Popular Electronics

WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE NOVEMBER 1981/$1

Substitute Any Melody for a Phone's Ringer

Experimenting with Pen-Battery-Power Lasers

Enjoy Time-Lapse Filming with Electronic Timer

Tested In This Issue

RCA Model 330[illegible] Computer Terminal
Optonica Model RT6605 Cassette Deck
Quasar [illegible] Receiver

Baked Apple.

Last Thanksgiving, a designer from Lynn/Ohio Corporation took one of the company's Apple Personal Computers home for the holidays.

While he was out eating turkey, it got baked.

His cat, perhaps miffed at being left alone, knocked over a lamp which started

a fire which, among other unpleasantries, melted his TV set all over his computer. He thought his goose was cooked.

But when he took the Apple to Cincinnati Computer Store, *mirabile dictu*, it still worked.

A new case and keyboard made it as good as new.

Nearly 1,000 Apple dealers have complete service centers that can quickly fix just about anything that might go wrong, no matter how bizarre.

So if you're looking for a personal computer that solves problems instead of creating them, look to your authorized Apple dealer.

You'll find everything well-done.

The personal computer. apple®

For the authorized dealer nearest you, call (800) 538-9696. In California, call (800) 662-9238. Or write: Apple Computer Inc., 10260 Bandley Dr., Cupertino, CA 95014.

In a world where sound reaches new levels every day, ADC delivers the ultimate high.

The ultimate high is total control. And an ADC Sound Shaper® Frequency Equalizer lets you control your sound and custom-tailor your music with the mastery of a pro.

And no better way demonstrates the benefits of an ADC Sound Shaper than taping. Even without a studio environment, you can recreate your personal recordings by changing the frequency response curve of the source material — making the sound more like the original and more agreeable to your ears.

Our complete ADC Sound Shaper IC line* has an equalizer that is right for you and your system. The SS-110 ten-band full octave equalizer, a step up from our SS-1, features LED-lit slide controls and one-way tape dubbing. If you desire even more control, our twelve-band SS-II and top-of-the-line SS-III include two-way tape dubbing and sub-sonic filters. Our SS-III Paragraphic™ with 24 ancillary switches that enable you to control 36 bands per channel combines

the ease and control of a graphic equalizer with the precision and versatility of a parametric. All at a price you can afford.

All of our equalizers feature LED-lit slide controls allowing for visual plotting of the equalization curve. And all ADC Sound Shapers embody the outstanding ADC technology that has made us the leaders in the industry.

To really complete your custom-tailored control-ability, our ADC Real Time Spectrum Analyzer is a must. Equipped with its own pink noise generator and calibrated microphone, the SA-1 provides a visual presentation of the changing spectrum through 132 LED displays. So you can actually see proof of the equalized sound you've achieved.

With an ADC Sound Shaper and an ADC Real Time Spectrum Analyzer, you can attain a new level of control. And ultimately, isn't that the musical high you've always wanted?

Sound Shaper®
Frequency Equalizers
and Spectrum Analyzer

ADC
A BSR COMPANY

Sound thinking has moved us even further ahead.

BSR (USA) Ltd., Blauvelt, N.Y. 10913, BSR (Canada) Ltd., Rexdale Ontario

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CIRCLE NO. 15 ON FREE INFORMATION CARD

NOVEMBER 1981 VOLUME 19, NUMBER 11

Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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Construction Articles

Equipment Reviews

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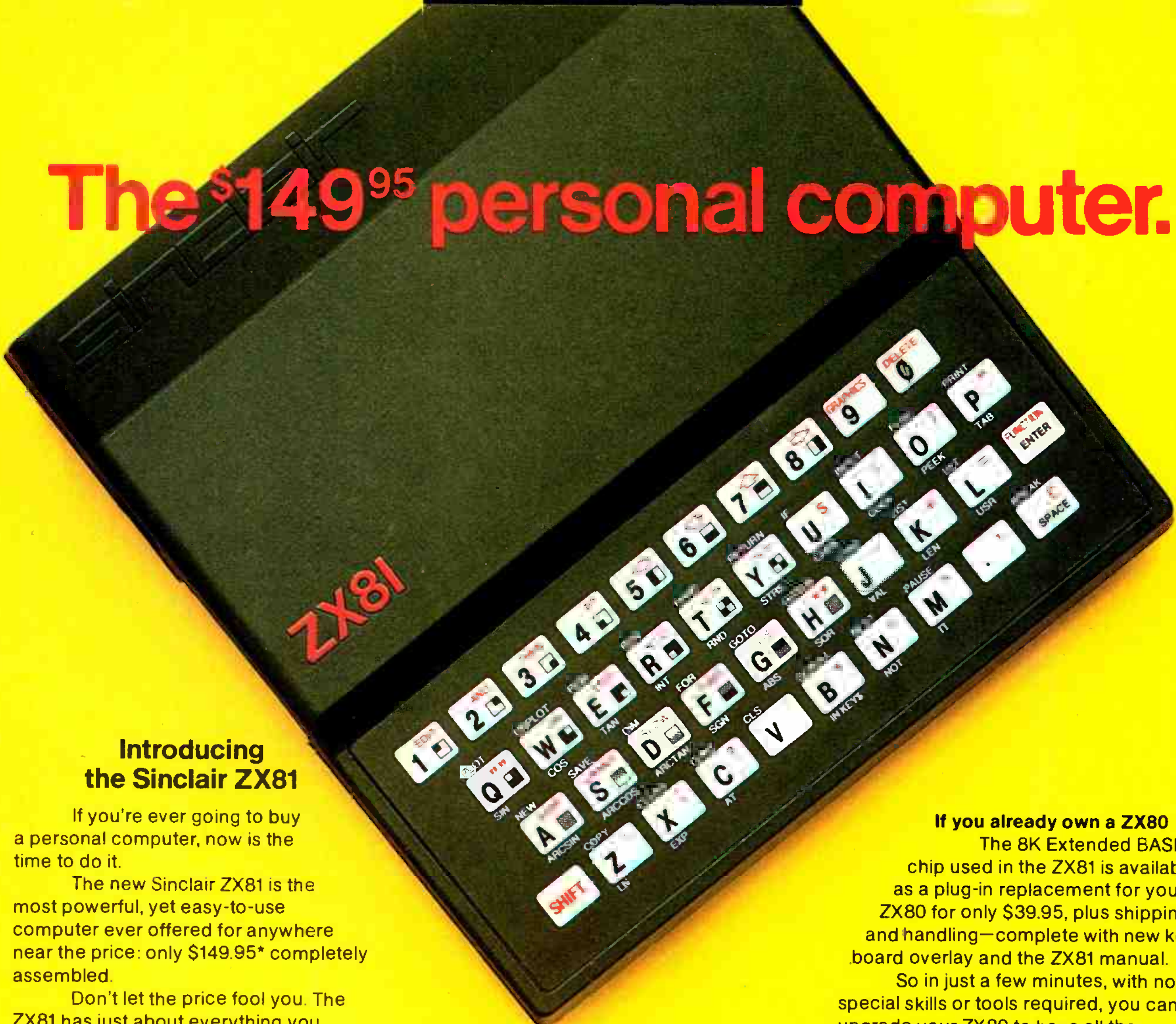
The 149^{95} personal computer.



Introducing the Sinclair ZX81

If you're ever going to buy a personal computer, now is the time to do it.

The new Sinclair ZX81 is the most powerful, yet easy-to-use computer ever offered for anywhere near the price: only $149.95* completely assembled.

Don't let the price fool you. The ZX81 has just about everything you could ask for in a personal computer.

A breakthrough in personal computers

The ZX81 is a major advance over the original Sinclair ZX80—the world's largest selling personal computer and the first for under $200.

In fact, the ZX81's new 8K Extended BASIC offers features found only on computers costing two or three times as much.

Just look at what you get:

- Continuous display, including moving graphics
- Multi-dimensional string and numerical arrays
- Mathematical ar d scientific functions accurate to 8 decimal places
- Unique one-touch entry of key words like PRINT, RUN and LIST
- Automatic syntax error detection and easy editing
- Randomize function useful for both games and serious applications
- Built-in interface for ZX Printer
- 1K of memory expandable to 16K

The ZX81 is also very convenient to use. It hooks up to any television set to produce a clear 32-column by 24-line display. And you can use a regular cassette recorder to store and recall programs by name.

*Plus shipping and handling. Price includes connectors for TV and cassette, AC adaptor, and FREE manual.

If you already own a ZX80

The 8K Extended BASIC chip used in the ZX81 is available as a plug-in replacement for your ZX80 for only $39.95, plus shipping and handling—complete with new keyboard overlay and the ZX81 manual.

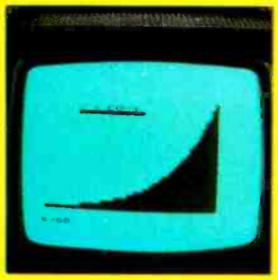
So in just a few minutes, with no special skills or tools required, you can upgrade your ZX80 to have all the powerful features of the ZX81. (You'll have everything except continuous display, but you can still use the PAUSE and SCROLL commands to get moving graphics.)

With the 8K BASIC chip, your ZX80 will also be equipped to use the ZX Printer and Sinclair software.

Warranty and Service Program**

The Sinclair ZX81 is covered by a 10-day money-back guarantee and a limited 90-day warranty that includes free parts and labor through our national service-by-mail facilities.

**Does not apply to ZX81 kits.



NEW SOFTWARE: Sinclair has published pre-recorded programs on cassettes for your ZX81, or ZX80 with 8K BASIC. We're constantly coming out with new programs, so we'll send you our latest software catalog with your computer.

ZX PRINTER: The Sinclair ZX Printer will work with your ZX81, or ZX80 with 8K BASIC. It will be available in the near future and will cost less than $100.

16K MEMORY MODULE: Like any powerful, full fledged computer, the ZX81 is expandable. Sinclair's 16K memory module plugs right onto the back of your ZX81 (or ZX80, with or without 8K BASIC). Cost is $99.95, plus shipping and handling.

ZX81 MANUAL: The ZX81 comes with a comprehensive 164-page programming guide and operating manual designed for both beginners and experienced computer users. A $10.95 value, it's yours free with the ZX81.

The 99^{95} personal computer.

Introducing the ZX81 kit

If you really want to save money, and you enjoy building electronic kits, you can order the ZX81 in kit form for the incredible price of just $99.95* It's the same, full-featured computer, only you put it together yourself. We'll send complete, easy-to-follow instructions on how you can assemble your ZX81 in just a few hours. All you have to supply is the soldering iron.

How to order

Sinclair Research is the world's largest manufacturer of personal computers.

The ZX81 represents the latest technology in microelectronics, and it picks up right where the ZX80 left off. Thousands are selling every week.

We urge you to place your order for the new ZX81 today. The sooner you order, the sooner you can start enjoying your own computer.

To order, simply call our toll free number, and use your MasterCard or VISA.

To order by mail, please use the coupon. And send your check or money order. We regret that we cannot accept purchase orders or C.O.D.'s.

CALL 800-543-3000. Ask for operator #509. In Ohio call 800-582-1364. In Canada call 513-729-4300. Ask for operator #509. Phones open 24 hours a day, 7 days a week. Have your MasterCard or VISA ready.

These numbers are for orders only. For information, you must write to Sinclair Research Ltd., One Sinclair Plaza, Nashua, NH 03061.

sinclair

AD CODE 11 PE	PRICE†	QTY.	AMOUNT
ZX81	$149.95		
ZX81 Kit	99.95		
8K BASIC chip (for ZX80)	39.95		
16K Memory Module (for ZX81 or ZX80)	99.95		
Shipping and Handling	4.95		$4.95
To ship outside USA add $10.00			
		TOTAL	

MAIL TO: Sinclair Research Ltd., One Sinclair Plaza, Nashua, NH 03061.

NAME ______________________

ADDRESS ______________________

CITY/STATE/ZIP ______________________

† U.S. Dollars

EDITORIAL

Onward, Ever Onward

Soon, subscribers to CompuServe and the Source will be able to benefit from a POPULAR ELECTRONICS feature on the data network menus devoted to computer clubs. Current club members and prospective members will have access to regularly updated information on computer club locations, meeting places and times, guest speakers, and other activities. Additionally, computerists will be treated to fresh news from our "Personal Electronic News" department.

Further, PE will soon launch a computer club section in its pages to enable readers to learn what's happened around the country at the "grass roots" level. To effect this, club information should be sent to us, attention of the Computer Club Editor. Thus, telephone networks will provide computerists with what's coming up, while PE will detail the exciting happenings.

Starting soon, also, will be a new column called "Fundamental Facts" by Walter Buchsbaum, Sc. D. These pieces will be fast-reading, succinctly written columns covering one subject in a specially informative manner. No, they will not be short treatises on Ohms Law and other such basic matter. Instead, they will be high-level discussions of devices and circuitry for readers who truly wish to upgrade their knowledge so that they will be able to better understand high technology. The first column will be devoted to network law, from Kirchhoff to Thevenin to Norton. Look for it!

It's important to keep up with the burgeoning advances in technology, but one must have a good foundation to truly understand them. That's what we expect the new column to provide. And there's plenty on the horizon that might break out of the research labs. For example, IBM is working on Josephson Tunnel switches in the labs. If completely developed, it would mean the evolution of computers to a very small size with operations that are 50 times faster than today's chips.

Service technicians, too, face increasing demands on their technical knowledge. TV circuits have changed. In order to identify the area of a breakdown, the tech must therefore readjust his thinking. For instance, scan-rectified power supplies are now commonplace, developed from a separate winding on the flyback transformer. A problem here could lead an uninformed tech to search through other circuits and waste a lot of time. Tuning systems are using logic and phase-locked loop circuits, so it's imperative to know how they work. The same electronic advances have been incorporated into a host of other consumer equipment: electronic games, clock radios, thermostats, ovens, scales, telephones, even typewriters.

Some devices have to be handled with great care since static electricity could easily ruin one that's being installed. The 3M Company, which sells inexpensive work stations for use when handling such sensitive parts, developed a voltage range of susceptibility to damage for device families, and this should be kept in mind when working with them. The company advises that MOSFETs can be ruined if hit by as little as 100 volts of electrostatic discharge, while CMOS devices can be damaged by as low as 250 volts. Compare this to, say, 680 to 1000 volts for an SCR and you can appreciate the different method needed in handling components today.

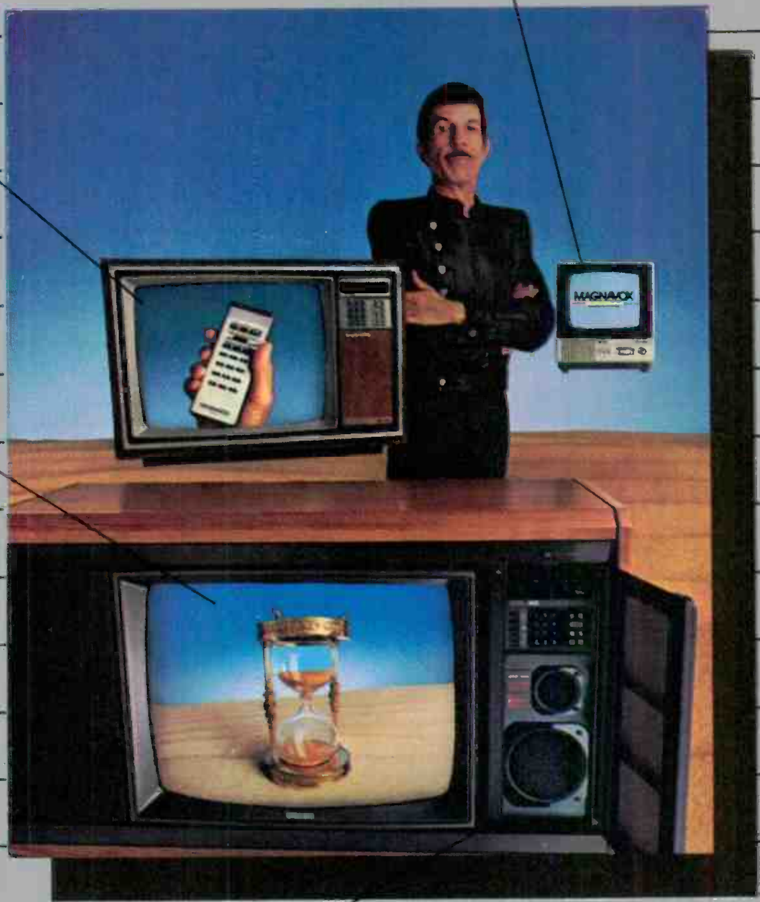
Keeping up with technology is a challenge, of course. But that's really what makes it that much more exciting.

Art Salsberg

Magnavox model 4012, 9-inch diagonal measurement AC/DC color portable with electronic tuning wheel and dial scale indicator.

Magnavox model 4265, 19 inch diagonal measurement Star System. All Star System infrared remote controls give you automatic switching between two channels and display time of day and channel number on TV screen.

Magnavox. A picture you can rely on time after time.



TV pictures and wood-grain cabinets simulated.
All models shown are Star Systems except model 4012.

Magnavox model 5260, 25-inch diagonal measurement Star System. This set even has expanded range high-fidelity sound.

TELEVISIONARY.

Magnavox sees the next stage of televiewing with you as the participant as well as the recipient.

For that, you will need the most reliable color television possible.

And now Magnavox Star® System color television sets combine advanced design concepts, high technology and new manufacturing systems to deliver the highest level of reliability in Magnavox history.

Magnavox. Television as visionary as tomorrow. With a picture as reliable as it is bright and clear.

Time after time.

MAGNAVOX

The brightest ideas in the world are here today.

CIRCLE NO. 42 ON FREE INFORMATION CARD

LETTERS

Likes the Sinclair ZX80

I must take exception to your equipment review conclusion of the ZX80 Personal Computer from Sinclair Research in the August 1981 issue. I have had no problem with mine since I got it. You may be too rough on the products you review. I have been in the data processing business as a systems programmer for eight years and am now getting into the personal computing field. I like the ZX80 because it is easily portable and has the capabilities I want for now.—*P. L. Jarboe, Jr., Owensboro, KY.*

Bits of RAM and ROM

In the "Solid-State Developments" column of September 1981, you refer to some new Hewlett-Packard devices with 128K bytes of RAM and 528K bytes of ROM. Surely, this should be bits, not bytes (1 byte = 8 bits). Otherwise, these would be awfully large memories.—*James Gaudreault, Herndon, VA.*

Perfect Answer 2 Telephone Price

We were pleased to see the mention of ITT's Perfect Answer 2 telephone answering machine in your New Products in the August 1981 issue. Unfortunately, the price given was for one of our other models. The Perfect Answer 2 is \$449.95.—*J. G. May, ITT Consumer Specialty Products Div.*

Information on Home Earth Stations

In the article "Home Earth Stations for Satellite Transmissions" (July 1981), you listed several companies that could be contacted for further information. I contacted one of them and I think it might be a good idea for you to let your readers know that Gardiner Communications Corp. of Houston, TX, does not provide information to private individuals. They deal only with cable companies.—*J. Tsantilas, Houston, TX.*

"Trick" Question

In the answer to Question 18 of the quiz "Some Like it Hot" (August 1981), the author says the question is a little tricky and that the standard junction is at a constant 120°F. This is, indeed, tricky since it was not stated in the question that the standard was at 120°F.—*M.J. Matthews, Shanksville, PA.*

You are right. The temperature of the standard junction was inadvertently left off of the drawing.

OUT OF TUNE

In the Review of the Atari Model 800 Personal Computer (June, p 48), Listing 1 is for a polygon, Listing 2 is for a triangle.

In "Burglar Baffler" (July, p 66), in Fig. 1, for *IC2B*, the inputs are 9, 10 and 11 while pin 8 is the output; the correct part number for *IC21* is 4049 as given in the Parts List, not 4009, as shown on the diagram; pin 1 of *IC1B* should have a bar over RST to indicate it is connected to pin 11 of *IC3D*. In Fig. 2, the pin numbers on *IC12A* should be as follows: change 1 to 13, 2 to 12, 3 to 11, 4 to 10, 5 to 9, and 6 to 8.

In "Tips and Techniques" for September (p 98), the lower truth table should read, top to bottom in the last column, 0, 0, 0, 1.

In "Designing with the 8080 Microprocessor, Part 2" (October, p 80), *R4*, *R5*, *R6*, and *R11* should be given in the Parts List as 3.3 kΩ as they are on the diagrams.

"Here's great news for electronics enthusiasts on small budgets.

Now you can take home a Fluke DMM for $125.*"

Whether you're just starting out in electronics or moving up from an analog VOM to a digital multimeter, you'll be smart to make sure that you're getting your money's worth.

In your search for a basic-performance DMM, be sure to consider the new D 800 from Fluke. Priced at only $125,* this dependable six-function handheld DMM is available now at select electronics supply stores throughout the U.S.

The D 800 offers 0.5% basic dc accuracy (five times better than analog voltmeters), a razor-sharp 3½-digit LCD readout, unsurpassed overload protection, and true, one-hand operation.

This hard-working basic measurement multimeter is designed from the inside out for long life and reliability. All D 800 specifications are traceable to the National Bureau of Standards.

As part of Fluke's new Series D line of low-cost digital multimeters, the D 800 carries a limited one-year parts and labor warranty and comes complete with the battery, and safety-designed test leads.

Ask your supplier about the D 800, then compare it feature-for-feature with any other low-cost DMM. You'll find that for only $125,* there's never been more multimeter than the new D 800 from Fluke.

From the world leader in DMM's. Now we've designed one for you.

*Suggested U.S. list price

For technical data circle no. 20 ON FREE INFORMATION CARD

If your dealer doesn't carry Series D Multimeters yet, call this number. We'll be happy to tell you who does. 1-800-426-9182

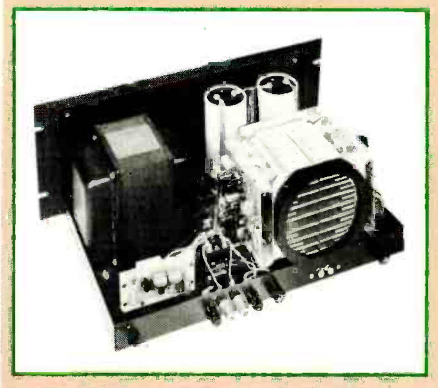
FLUKE®

YOU ALREADY OWN HALF OF THE WORLD'S MOST ADVANCED HOME ENTERTAINMENT SYSTEM.

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.

High-Power Amplifier



The David Hafler Company announces the release of the DH-500, a power amplifier that uses MOSFETs. According to the manufacturer, the DH-500 delivers 250 W/ch into 8 ohms with less than 0.025% distortion. Into 4 ohms, the figure claimed is 400 W/ch. More than 800 W/ch may be delivered into an 8-ohm load using an optional bridging kit. The MOSFETs are enclosed in a heat sink cooled by a multispeed fan. A relay is said to protect speakers against turn-on thumps or dc shifts. $600, kit; $750, assembled.

CIRCLE NO. 91 ON FREE INFORMATION CARD

Bose Free Space Array

The 601 Series II floor-standing speaker has two 8″ long-excursion woofers and four 3″ tweeters. Each of the woofers is housed in a separate injection-molded compartment. The tweeters and one woofer are mounted above the main enclosure in a multidirectional array. This is claimed to spread stereo image and reduce mid-bass "boominess" caused by room boundary reflections. Also featured is a "Dual Frequency" crossover network that allows the woofers and tweeters to operate together over nearly a full octave. Woofer transition frequency, 2.5 kHz; tweeter transition frequency, 1.5 kHz. Nominal impedance is 8 ohms. Amplifier power handling ranges from 20 to 150 W/ch. The cabinet is walnut-grain vinyl laminated to particle board. Dimensions are 29.5″H × 14″W x 13″D. $445 each.

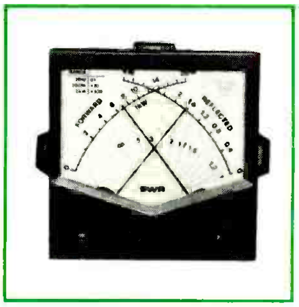
CIRCLE NO. 88 ON FREE INFORMATION CARD

Programmable DMM

The Keithley 192 offers programmable range and function via an optional IEEE-488 bus interface. Accuracy is given as 0.005% dc V, with a bus rate of 33 readings per second. A seven-digit display reads out measurements from either manual or autoranging (150 ms per range change). Resolution is 0.5 ppm over the 20-V range, with input impedance greater than 1000 megohms. Sensitivity in the 20-V range is claimed to be 10 μV. Up to 100 readings can be stored over intervals of up to one hour, so that data accumulations over four days are possible. The 192 is said to be able to abort a data cycle in progress and be recalibrated for a new reading within 27 ms. Settling time is 250 ms. $1095, base price; $395 extra for the IEEE-488 bus interface.

CIRCLE NO. 92 ON FREE INFORMATION CARD

SWR/Power Meter



The Daiwa CN-520 uses a cross-needle configuration to measure forward power, reflected power, and resultant SWR on one meter. The unit plugs into an existing antenna system via the included SO-239 connectors. Specs: frequency, 1.8 to 60 MHz; power range, forward 200 W to 2 kW, reflected 40 W to 400 W; accuracy, 10%; detection sensitivity, 40 W. $70.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Visual Display Terminal

The SOROC IQ 130 is a Z80-based VDT. Features include screen editing, full video attributes, 14 programmable function keys, programmable repeat/blink rates, adjustable right-hand margin, and a 25th status line with a 36-character user message. Block and conversational modes are standard at selectable transmission rates from 110 to 19,200 baud. 128 bytes of memory service 128 ASCII characters, with 15 line graphics characters available as an option. Additional features include keyboard lock, multiple character writing, typewriter and columnar tabbing, and an enable/disable cursor. Dimensions: 18″W x 13″H x 20.5″D; 45 lb. $699.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Automobile In-Dash Cassette/Tuner

Kenwood's KRC-722 has a small chassis, separate bass and treble controls, and fader control for front-to-rear balance. It provides PLL synthesizer tuning, a digital frequency display, ten station presets (five each for AM and FM), cassette standby,

Synthesized Hand-Held Scanner!

Chances are the police, fire and weather emergencies you'll read about in tomorrow's paper are coming through on a scanner right now. All scanners sold by **Communications Electronics** bring the real live excitement of action news into your home or car. With your scanner, you can monitor the exciting two-way radio conversations of police and fire departments, intelligence agencies, mobile telephones, energy/oil exploration crews, drug enforcement agencies and more.

Some scanners can even monitor aircraft transmissions! You can actually hear the news *before* it's news. If you do not own a scanner for yourself, now's the time to buy your new scanner from **Communications Electronics.** Choose the scanner that's right for you, then call our *toll-free* number to place your order with your Master Card or Visa. A scanner is an excellent holiday gift.

We give you excellent service because **CE** distributes more scanners worldwide than *anyone* else. Our warehouse facilities are equipped to process thousands of scanner orders every week. We also export scanners to over 300 countries and military installations. Almost all items are **in stock** for **quick shipment**, so if you're a person who prefers fact to fantasy and who needs to know what's *really* happening around you, order your scanner today from **CE**!

NEW! Bearcat®† 350

The Ultimate Synthesized Scanner!

Allow 30-60 days for delivery after receipt of order due to the high demand for this product.

List price $599.95/**CE price $419.00**

7-Band, 50 Channel • Alpha-Numeric • No-crystal scanner • AM Aircraft and Public Service bands. • Priority Channel • AC/DC

Bands: 30-50, 118-136 AM, 144-174, 421-512 MHz.

The new *Bearcat* 350 introduces an incredible breakthrough in synthesized scanning: Alpha-Numeric Display. Push a button—and the Vacuum Fluorescent Display switches from "numeric" to word descriptions of what's being monitored. 50 channels in 5 banks. Plus, Auto & Manual Search, Search Direction, Limit & Count. Direct Channel Access. Selective Scan Delay. Dual Scan Speeds. Automatic Lockout. Automatic Squelch. Non-Volatile Memory. Reserve your *Bearcat* 350 today!

Bearcat® 300

List price $549.95/**CE price $339.00**

7-Band, 50 Channel • Service Search • No-crystal scanner • AM Aircraft and Public Service bands. • Priority Channel • AC/DC

Bands: 32-50, 118-136 AM, 144-174, 421-512 MHz.

The *Bearcat* 300 is the most advanced automatic scanning radio that has ever been offered to the public. The *Bearcat* 300 uses a bright green fluorescent digital display, so it's ideal for mobile applications. The *Bearcat* 300 now has these added features: Service Search, Display Intensity Control, Hold Search and Resume Search keys, Separate Band keys to permit lock-in/lock-out of any band for more efficient service search.

NEW! Bearcat® 350

Bearcat® 250

List price $429.95/**CE price $269.00**

6-Band, 50 Channel • Crystalless • Searches Stores • Recalls • Digital clock • AC/DC Priority Channel • Delay • Count Feature

Frequency range 32-50, 146-174, 420-512 MHz.

The *Bearcat* 250 performs any scanning function you could possibly want. With push button ease you can program up to 50 channels for automatic monitoring. Push another button and search for new frequencies. There are no crystals to limit what you want to hear. A special search feature of the *Bearcat* 250 actually stores 64 frequencies and recalls them, one at a time. Overseas customers should order the *Bearcat* **250FB** at $379.00 each. This model has 220 V AC/12 V DC power supply and 66-88 MHz low band coverage.

NEW! Bearcat® 20/20

List price $449.95/**CE price $279.00**

7-Band, 40 Channel • Crystalless • Searches AM Aircraft and Public Service bands • AC/DC Priority Channel • Direct Channel Access • Delay

Frequency range 32-50, 118-136 AM, 144-174, 420-512 MHz.

The *Bearcat* 20/20 automatic scanning radio replaces the *Bearcat* 220 and monitors 40 frequencies from 7 bands, including aircraft. A two-position switch, located on the front panel, allows monitoring of 20 channels at a time.

Bearcat® 210XL

List price $349.95/**CE price $219.00**

6-Band, 18 Channel • Crystalless • AC/DC

Frequency range: 32-50, 144-174, 421-512 MHz.

The *Bearcat* 210XL scanning radio is the second generation scanner that replaces the popular *Bearcat* 210 and 211. It has almost twice the scanning capacity of the *Bearcat* 210 with 18 channels plus dual scanning speeds and a bright green fluorescent display. Automatic search finds new frequencies. Features scan delay, single antenna, patented track tuning and more!

Bearcat® 160

List price $299.95/**CE price $184.00**

5-Band, 16 Channel • AC only • Priority Dual Scan Speeds • Direct Channel Access

Frequency range: 32-50, 144-174, 440-512 MHz.

Would you believe...the *Bearcat* 160 is the least expensive *Bearcat* crystalless scanner.

This scanner presents a new dimension in scanning form and function. Look at the smooth keyboard. No buttons to punch. No knobs to turn. Instead, finger-tip pads provide control of *all* scanning operations, including On/Off, Volume and Squelch. Of course the *Bearcat* 160 incorporates other advanced *Bearcat* features such as Priority, Direct Channel Access, Dual Scan Speeds, Lockout, Scan Delay and more.

NEW! Bearcat® 100

The first no-crystal programmable handheld scanner.

Allow 60-120 days for delivery after receipt of order due to the high demand for this product.

List price $449.95/**CE price $299.00**

8-Band, 16 Channel • Liquid Crystal Display Search • Limit • Hold • Lockout • AC/DC

Frequency range: 30-50, 138-174, 406-512 MHz.

The world's first no-crystal handheld scanner has compressed into a 3" x 7" x 1¼" case more scanning power than is found in many base or mobile scanners. The *Bearcat* 100 has a full 16 channels with frequency coverage that includes all public service bands (Low, High, UHF and "T" bands), the 2-Meter and 70 cm. Amateur bands, *plus* Military and Federal Government frequencies. It has chrome-plated keys for functions that are user controlled, such as lockout, manual and automatic scan. Even search is provided, both manual and automatic. Wow...what a scanner!

The *Bearcat* 100 produces audio power output of 300 milliwatts, is track-tuned and has selectivity of better than 50 dB down and sensitivity of 0.6 microvolts on VHF and 1.0 microvolts on UHF. Power consumption is kept extremely low by using a liquid crystal display and exclusive low power integrated circuits.

Included in our low **CE** price is a sturdy carrying case, earphone, battery charger/AC adapter, six AA ni-cad batteries and flexible antenna. For earliest delivery from **CE**, reserve your *Bearcat* 100 today.

Bearcat® 5

List price $134.95/**CE price $94.00**

4-Band, 8 Crystal Channels • Lockout • AC only

Frequency range: 33-50, 146-174, 450-508 MHz.

The *Bearcat* 5 is a value-packed crystal scanner built for the scanning professional — at a price the first-time buyer can afford. Individual lockout switches. Order one crystal certificate for each channel.

Bearcat® Four-Six ThinScan™

List price $189.95/**CE price $124.00**

Frequency range: 33-47, 152-164, 450-508 MHz.

The incredible, *Bearcat* Four-Six Thin Scan™ is like having an information center in your pocket. This four band, 6 channel crystal controlled scanner has patented Track Tuning on UHF. Scan Delay and Channel Lockout. Measures 2¾ x 6¼ x 1." Includes rubber ducky antenna. Order crystal certificate for each channel. Made in Japan.

TEST ANY SCANNER

Test any scanner purchased from **Communications Electronics**™ for 31 days before you decide to keep it. If for any reason you are not completely satisfied, return it in original condition with all parts in 31 days, for a prompt refund (less shipping/handling charges and rebate credits).

Fanon Slimline 6-HLU

List price $169.95/**CE price $109.00**

Low cost 6-channel, 4-band scanner!

The *Fanon* Slimline 6-HLU gives you six channels of crystal controlled excitement. Unique Automatic Peak Tuning Circuit adjusts the receiver front end for maximum sensitivity across the entire UHF band. Individual channel lockout switches. Frequency range 30-50, 146-175 and 450-512 MHz. Size 2¾ x6¼ x 1." Includes rubber ducky antenna. Order crystal certificates for each channel. Made in Japan.

Fanon Slimline 6-HL

List price $149.95/**CE price $99.00**

6-Channel performance at 4-channel cost!

Frequency range: 30-50, 146-175 MHz.

If you *don't* need the UHF band, get this model and save money. Same high performance and features as the model HLU without the UHF band. Order crystal certificates for each channel. Made in Japan.

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NEW! Regency® H604 Scanner	$129.00
Regency® M400 Scanner	$259.00
Regency® M100 Scanner	$199.00
Regency® R1040 Scanner	$149.00
SCMA-6 Fanon Mobile Adapter/Battery Charger	$49.00
CHB-6 Fanon AC Adapter/Battery Charger	$15.00
CAT-6 Fanon carrying case with belt clip	$15.00
AUC-3 Fanon auto lighter adapter/Battery Charger	$15.00
PSK-6 Base Power Supply/Bracket for SCMA-6	$20.00
SP50 *Bearcat* AC Adapter	$9.00
SP51 *Bearcat* Battery Charger	$9.00
SP58 *Bearcat* 4-6 ThinScan™ carrying case	$12.00
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FB-W Frequency Directory for Western U.S.A.	$12.00
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B-4 1.2 V AAA Ni-Cad batteries (set of four)	$9.00
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CIRCLE NO. 1 ON FREE INFORMATION CARD

(continued from page 12)

ABSS, and scan tuning. Cassette features include Dolby noise reduction, metal-tape capability, a permalloy tape head, and two preouts (300 mV or 1 V). In addition, a cassette is automatically ejected from the player when the ignition is turned off. The tuner section features a local/distance switch, and an Automatic Noise Reduction Circuit that monitors FM signal strength and switches from full stereo to a sequence of alternate modes—ensuring, according to Kenwood, optimal sound in a moving vehicle. Dimensions are: 7¼″W x 2″H x 5½″D. $499.

CIRCLE NO. 94 ON FREE INFORMATION CARD

Phone Censor

Phone Censor from Chrono-Art uses solid-state timers to turn off a phone for 1, 2, or 8 hours. Wrong numbers and crank calls are screened out by codes that ensure that only selected callers can get through. The standard phone ring is replaced by a selection of chimes and lights; a chime can be programmed to sound only once for each incoming call, or be delayed for several ring signals. Installation is via direct plug into a modular jack with T adapter. The system can be set on a table or wall-mounted. It uses three AA alkaline batteries. $69.95. **Address**: Chrono-Art, 9175 Poplar Ave., Cotati, CA 94928.

Tape Cleaning System

Clean-n-Check from Boughton Enterprises is a tape cleaning kit that features a "Drive Analyser Cassette." The cassette monitors the drive mechanism of a tape deck in each operating mode: forward, fast forward, play, and reverse. One places the cassette into the machine, and a needle indicates the machine's operational effectiveness in terms of "normal," "faulty," or "requiring service soon." $6.95. **Address**: Boughton Enterprises Inc., Box 6096, Ventura, CA 93003.

Function Generator

The TG102 is the newest product in the Thandar line of test instruments. Ac operated, it has a frequency range from 0.2 Hz to 2 MHz. It produces sine, square, and triangle waveforms plus dc from a variable-amplitude 50-ohm output. TTL output is also provided. External sweep facility is available, too, permitting a greater than 1000:1 frequency change within a selected range. $300.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Heathkit Memory Keyer

The SA-5010 μMatic uses a microprocessor to provide ten variable length buffers for storing up to 240 characters of text or commands. The buffers eliminate wasted memory capacity by storing text in several buffers—stringing them together in any desired sequence. The speed, weight, spacing and auto-repeat count are controlled by a user-selected command string. The SA-5010 employs a 20-position keypad for entries, and features integral capacitive touch paddles. A mechanical paddle can also be used. Ham operators, it is claimed, can make use of 100 repeatable random sequences that can be altered by the keyer to give a total of 6400 practice sessions. Battery backup retains the memory when the unit is turned off. Other features include a built-in side-tone oscillator and speaker with variable pitch and volume controls, and a phone jack and earphone for private listening. An optional Heathkit PS-5012 power supply is needed. $98.

CIRCLE NO. 90 ON FREE INFORMATION CARD

(continued on page 20)

Why use their flexible discs:

Athana, BASF, Control Data, Dysan, IBM, Maxell, Nashua, Scotch, Shugart, Syncom, 3M, Verbatim or Wabash

when you could be using

MEMOREX

for as low as $1.94 each?

Find the flexible disc you're now using on our cross reference list... then write down the equivalent Memorex part number you should be ordering.

Product Family	Product Description	Memorex Part Number (3201.)	CE quant. 100 price per disc ($)	Athana	BASF	Dysan	IBM	Maxell	Nashua	Scotch 3M	Shugart	Syncom	Verbatim	Wabash	Control Data
Flexible Disc 1s Single Headed Drives Single Density Media	IBM Compatible (128 B/S 26 Sectors)	3060	1.99	473071	53428	800506	2305830	FD1-128	FD-1	740 0	S/A 100	15002	FD34 9000	F111111X	421602
	IBM Compatible (128 B/S 26 Sectors) w/ W P N	3062	2.04	—	—	—	—	—	—	740 0	—	—	FD34-9000	—	—
	IBM Compatible (128 B/S 26 Sectors) w/ W P N & Hub Ring	3064	2.39	—	—	—	—	—	—	—	—	—	FD34-9000	—	—
	IBM Compatible (128 B/S 26 Sectors) REVERSIBLE	1729	3.19	473072	54431	—	—	—	FD-2	740/2.0	—	15150	FF34 9000	F171111X	—
	IBM System 6 Compatible	3066	2.04	473077	54561	800509	1669959	—	—	740 0 058	—	15003	FD80 9000	F116111X	—
	IBM Compatible (256 B/S 15 Sectors)	3109	1.99	473073	—	800584	2305845	—	—	740-3600	—	15005	FD36-9000	F112111X	—
	IBM Compatible (512 B/S 8 Sectors)	3110	1.99	473074	—	800585	1669954	—	—	—	—	15004	FD60-9000	F113111X	—
	Shugart Compatible 32 Hard Sector	3015	1.99	470901	53802	101/1	—	FH1 32	FD 132	740 32	S/A 101	15025	FD32-9000	—	421322
	Wang Compatible 32 Hard Sector w/Hub Ring	3087	2.49	—	54491	—	—	—	—	740 32RH	—	—	—	F37A411X	—
	CPT 8000 Compatible	3045	2.69	—	—	—	—	—	—	—	—	15226	—	—	—
Flexible Disc 1d Single Headed Drives Double Density Media	IBM Compatible (128 B/S 26 Sectors)	3090	2.69	474071	54568	3740/1D	—	FD1-128/M2100	FD 1D	741.0	—	—	FD34 8000	F131111X	423002
	Soft Sector (128 B/S 26 Sectors) REVERSIBLE	3093	3.69	—	—	—	—	—	—	—	—	—	—	—	—
	Shugart Compatible 32 Hard Sector	3091	2.69	470801	54596	101/1D	—	FH1 32D	—	741 32	S/A 103	15075	FD32 8000	F33A411X	423322
	Wang Compatible 32 Hard Sector w/Hub Ring	3088	3.09	—	—	—	—	—	—	—	—	—	—	—	—
Flexible Disc 2s Double Headed Drives Single Density Media	Soft Sector (128 B/S 26 Sectors)	3113	3.09	—	54428	800814	1766870	—	—	—	S/A 150	15153	FD10-4026	F121111X	—
	Soft Sector (256 B/S 15 Sectors)	3106	3.09	473477	54226	800815	2736700	FD2 256D	—	742 0	—	15154	FD10 4015	F122111X	424812
Flexible Disc 2d Double-Headed Drives Double Density Media	Soft Sector (Unformatted)	3102	3.09	473485	—	DY150	—	FD2 XDM	FD-2D	743 0	—	15103	DD34 4001	—	425002
	Soft Sector (128 B/S 26 Sectors)	3115	3.09	—	—	—	—	—	—	—	S/A 150	—	—	—	—
	Soft Sector (256 B/S 26 Sectors)	3103	3.09	473471	54325	800817	1766872	FD2 256D	—	743-0/256	—	15101	DD34-4026	F144111X	425802
	Soft Sector (512 B/S 15 Sectors)	3114	3.09	473472	54479	800818	1669044	—	—	743-0/512	—	15100	DD34-4015	F145111X	425612
	Soft Sector (1024 B/S 8 Sectors)	3104	3.09	473473	54485	800819	1669045	—	—	743-0/1024	—	15102	DD34-4008	F147111X	425622
	32 Hard Sector	3105	3.09	470851	—	101/2D	—	FH2 32D	—	743-32	S/A 151	15125	DD32 4000	F34A411X	425322
	Burroughs B 80 Compatible 32 Hard Sector	3092	3.09	—	—	—	—	—	—	—	—	—	—	F34A611X	—
	Soft Sector (1024 B/S 8 Sectors) w/ Hub Ring	3116	3.49	—	—	—	—	—	—	—	—	—	—	—	—
	Shugart Compatible 32 Hard Sector	3181	3.39	—	—	—	—	—	—	—	—	—	DD32-4000	—	—
Flexible Disc FD Memorex 651 or Equiv Drive Compatible	FD VI (Vinyl Jacket)	30712003	2.69	470851	—	FDIV	—	—	FD 185	511-0	—	15026	FD65 1000	F81A111X	—
Mini Flexible Disc 1s 5¼ Single Headed Drives Single Density Media	Soft Sector (Unformatted)	3401	1.94	475001	54256	104/1	—	MD1	MD 1	744-0	S/A 104	15300	MD525-01	M11A211X	441002
	10 Hard Sector	3403	1.94	475010	54257	107/1	—	—	MD 110	744-10	S/A 107	15325	MD525-10	M41A211X	441102
	16 Hard Sector	3406	1.94	475016	54256	105/1	—	MH1	MD 116	744 16	S/A-105	15326	MD525-16	M51A211X	441162
	Soft Sector (Unformatted) w/Hub Ring	3431	2.14	—	—	—	—	—	—	—	—	—	MD525-01	—	—
	10 Hard Sector w/Hub Ring	3433	2.14	—	—	—	—	—	—	—	—	—	MD525-10	—	—
	16 Hard Sector w/Hub Ring	3435	2.14	—	—	—	—	—	—	—	—	—	MD525 16	—	—
Mini Flexible Disc 1d 5¼ Single-Headed Drives Double-Density Media	Soft Sector (Unformatted)	3417	2.14	—	54646	104/1D	—	—	—	—	—	—	MD525-01	—	—
	10 Hard Sector	3418	2.14	—	54649	107/1D	—	—	—	—	—	—	MD525 10	—	—
	16 Hard Sector	3419	2.14	—	54652	105/1D	—	—	—	—	—	—	MD525-16	—	—
	Soft Sector (Unformatted) w/Hub Ring	3481	2.34	—	—	—	—	—	—	—	—	—	MD525-01	—	—
	10 Hard Sector w/Hub Ring	3483	2.34	—	—	—	—	—	—	—	—	—	MD525 10	—	—
	16 Hard Sector w/Hub Ring	3485	2.34	—	—	—	—	—	—	—	—	—	MD526-16	—	—
Mini Flexible Disc 2d 5¼ Double Headed Drives Double Density Media	Soft Sector (Unformatted)	3421	2.59	—	54624	104/2D	—	—	—	—	S/A-154	—	MD550-01	—	—
	10 Hard Sector	3423	2.59	—	54627	107/2D	—	—	—	—	S/A-157	—	MD550-10	—	—
	16 Hard Sector	3425	2.59	—	54630	105/2D	—	—	—	—	S/A-155	—	MD550-16	—	—
	Soft Sector (Unformatted) w/Hub Ring	3491	2.79	—	—	—	—	—	—	—	—	—	MD550-01	—	—
	10 Hard Sector w/Hub Ring	3493	2.79	—	—	—	—	—	—	—	—	—	MD550-10	—	—
	16 Hard Sector w/Hub Ring	3495	2.79	—	—	—	—	—	—	—	—	—	MD550-16	—	—

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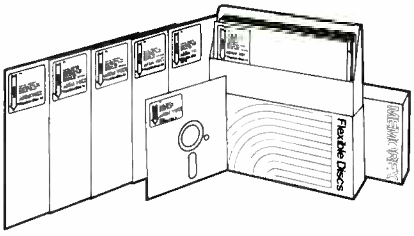

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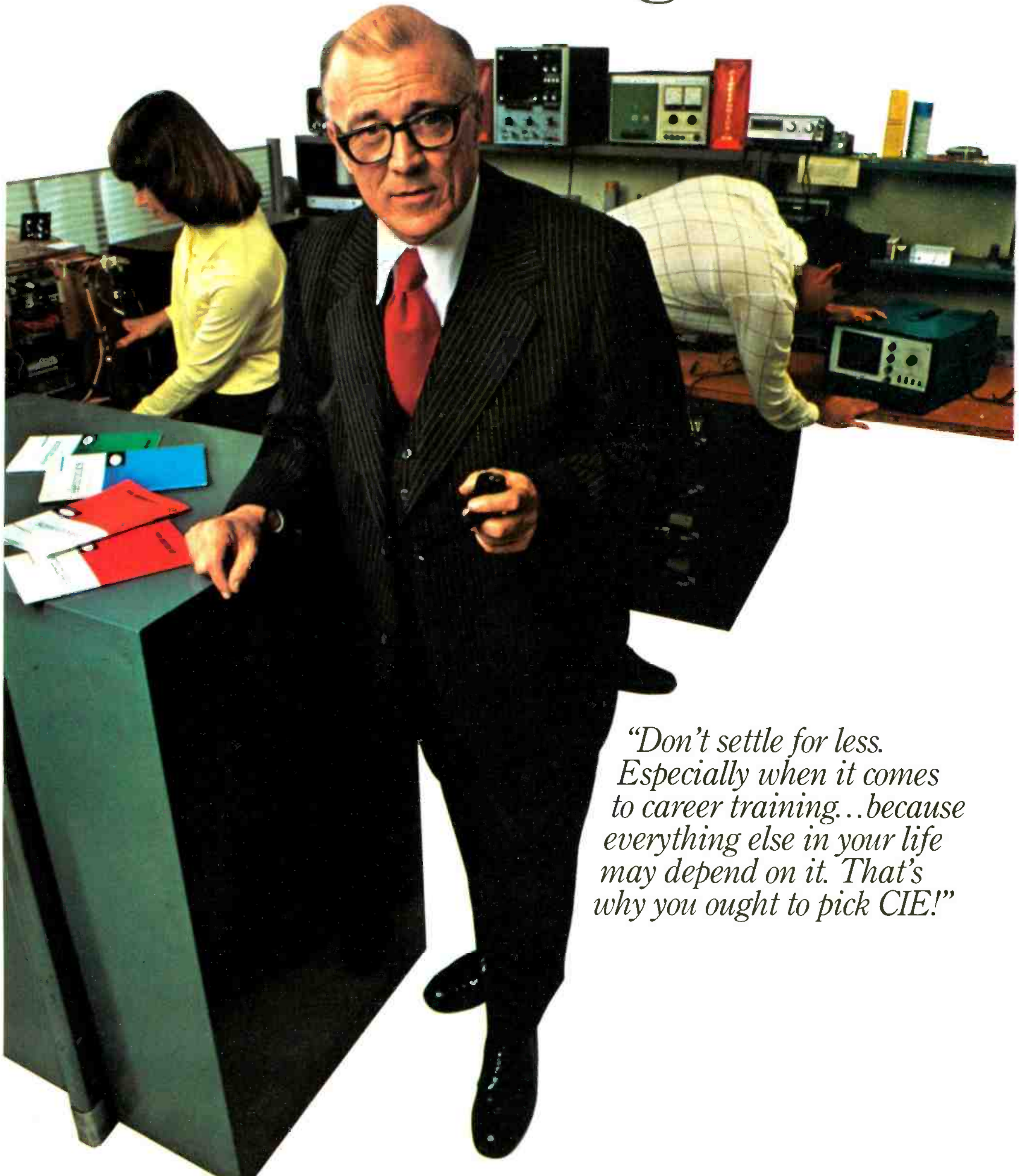

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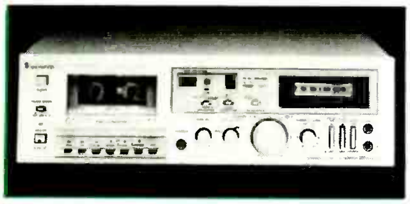
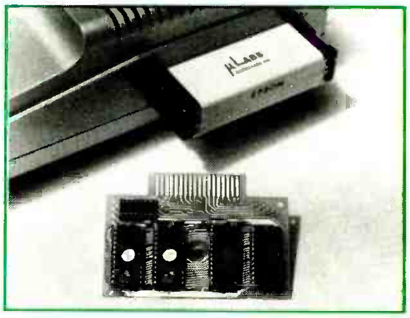


Sherwood's S-5000CP uses a microprocessor-controlled tape transport with timer start for record or play. The player features soft-touch controls and an automatic music selector that senses pauses between musical selections fast-forwards or rewinds to a pre-selected track. It also has a memory rewind with repeat, and memo play and stop, with an LED numeric track display. A hold circuit is incorporated into the 24-bar, two-color fluorescent peak signal display. Specs: frequency response (metal tape), 25 to 19,000 Hz; S/N (chrome, with Dolby NR), 63 dB; THD (metal, 1 kHz), 1%; wow and flutter (wrms), 0.05%; tape speed deviation, 0.5%. Bias is variable for metal, chrome, ferrichrome, and normal tape. $350.

CIRCLE NO. 96 ON FREE INFORMATION CARD

TRS-80 Plug-In Memory



The CMEMORY plug-in cartridge from Micro-Labs, Inc. is designed for the TRS-80 Color Computer. It provides 8K of continuous memory that can be divided into any combination of 2K RAM blocks and/or 2716 EPROMs. Thus, it is claimed, a user can store a utility, game, or monitor on an EPROM, while debugging another program on a RAM. The CMEMORY occupies the unused address space $C000 to $E000 normally reserved for plug-in games. Without memory, the cartridge sells for $24.95, and can be interfaced to the memory of the TRS-80. It can also interface with the 2K RAM chips ($19.95 each), or the 2K 2716 EPROMs ($14).

CIRCLE NO. 97 ON FREE INFORMATION CARD

Computer Cleaner

Innovative Computer Products has introduced the VARI-CLEAN cleaning kit for the small computer user. The kit is said to contain components for cleaning everything from the CRT screen, to the printer, to the heads of the magnetic peripherals. Also included in the kit is an antistatic spray that, under conditions of low humidity, reduces the static charge in carpets. $40.

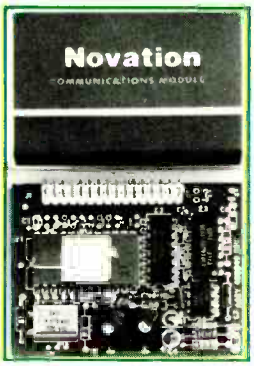
CIRCLE NO. 98 ON FREE INFORMATION CARD

Marantz AM/FM Receiver

The SR 8100DC AM/FM stereo receiver features quartz-lock frequency synthesized tuning, 16 memory presets, station search, and a five-band graphic equalizer. The unit is said to deliver a flat response down to 0 Hz. Power capability is given as 90 W/ch, with 0.06% THD into 4 ohms from 20 Hz to 20 kHz. $750.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Data Communications Modems



Novation Inc. has announced the availability, so far, of seven LSI modem modules than can communicate on a variety of networks and operate at rates up to 1200 baud. These include: a Low Speed (300 baud) Modem featuring full or half duplex answer or originate, plus self-test; a Phone Line Interface with auto or manual answer, pulse dialing, multitiming, and holding circuits; a Deaf Modem, whereby one can communicate with the deaf via the TTY network, etc. Prices for a single module (2 7/8" x 2 1/8") start at $99.

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THE GRAPHIC DIFFERENCE

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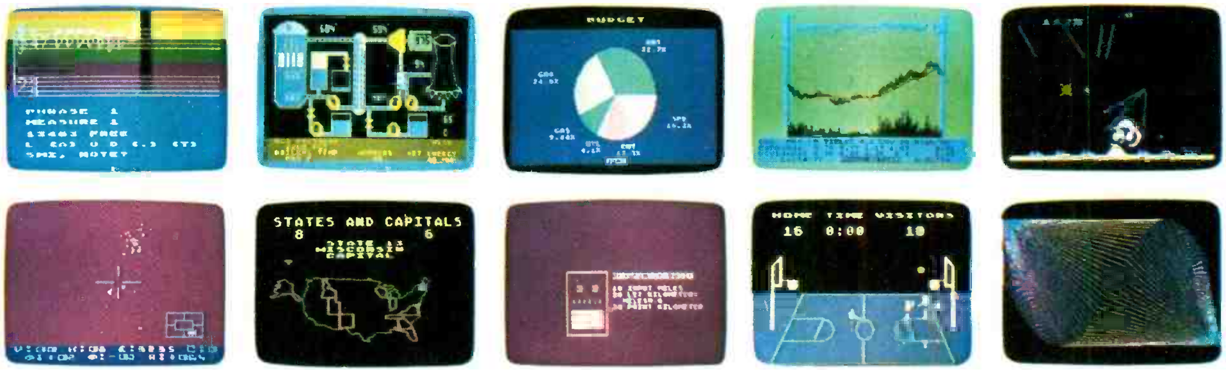

3.7 million reasons why the ATARI Personal Computer is something to see.
The display screen used with our computers is composed of 192 horizontal lines, each containing 320 dots. Delivering color and luminosity instructions to each dot for a second requires 3.7 million cycles...a lot of work for the normal 6502 processor.

That's why the ATARI computer has equipped its 6502 with its own electronic assistant. It's called ANTIC, and it handles all the display work, leaving the 6502 free to handle the rest. What this means to you is uncompromisingly spectacular display capabilities without loss of computer power needed to carry out the demands of your program.

That's a quality you just don't find in ordinary personal computers. And it's one of the reasons some computer experts say that ATARI computers are so far ahead of their time.

There's more...which is what you'd expect from ATARI.
Language. The ATARI Personal Computer uses several programming languages to give the user maximum control of its extraordinary capabilities. PILOT, Microsoft BASIC,* and ATARI BASIC are understood and spoken by the ATARI computer. You'll also find our Assembler Editor cartridge indispensable for machine language programming.

Sound. An ATARI computer has four sound generators, or voices, activated by a separate microchip. This leaves the principal microprocessor chips free to perform other tasks. And you can take full advantage of this capability which is designed for easy programming.

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And the ATARI ROM cartridge system also makes it easy to change languages. In short, your ATARI computer won't be obsoleted by future developments...*because it already incorporates the future.*

Sharing. To learn more about the amazing capabilities of ATARI computers, visit your local computer store for a demonstration. Or send for our Technical User's Notes, intended for the serious programmer. They are only $27 and contain a lot more information about our computers' special capabilities than most companies could tell. See your ATARI dealer, or send $30 ($27 plus $3 postage and handling), payable to ATARI, to Technical User's Notes, c/o ATARI Customer Service, 1340 Bordeaux Avenue, Sunnyvale, CA. 94086.

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The heart of the Heath/Zenith line is the stand-alone *89 Computer.* It's a complete system with built-in 5¼-inch floppy disk drive, professional keyboard and keypad, smart video terminal, two Z80 microprocessors, and two RS-232C serial I/O ports. It comes with 16K RAM, expandable to 64K.

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3. Software

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CP/M by Digital Research makes your system compatible with thousands of popular CP/M programs.

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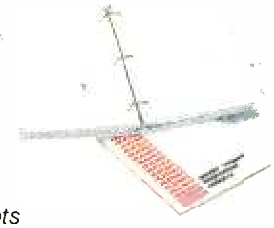

Learn at your own pace with *Programming Courses* that teach you to write and run your own programs in Assembly, BASIC, Pascal or COBOL.

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REASONS TO MAKE COMPUTER PARTNER

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ENTERTAINMENT ELECTRONICS

By Ivan Berger

Video Begins to Get Convenient

I'M GLAD to see that designers of VCRs and cameras are starting to build them as though they might actually be used. The designers of the early models had too much to do just getting the features in and functioning to worry about how useful and convenient they might be. Now that many of the basic problems have been licked, there's some breathing space, a chance to work on the human-engineering problems.

Take the shape of cameras, for instance. The early ones looked like Super-8 home movie cameras, a shape that was easy for the designer to conceive and for the public to accept. Now, we're getting into functionally designed "ugly ducklings" like Sony's HVC-2200, which look like nothing else on earth (except for professional TV news and cine cameras)—and which work all the better for it.

The two main things that make the Sony look odd are its grip (horizontal and set well to the right) and its eyepiece (offset to the left of the camera body). The grip is horizontal because your fist is naturally oriented that way when you raise your forearm—conventional grips make you bend and strain your wrist unnecessarily. Making that grip still handier, Sony puts a rocker switch for the power zoom lens under your fingertips, and the trigger button under your thumb.

Electronic (TV-screen) finders like the 2200's can be built into the camera body, as the optical ones on movie cameras are; but they don't have to be. Since they're connected by wire, they can be mounted anywhere. Mount them outside, and you get much handier designs. The finder can be shifted forward, letting much of the camera's weight rest on your shoulder, so your arms don't get as tired. (The HVC-2200 rests more comfortably than most on a shoulder, too, because its shoulder rest is not only padded but cut away to match the shoulder's natural droop.)

The finder's position can even be shifted forward and back or from side to side, to custom-fit your face. (The finders on some RCA cameras can even be flipped over the camera for left-handed use.) You can tilt the finder up when you're working with a low camera angle, so you needn't squat to see it—or, sometimes, tilt it down when the camera is mounted high. On some cameras (including the Sony), the finder can even be removed and put on the end of an extension cord for remote-control use.

Not all the new camera conveniences change the camera's shape. You have to look twice at Sanyo's new VSC450 camera to notice that it has built-in remote control for the matching VPR4800 VCR. Quasar and Panasonic have optional remote controls for some VCR models which mount directly on their cameras and send their commands through the camera cables.

With these, you can not only start and stop the VCR, but rewind the shot you've just made (in fast-scan mode, so you can see where it begins), replay it through the viewfinder, and resume recording right at the spot where you want the new shot to begin—all without having to take your hand off the camera and hunt for the VCR's controls. The Panasonic/Quasar remotes even have single-frame advance, in case you want a really close look.

Since I haven't actually had the chance to use them I can't tell yet how convenient these camera-mounted remote controls will prove to be in practice. But there's no question the idea's a great one.

VCR Conveniences. VCRs are benefiting from the new emphasis on convenience, too. More and more of them have full-featured, multifunction remote controls (often wireless) that even change channels. Grundig's new TV sets and VCRs will share a common remote control, with a shift key to select one or the other. And VCRs with cable-ready tuners are beginning to appear, so you can watch one cable show and tape another without needing two of the cable company's adapter boxes. If your TV receiver is cable-ready, too, you won't even need one adapter box—unless you're watching a scrambled pay-cable signal.

Sony's HVC-2200 color video camera has a 6:1 motor-driven zoom and macro lens.

VCRs still have a way to go before they grow as responsive to command as audio tape recorders. Even so, there are some nice VCR features which do make life more convenient.

My favorite is visual scan. Like the audio tape decks which let you listen to the tape's chatter in fast-wind modes, so you can tell where selections start and end or where the nature of the sound changes, VCRs with visual scan let you watch the picture as you fast-wind their tapes. Visual search isn't as fast as the true fast-wind modes—about 5X to 40X normal speed, which means it would take from 1 1/5 hours to 9 minutes to scan through a six-hour tape. The picture you see in visual search is full of noise bars—but still clear enough to tell what portion of the tape you're seeing, which is all you need. And many recorders don't offer visual search at all their speeds. Nonetheless, it's a big advance.

Another convenience is a feature that Sony calls "Tab Marker." (Other makers call it by other names, when they bother mentioning it at all.) It leaves a little marker pip on the tape wherever you switch into Record mode; in fast wind or rewind, the deck stops at each such pip. In live recording, it makes it easier to rewind right back to the start of the last shot you made, to review it. When recording off the air, it lets you quickly find the start of each show.

Grundig's new Video 2000 VCR (a new tape format, in this country) has a counter which reads actual tape time—the first I can recall in any VCR, though there are a few of them in audio decks. It automatically measures how long the tape is and how much time is left. If you set it to make a timer-controlled recording longer than the time remaining on the tape, it will automatically tell you that there isn't enough room left.

The more advanced VCRs become, the more such conveniences we'll see. Sometimes, the advancements make the conveniences more necessary. The longer the tape, for example, the more vital the ability to locate specific spots on it.

This is just one of the areas where there's not only room for improvement, but ideas lying around waiting to be used. For example, why couldn't a deck with a counter like the Grundig's also allow you to punch in the time of the spot on the tape you wish to find, and have the tape advance directly to it? I'm playing with an audio cassette deck (Bang & Olufsen's 8002) which does precisely that, and it's delightful. ◇

Popular Electronics Tests

RCA VP3301 Interactive Data Terminal

THE RCA Interactive Data Terminal VP3301 is essentially a high-quality monochrome or color "intelligent" terminal without a CRT monitor. It can be interconnected via an internal RS232 or 20-mA port to any RS232/20-mA device such as a modem, printer, or computer. The baseband video can either feed a conventional CRT monitor or be applied via an FCC-approved r-f modulator to a conventional monochrome or color-TV receiver.

It has two companion terminals: the VP3303 is identical but has a built-in r-f modulator (channels 3/4), while the VP3501 has an r-f modulator and a direct modem and cassette port.

The character display is selectable from 40 characters per line and 24 lines or 20 large-size characters on 12 lines. This choice, like all other functions on this device, can be selected either by switch settings or software control. There are 52 upper- and lower-case alphabetics, 10 numerals, 32 punctuation and math characters, and 31 control characters. Each key can be redefined under software control to create any character of the user's choosing, up to 128. Each or all characters can be displayed in any of eight colors (seven gray scales when using a monochrome CRT monitor), with a selection of eight background colors. Reverse video also enhances the display.

A built-in tone generator with internal loudspeaker is used for keypress feedback (which can be switched off if desired). This feature can be reprogrammed for almost any audio effect—or even used to create music. An 8-octave frequency range is provided while a white-noise generator can be programmed to emulate explosions, gun shots, etc., for game playing or as a unique alerting signal.

The keyboard uses flexible-membrane switching with a light, positive pressure, and it is impervious to liquids, cigarette ashes and other contaminants. It can be cleaned easily using a damp cloth.

The "power supply" is a wall receptacle plug-in similar to those used by many calculators (but a trifle larger).

Specifications. The keyboard contains 58 keys, arranged in the familiar QWERTY fashion. Each key has auto-repeat after it has been held down for a second or so. Two keys (switch closures) can be user defined, with each of these spst keys capable of switching 30 volts at 0.1 ampere. The BREAK key generates a binary zero.

The video display can be hardware or software selected from 24 lines with 40 characters/line for an effective dot resolution of 240 dots horizontal by 192 vertical, or 20 larger-sized characters on 12 lines for an effective dot resolution of 120 x 96. Each character is formed using a 5 x 6 matrix within a 6 x 8 character block. Descenders are provided in lower case. Any character, up to a maximum of 128, can be user defined with each new character block if desired. This enables creation of contiguous figures. Reverse video can also be created

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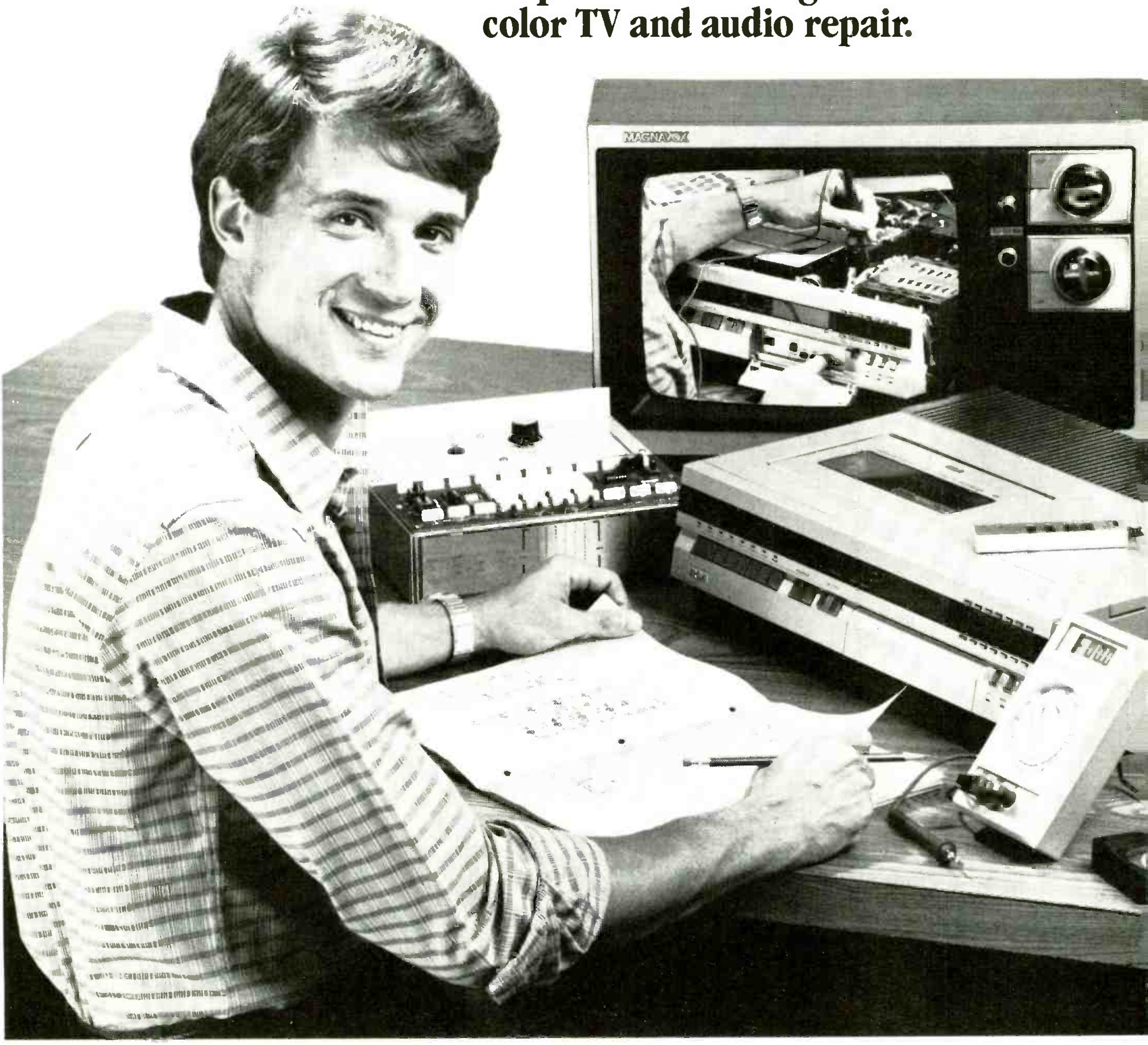


via software. This allows creation of reverse words, characters, or lines. The internal memory holds 960 characters (one screen on high resolution).

Both characters and background can be selected from any of eight colors (7 levels of gray scale) on a choice of 8 background colors (also 7 levels of gray on a monochrome monitor). The composite video output, available at a conventional RCA connector is 1 volt peak-to-peak, into a 75-ohm termination.

The I/O port transmits the ASCII signals as 1 start bit, 7 data bits, 1 parity bit (odd, even, or space), and 1 or 2 stop bits. The mode is switch selectable as half or full duplex, and there is a line/local selection switch. The RS232 data rate can be selected from 110, 300, 1200, 4800, 9600, or 19,200 baud. The current-loop can be switch selected from 110, 300, or 1200 baud. Control signals include request-to-send, and clear-to-send, both RS232 compatible. The receive port is similar to the transmit port except that it features a clear-to-receive RS232 signal. A 20- or 60-mA loop is provided on the 25-pin connector.

There is one LED on the keyboard that glows when the clear-to-send is true and acts as the power-on indicator when this signal is not being used. As each key is depressed, an audio tone is generated, with a different tone when the shift or control keys are used. The keyboard tone can be defeated via a rear-apron switch. The control-G bell code actually sounds like a bell.

On the left-side end panel, there is a slot that allows access to 16 switches. These allow for hardware selection of upper or upper/lower case; the status of the 8th bit sent from the VP3301 as either even/odd parity or mark/space; 1 or 2 stop bits; full or half duplex; turning off the control features to emulate a "dumb" terminal; display of control codes; 40/24 or 20/12 character set; choice of RS232 or 20-mA I/O; local or line operation; and a choice of baud rates from 110, 300, 1200, 4800, 9600, or 19,200 baud.

The power switch, ac-line connector, 25-pin I/O connector, video output jack, and the keyboard tone ON/OFF switch are all located along the rear apron. The keyboard slants upward at a convenient angle.

Besides the usual RETURN, LINE FEED, SHIFT, DELETE, CONTROL, ESCAPE, TAB, and BREAK keys, the keyboard also contains two user-definable keys. Under software control are the bell, horizontal tab, line feed, up line, clear screen, carriage return, reverse video on/off, forespace, home cursor, up/down line, backspace, clear screen from cursor, clear to end of line, and cursor position on screen. Other control functions determine background and foreground color, character color, blinking/nonblinking/off block cursor, English character set to return the keyboard to normal after defining an alternate character set, and insertion of a literal character. All of the functions can be easily implemented by depressing the ESCAPE key plus the pertinent ASCII character.

In the sound department, there is a selection of 128 tones in each of 8 octaves that can be heard via a built-in speaker with choice of amplitude. A white-noise generator having eight selectable cut-off frequencies is provided for other sound effects. There are 16 levels of amplitude. A change-command delimiter is included in the software for system flexibility as a substitute for the ESCAPE command.

Physically, the metal-cased VP3301 is a little over 13″ wide, 7″ deep, 2″ high and weighs approximately 5 pounds. Environmentally, the keyboard is claimed to be able to operate between 0 and 30 degrees C, and can be stored between −40 and +85 degrees C. It can operate at 90% relative humidity at 30 degrees C, noncondensing. Suggested retail price is $369. The VP 3303 is $389, and the upcoming VP3501 will be approximately $450.

Comments. The scope display of the baseband video signal was very clean with fast rise and fall times. The only limit to image resolution is the bandwidth of the video monitor used. We put the VP3301 on line simply by connecting the baseband video output to our monochrome video monitor. The manual is well written and completely covers the various areas to thoroughly use the terminal. After testing all the control functions, and finding them to work as claimed, we fed the video output to our broadband color modulator/r-f system and color-TV receiver. The color elements worked fine and we could find no fault. The resulting display is as good as any color computer we have used.

Once the basic testing was performed on the video monitor, we coupled the VP3301 to the RS232 port on our computer. Since we use CP/M, and have WordStar, we changed the coding for the terminal portion of the word processor to be able to use the many control functions of the VP3301. The results were quite good and comparable to the expensive "intelligent" terminal we usually use.

Several game programs were rewritten to take advantage of the color attributes of the terminal. The colors were fine, and some interesting effects could be produced.

The only minor demerit we could find was with the keyboard. Although the "touch" is fine, we did not like the loud, penetrating "beep" that indicates key-down, and neither did we like the two-tone effect when the SHIFT/CONTROL keys are used in conjunction with other keys. As provided by RCA, we feel that these tones are too loud and sharp. When the keyboard touch tones are turned off via the rear apron switch, we did miss a few keys since there is very little physical feedback from the membrane keys. We settled the situation by using the built-in software to create a tone more to our liking.

We hooked the VP3301 to a modem and called our local data base. The system formed from the VP3301, modem, and video monitor works fine and can be used with any data base accessible via the phone line.

We have used the VP3301 for several weeks now, both as our computer terminal and as access to the "Source," and it has performed in an excellent fashion throughout.

Because of its relatively small size and weight, a VP3301 (with r-f modulator) or VP3303, and a small modem can be easily carried so that someone away from home or office need only use the TV receiver and phone in his hotel room to transfer information data to and from his base computer.

There is no question that the VP3301 will be an asset to any computer that requires a flexible terminal, color, and an almost infinite variety of user-defined characters. We would not hesitate to use the VP3301 as the main terminal of our computer system either.

—Les Solomon

CIRCLE NO. 102 ON FREE INFORMATION CARD

COMPUTER BITS

By Carl Warren

Systems And Software

IF YOU'VE been waiting for IBM to enter the personal computer field, you don't have to wait any longer. The IBM Personal Computer was introduced this past August, and it sports a number of very exciting features. Among them:

- An 8088 microprocessor, which provides the best of both the 8- and 16-bit worlds.
- An 83-key adjustable keyboard, with up to 262,144 characters of user memory (it comes with 16K).
- Color graphics that permit displaying 256 characters in any of 16 foreground and 8 background colors.
- An advanced disk operating system, plus Digital Research's CP/M-86, and UCSD Pascal.

Prices for the system start at $1565 which includes the keyboard module, with 16K RAM, the 40K operating system ROM, an adapter to use with home television, and an audio cassette interface. You can add up to four joysticks, and five expansion slots are available for memory (up to 256K), communications boards, and other peripheral controller cards.

If you're worried about application software, don't be. IBM is offering Personal Software's "VisiCalc," IUS's "Easywriter" word-processing package, Peachtree Software's business packages, and a communications package.

Of course IBM doesn't plan to stop there. According to a spokesman, they have established a division dedicated to creating and finding software packages for the machine. Authors can be professional or hobbyist.

Although the basic $1565 machine seems palatable, you might want to spend $4500 and get the complete system, which includes the keyboard, 64K RAM, a full-size green-phosphor monitor, two 5.25-in. disk drives (160K bytes each), and an 80-cps MX-80 printer.

The machines may be seen at your local store (Sears, Computerland or IBM outlets).

Other Systems. The "Findex," which is not really a new system, offers some unusual attributes. This Z-80 microprocessor-based system is characterized by the use of a 240-character (6 lines × 40 characters) plasma display. This unique display operates at a 75.7-Hz scan rate, permits the displaying of upper- and lower-case characters with scrolling.

The display is only a small part of the under-$7000 system. Surrounding the display is a stylized enclosure that houses a 72-key keyboard and 10-key numeric keypad, the Z-80 microprocessor, 4 serial and 1 parallel ports, a dot matrix printer, and an acoustic coupler (the last two being optional). The optional minifloppy, has a capacity of 400K bytes, and works with CP/M.

Although hardware is important in some respects, the manufacturer, based in Torrance, CA, (phone 213-533-6842), hasn't stopped there. He is offering a series of software packages designed to enhance the system. Among these are: "Termio," a terminal I/O package that works with the optional acoustic coupler and provides asynchronous communications in either full or half duplex. Should general business be more your style, packages for financial analysis (TASK), patient accounting for the doctor's office, and a general accounting package are available. Moreover, standard CP/M compatible languages are available and include BASIC, COBOL, FORTRAN, APL, Pascal, and a macro assembler.

The 31-lb machine comes with 8K bytes of system ROM, 1K bytes of static RAM, and 64K bytes of dynamic RAM plus battery backup good for one-half hour. Pricing ranges from under $7000 to $20,000 (depending on add-ons).

Looking for a Machine Built Around Software? You might want to consider the $3450 CPC-1000 from Performance Business Machines Corp, San Rafael, CA (415-457-8990). This latest entry to the microshopping list employs a Z-80 microprocessor and 80K of RAM.

The RAM is divided up so that 16K are dedicated to CP/M and the other 64K are for you. This makes handling of I/O a little quicker and gives you an almost unlimited amount of work space. But that is only part of the excitement of this machine. Included in the low price tag is a Seagate Technology ST-506 6.38M-byte (unformatted) Winchester and a Tandon quad-density 5.25-in. floppy. These two storage devices come under control of a special bit-sliced processor designed to handle all I/O functions, including terminals and printers.

The use of a dedicated I/O processor relieves the main Z-80 of such duties, which means that you have greater throughput and aren't interrupted when performing such tasks as printing a document under a SPOOLing operation such as found in MicroPro's "Wordstar," which happens incidentaly to be the parent organization of Performance Business Machines Corp.

Interestingly, the CPC-1000 is a single-board computer sold for $2100 with a case. You add $175 for power supply, $850 for the Winchester, and $350 for the floppy. Although the machine is intended to be a software vehicle, and was in fact designed to optimize the software rather than the other way around, you still have to purchase your application-ware.

The CPC-1000 in its present configuration is top-notch, but the system designers have more planned for early 1982. The machine, as designed, offers an excellent stand-alone intelligent system once you add the terminal of your choice. Future plans call for adding a local networking interface so that several systems can be connected together in a synergistic manner.

Speaking of Networking. If you own an S-100 bus-based system or, more precisely, if you are lucky enough to own one from Vector Graphics (Westlake

IBM Personal Computer System

Village, CA), you might start planning to add a few more systems and picking up a new board developed by company chairman Dr. Robert Harp. The yet-unnamed board provides low-cost networking (under $500) to S-100 bus systems operating in a CP/M environment. This innovative design uses inexpensive 75-ohm coax cable, operates at 5M bits/s, and permits a maximum cable length of 1000 feet between any two units. Furthermore, up to 127 logical addresses can be implemented, as well as global (all stations) addressing with a carrier sense multiple access/collision detection protocol.

Although much has been defined for the board, and production has been set up, the software is still being defined. However, Harp advises that production units will be available early in the first quarter of '82.

The Whole World Isn't Hardware. In fact, more of it is becoming software-oriented as evidenced by the number of packages becoming available for a wide spectrum of machines. Software packages for the Apple, for example, are bursting on the scene at an unprecedented rate. One source of such packages is Information Unlimited Software Inc., Berkeley, CA (415-525-9452).

Among the offerings is "EasyWriter," priced at $250. This package requires at least a 48K Apple II or II Plus, an 80-column video card such as that manufactured by Videx, and an interface card for a printer. The package provides such standard features as word wrap, block moves, and formatted output. Also, boilerplate files, and data files can be easily inserted, usually with simple keystrokes from a displayed menu.

Although EasyWriter offers some classy features, most are standard in available word-processing packages. What makes this product unusual is the well-written manual and integrated tutorial to get you up to speed quickly. This is a feature not frequently found in most software documentation.

Since one of the real reasons for owning a micro is to handle data, IUS hasn't been left behind. They offer Datadex for $395 that lets you design the data fields the way you want them rather than restricting you to a fixed format. Furthermore, the designers have added a fast-sorting feature that stands up well even against larger machines. In addition, since you might be building data files to be used for multiple purposes, you can easily extract the information from the database either with a standard Applesoft INPUT statement or by calling the data from EasyWriter.

Even though it would seem as if business is the main objective of software designers, you can always expect to come across a good game, or for that matter a learning tool disguised as a game. Such is the case with IUS's third package, called "Tellstar." This package allows you to study the cosmos from anywhere on earth from the comfort of your own home. It has all the attributes of becoming the hottest software package available to date—and that's all I'm going to tell you for now! You can, however, drop in to your local computer store and ask for a demo.

Prices Are Dropping. Currently, microprocessors are very low in cost, and in the case of 8-bit processors, prices will get even lower (less than $3). Furthermore, with the state-of-the-art being what it is, most designers are able to create very powerful single-board computers for less than $100.

I insist that there is no hardware today that can be considered really fantastic. What can be, though, is the software that turns the hardware into a useful tool. To make my point, turn the pages back to about 18 months ago; most of the available software—I'm speaking of applications—was really barely adequate. Software designers were still refining their ability to handle 8-bit processors. Today you can find virtually an unlimited source of extremely high-level software products that perform tasks not even thought of as early as last year. And if you don't believe me, just check with IBM. Their new system is designed around software that actually optimizes the hardware.

With this almost explosive growth in the past 18-months, just imagine what I'll be writing about next year. Have a happy and joyous Thanksgiving. ◇

COMPUTER SOURCES

By Leslie Solomon
Senior Technical Editor

Hardware

Atari I/O. The MOSIAC I/O package allows the four ports of the Atari computer to connect to a PIA for use as output as well as input ports. This allows the system to communicate with custom controllers, interface to home-control circuits, or any other hardware. The package comes with four 9-pin connectors, four 12" lengths of 9-conductor ribbon cable, and complete instructions. Documentation includes program examples; how to access the ports via BASIC commands, shadow registers, or directly; and how to set up and address the ports for output. $18 (order number H309). **Address:** Mosiac Electronics, Box 748, Oregon City, OR 97045.

New Computer. The "Advantage" contains a 4-MHz Z80A, 64K bytes of 200 ns dynamic RAM (with parity), a separate 20K byte RAM for the bit-mapped graphics display, a 2K byte ROM, and an 8035 for keyboard and floppy disk control. The display is 24 lines of 80 characters or 240 × 640 bit-mapped pixels. The CRT is a 12" green (P31) display with nonglare viewing. The two floppies are 5¼" double-sided, double-density providing 360K bytes per drive for a total of 720K bytes. The n-key rollover keyboard contains 49 standard, 9 symbol or control, and a 14-key numeric cluster. There are 15 user definable keys. Six slots are provided for

expansion. Software includes Business Graphics, system diagnosis, and graphics demo. All NorthStar software can be run. For graphics-intensive applications, G-DOS with G-BASIC is used to exploit the system features. $3999. **Address:** NorthStar Computers Inc., 14440 Catalina St., San Leandro, CA 94577 (Tel: 415-357-8500).

Data Buffer. The Model 150 Type Ahead Buffer, is compatible with all Apple II systems and software. It features a 40-character type-ahead capability that eliminates the need to wait for computer prompts before entering the next command or data. It requires no software patches or hardware cuts or jumpers. $49.95. Address: Vista Computer Co., 1317 E. Edinger, Santa Ana, CA 92705 (Tel: 714-953-0523).

Membrane Keyboards. If you do your own construction, you can get a free four-page brochure covering a line of membrane keyboards. Ask for CE-952. **Address:** Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, IL 60085.

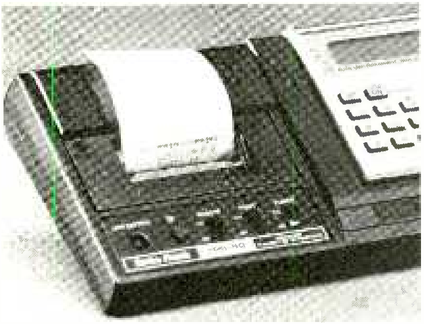
H-8 CPU Card. The HA-8-6 Z80 CPU card for the Heath H-8 Computer allows the choice of two CPU's—the Z80 on this board or the 8080 in the H-8. It is compatible with all current Heath disk-based software for the H-8, and includes all the features of the HA-8-8 Extended Configuration Option, thus eliminating the need to purchase the extended configuration separately before adding the Heath CP/M OS or the H-47 8-inch floppy. Factory assembled and tested. $199. **Address:** Heath Company, Dept. 350-135, Benton Harbor, MI 49022 or any Heath Center.

S100 RAM Board. SUPERAM 4C is a 64K dynamic RAM board functionally equivalent to the Cromenco 64KZ RAM card. It is organized in two blocks of 32K bytes that can be placed in any of eight different memory banks. Bank selection is on 32K boundries. It features bank select for up to 16 megabyte expansion. Memory refresh is totally transparent to the processor, access time is 250 ns, operating speed is 4 MHz, and there are no wait states. Operating power is +8 volts at .8 ampere and +18 volts at .2 ampere. $995. **Address:** Pii-ceon, Inc., 2350 Bering Drive, San Jose, CA 95131 (Tel: 408-946-8030).

Apple Power. The APS-5 Reserve Power Supply protects Apple II and III machines against power "flickers", prolonged power outages, and brownouts. Audible and electronic signals are provided. Operation is one hour and 45 minutes and features auto turn on, auto battery recharge, auto shut off, low battery indicator, and steel case. An optional APS-5DC adapter allows use with any 12-volt dc source including vehicle supplies. $389.95. **Address:** Control Technology Inc., 8200 N. Classen Blvd, Suite 101, Oklahoma City, OK 73114 (Tel: 405-840-3163).

PROM Burner. The APB PROM programmer is designed for the TRS-80 or Apple computers and can handle 2704, 2708, 2716, 2732, 2508, 2516, and 2532 EPROMs. The package includes the interface card, personality modules, software on disk, and instruction manual. Features include verify ROM is erased, read ROM, copy ROM, copy between different ROMs, program ROM, partial programming and copies, verify, read or save ROM data on disk or cassette (Apple only), program directly from computer memory, examine/modify working memory, and preset working memory. $149. **Address:** Apparat Inc., 4401 S. Tamarac Pkwy, Denver, CO 80237 (Tel: 303-741-1778).

Pocket Computer Interface. The combined printer and cassette interface for the Radio Shack Pocket Computer (26-3505) comes with rechargeable batteries, ac adapter/charger, cassette recorder cable, replaceable printer ribbon cartridge, three rolls of paper, and a



manual. A paper-advance button and papercutter edge are also provided. It uses the computer's PRINT and LIST commands to print a 16-column alphanumeric array. The printer operates at one line per second, and about 8000 lines per battery charge. An indicator alerts to low battery. Several options are available. $149.95. **Address:** Radio Shack stores and Computer Centers.

Apple Paddles. The Pro-Paddle for the Apple II features heavy metal construction, long-life switches with large buttons, tactile feedback, high-accuracy paddle movement, shielded coaxial cables, and a molded plug. $39.95. **Address:** Rainbow Computing, Inc., 19517 Business Center Drive, Northridge, CA 91324 (Tel: 213-349-0300).

STD Processor. This new CPU card is a Z80-based unit configured for the STD Bus. It features up to 4K of EPROM and up to 4K of RAM jumper selectable. An on-board RS232 port with selectable baud rates is also provided. Model 2007, 2-MHz version less EPROM and RAM is $159; Model 2007A, 4-MHz version is $169. **Address:** Robotics Technology, Inc., Box 401411, Dallas, TX 75240 (Tel: 214-328-8455).

Software

Job Control. Designed for the Apple II with 48K PASCAL, three-disk drives, and a 132-column printer, the Job Control System follows labor hours, material costs, outside service costs, production quantities, shipped quantities, etc. Reports include job listings, cost summaries, detailed job reports, and work-in-progress reports. They give profit/loss values and variances so job estimates and work standards can be fine tuned. It can be customized so that rate structure, report formats and up to 500 cost centers can be tailored. $750. **Address**: High Technology Software Products, 8001 N. Classen Blvd., Oklahoma City, OK 73113 (Tel: 405-840-9900).

H89 WordStar. The famous WordStar word processor is now available for the Heath/Zenith H89 system. Features include simultaneous printing and editing, alignment of numeric information in columns, and a number of on-screen menus. A hyphen-help feature, boldface, double strike, strikeout, subscript, superscript, overprint, and accent entry are provided. Version 2.6 is provided on 5¼" diskette, it runs under CP/M, and requires 48K bytes of RAM. The simultaneous edit/print version requires 64K. $395. Three optional programs—MailMerge, DataStar, and SuperSort—will soon be available. **Address**: Zenith Data Systems, 1000 Milwaukee Ave., Glenview, IL 60025 (Tel: 312-391-8181).

Forth Cross-Compiler. The Cross Compiler provides a convenient method to implement FORTH on a target computer or to extend/modify FORTH on a host computer. It will automatically forward–reference any word or label, and can produce headerless code. It can also produce ROMable code with initialized variables, and contains a load map and comprehensive list of undefined symbols. Machine-readable versions are available for CP/M, TRS-80 Model 1, H89, and North Star. Each version includes an executable version of fig-FORTH 1.0, the cross-compiler source code, the cross-compilable source, and complete documentation. $200. **Address**: Nautilus Systems, Box 1098, Santa Cruz, CA 95061 (Tel: 408-475-7461).

Apple FORTH. FORTH-79 requires an Apple II Plus with 48K of RAM and a disk. This language is useful where execution speed is important as programs run several times faster than BASIC. It features 16- and 32-bit integer arithmetic operators, but does not handle floating point. This is not a problem in many areas since the 32-bit integers can handle a range of -2,147,483,648 to 2,147,483,647 and can be printed in dollars and cents format. There are string commands similar to Applesoft BASIC, lo-res graphics words are provided for plotting and line drawing. You can create your own data type via CREATE and DOES, and the dictionary comes with about 400 words. It has a full-screen editor with 26 commands, using 23 lines by 40 columns. A 6505 assembler with macro capability is included, and the operating system allows for 14 disk drives. $89.95. **Address**: MicroMotion, 12077 Wishire Blvd., #506, Los Angeles, CA 90025 (Tel: 213-821-4340).

ZX80 Programs. Sinclair users interested in program interchange can contact Imelda Cardenas, Porvenir No. 12, Tlaquepaque, Mexico.

Comstar Utility. Comstar-CP/M is an interface that allows BASIC programs, compiled with the Comstar compiler, to run under CP/M. The interface contains a North Star-to-CP/M transfer routine, and a module to map the North Star DOS into the CP/M environment. The package is available to registered owners of the Comstar compiler for version 5.2 North Star BASIC. $75. **Address**: Allen Ashley, 395 Sierra Madre Villa, Pasadena, CA 91107 (Tel: 213-793-5748).

Appointment Book. DATEBOOK II maintains a record of appointments for up to 27 people in nine groups of three for an unlisted time in the future. All entries are checked for validity as they are entered. Menu items include appointment, scheduling, cancelling, modifying, rescheduling, searching for appointments for a specified person, scanning for openings, inspecting appointments for days in the future, and printing a day's appointments. It is written in PASCAL and is available to run on CP/M or CP/M 86, as well as UCSD PASCAL systems. $295. **Address**: Organic Software, 1492 Windsor Way, Livermore, CA 94550 (Tel: 415-455-4034).

Apple Mail. Micro-Courier allows Apple II computers to transmit charts, graphs, correspondence, VisiCalc reports or entire programs to other Apple computers via conventional telephone lines. The program is menu driven and requires no computer knowledge. $250. Micro Telegram allows access to Western Union Services worldwide and allows TWX, telex, and international cables. It permits on-screen editing, auto transmission, computer-stored subscriber lists, and directories. $250. **Address**: Microcom, 89 State St., Boston, MA 02109 (Tel: 617-367-6362).

ZX-80 Ball Game. Double Breakout is a fast ball game featuring continuous graphics for the 1K ZX-80. Nine balls are available and an inventory appears onscreen. There are seven levels of speed and skill. $14.95 plus $1.50 shipping/handling. **Address**: Softsync Inc., Box 480, Murray Hill Stn., New York, NY 10156.

Audio Product of the Month

CHOSEN BY THE EDITORS OF POPULAR ELECTRONICS

Optonica RT-6605 Stereo Cassette Deck

THE Optonica RT-6605 cassette deck departs from normal practice in that it contains two separate transport systems. One, designated Tape 1, is for playback only, using a single Sendust core head with a 0.8-micrometer gap. A second head is also included, apparently to sense the blank intervals that trigger the APSS system.

The other transport, Tape 2, is basically for recording only, with a 3-micrometer gap in its single head. (Of course, it also has a combination bias/erase head for recording).

The transport's controls are "soft-touch" buttons, most of them not operating solenoids. The bulk of the mechanical work in the transports is done by the drive motors (one per transport) through plastic gears and levers. The control buttons can be operated in any sequence.

Except for the need to transfer the tape from the Tape 2 to Tape 1 mechanism for playback after recording, and the separate controls for setting the BIAS/EQ and Dolby operation for the two decks, the normal operation of the RT-6605 is straightforward. However, the presence of two transports allows for a convenient built-in dubbing facility. Pushing the DUBBING button and setting the RECORD level control to a calibrated point are all that is needed to copy from Tape 1 to Tape 2.

The metal cabinet of the Optonica RT-6605 is finished in black, with simulated leatherette grain. It is 17″W × 12½″D × 4½″H, and weighs 16.5 pounds. Suggested retail price is $550.

General Description. Each of the two tape transports has its own motor, with a frequency-generator servo system to control speed. Although separate, the tape drives can be linked to the Tape 2 PAUSE button so that releasing it will start them in synch. Separate heads for recording and playback give the RT-6605 the performance potential of a conventional three-head machine, except for the ability to monitor the tape while recording.

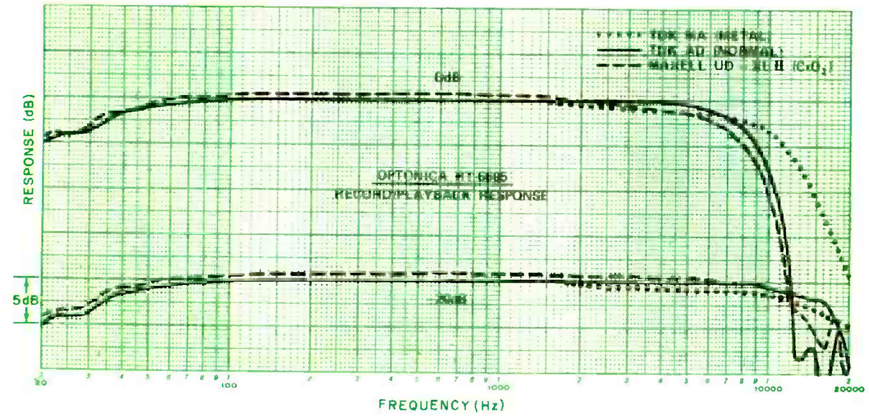
Tape 2 PLAY MONITOR button appears to provide that function, but it can be used to monitor a tape in the Tape 2 transport only *after* recording. *During* recording, the incoming signal is heard via the LINE OUT jacks. After the tape is recorded and rewound, pressing PLAY MONITOR starts the Tape 2 transport and plays the tape through the LINE OUT jacks, using the record head for playback. In this mode, frequency response is not flat, and there is no Dolby decoding. Proper playback frequency response and noise levels can only be obtained via Tape 1.

The "soft touch" transport controls operate smoothly, but with mechanical noises that last a second or so each time a button is pressed. On Tape 2, only the RECORD button need be pressed to make a recording (there being no "play" button as such), and one can change from any tape direction or mode to any other (even from a fast speed into record) without touching STOP. The same flexibility exists for Tape 1, except that it has no recording function (or tape index counter) and the APSS is always available for operation. In either fast-forward or rewind, when a four-second unrecorded tape segment is encountered, the tape stops and goes into play (or remains stopped if the PAUSE button was previously engaged).

Even though it lacks an index counter, Tape 1 can still be used to return a tape to a previously selected reference point. If the four-second silent sections have been inserted into the recording between selections or parts of longer works (by pressing REC MUTE while recording) the APSS will help locate parts of a recorded tape when it is played in Tape 1 transport.

Both transports can be used with timer-controlled operation for unattended recording or playback. The buttons for PLAY and RECORD engage mechanically, so that when power is later applied, the soft-touch mechanism completes its operating cycle.

Levels for dubbing are set by an index mark on the RECORD level knob, but there is provision for transferring between tapes that have very different output levels for the same recording reference level, or in cases where the master tape was recorded at a higher or lower



Frequency-response curve for three different tape types.

level than usual. The RECORD knob has calibrations over a ±7-dB range at 1-dB intervals, and the instruction manual lists recommended settings for various combinations of tape formulations and master levels (as read on the recorder's peak-level indicators).

The peak-level indicators are twin parallel lines of fluorescent marks calibrated from −20 to +8 dB (the standard Dolby level of 200 nw/m comes at the 0-dB calibration). The indicators have a very fast attack time and slower decay. As a further aid to setting levels for dubbing, the PEAK HOLD button on the panel causes the maximum peak levels in each channel (higher than 0 db) to be retained on the display while the rest of it continues to show the changing program levels.

Laboratory Measurements. The instruction manual for the Optonica RT-6605 lists a number of currently available tape formulations together with the recommended EQ settings and the suggested range of BIAS ADJUST variation that might be used for flattest response with each. The manual also suggested a few tapes that (we assume) were used to establish the recorder's specifications. We used some of these, plus our own choices, for the measurements on the recorder.

Our NORMAL (low-bias ferric) tape was TDK AD, with Maxell UD-XL II serving as a "chrome equivalent" tape, and TDK MA for metal tape. Although the machine has a switch setting for FeCr tape, none was specifically recommended and we did not use one in our tests.

The BIAS ADJUST was set to its midposition (lightly detented) for each tape and its record/playback frequency response was measured at recording levels of 0 and −20 dB. The "tracking" of the Dolby circuits was checked by measuring the record/playback response at −20 and −40 dB, with and without the Dolby switched on, to see how much the frequency-response was affected. Response of the MPX filter was also measured at a −20-dB level. The range of the BIAS ADJUST control was measured for each tape by plotting its frequency response (at −20 dB) for center and extreme settings of the control. Playback equalization was measured on Tape 1 with both 70-μs and 120-μs standard tapes, and also in the PLAY MONITOR mode of Tape 2. For all of our combined record/playback response measurements, we recorded in Tape 2 and transferred the cassette to Tape 1 for playback.

A line input of 70 mV at 1 kHz produced a 0-dB recording level indication. The maximum playback output from that signal was in the range of 1 to 1.25 V, depending on the tape used, from the Tape 2 PLAY MONITOR, and about 0.8 to 0.85 V from the Tape 1 output. The third-harmonic distortion in the playback from a 0-dB signal was 0.7% with TDK AD and MA tapes, and 1% with Maxell UD-XL II. To reach the reference distortion level of 3%, we had to record at +6 dB with TDK AD, +4 dB with Maxell UD-XL II, and +7 dB with TDK MA. The unweighted S/N in the output, referred to those signal levels, was about 55 dB with the two ferric tapes and 58 dB with metal tape. With the Dolby system on, and CCIR weighting, the respective S/N readings were 66 to 67 dB, and just over 70 dB.

The level indicators read −1 dB with a standard level Dolby calibration tape on Tape 1, and 0 to +1 dB on Tape 2. The level indicators read 100% of their steady-state readings on 0.3-second tone-burst signals. The two transports operated at identical speeds, which appeared to be exact.

Flutter readings on both were very low—0.065% weighted peak and 0.04% weighted rms. The fast tape speeds were not particularly fast, with 103 seconds required on either transport to move a C60 tape from one end to the other.

The 120-μs playback response (Tape 1) was flat within +0.5, −1.5 dB from 40 to 12,500 Hz, and the 70-μs response had about the same variation, but at different frequencies. Response of the PLAY MONITOR output of Tape 2 dropped off below 200 Hz, to −5 dB at 40 Hz with both test tapes. The equalization (fixed in this mode of operation) was fairly good for the 70-μs tape, with a 2.5-dB rise in the 4-to-6-kHz range and a drop-off to −1.2 dB at 10,000 Hz. The error with 120-μs tape was much larger, with the response rolling off above 3 kHz to −11dB at 12.5 kHz.

The record/playback frequency response of all the tapes at −20 dB was fairly similar. It was notably flat, smooth, and free of low-frequency "head bumps", although the low-frequency output sloped downward below about 50 Hz and was typically about −5 dB at 20 Hz. The response curve

OPERATING FEATURES

Front-Panel:

POWER: Switch button.

EJECT: (Separate for two cassette transports.) Opens cassette door for loading or removing tape.

REC MUTE: Removes recording signal from Tape 2 while it is held in, to provide pauses necessary for operation of APSS.

TAPE: A four-position bias/eq switch for FeCr, CrO_2, NORMAL, METAL tapes.

DOLBY NR: A three-position switch for OFF, ON, MPX (filter that affects only recording input).

RECORD: Concentric level adjustments for recording inputs. Calibrated for dubbing mode.

OUTPUT: Playback output level adjustments, controlling line and phone levels from either deck.

BIAS ADJUST: Provides a ±10% vernier adjustment of bias for each of the tape settings.

PEAK HOLD: A button that causes the level of display to retain its highest reading, while showing variations of program level, in either record or playback operation.

PHONES: Jack for stereo headphones.

Tape 1: Transport control push buttons: REWIND, FAST FORWARD, PLAY, STOP, PAUSE. Tape 1 also has APSS (Auto Program Search System) feature that stops tape at beginning or end of a recorded segment in fast speed.

Tape 1: Electronics pushbuttons: EQ (70 or 120 μs), DOLBY NR (ON or OFF), DUBBING (internal connection to Tape 2 recording input), MONITOR (connects line and phones outputs to playback from either Tape 1 or Tape 2.

Tape 2: Transport control pushbuttons: REWIND, FAST FORWARD, RECORD, PLAY MONITOR (uses record head for playback, with limited frequency response and no Dolby decoding), STOP, PAUSE/ONE TOUCH START (can be used to start both transports for dubbing).

Rear Panel:

Phono Jacks: LINE IN and LINE OUT

was virtually ruler-flat from 100 to about 9,000 Hz with all the tapes, with no high-frequency peak and only a gentle downward slope above 10,000 Hz. The −3-dB response frequencies for TDK AD tape were 32 and 17,800 Hz; for Maxell UD-XL II, they were 32 and 13,000 Hz; and for TDK MA, they were 32 and 15,000 Hz.

The BIAS ADJUST control had a profound effect on the high-frequency response of all the tapes. Typically, the response was affected above 1 kHz with the maximum change occurring at about 17 kHz (20 kHz with the MA tape). The range of variation was about ±6 dB, so that it would have been possible to achieve a nearly flat response up to well beyond 15 kHz with any of the tapes. However, there is no built-in means of optimizing the bias, and it is extremely tedious to record noise or other signals on Tape 2 and transfer the tape to Tape 1 to determine the effect of each small bias change on response.

The 0-dB record/playback response with most of the tapes followed the usual pattern, rolling off at high frequencies and intersecting the −20-dB curve at 12 to 13 kHz. The metal tape, due to its superior high-frequency saturation properties, had a 0-dB response that remained well above the −20-dB curve all the way up to our 20-kHz measurement limit.

The Dolby tracking was very close at −40 dB, but at −20 dB there was an error of about 3 dB over most of the upper-middle and high-frequency range. The MPX filter cut off the recorded signal sharply above 17 kHz. Since the recorder's inherent response falls rapidly in that range, the filter can safely be left on whenever the Dolby is engaged.

User Comment. The Optonica RT-6605 is truly a unique cassette deck (or *pair* of decks). Its electrical performance is first-rate, as evidenced by its very smooth and extended frequency response, low distortion, and a S/N of better than 70 dB with metal tape. Of course, this is, functionally speaking, a machine with separate recording and playback heads and electronics—and even transport mechanisms!—although it lacks the off-the-tape monitoring feature of most three-head machines.

For many people, the internal dubbing connection of the RT-6605 will more than compensate for any such omissions. Even if two good decks are available for dubbing tapes, there is always some awkwardness and the possibility of problems in the interconnection between them. We have also found it clumsy at some times to start two machines simultaneously. This is done with one button in the Optonica RT-6605 and so effortlessly that one comes to take it for granted.

Less easy to accept, perhaps, is the operation of the RT-6605 as a normal cassette deck. Frankly, it is annoying, after recording a cassette in Tape 2, to have to rewind it to 000 on the single index counter (which only functions on Tape 2), then unload it and load it into Tape 1 before playing it. This problem is aggravated by a rather critical fit between the cassette and the guide rails in the loading door. If the cassette is inserted hurriedly or carelessly, it will not seat properly and the door cannot be closed.

In fairness, we must say that after some use operation becomes less awkward, and we certainly cannot fault the actual performance of the recorder in any way. A careful study of the manual is a "must" if one expects to use this deck at all, however. We also would have appreciated a distinctive marking or color coding for the Tape 1 buttons and other controls, to distinguish them from those affecting only Tape 2.

In summary, the Optonica RT-6605 is a very fine double cassette deck with unparalleled versatility for many types of operation. For all that it does, it is priced very competitively. And when dubbing is required, the RT-6605 is far superior in compactness, versatility, and convenience than two machines would be.—*Julian D. Hirsch*

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Quasar Model WT5977T 19" Color TV Receiver

QUASAR, a Matsushita subsidiary, is moving into the 1981-1982 season with a 105-channel, table-top receiver that has a comb filter and uses RCA's 19VJTP22 CRT and seven integrated circuits (four of which are off-the-shelf domestic items). These U.S. ICs are in the video i-f amplifiers and the automatic fine tuning (aft), sound amplification, demodulation, and chroma processor circuits, leaving only 17 discrete transistors on the chassis proper. Price is not firm at this writing, but it is expected to be over $600.

General Description. The operating portion of the WT5977T model is a LDTS-989 chassis (formerly LDTS-979) which was originally offered in the fall of 1980. It appears in the new line with only the chassis layout changed. The cabinet photo is of the new set, but all chassis and tuner information derives from the LDTS-979.

Compumatic Tuning consists of a large 28-pin microprocessor, an automatic fine-tuning comparator, power supply, an infrared remote-control sensor amplifier, LED channel indicators, and driver transistors for tuner band selection and u/v switching and volume control. The front keyboard connects to the microprocessor for direct address. The system has its own regulated and isolated 5-V power supply, as well as +12-V and −138-V sources.

When used with cable, a manual three-position TV/CATV switch actually programs the microprocessor so it will handle midband A-I frequencies for channels 14-22 as well as the superband J-W ranges over channels 23-36.

Although this microprocessor features a tight 7.162109375-MHz crystal reference, the adjacent aft comparator is designed to permit enough leeway to handle most (if not all) of the nonstandard offset carriers found in some cable systems.

Main Receiver Characteristics. The block diagram of the receiver (Fig. 1) shows that all components except for the deflection yoke, flyback transformer, Dynafilter, and CRT/video output board are mounted (and soldered) on a single "planar" chassis. It has slide rails and two retaining screws for easy servicing. Integrated circuits *IC101, IC151*, and *IC601* are RCA Semiconductor Division products, while *IC201* was first developed by SGS/ATES, but is now available from other U.S. sources.

The *IC201* TDA1190Z sound chip consists of an i-f amplifier and limiter, low-pass filter, peak FM detector, regulated power supply, dc volume control, and complex audio frequency power amplifier, all on a single heat-sunk IC. CA3139 aft *IC151* has a cascode amplifier, bias circuit, phase detector and dc amplifier, an internal shunt regulator, and a mixer/amplifier combination that detects 4.5-MHz sound intercarrier for *IC201*. Video i-f processor, agc, and video detection all appear on *IC101*, a 16-

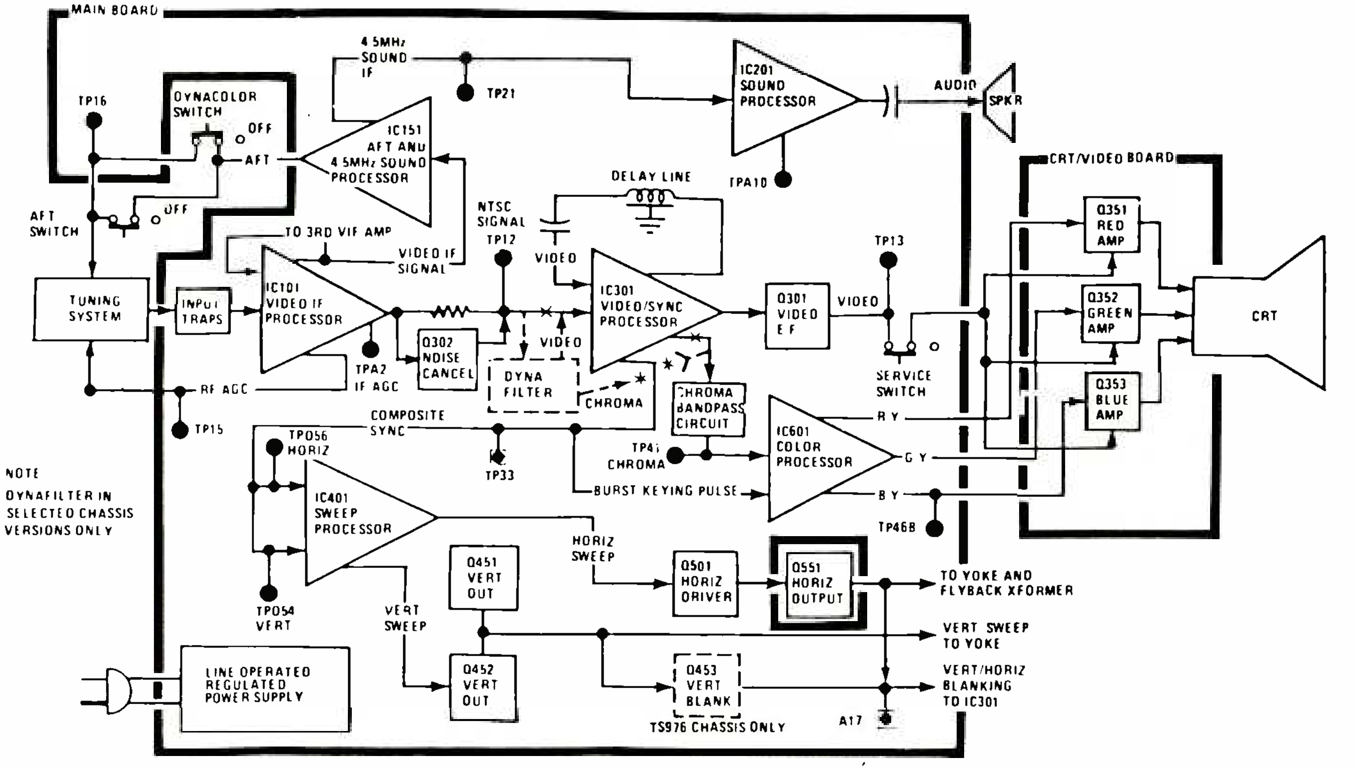


Fig. 1. Block diagram of the LDTS-979 chassis.

pin CA3153G with sample-and-hold and other sophisticated circuits. *IC601* can be identified as a CA3151G designed to produce complete chroma processing and demodulation on a single 24-pin chip, including a "flesh corrector" carrier output which Quasar calls "Dynacolor." Both video i-f and chroma circuits represent state-of-the-art video processing.

A novel integrated circuit is the *IC401* sweep processor that contains the horizontal afc and oscillator, as well as the vertical oscillator and initial amplifier. Among the discretes are the usual chroma/video, horizontal, and stacked vertical outputs, in addition to a standard overvoltage protection circuit and +12-V regulator.

This receiver, like most 19-inch table models, has no isolation power transformer. It does use standard rectification, however, with one side of the power line going to chassis (and not to the less-desirable above-ground bridge rectifier that some manufacturers still use.)

Finally, there is a light-sensitive resistor connected to one end of the picture control that automatically changes luminance bias as the ambient light changes. Regular video peaking, gain, blanking, sync separation, noise cancellation, and pedestal black level clamping are taken care of in *IC301*.

Integrated Circuits. The CA3153G is a multifunction IC of considerable utility that is worth analyzing if only briefly. What you see in the lower left corner of Fig. 2 is an input from the u/v tuner combination that has an IC for its output. There is a well-designed 39.75-MHz upper adjacent-channel video, a 47.25-MHz lower adjacent-channel audio, and 41.25-MHz initial audio carrier trapping. All of this effectively eliminates Citizens Band and other routine interference, yet delivers a well-balanced 44-MHz signal to the i-f stages for excellent automatic gain control and video/audio processing. Amplifiers *A1* and *A2* have 44-MHz throughput bandpass tuning, and *A1* is gain-con-

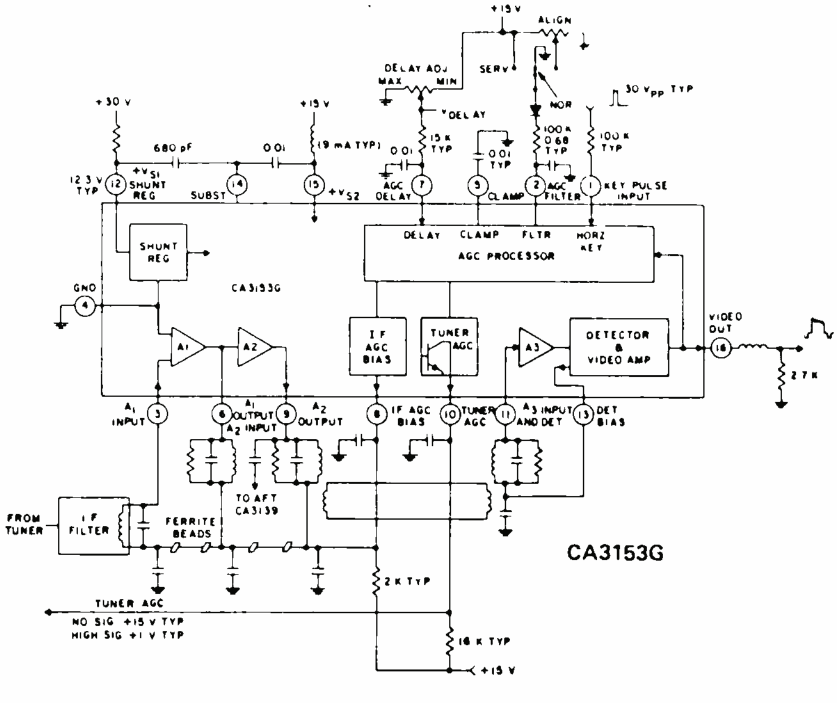


Fig. 2. Functional diagram of the CA3153G video i-f, agc and detector.

trolled by filtered i-f agc bias via its input. Remaining audio/video signals become transformer-coupled to *A3*, a multi-stage amplifier, followed internally by transistor and capacitor peak video detectors and a final stage of noise and overload-protected output. Should spikes of noise appear in the video, three chip transistors conduct and shunt the interference to common ground.

Agc also derives potential from video output as the luminance is clipped, leaving only sync pulses for processing. When these broadcast sync tips are coincident with those entering the keyed pulse input, they develop current for the agc filter at terminal 2. Following initial charge, this capacitor "sees" only the differences between charge and discharge currents during key pulse times, providing a "sample-and-hold function." The capacitor at the clamp terminal receives positive inputs above a certain potential through a diode at terminal 3 and limits operating levels of the other agc transistors. The 0.01-μF capacitor at the agc delay is nothing more than a filter, preventing "hash" from entering dc operating voltages.

As previously stated, *IC601* is an RCA CA3151G LSI (Fig. 3). Its internal "Dynacolor" and external wideband comb filter supplant many formerly discrete components from the main circuit board, improving color processing.

Chroma sidebands and burst enter the 24-pin IC through the first chroma amplifier. They proceed to the second chroma amplifier, where automatic phase and chroma detectors rectify and phase shift the 3.58-MHz signals while being keyed by horizontal broadcast sync pulses. The balanced/unbalanced translator responds to the presence of burst during the horizontal blanking interval, keeping the color killer off. This permits the acc amplifier to develop gain for the first chroma amplifier, which operates only during line scan time and cut off during blanking. The automatic frequency and phase control (AFPC) also receives feedback from the 3.579545-MHz crystal-controlled subcarrier oscillator, as does the acc detector. If this oscillator is not on precisely the same frequency as the broadcast signal, a dc correction voltage through the sample-and-hold arrangement of the AFPC returns the oscillator to proper operation. The sample-and-hold circuit can also correct the oscillator frequency by storing error signal differences in its charge and discharge paths.

Tint-amplifier phase can also be changed manually with an external tint control, which is then routed to a dynamic fleshtone circuit that receives color information from the second chroma amplifier. This well-known RCA "ColorTrak" circuit may be either disabled or energized in the receiver by an external switch. In operation, chroma from the second amplifier is both buffered and limited, while tint (phase) enters through another port. Chroma signals, thereafter, are amplitude modulated by chroma phase, producing broad dynamic fleshtone correction. The price for this is a squeezing together of the oranges and reds, with some skew of greens. The resulting color continues to the I and Q demodulators where chroma is synchronously detected by application of phase shifted cw sinewaves from the subcarrier regenerator. This produces a resistively matrixed RGB-Y output.

Dynafilter. Usually called a comb filter because of its alternate line chroma subtraction or luminance addition, the dynafilter consists of five transistors (Fig. 4) and associated passive components mounted on a small printed-circuit board at the rear of the chassis. It receives a single composite video input and produces separate chroma and luminance outputs for sync/video *IC301* and chroma processor *IC601*.

This ac-coupled composite video passes through or around a single 1-H tapped inductor to delay the signal for exactly 63.5 microseconds. Since the color subcarrier changes the line phase 180 degrees on any two successive scans, summing the lines doubles the value of luminance and removes chroma. Conversely, subtracting the ouputs permits passage of chroma while rejecting lumi-

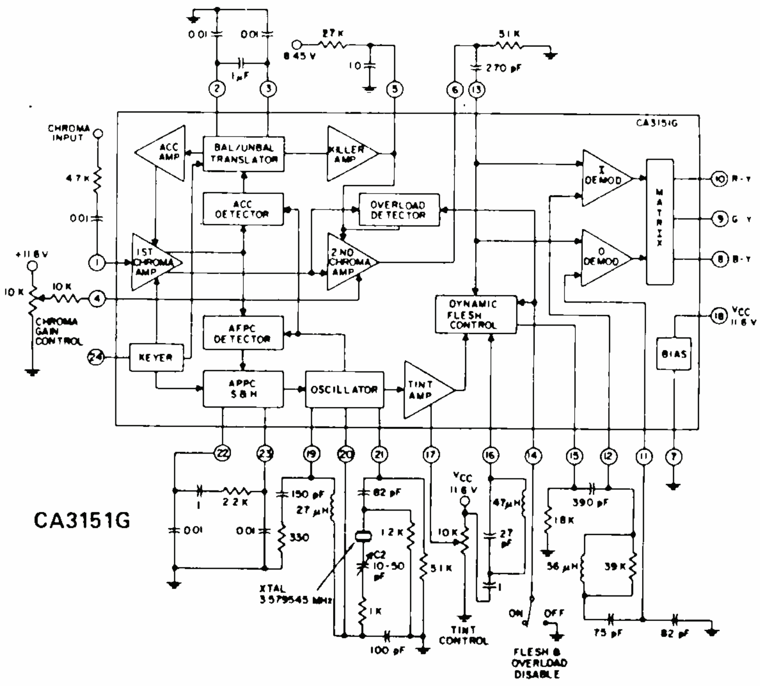


Fig. 3. The CA3151G single-chip chroma processor and demodulator.

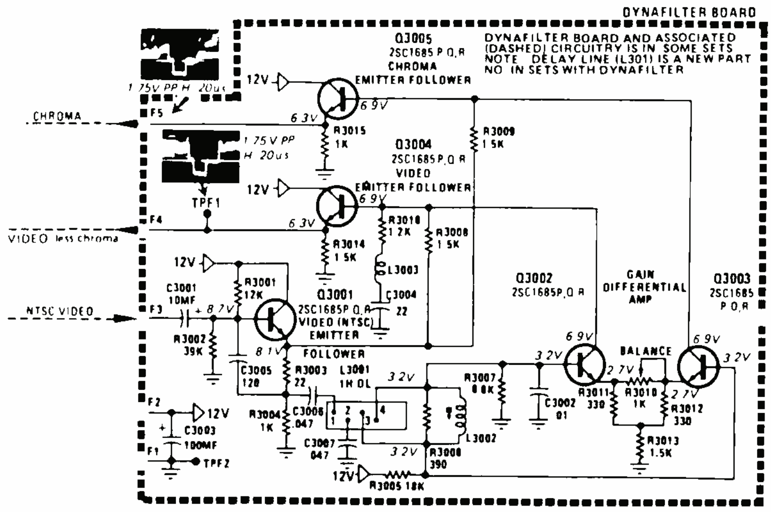


Fig. 4. Quasar's differential amplifier dynafilter.

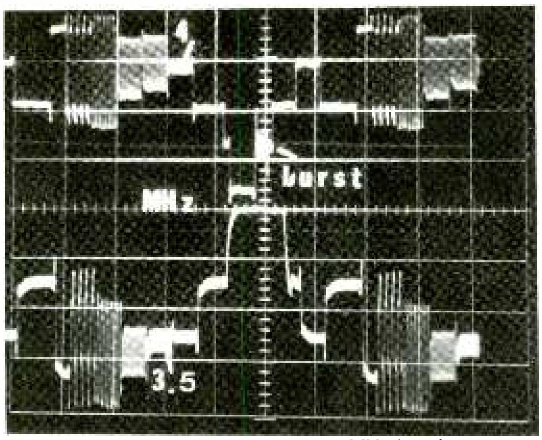


Fig. 5. Multiburst test shows 5 MHz bandpass at video detector and 3.5 MHz at cathode ray tube.

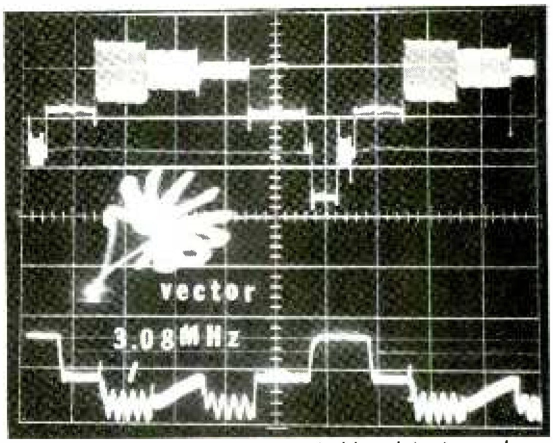


Fig. 6. Swept chroma test at video detector and cathode ray tube. Vector is somewhat irregular.

nance. Thus, if signals passing through input follower *Q3001* are delayed by *L3001*, and then added to the original information, only the chroma is able to proceed to *Q3003*. Here it is amplified for the low-impedance output driver *Q3005*. When it is not necessary for luminance to pass through *L3001* for cancellation, the two adjacent lines add. Chroma is then filtered by *L3002*, *C3302* and *R3006*, and *R3007*. Finally, chroma-free luminance is differentially amplified by *Q3002* before proceeding to low-impedance output driver *Q3004*.

Since dc as well as ac currents are flowing in the emitters of the differential amplifier, the *R3010* balance control adjustment is critical. This type of bypass configuration ensures that maximum luminance bandpass reaches the cathode ray tube whether or not color is being received. Unfortunately, many comb filter systems used in U.S. sets require color burst to produce full bandpass triggering. This one does not! There is, however, some attenuation of bandpass because of *L3003* and *C3004* in the base circuit of video follower *Q3004*. But this helps to prevent any chroma-luminance crosstalk.

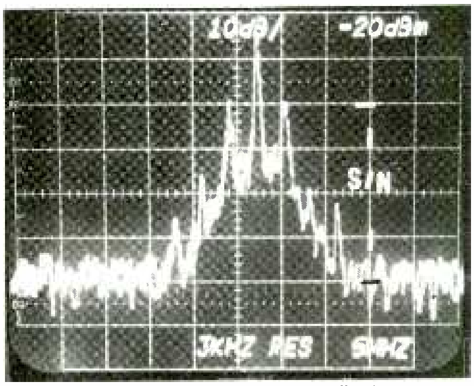


Fig. 7. Spectrum analyzer display of luminance at the CRT. S/N ratio measures 40 dB.

Comments. Basically, the WT5976S/WT5977T receivers are conventional sets with very good tuners. COLOR/LUMINANCE/AUDIO controls are located beneath the keyboard channel-select, and are readily accessible. Tuner/system signal pickup is average or a little better; agc swing of 68 dB is very good; and at 60 feet no CB interference was noted.

The 3.5-MHz horizontal frequency response cutoff was somewhat disappointing (Fig. 5), but Quasar and several other manufacturers would rather have clean pictures and avoid chroma/luma crosstalk. AM riding on the swept chroma in Fig. 6 is nothing unusual, but is visible in both the vector and the 3.08-MHz portion of the swept color output as a slight "fuzz."

Figure 7, shows the 40-dB signal-to-noise ratio—an acceptable figure for this type of receiver. Dc restoration of 82.9% is fine and almost a requirement for a good picture because so many broadcasters seem to vary their black levels and chroma phase arbitrarily. Voltage regulation, while not superb, is adequate for overall receiver operation. We also checked the set on midband cable hookup and it performed well.

A 110-degree color picture tube would have shortened cabinet depth nicely, but the extra cost over the 90-degree tube used might have been prohibitive.—*Stan Prentiss*

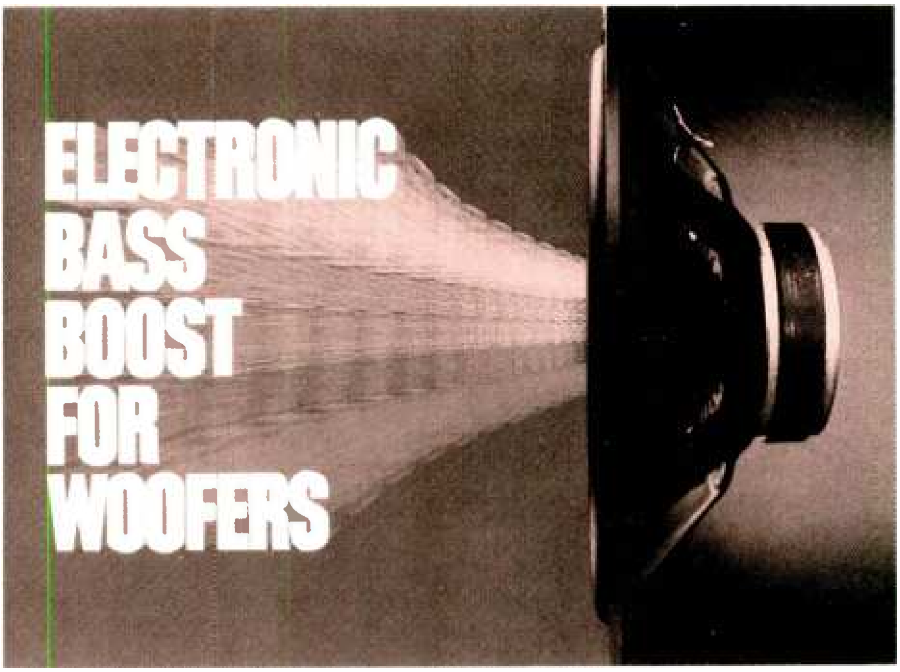
CIRCLE NO. 103 ON FREE INFORMATION CARD

QUASAR MODEL WT5977T 19" COLOR TV RECEIVER LABORATORY DATA

Parameter	Measurement
Tuner/receiver sensitivity (min. signal for snow-free picture):	vhf (Ch.6): −8 dBmV uhf (Ch. 30): −3 dBmV
Voltage regulation (line varied between 105 and 130 V):	Low voltage: 123-V supply—92% 12-V supply—99% High voltage: 26-kV supply—91%
Luminance bandpass at video detector:	4 MHz
Luminance bandpass at CRT:	3.5 MHz
Dc restoration:	82.9%
Agc response before white/black level changes or sync clipping: (−8 dBmV to + 60 dBmV):	68 dB
S/N ratio at CRT:	40 dB
Horizontal overscan:	15%
Convergence:	99%
Audio bandpass (3 dB down):	65 Hz to 4.5 kHz
Aux. audio output impedance:	9 ohms
Power requirements (signal applied):	125 W

NOTE: Test equipment used: Tektronix - 7L12 spectrum analyzer, C5A camera; Telequipment D66 and D67A - oscilloscopes; Sadelco FS-3D VU f/s meter; Winegard DX-300 amplifier; Data Precision 245, 248, 258 multimeters; B & K-Precision 1248, 1250 color bar generators and 3020 f/g; Sencore VA48 (modified) video analyzer, CG169 color bar generator, and PR57 AC "Powerite."

Popular Electronics
NOVEMBER 1981



Electronic Bass Boost for Woofers

Add an extra octave of clean bass with a low-cost active filter

BY RICHARD KAUFMAN

TO CONNECT a filter network costing, say, $30, ahead of your power amplifier and get the bass response characteristic of giant woofers from your inexpensive bookshelf speakers may sound farfetched, but the principle is already at work in several commercial products. Properly matched and adjusted for a specific speaker, such networks can provide an extra octave or so of clean bass. Mismatched, they are at best ineffective and can be destructive to drivers. A home builder, however, should have no problem in adjusting the booster circuit to his speaker.

Thiele's Equations. In 1962 an Australian physicist named Neville Thiele published a paper in which he was able to explain the behavior of both acoustic-suspension and tuned-port loudspeakers by treating loudspeakers as electrical high-pass filters. The mathematics describing filter behavior had been worked out long ago, and Thiele's insight let him plug the equivalent values for speakers into the formulas and predict the way the system would behave. Now, for the first time, a loudspeaker designer could start with certain given factors, such as box size or a particular driver, and determine, without tedious trial and error, if the desired performance was achievable. Thiele published a table of "alignments" relating parameters such as speaker compliance, mass, box size, and duct tuning with acoustic performance. He named his alignments after electrical filters with the same behavior, such as Butterworth and Chebyschev.

Thiele also showed that by cascading an electrical network with the speaker, one could obtain the response of a higher-order filter. This technique has been used commercially with tuned-port speakers for several years; we will use a similar method to extend the response of an acoustic-suspension speaker.

High-Pass Filters. A capacitor is the simplest high-pass filter since its response is down 3 dB at the cutoff frequency, and continues to rolloff at a rate of 6 dB per octave. This is called a first-order filter and is shown in Fig. 1A. If an inductor is added to the circuit (Fig. 1B) we have a second-order filter whose response rolls off at an ultimate rate of 12 dB per octave. The rate can be higher

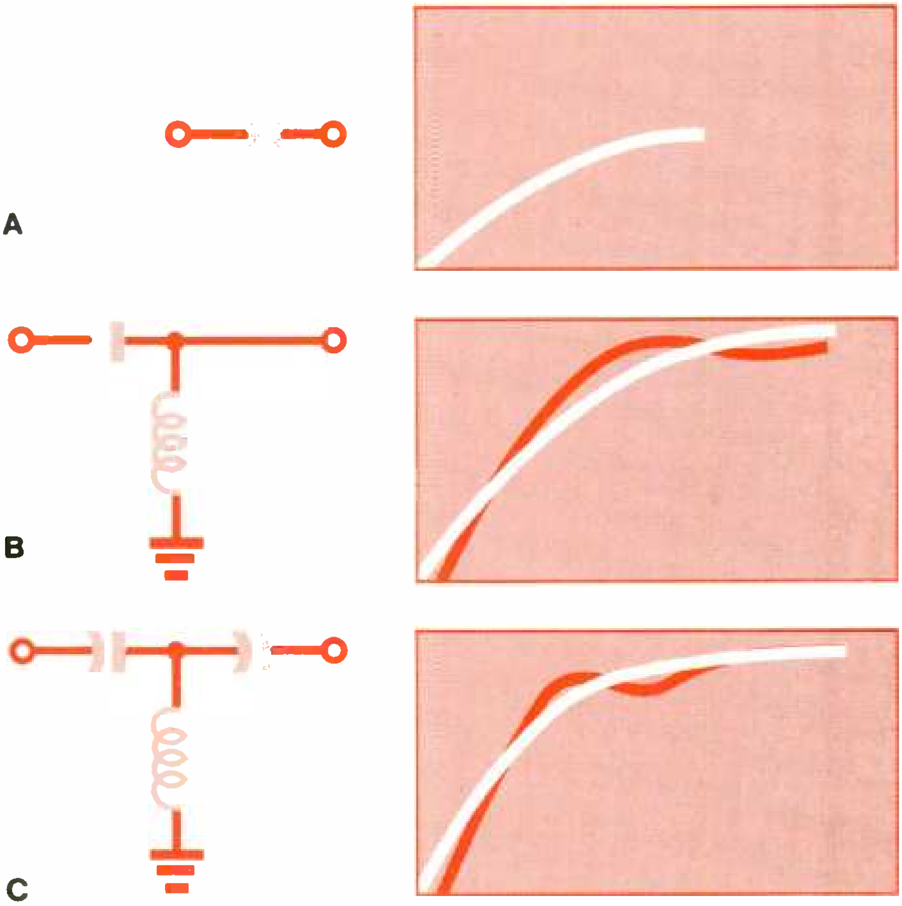


Fig. 1. First (A), second (B), and third (C) order filters and responses. Smooth curves are Butterworth, others are Chebyschev.

or lower near the cutoff frequency where response is down by 3 dB, depending on the values of the components used. Chebyschev filters have the sharpest cutoff, but at the expense of some ripple (uneven response) in the passband. Butterworth filters give the flattest response, but cutoff is not as sharp. Bessel filters have the best phase-shift and transient response, but the attenuation extends several octaves up into the passband.

As shown in Fig. 1C, adding another capacitor to a second-order filter makes a third-order filter, with a rolloff of 18 dB per octave. Adding another inductor gives a fourth-order filter, with 24-dB/octave rolloff. Higher-order filters, with their sharper cutoffs, are also characterized as Chebyschev, Butterworth and Bessel. With Chebyschev filters, the number of ripples in the passband increases with the order of the filter.

Thiele showed that acoustic suspension speakers behave like second-order high-pass filters, and that tuned-port speaker systems behave like fourth-order high-pass filters. Just as it is possible to cascade filters to obtain a desired response, it is possible to substitute a speaker for one of the filters. Thus, as Thiele's data showed, a speaker can be made to give a response of higher order than it normally would. By matching the filter and speaker properly, we can extend bass response and increase the final rate of rolloff.

Filter Parameters. The Q of a filter is inversely related to damping. A high-Q filter has a bump, or boost, near the cutoff frequency. The higher the Q, the higher the bump in the response curve, and the lower the damping. An underdamped, high-Q filter is an oscillator. Cheap speakers with "boomy" bass have a high Q and any low note forces them to "boom" at their resonant frequency, instead of reproducing the low-frequency note. Designers consider a system Q of 1 to be the maximum desirable for acoustic-suspension speakers. Many design for a Q of just under 1 to allow for minor production differences in their drivers, and to lower distortion. This is fortunate, since second-order response with a Q of just under 1 can be cascaded with an electrical filter to give a very nearly smooth 4th-order response extending much lower than the original cutoff point.

Using the passive circuits shown in Fig. 1, would cause too much attenuation, but operational amplifiers make it possible to construct an active filter that doesn't have this loss. First- and second-order active high-pass filters are shown in Fig. 2. Note that resistors and an op amp have been substituted for the inductors shown in Fig. 1. By adjusting the values of the resistors and capacitors, one can control the cutoff frequency, and, for the second-order filter, independently adjust Q. Not all op amps will work with the second-order circuits. For example, a 741 would limit high-frequency response to 10 kHz, while an LM318 would work up to 20 kHz. Newer BiFet devices are even better.

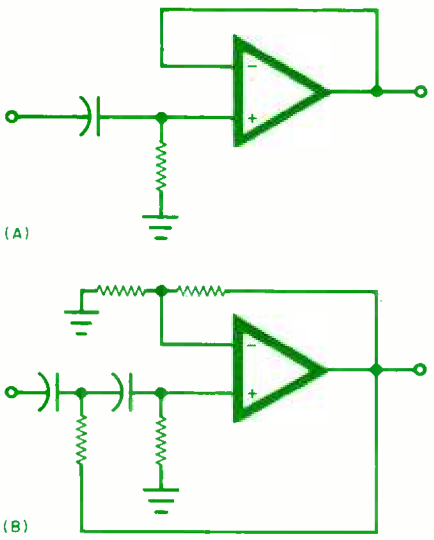


Fig. 2. Simplified active filters: (A) first order and (B) second order.

Table I is a chart of design information for speakers with Q in our range of interest. Knowing a speaker's Q and its resonance frequency, one can determine the resonance frequency and Q for a filter that will extend bass response. Figure 3 shows the result of cascading a second-order filter with a second-order speaker. Note that the cascaded curve extends to lower frequencies with only slightly more deviation from a flat response than the original.

It is also possible to use a filter with a tuned-port loudspeaker, to improve bass and to protect against infrasonic overdrive. One should never apply bass boost below the resonant frequency of the port, since the speaker is decoupled from the port below this resonance, and high-amplitude signals could force the cone to too great an excursion. By retuning the port half an octave below its present frequency, and designing the active filter for a frequency 7% above the new frequency, it is possible to extend bass response down by half an octave. Retuning the port involves lengthening the duct by about 50% of its present length. It is permissible for the duct to bend or project beyond the outside of the cabinet. Measure the resonance, using the procedure described below, and cut the new duct tube until the resonance is three-quarters of the old resonance.

Determining Speaker Parameters. Most often, acoustic-suspension speaker systems have a Q of about 0.9, and the system resonance of 8″ speakers averages about 58 Hz. The resonance of 10″ speakers averages about 46 Hz, 12″ units about 36 Hz, and 6″ about 72 Hz. These are such rough estimates that they are good only for determining a range of values to allow one to tune by ear. When the actual cutoff point—the point at which response is down by 3 dB—is known, it is safe to assume a Q of 0.9 and estimate system resonance from Table II. If the frequency response is not stated unequivocally, write to the manufacturer and ask for system resonance and anechoic cutoff frequency. (Make sure the resonance figure you get is not the free-air resonance—it will be far too low.) Product reviews in audio and consumer testing magazines are also good sources for cutoff-frequency data.

Measuring system resonance is easy with a VOM and a signal generator, by finding the impedance peak. Apply a

TABLE I—SPEAKER-FILTER CASCADE

Chebyschev Response Type	Speaker			Filter				
	Resonance Frequency	Damping	Q	Resonance Frequency	Damping	Q	Peak dB	Peak V Gain
Least Dip (0.1DB)	1.410f	1.534	0.652	1.029f	0.463	2.16	+7.74	2.4
1-DeciBel Dip	1.992f	1.275	0.784	1.060f	0.281	3.56	+11.1	3.6
2-DeciBel Dip	2.146f	1.088	0.919	1.057f	0.224	4.46	+12.5	4.2
3-DeciBel Dip	2.257f	0.929	1.076	1.053f	0.179	5.59	+14.9	5.6

Note: f is the -3 dB point for the cascaded system relative to the peak response

400-Hz signal to the speaker through your amplifier, measuring the voltage across the speaker. (This test is more sensitive with a 500-ohm, 2-watt resistor in series with the speaker. The resistor also protects the speaker from overdrive.) Take care not to overload your amplifier input, and slowly turn up the amplifier's volume control until the voltage drop across the speaker is between 0.7 and 1.0 volt. Sweep the signal frequency downward from 100 Hz, checking the VOM as you go. The frequency for which the voltage drop across the speaker is greatest is the resonance frequency. If the impedance peak is flat and broad, use the point one-third of the way between the lowest frequency and the highest frequency in the resonant range. There should be only one peak for an acoustic suspension speaker. Tuned-port speakers will have two impedance peaks. The valley between them, the point of least voltage drop, is the tuned-duct frequency that must be lowered by 25% to extend bass response. Using a VOM, keep the minimum above 0.7 V to get an accurate reading.

A Design Example. Assume a typical high-quality bookshelf system with an 8″ acoustic-suspension woofer having the following specifications: impedance, 8 ohms; frequency response, 48 to 20,000 Hz, ±3 dB; and recommended power range, 12 to 80 watts. If we assume the system Q is 0.9, Table II indicates that the *fc* to *fr* ratio is 0.83. Divide the cutoff frequency by the *fc/fr* ratio, which for our example is 48 Hz/0.83 or 57.8 Hz. Since we will work only with two-digit accuracy, round this out to 58 Hz. Dividing *fc* by *fr* gives 48/58 or 0.83 (rounded to two digits). Table II shows a Q of 0.9 for this ratio.

In Table I, the closest speaker Q listed is 0.919; therefore we will use the response with a 2-dB dip to design the filter. The required accuracy of Q is 10% for the cascade to work. Note that it is possible to interpolate for values between those given in the table. In theory, the 1-dB dip is preferable, but to use it would have required modifying the system Q as described below. It turns out that the 2-dB dip is satisfactory with this speaker.

If your system's Q is much higher or lower than the range shown in Table I, recheck your measurements and calculations. If the Q is only marginally too high or too low, it can be altered by changing the effective volume of the speaker cabinet. This also changes the system resonance frequency. Placing solid volume, such as wooden blocks, inside will raise the Q, while loosely packed fiberglass or dacron fibers will lower Q by effectively increasing cabinet volume—if the cabinet is not already fully packed. (Don't pack the enclosure too tightly, and don't use lumberyard fiberglass, as it sheds fibers that will get in the speaker magnet gap.) The change in resonance frequency will be approximately equal to the change in Q, and raising the resonance frequency 5% will raise the Q by 5%. Lowering resonance will lower Q. Use the new resonance frequency in your calculations.

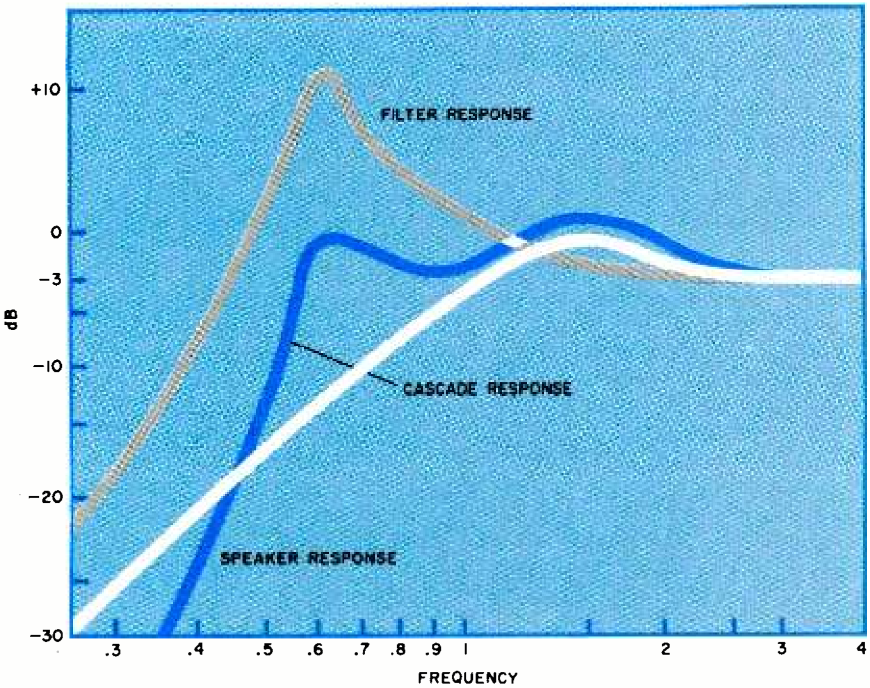


Fig. 3. Responses (with irregularities exaggerated) of a speaker and filter and the cascaded combination.

Determining Filter Parameters. Referring to Table I for the 2-dB dip, the speaker system resonance frequency is 2.146 times the cascade cutoff frequency. Using the design example, 58 Hz/2.146 is 27 Hz (rounded out). This means extending the low-frequency response from 48 to 27 Hz, nearly one octave. Actually, the figures are better than that. The speaker cutoff was measured relative to the average high-frequency response, while the cascade cutoff is relative to the peak response. Looking at the filter side of Table I, note that we require a filter resonance frequency of 1.057 times the cascade cutoff frequency, or 27 x 1.057 = 28.5 Hz. Thus, the required damping factor is 0.224 and the Q is 4.46. Such a filter is technically realizable.

Power Handling. There still remains the question of whether the speaker will handle the extra demand put on it. Fortunately, most speakers are sufficiently over-designed that they will. The extra bass won't require too much excursion of the cone or voice coil, and there is sufficient headroom for the midbass so that the cone and voice coil can make the necessary excursion without strain or distortion. It is true that the loudness attainable won't be as great, but chances are that you are not, at present, driving your speakers to the maximum.

In the end, however, everything has its price, and extra bass costs power. Generally, equal amounts of power are required per octave, and we are applying a large amount of boost to a very small portion of the audible spectrum. Actually, we need extra power only near the filter's resonance frequency. Twice the manufacturer's recommended minimum rms power will be adequate; 2½ times will be ample. For the design example with a rated minimum of 12 watts, this works out to 24 watts minimum, 30 watts ample. In practice, lower-powered amplifiers will sometimes be adequate.

In any case, you should fuse your speakers before adding any boost. If your amplifier's power rating is lower than the manufacturer's maximum rating for the speakers, fuse the speakers for the maximum rated output. For, say, a 60-watt amplifier, calculate the fuse size from $I = \sqrt{P/R} = \sqrt{60/8} = 2.8$ amperes. Use the next smaller available size, 2.5 amps. Fusing the speakers to the amplifier's maximum rated power output will usually disconnect the speakers before clipping can occur, especially since most manufacturers don't give the actual maximum rms power but the power at which distortion reaches a specified level. With a 100-watt amplifier, fuse the speakers for the manufacturer's rated power. We will use a 3-A fuse for the example with an 80-watt rating.

Will the extra bass produced be distorted? Since the speaker is overdamped at frequencies below resonance, the answer is no. There will be some second-harmonic distortion produced by fundamentals at the resonance frequency, but it will seem less than is now present. (Second-harmonic distortion is inaudible in the presence of the fundamental unless it exceeds 10%.) As for more exotic forms of distortion such as phase shift, overshoot, transients and pulse-stretching, the ear is a lot less sensitive to them at low frequencies than in the midrange, nor will they be significantly higher than in a speaker that produced this kind of bass without the active-filter subwoofer.

Then there is the 2-dB ripple in the passband of the design example, with one bump at 58 Hz and another at 28.5 Hz. While it's theoretically desirable to minimize all response unevenness, differences of less than 3 dB are usually not discernable even to trained ears. Below 50 Hz, a slight boost can sound better than a flat response, and room acoustics and speaker placement can have more audible effect than the intrinsic ripples in the response.

Circuit Design. The schematic in Fig. 4 is for one channel and the supply. *IC1* requires a reference midway between the positive and negative supplies, and this is provided by zener diodes *D1* and *D2*. *IC1* is a BiFet device (LF353) having low-noise JFet inputs and wide bandwidth. Two op amps are contained on one chip: Other compatible dual-BiFet op amps are the TL072CP and TL082CP. The power supply will drive two active filters. Capacitors *C6* and *C7* decouple the op amps from the power supply and one should be mounted as close to each chip as possible.

Buffer *IC1A* isolates the filter from loading, while *IC1B* forms a Sallen and Key high-pass filter. Components *C2, C3, R2,* and *R4* control the resonance frequency, while the ratio of *R3A* to *R3B* controls Q. Since the filter provides overall gain, potentiometer *R5* is used at the output to reduce the signal to its original level. Making *C2*= *C3* and *R2*= *R4* makes Q totally independent of frequency, as well as simplifying design. A value of 0.1 μF turns out to be convenient. With this capacitance value, values for *R2* and *R4* in ohms are calculated from 1,590,000/*f*, where *f* is the desired resonance frequency for the filter. Using the design example which requires a resonance frequency of 28.5 Hz: 1,590,000/28.5 = 55,789 ohms. Five percent accuracy is required for the frequency-determining resistors, and 33-kΩ and 22-kΩ resistors in series are accurate enough. Do not use disc ceramics for *C2* or *C3*; polystyrene or Mylar types are recommended. Five percent-tolerance types should be used, but the more readily available 10% tolerance is acceptable if *R2* and *R4* are adjustable. The ratio of *R3B* to *R3A* determines Q (*R3B/R3A* = 2−*b*, where *b* is the damping factor, the inverse of Q). For the desired damping factor of 0.224, the ratio works out to 1.78 to 1. Therefore, *R3B* should be 320 kΩ, and *R3A* should be 180 kΩ. It is possible to measure and set this ratio before soldering *R3* into the circuit, but in practice the measurements won't be accurate enough. However, it is easy to adjust Q once the system is in operation.

TABLE II—Q VERSUS SPEAKER CUTOFF-TO-RESONANCE RATIO

Speaker System Q	fc/fr
0.6	1.22
0.7	1.00
0.8	0.90
0.9	0.83
1.0	0.79
1.1	0.76
1.2	0.74

Note: *fc* = Cutoff frequency (-3 dB) relative to high-frequency response
fr = System resonance

Construction. The active filter can be assembled either on perf board, or a pc board. Use a socket for *IC1*. Since the power supply can handle two filters, a second one can be mounted on the same circuit board.

If you have difficulty locating the series-parallel combination of resistors required for *R2* and *R4*, use a dual-100-kΩ audio-taper potentiometer as a substitute. Note that snap-together pots are not accurate enough for this purpose. Potentiometers are necessary if you are going to tune the subwoofer by ear, and are recommended if your assumed speaker Q is 0.9. Connect the low end of the taper to the wiper terminal, to put the low frequencies at the low end of the scale and keep them from being too cramped. Similarly for *R3A* and *R3B*. Use a 500-kΩ (or any value down to 100 kΩ) audio-taper pot. Resistance *R3B* should be between the wiper and the high end, and *R3A* from the wiper to the low end. This keeps high Q's from being crowded, though it puts high Q's at the low end of the dial unless you use reverse taper pots. If the frequency and Q controls are to be accessible from the outside, do the same for the two output controls. Use audio taper for these controls. Keep each set of potentiometer leads slightly twisted together, as short as possible, and away from the power supply. Use shielded audio cable for the input and output leads. The input cable shield should be grounded at the circuit board and at the phono jack, but leave the ground floating on the output side to prevent ground-loop hum; i.e., ground the output lead to the chassis at the phono jack, but not at the circuit board.

The subwoofer filter should be inserted in the tape-monitor circuit of your preamp or receiver or between the preamp and amplifier. To maintain monitor capabilities, include a dpdt switch and extra jacks.

Tuning. A signal generator or audio test record is a great aid in tuning. If one is not available, be careful in choosing a test-signal source. Most FM stations cut off the low end below 40 Hz, while cassette tapes start to roll off below 40 Hz. Records will have the bass, if the instruments produced it. The lowest note on a piano is 27.5 Hz, while the bass viol and tuba are about 40 Hz. Organ music is much the best choice for tuning.

Assuming you have predicted and set the optimum tuning frequency, switch the active filter subwoofer into the circuit, and slowly turn up the volume. (Tune one channel at a time.) If Q is set too high *(R3)*, you will hear a slow "motor-boat" sound, indicating that the filter is oscillating. Set the Q just below the point where the circuit oscillates.

If you have a signal generator, sweep it downward from 100 Hz to the cutoff frequency; if it sounds linear all the way, the circuit is tuned. A sound pressure meter or a microphone and the VU meter of a tape deck can be used to measure the response if the microphone response extends far enough into the bass. If the response rolls off toward the cutoff point, the Q is too low. Raise it slightly and try again. If the Q is too high, there will be a dip in response midway between the speaker resonance frequency and the cutoff frequency. Tune the generator to this "dip" frequency (for the design example, about 45 Hz) and slowly *decrease* the Q until the dip disappears. Sweep downward again,

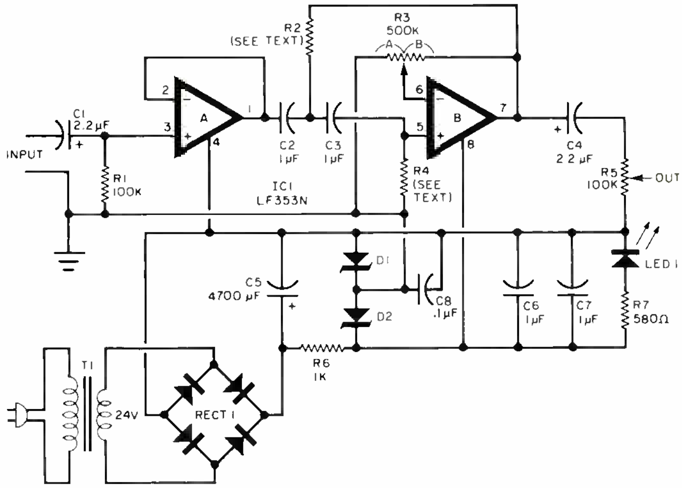


Fig. 4. Schematic of the active filter for bass boost.

PARTS LIST

C1*,C4*—2.2-µF tantalum capacitor
C2*,C3*—0.1-µF, Mylar capacitor
C5—4700-µF, 35-V capacitor
C6,C7,C8—0.1-µF capacitor
D1,D2—6.2- or 6.8-V, 1-W zener
IC1,IC2—LF353N BiFet dual op amp
LED1—LED
R1*—100-kΩ resistor
R2*—see text
R3*—500-kΩ potentiometer
R4*—See text
R5*—100-kΩ, audio-taper potentiometer
R6—1-kΩ, ½-W resistor
R7—580-Ω, ½-W resistor
RECT1—50-V, 1-A bridge rectifier
T1—24-V transformer
*** Parts must be duplicated for second channel**

checking that the response is flat, and repeat the process until the response is flat. Perform these tests at the lowest possible signal levels. An alternate procedure for adjusting Q to a predetermined value is to use a DMM to measure the peak output of the filter near resonance as compared to the output at high frequencies. Table I shows the peak voltage gain; for the 2-dB dip, the peak output should be 4.2 times the voltage at 400 Hz.

If you don't have test equipment, you'll have to do a lot of listening to find the optimum Q setting, but it can be done. The best setting will be just below the one which produces the most dramatic thump in bass viol or "rumble" in the lowest notes on a piano.

The tuning process is essentially the same when the optimum frequency is unknown, except that it has to be repeated at several different frequencies. If adjusting Q has no audible effect, increase the frequency. If Q changes produce large, dramatic changes in the bass, lower the frequency. Eventually you will find a setting that produces the smoothest, most extended bass.

Adjusting the second channel will be much easier, since you'll be able to copy the settings from the first channel and trim them as required. Adjust the level controls (*R5*)so that the higher frequencies are the same loudness with the subwoofer in or out of the circuit.

The design example was worked out for a speaker with a 48-Hz cutoff and a 58-Hz resonance frequency. Suppose we had started with a speaker with a 38-Hz cutoff and a Q of about 0.9. The response could be extended down to 21 Hz. A speaker that cuts off at 32 Hz could be extended down to 18 Hz.

There is room for improvement if we go back and rework the speaker design. Because of the speaker Q, we were forced to choose a filter that gave 2-dB dips in the passband. While inaudible, the dips indicate a certain amount of overshoot and ringing. If the speaker enclosure were reworked to give a lower Q, incidentally lowering the resonance frequency, these effects could be lessened. The system could achieve a cutoff point of 30 Hz for a 0.1-dB dip. This is not much worse than 27 Hz, and virtually flat from the midbass down. The 1-dB dip would work out to a 25-Hz cutoff and this indicates that the ideal Q for equalized speakers is lower than that used in current design.

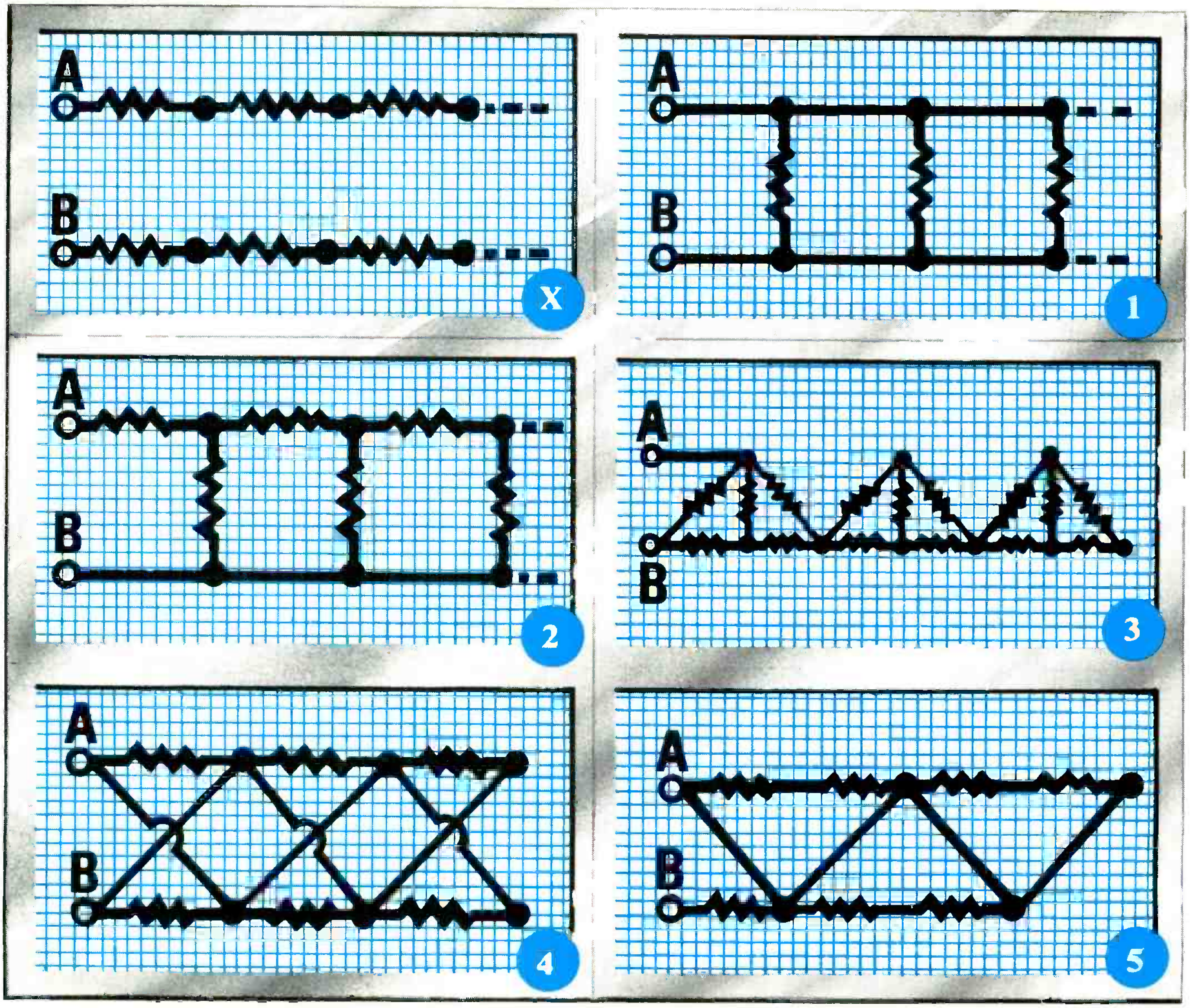
As commercial designers have shown, designing the filter and speaker together can result in very fine bass response. The home constructor starting with an existing speaker system may want to make a few small compromises. But with sufficient effort, the results will be as good as a professional product. ◇

INFINITE RESISTOR

BY TOM FOX

HERE IS a quiz that tests your electronic know-how, as well as your imagination. Each problem in this quiz shows a resistor network that consists of an infinite number of resistors. To simplify things, assume that all resistors in each network is *exactly* one ohm; and any wires, including jumpers, are perfect conductors. To take the quiz, you must figure out what a perfectly accurate 5½-digit ohmmeter that has a resolution of 1/100,000 of an ohm would read if its probes were connected to points A and B of each network. Assume that the leads and probes have no resistance. (Obviously, this ohmmeter is an imaginary instrument.)

Look at example *X* shown below to see how one of these problems can be solved. Notice that the resistors in this network are all connected in series. There are several ways of approaching and solving this problem. One way is to imagine that points A and B are only connected (through the 1-ohm resistors, of



NETWORK QUIZ

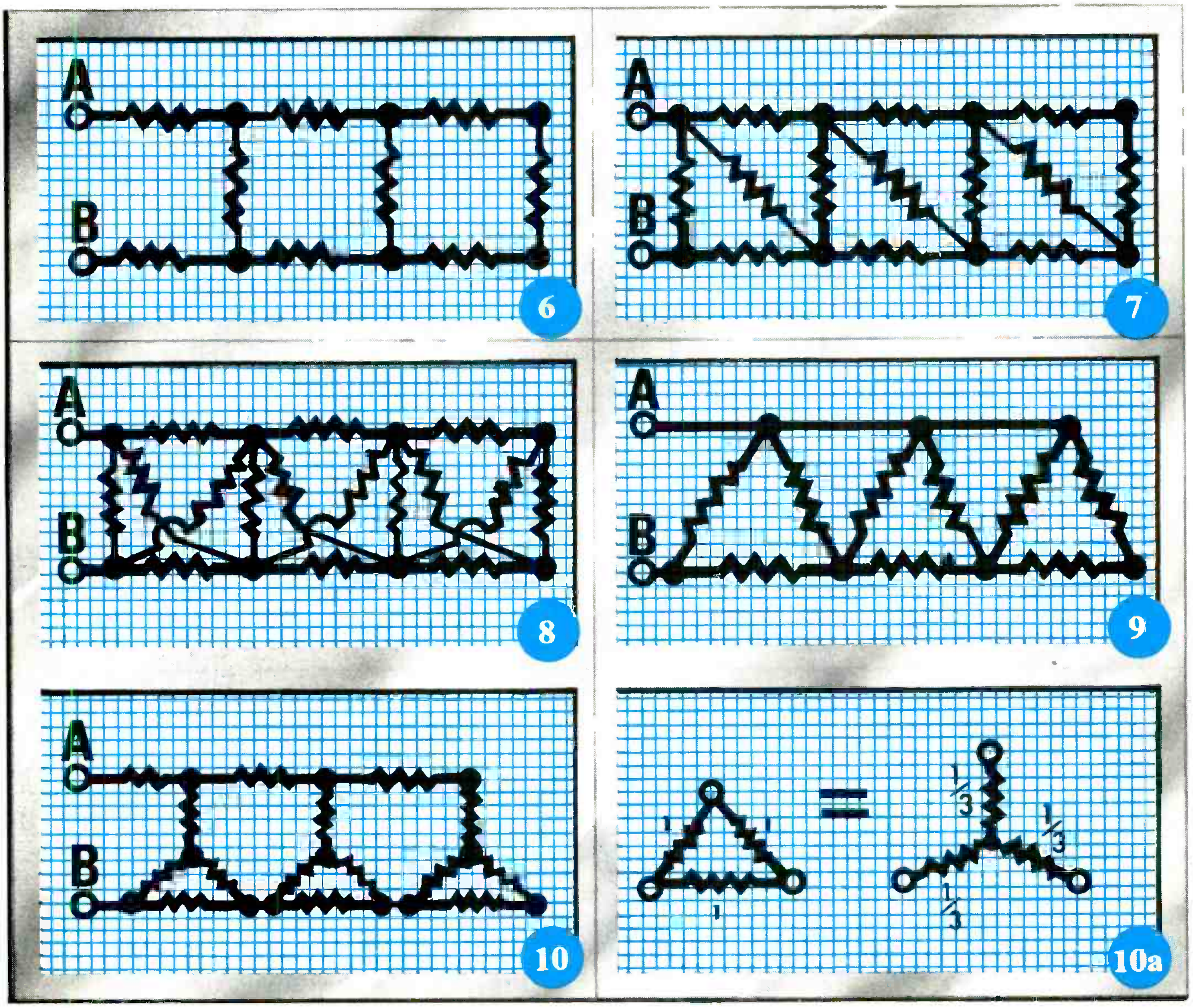
See how well you can apply the principles of network theory to determine the terminal resistance of these matrices.

course) at infinity. Points A and B can be looked upon as *not* being connected at all in the real world, and a 5½-digit ohmmeter would show an open circuit.

Another way to look at this problem is to think of the resistance between A and B (the equivalent resistance of the network) as being equal to 1 + 1 + 1 + 1 + 1 . . . . ohms, where you add up an infinite number of ones. Obviously, when you place enough one-ohm resistors in series (say more than 1 billion), the meter will indicate an open circuit.

Several of the problems in this quiz require no computation whatsoever, just a little insight into simple resistive circuit theory. The remainder of the problems require only arithmetic to solve, although basic algebra can be used to reduce calculations.

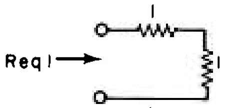
Having examined example *X*, solve problems 1 through 10. (Note Fig. 10a is a hint to help solve problem 10.) Answers, with explanations where needed, are given overleaf.



ANSWERS:

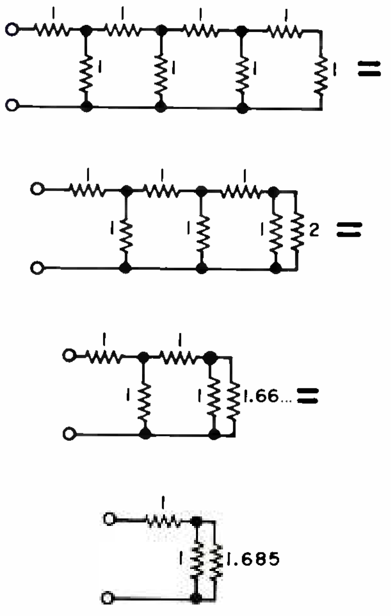
Problem 1: 0.00000. *Note:* All the resistors in this network are connected in parallel. It can be shown that a 2-resistor network has an equivalent resistance of ½ ohm; a 3-resistor network, a resistance of ⅓ ohm; a 4-resistor network, ¼ ohm; etc. From this, it is obvious that an infinite-resistor network has a resistance of 0 ohms.

Problem 2: 1.61803. *Note:* Since this problem is typical of many in the quiz, its solution will be detailed. The problem can be solved in at least two different ways. The most obvious way is to start with the basic circuit (see A below). Here Req_1, the equivalent re-



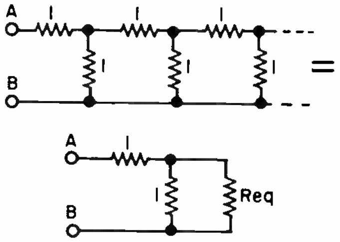
A

sistance of the basic circuit, is 2 ohms. This equivalent resistance can replace two resistors in the problem. (It might be helpful to think of Req_1 as replacing the two resistors that are located at infinity.) We can thus reduce a 4-resistor network to just 3 resistors. The resistance of the 4-resistor network can then be found and substituted into a 6-resistor network, reducing the number of resistors in this network from 6 to 3. At B, we see how an



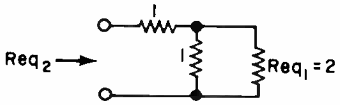
B

8-resistor network is reduced to just 3 resistors. We can continue this procedure and reduce a network with any number of resistors (even a million or more) down to a three-resistor network as shown at C. Now let's see how we actually do it.



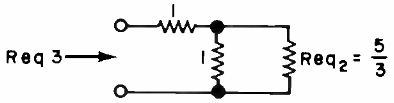
C

We already know $Req_1 = 2$ ohms. In the circuit at D, $Req_2 = 1 + (1 \times 2)/(1+2) = 1 + 2/3 = 5/3$. Then substitute this equivalent resistance in a



D

network that originally contained 6 resistors as at E. This equivalent resistance is $Req_3 = 1 + (1 \times 5/3)/(1 + 5/3) = 1.625$. This procedure is repeated until the equivalent resistance remains unchanged to 6 signifi-



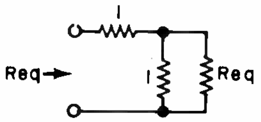
E

cant places. For problem 2, you would continue this procedure until you found that two equivalent resistances in a row came to 1.61803. which happens to be the answer we are looking for. (By the way, the equivalent resistance of an 8-resistor network is $Req_4 = 1.6190476$; a 10-resistor network is $Req_5 = 1.6181818$; a 12-resistor network is $Req_6 = 1.6180555$; a 14-resistor network is $Req_7 = 1.618037$; a 16-resistor network is $Req_8 = 1.618034$; and an 18-resistor network is $Req_9 = 1.618034$; as is a 20-or 20,000-resistor network.)

This method of repetitive calculations for solving problems is known as the *iterative* method. Any process that requires many repetitive calculations is ideally suited to a programmable calculator or computer; the iterative method is no exception. However, since nearly all the problems in this quiz require a maximum of 10 calculations to find the answer to 6 places, a good old scratch pad is all that is really necessary.

A more sophisticated method of solving this problem requires some reasoning and a little algebra. From the previous calculations, notice that, basically, Req_1 is close to Req_2, which is even closer to Req_3, and that Req_9 is equal to Req_{10} to at least 7 significant places. From this, or from just plain logic, we can assume that, *if there are an infinite number of resistors, the addition of two more will not change the equivalent resistance of the network.*

To find the equivalent resistance for a network that continues out to infinity (which is the same as R_{AB}) by using a little algebra, in the diagram at F, $Req = 1 + (1 \times Req)/(1 + Req)$



F

or $Req + Req^2 = 1 + Req + Req$, which reduces to $Req^2 - Req - 1 = 0$. This last equation can be easily solved with the use of the quadratic formula, a simple method of solving an equation that has one term squared. Thus, for equations of the form $ax^2 + bx + c = 0$, the formula gives the roots as $x = (-b \pm \sqrt{b^2 - 4ac})/2a$. In the equation, $Req^2 - Req - 1$, $a = 1$, $b = -1$, and $c = -1$. Substituting in the quadratic formula, we have $Req = (1 + \sqrt{5})/2 = 1.618033989....$ (The other possible answer is $-0.61803...$, which is impossible because resistance cannot be negative.)

Problem 3: 0.62500. *Note:* Only the first network need be considered.

Problem 4: 0.00000. *Note:* Every resistor is in parallel with every other resistor. This is basically identical to Problem 1.

Problem 5: 1.00000. *Note*: Why is this one so simple?

Problem 6: 2.7320. *Note*: Can be solved using the same methods given in Problem 2.

Problem 7: 0.61803. *Note*: Again, this can be solved using the methods in Problem 2.

Problem 8: 050000. *Note*: There are resistors in this network that can be changed to any value without changing the outcome. Where are they located in the network? (Hint: They are located in the same repetitive location.)

Problem 9: 0.57735. *Note:* Same as Problem 2.

Problem 10: 2.2078. *Note*: If you use the hint that is given in 10a, the problem can be solved using the basic techniques of Problem 2. ◇

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MELODIC TELEPHONE RINGER

BY RICKEY CHAPMAN
AND MIKE PAULKOVICH

Design your own pleasant tune to replace the standard ring

DO YOU yearn for something a bit more distinctive than Ma Bell's standard-issue telephone bell? The melodic telephone ringer described here replaces the usual jangle with a pleasant tune.

The project requires a direct connection to the telephone line, which some telephone companies prohibit unless the device is approved or an interface module is installed by the phone company. The melody unit does provide the isolation required, but check with your local telephone company before connecting it to the line.

Circuit Operation. The melody used with this project is based on one in the spy spoof, *In Like Flint*, in which super-spy Derek Flint's hot line to the President signals that the latter is calling by playing a distinctive tune. Accordingly, we created a diagram of what the sonic output of the device should be (Fig. 1) to imitate the ring used in the motion picture.

The numbers indicate the number of the clock pulse and the letters indicate the desired musical tone. The complete schematic of the project is shown in Fig. 2. CMOS logic is used because it is easy to interface with linear circuitry and it has simple power requirements. The design is based on the CD4051 8-bit analog multiplexer that acts as digitally controlled, 8-position switches. In the ON position, the switch acts as a simple resistor of typically 80 ohms. In the OFF position, it has an impedance greater than 10 megohms.

One CD4051 (*IC6*) is used for frequency control, while the other (*IC5*) is used for amplitude control. Both are driven by counter *IC2*. Stop-start control is provided by quad two-input NAND gate *IC3*. *IC3A* drives the clock-enable line low when *IC2* reaches the count of 40. This enables trigger gate *IC3C*, and with no trigger pulse appearing at *IC3C* pin 9, the reset (pin 2) of *IC2* is held low. This is the standard wait state of the device.

The telephone ring signal causes the LED in optoisolator *IC1* to glow and turn on the photo-transistor in *IC1*. The trigger line is turned on by this, causing the reset line of *IC2* to be set high, and resetting counter *IC2* to zero. This action turns off both inputs to *IC3A*, thus enabling the two oscillators built around the op amps *IC4A* and *IC4B*.

FREQUENCY CALIBRATION VALUES

Component	Note	Frequency (Hz)	Resistance (ohms)
R13	B	987.8	124.8
R14	C	1046.5	117.8
R15	D	1174.6	105.0
R16	E	1318.5	93.5

The oscillator built around *IC4B* forms the clock that drives counter *IC2*. The clock frequency is controlled by *R12*. Oscillator *IC4A* is an audio oscillator whose frequency is varied by using *IC6* to switch between one of the four frequency-controlling potentiometers *R13* through *R16*. The output of audio oscillator *IC4A* is connected through *R9* to the common input of *IC5*. Selected outputs of *IC5* are grounded, to provide no output, while the remaining outputs are buffered by *IC4C* and amplified by audio amplifier *IC7*, whose output volume is controlled by *R17*.

Construction. The circuit can be built on perf or a pc board. It is recommended that IC sockets be used, to simplify calibration.

Component location is not critical, except for *C5* and *C7* (in the *IC7* circuit), which should be kept close to *IC7* to prevent oscillation. The power

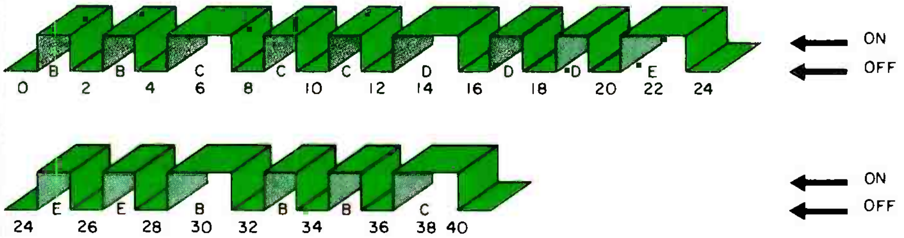

Fig. 1. Output tone sequence of the circuit.

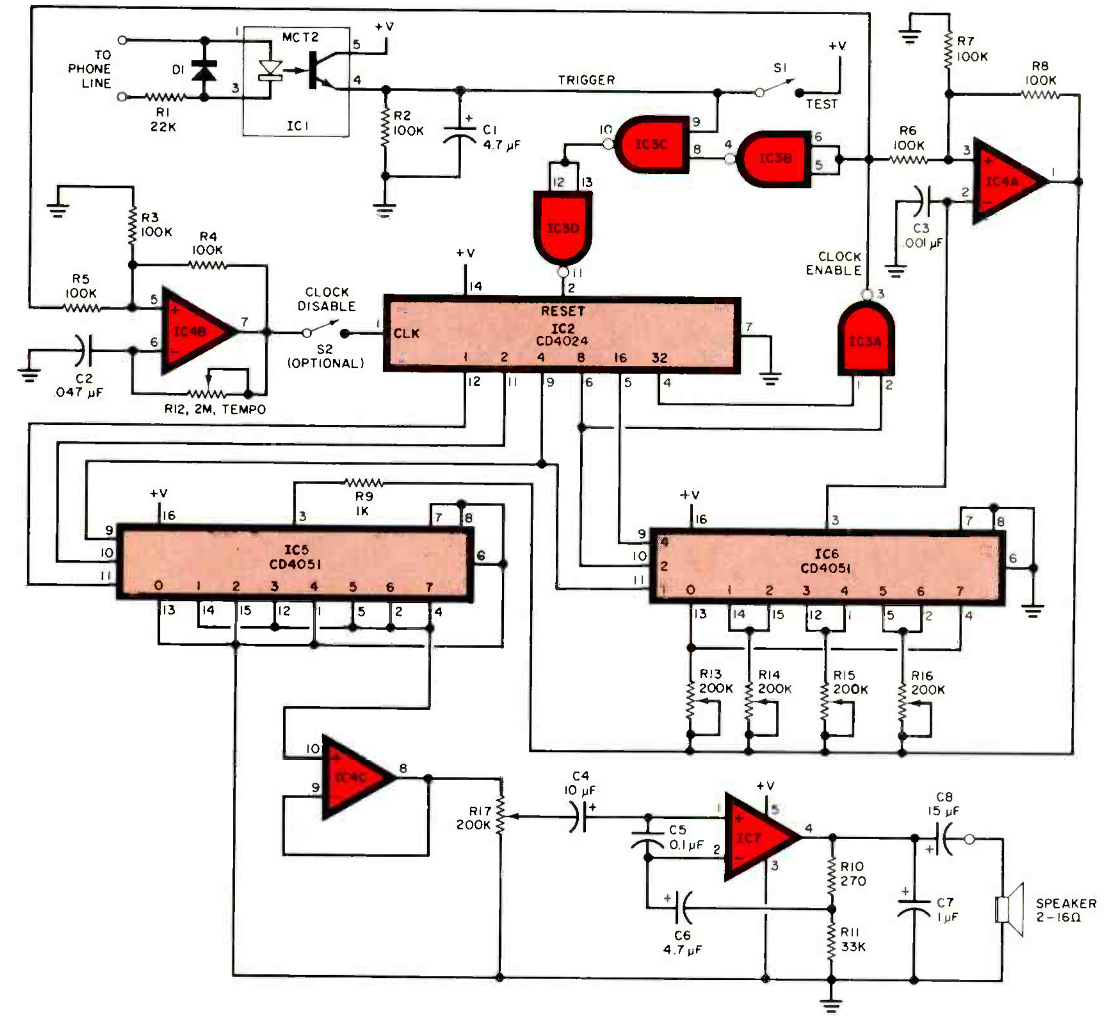

Fig. 2. CMOS logic is used because it interfaces easily with linear circuitry and has simple power needs.

PARTS LIST

C1, C6—4.7-µF, 16-V electrolytic
C2—0.047-µF, 25-V ceramic disc capacitor
C3—0.001-µF, 25-V ceramic disc capacitor
C4—10-µF, 16-V electrolytic
C5—0.1-µF, 25-V ceramic disc capacitor
C7—1.0-µF, 16-V electrolytic
C8—15-µF, 16-V electrolytic
D1—1N4002
IC1—Optoisolator (Monsanto MCT2)
IC2—4024 binary counter
IC3—4011 quad two-input NAND
IC4—LM324 quad op amp
IC5-IC6—4051, 8-channel multiplexer
IC7—LM383T audio power amp
R1—22-kΩ, ¼-W resistor
R2-R8—100-kΩ, ¼-W resistor
R9—1-kΩ, ¼-W resistor
R10—270Ω, ¼-W resistor
R11—33-kΩ, ¼-W resistor
R12—2.0-MΩ, linear-taper potentiometer
R13-R17—200-kΩ linear-taper, 10-turn potentiometer
S1—Normally open pushbutton switch
Misc.—Circuit board, connector, 8-12-V power supply, speaker, cabinet, hardware, telephone silencer (Radio Shack #43-125).

supply can be any regulated supply capable of providing 8-12 volts at 100 mA. In the authors' version, an external power supply was used, but an on-board supply could be added. If an external supply is used, an on-board bypass capacitor of several microfarads may be needed.

Calibration and Installation. To calibrate the telephone ringer, frequency-controlling resistors *R13* through *R16* must be set to produce the notes B, C, D, and E, as illustrated in Fig. 1. The resistances necessary to obtain these frequencies are given in the Table. Note that to obtain an accurate resistance measurement on *R13* through *R16*, *IC6* must be removed from the circuit, hence the need for IC sockets in the construction. After making the adjustments, insert the ICs and apply power. Closing TEST switch *S1* will activate the device. Adjust *R12* for a pleasing tempo (an approximately two-second sequence is used by the authors) and calibration is complete.

For greater accuracy, wire CLOCK-DISABLE switch *S2* between pin 7 of *IC4B* and pin 1 of *IC2*, as shown in Fig. 2. Apply power to the circuit. With *S2* closed, operate *S1* to test the circuit. Adjust TEMPO control *R12* for maximum resistance, thus making the sequence very long. Attach a frequency counter to the speaker leads. Close switch *S1*, and when the first note comes on, open *S2*. Adjust *R13* for the proper frequency. (Alternatively, a piano or other tuned instrument could be used to set *R13*.) Close *S2* and proceed to the next note in the sequence. In this way, adjust all four frequencies via *R13* to *R16*. Finally, adjust *R12* for a pleasing tempo.

To test the project, connect it to the phone line and have a friend call you. The project should not be affected by line transients and has proven reliable in over two years of operation at several different locations.

Designing In Your Own Tune. It is relatively simple to redesign the project to play any tune that you want. Start by diagramming the desired tune sequence as in Fig. 1. This specifies the desired output for each and every clock pulse.

The second step is to modify the counter circuit to count to the end of the chosen tone sequence and then stop. This is done by forcing the clock-enable line low when *IC2* reaches the desired count. In the version shown in Fig. 2, *IC3A* performs this function when the count reaches 40. For example, if a tone sequence of length 34 is desired, pin 2 of *IC3A* should be connected to pin 11 of *IC2*.

The next modification is to amplitude control *IC5*. In the version shown here, the sequence 01010111 repeats every eight clock pulses, where the 0s are on and the 1s are off. To program this sequence, channels 0, 2 and 4, corresponding to the off's in the sequence, are grounded. All other channels are connected to pin 10 of *IC4C*. To program different 8-pulse sequences, the connections to channels 0-7 of *IC5* should be changed appropriately. If a larger sequence is desired, you can parallel additional 4051 IC's, making use of the inhibit input on pin 6 to select one and only one 4051 at a time. Additional logic will be required to control the inhibit lines.

The final step is to modify the tone-controlling circuit (*IC6*). The methods used in redesigning the amplitude control also apply here. The difference is that channels 0 to 7 of *IC6* are connected to one of the frequency-controlling potentiometers there must be one potentiometer for each distinct note in the sequence. In our version, we again take advantage of a repeated sequence of eight. The note sequence is BCCDDEEB, where each note is held for four clock pulses. Together, the note sequence and the amplitude sequence make up the output tone sequence in Fig. 1. Again, if you desire a tone sequence that is longer than eight units, you will have to parallel additional 4051s and add some inhibit control logic. ◇

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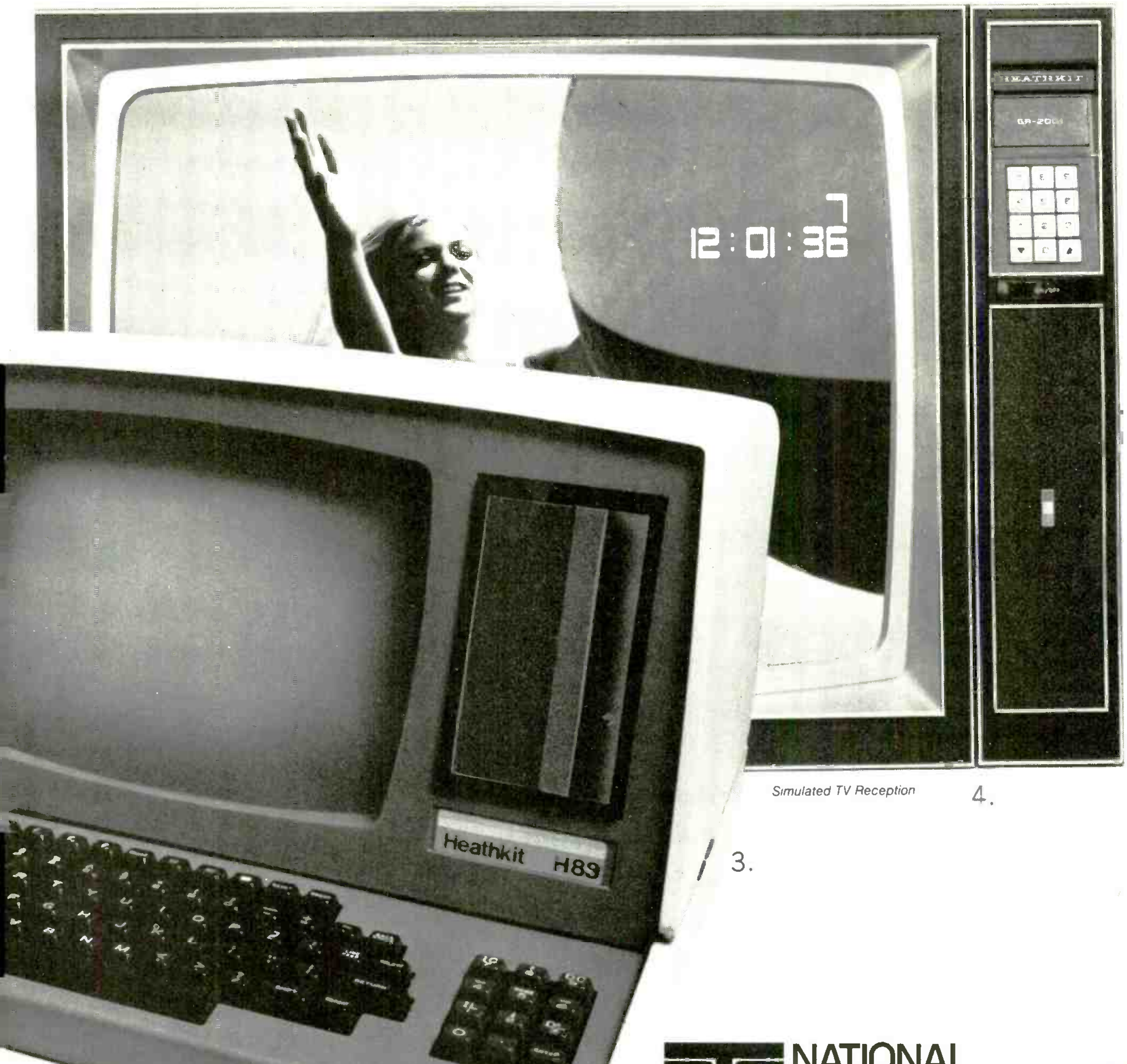

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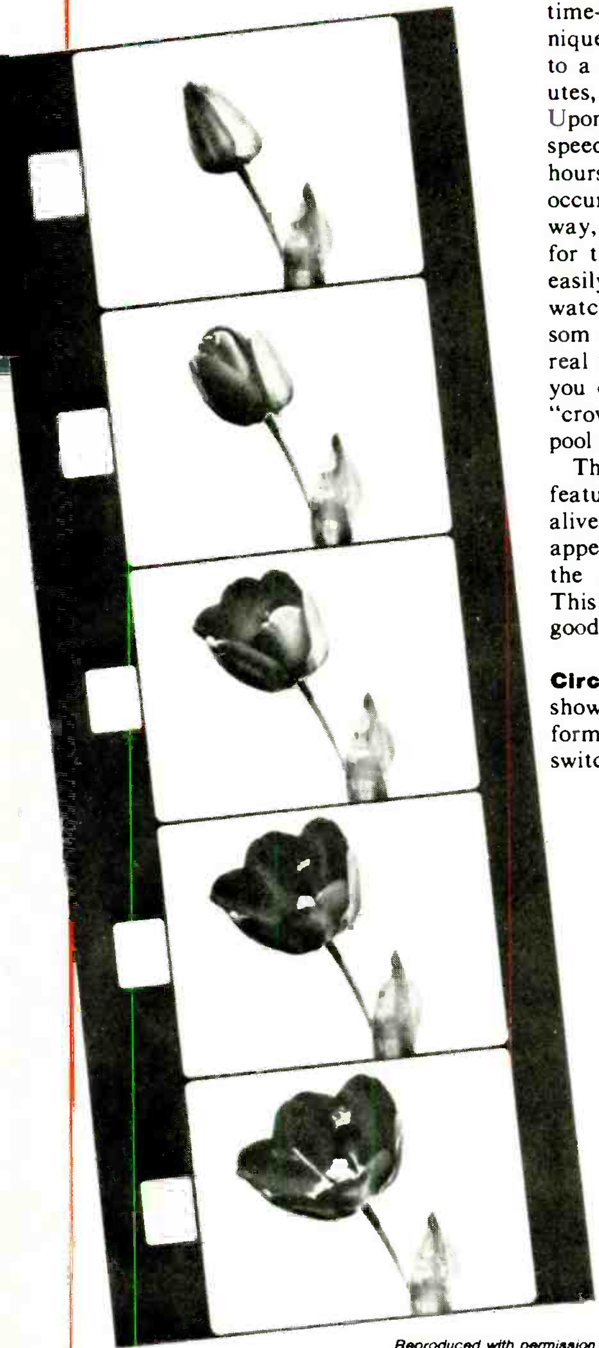
Permits adjustable timing of film exposures to create many interesting effects

BY WILLIAM T. LEMEN



Film strip of a tulip opening shows one of the many fascinating effects that can be created with time-lapse photography.

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ONE OF the most interesting applications for a movie camera is time-lapse photography. This technique exposes one film frame at a time to a scene that normally takes minutes, hours, or even days to complete. Upon film playback at conventional speed, the action that may have taken hours in real time can be observed to occur within a few moments. In this way, action that is too fast or too slow for the human eye to follow can be easily observed. For example, you can watch a flower go from bud to blossom (an event that may take days of real time) within a few moments. Or you can see a drop of water form a "crown" as it contacts the surface of a pool of water.

The timer discussed in this article features a floodlight relay that comes alive when the trigger signal first appears, and remains powered during the slightly delayed film exposure. This assures enough light to take a good picture.

Circuit Operation. In the schematic shown in Fig. 1, transistors *Q1* and *Q2* form a multivibrator circuit, where switched capacitors provide a choice of timing between trigger pulses. In this case, the combination of *C1* and *C6* gives the shortest time while *C5* and *C10* produce the longest time between trigger pulses. The approximate times between camera operations for this circuit are 24 s for *C1* and *C6*, 60 s for *C2* and *C7*, 2 min for *C3* and *C8*, 4 min for *C4* and *C9*, and 6 min for *C5* and *C10*.

If it is desired to take pictures at a faster or slower rate, then the values of the capacitors can be altered to speed up or slow down the timing rate.

Potentiometer *R4* fine-tunes the multivibrator to obtain a symmetrical output waveform. Transistor *Q3* is a buffer and wave-shaper that feeds the timing pulse to the input of *IC1*, a binary counter/divider. The output of *IC1* is fed to transistor *Q4*, a buffer used to assure a clean pulse to the following one-shot. Capacitor *C11* eliminates any hash that may be present at the output of *Q4*.

Transistors *Q5* and *Q6* form a one-shot circuit that pulses output stage *Q7* with capacitors *C12* through *C14* selected to determine the duration of the trigger pulse. If desired, these capacitors could also be changed in value for pulses of different duration. However, the pulse length must be long enough to allow the floodlight and solenoid to operate before the one-shot switches off and a new timing sequence begins. Transistor *Q7* must have enough power capability to operate relay *K1*. Diode *D1* is used as a transient protector for *Q7*. Also, manual switch *S3* is used to trip the camera manually if necessary.

When *K1* is energized, it energizes *K2*, which supplies power to *SO1* and the flood lamp. Switch *S4*, across the contacts of *K2*, facilitates setup and testing. Be sure that the contacts of relay *K2*, switch *S4*, and the associated wiring are capable of carrying the flood-lamp current.

Relay *K1* also closes the circuit to the coil of *K3* through a time-delay network consisting of *R16*, *R17*, *C15*,

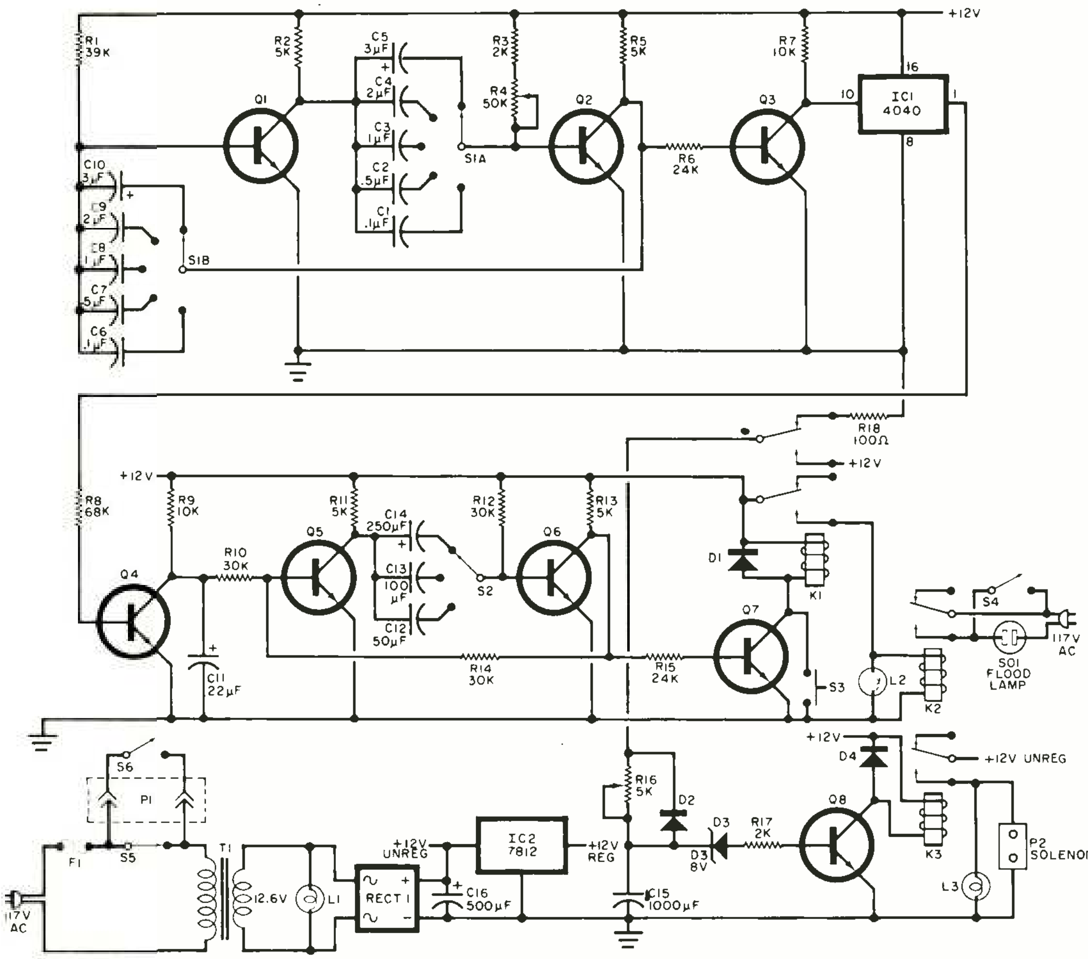

Fig. 1. Schematic of the timer circuit. Transistors Q1 and Q2 form multivibrator circuit whose timing is determined by the choice of capacitors controlled by switch S1.

PARTS LIST

C1,C6—0.1-μF capacitor
C2,C7—0.5-μF capacitor
C3,C8—1.0-μF capacitor
C4,C9—2-μF capacitor
C5,C10—3-μF capacitor
C11—22-μF capacitor
C12—50-μF capacitor
C13—100-μF capacitor
C14—250-μF capacitor
C15—1000-μF, 25-V capacitor
C16—500-μF, 25-V capacitor
D1,D2,D4—1-ampere silicon diode
D3—8-V zener diode
F1—1-ampere fuse and holder
IC1—CD4040 binary counter/divider
IC2—7812 12-volt regulator
K1—Dpdt, 12-V dc relay (Potter Brumfield KM11D or similar)
K2—Spst, 12-V dc relay (Magnecraft W88KDX2 or similar)
K3—Spdt, 12-V dc relay (Potter Brumfield (KM5D or similar)
L1—12-V lamp, green
L2—12-V lamp, orange
L3—12-V lamp, red
P1,P2—Connectors (optional)
Q1 through Q6, Q8—2N2712 transistor (or similar)
Q7—2N5307, 2N5308 Darlington transistor (or similar)
Unless otherwise specified, the following are ½-Watt, 10% resistors:
R1—39 kΩ
R2, R5, R11, R13—5 kΩ
R3, R17—2 kΩ
R4—50-kΩ trimmer potentiometer
R6,R15—24 kΩ
R7,R9—10 kΩ
R8—68 kΩ
R10, R12, R14—30 kΩ
R16—5-kΩ, 10-turn trimmer potentiometer
R18—100 Ω
RECT1—10-ampere bridge rectifier
S1—2-pole, 5-position rotary switch (Centralab PA-1032, two sections, or similar)
S2—1-pole, 3-position rotary switch (Centralab PA-1031, or similar)
S3—Normally open pushbutton switch
S4—6-ampere spst switch
S5—Spst, 5-ampere switch
S6—Same as S5 (optional)
S01—Receptacle
Solenoid—12-V dc solenoid (Guardian Electric 28P-DC-1-12V or similar)
T1—12.6-V, 1.2-A transformer (Radio Shack 273-1505 or similar)
Misc.—Suitable enclosure, knobs, IC sockets (16 pin), mounting hardware.

D2, *D3*, and *Q8*. This circuit delays relay *K3* to assure proper lighting of the scene. Time delays up to 10 s can be obtained by adjusting *R16*. A set of contacts on *K1* is used to discharge capacitor *C15* through resistor *R18*.

Relay *K3* operates the solenoid and plunger mechanism that activates the camera. The power to the solenoid (shown as +12 volts unregulated) at one contact of *K3* may not be sufficient to operate high-current solenoids. In this case, an external source of +12 volts at high current may be used.

The power supply uses a conventional transformer-bridge rectifier feeding 12-volt regulator *IC2*.

Construction. The circuit can be assembled on perf board using point-to-point wiring, or an etched circuit board can be designed. Capacitors *C1* through *C10* can be mounted on *S1*, while *C12* through *C14* can be installed on *S2*. These switches, along with power switch *S5* (or optional *S6*), socket *SO1*, and solenoid con-

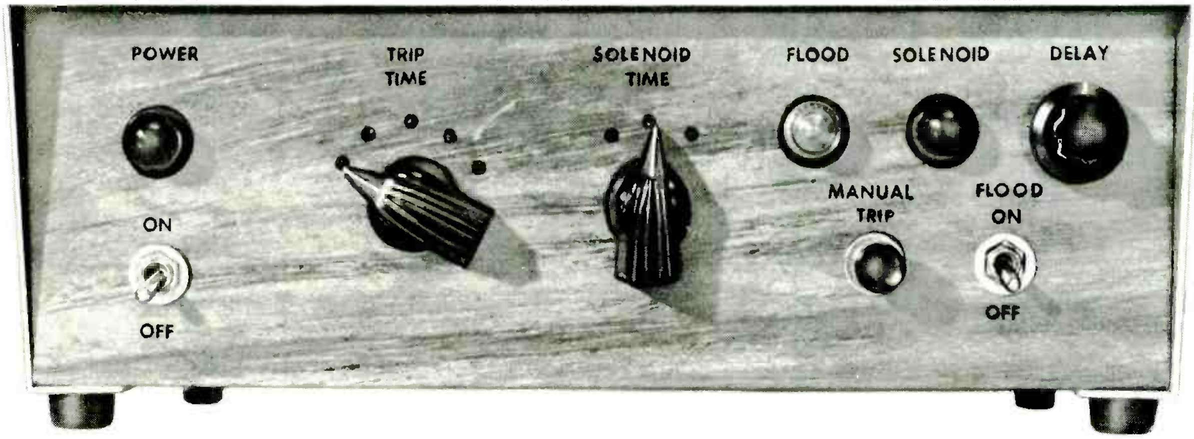

Photo of the front panel of the author's prototype camera timer shows arrangement of controls for varying timing. Output jacks are on the rear.

nector *P2* can be mounted on the selected front panel. Any type of enclosure can be used.

To test operation of the circuit, connect an oscilloscope to the collector of *Q3* and observe a square wave whose duty cycle can be set to 50% via control *R4*. With *S1* set to the *C1/C6* position and *S2* set to the *C14* position, transistor *Q7* should produce a 5-s pulse between 24 and 30 s apart.

If 0.156-inch is assummed for each frame in a movie film, then a 50-foot reel should contain approximately 3846 frames. Therefore, using a 24-second timing between pulses, a 50-foot reel should last 25.6 hours. (Some reels may have to be turned at the 25-foot midpoint.) If you wish to monitor the opening of a flower, reduce the value of *C1/C6* accordingly. For long-term events, that may last a year or so, the 6-min rate will last some 384 hours (16 day/night intervals).

Once a floodlamp operating range has been determined, potentiometer *R16* is adjusted for a slight delay between the turning on of the floodlamp and operation of the camera-activating solenoid. The time delay should be long enough for the light to stabilize before the camera shutter is opened.

Using the foregoing time-lapse methods opens up a new world of motion-picture photography. ◇

BY RANDY CARLSTROM

DESIGNING WITH THE 8080 MICROPROCESSOR

Part 3: Software

CPU instructions are defined with details on preparing a program

IN THE first two parts of this series we introduced 8080 I/O interfacing, general CPU architecture (though to a lesser extent), and a few applications. Until now we have limited the discussions to the microprocessor's *hardware*. But there is one other equally important realm of microprocessors that we must take into consideration: its *software*. A processor's software may be thought of as the collection of programs that have been developed for it.

CPU Instructions. Each instruction is stored in memory as a sequence of one, two, or three bytes. The first byte is called the *Instruction Code* or *Operation Code* (or simply *op code*), as it defines the general instruction or operation to be performed. For multiple-byte instructions the memory address of the op code is always the address of the instruction. The second byte of a multiple-byte instruction is called an *operand* and contains data or an address to modify or complete the instruction. The third byte of a three-byte instruction is a second operand, which again contains either data or an address to complete the instruction. The exact instruction format will depend upon the particular operation to be executed, as illustrated in Fig. 17. As an example of a three-byte instruction, consider one which operates on a byte of data contained in memory. The instruction must convey to the CPU *where* this data is located by specifying its memory address. Because memory addresses are 16 bits in length, two bytes will be required to specify the memory location. When a three-byte instruction references memory directly, the low-order bits of the memory address (which are sent out on A0-A7 of the address bus during execution of the instruction) are contained in byte 2, and the high-order bits (which are sent out on A8-A15) in byte 3.

The 8080 instruction set can manipu-

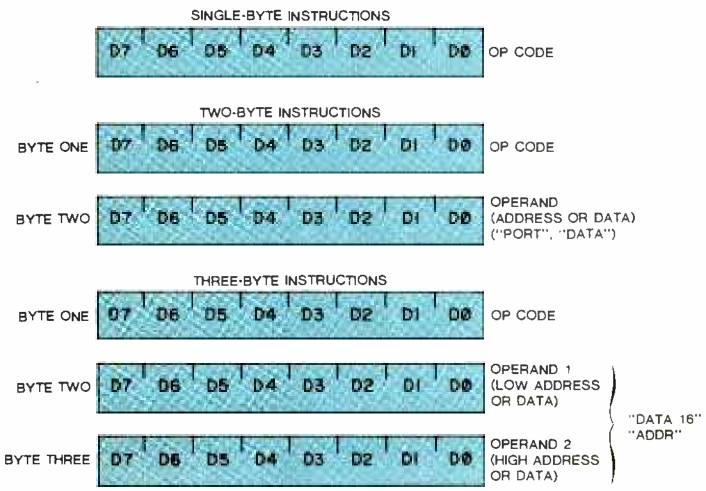

Fig. 17. 8080 instruction formats. Typical instructions for single-byte (top) are register-to-register, return, push, and pop; for two-byte: immediate mode and I/O; for three-byte: jump, call, and direct load. D0 is least significant bit; D7, most significant.

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late seven 8-bit registers (internal to the CPU), a 16-bit Program Counter (PC), memory, I/O devices, and a 16-bit Stack Pointer (SP). The seven register names are A, B, C, D, E, H, and L, where register A is the all-important accumulator. Note that the SP and PC are 16 bits in length since they must be able to access any location in the 64K memory space. A number of 8080 operations use pairs of registers for 16-bit operands, and for these operations, register B is paired with register C, D with E, and H with L. Registers B, D, and H are the high-order bytes of these pairs, respectively. A register pair is designated by the name of the most significant byte of the pair. The SP is also considered to be a valid register pair. Figure 18 illustrates a way in which the 8080 registers may be visualized as paired together and stacked.

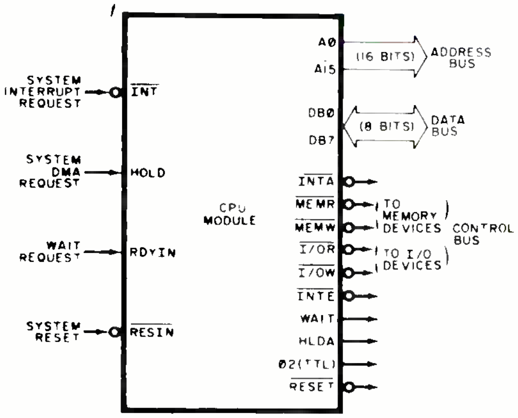
Conditionals. A number of 8080 instructions are "conditional," meaning that the full operation is performed *only if* a specified condition of the instruction is met. These conditionals are based on the state of one of the five processor flags. The flag bits are defined as:

Zero (Z): If the result of an instruction has the value zero, this flag is set; otherwise it is reset.

Sign (S): If the MSB of the result of

THE 8080 INPUTS AND OUTPUTS

IN OUR continuing discussion of the 8080 microprocessor, it is important to keep in mind the various input and output signals for the chip. They are as follows (and as shown in the diagram):



INT. By placing a low on this input line, an external device can interrupt the CPU operation. The interrupt system must be enabled for the CPU to honor the request (see INTE).

HOLD An external device may suspend normal processor activity by putting a high on this input line. When acknowledged by the processor (HLDA), the address and data busses go into their high-impedance state so that the peripheral requesting the HOLD may conduct memory transfers without processor intervention (Direct Memory Access).

RDYIN. The Ready Input signal indicates to the CPU that valid data is available on the data bus. It is used to synchronize the CPU with slow memory or I/O devices. If, after sending out an address to an I/O device or memory, the CPU does not receive a high on this line, the CPU will idle as long as the line is low. If desired, the circuit can be arranged so that the CPU can be single-stepped (execute one instruction and halt) using this input.

RESIN. A low on the Reset Input line will clear the program counter, INTE and HLDA flip-flops. After reset, the CPU will begin program execution at memory location zero.

RESET. This output is used as a system reset for clearing external devices. It goes low when RESIN is active.

$\phi 2$. The phase-2 clock is a TTL output used for system timing. In a typical 8080 system, the clock frequency is approximately 2 MHz.

HLDA. This output goes high in response to a HOLD request and indicates that the data and address busses are going into their high-impedance state after the next rising edge of the phase-2 clock.

WAIT. This output goes high when the CPU enters a WAIT state (in response to RDYIN going low).

INTE. The Interrupt Enable output indicates the status of the CPU's internal interrupt enable flip-flop. This flip-flop can be set (INTE = low) using the 8080 "Enable Interrupts" instruction and reset (INTE = high) using the "Disable Interrupts" instruction. Interrupt requests on the INT line are ignored when the internal interrupt enable flip-flop is reset (when the interrupt system is disabled).

I/O W. The Input/Output Write line goes low when the CPU is executing an "Output" instruction, indicating that the address bus contains an output device address and the data bus contains the output data byte. Either the high- or low-order byte of the address bus (A15-A8 or A7-A0) may be decoded since both bytes contain the same information. I/O W may be used as a "strobe" signal to clock output latches, etc.

I/O R. The Input/Output Read line goes low when the CPU is executing an "Input" instruction, indicating that the address bus contains an input device address and that the input data may be placed on the data bus. Either the high- or low-order byte of the address bus (A15-A8 or A7-A0) may be decoded since both bytes contain the same information. I/O R may be used to gate input data onto the data bus.

MEMW. The Memory Write output goes low when the CPU is writing data to memory. The address bus contains the address of the memory location to be written into, while the data bus contains the data byte to be written. MEMW is usually connected to the read/write input of the RAM and strobes the data into the addressed location.

MEMR. The Memory Read output goes low when the CPU is reading data from memory (ROM or RAM). The address bus contains the address of the memory location to be read, while the data bus expects the memory data from the addressed memory location. MEMR is usually connected to a memory chip select or data buffer enable input to gate the read data onto the data bus.

INTA. The Interrupt Acknowledge output goes low in response to an INT request (assuming that the interrupt system is enabled). INTA is used to gate the "Restart" instruction from the interrupting device onto the data bus.

DB0-DB7. The data bus is formed from eight bi-directional lines (data may flow in either direction). This bus provides communication between memory, I/O devices, and the CPU for instructions and data transfers. The bus may go into its third (high-impedance) state in response to a HOLD request. DB0 is the least significant bit. The Control Bus provides the necessary timing signals to gate memory and I/O data on and off the data bus at the proper time.

A0-A15. The 16-line address bus provides the binary memory address during memory accesses (read or write) and also I/O device (port) numbers during input/output. Up to 65,536 bytes of memory (RAM, ROM, or any mixture thereof) and up to 256 input and 256 output devices can be directly addressed. The least significant bit is A0.

Through proper use of these CPU module signals, it is possible to design anything from a music synthesizer or darkroom controller to a full-blown computer system. It is not our intent here, however, to design a "computer" as such, but rather to demonstrate how this versatile device can be used to implement functions that would be impractical, or otherwise impossible, using traditional analog and digital circuits. ◇

the operation has the value 1, this flag is set; otherwise it is reset.

Parity (P): If there are an even number of binary 1's in the result of the operation (even parity), this flag is set; otherwise it is reset (odd parity).

Carry (CY): If the instruction resulted in a carry (from addition) or a borrow (from subtraction or a comparison) out of the high-order bit, this flag is set; otherwise it is reset. In this respect, the CY bit may be thought of as an extension, or ninth bit, of the register being operated on.

Auxiliary Carry (AC): If the instruction caused a carry out of bit 3 and into bit 4 of the resulting value, this flag is set; otherwise it is reset. This flag is affected by single precision (8-bit) additions, subtractions, increments, decrements, comparisons, and logical operations, but is principally used preceding a DAA (Decimal Adjust Accumulator) instruction.

We now know enough of the 8080 architecture to understand and use its machine language. Soon to follow is a summary of all 78 instructions of the 8080 instruction set. Once you are able to program the 8080, you will also be able to program the 8085 and are halfway to mastering the Z-80. Each machine instruction will be listed in its *assembly language* form, in which each instruction is assigned a unique mnemonic, making it easier to read and remember. A program written in assembly language is called a *source program.* A special program known as an *assembler* can then take this source program and generate the binary equivalent (machine code, or *object code*) of each instruction mnemonic. This binary object code is then stored in memory for the CPU hardware to execute. Assembler programs offer many other advantages; but since very few of us have access to a computer system with an 8080 assembler, source program assembly "by hand" will have to suffice. This is fairly easy with the aid of Fig. 19.

In the following summary of the 8080 instruction set, the term "addr" indicates that a 16-bit address must immediately follow the op code in program memory (refer to Fig. 17). Similarly, "data16" indicates a 16-bit data quantity must immediately follow the op code. In both cases, byte 2 of the instruction is the low-order address or data byte, and byte 3 is the high-order byte. The term "data" indicates that an 8-bit data quantity must immediately follow the op code in memory. The actions taken by each instruction on the five flag (condition) bits will be given with the description of each instruction. We will begin with the group of instructions called the "Data Transfer Group," which transfers data to and from the registers and memory. Condition flags are not affected by any instruction in this group.

Data Transfer Group.

MOV *r1, r2* (Move register to register)

The content of register *r2* is transferred (copied into) to register *r1*. Any of the seven register names are legal values for *r1* and *r2*. The content of register *r2* is not affected.

MOV *M, r* (Move register to memory)

The content of register *r* is transferred to the memory location whose address is

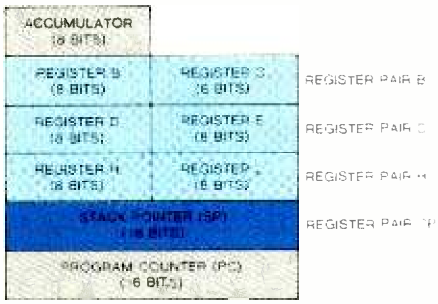


Fig. 18. The 8080 has seven 8-bit general-purpose registers and two 16-bit registers.

contained in register pair *H*.

MOV *r, M* (Move memory to register)

The content of the memory location, whose address is contained in register pair *H*, is transferred to register *r*.

MVI *M, data* (Move data immediate to memory)

The content of byte 2 of this instruction is transferred to the memory location whose address is contained in register pair *H*.

MVI *r, data* (Move data immediate to register)

The content of byte 2 of this instruction is transferred to register *r*.

LXI *rp, data16* (Load register pair with data immediate)

The 16-bit value of *data16* is stored in register pair *rp*.

STA *addr* (Store accumulator in memory)

The content of the accumulator is stored in the memory location specified by *addr*.

LDA *addr* (Load accumulator from memory)

The content of the memory location specified by *addr* is transferred to the accumulator.

SHLD *addr* (Store register pair *H* in memory)

The content of register *L* is stored in the memory location specified by *addr*. The content of register *H* is stored in the succeeding memory location *(addr+1)*.

LHLD *addr* (Load register pair *H* from memory)

The content of the memory location specified by *addr* is transferred to register *L*. The content of the succeeding memory location *(addr+1)* is transferred to register *H*.

STAX *rp* (Store accumulator indirect)

The content of the accumulator is stored in the memory location whose address is obtained from register pair *rp*. Only register pairs *rp=B* and *rp=D* can be specified.

LDAX *rp* (Load accumulator indirect)

The content of the memory location, whose address is obtained from register pair *rp*, is transferred to the accumulator. Only register pairs *rp=B* and *rp=D* can be specified.

XCHG (Exchange register pairs *H* and *D*)

The content of register *H* is exchanged with the content of register *D*. The content of register *L* is exchanged with the content of register *E*.

Arithmetic Group. This group performs arithmetic operations on data contained in registers and memory. Unless indicated otherwise, all instructions in this group affect the condition flags according to the standard rules. All subtraction operations are performed using two's-complement arithmetic and set the Carry flag to 1 to indicate a borrow, and clear it to indicate no borrow.

ADD *r* (Add register to accumulator)

The content of register *r* is added to the content of the accumulator, with the result placed in the accumulator.

ADD *M* (Add memory to accumulator)

The content of the memory location specified by register pair *H* is added to the content of the accumulator; the result is placed in the accumulator.

ADI *data* (Add data immediate to accumulator)

The content of the second byte of this instruction is added to the content of the accumulator; the result placed in the accumulator.

ADC *r* (Add register with carry to accumulator)

The content of register *r* and the content of the CY bit are added to the content of the accumulator. The result is placed in the accumulator.

ADC *M* (Add memory with carry to accumulator)

The content of the memory location specified by register pair *H* and the content of the CY bit are added to the content of the accumulator. The result is placed in the accumulator. This instruction is used primarily in "multiple precision" additions in which a number is actually contained in several, usually adjacent memory locations. Such an addition begins at the low-order end (byte) of the two numbers being added using the ADD *M* instruction. Successive additions on more significant bytes of the numbers use the ADC *M* instruction, which corrects for overflow (carries) from preceding (less significant) additions.

ACI *data* (Add data immediate with carry to accumulator)

The content of the second byte of this instruction and the content of the CY bit are added to the content of the accumulator. The result is placed in the accumulator.

SUB *r* (Subtract register from accumulator)

The content of register *r* is subtracted from the content of the accumulator, with result placed in the accumulator.

SUB *M* (Subtract memory from accumulator)

The content of the memory location specified by register pair *H* is subtracted from the content of the accumulator. Result is placed in the accumulator.

SUI *data* (Subtract data immediate from accumulator)

The content of the second byte of this instruction is subtracted from the content of the accumulator. The result is placed in the accumulator.

SBB *r* (Subtract register with borrow from accumulator)

The content of register *r* and the content of the CY bit are subtracted from the content of the accumulator. The result is placed in the accumulator.

SBB *M* (Subtract memory with borrow from accumulator)

The content of the memory location specified by register pair *H* and the content of the CY bit are subtracted from the content of the accumulator. The result is placed in the accumulator. This is the "multiple precision" form of the SUB *M* instruction (see ADC *M*).

SBI *data* (Subtract data immediate with borrow from accumulator)

The content of the second byte of this instruction and the content of the CY bit are subtracted from the content of the accumulator. The result is placed in the accumulator.

INR *r* (Increment register)

The content of register *r* is incremented by one. The CY flag is not affected by this instruction.

INR *M* (Increment memory)

The content of the memory location specified by register pair *H* is incremented by one. The CY flag is not affected by this instruction.

DCR *r* (Decrement register)

The content of register *r* is decremented by one. The CY flag is not affected by this instruction.

DCR *M* (Decrement memory)

The content of the memory location specified by register pair *H* is decremented by one. The CY flag is not affected by this instruction.

INX *rp* (Increment register pair)

The content of register pair *rp* is incremented by one. No condition flags are affected.

DCX *rp* (Decrement register pair)

The content of register pair *rp* is decremented by one. No condition flags are affected.

JUMP

C3	JMP	Adr
C2	JNZ	Adr
CA	JZ	Adr
D2	JNC	Adr
DA	JC	Adr
E2	JPO	Adr
EA	JPE	Adr
F2	JP	Adr
FA	JM	Adr
E9	PCHL	

CALL

CD	CALL	Adr
C4	CNZ	Adr
CC	CZ	Adr
D4	CNC	Adr
DC	CC	Adr
E4	CPO	Adr
EC	CPE	Adr
F4	CP	Adr
FC	CM	Adr

RETURN

C9	RET
C0	RNZ
C8	RZ
D0	RNC
D8	RC
E0	RPO
E8	RPE
F0	RP
F8	RM

RESTART

C7	RST	0
CF	RST	1
D7	RST	2
DF	RST	3
E7	RST	4
EF	RST	5
F7	RST	6
FF	RST	7

ROTATE

07	RLC
0F	RRC
17	RAL
1F	RAR

CONTROL

00	NOP
76	HLT
F3	DI
FB	EI

MOVE IMMEDIATE

06	MVI	B	D8
0E	MVI	C	D8
16	MVI	D	D8
1E	MVI	E	D8
26	MVI	H	D8
2E	MVI	L	D8
36	MVI	M	D8
3E	MVI	A	D8

Acc IMMEDIATE

C6	ADI	D8
CE	ACI	D8
D6	SUI	D8
DE	SBI	D8
E6	ANI	D8
EE	XRI	D8
F6	ORI	D8
FE	CPI	D8

LOAD IMMEDIATE

01	LXI	B,	D16
11	LXI	D,	D16
21	LXI	H,	D16
31	LXI	SP,	D16

STACK OPS

C5	PUSH	B
D5	PUSH	D
E5	PUSH	H
F5	PUSH	PSW
C1	POP	B
D1	POP	D
E1	POP	H
F1	POP	PSW
E3	XTHL	
F9	SPHL	

DOUBLE ADD

09	DAD	B
19	DAD	D
29	DAD	H
39	DAD	SP

MOVE

40	MOV	B,B
41	MOV	B,C
42	MOV	B,D
43	MOV	B,E
44	MOV	B,H
45	MOV	B,L
46	MOV	B,M
47	MOV	B,A
48	MOV	C,B
49	MOV	C,C
4A	MOV	C,D
4B	MOV	C,E
4C	MOV	C,H
4D	MOV	C,L
4E	MOV	C,M
4F	MOV	C,A
50	MOV	D,B
51	MOV	D,C
52	MOV	D,D
53	MOV	D,E
54	MOV	D,H
55	MOV	D,L
56	MOV	D,M
57	MOV	D,A

MOVE (cont)

58	MOV	E,B
59	MOV	E,C
5A	MOV	E,D
5B	MOV	E,E
5C	MOV	E,H
5D	MOV	E,L
5E	MOV	E,M
5F	MOV	E,A
60	MOV	H,B
61	MOV	H,C
62	MOV	H,D
63	MOV	H,E
64	MOV	H,H
65	MOV	H,L
66	MOV	H,M
67	MOV	H,A
68	MOV	L,B
69	MOV	L,C
6A	MOV	L,D
6B	MOV	L,E
6C	MOV	L,H
6D	MOV	L,L
6E	MOV	L,M
6F	MOV	L,A
70	MOV	M,B
71	MOV	M,C
72	MOV	M,D
73	MOV	M,E
74	MOV	M,H
75	MOV	M,L
77	MOV	M,A
78	MOV	A,B
79	MOV	A,C
7A	MOV	A,D
7B	MOV	A,E
7C	MOV	A,H
7D	MOV	A,L
7E	MOV	A,M
7F	MOV	A,A

ACCUMULATOR

80	ADD	B	A8	XRA	B
81	ADD	C	A9	XRA	C
82	ADD	D	AA	XRA	D
83	ADD	E	AB	XRA	E
84	ADD	H	AC	XRA	H
85	ADD	L	AD	XRA	L
86	ADD	M	AE	XRA	M
87	ADD	A	AF	XRA	A
88	ADC	B	B0	ORA	B
89	ADC	C	B1	ORA	C
8A	ADC	D	B2	ORA	D
8B	ADC	E	B3	ORA	E
8C	ADC	H	B4	ORA	H
8D	ADC	L	B5	ORA	L
8E	ADC	M	B6	ORA	M
8F	ADC	A	B7	ORA	A
90	SUB	B	B8	CMP	B
91	SUB	C	B9	CMP	C
92	SUB	D	BA	CMP	D
93	SUB	E	BB	CMP	E
94	SUB	H	BC	CMP	H
95	SUB	L	BD	CMP	L
96	SUB	M	BE	CMP	M
97	SUB	A	BF	CMP	A
98	SBB	B			
99	SBB	C			
9A	SBB	D			
9B	SBB	E			
9C	SBB	H			
9D	SBB	L			
9E	SBB	M			
9F	SBB	A			
A0	ANA	B			
A1	ANA	C			
A2	ANA	D			
A3	ANA	E			
A4	ANA	H			
A5	ANA	L			
A6	ANA	M			
A7	ANA	A			

INCREMENT

04	INR	B
0C	INR	C
14	INR	D
1C	INR	E
24	INR	H
2C	INR	L
34	INR	M
3C	INR	A
03	INX	B
13	INX	D
23	INX	H
33	INX	SP

DECREMENT

05	DCR	B
0D	DCR	C
15	DCR	D
1D	DCR	E
25	DCR	H
2D	DCR	L
35	DCR	M
3D	DCR	A
0B	DCX	B
1B	DCX	D
2B	DCX	H
3B	DCX	SP

LOAD/STORE

0A	LDAX	B
1A	LDAX	D
2A	LHLD	Adr
3A	LDA	Adr
02	STAX	B
12	STAX	D
22	SHLD	Adr
32	STA	Adr

SPECIALS

EB	XCHG
27	DAA
2F	CMA
37	STC
3F	CMC

INPUT/OUTPUT

D3	OUT	D8
DB	IN	D8

D8 = constant, or logical arithmetic expression that evaluates to an 8 bit data quantity

D16 = constant, or logical/arithmetic expression that evaluates to a 16 bit data quantity

Adr = 16 bit address

Fig. 19. Machine codes for the 8080 assembly language instructions. The hexadecimal machine code for each op code appears to the left of the instruction mnemonic.

DAD *rp* (Double precision add)

The content of register pair *rp* is added to the content of register pair *H*. The result is placed in register pair *H*. Only the CY flag is affected. It is set if there is a carry out of the double precision add; otherwise it is reset. Any register pair *(B, D, H, SP)* can be specified.

DAA (Decimal adjust accumulator)

The 8-bit number in the accumulator is adjusted to form two 4-bit binary-coded decimal digits by the following process:

1. If the value of the least significant four bits of the accumulator is greater than 9, or if the AC flag is set, 6 is added to the accumulator.
2. If the value of the most significant four bits of the accumulator is now greater than 9, or if the CY flag is set, 6 is added to the most significant four bits of the accumulator.

Logical Group. These instructions perform logical (Boolean) operations on data contained in registers, memory, and on condition flags. All instructions in this group affect the condition flags according to the standard rules, unless indicated otherwise.

ORA *r* (OR register with accumulator)

The content of register *r* is bit-wise logically inclusive-OR'd (Boolean addition) with the content of the accumulator. The result is placed in the accumulator. The CY and AC flags are cleared. Each bit of the result is set to 1 if *either* of the corresponding accumulator/register bits is 1. For example, the value 10011101 OR'd with 01001011 will produce a result of 11011111 in the accumulator.

ORA *M* (OR memory with accumulator)

The content of the memory location specified by register pair *H* is logically inclusive-OR'd with the content of the accumulator. The result is placed in the accumulator. The CY and AC flags are cleared.

ORI *data* (OR data immediate with accumulator)

The content of byte 2 of this instruction is logically inclusive-OR'd with the content of the accumulator. The result is placed in the accumulator. The CY and AC flags are cleared.

ANA *r* (AND register with accumulator)

The content of register *r* is bit-wise logically AND'ed (Boolean multiplication) with the content of the accumulator. The result is placed in the accumulator. The CY flag is cleared. Conceptually this operation is performed independently on each corresponding bit position of the accumulator and register *r*. The corresponding bit position in the result is set to 1 if, and only if, *both* of the corresponding accumulator/register bits are 1. The value 10011101 AND'ed with 01001011 will produce a result of 00001001 in the accumulator.

ANA *M* (AND memory with accumulator)

The content of the memory location specified by register pair *H* is logically AND'ed with the content of the accumulator. The result is placed in the accumulator. The CY flag is cleared.

ANI *data* (AND data immediate with accumulator)

The content of byte 2 of this instruction is logically AND'ed with the content of the accumulator. The result is placed in the accumulator. The CY and AC flags are cleared. This instruction is often used to isolate or mask bits of the accumulator after an Input instruction for testing the status (ready/not ready) of external devices.

XRA *r* (Exclusive-OR register with accumulator)

The content of register *r* is bit-wise logically exclusive-OR'd with the content of the accumulator. The result is placed in the accumulator. The CY and AC flags are cleared. Each bit of the result is set to 1 if one, *and only one,* of the corresponding accumulator/register bits is 1. The value 10011101 exclusive-OR'd with 01001011 will produce a result of 11010110 in the accumulator. The instruction XRA *A* is often used to clear the accumulator and CY flag.

XRA *M* (Exclusive-OR memory with accumulator)

The content of the memory location specified by register pair *H* is logically exclusive-OR'd with the content of the accumulator. The result is placed in the accumulator. The CY and AC flags are cleared.

XRI *data* (Exclusive-OR data immediate with accumulator)

The content of byte 2 of this instruction is logically exclusive-OR'd with the content of the accumulator. The result is placed in the accumulator. The CY and AC flags are cleared.

CMP *r* (Compare accumulator with register)

The content of register *r* is subtracted from the content of the accumulator. The accumulator remains unaltered, and the condition flags are set as a result of the subtraction. The Z flag is set if the two values being compared are equal. The CY flag is set if the value in register *r* is greater than the value in the accumulator.

CMP *M* (Compare accumulator with memory)

The content of the memory location specified by register pair *H* is subtracted from the content of the accumulator. The accumulator remains unaltered. The condition flags are set as a result of the subtraction (see CMP *r*).

CPI *data* (Compare accumulator with data immediate)

The content of byte 2 of this instruction is subtracted from the content of the accumulator. The accumulator remains unaltered. The condition flags are set as a result of the subtraction (see CMP *r*).

There are four instructions in this group which are used to shift the contents of the accumulator. Each of these instructions shifts the accumulator bits one place left or right depending on the particular instruction. The only flag bit affected by these instructions is the CY flag. The directions "left" and "right" in the following descriptions assume that the more significant bits of the accumulator lie to the left.

RRC (Rotate right)

This is a circular right shift in which the CY bit receives the bit value shifted from the LSB of the accumulator. This same value shifted into the CY bit is also shifted into the MSB of the accumulator. For example, 00111001 becomes 10011100 after the shift and the CY bit is set to 1. Another shift of this value gives 01001110 and a CY value of 0.

RLC (Rotate left)

This shift is a left shift similar to RRC except the MSB is shifted into the CY bit and the LSB. All other accumulator bits are shifted left one position.

RAR (Rotate right through Carry)

This instruction shifts the accumulator contents one place right. The LSB is shifted into the CY bit as in the RRC instruction, but the old value of the CY bit is shifted into the MSB position of the accumulator. Shifting 00111001 with a value of 0 in the CY bit produces 00011100 and a CY value of 1. A second shift of this value produces 10001110 and a CY value of 0.

RAL (Rotate left through Carry)

The accumulator contents are shifted one place left with the MSB being sent to the CY bit and old value of the CY bit being shifted into the LSB position of the accumulator.

CMA (Complement accumulator)

The one's complement of the accumulator is placed in the accumulator. No condition flags are affected.

CMC (Complement Carry)

The CY flag is complemented, and no other flags are affected.

STC (Set Carry)

The CY flag is set to 1, and no other flags are affected. This instruction and the CMC instruction will affect all CY-related condition instructions as well as the addition, subtraction, and shift instructions which use CY. These instructions are frequently used to return a status condition from a subroutine.

Branch Group. The 8080 is equipped with a full set of branch instructions which have the ability to alter the normal sequential flow of a program's execution. There are two types of branch instructions: conditional and unconditional. The execution sequence of a program is always altered by the unconditional type of transfer. The conditional type of transfer, on the other hand, examines the status of a condition flag in the instruction to see if the proposed branch is to be made. If the specified condition does not meet the requirement of the instruction, no branch is made and the program will resume execution at the next sequential instruction in memory. Condition flags are not affected by any instruction in this group. The conditions that can be specified are as follows:

Z - zero (Z=1)
NZ - not zero (Z=0)
C - carry (CY=1)
NC - no carry (CY=0)
PE - parity even (P=1)
PO - parity odd (P=0)
M - minus (S=1)
P - plus (S=0)

The AC flag cannot be used in a conditional branch instruction.

JMP *addr* (Unconditional jump)
Program control is unconditionally transferred to the memory address specified by *addr*. The next instruction executed will therefore be the one starting at this address (*i.e.*, the value of *addr* is moved into the PC).

J*condition addr* (Conditional jump)
A jump is made to the specified memory address if the specified condition is true (see JMP addr). If it is not true, program execution continues sequentially. There are actually eight unique instructions included here, since there are eight unique conditions that can be specified in the instruction op code (JZ, JNZ, JC, etc.).

PCHL (Jump H and L indirect)
This instruction performs the same operation as the JMP *addr* instruction except the transfer address is obtained from register pair *H*. This is most often used to branch to a routine in memory whose address has been computed or located in a table.

A transfer to a subroutine is made with one of the Call instructions to be described. When a call is made, two addresses become important. The "transfer address," the address of the subroutine being called, is contained in bytes 2 and 3 of the instruction (as in the Jump instructions). As the call is being made, however, a "return address" is stored (pushed) on the next available position (the top) of the Stack. The return address is obtained from the contents of the PC. The PC contains the address of the next sequential instruction. When the subroutine is finished, it can execute one of the Return instructions which will retrieve (pop) this address from the top of the Stack and perform a jump to this address. This return address represents the location of the instruction immediately following the Call instruction which gave control to the subroutine.

CALL *addr* (Unconditional call)
The most significant eight bits of the PC are stored in the memory location whose address is one less than the content of the SP (SP-1). The least significant eight bits of the PC are stored in the memory location whose address is two less than the content of the SP (SP-2). The content of the SP is decremented by two. A jump is then made to the memory location specified by *addr* (the branch address).

C*condition addr* (Conditional call)
The subroutine beginning at the specified memory address is called if the specified condition is true (see CALL *addr*). If it is not true, program execution continues sequentially. There are actually eight unique instructions included here, since eight unique conditions can be specified in the instruction op code (CZ, CNZ, CC, etc.).

RET (Unconditional return)
The content of the memory location specified by the SP is moved into the low-order byte of the PC. The content of the memory location whose address is one more than the content of the SP (SP+1) is moved into the high-order byte of the PC. The content of the SP is incremented by two. Care must be exercised when using this instruction to ensure that the Stack has been properly maintained in the subroutine, or a return may be made to an erroneous address.

R*condition* (Conditional return)
A return is made if the condition specified in the instruction is true (see RET). If it is not true, program execution continues sequentially. There are actually eight unique instructions included here, since eight unique conditions can be specified in the instruction op code (RZ, RNZ, RC, etc.).

RST *n* (Restart)
A Call is made to the memory location whose address is *eight times* the value of *n*, where *n* must be an integer value between 0 and 7. This is a single-byte instruction which is used primarily during program interrupt I/O, when a slow or sporadic peripheral has requested an interrupt from the CPU. It is similar to the subroutine Call instruction, except an external device will usually initiate this type of Call rather than the program itself. It is the responsibility of the peripheral that requested the interrupt to jam the Restart instruction's machine code onto the CPU's data bus for the CPU to execute during the Interrupt Acknowledge period ($\overline{\text{INTA}}$ low). If only one peripheral in the system is capable of requesting an interrupt, a RST 7 instruction may be automatically gated onto the data bus at the proper time by connecting a 1-kΩ resistor between the $\overline{\text{INTA}}$ output (P3-9) and +12 V. When

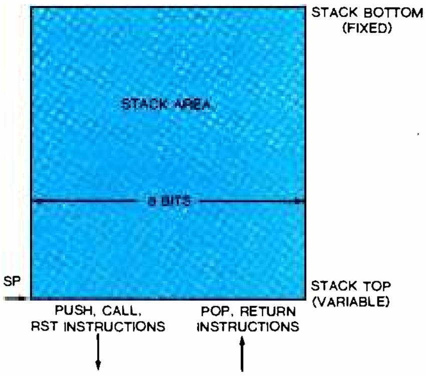


Fig. 20. The 8080 Stack is fixed at the bottom by the LXI SP, data16 instruction and grows downward from there. The Stack Pointer keeps track of the top.

an interrupt is acknowledged, the interrupt system is immediately disabled ($\overline{\text{INTE}}$ high), keeping other interrupting peripherals from confusing things while the first interrupt is being handled. (Other methods exist which allow multiple interrupts to take place, that is, a second interrupt may interrupt the first interrupt, a third interrupt the second, etc. One such method is "interrupt vectoring," where each interrupting device is assigned a priority level and is serviced accordingly.) A routine to service the interrupting device must begin at the address specified by the Restart instruction. The possible Restart addresses are: 0000, 0008, 0010, 0018, 0020, 0028, 0030, and 0038 hexadecimal. When the interrupt-servicing routine is completed, control may be returned to the main program where the interrupt took place by executing one of the Return instructions (since RST *n* is a form of Call instruction).

Stack, I/O, and Machine Control Group. Unless indicated otherwise, the condition flags will not be affected by these instructions, which give the programmer direct control of the Stack and its pointer. The Stack can be a very versatile data storage area for particular applications, but the programmer must be careful that the data stored in the Stack area is not confused with the return addresses stored there from subroutine Calls. Note that as data is stored (pushed) on the Stack, the Stack "grows downward" in memory. When data is retrieved (popped) from the Stack the reverse is true—the Stack "shrinks upward" in memory (Fig. 20).

PUSH *rp* (Push register pair)

The content of register pair *rp* is placed on the Stack in the following manner: The content of the high-order register of register pair *rp* is stored in the memory location whose address is one less than the content of the SP (SP-1). The content of the low-order register is stored in the memory location whose address is two less than the content of the SP (SP-2). The SP is decremented by two. Register pair *rp*=SP can not be specified.

POP *rp* (Pop register pair)

This instruction performs the inverse operation of the PUSH *rp* instruction. The content of the memory location specified by the SP is moved into the low-order register of register pair *rp*. The content of the succeeding memory location (SP+1) is moved into the high-order register of register pair *rp*. The content of the SP is incremented by two. Register pair *rp*=SP may not be specified.

PUSH PSW (Push processor status word)

The content of the accumulator is stored in the memory location whose address is one less than the content of the SP (SP-1). The processor flags are assembled into what is called the "processor status word," which is then stored in the memory location whose address is two less than the content of the SP (SP-2). The SP is decremented by two. The processor status word is assembled as follows:

D7	D6	D5	D4	D3	D2	D1	D0
S	Z	0	AC	0	P	1	CY

POP PSW (Pop processor status word)

This instruction performs the inverse operation of the PUSH PSW instruction. The content of the memory location specified by the SP is disassembled and moved into the processor flag bits. The content of the succeeding memory location (SP+1) is moved into the accumulator. The content of the SP is incremented by two.

SPHL (Move register pair *H* into SP)

The content of register pair *H* is moved into the Stack Pointer, destroying its previous contents. This provides a convenient way of changing the SP during a program, thereby allowing two or more Stacks to exist at once (one for subroutine control, one for data, etc.).

XTHL (Exchange top of Stack with register pair *H*)

The content of register *L* is exchanged with the content of the memory location whose address is specified by the SP. The content of register *H* is exchanged with the content of the succeeding memory location (SP+1).

IN *port* (Input)

This instruction reads the specified port and stores the data byte which it read (via the data bus) in the accumulator. During execution of this instruction, the specified port number is sent out on the high- and low-order bytes of the address bus for Port-Select decoding by the interface. The port number must be an integer value between 00 and FF_{16}. Attempting to read a nonexistent port with this instruction will place FF_{16} in the accumulator.

OUT *port* (Output)

This instruction writes the content of the accumulator to the specified port via the data bus. During execution of this instruction, the specified port number is sent out on the high and low-order bytes of the address bus for port-select decoding by the interface. The port number must be an integer value between 00 and FF_{16}. The content of the accumulator is unaltered. (See Part II for interfacing techniques).

EI (Enable interrupts)

The interrupt system is enabled ($\overline{INTE}$ *low*) following the execution of the *next* instruction. The CPU will then honor the next interrupt requested by an external device.

DI (Disable interrupts)

The interrupt system is disabled ($\overline{INTE}$ *high*) immediately following execution of this instruction. Devices attempting to interrupt the CPU with the interrupt system disabled will be ignored by the CPU and its related hardware. The interrupt system is automatically disabled when an interrupt is acknowledged or when the CPU is reset.

HLT (Halt)

The CPU is completely stopped by this instruction and can be reactivated in only two ways. One is to reset the CPU by forcing the $\overline{RESIN}$ input (P3-11) low, which will also reset the Program Counter. The other is to interrupt the CPU. Should the interrupt system be disabled at the time this instruction executes, the CPU must be reset to exit the Halt state.

NOP (No op)

No operation is performed. This instruction can be used in programs under development to reserve space in memory where changes are expected to be made. It may also be used to "delete" unwanted instructions in a program.

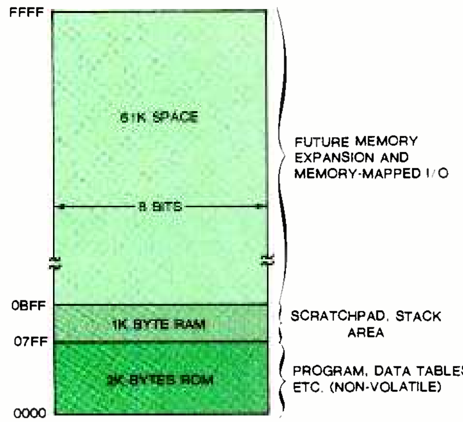


Fig. 21. Configuration of the CPU module memory. Permanent data are stored in ROM. Stack and scratchpad area is from 0800 to 0BFF. Top part is for memory expansion.

Writing Software for the CPU Module. It is easy to write programs for the CPU module. There are basically three steps to writing programs, and Fig. 21 will aid in the following summary of these steps.

1. Determine the maximum size (in bytes) that the Stack will be. This is most easily done by estimating the maximum number of nested subroutines and Push instructions that will be active in your program at any given time. This number should then be multiplied by two since each Call and Push instruction will use two bytes of Stack storage area. It is usually a good idea to increase this estimated value by a factor of 10% or 20% to ensure enough RAM will be reserved for the Stack area, just in case you underestimated the maximum Stack depth.

Now add the value just determined to the starting address of the RAM area

(800_{16}). This will be the address of the bottom of the Stack. Any RAM remaining above this address is free for any other use you may have (scratchpad, parameter storage, etc.)

2. Write your source program. A LXI SP, *data16* instruction initializing the SP to the value computed in step 1 should be included in the beginning of your program before any Stack-related instructions (Calls, Pushes, etc.) appear. For most programs, the SP may be initialized to BFF_{16}, the end of RAM, which eliminates the need of performing step 1. This should be done only if you can make certain the Stack will not be interfered with by other data the program may store in RAM. If any uncertainty exists, it is safer to perform step 1 first.

3. "Assemble" your source program into the object program with the aid of Fig. 19. The object program *must* originate at memory location 0 since the CPU automatically begins execution at this location at power-up. If your program must begin at a memory location other than 0 for one reason or another, a JMP *addr* instruction may be stored at location 0 which will transfer control to the beginning of your program (in this case *addr*=starting address of your program).

Sample Program. Let's try to write a short-machine-language program using the 8080 instruction set to demonstrate how easy it really can be.

You have just installed six sensors in various areas of your house for a new security system. Each sensor output is two-state (+5 or 0 volts) and is connected to an existing input port of your CPU module. In an attempt to devise the most complex security system in the neighborhood you are now confronted with the task of writing the software. Write a machine-language subroutine beginning at memory location 100_{16}, which will return to the calling program with the CY flag *set* if any one of the sensors has detected an intrusion. The subroutine should otherwise return with the CY flag *reset* if the house has been determined to be "secure." Assume that the input interface Port-Select circuitry has been wired to decode I/O port address 23_{16} and the six sensor outputs are connected to bits 0-5 of the port (bits 6 and 7 are grounded). Also assume that, when a forced-entry is detected, the triggered sensor's output goes high (+5 V). Try to write this subroutine yourself before reading any further. If you cannot, see the sample in the box:

SAMPLE PROGRAM

Mem. Address	Machine Code	Mnemonic	Explanation
0100	DB 23	IN 23H	Input status of sensors
0102	B7	ORA A	Update flags
0103	C8	RZ	Return with CY=0 if all sensors are 0 (Z flag=1 from last instruction)
0104	37	STC	Otherwise set CY=1
0105	C9	RET	and return to main program

This is how a typical assembly listing would appear after an assembler program assembled the source program. This is also a good method to follow when writing your own programs without an assembler program.

The above subroutine is, of course, only *one* of a number of ways in which the algorithm can be written. You may have come up with something entirely different, but which, in fact, performs the same function. The fewer instructions used, however, the better (to save memory space and execution time).

The instruction following the one which called the above subroutine could be a conditional branch instruction which will branch-on-carry to another routine that determines which area of the house has the uninvited guest. This could be done by repeated use of the rotate instructions and testing the CY flag after each rotate. Another routine could take appropriate action—turn on the lights, sound an alarm, call the police—whatever you desire. And don't forget that heat, smoke, and moisture detectors can also be interfaced to the CPU.

If turning on lights is a response to an intrusion, the hardware already exists to automatically cycle the lights on and off systematically or randomly during vacation periods (which would give the house the appearance of being occupied). All that need be done is to write an appropriate program, which may even be stored in the same ROM with the security program. By interfacing a clock chip to the CPU (such as the National MM58167 or MM58174), it is a simple matter to write a short program which will turn on the lights and coffee pot before you get up in the morning.

To gain experience in writing longer programs, next month we will show how to write a program to receive Morse code off the air. ◇

OSCILLOSCOPE TIME-BASE GENERATOR

BY REX C. GEIVETT

Provides Z-axis modulation for inexpensive scopes

INEXPENSIVE home-use oscilloscopes are often of the recurring sweep type and lack the capability of measuring pulse width or frequency with any notable accuracy. The Time-Base Generator detailed here provides a means of making these measurements very precisely, at crystal oscillator tolerance, and can be built for about $15. It does this by displaying dots on the scope trace at the selected frequency, i.e. modulating the Z axis of the scope.

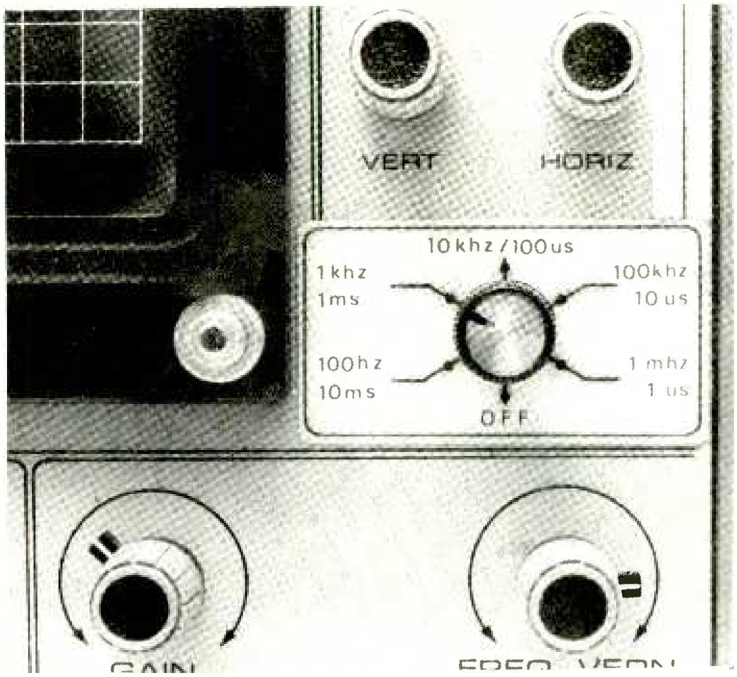
Operation. The signal to be measured is displayed on the scope and synced in the usual manner. The Time-Base Generator is then switched to one of the five frequencies, which displays a series of dots across the CRT. By comparing the number of dot intervals with the signal, one can easily determine signal timing. The horizontal gain control as implemented on most of these scopes can be used to calibrate the sweep length so that the dots are coincident with the scope's graticule. The graticule can then be used to make the actual signal measurement.

As shown in Fig. 1, *IC1A* and its associated components form a 4-MHz crystal-controlled oscillator. The output is buffered by *IC1B* and drives the dual flip-flops in *IC2*, with the output of *IC2B* driving four stages of divide-by-10 counters formed by *IC3* and *IC4*. The NAND gates within *IC5* and *IC6* are connected to the countdown chain in a decoding scheme that produces five precise frequencies—1 MHz (1 μs), 100 kHz (10 μs), 10 kHz (100 μs), 1 kHz (1 ms), and 100 Hz (10 ms), having a duty cycle of about 5%. This small duty cycle produces a sharp dot on the CRT trace. The signals are selected by *S1*.

The selected signal is inverted by one gate in *IC6* and applied to the base of output transistor *Q1*. Potentiometer *R7* forms the collector load for *Q1*, and the rotor of this control determines the level of the negative-going pulses that will be applied to the cathode of the scope CRT to intensify the trace during each dot period. Coupling to the relatively high-voltage CRT cathode is made via high-voltage capacitor *C6*.

The reset circuit, formed by *IC1C* and its associated components, accepts the negative-going pulse from the scope blanking circuit. The network at the input of *IC1C* shapes and limits this pulse. The output of *IC1C* is applied to the common reset line of the counters, so that each time the scope starts a new trace and a blanking pulse occurs, all counters are reset to zero. This synchronizes the time-base generator to the scope.

Construction. The circuit can be



The switch can be mounted on a vacant space on the scope's front panel, cutting an opening for the shaft, with the circuit board inside.

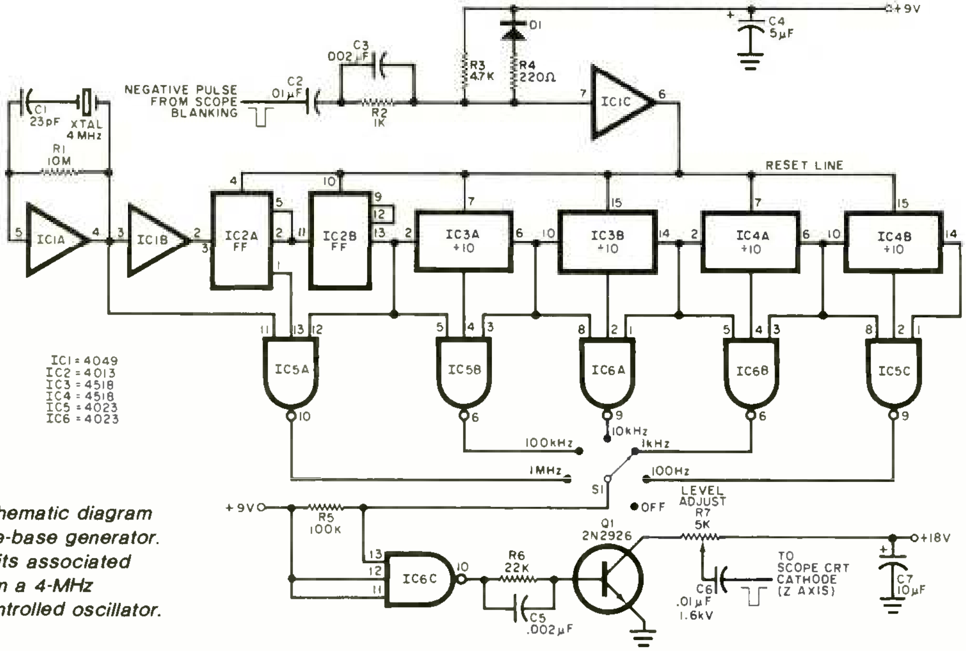


Fig. 1. Schematic diagram of the time-base generator. IC1A and its associated circuit form a 4-MHz crystal-controlled oscillator.

PARTS LIST

C1—23-pF capacitor
C2—0.01-μF disk ceramic capacitor
C3,C5—0.002-μF disk ceramic capacitor
C4—5-μF, 15-V electrolytic
C6—0.01-μF, 1.6-kV ceramic capacitor
C7—10-μF, 35-V electrolytic
D1—1N914 or similar
IC1—4049 hex buffer
IC2—4013 dual D flip-flop
IC3,IC4—4518 dual synchronous decade counter
IC5,IC6—Triple 3-input 4023 NAND
Q1—2N2926 or similar
R1—10-MΩ resistor
R2—1-kΩ resistor
R3—4.7-kΩ resistor
R4—220-Ω resistor
R5—100-kΩ resistor
R6—22-kΩ resistor
R7—5-kΩ potentiometer
S1—Six-position rotary switch
XTAL—4-MHz crystal
Misc.—IC sockets, mounting hardware, hook-up wire, solder, etc.

assembled on a small piece of perforated board using point-to-point wiring, or a small pc board can be fabricated. The board can be mounted within the scope, with only *S1* on the front panel.

Power for the circuit can be derived from the scope power supply, or a pair of 9-volt batteries may be used.

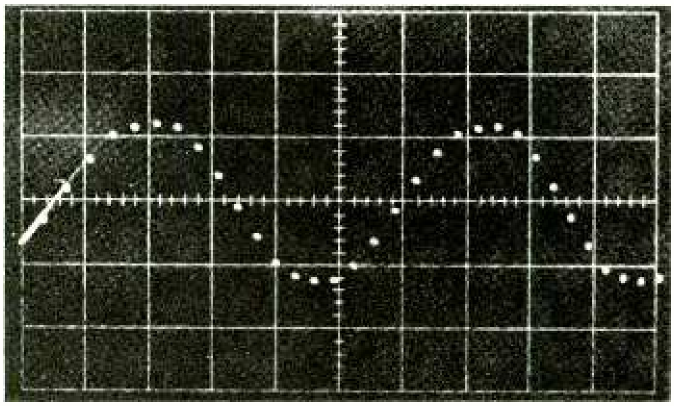
Testing and Use. Connect the time-base generator to the scope, but do not connect the loose end of *C6* to the CRT cathode.

With the reset circuit connected to the scope blanking line (negative going), connect the vertical input of the scope to the loose end of *C6* and observe a negative-going pulse. This pulse will have its frequency dependent on *S1* and its amplitude dependent on *R7*. The pulses will not be synced to the scope trace at this time. Once the time base is found to be working properly, shut down the power to the scope and carefully connect the loose end of *C6* to the CRT cathode socket connector.

Set the scope to display a locked 60-Hz sine wave, then set the time base *S1* to the 1-kHz position. Adjust *R7* for the desired dot intensity. There should be 16.7 dot intervals for one full sine wave.

With no signal displayed on the scope, set the time base for 1 kHz, then adjust the scope horizontal sweep and gain for two widely spaced dots. Without altering the scope controls, set *S1* to the 10-kHz position and note that there are 10 dot intervals between the same two dot positions noted on the 1-kHz test.

Since there is no connection between the input signal and the dots, the time-base generator can be turned on whenever desired. Since it is fully synchronized with the scope sweep, the dots will remain stable. ◇



The generator circuit provides 16.7 dot intervals of one full sine wave as shown here.

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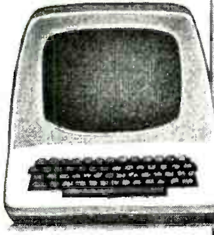

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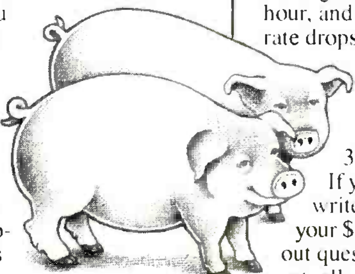

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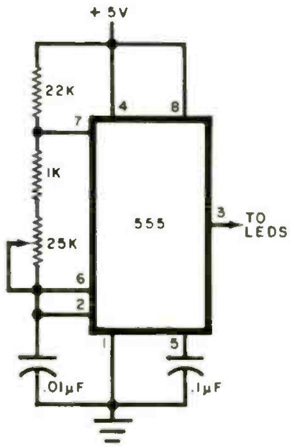
HOBBY SCENE

By Leslie Solomon
Senior Technical Editor

LED Brightness Controller

Q. ***The LED readouts on my home-built FM tuner are fine when the room light is bright. However, when the room light is dimmed, the LEDs are too bright. Other than changing the current-limiting resistors, what can be done?—Charles Lee, San Francisco, CA***

A. The circuit shown here can vary the duty cycle of the power applied to the LEDs from 50% to 99%—quite a range.

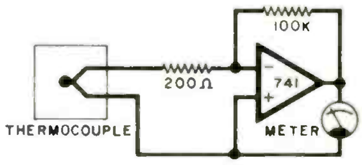


If you wish, substitute a photoresistor for the two resistors between pins 7 and 6-2. The circuit then automatically controls the LED brightness depending on room lighting.

Temperature Sensor

Q. ***I work with ceramics and often have the need to know kiln temperature when I am seated at my desk across the room. Is there some simple electronic method I can use for such a remote temperature sensor and indicator?—Ben Aaronson, Philadelphia, PA***

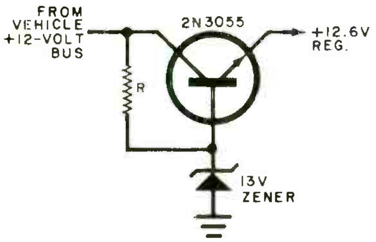
A. The simplest approach I can think of is to use a thermocouple and op amp/meter circuit such as that shown here. Place the thermocouple within the kiln and the op amp/meter at your desk. Use the kiln thermometer to "calibrate" the new sensor. It will not be precise, but will be close enough for most uses.



Protection for CB

Q. ***I recently "lost" an expensive CB rig in my car when the voltage regulator in the battery charging circuit failed. Is there any way that I can protect my next CB rig against such damage?—Ian Warren, San Francisco, CA***

A. You could always place a fuse in the circuit, but if the fuse blows on overcurrent, the CB rig will be inoperative. The circuit shown here will provide regulated +12 volts to the load if the regula-

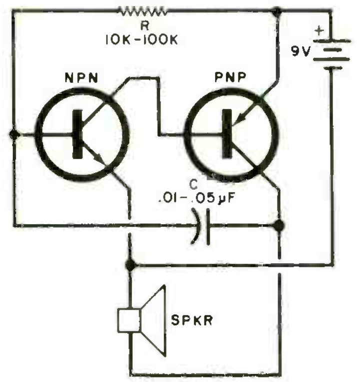


tor fails. Adjust the value of the resistor until the circuit produces +12 volts under load of the CB.

Testing Transistors

Q. ***I have a box full of unmarked transistors that I have collected over the years. Most are either unmarked, or have foreign markings. Is there some simple way to identify them as to type (npn or pnp) and tell if they are good?—Robert D'Angelo, San Antonio, TX.***

A. The easiest way to sort them out is to build a simple two-transistor audio oscillator like the one shown here. (Some other circuit may work as well but this is a simple one.) Select the values of *R* and *C* to produce any desired tone. Use known good transistors when constructing, and use sockets. All you have to do is remove one transistor and start substi-



tuting the unknowns. If the oscillator sounds off, you know the unknown transistor's type (npn or pnp), that it works at audio frequencies, and the pinout. Use the other socket for identifying the other types of transistors.

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.

NEW LITERATURE

Reed Switches and Relays

Standex Electronics announces availability of specification sheets on its new L-Series Reed Switches and Reed Relays. These devices have found applications in diverse areas—from electronic cash registers to TV games. In a six-page 8½" x 11" foldout, twelve series of switches and relays are listed with illustrations. **Address:** Standex Electronics, 4538 Camberwell Road, Cincinnati, OH 45209.

Short Form Catalog

A new catalog from Exact Electronics covers over 30 models of function generators, combination pulse/function generators, materials test and waveform generators, IEEE-488 programmable generators, and precision current and voltage sources. An instrument selection chart is included with a listing of worldwide sales and service offices. **Address:** Exact Electronics, Inc., Box 347, Tillamook, OR 97141.

Buss Directory

Hardware and software for Heathkit computers can be found in the fourth revision of the *Buss Directory*. Over 130 suppliers and clubs are listed along with their wares. The items include games, specialized applications and general interest products. These products are said to be compatible with Heath equipment. **Address:** *Buss*, 325 Pennsylvania Ave., S.E., Washington, DC 20003. $7.50.

Audio Equipment

Gladstone Electronics has released a new 16-page catalog listing product lines of interest to sound installers, audio hobbyists, technicians, experimenters, and engineers. Products include amplifier and preamp modules with matching power supply units and transformers. Also, Thandar test instruments, e.g., multimeters, frequency counters, etc. **Address:** Gladstone Electronics, 901 Fuhrmann Blvd., Buffalo, NY 14203.

Plastic Capacitors

Literature discussing the latest European circuit design practice with miniature and microminiature plastic capacitors is available from the Inter-Technical Group. It includes reprints of two technical papers, as well as a bulletin describing the relative advantages and disadvantages of metallized film and ceramic capacitors when used in microelectronic applications. **Address:** The Inter-Technical Group, Inc., Box 23, Irvington, NY 10533.

SOLID-STATE DEVELOPMENTS

By Forrest M. Mims

The Flashlight-Battery Laser

DEVELOPMENTS in the field of semiconductor junction lasers continue to provide new areas for experimentation. Recently, for example, I've been working with a laser diode that can be powered by a couple of penlight cells! But before we take a closer look at the device, let's review a little background on diode lasers.

In our "Solid-State Developments" of December 1980 ("The Laser at Twenty"), we discussed several major families of diode lasers. Thus far, the most important of these lasers are made from pn junctions of gallium arsenide (GaAs) and aluminum gallium arsenide (AlGa)As. The wavelength of the radiation emitted by such lasers ranges from the visible red to about 910 nanometers in the near infrared.

Early laser diodes could be operated only for brief flashes of a few tenths of a microsecond. This was a result of the very high current required to reach the lasing threshold. Typical thresholds for these lasers range from about 3 to 15 or more amperes.

These early pulsed lasers, some of which are still important sources of pulsed near-infrared radiation, could be operated continuously if they were first cooled to a very low temperature. At the temperature of liquid nitrogen, for example, the threshold for such lasers is greatly reduced. Furthermore, the emission wavelength of such lasers is reduced by cooling.

The solid-state physicists, chemists and crystallographers who design and make diode lasers have long wanted to create a laser which would operate at the same current levels of ordinary indicator LEDs. A decade ago they succeeded in developing a diode laser which operated *continuously* at room temperature. This was the important double heterostructure (DH) injection laser.

Early DH lasers had current thresholds of a few tenths of an ampere or more. In the last few years, modified DH lasers with thresholds as low as 10-15 milliamperes have been developed!

These ultra-low thresholds are a result of isolating the junction region to a thin strip between the laser's end mirrors. The region under the strip is further isolated by any of several crystal growth processes which erect a combined optical and electron barrier. This effectively concentrates the stimulated emission of photons to a threadlike channel through the laser. The result is highly efficient power-to-light conversion and exceptionally low lasing thresholds.

The ultra-low-threshold laser I mentioned at the beginning of this column is an LCW-5 made by Laser Diode Laboratories. This new LCW-5 is far superior to previous versions of this laser with which I've experimented. Though the packing case and power measurement curve supplied with the laser specified a threshold of 22 milliamperes, I was initially skeptical. Since earlier LCW-5's had thresholds ranging from about 100 to 350 milliamperes, I assumed the specified threshold was due to a decimal error. Therefore I was eager to check out the new laser to determine the actual threshold.

Since this and other CW laser diodes must *not* be exposed to current spikes like those produced by some line operated power supplies when switched on, I tested the LCW-5 using the arrangement shown in Fig. 1.

Before connecting the laser into the test circuit, I made sure that the wiper arm of the current control potentiometer (*R1*) was set to provide the highest possible resistance and lowest current.

The only remaining problem was to determine when the lasing threshold was reached. One way to do this is to monitor the laser's output with a solar cell or photodiode and plot the results on a graph. The threshold point is indicated by the sharp knee where light output dramatically increases. This point is clearly shown in Fig. 2, the performance plot supplied with the laser.

Another way to monitor the threshold of a laser diode is simply to observe its output visually, and note when there is a sudden increase in the laser's output. Since the radiation emitted by the LCW-5 is mostly invisible (841 nanometers), I placed a Kodak infrared sensitive phosphor card in front of the laser. Portions of the card illuminated by near infrared radiation glow orange.

I then dimmed the room lights and began to increase the current to the laser by adjusting *R1*. The phosphor card was at first quite dark, but as the current was increased to about 15 milliamperes the entire card emitted a barely discernable orange glow. The glow brightened slightly as the current passed through 20 milliamperes.

As I increased the current to just beyond 22 milliamperes, a bright orange oval glowed at the center of the phosphor screen. This proved the accuracy of the specified threshold for this particular laser. And the oval pattern demonstrated that the above-threshold light emerging from the laser is in the form of a distinct beam. Below threshold, laser diodes emit light in all directions much like an LED.

This simple demonstration was very exciting. Imagine, a laser diode that operates at the same current as a typical indicator LED! More good news is the $95 price of this laser. Earlier, less-efficient LCW-5's cost $210.

Not all LCW-5's exhibit the same threshold and power output as the unit with which I am experimenting. Thresholds may exceed 100 milliamperes, and output powers may range from 5 to 10 milliwatts. The LCW-10, a superior laser with a $250 price, will deliver from 10 to 20 milliwatts.

Both the LCW-5 and LCW-10 represent a sizable improvement in efficiency

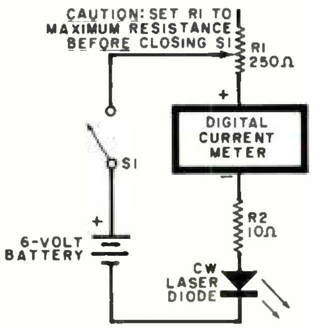


Fig. 1. Simple dc test circuit for continuous-wave laser diode.

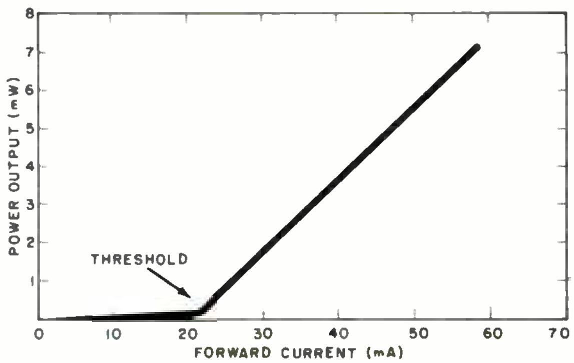


Fig. 2. Graph showing power output of a Laser Diode Labs. LCW-5 laser diode.

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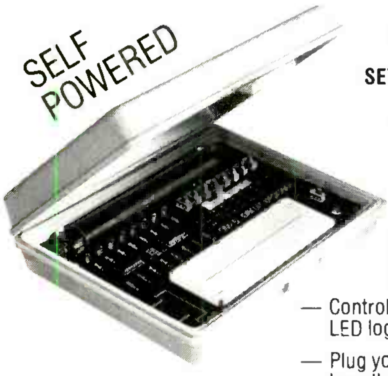

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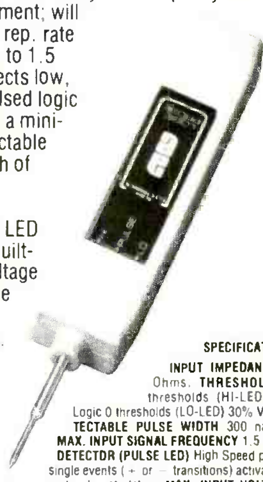

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Fig. 3. Laser current supply made by Laser Diode Labs.

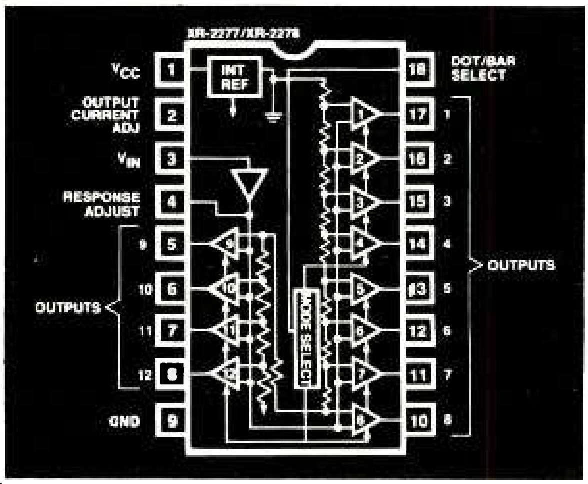

Fig. 4. Functional block diagram and pinout of Exar Integrated Systems LED drivers.

and output over helium-neon lasers costing a few hundred dollars. Such lasers may emit up to about a milliwatt in a very narrow, bright-red beam. Though the radiation from the LCW-5 and LCW-10 is mainly invisible, it can be easily collimated into a narrow beam with the help of a simple lens. The result is a laser with considerably more power output than the helium-neon unit.

I'll continue experimenting with the LCW-5 in coming months. If I come across any unusual applications, I'll report upon them in a future installment of "Experimenter's Corner." In the meantime, you can find out more about diode lasers by looking up the subject in any good technical library.

For details about specific lasers and their prices, please contact the manufacturers directly (not this column). Some of the principle laser diode manufacturers are:

General Optronics
3005 Hadley Road
S. Plainfield, NJ 07080

Hitachi America Ltd.
1800 Bering Dr.
San Jose, CA 95112

Laser Diode Laboratories
1130 Somerset St.
New Brunswick, NJ 08901

Mitsubishi Electronics America
220 W. Artesia Blvd.
Compton, CA 90220

RCA
New Holland Ave.
Lancaster, PA 17604

ITT Components Group
Brixham Rd.
Paignton, Devon TQ4 7BE
United Kingdom

Some of these companies offer excellent brochures and application notes. Hitachi's "Laser Diode Application Manual" and ITT's "Summary Catalogue—Laser Diodes" are particularly good. RCA's "Solid State Emitters" manual gives several laser-diode drive circuits. So does Laser Diode Laboratories' "CW Lasers and LED's" (Application Note 101).

Incidentally, these and other firms sell various kinds of drive, modulator and detector circuits for lasers. For example, laboratory users of CW laser diodes may be interested in Laser Diode Laboratories' LCS-350/R Laser Current Supply shown in Fig. 3. This unit includes a digital current meter and is specifically designed to provide a stable, transient-free output. A built-in ramp feature provides a slow sweep to any level within the 350-mA rating of the supply.

Low-Loss Fiber Optics. While we are on the subject of light, it's fitting to report upon a major breakthrough in fiber optics. Scientists at Japan's Nippon Telegraph and Telephone Public Corporation have produced a single, ultralow-loss silica fiber having a length of 100 kilometers. That's a strand of glass more than 62 miles long!

At 1.55 microns, this new fiber has an attenuation of only 0.3 dB per kilometer. The loss at 1.3 microns is 0.5 dB per kilometer. Both these wavelengths fall in the so-called "second generation" range of wavelengths under active development for practical, widespread lightwave communications. The attenuation of silica is much lower at second generation wavelengths than the 800-850-nanometer range of first generation optical-fiber communication systems.

The new fiber is made using the vapor-phase axial deposition (VAD) process which was developed in Japan. It allows fiber of virtually any length to be fabricated at a drawing speed of up to 120 meters per minute.

The significance of the 100-kilometer fiber is the prospect of repeaterless transmission of telephone signals within large cities. At an attenuation of 0.5 dB per kilometer, the total fiber loss would be 50 dB. This means a detector having a sensitivity of 10 nanowatts would be required to detect the signal from an LED or laser which launched 1 milliwatt of radiant power into the opposite end of the 100-kilometer fiber. Detectors with this sensitivity are readily available. Indeed, new phototransistors made from InGaAsP would be well suited for this application.

If this is typical of what Japan has accomplished so far in optical-fiber communications, expect more developments as time passes. Though the United States is making important developments in this fast moving field, major progress is also reported in Canada, Italy, France, and England.

New Bargraph Drivers. Exar Integrated Systems has announced three new integrated LED bargraph drivers, providing 12 LED outputs.

The outputs of the XR-2279 are spaced 2 dB apart and cover a dynamic range of −27 to +6 dB with respect to an internal 0-dB reference that can be externally adjusted. The XR-2277 has an internal 0-dB reference of 0.2 volt rms and an input-signal range from −30 to +6 dB. The XR-2278 has an internal 0-dB reference of 0.13 volt rms and offers an input signal range from −20 to +8 dB.

Figure 4 shows the functional block diagram and pinout of the XR-2277 and XR-2278 LED drivers. The comparator arrangement shown here is similar to that employed in most other LED bargraph drivers. Note that both moving-dot and bargraph modes can be selected by means of pin 18.

LED bargraph drivers make excellent audio level indicators. They can also be used in various kinds of LED arrays and displays as previously described many times in POPULAR ELECTRONICS. Replace the LEDs with appropriate output buffers and the driver chips can be used as controllers which respond to predetermined input signal levels.

All three of Exar's new chips are packaged in 18-pin DIPs and require a +15-volt supply. For more information about these new chips, write Exar Integrated Systems, Inc., 750 Palomar Ave., Sunnyvale, CA 94086. ◇

EXPERIMENTER'S CORNER

By Forrest M. Mims

Experimenting With a Joystick
Part 1: Basic Concepts and Applications

JOYSTICKS are used to provide an interface between an operator and radio-controlled airplanes, video games, computers, audio systems and many automated industrial systems. In the past, joysticks were rather expensive, and only a small number was sufficient to supply those hobbyists and experimenters able to afford them. Increased production to meet the demand of video-game makers and the use of more plastic have brought the single quantity price as low as $5.00 for some models. Inexpensive units are now available from several of the electronic parts suppliers that advertise in POPULAR ELECTRONICS.

Basic Concepts. A typical joystick consists of two potentiometers installed in a boxlike assembly as shown in Fig. 1. A two-axis mechanical linkage allows the rotation of each potentiometer to be controlled by a single, movable rod (the stick). Some joysticks include four potentiometers that operate in two ganged pairs.

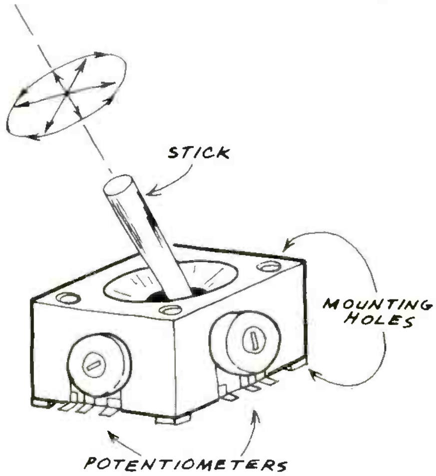

Fig. 1. Three-dimensional representation of a typical two-axis joystick.

As you can see in Fig. 2, moving the control stick up and down rotates only *R1*'s shaft. Moving the stick left and right rotates only *R2*'s shaft. When the stick is moved in any other direction, the shafts of both potentiometers are rotated. In short, the resistances of *R1* and *R2* are functions of the position of the stick.

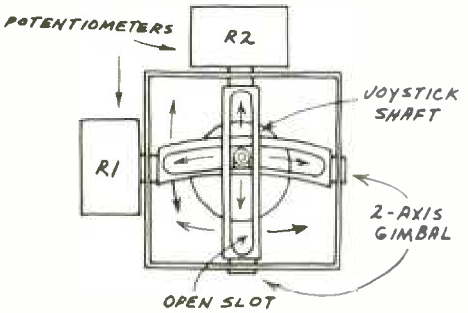

Fig. 2. Diagram of internal construction of a typical low-cost joystick.

Depending upon the application, various methods may be employed to connect the potentiometers of a joystick into a working circuit. Figure 3, for example, shows how the two potentiometers can be connected to form a two-stage voltage divider. A single potentiometer is essentially a one-stage voltage divider. Cascading two potentiometers as shown provides a wide range of output voltages for various positions of the stick.

Figure 4 shows some of the voltages I measured for various positions of a low-cost joystick (Radio Shack 271-1705). Each of the potentiometers in this joystick has a resistance of 100,000 ohms. The input voltage was 5.5 volts. So long as the resistances of the two potentiometers are equal, other joysticks will give similar results.

Examination of Fig. 4 shows that the output voltages for various positions of the stick are not necessarily exclusive. This limits the utility of the circuit configuration in Fig. 3. Nevertheless, this arrangement does have some interesting applications as we shall see later.

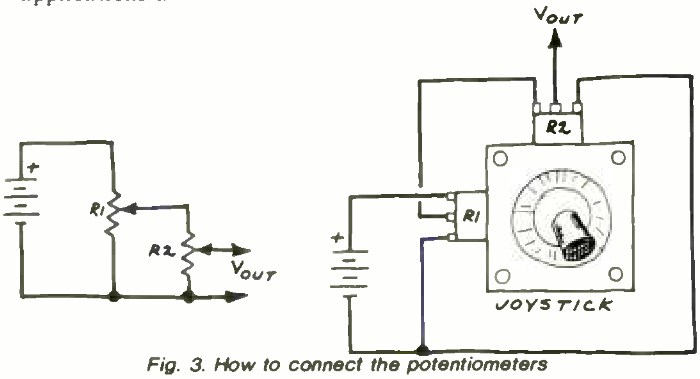

Fig. 3. How to connect the potentiometers in a joystick as a two-stage voltage divider.

A Single-Axis Joystick. Even if you do not yet have a joystick, you can begin experimenting with circuit techniques by converting a standard potentiometer into a single-axis joystick. Figure 5 shows a simple way to accomplish the transformation with the help of two short lengths of wood dowel and a single 6-32 set screw.

Figure 6 shows a 1-of-10 controller circuit ideally suited for use with a single-axis joystick. The circuit consists of an LM3914 LED dot/bar generator. The joystick (*R1*) provides a variable voltage input to the LM3914.

In operation, the outputs of the LM3914 are sequentially enabled as the voltage at pin 5 is increased. This voltage, of course, is a function of the position of *R1*'s shaft.

The circuit in Fig. 6 includes output indicator LEDs. Resistor *R2* provides current limiting for all the LEDs. The outputs can drive SCRs, TRIACs, small relays or external logic.

If *R1* is a linear taper potentiometer, it can be effectively converted to a logarithmic taper potentiometer by substituting an LM3915 for the LM3914. The LM3915 is functionally identical to the LM3914 except it provides a logarithmic output in which each output level is separated from its adjacent levels by 3 dB.

If you want to convert the 1-of-10 output from the LM3914 or LM3915 into binary coded decimal (BCD), connect the outputs to a 74147 priority encoder. This will provide true analog-to-digital conversion for the joystick.

A Two-Axis Joystick Controller. Figure 7 shows how a two-axis joystick can be connected to the one-axis controller shown in Fig. 6. The result is a highly flexible, combination narrow- and wide-range controller system which is fully adjustable with a two-axis joystick.

This application utilizes the cascaded voltage divider circuit shown in Fig. 3. It requires that the LM3914 range potentiometer (*R3* in Fig. 6) be adjusted so that the lowest and highest order LEDs are off when the joystick is at its extreme lower left and upper right positions.

In this application the output LEDs provide important visual feedback which informs the operator exactly what is happening. The LEDs can be arranged in a row or in a 3 x 3 square array as shown in Fig. 7. In either case, moving the stick from full lower left to full upper left sequentially activates LEDs 1-3. Moving the stick from lower center to upper

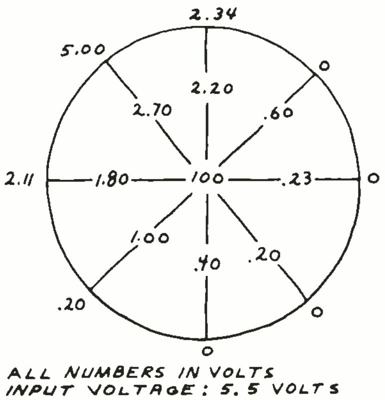

Fig. 4. Output voltage versus stick position for 2-axis joystick.

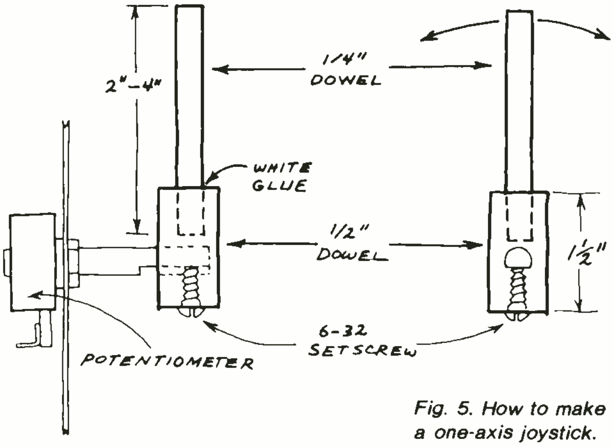

Fig. 5. How to make a one-axis joystick.

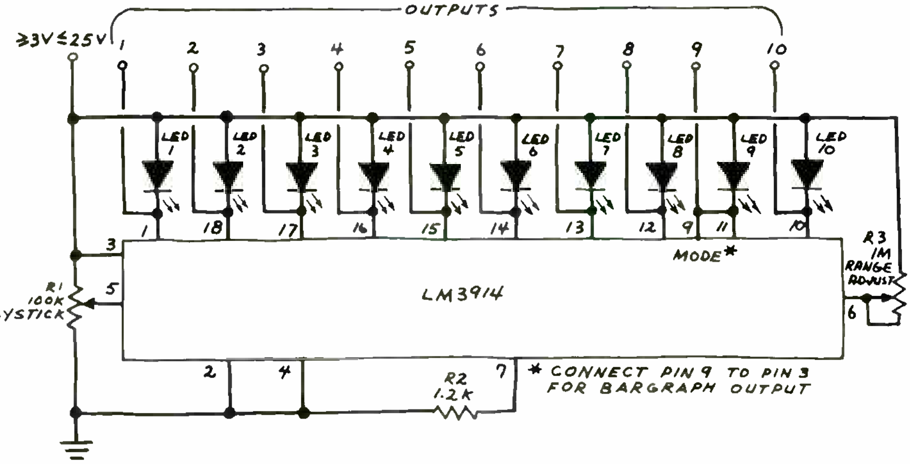

Fig. 6. Schematic diagram of a single-axis joystick controller using an LM3914 LED dot/bar generator chip.

center sequentially activates LEDs 1-6. And moving the stick from lower right to upper right sequentially activates LEDs 1-9. Depending upon *R3*'s adjustment (see Fig. 6), these results may vary by one or two LEDs.

For best results, a square template that restricts the movements of the stick may be necessary. You can make a template by cutting a square aperture in a piece of plastic or card stock. The joystick I used has four mounting holes to which the template could be attached with self-threading screws supplied with the joystick. You can determine the approximate dimensions of the aperture in the template by using strips of tape to restrict the movement of the stick while monitoring the results.

As in the single-axis joystick controller in Fig. 6, the LM3914 outputs can control external logic, various solid-state switches or relays. An interesting possibility is to use a 74147 priority encoder to convert the results to BCD for digital processing.

In a subsequent column we'll look at ways of converting the analog output from a joystick into digital form. We'll also look at some audio applications for joysticks.

More About Tinnitus. In a letter to the editor in the November 1980 issue of POPULAR ELECTRONICS, I mentioned several letters from readers who suffer from *tinnitus* (the perception of sounds which are not actually present). These readers were interested in the possibility of using noise generators like those described in the March 1980 installment of this column to block their tinnitus.

Mr. Patrick Dubois, an audiologist in Montreal, Canada, has written an interesting letter on this subject. Since this topic is of great interest to readers who either suffer from tinnitus or have friends and relatives with this ailment, I would like to quote from Mr. Dubois's letter.

"I have been interested by the case of your reader who suffers from tinnitus and experimented with noise generators as tinnitus maskers. I cannot recommend a hobbyist approach to this problem . . . tinnitus represents a symptom of an abnormality in the auditory system. Therefore, the normal procedure should be to visit an otologist for a neuro-otologic evaluation to rule out . . . possible diseases, then to consult a clinical audiologist and a hearing aid specialist. It should be pointed out that not all patients may benefit from tinnitus maskers and a careful evaluation should be made by professionals. The American Tinnitus Association has always recognized tinnitus as a medical problem and insists on medical clearance for every potential user.

"For the information of your readers, here are some guidelines about the selection of tinnitus maskers. When selecting a tinnitus masker it is necessary to evaluate the pitch and loudness of the tinnitus. A pitch matching procedure is generally used. This is not an easy task for many people are subject to octave confusion.

"It is commonly accepted that the masker should produce a band of masking noise that is just wide enough to cover up the tinnitus. Ideally, masking is done by broad-band maskers having a center frequency as near the pitch of the tinnitus as possible. However, due to technical limitations, the usual maskers can not be truly narrow-band units.

"If very broad-band maskers are used, it may be possible to successfully cover up the tinnitus. However, considerable energy will be supplied at other frequencies and may decrease the patient's ability to discriminate between different sounds. It is also very important to be aware of the potential risks to hearing (and possibly overall health) associated with the long-term exposure to wide-band tinnitus masking noise."

I very much appreciate Mr. Dubois's very helpful letter. For more information about tinnitus, write the American Tinnitus Association, P.O. Box 5, Portland, OR 97207. ◊

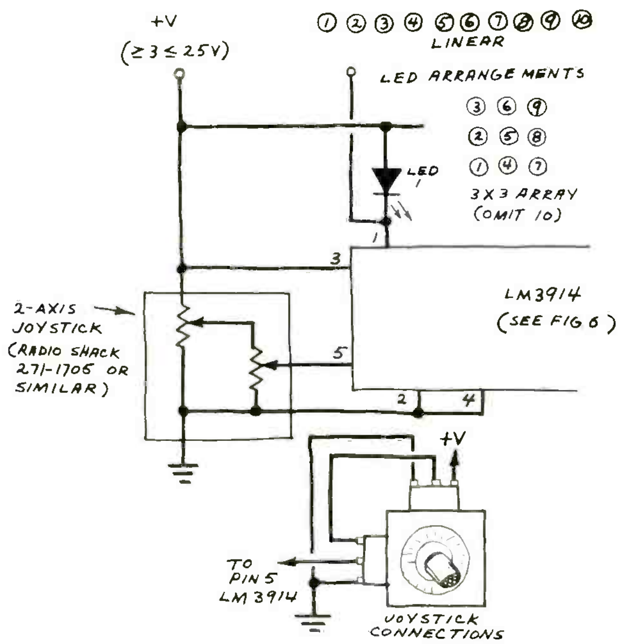

Fig. 7. How to add a two-axis joystick to the circuit shown in Fig. 6.

DX LISTENING

By Glenn Hauser

About Time to Stop Tampering

EVER since standard time was first established in 1888, people have been chipping away at the whole principle. Ideally, time-zone boundaries should run due north and south every 15° of longitude, starting 7½° east and west of Greenwich, England. That way, every place on earth would be no more than 30 minutes ahead of, or behind, sun time. I take the radical position of advocating a return to these boundaries. In my opinion, scientific observance of time should be something quite above political, economic and social tampering. [Most countries use DST in an effort to use less energy.—Ed.] Being involved as I am in schedules—both live programs and broadcast ones—sending and receiving, I'm forced to conform to daylight time shifts.

All of this, naturally, has a direct connection to international broadcasting and DX listening because DST changes the real time of programming on some stations, while it does not on others.

Daylight Saving Time gives us a way of separating the true international broadcasters from the ones where external broadcasting is merely a subsidiary of domestic broadcasting. For instance, the BBC does not shift all its programming by one hour during local summer time. It is far less bother for the people at Bush House to readjust their working schedules twice a year than for BBC World Service listeners all over the world to do so.

Yet there are several other international broadcasters which change the real time of their *ex*ternal transmissions to conform with *in*ternal daylight shifting. DST is almost unknown on the African continent (it's pointless in the tropics), but both Radio France Internationale and Belgium's external services make the shifts to conform with time changes in the home country, despite the fact that their shortwave broadcasts are for consumption abroad. So for half the year, "Paris Calling Africa" is at 1705 GMT, and the other half at 1605 (this is only so it will always be at 1805 Paris local time).

As more and more so-called "developed" countries adopt DST, more and more external services are faced with the dilemma of how to accommodate their programming. From the last Sunday in March to the last Sunday in September, Belgium and the Vatican schedule some of their external programming (mainly that to Europe) an hour earlier, while some do not change. Radio Budapest moved everything an hour earlier, as did Radio Berlin International. Another country tried DST for the first time this year—Finland. It imposed one-hour time jumps on its listeners abroad, as well.

Even the USSR adopted DST this year; I say "even" because those who inspect time zone maps carefully will be aware that the Soviet Union was already on daylight time the year round. Therefore, most of the USSR was *two* hours ahead of sun time, from April 1 through October 1 (note the dates are out of step with Europe). And this led to such absurdities as a GMT + 14 hour time zone at the eastern tip of Siberia. All Soviet external services in English, except Radio Tashkent, jumped an hour earlier during those six months. Radio Moscow World Service programs, as opposed to transmissions, did not shift, however.

"Summer time" is generally considered to mean the same thing as DST; so in El Salvador, when DST was imposed temporarily in January during the fighting, they still called it "summer time." However, in Italy DST is called "sun time," just what it isn't!

Speaking of misnomers, among North American mediumwave DX listeners there has arisen a term called "Eastern Local Time." This is supposed to facilitate the reporting of DX receptions in eastern time, whether standard or daylight, depending on the date. And for uniformity, ELT is applied to stations all over the country, not just in the eastern zone. It's not "local" at all in the geographical sense. Better just to say ET for eastern time.

And why should eastern be the one zone of reference for North America? Would it not be more fair to choose central, or even mountain, so the greatest number of people would be inconvenienced in converting from it? When I started listing some of the shortwave schedules in POPULAR ELECTRONICS in central time, there were some howls of protest from easterners.

If this is confusing, pity the poor countries that have not even adopted standard time (one hour apart from neighboring zones). India is the best example of this, where standard time is GMT + 5½ hours. *All India Radio* is so proud of this that its external programming is listed in its program guide in IST rather than GMT. Now quick, tell me, when it's 0115 IST, what time is it GMT? I suspect only Indian and Sri Lankan

dx listening

DXers could give me the answer without having to compute it.

Not to be outdone by neighboring India, Nepal has an even odder time zone, GMT + 5 hours and 40 minutes. Perhaps this is fitting for a place once so isolated. And you know, I've finally figured out why Radio Ulan Bator, Mongolia, schedules its English broadcast at the strange hour of 1220-1250 GMT: 1220 GMT is exactly 6 p.m. in Kathmandu! This argument is further buttressed by the fact that both in Mongolia and Nepal, English is a foreign language. At least they know what time they think it is. In Israel, one can never be sure whether advanced time will suddenly be adopted, as it was for six weeks in the summer of 1980.

I don't say that shortwave services consisting of simulcasts (more accurate term than relay) of domestic broadcasts, should disregard local DST. But I do expect programs which are designed for outside consumption only to be broadcast at one time throughout the year. Whatever the inconveniences for the station may be, they are minor compared to those of the untold audience of millions listening abroad, where DST either is not observed, or observed between different dates.

October is a particularly confusing month, since DST is still in force in North America, while European countries have gone back to standard time; vice versa for April. So we in North America have to adjust to programs from Denmark, East Germany, Finland, France, Hungary and the USSR being one hour later by the local clock for a month; and then in November they seem to move again when DST goes off. A further confusion arises from the fact that frequency changes are normally made on the first Sundays of certain months, while time changes occur on the last Sundays. This always leads to some unnecessary frequency conflicts.

Islamic countries go their own separate way. Iran observes DST some years, others not, and on different dates. This determines whether the sole English broadcast at 2300 Teheran time makes a GMT jump. (Last year it did, this year it didn't.) Algeria has been observing DST and jumping its program times between yet another set of dates, but there have been reports that Algeria would make a permanent time-zone change this year.

As Europe approaches some kind of uniformity in the dates of changeovers—the last Sundays in March and September—this influences stations to coordinate their frequency changes with programming changes, with these dates, rather than the traditional International Frequency Registration Board dates a few weeks earlier and later. This is most notably the case with *BBC*. Instead of major program time shuffles thrice a year, *BBC* has just started doing this twice a year at the same time. That's one step in the right direction. ◇

ELECTRONICS LIBRARY

103 Projects for Electronics Experimenters

by Forrest M. Mims, III

Based on the "Experimenter's Corner" column in POPULAR ELECTRONICS, Mr. Mims has compiled a list of projects that will appeal to the interests of novices and serious hobbyists alike. The book begins with an introduction to the basics of electronic devices, combined with easy-to-follow instructions and how-it-works information. This is followed by an overview of construction techniques. The projects themselves cover devices ranging from microphone amplifiers, to pulse generators that use op amps, to bandpass circuits, multiplexers, flip-flops, etc. Special sections are devoted to projects using digital ICs, A/D and D/A converters, and optoelectronics.
Published by TAB Books, Inc. Blue Ridge Summit, PA 17214. Soft cover. 308 pages. $8.95.

The 8086 Primer

by Stephen P. Morse

The 8086 microprocessor operates on data that is 16 bits long, while retaining the ability to process 8-bit data items. Its distinguishing feature, however, is that it can address over one-million locations of memory. This book describes 8086 architecture, and discusses how to write programs that run on the 8086. Architecture is broken down into register, memory, and addressing modes. A chapter on design applications shows how to put the 8086 together with other components to form a complete system. Programming is divided into assembly and high-level language structures. The main focus of the book is on the 8086 instruction set, noting its limitations as well as its capabilities.
Published by Hayden Book Company, Rochelle Park, NJ 07662. Soft cover. 224 pages. $8.95.

Encyclopedia of Integrated Circuits

by Walter H. Buchsbaum

Integrated circuits are dealt with in four large categories: analog, digital, consumer, and interface (A/D—D/A conversion). Over 1,000 alphabetically arranged entries are numbered to correspond to one of the four categories, and are cross-referenced to related circuits. A brief description outlines the form and function of each IC and is accompanied by a block diagram, a list of key parameters, and an overview of its practical applications. Attention is given to a user's, rather than a manufacturer's point of view; i.e, if you know the functional name of an IC you can look it up directly. The encyclopedia is also useful as a troubleshooting guide; the schematics and data tables are clear and abundant. Appendices list names, addresses, and telephone numbers of IC suppliers.
Published by Prentice Hall, Englewood Cliffs, NJ 07632. Hard cover. 420 pages.

Electrical Interference in Electronic Systems

by R.E. Martin

Intended primarily for those charged with the responsibility of maintaining the integrity of electronic communications in electrically noisy environments, this text could also prove useful to anyone interested in isolating almost any electronic devices from the effects of electrical interference. The author assumes that the book will be used in conjunction with other documents referenced to facilitate interference immunization by isolation, screening, filtering, or grounding. Various design schemes are presented toward that end.
Published by Research Studies Press, Forest Grove, OR 97116. Hard cover. 198 pages. $22.50.

Using the Radio Shack TRS-80 in Your Home

by Kenniston W. Lord, Jr.,CDP

A TRS-80 costs about the same as a good television receiver, and according to the author, is not much more difficult to use. Not merely a list of programs, the book explores the reasons for using a computer in the home, and leads the reader step-by-step through the language and application of microcomputers in general. The focus is on home applications, using the BASIC programming language. Topics covered include home finances, supermarket shopping, automobile maintenance schedules, recreational planning, meal preparation, etc. There is also a section on the construction of computer games.
Published by Van Nostrand Reinhold, N.Y., NY 10020. Hard cover. 457 pages. $21.95.

Apple Machine Language

by Don Inman and Kurt Inman

This book builds upon the reader's previous knowledge of BASIC to teach the Apple machine language, and eventually to write programs using the Apple System Monitor. Each program is presented in functional blocks, with sketches of video displays to show the predicted results at each step. There are also suggestions for variations in the demonstrated programs. Chapter summaries and question and answer sessions are provided at the end of each section.
Published by Reston Publishing Company, Reston, VA 22090. Hard cover. 296 pages. $9.95.

OPERATION ASSIST

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

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Silvertone Chassis #52859070 audio amplifier and chassis #101583-2 radio receiver. Need schematics. Ronnie Konvalin, 7722 Vineyard Rd., Sacramento, CA 95823.

Hallicrafters SX-100 receiver. Need instruction manual and two 6HU8 audio output push/pull tubes. **Hammurland** SP600 receiver. Need cabinet. Baron Von Thoma, 6048 Meteor Ave., Toledo, OH 43623.

Elco Model HF90s FM tuner, **Knight** Model R-55 amateur band receiver and **National** Model NC-77X shortwave receiver. Need schematics, operating manuals and other technical data. Bill Hartmann Radio Club, La Salle School for Boys, 291 Western Ave., Albany, NY 12203.

Shiba Electric Co., Ltd., Model FP-108 television camera. Need schematic and any other available information. Michael Harris, 3408 W. Redondo Beach Blvd, #16, Torrance, CA 90504.

Schober reverbatape echo unit with Type 11110-A circuit board. Need service and owner's manual and parts list. Russell Salerno, 2421 Myron Rd., Westbury, NY 11590.

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Electronics Communications Inc., Model 23339, serial #17520 23 channel CB. Need schematic diagram. Mike Meharra, 2512 A St., McKeesport, PA 15133.

Channel Master Model 6512 transistor radio. Need operation manual. Robert M. Petri, 133-4 Nimitz Dr., West Lafayette, IN 47906.

Pilot Model PMP 2000 AM/FM stereo. Need schematic. Dale L. Sherwood, 1635 Park Towne Lane, NE, Suite E1, Cedar Rapids, IA 52402.

Jackson Model 648R tube tester. Need owners manual. Ray Etchepare, 8018 Handley Ave., Los Angeles, CA 90045.

Webster Electric Model 342 tape recorder. Need schematic and control panel. Ryan Trullinger, 2696 So. Federal Blvd., #302, Denver, CO 80219.

Teledyne Model RA-65 phase power AM/FM stereo. Need schematic and operation manual. John Wammack, 819 So. Prairie Rd., New Lenox, IL 60451.

Bohsei Model M-705 frequency counter. Need schematic and manual. George Bloom, 6411 Longford Rd., Huber Heights, OH 45424.

(continued opposite)

operation assist

Allied Radio Knight span shortwave receiver. Need schematic and manual. Jay Rosenhaus, 2055 Rockaway Pkwy., Brooklyn, NY 11236.

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Panasonic Model R-1397 AM radio. Need back battery cover and owners manual. Gary Lamia, 101 Mitchell Ave., Long Beach, NY 11561.

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Silvertone Model 5501D, serial #911729. Need schematic, voltage chart, parts list and alignment data. Bruce F. Anderson, 95 Mill Rd., Edison, NJ 08817.

Production Devices Model 180 digital probe voltmeter. Need circuit diagram and equivalents of IC's. H. Peter Harle, 228 Memorial Ave., Liverpool, 2170, Australia.

Telonic Model SN-3 uhf sweep generator. Need schematic, and component layout of motherboard. John T. Morgan, 1119 Medlin St., Apt. L8, Smyrna, GA 30080.

Imlac Model PDS-1 graphic computer. Need schematic, drawings, operation manual or any information available. John Tinker, Box 1693, Iowa City, IA 52244.

Madison Fielding Model 754070 AM/FM radio. Need schematic and parts list. Louis Ceccanti, 238 Townline Rd., Commack, NY 11725.

By Forrest M. Mims

A Solid-State Panel Meter

ANYONE who has assembled an LED dot-bar driver from individual comparators, resistors and LEDs has a special appreciation for single-chip LED dot-bar drivers like National's LM3914/15/16 series. But even dot-bar driver chips require connections to each readout LED.

Last year National solved this problem with the introduction of its NSM3914/15/16 modules. These new modules can be used as low-cost, solid-state replacements for conventional panel meters. Each module consists of an LM3914/15/16 chip installed on a small printed circuit board measuring 1.99 x 0.850 inches. The chip is protected by an opaque plastic cover.

Also installed on the circuit board is a row of ten red LEDs. The LEDs are protected by a plastic bar having individual windows for each LED. Connections to the module are made via a row of edge terminals. The LED strip is oriented to make possible end-to-end stacking of multiple modules.

Figure 1 is a pictorial representation of the NSM3914/15/16 module. The terminals are numbered 1 through 12 beginning at the left. The connections to each terminal are as follows:

Pin	Electrical Connection
1	V_{LED}
2	LED 1
3	Ground
4	V+
5	R_{LO}
6	Signal In
7	R_{HI}
8	Reference Out
9	Reference Adjust
10	Mode (dot-bar)
11	LED 9
12	LED 10

For a more detailed explanation of these functions, see the data sheet for the LM3914, LM3915 or LM3916.

National's data sheets for the LM3914/15/16 provide plenty of application ideas for the modular displays which use these chips. Figure 2, for instance, shows how to connect the NSM3915 in accordance with one of the application circuits given in the data sheet for the LM3915.

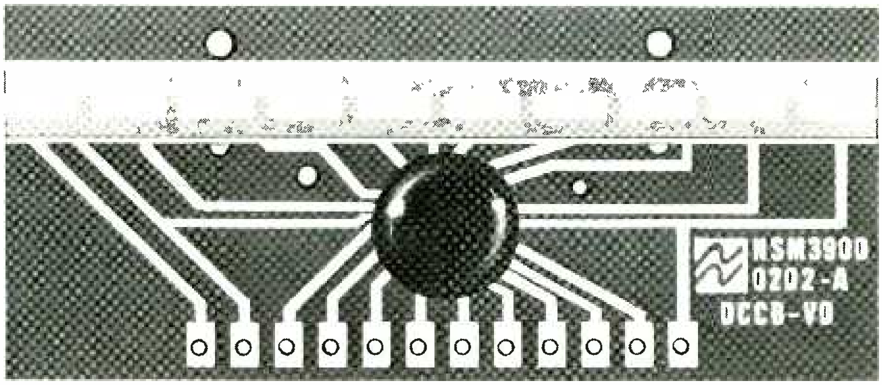

Fig. 1. Combining a dot-bar driver chip and a row of LEDs in one module provides a low-cost, solid-state meter.

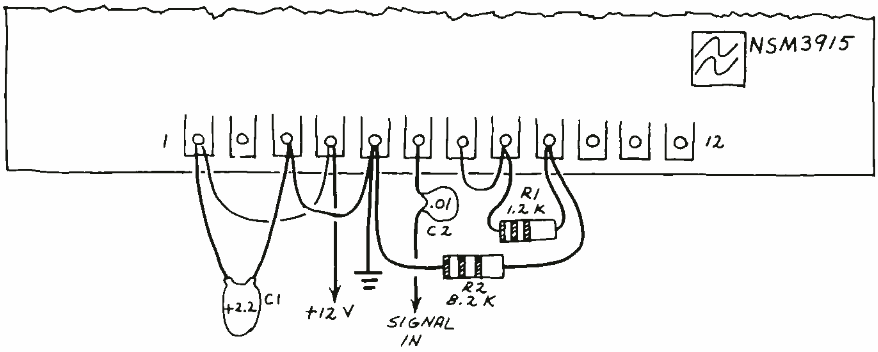

Fig. 2. How to connect the NSM3915 as a logarithmic readout. See the LM3915 data sheet for more information.

This circuit provides a logarithmic display suitable for various audio applications. Each LED is activated at intervals of 3 dB. Power supply filtering is provided by *C1*; it may be omitted if the leads from the power supply to the module do not exceed six inches length.

The components in Fig. 2 can be soldered directly to the terminals on the NSM3915. Use care to avoid applying excessive stress to the circuit board since it is fragile. Also, do not overheat the terminals or the copper foil from which they are formed will peel away from the substrate.

The circuit in Fig. 2 is only an example of what can be done with one of the new National modules. I urge you to have a look at the data sheets for the various National LED dot-bar drivers before making a final circuit decision. ◇

7400

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SN7400N	.20	SN7472N	.29	SN74156N	.79
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SN7403N	.25	SN7475N	.49	SN74161N	.89
SN7404N	.25	SN7476N	.35	SN74162N	.89
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SN7407N	.35	SN7482N	.99	SN74165N	.89
SN7408N	.29	SN7483N	.69	SN74166N	1.25
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SN7417N	.29	SN7494N	.69	SN74177N	.79
SN7420N	.25	SN7495N	.69	SN74179N	1.49
SN7421N	.29	SN7496N	.69	SN74180N	.79
SN7422N	.45	SN7497N	3.00	SN74181N	2.25
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SN7427N	.25	SN74107N	.35	SN74190N	1.25
SN7428N	.49	SN74109N	.39	SN74191N	1.25
SN7430N	.25	SN74116N	1.95	SN74192N	.89
SN7432N	.29	SN74121N	.39	SN74193N	.89
SN7437N	.25	SN74122N	.55	SN74194N	.89
SN7438N	.40	SN74123N	.59	SN74195N	.69
SN7439N	.25	SN74125N	.49	SN74196N	.89
SN7440N	.20	SN74126N	.49	SN74197N	.89
SN7441N	.89	SN74132N	.75	SN74198N	1.49
SN7442N	.59	SN74136N	.75	SN74199N	1.49
SN7443N	1.10	SN74141N	.99	SN74221N	1.25
SN7444N	1.10	SN74142N	3.25	SN74251N	.99
SN7445N	.89	SN74143N	3.49	SN74276N	1.95
SN7446N	.79	SN74144N	3.49	SN74279N	.79
SN7447N	.69	SN74145N	.79	SN74283N	1.49
SN7448N	.79	SN74147N	1.95	SN74284N	3.95
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SN7453N	.20	SN74151N	.69	SN74366N	.69
SN7454N	.20	SN74152N	.69	SN74367N	.69
SN7459A	.25	SN74153N	.79	SN74368N	.69
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74LS03	.29	74LS96	1.15	74LS195	1.15
74LS04	.35	74LS107	.45	74LS197	1.19
74LS05	.35	74LS109	.45	74LS221	1.19
74LS08	.35	74LS112	.45	74LS240	1.49
74LS09	.35	74LS113	.49	74LS241	1.49
74LS10	.35	74LS114	.49	74LS242	1.49
74LS11	.39	74LS122	.89	74LS243	1.49
74LS12	.35	74LS123	1.25	74LS244	1.49
74LS13	.59	74LS125	.59	74LS245	2.95
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74LS15	.35	74LS132	.99	74LS248	1.19
74LS20	.35	74LS133	.89	74LS249	1.19
74LS21	.35	74LS136	.49	74LS251	.99
74LS22	.35	74LS138	.89	74LS253	.99
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS151	.89	74LS258	.69
74LS28	.35	74LS153	.89	74LS260	.69
74LS30	.35	74LS154	1.75	74LS266	.69
74LS32	.35	74LS155	.89	74LS273	1.95
74LS33	.59	74LS156	.89	74LS279	.69
74LS37	.45	74LS157	.89	74LS283	.89
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74LS40	.35	74LS160	1.15	74LS293	.99
74LS42	.89	74LS161	1.15	74LS298	1.25
74LS47	.89	74LS162	1.15	74LS352	1.29
74LS48	1.15	74LS163	1.15	74LS353	1.29
74LS49	1.15	74LS164	1.15	74LS365	.69
74LS51	.35	74LS165	1.15	74LS366	.69
74LS54	.35	74LS168	1.19	74LS367	.69
74LS55	.35	74LS169	1.19	74LS368	.69
74LS73	.45	74LS170	1.95	74LS373	1.95
74LS74	.45	74LS173	.99	74LS374	1.95
74LS75	.59	74LS174	.99	74LS375	.89
74LS76	.45	74LS175	.99	74LS386	.69
74LS78	.49	74LS181	2.95	74LS393	2.49
74LS83	.89	74LS190	1.25	74LS399	2.49
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74S

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74S03	.45	74S134	.69	74S251	1.45
74S04	.55	74S135	1.19	74S253	1.45
74S05	.55	74S136	1.35	74S257	1.35
74S08	.50	74S138	1.35	74S258	1.35
74S09	.50	74S139	1.35	74S260	.79
74S10	.45	74S140	.79	74S280	2.95
74S11	.45	74S151	1.35	74S287	3.25
74S15	.45	74S153	1.35	74S288	2.75
74S20	.45	74S157	1.35	74S373	3.49
74S22	.45	74S158	1.35	74S374	3.49
74S30	.45	74S160	2.95	74S387	2.95
74S32	.55	74S174	1.59	74S471	10.95
74S38	1.25	74S175	1.59	74S472	10.95
74S40	.50	74S188	2.95	74S473	10.95
74S51	.45	74S194	1.95	74S474	12.95
74S64	.50	74S195	1.95	74S475	12.95
74S65	.50	74S196	1.95	74S570	5.95
74S74	.75	74S240	2.95	74S571	5.95
74S86	.79	74S241	2.95	74S572	9.95
74S112	.79	74S242	3.25	74S573	9.95
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CA3035H	2.49	CA3082N	2.00	CA3140H	1.25
CA3039H	1.35	CA3083N	1.60	CA3160H	1.25
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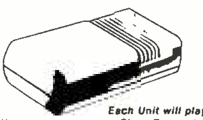

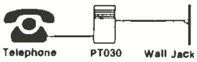

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XC22G	.200"	green	4/$1	XC526G	.185"	green	4/$1
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MAN 52	C.A.—green	.300	.99
MAN 54	C.C.—green	.300	.99
MAN 71	C.A.—red	.300	.75
MAN 72	C.A.—red	.300	.75
MAN 74	C.C.—red	.300	1.25
MAN 82	C.A.—yellow	.300	.49
MAN 84	C.C.—yellow	.300	.99
MAN 3620	C.A.—orange	.300	.49
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MAN 6740	C.C.—red—DD	.560	.99
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DLG500	C.C.—green	.500	1.25

Type	Polarity	Ht	Price
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DL704	C.C.—red	.300	1.25
DL707	C.A.—red	.300	1.25
DL728	C.C.—red	.500	1.49
DL741	C.A.—red	.600	1.25
DL747	C.A.—red	.600	1.49
DL750	C.C.—red	.600	1.49
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DLO850	C.C.—orange	.800	1.49
DL33B	C.C.—red	.110	.35
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FND507	C.A. (FND510)	.500	.99
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HDSP-3403	C.C.—red	.800	1.50
HDSP-3406	C.C. red ±1	.800	1.50
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Part No.	Pins	Price	Part No.	Pins	Price
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216-3593	16 pin	9.95	224-3597	24 pin	12.75
218-3594	18 pin	10.95	228-3598	28 pin	13.95
220-3595	20 pin	11.95	240-3599	40 pin	15.95

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16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)

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

SOLDERTAIL (GOLD) STANDARD

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

WIRE WRAP SOCKETS (GOLD) LEVEL #3

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

1/4 WATT RESISTOR ASSORTMENTS – 5%

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

INTERSIL

Part No.	Function	Price
7045IPI	CMOS Precision Timer	14.95
7045EV/Kit*	Stopwatch Chip, XTL	24.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	29.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
72011DR	Low Battery Volt Indicator	2.25
7205IPG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
7206CEV/Kit*	Tone Generator Chip, XTL	12.95
7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	13.95
7208IPI	Seven Decade Counter	17.95
7209IPA	Clock Generator	3.95
7215IPG	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
7216AIJI	8-Digit Univ. Counter C.A.	32.00
7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter	12.95
7218CIJI	8-Digit Univ. LED Drive	10.95
7224IPL	LCD 4½ Digit Up Counter DRI	11.25
7226AIJL	8-Digit Univ. Counter	31.95
7226AEV/Kit*	5 Function Counter Chip, XTL	74.95
7240IJE	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	5.25
7555IPA	CMOS 555 Timer (8 pin)	1.45
7556IPD	CMOS 556 Timer (14 pin)	2.20
7611BCPA	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8038CCPD	Waveform Generator	4.95
8048CCPE	Monolithic Logarithmic Amp	21.60
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.95
8212CPA	Volt Ref/Indicator	2.95

74C

Part	Price	Part	Price	Part	Price
74C00	.39	74C95	1.59	74C221	1.95
74C02	.39	74C107	1.89	74C240	2.25
74C04	.39	74C151	2.95	74C244	2.25
74C08	.39	74C154	3.95	74C373	2.49
74C10	.39	74C157	2.25	74C374	2.59
74C14	.75	74C160	1.69	74C901	.69
74C20	.39	74C161	1.69	74C903	.69
74C30	.39	74C162	1.49	74C911	10.95
74C42	1.39	74C163	1.69	74C912	10.95
74C48	1.95	74C164	1.59	74C915	1.69
74C73	.79	74C173	1.39	74C917	10.95
74C74	.79	74C174	1.39	74C922	5.49
74C85	1.95	74C175	1.19	74C923	5.75
74C86	.99	74C192	1.69	74C925	7.50
74C89	6.95	74C193	1.69	74C926	7.50
74C90	1.29	74C195	1.59	80C95	.79
74C93	1.29			80C97	.79

LINEAR

Part	Price	Part	Price	Part	Price
LH0002CN	6.85	LM340T-5	1.25	LM702H	.79
LM10CLH	4.50	LM340T-12	1.25	LM703CN	.89
LM11CLH	4.75	LM340T-15	1.25	LM709N	.29
LH0070-0H	4.95	LM341P-5	.75	LM710N	.79
TL071CP	.79	LM341P-12	.75	LM711N	.79
TL072CP	1.39	LM341P-15	.75	LM723N	.69
TL074CN	2.49	LM342P-5	.69	LM733N	1.00
LH0082CD	35.80	LM342P-12	.69	LM739N	1.19
TL082CP	1.19	LM342P-15	.69	LM741CN	.35
TL084CN	2.19	LM348N	1.25	MC1741SCG	3.00
LH0094CD	36.80	LM350K	5.75	LM747N	.79
LM300H	.99	LF351N	.60	LM748N	.59
LM301CN	.35	LF353N	1.00	LM1014N	2.75
LM302H	1.95	LF355N	1.10	LM1310N	1.95
LM304H	1.95	LF356N	1.10	LM1458CN	.59
LM305H	.99	LM358N	1.00	LM1488N	1.25
LM307CN	.45	LM359N	1.79	LM1489N	1.25
LM308CN	1.00	LM370N	4.49	LM1496N	1.95
LM309H	1.95	LM373N	3.25	LM1556V	1.75
LM309K	1.25	LM377N	2.95	LM1800N	2.95
LM310CN	1.75	LM380N	1.25	LM1871N	5.49
LM311/CN	.90	LM381N	1.95	LM1872N	5.49
LM312H	2.49	LM382N	1.79	LM1877N-9	3.25
LM317MP	1.15	LM384N	1.95	LM1889N	3.20
LM317T	1.75	LM386N-3	1.29	LM1896N	1.75
LM317K	3.95	LM387N	1.45	LM2002T	1.49
LM318CN	1.95	LM389N	1.35	LM2877P	2.05
LM319N	1.95	LM392N	.69	LM2878P	2.25
LM320K-5	1.35	LF398N	4.00	LM2896P-1	2.25
LM320K-12	1.35	LM399H	5.00	LM3189N	2.95
LM320K-15	1.35	TL494CN	4.49	LM3900N	.69
LM320T-5	1.25	TL496CP	1.75	LM3905CN	1.25
LM320T-12	1.25	NE510A	6.00	LM3909N	1.15
LM320T-15	1.25	NE529A	4.95	LM3914N	3.95
LM323K	5.95	NE531H	3.95	LM3915N	3.95
LM324N	.99	NE536H	6.00	LM3916N	3.95
LM329DZ	.65	NE540H	6.00	RC4136N	1.25
LM331N	3.95	NE544N	4.95	RC4151NB	3.95
LM334Z	1.30	NE550A	1.30	RC4194TK	6.95
LM335Z	1.40	NE555V	.39	RC4195TK	5.49
LM336Z	1.75	LM556N	.99	LM4500A	3.25
LM337T	1.95	NE564N	3.95	ICL8038B	4.95
LM337MP	1.15	LM565N	1.25	LM13080N	1.29
LM338K	6.95	LM566CN	1.95	LM13600N	1.49
LM339N	.99	LM567V	1.25	75138N	1.95
LM340K-5	1.35	NE570N	4.95	75450N	.89
LM340K-12	1.35			75451CN	.39
LM340K-15	1.35			75492	.89

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

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

100 VOLT MYLAR FILM CAPACITORS

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

+20% DIPPED TANTALUMS (Solid) CAPACITORS

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

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial	1-99	100-499	500+	Radial	1-99	100-499	500+
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.16	.14	.10	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.24	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.30	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.21	.19
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

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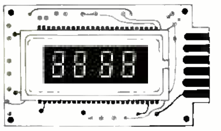
11/81

National Semiconductor Clock Modules



12VDC AUTOMOTIVE/ INSTRUMENT CLOCK

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

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

MA1003 Module (3.05"Lx1.75"Hx.98"D) . **$16.95**

CLOCK MODULES

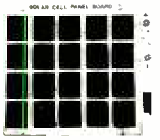
MA1023	.7" Red Digital LED Clock Module	8 95
MA1026	.7" Dig. LED Alarm Clock/Thermometer	18.95
MA5036	.3" Red Digital LED Clock/Timer	6.95
MA1002	.5" Red Digital LED Clock & Xformer	9.95
MA1010	.8" Red Digital LED Clock	7.95
MA1032	CBA .5" Digital LCD Clock	17 95
MA1043	.7" Green Digital LED Clock	8 95

TRANSFORMERS

102-P20	Xformer for MA1023 1043 & 5036 Mods.	3.49
102-P22	Xformer for MA1026 Clock Modules	3.49
102 P24	Xformer for MA1010 Clock Modules	3 49

NEW!

Sun Power Your Electronics! SOLAR CELL PANEL KIT

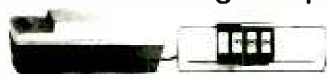


Features:
- **Output: 10VDC, to 100mA in Series 5VDC, to 200mA in Parallel**
- **Panel may be easily connected for Series or Parallel out**
- **Over 11 square inches of active cell surface**
- **Voltage line tap @ 0.5V increments**
- **Provision for charging batteries**
- **Overall panel size: 4¾"L x 4½"H x ⅓"D**

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

JE305 .... $39.95

EPROM Erasing Lamp

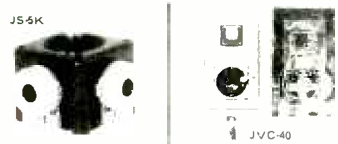


- **Erases 2708, 2716, 1702A, 5203Q, 5204Q, etc.**
- **Erases up to 4 chips within 20 minutes.**
- **Maintains constant exposure distance of one inch.**
- **Special conductive foam liner eliminates static build-up.**
- **Built-in safety lock to prevent UV exposure.**
- **Compact — only 7-5/8" x 2-7/8"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

UVS-11EL Replacement Bulb $16.95

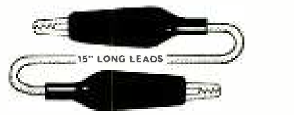
UVS-11E $79.95

JOYSTICKS



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

ALLIGATOR CLIP TEST LEADS



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

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

NEW!

JE215 Adjustable Dual Power Supply

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

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

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

(Picture not shown but similar in construction to above)

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

MICROPROCESSOR COMPONENTS

8080A/8080A SUPPORT DEVICES

INS8080A	CPU	4.95
DP8212	8-Bit Input/Output	3.25
DP8214	Priority Interrupt Control	5.95
DP8216	Bi-Directional Bus Driver	3.49
DP8224	Clock Generator/Driver	3.95
DP8226	Bus Driver	3.49
DP8228	System Controller/Bus Driver	4.95
DP8238	System Controller	5.95
INS8243	I/O Expander for 48 Series	9.95
INS8250	Asynchronous Comm. Element	16.95
DP8251	Prog. Comm. I/O (USART)	6.95
DP8253	Prog. Interval Timer	8.95
DP8255	Prog. Peripheral I/O (PPI)	5.95
DP8257	Prog. DMA Control	9.95
DP8259	Prog. Interrupt Control	9.95
DP8275	Prog. CRT Controller	39.95
DP8279	Prog. Keyboard/Display Interface	9.95
DP8303	System Timing Element	6.95
DP8304	8-Bit Bi-Directional Receiver	3.95
DP8307	8-Bit Bi-Directional Receiver	3.95
DP8308	8-Bit Bi-Directional Receiver	3.95
DP8310	Octal Latched Peripheral Driver	5.25
DP8311	Octal Latched Peripheral Driver	5.25

6800/6800 SUPPORT DEVICES

MC6800	MPU	7.95
MC6802CP	MPU with Clock and RAM	14.95
MC6810API	128x8 Static RAM	4.95
MC6821	Peripheral Inter. Adapt. (MC6820)	7.49
MC6828	Priority Interrupt Controller	11.95
MC6830L8	1024x8-Bit ROM (MC68A30-8)	14.95
MC6850	Asynchronous Comm. Adapter	6.95
MC6852	Synchronous Serial Data Adapter	6.95
MC6860	0-600bps Digital MODEM	10.95
MC6862	2400bps Modulator	12.95
MC6880A	Quad 3-State Bus. Trans. (MC8T26)	2.25

MICROPROCESSOR CHIPS

Z80 (780C)	CPU (MK3880N) (2MHz)	11.95
Z80A (780-1)	CPU (MK3880N-4) (4MHz)	13.95
CDP1802	CPU	19.95
2650	MPU	16.95
IOM2901ADC	CPU 4-Bit Slice (Com. Temp. Grade)	19.95
MC56502	MPU w/Clock (65K Bytes Memory)	11.95
INS8035N-6	MPU—8-Bit (6MHz)	7.95
INS8039N-6	CPU—Sgl. Chip 8-Bit (128 bytes RAM)	9.95
INS8040N-6	CPU (256 Bytes RAM)	24.95
INS8070N	CPU 64 Bytes RAM	24.95
INS8073N	CPU w/Basic Micro Interpreter	29.95
P8085	CPU	9.95
TMS9900JL	MPU—16 Bit	39.95

SHIFT REGISTERS

MM500H	Dual 25-Bit Dynamic	.50
MM503H	Dual 50-Bit Dynamic	.50
MM506H	Dual 100-Bit Static	.50
MM510H	Dual 64-Bit Accumulator	.50
MM1402N	Quad 256-Bit Dynamic	2.95
MM5013N	1024-Bit Dynamic/Accumulator	1.95
MM5016H	500/512-Bit Dynamic	1.95
MM5034N	Octal 80-Bit	9.95
MM5035N	Octal 80-Bit	9.95
2504V (1404A)	1024 Bit Dynamic	1.95
2518N	Hex 32-Bit Static	3.95
2522V	Dual 132-Bit Static	2.95
2524V	512-Bit Dynamic	.99
2525V	1024-Bit Dynamic	2.95
2527V	Dual 256-Bit Static	2.95
2528V	Dual 250-Bit Static	4.00
2529V	Dual 240-Bit Static	4.00
2532N	Quad 80-Bit Static	2.95
3341PC	Fifo (Dual 80)	6.95

DATA ACQUISITION

AF100-1CN	Universal Active Filter 2.5%	5.95
AF121-1CJ	Touch Tone Low Band Filter	19.95
AF122-1CJ	Touch Tone High Band Filter	19.95
LM308CH	Super Gain Op Amp	1.15
LM334Z	Constant Current Source	1.30
LM335Z	Temperature Transducer	1.40
LF356N	JFET Input Op Amp	1.10
LF398N	Sample & Hold Amplifiers	3.95
LM399H	Temp. Comp. Prec. Ref. (.5ppm/C°)	5.00
ADC0804LCN	8-Bit A/D Converter (1 LSB)	4.95
DAC0806LCN	8-Bit D/A Converter (0.78% Lin.)	2.25

DATA ACQUISITION (CONTINUED)

ADC0809CCN	8-Bit A/D Converter (8-Ch. Multi.)	5.25
ADC0817CCN	8-Bit A/D Converter (16-Ch. Multi.)	10.95
DAC1000LCN	10-Bit D/A Conv. Micro. Comp. (0.05% Lin.)	13.95
DAC1008LCN	10-Bit D/A Conv. Micro. Comp. (0.20%)	8.95
DAC1020LCN	10-Bit D/A Converter (0.05% Lin.)	8.49
DAC1022LCN	10-Bit D/A Converter (0.20% Lin.)	5.95
DAC1222LCN	12-Bit D/A Converter (0.20% Lin.)	9.95
CD4051N	8-Channel Multiplexer	1.19
AY5-1013	30K BAUD UART	6.95

RAM'S

1101	256x1 Static	1.49
1103	1024x1 Dynamic	.99
2101 (8101)	256x4 Static	3.95
2102	1024x1 Static	1.75
21L02	1024x1 Static	1.95
2111 (8111)	256x4 Static	3.95
2112	256x4 Static MOS	4.95
2114	1024x4 Static 450ns	3.25
2114L	1024x4 Static 450ns Low Power	3.49
2114-2	1024x4 Static 200ns	3.95
2114L-2	1024x4 Static 200ns Low Power	4.95
74S200	256x1 Static	6.95
4116N-4 (UPD416)	16K Dynamic 250ns (MM5290N-4)	2.95
4164N-3	64K Dynamic 200ns	19.95
MM2147J	4096x1 Fast 70ns	7.95
5101	256x4 Static	7.95
MM5261	1024x1 Dynamic Fully Decoded	.99
MM5262	2Kx1 Dynamic	.99
MM5280/2107	4096x1 Dynamic	4.95
MM5290N-2 (4116)	16K Dynamic 150ns (UPD416C-3)	3.95
MM5298J-3A	8K Dyn. 200ns (lower ½ of MM5290J)	1.95
HM6116-4	16K (2Kx8) Static 200ns	14.95
82S25	64 Bit RAM (16x4OC)	2.95
UPD414/MK4027	4K Dynamic 16-pin	4.95
TMS4044-45NL	4K Static	9.95
TMS4045	1024x4 Static	9.95

PROMS/EPROMS

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

— Over 30 More PROMS Listed in Our Catalog —

ROM'S

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

NMOS READ ONLY MEMORIES

MCM6671OP	128x9x7 ASCII Shifted w/Greek	13.50
MCM6674OP	128x9x7 Math Symbol & Pictures	13.50
MCM6675OP	128x9x7 Alpha. Control Char. Gen.	13.50

MICROPROCESSOR MANUALS

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

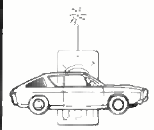
SPECIAL FUNCTION

DS0025CN	Dual MOS Clock Driver (5MZ)	3.50
DS0026CN	Dual MOS Clock Driver (5MZ)	3.95
INS1771N-1	Floppy Disc Controller	24.95
INS2651N	Communication Chip	19.95
MM58167N	Microprocessor Real Time Clock	8.95
MM58174N	Microprocessor Compatible Clock	11.95
COP402N	Microcontroller with 64-Digit RAM and Direct LED Drive	6.95
COP402MN	Microcontroller with 64-Digit RAM & Direct LED Drive w/N Buss Int	7.49
COP470N	32-Seg. VAC Fluor. Driver (20-pin pkg.)	3.25

TELEPHONE/KEYBOARD CHIPS

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

RADIO CONTROL CIRCUITS

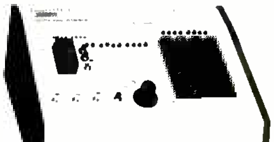


Ideal for remote control systems which use pulse amplitude modulation (toy cars, boats, tanks, etc.) Features: five function control, adjustable steering angle, suitable for 27 and 47MHz bands and low power consumption

KB-4428 TRANSMITTER **$4.25**
Abs. max. rating (TA@25°C) Supply volt. Vcc1 12VDC Power Dissipation PD 300mW. Temp. range Oper. 0—+50°C — Storage -30—+125°C Recommended oper. volt 7 11V. Crystal or CR Oscillation circuits acceptable

KB-4429 RECEIVER **$5.95**
Abs. max. rating (TA@25°C) Supply volt. Vcc1 11V Vcc2 7.5V Power Dissipation 600W. Temp. range Oper. 0 ± 50°C Recommended oper. volt VOP1 7 11V — VOP2 3-6V

JE608 PROGRAMMER
2704/2708 EPROM PROGRAMMER



GENERAL APPLICATIONS:
- **To program EPROMS 2704 and 2708.**
- **Developmental system for microcomputer circuits**
- **To read the contents of a pre-programmed EPROM**
- **To compare EPROM(s) for content differences**
- **To emulate a programmed EPROM**
- **To store program in RAMS for alterations**
- **Three separate Display Registers: 8 LED's for Hex Key entries, 10 LED's (2^0-2^9) 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 microprocessor systems by means of a ribbon cable from the programmer panel test socket to the EPROM socket on the microprocessor board. Rapid checking verification of programmed data changes. User may move data from a master to RAM's or write into RAM's with keyboard entries. Allows manual stepping manipulation (up and down) at any address location. Stand-alone EPROM Programmer consisting of: A 19-key Hexadecimal Keyboard assembly, Programmer Board assembly with 4 power supplies and a LED/Test Socket Panel Board assembly. The Test Socket is zero force insertion type. Power requirements: 115VAC, 60Hz, 6W. Compact desk-top enclosure: Color-coordinated designer's case with light tan panels and molded end pieces in mocha brown. Size: 3¼"H x 11"W x 8¾"D. Weight: 5 lbs.**

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

JE608K Kit $399.95
JE608A Assembled and Tested $499.95

JE608-16K ADAPTER BOARD
FOR 2716/2758 EPROMS

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

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

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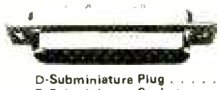
30002	**National Interface Data Book** (704 pages) DP, DS8000, DS3600, DS75000, etc	$5.95
30003	**National Linear Data Book** (1376 pages) LM, LF, ADC, DAC, LH Series	$8.95
30004	**National Series 80 — Board Level Computer** (224 pages)	$4.95
30005	**National TTL Logic Data Book** (624 pages) 7400,LS,L,H,S, and DM8000 Series	$8.95
30006	**Buy above (3) 30001,3,5 as a set**	$19.95/lot
30009	**Intersil Data Book** (1074 pages)	$6.95
010400	**Intel Component Data Catalog** Full data sheets for Intel's products incl. memory devices, microproc. peripherals & indust./mil. products (1328 pages)	$10.00
206610	**Intel Peripheral Design Handbook** Full data sheets, appl. notes for Intel peripheral device components (644 pages)	$7.50

AC and DC Wall Transformers

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

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

CONNECTORS



DB25P	D-Subminiature Plug	$2.95
DB25S	D-Subminiature Socket	$3.50
D20418-2	Screw Lock Hdwr. (2) DB25S/P	2/$.99
OB51226	Cover for DB25P/S	$1.75
22/44SE	P.C. Edge (22/44 Pin)	$2.95
UG88/U	BNC Plug	$1.79
UG89/U	BNC Jack	$3.79
UG175/U	UHF Adapter	$ .49
SO239	UHF Panel Recp.	$1.29
PL258	UHF Adapter	$1.60
PL259	UHF Plug	$1.60
UG260/U	BNC Plug	$1.79
UG1094/U	BNC Bulkhead Recp.	$1.29

TRS-80 16K Conversion Kit

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

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

JE610 ASCII Encoded Keyboard Kit

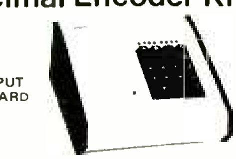
The JE610 ASCII Keyboard Kit can be interfaced into most any computer system. The kit comes complete with an industrial grade keyboard switch assembly (62-keys), IC's, sockets, connector, electronic components and a double-sided printed wiring board. The keyboard assembly requires +5V @ 150mA and −12V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

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

JE610 Kit 62-Key Keyboard, PC Board, & Components (no case). . . . . **$ 79.95**
K62 62-Key Keyboard (Keyboard only) . . . **$ 34.95**
DTE-AK (case only — 3¼"Hx11"Wx8¾"D) **$ 49.95**

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

JE600 Hexadecimal Encoder Kit



FULL 8-BIT LATCHED OUTPUT 19-KEY KEYBOARD

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

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

JE600 Kit 19-Key Hexadec. Keyboard, PC Board & Cmpnts. (no case) . . **$59.95**
K19 19-Key Keyboard (Keyboard only) **$14.95**
DTE-HK (case only — 3½"Hx8¾"Wx8¾"D) **$44.95**

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74LS05	25	74LS170	1.75
74LS08	35	74LS173	80
74LS09	25	74LS174	95
74LS10	25	74LS175	95
74LS11	35	74LS181	2.15
74LS12	35	74LS189	9.95
74LS13	45	74LS190	1.00
74LS14	1.00	74LS191	1.00
74LS15	35	74LS192	85
74LS20	25	74LS193	95
74LS21	35	74LS194	1.00
74LS22	25	74LS195	95
74LS26	35	74LS196	85
74LS27	35	74LS197	85
74LS28	35	74LS221	1.20
74LS30	25	74LS240	1.85
74LS32	35	74LS241	1.85
74LS33	55	74LS242	1.85
74LS37	55	74LS243	1.85
74LS38	35	74LS244	1.75
74LS40	25	74LS245	2.85
74LS42	55	74LS247	76
74LS47	75	74LS248	1.25
74LS48	75	74LS249	99
74LS49	75	74LS251	1.30
74LS51	25	74LS253	85
74LS54	35	74LS257	85
74LS55	35	74LS258	85
74LS63	1.25	74LS259	2.85
74LS73	40	74LS260	65
74LS74	45	74LS266	55
74LS75	50	74LS273	1.65
74LS76	40	74LS275	3.35
74LS78	50	74LS279	55
74LS83	75	74LS280	1.98
74LS85	1.15	74LS283	1.00
74LS86	40	74LS290	1.25
74LS90	65	74LS293	1.85
74LS91	89	74LS295	1.05
74LS92	70	74LS298	1.20
74LS93	65	74LS324	1.75
74LS95	85	74LS352	1.55
74LS96	95	74LS353	1.55
74LS107	40	74LS363	1.35
74LS109	40	74LS364	1.95
74LS112	45	74LS365	95
74LS113	45	74LS366	95
74LS114	50	74LS367	70
74LS122	45	74LS368	70
74LS123	95	74LS373	1.85
74LS124	2.99	74LS374	1.80
74LS125	95	74LS377	1.45
74LS126	.85	74LS378	1.18
74LS132	75	74LS379	1.35
74LS136	55	74LS385	1.90
74LS137	99	74LS386	65
74LS138	75	74LS390	1.90
74LS139	75	74LS393	1.90
74LS145	1.20	74LS395	1.65
74LS147	2.49	74LS399	1.70
74LS148	1.35	74LS447	37
74LS151	75	74LS490	1.95
74LS153	75	74LS668	1.69
74LS154	2.35	74LS669	1.89
74LS155	1.15	74LS670	2.20
74LS156	95	74LS674	9.65
74LS157	75	74LS682	3.20
74LS158	75	74LS683	2.30
74LS160	90	74LS684	2.40
74LS161	95	74LS685	2.40
74LS162	95	74LS688	2.40
74LS163	95	74LS689	2.40

8200

8202	45.00
8205	3.50
8212	1.95
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8216	1.85
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8228	4.95
8237	19.95
8238	4.95
8243	4.50
8250	14.95
8251	5.50
8253	9.85
8253-5	9.85
8255	5.25
8255-5	5.25
8257	9.00
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8279-5	10.50
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Z80	8.95
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6860	10.95
6862	11.95
6871	25.95
6875	6.95
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T.V. CIRCUITS

MC1330	1.89
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MC1358	1.79
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4000	SERIES	CMOS
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EPROMS

					8pcs
1702	256 x 8	(1us)		4.95	4.50
2708	1024 x 8	(450ns)		3.95	3.50
2758	1024 x 8	(450ns)	(5v)	9.95	8.95
TMS2516	2048 x 8	(450ns)	(5v)	7.95	6.95
2716	2048 x 8	(450ns)	(5v)	5.95	5.50
2716-1	2048 x 8	(350ns)	(5v)	12.95	11.95
TMS2716	2048 x 8	(450ns)		9.95	8.95
TMS2532	4096 x 8	(450ns)	(5v)	19.95	17.95
2732	4096 x 8	(450ns)	(5v)	16.50	15.95

STATIC RAMS

					100pcs
2101	256 x 4	(450ns)		1.95	1.85
2102-1	1024 x 1	(450ns)		.89	.85
21L02-1	1024 x 1	(450ns)	(LP)	1.29	1.15
2111	256 x 4	(450ns)		2.99	2.49
2112	256 x 4	(450ns)		2.99	2.79
2114	1024 x 4	(450ns)		8/17.95	2.10
2114L-2	1024 x 4	(200ns)	(LP)	8/22.95	2.45
2114L-3	1024 x 4	(300ns)	(LP)	8/21.95	2.45
2114L-4	1024 x 4	(450ns)	(LP)	8/18.95	2.25
TMS4044-4	4096 x 1	(450ns)		3.49	3.25
TMS4044-3	4096 x 1	(300ns)		3.99	3.75
TMM2016	2048 x 8	(200ns)		CALL	
HM6116	2048 x 8	(200ns)		CALL	

DYNAMIC RAMS

				100pcs
4027	4096 x 1	(250ns)	2.50	2.00
4116-150	16.384 x 1	(150ns)	8/19.95	2.35
4116-200	16.384 x 1	(200ns)	8/17.50	1.95
4116-300	16.384 x 1	(300ns)	8/16.95	1.85
4164	65.536 x 1	(200ns)	CALL	

LP=LOW POWER

DIP SWITCHES

4 position	85
5 position	90
6 position	90
7 position	95
8 position	95

CONNECTORS

RS232 MALE	3.25
RS232 FEMALE	3.75
RS232 HOOD	1.25
S-100 ST	3.95
S-100 WW	4.95

LEDS

Jumbo Red	10/1.00
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Jumbo Yellow	6/1.00
5082-7760 .43"CC	79
MAN74 .3"CC	99
MAN72 .3"CA	.99

LINEAR

LM301V	34	LM741V	29
LM308V	98	LM747	79
LM309K	1.49	LM748V	59
LM311	64	LM1310	2.90
LM317T	1.95	MC1330V	1.89
LM317K	3.95	MC1350V	1.29
LM318	1.49	MC1358	1.79
LM323K	4.95	LM1414	1.59
LM324	59	LM1458V	69
LM337K	3.95	LM1488	99
LM339	99	LM1489	99
LM377	2.29	LM1800	2.99
LM380	1.29	LM1889	2.49
LM386V	1.50	LM3900	59
LM555V	39	LM3909V	98
LM556	69	LM3914	3.95
LM565	99	LM3915	3.95
LM566V	1.49	LM3916	3.95
LM567V	1.29	75451V	39
LM723	49	75452V	39
LM733	98	75453V	39

T=TO-220 V=8 PIN K=TO-3

VOLTAGE REG'S

7805T	89	7905T	99
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7812T	89	7915T	1.19
7815T	99	7924T	1.19
7824T	99		
7805K	1.39	7905K	1.49
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7815K	1.39	79L05	79
78L05	69	79L12	79
78L12	.69	79L15	79
78L15	69	LM317K	3.95
LM309K	1.49	LM323K	4.95
LM317T	1.95	LM337K	3.95

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14 pin ST	15	12
16 pin ST	17	13
18 pin ST	.20	18
20 pin ST	.29	27
22 pin ST	.30	27
24 pin ST	30	27
28 pin ST	40	.32
40 pin ST	.49	.39

ST = SOLDERTAIL

8 pin WW	59	.49
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16 pin WW	69	.58
18 pin WW	99	90
20 pin WW	1.09	98
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Quad 2-Input NOR Gate	74LS02	276-1902	.79	.59
Hex Inverter	74LS04	276-1904	.79	.59
Quad 2-Input AND Gate	74LS08	276-1908	.79	.59
Quad 2-Input OR Gate	74LS32	276-1915	.89	.69
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1 of 8 Decoder/Demultiplexer	74LS138	276-1939	1.19	.99
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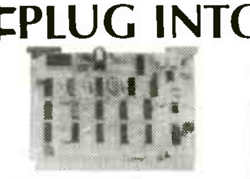

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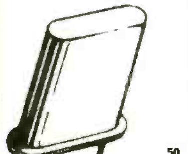

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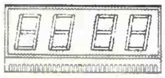

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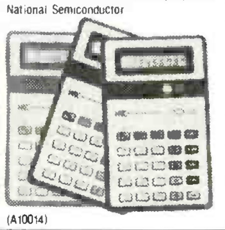

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F10001	1×15 Aluminum Electrolytic (A)	.20
F10002	2.2×50 Aluminum Electrolytic (A)	.24
F10003	3×100 Aluminum Electrolytic (A)	.26
F10004	5×50 Aluminum Electrolytic (A)	.30
F10005	10×16 Aluminum Electrolytic (A)	.50
F10006	16×100 Aluminum Electrolytic (A)	.52
F10007	22×100 Aluminum Electrolytic (A)	.55
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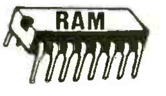
RAM



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74LS04N	35
74LS05N	25
74LS08N	35
74LS10N	35
74LS13N	55
74LS14N	1 00
74LS20N	35
74LS22N	35
74LS28N	35
74LS30N	35
74LS33N	60
74LS38N	50
74LS74N	45
74LS75N	65
74LS90N	60
74LS93N	75
74LS95N	1 00
74LS107N	45
74LS112N	45
74LS113N	45
74LS132N	89
74LS136N	50
74LS151N	75
74LS155N	79
74LS157N	1 10
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8 4116 200ns	18 40
MM5262	40
MM5280	3 00
MM5320	9 95
MM5330	5 94
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4200A	9 95
82S25	2 90
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2708	4 70
2716T1	8 50
2716 5 Volt	6 50
8/2716 5 Volt	48 00
2732	19 75
2758	14 00
8741A	55 00
8748	55 00
8748-8	55 00
8755A	55 00
N82S23	2 95
N82S123	4 95
N82S126	4 75
N82S129	4 95
N82S131	4 95
N82S136	8 75
N82S137	8 75
DM8577	2 90
8223	3 50

INTERFACE	
8095	65
8096	65
8097	65
8098	65
8T09	1 25
8T10	4 50
8T13	3 00
8T20	5 50
8T23	3 10
8T24	3 50
8T25	3 20
8126	1 69
8T28	2 [illegible]5
8T97	1 69
8198	1 69

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6504	9 95
6522	9 95
6800	6 95
6802	11 95
6820	4 95
6850	5 95
8080A	3 95
8085	12 95
Z80	9 95
Z80A	11 95
8212	2 90
8214	3 95
8216	2 90
8224	3 45
8228	4 95
8251	6 95
8253	15 00
8255	5 75
8257	10 95
8259	14 95
1802CP plas	13 95
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10 per type	03
25 per type	025
100 per type	015
1000 per type	012
350 piece pack 5 per type	6 75
½ watt 5% per type	05

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

2 level 14 pin ww 20

WIRE WRAP LEVEL 3

PIN		PIN	
14	55	24	93
16	57	28	1 00
18	67	40	1 59

CRYSTALS	
1 MHz	4 50
2 MHz	4 50
4 MHz	4 25
5 MHz	4 25
10 MHz	4 25
18 MHz	3 90
20 MHz	3 90
32 MHz	3 90
32768 Hz	4 00
1 8432 MHz	4 50
3 5795 MHz	1 20
2 0100 MHz	1 95
2 097152 MHz	4 50
2 4576 MHz	4 50
3 2768 MHz	4 50
5 0688 MHz	4 50
5 185 MHz	4 50
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6 5536 MHz	4 50
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18 432 MHz	4 50
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DISPLAY LEDS			
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MAN72 74	CA CA	300	1 00
DL704	CC	300	1 25
DL707 DL707R	CA	300	1 00
DL727 728	CA CC	500	1 90
DL747 750	CA CC	600	1 95
FND359	CC	357	70
FND500 507	CC CA	500	1 35
FND503 510	CC CA	500	90
FND800 807	CC CA	800	2 20
3 digit Bubble			60
10 digit display			1 25
7520 Clarex photocells			39
TIL311 Hex			9 50
MAN3640	CC	30	1 10
MAN4610	CA	40	1 20
MAN4640	CC	40	1 20
MAN4710	CA	40	95
MAN4740	CC	40	1 20
MAN6640	CC	56	2 95
MAN6710	CA	60	1 35
MAN6740	CC	60	1 35

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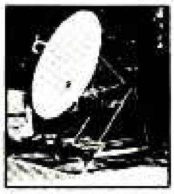

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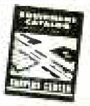

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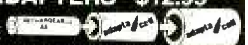

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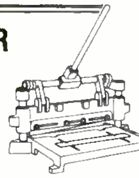

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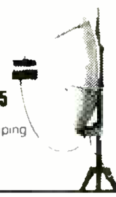

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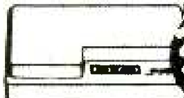

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ELECTRONICS WORLD® Personal Electronics News

CBS CABLE TO BROADCAST STEREO SOUND in transmission debut scheduled for Oct. 12. The stereo channel, with full Dolby noise reduction, is transmitted to cable systems on the 5.8-MHz subcarrier. Connecting a standard FM receiver at the subscriber's location, a jack-type plug permits the customer to use his stereo system as the audio section of a cable TV broadcast. Mono audio is received on the subscriber's TV receiver in the normal manner. CBS Cable's cultural program service is carried on more than 200 cable systems nationwide, with over three-million subscribers.

HIGHEST 1981 OFFICE SALARIES go to those in data processing, according to the 1981-82 "Office Salaries Directory" published by the Administrative Management Society in Willow Grove, PA (215-659-4300). The average range given for four DP positions is $212 per week for data entry operators to $405 per week for programmer/analysts (computer operators and programmers averaged $270 and $344 per week, respectively). By region, the highest DP salaries are in the West, the lowest in the South. Also covered in the directory is a salary breakdown by type of business. Separate figures are given for Canadian industry.

REGGIE THE ROBOT from the General Development Co. is reported to have come to the First Annual Sunbelt Computer Expo in Phoenix this past September. Planned to sell for under $10,000, Reggie is about 5 ft tall, moves independently via wheels, and, through voice synthesis, is capable of selecting key words from among 50 questions commonly asked of him and then formulating a reply. In his initial mode, Reggie will be able to vacuum or polish a floor, but later models will also function as security devices—challenging an intruder and zapping him with tear gas if he doesn't respond correctly within, say, 20 seconds (while, of course, alerting the police via a telephone interface). Smoke detection and thermostat adjustment are other capabilities that can be built into the system. Reggie does not have arms or legs, so a user need not fear being mangled by the device in his sleep.

CELLULAR SYSTEM MOBILE STATIONS are now covered by a compatibility standard called Communications Interim Standard No. 3. Announced by the Engineering Department of the Electronics Industries Association, its purpose is to ensure that any mobile telecommunications station can obtain service in a cellular system. The requirements set forth by the standard address themselves to radio system characteristics and call processing procedures. The speech-filtering, modulation, and r-f emission parameters have been updated and expanded to fit the unique radio plan upon which cellular systems are used. The land station is subject to fewer compatibility requirements than the mobile station, permitting a more flexible response to local service need.

RCA RECORDS ADOPTS THE "CX" PROCESS, an audio system said to eliminate surface noise and increase the dynamic range of phonograph records by 20 dB. Developed by the CBS Technology Center in Stamford, CT, the CX encoded records can be played on conventional stereo equipment and are priced the same as standard LPs. A CX decoder has been available since early summer 1981, with at least half-a-dozen companies announcing decoder models.

ATARI'S CENTIPEDE ™ is the official coin-operated video game that all players will compete on in the Atari World Championships scheduled to be held in Chicago on Oct. 29 thru Nov. 1. The game features a colorful, segmented centipede that winds downward through a dangerous mushroom field. An attacking spider, a flea, and a deadly scorpion are also targets the player must destroy. The object of the game is to destroy the centipede and other targets with the Trak-Ball bug blaster before the blaster is hit. The graphics change with each level of play. A total of $50,000 in cash and prizes is offered to the winners in six categories of competition. Participating locations offering Atari video games are holding pre-tournaments to produce local winners, who are then invited to compete in the open finals in Chicago. For additional information call toll-free: 1-800-426-8897; in AK, HI, WA, and Canada call 206-763-1362.

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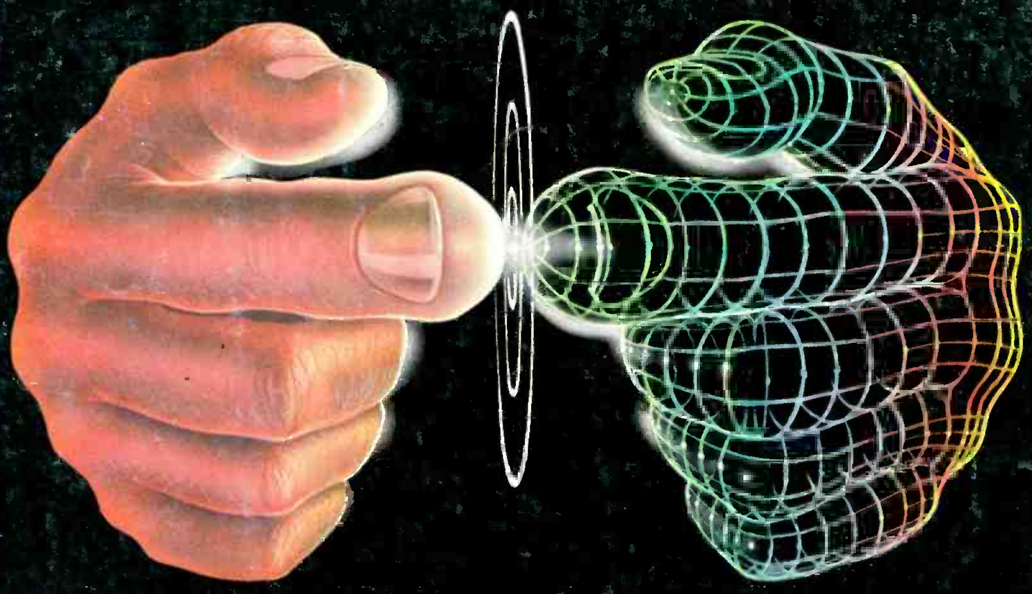

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