these frequencies very useful to radiolocation services such as *LORAN* and *OMEGA*. The *LORAN-C* system is used primarily by both ships and planes to accurately determine position anywhere in the coverage area, which now encompasses more than 16 million square miles. *LORAN-C* can tell you where you are, with ¼-mile accuracy, and let you return to within 50 to 300 feet of that same spot, time after time. It operates continuously, no matter what the weather, and is accurate, dependable and cost-efficient. *LORAN-C* is an advanced version of *LORAN-A*, an almost obsolete service that shares the 160-meter band with radio amateurs.

LORAN-C is used by the merchant marine, commercial fishermen, tugboats, charter boats, and pleasure boaters. This year, coverage will be available in all coastal waters of the U.S. mainland except those off the northern coast of Alaska, and the system will have replaced the older, less accurate *LORAN-A*. A two-year overlap is being provided before the *LORAN-A* transmitters are turned off.

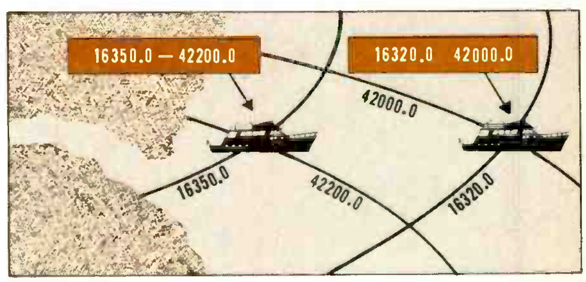


Fig. 2. Radiolocation by LORAN-C signals and charts. A special receiver directs the user to two curved "lines of position." The intersection of these lines pinpoints receiver location.

LORAN-C transmitters operate in chains, sending out pulsed 100-kHz signals. A special *LORAN-C* receiver at the position to be determined measures the slight difference in time between the arrivals of signals from a pair of transmitters spaced hundreds of miles apart. This time difference, measured in microseconds, is read off a display in the receiver and correlated with a curved "line of position" on a *LORAN-C* chart. The receiver is then turned to a different pair of transmitters and a second time difference determined. This is correlated with a second curved line of position on the *LORAN-C* chart. The intersection of the two "lines of position" allows the user to identify his specific location. A sample *LORAN-C* chart, shown in Fig. 2, illustrates how vessels can plot their positions using this system.

For best results, a fully automatic *LORAN-C* receiver should be used. If ultimate accuracy is not required, a semiautomatic, manual or combination *LORAN-A/LORAN-C* receiver is acceptible. Those who merely want to tune in a *LORAN-C* transmitter and hear what one sounds like can use any standard communications receiver that tunes down to 100 kHz. *LORAN-C* transmitters operate on that frequency and can be readily identified by their characteristic pulsating sound.

On even longer wavelengths than *LORAN-C* is the *OMEGA* navigation system, which began operation in the late 1960's. It works somewhat like *LORAN*, but in the region of from 10 to 14 kHz, which is more stable from a propagation standpoint than the somewhat higher frequencies used by *LORAN-C*. Its range, more than 8000 miles, is greater than that of *LORAN*. A network of only eight stations is enough to cover the entire world, day and night. The longer wavelengths *OMEGA* employs are, to some extent, able to penetrate water, making it possible for submerged submarines to determine their positions.

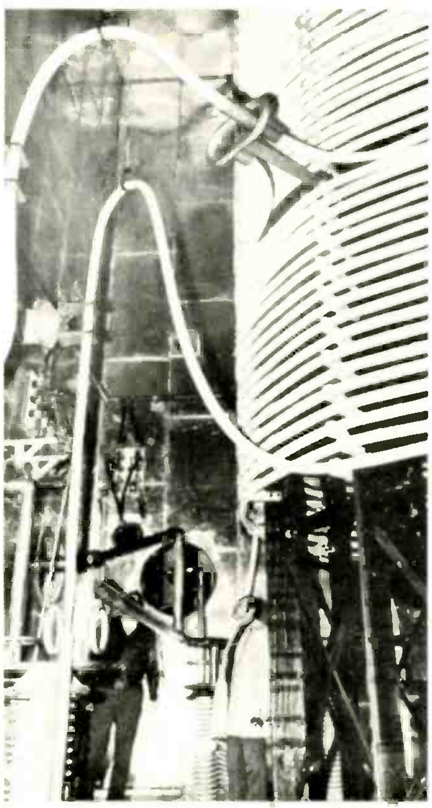
You can hardly miss the strange-sounding *OMEGA* transmissions, and you might even hear signals from *ALPHA*, the somewhat similar Russian longwave radiolocation system. Another, slightly older system you might also hear is *DECCA*. Look for its carriers around 71, 85, and 113 kHz. None of the transmitters associated with these systems broadcasts a recognizable identification, but you can hardly miss hearing their signals. You're a bit too late, though, to hear an unusual type of longwave transmission called *CONSOLAN* which has been rendered obsolete by *LORAN-C* and *OMEGA*. For years, navigators charted their way across the Atlantic aided by such *CONSOLAN* stations as the 194-kHz *TUK* located at Nantucket, Massachusetts. A *CONSOLAN* station broadcast a special sequence of dits and dahs which enabled a navigator to determine an approximate bearing with respect to that station. He did this by counting the number of dits and dahs he heard and then plotting the information on a special chart. He could then cross-reference this bearing with two other bearings (such as from *LORAN* or other *CONSOLAN* stations, a celestial "sun-shot" or a radio bearing) to get a fairly accurate fix on his position. The 2000-watt Nantucket station is still on the air, but when *CONSOLAN* was phased out a few years ago, it became an ordinary radio beacon.

Broadcasters. The 150-to-285-kHz band is a popular broadcast band in Europe, Africa, and some parts of Asia. Range is usually much greater than that on the domestic AM broadcast band. A number of Americans were first exposed to long-wave broadcasting during service in World War II and in the occupation following it. While they were overseas, they discovered the many good musical programs that Europeans could tune in on the long waves. There are few longwave broadcast enthusiasts in this country, however, and most SWL clubs don't pay much attention to LW/BC DXing. This is primarily because relatively few receivers cover it, and it's also tough to pull the broadcasters through the heavy interference from the many beacon and weather stations in the Western Hemisphere.

Broadcasters, like many long wave users, tend to employ super-high-power transmitters and very large antennas to make received signals as strong as possible. What do transmitting tubes that can handle large amounts of power look like? Shown in Fig. 3 is an Eimac X-2159 water-cooled power tetrode rated at a plate dissipation of 1250 kilowatts (1.25 megawatts) and a typical class-C r-f output power of 2.158 megawatts! It is designed for use in megawatt-range medium- and longwave transmitters. This giant tube weighs 175 lb (80 kg), is more than 25 inches (64 cm) high, and has a diameter of 17 inches (43 cm). The tetrode's two-section *filament* requires 700 amperes at 18.5 volts per section!

Table III is a list of some of the broadcast stations using the long waves, many of which can be received in the continental U.S. All run power levels of *one megawatt* or more. Besides these super-power stations, there are low-power broadcasters in, among other countries, the United Kingdom, Denmark, Iceland, Finland, Norway, Sweden, Algeria, and Morocco. Note that most longwave broadcasters do not use call signs.

The Military. Longwave signals follow the curvature of the earth over vast distances, and can even penetrate to short depths beneath the ocean's surface. These and other characteristics make the long waves well suited for the ultrareliable world-wide communications that the Armed Forces require. The Navy, in particular, is interested in the long waves because they offer the ability to communicate reliably with submerged submarines—something that's just not possible on the higher frequencies. Accordingly, it operates very high-power stations in such far-flung locations as San Francisco; Cutler, Maine; and the Canal Zone on frequencies between 15 and 30 kHz. They enable the Navy to maintain dependable, world-wide communications almost unaffected by propagation conditions and solar activity. Tuning around the long waves you'll hear such Naval calls as *NPG*, *NBA*, *NPM*, and *NSS* on both CW and RTTY. Many of these stations operate continuously, and reception is usually very steady. The beginner who would like to improve his proficiency in Morse Code will find some excellent practice material free for the asking.



U.S. Coast Guard Photo

Two workers are dwarfed by the 40-foot tapped inductor helix at OMEGA station at Aldra, Norway.

Other Longwave Users. There are a number of stations operating below 600 meters, including those operated by such news services as the Associated Press. So they, too, can be put to good use for code practice. Many use radioteletype, which makes it possible to adjust and calibrate RTTY receiving equipment using their very stable transmissions. As we'll see later, there's a sort of ham band down there, too—the so-called "1750-meter experimenters band," where low-power transmissions are allowed by the FCC without a license of any kind.

Below approximately 3 kHz is a *strange* world where wavelengths are measured in hundreds or thousands of kilometers or miles. Not much is really known about this portion of the radio spectrum where frequencies overlap on what we know as "audio." There have been experiments on frequencies lower than 100 Hz, most of them employing digital techniques and very narrow bandwidths. The military is especially interested in the communications potential of these lowest of frequencies.

The long waves have many other applications besides wireless communications. For example, many "wireless" intercoms operate between 130 and 200 kHz. These low frequencies are used to prevent interference with standard AM broadcast reception and excessive radiation from the house wiring that carries the signals. Digital watches also make use of low-frequency oscillations for timekeeping. They contain miniature oscillators whose operating frequencies, usually 32.768 kHz, are derived from quartz crystals. You might be able to see or hear the output of a digital watch if you have a sensitive oscilloscope, a frequency counter with a high-gain preamplifying probe, or a sensitive longwave receiver. Ultrasonic cleaners, such as those used by industrial firms and jewelers, make use of the fact that ultrasonic sound waves generated by a transducer in a liquid-filled tank can do wonders in cleaning the inaccessible nooks and crannies of delicate jewelry and watches. A typical ultrasonic cleaner employs a powerful oscillator operating at between 25 and 50 kHz whose output is used to drive a piezoelectric transducer. My own 100-watt, 41-kHz Heathkit cleaner puts out a healthy dose of longwave radio-frequency energy that hopefully won't set any DX records!

Whistlers. One source of signals found in the longwave portion of the spectrum isn't human at all—it's a natural phenomenon known as "whistlers," one of radio's oldest mysteries. Whistlers are believed to emanate from lightning discharges in the earth's atmosphere. According to the prevalent theory, the lightning discharges disturb the earth's magnetic field, resulting in the generation of electromagnetic "signals". Whistlers can sometimes be heard on longwave receivers and even on long, high-gain audio lines. (The lines act as antennas of sorts.) Whistlers have been variously described as rushing noises, strange hisses, whistles descending in pitch, and even as a "dawn chorus" heard at sunrise, akin to the sound of birds at dawn.

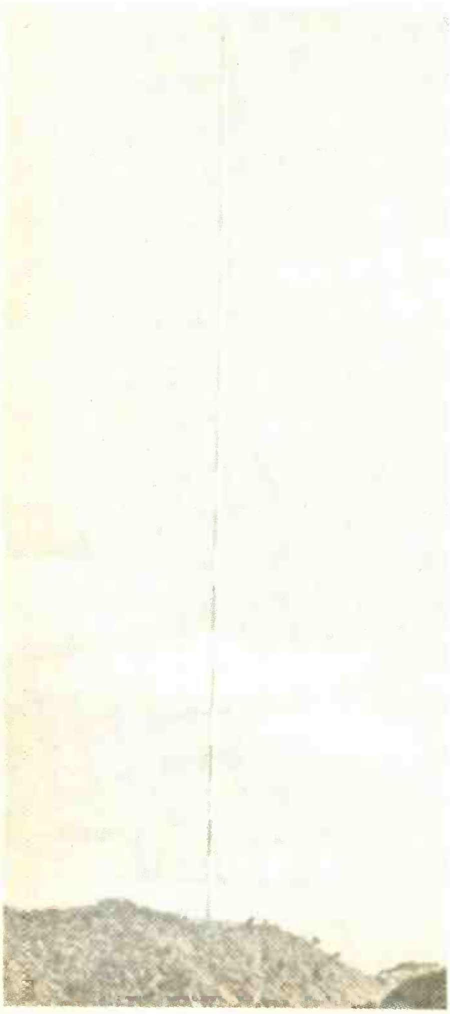
Propagation. How do signals propagate at these low frequencies? There's no blanket answer to this question because much depends on just *how low* the frequencies are. At the high-frequency end of the long waves, around 500 kHz, propagation isn't much different from that of the AM broadcast band or the 160-meter amateur band. Daytime propagation is limited to ground wave

Courtesy of EIMAC, Div. of Varian Corp.

Fig. 3. Giant power vacuum tube typically found in longwave transmitters. This water-cooled tetrode weights 175 lb (80 kg) and has a rated plate dissipation of 1.25 megawatts!

U.S. Coast Guard Photo

Two views of the 1500-foot antenna tower at OMEGA Station H in Tsu-Shima, Japan. Surrounding islands were used to anchor guy wires. Ten feet wide, the structure is tallest in Orient.



U.S. Coast Guard Photo

(one hundred miles or so), and nightfall extends reception out to several thousand miles. As the frequency of interest decreases, however, say to 100 kHz or less, signals tend to propagate in "duct-like" or waveguide fashion. The groundwave travels over greatly extended distances because it hugs the earth and follows its curvature. The very low frequencies can easily travel halfway around the world, and even penetrate a short distance beneath the surface of the ocean!

There are several reasons why long waves propagate as they do. The ionosphere, that highly charged or "ionized" region of the earth's atmosphere that extends from 30 to 250 miles above the surface, tends to act like a duct or "rubber waveguide" for signals with very long wavelengths. This is at least partially explained by the fact that the altitude of the ionosphere is comparable to the wavelengths of radio signals at these frequencies. Also, although medium- and high-frequency signals tend to be absorbed by the lower layers of the ionosphere and by the earth itself, the long waves are usually absorbed to a much lesser extent. Furthermore, the *reflectivity* of the ionosphere with respect to longwave signals tends to remain fairly constant, making long-distance communications on the long waves much more stable than those on higher frequencies on hourly, daily, and seasonal basis. This is one reason why longwave broadcasting is so popular in many parts of the world—stations operating on these low frequencies can be heard coming through "loud and clear" morning, noon or night, every day of the year.

During the daytime, longwave propagation is almost exclusively by ground waves traveling close to the surface of the earth. Over land paths, maximum distances are reduced by absorption caused by ohmic resistance of the ground. This is much less of a problem, however, than it is at medium or high frequencies. For a given level of transmitter power, *ground-wave* range is much greater on the longer wavelengths than on short waves. At the lowest frequencies, it can become global in scope. To benefit from the DX possibilities of the long waves, however, transmitter power must be high and antennas large. At the lowest frequencies, antennas may be found strung between mountains or even *buried* in the earth! There is *some* sky-wave propagation of the long waves. As frequencies increase and approach the medium waves (around 300 kHz or so), sky-wave propagation becomes more common, especially at night. Actually, if there were *no* sky-wave propagation, there would be no fading or any change at all in received signal strength at great distances from the transmitting site. There often is some fading, particularly at the higher long-wave frequencies, attesting to the existence of sky waves. During the daytime, the lower frequencies tend to be slightly reflected from the *D* or lowest layer of the ionosphere. At night, the *D* and *E* layers mostly disappear and absorption of radio signals decreases dramatically. Signals can then be reflected back to earth from the highest ionospheric *F* layers as sky-wave or skip signals. Because of phase differences, the sky wave tends to destruc-

TABLE I
SELECTED BEACONS AND WEATHER STATIONS

Call	Location	Frequency (kHz)
SFI	Petaluma CA	192
SOG	Norwood, MA	201
EZ	Elizabeth, NJ	208
ZFP	Freeport, Bahamas	209
UKT	Quakertown, PA	210
UCF	Cienfuegos, Cuba	212
BH	Birmingham, AL	224
LG	Long Beach, CA	233
GNI	Grand Isle, LA	236
YZE	Gore Bay, Ontario, Canada	245
YWG	Winnipeg, Manitoba, Canada	248
HZ	Halifax, Nova Scotia, Canada	248
MFR	Medford, OR	263
VKN	Montpelier, VT	268
AUH	Aurora, NE	278
IA	Houston, TX	326
ZIY	Grand Cayman, BWI	344
AAA	Lincoln, IL	329
ICL	Clarinda, IA	350
AK	Akron, OH	362
LEO	Leon, Mexico	365
ZP	Sandspit, British Columbia, Canada	368
5E	Ringes Island, N.W.T., Canada	380
PCZ	Waupaca, WI	382
DDP	San Juan, Puerto Rico	391
ZBB	Bimini, Bahamas	397
EWP	Newport, AR	400

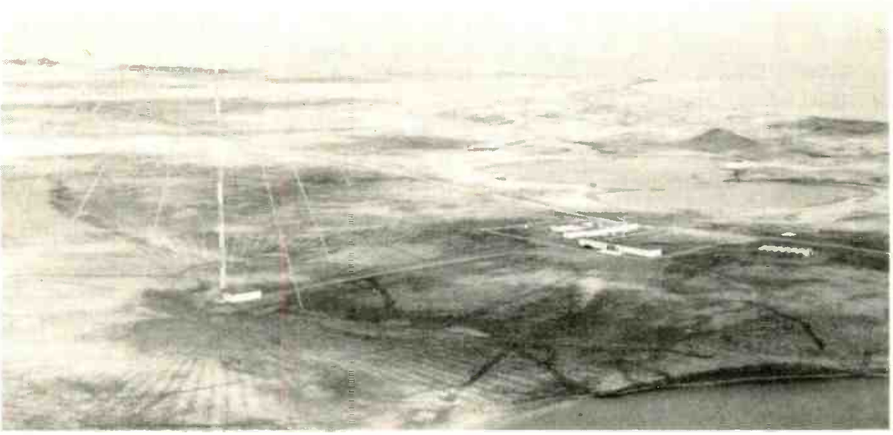
tively interfere with the ground-wave if both are incident upon the receiving antenna. This causes fading and "jitter" in reception. At the lower frequencies, sky-wave propagation and the attendent phasing effect become less and less pronounced. Their absence makes for superb, rock-steady signal reception—most uncommon in hf communications.

Noise. Of course, there is an important limiting factor in longwave communications. It is atmospheric noise or QRN. High noise levels plague the long waves, with the tropical regions being the worst. Thunderstorm static can be horrendous, as longwave listeners (LWLs) will readily attest. Severe thunderstorms in the vicinity of your longwave receiver can easily increase your noise level *90 dB or more*! To overcome the high noise levels and improve the signal-to-noise ratio at the receiver, transmitting power must be very high. This is really the only way to get a jump on the QRN because in most cases it's not practical to build Yagi beams or other high-gain directional antennas for these wavelengths. Can you imagine how big a 5-element, rotatable beam cut for 10 kHz would be? About the only partial remedy in the way of antennas is to use a slightly directive, noise-cancelling antenna such as a loop or "wave" antenna at the receiver.

The high atmospheric noise level is a major impediment to experimental communications on the so-called "1750-meter band" which we'll cover in the second part of this article. Transmitter power is limited on that band to only one watt! Line-noise RFI is a big problem, too. It is much more bothersome than on the higher frequencies. Electric light dimmers, motors, heating pads, household appliances, and "leaky" power lines are major sources of electrical noise that interferes with experimenter communications.

Owing to high noise levels at most big-city and suburban locations, many of the more serious LWLs (much like amateur astronomers) pack their gear and go to the mountains or seashore to escape man-made interference. Portable loop antennas and battery-powered transmitters, receivers, and receiving converters make this a fairly practical enterprise.

This concludes Part One of this article. In Part Two, we'll take a look at equipment that can be used for longwave listening and give details about the 160-to-190-kHz, license-free experimenters band.


U.S. Coast Guard Photo

LORAN-C transmitter at St. Paul Is., Alaska, has a 625-foot antenna.

TABLE II
LONGWAVE TIME AND FREQUENCY STATIONS AROUND THE WORLD

Call	Location	Frequency (kHz)
GBR	Rugby, England	16
NBA	Canal Zone (Panama)	24
JG2AS	Chiba, Japan	40
RTZ	Irkutsk, USSR	50
OMA	Prague, Czechoslovakia	50
MSF	Rugby, England	60
WWVB	Fort Collins, Colorado	60
HBG	Prangins, Switzerland	75
DCF77	Mainflingen, Germany	77.5
FTA91	Paris, France	91.15
DGI	Oranienburg, Germany	185

TABLE III
SELECTED LONGWAVE BROADCASTING STATIONS

Location	Frequency (kHz)
Brasov, Romania	155
Khabarovsk, USSR	155
Allouis, France	164
Minsk, USSR	164
Moscow, USSR	173
Saarlouis, Germany	180
Ankara, Turkey	182
Konigswusterhausen, Germany	185
Birobidjan, USSR	191
Blagoveshensk, USSR	191
Monte Carlo, Monaco	218
Konstantynow, Poland	227
Jinglinster, Luxembourg	236
Leningrad, USSR	236
Vladivostok, USSR	245
Tipasa, Algeria	251
Irkutsk, USSR	263
Moscow, USSR	263
Uherske, Czechoslovakia	272

FOR MORE INFORMATION

The Long Wave Club of America, Box 33188, Granada Hills, CA 91344, publishes the bimonthly *Lowdown* and other items of interest to the LWL. Membership dues of $6 annually includes a subscription to the *Lowdown*. For more information, send a *large*, self-addressed envelope with two units of first-class postage attached.

The National Radio Club Publications Center, Box 401, Gales Ferry, CT 06335, offers reprints of various articles dealing with the long waves.

The U.S. Government Printing Office, Washington, DC 20402, offers a number of publications dealing with longwave beacons and broadcasters, such as *Airman's Information Manual, Location Identifiers*, and *Broadcasting Stations of the World*.

Acknowledgements: Mr. W.R. McIntosh, Publisher of the LWCA *Lowdown*, and Ken Cornell, W2IMB, for technical assistance. *The Lowdown* was used with permission as the author's source of much of the receiving equipment, beacon, and 1750-meter information.

BY JOHN D. RICHARD

PROTECT YOUR PROPERTY WITH A CMOS GUARDIAN

Lets you know if an unauthorized person has used any electric machines when you weren't present

Wouldn't it be nice to have a device that would tell you when someone has operated any line-powered electrical device in your home or office without your permission? Well, the Sentinel described here does just that. Once coupled to any 117-volt ac line-operated equipment or lighting circuit, the Sentinel constantly monitors the ac power. To determine if the ac circuit has been switched on since the last time you checked, you simply push a button. No telltale lights or alarms sound when unauthorized use occurs; to find out, you must close a switch.

About the Circuit. Although *IC1* in the illustration contains four 2-input NAND gates, the two inputs of each gate are wired in parallel to form four inverters. Gates A and B are wired in a set/reset flip-flop configuration.

A low input to gate B generates a high condition at its output. Because this signal is also present at the input of gate A, its output is forced low. The circuit is completed by feeding the low output of gate A to the input of gate B. Output current from gate A is limited by *R3* during changeover.

The high output from gate B is also routed to the input of gate D, forcing the latter's output, which is connected to *LED1*, low. The low output from gate A is inverted by gate C whose output, connected to *LED2*, goes high. Hence, if *S3* is pressed (closed) at this time, only *LED2* (which is green) can come on. If the input to gate B is forced high, the flip-flop changes states. Now only *LED1* (red) can come on when *S3* is pressed.

In the flip-flop's "normal" state, with no power applied to *T1*, closing *S2* places the flip-flop in the state where only *LED2* can light when *S3* is pressed.

The primary of *T1* connects to either the power line or the primary of the power supply (after the power switch) of the device to be monitored. If *T1*'s primary is energized, the *C1/D1* circuit creates a positive voltage that is applied to the input of gate A via current-limiting resistor *R2*. When this voltage exceeds the switching level of gate B, the flip-flop changes states. Then, pressing *S3* causes *LED1* to light.

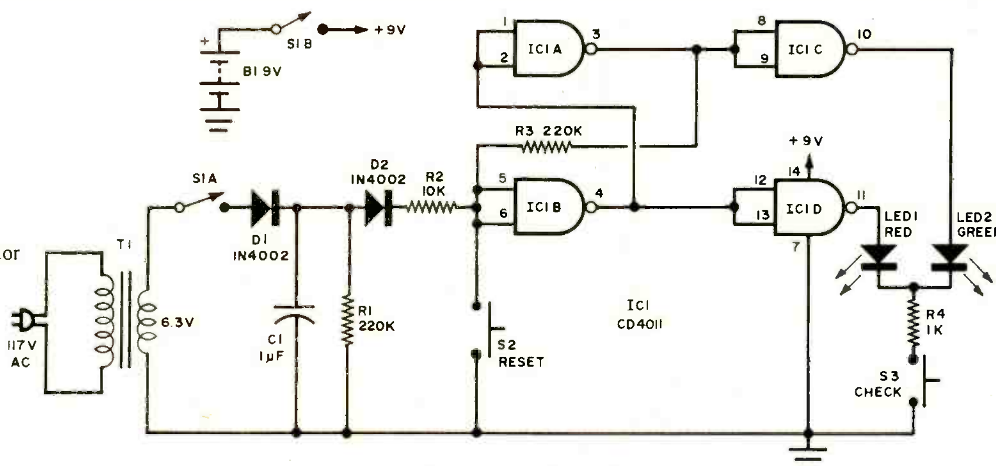
Momentary application of power from the ac line produces enough dc voltage for the flip-flop to change states. When the ac is removed, *R1* discharges *C1*, but *D2*, now reverse biased, keeps the flip-flop from changing states. Once tripped, the circuit does not go into automatic reset.

Once *S2* is pressed to reset the Sentinel, operating *S3* will cause only the green LED to come on. If you press *S3* later and the red LED comes on, someone has applied ac power to the device being monitored. Both ac-line and 9-volt dc power can be disconnected from the sentinel by opening *S1*.

Construction. Although the Sentinel can be assembled with just about any wiring technique, it is best assembled on a piece of perforated board or a printed-circuit board of your own design. Component placement and orientation, wire routing, and lead dress are not critical. Just arrange the circuit neatly. Then house it in an appropriate-size box that is predrilled for the three switches and two LEDs. ◇

PARTS LIST

B1—9-volt battery
C1—1-µF polyester capacitor
D1, D2—1N4002 diode
IC1—4011 quad 2-input NAND gate
LED1—Red light-emitting diode
LED2—Green light-emitting diode
R1, R3—220,000-ohm ¼-W 10% resistor
R2—10,000-ohm, ¼-watt 10% resistor
R4—1000-ohm, ¼-watt, 10% resistor
S1—Dpst switch
S2, S3—Normally open pushbutton
T1—6.3-V transformer
Misc.—9-volt battery and holder; suitable enclosure; machine hardware; line cord; hookup wire; etc.



In normal state of flip-flop IC1/IC2, LED2 glows when S3 is pressed. If flip-flop is toggled, LED1 glows.

Hobby Scene Q&A

By John McVeigh, Technical Editor

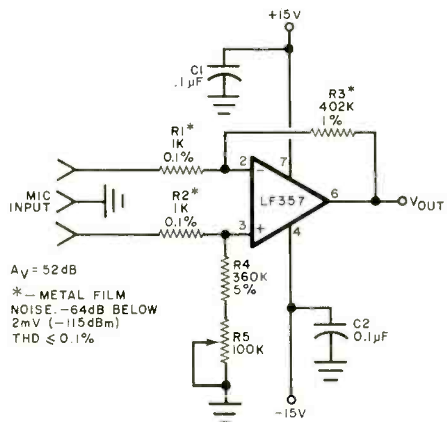
MIKE TRANSFORMER SUBSTITUTE

Q. ***Have you investigated the cost of line-matching transformers recently? I'm sure there's a cheaper way to match low-impedance balanced microphones to high-impedance unbalanced inputs. Can you tell us what type of miniature transformer the manufacturers use and show us how to build our own for a lot less?—Doug Hulstine, Clovis, CA.***

A. No, I cannot show you how to build one for a lot less. There's much more to line-matching transformers than impedance transformation. These devices must be manufactured in such a way that there is a high degree of symmetry between each end of the primary winding and the primary's center tap. Otherwise, rejection of common-mode signals will not be optimal. Also, the transformer design must include electrostatic shielding. Finally, quality transformers are designed to minimize the amount of harmonic distortion they introduce. All this points to the fact that high-quality input matching transformers can not be made at low cost.

However, I can show you a relatively inexpensive solid-state *substitute* for a line-matching transformer. The circuit shown schematically in the figure is taken from National Semiconductor's *Audio Handbook*. It takes advantage of the inherent ability of an operational amplifier to amplify differential signals while simultaneously rejecting common-mode ones. A FET-input op amp (LF357) is employed as a differential amplifier. This device, which is now being sold by some of the semiconductor dealers who advertise in the Electronics Market Place section of this magazine, was selected over quieter op amps because of its large common-mode rejection ratio.

Input resistors *R1* and *R2* are selected to be large compared to the source impedance



but as small as possible to achieve a good compromise between input loading effects and low-noise performance. The common-mode rejection ratio of the LF357 is rated at 100 dB so, if the input resistors are perfectly matched, this figure represents the highest attainable CMRR. The effect of resistor matching on CMRR is critical because the amplifier's ability to reject common-mode interference assumes that exactly the same signal voltage is simultaneously present at both the inverting and noninverting inputs. Any mismatch between resistance values will result in the creation of a differential signal that will be amplified by the op amp.

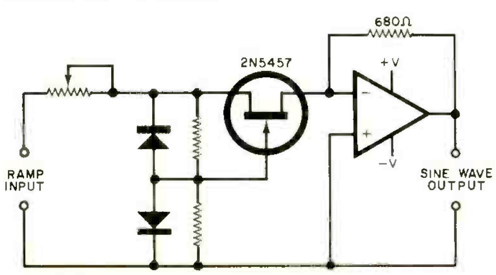
The use of 0.1% tolerance resistors for the asterisked components and a careful adjustment of *R5* for minimum output when the op amp is driven by a common-mode signal, a CMRR of almost 100 dB can be achieved. Using 1% tolerance resistors will degrade the common-mode rejection ratio to approximately 80 dB. Substituting an LF356 op amp for the LF357 will reduce the circuit's slew rate from 50 to 12 volts/microsecond and its unity-gain bandwidth from 20 to 5 MHz.

This circuit can be built for less than the cost of a high-quality matching transformer. It can be powered by a battery supply, an advantage if portability is desired. Due to the thermal noise contributions of the relatively large input resistors, the circuit is not as quiet as others that appear in the National Semiconductor *Audio Handbook*. It is simpler than the more quiet designs, however, and it uses few components, eliminates the need for a costly transformer, and offers a high degree of hum rejection.

SINE-WAVE CONVERTER (CONTINUED)

Q. ***In the October 1979 issue, you discussed the use of a voltage-controlled filter for the conversion into sine waves of ramp, sawtooth, or square-wave VCO output signals. May I offer a much simpler circuit that I included in my sweep generator? Your readers might find it useful.—Cyrus W. Roton, Ridgecrest, CA.***

A. Sure! I'm always glad to receive suggestions from readers. Cy's circuit is shown in the figure. I'll let him take it from here. "The input waveform is a symmetrical ramp of fixed amplitude, approximately 6 volts peak-to-peak. The input amplitude and the 2000-ohm potentiometer are adjusted for the best-looking output waveform and the smallest amount of harmonic distortion (which can be 1% or less, depending on the components used and symmetry of the input waveform). If a p-channel FET is to be used, reverse the polarities of the 1N914 steering diodes. The 680-ohm feedback resistor was selected for best results with the particular FET I used. The high-frequency response of the circuit is limited mainly by the slew rate of the op amp."



MAGNETOSTRICTION

Q. ***My television emits a high-frequency sound which, quite frankly, drives me crazy! Is there any way to get rid of it?—Jon Dattorro, Boston, MA.***

A. The source of the high-frequency sound is a component in the horizontal section of the television receiver that is acting as a transducer, converting an electrical signal into sound waves.

Usually, the sound is generated by the horizontal output transformer due to the effects of *magnetostriction*—that is, the physical deformation of a ferromagnetic object caused by a change in its state of magnetization. The horizontal output transformer is excited by a high-level sawtooth waveform at the horizontal sweep frequency, resulting in a constantly changing magnetic field around the core of the transformer. The core deforms in step with changes in the magnetic field, and in doing so generates sound waves in the surrounding air. The frequency of the sound is 15,750 Hz, the horizontal sweep frequency, and its amplitude can be very large.

There is not much you can do about this very annoying problem. You cannot prevent magnetostriction, and any attempt to damp out the sonic energy will probably interfere with adequate ventillation of the television receiver. You can, however, give up television (!) for a few years. Most children can hear as high as 15,750 Hz and even beyond; but as they age, the upper limit of their hearing falls off. Some middle-age people are hard-pressed to hear 10,000 Hz. So, although the high-frequency sound is now very annoying, eventually you won't be able to hear it.

Have a problem or question in circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, N.Y. 10016. Though all letters can't be answered individually, those with wide interest will be published.

Experimenter's Corner

By Forrest M. Mims

DO-IT-YOURSELF COUNTERS

THE MC14553B is a 3-decade BCD CMOS counter that you can use to make various event and frequency counters. Each of the three counter stages in this chip is teamed to a set of latches, which are registers comprising four flip-flops permitting the count at any given instant to be sampled and stored. The displayed count is thus periodically updated and "frozen" on the associated digital readout while the counters continue counting. This flexibility and the other attributes (modest power consumption, relatively high counting capabilities in a single IC) make the MC14553B ideally suited for use in many experimenter projects. Let's take a closer look at this chip.

MC14553B Operation. Figure 1 is the pin outline of the MC14553B. Here's an explanation of the pin functions:

- *CLOCK* (pin 12)—Counter input.
- *LE* (pin 10)—Latch Enable. When *LE* is at logic 1, the latch is loaded with the current count.
- *DIS* (pin 11)—Disable. Must be at logic 0 for counting to occur. Inhibits the input (blocks incoming clock pulses) when at logic 1.

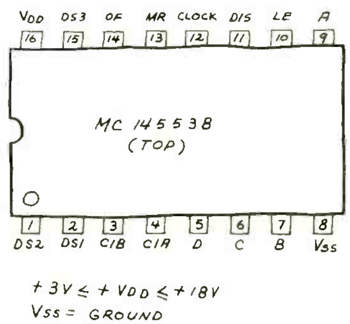


Fig. 1. Pin arrangement of the MC14553B counter.

- *MR* (pin 13)—Master Reset. Must be at logic 0 for normal operation. Resets all four BCD outputs to logic 0 when brought to logic 1. Keep LE at logic 1 during reset operations to preserve the latest count in the latch.
- *A, B, C, D* (pins 9, 7, 6, 5)—BCD outputs (TTL compatible).
- *DS1, DS2, DS3* (pins 2, 1, 15)—Digit select outputs (TTL compatible).
- *C1A, C1B* (pins 4 and 3)—Connection points for the external capacitor that controls the speed of the on-chip digit-select multiplex oscillator.
- *OF* (pin 14)—Overflow Output. Normally at logic 0, this pin goes to logic 1 when count exceeds 999.

Having acquainted ourselves with the basic layout of the MC14553B, let's now examine some circuits designed around this versatile IC.

Three-Decade Event Counter. A very simple application for the MC14553B is the three-decade event counter shown in Fig. 2. This circuit will count pulses arriving at pin 12 of the MC14553B when both the *Master Reset* (pin 13) and *Disable* (pin 11) inputs are low. The maximum count rate is dependent upon power supply voltage $+V_{DD}$, and is typically 1.5 MHz at +5 volts, 5.0 MHz at +10 volts and 7.0 MHz at +15 volts.

The BCD output of the MC14553B is decoded by an MC14543B BCD-to-seven-segment latch/decoder/driver. This chip was designed specifically to drive liquid-crystal displays. It can safely drive LED displays, however, if the current to each LED segment does not exceed 10 mA or if buffer transistors are used. Incidentally, both the MC14553B and MC14543B are 16-pin DIPs. Because their part numbers differ by only one digit, use care to avoid interchanging the two chips inadvertently when assembling this circuit! Also, both are CMOS ICs, so be sure to follow the appropriate handling procedures for such devices.

The common-anode LED display shown in Fig. 2 is a multiplexed unit containing three or more digits. It can be purchased new or surplus, or can even be salvaged from a defective pocket calculator. I've not included pin numbers because many different types of displays are available. You can even make your own multiplexed display by connecting together the segments of three individual common-anode readouts. The common anodes of each display are connected to driver transistors *Q1, Q2* and *Q3*. These transistors are switched on and off in rapid sequence by *digit select* (*DS*) outputs 1, 2 and 3 of the MC14553B at a multiplex frequency determined by the value of *C1*.

If you prefer, you can use common-cathode readouts. The circuit described in the next section and shown schematically in Fig. 3 incorporates the appropriate modifications.

Current through the LED segments is limited by resistors *R1* through *R7*. It's important to restrict the amplitude of this current to a *maximum* of 10 mA. A convenient formula for determining the values

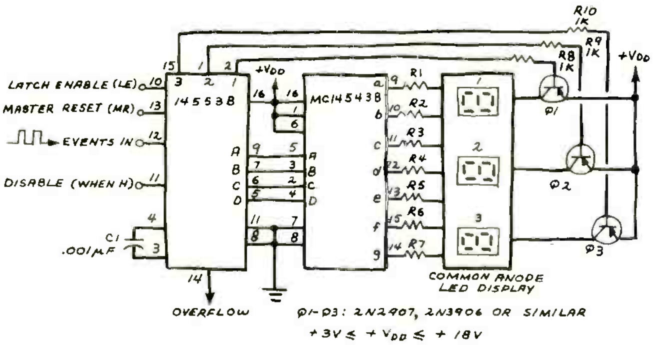


Fig. 2. Schematic diagram of a three-digit event counter using common-anode LED display.

of *R1* through *R7* for a segment current of 10 mA is: $R = 100 \times (+V_{DD} - 2)$. If $+V_{DD}$ is supplied by a 9-volt battery, for example, then *R1* through *R7* should be 700 ohms each. A more convenient value, 1000 ohms, will limit the forward current to 7 mA per segment, enough to provide ample display brightness for most applications.

Six-Decade Event Counter. Two or more MC14553Bs can readily be cascaded to provide additional decades of counting. Figure 3 illustrates how easy it is to double the number of decades of the basic event counter that we just discussed. As you can see by comparing the two circuits, the 6-decade counter is actually two 3-decade counters in series. Two convenient simplifications are that only one multiplex oscillator capacitor is required and that the digit-select transistors for one stage also control the displays of the second stage.

Note that the circuit in Figure 3 is designed to drive *common-cathode* displays, not common-anode displays as used in Fig. 2. You can use common-anode readouts by following the display configuration shown in Fig. 2. There are three significant differences between the two circuits resulting from the use of different displays. Pin 6 of the MC14543B is connected to ground instead of $+V_{DD}$ when common cathode displays are used. Also, npn digit-select transistors are employed, not pnp devices. Finally, the emitters of these digit-select transistors must be connected to ground, not $+V_{DD}$.

Frequency Counter. Figure 4 shows a network that can be connected to the 6-decade event counter to convert it into a frequency counter. This network consists of a crystal-controlled timebase employing an MM5369 IC oscillator/divider and four NAND gates. The MM5369 generates a 60-Hz pulse train when it is connected to a readily available 3.579545-MHz color-television crystal and a few passive components. A 4017 CMOS decade counter connected as a divide-by-six counter divides the output of the MM5369 into a 10-Hz signal. An additional 4017 connected as a divide-by-ten counter divides the 10-Hz output of the first counter into a 1-Hz pulse train. The frequency of a counter's timebase determines the resolution of that counter. For example, a 10-Hz timebase samples the accumulated count and updates the display ten times each second, but this means that the frequency shown on the display is only one tenth of the actual frequency. A 1-Hz timebase causes the readout to be updated only once each second, but the displayed frequency is the actual frequency of the input signal.

Both the timebase and the input signal whose frequency is to be counted are applied to a control circuit made up of all four gates in a 4011 CMOS quad NAND gate. One gate allows the input signal to reach the counter during each timebase cycle. A second gate is connected as a half-monostable which activates the *Latch Enable* input of the counter. This results in the storage of the total count accumulated during one timebase period. The remaining two gates strobe the *Master Reset* input of the counter after each counting interval to clear the counters prior to the next count cycle.

The accuracy of the frequency counter is of course dependent upon the accuracy of the timebase oscillator. National Semiconductor, the manufacturer of the MM5369 suggests capacitance values of 30 pF for *C1* and 6.36 pF for *C2*. For best results, use a small trimmer capacitor (0-to-30-pF or similar) for *C2*. Carefully adjust it until the output frequency at pin 7 of the MM5369 is 3.579545 MHz.

You'll need a frequency counter of known accuracy for this calibration procedure. If you don't have one, a polite request directed to a college electrical engineering department or an electronics repair shop might result in permission to use a counter for the few minutes it takes to adjust *C2*. Incidentally, you can use a "gimmick" capacitor consisting of two lengths of twisted wrapping wire for *C2*. Start with a 2-inch length and carefully trim short bits from the free end of the twisted pair until the correct frequency is obtained.

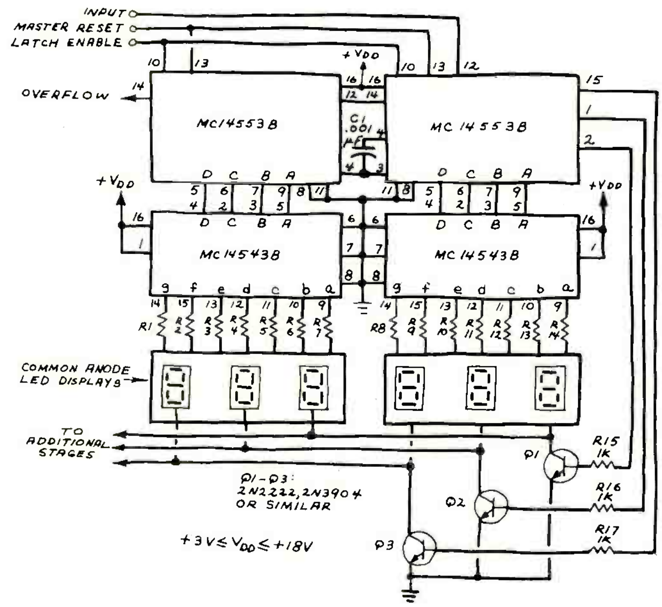


Fig. 3. Circuit for a six-digit event counter made from cascaded MC14553Bs.

There's an alternative procedure you can follow to adjust the counter's timebase. It requires a 100-kHz or 1-MHz crystal-controlled oscillator whose output is rich in harmonics (such as a crystal

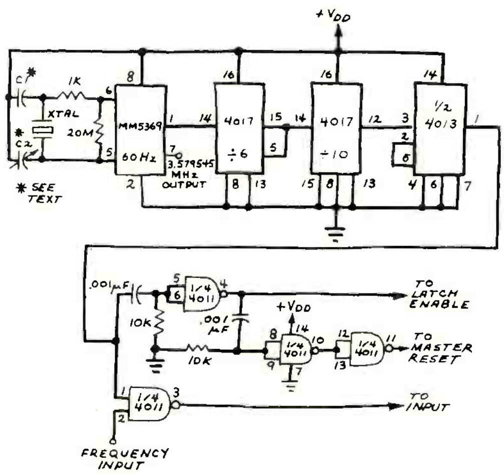


Fig. 4. A time-base network added to a six-decade event counter to convert it into frequency counter.

calibrator designed for communications applications) and also requires a shortwave receiver capable of receiving the National Bureau of Standards radio station WWV or WWVH. During an interval when no audio tones modulate the station's carrier, zero beat the oscillator against the carrier. Then couple a portion of the oscillator's output to the input of the frequency counter, verifying that zero beat is maintained. (A signal-conditioning input circuit might be needed to square up the output of the oscillator to CMOS-compatible levels.) Finally, adjust *C2* so that the counter displays the nominal output frequency of the oscillator. Make sure that the oscillator remains in zero beat with WWV's carrier while you adjust *C2* for the proper readout on the circuit's LED display. ◇

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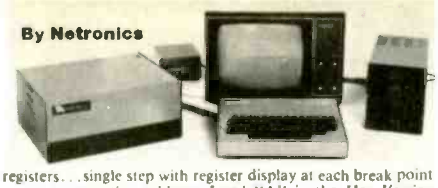

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System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at F000 leaving 0000 free for user RAM/ROM. Features include tape load with labeling...tape dump with labeling...examine/change contents of memory ...insert data...warm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

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Hex Keypad/Display.

Hex Keypad/Display Specifications

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Explorer/85 with Level "C" card cage.

Level "C" Specifications

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

Level "D" Specifications

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Level "E" Specifications

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

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Video Output: *1.5 P/P into 75 ohm (EIA RS-170)* • **Baud Rate:** *110 and 300 ASCII* • **Outputs:** *RS232-C or 20 ma. current loop* • **ASCII Character Set:** *128 printable characters—*

BAUDOT Character Set: *A B C D E F G H I J K L M N O P Q R S T U V W X Y Z - ? : • 3 $ # ( ) . , 9 0 1 4 ! 5 7 ; 2 / 6 8* • **Cursor Modes:** *Home, Backspace, Horizontal Tab, Line Feed, Vertical Tab, Carriage Return. Two special cursor sequences are provided for absolute and relative X-Y cursor addressing* • **Cursor Control:** *Erase, End of Line, Erase of Screen, Form Feed, Delete* • **Monitor Operation:** *50 or 60Hz (jumper selectable.*

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Product Test Reports

Grundig Satellit 3400 Professional Communications Receiver

GRUNDIG's highly versatile Satellit 3400 Professional portable all-wave receiver can tune the full AM frequency range from 145 kHz to 30 MHz (excluding the i-f range between 420 and 510 kHz) and the 87.5-to-108-MHz FM band. Tuning is accomplished in 13 separate general-coverage bands, plus eight shortwave bandspread ranges.

Supplementing conventional analog tuning scales is a digital numeric display that operates from a built-in counter. The receiver also has a separately powered, quartz-controlled digital clock with a day (in German)/date/time LCD display. Hours, minutes, and seconds are displayed in a 24-hour format. Power for the receiver can be obtained from six built-in D cells, 117- or 230-volt 50/60-Hz power line, or any 10-to-16-volt dc source, such as an automobile battery.

Housed in a black plastic case with contrasting markings, the receiver comes with a fully retracting telescoping whip antenna that extends to about 57" (1440 mm). Overall size is 20.3"W × 11.7"H × 5.5"D (516 × 297 × 140 mm) and weight is 19.6 lb (8.9 kg), less batteries. Suggested price is $1350.

General Description. The receiver has three rectangular tuning dials, each with its own knob, and a central grouping of tuning/battery-condition meter, digital clock, and digital frequency display with ½" (12.7-mm) red LED numerals. An elliptical speaker with a switchable coaxial tweeter is built in.

Most of the operating controls are grouped along the bottom of the front panel along with a headphone jack (for miniature phone plug). The bass and treble controls give their flattest response when set fully clockwise. Power, dial/meter/clock illumination (which can be defeated when operating from internal battery), and auxiliary tweeter are controlled by lever switches. A separate three-position lever switch controls the frequency-counter circuits, which can also be defeated to conserve batteries. Pressing downward against a return spring turns on the counter momentarily to allow checking of the tuned frequency. When ac line power is used, the lights and counter are in operation any time that the receiver is on.

Other lever switches control the bfo for CW and SSB reception and an automatic noise limiter (anl). Three knobs to the right of these switches are used for CW/SSB reception. One is the r-f gain control, which switches on the agc when rotated fully clockwise. The second is a selector for upper and lower sidebands. The last is a bfo pitch control for vernier tuning of CW and SSB signals. It does not affect the frequency-counter reading.

A large recessed knob turns the band-switching coil turret for bands SW3 through SW10. The dial scale for the selected band appears behind the lowest window on the front panel. There are general-coverage and bandspread (fine-tuning) scales for each band. A lever switch allows selection of either. The middle dial has four fixed scales for longwave (LW), broadcast (MW), SW1, and SW2 band reception. The last two bands cover the range from 1.6 to 5.2 MHz. An additional lever switch chooses any of three different audio bandwidths for AM and SW reception. There is also a trimmer control for use with a mobile antenna.

The uppermost of the three dials contains only the FM and a second scale labelled for the FM channels used in Germany. Nearby switches cut the FM afc in and out and switch the tuning meter to its battery-check mode.

A handle for carrying the receiver extends across the top and folds flat when not in use. Beneath it are a number of square pushbuttons. Six are for selecting preset FM channels, tuned by means of six small knobs on the back of the receiver. The digital frequency display can be used in tuning the presets. Two other buttons operate the range selectors for FM (tunable), SW3 through SW10 (individually selectable by the knob on the side of the receiver), SW2, SW1, MW, and LW. Another button can select a PHONO/TAPE input from an external high-level source through a DIN socket. The last button connects the antenna inputs to rear jacks instead of the built-in antennas, a telescoping whip for most ranges (including FM) and a ferrite rod for the LW and MW bands.

Recessed into the back of the receiver are terminals for external long-wire, 300-ohm FM, and standard car antennas. There is also a DIN socket for the PHONO/TAPE input. A group of sockets and switches near the bottom accept any of the power sources for which the receiver is designed, and there is a covered compartment for storing the ac line cord when operating on battery power. A small DIN speaker socket can be used to drive an external 4-ohm speaker; it disables the internal speaker when a plug is inserted. The front-panel headphone jack is connected to the same point in the circuit and also silences the speaker when phones are used. Holes are provided in the bottom of the cabinet to bolt the receiver down for use in a vehicle.

Laboratory Measurements. The only electrical performance rating given for the Satellit 3400 is audio output power, specified at 2.5 watts with battery and 5 watts with ac-line operation. We connected the receiver to an external 4-ohm load and drove it through its PHONO/TAPE socket to test its audio operation. Distortion at 1000 Hz was 0.14% at 0.1 watt output, 0.18% at 1 watt, and 0.28% at 4 watts. Output clipping occurred at 4.4 watts, where distortion was only 0.4%. An input signal of 0.225 volt was needed to drive the amplifier to a 1-watt reference output.

The frequency response of the audio amplifier, with the tone controls fully clockwise, was 80 to 20,000 Hz ±2 dB, falling off at about a 9-dB/octave rate below 80 Hz. With the controls fully counterclockwise, the response rolled off steeply below 300 and above 2000 Hz. A-weighted output noise at maximum gain was 71.2 dB below 1 watt.

Frequency response on AM with NARROW audio bandwidth was within ±3 dB from 85 to 1000 Hz. It fell off at about a 20-dB/octave rate above 1500 Hz. With MEDIUM and WIDE bandwidths, there was a 10-dB response peak at 130 Hz, and the output fell to −6 dB, relative to the 1000-Hz response, at 35 Hz and at 2500 and 3500 Hz at the high end. We did not measure the FM frequency response, as there was no convenient way to separate it from the audio response.

Minimum FM distortion was about 3%, and IHF usable sensitivity was 45 to 50 dBf (100 to 350 microvolts). Distortion was largely third harmonic, reflecting insufficient bandwidth in the i-f and detector circuits. The spectrum analyzer photo shows the tuner's output with a 65-dBf (1000-microvolt) signal modulated 100% with a 1000-Hz signal.

Reducing the FM modulation levels reduced distortion substantially, down to 0.83% at 50% modulation and 0.37% at 25%. These levels are more typical of actual operation, as FM stations approach 100% modulation only on occasional program peaks.

Unweighted FM S/N at a 65-dBf input measured 52 dB. The 6-dB capture ratio and high distortion represent a tradeoff for the excellent selectivity which averages 69 dB with 400-Hz alternate-channel spacing and 19.7 dB with 200-kHz adjacent-channel spacing. Image rejection was a modest 54 dB, but AM rejection was a fine 68 dB. The afc system reduced tuning errors by a factor of three. Counter accuracy, ±1 kHz on AM, ±10 kHz on FM, was more than adequate.

User Comment. The digital frequency display, which functions on all bands, is a great convenience in tuning. One soon learns to use it and not the tuning-dial scales.

Once one becomes familiar with basic operation, this is an easy receiver to use. Judging from what we heard on the various short-wave bands, its sensitivity with the built-in antenna is adequate for general SWL purposes, and the frequency counter makes it possible to pretune a known station with some assurance of hearing it.

Setting the clock is rather tricky. We found a couple of display modes not mentioned in the manual and which seem to bear no relation to the normal time display, although they were mostly numerical. As far as we can tell, this is nothing to worry about. In its conventional modes, the clock can be removed and used as a separate unit.

The sound quality of the FM section was excellent and outdistanced the lab performance, especially when the built-in tweeter was used. The volume too was surprisingly loud. In our suburban location, sensitivity was more than adequate with the telescoping antenna on both FM and AM. Electrical noise made the longwave band useless at our location, but the shortwave bands were well populated with signals at most times. The anl was effective for some types of noise.

Amateur-band reception was less impressive. The receiver simply does not have the slow tuning, stability, or selectivity needed for ham SSB and CW operation. We experienced a "rubbery" feel when we tried to tune SSB signals, and the SSB bfo vernier was of limited value. Lacking a product detector, the receiver can be tuned to SSB only by cranking up the audio gain and using the r-f gain control volume—which disables the agc.

Our overall reaction to the Satellit 3400 was amazement that it managed to do so many things at least passably well. To be sure, it has shortcomings that may seem disappointing in such an expensive receiver, but it offers in exchange a versatility far beyond anything we have ever seen in a comparable package. Our guess is that the owner of a boat, trailer, or RV will find the universal receiving capability of the Satellit 3400 to be just what he needs for entertainment and information during his travels.

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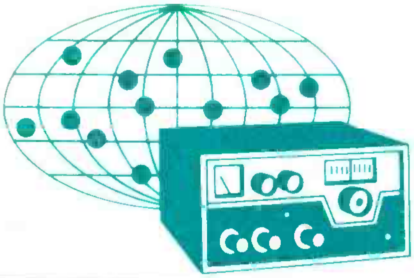


DX Listening

By Glenn Hauser

SELECTED SHORTWAVE PROGRAMS

THOUGH WE usually deal in this column with news developments and transmission schedules, programming is really what shortwave broadcasting is all about. So this month, condensed from the pages of *Review of International Broadcasting* (University Radio WUOT, Knoxville, TN 37916), we present a selection of some of the best programming on radio (primarily shortwave, but some widely heard AM-band items). Times are strictly GMT so, for example, in the EST zone, a program listed at 0030 Saturday would be heard *Friday* at 7:30 p.m. Frequencies shown are not the only ones, but those that are known or believed to give the best reception as of press time.

BBC information is correct as of January, but evolves month-to-month as programme series go and come. Complete *BBC* schedules in advance are provided in *London Calling* (a sample copy is free; a year's subscription is $10) from *BBC*, 630 Fifth Ave., New York, NY 10020.

Programs all in caps in the list are the cream of the cream, in our opinion. Most stations stay on GMT year-round, but AFRTS times shift to an hour earlier of real time the last Sunday in April. The same holds true for domestic CBC programs, but major changes are expected as of March 31. *Radio New Zealand* programs shift to an hour later the first Sunday in March.

SATURDAY

0030-0100 CBC: "FRIDAY NITE THEATRE" 11710, 5960, 740
0110-0125 Australia: "Pick Of The Week" 21740, 17795
0115-0125 RCI: "Mailbag" 5960, 11830, 11940
0125-0140 Prague: "Cultural Report" 7345, 5930, 11990
0140-0155 Australia: "Science Week" 21740, 17795
0145-0159 BBC: "South Asia Survey" 9410 only
0145-0159 BBC: "King Of Instruments" 7325, 6175, 5975
0215-0225 RCI: "Mailbag" 5960, 11845, 11940
0215-0245 RSA: "Panorama/Talking Point/New Nations" 15220, 11900, 15155, 17780
0223-0228 Budapest: "INSIDE HUNGARY" 9835, 9585
0225-0235 Cairo: "Scene From Egypt" 12050, 9475
0230-0259 BBC: "The Lady of the Camellias" 9410, 7325, 6175, 6120, 5975
0240-0255 Australia: "Club Forum" 21740, 17795
0309-0324 Holland: "Focus" 9590, 6165
0310-0325 RCI: "Mailbag" 5960, 9535, 11770, 11845, 11940
0310-0330 Portugal: "Mailbag/DX/Stamps" 11925, 6025
0323-0328 Budapest: "INSIDE HUNGARY" 9835, 9585
0335-0359 BBC: "Week In Africa" 11860, 17885
0340-0350 Prague: "Cultural Report" 7345, 5930, 11990
0340-0355 Australia: "This Australia" 17795
0400-0415 Budapest: "Calling Dxers" 9835
0410-0425 RCI: "Mailbag" 5960, 11770, 11845
0430- RNZ: "Pacific Newsletter" 17860, 15345
0435-0450 Sofia: "DX Program" 7115, 9765
0440-0455 Australia: "Book Serial" 17795
0500-0515 Nigeria: "Hilife Music" 7255
0510-0530 Portugal: "Mailbag/DX/Stamps" 6025, 11925
0515-0530 Nigeria: "W African Scene" 7255
0530-0544 BBC: "King Of Instruments" 9510, 6175, 5975
0605-0700 WGN: "Friday Night Highlight" 720
0609-0624 Holland: "Focus" 9715, 6165
0630-0659 BBC: "Command Performance" 9510, 9410, 6175
0630-1000 RNZ: "Saturday Scrapbook" 6105
0715-0729 BBC: "From the Weeklies" 9510, 6175
0730-0744 BBC: "Music from Scotland" 11955, 9640, 9510
0740-0755 Australia: "Week In Science" 9670, 9570
0815-0829 BBC: "Peers Of The Realm" 9510
0819-0824 Holland: "Stamp Corner" 9770, 9715 (alt. weeks)
0840-0855 Australia: "Club Forum" 9670, 9570
0919-0924 Holland: "Stamp Corner" 9715 (alt. weeks)
1110-1125 Australia: "Pick Of The Week" 9580
1115-1124 BBC: "New Ideas" 25650, 11775
1115-1300 Perth: "SENTIMENTAL JOURNEY" 9610
1124-1129 BBC: "Week in Wales" 25650, 11775
1140-1155 Australia: "Profile" 9580
1215-1244 BBC: "Jazz for the Asking" 25650, 21710
1224-1238 DW: "Science Magazine" 21600
1230-1255 Peking: "Music From China" 9820
1240-1255 Australia: "AUSTRALIAN INVENTOR" 9580
1245-1259 BBC: "Pedagogical Pop" 21695
1300- Perth: "Orchestral Concert" 9610
1321-1344 SRI: "TALKBACK/MERRY GO ROUND" 21570
1345-1359 BBC: "House At Pooh Corner" 25650, 21710
1400-1428 Sweden: "SATURDAY SHOW" 21615
1435-1442 AFRTS: "Spectrum" 11805, 9700, 15330, 15430
1430-1500 VOA: "New York, New York" 9565, 11715
1449-1459 AFRTS: "TAKE TEN" 11805, 9700, 15330, 15430
1459-1529 BBC: "THIS WEEK IN AFRICA" 17695
1517-1526 AFRTS: "Wallace & Rather" 15330, 11805, 15430
1519-1524 Holland: "Stamp Corner" 21480, 17855 (alt.)
1530-1615 NSB: "Tokyo Forum Get-Together" 9595
1535-1559 AFRTS: "WORLD OF RELIGION" as above
1536-1559 SRI: "TALKBACK/MERRY GO ROUND" 21570
1611-1630 VOA: "Africa In Print" 15410
1630-1659 CBC NS: "Comedy/Satire" 11720, 9625
1630-1700 VOA: "New York, New York" 21485, 15410
1635-1659 AFRTS: "Special Assignment" 15430, 15330
1705-1759 CBC: "QUIRKS & QUARKS" 11720, 9625
1711-1722 AFRTS: "Paul Harvey" 15430, 15330
1811-1830 RMWS: "Science & Engineering" 11860, 12060, 12010
1830-1859 VOA: "New York, New York" 21590, 15140
1835- AFRTS: "PROGRAM NOTES" 17765, 15430, 15330 (often pre-empted)
1911-1930 VOA: "Voices Of Africa" 15410
1914-1919 Holland: "Stamp Corner" 17605 (alt. weeks)
2035-2059 AFRTS: "World Of Religion" 17765, 15430
2045-2114 BBC: DOCUMENTARIES 17830, 15260, 11750
2111-2122 AFRTS: "Paul Harvey" 17765, 15430, 15330
2114-2119 Holland: "Stamp Corner" 21640, 17695 (alt.)
2115-2145 RSA: "Touring/Sat Nite/DX" 17780, 15155
2130-2200 HCJB: "DX Party Line" 21480, 17885
2133-2200 RMWS: "JUST FOR FUN" 11860, 7390
2135-2155 Turkey: "DX Corner" 11955, 9515
2135-2155 RCI: "Bonsoir Africa" 17820, 15325, 15150, 11945
2135-2159 AFRTS: "Special Assignment" 21570, 17765
2145-2159 BBC: "Pedagogical Pop" 15395, 11820
2145-2159 BBC: "FROM OUR OWN CORRESPONDENT" 15260, 11750, 9410
2215-2230 Turkey: "Letterbox" 11955, 9515
2230-2239 BBC: "New Ideas" 15260, 11750, 9410
2235-2255 Turkey: "Classical Music" 11955, 9515
2300-2328 Sweden: "Saturday Show" 11705, 9695
2315-2329 BBC: "LETTERBOX" 9590, 9410, 7325, 6175
2325-2335 Moscow: "DX Program" 9490
2325-2345 Italy: "Tunes to Whistle" 9570, 11800
2330-2359 BBC: "Jazz for the Asking" 9590, 9410, 7325, 6175
2350-2400 DW: "DX Program" (2nd week) 9700, 9735

SUNDAY

0005-0035 Japan: "HELLO AMERICA" 17825, 15270
0015-0030 Moscow: "Mailbag" 9490
0030-0058 Sweden: "Saturday Show" 11905
0030-0100 DW: "Music" 15410
0030-0130 BBC: "PLAY OF THE WEEK" 6175, 5975 or 0200
0125-0135 Moscow: "DX Program" 9490
0135-0159 WBBM: "NEWSMARK" (last Sat. of mo.) 780
0130-0159 AFRTS: "Communique" 25615, 21570, 6030
0135-0155 Peking: "Music From China" 17680, 15520
0135-0155 Prague: "Sat Nite Jukebox" 7345, 5930, 11990
0140-0147 DW: "GERMANY THIS WEEK" 6145, 6040
0140-0155 Australia: "MAILBAG =1" 17795, 21740
0150-0220 Japan: "HELLO AMERICA" 21640, 17825
0151-0214 SRI: "TALKBACK/MERRY GO ROUND" 11715, 15305, 9725, 6135
0211-0220 AFRTS: "Safer & Wallace" 6030
0212-0220 Australia: "LETTERS TO ED." 21740, 17795
0213-0220 Budapest: "DXer Weekend" 9835, 9585
0215-0230 Moscow: "Mailbag" 9490
0215-0245 RSA: "Touring/Satnite/DX" 11900, 15220, 15155, 17780
0225-0235 Egypt: "US In Egyptian Press" 9475, 12050
0230-0300 HCJB: "DX Party Line" 11910, 15115, 9745
0230-0258 Sweden: "Saturday Show" 11705, 9695
0235-0239 AFRTS: "DATELINE AMERICA =1" 6030, 17765, 21570
0235-0255 Peking: "Music From China" 17680, 15600
0312-0325 Australia: "REPORT FROM ASIA" 21740
0313-0320 Budapest: "DXer Weekend" 9835, 9585
0315-0329 BBC: "FROM OUR OWN CORRESPONDENT" 9410, 7325, 6175, 5975
0325-0335 Moscow: "DX Program" 9490
0319-0324 Holland: "Stamp Corner" 9590, 6165 (alt. Weeks)
0330-0359 BBC: "Command Performance" 9410, 6175, 5975
0335-0359 AFRTS: "LISTEN CLOSELY" 6030, 17765, 21570
0335-0359 BBC: "African Perspective" 11860, 17885
0335-0355 Prague: "Sat Nite Jukebox" 7345, 5930, 11990
0340-0359 RA: "AUSTRALIAN INVENTOR" 17795
0350-0400 DW: "DX Program" (2nd Sat.) 6145, 6085
0425-0435 Moscow: "DX Program" 12050
0430-0500 DW: "Music" 6145, 9735
0436-0459 SRI: "TALKBACK/MERRYGOROUND" 9725, 11715
0445-0454 BBC: "New Ideas" 9510, 9410, 6175
0500-0515 Nigeria: "The Evergreens" 7255
0508-0559 CBC: "Best Of Radio Noon" 9625, 6195, 740
0508-0559 CBM: "ARMCHAIR TRAVELLER" 940
0515-0529 BBC: "LETTERBOX" 9510, 9410, 6175
0515-0530 Moscow: "Mailbag" 12050
0515-0530 Nigeria: "Week In Africa" 7255
0530-0544 BBC: "Sounds That Sold a Million" 9510, 9410, 6175
0540-0547 DW: "GERMANY THIS WEEK" 6185, 5960
0545-0559 BBC: "LETTER FROM AMERICA" 9510, 9410, 6175
0619-0624 Holland: "Stamp Corner" 9715, 6165 (alt. weeks)
0625-0635 Moscow: "DX Program" 12050
0630-0659 AFRTS: "Communique" 6030
0715-0729 BBC: "FROM OUR OWN CORRESPONDENT" 9510, 9410, 6175
0730-0744 BBC: "King Of Instruments" 9510

0730-0825 Holland: "Happy Station" 9770, 9715
0737-0755 Australia: "Mailbag =2" 9670, 9570
0745-0759 BBC: "WORLD RADIO CLUB" 9510, 9410
0810-0825 Australia: "REPORT FROM ASIA" 9670, 9570
0830-0925 Holland: "Happy Station" 9715
1100-1130 SLBC:: "Radio Monitors Int'l" 11835
1115-1129 BBC: "LETTER FROM AMERICA" 25650, 11775
1115-1130 VOA: "New Horizons" 9565, 11715
1130-1157 Perth. "MY MUSIC" 9610
1130-1230 BBC: "Play Of The Week" 21710, 25650
or-1300
1140-1155 Australia: "The Body Program" 9580
1200- Perth. "Play Break" 9610
1210-1225 Australia: "REPORT FROM ASIA" 9580
1211-1230 RMWS: "DX Program" 9600
1215-1226 Tashkent: "DX Club (2nd week of mo.) 11785, 9540, 6025
1215-1300 VOA: "Concert Hall" 9565, 11715
1230-1300 RMWS: "JUST FOR FUN" 9600
1230-1255 ORF: "Austrian Musical Trip" 17860
1240-1255 Australia: "MAILBAG =1" 9580
1307-1328 VOA: "New Products/Critics Choice" 9565, 11715
1315-1329 BBC. "FROM OUR OWN CORRESPONDENT" 25650, 21710, 11775
1320-1345 SRI: "Documentaries/Jazz" 21570
1330-1359 CBCNS: "Food Show" 9625
1330-1400 VOA: "Studio One" 9565, 11715
1335-1359 AFRTS: "Voices In Headlines" 9700, 11805, 15330, 15430
1400-1428 Sweden: "Mailbag" 21615
1405-1659 CBCNS: "SUNDAY MORNING" 11720, 9625
1430-1445 Indonesia: "Mailbag" 11789, 15200
1430-1459 BBC. "The Small, Intricate Life of Gerald C. Potter" 25650, 21710
1430-1525 Holland: "Happy Station" 21480, 17855
1440-1500 Finland: Various Features 21475, 15400
1435-1459 AFRTS: "Speaking Of Everything" 11805, 9700
1459-1529 BBC: "AFRICAN PERSPECTIVE" 17695
1515-1559 BBC: "Concert Hall" 25650, 21710, 17830, 15260
1535-1559 AFRTS: "PERSPECTIVE =1" 15330, 11805, 9700, 15430
1535-1559 SRI: "Documentaries/Jazz" 21570
1600-1615 Korea: "Week In Review" 11830, 9720
1611-1630 VOA: "Voices Of Africa" 21485, 15410
1615-1644 BBC: "Science in Action" 25650, 21710, 17830, 15260
1630-1700 VOA: "Studio One" 21485, 15410
1635-1659 AFRTS: "PERSPECTIVE =2" 15330, 11805, 15430
1645-1659 BBC: "LETTER FROM AMERICA" 25650, 21710, 17830, 15260
1715-1730 France: "BOX 9516" 21620, 21580, 17860
1715-1742 BBC: "My Music" 21710
1730-1800 VOA: "Studio One" 15195
1734-1757 VOA: "African Scientists" 21485, 15410
1730-1759 AFRTS: NBC Special 15330, 15430
1805-1829 CBCNS: "ROYAL CANADIAN AIRFARCE" 11720, 9625
1807-1821 RCI: "DX DIGEST 1 & 2" 17820, 15260
1811-1830 RMWS: "Roundabout The USSR" 12060, 12010, 11860
1830-1920 Holland: "Happy Station" 17605
1830-1900 VOA: "MUSIC TIME IN AFRICA" 15410
1835-1859 AFRTS: "Voices In The Headlines" 17765
1907-1927 RCI: "Bonsoir Africa" 17820, 15260
1907-1927 RCI: "Mailbag & DX Digest =1" 15325, 17760, 11905
1913-1928 VOA: "New Horizons" 15140
1935-1959 AFRTS: "Speaking Of Everything" 17765
2007-2027 RCI: "Mailbag & DX Digest =2" 15325, 17820, 17760, 11905
2010-2030 Israel: "Calling Listeners & DX" 11655
2015-2029 BBC: "LETTERBOX" 17830, 15260, 11750
2030-2120 Holland: "Happy Station" 21640, 17695, 17605
2034-2057 VOA: "African Scientists" 21485, 15410
2035-2059 AFRTS: "Perspective =1" 17765, 15430, 15330
2100-2114 BBC: "WORLD RADIO CLUB" 17830, 15260, 11750, 9410
2108-2128 VOA: "NEW PRODUCTS & CRITICS CHOICE" 15410
2130-2200 VOA: "Studio One" 15410
2135-2155 RCI: "Accent" 17820, 15325, 15150, 11945
2135-2150 Sofia: "DX Program" 9665, 7115, 9765, 5915

2135-2159 AFRTS: "Perspective #2" 17765, 15430, 15330
2200-2230 Norway: "This Week" 15175
2209-2238 BBC: "Science in Action" 15260, 11750, 9410
2209-2244 BBC: "Calling Falklands" 12040, 9915
2215-2300 VOA: "Concert Hall" 21485, 21660
2230-2259 AFRTS: NBC Special 17765, 15430, 15330, 21570
2240-2300 Israel: "CALLING LISTENERS/DX" 11637½, 9815
2245-2255 Turkey: "Folk Music" 11955, 9515
2245-2300 Belgium: "DX Corner" (2nd & 4th) 11715, 15175
2300-2328 Sweden: "Mailbag" 11705, 9695
2305-2320 ORF: "SW PANORAMA" 12015, 9770, 5945
2315-2325 Cairo: "Egypt A-Z" 9805
2315-2329 BBC: "LETTER FROM AMERICA" 9590, 9410, 7325, 6175

MONDAY

0006-0030 WCKY: "NEWSMARK" (after last Sat. of month) 1530
0015-0030 VOA: "CRITICS CHOICE" 9640, 6130, 11740, 15205, 17730
0015-0030 Moscow: "Mailbag" 9490
0030-0058 Sweden: "Mailbag" 11905
0030-0055 Prague: "Classical Concert" 6055
0040-0055 Belgium: "DX Corner" (2nd & 4th Sun.) 11715, 15175
0050-0105 Spain: "CQ CQ" 11880, 9630
0100-0144 BBC: "Concert Hall" 9410, 7325, 6175, 5975
0109-0129 VOA: "NEW PRODUCTS & HORIZONS" 6130, 17730, 15205, 11740, 9640
0118-0126 RCI: "DX DIGEST #3" 5960, 11830, 11940
0130-0200 VOA: "Studio One" 9640, 6130, 11740, 15205, 17730
0130-0155 ORF: "Profile/Post Box 700" 9770, 5945
0135-0147 DW: "Mailbag" (irregular) 6145, 6040
0150-0214 SRI: "Documentaries/Jazz" 6135, 9725, 11715, 15305
0200-0230 Norway: "This Week" 9590
0200-0230 KSTP: "ALIEN WORLDS" 1500
0211-0229 AFRTS: "Collingwood/Wallace/This Week" 6030
0215-0229 BBC: "Nature Notebook" 7325, 6175, 5975
0215-0230 Moscow: "Mailbag" 9490
0218-0226 RCI: "DX Digest #4" 5960, 11845, 11940
0230-0300 WHO: "Voice Of Southeast Asians" 1040
0230-0300 WGST: "ALIEN WORLDS" 920
0230-0258 Sweden: "Mailbag" 11705, 9695
0230- Colombia: "Colombian Composers" 15335
0230-0325 Holland: "Happy Station" 9590, 6165
0235-0239 AFRTS: "DATELINE AMERICA #2" 6030, 17765, 21570
0300-0330 ORF: "Folk Music" 5945, 9770
0303-0310 Brazil: "Weekly News Review" 15290
0310-0330 Budapest: Documentaries 9835, 9585
0315-0329 BBC: "Peers Of The Realm" 7325, 6175, 5975
0318-0326 RCI: "DX DIGEST #1" 5960, 9535, 11770, 11845, 11940
0330-0355 ORF: "AUSTRIAN MUSICAL TRIP" 5945, 9770
0335-0359 AFRTS: "Face The Nation" 6030, 17765, 21570
0400-0430 Budapest: "History Of Hungary" 9835, 9585
0400- "La Hora De Mexico" 540, 730, 900, 1050, 15430
0418-0426 RCI: "DX Digest #2" 5960, 11770, 11845
0430-0455 ORF: "Profile/Post Box 700" 15260
0435-0459 AFRTS: "Meet The Press" 6030, 15330, 17765
0435-0450 Sofia: "DX Program" 7115, or 9765
0445-0450 BBC: "NOTES FROM AN OBSERVER" 6175, 5975, 9410
0440-0455 RHC: "Philately In Cuba" 11760
0500-0530 Nigeria: "Cavalcade" 7255
0500-0600 WOR: "HEYWOOD HALE BROUN" 710
0511-0530 Moscow: "Mailbag" 12050
0530-0555 ORF: "Homeland Melodies" 15260
0530-0544 BBC: "Taken At The Flood" 9510, 9410, 6175
0530-0625 Holland: "Happy Station" 9715, 6165
0535-0559 AFRTS: "Issues & Answers" 6030, 15330
0600-1000 WOR: "Night Talk" 710
0630-0659 BBC: "The Orchestra" 9510, 6175
0749-0824 Holland: "MONDAY PROGRAMME" 9770, 9715
0849-0924 Holland: "MONDAY PROGRAMME" 9715
1035-1059 AFRTS: "Issues & Answers" 6030
1115-1129 BBC: "WORLD RADIO CLUB" 25650, 21710, 11775
1130-1159 BBC: "The Lady of the Camellias" 25650, 21710
1130-1159 VOA: "FORUM" 9565, 11715
1310-1330 FIR: "Voices Of Finland" 15400
1400-1430 BBC: "Into The Eighties" 25650, 21710
1415-1430 VOA: "Making A Nation" 9565, 11715
1430-1445 VOI: "All About Indonesia" 11789
1440-1500 FIR: "Voices Of Finland" 21475, 15400
1449-1519 Holland: "Monday Programme" 21480, 17855
1505-1530 CBCNS: "SOUNDS OF SHORTWAVE" 11720, 9625, (irregular)
1615-1630 Korea: "Listeners Corner" 9720, 11830
1730-1800 VOA: "FORUM" 15195, 15205
1811-1830 RMWS: "Culture And The Arts" 12060, 12010, 11860
1812-1827 VOA: "Making A Nation" 26040, 21485, 15410
1815-1830 Korea: "Listeners Corner" 11830
1915-1930 India: "Mailbag" 11620
1930-2000 VOA: "FORUM" 26040, 21485, 17710, 15445, 15410
2115-2130 India: "Mailbag" 11620
2130-2200 HCJB: "DX Party Line" 21480, 17885
2135-2155 Turkey: "DX Corner" 11955, 9515
2200-2215 Grenada: "Your Radio Doctor" 15045
2215-2245 Turkey: "STROLLING THRU ANATOLIA" 11955, 9515
2315-2329 BBC: "House At Pooh Corner" 9590, 7325, 6175
2330-2359 BBC: "These Musical Islands" 9590, 9410, 7325, 6175

TUESDAY

0015-0030 VOA: "Making A Nation" 9640, 6130, 17730, 15205, 11740
0020-0035 Japan: "1/100,000,000" 17825, 15270
0030-0114 BBC: DOCUMENTARIES 11750, 9410, 7325, 6175, 5975
0104-0129 CBC: "DR BUNDOLO'S PANDEMONIUM" 740, 940
0115-0130 DW: "New LPs" 15410, 9735, 9700
0130-0200 VOA: "FORUM" 17730, 15205, 11740, 9640, 6130
0205-0220 Japan: "1/100,000,000" 21640, 17825
0215-0230 WOWO: "HOLLYWEIRD REPORT" 1190
0230-0257 BBC: "My Word!" 9410, 7325, 6175, 5975
0230-0300 HCJB: "DX Party Line" 11910, 9745, 15115
0235-0245 Cairo: "Life In Egypt" 9475, 12050
0249-0324 Holland: "MONDAY PROGRAMME" 9590, 6165
0300-0330 ORF: "Thru Austria In Music" 5945, 9770
0411-0430 RMWS: "Roundabout USSR" 9490
0505-0530 ORF: "Music For Winds" 15260
0515-0530 DW: "New LPs" 6145, 6085
0549-0624 Holland: "MONDAY PROGRAMME" 9715, 6165
0730-0744 BBC: "House At Pooh Corner" 9510
0815-0845 RNZ: "Spectrum" 6105, 11945
1115-1124 BBC: "LETTER FROM LONDON" 25650, 21710, 11775
1124-1129 BBC: "Scotland This Week" 25650, 21710, 11775
1130-1157 BBC: "Animal, Vegetable or Mineral?" 25650, 21710
1235-1250 Peking: "Music From China" 9820
1310-1330 Finland: "AIR MAIL" 15400
1414-1426 Sweden: "CALLING DXERS" 21615
1440-1500 Finland: "AIR MAIL" 21475, 15400
1611-1630 RMWS: "DX Program" 11860
1615-1629 BBC: "Peers Of The Realm" 17830, 15260
1630-1644 BBC: "Taken At The Flood" 17830, 15260
1830-1900 RMWS: "JUST FOR FUN" 12060, 12010, 11860
2011-2030 RMWS: "Stamps & Hobbies" 12060, 12010, 11860
2030-2114 BBC: DOCUMENTARIES 17830, 15260, 11750, 9410
2115-2159 BBC: "The Pleasure's Yours" 15260, 11750, 9410
2215-2230 Turkey: "Stamps" 11955, 9515
2224-2229 BBC: "Scotland This Week" 15260, 11750, 9410
2314-2326 Sweden: "Calling DXers" 11705
2330-2359 BBC: "Thirty-Minute Theatre" 9590, 9410, 7325, 6175

WEDNESDAY

0030-0100 DW: "Music" 15410
0040-0100 Belgium: "MAILBAG" 11715, 15175
0044-0056 Sweden: "Calling DXers" 11905
0104-0129 CBC: "Playhouse" 740, 940
0115-0130 DW: "Folk Music" 15410, 9735, 9700
0130-0150 Australia: "Indian Film Music" 17795, 21740
0145-0159 BBC: "Taken at the Flood" 7325, 6175, 5975
0130-0158 Budapest: "Hungarian History" 9835, 9585
0135-0155 Peking: "Music From China" 17680, 15520
0145-0159 BBC: "Taken At The Flood" 7325, 6175, 5975
0206-0256 WCAU: "Sears Comedy" 1210
0207-0257 WHAS: "Sears Comedy" 840
0235-0255 Peking: "Music From China" 17680, 15600
0236-0326 WBBM: "Sears Comedy" 780
0240-0250 Cairo: ARAB POETRY" 9475, 12050
0244-0256 Sweden: Calling DXers" 11705, 9695
0305-0315 Cairo: "Islamic World" 9475, 12050
0310-0330 Budapest: "Report" 9835, 5985
0400-0415 Budapest: "Calling DXers" 9835
0411-0430 RMWS: "Stamps & Hobbies" 9490
0430-0444 BBC: "Sounds That Sold a Million" 9410, 6175, 5975
0430-0500 DW: "Music" 6145, 9735
0440-0455 RNZ: Letter From America" 17860, 15345
0500-0530 Nigeria: "Link-Up" 7255
0515-0530 DW: "Folk Music" 9735, 6145, 6085
0530-0544 AFRTS: "SCIENCE EDITOR" 6030, 15330
0530-0544 BBC: "Nature Notebook" 9510, 9410, 6175, 5975
0630-0659 BBC: "Jazz for the Asking" 9640, 9510, 9410, 6175, 5975
0745-0759 BBC: "Report on Religion" 9640, 9510
0745- RNZ: Play 11945, 6105
1030-1044 AFRTS: "SCIENCE EDITOR" 6030
1130-1159 BBC: "Farming World" 25650, 21710
1133-1159 Perth: "ROUND THE HORNE" 9610
1215-1244 BBC: "Thirty-Minute Theatre" 25650, 21710
1230-1257 Perth: "GOON SHOW" 9610
1232-1300 RMWS: "Russian By Radio" 9600
1330-1414 BBC: DOCUMENTARIES 25650, 21710
1415-1429 BBC: "Report on Religion" 25650, 21710
1519-1524 Holland: "Here In Holland" 21480, 17855
1611-1630 RMWS: "Roundabout The USSR" 11860
1615-1644 BBC: DOCUMENTARIES 17830, 15260
1705-1755 "Paris Calling Africa" including "Arts In France" 21580, 17720, 21620
1715-1744 BBC: "The Orchestra" 21710, 15070
1812-1827 VOA: "SPACE AND MAN" 26040, 21485, 15410
2030-2059 BBC: "Into The Eighties" 17830, 15260
2115-2129 BBC: "Nature Notebook" 15260, 11750, 9410
2141-2156 RCI: "DX DIGEST 3 & 4" 15325, 17820, 15150, 11945
2240-2255 Turkey: "Folk Music" 11955, 9515
2315-2329 BBC: "World Radio Club" 9590, 9410, 7325, 6175

THURSDAY

0015-0030 Moscow: "Mailbag" 9490
0015-0030 VOA: "SPACE & MAN" 6130, 9640, 11740, 15205, 17730
0030-0114 BBC: "Radio Theatre" 11750, 9410, 7325, 6175, 5975
0043-0058 Kiev: "DX Club" 7215, 7150
0142-0148 RA: "Postmark Australia" 21740, 17795
0145-0159 BBC: "REPORT ON RELIGION" 7325, 6175, 5975
0215-0230 Moscow: "Mailbag" 9490
0215-0230 Budapest: "Popularity Playbacks" 9835
0230-0259 BBC: "DISCOVERY" 9410, 7325, 6175, 5975
0230-0300 HCJB: "DX Party Line" 11910, 9745, 15115
0235-0245 Cairo: "EGYPTIAN THINKERS" 9475, 12050
0300-0355 Juventud: "Jazz" 4900
0310-0330 Portugal: "Culture" 11925, 6025
0313-0328 Kiev: "DX Club" 7215, 7150
0315-0330 Budapest: "Popularity Playbacks" 9835, 9585
0319-0324 Holland: "Here in Holland" 9590, 6165
0330-0359 BBC: "Into The Eighties" 9410, 6175, 5975
0500-0515 Nigeria: "Cavalcade" 7255
0510-0530 Portugal: "Culture" 11925, 6025
0515-0530 Nigeria: "West Africa Scene" 7255
0515-0530 Moscow: "Mailbag" 12050
0619-0624 Holland: "Here In Holland" 9715, 6165
0715-0730 Moscow: "Mailbag" 12050
0749-0824 Holland: "DX JUKEBOX/HOME NEWS" 9770, 9715
0849-0924 Holland: "DX JUKEBOX/HOME NEWS" 9715
1211-1230 RMWS: "Stamps & Hobbies" 9600
1215-1230 Israel: "STUDIO THREE" 25640

1225-1255 Peking: "CULTURE IN CHINA" 9820
1345-1429 BBC: "The Pleasure's Yours" 25650, 21710
1411-1430 RMWS: "Science & Engineering" 9600
1415-1430 VOA: "Making A Nation" 9565, 11715
1449-1519 Holland: "DX JUKEBOX/HOME NEWS" 21480, 17855
1611-1630 RMWS: "Culture & The Arts" 11860
1615-1644 BBC: "The Lady Of The Camellias" 17830, 15260
1815-1830 VOA: "Making A Nation" 26040, 21485, 15410
1849-1919 Holland: "DX JUKEBOX" 17605
2012-2025 Israel: "Studio 3" 11655
2049-2119 Holland: "DX JUKEBOX" 21640, 17695, 17605, 11730
2115-2120 BBC: "Ulster Newsletter" 15260, 11750, 9410
2120-2129 BBC: "IN THE MEANTIME" 15260, 11750, 9410
2130-2200 HCJB: "DX Party Line" 21480, 17885
2135-2155 Turkey: "DX Corner" 11955, 9515
2215-2240 Turkey: "News Magazine/Music Explained" 11955, 9515
2242-2255 Israel: "STUDIO 3" 11637½, 9815, 7412½
2320-2325 Cairo: "Science In Egypt" 9805

FRIDAY

0015-0030 Moscow: "Science & Engineering" 9490
0015-0030 VOA: "Making A Nation" 9640, 6130, 11740 15205, 17730
0030-0059 BBC: "The Small, Intricate Life of Gerald C. Potter" 11750, 9410, 7325, 6175, 5975
0030-0100 DW: "Music" 15410
0040-0100 Belgium: "MAILBAG" 11715
0115-0130 DW: "Folk Music" 15410, 9735, 9700
0130-0158 Budapest: "Hungarian History" 9835, 9585
0135-0145 Prague: "DX Program" 7345, 5930, 11990
0145-0150 BBC: "Ulster Newsletter" 7325, 6175, 5975
0150-0159 BBC: "IN THE MEANTIME" 7325,6175, 5975
0200-0210 Bucharest: "SKYLARK" 9570
0215-0229 BBC: "Music From Scotland" 7325, 6175, 5975
0215-0230 Moscow: "Science & Engineering" 9490
0230-0259 BBC: DOCUMTARIES 9410, 7325, 6175, 5975
0235-0305 Cairo: "EGYPTIAN SONG & FOLKLORE" 9475
0249-0324 Holland: "DX JUKEBOX & HOME NEWS" 9590, 6165
0300-0330 DRF: "Operetta Concert" 9770, 5945
0300-0355 Juventud: "Jazz" 4900
0305-0315 Cairo: "Stamp Collectors' Club" 12050, 9475
0330-0345 HCJB: "MUSICA DEL ECUADOR" 11910, 9745, 15115
0335-0345 Prague: "DX Program" 7345, 5930, 11990
0411-0430 RMWS: "PROGRAM GUIDE" 9490
0430-0439 BBC: "LETTER FROM LONDON" 9410, 6175, 5975
0430-0500 DW: "Music" 6145, 9735
0500-0515 HCJB: "MUSICA DEL ECUADOR" 6095, 9745, 11915, 15115
0515-0530 DW: "Folk Music" 9735, 6145, 6085
0515-0530 Moscow: "Science & Engineering" 12050
0530-0544 AFRTS: "Meet Author/Newsmaker" 6030
0549-0624 Holland: "DX JUKEBOX & HOME NEWS" 9715, 6165
0611-0630 RMWS: "Science & Engineering" 12010
0630-0700 RMWS: "Russian By Radio" 12010
0715-0730 Moscow: "Science & Engineering" 12050
0809-0824 Holland: "Focus" 9770, 9715
0909-0924 Holland: "Focus" 9715
1030-1044 AFRTS: "Meet The Author/Newsmaker" 6030
1115-1124 BBC: "IN THE MEANTIME" 25650, 21710, 11775
1124-1129 BBC: "Ulster Newsletter" 25650, 21710, 11775
1215-1244 BBC: "These Musical Islands" 25650, 21710
1240-1252 Australia: "LETTERS TO THE EDITOR" 9580
1310-1330 Finland: Documentaries 15400
1330-1414 BBC: "Radio Theatre" 25650, 21710
1411-1430 RMWS: "Stamps & Hobbies" 9600
1415-1429 BBC: "Letterbox" 25650, 21710
1430-1459 BBC: "Command Performance" 25650, 21710
1440-1500 Finlad: Documentaries 21475, 15400
1509-1524 Holland: "Focus" 21480, 17855
1611-1630 RMWS: "PROGRAM GUIDE" 11860
1635-1644 BBC: "New Ideas" 17830, 15260
1811-1830 RMWS: "DX Program" 11860, 12010, 12060
1833-1900 RMWS: "JUST FOR FUN" 11860, 12010, 12060
1904-1919 Holland: "Focus" 17605
1930-2000 RMWS: "Russian By Radio" 11860, 12010, 12060
2011-2030 RMWS: "PROGRAM GUIDE" 11860, 12010, 12060

2115-2145 RSA: "Panorama/Talking Point/New Nations" 21535
2135-2150 Sofia: "DX Program" 9765, 9665, 7115, 5915
2145-2154 BBC: "LETTER FROM LONDON" 15260, 11750, 9410
2150-2200 Free Europe: "COMMENTARY" 11770
2245-2300 UN Radio: "CARIBBEAN MAGAZINE" 11830
2315-2325 Cairo: "Land Of Minarets" 9805
2315-2329 BBC: "FROM THE WEEKLIES" 9590, 9410, 7325, 6175
2330-2357 BBC: "Animal, Vegetable or Mineral?" 9490, 9410, 7325, 6175

MULTI–DAY

0005-0030 Spain: "KALEIDOSCOPE" 11880, 9630
0015-0029 BBC: "Radio Newsreel" 7325, 5975, 9590
0030-0045 Moscow: "USSR NEWS/POZNER" 9490
0030-0100 VOA: "Magazine Show" 6130, 9640, 11740, 15205, 17730, Tu-Sa
0100-0229 AFRTS: "All Things Considered" 6030 Tu-Sa, 21570
0105-0130 Spain: "KALEIDOSCOPE" 11880, 9630
0115-0144 BBC: "OUTLOOK" 7325, 5975 Tu-Sa
0209-0215 BBC: "British Press Review" 7325, 6120, 5975
0215-0230 DW: "Music From Germany" 6145, 6085 Tu-Sa
0230-0245 Moscow: "USSR NEWS/POZNER" 9490
0303-0400 RNZ: "Appt. John Gordon" M-F 17860, 15345
0309-0315 BBC: "News About Britain" 7325, 5975
0315-0329 BBC: "THE WORLD TODAY" Tu-Sa 7325, 5975
0320-0334 CBC: "Booktime" 740, 940 Tu-Sa (EST zone)
0335-0459 CBC: "Mostly Music" as above
0412-0455 Israel: B net light classics 11655
0415-0445 Cuba: Classical Music 640 Tu-Sa
0435-0459 AFRTS: "Cronkite/Reasoner/etc." 6030, 15330 Tu-Sa
0505- WGN: "Great Music From Chicago" 720
0505- WJR: "Night Flight" 760
0508-0800 WSB: "Larry King Show" 750 Tu-Sa
0510-0559 CBC: "ECLECTIC CIRCUS" (EST zone) 740 Tu-Sa
0515-0540 Spain: "KALEIDOSCOPE" 9630, 6065, 11880
0545-0559 BBC: "THE WORLD TODAY" 6175, 9510 Tu-Sa
0610-0659 CBC: "ECLECTIC CIRCUS" (CST zone) 990 Tu-Sa
0635- AFRTS: "PROGRAM NOTES" 6030, 15330 Tu-Sa
1015-1029 Japan: various features 9505
1030-1057 CBL: BBC Comedy 740 M-F
1210-1219 Australia: "International Report" 9580 M-F
1215-1300 VOA: "Music USA Jazz" M-S 9565, 11715
1230-1240 Australia: "Australian News" 9580
1309-1329 BBC: "24 Hours" 11775 M-F
1330-1359 AFRTS: "ABC & CBS News" 9700, 11805 M-Sa
1411-1416 AFRTS: "NEWSBREAK" 9700, 11805, 15330, 15430 M-F
1415-1430 Japan: various features 9505
1435-1442 AFRTS: "Spectrum" 9700, 11805, 15430 M-Sa
1445-1455 Indonesia: Music 11789, 15200
1530-1615 NSB: "Tokyo Forum Gettogether" 9595 M-Sa
1609-1615 BBC: "Commentary" 17830, 15260
1711-1722 AFRTS: "Paul Harvey" 15430, 15330, 11805 M-F
1824-1829 AFRTS: "NEWSBREAK" 17765, 15430, 15330 M-F
1835- AFRTS: "PROGRAM NOTES" 17765, 15430, 15330, 15345 M-Sa
1904-1929 CBCNS: various features 11720, 9625 M-F
1935-1942 AFRTS: "Spectrum" 17765, 15430, 15330, 15345 M-Sa

2009-2029 BBC: "24 Hours" 17840, 15260 M-F
2015-2100 VOA: "Music USA Jazz" 21590, 17785, 15140 M-Sa
2111-2122 AFRTS: "Paul Harvey" 17765, 15430 M-Sa 15330, 15345
2209-2225 BBC: "THE WORLD TODAY" 15260 M-F, 11750, 9410
2215-2230 DW: "Music From Germany" 15410 M-F
2215-2300 VOA: "Music USA Jazz" M-Sa 21485
2230-2259 RCI: "AS IT HAPPENS" 15325, 11925, 9760 M-F
2235-2255 AFRTS: "Cronkite/Reasoner/etc" 21570 M-F
2309-2315 BBC: "Commentary" 15260, 7325, 6175, 5975
2309- Grenada: "OBITUARIES" 15045
2315-2330 Japan: various features 17755
2321-2326 AFRTS: "REST OF THE STORY" 17765, 15330 M-F
2330-2400 Grenada: "Tonight" 15045 not Sun
2330-2459 RCI: "AS IT HAPPENS" 11710, 5960 M-F

Computer Bits

By Leslie Solomon
Technical Director

THE COMPUTER WORLD "OVER THERE"

LAST NOVEMBER, I had the pleasure of attending the Personal Computer World Show that took place in London, England. This three-day computer hobbyist fair had the same "look" as any of the similar computer shows that take place in this country, except that it was slightly smaller, and there were a lot of strange languages being spoken. Visitors came from all over the British Isles, Scandinavia, and the rest of Europe, including some from behind the iron curtain countries, such as Yugoslavia and Poland.

There were about 50 booths on the main floor; and, since the majority of the exhibitors were European representatives of American manufacturers, most of the systems on display were quite familiar to a visitor from the States. In many cases, each booth carried several American devices that were up and running. However, there were a number of excellent hardware systems that were designed and manufactured in Europe, particularly England.

It was interesting to note that there is quite a market for standards conversion and NTSC monitors. This is a result, of course, of the different video bases used by American and British computer manufacturers. Ours is NTSC, while they use PAL.

There was no difference in the enthusiasm of the European computer hobbyist compared to his American counterpart—it was in abundant evidence everywhere. The enthusiasm is all the more striking when one considers the prices that the Briton must pay for a piece of American equipment. Owing to a number of factors (including shipping, inflation, taxes, etc.), an American computer costs about twice as much in England as it does here. Thus, a $1000 item in New York costs 1000 pounds in London—the pound being approximately equivalent to two dollars currently.

The cost of computer hardware may be one reason that the British are devoting a great deal of time to creating their own software. And they are beginning to catch up with us when it comes to hardware. Last year, when I was there, they appeared to be about a year or two behind us—judging by the oohing and aahing I heard at some of the latest peripherals that I brought over to show them. This year, they seemed to have caught up since I saw many peripherals at this show that were just starting to appear on the American market.

Unfortunately, high costs were also reflected in the admission charges to the Show. Admission to the exhibition alone was $3—not so bad. However, during the three-day show, there was a seminar during which 12 speakers "did their thing" (yours truly being one of them). Price for entry to the seminar (and show) was $90 plus $13 tax (!) for the first two days (Thursday and Friday) which also included lunches, while on Saturday, it cost $28 plus $8 tax, including a sandwich lunch.

PACS Game Festival. The Philadelphia Area Computer Society, in conjunction with LaSalle College Physics Department, is holding a computer games festival on March 15, 1980 between 10 AM and 6 PM in the LaSalle College Ballroom, 20th and Olney, Philadelphia, PA 19141. For further information, contact Dr. Stephen A. Longo, Physics Dept., LaSalle College, Philadelphia, PA 19141 (Tel: 215-951-1255).

Small Computer Symposium. To be held at the University of Tennessee, Knoxville, TN, during the fourth weekend in February, this symposium will present a forum for the display and discussion of small computers in the area of hobby, education and business. For further information, contact Mike Sappington, 8 Ayres Hall, University of Tennessee, Knoxville, TN 37916.

PET Cursor Problems. A problem that seems to occur in the use of machine language programs or one of the early PET-2001's is loss of cursor for unknown reasons. The New Cursor® can be installed without soldering or modifications to the PET and no special tools are required. It provides instant pushbutton cursor retrieval without machine power-down or software manipulation. $4.95. Specify type of PET or CBM computer. International Technical Systems, Inc., P.O. Box 264, Woodbridge, VA 22194 (Tel: 804-262-9709).

Super Graphics. The VMS (video modular systems) is a series of video processing modules having 4-bit resolution for the red, green and blue channels and operates with a general-purpose microcomputer. The series includes an A/D converter, D/A converter, and RGB Encoder. Through software, the devices function as a mapped colorizing unit. The configured modules will internally generate, mix and display all 16 levels of red, green and blue images, as well as their combinations. This produces 4096 colors. It has the ability to update the colorizer signal each $1/60$th of a second. Upcoming modules include an 8 × 3 matrix switcher, frame buffer, vertical and horizontal pattern generator, color vector display and waveform adapter, firmware I/O interface, RGB decoder, multiplexer key matrix and a video processing unit. For further information on this professional system, contact Ron Wilton, G.E.S.I., 1440 San Pablo Ave., Berkeley CA 94702 (Tel: 415-527-7700).

Apple and S-100 Modems. The MICROMODEM II is a data communication system for the Apple II, and the MICROMODEM 100 is for S-100 systems. Both feature MICROCOUPLER data access arrangement, an FCC-registered device that provides direct access into the telephone system with none of the losses or distortions associated with acoustic couplers. It can automatically answer the phone or originate a call. Both are Bell 103 compatible. The MICROMODEM II is supplied with firmware in ROM and plugs into any Apple I/O slot. The MICROMODEM 100 is fully compatible with 16-bit and 4-MHz processors. D.C. Hayes Associates Inc., 10 Perimeter Park Dr., Atlanta, GA 30341 (Tel: 404-455-7663).

Digitizer. The Hi-Pad Digitizer allows graphics input with both serial and parallel interfaces as standard features. In addition to resolution by inch, metric measurement is included. It also has a translucent tablet area for rear projection. It can be used with any North Star-based system or Vector Graphics High Resolution Video Display. $795. Microage Wholesale, 1425 West 12th Place, Tempe, AZ 85281 (Tel: 602-894-9247).

Apple Interface. The A10 Serial and Parallel Apple Interface features a software programmable serial interface using the RS-232 standard at 9 selected baud rates. Onboard firmware provides a driver routine so the user does not need to write software. The parallel portion features software programmable I/O ports that can handle two printers simultaneously. A parallel driver routine is available in firmware as an option. Solid State Music, 2116 Walsh Ave., Santa Clara, CA 95050 (Tel: 408-246-2707).

Transient Protection. The Blitz-Bug is a fast-acting transient and surge protector that keeps guard over your electric power lines. It has a response time of less than 50 nanoseconds, and can sustain up to 20 joules of current for a short period. All impulses are restrained to 186 volts. $19.95. Omni Communication Co., Inc., 200 West Country Line Rd., RD 3 Box 200, Jackson, NJ 08527.

Typewriter I/O. The I/O Pak (actually just an output port) is an electromechanical interface that fits over the keyboard of any electric typewriter and connects it to a computer. The unit consists of a bank of solenoids that operate each key. It produces no more key pressure than a conventional typist. No mechanical modifications of the typewriter are required, and the Pak can be instantly removed. $439. TRS-80 Interface $89.50, Apple Interface $79.95, GPI (S-100) Interface $69.50. Rochester Data Inc., 3100 Monroe Ave., Rochester, NY 14618 (Tel: 716-385-4336).

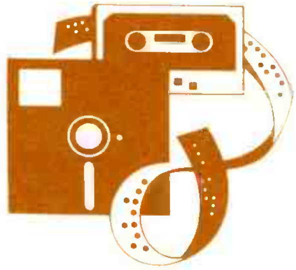
Equipment Covers. You can now protect your valuable computing equipment from dust, spills and scratches with attractive leather-grained, cloth-backed vinyl. The covers come in gold, chestnut, black or olive and feature double stitching and corded seams. Contact the company for styles and prices. International Technical Systems, Inc., P.O. Box 264, Woodbridge, VA 22194 (Tel: 804-262-9709).

New Disk Systems. The Maxi-Disk runs CP/M (with the Shuffleboard option), TRS-DOS, uses a Shugart 800 drive having a capacity of 250K bytes, and has a transfer rate of 250K bytes per second on 77 tracks. The disk system plugs into the TRS-80 expansion interface and is style coordinated with the existing system. Price is $995, including power supply, cabinet and interface board. Additional drives are $845 (with cabinet and power supply). TRS-80 cables are $60. The Shuffleboard option plugs into the Z-80 socket and releases the lower 16K of memory for use as RAM. It allows the use of standard CP/M. An on-board bootstrap phantom ROM allows instant boot-up of CP/M from the Maxi-Disk. The Shuffleboard with CP/M on an 8" diskette and documentation is $249. Parasitic Engineering, 1202 10th St., Berkeley, CA 94710.

DISCUS/2D is a single/double density disk compatible with the IBM System-34 format and is compatible with IEEE standard S-100 bus. The disk drive is a full-size Shugart 800R and features power-on jump circuitry, 1K of RAM, 1K of ROM with built-in monitor and a hardware UART to make I/O interfacing easy. Software includes BASIC-V virtual disk BASIC, DOS and Disk/ATE assembler/editor. Patches for CP/M are included. Microsoft disk BASIC and FORTRAN are available. $1149. Up to three additional drives can be added at $795 each. Thinker Toys, 1201 10th St., Berkeley, CA 94710 (Tel: 415-524-2101).

2650 For the S-100. The Slavemaster 2650 uses the Signetics 2650 processor and includes cassette interface, serial I/O (RS-232/20-mA), 8 vectored interrupts, 4K of 2708 ROM, a digital input, and two digital outputs. Software includes the Signetics PIPBUG, and Real Time Control ($25 each). Assembled and tested boards are $269, and $198 in kit form. Two of these boards can be used to form a multiprocessor system. One is the slave and the other is the master. They reside in an S-100 bus mainframe with multiprocessing control via a ribbon cable. Each has full access to S-100 resources. One card may be used as a stand-alone 2560 S-100 bus computer. Victoria Micro Digital, 401 Dundee St., Victoria, TX 77901 (Tel: 512-575-3836).

New Keyboard. The Micro Proximity Keyboard is fully solid-state and virtually indestructible, impervious to environmental pollution, and consists of microproximity touch sensors protected by a polycarbonate shield. There is no way that it can wear out or short because it has no exposed components and in fact no moving parts. It resembles a conventional keyboard only in format (full ASCII set), and the keyboard is thin (0.325 inches thick), with a totally flat surface, and weighs 19 ounces. $75. TASA Inc., 2346 Walsh Ave., Santa Clara, CA 95050 (Tel: 408-247-2301). ◇



Software Sources

By Leslie Solomon
Technical Director

Catalogs. There are many companies springing up around the country that specialize in software and have so many programs that a catalog is required. Listed here are three of them so that interested readers can send for their own catalogs.

Aardvark Technical Services, 1690 Bolton, Walled Lake, MI 48088 (Tel: 313-624-6316) specializes in programs in BASIC particularly for OSI machines. The catalog includes about 30 games, some 6 utility programs, a number of "data" sheets, and general material for OSI machines.

Mad Hatter Software, 900 Salem Rd., Dracut, MA 01826 (Tel: 617-682-8131). This firm's catalog contains some 150 programs of games, utilities and general programs for the TRS-80, PET and Apple-II computers. (Editor's Note: We had occasion to try one of the games, "Android Nim," on a TRS-80, and found it to be the wildest graphics game with sound we have ever played.)

Real-Life Simulations, 3107 Ridge Rd., Warren, OH 44484. This firm's catalog includes a large number of games, quizzes, simulations, telephone dialers, statistical and "sound patch" programs for the TRS-80.

Apple Development Package. Designed to run on a 48K Apple II with disk and autostart ROM, the 6502 Development Package includes a free-standing EPROM programmer, a ROM-based comprehensive Monitor/Debugger, a diskette-based Editor/Macro Assembler, a diskette-based Relocator Loader and a diskette utility package. All operating modes are accessed from the screen-oriented monitor via the RESET key. Micro Power Designs, Inc. 13955 Murphy Rd., #112, Box 393, Aliet, TX 77411 (Tel. 713-499-5402).

TRS-80 CP/M. A total of 77 disks of software from the CP/M Users' Group are now available to TRS-80 users at $7.50 per diskette (media and handling charge). These include games, various BASIC's, PILOT, Assemblers, and numerous utilities. This firm also makes available a General Ledger, Payroll W/Cost Accounting, and Accounts Receivable and Payable for TRS-80 CP/M and CBASIC. Each package is $250. Another product, DOWNLOAD ($95), is a utility program for TRS-80 (or other) CP/M systems to allow transferring files from one CP/M system to another over RS-232 lines. Cybernetics Inc., 8041 Newman Ave., Suite 208, Huntington Beach, CA 92647 (Tel: 714-848-1922).

Mail List. MAILING LIST for TRS-80 includes add, delete, search, sort list, modify address or remarks, and sequential printout. Up to 61 characters for either name/title/company/remarks can be used. Also features exact placement of 5 labels across a page and zip code on each label. Names can be sorted from two fields and the user can specify a range of values to be listed according to any one field. Over 500 names can be stored on one disk, over 1500 with two drives. It is written in Disk BASIC and comes on diskette with its manual and hard-copy listing. $39.95. Software Industries, 902 Pinecrest, Richardson TX 75080 (Tel: 214-235-0915).

PET/TRS-80 Items. Several programs and joysticks are available for the PET and TRS-80. The TRS-80 Joystick Interface ($65) is used in conjunction with the Fairchild or Atari joysticks ($15 each). The PET Joystick Interface is $45 and also requires joysticks. The PET-Fairchild Joystick with interface is $35. Among the programs are Space War for the PET (requires joystick) at $10, Road Race for the PET (requires dual joysticks) at $10, Tag for the PET and TRS-80 (requires dual joysticks) at $10, Sketchpad and Maze for the PET (requires dual joysticks) at $10, Star Wars for the PET (requires joystick) at $10, Breakout for the PET (requires joystick) at $10, Seawolf for the PET at $10, Life for the PET at $15, PETWord word processor for use with a printer at $75 and Household Utility for the PET at $15. For up to 2 programs add $1.50 shipping charge, for 3-4 programs add $2, and 5 or more add $2.50. For PET-Fairchild joystick add $2.50, for the PET dual interface add $1.50 and $3 for the TRS-80 interface. California residents add 6% sales tax. Creative Software, Box 4030, Mountain View, CA 94040

Backgammon. BACK-40, a backgammon program for the Level-II TRS-80, displays a backgammon board and dice. Using machine language, response is within two seconds. It features computer or player opening, depending on dice roll, computer and player doubling, and scoring of all regular, gammon, and backgammon endings. Points are numbered to make the input simple, and all moves are checked for legality. The program is on cassette. $14.95. The Software Association, P.O. Box 58365, Houston, TX 77058 (Tel: 713-482-0883).

Apple File Helper. BACLAN File Helper consists of five programs that can be used as general utilities to build, copy, scan, sort, and print data files. These programs are designed to examine fixed length data files, and can be used with EXEC files to build dedicated input-merge-sort-report data management systems. Any one file can contain thousands of records, with the limit being the diskette's storage. The diskette package is $39 for integer and $49 for Applesoft. Documentation is $5. BACLAN Inc., Box 36, Columbia, MD 21045 (Tel: 301-997-9610).

Integrated Accounting System. Using North Star DOS and BASIC, two disk drives and 32K of memory, the IAS features direct cursor control for the SOL, SOROC, ADM-3, ADDS-100, Intertube and Hazeltine 1500 systems. Over 65 programs are available and the approach uses random access and Skip Sequential files for speed. General Ledger is standard double-entry that supports 200 accounts, numerous reports and listings which include income statement, balance sheet, data file listing and others. It has full printing of check, data posting by account number, name or both and includes automatic reformating of income statements. Payroll supports up to 400 names and maintains all data with full editing. Prints paychecks and W2 forms, etc. Accounts Payable supports up to 1100 vendors and maintains all data with full editing capability. Accounts Receivable supports up to 1100 clients and maintains all data with full editing and printing capabilities. All programs are in BASIC and can be modified if required. General Ledger alone is $125, GL plus one subsystem package of your choice is $225, GL plus two subsystem packages is $300, and all four packages are $350. Contact ECOSOFT, P.O. Box 68602, Indianapolis, IN 46268.

SOLOS CP/M. SOL cassette systems can now be upgraded to disk without losing software and data files with this new product that converts Processor Technology Extended Cassette BASIC to disk BASIC running under CP/M. All tape functions are converted to disk and a tape-disk-tape transfer utility is provided. The approach uses SOLOS/CUTER I/O and overlaps the CP/M CCP for maximum memory utilization. It includes a TRACE command and user-definable filetypes. Patches are included for BASIC5 conversion. The user must supply his own CP/M and BASIC. Comes on conventional CUTS 1200-baud cassette with user manual. $49.95 from TAD Enterprises, P.O. Box 257, Hazelcrest, IL 60429.

6502 Packages. The editor/assembler package requires less than 1K of RAM (assembler overlays editor), with the assembler using a single pass. The commands include Find, Delete and Insert a line; Define origin of object code, List source code, and List symbol table. It uses MOS mnemonics as closely as possible and the editor command set is easily extendable by the user. A user option is provided to allow the object code to overwrite the source code to keep required memory size down. Source listing $19.95 (add $3 for KIM-1 hypertape cassette). ROBOT is an interactive language written in machine language for controlling a "turtle", plotter or CRT cursor. This will work with a TVT-6 or any other memory-mapped TVT. It requires only slightly more than 1K of RAM. Source listing is $5 (add $3 for KIM-1 hypertape cassette). MUSIC requires the KIM cassette output port to be connected to an audio amplifier. It takes slightly more than 1½K of RAM. It uses complex strings of subroutines that allow the user to program intricate and surprising compositions. Basic music can be supported. Source listing $10 (add $3 for KIM-1 hypertape cassette). A disassembler for the tiny editor/ assembler is also available for $10, $3 more for cassette. Michael Allen, 6025 Kimbark, Chicago, IL 60637.

TRS-80 Terminal. SMARTTERM is a software package that turns a TRS-80 into an intelligent terminal. It is compatible with TRSDOS 2.2, VTOS 3.0 and NEWDOS 2.1C. It features a new keyboard driver with auto-repeat, and 16 "soft" keys can be programmed with any desired message. Up to 240 characters can be apportioned among the keys. The display driver features multi-page scrolling, and two special cursors are provided to allow transmission of selected portions of the display. Horizontal TAB is provided, as well as a debug mode for checking line protocols. SMARTTERM can receive up to 4800 baud without nulls or fill characters. A True Break key and control character conversion is also provided. It has an off-line mode to allow typing directly into the display buffer, and print screen and transmit screen capability. SMARTTERM requires a disk with 16K of RAM. $79.95 from Micron, Inc., 10045 Waterford Drive, Ellicott City, MD 21043 (301-461-2721).

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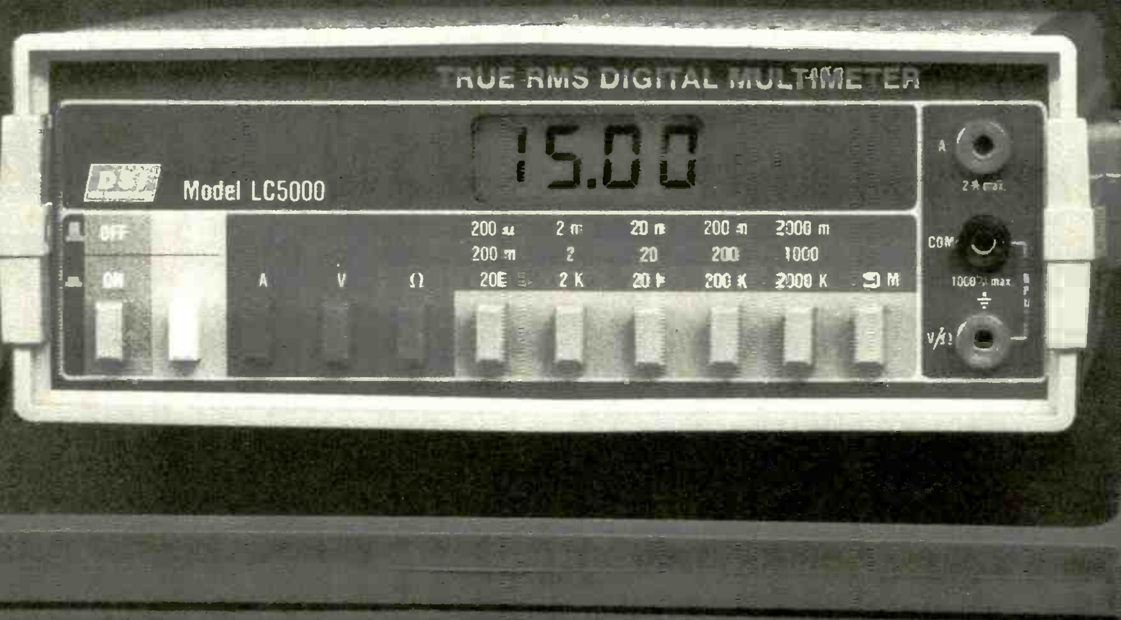

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PROJECT OF THE MONTH

Dark/Light Detector

BY FORREST M. MIMS

HERE IS a simple but useful circuit that can function as either a light detector or a dark detector. The circuit's photosensor is a standard cadmium-sulfide (CdS) light-dependent resistor. When the project is operating in its light-detection mode and the photosensor is dark, there is no output. When light strikes the sensitive surface of the LDR, the speaker emits a tone. When the circuit is in its dark-detection mode and the LDR is illuminated, the speaker is quiet. It emits a tone when the photosensor is dark.

The circuit is actually an astable oscillator operating as a tone generator. The oscillator is designed around a 555 timer chip whose reset input (pin 4) is the key to the project's two modes of operation. When pin 4 is at or close to $+V_{cc}$, the circuit will oscillate. When pin 4 is grounded, however, *C1* is discharged and the circuit ceases oscillation.

In both the light- and dark-detection modes, the light-dependent resistor and *R3* form a voltage divider whose center node is connected to pin 4 of the timer IC. When *S1*, a dpdt toggle switch, is placed in position L, the photosensor is connected between pin 4 of the IC and $+V_{cc}$. When the level of ambient light increases sufficiently, the resistance of the photosensor decreases to a low value, pin 4 approaches $+V_{cc}$ and the circuit oscillates. This is the circuit's light-detection mode.

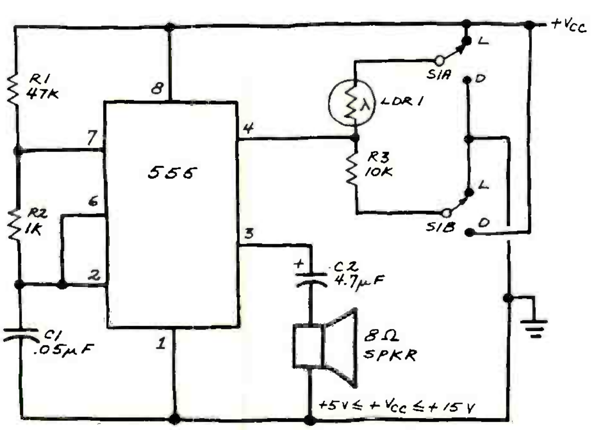
When *S1* is placed in position D, the photosensor is between pin 4 and ground and fixed resistor *R3* is between pin 4 and $+V_{cc}$. Now, when sufficient light strikes the photosensor, pin 4 approaches ground potential and the circuit ceases to oscillate. The project thus functions as a dark detector because removing light from the LDR permits the 555 to oscillate.

The circuit is easily modified. For example, increasing the value of *C1* will decrease the frequency of oscillation. Reducing the capacitance of *C1* will increase the frequency. For more volume, the speaker can be driven by an audio amplifier whose input is capacitively coupled to pin 3 of the timer IC. If only light (or dark) detection is desired, *S1* can be eliminated. The photosensor and *R3* should then be permanently in the positions corresponding to the desired operating mode.

This project has many useful applications. In its light-detection mode, for example, it can be used as an open-door alarm for a refrigerator or freezer or an open-drawer alarm for a cash register. The circuit makes a simple annunciator when used in its dark-detection mode. A source of steady light (artificial or sunlight) beamed at the photosensor inhibits the tone. An interruption of the light beam, such as occurs when a physical object passes between the light source and the sensor, stimulates oscillation.

Both operating modes make interesting day/night indicators. In the light-detection mode, the speaker will sound when the sun rises; and in the dark-detection mode, it will sound when the sun sets.

Laser Transmitter. In a previous column, I briefly described a miniature semiconductor laser transmitter I had built. Complete with battery, driver circuit and lens, the transmitter is not much bigger than a lipstick holder. Many readers have requested construction details for this laser. Unfortunately, however, the 4-layer diode which switches current through the laser diode is no longer available in small quantities. If an economical source for a 4-layer diode with a 20-to-25-volt switching level can be found, plans for the transmitter will appear as a future Project. ◇



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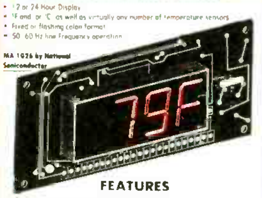

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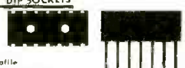

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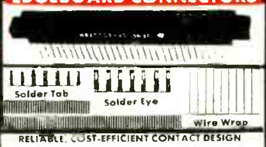

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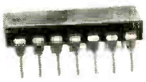

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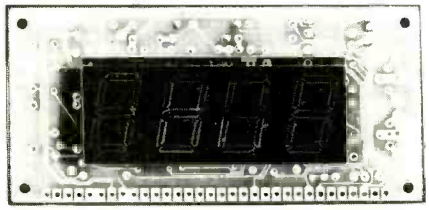

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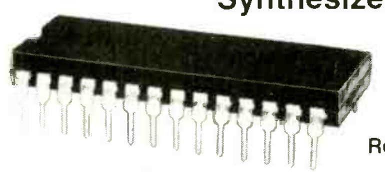

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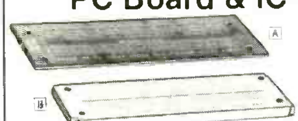

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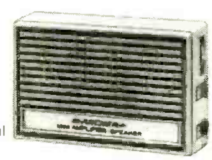

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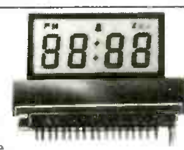

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Heathkit model AR-2 receiver. Need schematic, construction manual, and alignment procedures. Rick Gregory, 14 Sun Plaza, Great Falls, MT 59405.

North East Engineering model R-584/MRC-20 receiver. Need schematic. John B. Riley, 914 N. Cordova St., Burbank, CA 91505.

Hallicrafters model SX-24 receiver. Need operation manual and service manual. Alfred Adams, Box 3394, Morehead City, NC 28557.

Gonset model G-14 citizens communicator. Need manual and schematic. Randy Davenport, Rt. 3, Box 306, Sylva, NC 28779.

Tektronix model 502 oscilloscope. Need manual and schematic. Anthony Surozenski, Bates Point RD., RD 1, Webster, MA 01570.

Marconi model 75 dual-wave receiver. Need schematic and service manual. Les Edwards, 105 Adventure Rd., Kelowna, B.C., Can. VIX 1N3.

F. L. Moseley model 135 X-Y recorder. Need operation manual and schematic. Alex Funk, 110 East Lynch St., Durham, NC 27701.

Tennelec model MS-2 memory scanner. Need schematic. Henry F. Blaha, 310 W. Sydenham St., Spring Grove, IL 60081.

Knight model R-100A receiver. Need schematic and owner's manual. A. Alto, 638 Millbury, La Puente, CA 91746.

Vikoa black and white video camera. Need schematic and any available information. Leonard Avilla, Box 785, Kemmerer, WY 83101.

Rutherford model B7F pulse generator. Need schematic and manual. John Pemberton, Jr., Box 83, Caddo Mills, TX 75005.

Lafayette model KT-208 signal generator and tracer and **Superior Instruments** model 76 capacitance resistance bridge and signal tracer. Need schematic and manuals. Stan Lopes, 1201 Monument Blvd., SP.74, Concord, CA 94520.

Lafayette model 12A Dyna-Com walkie talkie. Need schematic. Tim Dill, 5099 Linbar Dr., Nashville, TN 37211.

Unicord Inc., model UR00G audio amplifier. Need schematic. Charles L. Spindler, 18-17 George St., Brooklyn, NY 11227.

Panasonic AM/FM model SE-990, serial #01-103-024147 stereo music center. Need schematic diagram. Bob Lester, RD 1, Box 140, Lincoln University, PA 19352.

Clough-Brengle model 230A ac bridge. Need manuals and schematics. Henry B. Claremont, RD #1, Box 241, Saranac, NY 12981.

Velixar Inc., model 36, serial #S-1633 depth finder. Need operation manual and schematic. George Kohn, RD #1, New Bloomfield, PA 17068.

Philips model DG7-32 cathode ray tube. Need base diagram and operating voltages. J. L. Pierce, 200 Beverly Rd., Cocoa, FL 32922.

Non-Linear Systems X-2 digital voltmeter. Need instruction manual, schematic and ohms/mV board. Jim Barcus, 12605 11th Ave., N., Plymouth, MN 55441.

Millivac type MV-45A ac voltmeter. Need operator's manual and schematics. T. Raj, 915 5th St., S.E., Minneapolis, MN 55414.

Pearce Simpson model 550 AM marine radio telephone. Need schematic, operation manual and crystal information. Charles C. Boehnke, Box 223, Los Gatos, CA 95030.

Eico model 460 oscilloscope, serial #9438. Need construction manual and schematic. Henry B. Gratton, RD #1, Box 143, Elliottsburg, PA 17024.

Lumatron model 120 sampling scope, GR LP3 signal generator and TS-47/APR test oscillator. Need schematics and service data. A. Selby, 1329 California, Mountain View, CA 94041.

Hallicrafters model 19 CB. Need schematic, component information, and operating instructions. Daniel L. McKnight, 32 Diamond St., Nelsonville, OH 45764.

Precision Apparatus Co., Inc. model ES500A oscilloscope. Need schematic and owner's manual. Russel A. Yingst, Jr., RD 3, Box 7960, Jonestown, PA 17038.

Concertone model 700 four speed reel recorder. Need schematic, parts list, and parts source. **Wilcox-Gay** model 6B100 recordio. Need schematic. Frederick E. Vipperman, 1415 E. Stoddard St., Dexter, MO 63841.

Blaupunkt Montreal AM/FM auto radio. Need schematic and service information. G. H. Barnes, 106 Mill Grove Dr., Audubon, PA 19403.

Hallicrafters Sky Courier receiver. Need schematic and operation manual. W.J. Bennett, 2946 Kolink Ave., San Diego, CA 92111.

P.O. Box 4430C Santa Clara, CA 95054
For will call only: (408) 988-1640
2322 Walsh Ave.

Quest ELECTRONICS

NEW PRODUCTS!

Super Color S-100 Video Kit $99.95
Expandable to 256 x 192 high resolution color graphics. 6847 with all display modes computer controlled. Memory mapped. 1K RAM expandable to 6K. S-100 bus 1802, 8080, 8085, Z80 etc.

Gremlin Color Video Kit $59.95
32 x 16 alpha/numerics and graphics; up to 8 colors with 6847 chip; 1K RAM at E000. Plugs into Super Elf 44 pin bus. Not expandable to high resolution Graphics.

Elf II Adapter Kit $24.50
Plugs into Elf II providing Super Elf 44 and 50 pin bus plus S-100 bus expansion (With Super Expansion). High and low address displays, state and mode LED's optional **$18.00**.

1802 16K Dynamic RAM Kit $149.00
1802/S-100 expandable to 32K. Hidden refresh w/clocks up to 4 MHz w/no wait states Addl. 16K RAM **$79.00**.

Quest Super Basic

Quest, the leader in inexpensive 1802 systems announces another first. Quest is the first company worldwide to ship a **full size Basic** for 1802 systems. A complete function **Super Basic** by **Ron Cenker** including floating point capability with scientific notation (number range ±.17E[38]), 32 bit integer ±2 billion; Multi dim arrays; String arrays; String manipulation; Cassette I/O, Save and load, Basic, Data and machine language programs; and over 75 Statements, Functions and Operators.

Easily adaptable on most 1802 systems. Requires 12K RAM minimum for Basic and user programs. Cassette version in stock now. ROM versions coming soon with exchange privilege allowing some credit for cassette version.

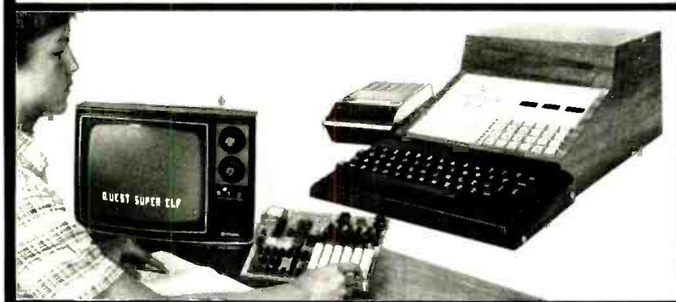
Super Basic on Cassette **$40.00**

Tom Pittman's 1802 Tiny Basic Source listing now available. Find out how Tom Pittman wrote Tiny Basic and how to get the most out of it. Never offered before. **$19.00**

S-100 4-Slot Expansion **$ 9.95**

Super Monitor VI.I Source Listing **$15.00**

Coming Soon: Assembler, Editor, Disassembler, DA/AD, Super Sound/Music, EPROM programmer.



RCA Cosmac Super Elf Computer $106.95

Compare features before you decide to buy any other computer. There is no other computer on the market today that has all the desirable benefits of the **Super Elf** for so little money. The Super Elf is a small single board computer that does many **big** things. It is an excellent computer for training and for learning programming with its machine language and yet it is easily **expanded** with **additional memory, Full Basic, ASCII Keyboards, video character generation, etc.**

Before you buy another small computer, see if it includes the following features: ROM monitor; State and Mode displays; Single step; Optional address displays; Power Supply; Audio Amplifier and Speaker; Fully socketed for all IC's; Real cost of in warranty repairs; Full documentation.

The **Super Elf** includes a **ROM** monitor for program loading, editing and execution with **SINGLE STEP for program debugging** which is not included in others at the same price. With **SINGLE STEP** you can see the microprocessor chip operating with the **unique Quest** address and data bus displays **before, during** and **after** executing instructions. Also, CPU mode and instruction cycle are decoded and displayed on 8 LED indicators.

An RCA 1861 **video graphics** chip allows you to connect to your own TV with an inexpensive video modulator to do graphics and games. There is a **speaker system** included for writing your own music or using many music programs already written. The speaker amplifier may also be used to drive relays for control purposes.

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, wait, input, memory protect, monitor select** and **single step**. Large, on board displays provide output and optional **high and low address**. There is a 44 pin standard connector slot for PC cards and a 50 pin connector slot for the Quest Super Expansion Board. Power supply and sockets for **all** IC's are included in the price plus a detailed 127 pg. instruction manual which now includes over 40 pgs. of software info. including a series of lessons to help get you started and a music program and graphics target game.

Many schools and universities are using the Super Elf as a course of study. OEM's use it for training and research and development.

Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Cabinet** with drilled and labelled plexiglass front panel **$24.95.** Expansion Cabinet with room for 4 S-100 boards **$41.00. NiCad Battery Memory Saver Kit $6.95.** All kits and options also completely assembled and tested.

Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for $12.00 per year.

Tiny Basic Cassette **$10.00**, on ROM **$38.00**, original Elf kit board **$14.95. 1802 software;** Moews Video Graphics **$3.50.** Games and Music **$3.00.** Chip 8 Interpreter **$5.50.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow you to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface**. Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf**. The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed**. EPROM can be used for the monitor and Tiny Basic or other purposes.

A IK Super ROM Monitor $19.95 is available as an on board option in 2708 EPROM which has been preprogrammed with a program loader/editor and error checking multi file cassette read/write software, (relocatable cassette file) another exclusive from Quest. It includes register save and readout, block move capability and video graphics driver with blinking cursor. Break points can be used with the register save feature to isolate program bugs quickly, then follow with single step. The Super Monitor is written with subroutines allowing users to take advantage of monitor functions simply by calling them up. Improvements and revisions are easily done with the monitor. If you have the **Super Expansion Board** and **Super Monitor** the monitor is up and running at the push of a button.

Other on board options include **Parallel Input and Output Ports** with **full handshake**. They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. Also a 1K Super Monitor version 2 with video driver for full capability display with Tiny Basic and a video interface board. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set** with ribbon cable is available at $15.50 for easy connection between the **Super Elf** and the **Super Expansion Board.**

Power Supply Kit for the complete system (see Multi-volt Power Supply).

Same day shipment. First line parts only. Factory tested. Guaranteed money back. Quality IC's and other components at factory prices.

INTEGRATED CIRCUITS

7400TTL
7400N 17
7402N 18
7404N 19
7409N 23
7410N 18
7414N 70
7420N 18
7422N 39
7430N 20
7442N 50
7445N 69
7447N 60
7448N 69
7450N 18
7474N 35
7475N 49
7485N 88
7489N 1 85
7490N 43
7492N 43
7493N 43
7495N 69
74100N 90
74107N .35
74121N 34
74123N 59
74125N 45
74145N 69
74150N 95
74151N 69
74154N 1 00
74157N 69
74161N 87
74162N 87
74163N 87
74174N 96
74175N 90
74190N 1 15
74192N 87
74193N 85
74221N 2 00
74298N 1 65
74365N 66
74366N 66
74367N 66

74LS00 TTL
74LS00N 35
74LS02N 35
74LS04N 35
74LS05N 35
74LS08N 35
74LS10N 35
74LS13N .55
74LS14N 1 10
74LS20N 35
74LS22N 35
74LS28N 41
74LS30N 35
74LS33N 75
74LS38N 55
74LS74N 1 25
74LS75N 1 00
74LS90N 85
74LS93N 70
74LS95N 1 10
74LS107N 45
74LS112N 45
74LS113N 35
74LS132N 89
74LS136N 45
74LS151N 85
74LS155N 85
74LS157N 85
74LS162N 1 15
74LS163N 1 15
74LS174N 2 00
74LS190N 1 06
74LS221N 1 95
74LS258N 67
74LS367N 1 35

LINEAR
CA3045 90
CA3046 1 10
CA3081 1 80
CA3082 1 90
CA3089 2 95
LM301AN AH 35
LM305H 87
LM307N 35
LM308N 89
LM309K 1 50
LM311H N 90
LM317T K 3 75
LM318 1 35
LM320K-5 1 50
LM323K-5 5 95
LM320K-12 1 50
LM320K 15 1 50
LM320T-5 1 60
LM320T-8 1 60
LM320T-12 1 50
LM320T-15 1 60
LM324N 1 15
LM339N 1 55
LM340K-5 1 35
LM340K-8 1 35
LM340K-12 1 35
LM340K-15 1 35
LM340K-24 1 35
LM340T-5 1 25
LM340T-8 1 25
LM340T-12 1 25
LM340T-15 1 25
LM340T-18 1 25
LM340T-24 1 25
LM343H 4 50
LM350 7 50
LM370 1 15
LM377 3 00
LM379 5 00
LM380N 1 00
LM381 1 60
LM382 1 60
LM703H 40
LM709H 28
LM723H/N 50
LM733N 67
LM741CH 35
LM741N 32
LM747H/N 75
LM748N 35
LM1303N 1 75
LM1304 1 10
LM1305 1 27
LM1307 2 00
LM1310 2.75
LM1458 47
LM1800 1 75
LM1812 7 50
LM1889 3 00
LM2111 1 75
LM2902 1 50
LM3900N 60
LM3905 1 75
LM3909N 89
MC1458V 50
NE540H 3.75
NE550N 1 00
NE555V 39
NE556A 85
NE565A 1 00
NE566V 1 50
NE567V 1 00
NE570B 5 00
78L05 60
78L08 60
78M05 85
75108 1 75
75491CN 50
75492CN 55
75494CN 89

A to D CONVERTER
8038B 4 50
8700CJ 13 95
8701CN 22 00
8750CJ 13 95
LD130 9 95
9400CJV/F 7 40
ICL7103 9 50
ICL7107 14 25

CMOS
CD34001 Fair 50
CD4000 16
CD4001 28
CD4002 28
CD4006 1 10
CD4007 28
CD4008 28
CD4009 45
CD4010 45
CD4011 28
CD4012 28
CD4013 39
CD4014 1 00
CD4015 1 00
CD4016 45
CD4017 1 05
CD4018 94
CD4019 45
CD4020 1 02
CD4021 1 25
CD4022 1 10
CD4023 28
CD4024 75
CD4025 28
CD4026 2 00
CD4027 66
CD4028 85
CD4029 1 02
CD4030 45
CD4035 1 02
CD4040 1 02
CD4042 85
CD4043 85
CD4044 85
CD4046 1 67
CD4049 45
CD4050 49
CD4051 1 13
CD4060 1 42
CD4066 71
CD4068 40
CD4069 40
CD4070 50
CD4071 28
CD4072 28
CD4073 28
CD4075 28
CD4076 1 45
CD4078 40
CD4081 28
CD4082 28
CD4116 47
CD4490 5 50
CD4507 1 00
CD4508 4 25
CD4510 1 02
CD4511 94
CD4515 2 52
CD4516 1 10
CD4518 1 02
CD4520 1 02
CD4527 1 51
CD4528 79
CD4553 3 50
CD4566 2 25
CD4583 4 50
CD4585 1 10
CD40192 3 00
74C00 28
74C04 40
74C10 28
74C14 2 10
74C20 28
74C30 28
74C48 1 95
74C74 75
74C76 1 40
74C90 1 15
74C93 1 40
74C154 3 00
74C160 1 44
74C175 1 35
74C192 1 65
74C221 2 00
74C905 6 00
74C906 75
74C914 1 95
74C922 5 50
74C923 5 50
74C925 6 95
74C926 6 95
74C927 6 95

INTERFACE
8095 65
8096 65
8097 65
8098 65
8T09 1 25
8T10 4 50
8T13 3 00
8T20 5 50
8T23 3 10
8T24 3 50
8T25 3 20
8T26 1 69
8T28 2 75
8T97 1 69
8T98 1 69

MOS MEMORY RAM
2101-1 3 95
2102-1 95
2102AL-4 1 25
2102AN-2L 1 60
21L02-1 1 18
21F02 1 25
2104A-4 4 95
2107B-4 3 75
2111-1 3 75
2112-2 3 95
2114L-1 7 40
2114L-3 7 90
4116 10 95
2513B 6 30
MM5262 40
MM5280 3 00
MM5320 9.95
MM5330 5 94
PD411D-3 4 00
PD411D-4 5 00
P5101L 13 95
4200A 9 95
82S25 2.90
91L02A 1 50
HD0165-5 6 95
MM57100 4 50
GIAY38500-1 9 95
MCM6571A 9.95
9368 3 50
4100 10.00
416 16 00

CLOCKS
MM5314 3 90
MM5369 2 10
MM5841 14 45
MM5865 7 95
CT7001 5 80
CT7010 8 95
MM5375AA/N 3 90
MM5375AG N 4 90
7205 16 50
7207 7 50
7208 15 95
7209 4 95
DS0026CN 3 75
DS0056CN 3 75
MM53104 2 50

MICROPROCESSOR
6800 17 50
6802 18 75
8080A 8 95
8085 27 00
Z80 14 75
Z80A 19 75
8212 2 90
8214 8 00
8216 2 90
8224 2 90
8228 5 35
8251 8 50
8253 15 00
8255 9 25
8257 19 50
8259 19 50
1802CP plas 13 95
1802DP plas 17 95
1861P 11 50
CDP1802CD 19 95
CDP1802D 25 00
CDP1861 12 95
6820 9 95
6850 12 95
6502 12 50
6504 6 50
6522 13 60

UART/FIFO
AY5-1013 5 50
AY5-1014 7 50
3341 6 95

PROM
1702A 3 95
2708 10 50
2716T1 29 50
2716 Intel 48 00
2732 115 00
2758 22 50
8741A 85 00
8748 75 00
8748-8 60 00
8755A 65 00
N82S23 2.95
N82S123 3 50
N82S126 3 75
N82S129 3 75
N82S131 3 75
N82S136 8 75
N82S137 8 75
DM8577 2 90
8223 2 90

CONNECTORS
30 pin edge 2 50
44 pin edge 2 75
100 pin edge 4 50
100 pin edge WW 5 25

IC SOCKETS
Solder Tin Low Profile

PIN	1 UP	PIN	1UP
8	15	22	30
14	14	24	35
16	16	28	42
18	27	36	58
20	29	40	57

2 level 14 pin ww 20

WIRE WRAP LEVEL 3

PIN		PIN	
14	32	24	86
16	33	28	1 00
18	57	40	1 23

CRYSTALS
1 MHz 4 50
2 MHz 4 50
4 MHz 4 25
5 MHz 4 25
10 MHz 4 25
18 MHz 3 90
20 MHz 3 90
32 MHz 3 90
32768 MHz 4 00
1 8432 MHz 4 50
3 5795 MHz 1 20
2 0100 MHz 1 95
2 097152 MHz 4 50
2 4576 MHz 4 50
3 2768 MHz 4 50
5 0688 MHz 4 50
5 185 MHz 4 50
5 7143 MHz 4 50
6 5536 MHz 4 50
14 31818 MHz 4 25
18 432 MHz 4 50
22 1184 MHz 4 50

KEYBOARD ENCODERS
AY5 2376 $12 50
AY5-3600 17 95
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HD0165-5 6 95

D Connectors RS232
DB25P 2 95
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TRANSISTORS
2N1893 40
2N222A 27
2N2369 30
2N2904A 20
2N2907A 25
2N3053 40
2N3638 25
2N3643 25
2N3904 18
2N3906 18
2N3055 69
2N4400 25
2N4401 75
2N4402 20
TIP31 60
TIP33A 1 00

RESISTORS ¼ watt 5%
10 per type .03 1000 per type .012
25 per type .025 350 piece pack
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½ watt 5% per type .05

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(specify red amber green yellow clear)

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Switches Mom. Pushbutton .27
3 pos. slide .25
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Clock Calendar Kit **$23.95**
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12 Volt 300 ma transformer 1.25
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24V CT 400 ma 3.95
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12V 3 amp wall plug 8.50

DISPLAY LEDS
MAN1 CA .270 2.90
MAN3 CC .125 .39
MAN72/74 CA/CA .300 1.00
DL704 CC .300 1.25
DL707/DL707R CA .300 1.00
DL727/728 CA/CC .500 1.90
DL747/750 CA/CC .600 1.95
DL750 CC .600 1.95
FND359 CC .357 .70
FND500/507 CC/CA .500 1.35
FND503/510 CC/CA .500 .90
FND800/807 CC/CA .800 2.20
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DG10 Fluorescent 1.75
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TIL311 Hex 9.50
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MAN4610 CA .40 1.10
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6502 based single board with full ASCII keyboard and 20 column thermal printer. 20 char alphanumeric display, ROM monitor, fully expandable. $375.00. 4K version $450.00. 4K Assembler $85.00, 8K Basic Interpreter $100.00.

Special small power supply for AIM 65 assem. in frame **$49.00.** Complete AIM 65 in thin briefcase with power supply **$485.00.** Molded plastic enclosure to fit AIM 65 plus power supply **$47.50.**

AIM 65/KIM/VIM/Super Elf 44 pin expansion board; 3 female and 1 male bus. Board plus 3 connectors **$22.95.**

AIM 65/KIM/VIM I/O Expansion Kit; 4 parallel and 2 serial ports plus 2 internal timers **$39.00.** PROM programmer for 2716 **$150.00.**

Multi-volt Computer Power Supply

8v 5 amp, ±18v .5 amp, 5v 1.5 amp, −5v .5 amp, 12v .5 amp, −12 option. ±5v, ±12v are regulated. Kit $29.95. Kit with punched frame $37.45, $4.00 shipping. Woodgrain case $10.00, $1.50 shipping.

PROM Eraser

Will erase 25 PROMs in 15 minutes. Ultraviolet, assembled **$37.50**

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Converts digital clocks from AC line frequency to crystal time base. Outstanding accuracy.

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Complete IC data selector, 2500 pg. master reference guide. Over 50,000 cross references. Free update service through 1979. Domestic postage $3.50. No foreign orders.

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Includes everything except case. 2-PC boards. 6-.50" LED Displays. 5314 clock chip, transformer, all components and full instructions. Orange displays also avail. **Same kit w/.80" displays.** Red only. **$21.95.** Case **$11.75**

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Opens shorted cells that won't hold a charge and then charges them up, all in one kit w/full parts and instructions. **$7.25**

S-100 Computer Boards

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16K Static RAM Kit	265.00
24K Static RAM Kit	423.00
32K Static RAM Kit	475.00
16K Dynamic RAM Kit	199.00
32K Dynamic RAM Kit	310.00
64K Dynamic RAM Kit	470.00
8K/16K Eprom Kit (less PROMS)	**$89.00**
Video Interface Kit	**$129.00**
Motherboard **$39.** Extender Board	**$8.99**

Video Modulator Kit $8.95

Convert your TV set into a high quality monitor without affecting normal usage. Complete kit with full instructions.

Digital Temp. Meter Kit $34.00

Indoor and outdoor. Switches back and forth. Beautiful, .50" LED readouts. Nothing like it available. Needs no additional parts for complete, full operation. Will measure −100° to +200°F, tenths of a degree, air or liquid. Beautiful woodgrain case w/bezel **$11.75**

TERMS: $5.00 min. order U.S. Funds. Calif residents add 6% tax. BankAmericard and Master Charge accepted. Shipping charges will be added on charge cards.

FREE: Send for your copy of our NEW 1980 QUEST CATALOG. Include 28¢ stamp.

CIRCLE NO. 57 ON FREE INFORMATION CARD

ALARM CLOCK KITS:
4 Digit .5"

Here it is! The first of several quality kits we have been asked for: Here is what you get — unbelievable as it may sound...

- 1 National - 5375AA Clock Chip
- 1 Bowmar Clock Stick Readout (L.E.D.) 4 digit - 1/2"
- 13 Transitors
- 2 Push Buttons for time set
- 2 Toggle Switches for alarm
- 1 Filter cap
- 4 1N4000 series diodes
- 1 1N4148
- 2 Disc caps
- 29 Resistors
- 1 Transducer (Speaker) for Alarm
- 1 LED Lamp for alarm indicator

ORDER KIT CK-100AC

NEW!

$9.99

P.C. Board **$2.25**

Plug In Transformer **$1.50**

D.C. MODEL

Same as above except it includes 60 Hz timebase.

This Kit Includes:

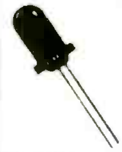
- 1 National 5375AA Clock Chip
- 1 Bowmar Clock Stick Readout - (L.E.D.) 4 digit - 1/2"
- 12 Transistors
- 2 Push Buttons for time set
- 2 Disc caps
- 27 Resistors
- 1 MOV
- 1 60 Hz time base

P.C. Board **$2.25**

ORDER KIT CK-100DC

NEW!

$12.75



We bought 350,000 LED's.
And you get the savings.

Reds, greens, yellows, orange, small, medium, large. Bags of 25 - mixed **$2.75**. That's only 11¢ each. Compare this bargain up to twice our price.

FACTORY PRIME
BI - Polar LED 59¢ ea. or 10 for $5

LAB-BENCH VARIABLE POWER SUPPLY KIT

5 to 20 VDC at 1 AMP. Short circuit protected by current limit. Uses IC regulator and 10 AMP Power Darlington. Very good regulation and low ripple. Kit includes PC Board, all parts, large heatsink and shielded transformer. 50 MV. TYP. Regulation. **$15.99 KIT**

Sonalert® on P.C. Board

Direct from a radar detector manufacturer! 4-741 on a board - plus 12 capacitors, trim pot and many usable components plus a Mallory Sonalert® - well worth the price of the board alone - while they last - **$2.50 ea.**

MICRO MINI
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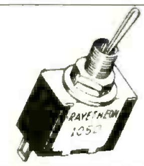

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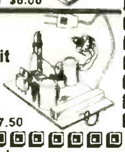

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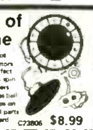

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SN7411N	.25	SN7486N	.35	SN74174N	.89
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SN7413N	.40	SN7490N	.45	SN74176N	.79
SN7414N	.70	SN7491N	.59	SN74177N	.79
SN7416N	.25	SN7492N	.43	SN74179N	1.95
SN7417N	.25	SN7493N	.43	SN74180N	.79
SN7420N	.20	SN7494N	.65	SN74181N	1.95
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SN7438N	.25	SN74125N	.49	SN74195N	.69
SN7439N	.25	SN74126N	.49	SN74196N	.89
SN7440N	.20	SN74132N	.75	SN74197N	.89
SN7441N	.89	SN74136N	.75	SN74198N	1.49
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74LS01	.29	74LS51	.29	74LS139	.89
74LS02	.29	74LS54	.29	74LS151	.89
74LS03	.29	74LS55	.29	74LS155	.89
74LS04	.35	74LS73	.45	74LS157	.89
74LS05	.35	74LS74	.45	74LS160	1.15
74LS08	.29	74LS75	.59	74LS161	1.15
74LS09	.35	74LS76	.45	74LS162	1.15
74LS10	.29	74LS78	.49	74LS163	1.15
74LS11	.75	74LS83	.89	74LS164	1.25
74LS13	.59	74LS85	1.25	74LS175	.99
74LS14	1.25	74LS86	.45	74LS181	2.49
74LS15	.35	74LS90	.59	74LS190	1.15
74LS20	.29	74LS92	.75	74LS191	1.15
74LS21	.29	74LS93	.75	74LS192	1.15
74LS22	.35	74LS95	.99	74LS193	1.15
74LS26	.35	74LS96	1.15	74LS194	1.15
74LS27	.35	74LS107	.45	74LS195	1.15
74LS28	.35	74LS109	.45	74LS253	.99
74LS30	.29	74LS112	.45	74LS257	.89
74LS32	.35	74LS123	1.25	74LS258	1.75
74LS37	.45	74LS125	.89	74LS260	.69
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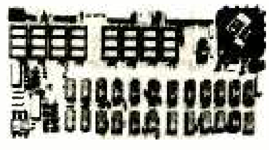

8K Bytesaver II

Memory Capacity: 8K bytes
Memory Type: 2708 PROM or equivalent
Memory Access Time: 450 nanoseconds
Wait States at 2MHz: none required
Wait States at 4MHz: one per machine cycle
Bus: S 100
Power Requirements: +8V @ 0.8A, +18V @ 0.4A, −18V @ 0.2A
Operating Environment: 0-55°C.

Cromemco's 8K BYTESAVER® card provides a built-in programmer for the popular 2708 PROM and has the capacity for a full 8K bytes of PROM memory storage. The BYTESAVER® II also offers a number of new features including convenient switch selection of board address and Cromemco's powerful memory bank selection. The BYTESAVER® II is assembled and tested (Model 8KBS-W) for $245.

Assembled
8KBS-W....$245.00

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.200" dia.

XC556R	red	5/$1
XC556G	green	4/$1
XC556Y	yellow	4/$1
XC556C	clear	4/$1

.200" dia.

XC22R	red	5/$1
XC22G	green	4/$1
XC22Y	yellow	4/$1

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MV10B	red	4/$1

.085" dia.

MV50	red	6/$1

INFRA-RED LED
1/4"x1/4"x1/16" flat
5/$1

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XC209R	red	5/$1
XC209G	green	4/$1
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.185" dia.

XC526R	red	5/$1
XC526G	green	4/$1
XC526Y	yellow	4/$1
XC526C	clear	4/$1

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LIQUID CRYSTAL DISPLAY
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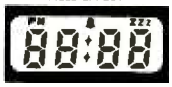

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MAN 2	5 x 7 Dot Matrix-red	300	4.95	MAN 6740	Common Cathode-red-D D	560	.99
MAN 3	Common Cathode-red	125	.25	MAN 6750	Common Cathode-red ± 1	560	.99
MAN 4	Common Cathode-red	187	1.95	MAN 6760	Common Anode-red	560	.99
MAN 7G	Common Anode-green	300	1.25	MAN 6780	Common Cathode-red	560	.99
MAN 7Y	Common Anode-yellow	300	.99	DL701	Common Anode-red ± 1	300	.99
MAN 72	Common Anode-red	300	.75	DL704	Common Cathode-red	300	.99
MAN 74	Common Cathode-red	300	1.25	DL707	Common Anode-red	300	.99
MAN 82	Common Anode-yellow	300	.49	DL728	Common Cathode-red	500	1.49
MAN 84	Common Cathode-yellow	300	.99	DL741	Common Anode-red	600	1.25
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MAN 3640	Common Cathode-orange	300	.99	DL749	Common Cathode-red ± 1	630	1.49
MAN 4610	Common Anode-orange	300	.99	DL750	Common Cathode-red	600	1.49
MAN 4640	Common Cathode-orange	400	.99	DL338	Common Cathode-red	110	.35
MAN 4710	Common Anode red	400	.99	FND70	Common Cathode	250	.69
MAN 4730	Common Anode-red ± 1	400	.99	FND358	Common Cathode ± 1	357	.99
MAN 4740	Common Cathode-red	400	.99	FND359	Common Cathode	357	.75
MAN 4810	Common Anode-yellow	400	.99	FND503	Common Cathode(FND500)	500	.99
MAN 4840	Common Cathode-yellow	400	.99	FND507	Common Anode (FND510)	500	.99
MAN 6610	Common Anode-orange-D D	560	.99	5082-7730	Common Anode-red	300	.99
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CA2023T	2.56	CA3083N	1.60
CA3035T	2.48	CA3086N	.85
CA3039T	1.35	CA3089N	3.75
CA3046N	1.30	CA3130T	1.39
CA3059N	3.25	CA3140T	1.25
CA3060N	3.25	CA3160T	1.25
CA3080T	.85	CA3401N	.59
CA3081N	2.00	CA3600N	3.50

CALCULATOR CHIPS/DRIVERS

MM5725	$2.95
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DM8887	.75
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MM5309	$4.95
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MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5387/1998A	4.95
CT 7001	6.95

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MC1408L7	$4.95
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MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
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14 pin LP	.20	.19	.18	24 pin LP	.38	.37	.36
16 pin LP	.22	.21	.20	28 pin LP	.45	.44	.43
18 pin LP	.29	.28	.27	36 pin LP	.60	.59	.58
20 pin LP	.34	.32	.30	40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

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16 pin ST	.30	.27	.25	36 pin ST	1.39	1.26	1.15
18 pin ST	.35	.32	.30	40 pin ST	1.59	1.45	1.30
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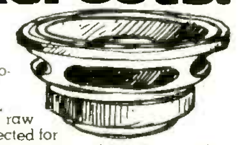

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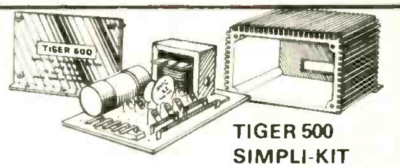

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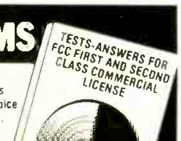

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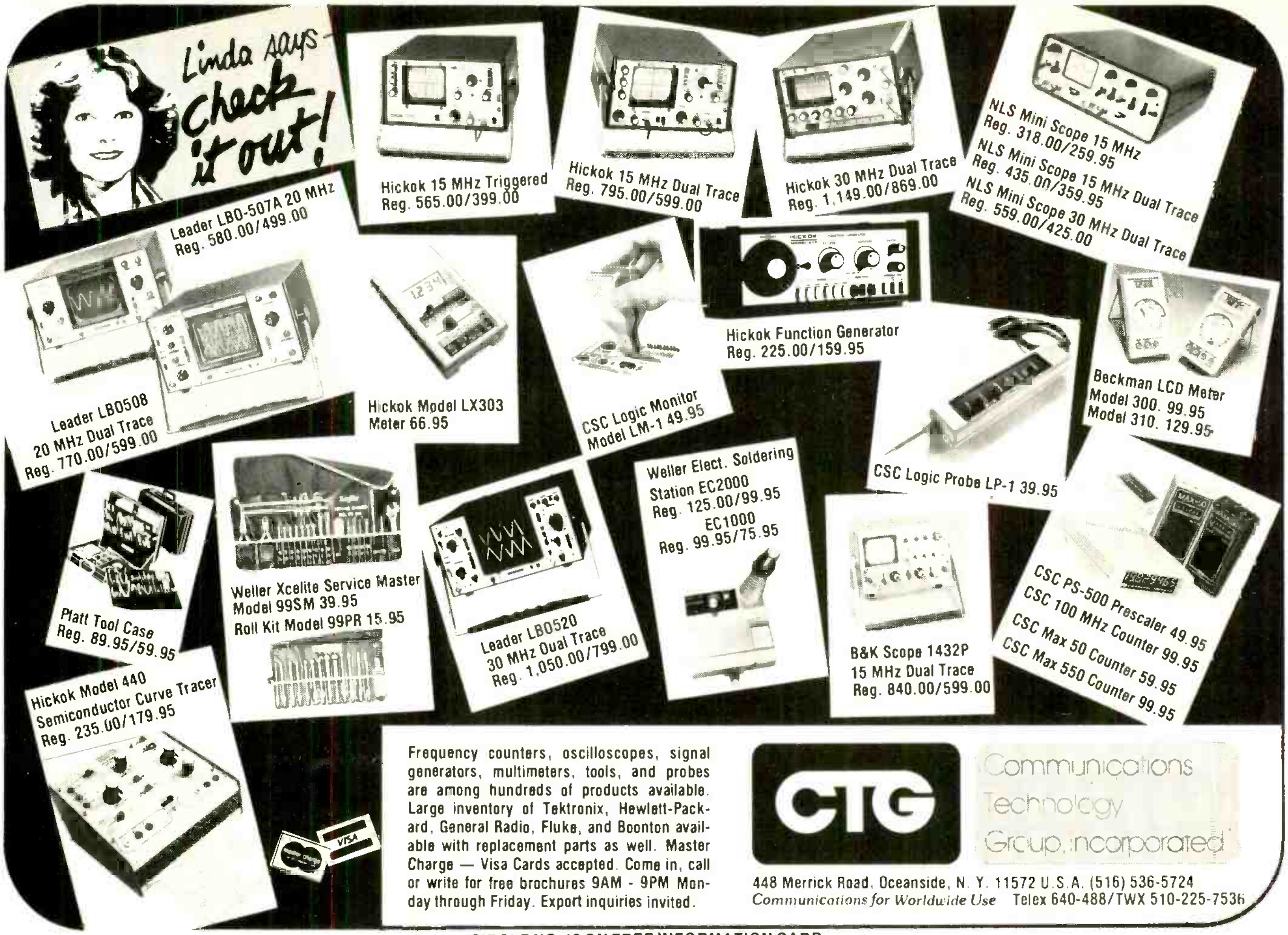

CIRCLE NO. 13 ON FREE INFORMATION CARD

MOVE TO FLORIDA! Complete list of Central Florida homes for sale. $2.00 and S.A.S.E. Rt. 1, Box 390, Apopka, FL 32703.

MOTION PICTURE/VIDEO FILMS

HOW ABOUT SPORTLITE MOVIES FOR HOME ENTERTAINMENT? Enjoy yourself with The Godfather I: John Travolta in Grease: John Travolta in Saturday Night Fever. Paramount Pictures S-8 Color Sd 400' selected scene editions are only $58.95 ea*. Saturday Night Fever complete version 118 min. (6 reels) S-8 Color Mag Sd $125.45 delivered. Buy Jaws seascape 10 min film S-8 color/sd 220' highlights $28.95 ea PPD. Or, turn to space epics. "Superman" Christopher Reeves 400' S-8 color/sd $49.75 ea* & "Buck Rogers" Gil Gerard 200' clear color sd $30.45 ea*. Combined special, 200' version of Superman & Buck Rogers both for $58.75 PPD. Now, for the 1st time ever, Major League baseball video cassettes — your choice of any World Series tape from 1942-1978 VHS or Beta $74.95 ea. — $2. shipping (each runs 30-40 min). Hollywood Gold Video Movie catalog 50 pgs. $1.25. Universal S-8 & 16 catalog $1.25; Columbia Pictures 48 pg catalog S-8 & S-8 Sd $1.25. Assorted brochures: Sportlite, Ring Classics, Universal 8 Video Cassettes, 40c ea. Marketing Films flyers, 50c. *Add $1.50 per film ship. ILL. Res. add 5% tax. SPORTLITE FILMS, Elect-2, Box 24-500, Speedway, IN 46224.

MISCELLANEOUS

MPG INCREASED! Bypass Pollution Devices easily, REVERSIBLY!! Free details — Posco GEE2, Box 300, La Grangeville, NY 12540.

NEW CAR FREE YEARLY! Workable secret method — free information: Supercar, Box 28101-N, St. Louis, MO 63119.

GASOLINE MILEAGE INCREASED DRAMATICALLY!! Details FREE!! Toll-free recording, 1-800-446-8289 anytime. Techneering, Box 12191 zd, Norfolk, VA 23502.

FREE! World's Leading Novelty Catalog. 1800 Jokes, Tricks, Science, Sports, Hobbies. Johnson-Smith, C-24, Mt. Clemens, MI 48043.

HAVE YOU ELECTRONIC PARTS OR EQUIPMENT TO SELL? ELECTRONIC PLANS OR KITS TO OFFER? Then you should advertise in the Electronics Marketplace of Popular Electronics where you reach 409,404 readers monthly. For rate & placement information see the first page of the classified section.

CompuPro™ continues to deliver...

NEW YEAR SPECIAL:

16K DYNAMIC RAMS — 8/$64!!

250 ns (4 MHz), 16K dynamic RAMs. Expand memory in TRS-80* I and II, Exidy, Apple, new PET, Heath H89, etc. Add $3 for 2 dip shunts plus instructions for TRS-80* expansion. **Hurry . . . quantities are limited at this special price.**

MEMORY!

Choose from **unkit** (sockets, bypass caps pre-soldered in place), **assembled** or boards qualified under our high-reliability **Certified System Component** (CSC) program (200 hour burn-in, extensive testing, immediate replacement in event of failure within 1 year of invoice date).

Size	Bus & Notes	Unkit	Assm	CSC
8K Econoram** IIA	S-100	$149	$179	$239
16K Econoram IV	S-100	$289	$339	$429
16K Econoram VIIA-16	S-100	$299	$349	$439
24K Econoram VIIA-24	S-100	$419	$499	$605
16K Econoram IX-16	Dig Grp	$319	$379	n/a
32K Econoram IX-32	Dig Grp	$559	$639	n/a
32K Econoram X	S-100	$549	$669	$789
32K Econoram XI	SBC/BLC	n/a	n/a	$1050
16K Econoram XIIIA-16	S-100 (1)	$349	$419	$519
24K Econoram XIIIA-24	S-100 (1)	$469	$539	$649
32K Econoram XIIIA-32	S-100 (1)	$579	$699	$849
16K Econoram XIV	S-100 (2)	$299	$359	$459
16K Econoram XV-16	H8 (3)	$329	$395	n/a
32K Econoram XV-32	H8 (3)	$599	$729	n/a

**Econoram is a trademark of Godbout Electronics
1) Compatible with all bank select systems (Cromemco, Alpha Micro, etc.), addressable on 4K boundaries
2) Extended addressing (24 address lines). Single block addressable on 4K boundaries
3) Bank select option for implementing memory systems greater than 64K

TERMS: Cal res add tax. Allow 5% for shipping, excess refunded. VISA*/Master Charge*, call our 24 hour order desk at (415) 562-0636. COD OK with street address for UPS. Prices good through cover month of magazine.

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Bldg. 725, Oakland Airport, CA 94614

OTHER BOARDS

S-100 ACTIVE TERMINATOR KIT $34.50.

S-100 2708 EROM BOARD, less EROMs but with support chips and manual. $85 unkit, $135 assm, $195 CSC

THE GODBOUT COMPUTER BOX The perfect home for your homebrew computer — just add power supply, motherboard and lots of boards. $259 desktop, $299 rack mount (introductory price).

HIGH-PERFORMANCE S-100 MOTHER-BOARDS Unkit versions have edge connectors and terminators resistors pre-soldered in place for easy assembly. 19 slot: $174 unkit, $214 assm. 12 slot: $129 unkit, $169 assm. 6 slot: $89 unkit, $129 assm.

S-100 MEMORY MANAGER BOARD Adds bank select and extended addressing to older machines. $59 unkit, $85 assm, $100 CSC.

2S "INTERFACER I" S-100 I/O BOARD Features dual RS-232 ports with full handshake. $199 unkit, $249 assm, $324 CSC.

3P PLUS S "INTERFACER II" S-100 I/O BOARD With 1 RS-232 serial I/O and 3 full duplex parallel ports. $199 unkit, $249 assm, $324 CSC.

MULLEN S-100 EXTENDER BOARD with logic probe. $49 kit.

MULLEN H8 EXTENDER BOARD: $39 kit.

MULLEN S-100 CONTROLLER BOARD 8 reed relays close in response to 8 bit word, 8 opto-isolators receive outside world data. $129 kit, $179 assm.

SEE COMPUPRO™ PRODUCTS AT A COMPUTER STORE NEAR YOU!

CIRCLE NO. 27 ON FREE INFORMATION CARD

Personal Electronics News

VIDEOCASSETTE COMPUTER LESSONS in local stores will be available soon, if Electronic Data Systems Corporation, Dallas, Texas (214 661-6000) has its way. Lessons in the first stage, Evolution I™, will be basic introductions to personal computing and business applications, instructions in BASIC programming, and techniques for using a computer in small businesses. If effective, more advanced cram courses will follow.

CABLE TV VIEWERS SHOP BY VIDEO in Reston, VA and Columbus, Ohio. Viewers will be seeing such products as housewares, jewelry, and sportswear at regular five-minute intervals throughout the day. If this new marketing concept, initiated by Warner Cable Corporation and American Express Company is successful, the comfort and convenience of selling and selecting merchandise at home will likely spread throughout the country. Here's how it works in Columbus, Ohio. Subscribers to Warner's QUBE two-way cable TV can buy any one of the merchandising products by simply pressing the appropriate button on the cable console. The item selected is then recorded on a central computer for delivery.

REPEATERS ON ALL ALLOCATED FCC FREQUENCIES is the hopeful goal of Metroplex, a New York metropolitan area club for amateur radio operators. For starters, the year-old club provides 24-hour emergency communications, a world-wide 10-meter link for all hams in all available modes, and repeaters in New York City and North Bergen, New Jersey, carrier-accessed with fully computerized autopatch facilities. In time, the club would like to see its international base broaden with the advent of autopatch and SSB on 10- and 6-meter bands and cross-linking repeaters from band to band. All hams are welcome to attend monthly club meetings in Fort Lee, NJ, and to participate in Swap Net every Thursday night and code practice sessions that will soon be simulcast on all repeaters. To promote club member fraternity, Metroplex throws a gourmet picnic in July, an October fall outing, and a Christmas party every year. For more information, write to Metroplex, PO Box 237, Leonia, NJ 07605 (201 592-1479).

DEVELOPING THE FIRST ANALOG MICROPROCESSOR is one of many accomplishments which earned Ted Hoff of Intel Corporation the Stuart Ballantine Medal from the Franklin Institute in Philadelphia, Pennsylvania. Previous recipients include John Bardeen, co-inventor of the transistor, and Claude Shannon, pioneer in information theory. Briefly, Dr. Hoff proposed a blueprint for microprocessors in 1969, followed by the production of the first microprocessor, the 4004, in 1971. His subsequent work on memory devices led to the 1103, 1024-bit RAM, the first high-density computer memory device. This year, Dr. Hoff shares the Medal with Benjamin Abeles and George D. Cody of Exxon Research and Engineering Company in Linden, New Jersey, for their contributions in the ever-growing field of semiconductors.

TAPE MAKER MAXELL OFFERS RECORDS to commemmorate its tenth U.S. anniversary. A choice of a rock, jazz, or classical stereo disc sampler can be obtained from any dealer upon purchase of either three Maxell UDXL-1 or UDXL-2 90-minute cassettes.

A NATIONWIDE INFORMATION UTILITY for the general public is said to be available from Telecomputing Corp. of America's (1616 Anderson Rd., McLean, VA 22102) SOURCE computer network. Any personal computer equipped with a 300 word/minute telephone interface can gain access to the system by paying a one-time registration charge of $100. Thereafter, SOURCE would be available, via local telephone call, in over 200 cities in the U.S. at $2.75/hr between 6:00 p.m. and 7:00 a.m., local time. The SOURCE provides over 2000 programs and data bases ranging from games such as Star Trek to the United Press International's world and local news. For those not yet equipped with a personal computer, TCA provides Telecomputers for connecting to the network starting at $595 for a keyboard, telephone coupler, and video display.

CLOCKS ADDED A BEAT on New Year's Eve to ring in the 1980 New Year on time. Since 1972, the National Bureau of Standards and other labs using atomic clocks have instituted the "leap second," so that these clocks follow the variations in solar time. In the U.S., the leap second occurred at one second before 7:00 PM EST, 6:00 PM CST, 5:00 PM MST, and 4:00 PM PST on December 31st.


HEWLETT·PACKARD 31E
HEWLETT·PACKARD 32E
HEWLETT·PACKARD 33E

In one year our K40™ antenna has become the largest selling CB antenna in the world!

1. It's the most expensive...

$42.50 suggested retail

And when you pay more, you expect more!

MORE PERFORMANCE: The K40 is guaranteed to transmit further or receive clearer than any antenna it replaces. We know it will. We've tested it with 771 CB'ers just like you for one year.

MORE FLEXIBILITY: You can fit your K40 to any mounting surface. It will fit any vehicle you'll ever own! That includes choppers, dune buggies, gutters, mirror mounts, luggage racks, trunks, hatchbacks, through roofs, semis, pick ups and RV's.

MORE QUALITY: It's not imported. It's not made in Taiwan, Korea or Japan. It's American made in an American town. It's made with better materials that cost more and by professional people we pay more. And we designed it right here in the U.S.A.

*Including optional mounts at extra cost.

2. It's made better...

3. It's proven best!

...Here's what the leading CB publications said.

CB TIMES: "... it's not often that a product bursts onto the market scene, dominates and improves CB'ing for everyone. American Antenna and the K40 are doing it—repeated tests showed the K40 could out-perform the major competitive brands."

RADIO ELECTRONICS: "The results of our tests showed that, in three different positions of the monitoring receiver, the *model K40* equaled or out-performed the competitive antenna. Apparently, American Antenna's advertising is not merely Madison Avenue showmanship."

PERSONAL COMMUNICATIONS: "... an impressive 95% of the trials, the K40 out-performed the existing mobile antennas. We had to try one for ourselves.
"... in every case, the K40 either equaled or out-performed its competitor.
"No ifs, ands, or buts! The K40 Antenna from American Antenna would have to be just about the best antenna around.

CB MAGAZINE: "Introduced in October, 1977, the K40 quickly became the top seller and in mid 1978, became the number one selling antenna in the nation."

...Here's what CB'ers all across the country said.

ANTENNA SPECIALISTS: "... truck driver and CB'er for 10 years ... 50% further than my M410 'Big Momma'."
—*J.H. Collett, 207 McFee, Bastrop, LA*

AVANTI: "I'm an electronic technician with a Second Class FCC license ... I was able to transmit 70% further and tune the SWR 75% lower than my Avanti."
—*H.R. Castro, VRB, Monserrante D-67, Salinas, Puerto Rico*

PAL: "... 20% better in transmission and reception than my 5/8 wave Pal Firestik."
—*John A. Blum, Box 446, Zelienolple, PA*

SHAKESPEARE: "... I've been a CB'er for three years and the K40 is the best I've ever had. Better in reception and transmission than my Shakespeare."
—*H. Bachert, Jr., 15 King Rd., Park Ridge, NJ*

HUSTLER: "Compared to my Hustler XBLT-4, the K40 can consistently transmit 40% further and the reception was better. The K40 is the perfect way to complete a CB system."
—*Jerome R. Brown, 7800 S. Linder, Burbank, IL*

...This Antenna is so DYNAMITE you receive a...

DOUBLE GUARANTEE

GUARANTEE I: The K-40 will transmit farther and receive more clearly than the antenna it replaces or the customer will receive a prompt and full refund from the Registered K-40 Dealer who installed and tuned it.

GUARANTEE II: Unconditionally guaranteed for 12 months. Guaranteed against cracking, chipping, or rusting. Guaranteed against mechanical failure. Guaranteed against electrical failure. Guaranteed against accidental breakage. No exclusions. No gimmicks. For a full 12 months.

(SPECIAL NOTE) IF YOU'RE A BEGINNER:

Our K40 Dealers will be happy to sell you any of the older style and less expensive antennas that are great bargains for any beginning CB'er.

AMERICAN ANTENNA
ELGIN, IL 60120

K40 POWER!

...Sold exclusively by 3500 American K40 Dealers throughout the U.S. & Canada.

CIRCLE NO. 4 ON FREE INFORMATION CARD