Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

OCTOBER 1980/95¢

For Motorists: A Road-Icing Alert

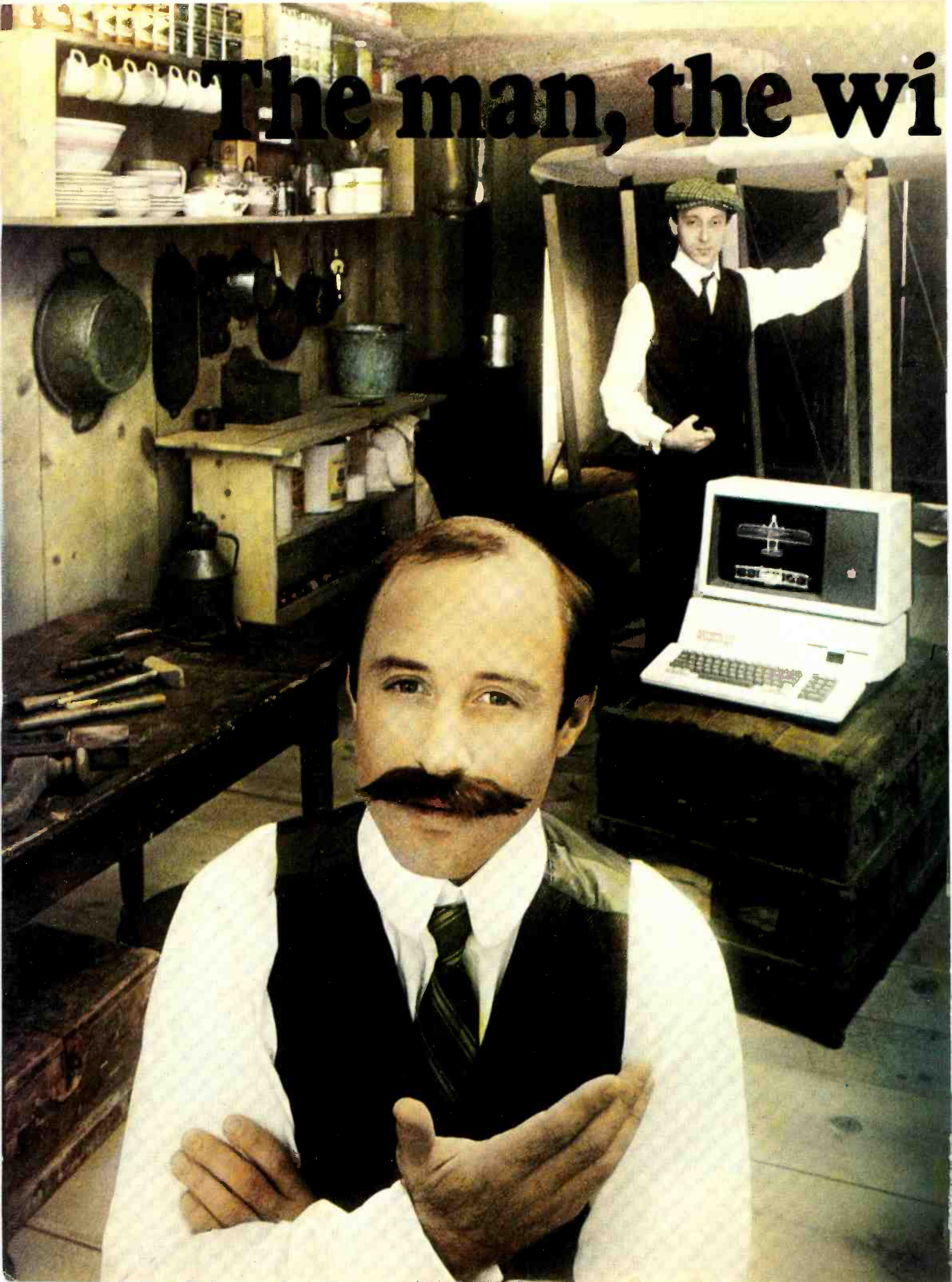
For Computerists: Alarm/Control Clock

For Experimenters: Accurate In-Circuit Ohms Tests

Electronic Games for 1981

From Talking Dolls to Hand-held Games to Video Games, New Electronic Technology is Changing the Face of Leisure Fun & Education.

Flash: Carl Warren Reveals Details on Radio Shack's New 6809-CPU Communication Computer


The man, the wi

ng and the Apple.

If you could talk to Orville Wright, he'd tell you the problems he faced as a turn-of-the-century engineer. You could tell him all about the technological solutions available to today's engineer and scientist... particularly a 20th century phenomenon that tests assumptions and defines models before a project gets off the ground. The Apple personal computer.

Computation, calculation, analysis...the power to pilot your projects.

With a highly-integrated system from the extensive Apple personal computer family, Orville and brother Wilbur would have increased their productivity. Perhaps even launched the Kitty Hawk Flyer well before 1903.

An Apple in their hangar would have freed them from the time and tedium of crunching numbers by hand.

An Apple in your lab or office will give you the problem-solving capabilities you demand from a big computer...without the time-consuming problems typical of remote processing.

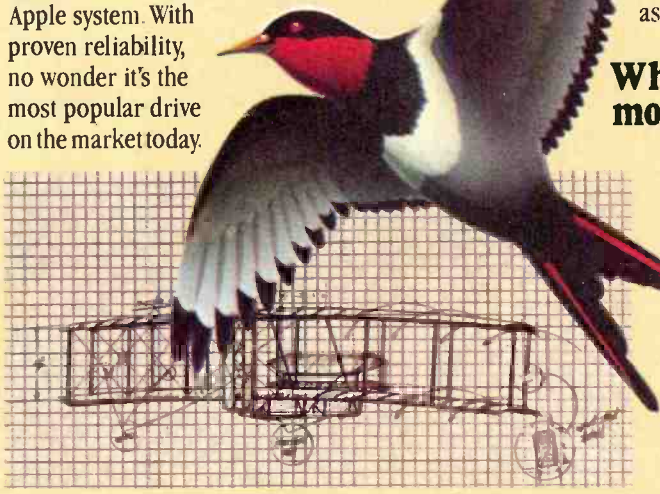
But the Apple system solution doesn't stop there. It keeps on soaring with proven performance, power and expandability

Apple's existing software library includes a program that plots the shape of an airfoil, given its parameters.

that's unparalleled for analyzing alternative paths of design and modeling a wide variety of physical processes.

Want more memory? Depending on your choice of system, Apple has memory expandable to 64K bytes or 128K bytes. Prefer wide displays? Choose 40 or 80 characters. Need to control instruments in the lab? Get on the IEEE 488 bus. Over 100 companies also supply peripherals for Apple because Apple is the most popular personal computer with the least complicated interface.

Want an efficient system of data storage and access? Apple's 5 ¼" disk drive not only offers you increased application versatility, but high density (143K bytes), high speed and low cost. You can even add up to four or more drives to your Apple system. With proven reliability, no wonder it's the most popular drive on the market today.



Wilbur determined that birds didn't have to constantly flap their wings to fly. With an Apple, he could've determined the fixed-wing design of the Kitty Hawk Flyer much faster.

FORTRAN that helped to design a 20th century flying machine.

Fluent in the same language that helped to design the 747, Apple FORTRAN lets you tackle differential equations at the touch of a key. And since more the 170 companies also offer software for the Apple family, you can have one of the most impressive program libraries ever...including vast subroutine libraries for math, science, engineering and statistics. When you write your own programs, the Apple also speaks in languages other than FORTRAN: Pascal, BASIC, PILOT and 6502 assembly language.

Where to learn more about Apple, the small-yet-serious solution.

Let your imagination soar with Apple.

Discover the 20th century tool versatile enough to monitor quality controls and manufacturing schedules, orchestrate tolerance tests and determine alternative parts selection. Learn why Apple emerges as the technological leader of reliable personal computer products that increase your productivity.

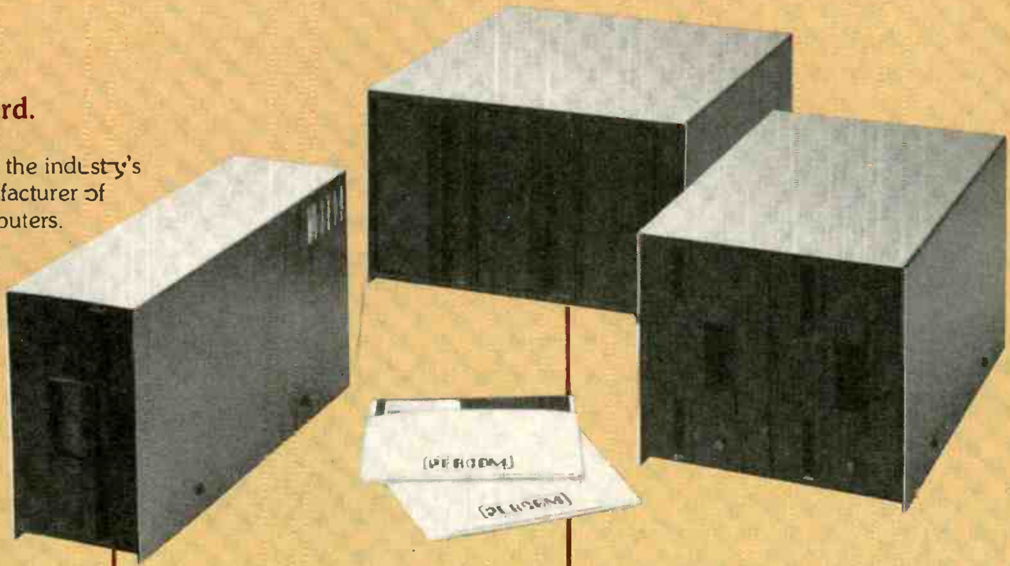
Let the Apple dealer show you how, by putting the system of your choice through its paces. He'll tell you about our extended warranty, support and service. And he'll prove that a personal computer is not just a flight of fancy but a serious solution. Don't let history pass you by. Visit your nearest Apple dealer, or call 800-538-9696. In California, 800-662-9238.

apple computer

CIRCLE NO. 4 ON FREE INFORMATION CARD

TRS-80* Computer Compatible . . .

Quality is the real difference. Low price is merely a dividend.



High quality. Competitive pricing. And a proven track record.

Three reasons why Percom is the industry's number one independent manufacturer of mini-disk systems for microcomputers.

And if you're looking at mini-disk drives, extra storage capacity is an added bonus.

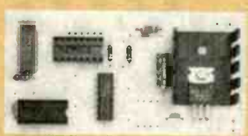
In fact, you store almost one fifth more data on Percom TFD-100tm drives and over two-and-one-fourth times as much on TFD-200tm drives.

Besides extra testing and superior design, you get free, with each system, a software patch on minidiskette that not only upgrades TRSDOS* for operation with the newer 40- and 77-track drives, but also deglitches version 2.1.

Available in 1-, 2- and 3-drive configurations, Percom drives for the TRS-80* computer start as low as $399.

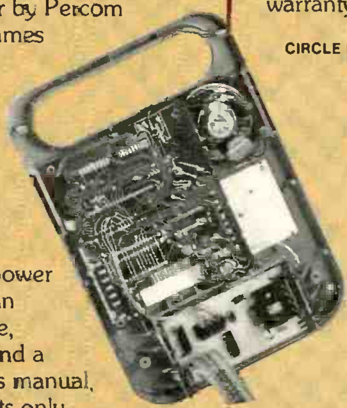
CIRCLE NO. 57 ON FREE INFORMATION CARD

The gift of speech



Called Speak-2-Me-2tm, this clever interface module makes a Texas Instruments' Speak & Spell† the voice of your computer — announcing, imploring, commanding with expressions and sentences created from the Speak & Spell† vocabulary.

Speech is controlled either at the keyboard or by your own Level II BASIC programs. Or by Percom minidiskette word games (available soon).



Speak-2-Me-2tm is installed in the battery compartment of your Speak & Spell†, and power is provided from an ordinary calculator power pak. Supplied with an interconnecting cable, operating software and a comprehensive users manual, Speak-2-Me-2tm costs only $69.95. (Speak & Spell™ not included.)

CIRCLE NO. 50 ON FREE INFORMATION CARD

the Separator:tm End "CRC error. Track locked out!"

This plug-in adapter virtually eliminates data read errors, a problem that plagues TRS-80* computer systems. The SEPARATORtm, so called, is installed in the Expansion Interface without modifying the host system. When installed, data and clock signals are reliably separated during playback, an essential function that the separator circuitry of the host computer performs very poorly. Price is only $29.95.

Note. Opening the Expansion Interface may void the Tandy limited 90-day warranty.

CIRCLE NO. 59 ON FREE INFORMATION CARD

OS-80tm uses Level II BASIC commands

With OS-80tm, Level II BASIC commands are used for DOS and Disk BASIC functions.

You extend the OS-80tm utility set indefinitely with your own BASIC disk-resident utilities.

OS-80tm resides in less than 7-Kbytes of RAM.

The program is supplied on minidiskette along with a simple file manager, BASIC disk utilities and an OS-80tm "Handbook" that you expand and maintain.

All are helpful programming examples.

Price, with instruction manual, $29.95.

NEW! OS-80tm Machine Language SAVE / LOAD Utility. Only $19.95 on minidiskette w/instructions.

CIRCLE NO. 60 ON FREE INFORMATION CARD

Quality Percom products are available at Percom dealers nationwide.
Call Percom's toll-free order number, 1-800-527-1592, for the address of your nearest dealer or to order direct.

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Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

Feature Articles

Construction Articles

Equipment Reviews

Columns

Departments

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Editorial

Electronic Games—The New Wunderkind

It's expected to be a boom year for electronic games and toys—a fortuitous situation created by the same electronic technology successfully used in calculators, watches and personal computers.

Whereas the industry started with TV games, nonvideo electronic games—especially hand-helds—have overtaken these in raw number of units sold. For example, there are some 130 of these small, relatively low-cost games on the market.

The talk of the industry is voice, of course, made possible by speech-synthesis circuits. The advent of synthesized speech in consumer products, in fact, prompted us to feature a female figure on the front cover—Fisher-Price's "Baby Soft Sounds" talking doll. Movement and position triggers its electronic circuitry, which randomly generates 16 different lifelike words and sounds. Texas Instruments spearheaded the consumer talking machine with its educational products. National Semiconductor and Vortex have been very aggressive in the field, too.

The Japanese are on the U.S.'s heels in this area, though, using Nippon Telegraph and Telephone's "Parcor" (partial correlation) system. Hitachi, interestingly, used it for its first electronic speech machine, an abacus trainer. (Don't knock it, as the production rate is said to be 5,000 per month.)

Our first of a two-part series on electronic games discusses their beginnings and the role played by integrated circuits. Next month, we will detail a truckload of games and compare many of them within their particular category. In addition, we'll present a weighted rating sheet so that you can compare similar-type games yourself.

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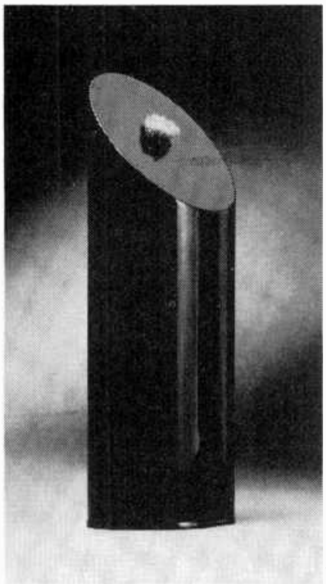
NEW INVENTION



The new Energaire ionized oxygen generator will make a handsome addition to any desk.

Miracle Fuzz

A new space-age invention and the same effect as lightning combine to create the world's first home oxygen regeneration system.

OVER 50,000 SOLD

You need oxygen to live. You can live without food for 60 days, without water for seven days, but without oxygen, you won't make it past two minutes.

That small piece of fuzz located on top of the cylinder shown above emits negatively-charged electrons which attach themselves to molecules of oxygen, thus creating ionized oxygen.

You are already familiar with ionized oxygen if you've smelled the air after a thunderstorm. You feel great, revitalized, and alert. The lightning from the storm adds a small negatively-charged electron to each oxygen molecule in a process called ionization.

SCIENTISTS DISCOVER

Scientists discovered that air quality can actually affect your moods, your feelings and your sense of well being. Air that is positively charged caused people to be depressed, moody and tired. Negatively-charged air made people feel good. We have all experienced air that is positively charged in air-conditioned buildings or in a polluted environment.

Scientists looking for a way to turn positively charged air into negatively charged air developed the negative ion generator—a product that produces negatively charged particles that attach themselves to air molecules and thus create the same fresh feeling you get after a thunderstorm.

The new space-age product shown above is an ionized oxygen generator called the Energaire air purifier. The copper mesh fuzz on top of the unit is one of the secrets of the system.

Although it has no moving parts, you can actually feel a wind of ionized oxygen produced from the fuzz which spreads to fill an average-sized room in one minute.

CIGARETTE SMOKE TEST

To show the dramatic effect of ionized oxygen, you can take the Energaire, blow cigarette smoke into a clear bowl, and hold the bowl inverted over the system. The smoke will vanish. The charged oxygen particles appear to dissolve the smoke particles, precipitating them from the air.

In a room, the Energaire air purifier surrounds you with these oxygen ions and cleans and purifies the air so that even in a smoke-filled room, you will be breathing cleaner, country-fresh air all day long.

WALL TEST

Take our unit and place it next to a wall. Also put a large piece of paper on the wall. Within a few days notice how black the paper gets. That black film is finite carbon particulate matter—the same pollutants you would normally breathe and that would pass through most air filters. By placing the unit in the center of a room or away from a wall, that same matter falls to the ground as dust.

A trip into the mountains exposes you to nature's freshly ionized oxygen. The Energaire produces this same effect. It will clean your room of odor-causing bacteria and stale, musty, or smoky air.

Ionized oxygen should not be confused with ozone. Ozone has a molecular formula of O_3, whereas the molecular formula for ionized oxygen is O_2 with a negatively-charged ion.

DON'T BE CONFUSED

After we announced the Energaire last year, many companies came out with their own ion generators. We purchased a unit from each company and tested them at an independent laboratory. The results are shown below:

Name	*Ions	Price
Energaire	438,000	49.95
Omega 700	63,000	245.00
AirCare	72,000	149.95
Modulion	75,000	79.95

**Measurements indicate total number of ions per cubic centimeter per second at one meter. These figures may vary by plus or minus 10%.*

Note: One unit not mentioned above produced no ions and actually produced ozone or several times the maximum ozone concentration allowed by federal government standards.

USED IN HOSPITALS

Many hospitals are now using ionized oxygen systems in their operating rooms and burn centers. Their units not only purify the air, but they also eliminate pollen and other irritants.

Working in a clean air environment, you think clearer, are more alert, and you function better. The Energaire is actually a miniature lightning machine. The minute you plug it in, energy is converted into ionized oxygen. This efficient system uses one watt of power or less than a penny per day to operate, so you leave it plugged in continuously.

We are so impressed with the pleasant effect of Energaire that we urge you to personally test it yourself in your home or office. Order one at no obligation. Put it by your desk, or in any room where you spend a great deal of time. See if it doesn't rid your room of odor-causing bacteria and stale, musty or smoky air. Try the smoke and paper tests mentioned in this advertisement.

SLEEP FASTER

At home, use the Energaire by your bed and see how country-fresh air allows you to sleep easier, deeper, and more relaxed.

You should notice the difference within one day—especially in a work environment. But use the Energaire for a full month. Then, if you do not feel totally convinced of the positive effects of ionized oxygen, return your unit for a prompt and courteous refund.

The Energaire is manufactured by the Ion Foundation, a leading ion research and development company.

Service should never be required, but if it is, there's a prompt service-by-mail center as close as your mailbox. JS&A is America's largest single source of space-age products—further assurance that your modest investment is well protected. The Energaire measures 9" high by 3" in diameter and weighs 24 ounces.

To order your Energaire ionized oxygen generator, send **$49.95** plus $3.00 for postage and handling (Illinois residents, please add 6% sales tax) to the address shown below or credit card buyers may call our toll-free number below. We will send your Energaire ion generator complete with 90-day limited warranty on the electronics, a five-year warranty on the fuzz, and complete instructions.

Let space-age technology revitalize your life with the world's first home ionized oxygen generator. Order one at no obligation today.

NEW LOW PRICE

JS&A PRODUCTS THAT THINK®

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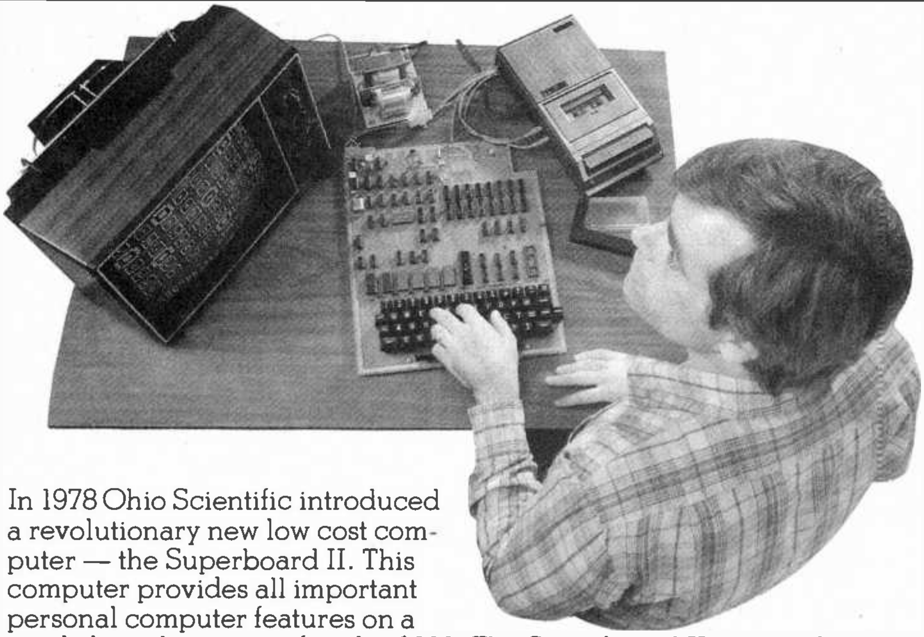
The Age of Affordable Pers



In 1978 Ohio Scientific introduced a revolutionary new low cost computer — the Superboard II. This computer provides all important personal computer features on a single board at a cost of under $300. The Superboard II received rave reviews by microcomputer experts such as:

"We can heartily recommend the Superboard II computer system for the beginner who wants to get into microcomputers with a minimum of cost. Moreover, this is a 'real' computer with full expandability."
POPULAR ELECTRONICS MARCH, 1979

"The Superboard II weighs in at $279 and provides a remarkable amount of computing for this incredible price."
KILOBAUD MICROCOMPUTING FEBRUARY, 1979

"The Superboard II and its fully dressed companion the Challenger 1P series incorporate all the fundamental necessities of a personal computer at a very attractive price. With the expansion capabilities provided, this series becomes a very formidable competitor in the home computer area."
INTERFACE AGE APRIL, 1979

"The graphics available permit some really dramatic effects and are relatively simple to program . . . The fact that the system can be easily expanded to include a floppy means that while you are starting out with a low-cost minimal system, you don't have to throw it away when you are ready to go on to more complex computer functions. At $279, Superboard II is a tough act to follow."
RADIO ELECTRONICS JUNE, 1979

"The Superboard is an excellent choice for the personal computer enthusiast on a budget."
BYTE MAY, 1979

Since the introduction of Superboard II, the cost of personal computers has actually gone up with new models by major manufacturers ranging from $1000 to well over $4000 due to the general cost of inflation and the increasing functionality included in these computers. Today Cleveland Consumer Computers is offering you the original Superboard II at its original price of just $279. In today's economy this is by far the best buy in personal computing ever!

The Superboard II can entertain your whole family with spectacular video games and cartoons, made possible by its ultra high resolution graphics and super fast BASIC. It can help you with your personal finances and budget planning, made possible by its decimal arithmetic ability and cassette data storage capabilities. It can assist you in school or industry as an ultra powerful scientific calculator, made possible by its advanced scientific math functions and built-in "immediate" mode which allows complex problem solving without programming! This computer can actually entertain your children while it educates them in topics ranging from naming the Presidents of the United States to tutoring trigonometry — all possible by its fast extended BASIC, graphics and data storage ability.

The machine can be economically expanded to assist in your business, remotely control your home, communicate with other computers and perform many other tasks via the broadest line of expansion accessories in the microcomputer industry.

This machine is super easy to use because it communicates naturally in BASIC, an English-like programming language. So you can easily instruct it or program it to do whatever you want, but you don't have to. You don't because it comes with a complete software library on cassette including programs for each application stated above. Ohio Scientific also offers you hundreds of inexpensive programs on ready-to-run cassettes. Program it yourself or just enjoy it; the choice is yours.

The Superboard II comes fully assembled and tested. It requires +5V at 3 Amps and a video monitor or TV with RF converter to be up and running. $279.00

Standard Features:

- Uses the ultra powerful 6502 Microprocessor.
- 8K Microsoft BASIC-in-ROM. Full feature BASIC runs faster than currently available personal computers and all 8080 based business computers.
- 4K static RAM on board expandable to 8K.
- Full 53-key keyboard with upper/lower case and user programmability.
- Kansas City standard audio cassette interface for high reliability.
- Full machine code monitor and I/O utilities in ROM.

onal Computing is Still Here.

Mini-Floppy Disk Drive

Direct access video display has 1K of dedicated memory (besides 4K user memory), features upper case, lower case, graphics and gaming characters for an effective screen resolution of up to 256 x 256 points. Normal TV's with overscan display about 24 rows of 24 characters without overscan up to 30 x 30 characters.

Optional Extras:

- Available 610 expander board features up to 24K static RAM (additional), dual mini-floppy interface, and an OSI 48 line expansion interface.
- Assembler/Editor and Extended Machine Code monitor available.
- 630 I/O Expander. RGB color and NTSC composite color outputs with up to 16 colors, Dual 8-axis joystick interface, AC remote control interface which mates with AC-12P, home security interface which mates with the AC-17P, 16-line parallel I/O interface, 16-pin I/O bus interface which allows the connection of parallel I/O lines or high speed analog I/O module, or a PROM blaster or solderless interface prototyping board, programmable sound generator and program selectable modem and high speed printer ports, and more.

Freight Policies All orders of $100 or more are shipped freight prepaid. Orders of less than $100 please add $4.00 to cover shipping costs. Ohio Residents add 5.5% Sales Tax.

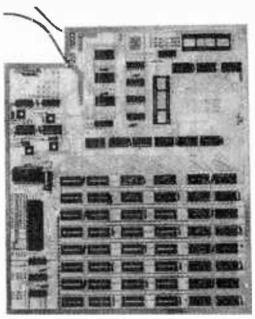
Guaranteed Shipment Cleveland Consumer Computers & Components guarantees shipment of computer systems within 48 hours upon receipt of your order. **Our failure to ship within 48 hours entitles you to $35 of software, FREE.**

Hours:
Call Monday thru Friday
8:00 AM to 5:00 PM E.D.T.

Software:

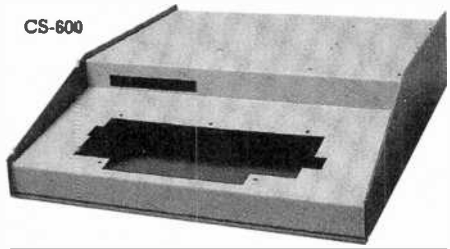
Ohio Scientific and independent suppliers offer hundreds of programs for the Superboard II, in cassette and mini-floppy form. Here is a sampling of popular Ohio Scientific programs for the Superboard II.

EDUCATIONAL PROGRAMS	SBII & C1P	Price
BASIC Tutor Series	SCE-336	$35.00
Clock Tutor	SCE-353	6.50
Continents Quiz	SCE-332	6.50
Definite Integral	SCE-326	6.50
French Drill & Tutor	SCE-339	6.50
German Tutor & Drill	SCE-342	6.50
Hangman (8K)	SCE-324	9.00
Log Tutors 1-3	SCE-344	6.50
Math Blitz	SCE-329	6.50
Math Intro	SCE-319	6.50
Mathink	SCE-337	9.00
Matrix Tutors 1-3	SCE-345	6.50
Metric Tutor & Quiz	SCE-335	6.50
Spanish Drill & Tutor	SCE-352	6.50
Spelling Quiz	SCE-333	6.50
Trig Tutor (8K) I & II	SCE-318	6.50
BUSINESS PROGRAMS		
Address Book	SCB-523	9.00
Advertisement Demo	SCB-520	6.50
Inventory Demo	SCB-518	6.50
Mailing List (8K)	SCB-524	6.50
Straight & Constant Depreciation	SCB-500	9.00
Time Calculator	SCB-525	9.00
PERSONAL PROGRAMS		
Biorhythm	SCP-716	9.00
Calorie Counter	SCP-708	6.50
Checking Account	SCP-719	9.00
Loan Finance	SCP-717	6.50
Personal Calendar	SCP-718	6.50
Savings Account	SCP-720	9.00
GAME PROGRAMS		
Baseball I	SCG-975	6.50
Black Jack	SCG-955	6.50
Civil War	SCG-977	6.50
Destroyer	SCG-951	6.50
High Noon	SCG-960	6.50
Hockey	SCG-979	6.50
Lander	SCG-925	6.50
New York Taxi	SCG-956	6.50
Poker	SCG-962	6.50
Racer	SCG-949	6.50
Space War	SCG-942	6.50
Star Trek	SCG-946	6.50
Star Wars	SCG-926	6.50
Tic-Tac-Toe	SCG-945	6.50
Tiger Tank	SCG-950	14.00



610 Board

CS-600



Hardware:

Superboard II	as specified in the advertisement.	$279
610 Board	For use with Superboard II and Challenger 1P, 8K static RAM expandable to 24K or 32K system total. Accepts up to two mini-floppy disk drives. Requires +5V @ 4.5 amps.	298
Mini-Floppy Disk Drive	Includes Ohio Scientific's PICO DOS software and connector cable. Compatible with 610 expander board. Requires +12V @ 1.5 amps and +5V @ 0.7 amps.	299
630 Board	As specified in the advertisement.	229
AC-3P	12" combination black and white TV/video monitor.	159
4KP	4K RAM chip set.	79
PS-005	5V 4.5 amp power supply for Superboard II.	35
PS-003	Mini-floppy power supply.	29
C1P Sams	C1P/Superboard II Manual.	8
OS-65D	V3.2 Disk Operating System with 9-digit extended BASIC, random access and sequential files.	49
CS-600	Metal case for Superboard II, 610 and 630 board and two power supplies.	49
CS-610	Metal case for single floppy disk drive and power supply.	49
AC-12P	Wireless AC remote control system. Includes control console, two lamp modules and two appliance modules for use with 630 board.	175
AC-17P	Home security system. Includes console, fire detector, window protection devices and door unit for use with 630 board.	249
C4P Sams	C4P Manual.	16
C3 Sams	Challenger III Manual.	40

To Order:
Or to get our free catalog **CALL 1-800-321-5805 TOLL FREE.** Charge your order to your **VISA** or **MASTER CHARGE** ACCOUNT Ohio Residents Call: (216) 464-8047. Or write, including your check or money order, to the address listed below.

CLEVELAND CONSUMER COMPUTERS & COMPONENTS
P.O. Box 46627
Cleveland, Ohio 44146

Order Form:

CLEVELAND CONSUMER COMPUTERS & COMPONENTS — P.O. Box 46627 Cleveland, Ohio 44146

☐ Superboard II $279. ☐ 630 Board $229.
☐ 610 Board $298. ☐ AC-3P 12" B-W Monitor $159.
☐ Mini-Floppy Disk Drive $299. ☐ C1P Sams Manual $8.
(Attach separate sheet for other items.)

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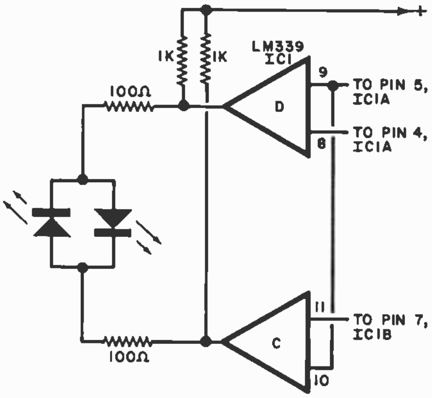
CIRCLE NO. 10 ON FREE INFORMATION CARD

Letters

A Pat On The Back

Robert Krieger deserves a pat on the back for his "Audible Logic Probe" (July 1980). This was one of the fastest and most satisfying projects I've ever breadboarded. I recall, however, that someone once wrote that you should never waste part of an IC if you can think of something it can do. With this in mind, I decided to add a LED visual indicator to the Audible Probe. As shown in the schematic, I jumpered the inputs of *IC1C* and *IC1D* to the inputs of *IC1A* and *IC1B*, respectively, and added pull-up resistors to the outputs of *IC1C* and *IC1D*, whose outputs are then coupled to a tristate LED via 100-ohm resistors. The only extra cost here is for the LED and resistors.—*Jim Cox, Stockton, CA*



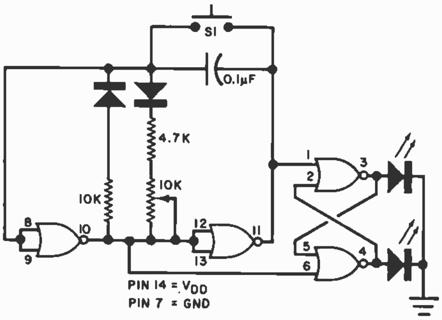
Moped Owner Responds

As a new moped owner, I found "How Far Did You Cycle Today?" (May 1980) very timely. The odometer project presented should serve two purposes for me: to determine fuel consumption and when to refill my fuel tank. However, I plan to simplify construction by substituting an inexpensive Unisonic Model LC-200 calculator for the digital counter described.

To utilize the calculator, the wires from the wheel motion-sensor switch are connected to the contacts of the calculator's M+ key. Operation is as follows: turn on the calculator and key in .1, ÷, (number of revolutions to travel 1 mile), =. Then, after each trip, distance traveled can be obtained by pressing the MR key and reading the display. Since these calculators usually shut down automatically if no entries are made in an 8-minute period, record the mileage after each trip. The number of revolutions to travel a distance of 0.1 mile is 75 for 27" wheels, 88 for 23" wheels.—*Markus Epstein, Boynton Beach, FL.*

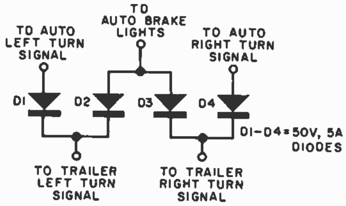
Another Way of Doing It

I noted with interest the CMOS coin tosser circuit in the April 1980 "Project of the Month" column. A circuit that works equally well can be built with a single 4011 or 4001 CMOS IC, half of either used as the clock, the other half as a bistable multivibrator, as shown here.



(Note that IC pin numbers in the diagram apply for both the 4001 and 4011.) With this circuit, it is necessary to adjust for a 50% clock duty cycle, using the potentiometer. If you don't have an oscilloscope to do this, simply measure the direct current flowing through each LED while adjusting the pot. When the same current level flows through each LED, the clock will be adjusted for a 50% duty cycle. —*Ed Johnston, Oshawa, Ontario, Canada.*

The "Turn/Brake Indicator for Trailers" (July 1980) has an interesting way of converting the four-circuit wiring used in newer cars to the three-wire scheme used in older cars. I've used the following circuit to accomplish the same



thing in my Volvo for several years. Note that my circuit is much simpler and has the added advantage that it can be housed inside a compact 35-mm film container. —*Rod Cleckler, Concrete AFS, ND.*

Out of Tune

In "Coupling to TTL Logic" (July 1980, p. 30), load resistor R_L is shown incorrectly connected from the transistor's emitter to ground. It should be connected from collector to the +20-volt line, and the emitter should be grounded.

New Products

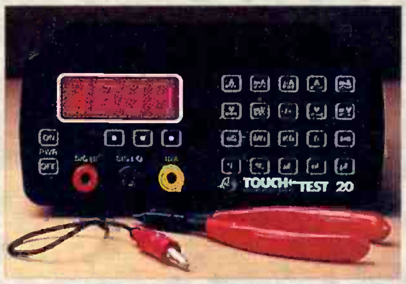
Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

Luxury-Class Receiver

The Revox Model B780 receiver teams a sophisticated integrated stereo amplifier with a synthesizer stereo-FM tuner and microprocessor. The tuner section permits instant access to 18 user-preset stations (accurate to within ±0.005%) or two-speed manual tuning. Station frequency appears in a LED numeric display. An internal battery prevents loss of station memory when power is turned off. Tuner specifications: 34.8 dBf sensitivity for 50 dB quieting; 78-dB alternate-channel selectivity; 0.25% stereo harmonic distortion; 70 dB S/N. The amplifier, monitored by a sophisticated protection circuit, is rated at 75 watts/channel into 8 ohms, 20 Hz to 20,000 Hz, with no more than 0.04% THD and IM. Features include three-way tone controls and capability for dubbing while listening to a different source. $2699.

CIRCLE NO. 94 ON FREE INFORMATION CARD

Touch-Switch Multimeter



Nonlinear Systems' new 3½-digit LED "Touch Test 20" multimeter uses modern touch switches on its front panel in place of mechanical switches to control function, range and power. In addition to traditional DMM tests, it includes capacitance, temperature, and conductance measurement capabilities. Test parameters are ac/dc volts from 10 μV to 750 volts rms (1 kV in dc), ac/dc current from 0.01 μA to 10 A, resistance from 10 milliohms to 20 megohms, capacitance from 1 pF to 200 μF, temperature in both C and F (−40° to +320°F), audible continuity, conductance from 0.01 to 1.999 nanosiemens (equivalent to 5 to 100,000 megohms), and diode test. Features include 0.55" LEDs, auto polarity and overload indication, in-circuit test capabilities, and LED indication of function in use. Size is only 2.9" × 6.4" × 7.5" and weight is less than 3 lb without batteries. Accessories include OSHA-style test leads, a temperature probe, and a component test adapter for radial lead components. $399 for line operation; $425 with rechargeable batteries and charger.

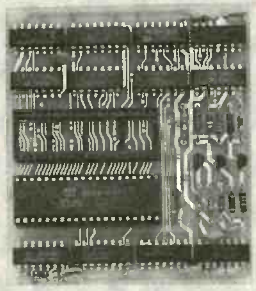
CIRCLE NO. 92 ON FREE INFORMATION CARD

Regency Programmable Scanner

Regency Electronics' Model Touch M400 is a six-band, 575-channel vhf/uhf scanner intended for fixed or mobile monitoring of the public-service bands. A factory-programmed ROM enables the receiver to tune in 545 commonly used PSB channels. An additional 30 channels can be programmed by the user to scan frequencies of special interest. Programming is performed by means of a 20-element, touch-sensitive keypad. Entering the BANK SEARCH command causes the scanner to search ROM channels across an entire band for a transmitted signal. Activating the SEARCH HOLD function allows the user to retain instant access to a given ROM channel without having to load it into one of the 30 user-programmable, scanned RAM channels. An internal NiCd battery maintains the data stored in the RAM when power is removed from the scanner, which is compatible with ac and dc sources. A seven-segment LED readout displays either the received frequency or the time (supplied by an internal clock) at either of two brightness levels. $379.

CIRCLE NO. 91 ON FREE INFORMATION CARD

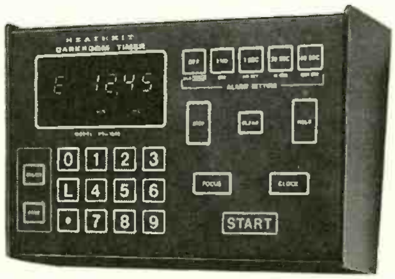
Double Density for TRS-80



Percom's new Doubler is a double-density disk controller that enables a TRS-80 Model I to store up to 354K formatted bytes on a 5" minidiskette (for comparison, a conventional 8" diskette stores 256K bytes). The system works with 5" drives rated for double density. The Doubler reads, writes and formats either single- or double-density diskettes and allows the use of TRSDOS, NEWDOS and Percom OS-80 single-density programs without hardware or software modification. The DBLDOS, the double-density DOS, is said to be fully TRSDOS compatible and a utility in DBLDOS converts files and programs from single- to double-density format and vice versa. The Doubler adapter plugs into the disk controller IC socket of the host controller, and no circuit modifications are required. The Doubler including DBLDOS and the utility is $219.95.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Microprocessor-Controlled Darkroom Timer



The Heathkit PT-1500 Darkroom Timer features a programmable

Attractive wood-grain unit adds to any decor and will Time Control your entire home. Measures: 5¾"x5¼" x3 1/8"

TIME CONTROL

Now, a new computer development lets you control and time your entire home even when you're 1,000 miles away!

In the fall of 1978, an English company, BSR Electronics introduced a remarkable new product, the X-10 Space Controller. The X-10 allowed you to page up to 16 appliances and lights throughout your house remotely from any location. It was an instant success and rightly so. But the most vital part of the system was still in development. Not any more — with Time Control —the system is complete.

Now you can turn your lights or appliances on and off anytime, even when you're on vacation. It can program your TV or radio to wake you and start your coffee all before you get out of bed every day. These are just a few of many things that Time Control does to increase your security and convenience. It can do much more!

IT'S REALLY QUITE SIMPLE

BSR's X-10 Space Controller is really quite simple. It's made up of a central transmitter and receivers, all of which are plugged into your 110 volt wall sockets. You press a number on the calculator-type keyboard of the central control and an electronic signal is transmitted through your existing house wiring to remote modules in which lamps and appliances are plugged.

Simple plug-in modules. No wiring required. Operates over existing in-house wiring.

Outside or overhead lights are controlled by installing a wall switch module that also receives commands from the central controller. Each remote module has a numbered thumb dial. The digital controller activates only those modules set to the desired number. You can control one or up to 16 modules with the system. Time Control adds the missing dimension to Space Control.

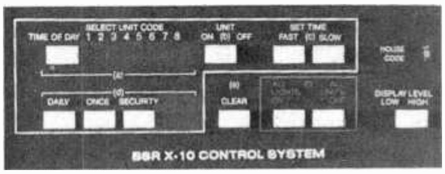
NOW THERE IS TIME CONTROL

Time Control consists of a computer memory and digital clock. You can now program the exact time you want a light or appliance to turn on or off. One mode allows you to even produce a random pattern automatically to make your home appear occupied when you're away.

SPACE AGE ROBOT

Time Control is your own space age robot with four-in-one modes for up to 16 separate functions in your home. Time Control will add conveniences and it may save you thousands of dollars when you're not at home.

• **Security Mode** is used primarily when you're away either one day or the entire summer. Selected lights and appliances are sequenced on and off to give that lived-in appearance. First, a light in one room and then another, a radio in a third, plus the den TV, all can be programmed to fool any would-be burglar "casing" your home. You just select the lights or appliances and the times you want each to be on. Time Control can be programmed in minutes using the calculator type keyboard. One avoided robbery and Time Control pays for itself many fold. Think of the increased peace of mind.



Easy to program Time Control keyboard times lamps, appliances and even outside or overhead lights.

• **Daily Timer** Select any one or all of 8 modules to time daily, then set in any time you want each to turn on and then off. Program your TV or radio to come on to wake you each morning. Turn the outside lights on at 7:00 p.m. and off at 6:30 a.m. Timed to the exact minute of each day automatically. Turn your coffee pot on each morning and shower while your coffee is brewing. Your life may never be the same again.

• **Quartz Clock** Digital Quartz accuracy in an attractive wood-grain finish. Attractive enough to add to the decor of any room. Accuracy unsurpassed by expensive chronometers costing $200 or more. With large easy to read green numbers. May be worth the price of the unit for this feature alone.

• **Panic Button** This bonus feature allows you to turn on all of your lights from your bedside to frighten away peeping toms or intruders. Further peace of mind when you're away and your spouse is home alone.

NO WIRES NEEDED

One of the nice features of time control is that no wires are required. All appliances and lamp modules simply plug into your wall sockets. For outside or overhead light control, you merely change your existing light switch with BSR's wall switch module. Time Control takes it from there.

BUILD YOUR OWN PERSONAL SYSTEM

If you already have a BSR X-10 Space Controller, all you may need is the timer at $74.99. If not, we recommend a starter kit at $119.95 consisting of the timer, two lamp modules and one appliance module. You save $6. We sell all BSR X-10 Accessories so you can add additional modules as you need them to Time Control your *entire* home.

30 DAY NO-RISK TRIAL

Test the Time Control for 30 days at no risk. If Time Control does not provide the convenience and peace of mind we say it can, or for *any* reason, return it to us. We will promptly refund your purchase price. What have you got to lose?

WARRANTED FOR ONE FULL YEAR

Time Control is an all solid state unit. It should provide you with many years of trouble-free service. If in the unlikely event anything should go wrong during one full year, it is factory warranted by a sizable company, BSR.

HURRY! QUANTITIES ARE LIMITED

When we were given the opportunity to introduce Time Control in this country, we jumped at the chance. We also knew quantities would be limited this year. BSR has set aside quantities of Time Controls for us. But there may not be enough. So to be assured of being one of the first to get your Time Control—Don't wait, order now!

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• Send me the following modules. Add $1.00 shipping & handling.

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______Appliance Modules at $15.99
______Wall Switch Module at $17.99

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In Texas Call: **1-214-349-3120 collect**

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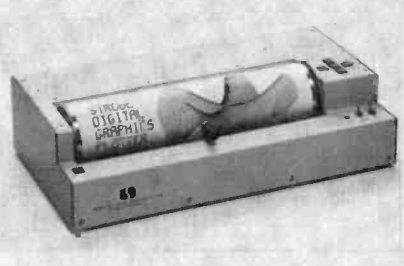
CIRCLE NO. 38 ON FREE INFORMATION CARD

memory that can hold times for up to nine processing steps and an enlarger step while an auto-step function sequences the timer. A 4-digit LED display times to 99 minutes and 59 seconds or to 999.9 seconds. A touch-control switch turns off LEDs and backlighting for complete darkness. Four alarm settings of 1-, 30- or 60-second intervals, selectable in any combination, are also provided. Enlarger and safelight outlets alternate; if an optional PTA-1500-3 Auxiliary Outlet accessory is used to connect the timer to an external device (color drum, etc.), the PT-1500 turns on the auxiliary outlet during countdowns in the process mode. The front panel is impervious to darkroom chemicals. Remote control of the start or focus is provided by an optional PTA-1500-1 foot switch, or both controls can be operated with the optional PTA-1500-2 foot switch. $119.95.

CIRCLE NO. 90 ON FREE INFORMATION CARD

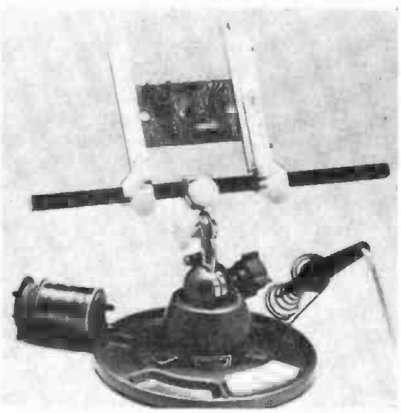
Graphics Plotter



Strobe's Model 100 combined alphanumerics and graphics plotter is a drum-type system that uses 4-phase stepping motors to achieve 0.004-inch (0.1 mm) motions on each axis. It accepts any 8½" by 11" paper and a variety of conventional pens. An interactive digitizing mode enters pen data into the computer. The software package allows for flexible alphanumeric generation, variable character sizes, horizontal and vertical character strings, 90° character rotation, and vector plotting. It works with most versions of BASIC and FORTRAN. Demonstration software is also provided. The plotter comes with assembly language support for 8080, 8085, Z-80 and 6502 machines (source listings and flowcharts are provided) and the printer requires two 8-bit parallel ports and one 8-bit input port. Interfaces for the TRS-80, Apple II, CBM, PET, and S-100 machines are available (RS-232 and IEEE 488 bus systems in the near future). $680.

CIRCLE NO. 97 ON FREE INFORMATION CARD

Panavise Work Station



Panavise Products, Inc. has amalgamated four of its component products—the Model 300 Standard Base, the Model 312 Tray Base Mount, the Model 315 Circuit Board Holder, and the Model 371 Solder Station—into its new Model 324 Panavise Work Center. The unit simplifies construction of electronic projects by holding a circuit board to be worked on at any convenient angle. The Tray Base Mount portion of the Panavise Work Station provides several storage trays in which hardware and electronic components can be stored temporarily. The Solder Station includes a heat-dissipating soldering-iron holder and a solder-spool holder. $49.95.

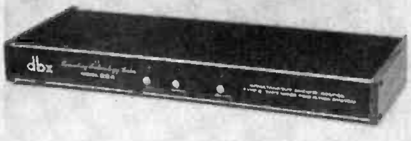
CIRCLE NO. 96 ON FREE INFORMATION CARD

JRC Synthesized Communications Receiver

Japan Radio Company's Model NRD-515 general-coverage communications receiver tunes continuously from 100 kHz to 30 MHz in 100-Hz increments. Its PLL synthesizer is said to drift less than 50 Hz/hour. The dual-conversion receiver employs an upverter (70.455-MHz first i-f), passband tuning, and a photo-chopper tuning dial that's claimed to eliminate backlash and "play." Two tuning rates are available—10 kHz per rotation of the tuning knob or +200 or −200 kHz per step by means of an UP/DOWN paddle switch. Included in the unit are a switchable 10- or 20-dB

r-f attenuator, variable bfo, LSB/USB/RTTY offsets, four selectivity positions (two supplied, two optional), a noise blanker, switchable agc, RIT, S meter, and a six-digit LED frequency readout. Rated sensitivity for 10 dB (S+N)/N is 0.5 μV CW/SSB, 2 μV AM from 1.6 to 30 MHz; 2 μV CW/SSB, 6 μV AM, from 100 kHz to 1.6 MHz. Image and i-f rejection is said to be 70 dB, audio output 1 watt into 4 ohms. An optional Model NDH-515 memory unit makes possible storage of and quick access to 24 often-monitored frequencies. Other options include two narrow i-f filters for CW reception and a matching speaker. Receiver, $1,395; memory unit, $250; 300-Hz crystal filter, $70; 600-Hz mechanical filter, $50; and matching speaker, $42.50. Address: Gilfer Assoc., Inc., P.O. Box 239, Park Ridge, NJ 07656.

dbx Tape Noise Reducer



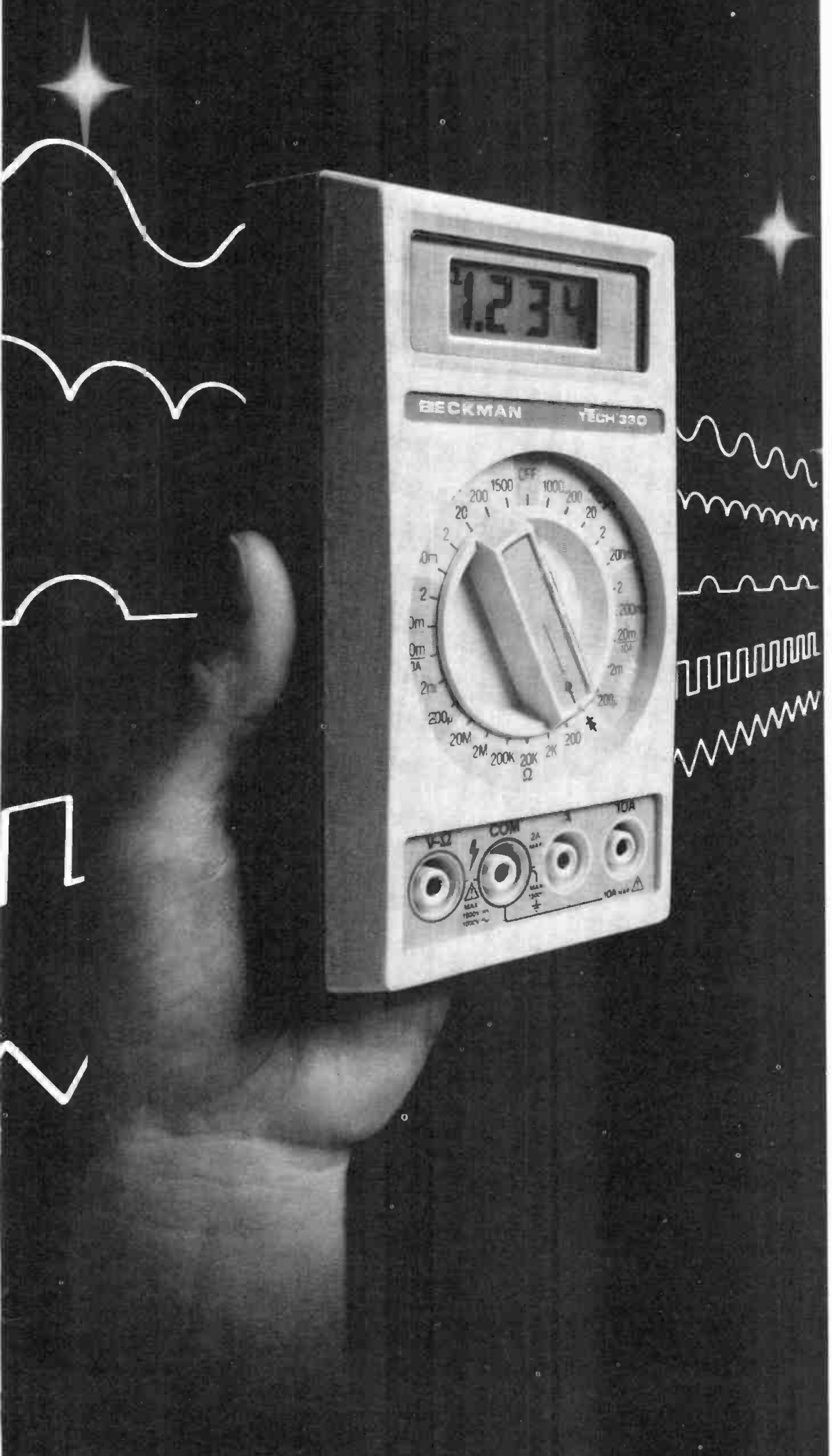
Model 224 Type II, a noise-reduction system from dbx, provides up to 40 dB increase in usable dynamic range in tape recording, and can decode dbx-encoded phonograph discs as well. Capable of encoding and decoding simultaneously, it provides full monitoring capability with three-head recorders. It can also be used with two-head decks. A unique rms detector is said to measure the program's dynamic content and set the gain of a voltage-controlled amplifier to perform compression and expansion during recording and playback. Compression and expansion ratios are 2:1 and 1:2 (fixed), dynamic range is 110 dB, frequency response is 30 to 20,000 Hz ±1 dB, and THD and IM are typically 0.5% and 0.2%. $275.

CIRCLE NO. 95 ON FREE INFORMATION CARD

TV Splitter/Switcher

"The Switcher" from Fidelitone is an r-f splitter/switcher that provides an interface between a standard TV receiver, video cassette recorder (VCR), and cable/pay TV "premium device."

Beckman brings a new dimension to hand held Digital Multimeters



True RMS capability at an affordable price

Now you can measure the exact power content of *any signal* – regardless of waveform. Beckman delivers the new TECH™ 330 multimeter with true RMS capability and many more fine performance features for just $200.

Unlike the common average responding multimeters calibrated to measure only sine waves, the TECH 330 with true RMS capability gives you accurate readings of both sine and non-sine waveforms.

True RMS makes a significant difference in accuracy when measuring switching power supplies, flyback power circuits, SCR or TRIAC controlled power supplies or any other circuit generating a non-sine signal.

The TECH 330 also accurately measures the entire audio band up to 20 kHz. But that's not all you can expect from Beckman's top-of-the-line multimeter.

Measurement Comparison Chart

Waveforms (Peak = 1 Volt)	Average Responding Meter	Beckman TECH 330	Correct Reading
Sine Wave	0.707V	0.707V	0.707V
Full Wave Rectified Sine Wave	0.298V	0.707V	0.707V
Half Wave Rectified Sine Wave	0.382V	0.500V	0.500V
Square Wave	1.110V	1.000V	1.000V
Triangular Sawtooth Wave	0.545V	0.577V	0.577V

You also get 0.1% basic dcV accuracy, instant continuity checks, 10 amp current ranges, a separate diode test function, 22 megohm dcV input impedance, and an easy-to-use rotary switch.

With so much capability in hand, you'll be able to depend on the TECH 330 for a long time. That's why Beckman designed it tough enough to go the distance.

Enclosed in a rugged water-resistant case, the TECH 330 can take a 6-foot fall onto concrete and still perform up to spec. And to further ensure reliable, trouble-free operation, the TECH 330 gives you 1500 Vdc overload protection, RF shielding, 2000-hour battery life, gold switch contacts, and fewer electronic components to worry about.

Add another dimension to your world of electronics. Visit your Beckman distributor today for more information on the TECH 330 and Beckman's complete line of digital multimeters, starting at $110.

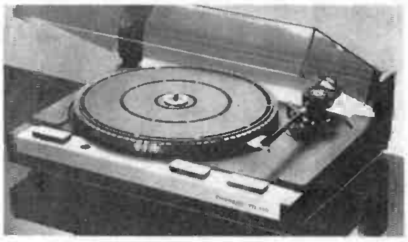
To find out which of our 500 distributors is nearest you, call: (714) 993-8803 or write Beckman Instruments, Inc., Electro-Products Group, 2500 Harbor Boulevard, Fullerton, CA 92634.

BECKMAN

CIRCLE NO. 7 ON FREE INFORMATION CARD

Using The Switcher, the TV receiver can be tuned to the output channel of the VCR, premium TV device, or directly to the cable system or antenna. Thus, one can watch one channel on the receiver while recording another channel on the VCR. Three r-f cables are provided with the device to simplify installation. Specifications: isolation, greater than 50 dB; shielding, greater than 45 dB; loss between CATV connection and CATV device, less than 4 dB; loss to VCR and direct connection to TV receiver, less than 9 dB. Address: Fidelitone Inc., 3001 Malmo Rd., Arlington Heights, IL 60005.

Thorens Belt-Drive Turntable



A dc-motor/belt-drive system, with motor mechanically isolated from the chassis, is featured in Thorens' new Model TD 115 turntable. A load-compensating circuit in the motor's servo system detects load variations and compensates to maintain accurate $33^1/_3$- or 45-rpm speed. The included Model TP 30 tonearm (with TP 70 cartridge wand) has an anti-skating force applied with repelling magnets. Tonearm friction is reduced to less than 15 mg via jeweled pivot bearings that are, in turn, protected by a spring loading system. Shutoff is automatic at end of play. An "ortho-inertial" suspension damps external shocks. Specifications: wow and flutter, approximately 0.05% (DIN 45507); rumble, −48 dB unweighted, −64 dB weighted (DIN 45539); pitch control, ±6%; effective tonearm mass, 7.5 grams; cable capacitance, 230 pF ± 10%; 1.3-kg zinc-alloy turntable platter. $435.

CIRCLE NO. 98 ON FREE INFORMATION CARD

RS-232 Data "Sponge"

The Micro-Sponge, an RS-232 version of the famous Exatron Stringy Floppy, connects to the RS-232 port of any computer and can store up to 80 kilobytes on a 75-foot-long stringy floppy wafer. Baud rates are selectable between 300 baud and 76.8 kilobaud. The software protocol consists of Read, Write, Go to Beginning of Tape, and Space File Forward. Rewind is unnecessary due to the Wafer's continuous-loop design. The sponge buffers up to 1000 bytes in internal RAM before writing out to the wafer and requires 4.5 seconds to transfer 5.3K bytes at 9600 baud, and 24 seconds to locate the beginning of the tape. $349.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Digital Capacitance Meter

The Micro-C PROBE from International Instrumentation Inc. is a microprocessor (6502) based digital capacitance meter having a range from 0.1 pF to over 100 F full scale, a resolution of 0.1 pF, and a claimed accuracy of 0.1%. Auto ranging and auto zero are featured. Readout annunciators are provided for pF, nF, μF, mF and F. The display is four-digit LCD. Average testing time is $^1/_{10}$ second, while maximum time for 100 μF is $^3/_{10}$ second. An optional multiple-limit comparator allows up to 16 sets of limits to be used. A 16-key keypad is used for operator control and entry. $299.95.

CIRCLE NO. 100 ON FREE INFORMATION CARD

We've got it all together.

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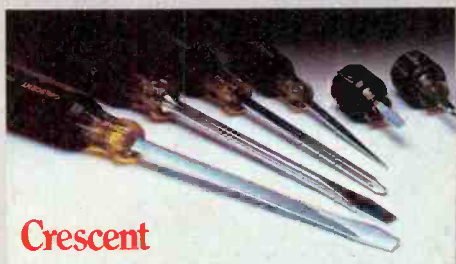
Weller, Wiss
Xcelite

Take a quick look round this ad and you'll agree that "All together" is no exaggeration. Whether you're making or mending, cutting or joining, measuring or stripping, there's a Cooper tool that's just right for the job. Don't take chances on tools. Specify Cooper and get 'em right the first time!



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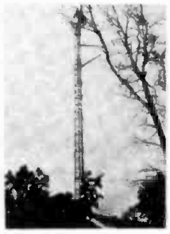
NRI will train you at home to be an electronics professional in the growing world of communications.

Learn to service, repair, and install everything from microwave antennas to two-way radios...from radar sets to TV transmitters.

TV Tape Recorders

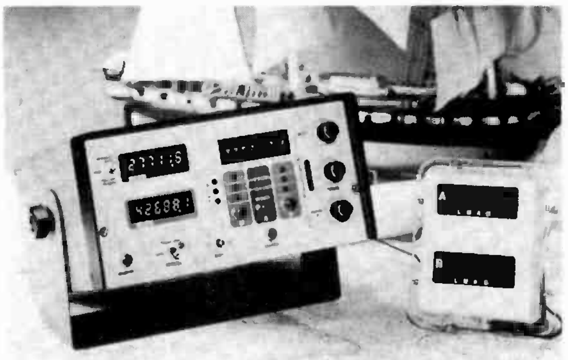
TV Broadcasting



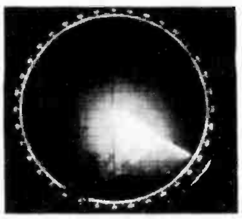
Antenna Systems

Marine Communications

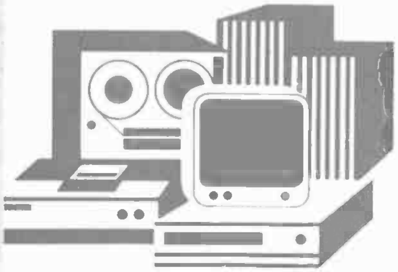
Aviation Communications & Navigation Systems



Direction Finders, Loran



Radar



Entertainment Electronics

By Harold A. Rodgers
Executive Editor

Notes on Sound and Hearing

HOW is a high-quality audio component to be distinguished from one that is mediocre? According to current practice, two methods are available: (1) Measure its input and output signals and verify that the relationship between them is correct or at least acceptable. (2) Set the component up as part of a system and listen to it, possibly comparing it to another unit of the same kind.

Though these methods are to a degree complementary, each contributing information inaccessible to the other, great controversy has arisen concerning their relative merits. One school of thought holds that every measurable approach to the ideal situation in which the output signal of a device is identical to its input (except possibly for level) constitutes an improvement. A second viewpoint considers measurements virtually meaningless, insisting that sensitive and properly trained ears can make discriminations that test equipment cannot. Fairly recently, members of the engineering community have begun to examine the subjective response scientifically. It is just possible that research of this kind will eventually reconcile these antagonistic positions.

Objectifying the Subjective. At the London convention of the Audio Engineering Society, held in late February of this year, Stanley P. Lipshitz and John Vanderkooy of the University of Waterloo in Canada delivered a paper describing some of their research into this subject. They postulate that certain conditions must be met for subjective tests to be meaningful to others: (1) They must be conducted by technically competent people who know how to keep external effects, subtle or obvious, from influencing the outcome. (2) Linear differences (frequency and phase response, acoustic polarity, and level) must be accounted for before conclusions can be reached about nonlinear differences. (3) The subjective judgement must be simple, as, for example, distinguishing between two components. (4) The test must be blind or, preferably, double blind. Lipshitz and Vanderkooy go on to advocate the use of A/B switch-boxes, allowing that the box itself can be tested for intrusive effects.

One significant pitfall warned against by these authors is reliance on listener preference. It has been observed that, in some circumstances, listeners asked to choose between two components will prefer the one with higher distortion. Reliance on commercially available program material as a test signal can also lead to false results. This can be especially true when qualities such as "ambience" and "imaging," which are as much or more properties of the source material as are the reproduction equipment under consideration.

In evaluating results, the authors point out, it is important to distinguish between *audible* and *significant* differences. A difference can be shown to be audible when, after a sufficiently large number of trials, statistical analysis shows that the listeners participating in the test can make a discrimination with a frequency better than would occur by chance. But an error that can be easily corrected, as by equalization, or that would be likely to go unnoticed outside the laboratory (e.g., a frequency response error of 0.5 dB) could well be deemed insignificant.

The conclusion of this paper states that the authors have not encountered any audible phenomena for which they could not measure a possible cause. Further, they found that they could easily measure differences that were not audible. Level differences as small as 0.2 dB were shown to be audible if present over a wide enough bandwidth.

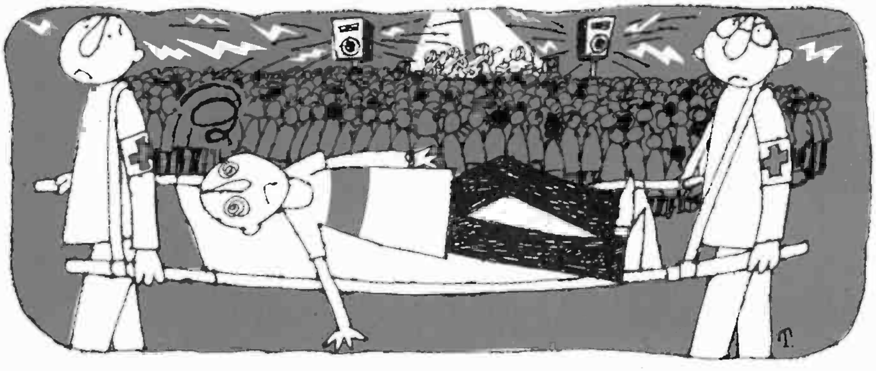
Investigation of the audibility of nonlinear distortion showed that crossover distortion in a Class B amplifier is not as audible as many people think. With a sine-wave test signal, crossover distortion was detectable at a level that averaged about 0.1%. When a music signal was used, the threshold rose to about 1%. Interestingly, solo piano is most sensitive to the effects of crossover distortion, which is heard in this case, as noise modulation.

Amplifier Clipping. A paper prepared for the same convention by Drs. P.A. Fryer and Gareth P. Millward of Rank Hi Fi in England investigated the matter of amplifier clipping and offered the surprising conclusion that it is often more problematic for the loudspeakers than for the listeners. Using a test setup that allowed controlled amounts of clipping to be added to the program material before it reached the power amplifier (which was never permitted to clip), these researchers tested for the audibility of clipping, using various test signals and different musical selections played at sound pressure levels (SPL) from 85 to 105 dBA. Clipping was quantified according to the fraction of the total duration of the program segment over which it occurred. Thus, a clipping level of 1% for a five-second selection would denote 50 ms of clipping.

It was found that white noise can be clipped with little change in perceived quality other than in level. Sine waves, on the other hand, show audible change quite readily. The authors suggest that the less a signal resembles a sine wave and the more it is like white noise, the less it will change in tonal quality when clipped.

On loud classical music, clipping was just detectable in the range of 1-4% over the whole passage and 7-15% on peaks, with the threshold falling as the level increased. Listeners did not, however, find the effect seriously objectionable until levels of 5% on average and 20% on peaks were exceeded.

With disco music, clipping became



far more tolerable. Listeners did not notice it until it reached 6-16% average and 12-28% on peaks, and were not disturbed by it until it reached 23-30% average and 33-36% on peaks.

Since clipping of a signal can raise the amount of power an amplifier delivers, a loudspeaker can be placed at considerable risk if the higher power is permitted to occur for a substantial length of time. The danger is compounded by the fact that listeners may not detect clipping audibly and may not reduce the level in time.

Sound Pressure Levels and Health. Damage to one's hearing is not the only risk associated with exposure to high SPLs, according to *The Mind and Sound*, a paper written by Martin Polon of UCLA, also for the London AES convention. Actually, the title is somewhat misleading, as the paper shows many of the effects of such exposure to be physiological and not just psychological. In particular, Polon states that blood levels of hormones associated with stress have been shown to double or triple after prolonged exposure to loud sounds. He cites deleterious effects on the endocrine, reproductive, circulatory, and nervous systems.

The SPLs attributed to concerts of "new wave" and "punk rock" music are surprisingly high, reaching 125-135 dBA consistently. It is said that, of 39 concerts surveyed in Los Angeles over a six-month period, only two had SPLs below 120 dBA.

Numerous deleterious effects are associated with such high sound levels and the physiological stress they create. Constriction of peripheral blood vessels with an accompanying rise in blood pressure and elevated levels of cholesterol and triglycerides has been shown to contribute to degeneration of the arteries and the heart muscle itself. In other cases, high levels of epinephrine and norepinephrine due to sonic exposure have been associated with the onset of psychotic episodes. Neural disturbances as severe as epilepsy have been shown to occur in sensitive individuals exposed to bursts of high-level sound.

Sensory dysfunction can occur too. Audio levels on the order of 130 dBA have been shown to cause dizziness, vertigo, and uncontrollable movements of the eyes. Other visual disturbances may include narrowing of the field of vision, loss of visual acuity, changes in color perception, and reduction of night vision. Polon points out that some people experience these effects at levels as low as 95-100 dBA and suggests that driving an automobile with the stereo system producing SPLs of this order may be questionable in terms of safety.

Overexposure to loud sound, according to the paper can also interfere with sexual and reproductive functioning. In particular, it has been shown that stress induced on a pregnant woman in this fashion can affect the developing fetus, often posing considerable risk. As a final point, it is suggested that changes in brain chemistry caused by high SPLs may cause sleep disturbances if exposure occurs close to bedtime.

Certainly, this paper brings to light some startling facts that should be investigated further. In the meantime, a survival kit for discos and rock concerts might well include a sound-level meter and ear protection. ◇

Audiophile Recordings

By Harold A. Rodgers
Executive Editor

HANDEL: ***Water Music Suite*; *Air from Concerto Grosso Op. 6, No. 12*.** J.S. BACH: ***Air for the G String*.** PACHELBEL: ***Canon in D*.** Zoltan Rozsnyai conducting the Philharmonica Hungarica. M & K RealTime Records RT 206 (dbx PS-1007). The combination of dbx-encoded disc plus digital master tape is truly amazing—even to the point of being a little unsettling at times. There's a tiny "thud" as the stylus settles into the lead-in groove and then silence . . . then music coming at you from out of nowhere. At least in the concert hall there's a sudden hush when things are about to get going—and you can see the conductor.

First-rate playing and ensemble are in evidence in the *Water Music Suite*, with the horns producing an especially lovely tone. This, however, makes it all the more frustrating that authenticity is given such short shrift. This "Water Music" bears only a slight resemblance to anything penned by Handel. Excerpts are taken from Suite No. 1 in F, rearranged in order for some reason, and one number from Suite No. 2 in D is grafted on, with timpani, which are *not* in the original, added. (Suite No. 3 in G is allowed to escape entirely.) The final lapse is that the harpsichord continuo, which is *de rigeur* (Handel would have conducted from the keyboard) is omitted. And Bach and Pachelbel fare no better.

Even granted that this is a "pops"-type presentation of baroque music, there is no reason to let performance practice stray so far afield.

SHOSTAKOVICH: ***Festive Overture*;** RAVEL: ***Bolero*;** GINASTERA: ***Estancia Ballet Suite*;** WEINBERGER: ***Polka and Fugue from "Schwanda"*.** Morton Gould conducting the London Symphony Orchestra. Chalfont SDG 301 (dbx PS-1019). This is another "pops" concert recorded in digital cum dbx, and the sonic result is equally amazing—in fact more so, as the orchestrations are more colorful. The hit of the disc is, of course, the redoubtable—if somewhat over-familiar—*Bolero*. Gould gives this piece the "funkiest" performance I've yet heard, emphasizing jazzlike turns of phrase and timing. I don't know what Ravel would think about this, but it seems to work very well.

What is particularly interesting about this reading is that it lets you hear details of the scoring. Frequently, the melody is taken by what sounds like a familiar instrument, but not quite. On this recording you can hear the familiar instrument with one of its *overtones* doubled softly by another.

The other works also seem well performed. Execution is precise and spirited, with brilliant orchestral color.

W. A. MOZART: ***Two Concertos for Flute and Orchestra: G major, KV 313; D Major, KV 314. Andante in C Major, KV 315.*** András Adorján, flute; Hans Stadlmair conducting the Münchener Kammerorchester. Denon PCM OX-7180-ND. According to the liner notes, András Adorján studied with Jean-Pierre Rampal, and his tone certainly sounds it. He plays with a big, opulent sound that has a neat vibrato and just enough edge tone to stand out over the orchestra. In fact, it may be just that little touch of brilliance that keeps this big tone from overpowering Mozart's rather delicate phrasing. And this young flutist has even risen to the challenge of preparing his own cadenzas.

Stadlmair, for his part, projects a rather romantic Mozart. Attacks, for example, are scattered in time by just enough to sound "softened," although without disturbing the rhythmic flow. This is by no means objectionable, but for my ear, a little more precision is called for. Part of the problem may be that the recording environment is a bit too reverberant. Nonetheless, these are pleasing performances by highly competent personnel.

Remastered Releases:

NEIL DIAMOND: ***Hot August Night*.** Mobile Fidelity MFSL 2-024.

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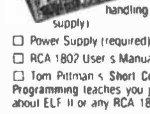

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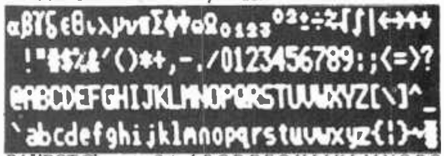

BAUDOT Character Set: *A B C D E F G H I J K L M N O P Q R S T U V W X Y Z - ? : • 3 $ # ( ) . , 9 0 1 4 ! 5 7 ; 2 / 6 8* • **Cursor Modes:** *Home, Backspace, Horizontal Tab, Line Feed, Vertical Tab, Carriage Return. Two special cursor sequences are provided for absolute and relative X-Y cursor addressing*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

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Audio Product of the Month

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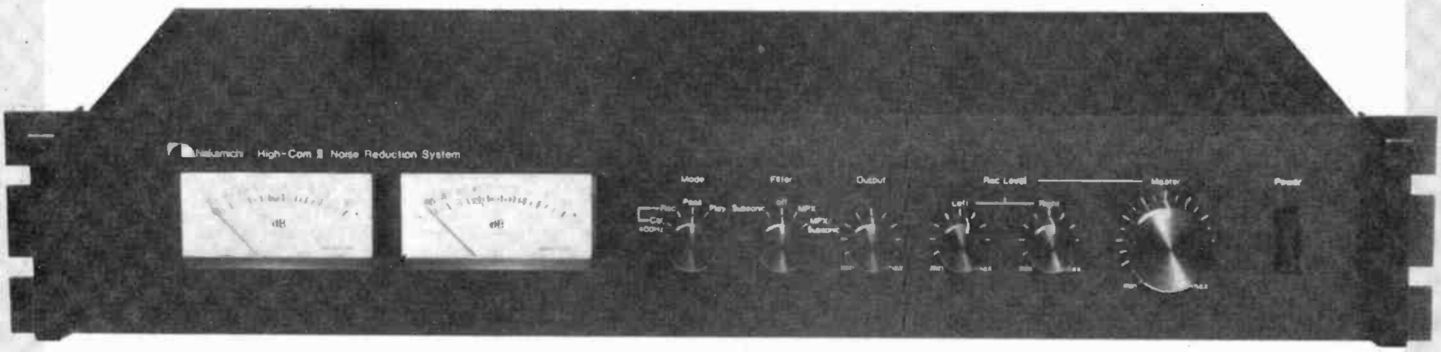

Nakamichi High-Com II Noise Reduction System

A sophisticated, two-band compander system based on a special integrated circuit from Telefunken

THE Nakamichi High-Com II noise-reduction system is a consumer version of the professional High-Com system developed in West Germany by AEG-Telefunken. Built by Nakamichi under license, it incorporates a special integrated circuit developed by Telefunken. In many respects High-Com bridges the gap between the ubiquitous Dolby B system and the professional Dolby A noise reduction system used on virtually all master tapes.

Operating in two frequency bands (in contrast to the single-band Dolby B and the four-band Dolby A), High-Com II is said to provide at least 12 dB more noise reduction than Dolby B, plus additional high-frequency headroom on the tape. According to Nakamichi, the total dynamic-range advantage over Dolby B is approximately 20 dB.

At present, the Nakamichi High-Com II is available only as an "add-on" accessory that connects between the tape deck and the associated amplifier. It is a low-profile, all-black package measuring 19"W × 10⅝"D × 3¼"H and is fitted with "ears" for mounting in a standard EIA rack. High-Com II weighs 11 lb (5 kg). Its suggested retail price is $420.

General Description. While no circuit details of the Nakamichi High-Com II are available, its block diagram and operating controls show both its similarity to and differences from the Dolby Noise reduction systems. Like Dolby, it is level sensitive, and a "0 dB" operating reference is established by an internally generated calibration tone.

In use, High-Com II takes over the recording and playback level control functions from the recorder, whose controls should be set to maximum gain. A 400-Hz reference tone is recorded on the tape at a level of 0 dB as indicated on the recorder's meters (it simultaneously reads 0 dB on High-Com's two level meters, which are peak reading and have a 50-dB range). Recording level is calibrated with two back-panel knobs.

With the MODE switch of High-Com II set to PLAY, the tape is played back and the input calibration knobs in the rear of the unit are adjusted for 0-dB readings on its meters. All subsequent level adjustments are made from the front panel of High-Com II with its OUTPUT control and three REC LEVEL controls (individual channel controls and a MASTER gain knob).

According to the markings on the meters of the High-Com II, their 0-dB level corresponds to a tape flux of 200 nWb/m (standard Dolby level). Not all tape decks calibrate their meters this way, but this is not a rigorous requirement if the High-Com II has been set correctly for the recorder.

Recording levels are set on the recorder's meters, using the High-Com's controls. (High-Com's own meters react to the unprocessed input signal,) Lacking separate recording and playback electronics, High-Com II must be switched between PLAY and REC by its MODE switch. Also, a second High-Com II unit would be required to monitor the playback output of a three-head deck while recording. A PASS position on the MODE switch bypasses the noise-reducing circuits.

Like Dolby, High-Com II can be affected by leakage of the 19-kHz multiplex pilot carrier into an FM program being recorded. It therefore incorporates a switchable 19-kHz rejection filter. Unlike the Dolby B system, which operates only at high frequencies and is not affected by low-frequency noise, the Nakamichi High-Com II processes the entire audio range. Therefore, a SUBSONIC filter cutting off sharply below 30 Hz is included. The FILTER switch can be set to OFF, SUBSONIC, MPX, or a combination of the two. The filters also work in the PASS mode. Nakamichi's High-Com II compresses and expands the low and high frequencies separately, using appropriate attack and release times for each band in order to suppress audible side effects, such as "breathing." While Dolby operates only on signals *below* a certain threshold, High-Com II affects signals only *above* a threshold level.

The compression slope is 2:1, so that for signals above the threshold

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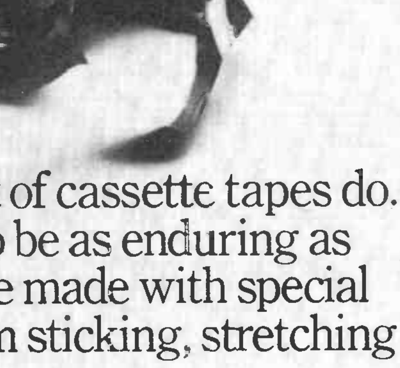

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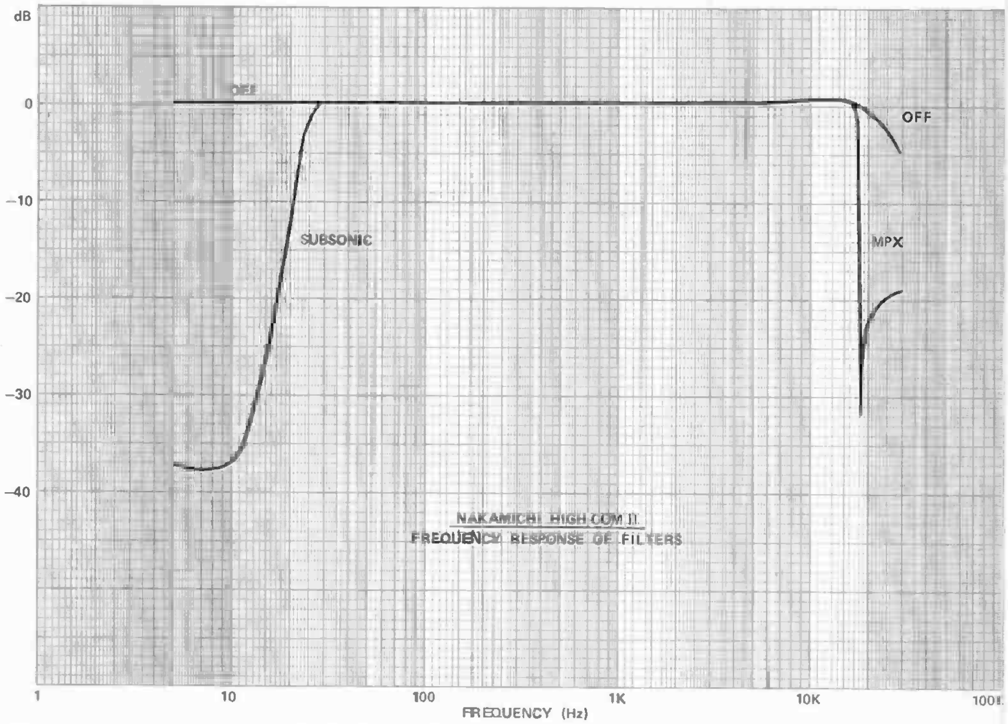


Frequency response curves with the filters off is flat within ±0.6 dB from 5 to 20,000 Hz. The subsonic filter cuts off below 30 Hz, and the MPX filter notches at 19 kHz.

level (−25 to −45 dB, depending on frequency) a 2-dB level change in the signal appears at the recorder inputs as a 1-dB change. In playback, the inverse operation restores the original dynamic range. The compression range extends above 0 dB (up to at least +10 dB), which has the effect of increasing system headroom, particularly at high frequencies.

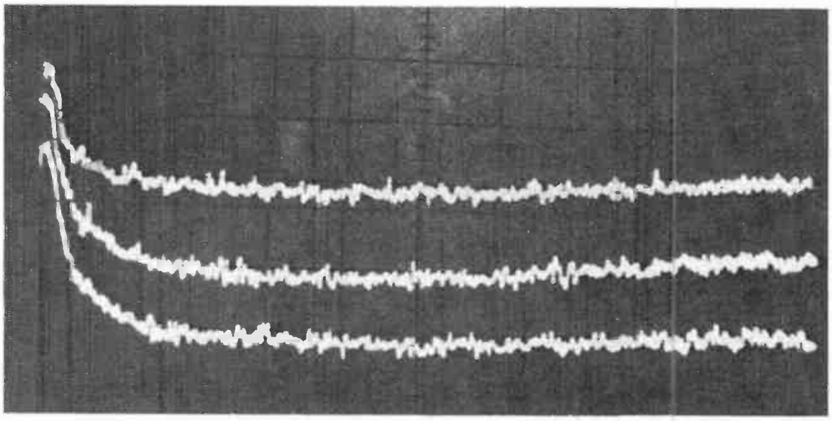
Below the compression threshold High-Com II acts as a linear (1:1) amplifier. This is said to provide further assurance against modulation of background noise by program-level variations. In addition, the separate processing of low and high frequencies minimizes modulation of hiss by low-frequency amplitude envelopes.

Laboratory Measurements. Although we were unable to measure the dynamic operation of the unit (which would have required access to its internal circuits) we did measure static transfer characteristics over a wide range of amplitudes at frequencies of 100 Hz, 1 kHz, and 10 kHz. The results generally confirmed the somewhat idealized plot of encoding and decoding characteristics presented by Nakamichi.

The CAL tone output level was 0.61 volts, and a playback signal of 60 millivolts was sufficient to calibrate the meters of the High-Com II to their 0-dB points. Frequency response and filter characteristics were measured in the PASS mode, bypassing the expansion and compression circuits. With the filters OFF, response was flat within ±0.5 dB from 5 to 20,000 Hz, falling off to −5 dB at 30,000 Hz. Leaving 30 Hz unaffected, the SUBSONIC filter cutoff very sharply below that point, reaching about −37 dB at 10 Hz and below. The MPX filter had no effect at 16 kHz or below, but notched the 19-kHz response to −32 dB, returning to −19 dB at 30 kHz.

The composite spectrum-analyzer photograph made with a high-quality cassette deck and linear scan from 0 to 20,000 Hz shows the smoothed noise output from a blank but biased TDK SA tape. The upper trace was made with no noise reduction, the middle trace with Dolby B, and the lower trace with the High-Com II set to PLAY (the absolute levels are purely arbitrary). The reduction of the noise level with High-Com II operating is an almost constant 20 dB across the audio range. The 12-dB improvement of High-Com II over Dolby is clearly visible, as is the fact that the Dolby is reducing noise by 9 to 10 dB.

Conventional meter noise measurements using CCIR/ARM weighting do not show such a dramatic difference between High-Com II and Dolby, presumably because the CCIR



Composite spectrum-analyzer photograph of response from 0 to 20,000 Hz with no noise reduction (top), with Dolby B (center) and with High-Com II (bottom). Dolby B reduces noise by 9 to 10 dB, High-Com by about 12 dB more.

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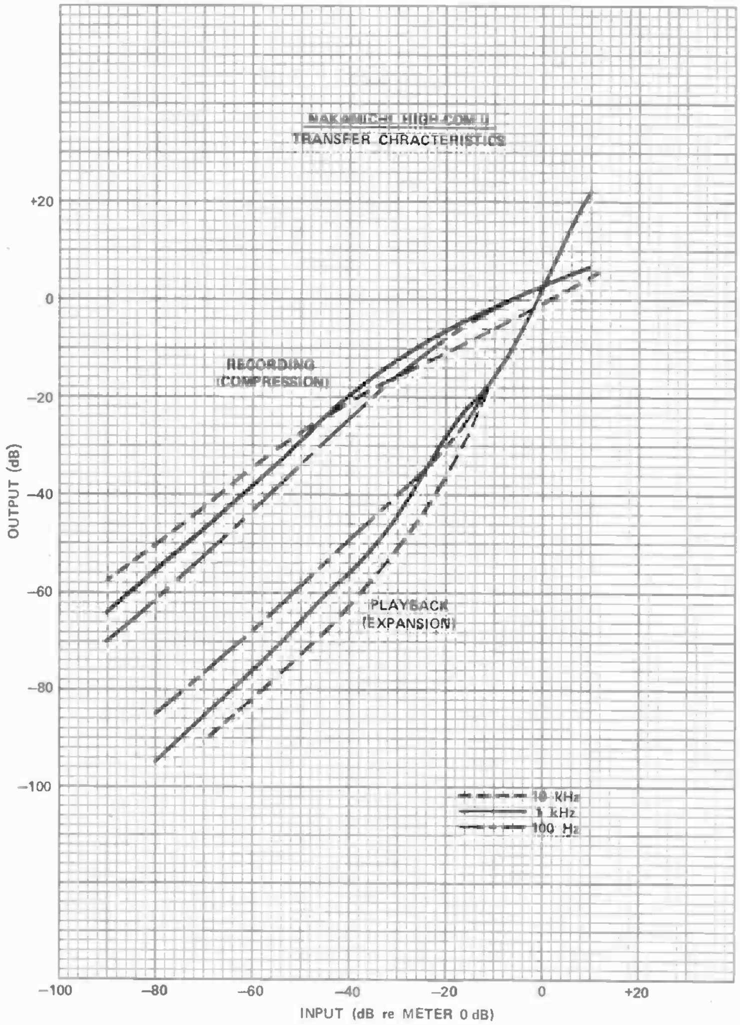

Static input-to-output transfer characteristics of High-Com II showing compression and expansion at frequencies of 100 Hz, 1 kHz, and 10 kHz.

weighting discriminates heavily against frequencies below 2 kHz. This, by eliminating hum and rumble, shows the Dolby system to best advantage. High-Com II works at low frequencies too. The weighting clearly diminishes the effect of low-frequency noise reduction performed by High-Com. Even so, the weighted effect of High-Com was 14 dB, 5 dB more than that of Dolby.

User Comment. The real proof of performance of a noise reduction system is its subjective effectiveness, and particularly its freedom from unwanted side effects. High-Com II passed that test with flying colors, eliminating audible noise, for all practical purposes. The total effect is less impressive when FM broadcasts or phonograph records (which may already be contaminated with noise) are used as program sources than with a blank cassette. In the absence of a recorded signal, playback hiss will always be audible if the gain is set high enough. Dolby B will reduce the hiss, perhaps eliminating it at usual listening levels, but at high gain settings it will be audible. High-Com II will remove it almost entirely, except possibly at very high volume levels. In addition, within the range of listening tests we were able to apply, we found no evidence of audible side effects.

An accessory as costly and sophisticated as this will be most in its element extracting the ultimate performance from a top-quality cassette deck, especially when using metal tape (in which case the high-frequency headroom can be used to full advantage). Even with ferric tapes, however, the unit will be very effective. Yet, unless the program material is wide in dynamic range and utilizes this performance, it is unlikely that the benefits of High-Com II will be worth their cost.

To demonstrate the effectiveness and potential of High-Com II, Nakamichi has produced an encoded phonograph record sampler for playback through a High-Com II decoder. To call the sound spectacular would be an understatement! The dynamics, total absence of noise, and lack of "fuzz" or other noise modulation effects are extremely convincing.

On the negative side, the need to manually switch the High-Com II between REC and PLAY modes is annoying, as is the inability to monitor the recording from a three-head machine without a second High-Com II. Finally, the rear-mounted REC and PLAY calibration knobs do the opposite of what one would expect (clockwise rotation *decreases* gain) with no hint of this given in the instruction manual or on the unit itself. Apparently, the designers, anticipating the need to *see* the front-panel meter while making the rear-panel adjustments, assumed that the user would reach across the unit to gain access to the knobs. They therefore arranged the controls to rotate as they would on the front panel.

Among noise reduction devices, High-Com II has clear advantages over Dolby B, but there are other payments to be made for this in addition to the cost of the product. First, High-Com II is compatible with no other noise-reduction system, not even other variants of High-Com. Second, undecoded playback is considerably less tolerable with High-Com II than with Dolby B. Yet, when used as its designers intended, the system works so well that many serious recordists will consider these drawbacks minor indeed.—*Julian D. Hirsch.*

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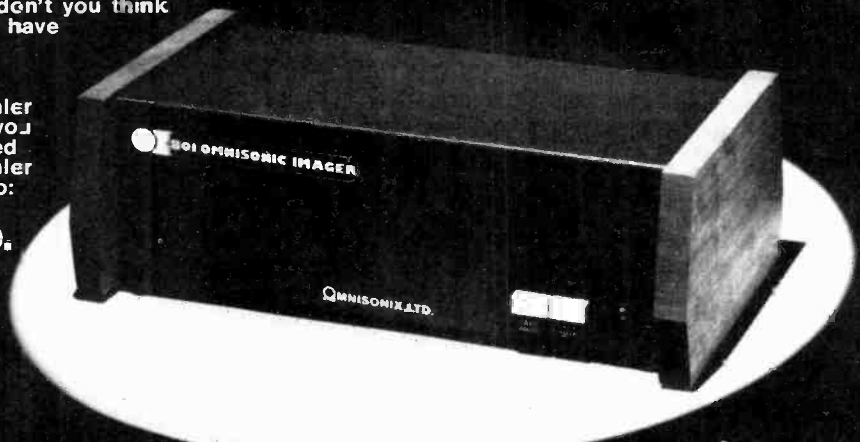

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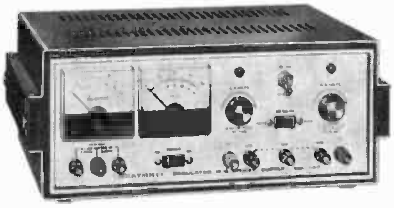

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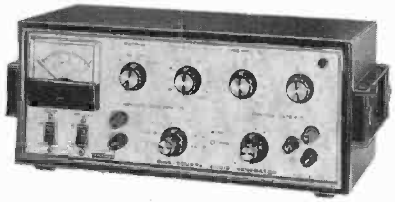

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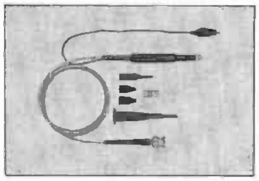

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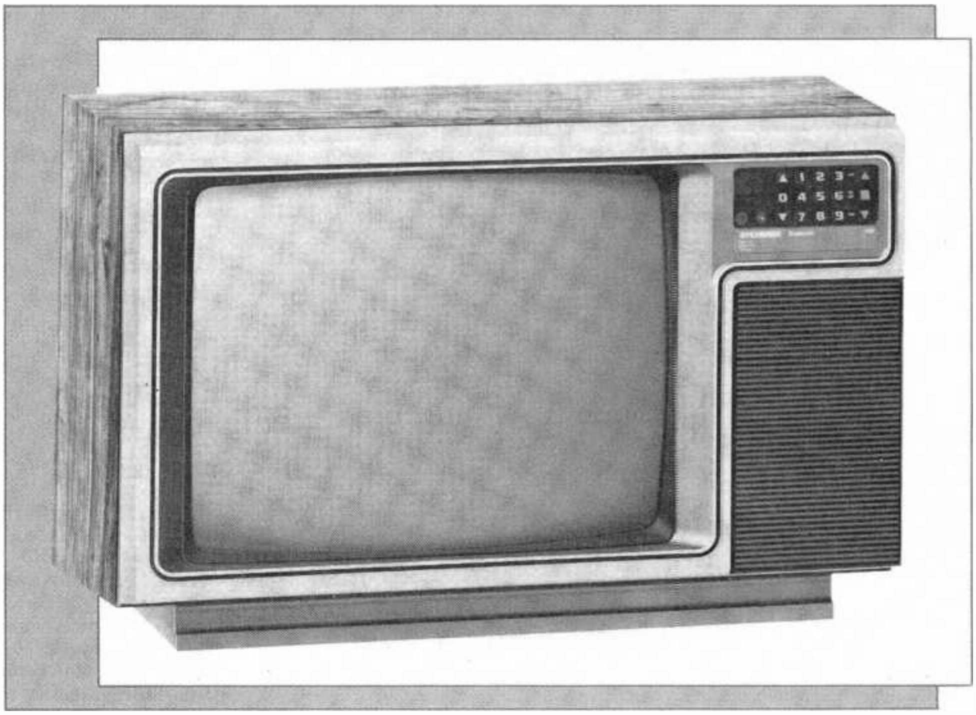
Popular Electronics Tests

Sylvania's 19" E53 Color TV



"SOMETHING old, something new, something borrowed, something blue" (the latter being circuit boards) probably describes Sylvania's new E51/E53 chassis even better than it does many of today's bridal outfits. Drop in a bevy of modern features and functions, such as a circuit to adjust color and contrast as room lighting changes and a six-inch oval speaker with tone control, and you have Sylvania's deluxe color chassis for 1981. Particularly noteworthy in the E51/E53 series are discrete four-stage video i-f strips and better-than-average serviceability in the home or shop.

The set we tested and will analyze here was the Model CX0178WR, complete with 100° 19" in-line picture tube with 29-mm neck, E53 aluminum chassis, and one minor and three major pluggable circuit boards. It comes in a high-impact plastic cabinet with walnut-grain finish and measures 16 3/4" H × 26 3/4" W × 17 3/8" D. All integrated circuits mounted on the boards are in sockets for easy access and substitution. Even the redesigned flyback transformer with its internal high-voltage diodes is screw-removable, and all tuners and remote receivers are conveniently plug-connected. Only the CRT board, which contains the final RGB amplifiers, is hard-wired into the chassis.

This is one of the few modern sets available that can be easily sweep-aligned without removing anything but the protective back cover. Though most TV manufacturers claim that a combination of low impedances and ac coupling and loading make mixer tuner coils and i-f alignments unnecessary, a sharper picture can always be obtained with tuners and i-f circuits connected during any swept, tuned-circuit alignment. Furthermore, when parts are changed in such r-f/i-f circuits, bandpass reshaping is more the rule than the exception.

Frequency Synthesis Tuning. Like other leading U.S. TV manufacturers, Sylvania is adopting frequency synthesis for its tuning voltages and crystal-controlled phase-locked loop (PLL) for its Varactor uhf/vhf tuners. In dealing with non-standard or offset-carrier CATV, MATV, and video games systems, automatic fine tuning (aft) is also included to capture signals within 1 MHz of normal frequency after an internal delay of 92 milliseconds. Standard receiver and remote tuning sys-

(Continued on page 38)

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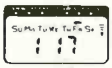

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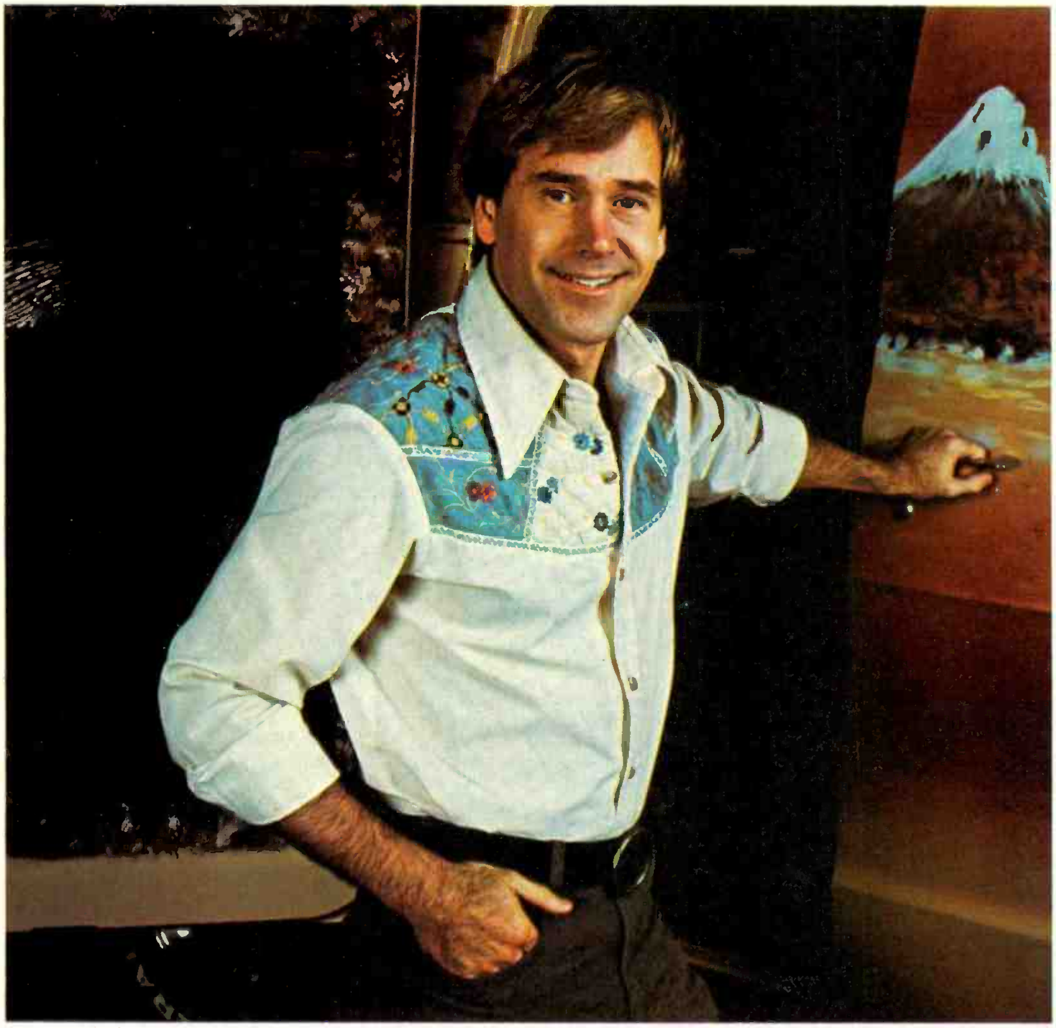

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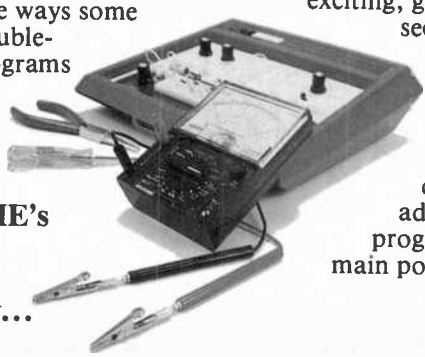

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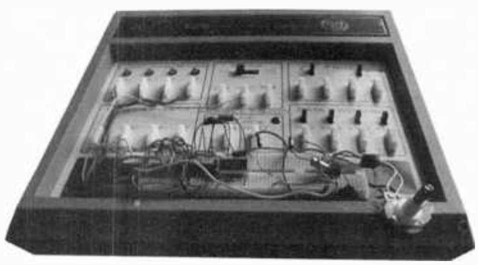

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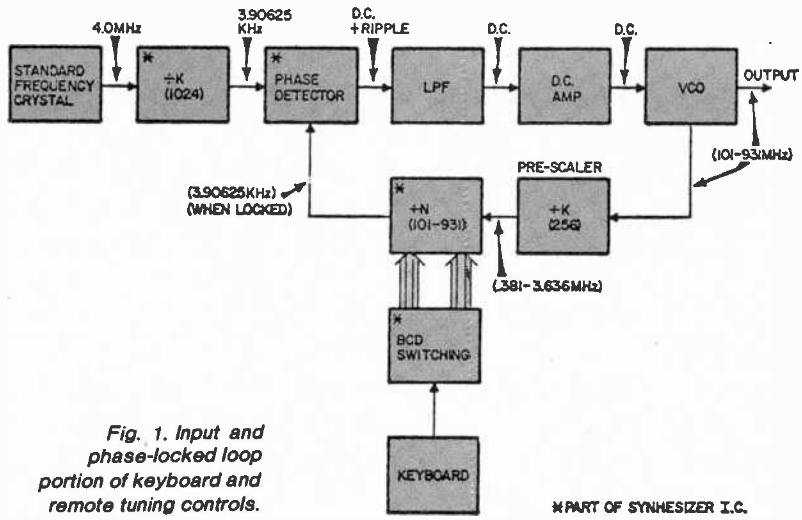

Fig. 1. Input and phase-locked loop portion of keyboard and remote tuning controls.

tems without channel scan have 10 keyboard command buttons for selecting any vhf or uhf channel. (Single-digit channel numbers must be keyed in preceded by zero, such as 02,03,04, etc.) Receivers with up/down channel scan have 12 buttons. Neither type of channel-selection system has receiver or remote programming for channel scan; stations must be sequenced in strict up or down numerical order.

Like competing PLL systems, this one has a divide-by-256 counter, 4-MHz crystal oscillator with divide-by-1024-counter, phase detector operating at 3.90625 kHz, control logic, read-only memory, and numeric LED channel-number display. Scan rate is 1.5 channels per second. A simplified block diagram of the frequency synthesizer (PLL) portion of the tuner is shown in Fig.1.

The low-pass filter (LPF) smooths the output of the phase detector into an error voltage that causes the voltage-controlled oscillator (VCO) to operate as a very stable local oscillator. The remote-controlled transmitter consists of three infrared diodes, remote encoder, and oscillator modulators, all operating on a 9-volt battery.

I-f Amplifiers. Sylvania's i-f amplifier system is unique. It consists of four stages of video i-f, conjugate tuner and i-f impedance coupling, simple diode envelope detector, several series interstage inductors, and i-f emitter back-bias agc control (Fig.2). Resurrected from proven solid-state Sylvania sets of the past, such as the Ell, the first, third, and fourth stages are common-emitter amplifiers. The second stage is a common-base, high-voltage-gain amplifier that is biased directly from the +24-volt supply.

> *". . . four-stage i-f strips offers increased reliability and additional gain."*

Input signals between −76 and −48 dBm are handled by agc action on the first i-f, while information above −48 dBm causes r-f tuner agc to become increasingly active, with i-f agc increasing by only a few millivolts at best. Measurements up to −20 dBm reveal that r-f agc swings from +4.7 V to +9.07 V as the input signal increases.

This unusual i-f arrangement was designed for better signal amplification, maximum first i-f voltage swing with little agc loading, minimum overall agc interference, and a clever split in sound and aft takeoffs shared between the third and fourth i-f stages. Ordinarily, in a three-stage i-f, the third amplifier carries both sound and aft loads and is usually the first semiconductor to fail in the i-f strip. This *four*-stage arrangement offers a considerable increase in reliability and some additional gain.

Hot Chassis. Like many other contemporary table model receivers, this 19" set has a combination hot/cold chassis and a switching low-voltage regulator (Fig.3). A four-diode bridge rectifier passes current from the ac line to a switching regulator that develops 110 V for the 19" (112 V for the 25") models. All other operating voltages are isolated from the line by the flyback transformer. Consequently, only the low-voltage and horizontal output stages actually occupy the Iso-Ground hot portion of the chassis. (Oscilloscope measurements must be referenced accordingly.)

Startup begins with bridge-rectified voltage being applied through predriver and regulator driver switching regulator output via *T502* and two transistors called the "startup switch." Outputs from this switch go to the horizontal/vertical processor and horizontal coupling driver. This turns on the horizontal output, which delivers current to the flyback transformer for the high-voltage and −40-, +19-, +25-, +110-, and +220-volt supplies. Feedback from

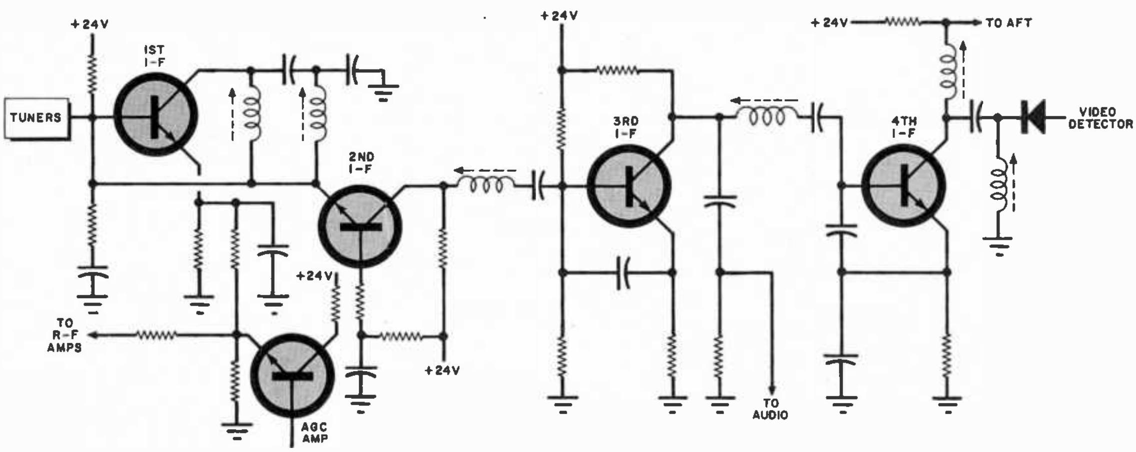

Fig. 2. Partial schematic of the automatic gain control circuit and four-stage video i-f strip.

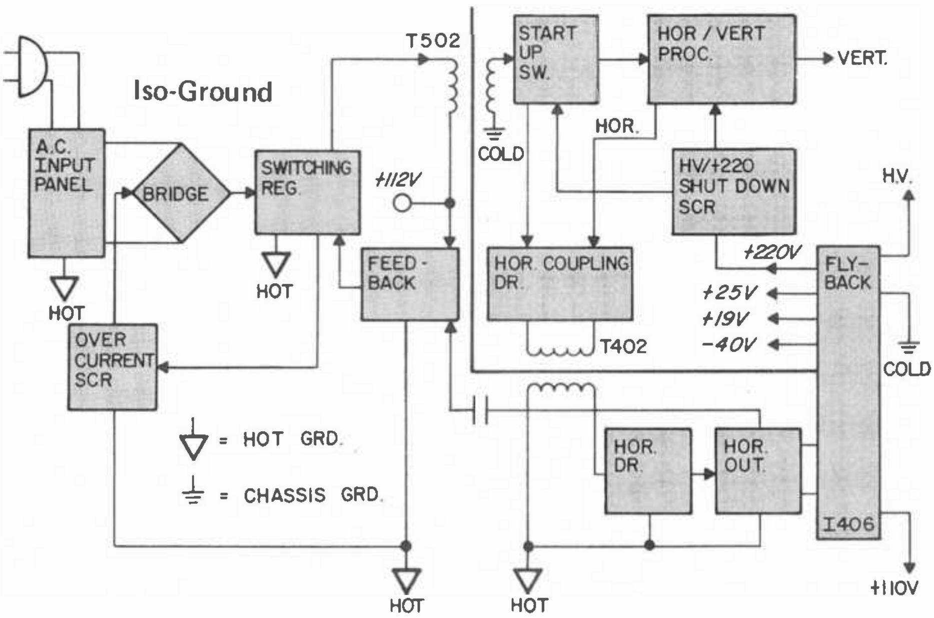

Fig. 3. Block diagram of the power supply system showing how two ground points (hot and chassis) are used.

the horizontal output stage keeps the switching regulator operating at 15.734 kHz. A reference voltage applied to the base of a feedback amplifier permits more or less current flow from the switching regulator through the primary of *T502*, to deliver a 110/112-volt regulated output.

Protection for these circuits is supplied by a pair of silicon-controlled rectifiers (SCRs), one for low voltage and the other for high voltage. The low-voltage overcurrent SCR fires when hot chassis currents cause a reference resistor drop in excess of 0.8 V dc, turning off the entire set. A second SCR continuously monitors the +220-volt output from the flyback in the cold chassis section. Should the potential of the 220-volt supply exceed 242 volts, the SCR conducts and removes horizontal drive, shutting down the entire high-voltage subsystem. Startup switch transistors may also be affected by the overvoltage condition since the zener-regulated 12-volt source at this point is shunted to ground.

Video/Chroma Processor. The most interesting circuit in this receiver (Fig.4) is *IC900*. A carefully selected RLC network allows delayed and undelayed video to enter *IC900* in the dc control and aperture corrector section. The term "aperture" comes from transmitter terminology, where such a circuit is used to correct spot scanning sizes in studio camera tubes. Since overcorrection increases receiver picture tube noise resulting from large high-frequency components, Sylvania has developed this IC to produce equal preshoots and overshoots and thus faster rise and fall times for video transients. Conventional peaking comes from a front-panel sharpness control that is part of an RC network that rolls off high frequencies.

Luminance information from the video amplifier and dc control attenuator is routed to a black level clamper that samples outgoing video and returns it to *IC900*. The result is that overshoots into the black portion of any video waveform cannot be detected by the black level circuit. A dc voltage and manual brightness (actually black level) control are in this loop to permit dc levels to be operator adjustable to suit viewer preferences.

Nominal vertical pulse serrations are eliminated by additional vertical blanking out of the vertical/horizontal blanking section. This vertical/horizontal portion of *IC900* receives horizontal blanking and composite sync pulses from the usual sources to develop a pedestal for the video signal applied to the black level clamper. Consequently, the video signal is normally blanked by vertical and horizontal blanking pulses. Slight adjustments of the horizontal pulse width and phase and the black level control alter blanking pedestal height. After the IC, a special horizontal blanking transistor (not shown) eliminates the 11.1-μs horizontal retrace interval via a pulse from the primary of the flyback transformer.

According to Sylvania, peaking currents in *IC900* are not blanked and, therefore, the video driver has a special vertical circuit connected to it to turn off this discrete transistor during the 1.4-ms vertical blanking interval so that VIRS and VITS reference impulses do not appear as disturbing images in the final video outputs.

A white peaking detector draws samples from the emitter of the video driver and returns certain control to the video amplifier dc control attenuator in the video/chroma processor IC. Sylvania states that, when the combined currents of the red, green, and blue (RGB) output stages at its

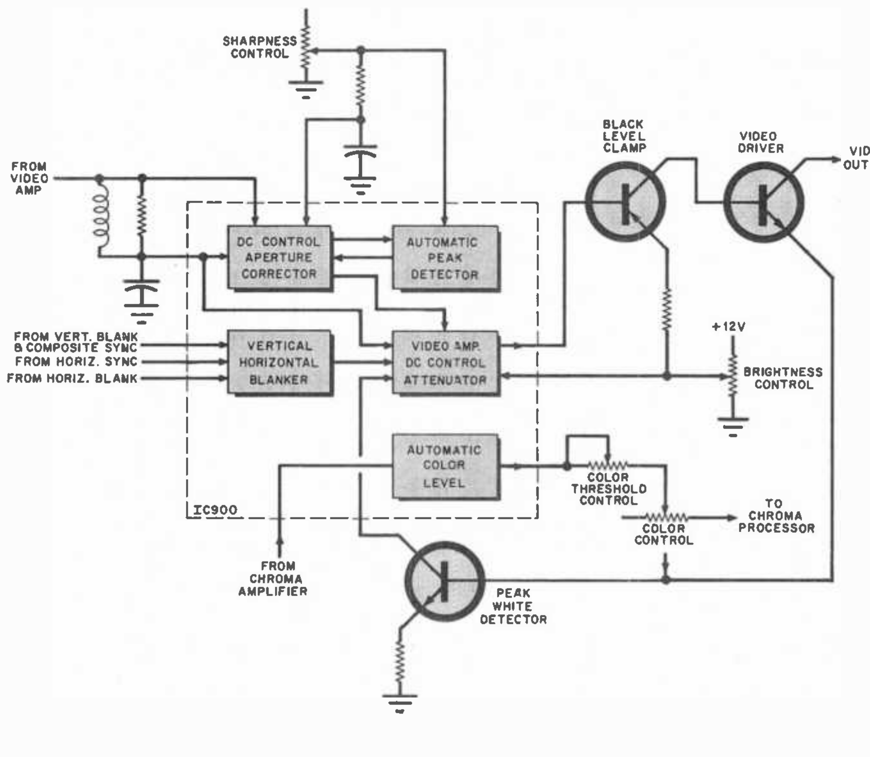

Fig. 4. Diagram showing operation of the IC900, the video clamp/processor and color amplitude noise limiter.

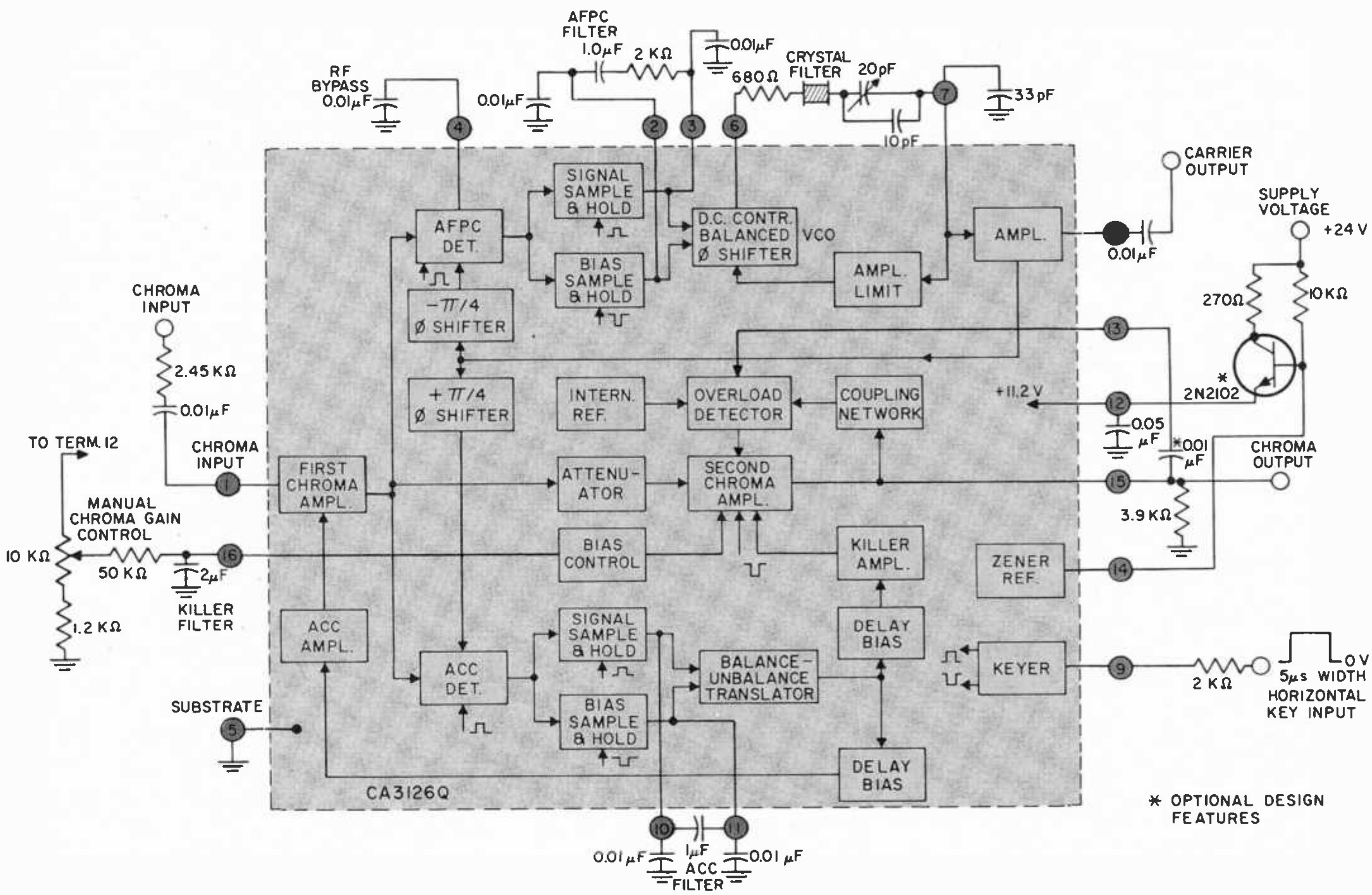

Fig. 5. Block diagram of IC600, an RCA CA3126Q chip which makes up the complex chroma processor circuit.

base exceed the emitter voltage, this transistor conducts and the drop in collector voltage reduces *IC900*'s gain, producing less output current. This results in a constant peak white level that is influenced by the brightness control's setting and a black level that is not upset by noise. The auto color-level circuit includes a peak detector and noise gate to keep chroma gain constant during noise pulses. Color threshold and color control potentiometers permit manual adjustment of chroma amplitudes prior to demodulation.

Chroma Processing. Sylvania uses an RCA CA3126Q in its chroma-processing circuits. While not new, this IC is a key part of several two-IC processor-demodulation systems and deserves special recognition.

A fairly detailed block diagram from RCA (Fig.5) illustrates significant signal flow and circuit operation. Burst and chroma signals enter the CA3126Q processor through an RCL network (the inductor is not shown in Fig.5) at the input chroma amplifier. Gain in this amplifier is influenced by an automatic chroma control (ACC) loop, with unbalance translator and delay bias sections providing a control signal. Output from the first chroma amplifier goes to the automatic frequency and phase control detector (AFPC), the automatic chroma control detector (ACC), and the second chroma amplifier through a 12-dB attenuator. The AFPC and ACC circuits are doubly balanced synchronous detectors that deliver keyed burst to a pair of sample-and-hold circuits. The ACC circuit detects in-phase components of the burst signal. Each of these two circuits produces pulses that are proportional to the amplitude of the burst. One sample-and-hold circuit in the AFPC section admits detected information during horizontal keying and stores any peak error signal in an external capacitor. The other produces a quiescent reference level during horizontal line scanning. Differences in sampling potential are passed to the dc control balance phase shifter for frequency adjustment of the VCO. The sample-and-hold circuits in the ACC section generate a control signal for balance-unbalance translator.

In the second chroma amplifier, the burst component is horizontally blanked so that only chroma continues through the system. A chroma-gain control on the receiver's front panel permits manual control of bias for the second amplifier.

Although it is initially crystal-controlled, the VCO can drift slightly. A dc control voltage from the phase shifter produces sufficient correction to return it to the 3.579545-MHz subcarrier frequency for the following amplifier, which generates the carrier output, the amplifier feedback limiter, and a true signal for the $-\pi/4$ ($-45°$) and $+\pi/4$ ($+45°$) phase shifters at the AFPC and ACC detector circuits.

Operation of the second chroma amplifier is interrupted when the color killer threshold, which is lower than that of the ACC loop, turns on the color killer and prevents further output. When the color killer operates, feedback from the second chroma circuit prevents the final video stages from being driven into visible saturation. An internal reference and a coupling network provide inputs to an overload detector for purposes of comparison and chroma threshold control. A linear relationship is maintained between manual chroma adjustments and chroma output.

Comments. The 50% light emissivity dark CRT faceplate on this receiv-

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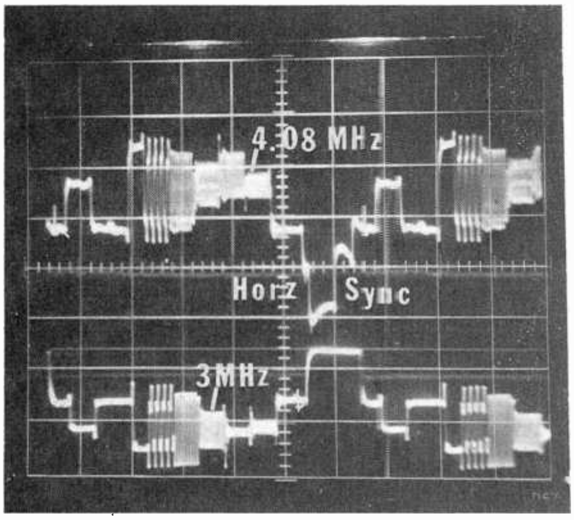
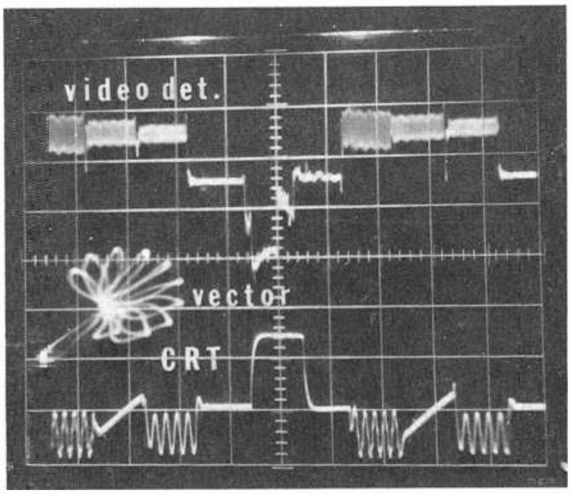


Fig. 6A. At top is multiburst at the video detector's output. Bottom trace shows that luminance bandpass allows only 3 MHz to reach the CRT.

Fig. 6B. Swept chroma frequencies of 3.02, 3.56, and 4.08 MHz at the video detector output (top) and at the CRT (bottom), with vector representation between.



MODEL CX0178WR RECEIVER LABORATORY DATA

Parameter	Measurement
Tuner/receiver sensitivity (min. signal for snow-free picture):	vhf (Ch. 3) −54 dBm uhf (Ch. 40) −50 dBm
Voltage regulation (line varied from 105 to 130 V):	Low voltage: 25-V supply (95.6%) 110-V supply (96%) High voltage: 27 kV (96%)
Luminance bandpass at CRT:	3 MHz
S/N at CRT:	34 dB
Horizontal overscan:	12%
Agc response:	>45 dB
Audio bandpass (3 dB down):	100 Hz to 9.8 kHz
Auxiliary audio output impedance:	16 ohms
Chassis power requirement (signal applied):	115 W (incl. remote)

er, which Sylvania has been featuring for several years, is favored by those who dislike glare and scattered reflections. It does suggest a more distinct picture by sharply contrasting dark and light colors. No amount of screen filtering, however, will take the place of maximum horizontal resolution and definition, which this set does not reach. While you can see 4-MHz multiburst at the video detector's output (Fig.6A), low-frequency rolloff occurs during the horizontal-pulse transition. (Also, i-f alignment could be touched up a bit to center the 3.56-MHz multiburst.) Thus, only 3 MHz is available at the cathode ray tube.

This receiver is doing the best it can without a synchronous video detector or a luminance/chroma comb filter. The 4.08-MHz bar (third from left in Fig.6B) at the video detector is down in amplitude somewhat, but that's not unusual. However, we found some amplitude modulation on all three swept chroma frequencies out of the video detector. A little of it also showed up around 3.02 MHz at the CRT, even though the 4.08-MHz portion was clean. The diagonal between the two, by way of explanation, was derived from a specially phased 3.56-MHz signal generator waveform that excites only the blue gun, providing what can be considered a simple sine wave of color. The vector representation between the two chroma swept frequencies reveals some phase crossover and could be improved by either a little closer channel tuning or a somewhat cleaner bandpass amplifier response, probably the latter.

As for tuning control, both tuner keyboard and remote transmitter didn't always precisely tune selected channels on the first-production-run receiver we tested. We expect this anomaly to be cleaned up in full production models, given the quartz-locked circuit used.

It is a pleasure to have in this Sylvania receiver a flat chassis layout, replaceable module boards, and all ICs in sturdy sockets. Sylvania has certainly designed this chassis for easy home/shop servicing. Furthermore, we observed no CB interference, even on channel 2, and its 1.9-V auxiliary audio output amplitude had an exact 16-ohm impedance.

The Laboratory Data gives the results of our lab tests for important receiver parameters. Not reflected in this table are conclusions reached for nonmeasureable parameters. For example, under actual viewing conditions, we would estimate convergence in this receiver at about 95%, dc coupling/restoration at better than 80%, and color response at 90%. These estimates reflect our opinion of how close the receiver's performance comes to expectations. —*Stan Prentiss*

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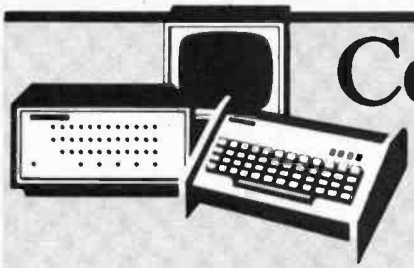


Computer Bits

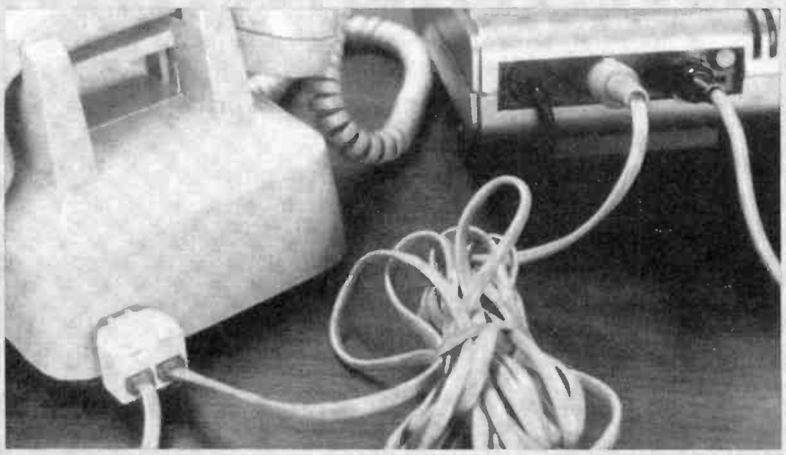
By Carl Warren

Low-Cost Machine Spells Communication

THE system about which there have been rumors for months has finally been announced. Dubbed the TRS-80 Videotex, Radio Shack's latest marvel is based on the Motorola 6809 microprocessor, has a built-in modem, and incorporates the MC6847 video display generator along with 16K bytes of internal RAM memory. What makes the $399 machine exciting are its many features, which include:

- The unit exhibits color graphics generated by the Motorola MC6847 VDG IC. This chip permits a picture element display (pixel) of 256 × 192 in 8 colors. The alphanumeric display is 32 characters by 16 lines. This character display is a function of the characteristics of the video generator IC and of a standard television set. The standard TV has a bandwidth of about 3 to 4 MHz and, consequently, inhibits the number of characters that can be displayed with clarity. However, the MC6847 takes this into account and displays a 5 × 7 font character in an 8 × 12 box.
- Videotex takes advantage of the two most powerful data processing and communication devices you own: your television receiver and telephone. The unit plugs into both with, at most, the help of a screwdriver.
- Videotex has a built-in keyboard and is small enough to fit into a standard-size attaché case.
- The unit is easy to use since the assumption was made that the buyer would not necessarily be inclined to learn how to program a computer.
- Videotex is more than a machine. It implies a complete communication philosophy. This communication feature is enhanced by an agreement between Compuserve (see "Computer Bits," PE June) and Radio Shack for a low-cost timesharing system. To fully support the communication concept for Videotex and the total TRS-80 line of computers, Radio Shack is offering a communication package that includes: required protocol software, Compuserve password and one hour of free time. All of this is priced at $29.95 and is available from any Radio Shack store.

Radio Shack's TRS-80 Videotex displays color graphics.



The Videotex can be plugged easily into your television receiver and telephone.

Although Radio Shack mainly markets its own, and supporting, products, it is also planning to offer the communication software for the Apple, Atari and PET microcomputers. The purpose of this is to provide maximum support for the age of electronic mail.

Further enhancing the communication concept, Radio Shack will be offering a 16-channel multiplexer for the company's Model II. This, according to Charles Philips, senior vice president of USA operations, will permit companies to set up their own communication systems. The multiplexer will allow up to 16 calls at a time and the Model II has the functional ability to store and forward messages. This, tied into the use of Videotex, will make it easier for field personnel to communicate vital information to their home offices, asserts Philips.

Videotex is available now in limited quantities, but by the first quarter of 1981, it is expected to be available in all Radio Shack stores.

The Compuserve connection is of vital importance to the success of the Videotex concept. The Compuserve people currently market the Micronet system and, as mentioned last month, began altering the system so that it would be more "people" oriented. According to Compuserve's director of corporate communication, John Meier, in order to fully support the color graphics functions of Videotex, they are developing very special user software and some exciting surprises. Some of the latter include the AP news wire service and full news from more than 10 newspapers nationwide.

More Printers. Both Okidata and Epson have printers that should interest personal computerists. Although

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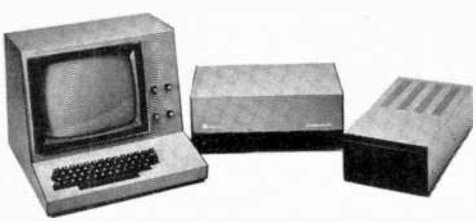
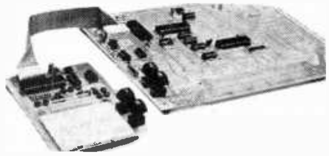


Full 8" disk system for less than the price of a mini (shown with Netronics Explorer/85 computer and new terminal). System features floppy drive from Control Data Corp., world's largest maker of memory storage systems (not a hobby brand!)

Level "A" is a complete operating system, perfect for beginners, hobbyists, industrial controller use. $129.95



Level "A" With Hex Keypad/Display.

LEVEL "A" SPECIFICATIONS

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

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

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

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

HEX KEYPAD/DISPLAY SPECIFICATIONS

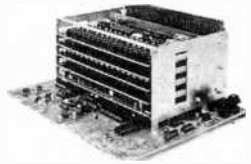
Calculator type keypad with 24 system-defined and 16 user-defined keys. Six digit calculator-type display, that displays full address plus data as well as register and status information.

LEVEL "B" SPECIFICATIONS

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

LEVEL "C" SPECIFICATIONS

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



Explorer/85 With Level "C" Card Cage.

LEVEL "D" SPECIFICATIONS

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

LEVEL "E" SPECIFICATIONS

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

DISK DRIVE SPECIFICATIONS

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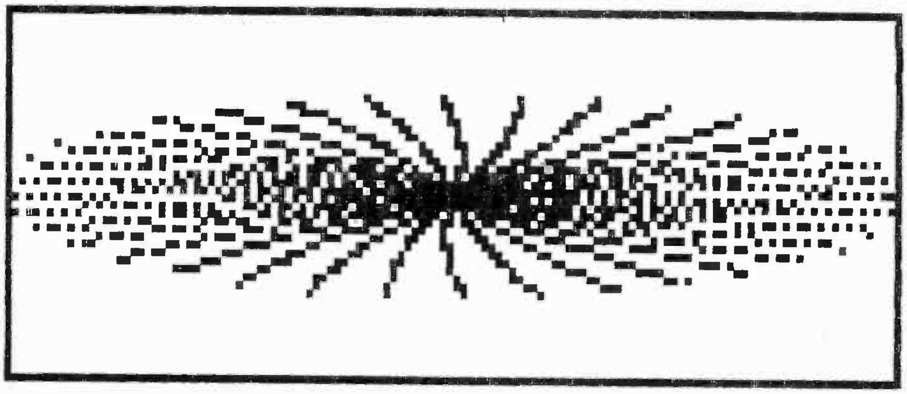


```
900 REM *** SPIRAL PATTERN ***  DEMO PROGRAM
1000 CLEAR 1000
1010 L=0:M=0:N=0
1020 KEY=0:K=10
1030 Q=0:R=0
1040 CLS
1041 A$=""
1050 FF$="WELLCOME TO THE OKIDATA BOOTH."
1060 GG$=" "
1070 HH$="OKIDATA EXHIBITS **
     MICRO LINE PRINTER FAMILY **"
1080 II$="** SPIRAL PATTERN **"
1090 JJ$="X=M*R*COS(Q)+64"
1100 KK$="Y=N*R*SIN(Q)+24"
1110 LL$="Q=L*3.14/180"
1120 MM$="* M *  IS AMP OF  * X * "
1130 NN$="* N *  IS AMP OF  * Y * "
1140 PP$="* L *  IS STEP IN DEGREE. "
2100 PRINT FF$
2110 PRINT GG$
2120 PRINT HH$
2130 PRINT GG$
2140 INPUT "PLS KEY IN (1) ONLY KEY= ";KEY
2150 IF KEY=1 THEN GOTO 2170
2160 GOTO 2140
2170 CLS
3200 PRINT II$
3210 PRINT JJ$
3220 PRINT KK$
3230 PRINT LL$
3240 PRINT GG$
3250 PRINT MM$
3260 PRINT NN$
3270 PRINT PP$
3280 PRINT GG$
3290 '
3300 INPUT "PLS KEY IN * M= ";M
3310 PRINT GG$
3320 INPUT "PLS KEY IN * N= ";N
3330 PRINT GG$
3340 INPUT "PLS KEY IN * L= ";L
3350 GOSUB 4000
3360 Q=L*3.14/180
3370 X=M*R*COS(Q)+64
3380 Y=N*R*SIN(Q)+24
3390 '
3400 IF X)127   THEN GOTO 3500
3410 IF X(0     THEN GOTO 3500
3420 IF Y)47    THEN GOTO 3500
3430 IF Y(0     THEN GOTO 3500
3440 '
3450 SET(X,Y)
3460 R=R+0.1
3470 L=L+K
3480 '
3490 GOTO 3360
3500 LPRINT FF$: LPRINT GG$:
     LPRINT HH$: LPRINT GG$
3510 LPRINT II$
3520 LPRINT GG$
3530 LPRINT JJ$
3540 LPRINT KK$
3550 LPRINT LL$
3560 LPRINT GG$: LPRINT GG$: LPRINT GG$:
     LPRINT GG$: LPRINT GG$
3570 GOSUB 5000
3580 FOR LC=1 TO 5
3590 LPRINT GG$
3600 NEXT
3601 LPRINT "THIS GRAPHIC PATTERN WAS PRINTED
     ON A MICROLINE 80 PRINTER CONNECTED TO A
     TRS-80 PERSONAL COMPUTER WITHOUT EXPAN
     SION INTERFACE. USE RADIO SHACK
     CABLE 26-1411."
3605 FOR LC=1 TO 10
3606 LPRINT GG$
3607 NEXT
3610 GOTO1000
4000 REM *OUTER FRAME **
4010 CLS
4020 A=0:B=0
4030 FOR X=0 TO 127
4040 SET(X,0)
4050 NEXT X
4060 FOR Y=0 TO 47
4070 SET(127,Y)
4080 NEXT
4090 FOR A=0 TO 127
4100 X=127-A
4110 SET(X,47)
4120 NEXT
4130 FOR B=0 TO 47
4140 Y=47-B
4150 SET(0,Y)
4160 NEXT
4170 RETURN
5000 FOR J=0 TO 15 : A$=""
5010 FOR I=0 TO 63
5020 A$=A$+CHR$(PEEK(15360+I+(64*J))):
     NEXT I : LPRINT A$:NEXT J
5030 RETURN
```

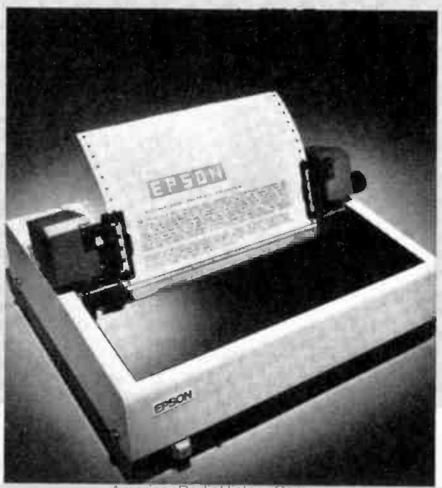
Okidata's Microline 80 printer can print graphics such as the above. The software, also shown, is straightforward and requires no special routines.

they are not letter-quality printers, they are good for first-draft material.

Okidata's printers, which are fairly new, include the Microline 80 for $800. This model is designed specifically to work with units like the TRS-80 and can print graphics, as illustrated. Notice that the software (for the TRS-80) is straightforward and requires no special routines to accommodate the printer.

Okidata also offers mid-range printers that feature better print quality, bidirectional printing and forms control. The Microline 82 is priced at $895 and is an 80-column unit, while the Microline 83 at $1195 is a 136-column unit. The latter can handle forms as wide as 15 inches, and operates at 120 char/s. All three units print condensed, double width, and enhanced characters as well as graphics characters.

The Epson Model TX-80 dot-matrix printer interfaces directly to a TRS-80.



As an enhancement to the Microline 80, Asent Computer Services has developed a $74.95 set of software products for the Apple computer. This software is extremely powerful and dumps every point on the Hi-Res Apple screen. If you want to get an idea of how powerful this software is, send a self-addressed, stamped envelope to Tim Dysert, National Sales Manager, Asent Computer Services, and ask for a Microline 80 dump of Donald Duck.

Offering similar features as the Microline 80 is the Epson Model TX-80 dot-matrix printer, priced at $799. This printer has PET-type graphics and is designed to interface directly to a TRS-80. However, for an additional $55, you can obtain the serial interface, which allows you to use either RS-232C or 20-mA current loop.

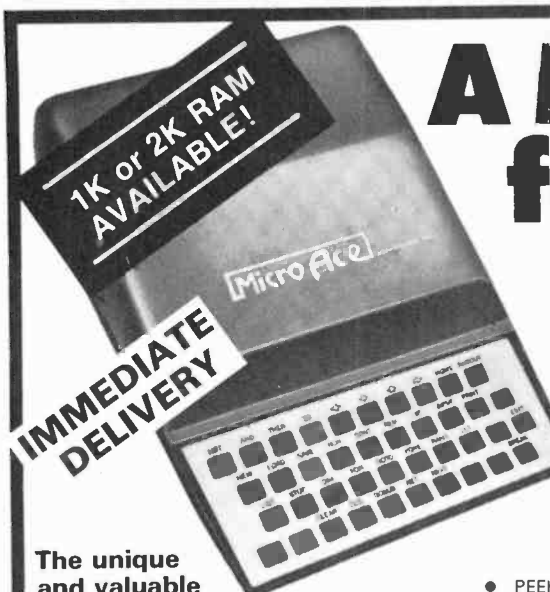
Should you want to use the TX-80 with a Heath/Zenith H-89, you will need the serial interface, configured in the following manner. First, mount the unit in the printer box, as shown in the manual. Next, set the word length to 8 bits rather than the factory-set 7 bits. Disable parity and enable serial data entry by cutting the jumper marked JNOR. (There is an error in the documentation at this point, so in most cases this jumper will need to be cut.) Also, solder in a jumper at JREV; this will set the reverse channel = MARK, and TTY-TXD = SPACE. This last jumper is important since it makes the interface compatible with Heath software. You will also find that it is necessary to put together a connection cable with male DB-25 connectors on both ends to allow for proper system connection.

Those of you that have or plan to buy an Apple computer will require the Apple interface for the TX-80. This unit is priced at $99. The card is designed to sit in the first slot of the Apple motherboard and can handle the correct electrical and software protocols with no modifications.

The TX-80 is a strong, consistent printer and, according to Epson's marketing manager, Chris Rutowski, PET owners are finding the unit a flexible and excellent addition to their systems.

Want to Ring Your Chimes? If you are not familiar with Epson as a printer company, you probably have heard of its melody ICs. The latest 7910 series offers renditions of "Greensleeves," "Home On The Range," and "Mary Had a Little Lamb." It can also operate as a door chime or a beeping alarm.

The board, which includes the melody chip, but without battery or speaker, costs $14. The little unit is great for that special music box you



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For just $149.00 (excluding handling charge) you get everything you need to build a personal computer at home... PCB, with IC sockets for all ICs; case; leads for direct connection to a cassette recorder and television (black and white or color); everything!

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The MicroAce owes its remarkable low price to its remarkable design: the whole system is packed on to fewer, newer, more powerful and advanced LSI chips. A single SUPER ROM, for instance, contains the BASIC interpreter, the character set, operating system, and monitor. And the MicroAce 1K byte RAM (expandable to 2K on board) is roughly equivalent to 4K bytes in a conventional computer — typically storing 100 lines of BASIC. (Key words occupy only a single byte.)

The display shows 32 characters by 24 lines.

And Benchmark tests show that the MicroAce is faster than all other personal computers.

No other personal computer offers this unique combination of high capability and low price.

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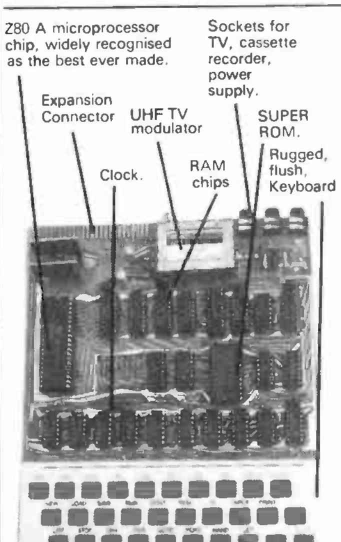
If the features of the BASIC interpreter mean little to you-don't worry. They're all explained in the specially-written book *free* with every kit! The book makes learning easy, exciting and enjoyable, and represents a complete course in BASIC programming-from first principles to complex programs. (Available separately-purchase price refunded if you buy a MicroAce later.)

A hardware manual is also included with every kit.

The MicroAce Kit:
$149.00 with IK COMPLETE
$169.00 with 2K

Demand for the MicroAce is very high: use the coupon to order today for the earliest possible delivery. All orders will be despatched in strict rotation. If you are unsuccessful in constructing your kit, we will repair it for a fee of $20.00, post and packing FREE. Of course, you may return your MicroAce as received within 14 days for a full refund. We want you to be satisfied beyond all doubt — and we have no doubt that you will be.



Your MicroAce kit contains...

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want to make for your little girl; or, if you're really inventive, a special function alarm or audible reminder in the darkroom.

If you live in Illinois and like dealing with a timesharing computer system, do the following three things: First purchase your favorite micro system. Then contact Universal Data Systems and order a model UDS 103 LP data Modem. This is a 300-bps, full-duplex unit for $195 that's designed to connect directly to the telephone. Once you have everything together, wait until the first Friday of the month. Then, in Illinois, dial 312-726-8260 and watch the screen of your system respond with the lobby of the Gamemaster's house.

Epson's melody evaluation board provides a choice of four tunes.

The Gamemaster is a unique communication system with a number of games, mail, technical data and so on. Basically, the system has a $50 sign-up fee and costs about $2.75/hr connect time. If you want more information, either wait for the free time from 10 a.m. to 10 p.m. on the first Friday of the month or contact them on the 24-hour hotline. ◇

MORE INFORMATION

For additional information about products mentioned, contact the companies directly.

Asent Computer Services
RR 3
Columbia City, IN 46725
219-625-3600

Epson America Inc.
23844 Hawthorne
Torrance, CA 90505
213-378-2220

Gamemaster
P.O. Box 1483
Evanston, IL 60204
312-236-7522

Okidata Corp.
111 Gaither Dr.
Mt. Laurel, NJ 08054
609-235-2600

Radio Shack
1400 One Tandy Center
Fort Worth, TX 76102

Universal Data Systems
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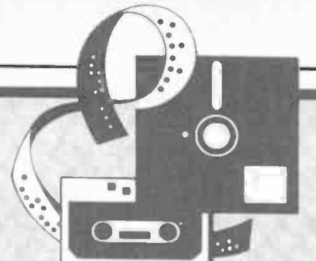
205-837-8100



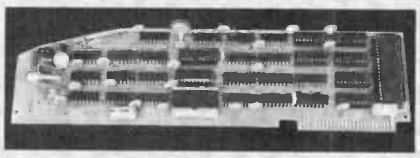
Computer Sources

By Leslie Solomon
Senior Technical Editor

Hardware

TRS-80 Memory Expansion. The MT-32 Printer/Memory expansion module for the TRS-80 will add 16 or 32K of RAM to a basic 16K machine. The module also drives a Microtek MT-80P dot-matrix or any Centronics-compatible printer. No hardware modification is required, simply plug it in the TRS-80 bus connector. Without RAM, MT-32K kit is $79.50; MT-32A assembled is $99.50; MT-32B, with 16K of RAM, assembled is $159.50; and MT-32C, with 32K of RAM, assembled is $199.50. Address: Microtek Inc., 9514 Chesapeake Drive, San Diego, CA 92123 (Tel: 714-278-0633).

80-Column Apple Board. The Sup'R'Terminal from M&R Enterprises plugs directly into an Apple II



and provides 80 columns by 24 lines, upper and lower case on a 5 × 8 dot matrix. Connection to the video monitor is via an on-board jack. The 2K of firmware includes upper/lower case shift, cursor movement, cursor and scrolling modes, clearing and linefeed functions, variable scrolling window, and character definition. The user can define his own characters and switch back and forth among up to 10 different character sets including different alphabets, scientific notation, graphic symbols, etc. These user-defined characters can be printed with a user-programmable dot matrix printer. $395. Contact your local Apple dealer.

AIM Programmer/Editor. The CO-ED A65-901 module features a PROM programmer and code editor in a single plug-in for the AIM-65 and SYSTEM-65 machines. The module provides PROM check, read, and verify in addition to programming. Data load, verify, and dump, each with offset, and an object code editor are additional features. The latter controls the editor program pointer and can search, disassemble, and modify R6500 object-code programs. The module includes 1K byte of RAM, which, when used with the 4K RAM AIM-65, allows single-pass programming of 4K × 8 PROMs. It includes logic to select 2758, 2716, 2732, TMS 2508, 2516, or 2532 PROMs without switch or jumper changes. $265. Address: Electronic Devices Div., Rockwell Intl., Box 3669, Anaheim, CA 92803 (Tel: 714-632-3729).

Atari Expansion. This new kit enlarges any Atari 8K RAM board to 16K to provide more space for high-resolution (GR 7) graphics and allows

access to higher-resolution (GR 8) 320 × 192 graphics. $79.95. Address: Mosaic Electronics, Box 748, Oregon City, OR 97045.

British S-100. The Tuscan S-100 is a Z80-based computer using the IEEE standard S-100 bus. Five S-100 cards can be plugged into the bus. The Tuscan has powerful I/O capabilities and is ready for immediate expansion. Both BASIC and PASCAL are available. Address: Transam, 12 Chapel St., London, NW1 5DH, England.

Apple NTSC. The Adwar Apple Proc Mod device is a plug-in circuit board which converts the nonstandard Apple video output into a format sufficiently close to NTSC standards to permit using a conventional video tape recorder. $800. Address: Adwar Video, 100 Fifth Ave., New York, NY 10011 (Tel: 212-691-0976).

Six Monitors on One Printer. The PC-1 Printer Controller provides means to hard copy the output of up to six CRT monitors on one printer. The PC-1 connects to any RS-232 printer and contains six channels that remain operative even if one or more of the monitors is down or off. A pushbutton allows the operator of any terminal to access the printer. When printing is finished, another push of the button frees the printer for selection by any other operator. The small unit has a built-in power supply and no adjustments are needed. $375. TC-20 cables are $65 and the CP-15 Controller-Printer cable is $35. Address: Teleray, Box 24064, Minneapolis, MN 55424 (Tel: 612-941-3300).

AIM-65 Auto Vector. The model AV65, for use with the Rockwell AIM-65 computer, passes program control from the AIM monitor to user-written code. Thus, when the computer is turned on, user programs are automatically executed while retaining access to the Rockwell monitor. No modification of AIM hardware is required. $29.95. Address: Cubit, 2267 Old Middlefield Way, Mountain View, CA 94043 (Tel: 415-962-8237).

Low-Cost Modem. The D-CAT modem is FCC approved for handset jack connection with any modular phone, and the Bell 103 compatible unit works with a single line or 50-pin,

six-line business phone. It features a separate power supply and a mode switch that allows the user to monitor whether voice or data is being transmitted. $199. Address: Novation, 18664 Oxnard St., Tarzana, CA 91356.

H8 Prototype Board. The HKB-1 is a prototyping board for the Heath H8 computer. It features a hooded 44-pin edge/cable connector opposite the bus connector and 0.042" diameter plated-through holes on 0.1" centers. Locations are provided for three 5-volt regulators along the mounting bracket/heat sink. There is also space for two filter capacitors, and extra holes are grouped near the +16-volt bus connectors for additional regulators. $46. Address: Mullen Computer Products, Box 6214, Hayward, CA 94544 (Tel: 415-783-2866).

Apple Data Acquisition. Three different components and an Apple interface board make the miniMUX 800 Series components suitable for use in almost any area of data aquisition and control. A starter kit consisting of an RS-232-C or Apple II interface, one miniMUX 801 I/O terminal having eight discrete inputs and seven discrete outputs, one miniMUX 802 analog terminal with one input of eight bits resolution and seven discrete outputs is available for $895. Address: American Multiplex Systems, Inc., 1148 E.Elm Ave., Fullerton, CA 92801 (Tel: 714-870-5821).

Software

CP/M Word Processor. To use the VTS/80 word processor that runs under CP/M, keytops of the terminal keyboard are replaced with custom keytops that are color coded by function and have the function written on the side of the key. It can be made available for 1802, 9900, 6800, and 8086 in PL/M. The processor is available in English, Spanish, German, Italian, and French. Four function keys allow insertion, erase, cut, and paste; there is automatic word wraparound; functions are by character, paragraph, word, page, sentence, screen, line, or variable; and five different tab stops are provided. Other functions include global find and substitute, phrases and cuts stored on disk, and automatic indenting. $549. Address: Micro Software Producers, 3169 Filmore St., San Francisco, CA 94123 (Tel: 415–346–7025).

OS PASCAL. This UCSD PASCAL system operates on Ohio Scientific computers having 48K of RAM, and two disk drives. The package has its own operating system and includes a screen-oriented text editor, a PASCAL compiler, and FORTRAN based on a subset of ANSI 77 standard FORTRAN. A compatible assembler and run-time linker, utilities for file maintenance, diskette initialization, and duplicating are also provided. The package includes several diskettes, a PASCAL primer, and PASCAL and FORTRAN user manuals. $450. Address: Ohio Scientific, 1333 South Chillicothe Rd., Aurora, OH 44202 (Tel: 1–800–321–6850).

TRS-80 Sequential Access. KFS-80 is an indexed sequential access method for a TRS-80. It provides keyed and sequential access to multiple files, with records of up to 240 bytes. Features a relatively constant number of disk accesses to reach a record no matter how large the file grows. A sector buffering mechanism minimizes disk accesses by "remembering" which sectors are in memory. The program is designed for inventory, accounts payable or receivable, or any application where direct record access is needed. Requires less than 8K bytes and a 2-drive 32K Model I or Model II system. $49.95 for Model I and $79.95 for Model II. Address: Automated Resource Management Inc., Box 4353, Irvine, CA 92716.

Apple Pie. Apple Computer Inc. recently introduced three new items. The first, called Apple Plot, enables users to create, revise, and print detailed charts and graphs quickly and easily. The user enters up to 100 data points and selects the format. The finished chart is then produced automatically. The six graphic formats are line, multiline, bar, multibar, bar with line overlay, and scattergraph. The user can label axes and plots, automatically center labels, extend grid lines, change graph color, and selectively insert and delete x and y values. Graph parameters can be changed. This software provides high-resolution video and hard-copy graphics. Requires 48K Apple II Plus and disk. $70. The second is DOS 3.3, an improved operating system for Disk II. It uses a 16-sector capacity format that increases diskette capacity to 143K bytes and can copy a program from one diskette to another using a single drive. It also includes a program that converts existing libraries and data files in 13-sector format to run under DOS 3.3. $60. Thirdly, Apple pilot, a high-level language for educators and CAI, has two modes: Author and Lesson. In Author, lessons are created using one of the four editors. Text, pictures, sound or foreign language characters can be used. Students use the Lesson mode. Requires Apple II with 48K and two disk drives. $150.

APF Space Destroyer. Pitting three space destroyers against a wall of phasor-firing aliens, this APF program for the Imagination Machine

can be used by two players. This game is similar to the arcade version currently available. $19.95. Available from APF dealers.

Hard Disk Reclaiming. Winchester hard-disk media cannot be replaced like a floppy if a track or two becomes unreliable. The Reclaim CP/M2 utility program tests floppy and hard disk systems for error-prone tracks and allocates those parts to files that are "invisible" to the user. Tests are made with or without disk data files and during operation, the program continuously displays its progress as it examines each track and sector. At the completion of the program, it announces the number of blocks hidden from the file system. $80. Address: Lifeboat Associates, 1651 Third Ave., New York, NY 10028 (Tel: 212–860–0300).

Small-C for CP/M. A Small-C Compiler is now available to CP/M users on a single-density 8-inch diskette. The compiler supports a subset of the C Programming Language, and provides interface to assembly language with its "#asm. . .#endasm" feature. The diskette includes a Small-C compiler, run-time support library, CP/M I/O functions, the source code for Small-C, and a demo program written in Small-C. $15. Address: The Code Works, Box 550, Goleta, CA 93017 (Tel: 805–967–0905).

Measurement / Control BASIC. XYBASIC offers all the standard features of regular BASIC plus ROM-ability, machine-language linkage, debugging commands, software interrupts, control commands, and a number of bit-manipulation commands. Versions are available for SBC/80, CP/M, INTELLEC 8 MOD 80, and MDS-800 systems. Nonstandard versions with patchable I/O are available for 8080, Z80, or 8085 systems. XYBASIC is available in integer (7K) or extended (14K) forms and provides the speed of integer arithmetic operations combined with full floating point and string functions. The Run-Time/Compiler package compresses the code and reduces execution time. Manual is $20. XYBASIC is $350. Address: Mark Williams Co., 1430 W. Wrightwood Ave., Chicago, IL 60604 (Tel: 312–472–6659).

North Star FORTH. OmniFORTH, modelled after fig-FORTH is now available for the North Star computer. FORTH combines structured programming, stack organization, virtual memory, compiler, assembler, and file system into an extensible macro-language. Organized as a dictionary of words, FORTH allows defining new words that extend the vocabulary to suit any application. Words are compiled on entry into code ready for immediate use and execute ten times faster than BASIC. It also supports coding time-critical outlines in assembler for fastest response. Requires 24K and NS DOS. $49.95. Introduction to FORTH manual is $15. Address: Interactive Computer Systems, Inc., 6403 DiMarco Rd., Tampa, FL 33614 (Tel: 813–884–5270).

TRS-80 Symbolic Math. Written in muSIMP, a superset of LISP, muMATH provides facilities to do algebra, trigonometry, calculus, integration, differentiation, and other symbolic math operations on a TRS-80 having 32K of RAM and a single disk drive. To take advantage of all the capabilities of muMATH, including exact rational arithmetic and automatic algebraic simplification, requires 48K. The user can control such transformations as expanding powers of polynomials and placing expressions over a common denominator. Other capabilities include trigonometric and logarithmic simplifications and symbolic differentiation and integration. All operations are to 611 digits. $74.95. Address: Microsoft Consumer Products, 10800 Northeast Eighth, Suite 507, Bellevue, WA 98004 (Tel: 206–454–1315).

Monopoly. "Monty Plays Monopoly," for the Apple II or TRS-80 Level II, is a computer opponent program designed to be used with a standard Monopoly game in accordance with the official rules. In essence, Monty acts as another player. Each human player can communicate with Monty via the game paddles.Comes as cassette or disk. Address: Ritam Corp., Box 921, Fairfield, IA 52556 (Tel: 515-472-8262).

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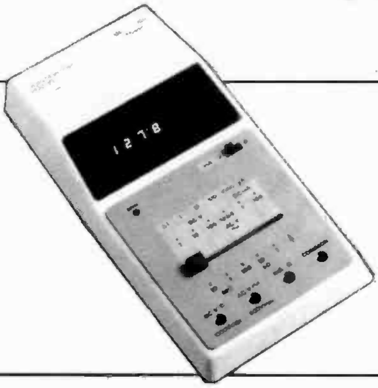

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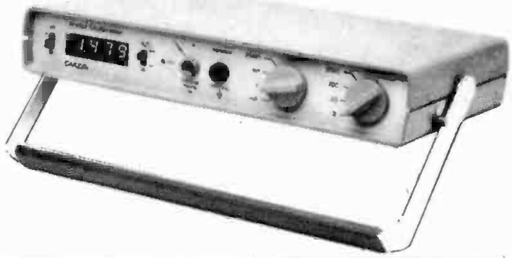

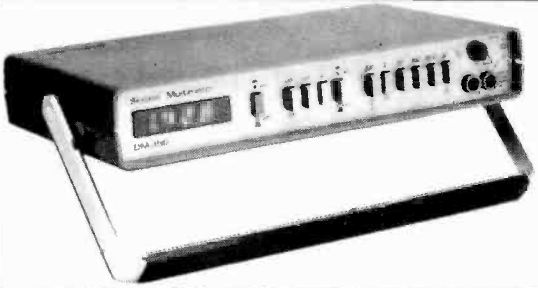

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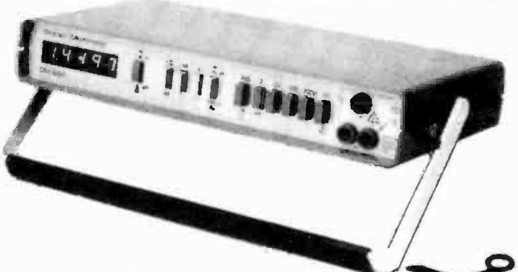

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electronic games

SPACE-AGE LEISURE ACTIVITY

BY JERRY AND ERIC EIMBINDER

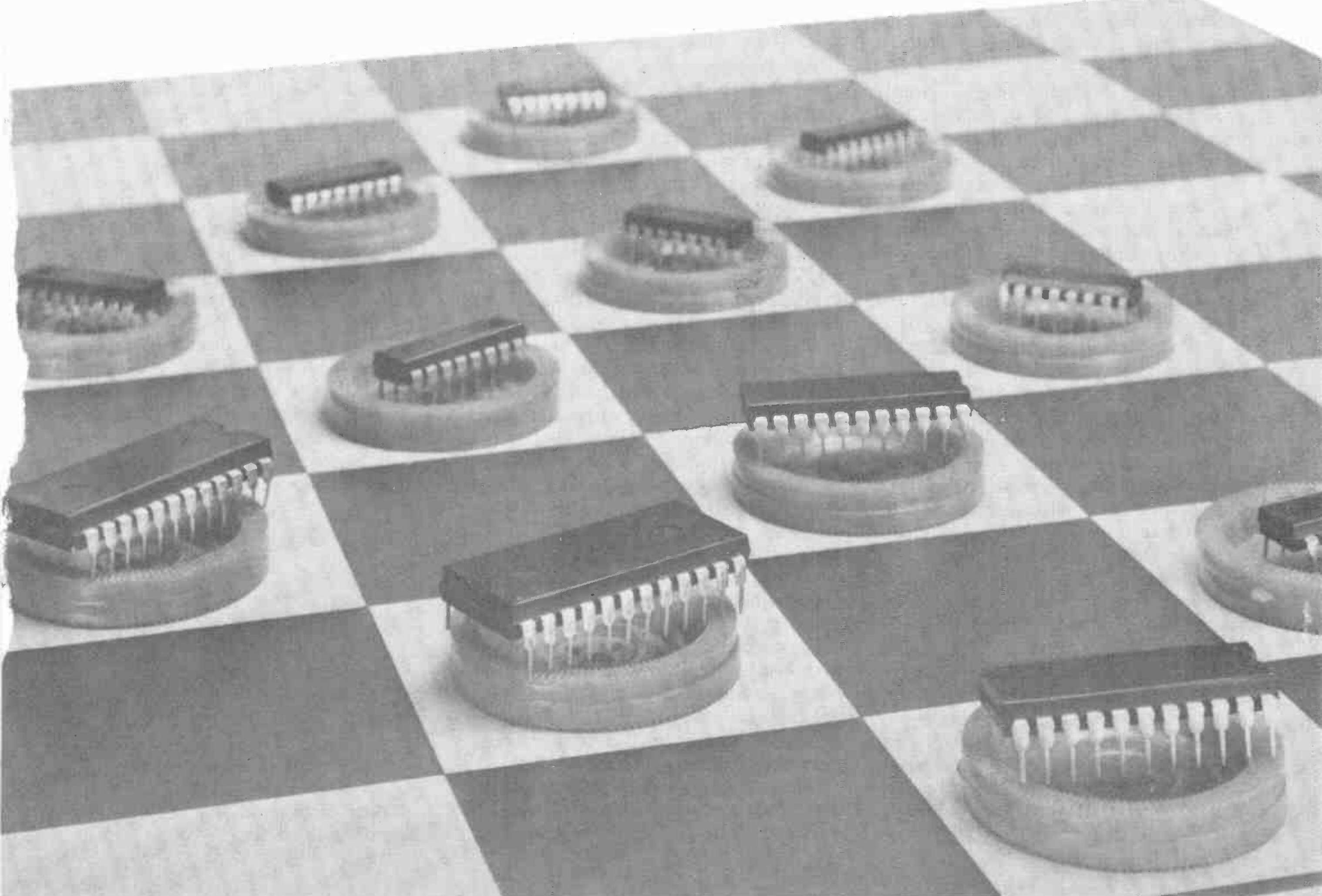
PART 1

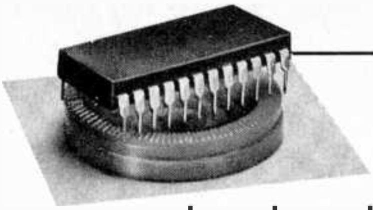
and in the beginning...

CHECKERS was invented by a Greek during the Trojan War. Chess originated in India. The Romans gambled with dice. Board games were played in ancient Crete. The advent of the electronic game, however, brought a whole new dimension to the art and science of games. For the first time, the opponent could be a computer program and the game could be played at a pre-selected level of difficulty. Integrated circuits made it economically possible to create new concepts in visual and sound effects, and microprocessors permitted continuous change and advancement.

There were many pioneers in electronic games. Let's look back to see how it all started.

In 1962, a graduate student at the Massachusetts Institute of Technology





electronic games...

named Steve Russell wrote a computer program for a game called "Spacewar." Research buffs estimate that Russell's ingenuity cost companies possessing computers several million dollars during the following four or five years because many employees, enthralled by the game, used computer time to guide rocket ships across computer displays.

"Spacewar" continued to be popular through the late 1960s. At this time, two students who learned the game on college campuses were Nolan Bushnell at the University of Utah and Bill Pitts at Stanford University's Artificial Intelligence Center.

Both Bushnell and Pitts set out independently to develop commercial versions of "Spacewar." Bushnell's model, "Computer Space," was finished first, in 1970. It used the raster monitor from a 19" G.E. television set and 185 commercially available integrated circuits, mostly transistor-transistor logic (TTL) devices.

Although Bushnell didn't actually produce the game (the rights were sold to another company), he learned much about user interest from studying reactions to "Computer Space" in the marketplace. The game wasn't a successful financial venture, though, because it was too complicated for most players. Not giving up, Bushnell developed an easy-to-play electronic game for the company he founded in 1972—Atari.

Bushnell installed a coin-operated table-tennis game, "Pong," in a bar in Sunnyvale, CA, called Andy Capp's. The machine ceased working after two days and he stopped by to see what was wrong. A complete check of its TTL logic circuitry uncovered nothing wrong and, finally, Bushnell checked the coin box. It was jammed to capacity! Bushnell then knew that he had a winner.

Meanwhile, Pitts completed a prototype unit in 1971 and followed with a second model called "Galaxy Game" a year later. He placed it in the Tressider Union Coffeehouse at Stanford, a few miles from where Bushnell's "Pong" game was under evaluation at Andy Capp's. Pitts' game, employing a Digital Equipment Corp. PDP-11 computer, challenged some and discouraged many. The machine still stands there today. No more have ever been built.

The score in electronic game evolution at this time was one successful idea ("Pong") and two failures ("Computer Space" and "Galaxy Game"). The "Pong" paddle game survived and prospered. (Eventually, space war games, in simplified versions, would also capture the public's fancy.) Nolan Bushnell went on to build Atari into a major factor in the electronic games industry. Besides producing coin-operated machines, he moved Atari into the home video game business in 1975, marketing "Pong" through Sears and Roebuck stores. By the end of 1976, there were some 70 companies in the TV-game business. Atari was then sold to Warner Communications for a reported price of $28 million.

The Thomas Edison of the home TV game was Ralph Baer. In 1966, as manager of the equipment design division of Sanders Associates, Manchester, NH, supervising a staff of up to 500 engineers and technicians, Baer was in a position to authorize work on TV games. He built a couple of symbol generators and soon had two spots chasing each other around the screen of a black-and-white TV set. Having convinced himself that the concept was feasible, he hired Bill Harrison to begin full-time work on TV-game development. Shortly afterwards, he also added engineer Bill Rusch to the project.

A 17-inch RCA color-TV set was purchased and, by early 1967, Baer, Harrison and Rusch were playing table tennis against a green background and hockey against a background of blue ice. Color signal generation was handled very simply. The parts used were a 6½¢ transistor, two diodes, a few resistors and capacitors, a 3.58-MHz chroma crystal, and a 15¢ oscillator tank coil. With these parts, they built the chroma oscillator and, through the use of the center-tapped secondary on the tank coil, they obtained two 3.58-MHz signals 180° out of phase with each other. Taking an output from one side of the secondary and gating it into video with horizontal sync pulses produced an adequate approximation of a color burst reference signal. Next, an RC phase-shift network was connected across the outer terminals of the secondary, using a potentiometer as a resistor, so that the phase at the junction of the resistor and capacitor could be varied from 0 to 180° with respect to the color burst reference phase. Horizontal sync was used to gate out the new phase signal via one of the 3¢ diodes, again into video, and background color was produced.

The project was a closely guarded secret. Harrison and Rusch worked in an enclosed 10-by-15-foot office containing two desks, a workbench and support electronic equipment. The door was kept locked at all times; only Baer, Harrison and Rusch had keys. Despite secrecy of these measures, the area was referred to as "The Game Room." Because Harrison and Rusch had a habit of playing recorded guitar music while working, most of their fellow employees assumed that the room was being used to develop an electronic guitar.

A working multi-game model was completed in mid-1967 and Sanders Associates began looking for licensees. Demonstrations for potential customers continued through 1969, when, after a deal with RCA fell through at the last minute, an agreement with Magnavox was arranged. Magnavox modified the design for high-volume production and demonstrated the game to the press in May 1972. By summer, the game, called "Odyssey," was on the production line. Nearly 100,000 Odyssey games were sold that year!

The original Odyssey contained approximately 305 discrete parts in its master control unit and hand controls. Overlays for the television screens were supplied with Odyssey to simulate field backgrounds. The Odyssey package also included dice, play money, card decks and game boards. Twelve games, some very similar, were offered.

The first version of Odyssey was manufactured until 1975, when large-scale-integration (LSI) parts became available. Nine complex integrated circuits were designed for use in Odyssey. The use of these chips cut the total number of parts needed to approximately 200 and reduced both cost and assembly time. Several advanced technologies were employed in the nine chips, including newly developed integrated injection logic (I^2L). Electronics also produced the TV-screen backgrounds, so overlays were no longer needed.

Not all nine chips were necessarily used in a particular model of Odyssey. By appropriate selection from the master set of nine chips, 18 possible combinations of chips were possible.

the front cover

The first of a new generation of electronic talking dolls, "Baby Soft Sounds" by Fisher Price, is shown. Behind it is a wafer of hundreds of speech-synthesis chips made for the doll by Precision Monolithics, Inc. Siltronics then dices the wafer to produce the chips.

Subsequently, in 1976, Magnavox further cut the number of components needed to build a video game to 75 by introducing a single-chip LSI system. The chip contained all of the spot generator, logic, sync, multitone sound and digital scoring circuitry, but offered less flexibility than provided by the multi-chip system.

GI's 6-in-1 TV—Game Chip. Prior to the development of one-chip game systems, a number of companies were testing the marketplace for TV games with models using TTL circuitry. One of these companies was First Dimension Corp., founded in mid-1975 in Nashville by Norvell L. Olive. First Dimension manufactured 7,000 games in time to ship for the Christmas 1975 season. Next, preparing for mass-volume production of its $129 game in 1976, it purchased $1.5 million worth of parts.

But in early 1976, General Instrument introduced the product that changed the nature of the video games industry. General Instrument put most of the circuitry needed for designing a video game on a single chip, the AY38500. The game designer was provided with one chip that provided four paddle games and two different rifle games. In addition, capability for fast ball and slow ball, steep angle and shallow angle, and long paddle and short paddle operation was offered.

For companies thinking about going into the TV-game business, the GI chip was the convincer. For First Dimension, sitting with a huge inventory of discrete parts, it was a crushing blow.

The cost of the GI chip ranged from $5 to $6, depending on the volume involved. It promised total system costs of $25 to $30 and retail prices in the $60 to $75 range. Development of the chip had been initiated for Salora OY in Finland for use in a television set; subsequently, Telefunken GmbH and Loew-Opta GmbH in West Germany and Vanguard S.A. in Spain had also ordered the device. In order to market the IC in the U.S., General Instrument's Hicksville, NY plant developed a 525-line, 60 half-frames-per-second NTSC system version of the original chip, designed for 625-line, 50 half-frames-per-second PAL systems in GI's Glenrothes, Scotland plant.

The GI chip made it possible for companies to establish simplified production lines and build lower-cost games.

Hard times loomed ahead for many video game builders, however. Many small-games companies found they couldn't get parts unless they paid in advance. Delays were encountered in getting FCC Class-I-device approval. Others learned, sometimes belatedly, that the demand for the GI chip far exceeded the supply and other integrated-circuit suppliers weren't ready to fill the void. For example, Lloyd's Electronics said it received only 20% of the chips it had ordered from General Instrument for games planned for the Christmas 1976 season. As readers might recall, the supply of games ran out during the Christmas 1976 season in many parts of the United States.

Coleco was the first major customer for General Instrument's industry-revolutionizing game chip and, as a result, received early delivery of the part. Approval for its game also came early from the FCC and, by May 1976, many stores had sufficient stock to meet Father's Day demands. Reorders poured in, encouraging Coleco to build up heavy production capability. Coleco president Arnold Greenberg estimated that his company's 1976 game sales exceeded $110 million. Sales for TV games during the Christmas 1976 season lifted the industry into the big business category.

The first home TV-game system to accommodate replaceable *cartridges* was introduced by Fairchild Camera and Instrument in August 1976. The unit had hockey and tennis built-in. The key to its versatility, of course, was its capability to accept a never-ending number of new cartridges as they were developed—blackjack, baseball, tank battle, etc.

Each Videocart cartridge contained a semiconductor memory programmed to reproduce specific games on the television screen in full color. The game console used a Fairchild F8 microprocessor and four semiconductor random-access memories to provide the basic game system electronics. For sports the score and elapsed time were displayed continuously at the bottom of the screen.

As 1977 began, RCA followed Fairchild into the plug-in-game business using its 1802 integrated circuit in a microprocessor-based, black-and-white video-game system. The RCA unit combined keyboard console control with read-only-memory cartridge game inputs. Bowling was among the games offered by RCA.

The outlook for video games was never brighter. National Semiconductor had sold over 200,000 Adversary video games in 1976, containing built-in hockey, tennis and handball. A newer model adding soccer, pinball and a game called "Wipeout" was being readied for June delivery. Fairchild had been back-ordered since it started delivering limited quantities of its Video Entertainment System the previous August. Although delays in getting approval for its system from the FCC had set back its time-table, in January 1977, it doubled the cartridges in its line from three to six and announced that it would bring out a new cartridge every month.

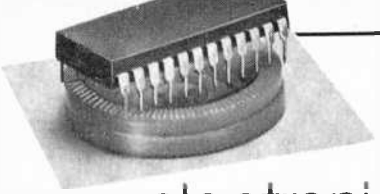
Also in January 1977, General Instrument shipped its seven-millionth 6-in-1 TV-game chip (the AY38500) and announced that a series of new chips, providing racing and combat games, would soon be available.

Magnavox, planning to use the new GI chips, announced that it would supply a 24-game, 4-player video system in September priced under $100. A backgammon game, in pilot production by Allied Leisure, was heralded as the beginning of the next evolution of electronic games. At least as impressive was a chess-playing game designed by Mostek that not only permitted playing against the computer, but let the player select the skill level at which the computer would operate. Mostek offered to provide the software for the game to any manufacturer who would build the game with Mostek microprocessors. Connected to a TV set, the control unit was used for entering moves. The board and the pieces were displayed on the screen. It was an exciting time. Few realized that the Camelot era of video games was about to end.

Despite the shortage of TV games during the Christmas 1976 season, the market collapsed in 1977. Allied Leisure went bankrupt before it could deliver its backgammon games. National Semiconductor stopped development of its improved version of Adversary; Magnavox cancelled its top-of-the-line 24-game system. Atari, thanks to a fresh infusion of money by Warner Communications, hung in. So did Coleco, somehow surviving losses of $30 million for 1977. One by one, most of the video game manufacturers dropped out. The casualties included the three semiconductor companies who were building games with their own chips: Fairchild, National Semiconductor, and RCA.

But as one electronic game industry suffered, another was being born.

(Continued overleaf)



electronic games...

Hand-Held Games. Until Texas Instruments introduced the hand-held learning aid called "Little Professor" in 1976, all of the activity in electronic games involved TV games. Another indication of what was soon to come took place late the same year when Mattel brought out two hand-held games, "Football" and "Auto Race," both controlled by Rockwell PPS-4 4-bit microprocessors. The Mattel games retailed in the $25 to $35 range.

At least 20 semiconductor companies had the technology in 1977 for massive penetration of the toy industry, but Texas Instruments moved the quickest. It explained to toy manufacturers that the same chip used in the "Little Professor," through appropriate programming, could play many other roles.

In designing the "Little Professor" as a learning aid for children five years or older, TI had combined electronics with an old educational practice, flash cards. The game generated a sequence of preprogrammed problems in addition, subtraction, multiplication and division; more than 16,000 individual problems could be presented. After the child selected one of four levels of difficulty, the "Little Professor" asked questions and the child replied. Answers were "graded" and a score was displayed.

According to a TI spokesman, the "Little Professor" may have been the best semiconductor salesman in the industry's history. TI's four-bit microcomputer caught on fast and in the three-year period which followed, it won over toy company after toy company. Today it is by far the most popular IC in the U.S. hand-held electronic-game market.

As the TMS1000 began to catch on in 1977, TI's own consumer products operation and the company's customers conveniently moved in different directions. TI continued to develop educational aids, while its customers concentrated on games of fun, chance, and skill. But TI's next learning aid, like the "Little Professor," also demonstrated features that the toy industry could appreciate.

The product was called "Data Man." It introduced a "beat-the-clock" timing feature and rewarded winners with "whiz-bang," a highly visual action-packed display styled after the "home run" antics provided by some stadium scoreboards. It also provided suitable commentary for errors (although Fairchild's "You lose, turkey," was probably the best of all display messages to losers). "Data Man" was a calculator-based learning aid like the "Little Professor," but it was more sophisticated and it included math strategy problems.

Many of the hand-held electronic games on the market are controlled by TI's TMS1000. Some of these games use only the TMS1000 for all functions, including memory and sound generation. Others have supplementary chips to expand memory capability or enhance sound effects. At the present time, Texas Instruments produces 27 different versions of the TMS1000 microcomputer chip.

First of the "Talkies." Encouraged by the success of the "Little Professor" and "Data Man," in late 1977, Texas Instruments decided to build a learning aid that could speak electronically, but with human inflection and fidelity. A massive research study was made to see if a market for such a product existed.

The conclusions reached were that the concept was viable, that a neutral, masculine voice was more acceptable than an unusual or artificial voice, and that the public would accept a $55 retail selling price (the price rose to $64.95 by Christmas 1979 and increased to $74.95 in mid-1980).

TI, after deciding that the talking aid would have to speak at least 200 words, consulted educators and selected words commonly misspelled for the product's vocabulary. At this point responsibility for development of the product was assigned to Paul Breedlove.

Breedlove found that he could generate audible speech from coded digital information for the desired 200 words through the use of four chips. One of these chips, obviously, would be the TMS1000, which was assigned to handle all of the control functions. Two of the chips were 128K-bit TMC0280 read-only memories, already designed by TI. The fourth chip, however, a speech synthesis integrated circuit, would have to be developed.

The job of designing the speech chip, designated the TMC0350, went to Larry Brantingham and Richard Wiggins. They decided, in effect, to develop an electronic model of the vocal tract. Just as human speech is created by air impelled through the vocal tract, synthetic speech would be generated by processing pulses through a rapidly changing electronic filter.

The concept was based on converting speech into frames of 12 digital codes, each at the rate of 40 frames per second. As each frame of a motion picture stops the action for that instant of time, each frame of speech "stops the action" of the vocal tract for 1/40th of a second. This action is then converted into twelve codes that represent the pitch for that instant. Thus, to artificially produce speech, the microcomputer recalls speech frames from the memory. The pitch characteristic for each frame determines if the electronic impulse will be a vowel or a hard consonant sound.

The sound is combined with a loudness level characteristic to determine how loud it should be, and it is then processed through a 10-stage lattice filter where it is combined with the 10 vocal tract characteristics. In effect, this filter acts on the electronic signal to accomplish what the vocal tract does to the air signals from the lungs. Next, the signal is passed through a digital-to-analog converter to a small loudspeaker.

"Speak and Spell." The new product was named "Speak and Spell." It was introduced to buyers in June 1978 at the Consumer Electronics Show.

Operation of Speak & Spell is simple. A child presses a button and is asked to spell a word. As the child presses each letter, the machine announces the letter. When the child has finished spelling the word, he presses "Enter," and the machine replies "That is correct," or "Wrong. Try again." After ten words, the learning aid plays a tune, and says, "Here is your score." If all ten words have been spelled correctly, it congratulates the player.

"Speak & Spell" was joined by two more TI learning products in 1979, "Spelling B" and "Mr. Challenger." Recently TI added an ear phone, an ac adapter plug and automatic powerdown (after five minutes of nonuse) to "Speak and Spell." It also brought out a plug-in module that converts the unit into a Japanese-speaking model. And, by Christmas 1980, it will market two advanced versions, "Speak & Read," and "Speak & Math."

Sometimes the requirements of an electronic game can't be satisfied by configuring the metalization layer of a microprocessor to correctly link up each individual IC element. In this case, the IC manufacturer will retain much of the microcomputer circuitry while replacing unneeded portions with specific circuits designed to answer the customer's needs. American Microsystems, Inc. used this approach in modifying its S2150 microcomputer for use in Parker Brothers' pinball game, "Wildfire."

how new chips are changing the name of the game

THE 4-bit microcomputer, heart of the hand-held electronic game since 1977, is expected to remain popular for several years.

In January 1978, Joseph W. Willhide, a leading electronic-game design consultant, was invited to choose and describe the semiconductor industry's best microcomputers for hand-held games (at a "Gametronics" seminar in San Francisco). Willhide selected the following seven 4-bit microcomputers:

Microcomputer	Manufacturer
SX2000	American Microsystems
SX200	Essex Group
COPS-MM5799	National Semiconductor
μCOM-44	NEC Microcomputers
MN1400	Panasonic (Matsushita)
PPS-4/1-MM76E	Rockwell International
TMS1000	Texas Instruments

He praised the SX2000 for off-chip expandability and a counter designed for timing applications; he criticized the SX200 and the MN1400 for being less efficient than the other devices with respect to addressing instructions (such as jumps, branches and subroutine calls). He applauded the MN1400 for being the only one of the seven microcomputers to directly address RAM registers without using data pointers, and he commended the SX2000 for its speed.

Willhide concluded that the group of seven devices didn't contain a clear-cut winner and that the specific needs would dictate the right device to use. He even speculated that an 8-bit microcomputer might put all of the seven devices out of contention.

Yet, Texas Instruments was clearly the winner of the game-chip business competition by the end of 1978. Its triumphs were strongly attributed to marketing strategy coupled with low price quotations, high-volume production capabilities and the impressive success of its "Little Professor" learning aid.

The field of contenders hasn't changed greatly since Willhide composed his original list. Today it reads:

Microcomputer	Manufacturer
S2000	American Microsystems
COPS-II	National Semiconductor
μCOM-44/45	NEC Microcomputers
MN1400, MN1500	Panasonic (Matsushita)
PPS-4/1	Rockwell International
TMS1000	Texas Instruments
1872/2272	Western Digital

As the foregoing list suggests, the "new" microcomputer chips for hand-held games are actually improved versions of the previous chips; advancements are in expanded memories, faster speeds, reduced power requirements, and added functions. The present state of the 4-bit microcomputer art is summarized up as follows.

TMS1000. It is estimated that Texas Instruments shipped at least 20 million TMS1000s in 1979. TI has added cost-saving features to its basic chip, such as triac output drives and an analog-to-digital converter. It also supplies a complementary-symmetry metal-oxide semiconductor version of the TMS1000 which has a 6-microsecond instruction execution time (compared to 15 microseconds for the basic TMS1000) and a "halt" reduced power mode that drops power to 500 microwatts. (Motorola is a second source for the CMOS microcomputer chip.)

The basic TMS1000 is a 4-bit p-channel MOS calculator-type microcomputer. The chip executes 43 instructions and includes a 64-by-4-bit data random-access memory, a 1K-by-8-bit instruction read-only memory, four keyboard inputs and eight segment-driver outputs with 11 strobe multiplex outputs.

PPS-4. An early version of Rockwell's PPS-4 was one of the industry's first two commercially available microprocessors. The other was Intel's 4004; both were announced in 1971.

The PPS-4 was the first microcomputer to be used in hand-held games. Mattel used it in "Football" and "Auto Racing," both designed in 1976, and is still using it today.

The PPS-4, a p-channel MOS device, employs split-memory architecture; it uses 8-bit instruction words and 4-bit data words, and it can provide up to 2048 bits of ROM and up to 128 bits of RAM. Its set of 50 instructions includes instructions for moving strings of 4-bit words for multiple precision operations. A special version, the MM78, has a 2-channel 8-bit A/D converter.

COPS-II. National Semiconductor's original p-channel COPS line has been redesigned in n-channel MOS and CMOS versions; both of these families provide faster speed than offered by p-channel MOS devices.

Two new COPS-II versions, designed in 1980, are the 444L with a 128-by-4 RAM, and the 420C with low-battery drain and an "asleep" operating mode. Like Rockwell's PPS-4, the COPS-II uses split-memory architecture (8-bit instruction and 4-bit data words).

S2000. American Microsystems has added the S2200 to its n-channel S2000 family and expects to complete designs of two more microcomputers, the S2210 and the S2400, by late 1980.

The S2200 has an 8-channel, 8-bit analog-to-digital converter, three fast-acting interrupts and a more complex timer. It also has 12 new instructions. The S2400 will have all of the S2200's features but double its ROM memory (4K-by-8 vs. 2K-by-8). The S2210 will be a CMOS version of the S2200. Previously available S2000 devices have a 51-instruction set and up to 80-by-4 RAM and 1.5K-by-8 ROM. The three new 63-instruction devices have 128-by-4 RAM.

Western Digital was recently licensed by National Semiconductor to make COPS devices; this could influence it to phase out its less powerful 1872/2272 family of n-channel devices.

It can be concluded from this discussion that the current 4-bit microcomputer, although refined, improved and expanded, is still very similar to its 1977 counterpart.

How then will games change?

It is likely that the next wave of hand-held electronic games will differ more from existing games in voice and sound capabilities than in any other respect. A fiercely competitive battle similar to the 1977 microcomputer war is shaping up for 1981 among semiconductor suppliers. This time, however, the combatants will be vying for the speech synthesis chip business.

Again, Texas Instruments is a prime contender and its close ties with the

game industry are certain to help. This time, "Speak & Spell" could be called upon to play the same role performed four years ago by the "Little Professor."

Three different techniques are used by semiconductor manufacturers to synthesize human speech. They are formant synthesis (also known as terminal analog synthesis), linear-predictive coding, and waveform digitization systems with compression.

Formant synthesis, the least expensive of the three approaches, is used in "Baby Soft Sounds," Fisher-Price's new talking doll. In this approach, formant frequencies are generated that correspond to the natural resonances created during speech. A modulated signal with controlled amplitude is generated and passed through two levels of filtering creating an analog of the corresponding mouth resonance. The center frequencies of the signal shift with time in accordance with changing resonances of the voice.

Coefficients for the filters are stored in ROM. Studies by the Bell System indicate that approximately 400 bits of memory are required to store a second of speech in a formant synthesis system.

Baby Soft Sounds uses two chips: a formant-synthesis speech chip and a controller/memory chip. The speech synthesis chip contains a pitch oscillator, a gain control, two formant filters, and an output amplifier, capable of directly driving a speaker.

Although the doll speaks 16 words, cries and hiccups, only eight words are contained in the memory; the additional words are created through speaking the same eight words at a different speed. Motion and position trigger the doll to talk; it contains no on/off switch. If the doll is laid down to sleep, it cries for awhile and goes to sleep; at this time the circuitry is powered down to only a few microamperes of current.

TI's Talking-Chip Set. Texas Instruments based its speech synthesis system on a voice-compression technique called linear predictive coding (LPC). LPC is based on a linear equation which formulates a mathematical model of the human vocal tract in order to predict a speech sample based on previous ones. TI combined a pipeline multiplier, an adder/subtracter and delay circuits on a chip to simulate a 10-stage filter. Codes for 12 synthesis parameters (10 filter coefficients, pitch and energy) serve as inputs to the synthesizer chip.

Processing of signals by the chip is depicted in Fig. 1. The input signal may be either periodic impulses or pseudorandom noise. The periodic inputs are used to reproduce voiced sounds that have a definite pitch such as vowel sounds or voiced consonants such as *Z*, *B* or *D*. A random input models unvoiced sounds such as *S*, *F*, *T* and *SH*.

A separate read-only memory (ROM) chip stores the coded digital data needed to specify the type of input signal, degree of amplification, and a set of filter coefficients. Pitch bits vary the

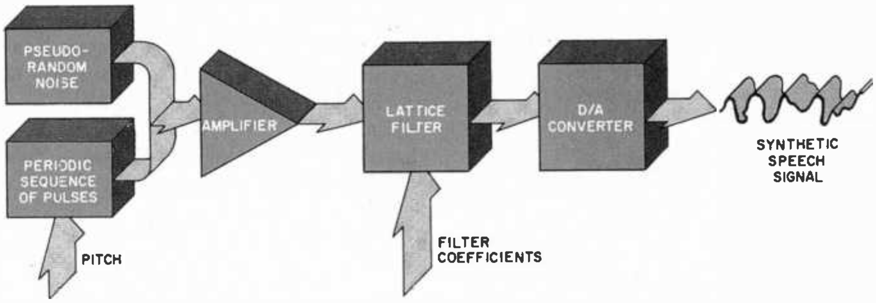


Fig. 1. The excitation signal for Texas Instruments' speech synthesizer system can be periodic impulses for voiced sounds or pseudorandom white noise for unvoiced sounds. Data needed to select type of excitation, determine degree of amplification, and specify filter coefficients is stored in ROM.

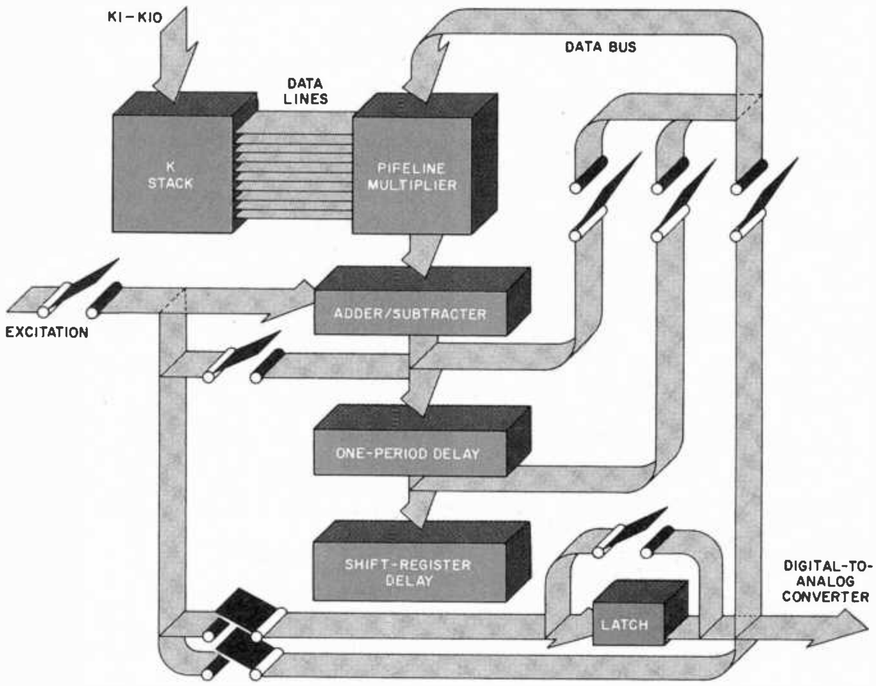


Fig. 2. In the 10-stage filter on TI's speech synthesizer chip, the pipeline multiplier performs all 20 of the multiplications required. It receives data and coefficients from the k stack of shift registers through the data lines and initiates a different multiplication operation every 5 microseconds. The multiplier's output consists of 13 data and one sign bits in parallel. Output of the adder/subtracter is also 14 parallel bits, but is delayed one time period before being stored in the shift register.

frequency of the periodic impulses being supplied or, if all are zero, select random data to excite the multi-stage filter.

The rate at which the memory delivers updating filter coefficient data determines the quality of the created speech. However, while increasing the rate improves the quality of the speech, it also adds to the amount of memory needed to store this data. For its system, TI decided that updating the filter coefficients every 20 milliseconds would provide good speech quality without requiring heavy storage.

Each stage of the 10-stage filter (except the last one) carries out two multiplications and two additions on its two digital inputs before moving the results back and forth to adjoining stages. The operations of the 10 stages take place sequentially, as do the four operations within each stage.

The pipeline multiplier carries out all 20 of the multiplications required by the lattice filter. A different multiplication operation starts every five microseconds. There are eight stages in the multiplier and, thus, eight multiplications, in various stages of completion, are taking place at any one time. The output from the multiplier is one of two inputs fed to the adder/subtracter circuit. The other input is controlled by digital switches and, at various times, arrives from the adder, multiplier or latch memory. The output from the adder/subtracter is delayed one time period and stored in one of 13 shift registers, each of which has eight stages. See Fig. 2.

The chip contains an 8-bit digital-to-analog converter that transforms the digital information processed through the filter into synthetic speech. The converter has an accuracy of one-half of the least-significant bit and the ability to drive a 200-milliwatt speaker.

The speech synthesizer is teamed with a read-only memory (a 131,072-bit, p-channel metal-oxide-semiconductor memory) and a controller chip, the TMC0270 (actually it is a custom TMS1000) in Speak & Spell. The TMC0350 ROM can accommodate approximately 165 words or 115 seconds of speech plus pitch, amplitude and filter parameter data.

In April 1980, Texas Instruments announced the availability of the TMS5000 single-chip synthesizer and the TMS6100 ROM, updated versions of the Speak & Spell chips, at $13 a set in production quantities.

Who Is the Competition? National Semiconductor and General Instrument are also sampling speech synthesis chips. National's SPC uses the waveform digitization with compression technique (Fig. 3); General Instrument's LISP-0256 uses a technique similar to TI's.

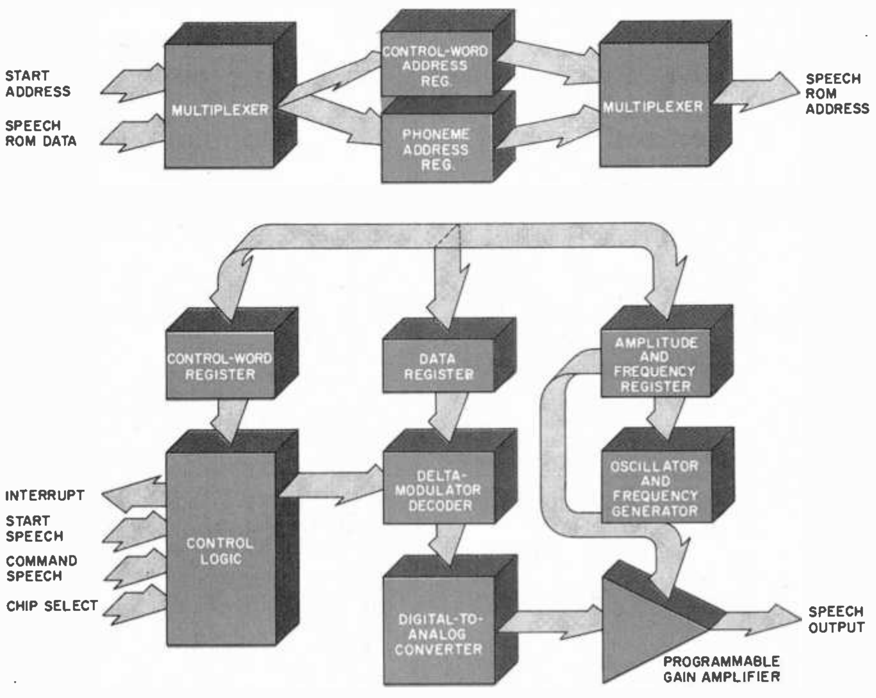


Fig. 3. In National Semiconductor's speech processor chip each block of data has a control word that provides a complete description of how to process the data. It gives frequency and amplitude information for recreating natural inflection; specifies ROM location, type of waveform to be generated, and number of times to repeat it; and indicates if it is the last control word.

Waveform digitization with compression was the first of the three speech synthesis techniques to be developed. With this system, the input signal is sampled and digitized at twice the highest frequency of concern (known as the Nyquist rate). The speech data is then compressed significantly to reduce storage requirements. Later, on a command from a microcomputer, the speech processor recreates the original signals from the compressed data.

Several game manufacturers are evaluating National Semiconductor's SPC two-chip set. Introduced in June 1980, the set consists of the speech-processor chip and a 16K-bit ROM, capable of storing 25 words; for larger vocabularies, the speech-processor chip can address up to 128K of ROM directly or, with the aid of almost any microprocessor, up to two megabits of ROM.

The speech data is created by simply talking into a microphone to produce the analog signals that represent the basic speech information. Next, these signals are passed through a differentiator to retain the higher frequency components. The differentiated waveform is then sampled and digitized. The ROM compresses the frequency and amplitude information as well as the speech data by employing three different compression techniques. One removes redundant pitch periods, portions of pitch periods, and redundant phonemes.

The second compression technique, known as adaptive delta modulation, operates on the speech waveform. Because this waveform is relatively smooth, the difference in amplitude between two successive digitizations is generally small. Less information has to be stored if the difference in amplitude between successive digitizations is used instead of the actual amplitudes. The third compression operates on the direction component of a speech waveform.

After digitization, compression and re-creation, using the National chips, speech is not only intelligent, but the voice of the speaker, male or female, can be clearly identified. Male voices require about 1,000 bits to store a word of speech; the female voice requires a larger number of bits per second because of its higher frequency.

National sells the two-chip set for $10 to $12 in quantities of 25,000.

General Instrument's LISP-0256 contains 16K bits of on-chip ROM and can handle up to 60 seconds of "computer-like" speech or four to ten seconds of specific voice emulation (depending on whether you'd rather have a talking robot or Humphrey Bogart). ◇

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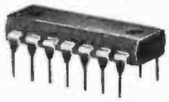

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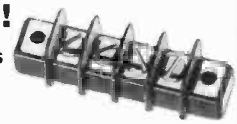

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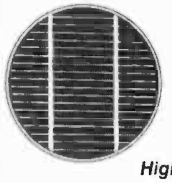

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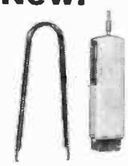

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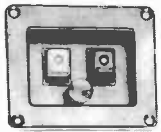

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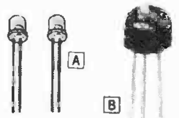

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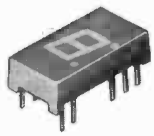

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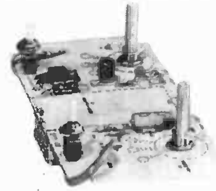

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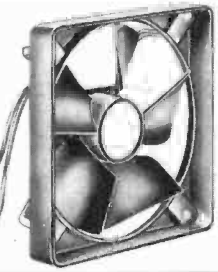

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BUILD AN INFRA-RED Road Icing Alert

BY THOMAS R. FOX

ROAD-SURFACE icing is one of the most dangerous hazards of winter driving. To warn drivers, ice-warning indicators for automobiles have indeed been developed. However, most of these indicators merely monitor air temperature a few inches from the road and alert the driver when that temperature falls to about 36°F. Unfortunately, this approach can deliver false alarms or, worse, fail to indicate danger when air and road temperatures are different.

The infrared road icing alert (IRIA) system described here overcomes this problem by responding to both air and road temperatures. It senses infrared radiation emitted by the road and warns drivers both audibly and visually that the conditions for icing are present.

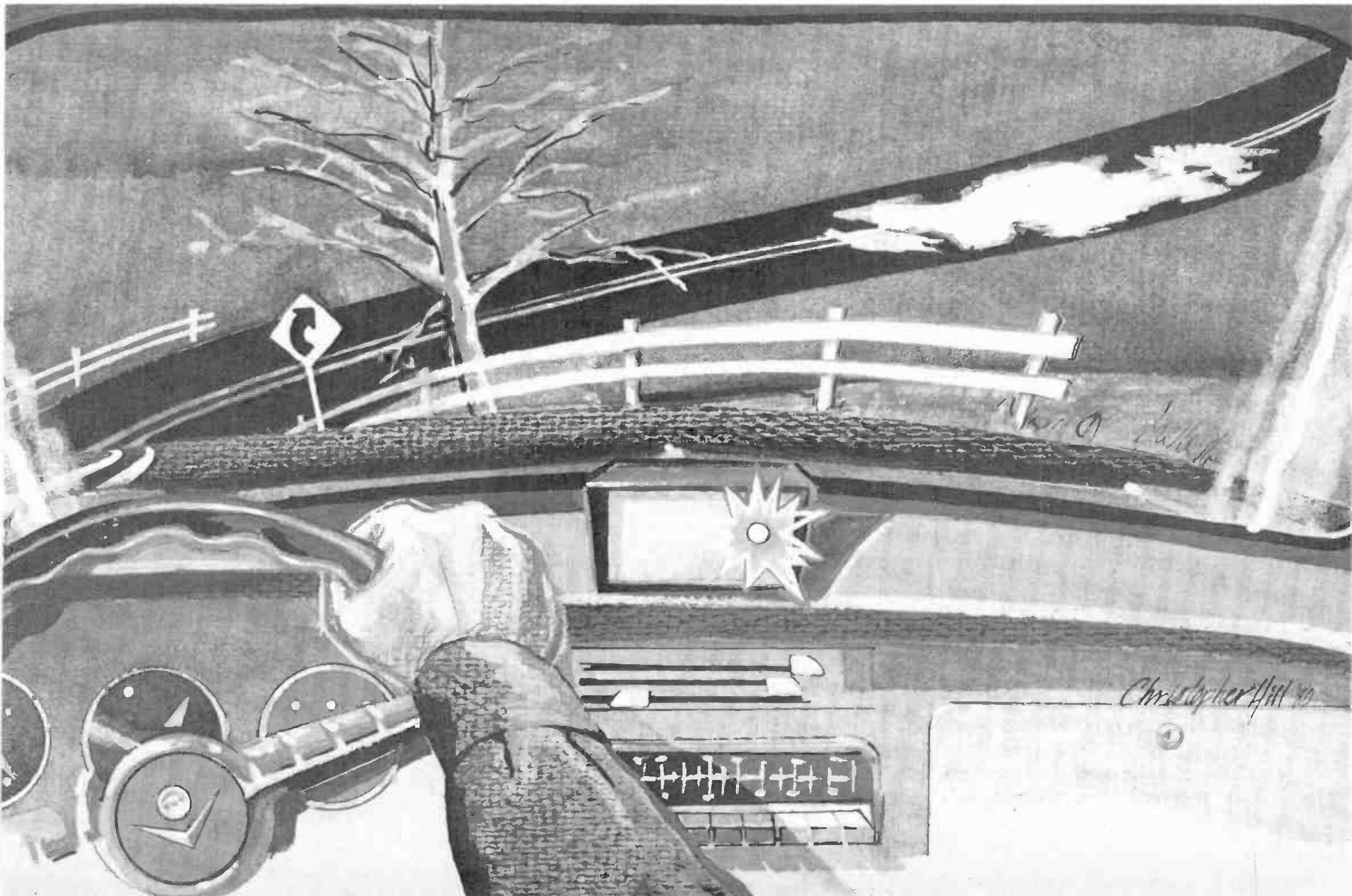
Sensor Operation. The sensor used in this project is a thermistor—a semiconductor device whose electrical resistance varies with temperature. Like any other material body, a thermistor can change temperature by conduction or radiation. As shown in Fig. 1, conduction is the exchange of heat between the air surrounding the thermistor and the thermistor, or the exchange of heat between the thermistor and any object making direct contact with it. In some remote cases, thermistor body temperature changes can occur by heat flowing along the thermistor leads. In all cases, the heat flow continues until the thermistor is at the temperature of the heat source and thermal equilibrium between the two is reached.

Temperature change through radiation occurs when the thermistor intercepts infrared radiation, that is electromagnetic radiation whose wavelength is just longer than visible light. When exposed to infrared radiation, the thermistor increases its internal temperature until it re-radiates energy at the same rate as it is being absorbed, and thus reaches equilibrium. Its electrical resistance, of course, changes accordingly.

A thermistor can also be heated by current flowing through it. However, in most applications, this current heating is small enough to be ignored.

While one does not usually consider ice or a road surface at or below freezing to be a source of infrared radiation, these objects like any in the universe that are above absolute zero (−273.16°C.), emit some electromagnetic energy. The magnitude and spectrum of the radiation vary with temper-

Detects when conditions for ice on the road exist, even in the dark or if air temperature seems too warm



ature and the characteristics of the radiating body in a fairly complex way, but it is sufficient for our purposes to note that as temperature rises, the radiation increases in intensity and the peak of its spectrum moves to shorter and shorter wavelengths. Objects at normal temperatures (including the freezing point) radiate substantial infrared, to which a thermistor can respond.

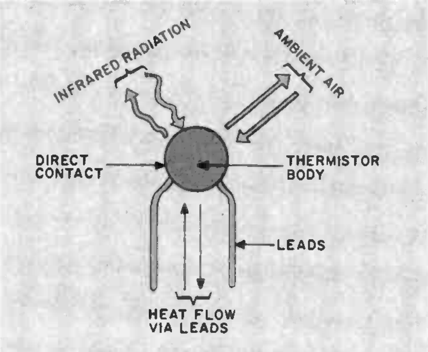


Fig. 1. How the temperature of a thermistor can change.

The Sensor Head. If a thermistor is mounted at the focal point of a parabolic reflector (a curved surface that has the property of focusing all incoming rays to a single point), and if the open end of the reflector is covered with a material that keeps air from circulating around the thermistor but allows infrared radiation to pass through, a sensor for infrared radiation is produced. This is shown in Fig. 2. Since the reflector and thermistor are not thermally insulated, the thermistor will have some response to ambient air temperature.

The reflector arrangement shown in Fig.2 is the approach used in the IRIA project. Such a sensor is mounted to the underside of the vehicle front bumper, with the open end facing the road underneath the vehicle. The temperature of the thermistor represents a weighted average of the road and air temperatures—with the road temperature predominating. If there were a perfect vacuum surrounding the thermistor, and the thermistor leads had the absolute minimum of support, the thermistor temperature would closely approximate that of the road.

The Sensor Assembly. The thermistor used in the author's prototype has a resistance of 1000 ohms at 25°C, is relatively small and inexpensive. It has a time constant of 10 seconds, and a diameter of 0.1 inch (see Parts List). The parabolic reflector used was a 4" type salvaged from a discarded lantern flashlight. Other sizes of reflectors can be used, but experiments show that a 2½" diameter is the smallest that can be used efficiently.

To determine the focal point of your reflector, remove the bulb and holder and temporarily attach a piece of styrofoam or balsa wood to the back of the reflector so that it covers the bulb holder hole. Stick a thin wood toothpick into the exact center of the holder hole so that it is supported by the styrofoam or balsa. On a clear, sunny day, aim the open end of the reflector to the midday sun until the toothpick begins to smoke. Remove the reflector from the sunlight and note that the charred part is at the reflector's focal point. Carefully measure and record the distance from the bottom of the reflector to this focal point as this is where the thermistor will be placed for maximum effect.

The reflector is mounted on a short length of 1" x 2" wood board, which in turn, is affixed to the car underside, far enough from the front so that direct sunlight will not strike the sensor. Once you determine where the wood element is to be mounted, you can then determine its length and method of mounting.

After the wood has been cut to length, the reflector is mounted to it using a pair of wood screws or epoxy as shown in Fig. 3A. After securing the reflector, carefully drill two 1/16-inch holes, ¼ inch apart and straddling the center point, through reflector and wood support. Cut two pieces of small-diameter insulated sleeving, about ⅛ inch shorter than the "focal length" previously determined. Mix a small batch of quick-setting epoxy and place some on each thermistor lead from the body to about 1¼ inches down. Slip the sleeving over each thermistor lead as shown in Fig. 3B. Insert the bare (unsleeved) thermistor leads through the two 1/16-inch holes drilled through the wooden support. As shown in Fig. 3C, adjust the height of the thermistor body so that it is centered

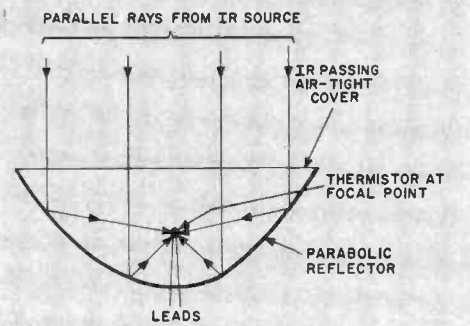


Fig. 2. A parabolic reflector focuses infrared rays onto the thermistor.

at the "focal point" previously recorded. Use a dab of epoxy at each lead to secure the two leads to the board. Make sure bare leads do not make contact with the metal reflector.

On the underside of the board, mount a two-lug terminal strip and connect both the two thermistor leads and a small two-conductor cable to the two terminals as shown in Fig. 3C. After the epoxy is cured, paint a thin coat of flat-

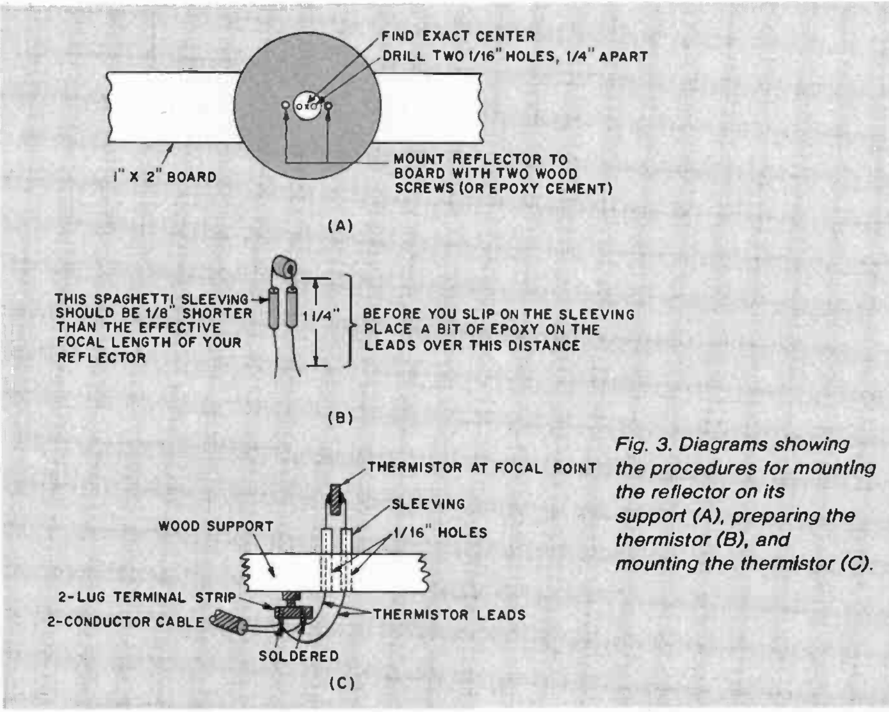


Fig. 3. Diagrams showing the procedures for mounting the reflector on its support (A), preparing the thermistor (B), and mounting the thermistor (C).

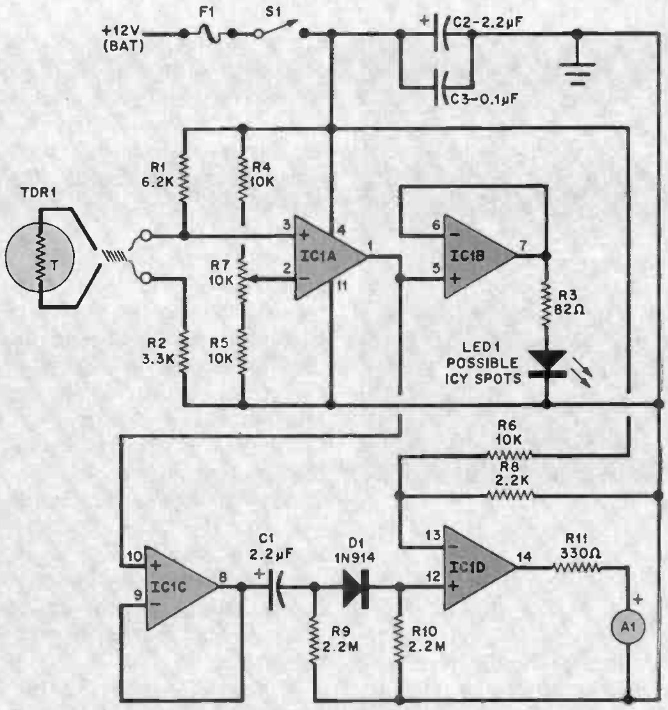


Fig. 4. The thermistor is part of a bridge that drives comparator IC1A. When this comparator turns on (detected temperature below preset), it activates a LED and an audible alarm.

PARTS LIST

A1—6- or 12-volt alarm (Sonalert or similar)
C1,C2—2.2-µF, 25-volt tantalum capacitor
C3—0.1-µF, 25-volt ceramic capacitor
D1—1N914 or similar diode
F1—¼-ampere fuse and holder
IC1—LM324N quad op amp
LED1—orange or red LED
The following are ¼-watt composition resistors unless otherwise specified:
R1—6.2 kΩ, 5%, film
R2—3.3 kΩ, 5%, film
R3—82 Ω
R4,R5,R6—10 kΩ, 5%, film
R7—10 kΩ, 10-turn pc mount potentiometer
R8—2.2 kΩ
R9,R10—2.2 MΩ
R11—330 Ω
S1—Spst switch
TDR1—1 kΩ @ 25°C thermistor, (Fenwall JB31J1 or similar)
Misc.—2½" or larger parabolic reflector (lantern or flashlight component), spaghetti sleeving, epoxy cement, 1" x 2" wood board, wood screws, machine screw, two-lug terminal strip, two-conductor cable, cable ties, etc.

Note: The following are available from Magicland Electronics, 4380 South Gordon Ave., Fremont, MI 49412: Fenwall JB31J1 thermistor at $2.95; thermistor and LM324N at $4.25 (kit IRIA 1).

black, oil-based paint on the thermistor body. Cover the open end of the reflector with a thin transparent plastic shield (transparent food packaging material or other thin flexible plastic is fine). Transparent plastics pass more infrared energy than does glass.

Circuit Operation. The circuit is shown in Fig. 4. At a temperature of 32°F (0°C), the thermistor called for in the Parts List has a resistance of approximately 2.8 kΩ. Thus, at 32°F, pin 3 of op amp *IC1A* is just under 6.8 volts (assuming the vehicle's electrical system is delivering about 13.6 volts when the generator is operating).

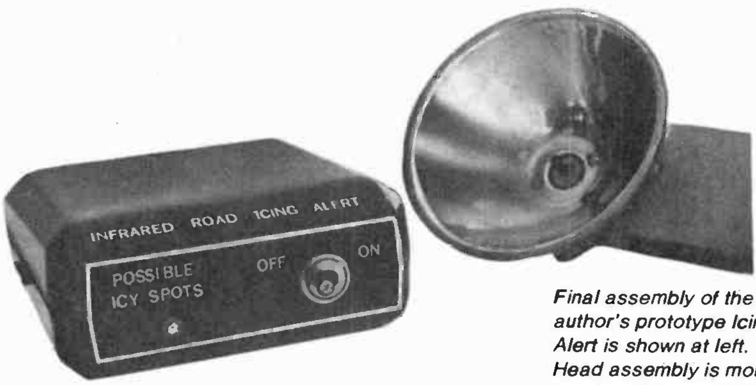
The output of *IC1A* is coupled to follower *IC1B* which in turn drives *LED1* through current-limiting resistor *R3*.

Reference voltage control *R7* is adjusted so that the LED is just below the point of glowing at the user-selected "critical point" (this is usually between 32 and 36°F). Once *R7* has been adjusted, the reference voltage at pin 2 of *IC1A* is just a fraction of a volt below that at its noninverting input (pin 3).

The noninverting input of *IC1A* is connected to the junction of *R1* and *TDR1* in series with *R2*. As the temperature of *TDR1* drops, its resistance increases, and the voltage at *IC1A* pin 3 increases above the reference voltage applied at pin 2. This causes *IC1A* to switch "on" which, in turn, forces buffer *IC1B* to supply current to *LED1* causing it to glow. This visually indicates that there is the possibility of an icy spot in the road.

The output (pin 1) of *IC1A* is also coupled to buffer *IC1C*, which drives a differentiator consisting of *C1* and *R9*. The output of this differentiator consists of a positive-going pulse when *IC1A* switches off. Diode *D1* allows only the positive-going pulse to pass to the noninverting input (pin 12) of *IC1D*. The inverting input (pin 13) is referenced to about 2.5 volts developed by network *R6* and *R8*. Therefore, *IC1D* will switch on only when its noninverting input is greater than the reference voltage (2.5 volts). When *IC1D* is activated, it supplies current to alarm *A1* via current-limiting resistor *R11*. This alarm turns on a fraction of a second after *IC1A* operates. After a time period determined by the values of *R6*, *R8*, *R9*, and *C1*, the alarm goes off. When the thermistor "sees" a higher temperature, its resistance drops, turning off *IC1A* and *IC1B*, and the LED goes dark.

The circuit is protected by fuse *F1*,



Final assembly of the author's prototype Icing Alert is shown at left. Head assembly is mounted on piece of wood with the thermistor at the focal point.

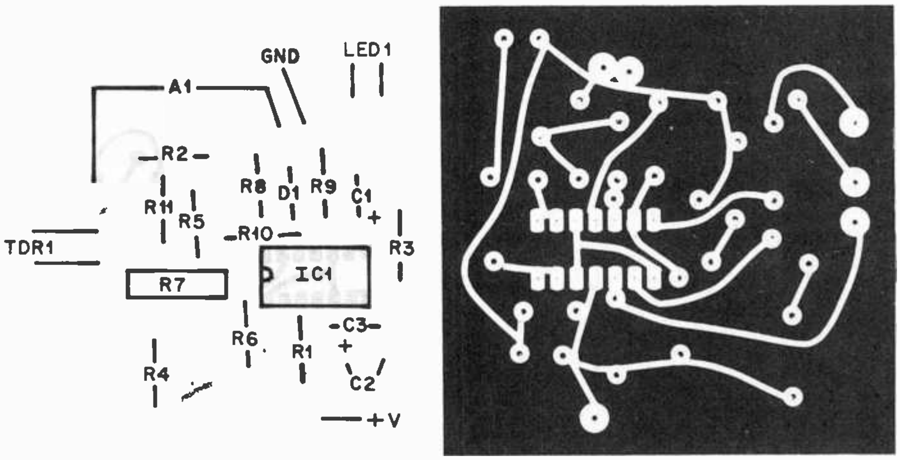


Fig. 5. Actual-size etching and drilling guide for a printed circuit board for the Infrared Road Icing Alert is shown above right. Component layout above left.

and capacitors *C2* and *C3* remove voltage transients that might produce a false alarm.

Circuit Construction. Although the circuit is simple enough to use direct point-to-point wiring on conventional perforated board, an actual-size foil pattern is shown in Fig. 5 along with the component installation. Note that *TDR1*, *F1*, *S1* and *A1* are not mounted on the small board. Though a single-turn potentiometer can be used for *R7*, a 10-turn type is recommended. If your alarm (*A1*) is a 6-volt version, use *R11*. If *A1* is a 12-volt type, *R11* can be eliminated. Resistor *R8* determines the "on" time for the alarm. Making this resistor smaller in value increases the *A1* "on" time. Conversely, for a shorter "beep," increase the value of *R8* to 3.3 kΩ.

The circuit board can be mounted in almost any type of small (usually plastic) container. Power on-off switch *S1* and *LED1* are mounted to the front panel. The two leads to *TDR1* and the power-ground leads exit via small holes at the rear.

Initial Test. Connect a source of 12 to 15 volts dc to the pc board, and turn power switch *S1* on. Adjust trimmer potentiometer *R7* until the alarm sounds and *LED1* glows. Carefully back down on *R7* to the point where the LED just turns on.

Place the palm of your hand near the open end of the reflector for a brief period of time and note that the LED goes dark. Remove your hand, and note that after a few seconds, the LED glows and the alarm sounds off.

To create a "home-made" 37°F day, place the detector-reflector assembly in a common brown-paper bag and lay it on a shelf in the middle of your refrigerator (not the freezer!). Leave the sensor in this position for about 15 minutes. Since the temperature of the sensor is now approximately 37°F (the usual temperature that a refrigerator is set to), adjust *R7* until the LED just turns on. The system is now set up to sound off when the sensor "sees" a temperature below 37°F.

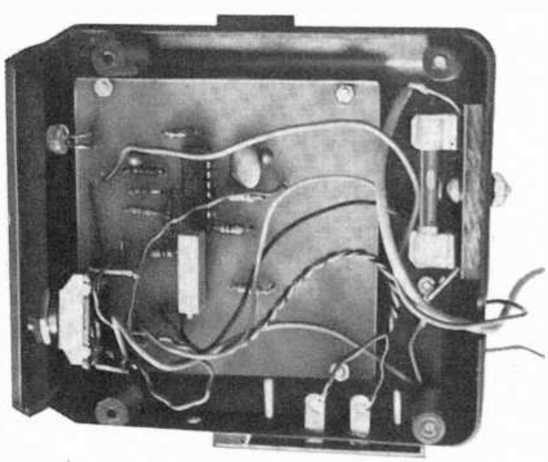
Installation. The sensor must be mounted under the vehicle, the open end pointed down at the road, and protected from direct sunlight. Any means can be used to affix the wood sensor support to the vehicle frame. Make sure that the reflector does not extend too far below the vehicle, or it will be knocked loose at the first large bump.

After the sensor is mounted, carefully pass its cable through the engine compartment making sure that the cable does not contact any hot or moving elements. Cable ties can be used to secure the twin-lead conductor to appropriate supports.

The slender sensor cable is passed through the firewall and snaked to the upper part of the dashboard where it is connected to the electronics. The ground can be made to any metal part of the chassis, and the +12-volts should be obtained from any source that is "live" when the ignition key is used.

If the sensor has been calibrated at 37°F, you will have to wait until the ambient temperature drops into the 30's. A nearly perfect day would be one with cloudy skies and a temperature well below freezing in the morning, and an afternoon temperature over 38°F.

Park the car in the shade so that the reflector is positioned over an accurate thermometer placed on the ground. If you are on the cautious side, adjust *R7* until the LED barely lights with a ground temperature of 36°F. If desired, you can make the calibration at lower temperatures of about 32 or 33°F. If the weather is too warm, you can always use a pan of ice under the reflector to simulate 32°F.



Internal view of the author's prototype shows circuit board in container with LED and switch on front and power leads exiting through back. Terminal strip on side is for leads to the thermistor.

The only maintenance required is keeping the reflector clean. You should wipe the reflector transparent cover at regular intervals. Contingent on the amount of road tar, sand, pebbles, etc., on the roads you use, you might have to replace the reflector cover when it becomes damaged.

Note that the IRIA does *not* detect road ice per se. Like conventional alarms, it responds to conditions under which icing may occur. The special characteristic of this system is that it assesses such conditions more accurately and offers a greater margin of safety when air and road temperatures are different, as they often are at dawn or early evening. ◊

OPTIMUM BIAS FOR YOUR TAPE RECORDER

BIAS AND EQ SETTINGS ARE COMPROMISES ON MOST TAPE RECORDERS. WITH A LITTLE WORK, YOU CAN GET THE "BEST" COMPROMISE

BY CRAIG STARK

AS MANY recordists know in theory but forget as a matter of practice, optimum performance from a tape and recorder depends as much or more on a happy marriage between the two than on what each is capable of individually. To purchase a tape formulation for its high-frequency headroom or high output level is folly unless you are reasonably certain that your deck can extract the performance you are paying for. Similarly, the most sophisticated of recorders will founder on a diet of tape for which it was not intended.

Another obstacle that stands in the way of getting the best from a tape/recorder combination is the variability of batches of tape. Two cassettes of a given type produced several months apart will probably match within a dB or two, but ± 2 dB still does not represent optimum performance—although it is often an acceptable compromise. To put the matter simply, if you demand the best that your tape and hardware can deliver, you will have to play matchmaker and execute far more critical adjustments of recording parameters than can be made via the customary front-panel switches. And, the variance between different tape types using the same switch settings is greater still.

User-accessible controls that allow fine tuning of bias are an increasingly frequent front-panel feature of today's high-quality cassette and open-reel recorders. Some are even semiautomatic, using microprocessors to make the adjustments for you at the touch of a button. Others work in conjunction with built-in tone generators and special metering. Still others require the use of external test instruments, and some let you adjust Dolby circuitry at the same time you adjust bias. A few also allow adjustment of record equalization.

It is sometimes overlooked that there may be legitimate differences of opinion about just what "optimum bias" for a given tape *means*. Is it "the bias level that maximizes high-frequency sensitivity"? Or that yields maximum low-frequency output? Or minimum distortion? Or is it the bias level that produces flattest frequency response when used with a specific amount of record equalization? All of these are, in fact, "optimum bias" points, so before you start "tweaking" bias level in your deck, it might be well to understand how these factors interrelate.

What Is Bias? Let's define bias and what it does, ignoring the more difficult question of precisely how it works. As applied to analog tape recording, "bias" is a current of ultrasonic frequency (typically 75 to 150 kHz in home recorders) that is fed to the record head along with the audio signal to be recorded. The amplitude of the bias current is about 10 times that of the audio signal current. Using ac bias dramatically reduces distortion and increases the level of undistorted signal that can be recorded.

Unfortunately, however, the bias level that produces these beneficial effects varies with the frequency of the audio signal and with the tape speed involved: that is, it is related to the *wavelength* of the recorded signal. (At a tape speed of 15 inches per second, the length of each wave of a 15-kHz tone is 0.001 of an inch; at 1⅞ ips the wavelength of the same frequency is only ⅛ as great, i.e. 125 microinches). When bias level is excessive, short-wavelength (high-frequency) response declines rather precipitously, and low-frequency distortion actually begins to rise again.

To develop a picture of where and how compromises are going to have to be made, the type of curves most tape engineers would use are presented in Fig. 1. They show several parameters of tape performance plotted as functions of bias. The 0-dB reference for bias is the factory setting of the Nakamichi 582 for this specific tape (TDK MA, metal alloy). The 0-dB level on the vertical scale corresponds to the "Dolby level" of 200 nanoWebers/meter. The curves shown in Fig. 1 are labelled as follows:

(A) *Maximum Operating Level (MOL).* The maximum output the tape can deliver for a low-frequency tone (315 Hz) at a third-harmonic distortion level of 3%.

(B) *Saturation Level at 15 kHz.* The high-frequency complement of (A), but since the third harmonic, 45 kHz, lies beyond the passband of the deck, saturation is used as the reference level. Saturation is the level at which the tape output begins to decrease as the driving signal gets stronger.

(C,D,E) *Tape Sensitivity at 315, 6,300, and 15,000 Hz.* Measured at a low level (−20 dB re nominal VU) to ensure that high-frequency overload does not occur.

(F) *Low-frequency Third-harmonic Distortion.* Measured with a 315-Hz tone, with the tape recorded to a constant level of 200 nWb/m. The plot is customarily shown on a dB scale, where 10% = −20 dB, 1% = −40 dB, etc. As a convenience to those accustomed to thinking of distortion in percentages, these figures have been included at appropriate points.

(G) *Signal-to-noise Ratio.* S+N/N (A-weighted) for a 315-Hz tone recorded to a level where 3% third-harmonic distortion occurs. Actually the noise level does not itself change much, the variation has to do with the level of signal the tape can handle.

Now that we've assembled all of this data, what conclusions can we draw from it about "optimum" bias for this particular tape? Nakamichi, as I indicated, uses the "0 dB" bias level, that corresponds to the peak low-frequency MOL point, lowest distortion at 0 VU, and maximum signal-to-noise. Many authorities would determine optimum bias on an open-reel deck basically the same way. What makes that possible in the cassette is the fact that metal-alloy tape has more high-frequency storage capacity than conventional tape.

But the three sensitivity curves reveal a couple of anomalies. One is trivial and can be dismissed at the outset: At a 0-dB bias level, 6.3 and 15 kHz are about 1 dB high relative to 315 Hz. That will show up on an ordinary frequency-response plot, but it's hardly serious, and it's probably caused by a batch-to-batch variation between this particular cassette and the one used to set up the deck. (Also, by being just a tiny bit "hot" at 15 kHz, you make sure that you'll make it easily to the upper frequency limit—20 kHz—without too much strain.) To correct it (I wouldn't), you'd just back down the record equalization by a dB.

The second peculiarity concerns the 315-Hz sensitivity curve. If you pick maximum low-frequency sensitivity as the criterion for optimal bias, you'll end up using a lot less bias (−2.5 dB) than Nakamichi recommends for this tape on this deck. Now 0-VU distortion will rise a bit (to about 1.1%, or −40.6 dB) which, although not terribly serious in itself, puts you on the steeply descending portion of the distortion curve. This

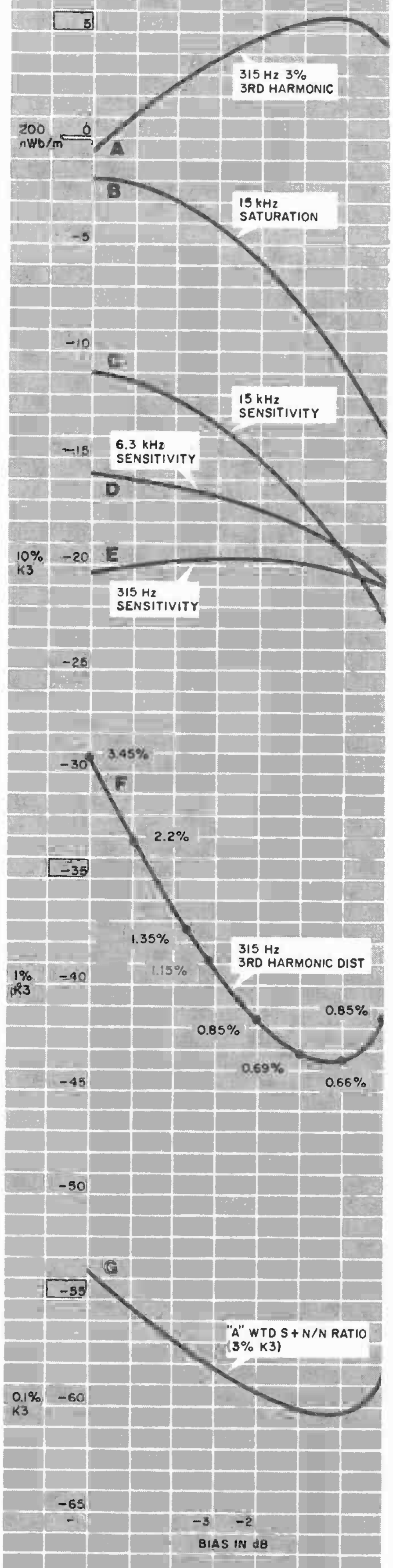


Fig. 1. Parameters (see text) of tape performance as functions of bias.

means that anything that makes the bias level fluctuate could affect distortion fairly markedly. Besides, you'll lose a couple of dB in low-frequency MOL (and, consequently, in signal-to-noise ratio). On the other hand, at this lower bias level, high-frequency saturation and sensitivity are improved by approximately 5 dB.

The Role of Record Equalization. Record equalization is the selective boosting of frequencies (principally in the treble range) before they are fed to the tape to compensate—in advance—for known losses that will occur in the record process. The specific record equalization curves used in the Nakamichi 582 for metal, high-bias, and ferric tapes are shown in Fig. 2. Looking at the metal curve we see that at 15 kHz the boost is approximately 13 dB. In conjunction with the 0-dB bias level, that degree of boost gives approximately flat frequency response with low-level signals, and a 15-kHz saturation level of −11 dB re 200 nWb/m (Fig. 1). If we selected a lower bias (−2.5 dB) the amount of this boost would have to be lowered by 5 dB. This shows why it is important to have adjustable record equalization as well as adjustable bias to maintain flat frequency response. At the same time, however, the high-frequency capacity of this tape would go up by 5 dB *and* the input signal would be subjected to 5 dB less equalization, further reducing the possibility of driving the tape into saturation. This is not to argue that the −2.5-dB bias level is a *better* choice for this tape than the level Nakamichi has chosen; it is only to show that there is a certain amount of room where reasonable men may differ.

When it comes to tapes that do not have the tremendous high-frequency potential of metal alloy—tapes, for example, where the 15-kHz sensitivity curve crosses over on the underbias side of the 315-Hz sensitivity peak—the choice is going to be much more painful. Then it will not be possible even to consider setting the bias for minimum distortion without raising the equalization requirements beyond all reason. Distortion, maximum low- and high-frequency output, and equalization all interact; and if you want to "optimize" bias for a given tape and deck, you have to know just how they interact.

Fortunately, finding out may be easier than you think. You have to go inside your recorder, but all the curves shown in Fig. 1 required only the attachment of a single test lead and a ground lead. The curves of Fig. 2 used the same test point and required only lifting one end of a jumper wire. So, if you can read a man-

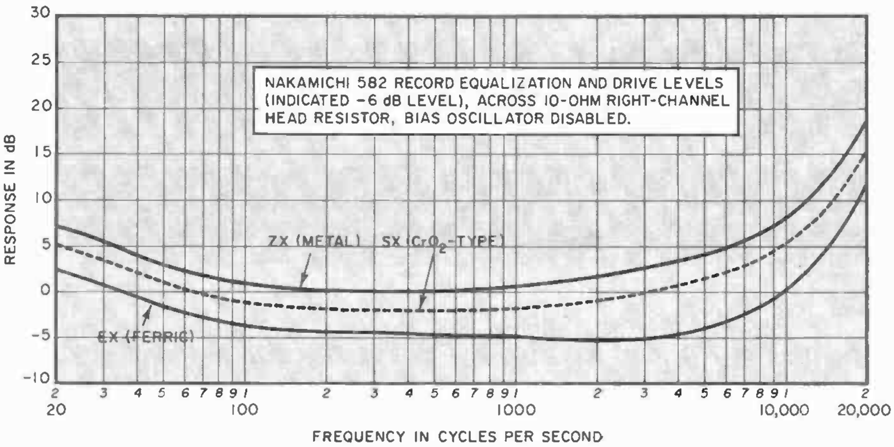


Fig. 2. Record equalization curves for Nakamichi 582 with three different tapes.

ufacturer's schematic—and *do* get one!—and have ordinary audio test equipment (sensitive ac voltmeter, audio generator, harmonic distortion meter, and a scope, the latter being handy, but not essential) you, too, can turn your deck into a tape-measuring system.

Inside the Deck. The reason it's likely to be so easy is simply that deck manufacturers must be able to set up their machines on a production-line basis, and so generally design into them just the facilities you'll need. It is assumed that you have a three-head deck. While it is *possible* to measure all the tape data I've presented in Fig. 1 with a 2-head deck, it would take a great deal of patience and time.

The time-honored method of specifying bias is as a current, so you can measure it by reading the voltage drop across a 10-ohm resistor inserted in the ground lead of the record head, as shown in Fig.3. Given the physical construction of most cassette decks, inserting such a resistor might prove difficult; fortunately, however, since the deck manufacturer has to measure bias himself, you'll almost always find a neat little pair of 10-ohm resistors—often with test-point terminals to clip a lead onto—built-in for you. For greatest accuracy in measuring bias level you'll want to turn down any audio signal (your audio generator simply goes into the line-level input of the deck, as you'd expect), though the level of normal audio signals is so low (about 1/10th) in comparison with bias that it will barely show up in a meter reading.

To measure record equalization you can use the same resistor (and a sensitive voltmeter or chart recorder), with the deck set to "source" and "record." But you need a way to turn *off* the bias oscillator, since its output would swamp out the readings. In the old tube days this was easy: pull out the oscillator tube! With modern transistorized recorders it could be more difficult; but, again, since the deck manufacturer has to be able to set up the record equalization, he generally makes it easy. The dc operating voltage for the bias oscillator is normally fed to the transistors through the center-tap of the oscillator transformer. (If it isn't on your deck, you'll have to find the feed point). This center-tap is generally connected to the dc supply via a jumper-wire on the underside of the pc board. Two seconds and a soldering iron are all you need to lift (and subsequently restore) this connection, just as the technician on the production line does.

If you wish, you can route the necessary monitoring and bias-killing facilities to front-panel jacks or—as I've done—via a short cable to a minibox. I recommend low-cap shielded cable for the connection across the resistors and using the original ground spot (the other end of the resistor) to prevent ground loops. When I made up my system, I used a pair of dpdt relays inside to ensure that unnecessary lengths of leads could be disconnected. I've since found that the measuring circuit doesn't seem to affect performance on this machine in any way. Details of my own setup are shown as part of Fig.3.

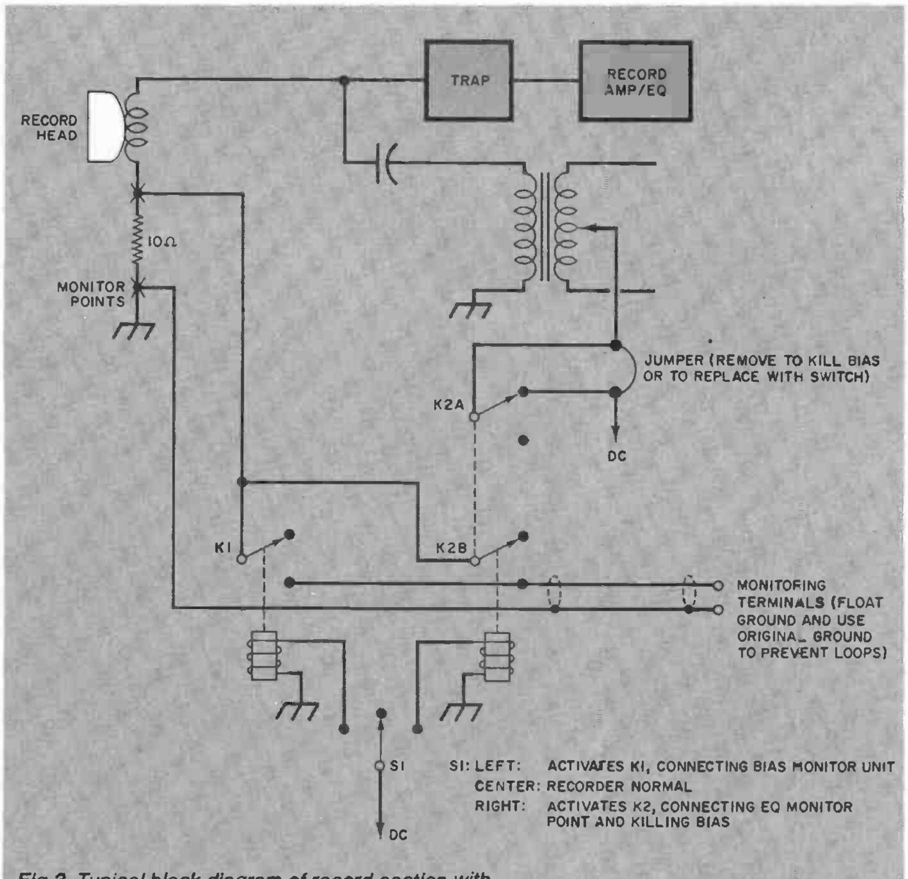


Fig 3. Typical block diagram of record section with connections for bias/EQ monitoring and bias kill.

In Conclusion. Is it all worth it? I think so, but then tape and tape measurements are both a passion and a business with me. In any case, I've shown you how and what to look for if you want to explore the multiple meanings of optimum bias for your recorder. ◇

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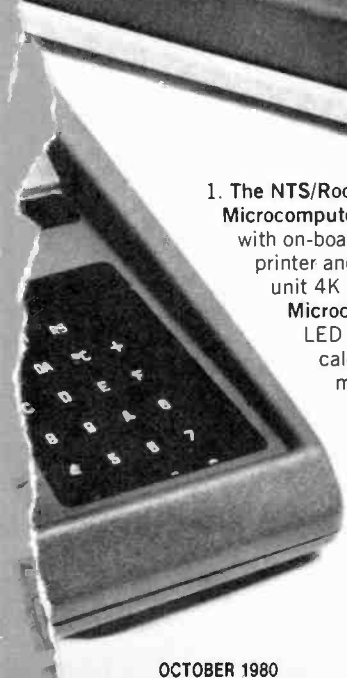

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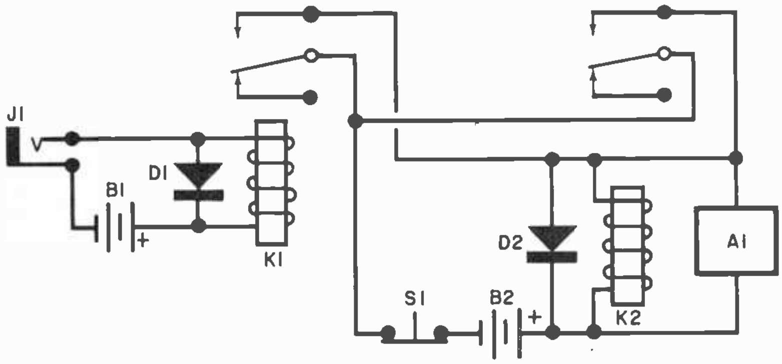
BY HOWARD BERENBON

TRS-80 CLOCK PROGRAM

```
100 CLS
110 PRINT CHR$(23)
120 PRINT "12/24 HR DIGITAL ALARM CLOCK:"
130 PRINT "STOPWATCH-PHONE CALL TIMER"
140 PRINT "COPYRIGHT (C) 1979 BY HOWARD BERENBON"
150 PRINT
160 PRINT "SELECT PROGRAM 1 OR 2"
170 PRINT
180 PRINT "ENTER '1' FOR CLOCK,  '2' FOR STOPWATCH"
200 INPUT A
210 IF A=1 THEN 470
220 IF A=2 THEN 1000
230 GOTO 160
240 CLS
250 PRINT CHR$(23)
470 PRINT "12/24 HR CLOCK"
480 INPUT "ENTER '1' FOR 12,  '2' FOR 24";A
490 IF A=1 THEN 1300
495 IF A=2 THEN 1340
500 GOTO 470
510 PRINT
520 INPUT "SET ALARM?  '1'-YES,  '2'-NO";W
530 IF W=1 THEN 560
540 IF W=2 THEN 570
550 GOTO 490
560 INPUT "ENTER ALARM TIME-(HR,MN)";H,M
565 GOTO 580
570 H=0:M=0
580 INPUT "ENTER TIME TO START-(HR,MN,SC)";Z,Y,X
590 CLS
600 PRINT CHR$(23)
610 PRINT TAB(05);T;" HR ALARM CLOCK"
620 PRINT:PRINT TAB(10);"ALARM SET: ";H;" : ";M
630 PRINT:PRINT @ 448,"HRS ";Z;" : MIN ";Y;" : SEC ";X,
640 GOSUB 800
650 X=X+1
660 IF X=60 THEN 700
670 GOTO 630
700 X=0
710 Y=Y+1
720 IF Y=60 THEN 850
730 IF (Y=M) * (Z=H) * (W=1) THEN 915
740 GOTO 630
800 FOR A=1 TO 330
810 NEXT A
820 RETURN
850 Y=0
860 Z=Z+1
870 IF Z=T+1 THEN 900
880 IF Z=1000 THEN 1060
890 GOTO 630
900 Z=1
910 GOTO 630
915 X=0:GOSUB 1400
920 PRINT:PRINT "ALARM ACTIVATED"
925 X=4
930 PRINT #-1,A
940 GOTO 590
1000 CLS
1010 PRINT CHR$(23)
1020 PRINT "STOPWATCH-PHONE TIMER"
1030 INPUT "ENTER A '1' TO START";A
1040 CLS
1045 PRINT CHR$(23)
1050 PRINT:PRINT "PRESS 'BREAK' TO STOP TIMER"
1060 W=0:T=1000
1070 X=0:Y=0:Z=0
1080 GOTO 630
1300 T=12
1310 GOTO 510
1340 T=24
1350 GOTO 510
1400 PRINT @ 448,"HRS ";Z;" : MIN ";Y;" : SEC ";X,
1410 RETURN
```



The simple, two-relay circuit shown here can be wired through J1 to the computer's cassette interface. The alarm can be deactivated by pressing pushbutton switch S1.

PARTS LISTS

A1—6-volt alarm (Sonalert or similar)
B1—9-volt battery and holder
B2—6-volt lantern battery and holder
D1,D2—1N914 or similar silicon diode
J1—Subminiature phone jack
K1,K2—6-volt dc relay, 500-ohm coil (Radio Shack No. 275-004 or similar)
S1—Normally closed spst pushbutton switch
Misc.—Perforated board, suitable enclosure, interconnecting cable, machine hardware, hook-up wire, solder, etc.

Note: The program is available on cassette for $4.95 postpaid from Software Exchange, 2681 Peterboro, W. Bloomfield, MI 48033.

The 12/24-hour alarm-clock program written in Level II Basic is given in the table and the circuit in the diagram.

The Program. The program begins by asking whether you want the clock (1) or stopwatch (2). If you use the clock program, you can request either 12- or 24-hour operation. If desired, the alarm setting can be requested and you can enter hours and minutes. Finally, the program requests starting time in hours, minutes, and seconds. The program responds by displaying setting of the alarm and time.

When displayed time corresponds to alarm setting, the alarm circuit is activated. The alarm can be deactivated by pressing normally closed pushbutton switch *S1*. To use the timer mode, enter a 1 (and carriage return to start timing) when the program begins. When the event being timed is complete, press the BREAK key on the TRS-80 to stop the timer.

The Hardware. The simple two-relay circuit can be built on a perforated board and wired to the TRS-80's cassette interface. Alarm *A1* can be a buzzer or Sonalert. ◇

ADD A "KEY-DOWN" AUDIBLE SIGNAL TO YOUR COMPUTER KEYBOARD

BY ROY AUER, Jr.

Simple circuit provides audible confirmation that a key has been struck properly

THE action of some modern computer keyboards is extremely "light." As a result, even an attentive user may press a key but not cause generation of the desired character. Presented here is a simple circuit that produces a brief audible tone every time a key contact is actuated and a character is generated. It gives the user audible reassurance that the selected key has been properly pressed, and thus improves his efficiency. The circuit can be assembled on a compact circuit board and tucked into a small, free space inside the keyboard enclosure. Its modest power requirement can be easily satisfied by the host keyboard's power supply.

About the Circuit. The tone generator is shown schematically in the Figure. It employs the two timer circuits contained in the readily available NE556 dual timer chip. One section is used as a monostable multivibrator, the other as an astable multivibrator.

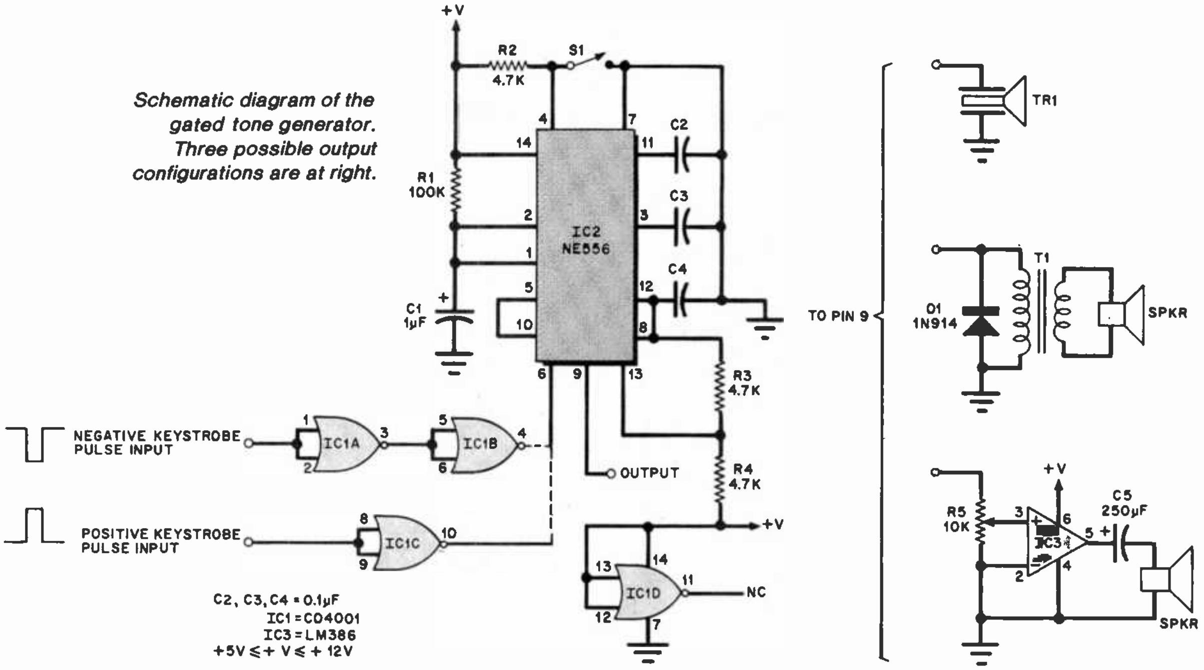
The monostable generates a 100-millisecond pulse upon the receipt of a "keystrobe" pulse from the keyboard. Such a pulse is generated every time a key contact is actuated and the corresponding character is generated. Duration of the monostable multivibrator's output pulse, which appears at pin 5, is determined by the values of *R1* and *C1*. When pin 5 switches from ground potential to +V, the astable multivibrator begins to oscillate and produces an audio-frequency pulse train at pin 9. The frequency of the pulse train is determined by the values of *R3*, *R4*, and *C4*, and the duty cycle by the relative values of *R3* and *R4*. For the values specified, the frequency of the pulse train is about 1 kHz with 67% duty cycle.

Note that three CMOS NOR gates are employed in the circuit. Actually, either *IC1A* and *IC1B* or *IC1C* will be used. If the keyboard with which the circuit will be used generates a positive keystrobe pulse, *IC1C* must be employed to invert it into the negative pulse that the monostable multivibrator requires for triggering. In that case, pins 8 and 9 of *IC1C* should be connected to the keyboard's keystrobe pulse line and pin 10 of *IC1C* to pin 6 of *IC2*. Pins 1 and 2 of *IC1A* should be connected to either +V or ground and pin 4 of *IC1B* should be left unconnected.

If the keyboard generates a negative keystrobe pulse, no inversion is necessary. In this case, however, *IC1A* and *IC1B* should be used as a noninverting buffer between the keystrobe pulse line and the trigger input of the monostable multivibrator. Pins 1 and 2 of *IC1A* should be connected to the keystrobe pulse line, pin 4 of *IC1B* to pin 6 of *IC2*, pins 8 and 9 of *IC1C* to either +V or ground, and pin 10 of *IC1C* should be left unconnected.

Three possible output configurations are shown in the Figure. At the top is a high-impedance crystal transducer. This transducer (*TR1*) can be driven directly by the circuit and can be either a conventional crystal earphone or one of the recently developed piezoelectric "wafer"

Schematic diagram of the gated tone generator. Three possible output configurations are at right.



PARTS LIST

C1—1-µF, 25-volt electrolytic
C2, C3, C4—0.1-µF disc ceramic capacitor
C5—250-µF, 25-volt electrolytic
D1*—1N914 signal diode
IC1—CD4001 quad NOR gate
IC2—NE556 dual timer
IC3*—LM386 audio amplifier

The following, unless otherwise specified, are 1/4-watt, 10% tolerance fixed carbon-composition resistors.
R1—100 kΩ
R2, R3, R4—4.7 kΩ
R5—10-kΩ logarithmic-taper trimmer potentiometer
S1—Spst switch

SPKR*—8-Ω dynamic speaker
T1*—10-kΩ to 8-Ω audio transformer
TR1*—High-impedance crystal transducer
Misc.—Printed circuit or perforated board, IC sockets or Molex Soldercons, suitable power source and enclosure, hookup wire, solder, hardware, etc.
*—Optional; see text.

transducers. If an earphone with a screw-in earplug is employed, best results will be obtained with the earplug removed. The author reports that a suitable crystal earphone can generate sound levels audible at distances of up to ten feet.

The middle alternative is to have the circuit drive a low-impedance dynamic loudspeaker. Here, a small audio output transformer (*T1*) couples the output of the astable multivibrator to the speaker. Diode *D1* protects the astable multivibrator's output transistor from inductive spikes that can appear across the transformer primary.

The output configuration appearing at the lower right can provide a considerable sound pressure level. The output signal at pin 9 of *IC2* is applied to potentiometer *R5*, which functions as a level control. Audio amplifier chip *IC3* boosts the signal present at its noninverting input and drives a low-impedance dynamic loudspeaker via coupling capacitor *C5*. As shown, *IC3* has a voltage gain of 20. This is adequate for most applications but can be increased to 200 by connecting a 10-µF electrolytic capacitor between pins 1 and 8 of *IC3*. The IC can be powered from the same source as the rest of the circuit because its current demand is modest.

Toggle switch *S1* controls the action of the monostable timer section of *IC2*. When the switch is open, the positive supply voltage is applied to the monostable multivibrator's RESET input (pin 4). This allows the timer to function normally. However, when the switch is closed, the monostable's RESET input is grounded and that timer's output (pin 5) is frozen at ground potential. When this happens, the astable multivibrator is disabled and no tone can be produced. Therefore, if the user does not want a tone to be generated each time a key contact is actuated, *S1* should be closed.

Construction. Because the project is relatively simple, it can be assembled on a small perforated or printed-circuit board. The use of IC sockets or Molex Soldercons is recommended. Be sure to observe the polarities of power supply leads, semiconductors, and electrolytic capacitors. Employ the minimum amount of heat and solder consistent with the formation of good solder joints. The project can be connected to the keyboard by suitable lengths of insulated, stranded hookup wire. If space permits, the project can be mounted inside the keyboard enclosure. Alternatively, it can be installed in a small enclosure of its own.

In Conclusion. Auditory confirmation of a proper key-contact actuation can speed and simplify the use of an ASCII or similar keyboard. The circuit that has been presented here will provide such confirmation and make the time spent at a keyboard more productive and enjoyable. If desired, the values of the resistors and capacitors associated with the two timer sections of *IC2* can be changed to suit the taste of an individual user. Increasing the time constant of *R1C1* will result in a longer "beep." Decreasing it will shorten the time that the astable multivibrator oscillates. The frequency and duty cycle of the audio output can be modified by appropriate changes in the values of *R3*, *R4*, and *C4*. Consult a 556 data sheet for the appropriate design equations. ◇

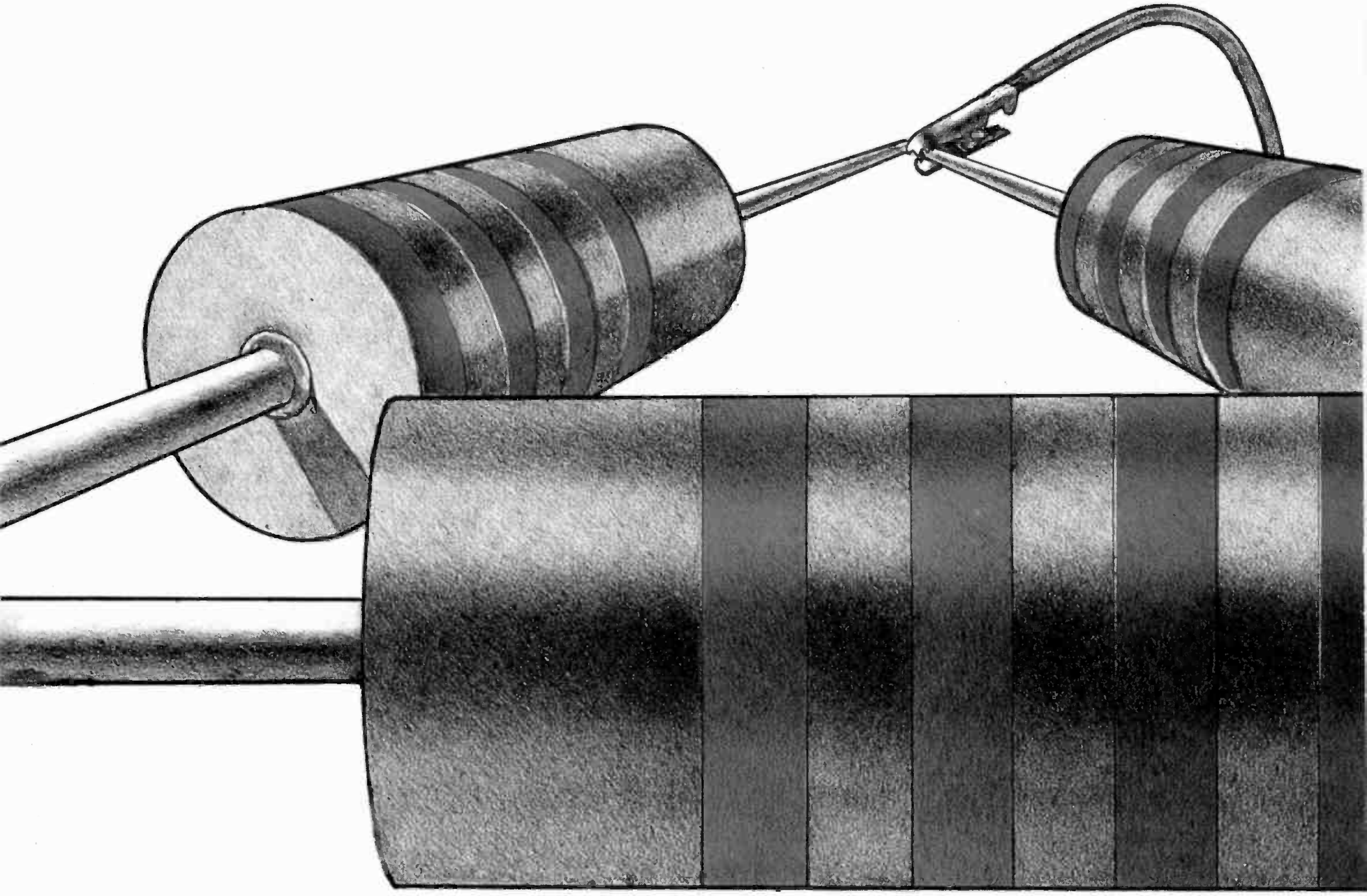
BY FRANK WITNER AND DIANE JASINSKI

Save time and avoid possible circuit damage with little-known techniques of component testing.

ACCURATE WAYS TO MEASURE IN-CIRCUIT RESISTANCES

IN-CIRCUIT measurement of a resistance offers several advantages compared to the alternative method of unsoldering one lead of the component to be measured. For example, it saves time and does not pose the risk of damage to printed-circuit boards and the components mounted on them. Presented in this article are techniques that provide accurate in-circuit resistance measurements. These are not to be confused with the use of so-called "low-power" ohmmeters that measure in-circuit resistance if the only shunting components are semiconductors. Rather, these techniques give accurate in-circuit resistance measurements even if the component to be measured is shunted by other resistors!

Measurement Basics. If an ohmmeter is used to measure the resistance of a component wired in a circuit, an inaccurate result will be obtained if there is any resistance in parallel with the resistance to be measured. Obviously, the parallel resistance causes a decrease in the overall resistance. The amount of error depends upon the ratio of the shunting circuit resistance to the



value of the resistance to be measured. It is shown graphically in Fig. 1.

Seldom is a resistor in a given circuit placed directly in parallel with another resistor. Rather, any resistors connected to either side of it usually run to other circuit nodes. The delta-network model of a typical circuit shown in Fig. 2 reflects this. The resistor whose value is to be determined is designated *R1*, and the shunting circuit paths are embodied in *R2* and *R3*.

The node at the junction of *R2* and *R3* makes it possible to electrically isolate the resistor to be measured without physically disconnecting one end of it. This is accomplished by placing each end of part of the shunt path at the same voltage. Because there is no voltage drop across part of the shunt path, the entire shunt path behaves like an open circuit and will not affect an in-circuit resistance measurement of the component under test. This technique can be used even in a complex circuit because any number of shunt paths can be reduced to an equivalent of a single path by connecting together their junction points (homologous to the node *R2R3*).

There are several circuits, most of them designed around the operational amplifier, that can perform the required isolating function. Two of the qualities of the ideal operational amplifier make it well suited for this application. Firstly, no current flows into either the inverting or noninverting input terminals. Secondly, in a noninverting amplifier with 100% feedback, there is no voltage difference between the inverting and noninverting inputs. These statements are true of ideal, not practical, operational amplifiers. However, contemporary practical op amps can, within certain limits, offer levels of performance closely approaching those of ideal amplifiers. The differences are then slight enough that they can be ignored.

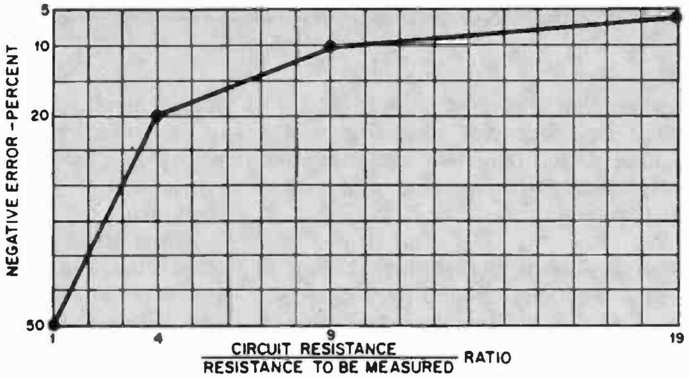


Fig. 1 Graphical analysis of the error in a resistance measurement caused by uncompensated shunting circuit resistances.

The Voltage Follower shown in Fig. 3 can electrically isolate the resistance to be measured from the shunting circuit resistances in the following manner. This stage has unity voltage gain and sets up at its output terminal the same voltage that appears at its noninverting input. When the ohmmeter is connected to the delta network as shown, a positive voltage appears at the HIGH TERMINAL and the follower's noninverting input. The follower then sources current into *R2* so that the node *R2R3* is at the same voltage as the HIGH TERMINAL. Therefore, no voltage drop appears across *R3*, and effectively no resistance is in parallel with *R1*, the component whose resistance is to be measured. This isolation causes the ohmmeter to provide an accurate resistance reading.

Two factors determine how much current the follower must source through *R2*—the measuring potential impressed across the network by the ohmmeter and the value of the shunt resistance driven by the follower (in this case, *R2*). If the voltage impressed across the network by the ohmmeter is too high, the necessary current level might exceed the maximum amount of current the follower can safely provide or the heat generated by the driven shunt resistance might exceed the component's dissipation capability.

Reversing the follower leads might prove helpful if either of the problems just mentioned is expected to be encountered. This will cause the follower to source current into the other shunt element (*R3*), which might have a higher resistance. The best solution, however, is to use an ohmmeter that employs a low measuring potential. A moment's reflection on the familiar equation $P = E^2/R$

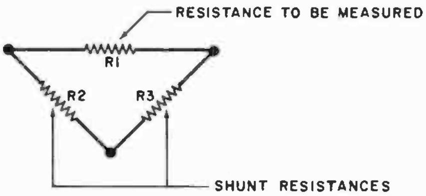
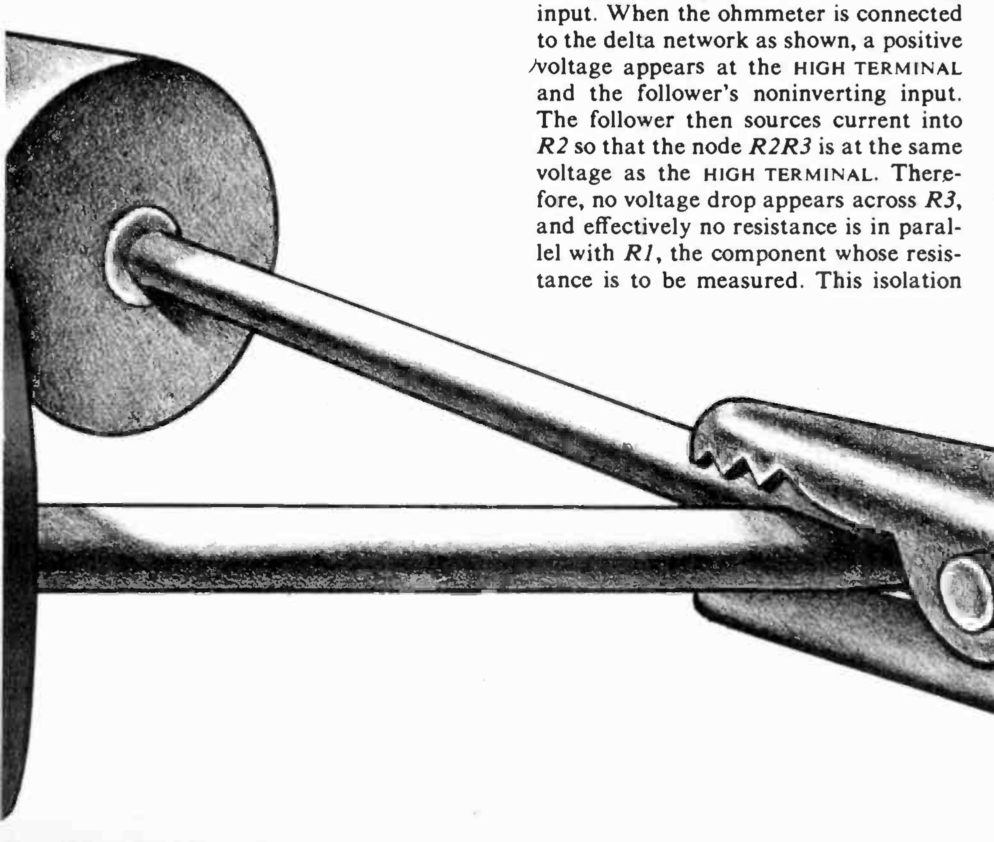


Fig. 2. Generalized model of a circuit containing a resistance to be measured and shunting components.



reveals that the power dissipated by a resistance decreases according to the square of the reduction in voltage but only linearly to an increase in the resistance value.

The Inverting Amplifier shown in Fig. 4 is another op-amp circuit that can be used for in-circuit resistance meas-

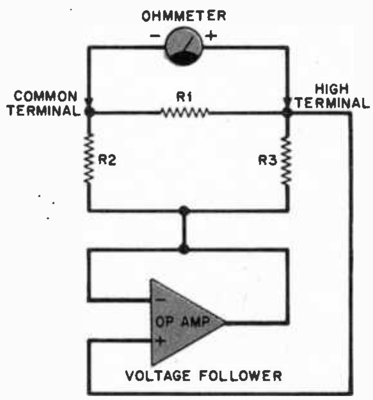


Fig. 3. Here, the voltage follower prevents shunting components from influencing theohmmeter reading.

urement. One well-known property of the inverting amplifier is that its voltage gain equals the ratio of the feedback resistance to the input resistance. In the in-circuit measurement application shown in Fig. 4, the component whose resistance is to be determined (*R1*) functions as the feedback resistance. Resistor *R4* behaves as the stage's input resistance. If the input resistance is a stable, known value, the op amp's output voltage is proportional to the feedback resistance.

The inverting op amp can be used to measure an in-circuit resistance if the junction of the two shunt components (the node *R2R3*) is connected to ground. A constant-current source drives the input resistance, and the op amp sources current into *R3* so that the same voltage appears across it as appears across *R1*, the resistance to be measured. Because of the feedback provided by *R1*, the HIGH TERMINAL is forced to virtually ground potential. Therefore, no voltage difference appears across shunt component *R2*, and the desired isolation of *R1* is achieved.

If the amplitude of the driving constant-current source is accurately known, the voltmeter reading can be converted to a resistance measurement by simple arithmetic. Alternatively, if an analog meter is used along with a constant-current source of known output, the meter's scale can be redrawn so that it reads directly in ohms. For resistance measurements over a wide range, it will probably be necessary to employ several meter scales and either a number of current sources with different output ratings or a single current source whose output can be varied in fixed, accurate increments.

Miller-effect analysis of this circuit reveals that resistances are reflected between the HIGH TERMINAL and ground and between the LOW TERMINAL and ground. These reflected resistances parallel shunt components *R2* and *R3* such that *R2* is in parallel with a resistance equivalent to $R1/(1-(1/A))$ and *R3* is in parallel with a resistance equivalent to $R1/(1-A)$, where A is the voltage gain of the stage. The effective resistances of the shunt paths thus depend upon both the value of the component to be measured and the values of the shunt components—not upon the values of the shunt components alone. Because of the Miller effect, in a practical circuit, the operational amplifier can work with a lower value of shunt resistance between the LOW TERMINAL and ground than between the HIGH TERMINAL and ground.

Another inverting op-amp circuit that can be used for in-circuit resistance measurement appears in Fig. 5. Here, the resistance to be measured (*R1*) functions as the stage's input resistance and a constant-voltage source drives the network. The output voltage generated by the op amp is *inversely* proportional to the value of the component to be measured, and is monitored by a voltmeter placed across the feedback resistor. As was the case in the previous circuit, feedback forces the HIGH TERMINAL to virtually ground potential. No voltage drop exists across *R2*, so the desired isolation of *R1* is achieved. Shunt component *R3* has no effect on the resistance measurement because it is connected directly across the constant-voltage source.

There are advantages that this inverting op-amp circuit has over the one previously presented. For example, the possibility exists in the constant-current case that the driven shunt resistance will be called upon to dissipate more heat than it is rated to do. This tends to be less of a problem when the constant-voltage circuit is employed. Also, the constant-voltage measuring circuit provides a faster response time when the resistance to be measured is shunted by one or more capacitors. The reason for this is simple. When a constant-current source is connected to a capacitive circuit, the voltage across the capacitor increases linearly to its maximum value. However, when a constant-voltage source is connected to an uncharged capacitor, the voltage across the capacitor increases exponentially until the capacitor is fully charged. This causes the capacitor to attain its ultimate voltage considerably faster than is the case when a constant-current source charges it, and allows for much shorter settling times during in-circuit resistance tests.

Bridge Measurements. A form of the classic Wagner bridge that can be used for in-circuit resistance measurements appears in Fig. 6. It can be thought of as two resistive bridges sharing common elements *R7* and *R1*, which is the component whose value is to be measured. As was the case in the circuits presented earlier, *R2* and *R3* are the in-circuit shunting components. Shunt resistor *R3* is placed across the null meter when *S1* is switched to its WAGNER position. This reduces the sensitivity of the null indicator for the Wagner adjustment but does not affect the balance of either bridge. Successive balancing of the bridge by means of potentiometers *R4* and *R6* (with *S1* switched alternately to each of its positions) results in no voltage drop across *R3*, the nondriven shunt resistance.

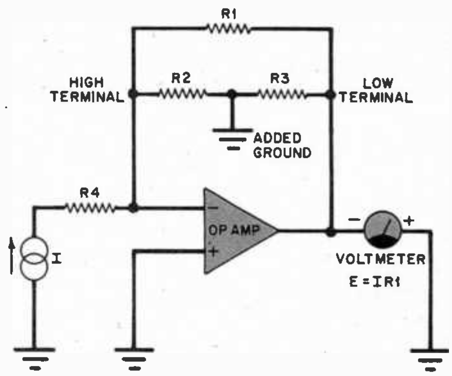


Fig. 4. An inverting op-amp circuit that can be used for in-circuit resistance measurements.

Measurement of the unknown value of *R1* now depends on the balancing out of shunt resistance *R3* such that the following relationship holds true:

$R1/R7 = R2/R4 = R5/R6.$

Note that this statement includes the standard balance equation of a four-arm resistive bridge.

An alternative bridge configuration has the side of potentiometer *R4* that was formerly connected to the node *R6R7B1*- shifted to the node *R5R6S1*. In effect, this is the same as interchanging the battery and the null detector in the bridge of Fig. 6. Measurement of *R1* now depends on the balancing out of shunt resistance *R2* so that:

$R1/R5 = R3/R4 = R7/R6.$

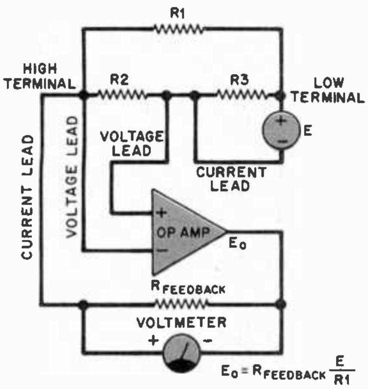


Fig. 5. Another inverting op-amp circuit where unknown resistance forms amplifier's input resistor.

In this latter configuration, a voltage drop will appear across each shunt resistor when the bridge is balanced.

Practical Tips. A number of in-circuit measurement techniques have been presented in this article. However, there are several practical effects that should be considered before these techniques are implemented. These will now be summarized.

Thermoelectric voltages can be set up at the junctions of dissimilar conductors, as well as between points on the same conductor across which a thermal gradient exists. Although they are very small for ordinary working temperatures and materials commonly fabricated into probes and leads, these voltages can cause significant error if they are amplified as part of the measuring process. They can also be troublesome if the test potential of the ohmmeter is kept low to prevent semiconductor junctions from becoming forward-biased and influencing the reading. This type of error can be reduced by certain design techniques or by determining its magnitude and then subtracting it from the overall reading. The latter technique is commonly employed in precision, computerized procedures that are used to measure resistance.

If the measured resistance is of low value, test-lead resistance can be a source of significant error. The standard remedy for this is to use separate current-carrying and voltage-measuring leads. This avoids measurement of the IR drop in each current-carrying lead and is known as the *Kelvin* technique.

The in-circuit measurement techniques that have been presented can also eliminate the effects of semiconductors upon the resistance reading. However, any semiconductor present in the circuit might be called upon to dissipate power if it is part of the driven shunt path. Two practices are advised if this is the case. In a constant-voltage circuit, employ a measuring voltage that is less than the conduction threshold of the pn junction. In a constant-current circuit, reverse the polarity of the meter probes. These steps will effectively turn the semiconductor junction into an open circuit for the purposes of the resistance measurement and eliminate a source of potential error.

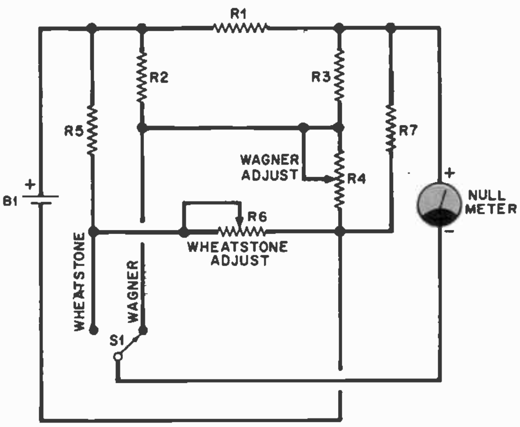


Fig. 6. A Wagner bridge circuit such as that shown here can be used to measure resistance of an in-circuit component.

In measuring circuits containing an operational amplifier, certain precautions should be observed. It is wise to install 0.01-μF disc ceramic bypass capacitors close to the IC package from the positive and negative power-supply leads to ground. This will enhance circuit stability. Input overvoltage and output short-circuit protection must also be considered. Many contemporary op amps, such as the Motorola MC1456, provide such protection internally. In those measurement situations which call upon the op amp to source more current into the driven shunt resistance than is available from the op amp, a current booster such as the Motorola MC1438R can be employed. Details on the use of the latter chip can be found in the manufacturer's *Applications Handbook* and its *Linear Circuits Manual.* ◇

Solid-State Developments

By Forrest M. Mims

Do-It-Yourself Logic Chips

IN THIS day of ultra-sophisticated semiconductor technology, large-scale and very-large-scale integrated circuits (LSI and VLSI respectively) containing hundreds or even thousands of logic gates have become commonplace. Nevertheless, examine any board containing one or more LSI or VLSI chips and you'll probably find an assortment of small- and medium-scale integrated circuits (SSI and MSI) with relatively few gates or flip-flops package.

Circuit designers have long wanted to combine in a few packages the relatively small number of gates and flip-flops required to support most LSI and VLSI chips. Custom ICs are usually out of the question because of their high price and long development time. And what happens if a design change is necessary?

Semi-custom integrated circuits are a better choice. These chips contain arrays of gates which have not been *metalized*. In other words, the gates are independent of one another since they've not yet been connected together electrically by a metalization pattern on the top surface of the chip. The customer tells the custom IC house how he wants the gates interconnected, and the gate chips are then metalized according to the customer's specifications and installed in DIPs.

This procedure is faster and cheaper than the custom IC route, but it's still relatively expensive since the customer usually must agree to buy a thousand or more chips. And as in the case of the custom IC, what happens if a design change is necessary?

A third alternative is the do-it-yourself logic chip. Included in this category are *field programmable logic array* (FPLA) and *programmable array logic* (PAL, a trademark of Monolithic Memories, Inc.) chips. These chips contain arrays of logic gates interconnected via the same kind of fusible links used to make programmable read-only memories (PROMs). By selectively applying high-current pulses to the programming pins of an FPLA or PAL, fusible links can be opened in various patterns to produce a customized integrated circuit.

The PROM is itself a versatile do-it-yourself logic chip since it can be used to implement any truth table for which it has sufficient inputs and outputs.

You can better understand the operation and compare the differences of PROMs, FPLAs and PALs be referring to Figs. 1, 2 and 3. They show the internal circuitry of ultra-simple, hypotheti-

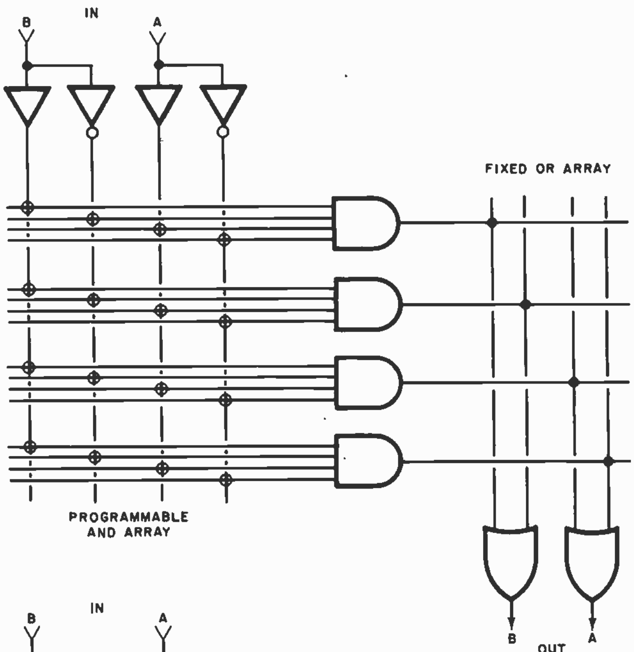


Fig. 2. A hypothetical PAL of two four-bit words. It is a backward PROM since the AND array is programmable while the OR is fixed.

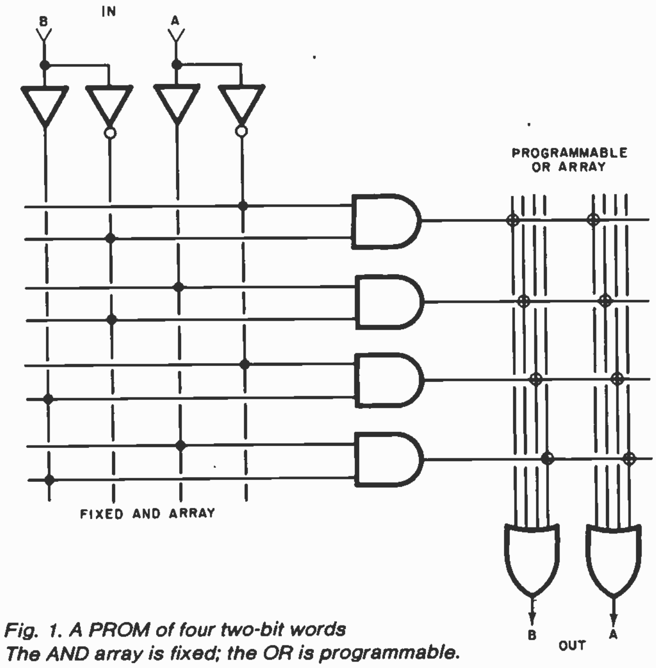


Fig. 1. A PROM of four two-bit words The AND array is fixed; the OR is programmable.

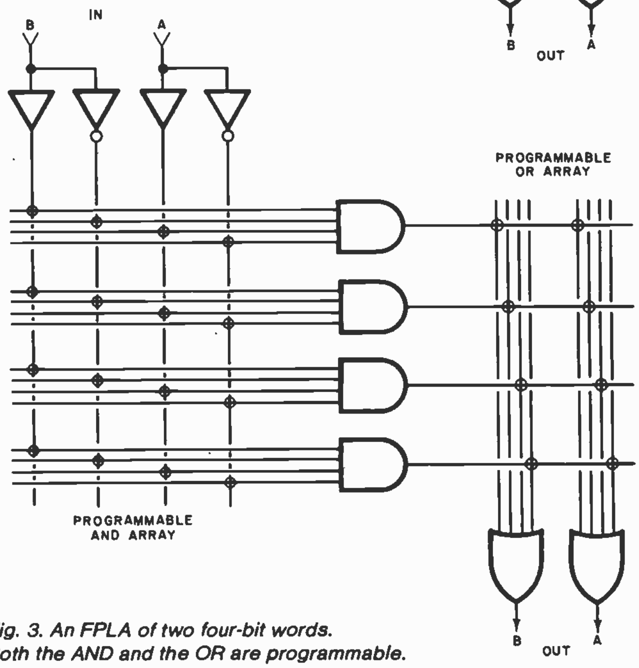


Fig. 3. An FPLA of two four-bit words. Both the AND and the OR are programmable.

cal versions of each of these three kinds of programmable logic arrays.

As is readily apparent from these figures, all three circuits contain an AND array followed by an OR array. The input word applied to the AND array can be considered an address, data word or bit pattern. In any case, the effect is the same since a particular input switches the output of one of the AND gates from low to high. The outputs then reflect whether or not connections are present at the junction of the output line from a selected AND gate and thc input lines to the OR gates.

A solid dot at the intersection of two array lines means the connection was unalterably programmed when the chip was made. User programmable fusible links are indicated by small circles at intersection array lines.

In the PROM (Fig. 1), the AND array is permanently programmed or *fixed* while the OR array is programmable. The AND array in Fig. 1 is programmed to address in turn each of the AND gates from top to bottom according to a standard 00, 01, 10, 11 input sequence.

The PAL (Fig. 2) is a backward PROM since the AND array is programmable while the OR array is fixed. In real PALs the OR array is factory programmed to give some of the most commonly used logic functions.

The FPLA (Fig. 3) is the ultimate do-it-yourself logic chip since *both* the AND and OR arrays are programmable. While this provides the highest

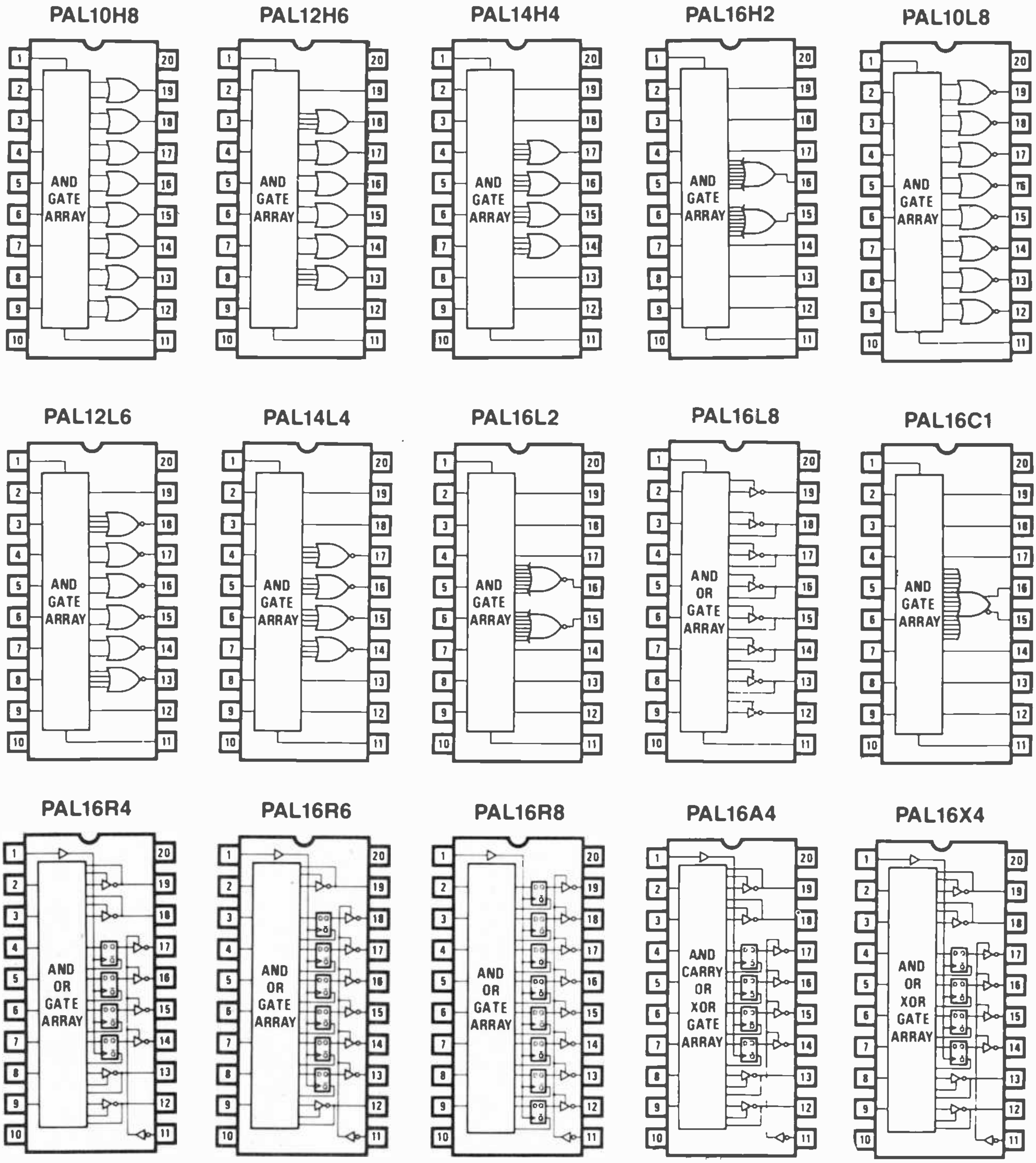


Fig. 4. Pin outlines and internal block diagrams of the PAL family of chips.

degree of flexibility, in practice the FPLA is much more dificult to use and more expensive than either the PROM or the PAL. All three kinds of chips can be programmed using standard PROM programmers, but the programming procedure for the FPLA is at least twice as cumbersome since both the AND and OR arrays must be programmed.

Fig. 5. Alphanumeric liquid-crystal displays from Epson America, Inc.

Some PALs and FPLAs include flip-flops to store output states and feed results back to the inputs. This makes possible such functions as counting, shifting and sequencing.

PALs without flip-flops can perform virtually any task now accomplished with SSI and MSI logic chips up to and including a 4-bit arithmetic logic unit! In many applications a single PAL can replace up to ten SSI/MSI packages.

A clever feature of PAL chips is a data security fuse. After the PAL has been programmed, the security fuse is blown to disable the circuit's internal verification logic. This prevents the internal program from being read out by a potential copier, thereby making the chip proprietary.

The PAL concept was pioneered by John Birkner of Monolithic Memories, Inc., and that firm now makes a family of fifteen PAL chips with National Semiconductor as a second source. Figure 4 shows the pin outlines and internal block diagrams for all fifteen chips. As you can see, considerable flexibility is provided by this lineup.

Information about PALs and FPLAs is not too abundant. The best way to learn more about PALs is to contact a Monolithic Memories or National distributor or representative. Try to obtain a copy of the excellent "PAL Programmable Array Logic Handbook" published by Monolithic Memories (1165 E. Arques, Sunnyvale, CA 94086).

Signetics (P.O. Box 9052, Sunnyvale, CA 94086) is a major maker of FPLAs. Their "Bipolar and MOS Memory Data Manual" contains FPLA data sheets and related information. Two Signetics engineers, Napoleone Cavlan and Stephen J. Durham, have written an excellent two-part article of the subject for *Electronics* (July 5, 1979, pp. 109-114 and July 19, 1979, pp. 132-139). In an article for *Computer Design* (April 1980, pp. 141-147), Mr. Durham described a complete 60-character keyboard encoder complete with key debouncing and made from a *single* Signetics 82S105 FPLA!

You can find the aforementioned articles in any good public or university library. For manufacturer's literature, check the yellow pages and call local electronics distributors or reps. If they can't help you, ask for the phone number of an authorized rep in any nearby city or state. If necessary, call the company direct. The cost of a few long distance calls may be well worth the results you'll harvest.

Do-it-yourself logic chips require careful design procedure and a PROM programmer so they're not necessarily suited for the typical hobbyist or experimenter. But if you want to greatly simplify a favorite logic circuit while learning about one of the latest trends in digital circuit design, get your hands on some manufacturer's literature and warm up your PROM zapper.

Component News. In a packet of recently received specification sheets for new National ICs was one which immediately attracted my attention. The new chip is the LH0082 Optical Communication Receiver. It's housed in a 14-pin metal DIP and includes a fast FET-input amplifier, output comparator with hysteresis (to prevent output oscillations near the reception threshold) and the feedback and coupling resistors and capacitors necessary for a complete receiver. With a suitable photodiode connected to its input, the LH0082 can receive 20-MHz analog signals sent via lightwaves through free space or by way of an optical fiber.

The new chip is housed in a metal DIP to reduce stray noise pickup and to

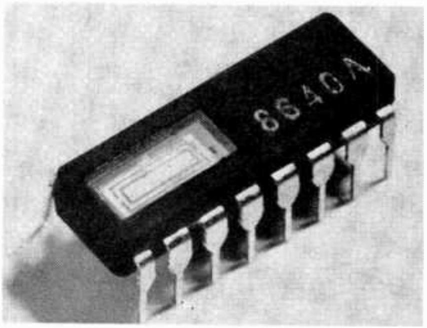


Fig. 6. Epson's programmable clock-pulse generator contains a quartz crystal oscillator.

provide a hermetic seal. That means it will be more expensive than ICs packaged in plastic. If the price is reasonable, I'll try to describe this chip in more detail in a future article.

News From Japan. Have you heard of Seiko watches? Seikos are made by Suwa Seiko Industrial Group in Nagano, Japan. Shinshu Seiki Co., Ltd., a member of the Suwa Seiko Industrial Group, makes a variety of interesting integrated circuits and liquid crystal displays and sells them in the United States through Epson America, Inc. (23844 Hawthorne Blvd., Torrance, CA 90505).

Figure 5 will give you an idea of the level of sophistication attained by the Shinshu Seiki Co. The dot-matrix alphanumeric liquid-crystal displays shown in the photograph include integral CMOS control and drive circuitry and are microprocessor compatible. The smallest display features a single 16-character line. The largest features two 32-character lines.

Shinshu Seiki also makes the 7910 melody IC, a 16-pin DIP that can play two 128-note tunes and sound an alarm and doorbell chimes. The chip is available with any two of ten preprogrammed tunes scored by the manufacturer or tunes specified by the customer.

Still another Shinshu Seiki chip you should know about is the 8640 series of CMOS clock-pulse generators. These novel chips are packaged in 16-pin DIPs (Fig. 6) complete with a self-contained quartz-crystal oscillator!

Custom versions of the 8640 can be supplied with an oscillator frequency ranging from 500 kHz to 1 MHz. Standard frequencies are 600 kHz, 768 kHz and 1 MHz. From these standard oscillator frequencies, 64 separate output frequencies can be obtained by means of six program pins connected to the chip's internal divider string. A nonprogrammable version, the 8640P, has fixed outputs of 50 and 60 Hz only. Cost is $8.00 each in single quantities.

I've described these new Japanese products to illustrate the level of sophistication attained by a company practically unknown to most electronics engineers, technicians and hobbyists. If you keep up with what's happening in electronics, you already know how far Japanese semiconductor technology has come in recent years. Now the Japanese show the beginnings of a challenge to the dominance by U.S. semiconductor firms of the microprocessor and memory chip market.

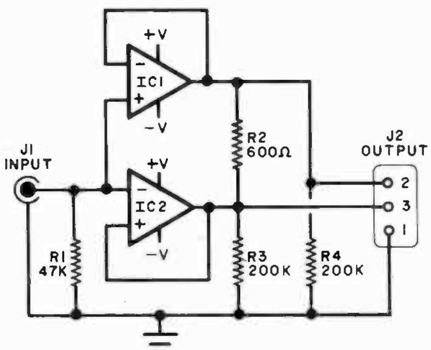
While the role of the United States as the world's leader in semiconductor technology is being eroded by technological advances in Japan and Western Europe, there's a positive side to this increased competition. Companies in the United States are already meeting the foreign challenge with newer and more creative designs of their own, and the 1980s will surely be an exciting decade in the history of electronics. ◇

Hobby Scene Q&A

By John McVeigh, Technical Editor

Hi-Z/Low-Z Balun

Q. *I noted your answer to Doug Hulstine's question in the February 1980 issue concerning a solid-state substitute for low-impedance balanced to high-impedance unbalanced transformers. How about a little help for those of us who want to go the other way? Do you have a simple, inexpensive method of matching the unbalanced output of a tape deck, microphone, or similar signal source to the input of a balanced system?—S. A. Newsom, Alpine, TX.*



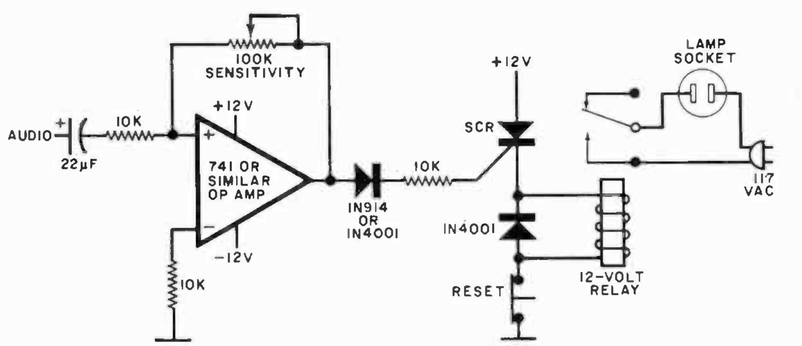
A. The circuit shown in the figure should work well for you. Two op amps functioning as voltage followers are employed. One follower (*IC1*) delivers a noninverted version of the input signal, but the other (*IC2*) inverts it. The outputs of the op amps appear across *R2* 180° out of phase with respect to each other and are applied to the signal-carrying terminals of balanced connector *J2* (Cannon XLR-3-13 or equivalent). Resistors *R3* and *R4* reference the "hot" output terminals to system ground.

Although separate component numbers have been given to the op amps (suggesting the use of two IC packages), a dual or quad op amp IC can be used. The selection of low-noise, high-performance op amps is recommended. If a bipolar supply is employed, the use of coupling capacitors before the output jack might not be necessary. Consider whether the subsequent balanced stage has direct coupling and what effect a dc offset might cause. Any dc offset appearing at the output of an op amp can be suppressed by careful matching of supply voltages and the use of an offset-nulling potentiometer.

Light Alarm For a Fireman

Q. *I need a circuit that can be connected to the audio output jack of my volunteer fire department monitor receiver to also turn on a light in the room when a call comes during the night. This way, I won't be stumbling around in the dark before I am thoroughly awake. Then I will be able to get ready and be out of the house faster.—John D. McKinney.*

A. You could try the circuit shown here. Audio from the earphone jack is amplified by the op amp and rectified by the diode. The rectified signal provides gate drive for the SCR which then latches on and energizes the relay. Power is thus supplied to a lamp plugged into the socket. Since the SCR is dc powered, it remains on (with the lamp glowing) until the normally closed pushbutton switch is depressed. You may have enough audio signal from your monitor to operate the rectifier/SCR combination without the op amp.



Adding Basic to the COSMAC Elf

Q. ***I have recently revised my COSMAC Elf minicomputer, and now want to add the TINY BASIC ROM chip that has become available. I have two questions. How is the ROM chip connected to the bus, and how is a keyboard connected to the bus? I built my Elf from scratch, and I want to do everything the same way! —Patrick Peters, Danville, CA.***

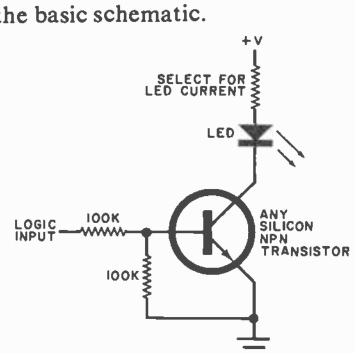
A. The ROM is connected to the data lines of the bus, and an address trap (a decoder) is used to cause the ROM to present data bits to the bus when the appropriate address is "called." If the ROM lacks tri-state outputs, a tri-state buffer chip must be used to gate the ROM data onto the bus and to isolate the ROM from the bus when it is not being addressed. A keyboard can be added to an Elf by using either a serial or parallel port.

Elf users should be aware (if they are not already) that there is an excellent source of information about Elf applications. It is the Association of Computer Experimenters (A.C.E.), a very active Elf Club in Canada. This group publishes a newsletter called *IPSO FACTO* which is a gold mine of information about Elf hardware and software. Membership dues (including newsletter subscription) are $15 per year for Canadians, $18 Canadian for members elsewhere. For more information about the club, write to the Association of Computer Experimenters, c/o M.E. Franklin, Treasurer, 24 Duby Road, Acton, Ontario, Canada L7J 2P1. Another reliable source of Elf information and products is Netronics R&D Ltd., 333 Litchfield Road, New Milford, CT 06776.

Basic Logic Probe

Q. ***I need a circuit to drive a discrete LED from either a TTL or CMOS logic signal. Do you know of such a circuit?—Chris Manning.***

A. This is probably one of the most widely used circuits in logic probes. Variations of it have been given many times in our construction articles. Here is the basic schematic.



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

Experimenting with Shift Registers

SHIFT registers are among the most versatile of digital logic circuits. This month, we'll cover the basics of shift register operation and design. We'll also look at some of the most important applications for shift registers. Next month, we'll look at some of the more important CMOS and TTL integrated shift registers. We will also present some application circuits you'll enjoy building.

The Basic Shift Register. Figure 1 is a block diagram of a very simple 4-bit shift register made from four D flip-flops connected in series. To understand the operation of this circuit, assume that the Q output of each flip-flop is at logic 0. When a clock pulse is applied to the SHIFT line, the logic level at the D input of each flip-flop is loaded into the corresponding flip-flop. Thus, if all of the Q outputs are initially at logic 0, the status of the four outputs (0000) will not be changed after the arrival of the clock pulse.

If a logic 1 is applied to the SERIAL INPUT, a logic 1 will be loaded into the first flip-flop when the next clock pulse arrives. The four-bit output nibble appearing at the PARALLEL OUTPUTS will then be 1000. If the logic level applied to the SERIAL INPUT is then changed to logic 0, the logic 1 will move one position to the right when the next clock pulse arrives. The four-bit nibble stored in the register will then be 0100. The rightward movement of the logic 1 will continue as additional clock pulses are received. The nibble changes to 0010 and then to 0001. Upon receipt of the fifth clock pulse, the logic 1 is pushed entirely out of the register and replaced by a logic 0. The register will then again contain the nibble 0000.

Several significant things have occurred during the course of applying five clock pulses to the basic shift register. First, the logic 1 applied to the SERIAL INPUT appeared at the SERIAL OUTPUT only after the arrival of four clock pulses. Therefore, the shift register has functioned as a *digital delay line*. Secondly, the logic 1 migrated through the register, appearing at one of the four Q outputs at any given time in a sequence controlled by the clock rate. Taken together, the PARALLEL OUTPUTS can be used to actuate sequentially or *strobe* a series of external circuits in accordance with any pattern of bits presented to the SERIAL INPUT. In general, the ENABLE inputs of many logic ICs are active when a logic 0 is applied to them, so a logic 0 would usually be used as an activating strobe bit.

Thirdly, the bit pattern appearing at the four PARALLEL OUTPUTS can be considered a binary word. As the logic 1 moved from left to right, the magnitude of the word was halved at each clock pulse (1000 = 8; 0100 = 4; 0010 = 2 and 0001 = 1). Thus, the shift register performed a numerical divide-by-two operation. Finally, between clock pulses, the shift register has acted as a conventional data storage register. The register stored data without changing or modifying them, and data were always available at the PARALLEL OUTPUTS

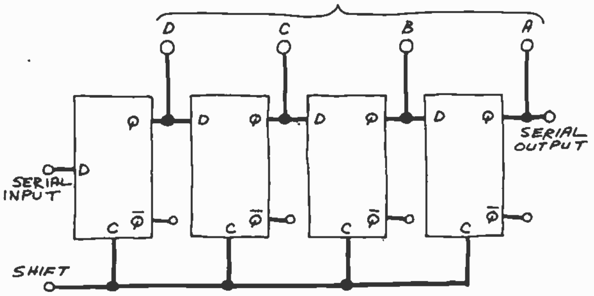


Fig. 1. Basic block diagram of a D flip-flop shift register.

Experimental Shift Register. Many different kinds of integrated shift registers are available, and we'll examine several of them next month. However, if you would like to build and experiment with your own flip-flop shift register, you can try the circuit shown in Fig.2. It is made from a pair of CMOS dual D flip-flops, and does everything the basic register of Fig. 1 does.

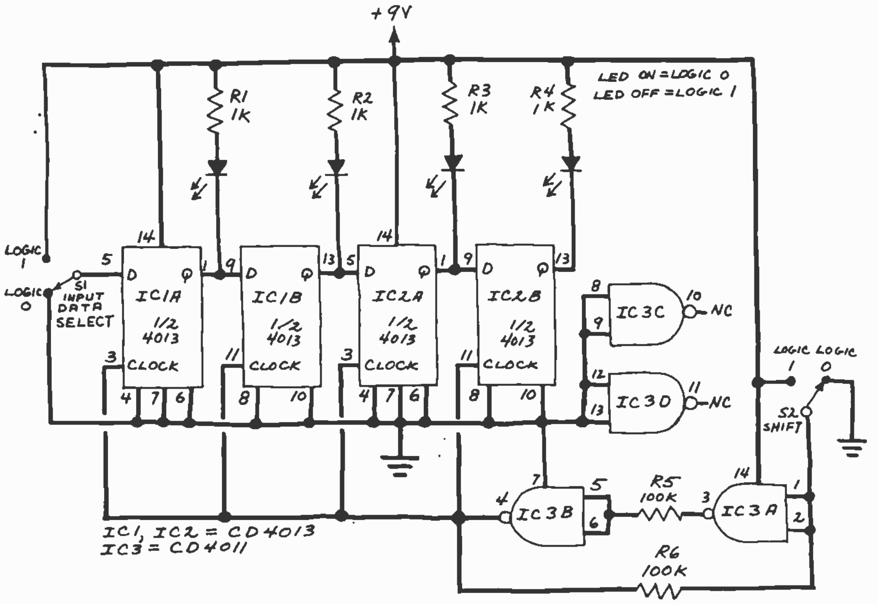


Fig. 2. Schematic diagram for an experimental CMOS shift register made from D flip-flops.

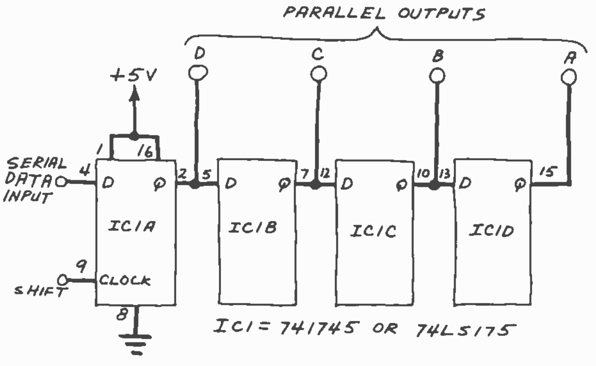


Fig. 3. A four-bit shift register made from a single quad D flip-flop.

Two NAND gates (*IC3A* and *IC3B*) connected as a bistable latch provide a bounce-free pulse to the clock inputs of each flip-flop when *S2* is placed in its LOGIC 1 position. This switch and the INPUT DATA SELECT switch allow you to cycle the shift register and change the input data in any fashion you choose. The logic level of each Q output is indicated by a LED.

If you prefer, you can use flip-flops other than those contained in the 4013 to make a shift register. For example, the 7474 is a TTL dual D flip-flop. The 74175 contains four D flip-flops in a single DIP and, as you can see in Fig. 3, readily lends itself to use as 4-bit TTL shift register.

Incidentally, if you don't have any D flip-flops on hand, but do have some JK flip-flops (such as the 4027, 7473, 7476, etc.), you can convert the JK units into D flip-flops. Simply connect the input and output of an inverter to the J and K inputs, respectively. The node comprising the flip-flop's J input and the inverter input behaves as a data (D) input.

Shift Register Types. Now that we've seen what a basic shift register can do and how it does it, let's examine some of the technical jargon used to characterize various types of shift registers. First, that shown in Fig. 1 is called a *serial-in/parallel-out and serial-out* shift register. It is a *serial-in* register because data can be entered bit by bit (serially) into the input of only the first flip-flop. It is a *parallel-out* register since all four outputs are simultaneously available. Because the final output is always available, the circuit also provides a *serial-out* capability. A *parallel-in* capability is not available with the circuit in Fig. 1, but can be added with the help of a suitable logic network.

These descriptive terms allow us to specify the most important kinds of shift registers:

Serial-In/Serial-Out. This is the basic shift register. It can be as simple as a 2-bit register or as complex as a million-bit bubble memory.

Serial-In/Parallel-Out. This register is more flexible than a simple *serial-out* register because all of the contents of the register are always available.

Parallel-In and Serial-In/Serial-Out. Such a register allows all of the bits in a complete digital word to be loaded simultaneously and then clocked out one bit at a time.

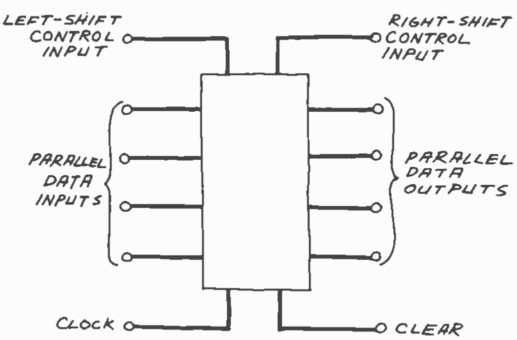


Fig. 4. Inputs and outputs for a hypothtical universal four-bit shift register.

Parallel-In and Serial-In/Parallel-Out and Serial-Out. This is the "complete" shift register. It can be used as a conventional data register or as a universal shift register.

Although the basic register shifts bits only to the right, some registers can shift bits in *both* directions. These are the most versatile of all shift registers. Figure 4 shows all the input, output and control lines of a 4-bit universal shift register.

Shift Register Applications. Shift registers have literally dozens of applications. In the remainder of this column we'll examine several important applications conceptually. We'll experiment with some specific circuits next month.

Multiplication. Shift registers are vital components in many digital computing circuits. Consider, for example, this problem in binary multiplication: Multiply 110_2 by 101_2.

```
    110  multiplicand
    101  multiplier
    110
   000    partial products
  110
  11110   final product.
```

The rules for binary multiplication are: (0) (0) = 0; (0) (1) = 0; (1) (0) = 0; and (1) (1) = 1. The rules for binary addition are: 0 + 0 = 0; 0 + 1 = 1; 1 + 0 = 1; and 1 + 1 = 0, carry 1, or 10.

Refer again to the multiplication problem above and you'll discover a binary-multiplication shortcut: When one bit in the multiplier is 0, its partial product is 000; when the bit is 1 the partial product equals the multiplicand. Therefore, to multiply two binary numbers, inspect the least significant bit in the multiplier. If it is 0, write down a string of 0s equal in length to the number of bits in the multiplicand. If it is 1, write down the multiplicand. This entry becomes the first partial product.

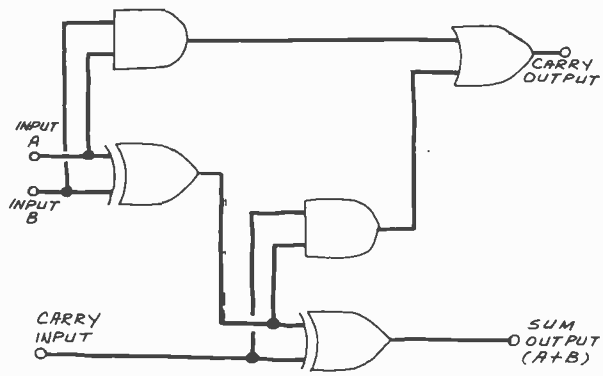


Fig. 5. Logic diagram of a binary full adder.

Next, move to the second-most significant bit in the multiplier. Repeat the foregoing procedure to arrive at the second partial product. Then shift the result one bit position to the left and add the two partial products.

Continue inspecting, shifting and adding until all the bits in the multiplier have been accounted for. The sum of the last two partial products becomes the final product.

This exercise illustrates a very important characteristic of digital arithmetic—binary multiplication can be accomplished by shifting left and adding. The arithmetic-logic unit (ALU) in virtually every microprocessor includes a logical comparator, an adder and a shift register. Multiplication can be performed by a relatively straightforward program that makes alternate comparisons, shifts and additions. If you would like to know more, Lou Frenzel has written a very clear explanation of this procedure in an excellent book, *Getting Acquainted with Microcomputers* (Howard W. Sams & Co., 1978, pp. 197-203).

Multiplication and Division by Two. Another neat binary-arithmetic trick that shift registers can perform is multiplication or division by a factor of two. As we have already observed, shifting any binary word one bit to the right divides the word integrally by two. For example, 1110 (14) shifted right one bit is 0111 (7). Similarly, shifting any binary word one bit position to the left multiplies the word by two. For example, 1001 (9) shifted left one bit is 10010 (18).

Serial Addition. A binary *full adder* is a straightforward combinational circuit made from two exclusive -OR gates and several additional gates connected as shown in Fig. 5. The circuit is called a full adder since it can both accept and generate carry bits.

A single full adder can add only two data bits plus one carry bit. Therefore a number of adders arranged in parallel are required to simultaneously add all of the bits in two data words. For example, the simultaneous addition of all of the bits in two bytes requires a parallel array of eight full adders.

It's possible to add two data words using just one adder if the addition is performed one bit position at a time. Two shift registers are required to store the words being added, and a third is required to store the sum. A single D flip-flop is needed to store the carry bit which will result when the two bits to be added are both 1 or if the sum of the two bits and carry bit which might be present is 10 or 11. Figure 6 is a block diagram of a serial-shift-register adder.

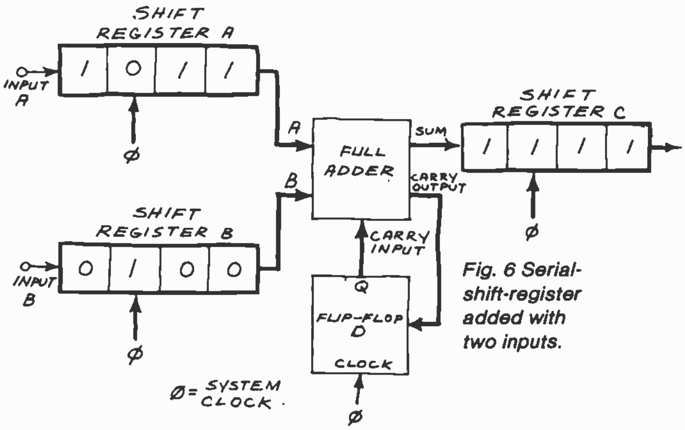


Fig. 6 Serial-shift-register added with two inputs.

The operation of a shift-register serial adder is a very good example of a sequential logic circuit. Referring to Fig. 6, the two words to be added are loaded into shift registers A and B. They are then clocked through the adder a pair of bits at a time and the resulting partial sums are loaded into shift register C. The complete addition requires only four clock cycles.

Can you think of a way to simplify the serial adder in Fig. 6? Shift register C can be eliminated entirely by feeding the output of the adder back to the input of Shift Register A, which then becomes an *accumulator*.

Although the operation of the serial adder seems simple enough, a control circuit is required to prevent the application of any more clock pulses once the addition has been completed. Otherwise, any new data that happens to be at the inputs of Shift Registers A and B will be cycled through the adder, and the sum stored in Register C will be pushed out and lost.

You can learn about an important aspect of the operation of the control section of a microprocessor or digital computer by designing a simple circuit. The circuit should monitor the operation of a serial adder and save the final sum by either disabling the clock pulses or moving the sum into still another register. Hint—the use of a 2-bit counter offers one solution.

Data Transmission. Computer data is usually transmitted in serial fashion one bit at a time. A shift register at the transmitting end reduces each word to be transmitted into its component bits, and one bit is transmitted each time a clock pulse arrives. A second shift register at the receiving end reconstructs the transmitted words bit by bit. It passes them to a storage register each time a complete word has been received and reconstructed. Figure 7 summarizes a shift-register data-transmission system.

A shift register that transmits a word one bit at a time is called a *parallel-to-serial converter*. A shift register that assembles data words from a stream of incoming bits is called a *serial-to-parallel converter*. Both applications find use in many operations other than data transmission. Closely related to data transmission are applications in which a shift register acts as a temporary storage register or delays the arrival of a data word by a preselected number of clock pulses.

Memory Stack. A *memory stack* consists of two or more data registers used to hold temporary data. In a microcomputer, a stack is implemented within the main memory (RAM) or by a special set of data registers. A *pointer register* keeps track of where data is stored in the stack.

Shift registers can be used to make a memory stack. In the version shown in Fig. 8, four shift registers are arranged in

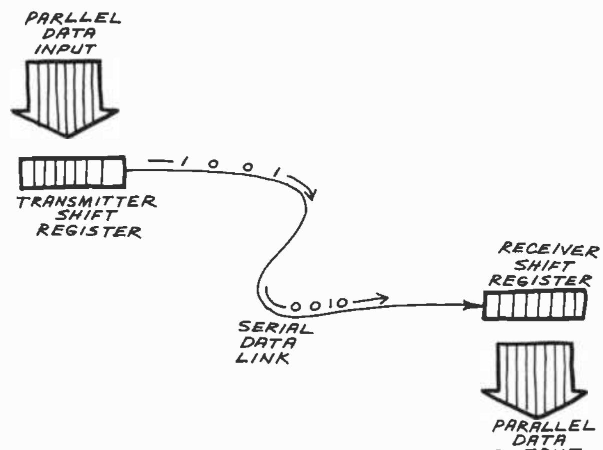


Fig. 7. How a shift-register data transmission system operates.

parallel so that up to four 4-bit data words or nibbles (half of an 8-bit byte) can be stored. The clock (shift) lines of all four registers are tied together so that a 4-bit nibble can be loaded into the stack in one operation. The nibble can then be pushed down into the stack as more are loaded.

If the nibble moves in only one direction through the stack, the first nibble to enter is the first to exit. This is a FIFO (first in/first out) stack. Several variations are possible. For example, the capability of shifting in both directions means that a nibble can be pushed into and popped out of the stack. In a LIFO (last in/first out) stack, the last nibble pushed into the stack is the first to be popped out of the stack.

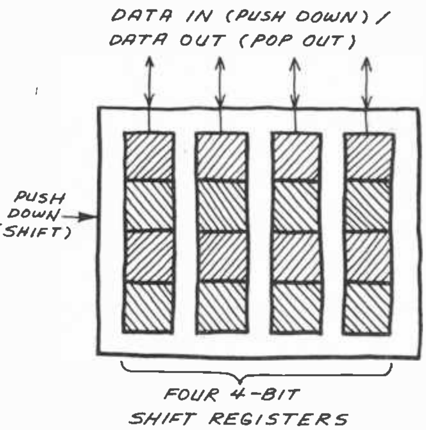


Fig. 8. Four 4-bit words can be stored in this memory stack.

Reader's Letters. Several readers have sent comments that many followers of this column might find helpful. R.C. Amendola, for example, detected an error in the circuit of the six-digit event counter described in the February 1980 "Experimenter's Corner." In Fig. 3 (p. 100), the strobe signals to *Q1-Q3* must be inverted for the display to work properly. Mr. Amendola suggests inserting inverters in the strobe lines. A better way is to do what I did in the prototype version and use pnp transistors for *Q1-Q3*. To do this, you'll need to reverse the collector and emitter connections of each transistor, as they appear in the schematic.

Incidentally, this same error appears on page 35 in the first printing of *Engineer's Notebook*, a circuit sourcebook I recently wrote for Radio Shack. Subsequent printings include the corrected circuit.

Noah T.W. Givens, a former research technician at Bell Laboratories in Norcross, GA, wrote to reaffirm my warning about the hazards of working with glass fibers (May 1980, p. 86). Mr. Givens states," . . . if you place (a) fiber on your index finer to score it, you risk getting an extremely nasty piece of optical fiber in your finger. A worse splinter you'll never find. Besides being so very small in diameter, the thing is virtually invisible."

He also suggests using a fresh razor blade to prepare fiber for cleaving. He doesn't like the word *score* as that implies "dragging the blade across the fiber." He points out all that's necessary is simply to *touch* the blade to the fiber at the desired point of separation and then apply tension to separate the fiber.

Finally, some readers continue to make requests for custom circuit designs or detailed information about specialized technical topics. Because of the great volume of mail I receive, it is not possible to repond personally to such requests. Nevertheless, I very carefully read all letters and I will consider describing in a future column those topics or circuits which appear to have wide reader interest. Letters pointing out errors receive prompt attention.

In short, although individual replies are impracticable, your suggestions, criticisms and comments about this column are always welcome. ◊

English Broadcasts Audible in No. America

by Glenn Hauser

TIME CDT	TIME UTC/GMT	STATION	QUAL.	FREQUENCIES, kHz
4:00-4:15 a.m.	0900-0915	BBC	A	15070, 11955, 11750, 9640, 9510, 6195
4:00-4:15 a.m.	0900-0915	R. Japan[1]	B	9505
4:00-5:30 a.m.	0900-1030	R. Australia	8	15145
4:00-6:00 a.m.	0900-1100	AFRTS Washington	A	11805, 9700, 9530, 6030, 9590
4:15-6:00 a.m.	0915-1100	BBC	C	17790, 17695, 15070, 21710, (21660 Sat. & Sun.)
4:30-5:30 a.m.	0930-1030	V. of Germany	C	17780
5:00-5:15 a.m.	1000-1015	UN Radio	A	15250, 11090-LSB † 9565, (Tue.–Sat.)
5:00-5:30 a.m.	1000-1030	R. Japan	B	9505
5:00-5:30 a.m.	1000-1030	V. of Vietnam	C	12033, 10080
5:00-6:00 a.m.	1000-1100	R. Korea	C	11725, 9570, 15570, 9870
5:00 fade out	1000	R. Australia	B	6045, 5995
5:00-9:00 a.m.	1000-1400	R. Moscow (via Cuba)	B	9600, 600 (5045-1100)
5:00-11:02 a.m.	1000-1602	ABC, Perth	B	9610
5:30-6:30 a.m.	1030-1130	Sri Lanka Br. Corp.	C	17850, 15120, 11835 (not all Eng.)
5:30-7:00 a.m.	1030-1200	V. of Asia, Taiwan	D	5980 (Sun 1030-1040) (time varies)
5:30-8:00 a.m.	1030-1300	CBC Northern Service	B-C	9625, 6065 (English: Mon.-Fri. 1200-1213; Sat. 1030-1200; Sun. 1103-1600)
5:55-6:55 a.m.	1055-1155	R. Thailand	C	11905, 9655
6:00-6:15 a.m.	1100-1115	R. Japan	B	9505
6:00-6:30 a.m.	1100-1130	V. of Vietnam	C	12035, 10080
6:00-6:30 a.m.	1100-1130	R. Mogadishu	D	9585
6:00-6:56 a.m.	1100-1156	R. RSA	C	25790, 21535
6:00-7:00 a.m.	1100-1200	AFRTS Washington	A	6030
6:00-7:30 a.m.	1100-1230	TWR Bonaire	A	11815
6:00-7:50 a.m.	1100-1250	R. Pyongyang	C	9977
6:00-8:00 a.m.	1100-1300	R. Australia	A	9580
6:00-8:30 a.m.	1100-1330	BBC	A-B	25650, 21710, 21660, 21550, 11775, 11750, 9510, 6195
6:00-9:00 a.m.	1100-1400	4VEH, Haiti	B	11835, 9770
6:00-10:00 a.m.	1100-1500	R. Moscow	B	15150, 12010, 17845, 15135
6:00-10:00 a.m.	1100-1500	VOA	B	11715, 9565
6:00-11:00 a.m.	1100-1600	AFRTS-Washington	A	15430, 15330, 11805, 9700
6:15-6:30 a.m.	1115-1130	Vatican R.	C	21485, 17840 (not Sun.)
6:30-6:45 a.m.	1130-1145	R.R.I. Yogyakarta	C	5046
6:30-6:55 a.m.	1130-1155	R. Nacional, Angola	D	11955, 9535 (Mon.-Fri.)
7:00-7:15 a.m.	1200-1215	R. Japan	B	9505
7:00-7:15 a.m.	1200-1215	V. of Kampuchean People	C	11938, 9694
7:00-7:20 a.m.	1200-1220	Vatican R.	B	21485 17900, 17840 (not Sun.)
7:00-7:30 a.m.	1200-1230	Kol Israel	C	25640, 17612.5
7:00-7:30 a.m.	1200-1230	R. Tashkent	C	15460, 11785, 9750, 9715
7:00-7:45 a.m.	1200-1245	V. of Germany	B	21600, 17875, 17765, 15410
7:00-7:45 a.m.	1200-1245	R. Berlin International	C	21540, 21465, 17700, 15320
7:00-7:55 a.m.	1200-1255	R. Peking	B	15520
7:00-8:00 a.m.	1200-1300	V. of Turkey	C	17860, 15185
7:00-8:00 a.m.	1200-1300	HCJB, Ecuador	A	26020, 15115, 11740
7:15-7:30 a.m.	1215-1230	V. of Greece	D	21455 †, 17835 †, 11730
7:20-7:50 a.m.	1220-1250	R. Ulan Bator, Mongolia	C	11825, 6383 (not Sun.) †
7:30-7:55 a.m.	1230-1255	Austrian R.	B	21655
7:30-7:55 a.m.	1230-1255	R. Tirana	D	11965, 9515
7:30-8:00 a.m.	1230-1300	R. Sweden	C	21690
7:30-8:00 a.m.	1230-1300	BBC (English by radio)	C	21695
7:30-8:00 a.m.	1230-1300	R. Bangladesh	C	21770 †, 15285
7:30-8:30 a.m.	1230-1330	TWR, Bonaire	A	15255 (Sat.; Sun.-1415)
7:30-10:51 a.m.	1230-1551	WYFR, Family Radio	A	21525, 17845 (Sun. only)
8:00-8:15 a.m.	1300-1315	R. Japan	B	9505
8:00-8:30 a.m.	1300-1330	R. Finland	B	15400
8:00-8:30 a.m.	1300-1330	R. Bucharest	C	17850, 15250, 11940
8:00-9:00 a.m.	1300-1400	R. Australia	C	11705, 9770, 6080
8:00-9:00 a.m.	1300-1400	R. Korea	C	7550, 11830
8:00-9:30 a.m.	1300-1430	HCJB, Ecuador	A	26020, 17890, 15115, 11740
8:00-10:50 a.m.	1300-1550	R. RSA	B	25790, 21535, 15220
8:00-11:00 a.m.	1300-1600	CBC Southern Service	B	11955, (1300-1400, 17860, 1400-1600 17710) (Sun. only)
8:00 a.m.-6:00 p.m.	1300-2300	CBC Northern Service	B-C	11720, 9625 (English: Mon. Fri. 1313-1500, 1600-1613, 1800-1830, 2200-2230; Sat. 1310 1405, 1500-1705, 2215-2300; Sun. 1300-1600, 1735 1900, 2000-2300)
8:15-8:45 a.m.	1315-1345	Swiss R. International	B	21570, 21520
8:30-8:45 a.m.	1330-1345	BRT, Belgium	C	21470, 17730 (Mon. Fri.)
8:30-9:20 a.m.	1330-1420	R. Nederland	C	17605
8:30-9:30 a.m.	1330-1430	R. Finland	B	15400 (Sun. only)
8:30-9:30 a.m.	1330-1430	V. of Vietnam	C	12035, 10080
8:30-10:00 a.m.	1330-1500	All India R.	C	15335, 11810
8:30-11:00 a.m.	1330-1600	BBC	B-C	25650, 21710, 21660, 21550, 15400 (from 1430), 15070
8:30 a.m.-5:00 p.m.	1330-2200	R. Moscow (via Cuba)	B	11840

8:57-11:55 a.m.	1357-1655	V. of Philippines	D	11950, 9579 (Sun. 1555)
9:00-9:30 a.m.	1400-1430	R. Japan	B	9505
9:00-9:30 a.m.	1400-1430	R. Sweden	B	21615
9:00-9:30 a.m.	1400-1430	R. Norway	B	17840, 21655 (Sun. only)
9:00-9:30 a.m.	1400-1430	V. Rev. Party, N. Korea	D	4557, 4109
9:00-9:30 a.m.	1400-1430	R. Tashkent	C	15460, 11785, 9750, 9715
9:00-9:45 a.m.	1400-1445	R. Berlin International	C	21540, 21465, 17700
9:00-10:00 a.m.	1400-1500	V. of Indonesia	C	15200, 11789
9:00-12:30 a.m.	1400-1730	R. Australia	C	17795, 9770
9:30-10:00 a.m.	1430-1500	R. Finland	B	21475, 15400
9:30-10:25 a.m.	1430-1525	R. Nederland	B	21480, 11735
9:30-11:00 a.m.	1430-1600	HCJB, Ecuador	A	26020, 17890, 15115
9:30-11:00 a.m.	1430-1600	Burma Br. Ser.	D	5985, 5040
9:30 a.m.-5:00 p.m.	1430-2200	UN Radio	A	21670, 15410 (when in session)
9:35-10:20 a.m.	1435-1520	R. Nepal	D	3425 or 7105 or 9590
10:00-10:15 a.m.	1500-1515	R. Japan	C	9505
10:00-11:00 a.m.	1500-1600	V. of Rev. Ethiopia	D	9560
10:00-11:00 a.m.	1500-1600	BBC	B	17830, 15260 (Sat. Sun)
10:00-11:00 a.m.	1500-1600	R. Moscow	B	15150, 12030, 11905, 11720, 9750, 9710
10:00-12:30 a.m.	1500-1730	BSHKJ, Jordan	D	9560
10:30-11:00 a.m.	1530-1600	R. Afghanistan	D	4775
10:30-11:00 a.m.	1530-1600	R. Yugoslavia	C	15300, 15240
10:30-11:00 a.m.	1530-1600	Swiss R. International	B	21570
10:30-11:30 a.m.	1530-1630	V. of Vietnam	C	15012, 10080
10:45-11:00 a.m.	1545-1600	R. Canada International	A	17820, 15160, 15325
11:00-11:15 a.m.	1600-1615	R. Japan	C	9505
11:00-11:15 a.m.	1600-1615	R. Pakistan	C	21755, 21635, 21486, 17910, 17660 †
11:00-11:30 a.m.	1600-1630	R. Norway	B	15175, 21655 (Sun. only)
11:00-11:30 a.m.	1600-1630	R. Portugal	C	21530
11:00-12:00 a.m.	1600-1700	R. Korea	B	11830, 9720
11:00-12:00 a.m.	1600-1700	R. Moscow	B	12030, 11905, 11770, 9750
11:00 a.m.-12:09 p.m.	1600-1709	BBC	B	21710, 21550, 17880, 17830, 15260
11:00 a.m.-1:00 p.m.	1600-1800	AFRTS-Washington	A	17765, 15430, 15330, 11805
11:00 a.m.-6:00 p.m.	1600-2300	VOA	A	26040, 21485, 17870, 17710, 15445, (15410 to 2200)
-11:30 a.m.	-1630	R. Singapore	C	11940 (fade-in time varies)
11:45-12:00 a.m.	1645-1700	R. Canada International	A	17820, 15325, 21695
11:45-12:45 p.m.	1645-1745	R. Pakistan	C	15485, 11675
12:00-12:15 p.m.	1700-1715	R. Japan	C	9505
12:00-12:15 p.m.	1700-1715	Vatican R.	C	17900
12:00-12:30 p.m.	1700-1730	HCJB, Ecuador	B	26020, 21480, 17790 †
12:00-1:00 p.m.	1700-1800	WYFR, Family Radio	A	21615, 15160
12:00-1:00 p.m.	1700-1800	R. Moscow	B	15245, 15150, 12030, 11905, 11720, 11960
12:00-3:00 p.m.	1700-2000	4VEH, Haiti	C	11835, 9770 (Sun.)
12:05-12:55 p.m.	1705-1755	R. France International	B	25900, 25820, 21620, 21580, 21515
12:09-12:45 p.m.	1709-1745	BBC	B	17830, 15260 (Sat & Sun only) 21710, 15070
12:10-12:58 p.m.	1710-1755	BRT, Belgium	C	17730 †
12:15-1:05 p.m.	1715-1805	V. of Germany	C	21600
12:45-3:00 p.m.	1745-2000	BBC	C	17705, 15400, 15070, 12095 (11820 from 1800)
12:45-5:30 p.m.	1745-2230	All India R.	C	11620
1:00-1:15 p.m.	1800-1815	R. Japan	B	9505
1:00-1:30 p.m.	1800-1830	R. Canada International	A	17820, 15260
1:00-1:30 p.m.	1800-1830	R. Norway	C	15175, 21655 (Sun. only)
1:00-2:00 p.m.	1800-1900	V. of Vietnam	C	15012, 10040
1:00-2:00 p.m.	1800-1900	R. Moscow	B	15245, 15240, 15455, 15150, 12050, 12030, 11960, 11905, 11720
1:00-2:00 p.m.	1800-1900	WYFR, Family Radio	A	21615, 15425
1:00-2:00 p.m.	1800-1900	V. of Nigeria	C	15119, 15185
1:00-3:00 p.m.	1800-2000	R. Australia	C	21630, 17795
1:00-4:00 p.m.	1800-2100	R. Kuwait	C	11665
1:00-5:00 p.m.	1800-2200	B.S.K. Saudi Arabia	C	11854
1:00-5:00 p.m.	1800-2200	AFRTS Washington	A	21570, 17765, 15430, 15345, 15330
1:00 p.m.-3:15 a.m.	1800-0815	R. New Zealand	C	15485
1:15-1:45 p.m.	1815-1845	Swiss R. International	C	21585, 17830, 17850
1:15-2:15 p.m.	1815-1915	R. Bangladesh	D	15285, 11765 (both vary) †
1:30-1:35 p.m.	1830-1835	UN Radio	A	19505 SSB, 15410 (Mon. Fri.) 11960, 17740, 15305
1:30-2:00 p.m.	1830-1900	V. of Revolution, Guinea	C	15308 (varies) (Mon. and Fri.) (irregular)
1:45-2:00 p.m.	1845-1900	R. Senegal	C	11895
1:45-2:15 p.m.	1845-1915	Sri Lanka Br. Corp.	C	17850, 15120, 15115, 11870
2:00-2:10 p.m.	1900-1910	R. Tahiti	C	15170, 11825 (exc. Sun)
2:00-2:15 p.m.	1900-1915	R. Japan	B	15270
2:00-2:30 p.m.	1900-1930	R. Canada International	A	17875, 15325, 21695
			A	17820, 15260
2:00-2:30 p.m.	1900-1930	R. Afghanistan	C	15076 (varies) or 17745 †
2:00-3:00 p.m.	1900-2000	HCJB, Ecuador	C	26020, 21480, 17825, 15300
2:00-3:00 p.m.	1900-2000	R. Moscow	B	15455, 15245, 15240, 15150, 12050, 12030, 11960, 11905, 11720
2:00-5:00 p.m.	1900-2200	WYFR, Family Radio	A	21615, 21525, 15130
2:30-3:30 p.m.	1930-2030	V. of Iran	C	9022
2:35-5:00 p.m.	1935-2200	TIFC, Costa Rica	C	9645 (Sun.)
2:45-4:15 p.m.	1945-2115	R. Free Grenada	C	15104 (time varies and irregular)
3:00-3:15 p.m.	2000-2015	R. Japan	B	15270
3:00-3:30 p.m.	2000-2030	R. Algiers	C	21635, 9610 or 9510 † (2100 from Oct 31)
3:00-3:30 p.m.	2000-2030	R. Canada International	A	17875, 17820, 21695, 15325
3:00-3:30 p.m.	2000-2030	Kol Israel	B	21675, 17645, 11610

3:00-4:00 p.m.	2000-2100	R. Moscow	B	15455, 15425, 15240, 15150, 12050, 12030, 11905, 11960
3:00-4:15 p.m.	2000-2115	BBC	A	21560, 15260, 15070, 6175
3:00-1200 p.m.	2000-0500	R. Moscow (via Cuba)	C	600
3:10-4:40 p.m.	2010-2140	R. Habana Cuba	A	15155
3:30-4:00 p.m.	2030-2100	R. Portugal	C	15125, 11800, 9745
3:30-4:20 p.m.	2030-2120	R. Nederland	B	21640, 17695, 17605, 15220, 9715
3:30-4:30 p.m.	2030-2130	V. of Vietnam	C	15012, 10040
3:30-4:30 p.m.	2030-2130	V. Turkey	C	11895, 11885
3:45-5:30 p.m.	2045-2230	All India R.	C	15110
3:50-4:00 p.m.	2050-2100	R. Free Europe	B	(Fri.) 21720, 17835, 15420 † 11825
3:50-4:40 p.m.	2050-2140	R. Habana Cuba	C	17750, 9770
4:00-4:15 p.m.	2100-2115	R. Japan	B	15270
4:00-4:50 p.m.	2100-2150	R. RSA	B	21535, 17780, 15155
4:00-5:00 p.m.	2100-2200	R. Andorra	D	6219 (Sun. only)
4:00-5:00 p.m.	2100-2200	V. of Nigeria	C	15185, 15119
4:00-5:00 p.m.	2100-2200	R. Moscow	B	15455, 15425, 15240, 12050, 11960
4:00-6:00 p.m.	2100-2300	CBC Radio	A	17875, 15325 (Mon. - Fri.)
4:15-5:00 p.m.	2115-2200	BBC	A	15420, 15260, 15070, 6175, 21690
4:15-7:00 p.m.	2115-2400	R. Free Grenada	B	15045 (time varies)
4:30-5:00 p.m.	2130-2200	R. Canada International	A	17820, 15150, 11945 (17875, 15325 Sat./Sun. only)
4:30-5:00 p.m.	2130-2200	KGEI, San Francisco	C	15280
4:30-5:00 p.m.	2130-2200	HCJB Ecuador	C	26020, 21480, 17825, 15300
4:30-5:00 p.m.	2130-2200	R. Sofia	B	15135, 11750 †
4:30-5:30 p.m.	2130-2230	R. Baghdad	C	9745
4:40-5:40 p.m.	2140-2240	V. of Free China	C	17890, 15270, 11825
5:00-5:15 p.m.	2200-2215	R. Japan	B	17755, (via Portugal 15180 †)
5:00-5:30 p.m.	2200-2230	R. Norway	C	15345, 15175 (Sun. only) 15135
5:00-5:45 p.m.	2200-2245	BBC	A	15420, 15260, 15070, 9590, 6175, 6120
5:00-6:00 p.m.	2200-2300	WYFR, Family Radio	A	21525, 15130, 11855
5 00-6:00 p.m.	2200-2300	R. Moscow	B	17700, 15525, 15425, 15100, 12050, 11960, 11770, 11750
5:00-6:00 p.m.	2200-2300	V. of Turkey	B	15360, 9515, 7215
5:00-7:00 p.m.	2200-2400	AFRTS—Washington	A	25615, 21570, 15430, 15345, 15330
5:00-7:00 p.m.	2200-2400	CBC Southern Service	A	9755, 5960
5:00-11:30 p.m.	2200-0430	VOA	A	21460
5:00-1:30 a.m.	2200-0630	R. New Zealand	C	17860
5:15-5:30 p.m.	2215-2230	R. Yugoslavia	C	9620
5:30-6:00 p.m.	2230-2300	Kol Israel	A	21710, 21675, 15582
5:45-6:00 p.m.	2245-2300	BBC	A	15420, 15260, 15070, 11637, 9815, 9590, 6175, 6120
5:45-6:00 p.m.	2245-2300	SODRE, Uruguay	C	11885, 9515 (time varies)
5:45-6:00 p.m.	2245-2300	UN Radio	A	15225, 11830 or 11920 (Mon.-Fri.)
6:00-6:30 p.m.	2300-2330	R. Japan	C	17755
6:00-6:30 p.m.	2300-2330	R. Sweden	B	15270, 11705
6:00-6:30 p.m.	2300-2330	R. Vilnius	B	15405, 11790, 11770, 11735
6:00-6:50 p.m.	2300-2350	Rdif. Argentina	C	11710 (Mon.-Fri.)
6:00-7:00 p.m.	2300-2400	4VEH, Haiti	B	11835, 9770
6:00-7:30 p.m.	2300-2430	BBC	A	15420, 15260, 15070, 11910, 9590, 9580, 9410, 7325, 6175, 6120, 5975
6:00-7:50 p.m.	2300-2450	R. Pyongyang	C	9977
6:00-8:00 p.m.	2300-0200	R. Moscow	A	21560, 17700, 15425, 15245, 15100, 12050, 12030, 11960, 11750, 11735, 9685, 9665, 9600, 9530
6:00-10:00 p.m.	2300-0300	R. Moscow World Service	C	15460
6:00 p.m.-12:07 a.m.	2300-0507	CBC Northern Service	B-C	9625, 6195 (English: Sun. 0300-0507 2300-2400, Mon. 0000-0100, 0230-0507, Tue.-Sat. 0400-0416, 0500-0507)
6:30-7:00 p.m.	2330-2400	V. of Vietnam	C	12035, 10080, 10040, 10010
6:35-6:55 p.m.	2335-2355	SODRE, Uruguay	C	11885, 9515 (time varies)
6:45-7:45 p.m.	2345-2445	R. Japan	C	17825, 15270
7:00-7:15 p.m.	0000-0015	R. Japan	C	17755
7:00-7:25 p.m.	0000-0025	R. Tirana	B	9750, 7065
7:00-7:30 p.m.	0000-0030	Kol Israel	A	21710, 15582, 11637, 9815
7:00-7:30 p.m.	0000-0030	R. Norway	C	15345, 15170 (Mon. only)
7:00-7:30 p.m.	0000-0030	R. Canada International	A	9755, 5960 (dropped after Oct.25)
7:00-7:55 p.m.	0000-0055	R. Peking	B	17855, 17680, 15120
7:00-8:00 p.m.	0000-0100	R. Sofia	B	15330 or 9705
7:00-8:00 p.m.	0000-0100	WYFR, Family Radio	A	17845
7:00-9:00 p.m.	0000-0200	AFRTS-Washington	A	25615 or 17765, 21570, 15330, 15345
7:00-9:00 p.m.	0000-0200	R. Luxembourg	C	6090 (Time varies)
7:00-9:00 p.m.	0000-0200	VOA	A	17730, 15205, 11740, 9650, 6130
7:00-12:00 p.m.	0000-0500	FEBC Philippines	C	17810
7:00 p.m.-4:00 a.m.	0000-0900	UN Radio	A	6055 (when in session)
7:05-8:55 p.m.	0005-0155	Spanish Foreign R.	B	11880, 9630
7:15-8:00 p.m.	0015-0100	BRT, Belgium	C	15385, 15175
7:30-7:50 p.m.	0030-0050	SODRE, Uruguay	C	11885, 9515 (time varies)
7:30-8:00 p.m.	0030-0100	R. Prague	C	6055
7:30-8:00 p.m.	0030-0100	R. Kiev	B	11735, 17870, 17845, 15180, 12060
7:30-8:00 p.m.	0030-0100	La Cruz del Sur, Bolivia	D	4875 (Mon. only)
7:30-8:30 p.m.	0030-0130	R. Mexico	C	17765, 15430, 11770, 9705, 5985 (Fri. only)
7:30-9:00 p.m.	0030-0200	HCJ8, Ecuador	A	15155 †
7:30-9:30 p.m.	0030-0230	BBC	A	15260, 15070, 11835, 11750, 9580, 9410, 7325, 6175, 6120, 5975
7:30-9:30 p.m.	0030-0230	HCJB, Ecuador	B	26020, 9745, 11915 or 11910
7:50-8:35 p.m.	0050-0135	TWR-Bonaire	B	11925
8:00-8:15 p.m	0100-0115	R. Japan	C	17755

8:00-8:15 p.m.	0100-0115	Vatican R.	B	11845, 9605, 6015
8:00-8:20 p.m.	0100-0120	RAI, Italy	B	11800, 9575
8:00-8:25 p.m.	0100-0125	Kol Israel	A	15582, 11637, 9815, 21710
8:00-8:30 p.m.	0100-0130	R. Canada International	A	5960, 17820, 9755
8:00-8:45 p.m.	0100-0145	R. Berlin International	C	11975, 9730
8:00-8:55 p.m.	0100-0155	R. Prague	B	11990, 9740, 9540, 7345, 5930
8:00-8:55 p.m.	0100-0155	R. Peking	B	17855, 17680, 15120
8:00-9:00 p.m.	0100-0200	R. Korea	C	15570, 15375
8:00-9:00 p.m.	0100-0200	V. of Free China	C	17890, 15345, 11825
8:00-10:30 p.m.	0100-0330	R. Australia	B	21740, 17795
8:00-11:50 p.m.	0100-0450	R. Habana Cuba	A	11930, 11725
8:00-12:00 p.m.	0100-0500	WYFR, Family R.	A	9715
8:20 p.m.-12:10 a.m.	0120-0510	R. Belize	C	3285, 834
8:20-8:50 p.m.	0120-0150	V. of Germany	A	15105, 11865, 9565, 9545, 6145, 6100, 6085, 6040
8:30-8:45 p.m.	0130-0145	V. of Greece	B	11730, 9655, 9515
8:30-8:55 p.m.	0130-0155	Austrian Radio	B	9770, 5945
8:30-8:55 p.m.	0130-0155	R. Tirana	B	9750, 7120
8:30-9:00 p.m.	0130-0200	R. Budapest	B	17710, 15220, 11910, 9835, 9585, (Wed., Fri. only)
8:30-9:25 p.m.	0130-0225	R. Bucharest	C	11940, 11840, 11735, 9690, 9570, 5990
8:30-9:30 p.m.	0130-0230	R. Japan	C	21640, 17825, 17725, 15235
8:45-9:15 p.m.	0145-0215	Swiss R. International	A	15305, 11715, 9725, 6135
9:00-9:15 p.m.	0200-0215	R. Japan	C	17755
9:00-9:25 p.m.	0200-0225	Kol Israel	A	15582, 11637, 9815
9:00-9:30 p.m.	0200-0230	R. Canada International	A	11940, 9655, 5960
9:00-9:30 p.m.	0200-0230	R. Norway	B	15175, 9595, 9590 (Mon. only)
9:00-9:30 p.m.	0200-0230	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000 (not Mon.)
9:00-9:40 p.m.	0200-0240	R. Polonia	C	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
9:00-9:50 p.m.	0200-0250	R. RSA	B	15155, 11900, 9610, 9585
9:00-9:55 p.m.	0200-0255	R. Peking	B	17680, 15230, 15120
9:00-10:00 p.m.	0200-0300	R. Nacional, Brazil	A	15290
9:00-10:30 p.m.	0200-0330	R. Cairo	B	12050, 9475
9:00-11:00 p.m.	0200-0400	R. Moscow	A	12030, 11770, 11750, 11720, 9700, 9665, 9600, 9530 †
9:00-11:30 p.m.	0200-0430	AFRTS-Washington	A	21570, 17765, 9755, 6030
9:30-9:45 p.m.	0230-0245	R. Pakistan	C	21590, 17835, 21745 †
9:30-9:45 p.m.	0230-0245	UN Radio	A	15240, 6035, 15752-SSB 10869-SSB (Tue.-Sat.)
9:30-9:55 p.m.	0230-0255	R. Tirana	B	9750, 7120
9:30-10:00 p.m.	0230-0300	R. Lebanon	C	15375 †
9:30-10:00 p.m.	0230-0300	R. Sweden	C	11705, 9695 †
9:30-10:15 p.m.	0230-0315	R. Berlin International	C	11975, 9730
9:30-10:25 p.m.	0230-0325	R. Nederland	A	9590, 6165
9:30-10:30 p.m.	0230-0330	BBC	A	11750, 9580, 9410, 7325, 6175, 6120, 5975
9:30-12:00 p.m.	0230-0500	HCJB, Ecuador	A	15155, 9745, 11910, 26020
10:00-10:15 p.m.	0300-0315	R. Japan	C	17755
10:00-10:30 p.m.	0300-0330	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000
10:00-10:25 p.m.	0300-0325	R. Polonia	C	15120, 11815, 9525, 7270, 7145, 6135, 6095 (length varies)
10:00-10:30 p.m.	0300-0330	R. Canada International	A	11940, 11845, 9655, 9535, 5960
10:00-10:30 p.m.	0300-0330	R. Portugal	B	11925, 15125
10:00-10:30 p.m.	0300-0330	R. Kiev	B	17870, 15180, 11735, 11715, 9655
10:00-10:30 p.m.	0300-0330	R. Australia	C	15260 (Fri.)
10:00-10:50 p.m.	0300-0350	V. of Free China	C	17890, 15270, 11825
10:00-10:55 p.m.	0300-0355	R. Prague	B	11990, 9740, 9540, 7345, 5930
10:00-10:55 p.m.	0300-0355	R. Peking	B	17680, 15120, 15230
10:00-11:00 p.m.	0300-0400	RAE, Argentina	C	9690 (Tue-Sat)
10:00-11:00 p.m.	0300-0400	Radiobrás, Brazil	C	15290 †
10:00-11:00 p.m.	0300-0400	TIFC Costa Rica	C	9645, 5055, (Mon. 0235-0435)
10:00-11:00 p.m.	0300-0400	R. Baghdad	C	11935
10:00-11:15 p.m.	0300-0415	R. Uganda	B	15325 (irregular)
10:00-11:26 p.m.	0300-0426	R. RSA	B	11900, 9585, 7270, 5980, 4990
10:00-11:30 p.m.	0300-0430	R. Cultural, Guatemala	B	3300 (Mon. 0030–)
10:00 p.m.-1:00 a.m.	0300-0600	HRVC, Honduras	B	4820
10:00 p.m.-2:30 a.m.	0300-0730	VOA	A	17865, 15240, 9670, 5995
10:30-10:55 p.m.	0330-0355	R. Tirana	B	7300, 6200
10:30-10:55 p.m.	0330-0355	Austrian Radio	C	9770, 5945
10:30-11:00 p.m.	0330-0400	R. Australia	B	21740, 21680, 17890, 17870, 17795, 17725
10:30-11:15 p.m.	0330-0415	R. Berlin International	B	11975, 11890, 11840
10:30-11:30 p.m.	0330-0430	R. Korea	C	15570
10:30-11:45 p.m.	0330-0445	BBC	A	9410, 6175, 5975
10:30-11:00 p.m.	0330-0400	R. Finland	C	15430, 15400
10:30-12:00 p.m.	0330-0500	AWR Guatemala	C	5980 †
10:30 p.m.-1:00 a.m.	0330-0600	R. Habana Cuba	A	11760, 11725
10:40-10:47 p.m.	0340-0347	V. of Greece	B	11730, 9650, 9515
10:50-11:10 p.m.	0350-0410	RAI, Italy	C	11905, 17795, 15330
10:51-10:58 p.m.	0351-0358	V. of Yerevan	C	17870, 15405, 15180 (Sun, Wed, Thu, Sat)
11:00-11:15 p.m.	0400-0415	R. Budapest	B	17710, 15220, 11910, 9835, 9585, 6000, (Wed. & Fri) (Mon. to 0430)
11:00-11:15 p.m.	0400-0415	R. Japan	C	17755
11:00-11:30 p.m.	0400-0430	R. Bucharest	C	11940, 11840, 11735, 9690, 9570, 5990
11:00-11:30 p.m.	0400-0430	R. Canada International	A	11845, 9655, 9535, 5960
11:00-11:30 p.m.	0400-0430	R. Norway	B	11895 (Mon. only)
11:00-11:30 p.m.	0400-0430	R. Mozambique	C	4855, 3265

11:00-11:55 p.m.	0400-0455	R. Peking	B	17680, 15230, 15120
11:00-12:00 p.m.	0400-0500	R. Australia	B	21740, 21650, 21680, 21525, 17890, 17870, 17795, 17755, 17725, 15240, 15160
11:00 p.m.-1.00 a.m.	0400-0600	R. Moscow World Service	B	12060, 11920, 11735, 11720, 9665
11:00 p.m.-3:00 a.m.	0400-0800	R. Moscow	B	15180, 15100, 12050, 12000, 11720, 11690, 9710
11:05-11:50 p.m.	0405-0450	FEBA, Seychelles	C	11850 †
11:30-11:55 p.m.	0430-0455	Austrian R.	B	12015
11:30-12:00 p.m.	0430-0500	Swiss R. International	B	11715, 9725
11:30-12:00 p.m.	0430-0500	R. Sofia	B	11750 †
11:30 p.m.-2:00 a.m.	0430-0700	AFRTS-Washington	A	17765, 15430, 15330, 9755, 6030
11:45 p.m.12:45 a.m.	0445-0545	BBC	A	15070, 9510, 6175, 5975
11:55 p.m.-1:00 a.m.	0455-0600	V. of Nigeria	C	15119, 15185, 7255
12:00-12:15 a.m.	0500-0515	Kol Israel	B	21710, 15582, 15105, 11638
12:00-12:15 a.m.	0500-0515	R. Japan	C	15270
12:00-12:30 a.m.	0500-0530	R. Portugal	B	11925, 9575
12:00-1:00 a.m.	0500-0600	WYFR, Family R.	A	9705
12:00-1:00 a.m.	0500-0600	R. Australia	C	21680, 17890, 17870, 17725, 15240, 15160
12:00-2:00 a.m.	0500-0700	HCJB, Ecuador	B	9745, 6095, 11915, 26020
12:00-3:00 a.m.	0500-0800	R. Kuwait	C	21545 †
12:00-5:00 a.m.	0500-1000	V. of Cuba	B	600
12:15-1:15 a.m.	0515-0615	Spanish Foreign R.	B	11880, 9630
12:22-12:30 a.m.	0522-0530	UN Radio	A	9540, 6055 (Tue.-Sat.)
12:30-12:50 a.m.	0530-0550	V. of Germany	A	11905, 11705, 9650, 9545, 6100, 5960
12:30-1:25 a.m.	0530-0625	R. Nederland	B	9715, 6165
12:45-1:00 a.m.	0545-0600	Vatican R.	C	6190 or 6210
12:45-1:00 a.m.	0545-0600	UN Radio	A	9540, 6055 (Tue.-Sat.)
12:45-2:30 a.m.	0545-0730	BBC	B	15070, 11955, 11860, 9640, 9510, 6175
1:00-1:15 a.m.	0600-0615	R. Japan	C	15270
1:00-1:30 a.m.	0600-0630	V. of Germany	C	17875, 15275, 11905, 11765, 9700
1:00-1:30 a.m.	0600-0630	R. Norway	B	9645 (Mon. only)
1:00-1:30 a.m.	0600-0630	R. Australia	C	21680, 21525, 17870, 17795, 17725, 17755, 15240, 15160
1:00-2:00 a.m.	0600-0700	RAE, Argentina	C	9690 (Tue.-Sat.)
1:00-2:00 a.m.	0600-0700	R. RSA	C	21535, 17780, 15220
1:00-6:00 a.m.	0600-1100	HCJB, Ecuador	C	11900, 6135, (0700-1030 also 9745)
1:15-1:30 a.m.	0615-0630	R. Canada International	B	11960, 11825, 9760, 9590, 6140 (Mon-Fri)
1:25-3:00 a.m.	0625-0800	TWR, Monte Carlo	B	9495 † (Sun. to 1000)
1:25-3:55 a.m.	0625-0855	V. of Malaysia	C	15295, 12350, 9750
1:30-2:00 a.m.	0630-0700	R. Australia	B	21680, 17870, 17725, 15240, 15145
1:30-2:00 a.m.	0630-0700	Radio Polonia	B	9675, 7270
1:30-3:00 a.m.	0630-0800	R. Habana Cuba	A	9525
1:40-7:15 a.m.	0640-1215	R. New Zealand	C	11945 (from 1045, also 6105)
1:45-2:00 a.m.	0645-0700	R. Canada International	B	11960, 11825, 9760, 9590, 6140 (Mon-Fri)
1:45-2:00 a.m.	0645-0700	UN Radio	A	15125, 11735
1:57-4:55 a.m.	0657-0955	V. of Philippines	C	11950, 9579
2:00-2:15 a.m.	0700-0715	R. Japan	C	15270
2:00-2:30 a.m.	0700-0730	Swiss Radio Int.	C	21520, 15305, 9535, 6165
2:00-3:00 a.m.	0700-0800	Xandir Malta	C	9670 or 9550 † (Sat. only) (irregular)
2:00-3:00 a.m.	0700-0800	V. of Vietnam	C	7512, 9840, 6383
2:00-4:00 a.m.	0700-0900	AFRTS	C	21670
2:00-4:00 a.m.	0700-0900	R. Australia	B	21680, 17725, 15145, 11740, 9570
2:07-2:15 a.m.	0707-0715	UN Radio	A	17815, 15195 (Tue.-Sat.)
2:30-3:25 a.m.	0730-0825	R. Nederland	B	9770, 9715
2:30-3:00 a.m.	0730-0830	R. Korea	B	11810, 9870
2:30-4:00 a.m.	0730-0900	BBC	B	15070, 11955, 9640, 9510
2:30-6:30 a.m.	0730-1130	Solomon Isl. Broadcasting	C	9545 or 5020
2:37-2:45 a.m.	0737-0745	UN Radio	A	17815, 15195
2:45-4:30 a.m.	0745-0930	KTWR, Guam	B	11840
2:55 a.m.-fade	0755-	Action Radio, Guyana	C	5950
3:00-3:15 a.m.	0800-0815	R. Japan	B	9505
3:00-3:15 a.m.	0800-0815	UN Radio	A	17860, 15235, 15125, 11735
3:30-4:25 a.m.	0830-0925	R. Nederland	B	9715
3:30-5:00 a.m.	0830-1000	FEBC, Philippines	C	11765 or 11890

Explanatory Notes.

1. Times in first column are CDT. For ADT add 2 hours, EDT, add 1 hour. MDT, subtract 1 hour. PDT, subtract 2 hours. Days of week are in GMT. (Certain broadcasts from Belgium, France, East Germany, Hungary and Vatican are 1 hour earlier until Sept. 28).
2. Quality. A—strong signal and very reliable reception. B—regular reception. C—occasional reception under favorable conditions. D—rarely audible. These ratings are for locations in the central USA. European and African stations are in general, more reliably received in eastern North America. Asian and Pacific stations are more reliably received in western North America. North American stations are received well except in areas too close to the transmitter site.
3. The information in this listing is correct to press time. However, frequencies and schedules are constantly changing. Listen to "DX Digest" on R. Canada International for late changes, Sunday at 1807; 1915 (to Europe); 2015; GMT Mondays at 0006 and 0406.
4. R.—Radio; V.—Voice

† = frequent changes

Operation Assist

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

Westrex 9B2 transceiver and power supply 901B. Need operating manual and schematic. Richard G. Johnson, 405 Hilltop Road, Paoli, PA 19301.

Telequipment D52 oscilloscope. Need schematic and calibration manual. Arturo Misanes, 90-17 179th Place, Jamaica, NY 11432.

RCA model #167-B test oscillator. Need schematic and operating instructions. Guy Edwards, 104 Hancock, San Francisco, CA 94114.

Lavoie model LA 239A-ITX oscilloscope. Need schematic, service manual, or any available data. K.V. Taylor, 844 West Hillsdale Blvd., San Mateo, CA 94403.

Knight model KG-790 recorder, Teac #A-20 cassette and JVC-Nivico CHR-250UB recorder. Need service and maintenance manuals. C. T. Huth, 146 Schonhardt, Tiffin, OH 44883.

Electro Instruments model 883 digital multimeter. Need schematic and manual. Neil Feiereisel, 414 E. Knob Hill Dr., Arlington Hts., IL 60004.

Laboratory for Electronics model 401 oscilloscope. Need schematics and manual. Gary Foss, 1911A W. 38th, Austin, TX 78731.

Conar model 250 oscilloscope. Need schematic. Jim Marinell, 3174 Colony Lane, Plymouth Meeting, PA 19462.

Jackson Electrical Instrument Co., tube tester, model 648 tube tester. Need charts. John N. West, 517 South B St., Arkansas City, KS 67005.

Precision model 912 tube tester. Need schematic and operating manual. Guy Edwords, 104 Hancock, San Francisco, CA 94114.

Weskit model BN-1 radio transceiver. Need schematic. Max R. Otto, 733 West Benton St., Iowa City, IA 52240.

Pilot model 525 stereo receiver. Need schematic. Richard Berner, 12 Doris Lane, Middletown, NJ 07748.

Mercury model 1101 tube tester. Need operating instructions and schematic. Frank Schofield, 37 Leonard St., Smithtown, NY 11787.

RCA model AR-594 radio 44. Need schematic and operations manual. Brian Taussig, 196 E. Lassen Avenue, Chico, CA 95926.

U.S. Army Signal Corps. BC-603-DM radio receiver. Need operation manual or any available information. George Kelm, Box 160, Yap Island, Guam 96943.

Hickock models OS121C/USM-140 oscilloscope, MX3078B/USM horiz. plug-in and MX2930/USM dual trace plug-in. Need manuals and schematics. David Grause, 6800 Betts Ave, Cincinnati, OH 45239.

Precision Radiation Instruments model 107B geiger counter and Harman Kardon model T120 receiver. Need schematics, service manuals and operation manuals. William Johnston, 2513 Cleveland ay, Bakersfield, CA 93304.

Precision Radiation Instruments model 107B professional geiger counter. Need service manual, schematic, parts list. Rudy Vener, 7 Old Hyde Rd, Weston, CN 06883.

Knight-Kit model KG-400 stereo amplifier. Need schematic and service manual. Francis Lentricchia, 3779 Bames Hill Rd., Horseheads, NY 14845.

Globe Electronics scout deluxe AM/CW transmitter. Need schematic and operation manual. Michael Nadeau, 28 King St., Waterville, ME 04901.

Solar model CF capacitor analyzer. Need operating and service manuals. E.J. Homa, 2936 5th St., Muskegon Hts, MI 49444.

Hy-Gain 10 channel scanner chassis programmable. Need schematic and any information available. Glen P. Bauer, 4756 Sherwood Drive, Indian River, MI 49749.

PROJECT OF THE MONTH

Hall-Effect Magnetic Sensor

BY FORREST M. MIMS

THE Hall effect, discovered in 1879, is the production of a voltage drop across a conductor or semiconductor through which a current is flowing under the influence of a magnetic field at right angles to the direction of current flow. Several types of semiconductor components that employ the Hall effect have been designed, one of which is the Hall-effect digital switch.

Figure 1 is the pinout and block diagram of a UGN-3020T Hall-effect switch. The chip, which is manufactured by the Sprague Electric Company, includes a self-contained amplifier that boosts the voltage generated by the Hall sensor and presents it to a Schmitt trigger. When the output of the amplifier exceeds a certain threshold, the Schmitt trigger turns on the output transistor.

The hysteresis of the Schmitt trigger prevents the circuit from oscillating when the amplifier output is near the turn-on threshold. In other words, the Schmitt trigger turns off only when the intensity of the magnetic field falls well below the level required initially to turn the Schmitt trigger on. Figure 2 summarizes the circuit's operation.

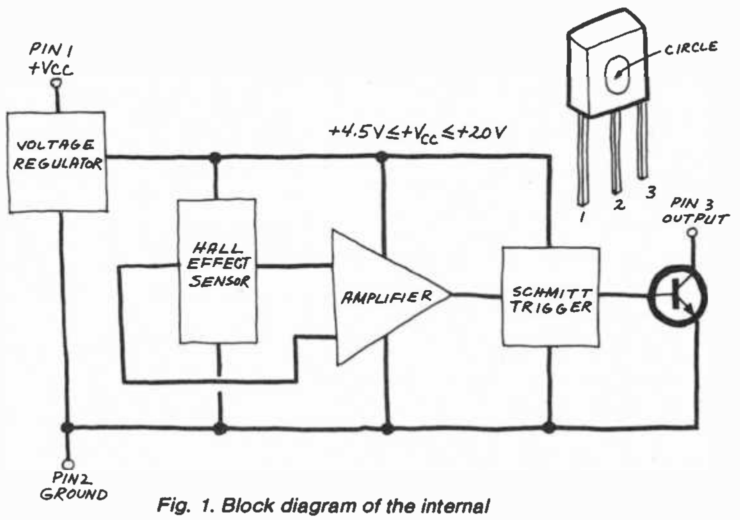


Fig. 1. Block diagram of the internal operation of a UGN-3020T Hall-effect switch.

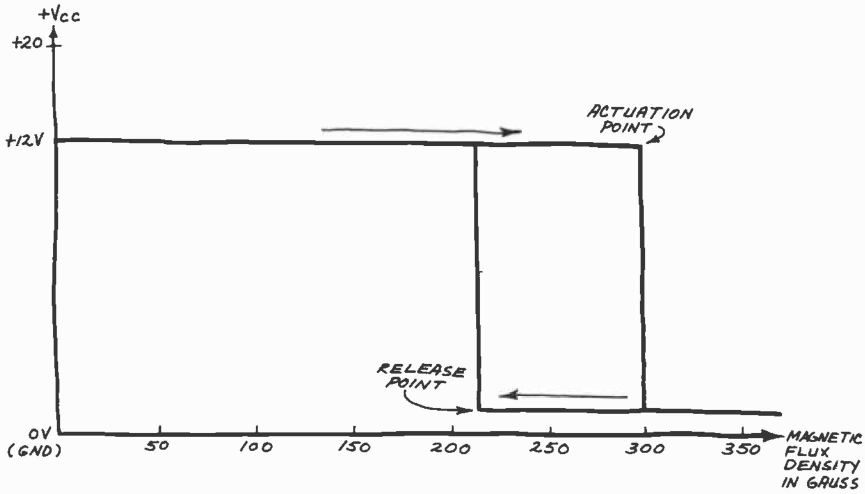


Fig. 2. Switching action, showing hysteresis, of a UGN-3020T.

As you can see by referring back to Fig. 1, the UGN-3020T includes its own voltage regulator. This permits the chip to be powered by a supply furnishing from 4.5 volts to as much as 20 volts. Typical current consumption is 12 mA when the supply voltage is 12 volts.

Figure 3 shows a simple circuit that you can use to experiment with the UGN-3020T or similar Hall-effect switch. The UGN-3020T is available from Sprague distributors. Alternatively, you can use Radio Shack's No. 276-1646 Hall effect switch because its specifications are identical to the UGN-3020T.

Figure 4 shows the optimum orientation of the trigger magnet with respect to the Hall-effect switch. To actuate the circuit shown in Fig. 3, place a magnet close to the circle on the package of the Hall-effect switch and adjust its position with respect to the switch package until the LED begins to glow. When this occurs, the south pole of the magnet will be closest to the switch.

To turn the LED off, move the magnet away from the chip. Note that the hysteresis of the switch allows the magnet to be moved several times more distant from the chip before the LED goes dark than the spacing at which the LED began to glow.

You can use many different kinds of magnets to activate the switch. The flexible magnets used in refrigerator door gaskets work, but not very well. The samples I tried (which are more than ten years old) had to be placed within a millimeter of the chip package's surface before the LED would begin to glow.

Metal magnets work much better. Some that I have tried will cause the LED to glow when the magnet is several millimeters from the chip. The LED will continue to glow until the magnet has been removed as much as a few centimeters from the chip. Incidentally, I tried without success to activate the circuit with lodestones (naturally occurring pieces of magnetite).

PROJECT OF THE MONTH *continued*

Good sources for powerful magnets include small defective motors and discarded speakers. Try radio and television repair shops and automobile junk yards. You might be able to obtain at a refrigerator repair shop some flexible magnets from now-useless door gaskets. The cost of these items should range from nothing to minimal. Edmund Scientific Company (101 E. Gloucester Pike, Barrington, NJ 08007) stocks dozens of magnet types, some of which are rated at 8,000 Gauss!

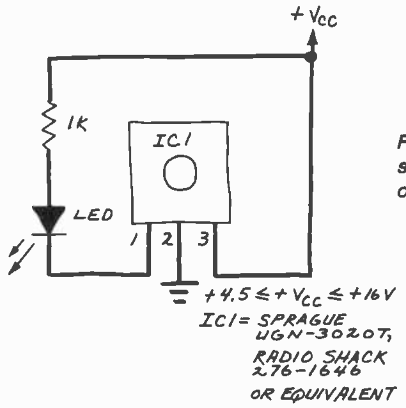


Fig. 3. A simple circuit showing operation of a Hall-effect switch.

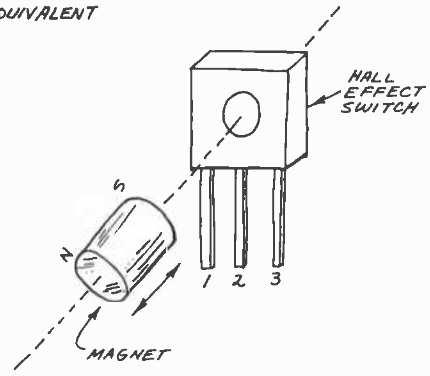


Fig. 4. How to orient a magnet with respect to a Hall-effect switch

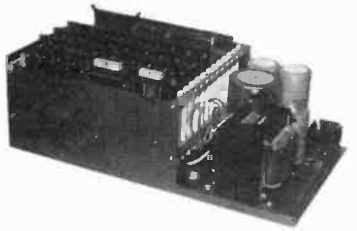
You might want to activate the Hall-effect switch with an electromagnet. I tried several small electromagnets that I had purchased from Edmund Scientific several years ago (they're no longer in stock) and that worked moderately well. However, the core of a 6-volt relay failed to activate the switch even when it was operated at 12 volts and was placed in direct contact with the Hall-effect switch. You can make your own electromagnet by wrapping several hundred turns of small-diameter enamelled copper wire around a large nail or a bundle of several small ones.

Applications. Now that you know how to use a Hall-effect switch, you've probably begun to think about possible applications. Hall-effect switches provide bounce-free operation and are very fast—typical rise and fall times of 15 and 100 nanoseconds, respectively. Accordingly, they're ideal for use in keyboards and in mechanical switches connected to digital-logic circuits. Such switches and keys employ self-contained magnets that are moved toward Hall-effect switches by plungers or cams.

The company that pioneered many Hall effect switch applications, Micro Switch, supplies Hall-effect switches that replace the traditional breaker-points in the Plymouth Horizon automobile's ignition system. Hall-effect switches made by Micro Switch and other companies are also used in brushless motors, interlocks, telephone line-current sensors, tire-pressure monitors, sewing machines, flow meters and even miniature signal pickups for electric guitars.

How reliable are they? Micro Switch has been testing Hall-effect switches since 1968 and reports that such devices have logged nearly 20 *billion* successful operations! Hall-effect switches employed in experimental mechanical hearts that have been implanted in calves have performed more than 42,000,000 operations without failure. In short, the Hall effect switch is an exceptionally reliable component, especially when compared to conventional mechanical switches! ◇

S-100 S-100 S-100 S-100



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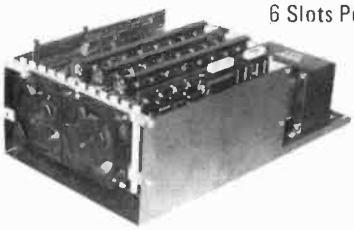

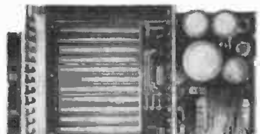

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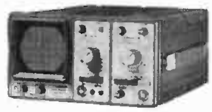


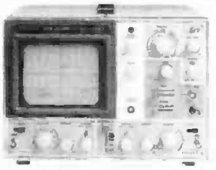
10 Megahertz
HM307
SINGLE TRACE OSCILLOSCOPE

- IDEAL SERVICE INSTRUMENT
- TIMEBASE 0.2 μs-0.2 s/cm
- LPS-TRIGGER ■ COMPACT
- BUILT-IN COMPONENT TESTER $404.25

20 Megahertz
HM312
DUAL TRACE OSCILLOSCOPE

- 10 × 8 cm DISPLAY
- LPS-TRIGGERING
- BANDWIDTH DC—20MHz
- TRIGGERING up to 30MHz
- FULL X—Y OPERATION $609.00

30 MHz **HITACHI** Dual Trace Oscilloscope



- TV sync-separater circuit
- High-sensitivity 1mV/div (5MHz)
- Sweep-time magnifier (10 times)
- Z-axis input (Intensity modulation)
- Signal delay line
- X-Y operation
- Trace Rotation

$945.00

More sensitive to your input

2716 EPROM
5 volt
16K
$18.80
Order 2pcs and Get 5% Discount
Order 5pcs and Get 10% Discount

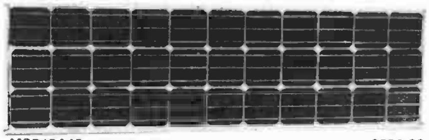
LIQUID CRYSTAL DISPLAY
1.8:8.8
- High Contrast Ratio
- Wide Viewing Angle
- 0.5 in. Digit Height
- ULTRA Low Power Consumption

LCD106 .... $13.50

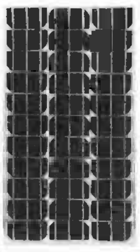
MOTOROLA
SOLAR SYSTEMS

40 WATT HIGH DENSITY SOLAR MODULE

- High Packing Density (82% of total area) using 100 mm x 100 mm square cells
- Designed to Exceed JPL Block 4 Requirements
- High Reliability due to Redundant Interconnects
- Across-The-Cell Contacts Eliminate Potential Power Loss Due to Cracked Cells
- Metric Dimensions, 340 mm by 1200 mm
- 33 Cells In Series
- Low Cell Temperature, NOCT = 45C
- 40 Watts Peak Power
- Exceeds National Electrical Code
- Maintenance Free Construction, Tempered Glass Superstrate.; Stainless Steel Frame



MSP43A40 .... $836.00



20 WATT SOLAR MODULE

- High Reliability due to Redundant Interconnects
- Across-The-Cell Contacts Eliminate Potential Power Loss Due to Cracked Cells
- 33 Cells in Series
- 20 Watts Peak Power
- Maintenance Free Construction, Tempered Glass Superstrate, Stainless Steel Frame
- Low Cell Temperature, NOCT = 45C
- Metric Dimensions, 355 mm x 660 mm
- Designed to Exceed JPL Block 4 Requirements

MSP23A20 .... $523.00

Intersil LED or LCD 3½ DIGIT PANEL METER KITS

BUILD A WORKING DPM IN ½ HOUR WITH THESE COMPLETE EVALUATION KITS

Test these new parts for yourself with Intersil's low cost prototyping kits, complete with A/D converter and LCD display (7106) or LED display (7107). Kits provide all materials, incl PC board, for a functioning panel meter.

ICL7106EV (LCD) .... $34.45 ICL7107EV (LED) $28.70

8 Digit - 10 MHz Universal Counter Kit

Kit Includes:
- ICM7226AIDC IC
- 10 MHz Quartz Crystal
- (8) 7 Segment .3" LED Displays
- PC Board
- Resistors
- Capacitors
- Diodes
- Switches
- IC Socket

Order Part Number ICM7226AEV $74.95

Capacitance Meter

- Easy to use - plug in capacitor, push range button and read the value to 0.1%
- 0.5 in. liquid crystal display
- Exclusive "Δcharge/Δvolt" measurement circuit (patent pending) holds ±0.1% basic accuracy for a full year.
- Up to 200 hrs operation on standard 9V Batt.
- 8 easy pushbutton ranges cover 0.1pf to 1999 microfarads.
- Best of all it's easy on the budget - only

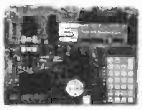
MODEL 938 $179

Power Supplies from ADTECH POWER

Model	Vdc	Amps	Model	Vdc	Amps
APS 5-3	5	3.0	APS 5-6	5	6.0
APS 12-1.6	12	1.6	APS 12-4	12	5.0
APS 15-1.5	15	1.5	APS 15-3	15	3.0
APS 24-1	24	1.0	APS 24-2.2	24	2.2

1-9	10 up	25 up	1-9	10 up	25 up
$42.50	$40.65	$38.85	$66.90	$64.00	$61.10

SYM-1 NEW LOW PRICE



$239.00

KTM-2 CRT/TV Kybd Term $349

FLUKE

8020A $179
8022A $139
8024A $219

Sanken HYBRID AUDIO POWER AMPLIFIERS

P/N	* Matching Transformer
SI-1010G(10W) $ 6.95	TR10 $ 7.90
SI-1020G(20W) $13.95	TR20 $10.90
A-SI-8(Socket for above)	.95
SI-1030G(30W) $19.00	TR30 $12.90
SI-1050G(50W) $27.80	TR50 $17.90
A-SI-10(Socket for above)	.95

* Note: One Transformer can power two audio amplifiers.

ANCRONA

Send check or Money Order to: P.O. Box 2208P, Culver City CA 90230. California residents add 6% sales tax. Minimum Order: $10.00 Add $1.00 to cover postage and handling. Master Charge and Visa welcomed. Please include your charge card number, interbank number and expiration date. PHONE ORDERS: (213) 641-4064

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CIRCLE NO. 3 ON FREE INFORMATION CARD

BLAK-RAY Ultraviolet Intensity Meter

TWO MODELS: LONG WAVE AND SHORT WAVE

Meter consists of a sensor cell attached to a compact (3" x 3¼" x 3") metering unit. Can be hand-held or placed directly on surface for measuring. Can be used remotely, while connected to a meter housing by a 4-foot extension cord. Two models available – one for long wave and one for short wave ultraviolet. Readings are in microwatts per square centimeter. Weight: 1 lb.

Completely assembled (includes sensor cell, reduction screen, extension cord, contrast filter and certification report.)

J-221 LONG WAVE (300nm-400nm) **$242.00**

J-225 SHORT WAVE (200nm-280nm) **$260.00**

EPROM Erasing Lamp

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

UVS-11E $79.50

Jumbo 6-Digit Clock Kit

* Four .630"ht. and two .300"ht. common anode displays
* Uses MM5314 clock chip
* Switches for hours, minutes and hold functions
* Hours easily viewable to 30 feet
* Simulated walnut case
* 115 VAC operation
* 12 or 24 hour operation
* Includes all components, case and wall transformer
* Size: 6¾ x 3⅛ x 1¾

JE747 .... $29.95

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

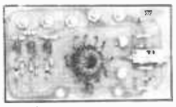
JE701

6-Digit Clock Kit $19.95

Regulated Power Supply

Uses LM309K. Heat sink provided. PC board construction. Provides a solid 1 amp @ 5 volts. Can supply up to ±5V, ±9V and ±12V with JE205 Adapter. Includes components, hardware and instructions. Size: 3½" x 5" x 2"H

JE200....... $14.95



ADAPTER BOARD – Adapts to JE200 – ±5V, ±9V and ±12V

DC/DC converter with +5V input. Toriodal hi-speed switching XMFR. Short circuit protection. PC board construction. Piggy-back to JE 200 board. Size: 3½" x 2" x 9/16"H

JE205 .... $12.95

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES		
8080A	CPU	$ 7 95
8212	8-Bit Input/Output	3.25
8214	Priority Interrupt Control	5.95
8216	Bi-Directional Bus Driver	3.49
8224	Clock Generator/Driver	3.95
8226	Bus Driver	3 49
8228	System Controller/Bus Driver	4 95
8238	System Controller	5.95
8251	Prog Comm I/O (USART)	7.95
8253	Prog Interval Timer	14.95
8255	Prog Periph I/O (PPI)	9.95
8257	Prog DMA Control	19.95
8259	Prog Interrupt Control	14.95

6800/6800 SUPPORT DEVICES		
MC6800	MPU	$14.95
MC6802CP	MPU with Clock and Ram	19.95
MC6810API	128X8 Static Ram	4.95
MC6821	Periph. Inter Adapt (MC6820)	7.49
MC6828	Priority Interrupt Controller	10.95
MC6830L8	1024X8 Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm Adapter	6.95
MC6852	Synchronous Serial Data Adapt.	6.95
MC6860	0-600 bps Digital MODEM	10.95
MC6862	2400 bps Modulator	12.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS—MISCELLANEOUS		
Z80(780C)	CPU	$13.95
Z80A(780-1)	CPU	15.95
CDP1802	CPU	19.95
2650	MPU	16.95
6502	CPU	11 95
8035N6	8-Bit MPU w/clock, RAM, I/O lines	19 95
P8085	CPU	19.95
TMS9900JL	16-Bit MPU	49 95

SHIFT REGISTERS		
MM500H	Dual 25 Bit Dynamic	$ 50
MM503H	Dual 50 Bit Dynamic	50
MM506H	Dual 100 Bit Static	.50
MM510H	Dual 64 Bit Accumulator	.50
MM5016H	500/512 Bit Dynamic	89
2504(1404A)	1024 Dynamic	3.95
2518	Hex 32 Bit Static	4 95
2522	Dual 132 Bit Static	2 95
2524	512 Bit Dynamic	99
2525	1024 Dynamic	2.95
2527	Dual 256 Bit Static	2.95
2528	Dual 250 Static	4 00
2529	Dual 240 Bit Static	4 00
2532	Quad 80 Bit Static	2 95
3341	Fifo	6.95
74LS670	4X4 Register File (TriState)	2.49

UART'S		
A-Y-5-1013	30K BAUD	5.95

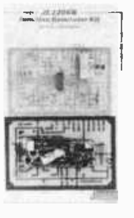
MICROPROCESSOR MANUALS		
M-Z80	User Manual	$7.50
M-CDP1802	User Manual	7.50
M-2650	User Manual	5.00

ROM'S		
2513(2140)	Character Generator(upper case)	$9.95
2513(3021)	Character Generator(lower case)	9.95
2516	Character Generator	10.95
MM5230N	2048-Bit Read Only Memory	1.95

RAM'S			
1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(8101)	256X4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
2111(8111)	256X4	Static	3.95
2112	256X4	Static MOS	4.95
2114	1024X4	Static 450ns	5.95
2114L	1024X4	Static 450ns low power	6.95
2114-3	1024X4	Static 300ns	7.49
2114L-3	1024X4	Static 300ns low power	7.95
5101	256X4	Static	7.95
5280/2107	4096X1	Dynamic	4 95
7489	16X4	Static	1 75
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
MM5290-2	16K	Dynamic 16 pin 150NS (UPD416/MK4116)	6.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1 00

PROM'S			
1702A	2048	FAMOS	$5 95
2716	16K*	EPROM (Intel)	29.95
TMS2516	16K*	EPROM (2716)	19.95
	*Requires single +5V power supply		
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716 T.I	16K**	EPROM	29.95
	**Requires 3 voltages, –5V, +5V, +12V		
5203	2048	PROM	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123(5610)	32X8	Tristate	3.95
74188	512	TTL Open Collector	9 95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	4.95

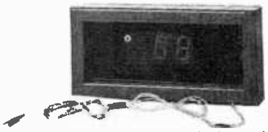
Function Generator Kit



Provides 3 basic waveforms: sine, triangle and square wave. Freq. range from 1 Hz to 100K Hz. Output amplitude from 0 volts to over 6 volts (peak to peak). Uses a 12V supply or a ±6V split supply. Includes chip, P.C. Board, components & instructions.

JE2206B....$19.95

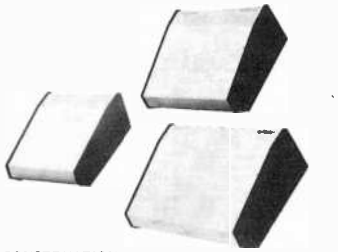
DIGITAL THERMOMETER KIT



- Dual sensors–control switch for indoor/outdoor or dual monitoring–extension up to 500 feet
- Continuous LED .8" ht. display
- Range: -40°F to 199°F / -40°C to 100°C
- Accuracy: ±1° nominal
- Calibrate for Fahrenheit/Celsius reading
- Sim. walnut case–AC wall adapter incl.
- Size: 3¼"H x 6-5/8"W x 1-3/8"D

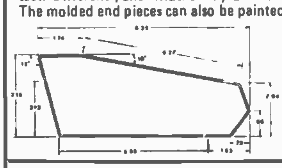
JE300 ....$39.95

DESIGNERS' SERIES
Blank Desk-Top Electronic Enclosures



- High strength epoxy molded end pieces in mocha brown finish.
- Sliding rear/bottom panel for service and component accessibility.
- Top/bottom panels .080 thk alum. Alodine type 1200 finish (gold tint color) for best paint adhesion after modification.
- Vented top and bottom panels for cooling efficiency.
- Rigid construction provides unlimited applications.

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



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

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

Spec Sheets – 25¢
1981 Catalog Available – Send 41¢ stamp

NEW 1981 CATALOG

Jameco ELECTRONICS

PHONE ORDERS WELCOME (415) 592-8097

MAIL ORDER ELECTRONICS – WORLDWIDE
1355 SHOREWAY ROAD, BELMONT, CA 94002
PRICES SUBJECT TO CHANGE

10/80

National Semiconductor

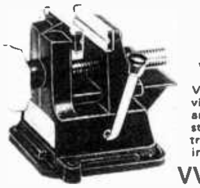
RAM SALE

MM5290J-2 (MK4116/UPD416)... **$6.95 each**
16K DYNAMIC RAM (150NS)
(8 EACH $49.95) (100 EACH $550.00/lot)

MM5298J-3A .... **$3.25 each**
8K DYNAMIC RAM (LOW HALF OF MM5290J) 200NS
(8 EACH $23.95) (100 EACH $250.00/lot)

MM2114-3 .... **$5.95 each**
4K STATIC RAM (300NS)
(8 EACH $43.95) (100 EACH $450.00/lot)

MM2114L-3 .... **$6.25 each**
4K STATIC RAM (LOW POWER 300NS)
(8 EACH $44.95) (100 EACH $475.00/lot)



ok

Vacuum Vise

Vacuum-based light-duty vise for small components and assemblies. ABS construction. 1⅞" jaws. 1¼" travel. Can be permanently installed.

VV-1......$3.49

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K.
Kit comes complete with:
* 8 each MM5290-2 (UPD416) (16K Dynamic Rams) 150NS
* Documentation for conversion

TRS-16K $49.95

JE610 ASCII Encoded Keyboard Kit

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

JE610 (Case not included) **$79.95**

Desk-Top Enclosure for JE610 ASCII Encoded Keyboard Kit

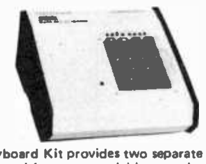
Compact desk-top enclosure: Color-coordinated designer's case with light tan aluminum panels and molded end pieces in mocha brown. Includes mounting hardware. Size: 3½"H x 14½"W x 8¾"D.

DTE-AK $49.95

SPECIAL: JE610/DTE-AK PURCHASED TOGETHER (Value $129.90) $124.95

JE600 Hexadecimal Encoder Kit

FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD



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

JE600 (Case not included) **$59.95**

Desk-Top Enclosure for JE600 Hexadecimal Keyboard Kit

Compact desk-top exclosure: Color-coordinated designer's case with light tan aluminum panels and molded end pieces in mocha brown. Includes mounting hardware. Size: 3½"H x 8¼"W x 8¾"D.

DTE-HK $44.95

SPECIAL: JE600/DTE-HK PURCHASED TOGETHER (Value $104.90) $99.95

7400 TTL

SN7400N	.25	SN7470N	.29	SN74160N	.89
SN7401N	.20	SN7472N	.29	SN74161N	.89
SN7402N	.25	SN7473N	.35	SN74162N	.89
SN7403N	.25	SN7474N	.35	SN74163N	.89
SN7404N	.25	SN7475N	.49	SN74164N	.89
SN7405N	.25	SN7476N	.35	SN74165N	.89
SN7406N	.35	SN7479N	5.00	SN74166N	1.25
SN7407N	.35	SN7480N	.50	SN74167N	1.95
SN7408N	.25	SN7482N	.99	SN74170N	1.95
SN7409N	.25	SN7483N	.69	SN74172N	6.00
SN7410N	.25	SN7485N	.89	SN74173N	1.25
SN7411N	.25	SN7486N	.35	SN74174N	.99
SN7412N	.35	SN7489N	1.75	SN74175N	.89
SN7413N	.40	SN7490N	.49	SN74176N	.79
SN7414N	.85	SN7491N	.59	SN74177N	.79
SN7416N	.29	SN7492N	.43	SN74179N	1.95
SN7417N	.29	SN7493N	.43	SN74180N	.79
SN7420N	.20	SN7494N	.65	SN74181N	1.95
SN7421N	.29	SN7495N	.65	SN74182N	.79
SN7422N	.39	SN7496N	.65	SN74184N	2.25
SN7423N	.29	SN7497N	3.00	SN74185N	2.25
SN7425N	.29	SN74100N	1.49	SN74186N	9.95
SN7426N	.29	SN74107N	.35	SN74188N	3.95
SN7427N	.25	SN74109N	.39	SN74190N	1.25
SN7429N	.39	SN74116N	1.95	SN74191N	1.25
SN7430N	.25	SN74121N	.39	SN74192N	.89
SN7432N	.25	SN74122N	.39	SN74193N	.89
SN7437N	.25	SN74123N	.59	SN74194N	.89
SN7438N	.40	SN74125N	.49	SN74195N	.69
SN7439N	.25	SN74126N	.49	SN74196N	.89
SN7440N	.20	SN74132N	.75	SN74197N	.89
SN7441N	.89	SN74136N	.75	SN74198N	1.49
SN7442N	.59	SN74141N	.79	SN74199N	1.49
SN7443N	.75	SN74142N	2.95	SN74S200	4.95
SN7444N	.75	SN74143N	2.95	SN74251N	.99
SN7445N	.75	SN74144N	2.95	SN74279N	.79
SN7446N	.79	SN74145N	.79	SN74283N	2.25
SN7447N	.69	SN74147N	1.95	SN74284N	3.95
SN7448N	.79	SN74148N	1.29	SN74285N	3.95
SN7450N	.20	SN74150N	1.25	SN74365N	.69
SN7451N	.20	SN74151N	.59	SN74366N	.69
SN7453N	.20	SN74152N	.59	SN74367N	.69
SN7454N	.20	SN74153N	.79	SN74368N	.69
SN7459A	.25	SN74154N	1.25	SN74390N	1.95
SN7460N	.20	SN74155N	.79	SN74393N	1.95
		SN74156N	.79		
		SN74157N	.65		

CMOS

CD4000	.39	CD4028	.89	CD4070	.55
CD4001	.39	CD4029	1.49	CD4071	.49
CD4002	.39	CD4030	.49	CD4072	.49
CD4006	1.19	CD4035	.99	CD4076	1.39
CD4007	.25	CD4040	1.49	CD4081	.39
CD4009	.49	CD4041	1.49	CD4082	.39
CD4010	.49	CD4042	.99	CD4093	.99
CD4011	.39	CD4043	.89	CD4098	1.19
CD4012	.25	CD4044	.89	MC14409	14.95
CD4013	.49	CD4046	1.79	MC14410	14.95
CD4014	1.39	CD4047	2.50	MC14411	14.95
CD4015	1.19	CD4048	1.35	MC14419	4.95
CD4016	.59	CD4049	.49	MC14433	13.95
CD4017	1.19	CD4050	.49	MC14506	.75
CD4018	.99	CD4051	1.19	MC14507	.99
CD4019	.49	CD4053	1.19	MC14562	11.95
CD4020	1.19	CD4056	2.95	MC14583	2.49
CD4021	1.39	CD4059	9.95	CD4508	3.95
CD4022	1.19	CD4060	1.49	CD4510	1.39
CD4023	.29	CD4066	.79	CD4511	1.29
CD4024	.79	CD4068	.39	CD4515	2.95
CD4025	.23	CD4069	.45	CD4518	1.79
CD4026	2.95			CD4520	1.29
CD4027	.69			CD4566	2.25

74C00

74C00	.39	74C85	1.95	74C163	1.69
74C02	.39	74C90	1.29	74C164	1.59
74C04	.39	74C93	1.29	74C173	1.39
74C08	.39	74C95	1.59	74C192	1.69
74C10	.39	74C107	1.89	74C193	1.69
74C14	.75	74C151	2.95	74C195	1.59
74C20	.39	74C154	3.95	74C922	5.49
74C30	.39	74C157	2.25	74C923	5.75
74C42	1.39	74C160	1.69	74C925	7.50
74C48	1.95	74C161	1.69	74C926	7.50
74C73	.79			80C95	.79
74C74	.79			80C97	.79

LINEAR

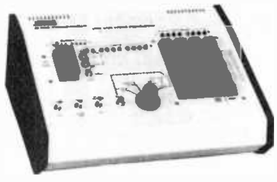
78MG	1.75	LM340K-18	1.35	LM710N	.79
LM106H	.99	LM340K-24	1.35	LM711N	.39
LM300H	.80	LM340T-5	1.25	LM723N/H	.55
LM301CN/H	.35	LM340T-6	1.25	LM733N	1.00
LM302H	1.75	LM340T-8	1.25	LM739N	1.19
LM304H	1.49	LM340T-12	1.25	LM741CN/H	.35
LM305H	.79	LM340T-15	1.25	LM741-14N	.39
LM307CN/H	.45	LM340T-18	1.25	LM747N/H	.79
LM308CN/H	1.00	LM340T-24	1.25	LM748N/H	.39
LM309H	1.10	LM358N	1.00	LM1310N	1.95
LM309K	1.25	LM370N	1.95	LM1458CN/H	.59
LM310CN	1.95	LM373N	3.25	MC1488N	1.95
LM311N/H	.90	LM377N	2.95	MC1489N	1.95
LM312H	1.95	LM380N	1.25	LM1496N	.95
LM317K	3.95	LM380CN	.99	LM1556V	1.75
LM318CN/H	1.95	LM381N	1.79	MC1741SCP	3.00
LM319N	1.30	LM382N	1.79	LM2111N	1.95
LM320K-5	1.35	NE510A	6.00	LM2901N	1.95
LM320K-5.2	1.35	NE529A	4.95	LM3053N	1.50
LM320K-12	1.25	NE531H/V	3.95	LM3065N	1.49
LM320K-15	1.35	NE536T	6.00	LM3900N(3401)	.59
LM320K-18	1.35	NE540	6.00	LM3905N	1.49
LM320K-24	1.35	NE544N	4.95	LM3909N	1.25
LM320T-5	1.25	NE550N	1.30	MC5558V	.59
LM320T-5.2	1.25	NE555V	.39	8038B	4.95
LM320T-8	1.25	NE556N	.99	LM75450N	.49
LM320T-12	1.25	NE560B	5.00	75451CN	.39
LM320T-15	1.25	NE562B	5.00	75452CN	.39
LM320T-18	1.25	LM565N/H	1.25	75453CN	.39
LM320T-24	1.25	LM566CN	1.75	75454CN	.39
LM323K-5	5.95	LM567V/H	.99	75491CN	.79
LM324N	.99	NE570N	4.95	75492CN	.89
LM339N	.99	LM703CN/H	.69	75493N	1.25
LM340K-5	1.35	LM709N/H	.29	75494CN	1.25
LM340K-6	1.35			RC4136	1.25
LM340K-8	1.35			RC4151	3.95
LM340K-12	1.35			RC4194	4.95
LM340K-15	1.35			RC4195	4.49

74LS00 TTL

74LS00	.35	74LS51	.29	74LS139	1.05
74LS01	.35	74LS54	.29	74LS151	1.05
74LS02	.35	74LS55	.29	74LS155	1.05
74LS03	.35	74LS73	.54	74LS157	1.05
74LS04	.42	74LS74	.54	74LS160	1.15
74LS05	.42	74LS75	.71	74LS161	1.39
74LS08	.35	74LS76	.54	74LS162	1.25
74LS09	.42	74LS78	.49	74LS163	1.39
74LS10	.35	74LS83	1.05	74LS164	1.50
74LS11	.75	74LS85	1.50	74LS175	1.25
74LS13	.59	74LS86	.54	74LS181	2.49
74LS14	1.25	74LS90	.71	74LS190	1.25
74LS15	.35	74LS92	.90	74LS191	1.25
74LS20	.35	74LS93	.90	74LS192	1.39
74LS21	.35	74LS95	.99	74LS193	1.39
74LS22	.35	74LS96	1.15	74LS194	1.39
74LS26	.35	74LS107	.54	74LS195	1.39
74LS27	.35	74LS109	.54	74LS253	1.25
74LS28	.35	74LS112	.54	74LS257	1.05
74LS30	.35	74LS123	1.50	74LS258	1.75
74LS32	.42	74LS125	1.05	74LS260	.83
74LS37	.45	74LS132	.99	74LS279	.90
74LS40	.35	74LS136	.59	74LS367	.75
74LS42	1.05	74LS138	1.05	74LS368	.75
74LS47	1.05			74LS670	2.49

JE608 PROGRAMMER

2704/2708 EPROM PROGRAMMER



- 3 separate Display Registers: 8 LED's for Hex Key entries, 10 LED's (2^8 2^9) for Address Register and 8 LED's for Data Memory Register. The Data Memory Register displays the content of the RAMs from the EPROM Chip.
- Development of microprogram systems by means of a ribbon cable from the programmer panel test socket to the EPROM socket on the microprocessor board.
- Rapid checking verification of programmed data changes.
- Use may move data from a master to RAM's or write into RAM's with keyboard entries.
- Allows manual stepping manipulation (up and down) at any address location.
- Stand alone EPROM Programmer consisting of A 19-key Hexadecimal Keyboard assembly, Programmer Board assembly with 4 power supplies and a LEO/Test Socket Panel Board assembly. The Test Socket is zero force insertion type. Power requirements: 115VAC, 60Hz, 8W.
- Compact desk-top enclosure. Color-coordinated designer's case with light tan panels and molded end pieces in mocha brown. Size 3¾"H x 11"W x 8¾"D. Weight: 5 lbs.

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

JE608K KIT $399.95
JE608A Assembled and tested $499.95

DISCRETE LEDS

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

INFRA-RED LED
¼"x¼"x1/16" flat
IRL — 5/$1

DISPLAY LEDS

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

Type	Polarity	Ht	Price	Type	Polarity	Ht	Price
MAN 1	C.A.—red	.270	2.95	DL707	C.A.—red	.300	.99
MAN 2	5x7 D.M.—red	.300	4.95	DL728	C.C.—red	.500	1.49
MAN 3	C.C.—red	.125	.25	DL741	C.A.—red	.600	1.25
MAN 4	C.C.—red	.187	1.95	DL746	C.A.—red ± 1	.630	1.49
MAN 7G	C.A.—green	.300	1.25	DL747	C.A.—red	.600	1.49
MAN 7Y	C.A.—yellow	.300	.99	DL750	C.C.—red	.600	1.49
MAN 72	C.A.—red	.300	.75	DL338	C.C.—red	.110	.35
MAN 74	C.C.—red	.300	1.25	FND70	C.C.	.250	.69
MAN 82	C.A.—yellow	.300	.49	FND358	C.C. ± 1	.357	.99
MAN 84	C.C.—yellow	.300	.99	FND359	C.C.	.357	.75
MAN 3620	C.A.—orange	.300	.49	FND503	C.C. (FND500)	.500	.99
MAN 3630	C.A.—orange ± 1	.300	.99	FND507	C.A. (FND510)	.500	.99
MAN 3640	C.C.—orange	.300	.99	5082-7730	C.A.—red	.300	.99
MAN 4610	C.A.—orange	.300	.99	HDSP-3400	C.A.—red	.800	1.50
MAN 4810	C.A.—yellow	.400	.99	HDSP-3403	C.C.—red	.800	1.50
MAN 4840	C.C.—yellow	.400	.99	5082-7613	C.C., R.H.D.—red	.300	1.25
MAN 6610	C.A.—orange—DD	.560	.99	5082-7620	C.A., L.H.D.—yel.	.300	1.25
MAN 6630	C.A.—orange ± 1	.560	.99	5082-7623	C.C., R.H.D.—yel.	.300	1.25
MAN 6640	C.C.—orange—DD	.560	.99	5082-7730	C.A., L.H.D.—red	.300	.99
MAN 6650	C.C.—orange ± 1	.560	.99	5082-7731	C.A., R.H.D.—red	.300	1.25
MAN 6660	C.A.—orange	.560	.99	5082-7750	C.A., L.H.D.—red	.430	1.25
MAN 6710	C.A.—red—DD	.560	.99	5082-7751	C.A., R.H.D.—red	.430	1.25
MAN 6750	C.C.—red ± 1	.560	.99	5082-7760	C.C., R.H.D.—red	.430	1.25
MAN 6760	C.A.—red	.560	.99	5082-7300	4x7 sgl. dig. RHDP	.600	19.95
MAN 6780	C.C.—red	.560	.99	5082-7302	4x7 sgl. dig. LHDP	.600	19.95
DL701	C.A.—red ± 1	.300	.99	5082-7304	Overnge.char. (±1)	.600	15.00
DL704	C.C.—red	.300	.99	5082-7340	4x7 sgl. dig. hex.	.600	22.50

RCA LINEAR

CA3013T	2.15	CA3082N	2.00
CA2023T	3.25	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	1.25	CA3401N	.59
CA3081N	2.00	CA3600N	3.50

CALCULATOR CHIPS/DRIVERS

MM5725	$2.95
MM5738	2.95
DM8864	2.00
DM8865	1.00
DM8887	.75
DM8889	.75
9374 7-seg. LED driver	1.50
MM5309	4.95

CLOCK CHIPS

MM5309	4.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5418	9.95
MM5369	2.95
MM5377	4.95
MM5387/1998a	4.95

MOTOROLA

MC1408L7	4.95
MC1408L8	5.75
MC1439L	2.95
MC3022P	2.95
MC3061P	3.50
MC4016(74416)	7.50
MC4024P	3.95
MC4040P	6.95
MC4044P	4.50

LOW PROFILE (TIN) SOCKETS

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

SOLDERTAIL STANDARD (TIN)

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

SOLDERTAIL (GOLD) STANDARD

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

WIRE WRAP SOCKETS (GOLD) LEVEL #3

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

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ASST. 1	5 ea	10 OHM 12 OHM 15 OHM 18 OHM 22 OHM					50 PCS	$1.95
		27 OHM 33 OHM 39 OHM 47 OHM 56 OHM						
ASST. 2	5 ea	68 OHM 82 OHM 100 OHM 120 OHM 150 OHM					50 PCS	$1.95
		180 OHM 220 OHM 270 OHM 330 OHM 390 OHM						
ASST. 3	5 ea	470 OHM 560 OHM 680 OHM 820 OHM 1K					50 PCS	$1.95
		1.2K 1.5K 1.8K 2.2K 2.7K						
ASST. 4	5 ea	3.3K 3.9K 4.7K 5.6K 6.8K					50 PCS	$1.95
		8.2K 10K 12K 15K 18K						
ASST. 5	5 ea.	22K 27K 33K 39K 47K					50 PCS	$1.95
		56K 68K 82K 100K 120K						
ASST. 6	5 ea	150K 180K 220K 270K 330K					50 PCS	$1.95
		390K 470K 560K 680K 820K						
ASST. 7	5 ea.	1M 1.2M 1.5M 1.8M 2.2M					50 PCS	$1.95
		2.7M 3.3M 3.9M 4.7M 5.6M						

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) $10.95 ea.

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TL074CN	Quad Low Noise bi-fet Op Amp	2.49
TL494CN	Switching Regulator	4.49
TL496CP	Single Switching Regulator	1.75
11C90	Divide 10/11 Prescaler	14.95
95H90	Hi-Speed Divide 10/11 Prescaler	11.95
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MC14433P	3½ Digit A/D Converter	13.95

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XR215	4.40			XR2556	3.20
XR320	1.55			XR2567	2.99
XR-L555	1.50	JE2206KB	19.95	XR3403	1.25
XR555	.39	XR1800	3.20	XR4136	1.25
XR556	.99	XR2206	4.40	XR4151	3.95
XR567CP	.99	XR2207	3.85	XR4194	1.45
XR567CT	1.25	XR2208	5.20	XR4202	3.60
XR1310P	1.95	XR2209	1.75	XR4212	2.05
XR1468CN	3.85	XR2211	5.25	XR4558	.75
XR1488	1.95	XR2212	4.35	XR4739	1.15
XR1489	1.95	XR2240	3.45	XR4741	1.47

DIODES

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
				1N4002	100 PIV	1 AMP	12/1.00
				1N4003	200 PIV	1 AMP	12/1.00
1N746	3.3	400m	4/1.00	1N4004	400 PIV	1 AMP	12/1.00
1N751	5.1	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N754	6.8	400m	4/1.00	1N3600	50	200m	6/1.00
1N757	9.0	400m	4/1.00	1N4148	75	10m	15/1.00
1N759	12.0	400m	4/1.00	1N4154	35	10m	12/1.00
1N959	8.2	400m	4/1.00	1N4733	5.1	1w	4/1.00
1N965	15	400m	4/1.00	1N4734	5.6	1w	4/1.00
1N5232	5.6	500m	4/1.00	1N4735	6.2	1w	4/1.00
1N5234	6.2	500m	4/1.00	1N4736	6.8	1w	4/1.00
1N5235	6.8	500m	4/1.00	1N4738	8.2	1w	4/1.00
1N5236	7.5	500m	4/1.00	1N4742	12	1w	4/1.00
1N5242	12	500m	4/1.00	1N4744	15	1w	4/1.00
1N5245	15	500m	4/1.00	1N1183	50 PIV	35 AMP	1.60
1N456	25	40m	6/1.00	1N1184	100 PIV	35 AMP	1.70
1N458	150	7m	6/1.00	1N1185	150 PIV	35 AMP	1.70
1N485A	180	10m	5/1.00	1N1186	200 PIV	35 AMP	1.80
1N4001	50 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

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C36D	15A @ 400V	SCR(2N1849)	$1.95
C36M	35A @ 600V	SCR	2.25
C106B1	3.6A @ 200V	SCR	.50
2N2328	1.6A @ 300V	SCR	.50
MDA 980-1	12A @ 50V	FW Bridge Rec.	1.95
MDA 980-3	12A @ 200V	FW Bridge Rec.	2.25

TRANSISTORS

				2N3904	4/1.00
MPSA05	3/1.00	2N3055	.89	2N3905	4/1.00
MPSA06	3/1.00	MJE3055	1.00	2N3906	4/1.00
TIS97	4/1.00	2N3392	4/1.00	2N4013	.65
TIS98	4/1.00	2N3398	4/1.00	2N4123	4/1.00
40409	1.75	PN3567	3/1.00	PN4249	4/1.00
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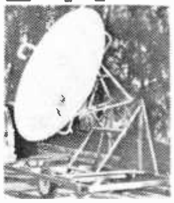

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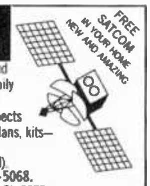

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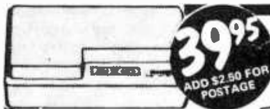

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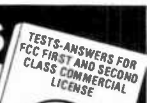

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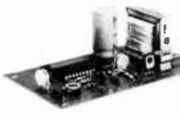

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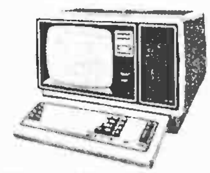

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ELECTRONICS WORLD®
Personal Electronics News

AM STEREO OK DELAY was announced recently by the FCC when it temporarily shelved its approval of the Magnavox system and announced plans to re-evaluate competing designs for stereo systems. Although the original decision was not definitely reversed, the agency cautioned transmission and receiver equipment manufacturers on proceeding with production plans until further notice.

RCA ADDS A NEW TV SCREEN SIZE to its ac/dc monochrome-TV receiver line. Called the "Playmate 5" series, the new receivers with 5" diagonal picture tubes feature AM/FM radio, sun shield, adjustable shoulder strap, and flip-up tilt stand. Optional retail prices are $159.95 for the Model AER055 and $199.95 for the deluxe Model AER057. The latter features an LED digital clock/timer with snooze alarm and user-settable automatic shutoff for radio (which includes a weather band) and TV modes.

VOLCANIC ASH CAUSES COMPUTER PROBLEMS (and so can any kind of superfine, abrasive dirt) according to a spokesman at Innovative Computer Products. The amount of down time and service calls necessitated by the fallout from Mt. St. Helens in Washington have emphasized the need for keeping magnetic media in covered containers and equipment covered when not in use. Magnetic reading heads that come in contact with the media should be cleaned on a daily basis.

COMPUTER IS SECOND IN OTHELLO CONTEST, losing only to World Champion Hiroshi Inoue. In a tournament at Northwestern University, IL, an Othello program written by Dan and Kathe Spracklen of San Diego, CA, and soon to be published by Hayden Book Co., defeated all other computer programs and U.S. Champion Jonathan Cerf. Mr. Inoue lost only to an IBM 370, programmed by a team from England, which was later defeated by Spracklens' program.

WORLD'S LARGEST TV SCREEN was used at Dodger Stadium July 8 to show instant replays and close-ups of action in the 1980 All-Star baseball game. The screen is 20-ft high and 28-ft wide and was made and installed by Mitsubishi Electric Corp. The full-color outdoor video display system is reported to present sharp images in full daylight through the use of a system called "Diamond Vision." The screen contains tens of thousands of lighting tubes in groups of three to form a combination of the primary colors. The three tubes form an image element whose brightness is controlled by a 5-bit digital signal from the video display system.

FOURTH ANNUAL NATIONAL SMALL COMPUTER SHOW will be held Oct. 30 to Nov. 1, 1980, in the New York Coliseum. Hardware and software of a wide variety will be shown and demonstrated, and there will be thirty 50-minute lecture presentations. The latter will cover subjects such as software for schools, educational applications in the home, word processing for law offices, and retrieval of personal medical data by numeric encoding. For schedule and information write: National Small Computer Show, 110 Charlotte Pl., Englewood Cliffs, NJ 07632.

A NEW PROGRAMMABLE PACEMAKER, from Intermedics, Freeport, TX, enables a physician to alter the instrument's output to suit a patient's changing needs without touching the device. A new program—with a choice of 15 pulse rates, 15 pulse widths, and seven sensitivity levels—is accomplished by placing a wand over the patient's chest and entering data on a programming device. Called the Cyberlith IV A-V (atrium-ventricle) pacemaker, it is also said to be the smallest, lightest and most versatile on the market. Moreover, it releases two electrical impulses (one for each chamber of the heart) for each heartbeat instead of the usual one.

A TALKING CALCULATOR with built-in printer and fluorescent display is being marketed by Canon. Utilizing a speech synthesizer, the Model SP1260-D desktop calculator's "voice" is used when an operator wishes to check entries on the roll paper. Pressing a key, it delivers an oral playback of numbers printed on the paper, eliminating the need for two people to check lists of numbers. Up to 128 pieces of data, including final result of entries, can be stored.

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