TROUBLESHOOTING COMMUNICATION RECEIVER

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Radio-Electronics

34140

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

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A guide to building a system that controls solar energy panels so they track the sun.

WIRE WRAP JUNGLE
New construction technique combines PC and wire-wrap assembly to get the best of both worlds.

AUDIO TEST STATION
Construction details for a high-quality audio test instrument that combines several important test instruments into a single cabinet.

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A roundup of commercially available off-the-shelf enclosures that add a professional look to your projects.

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RETAILER: SEE PAGE 97 FOR SPECIAL DISPLAY ALLOWANCE PLAN

The President base station.
In the manner to which you've become accustomed.

People have come to associate superb quality with President CB.

And rightly so. When we build a base station, we go all out.

Every President base station is a masterpiece of performance, with a full complement of controls and indicators for your enjoyment of CB at its absolute best.

The Madison is a good example: the finest 40 channel base yet achieved by the President engineering art.

It's a single sideband CB, with a full 4 watts output on AM, 12 watts peak envelope power on single sideband for extraordinary performance, range and total talkpower.

Despite unsurpassed receiver sensitivity, bleedover just isn't a problem. Our adjacent channel rejection sets a standard for the industry. And you can set your own standard of sensitivity with a variable RF gain control.

A digital clock turns on the radio at a pre-selected time. An alarm reminds you of scheduled calls.

Two big meters read signal strength received, relative RF output, modulation and standing wave ratio.

There's a digital LED channel indicator. Three more LEDs to indicate when you're on upper sideband, lower sideband or AM. Still another LED glows when you're transmitting.

A built-in variable mike gain control eliminates the need for a separate power mike.

We've even given the Madison's big speaker its own separate cabinet, so you can put it where it sounds best.

Your local CB specialist is the place to find President equipment. Plus the best in accessories and service, including installation, warranty back-up and the most expert advice in town. Ask him about the new Madison base station.

It's unequivocally President.

In the grand manner.

PRESIDENT

Engineered to be the very best.

President Electronics, Inc.
16691 Hale Avenue · Irvine, CA 92714 · (714) 556-7355
In Canada: Lectron Radio Sales Ltd., Ontario

CIRCLE 38 ON FREE INFORMATION CARD

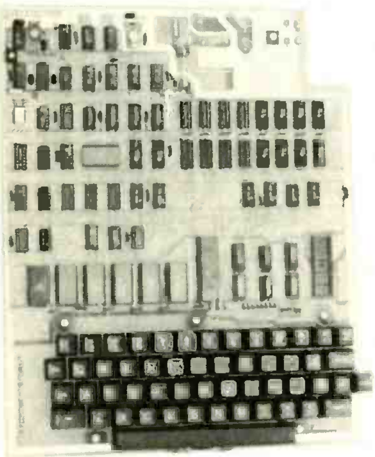
The Age of Affordable Personal Computing Has Finally Arrived.

Ohio Scientific has made a major breakthrough in small computer technology which dramatically reduces the cost of personal computers. By use of custom LSI micro circuits, we have managed to put a complete ultra high performance computer and all necessary interfaces, including the keyboard and power supply, on a single printed circuit board. This new computer actually has more features and higher performance than some home or personal computers that are selling today for up to $2000. It is more powerful than computer systems which cost over $20,000 in the early 1970's.

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

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

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



Ohio Scientific offers you this remarkable new computer two ways.

Challenger 1P $349
Fully packaged with power supply. Just plug in a video monitor or TV through an RF converter to be up and running.

Superboard II $279
For electronic buffs. Fully assembled and tested. Requires +5V. at 3 Amps and a video monitor or TV with RF converter to be up and running.

Standard Features

- Uses the ultra powerful 6502 microprocessor
- 8K Microsoft BASIC-in-ROM
  Full feature BASIC runs faster than currently available personal computers and all 8080-based business computers.
- 4K static RAM on board expandable to 8K
- Full 53-key keyboard with upper/lower case and user programmability
- Kansas City standard audio cassette interface for high reliability
- Full machine code monitor and I/O utilities in ROM
- Direct access video display has 1K of dedicated memory (besides 4K user memory), features upper case, lower case, graphics and gaming characters for an effective screen resolution of up to 256 by 256 points. Normal TV's with overscan display about 24 rows of 24 characters; without overscan up to 30 X 30 characters.

Extras

- Available expander board features 24K static RAM (additional), dual mini-floppy interface, port adapter for printer and modem and an OSI 48 line expansion interface.
- Assembler/editor and extended machine code monitor available.

ORDER FORM

Order direct or from your local Ohio Scientific dealer.

☐ I'm interested. Send me information on your:
☐ Personal Computers ☐ Business Systems
☐ Send me a Superboard II $279 enclosed
☐ Send me a Challenger 1P $349 enclosed
☐ Include 4 more K of RAM (8K Total) $69 more enclosed

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TOTAL CHARGED OR ENCLOSED __________

All orders shipped insured UPS unless otherwise requested. FOB Aurora, OH

Interested in a bigger system? Ohio Scientific offers 15 other models of microcomputer systems ranging from single board units to 74 million byte hard disk systems.

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America's Largest Full Line Microcomputer Company
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CIRCLE 15 ON FREE INFORMATION CARD

GOULD PROFESSIONAL OSCILLOSCOPES AT PRICES YOU CAN AFFORD.

Whatever your interest in electronics, you know that a quality oscilloscope with a broad range of features and functions can make your work a lot easier. Gould oscilloscopes are built to solve your problems and priced so you can afford the professional equipment you need right now. All are complete, ready for use, including passive probes, input leads and a comprehensive maintenance and operation manual.

The OS245A is a compact, dual trace instrument with a 10MHz bandwidth and 5mV/div sensitivity. It has exceptional trigger performance and a full compliment of facilities for industrial, educational, and field service applications.

The OS253 is a 12MHz dual-channel scope with all the features of the OS245A plus a larger display area, more sensitivity and channel sum and difference.

The dual trace OS255 weighs only 15 lbs. yet offers features normally found in more expensive instruments such as flexible triggering facilities and 2mV/cm sensitivity across its full 15MHz bandwidth.

The dual beam OS260 gives true representation of two separate signals on the same time frame without beam chopping or alternating. Features include a high brightness CRT operating at 10kV allowing a clear display of all waveforms.

For additional information on this exciting new line of sensibly priced, professional oscilloscopes or for sales locations in your area: call toll free (800) 325-6400 Ext. 77. In Missouri call (800) 342-6600.

Gould also manufactures an additional line of general purpose oscilloscopes for industrial, scientific and laboratory applications.

GOULD

CIRCLE 7 ON FREE INFORMATION CARD

Radio-Electronics®

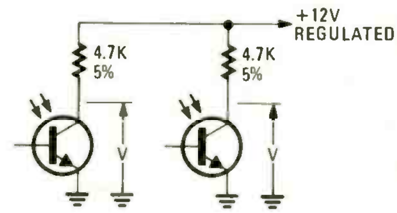
THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

Electronics publishers since 1908

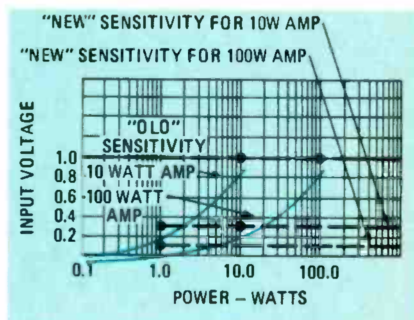
FEBRUARY 1979 Vol. 50 No. 2

ON THE COVER

It looks like an electronic organ, but it isn't. It is a string synthesizer. Plunk the keys and play a banjo, or guitar, or piano, or. . . . Build one for yourself. Construction details start on page 37.



PHOTOTRANSISTOR SENSORS for the heart of this solar tracking device that follows the sun. Use it with your solar energy collection system. Complete details start on page 42.



NEW IHF SENSITIVITY RATING specifies the input voltage required to produce a 1-watt output. Story starts on page 56.

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looking ahead

Videodisc mergers? Although many different noncompatible videodiscs have been demonstrated, as outlined previously ("Looking Ahead," **Videodisc boxscore**, November, 1978), the multiplicity of these systems may evaporate or dwindle as manufacturers face reality. The optical system, which basically was a compromise between similar Philips and MCA systems, is already being produced by Magnavox (videodisc players) and MCA Disco-Vision (videodisc records) in the United States. In Japan, the joint Japanese-American company, Universal Pioneer, plans to start player production this year.

So the optical system is the one manufacturers wish to stop, if they want to field simpler nonlaser players. Nonlaser systems have been demonstrated by RCA, Matsushita, JVC, Toshiba and Telefunken—the latter now being on limited sale in both Europe and Japan in a 10-minute-per-disc version. The RCA and JVC versions are capacitance systems. Matsushita and Telefunken are classified as mechanical systems. Except for RCA and Toshiba, which are compatible, the systems have little in common except that they're nonoptical. They all use grooved discs (except for JVC) and spin at 450, 900, or 1800 rpm. Even the center-hole diameters are different.

Although it's not official yet, there's strong evidence to suggest an effort will be made to bring all these systems into compatibility before commercializing them. The resulting system—if there *is* one—is expected to have some features of the optical version, such as being able to provide slow and fast motion but to be potentially less expensive in terms of players and perhaps discs. The result could be a sort of "stop-Philips" effort; in effect, optical vs. nonoptical systems. Although this situation isn't ideal, two "standards" are preferable to five or six.

New watch display: Electrochromic displays are claimed to be price-competitive with LCD's, but have some major advantages. The first company to announce the commercialization of this technique is Sharp, which says it will have a line of ECD's this spring.

Several companies have been working on ECD's for four or five years. These displays use metallic chemicals that change to a dark color when a voltage is applied. Once changed, they retain their color until the voltage is reversed—a power-saving feature. They have considerably higher visibility than LCD's, primarily because their image is nondirectional. They can be manufactured in any color, and the numerals stand out clearly against a contrasting background. The color of Sharp's initial displays will be blue. Electrochromic displays are relatively slow and, in their initial development, at least, it was felt they were not fast enough for calculators. Sharp hasn't stated whether its product will have a calculator display.

TV developments: A new single-gun color tube, scheduled to be sold this year in small-screen battery-powered sets manufactured by Matsushita, is claimed to have an extremely low power drain, making it possible for a set to operate for three hours on nine flashlight batteries. Its color phosphors are separated by black control stripes that emit ultra-violet rays for beam indexing. If this sounds familiar to some color TV oldtimers, it bears a striking similarity to Philco's widely demonstrated (but never produced) "Apple" tube of the 1950's.

Photochromic glass has been used in windows and sunglasses, and now it may be adapted to black-and-white TV. The Corning Glass product darkens under strong light and lightens when ambient light is less intense. For outdoor viewing of a portable TV, the glass darkens enough to eliminate the need for a separate plastic sunshield. For indoor viewing, the glass lightens—providing proper contrast under all viewing conditions. Corning is now working on the development of a glass that darkens enough to provide these contrast-enhancing features.

"Picture-in-picture" TV is offered in Europe as a special feature that lets the viewer watch two channels simultaneously, the supplementary channel being superimposed in a corner or at the bottom of the large-screen color picture. The only trouble is, the secondary picture is in black-and-white. Now, Hitachi says it has changed all that and will be selling a two-picture color set in which *both* the main and the superimposed pictures are in color. A digital semiconductor memory makes it possible to provide the second-channel insert in color.

In-flight video: Video tape is about to take over for film in the airborne movie business. Bell & Howell has sold American, Continental and Laker Airlines on a new technique that uses a modified VHS ½-inch videocassette recorder and a projection TV system. Among the advantages of a VHS system is the size of the cassette, as contrasted with the large 16-mm movie reel used in film systems. And with film systems, the reels generally are changed by engineers on the ground. Flight attendants can easily flip a cassette in the VCR, which is mounted in a luggage rack. The projector uses three side-by-side 5-inch monochrome projection tubes, weighs 65 lbs. and is installed in the cabin ceiling. The picture is projected onto a standard 30- by 40-inch pull-down screen. Bell & Howell says it plans to introduce a home version of the projector this year for built-in and conventional installations. Its advantages over other home systems, as claimed by the manufacturer, are: it's bright enough to be able to use any flat movie screen, or even a light-colored wall, instead of a parabolic directional screen.

Another new Bell & Howell "why-didn't-they-think-of-it-before" system for the airlines is a wireless headphone for stereo music or movie sound. For the high-ceilinged new planes, Bell & Howell will also supply wireless attendant-call and light-switch systems.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

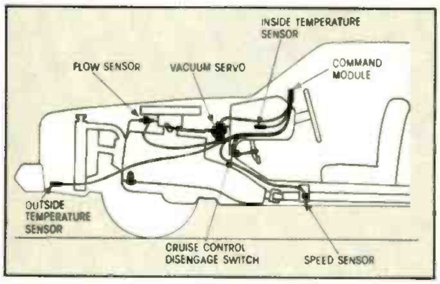
Automotive "brain" astounds the experts, puts both computer and cruise control at your fingertips!

For the first time ever, you can put a true computer in your car, truck or RV which gives you the most effective and functional cruise control ever designed, plus complete trip computing, fuel management system, and a remarkably accurate quartz crystal time system. It is called CompuCruise$_{TM}$.

So simple a child can operate, the new CompuCruise combines latest computer technology with state-of-the-art reliability in a package which will not likely be available on new cars for years to come.

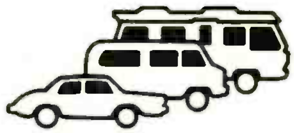
CRUISE CONTROL WITH A MEMORY, UNIQUE SEEK-AND-HOLD CAPABILITY.

CompuCruise remarkable cruise control performs in a totally different manner than any other unit because it is more than a simple speed maintaining device. With CompuCruise, you establish your desired cruising speed even before you reach the highway and activate the system any time by simply pressing a button. CompuCruise then seeks and maintains the desired speed until you override or shut off the system. You resume cruise control again at any time by pressing the same button. CompuCruise, unlike most vacuum-mechanical systems, is fully electronic, more accurate and more reliable than any other unit you can buy.



AIRLINE PILOTS COMPARE COMPUCRUISE$_{TM}$ TO SOPHISTICATED AVIONICS EQUIPMENT.

Similar to types of computers used on modern airliners, the CompuCruise slim panel-mounted control module contains a digital readout and back-lighted control buttons, both readily visible in the dark. By quickly learned systems of inquiry, the driver can elicit virtually any information relating to time, distance, fuel and performance of his vehicle.



There are a number of digital-type instruments on the market which can be purchased for your car, purporting to provide functional data on performance, but all are basically calculators, operating on fixed information provided by the driver.

CompuCruise is a true computer, operating from automatic data sensors which constantly react to changing conditions, automatically recomputing vital data every second. Each function operates independently, with data displayed and updated constantly until you change your request of the computer.

Fuel management takes on new significance because CompuCruise tells you the most effective driving speeds, the type and brand of gasoline most suitable for your vehicle. It will tell you the effects of different types of tires and different tire pressures, road conditions, and engine tune-up condition. You can get instantaneous computations on current gas mileage, fuel required to arrival, and actual fuel remaining.

Battery condition can be checked regularly, saving you from the potential embarassment of being stranded without warning.

TYPICAL DATA:

- Cruise Control
- Time, E.T., Lap Timer, Alarm
- Time, Distance, Fuel to Arrival
- Time, Distance, Fuel to Empty
- Time, Distance and Fuel on Trip
- Current or Average MPG, GPH
- Fuel Used, Distance since Fillup
- Current and Average Vehicle Speed
- Inside, Outside or Coolant Temperature
- Battery Voltage
- English or Metric Display

COMPUCRUISE$_{TM}$ DIGITAL QUARTZ CRYSTAL TIME SYSTEM IS INCREDIBLE.

CompuCruise digital time system performs four independent time functions encompassing (a) stop watch and lap timer functions, (b) hours, minutes and seconds, (c) alarm or warning function, and (d) trip time indicator. The time system operates full time, whether your vehicle is operating or not. It will even wake you up after a short roadside nap.

YOUR COMPUCRUISE IS SMART! IF YOU PUSH THE WRONG BUTTON IT WILL LET YOU KNOW BY DISPLAYING "ERROR".

COMPUCRUISE$_{TM}$ WORKS ON FOREIGN OR AMERICAN CARS; IS PRICED FOR THE AVERAGE MAN'S BUDGET

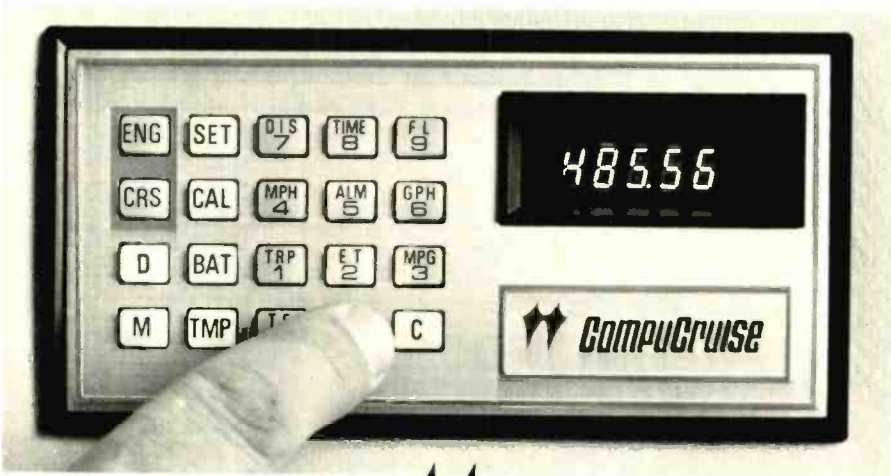
You do-it-yourselfers can readily install the unit, but complete and detailed instructions are also included for the automotive service facility. CompuCruise units are fully operable on most foreign or American cars, trucks or RV's. At $199.95 the unit is only a few dollars more than the cost of cruise control alone on most vehicles, yet offers a whole new world of computerized management functions.

This is an exclusive system, fully warranted for 90 days from installation, delivered to you complete with all required hardware. You need only basic tools for the total job.

When you receive your unit, inspect it completely. If you are not 100% satisfied, return the complete unit before installation and your money will be refunded without question.

TO ORDER YOUR UNIT, complete the coupon below, enclosing $199.95 (ADD $5.50 if front-wheel drive). This covers all shipping, insurance and handling costs. Your unit will be shipped within three weeks.

NOTE: Mountable on foreign or domestic vehicles including standard trans. **EXCEPT FOR DIESEL OR FUEL INJECTED ENGINES.**



(415) 935-4960
Technically competent personnel available to answer your questions.

CompuCruise

TO: ZEMCO, Inc. (415) 935-4960
1136 Saranap Avenue
Walnut Creek, CA 94595

Ship ______ CompuCruise$_{TM}$ units @ $199.95
Model 44 (WITH CRUISE CONTROL)
☐ Add $5.50 for front-drive

Ship ______ CompuCruise$_{TM}$ Units @ $159.95
Model 41 (WITHOUT CRUISE CONTROL)
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Total enclosed: $ ____________
(CA residents add Sales Tax)

Charge to my ☐ Master Charge ☐ Visa

Card Number ____________

Date Expires ____________

Signature ____________

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Name: ____________

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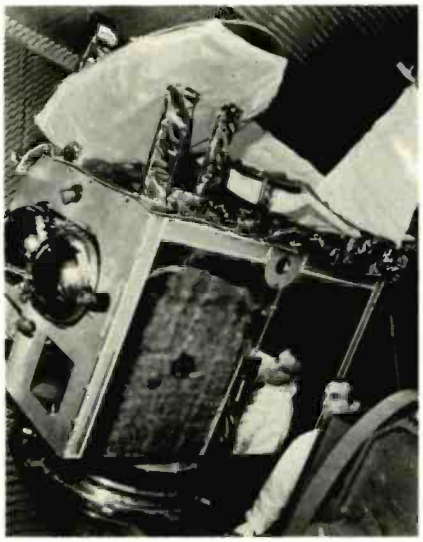
CIRCLE 30 ON FREE INFORMATION CARD

new & timely

Electronic music newsletter now available

A monthly newsletter, *Device*, is now available to those in the electronic music field. The publication covers such topics as new product reviews of musical equipment, construction articles, circuit-design features, etc.; it carries no advertising and is entirely subscription-supported. Yearly rates: $15 (U.S.); $16 (Canada/Mexico); $18 (international). For information, write *Device*, P.O. Box C, Carmichael, CA 95608.

ANIK-B COMMUNICATIONS SATELLITE



ANIK-B, a domestic communications satellite, has been constructed by RCA Astro-Electronics for Telesat Canada. It is the first such satellite to operate in the dual frequency bands of 6- and 4- GHz and 14- and 12- GHz. A Telesat engineer is shown here performing antenna pattern measurements. The mirrors are part of the thermal system that keeps the spacecraft at cool operating temperatures.

Bell Labs scientists win 1978 Nobel Physics Prize

Bell Labs scientists Dr. Arno A. Penzias and Dr. Robert W. Wilson received the 1978 Nobel Prize in Physics jointly with Professor Piotr Kapitsa of the Moscow Academy of Sciences (Prof. Kapitsa received his award for his work in low-temperature physics).

Drs. Penzias and Wilson won their shared prize for their work in cosmic microwave background radiation. As early as 1964, when they were using a Bell Labs antenna to search for radio noise sources that were interfering with satellite communications, they discovered a faint pervasive radio signal that remained steady round the clock, season to season—an unusual and unique phenomenon. After eliminating possible sources of the signal (such as the Milky Way, the sun, poorly fitted antenna joints, even nesting pigeons!), the conclusion became inescapable—the signal was the result of the radiation still remaining after the big bang that had created the universe approximately 2 billion years ago. Their conclusions were verified by Professor Robert H. Dicke of Princeton who had been conducting similar studies.

Although the "Big Bang" theory had been known to astro-physicists for a long time, up until Penzias and Wilson's discovery of the background radiation, the theory had never been satisfactorily verified. When the two physicists (along with Prof. Dicke and his co-workers independently) published their results, their discovery was finally understood to be a major breakthrough in understanding the origins of the universe.

Videocassette exchange service available

Owners of Beta and VHS ½-inch format VCR's can avail themselves of the services provided by the Video Cassette Exchange Division of Discotronics Inc., New Jersey, in which customers can either buy or exchange videocassettes at greatly reduced rates.

The 1979 catalog lists approximately 600 prerecorded film titles, some of which have never been seen on TV. The company also offers trade-in privileges that are similar to those of a rental library. And, for convenience, they also provide a nationwide home pickup service for a small charge. For more information, contact Robert Edwards, Discotronics Inc., 50 North Main Street, Cranbury, NJ 08512.

New communication service proposed by radio amateur group

In 1977 amateur radio operators of WA2RPC (Center for Advanced Study in Education, Graduate School of CUNY, New York City) filed a petition with W2KPQ, requesting the implementation of a community service that would use the communicasting concept to broadcast messages on UHF channels.

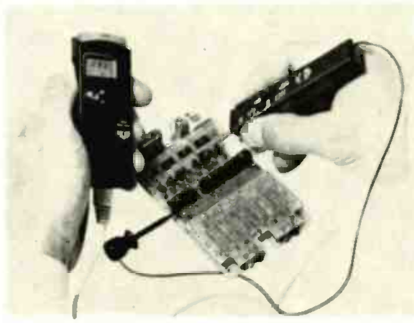
Communicasting uses a low-power community-based repeater station that can transmit audio and video signals up to a 30-mile radius, using a high antenna. The repeater station receives signals from different areas of the community and then transmits them via any unused UHF TV channel. The petitioning group additionally requested that low-power facilities be exempt from the usual rigid broadcast standards in an effort to keep costs down.

Praising the communicasting concept, the FCC has stated that: "The petition and comments by others suggest an imaginative and potentially beneficial public service television concept . . . an activity that deserves considerable attention in the overall inquiry."

Swiss watch firm designs microminiature DMM

Heuer Time & Electronics, Inc., watch and timepiece manufacturer, has taken the plunge into the world of microelectronic instrumentation by designing what it calls "the world's smallest digital multimeter," using the company's experience in microminiaturizing watches.

The *model DM 2000* meter (displayed for the first time at Newcom '78, Las Vegas) weighs less than 3 oz., including probe and batteries, and (minus probe) measures only 4 × 0.78 × 0.47 inches. In addition to its four measurement range capability—to 1000 DC, 700 VAC, AC/DC current to 2 amperes, and resistance to 20 megohms—two major technical features lie in its true AC RMS measurement and complete RF shielding. It also provides up to 100-hour battery life, an error-free LCD display (due to its remote-control probe), plus great reliability for field-service applications where accuracy and portability can be vital.



MICROMINIATURE DIGITAL MULTIMETER provides multiple ranges, modern microminiaturization techniques, remote-control probe, LCD readout and high reliability. The instrument weighs less than 3 oz., including probes and batteries.

The *model DM 2000* is expected to sell for $450. For further information, write Hans J. Kueffer, Heuer Time & Electronics, 960 South Springfield Avenue, Springfield, NJ 07081.

Newsflash!

As we're about to go to press, we've received word that Texas Instruments has received type-approval from the FCC on a computer that connects to the antenna terminals of a TV receiver. Could it be that Texas Instruments will be entering the home computer market? Formal introduction of this new device is scheduled to take place at the Consumer Electronics Show,

continued on page 12

new design... new features...unique, time-tested principle!

Weller® controlled output soldering station

Model WTCPN. New convenience-features. Striking contemporary appearance. Completely new design. Now more than ever in a class by itself. Only Weller's advanced engineering could have improved on its own predecessor WTCPL Station, popular standard of the electronics industry.

- new heat shield for cool operator comfort
- new plug-in iron design for zero down-time
- new integral tip-storage tray
- new larger sponge for easier tip cleaning
- improved, unitized rocker switch and neon indicator light
- new impact-resistant case

And add to these new features Weller's unique, proven, closed-loop, low-voltage circuit, with its "interchangeable brains" in the tip . . . a ferromagnetic sensor that controls the temperature at 600, 700, or 800°F., protecting sensitive workpieces. To change temperatures, simply change tips with knurled thumb-screw. More than 50 options in configuration, tip size, reach, and temperature! Exclusive-process triple-plating prevents tip oxidation and "freezing".

With all these new features and exclusive principles, Model WTCPN is still all function . . . no frills! It's UL-listed and OSHA-compliant, of course. And now it's available at leading electronic distributors . . . coast-to-coast. See it there. For technical information, write on your letterhead.

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CIRCLE 41 ON FREE INFORMATION CARD

Everybody's making money selling microcomputers. Somebody's going to make money servicing them.

New NRI Home Study Course Shows You How to Make Money Servicing, Repairing, and Programming Personal and Small Business Computers

Seems like every time you turn around, somebody comes along with a new computer for home or business use. And what's made it all possible is the amazing microprocessor, the tiny little chip that's a computer in itself.

Using this new technology, the industry is offering compact, affordable computers that will handle things like payrolls, billing, inventory, and other jobs for businesses of every size...perform household functions including budgeting, environmental systems control, indexing recipes, and more. And thousands of hobbyists are already owners, experimenting and developing their own programs.

Growing Demand for Computer Technicians

This is only one of the growth factors influencing the increasing opportunities for qualified computer technicians. The U.S. Department of Labor projects over a 100% increase in job openings for the decade through 1985. Most of them *new* jobs created by the expanding world of the computer.

Learn at Home in Your Spare Time

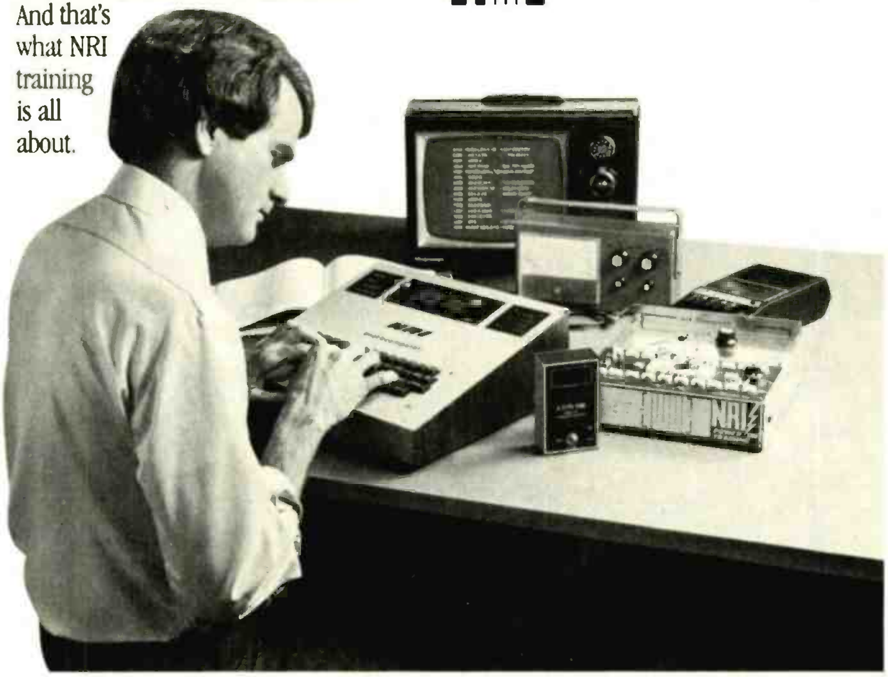
NRI can train you for this exciting, rewarding field. Train you at home to service not only microcomputers, but their larger brothers, too. Train you at your convenience, with clearly written "bite-size" lessons that you do evenings or weekends, without going to classes or quitting your present job.

Assemble Your Own Microcomputer

NRI training goes far beyond theory. It includes practical experience, too. As you progress, you perform meaningful experiments building and studying electronic circuits on the NRI Discovery Lab.® You assemble test instruments that include a transistorized volt-ohm meter and a CMOS digital frequency counter...instruments you learn on, use later in your work.

And you build your own microcomputer. Each step of construction advances your knowledge, gives you deeper insights into this amazing world that's upon us.

This is the only microcomputer designed for learning. It looks, operates, and performs just like the finest of its kind...actually does more than many commercial units. But NRI engineers have designed components and planned the assembly procedure so it demonstrates important principles, gives you working experience in detecting and correcting problems. And that's what NRI training is all about.



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new & timely

continued from page 6

which will be held in Las Vegas on January 6-9.

We have also learned that Atari is preparing to introduce a BASIC interpreter for their programmable video game. This will also be introduced at CES.

Admiral TV production is discontinued

Rockwell International Corporation recently announced that it would discontinue all its Admiral TV products. Admiral marketing activities are currently being phased out, and, once current commitments are fulfilled, all production will cease at the Harvard, IL, and Taiwan plants.

Charles Fazio, president of Rockwell's consumer operations, has emphasized that the company would continue to provide warranties, service and spare parts support; and added that the phasing out of its TV production would enable Rockwell to concentrate its efforts on its ongoing appliance business and other operations.

The reason given for discontinuing the Admiral TV line was "intense price competition, particularly from Japanese sources," which the company felt did not justify any additional outlay of its resources.

Two-layer solar cell provides 28% conversion to electricity

Varian Associates, Inc., of Palo Alto (under contract to the Department of Energy's Scandia Labs) has developed a prototype solar cell system that converts 28.5% of the sun's rays to electricity.

The Varian system uses two different cells—an aluminum gallium arsenide (AlGaAs) cell and a silicon cell—to perform the conversion. A special filter between the cells separates solar radiation into long and short wavelengths; it permits the longer rays to penetrate the silicon cell, while allowing the shorter rays to pass through into the AlGaAs cell. This effect is achieved by using a concave mirror to focus the solar energy onto the filter. The AlGaAs cell converts 17.4% of the rays to electricity, while the silicon cell converts 11.1% of the rays.

Sandia Labs supervisor Dr. Donald G. Schueler predicts that by 1986, photovoltaic systems "will produce electricity for $1 per-peak-watt of installed capacity, or from 6¢ to 8¢ per kilowatt-hour."

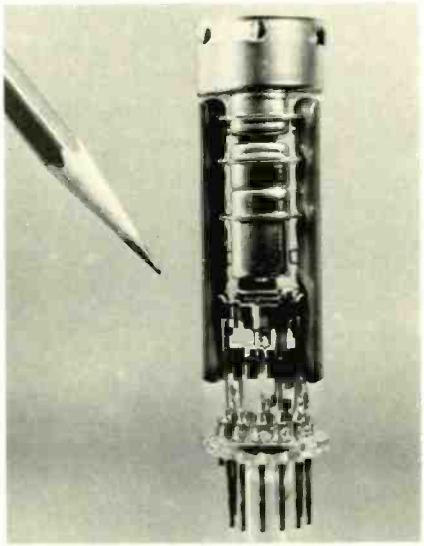
Sprague and Johnson receive EIA awards

During its fall 1978 conference, the Electronic Industries Association voted to award the EIA Medal of Honor to Robert C. Sprague, Sr., for his devotion and long years of service to the Association and the electronic industry. Among Mr. Sprague's most recent accomplishments are his efforts to revise the Custom Penalty Laws to remove unfair penalty provisions for the industry. Active for many years in EIA, he was a member of the Board of Governors since 1943 and board chairman from 1950–1954. This is the second time Mr. Sprague has won the EIA Medal of Honor, the first having been 25 years ago. The presentation will be made at EIA's spring 1979 meeting.

At the same conference, Raymond E. Johnson, EIA general counsel, received the EIA Distinguished Service Award, the first staff member to be so honored. Mr. Johnson has served as EIA general counsel since 1970 and was elected corporate secretary in 1972. He received his award for his years of distinguished service to EIA and his involvement in the Association on all levels.

RCA electron gun sharpens color TV pictures

RCA Laboratories and the technical staff of the RCA Picture Tube Division have developed a device that is used to create sharper color television pictures. This latest development is a new kind of electron gun that "shoots" invisible beams at color phosphors on the picture tube face. The result is improved focus and, thus, sharper pictures. The gun, which is now in commercial production, can be used on any size picture tube.



IMPROVED ELECTRON GUN developed by RCA Picture Tube Division can be used in all sizes of color TV tubes to create sharper pictures.

The results of this joint effort were presented in a paper delivered at the annual Chicago Fall Conference on Consumer Electronics by Picture Tube Division engineers Richard H. Hughes and Jim Y. Chen.

Metal-tape standards surveyed at ITA meeting

Representatives of companies manufacturing record and playback equipment, audio tape, duplicating equipment and ferric oxide attended a late 1978 meeting of the Audio Technical Executive Committee of the International Tape Association (ITA), to discuss industry-wide standardization of metal audio cassette tape.

However, because record/playback and erase heads are still not standardized, the committee could not come to any firm decision about standards for metal tape. Several companies, however, stated their readiness to enter the metal-tape market.

Among these were 3M Company, which already introduced their metal-particle *Metafine* tape, and Sharp Electronics with its prototype metal-tape recorder. Panasonic is presently developing metal-tape cassette decks and a duplicator for ½-inch VHS videocassettes. Fuji and 3M together are working on high-energy contact duplication of metal-particle videotape. BASF plans to introduce its metal-tape product at the 1979 Berlin Fair. Other companies continuing their R & D activities are Ampex, Maxell, Sony and TDK. Oxide supplier Hercules, Inc., said it would be producing metal-tape particles in quantity by 1979.

FCC asks, should TV sets be graded?

The Federal Communications Commission has started an inquiry to determine whether it should set up a system for grading TV receivers, since it feels that customers do not presently have enough information to help them select the best TV's and antennas for their needs. Here are some of the questions the FCC is asking:

1. If the consumer wants more information on TV systems, what kinds of data should be made available, how should it be presented and would it really improve one's ability to select a set? Should the equipment have a permanent label affixed? Should there be a brochure enclosed with each set? A letter-grading system, or a descriptive grade system (i.e., "excellent," "good," etc.)?
2. Some TV sets experience "snow" on the picture screen that is the result of noise. Should TV receivers show the maximum noise value for that set? How should this be presented to the public?
3. Should each purchased set contain more installation and operating instructions than are presently provided?

Deadline for filing comments with the FCC is February 1, 1979. The docket number is Gen. Doc. 78-307, and for a copy of the notice, write Consumer Assistance Office, Federal Communications Commission, Washington, DC 20554. **R-E**

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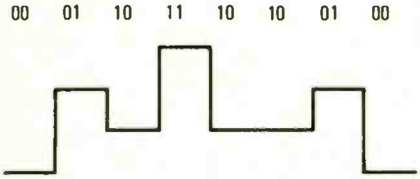
letters

THE TERM "BAUD" EXPLAINED

The article entitled "Digital Data Transmission—How A Computer Communicates" (May 1978 issue) provides a highly readable introduction to the subject that many novice computer enthusiasts will find



enlightening. However, the author commits a "technical foul" in making the unqualified statement that the term "baud" is used interchangeably with the term "bits-per-second."

The term baud means the number of times-per-second the line condition changes. If the line condition represents the presence or absence of a *single* bit (as in two-state signaling), then the signaling speed in bauds is the same as bits-per-second. If, however, the signaling is not two-state, then bauds are *not* equal to bits-per-second. The latter condition exists, for instance, in "di-bit" or four-state signaling (see diagram), in which the baud rate is equivalent to the number of bits-per-second times two.

This explanation is an adaptation from *Introduction to Teleprocessing* by James Martin, a reference I recommend for those interested in further exploring the subject of digital data transmission.

MARVINO A. HILL
Los Angeles, CA

THE FUTURE OF ELECTRONICS

This is in answer to your September 1978 editorial in which you invited readers to send in their look at the future of electronics. Your No. 4 idea is not at all far out. At the very least, should gravity prove to be meta- or paraphysical, control of the successful anti-gravity device will almost certainly be electronic in nature.

Electronics touches all fields of activity, even if remotely. Thus, all one has to do is just settle back and enter the light-trance state to foresee some very likely developments in coming decades. Whatever they may be, electronics will play a major part in their initiation, development, production, use and, yes, even in their eventual obsolescence. Here are my "predictions":

Transportation: In but half a century we have seen a transition from the horse to 500-passenger aircraft; the motor car has changed our life so drastically that should we run out of fuel our society as we know it would die like the dinosaurs; and the locomotive has been relegated to hauling freight. And still the insatiable appetite for travel expands.

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continued on page 23

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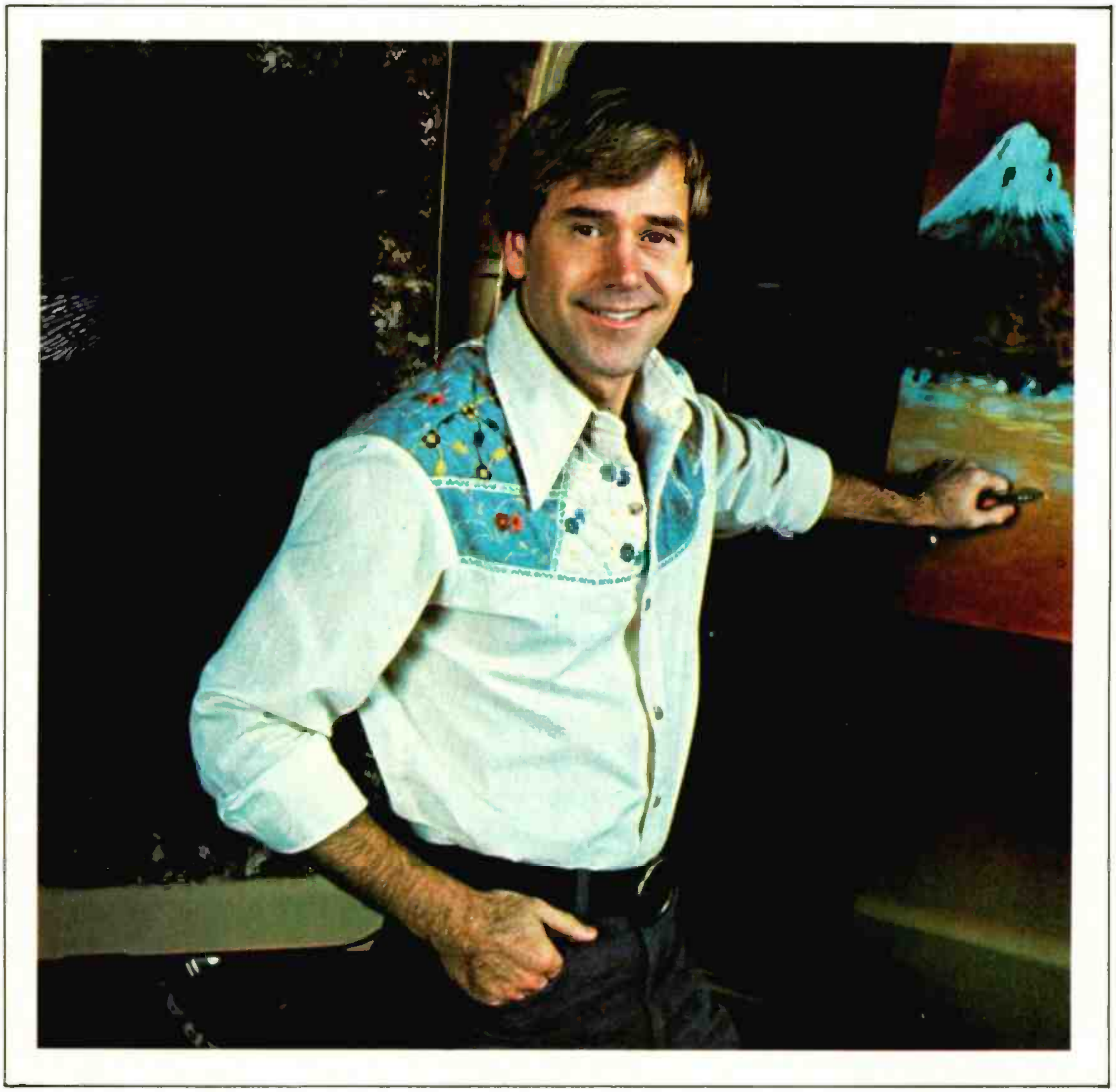
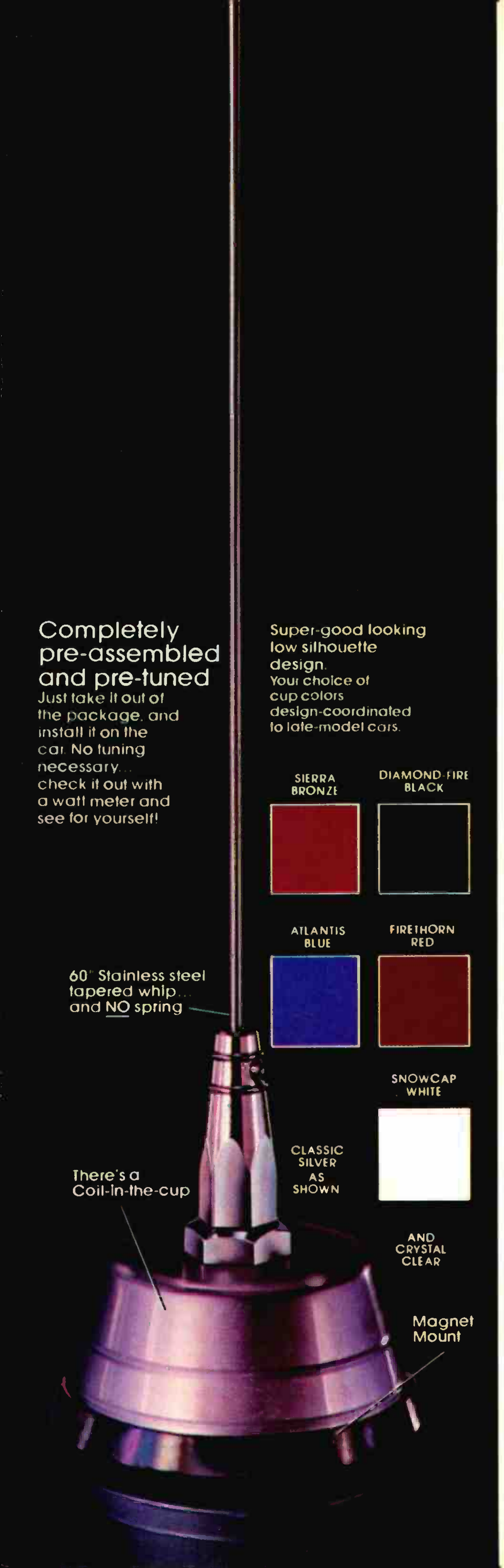


When you do, you'll probably pick CIE. You can't afford to settle for less when it comes to something like electronics training that could affect your whole life.



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LETTERS

continued from page 16

portation: The Transmatter! It is inconceivable that electronics will not play a major role in bringing the matter transceiver out of the sixth dimension and into the fifth, perhaps by the year 2000.

The workhorse locomotive will continue to be the major transport for heavy goods. Two excellent substitutes besides anti-grav for the rails: freight transmatters and automated factories that will manufacture any product (including foodstuffs) locally upon demand. An automated factory that might use hydrogen from water as its raw material would certainly use electronics in 100 interconnected ways.

Entertainment: Stage plays have given way to movies, and movies in turn have been taken over by TV. The same play that was artfully done for 1978 airwaves, can carry its message via satellite simultaneously to easily a hundred million, or even a couple of billion viewers.

The future patron of the arts must be so enraptured by sight, sound, smell, etc., that he *becomes* the protagonist. While we might anticipate that we'll tap into nerve endings surgically to heighten the total effect, it is more likely that a helmet fitted over your head will have the desired effect. Electronic? Of course.

Students of metaphysics declare that everyone who ever lived is recorded in the "Akashic" records "out there" in the sixth dimension. Assume that there *is* such a record, most certainly one day a workshop experimenter will discover the way to tap that great recording at will and select out one at a time of the billions of recordings that exist in that "other dimension," like tuning across AM, FM, SSB, CB, etc. frequency bands. Through the simple application of tuned resonance or PLL, we'll separate each (recording) to be received serially, and the roar of "pure noise" will change to recognizable intelligence.

To any who say that everything's been invented, I can only reply, "There are more things in heaven and earth, Horatio, than are dreamed of in your philosophy!"

A READER
Geyserville, CA

HEAT ENGINE EFFICIENCY

Mr. Smiles' letter in the August 1978 issue merits congratulations for compactness, but I have never seen so much misinformation packed in so little space!

The limiting efficiency of heat engines (of which the internal combustion engine is one type and not the most efficient, at that) is determined by the second law of thermodynamics. According to this law, the limiting efficiency is determined by the equation:

$$E = \frac{T_h - T_c}{T_h}$$

where T_h represents the high-temperature side of the engine and T_c, the low-temperature side of the engine.

For an internal combustion engine, the high temperature can be taken as the combustion temperature, which is approximately 1700°C or 2000°K (Kelvin or absolute temperature); my conversion is not exact, but the value is only approximate. The low temperature is the temperature at which the gas is exhausted from the cylinder, which can be taken as 500°K. Then, the theoretical limiting efficiency of such an engine is easily calculated as 75%, which is far greater than Mr. Smiles' value of 30%.

It is true, of course, that present-day internal combustion engines are far less efficient than the value calculated above. This is due to *practical* limitations on what type of engines can be constructed economically, a far cry from the theoretical limitation Mr. Smiles complains about.

However, there is an even greater flaw in his argument. This lies in assuming that the efficiency of converting light into electricity by a photovoltaic cell is limited by the same considerations that limit heat engines, when in fact such a cell is not a heat engine. The best analogy in this case is that of a storage battery that is charged and discharged at the same temperature. If heat-engine considerations were applied to this case, the above equation would indicate that E=0, so that no matter how much energy you could transmit to the battery, none would be extracted. However, real storage batteries are 80% to 90% efficient, as is the photocell. There is no *theoretical* reason why the efficiency could not be created as high as desired, although there may be *practical* reasons for not doing so.

DR. HOWARD MARK
Suffern, NY

CABLE TV CONVERTERS

With reference to the Looking Ahead article regarding the problem of cable TV converters used with VTR's, perhaps you'd be interested in a few of the tricks we've come up with to get around the converter hassle.

The first is quite simple: A few of the converter-only channels have harmonics that fall into the standard VHF TV broadcast frequencies, although not, of course, right on top of the existing channels. If you off-tune the fine-tuning adjustment far enough, these harmonics can be received as clearly as on Channels 2–13, without a converter box. Just what can be received this way will vary from cable company to cable company; obviously not all stations can be picked up without the little black box (actually ours is brown). For a start, Channel "1" comes in just off Channel 7. Most color sets and some black-and-white sets have enough range to pull in these extra channels. Presumably, the tuners on VCR's can also receive them (all our VTR's are studio models without integral tuners, so I don't know for sure).

The second trick is a bit more complex: We "borrowed" it from Philips. Here in Canada converters cost around $100 a shot, except for Philips' little black box, which goes for $45. Rather than having a mass of buttons and a varactor tuner, their "converter" is just an oscillator that shifts everything up into the TV's UHF frequency band, where the UHF tuner can sort out the extra channels, much like the front end of a superheterodyne radio. We've built up several circuits to do this, and, of course, they are very simple.

Thank you for the prolific video material you put into **Radio-Electronics.**

STEVE RIMMER
The Underground Tube
Markham, Canada

equipment reports

AP Products Powerace Model 103 Breadboard Systems

THE POWERACE SERIES OF SOLDERLESS BREADboarding systems manufactured by AP Products adds the convenience of combining various built-in power supplies, meters, LED indicators, switches, debouncing circuits, and pulse and clock generators on the basic plug-in matrix boards. If you do a fair amount of IC breadboarding, the usefulness of built-in sources and monitors is well worth their additional cost.

The *model 103 Powerace* includes three fixed-voltage power supplies. The alternative is to use three separate, or even combined, supplies, which, with their bulk and interconnecting leads, add greatly to the cost of a basic breadboarding system and severely restrict its portability.

In the *Powerace model 103*, a slanted control panel contains the data and logic

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switches, power-supply distribution buses, a voltmeter and an ON-OFF switch. The nearly horizontal breadboarding section is a 1680 terminal—a solderless panel composed of two AP Products *Super Strips*.

The *Powerace model 103* has self-contained +5-volt power supplies, plus tracking +15-volt and −15-volt power supplies. Ripple and noise measurements are less than or equal to 10 mV under full load, and load and line regulation is better than 1% for all three power supplies. The 5-volt supply is current-rated to 650 mA, and the 15-volt supplies are rated to 250 mA each. The power supplies are protected with a 1-amp fuse in the transformer primary, and their outputs are brought out to four-terminal distribution buses.

The zero-center, 5% accuracy voltmeter is calibrated from −15 to +15 volts and is wired to a solderless bus strip on the panel. One side of the meter and its corresponding four terminals are wired to the power-supply ground.

Two LED driver/displays (L1 and L2) are mounted on the control panel; each consists of an LED and a single solderless terminal that is used to jumper to the logic points that will be monitored on the breadboard section. Each LED indicator is driven by a Darlington-transistor-connected circuit with an LED current-limiting resistor and a 100K base input resistor. The maximum input drive current is 1 μA.

Two single-pole, double-throw (SPDT) data switches toggle between ground and the 5-volt power supply via an isolation resistor. Each SPDT switch can supply 10 mA, and four-terminal buses are provided for each. Two additional momentary contact Q-$\overline{Q}$ logic switches complete the controls. These SPDT switches toggle ground between the inputs of two 7403 flip-flops. The noninverted and inverted outputs of the two switch-controlled debouncing flip-flops are brought out to four-terminal buses. The flip-flops have a sink capability of 15 mA in the low state, and supply up to 5 mA in the high state.

The breadboard matrix itself uses tie-point blocks with 0.1- × 0.1-inch spacing. Two *Super Strips* are mounted side by side on a metallic ground plane, each strip with 25 five-terminal buses that can be chained to form supply ground feeders. Groups of five interconnected terminals form insertion points for IC's, with a total of 1280 tie points for plugging in circuit components. Nine 14-pin DIP's can fit on the *Super Strips*, which are composed of acetal copolymer. Transistors, resistors, capacitors and diodes can be inserted in the board by bending their leads to the proper spacing. The solderless pins accept solid wire between sizes AWG No. 20 and No. 30.

The *model 103*'s instruction sheet comes complete with schematic and parts list so you know just where you stand in case you try some unconventional hookup. An optional breadboard jumper wire kit (No. 923351 JK1) contains a set of 350 No. 22 wires in 14 lengths—0.1 to 5 inches; the kit sells for $10. The *Powerace model 103* is priced at $124.95. AP Products Incorporated, Box 110-Q, 72 Corwin Drive, Painesville, OH 44077. **R-E**

Simpson Model 462 Digital Multimeter

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SIMPSON ELECTRIC COMPANY (853 DUNDEE Ave., Elgin, IL 60120) has developed a very compact digital multimeter, the *model 462*. This DMM makes all the standard readings: AC/DC volts, ohms, and either AC or DC current, with an accuracy of 0.25% of reading. The display uses 3½-inch-high LED's that are large enough to be read 15 feet away.

Both AC and DC voltages start at a very low 0–200-mV range. The DMM reads DC up to 1000 volts, and AC to 600 volts RMS. The resistance range can be read from 1.0 ohm to 20 megohms, with the lowest resistance range from 0–2000 ohms.

Here comes the handy part: Both voltage ranges *and* the resistance ranges are *autoranging*. You can read any voltage from 0.01 to 1000 VDC without any adjustment; all you have to do is move the test leads! Just "stick 'em on" there and read the meter. Other features include fully automatic decimal-point placement and zeroing. Only the two lowest voltage ranges, 0–200 mV, are not autoranging. The lowest resistance range, however, is autoranging, and is selected by pressing the white AUTO pushbutton. All other ranges are manually selected by pressing one of five grey pushbuttons in the bottom row.

You select the desired reading by pressing one of four black pushbuttons in the top row, marked K-Ohms, mA, 200 mV or V. The AC/DC and ON-OFF switches are push-push controls. All other controls are of the standard latching type; when one is pushed, the other is released. The pushbuttons are spaced far enough apart to allow a normal human fingertip to hit only the one desired. (I've seen earlier-model DMM's where you had to use a darning needle to hit 'em!)

The *model 462* is housed in a neat, compact and insulating plastic case. The test leads are recessed, no bare metal is exposed at all; test prods are also included with the *model 462*. The handles are corrugated with a guard ring, and the points are sharp. The test clips are well insulated; they screw on and won't fall off, which can save you a lot of time fishing them out of tight places in the chassis that you happen to be servicing.

The *model 462* is powered by four heavy-duty type AF NiCad batteries. A special charging unit with a recessed plug comes with the instrument. Fully charged batteries provide eight hours of use. The charger can be left permanently plugged in for bench work. For portable use, just pull the charger plug and take off. For emergencies when the heavy-duty batteries are not available, four AA NiCad batteries can be used, but they will provide only six hours of use.

continued on page 32


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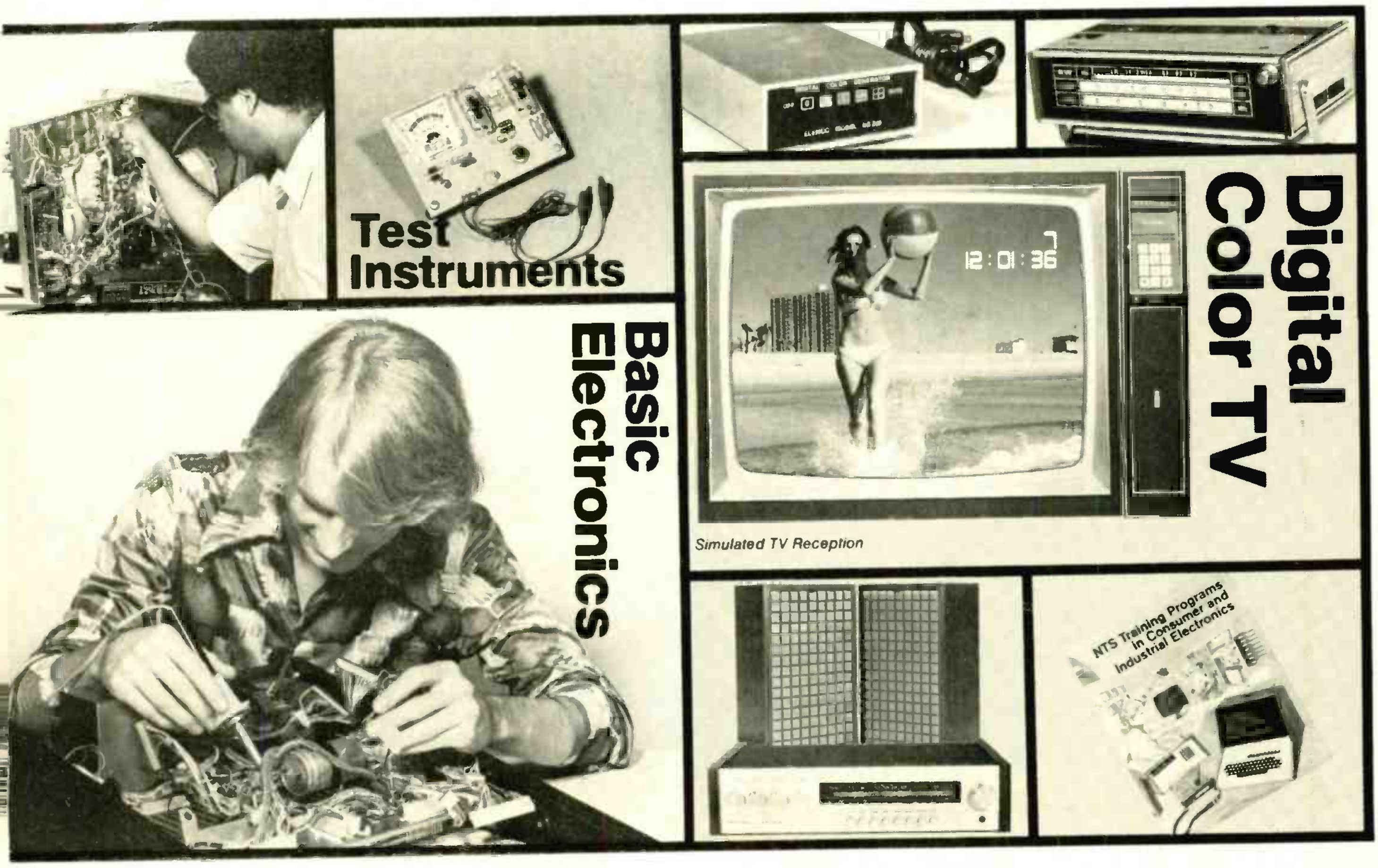

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CIRCLE 2 ON FREE INFORMATION CARD

EQUIPMENT REPORTS

continued from page 26

The *model 462* is well protected against accidental overload. Over-voltage protection is provided to 1000 volts on all autoranging modes and to 650 volts on even the manually selected 0–200-mV ranges. The AC ranges are protected up to 600 volts on the autorange, to 240 volts RMS on the two low ranges, and to 650 volts on the higher ranges. Even the ohmmeter ranges are protected against over-voltage up to 250 VRMS on all ranges. I made the stock AC rejection test, and it came out

EQUIPMENT REPORTS

continued from page 32

4400 words, this means sacrificing some functions, including one of the best—the EDIT command.

For maximum system flexibility and use, two external pieces of hardware are required: an audio cassette recorder, and a separate playback cassette machine. The system also supports a CRT, keyboard and printer.

The text editor, which occupies half of the program space, executes 20 commands. The AUTO command sets up automatic line numbering with user-specified increment size. Text files can be loaded, renumbered, recorded and printed. The RUN command executes an assembled program; the ASSEMBLE command calls the assembler; and the MANUSCRIPT command suppresses line numbers when listing. The EDIT command performs text file searches to change or delete selected alphanumeric characters within specified line-number ranges.

The assembler recognizes labels up to 10 characters long and has five conventional fields: line number, label, mnemonic, operand and comment. Assembly can be performed from the text file that was previously created with the text editor or from tape. Programs longer than available memory storage space are assembled from tape.

The first assembler pass generates the symbolic table (label file) and outputs whatever errors are detectable at that stage. A second pass creates the object file and output listings. An optional third assembler pass creates an object file in relocatable format. A series of 16 pseudo-ops allow you to control assembler features such as continuing assembly in spite of low severity errors, as well as storing data bytes.

There are six listings: First, a hexadecimal dump program that produces a formated object-code output listing. The next four listings are commented source listings, including break detection, motor control, relocating loading and tape loader software. The system is recorded on a cassette tape for easy initialization. The cassette loading program must be performed manually since it prepares the computer to load the editor-assembler tape itself.

The cassette tape, a 24-page manual and the program listings are available for $30 from C. W. Moser, 3239 Linda Drive, Winston-Salem, NC 27106. **R-E**

Hustler Model MOT Monitor Antenna

WITH THE WIDESPREAD USE OF THREE-BAND (low-VHF, high-VHF and UHF) programmable scanners, more and more antenna manufacturers are meeting the demand for compatible three-band monitor antennas. New-tronics Corporation (15800 Commerce Park Drive, Brookpark, OH 44142) has recently introduced the *Hustler model MOT* mobile antenna. The *model MOT* is available only as a trunk-mount unit. It performs well on the three frequency ranges for which it was designed—37–50 MHz, 150–174 MHz and 450–512 MHz.

The *model MOT* comes equipped with 16 feet of RG-58 coaxial cable, and is terminated with a Motorola antenna plug.

The *model MOT* is a center-trap antenna designed to act as a 16-inch one-quarter-wave whip when operating in the high-VHF band, and it automatically couples an additional 18 inches of active length (including resonant trap) when operating in the low-VHF band. The lower 16 inches is used as a three-quarter-wave whip in the UHF band.

The mounting assembly is firmly secured, both mechanically and electrically, to the trunk lid of a car by tightening two Allen-head set screws (a wrench is provided).

Because the entire antenna when mounted measures less than 3 feet, the *model MOT* poses no particular problem when used under normal mobile operating conditions. No tuning or pruning of the antenna is required; it is factory-pretuned.

In our tests, the *model MOT* proved most satisfactory for a low-cost, three-band monitor antenna. Remember that a mobile antenna uses the vehicle body as part of a complete system, and unless the manufacturer's recommended application techniques are not followed closely, the antenna cannot be expected to perform at maximum efficiency.

The antenna comes in a blister package for rack display, with the element separated from the mount. The element is easily installed through a hole in a tightening nut and locked securely in place on the mount by a small wrench (also provided).

The *model MOT* monitoring antenna appears to be well designed and rugged enough to withstand most mobile monitoring applications. It is available for $24.95. **R-E**

SWITCHES CRYSTALS CONNECTORS HEAT SINKS FUSEHOLDERS TEST CLIPS BOOKS KITS DIP JUMPERS CABLE ASSEMBLIES SWITCHES CRYSTALS CONNECTORS HEAT SINKS

INTEGRATED CIRCUITS MICROPROCESSOR LED'S SOCKETS CAPACITORS DIODES TRANSISTORS RESISTORS POTENTIOMETERS

String Synthesizer

An introduction to the latest innovation in electronic music synthesizers. The string synthesizer gives the soloist and small groups the background needed to enhance the performance.

MARVIN JONES

STRING SYNTHESIZERS, AND THEIR RECENT popularity, represent the culmination of over a decade's worth of work in developing and improving electronic music synthesizers. String synthesizers are the first of what we expect will be a long line of special-purpose instruments designed to avoid the clutter of patch cords and a strong technical background required to run the early breeds of synthesizers. Recent surges of interest in guitar and drum synthesizers indicate that these instruments will follow in the string synthesizers' path.

It is very natural that the string synthesizer was the first special-purpose synthesizer to come along. Since the inception of popular music, one of the staples of the "hit record" sound has been the lush, flowing orchestrated backgrounds. Unfortunately, few vocalists and solo musicians do well enough to allow hiring orchestras to perform live. Thus, the lush background was always missing in concerts. Organs helped, but weren't quite the same. Then there's always the problem of being able to afford an orchestra for the recording session in the first place! String synthesizers have changed all that. Now musicians are using these units to perform anything from country music to avant garde, in locations ranging from your neighborhood bar to Madison Square Garden!

Strangely enough, the basic circuitry in a string synthesizer is more a result of combo organ technology than of synthesizer technology. The rich moving sounds they produce are so powerful that most anyone (musician or not) gets a kick out of playing with them. And all the commercially available units use the same basic circuitry to achieve the effect of violins and cellos 'en masse.'

This article will describe how to build a professional-quality string synthesizer, but first let's take a look at how these magical machines are used, and then discuss how the circuitry works. The model 1550 synthesizer is of particular interest since it is available in kit form as well as assembled, and there are a number of options available such as stereo outputs and a microprocessor interface card. The instrument also produces a percussive electric-piano voicing.

How it is used

The majority of the features on string synthesizers can be found on the front

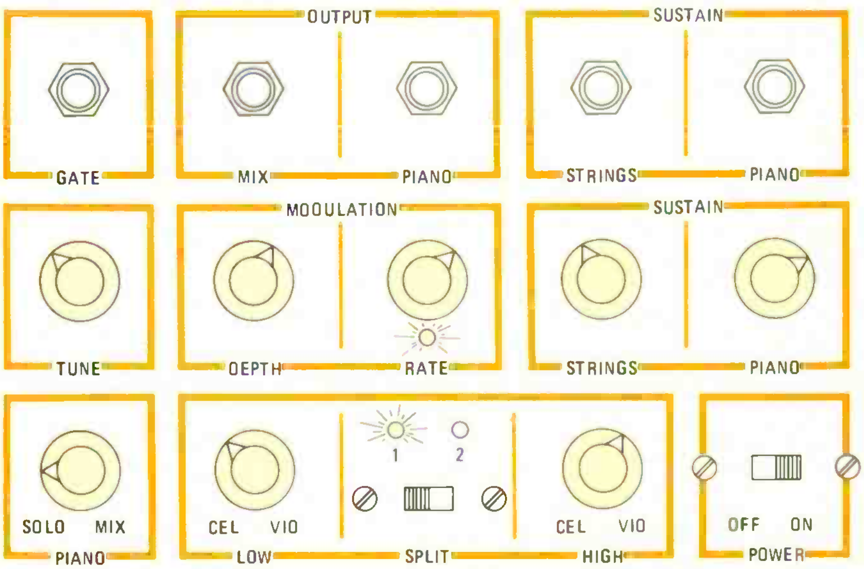


FIG. 1—LAYOUT OF THE CONTROL PANEL. It is operated with the left hand. Five jacks are provided for output and interfacing connections.

panel of the instrument. The front panel of the model 1550 is shown in Fig. 1. All connection points for outputs and interfacing are in the top row of the panel, and are provided via five ¼-inch phone jacks. The bottom two rows of the panel provide the multiple user controls which alter and mix the various voices of this instrument.

The GATE jack provides a voltage which steps from 0 to about +9 volts whenever a key is pressed on the keyboard. This allows the instrument to trigger external effects or processing equipment such as synthesizer modules. Many of the standard synthesizers manufactured today have an array of "systems interfacing" jacks to allow external signals to be processed and become the basis for more complex sounds with polyphonic synthesizer textures. When string synthesizers are used in this way, it is easy to synthesize "brass" sounds, and other special effects using the circuitry inside the synthesizer in conjunction with the string synthesizer.

There are two signal outputs on the stock synthesizer. The first is the MIX output, or the master output. At this jack will appear the sustained string voices plus a variable mix of the electric piano sound. The second output provides only the PIANO signal. This output is useful if you wish to use separate mixing, equalization, or special effects for the two different voicings. When using a standard ¼-inch 2-conductor phone plug in the PIANO jack, the piano signal is automatically removed from the composite signal at the MIX jack. This allows complete separation of the two types of signals if desired. Alternatively, you could use a ¼-inch 3-conductor phone plug which has no connection made to the ring section of the plug. The piano signal will appear now at both output jacks, with the user selecting either or both outputs with the PIANO mix control (explained later).

The SUSTAIN jacks allow provisions for remote control of the amount of time it takes for a signal to fade out once the key is released. For those of you familiar with synthesizer terminology, this would actually relate to the "release" control on an ADSR (*A*ttack, *D*elay, *S*ustain, *R*elease) envelope generator. Note that there are separate, fully variable sustain controls for each of the two types of signals—string and piano. Some commercial units have only a long/short sustain switch, or no control at all. The most common use of the sustain jacks will be for sustain foot switches, which will operate much like the sustain pedal on an acoustic piano. When the two conductors of the jack are shorted together, the front panel sustain control will operate normally to set the minimum sustain time. When the foot switch contacts are opened, the sustain time increases to maximum as though the front panel control were turned to maximum. For the foot switch itself, a normally

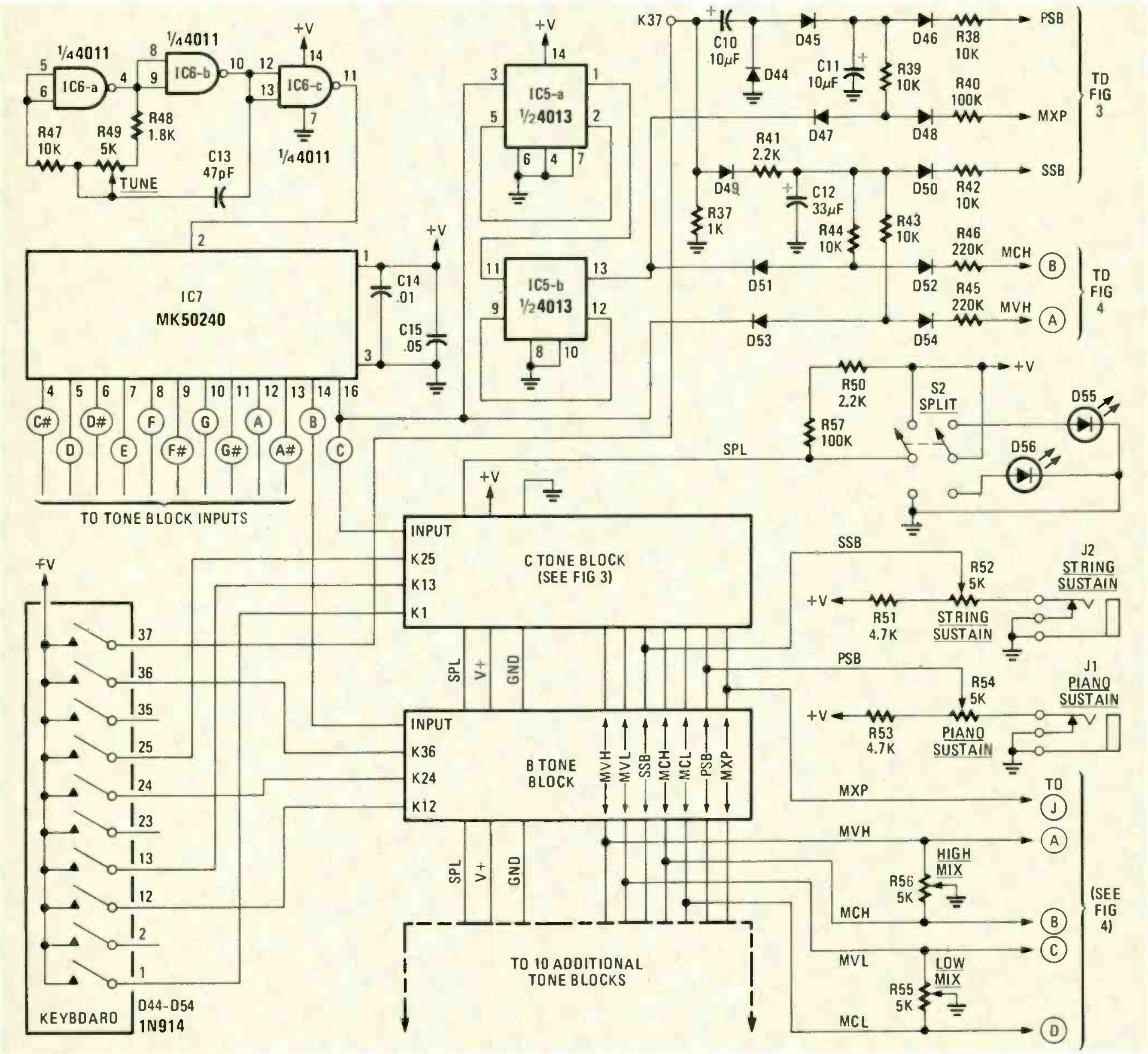


FIG. 2—BASIC SCHEMATIC for the main section. This circuit contains the twelve identical tone blocks that develop the shaping, keying and mixing for the three octaves of each note.

closed momentary-contact switch can be used to provide action similar to acoustic piano sustain pedals, or a positive contact switch can be used to provide push-on, push-off sustain control action.

Internal design of the model 1550 synthesizer allows for use of variable foot pedals (such as pedal volume control voltage (0 to +5 volts) to remotely program the sustain times for either of the voices. This allows all the versatility of the front panel controls without requiring the musician to remove his hands from the keyboard.

The TUNE control is fairly standard. It allows the instrument to be tuned to other instruments, yet provides a full octave of transposition so you can extend the range of the instrument for special compositions. With a little practice, the TUNE control can even be used as a performance device, allowing orchestral glides or pitch blends for special effects.

Perhaps the most important and powerful controls on the model 1550 (or any string synthesizer) are those controls that allow the user to modify the operation of the chorusing and vibrato circuits. These controls are important in allowing each musician to alter the basic string sound to suit musical requirements or individual tastes. Unfortunately, this is where many commercial units fall short in the eyes of musicians. The chorusing circuitry is responsible for taking the single "reedy" voice of the organ circuitry and making it sound as if there are a great number of simultaneous voices occurring. This effect is obtained by using analog delay lines to generate two "echoes" of the original signal. The time delay is so short (constantly varying between 0.5 ms and 20 ms) that it is not heard as a distinct echo. Rather, it appears as if there is another instrument playing in unison with the original voice. With two delay lines, we can generate three-voice chorusing which is sufficient to confuse the human ear into believing it is hearing a large number of voices. By now you should see why this circuitry is so important to the effective generation of orchestral effects.

This synthesizer provides two controls for user alteration of chorusing effects. DEPTH determines the amount of chorusing in the effect. At minimum setting, there is no frequency modulation occurring at all, yielding a bland reed-organ voice. This would be useful for basic combo organ effects, or for external processing as mentioned earlier. As the DEPTH control is advanced, the two delayed voices are frequency modulated by an increasing amount. At approximate mid-rotation, the typical string chorus with vibrato is achieved. Further rotation of the control creates very heavy vibrato and pitch deviations of about a semi-tone for special effects.

The RATE control varies the speed of pitch fluctuations (vibrato) in the chorusing circuitry. At minimum, the vibrato is so slow that it is not heard as actual pitch variations but as a rich, ethereal rolling effect similar to several phase shifters or flangers sweeping simultaneously. This control setting provides a thick pipe-organ effect that is actually spine-tingling! As it is advanced, the vibrato rate increases through normal settings to fast quivering vibrato for special effects. The adjacent LED indicates the speed of one of the low-frequency vibrato oscillators for use as a visual guide of control settings when you are on stage or in the studio.

The PIANO SOLO/MIX control is used to send the piano voice to either the master MIX output, or to the solo PIANO output. The control acts as a panning control, so the signal can be applied to the two outputs in any blend. When using only the MIX output, the PIANO control will act as a volume control for the amount of piano signal available in the master mix. When a standard 2-conductor ¼-inch plug is used to carry the piano signal from the PIANO jack, the piano signal is disabled from the MIX jack and the PIANO MIX control will act as a volume control for the amount of signal appearing at the PIANO jack. When a 3-conductor plug is used (with no connection to the ring) for the piano output, the PIANO MIX control acts as a panning control to send variable amounts of piano signal to the two outputs. Interesting stereo imaging effects can be obtained with this configuration.

The large box of controls centered in the bottom of the panel is used to design the string voicing you desire. The SPLIT switch is used to select the point at which the keyboard can be divided. At position 1, the keyboard voicing will be split at the first octave. In position 2, the keyboard will split at the second octave. LED's show the selected split location at a glance. Once the split function is selected, the LOW mix control will set the desired blend of violins and cellos for all keys *below* the selected split position. The performer can select violins only, cellos only, or any combination of the two. It should be mentioned here that the cellos are 2 octaves lower than the violins.

The HIGH mix control serves a similar function for all keys *above* the selected keyboard split point. With these controls, you can easily configure the keyboard for the type of music you will be playing. For example, if the composition uses simple droning cello parts, but a violin part that moves and jumps over a wide range, then you would set the split switch for the first octave, and set the LOW mix for cellos and HIGH mix for violins. An infinite variety of voicings are available with these controls. The string mix and split controls take on added power when the stereo output is added to the unit. With the option installed, the selected split location can also become the point at which the stereo effect is split. Or, in an alternate stereo operation mode, the violins can be routed to one side and cellos to the other side. In this mode, the LOW and HIGH mix controls are instrumental in determining the "width" of the stereo effect by determining the violin/cello content of each half of the keyboard.

How it works

The schematic for the main circuit is shown in Fig. 2. Three of the four gates in IC6 generate a high-frequency clock signal (around 1 MHz.) This clock signal is applied to the Top-Octave Generator, IC7, where it is divided by the twelve integers required to produce the twelve equally tempered frequencies of a scale. These frequencies will be divided into the lower octaves inside each of their respective tone blocks. Since the keyboard used in this synthesizer is actually 3 octaves plus one note (the highest "C"), additional circuitry must be provided for the tone generation of that extra note.

IC5 and associated resistors, capacitors, and diodes provide this function. This circuitry works exactly like the circuitry in the Tone Blocks, and will be discussed later. The additional circuitry in Fig. 2 shows the operation of the various front panel controls. The SPLIT switch, S2, generates a high (+V) or low (ground) logic signal which represents a high or low keyboard split location, respectively. The second section of S2 controls the LED SPLIT function indicators. Sustain controls, R52 and R54, generate control voltages that are variable from 0 to about +5 volts.

The selected control voltage is applied to the buses that run along the edge of the tone block circuit boards. Thus, this voltage is a master control that effects the sustain time of all thirty-seven notes of the keyboard. The sustain jacks, J1 and J2, provide an interrupt function for the sustain control voltage. When a plug is inserted into a jack, the voltage on that sustain bus can be remotely varied or switched (shunted) for variable sustain function. The MVH, MVL, MCH and MLH string voice signal buses (*M*ix *V*iolins *H*igh, *M*ix *V*iolins *L*ow, *M*ix *C*ellos *H*igh, and *M*ix *C*ellos *L*ow) are applied to mix controls, R55 and R56.

With these controls, the signals can be shunted to ground in the desired proportions. The resulting mixtures of string voices, as well as the raw piano-bus signal, is fed to additional circuitry for final processing.

In Fig. 2, also note that +V is applied to the common bus of the keyboard, and depression of any key provides, in effect, a logic signal to the tone block circuitry. A positive voltage designates a key being played. The open circuit of a released key is pulled back to ground by an input pull down resistor at each keying input of each tone block. Master buses running throughout the tone blocks also distribute +V, ground, and the split logic signal.

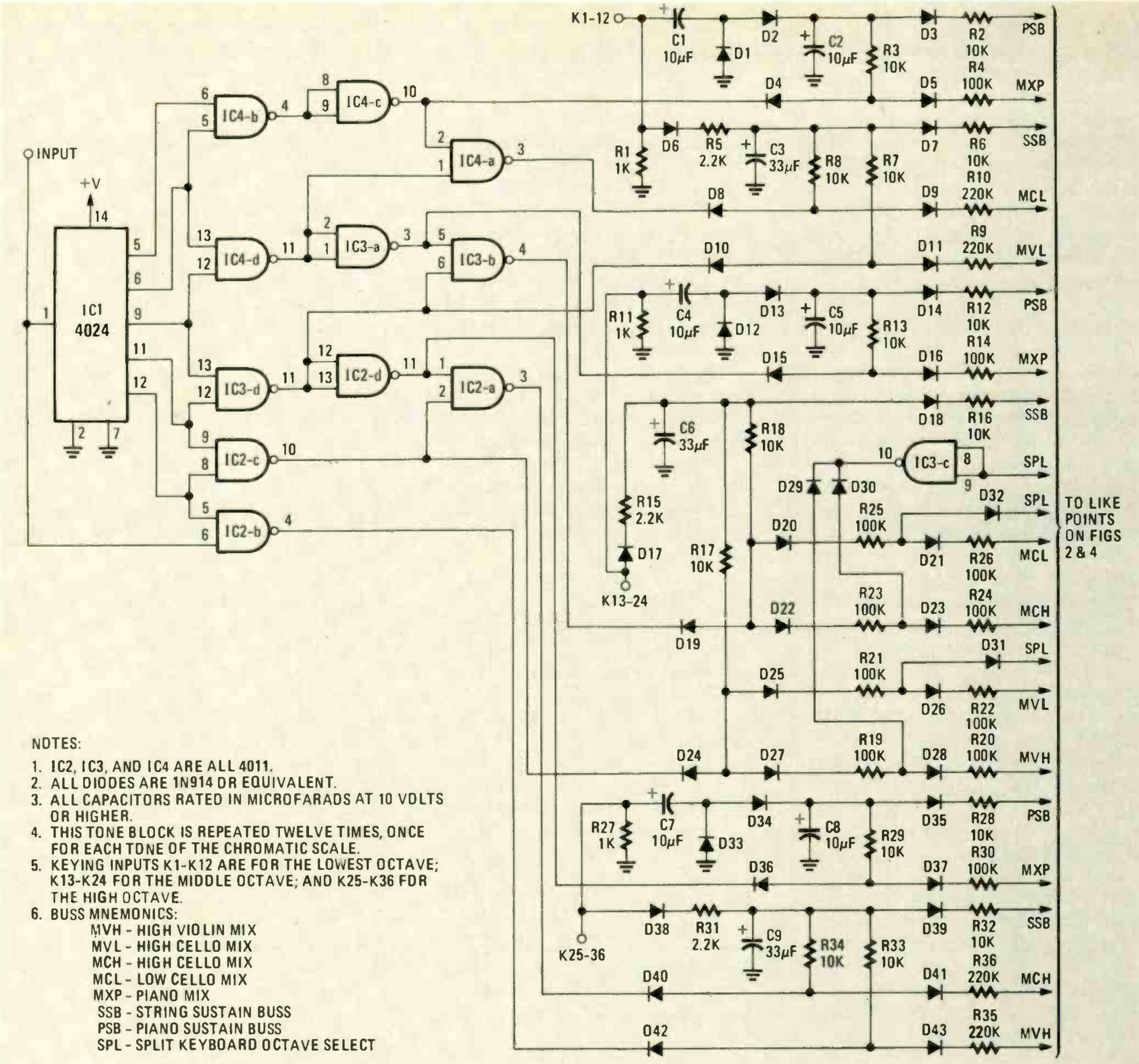


FIG. 3—CIRCUIT OF ONE OF THE TWELVE TONE BLOCKS. These identical circuits provide the necessary waveshaping, keying and mixing for all notes. The mixing and chorusing circuit (Fig. 4) will be presented next month.

The circuitry for one of the twelve tone blocks is shown in Fig. 3. This circuitry generates the waveshaping, keying, and mixing for three octaves of any chromatic note. The twelve tone blocks are identical and all are contained on two large PC boards in addition to the top octave and highest "C" circuitry discussed in the main schematic.

The whole process begins with the input of a high-pitched squarewave from the top-octave generator. This waveform switches between +V and ground, and directly drives the input of the tone block circuitry. IC1 is a 4024 7-stage counter which divides the input frequency into lower octaves. Only the first five divisions, plus the original input, will be used. The first bank of NAND gates (IC4-b and -d, IC3-d and IC2-b and -c) are driven by the counter and used to convert the squarewave signals to pulse waves with a 25% duty cycle.

The harmonic content of this type waveform more closely approximates the sound of a violin. The high-octave violin signal is obtained at pin 4 of IC2-b, while the middle-octave violin appears at pin 10 of IC2-c, and the low violin at pin 11 of IC3-d. The three lowest octaves of NAND gate outputs are additionally fed through inverters consisting of IC4-c, IC3-a, and IC2-d. This inversion maintains proper phase relationships so the remaining waveshaping circuit will operate correctly.

Immediately after inversion, these waveforms are selected for use as the piano signal. At this point, these waveforms still have a 25% duty cycle. Finally, NAND gates IC4-a, IC3-b, and IC2-a are used to mix the inverted waveform with the non-inverted waveform which originated one octave higher. The result is a pulse wave with a 12.5% duty cycle. The extremely wide harmonic spacing occurring in this waveform very closely approximates a cello waveform, and is consequently used as the signal source for this voicing.

The remaining keying and mixing circuitry is roughly divided into three sections, one for each octave that will be keyed by the keyboard. Additionally, each of these three sections is further divided into a section for strings and another for the piano effect. The input terminal labelled K1–K12 is the lowest octave keying input. NOTE that there is actually only one input at this point to each tone block. However, this one point will be labelled differently for each chromatic tone block. For example: K1 will be in the "C" tone block, K2 in the "C♯" tone block, and so on through K12 in the "B" tone block.

When a key is depressed, the keying input jumps to a positive voltage. The first thing to happen is the piano keying.

PARTS LIST

The following lists the components according to type and quantity and is included as an aid to help you acquire the parts necessary to build the model 1550.

Resistors—¼-watt, 10% unless otherwise noted

5—10 ohms
1—100 ohms
5—470 ohms
46—1000 ohms
1—1800 ohms
37—2200 ohms
6—2700 ohms
6—4700 ohms
1—8200 ohms
205—10,000 ohms
1—15,000 ohms
3—22,000 ohms
147—100,000 ohms
50—220,000 ohms
1—170,000 ohms

Potentiometers

2—100 ohms, trimmer
5—1000 ohms, trimmer
1—50,000 ohms, trimmer
7—5000 ohms, linear taper
1—100,000 ohms, dual-section, linear taper

Capacitors

1—47 pF disc ceramic
2—100 pF disc ceramic
1—500 pF disc ceramic
10—.001 µF disc ceramic
3—.01 µF disc ceramic
7—.05 µF disc ceramic
1—0.1 µF Mylar
12—1 µF, 10 volts, electrolytic
2—2.2 µF, 10 volts, electrolytic
4—5 µF, 10 volts, electrolytic
82—10 µF, 10 volts, electrolytic
37—33 µF, 10 volts, electrolytic
1—250 µF, 20 volts, electrolytic
1—1000 µF, 20 volts, electrolytic

Semiconductors

12—CD4024 7-stage divider (RCA, National, Motorola)
37—CD4011 quad NAND gate (RCA, Motorola, National)
1—MK50240 top-octave generator (Mostek, AMI)
2—CD4013 Dual D-type flip-flop (Motorola, National, RCA)
1—7805 positive 5-volts regulator (Motorola, National, Signetics)
1—7905 negative 5-volts regulator (Motorola, National, Signetics)
1—CA3080 transconductance amplifier (RCA)
2—SAD-1-24 analog delay line (Reticon)
4—566 voltage-controlled oscillator (Signetics, National)
4—2N5139 or similar NPN transistor
1—2N5129, 2N3904 or similar PNP transistor
4—1N4003 rectifier diodes
527—1N914 silicon switching diode
3—TIL209 red light-emitting diode

Miscellaneous

1—power transformer, 24 VCT, 1A
40—flea clips
2—socket, 16-pin DIP (for SAD-1024's)
control knobs, mounting hardware, case, line cord, etc.

Note: The following are available from Paia Electronics, 1020 W. Wilshire, Oklahoma City, OK 73116:
1550A PC board $30.00 postpaid
1550B PC board $30.00 postpaid
1550C PC board $10.00 postpaid
1550LED PC board $2.00 postpaid
(All boards are etched, drilled and screened with parts placement layout.)
Set of four PC boards $70.00 postpaid
A 37-note (3-octave) organ keyboard (Order No. AGO-37) $60.00 plus $5.00 postage and handling
Complete kit of parts including case, keyboard and step-by-step instructions (Order No. 1550) $295.00 shipped freight collect
Fully assembled unit (order No. 1550AS) $600.00 freight collect.

The positive step-voltage that is dropped across R1 is differentiated by C1. The positive spike generated is sufficient to forward bias D2 and dump a charge on C2. Simultaneously, C1 is charging to absorb that +V which has been applied to it. By the time the positive charging spike for C2 falls and C1 has a full charge, D2 has become reverse biased, eliminating the front end of this circuit as a possible discharge path for the charge on C2. The only possible discharge is through R3 and R4 to the virtual ground of the piano mix bus (MXP). This R—C combination (R3, R4, C2) sets the maximum sustain time for the piano signal.

To get a variable amount of shorter sustain time, the voltage on the piano sustain bus (PSB) can be lowered from about +5 volts to ground with the front panel control. If this bus is anywhere lower than the peak charge of C2 (about +5 volts), D3 becomes forward biased, offering C2 a lower impedance discharge path through R2. This causes the charge on C2 to fall more rapidly than normal thus making the sustain time shorter. When the key is released, the drop in keying voltage across R1 causes a negative spike to be generated by C1. Diode D1 becomes forward-biased by the spike and shorts it to ground. Resistor R1 will then serve to quickly discharge C1, preparing the piano keying circuit for the next key depression.

The only remaining section of the piano circuit is the signal-gating (envelope or amplitude contour) circuitry built around D4 and D5. This circuit is the standard diode-keying configuration that has been used in electronic organs for quite some time. The pulse wave being used as the piano-signal source is being continuously applied to the cathode of D4. While the piano circuit is at rest, C2 is discharged leaving the anode of D4 at ground. This leaves D4 continuously reverse-biased and stops any signal transmission through it. When a key is pressed, a pattern of rising and falling DC voltage is generated across C2 as described earlier. This voltage will now forward bias D4 and allow the piano signal to pass. When the piano signal happens to be at a high level (the top of the pulse wave), the voltage at the junction of D4 and D5 will be pulled up to a DC voltage equivalent to the charge remaining on C2. When the piano pulse wave switches to a low level (near ground), D4 conducts and the junction of D4 and D5 will be pulled nearly to ground.

This high-speed (audio frequency) switching continues until the C2 charge has been depleted via the discharge path through R3 and R4. From the previous discussion, we see that the charge on C2 has a sharp increase followed by a long decay. The audio signal passed through D4 and D5 takes on the same attack and decay characteristics, thus duplicating the effect of a plucked or hammered piano string.

Diode D5 is used primarily to avoid interaction with other notes which may be simultaneously applied to the audio mix buses. In addition to being one of the major determinants of the timing for the piano effect, R4 is also used as a mixing resistor and gain-setting component for this one piano note.

The same low-octave keying input we have been discussing for the piano circuits will also be used to gate a violin and cello sound at the same time. The keying voltage applied to R1 will forward bias D6 and cause C3 to charge via R5. The larger value of C3 and the current limiting of R5 cause C3 to charge more slowly, generating a "softer" attack, to more closely imitate the build-up that occurs when a section of strings bows a new note. This DC voltage is concurrently applied to two diode keying sections. Resistor R8, D8, and D9 are used to gate the low-octave cello signal being applied to D8. Resistor R7, D10, and D11 impose envelope control on the violin signal.

The entire keying section for the top octave of the tone block is identical to the circuitry we have just covered. The high-octave keying inputs are K25 through K36, and the high-octave signal sources are tapped from higher frequency outputs of the NAND gate waveshaping circuit. Also, the violin and cello outputs from the high-octave keying are permanently connected to the high-violin and cello-mix buses. Otherwise, the circuits are the same.

Next month we will discuss the power supply and the middle-octave mixing and chorusing circuits and then go on to construction details. This will include foil patterns for the PC boards and diagrams showing parts placement. **R-E**

BUILD THIS

Solar Tracking System

Solar-energy collectors work best when constantly oriented to trap the most energy from the sun. This electronic servo system swivels the collector panel so it follows the sun across the sky.

RODNEY A. KREUTER

THE MOST COMMON USES FOR SOLAR energy systems today are space heating and hot-water preheating. These systems generally use nonmovable flat-plate collectors; and for a low-temperature system, flat plate is probably the best choice. If, however, your system needs high-temperature water or steam, or uses solar cells to generate electricity, a tracking system is the only way to go.

A solar tracking system consists of a motor-sensor combination that locates the sun and points a collector toward it. A non-sensing system can even be built using a constant speed motor, but such a system has more disadvantages than advantages.

The solar collector tracking system discussed in this article is intended as a guide, not as an absolute system. (For example, why track the sun if there is little or no energy to be gained?) We'll examine how to construct a simple circuit using a comparator that will not let the motor operate until a certain level of sunlight is present.

The basic system

Figure 1 shows a block diagram of the solar tracking system, which consists of four basic modules: 1) a pair of phototransistor sensors; 2) a difference amplifier; 3) a deadband amplifier; and 4) a servomotor and motor drive transistors.

Figure 2 shows how the phototransistor sensor is constructed. Note that the phototransistors are mounted on perpendicular surfaces so that a shadow effect occurs when the sun is not directly overhead.

The difference amplifier (see Fig. 1) subtracts the output of sensor B from the output of sensor A and multiplies the result by about 4.7.

The deadband amplifier is a fairly unique device. It amplifies the output of the difference amplifier by about 2.5 only if the output of the difference amplifier is greater than 0.6 volt

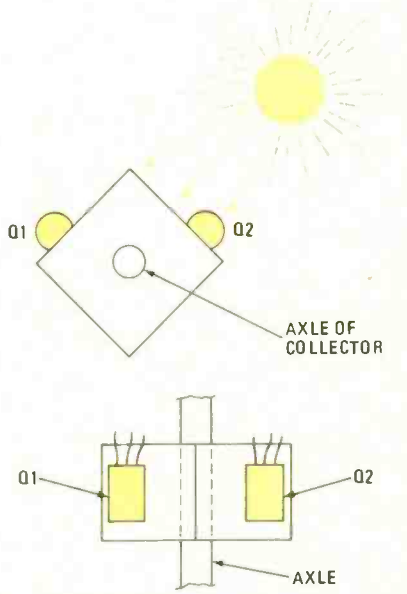


FIG. 2—PHOTOTRANSISTOR SENSORS are mounted at right angles to each other. The output of the sensors are equal when the sun is directly over the apex.

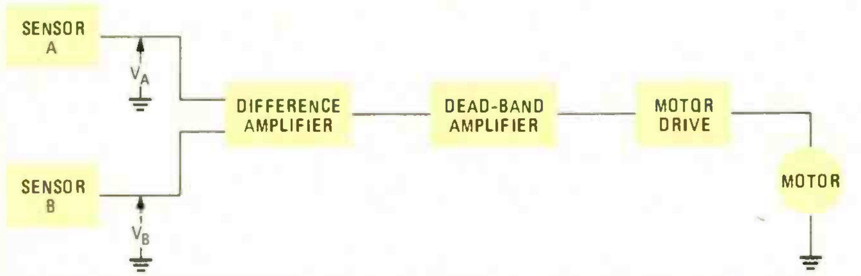


FIG. 1—SOLAR TRACKING SYSTEM uses phototransistor sensors to detect the position of the sun. Circuitry drives motor to position solar energy panels and minimize the difference in output from the two sensors.

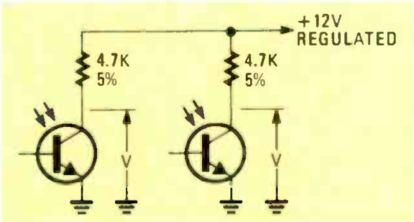
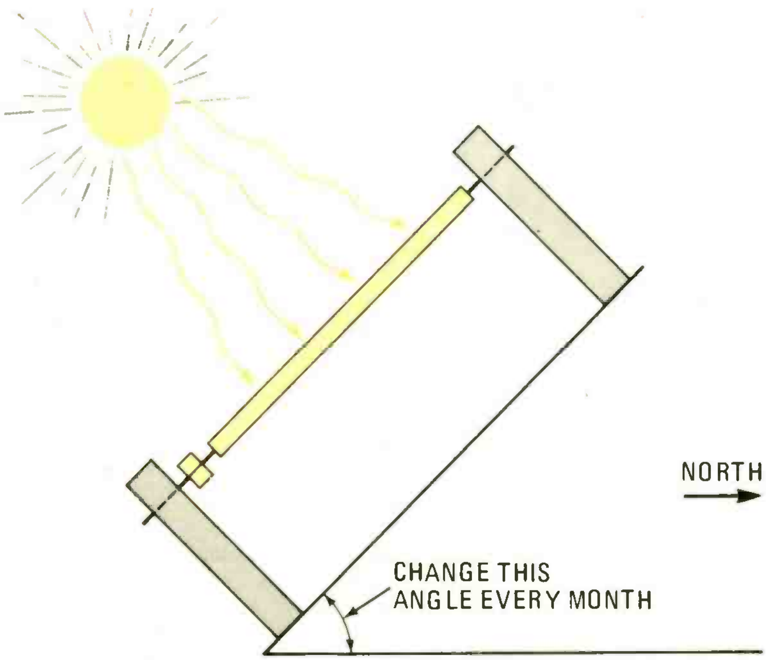


FIG. 3—PHOTOTRANSISTOR SENSORS must have matched outputs for correct circuit operation. Circuit above provides easy method for obtaining matched outputs.



or less than −0.6 volt. If the output of the difference amplifier is between −0.6 volt and 0.6 volt, the deadband amplifier provides a stable zero volt output.

The servomotor drive circuit consists of four push-pull Darlington connected transistors, which produce enough current to drive a fair-sized 12-volt motor.

Circuit operation

Two phototransistors are used as brightness sensors. When operated from a constant-voltage power supply, the collector current of each transistor is proportional to the amount of illumination they receive. Due to variations in manufacturing processes, the phototransistors may not be well matched, so it is a good idea to buy a few extra phototransistors and match them yourself. The procedure is very simple.

First, breadboard the circuit shown in Fig. 3. Place two phototransistors side by side with the flat side down. Shine a *diffused* light source (a handkerchief placed over a bare high-intensity bulb will do) on the transistors. Note that the base connection is not used.

Apply power to the circuit and measure the voltage from one of the collectors to ground; this will be your reference transistor. Adjust the distance of the light source so that the reference voltage reads about 3. Measure the collector voltage of the second transistor and write it down. Repeat this procedure with a reference voltage of 6 and 9, measuring all the transistors against the same reference transistor. Select the two transistors that give the closest results for your sensors.

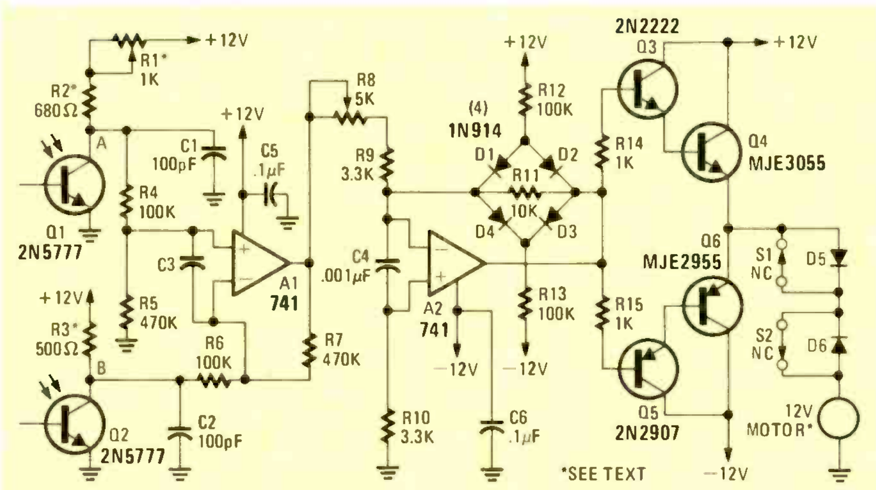


FIG. 4—CIRCUITRY detects difference in output from phototransistor sensors and switches the Darlington motor-drive transistors to minimize the difference.

PARTS LIST

All resistors ½ watt, 10%.
R1—1000 ohms (to start—see text)
R2—680 ohms (to start—see text)
R3—500-ohm trimmer (to start—see text)
R4, R6, R12, R13—100,000 ohms
R5, R7—470,000 ohms
R8—5000-ohm trimmer
R9, R10—3300 ohms
R11—10,000 ohms
R14, R15—1000 ohms
C1-C4—0.0001 µF
C5, C6—0.1 µF
D1-D4—1N914
D5, D6—50-volt rectifiers (current rating depends on motor current)
Q1, Q2—2N5777 photodarlington or equal
Q3—2N2222
Q4—MJE3055
Q5—2N2907
Q6—MJE2955
A1, A2—Op-amps, dual 741, 1558, 747, two 741's, two 301's, etc. Pin numbers depend on type and case style; 3900 or 324 types not recommended.
S1, S2—Normally closed switches
M1—12-volt reversible motor
Misc.—Power supply, case, shielded cable for sensors, etc.

This matching may sound confusing but remember, you need two transistors that will give equal output voltages when illuminated equally. Small variations can be compensated for by the circuit, so it's not critical if the transistors are not matched exactly.

Figure 4 shows the schematic diagram of the tracking system. Difference amplifier A1 is fairly straightforward. Its output can vary from about −11 to 11 volts. The output polarity determines the direction the collector must move and the magnitude determines how far it must move. The whole idea is to move the collector and sensors so that the two phototransistors are equally illuminated by the sun. This condition occurs when the outputs from the two phototransistors are equal.

In electronics, two voltages are almost never equal for any period of time. I learned this the hard way by trying to get a simple comparator to output zero volts when the two input voltages were "equal." I didn't take drift into account.

The deadband circuit is an "almost equal" circuit. If the output of the difference amplifier is almost zero (meaning the two sensor outputs are almost equal), the output of the deadband amplifier will be zero. If the output of the difference amplifier exceeds the "deadband range," the output of the deadband amplifier heads for the rails (positive or negative saturation, in this case −12 or 12 volts). The amount of deadband output is adjustable by R8, and, with the values shown, can vary from about ±0.37 volt to ±0.95 volt.

Transistors Q3–Q6 are used as current amplifiers since the output of the op-amp cannot drive a motor directly. Almost any transistor types can be used as long as they can handle the motor current.

Normally closed switches S1 and S2 are placed at the two travel limits of the collector. When the collector reaches one of these limits, a switch opens, and this places a diode in the motor's current path. If the motor and diodes are connected correctly, this will prevent the collector from moving any farther in this direction but will allow the motor to reverse the current. You may have to reverse the polarity of both diodes depending on the type motor used.

Construction

Since only one IC is used for the tracking system, almost any type of construction is possible, including PC or perforated board construction and the component layout is not critical.

Heat-sink output transistors Q4 and Q6 if your motor draws more than 500 mA.

Use trimmers for R1 and R8 since they are only set once.

Mount the sensors on the axle of the collector, not on the collector itself. Mounting them on the collector would cause the collector to overshadow the sensors in the morning (see Fig. 5). Paint the area around the sensors with flat black paint so that they will not respond to reflections.

Use a 12-volt reversible motor that draws less than approximately 6 amps with the transistors shown. The power supply must be able to handle the total motor load so make sure it is sized accordingly. It's a good idea to provide the final transistors with their own unregulated power supply, and the rest of the circuit should have a regulated 12-volt supply. The total current drawn by the op-amps is negligible, so a pair of Zener diodes should be adequate.

The motor should be geared down so that running flat out, the collector takes about 10 minutes to travel from one limit to the other. A small motor geared down as much as this will move a fair-sized collector.

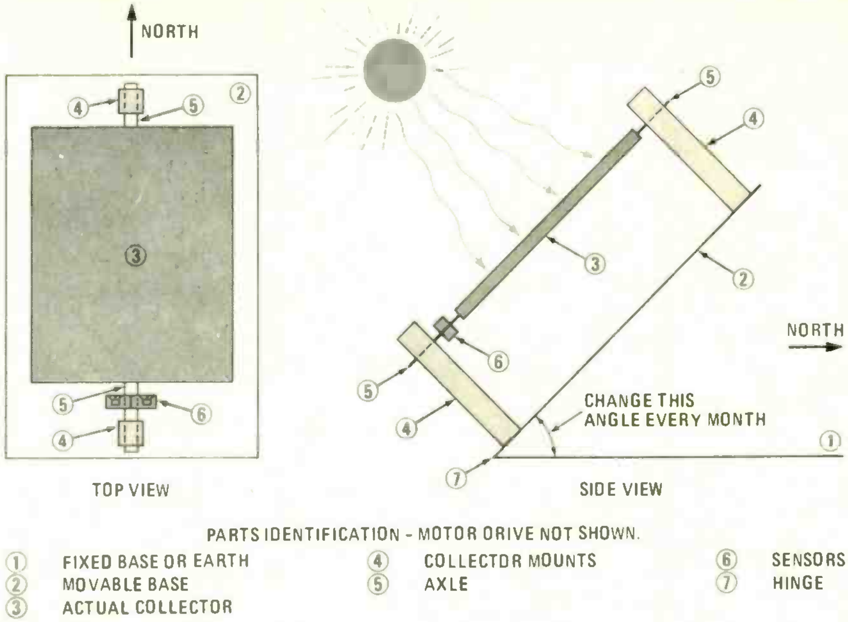


FIG. 5—SENSOR UNIT is correctly mounted on the axis of the solar energy panels.

Adjustments

Since the angle of the sun changes very slowly throughout the year, changing the angle of the collector once a month should be sufficient.

For the following electrical adjustments you will need: a bright sunny day; the circuit described in this article and a geared-down motor connected to a collector-sensor; a VOM; and a 12-volt bipolar power supply.

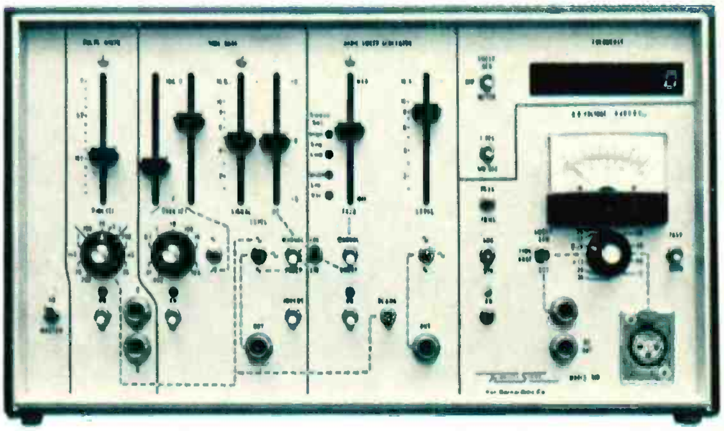
With the collector and sensors pointed *directly* at the sun and the motor disconnected, measure the output of the two sensors. Resistors R1, R2 and R3 may have to be changed to compensate for transistor variations. Even though they should be matched, the light current can vary by a factor of 100. For example, with a white light source of 2 mw-per-cm² falling on a 2N5777, the collector current can vary from 0.5 mA to 50 mA. (Remember that while you are testing, the sun is moving, so you must keep the collector pointed directly at the sun.)

Select an R3 resistor that will yield an output of about 3 volts with a bright sun. Raising the resistance will drop the voltage. Resistor R2 should equal about 70% of resistor R3 and resistor R1 about 60%; use the closest standard values.

After selecting R1, R2 and R3, point the sensors directly at the sun again and measure V_a and V_b. Adjust R1 until these values are equal, and connect the motor.

The setting of R8 determines how far the sun must move before the tracking system compensates for the movement. Your system requirements will determine your choice. If the system seems to "hunt," increase the setting of R8. **R-E**

Audio Test Station



Part 2—A host of precision instruments are required if you want to put high-quality audio equipment through its paces. This month we cover the test station's power supply and timebase circuits.

RAY DAVISON

THIS, THE SECOND ARTICLE DESCRIBING Fidelity Sound's *model 101* Audio Test System describes the power supply and timebase circuits and presents the construction details for these sections. Last month, we presented the overall block diagram and described the general operation of the model 101.

The traditional straightforward and largely self-explanatory power-supply circuit is shown in Fig. 3. The timebase and audio-generator output amplifiers are supplied by single-stage regulated supply. The rest of the analog circuitry is double-regulated. The pulse and counter sections have individual regulators. The diode/R-C circuits coming directly from the secondary of the transformer provide the trigger for the counter timebase.

The timebase circuit is shown in Fig. 4. The basis of this section is oscillator IC201. It is an emitter-coupled multivibrator that can be considered as an integrator and a comparator in a closed loop. The output of the comparator will always be one of two possible voltages. The output of the integrator will be a straight line whose slope is a function of the

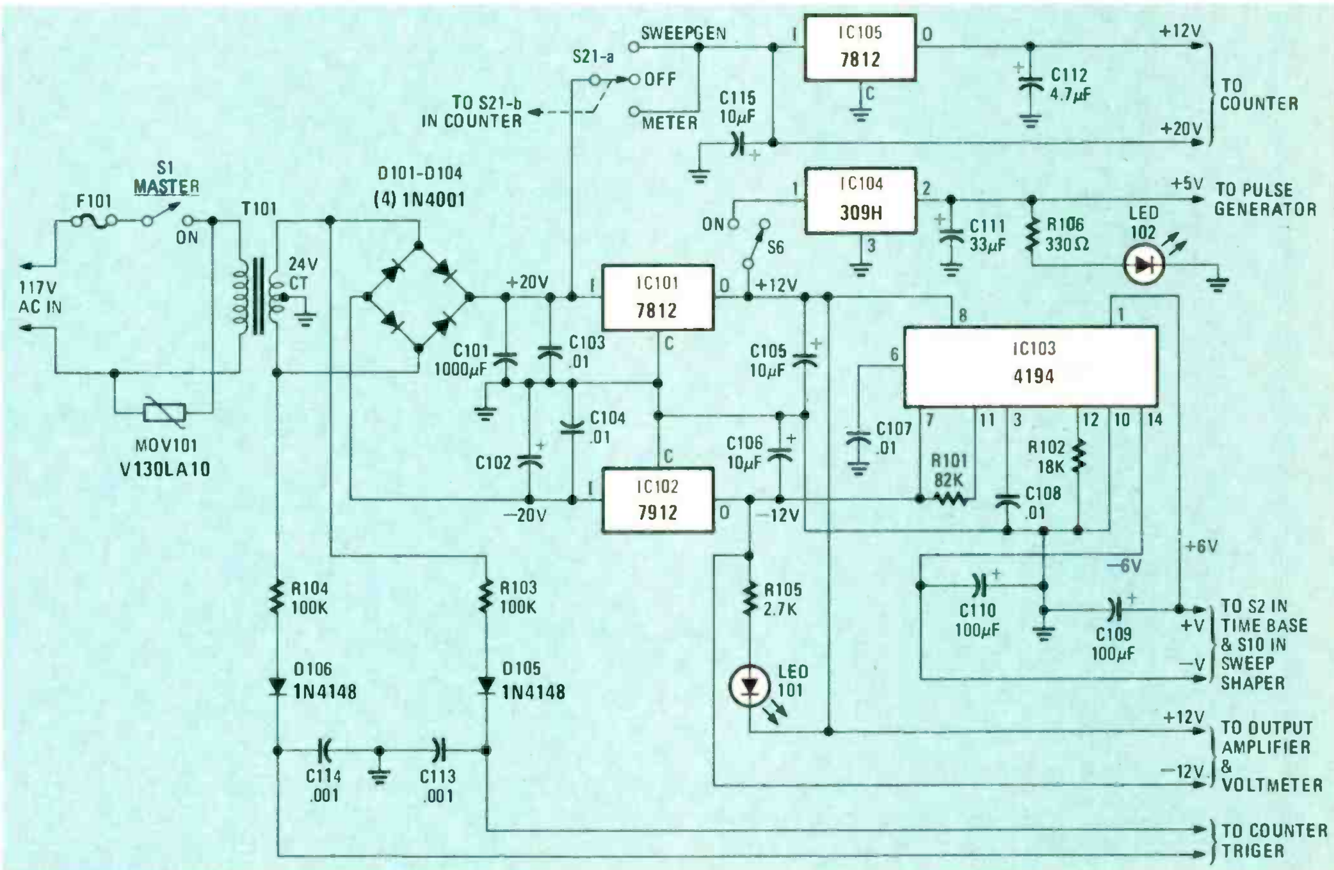


FIG. 3—THE POWER SUPPLY delivers all the operating voltages required by the various internal circuits. Some supply sources are double-regulated.

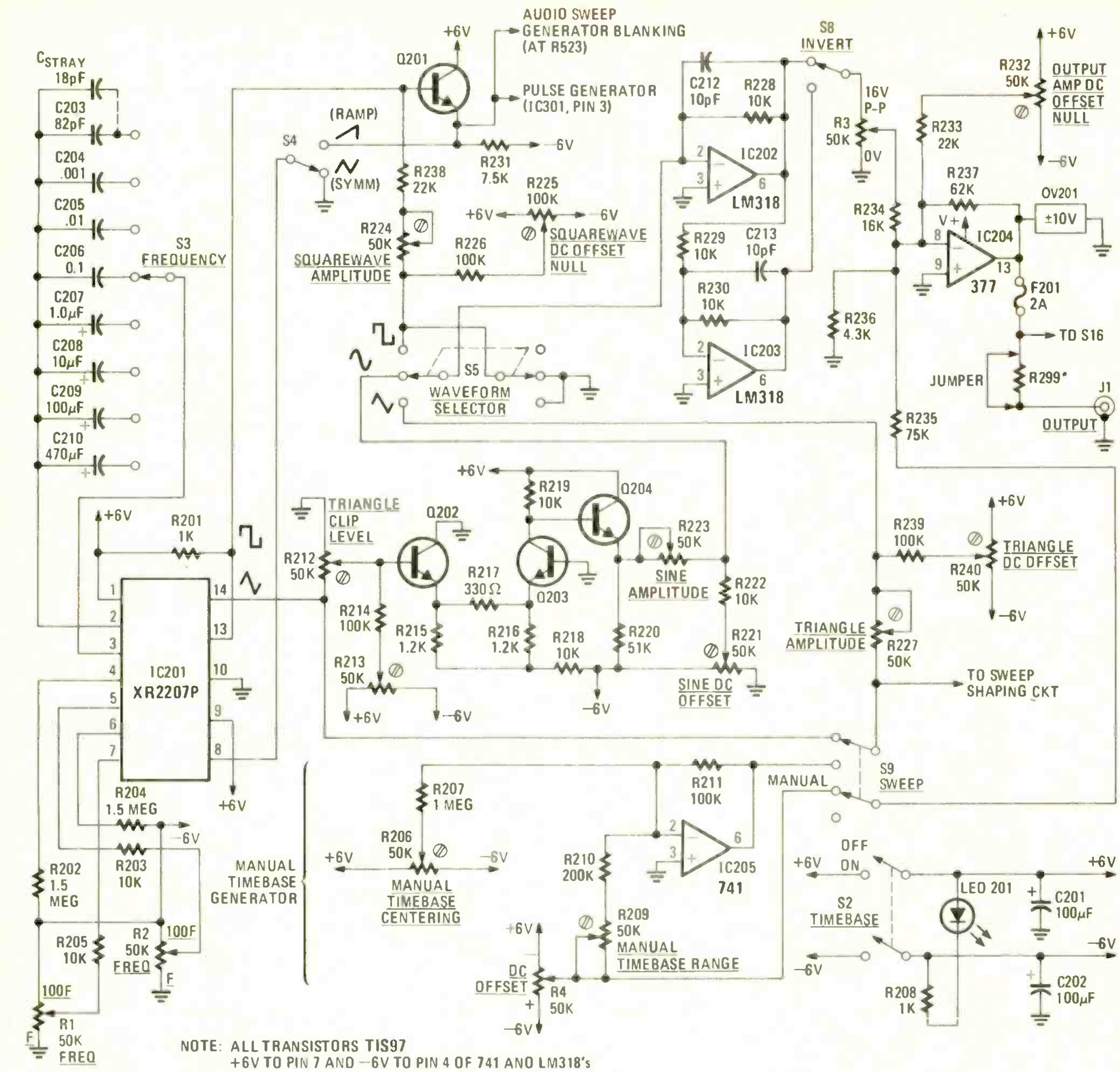


FIG. 4—THE TIMEBASE GENERATOR is designed around the Exar 2207 current-controlled oscillator. Frequency is determined by switchable capacitors and two slide pots on the front panel.

TIMEBASE

Resistors, ¼ watt, 5% unless otherwise specified
R201, R208—1000 ohms
R202, R204—1-5 megohms
R203, R205, R218, R219, R222, R228-R230—10,000 ohms
R206, R209, R212, R213, R221, R223-R225, R227, R232, R240—50,000 ohms, trimmer
R207—1 megohm
R210—200,000 ohms
R211, R214, R226, R233, R239—100,000 ohms
R215, R216—1200 ohms
R217—310 ohms
R220—51,000 ohms
R231—7500 ohms
R234—16,000 ohms
R235—75,000 ohms
R236—4300 ohms
R237—62,000 ohms
R238—22,000 ohms
R299—See text

Capacitors
C201, C202—100 µF, 10 volts
C203—82 pF
C204—0.001 µF
C205—0.01 µF
C206—0.1 µF
C207—1.0 µF, aluminum electrolytic, low voltage, low leakage. See text.
C208—10 µF, aluminum electrolytic, low voltage, low leakage. See text.
C209—100 µF, aluminum electrolytic, low voltage, low leakage. See text.
C210—470 µF, aluminum electrolytic, low voltage, low leakage. See text.
C212, C213—10 pF
Q201-Q204—TIS97
IC201—XR-2207
IC202, IC203—LM318
IC204—LM377
IC205—LM741
OV201—LA10 over-voltage limiter
F201—2-amp fuse
S2, S9—SPDT toggle switch
S3—SPDT rotary switch
S4, S8—SPDT toggle switch
S5—DPDT toggle switch
J1—BNC panel jack

POWER SUPPLY

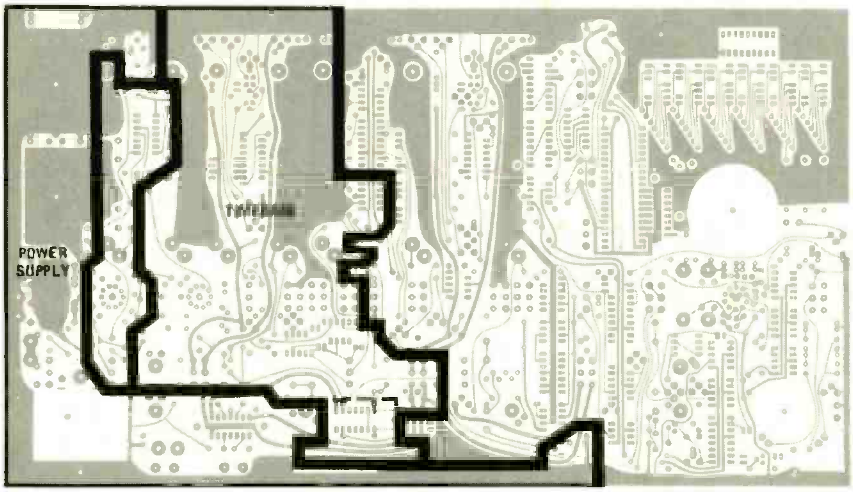
Resistors ¼ watt, 5% unless otherwise noted
R101-82,000 ohms
R102—18,000 ohms
R103, R104—100,000 ohms
R105—2700 ohms
R106—330 ohms

Capacitors
C101—1000-μF, 16-volt, electrolytic (two 500 μF in parallel)
C102—500 μF, 16-volt electrolytic
C103, C104, C107, C108—0.01-μF disc
C105, C106, C115—10-μF, 16-volt electrolytic
C109, C110—100-μF, 16-volt electrolytic
C111—33-μF, 16-volt electrolytic
C112—4.7-μF, 16-volt electrolytic
C113, C114—0.001-μF disc

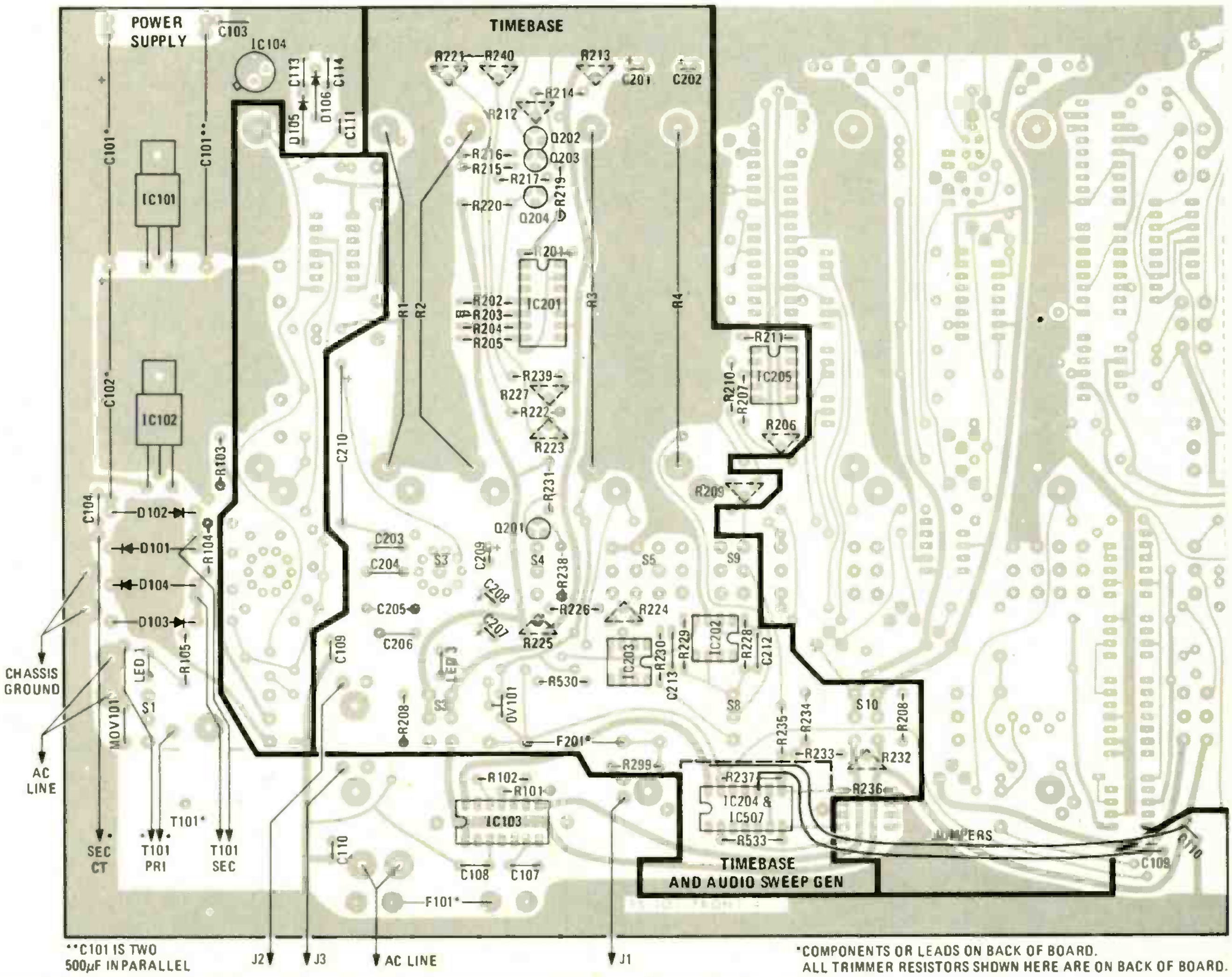
Miscellaneous
MOV1-V130LA10 thyristor
D101-D104—1N4001
D105-D106—1N4148
IC101, IC105—7812
IC102—7912
IC103—4194
IC104—309H
LED1, LED2—
T101—24-volt, 1-amp transformer
F101—
S1—SPST toggle switch
S21—DP3T toggle switch

The following are available from FSI, 1894 Commercenter W., No. 105. San Bernadino, CA 92408: Complete kit, $495.00; cabinet and circuit board, $115.00. Set of semiconductors, $195.00; seven slide pots with knobs, $17.00, set of trimmers including four multiturn pots, $17.00.

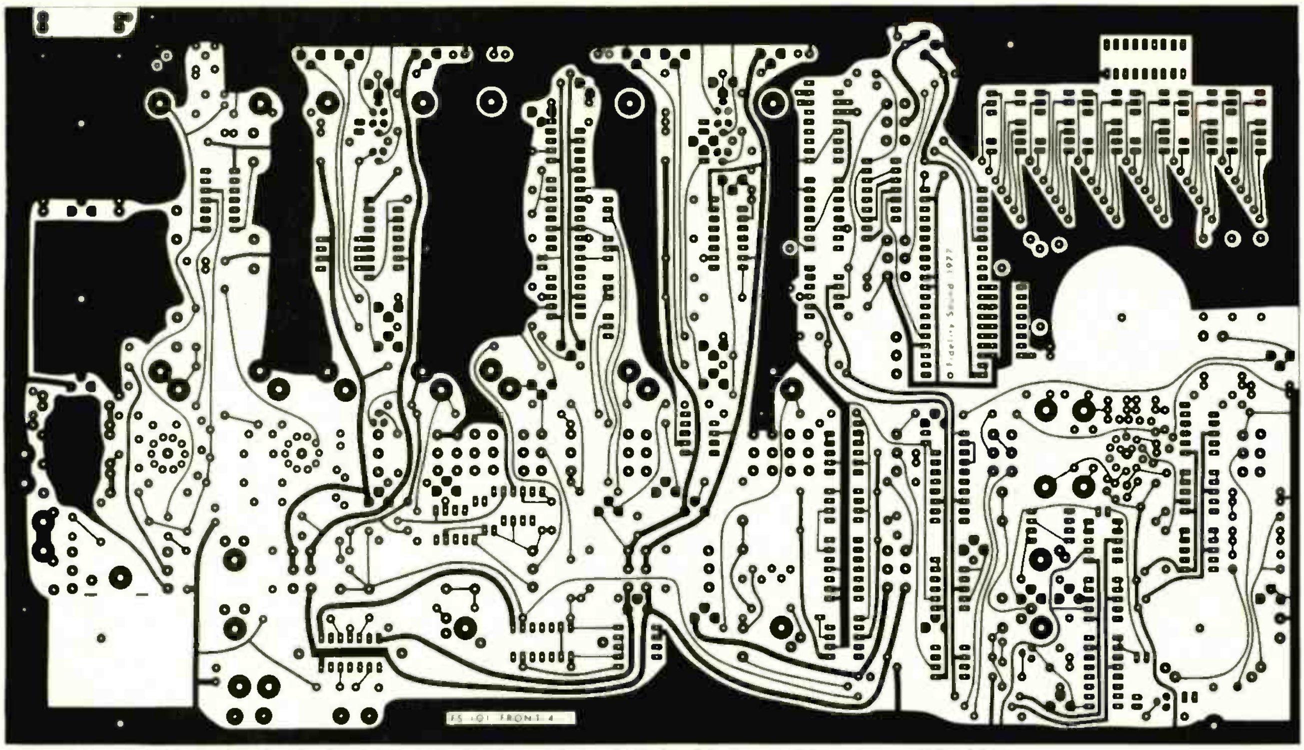
California residents add state and local taxes as applicable.



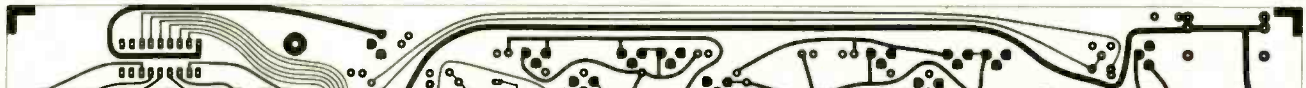
FOIL PATTERN of the component side of the PC board overlayed with the outlines of the power supply and timebase sections that are shown in the parts-placement illustration below.



COMPONENT LAYOUT for the power supply and timebase generator are shown. Power supply parts are coded in the 100 series and timebase parts in the 200 series. Components on the front panel have codes beginning with 1.



PRINTED CIRCUIT PATTERN for the front side of the PC board shown half size. Most components are on this side.



FOIL PATTERN for the back surface of the board shown half size. It carries the fuses and most trimmers.

charging current supplied to the capacitor. The output of the integrator is then fed back to the comparator.

The integrator is essentially a constant-current source applied to a capacitor. If the current applied to the capacitor is constant, the change in voltage across that capacitor will also be constant. When power is applied, the output of the comparator begins to charge the capacitor through the constant-current source. This causes the voltage across the capacitors to rise linearly. When that voltage, which is applied back to the comparator, reaches a predetermined point, the comparator switches states and begins to charge the capacitor in the reverse direction. This causes the voltage across the integrating capacitor to change linearly in the opposite direction.

The result is that the output of the integrator is a triangle wave and the output of the comparator is a squarewave. The peaks of the triangle wave align with the edges of the squarewave since it is these edges that cause the integrator to change its output slope. If the charging rates represented by the plus and minus slopes of the integrator are equal, the slopes will be of equal magnitude and opposite sign, and, hence, both the triangle wave and the squarewave will be symmetrical.

The output of the integrator is at IC201 pin 14, and the comparator output is at pin 13. Both these outputs are buffered and do not represent the actual oscillator voltages.

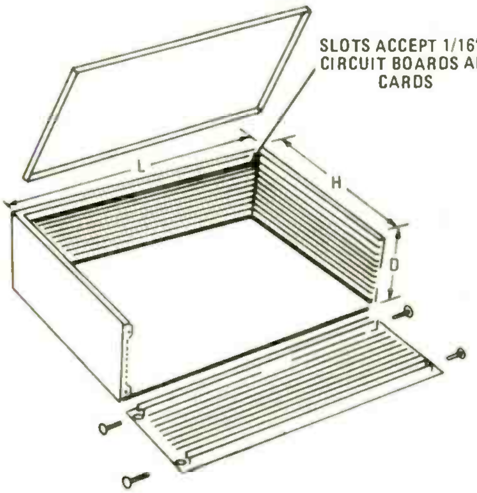
continued on page 78

Cases And Cabinets For Your Projects

ONE OF THE MAJOR CONSIDERATIONS FACING THE amateur electronic experimenter and constructor is the physical layout and appearance of the finished project. In the days of vacuum tube and 12 by 16 in. chassis, most projects could be finished off nicely by adding a front panel and slipping the whole thing into a cabinet that could be handcrafted from wood or readily available sheet metals. Today, most electronic projects are assembled on printed-circuit boards or similiar materials and are sometimes only one-tenth the size of its old vacuum-tube equivalent.

To select a case or enclosure that is most suitable for your project, you must have a pretty good idea as to what is available. Too, if your make and model specified in a magazine article is not available through your usual supplier, you should be aware of equivalents and possible substitutes. These charts list off-the-shelf enclosures, cases and chassis boxes in various material combinations, colors and sizes.

These charts list cases and cabinets not covered in the June and October 1978 issues of Radio-Electronics. While every effort has been made to ensure that these charts are as complete as possible, it is not always possible to include all the options and ordering information. It is, therefore, a good idea to obtain catalogs from the manufacturers.



To find out more about the products or distributors, a list of addresses of each manufacturer follows. To obtain a catalog, simply circle the corresponding No. on the Free Information card.

Apollo – Box 245, Vaughnsville, OH 45893. **Circle No. 135.**
Buckeye – 555G Marion Road, Columbus, OH 43207. **Circle No. 136.**
Bud Electronics – Dept. G., 4605 East 355 Street, Willoughby, OH 44094. **Circle No. 137.**
GC Electronics – Division of Hydrometals, Inc., Rockford, IL 61101. **Circle No. 138.**
Intra Fab, Inc., – 660 Lenfest Rd. San Jose, CA 95133. **Circle No. 139.**
Lafayette Electronics – 111 Jericho Turnpike, Syosset, NY 11791. **Circle No. 140.**
La France – Enterprise and Executive Avenues, Philadelphia PA 19153. **Circle No. 141.**
LMB Products – 725 Ceres Avenue, Los Angeles, CA 90021. **Circle No. 142.**
Premier Metals – 381 Canal Place, Bronx, NY 10451. **Circle No. 144.**
Radio Shack – 2617 West 7th Street, Ft. Worth TX 76107. **Circle No. 144.**
Rose/Stahlin – 500 Maple Street, Belding, MI 48809. **Circle No. 145.**
Scientific-Atlanta – Optima Enclosures-2166 Mountain Industrial Road, Tucker, GA 30084. **Circle No. 146.**
TenTec, Inc. – Dept. G., Industrial Park, Sevierville, TN 37862. **Circle No. 147.**
Vector Electronics Co., – 12460 Gladstone Ave., Sylmar, CA 91342. **Circle No. 148.**
Vero Electronics, Inc. – 171 Bridge Road, Hauppauge, NY 11787. (516) 234-0400. **Circle No. 149.**
Zero Mfg. – 777 Front Street, Burbank, CA 91503. **Circle No. 150.**

INSTRUMENT CASES

Internal side walls are grooved to position and hold PC boards. Both base and two side panels are removeable for easy acess to contents.

Length	Height	Depth	Mfr.	Model No.	Case Material	Comments	Options	Color
1.21	1.21	1.6	Vector	W-16-12-12B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
1.51	1.51	2.0	Vector	W20-15-15B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
2.31	3.81	1.0	Vector	W10-23-38B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors

chart continued on following oage

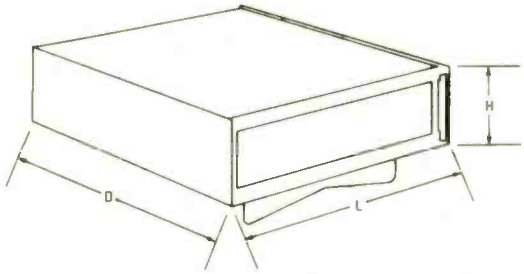
INSTRUMENT CASES

Length	Height	Depth	Mfr.	Model No.	Case Material	Comments	Options	Color
2.85	2.11	4.5	Vector	W45-28-21B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
2.85	4.61	1.6	Vector	W16-28-46B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
2.85	4.61	2.0	Vector	W20-28-46B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
3.10	2.11	1.6	Vector	W16-31-21B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
3.10	3.10	1.6	Vector	W16-31-31B	Al	holds 1/16" p.c. cards	inner panels, base; bezels	consult mfr for latest colors
3.10	3.10	2.0	Vector	W20-31-31B	Al	holds 1/16" p.c. cards	inner panels, base; bezels	consult mfr for latest colors
3.10	4.17	2.0	Vector	W20-42-31B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
4.61	2.11	4.5	Vector	W45-46-21B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
4.61	3.10	2.0	Vector	W20-46-31B	Al	holds 1/16" p.c. cards	inner panels, base; bezels	consult mfr for latest colors
4.61	3.61	2.0	Vector	W20-46-36B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
4.61	4.62	3.0	Vector	W30-46-46B	Al	holds 1/16" p.c. cards	inner panels, base; bezels	consult mfr for latest colors
4.61	6.17	2.0	Vector	W20-46-62B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
4.61	6.61	2.0	Vector	W20-46-66B	Al	holds 1/16" p.c. cards	inner panels, base; bezels	consult mfr for latest colors
6.61	3.61	2.0	Vector	W20-66-36B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
6.61	4.61	2.0	Vector	W20-66-46B	Al	holds 1/16" p.c. cards	inner panels, base, slide panels, bezels	consult mfr for latest colors
6.61	4.61	3.0	Vector	W30-66-46B	Al	holds 1/16" p.c. cards	inner panels, base; slide panels, bezels	consult mfr for latest colors
6.61	4.61	4.5	Vector	W45-66-46B	Al	holds 1/16" p.c. cards	inner panels, base; slide panels, bezels	consult mfr for latest colors
8.61	4.61	3.0	Vector	W30-86-46B	Al	holds 1/16" p.c. cards	inner panels, base; slide panels, bezels	consult mfr for latest colors
8.61	4.61	4.5	Vector	W45-86-46B	Al	holds 1/16" p.c. cards	inner panels, base; slide panels, bezels	consult mfr for latest colors
10	4.61	3.0	Vector	W30-100-46B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
10	4.61	4.5	Vector	W45-100-46B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
10	6.61	3.0	Vector	W30-100-66B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
10	6.61	4.5	Vector	W45-100-66B	Al	holds 1/16" p.c. cards	inner panels, base	consult mfr for latest colors
13	7	8	Bud	MD-1960	Steel	removable side & top	1963 for slope front	grey or blue

chart continued on following page

INSTRUMENT CASES

Length	Height	Depth	Mfr.	Model No.	Case Material	Comments	Options	Color
14	8	9	Bud	MD-1961	Steel	removable side & top	1964 for slope front	grey or blue
16	8	9	Bud	MD-1962	Steel	removable side & top	1965 for slope front	grey or blue



PORTABLE INSTRUMENT CASES

Modern design with handles and tilt stands available. Some are even adaptable to rack mounting.

Length	Height	Depth	Mfr.	Model No.	Case Material	Comments	Options	Color
5-7/10	3-1/2	13	Buckeye	3501	Al	concealed fasteners	tilt stand rack adapter	
5-7/10	5-1/4	13	Buckeye	5251	Al	concealed fasteners	tilt stand rack adapter	
5-7/10	7	13	Buckeye	7001	Al	concealed fasteners	tilt stand rack adapter	
5-7/10	8	13	Buckeye	8001	Al	concealed fasteners	tilt stand rack adapter	
5-7/10	8-3/4	13	Buckeye	8751	Al	concealed fasteners	tilt stand rack adapter	
5-7/10	10-1/2	13	Buckeye	1051	Al	concealed fasteners	tilt stand rack adapter	grey with suede-like finish consult mfr for color
8-1/2	3-1/2	13	Buckeye	3502	Al	concealed fasteners	tilt stand rack adapter	
8-1/2	5-1/4	13	Buckeye	5252	Al	concealed fasteners	tilt stand rack adapter	
8-1/2	7	13	Buckeye	7002	Al	concealed fasteners	tilt stand rack adapter	
8-1/2	8	13	Buckeye	8002	Al	concealed fasteners	tilt stand rack adapter	
8-1/2	8-3/4	13	Buckeye	8752	Al	concealed fasteners	tilt stand rack adapter	
8-1/2	10-1/2	13	Buckeye	1052	Al	concealed fasteners	tilt stand rack adapter	
8-1/2	2-7/16	9-1/4	La France	CH 200	ABS		without handle	
8-1/2	2-11/16	9-1/4	La France	CH 225	ABS		without handle	
8-1/2	2-15/16	9-1/4	La France	CH 250	ABS		without handle	
8-1/2	3-3/16	9-1/4	La France	CH 275	ABS	detented tilt/carry handle	without handle	Stock and custom colors. Consult manufacturer
8-1/2	3-7/16	9-1/4	La France	CH 300	ABS		without handle	
8-1/2	3-11/16	9-1/4	La France	CH 325	ABS		without handle	
8-1/2	4-7/16	9-1/4	La France	CHS 400	ABS		without handle	
8-1/2	5-7/16	9-1/4	La France	CHS 500	ABS		without handle	
8-1/2	6-7/16	9-1/4	La France	CHS 600	ABS		without handle	

chart continued on following page

PORTABLE INSTRUMENT CASES

Length	Height	Depth	Mfr.	Model No.	Case Material	Comments	Options	Color
9-1/2	3-1/2	13	Premier	TIC-030913	Al/vinyl	top carrying handle		
9-1/2	5-1/4	13	Premier	TIC-050913	Al/vinyl	top carrying handle		
9-1/2	7	13	Premier	TIC-070913	Al/vinyl	top carrying handle		
9-1/2	8-3/4	13	Premier	TIC-080913	Al/vinyl	top carrying handle		
9-1/2	10-1/2	13	Premier	TIC-100913	Al/vinyl	top carrying handle		
9-1/2	12-1/4	13	Premier	TIC-120913	Al/vinyl	top carrying handle	tilt stand rack adapters PC card cages	13 stock colors available. Consult manufacturer
9-1/2	14	13	Premier	TIC-140913	Al/vinyl	top carrying handle		
9-1/2	3-1/2	17	Premier	TIC-030917	Al/vinyl	side carry handgrips		
9-1/2	5-1/4	17	Premier	TIC-050917	Al/vinyl	side carry handgrips		
9-1/2	7	17	Premier	TIC-070917	Al/vinyl	side carry handgrips		
9-1/2	8-3/4	17	Premier	TIC-080917	Al/vinyl	side carry handgrips		
9-1/2	10-1/2	17	Premier	TIC-10017	Al/vinyl	side carry handgrips		
9-1/2	12-1/14	17	Premier	TIC-120917	Al/vinyl	side carry handgrips		
9-1/2	14	17	Premier	TIC-14017	Al/vinyl	side carry handgrips		
11-1/3	3-1/2	13	Buckeye	3503	Al	concealed fasteners	tilt stand; rack adapter	
11-1/3	5-1/4	13	Buckeye	5253	Al	concealed fasteners	tilt stand; rack adapter	
11-1/3	7	13	Buckeye	7003	Al	concealed fasteners	tilt stand; rack adapter	grey with suede-like finish. Consult mfr. for stock colors
11-1/3	8	13	Buckeye	8003	Al	concealed fasteners	tilt stand; rack adapter	
11-1/3	8-3/4	13	Buckeye	8753	Al	concealed fasteners	tilt stand; rack adapter	
11-1/3	10-1/2	13	Buckeye	10503	Al	concealed fasteners	tilt stand; rack adapter	
12-1/2	6-3/4	11-5/8	La France	CLS 625	ABS		tilt stand	
12-1/2	7-3/4	11-5/8	La France	CLS 725	ABS		tilt stand	Stock and custom color Consult manufacturer
12-1/2	8-3/4	11-5/8	La France	CLS 825	ABS		tilt stand	
15-5/8	3-1/2	13	Premier	TIC-031513	Al/vinyl	side carry handgrips	tilt stand; PC card cages	
15-5/8	5-1/4	13	Premier	TIC-051513	Al/vinyl	side carry handgrips	tilt stand; PC card cages	
15-5/8	7	13	Premier	TIC-071513	Al/vinyl	side carry handgrips	tilt stand; PC card cages	
15-5/8	8-3/4	13	Premier	TIC-081513	Al/vinyl	side carry handgrips	tilt stand; PC card cages	
15-5/8	10-1/2	13	Premier	TIC-101513	Al/vinyl	side carry handgrips	tilt stand; PC card cages	

PC/Wire-Wrap-New Construction Technique

Combining wire-wrap with a printed circuit can be the answer to many layout and construction problems connected with many projects. Here are some hints in using this technique.

JAMES E. TEMPLE

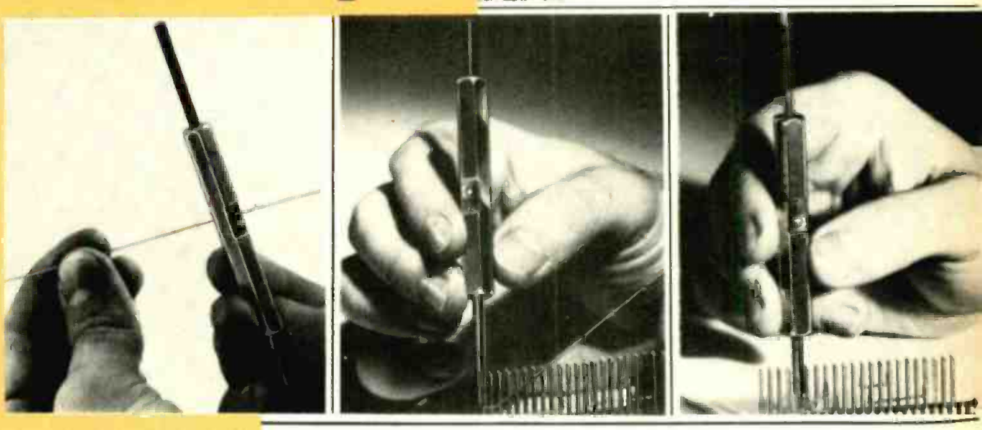
WITH SO MANY FINE DIGITAL CIRCUITS BEing presented in electronic hobbyist magazines, one is tempted to construct them at the earliest possible opportunity. These articles generally present the projects using one of two construction techniques—either using a printed-circuit type of construction, or wire-wrap techniques. Little needs to be said about the PC board type of project construction, since usually a complete PC layout is provided with the article that can be copied using many different techniques to reproduce the circuit (or sometimes a PC layout may even be offered by a manufacturer at a bargain price).

This article discusses the wire-wrap technique and presents several ways to cut down on the time-consuming job of wire-wrapping each and every individual terminal point. The technique is useful for digital and computer-circuit applications, and hams and CB enthusiasts will also find it useful.

Wire-wrap tools

First, let's discuss the various tools and wire-wrap terminals that are currently available to the hobbyist. An example is the wire-wrap tool manufactured by the OK Machine & Tool Corp. The cost of this tool is nominal for what it will do; i.e., wire-wrap a measured and stripped length of wire between two terminals. It does the job quickly (after the wire is prepared) and is an excellent addition to your electronic tool kit. Not only does it wrap the wire, it is also designed to unwrap it, which adds up to a good design in a single tool.

Now, here's what I consider to be a versatile wire-wrap tool—the Vector *Slit-N-Wrap*. Here, an ingenious design makes wire-wrapping a simple job. No need to measure the wire length between terminals that will be wire-wrapped together to form the circuit path. This single tool allows you to slip the tool (the wire is contained on a spool in the tool's



handle) over the terminal, wrap the wire seven turns or more and then directly run the wire to the next terminal to be wrapped, again slipping the tool over the end of that terminal and wrapping seven times around the post. If the particular circuit path must be wired to more than two terminal posts, then this tool allows you to continue wrapping to the next post without having to measure a new wire length. Just continue to wrap all the terminals that must be connected to this particular circuit path. When the last terminal in the series to be wire-wrapped is finished, just cut the wire and proceed to the next circuit path. It is just that simple with the Vector *Slit-N-Wrap* tool, and a great time-saver.

One of the nicest things that Vector has done is to support the needs of those who must use wire-wrap for their circuits. Vector has a complete line of wire-wrap posts and the tools to insert them in the epoxy boards.

Sockets

There are also IC wire-wrap sockets that are usually available with three levels of wrapping space. Many companies offer these sockets; and, of course, the choice of terminal pins or sockets is up to you. However, Robinson-Nugent, Inc., has an extensive line of different types of sockets, terminals and pins. One of the most handy types of sockets is the wire-wrap strip socket (*model WB-25-55-G*), which comes in a 25-pin-length IC connector. These sockets are easily cut to the pin length you need, are easily cemented to the board for mounting and are flexible if changes are required. If you have an oddball type of IC (let's say, 22-pins, 30-pins, etc.) and you just cannot find the right wire-wrap socket for it, then these strip sockets can come to the rescue. Simply cut the strip to size and form the IC socket from it.

Another excellent product manufactured by Robinson Nugent is their low-profile, wire-wrappable J-pin designed for IC DIP packages. These pins offer an extreme low profile to the circuit board; sockets can be made from them directly; they are space-savers; and are wire-wrapped to the underside of the J-pin.

Avoiding the jungle

Up to now we have discussed the tools, terminals and many other products offered by manufacturers that support the wire-wrap construction technique. Now let's get to the heart of the article—how to avoid the jungle and mass of wires when you wire-wrap. If you are like many hobbyists who have used the technique and have completed several wire-wrap projects, you will know what I mean by a jungle. The back of a finished wire-wrap board contains hundreds of inches of wire, and many wires cross each other, along with various colors you may have used to color-code the wires. If a change is made, you must be very careful to cut or unwrap the correct wires, and if several levels of wire-wrap exist on any single terminal, extra care is needed to make these changes.

There are ways to cut down on the number of wire-wrap connections you have to make. You can combine a printed-circuit board with wire-wrap terminals. The number of connections can be reduced by using a combination of similar lines, wire-wrap sockets, and just plain common sense and planning. For example, when a construction project calls for similar pinouts to be connected, as in the case of a computer memory board, print the redundant connections to the IC sockets right on a PC board. Then just solder in the similar terminals to be connected, either to the upper side or the lower side of the PC board.

As for other electronic circuits, review your project and look for similar pinouts of the IC; for instance, the power connections, the clock inputs, or a group of IC's that are of the same type. All that you need do is plan a PC card (double-sided copper), layout the IC on the board, use an etchant pen or lacquer etchant to draw the connecting lines that are redundant in nature (after drilling the holes into the PC board, of course), and eliminate as many wire-wrap connections as possible in the design. Be sure to provide for the terminal pins that act as connectors between the foils on the top of the board to the foils on the bottom of the board. Once the design has eliminated as many wire-wrap lines as possible, etch the board, clean it, insert the sockets or J-pins, and finish wrapping the circuit paths you could not combine onto the PC card. With the right design and careful preparation, the PC lines will eliminate as much as one-half or more of the wire-

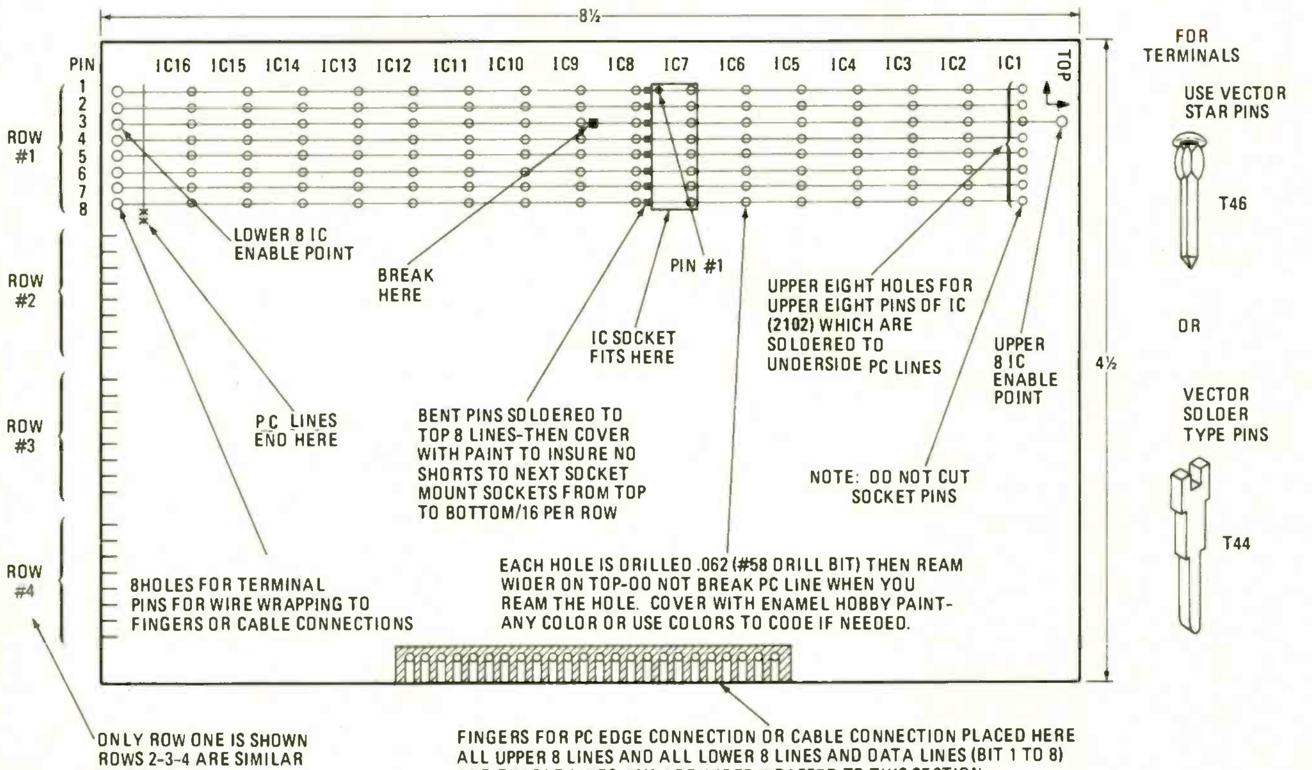


FIG. 1—A PRINTED-CIRCUIT card for a memory board. Bottom tracks are directly under the top ones. The trick here is to solder pins on one side of each socket directly to the upper tracks.

wrap lines. Rather than having a jungle of wires, you will have an orderly system that is easy to change or add to. It works!

How to design a PC board

Let's take a particular type of IC package and design a PC card and plan the wire-wrap terminals. (See Fig. 1.) I can best show how to eliminate redundant lines by using the popular 2102 memory IC. I have constructed a memory card, 3½ inches wide by 7 inches long, containing over 64 IC's. Consider this: Eight 2102's provide a memory word that is 8 bits wide.This means eight 2102's will provide 1024 8-bit memory locations. Each 2102 has 16 pins, eight on each side. Of the 16 pins, 10 are used for the memory address, one for read-write control, and one for chip-enable. Of the four remaining pins, one is used for the positive power-supply connection and one for the ground or return connection. All these pins are paralleled together between the eight 2102's. Only the data-in pin and the data-out pins will be considered as separate line- or wire-wrap connections. Of course, if several 8-bit-wide memory banks are being considered, these same pins will be paralleled to the same pins within the other memory banks.

Let's take a look at how we can eliminate some wire-wrap connections so that there are only a few. This will enable you to get a large number of IC packages in a very tight space.

Figure 1 shows the layout of the double-sided PC board. Two memory banks are shown. Each bank contains 1024 8-bit words. One bank consists of IC1—IC8, the upper lines of the PC layout and the terminal pins for wire-wrapping. The other consists of IC9—IC16. The eight foil traces on the foil side of the board parallel eight traces on the component side and are, therefore, not visible in Fig. 1.

Note from the layout for the 64 IC's (8K of memory, 2102 type) that only 32 holes are drilled for each 1K of memory. These holes are for the upper eight pins (one side) of the DIP wire-wrap socket.

Bend eight socket terminals (only one side of the DIP) at a right angle to the socket (see Fig. 2), cut the leads short and insert the other eight socket pins through the holes to be soldered to the lower PC traces. The right-angle pins are soldered to the upper PC traces. Thus, there are eight parallel foil traces on the upper and lower side of the PC card that are isolated by the thickness of the epoxy board itself.

To make sure the eight socket pins that are pushed through the board do not make contact with the upper eight parallel foil traces, it is best to take an *Xacto* knife with a No. 17 blade and ream the holes from the top of the PC board (see Fig. 3). To further insure isolation, use enamel paint to cover the holes on the top side. Now, when the sockets are pushed into place, the top right-angle pins and the lower terminal pins are soldered, and the lower eight pins and the upper eight pins are electrically isolated from each other. This type of setup requires that when you insert the sockets, you start

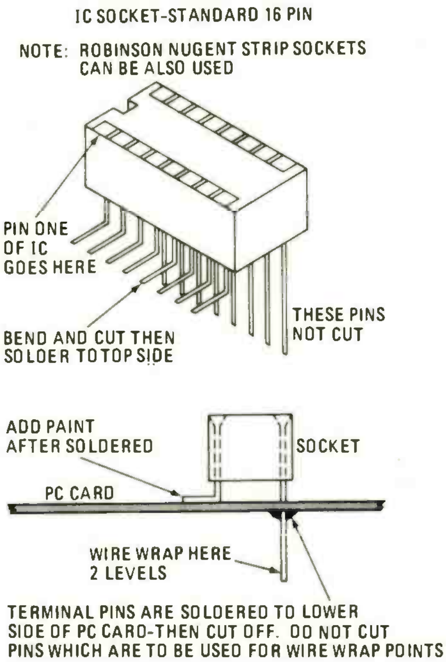


FIG. 2—HOW SOCKETS ARE MODIFIED when you are using the combined printed-circuit and wire-wrap techniques.

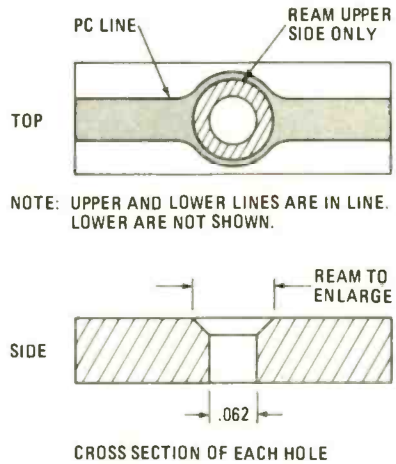


FIG. 3—ISOLATING THE PINS that go through the board to the bottom traces is simple. You can use an Xacto knife as a reamer.

from the uppermost top socket (IC1) and solder the connections. Then, to protect against possible shorts, paint over the top soldered pins with the enamel. Now, the next row of IC sockets can be soldered in place until all sockets are mounted to the PC board.

When you design the PC layout, bring the eight foil traces on the component side to a stopping point beyond the foil traces on the bottom of the board. On the component side, also extend the IC enable trace at the opposite end of the board and break the trace between IC8 and IC9 (this isolates the two memory banks). Now (for the traces on the component side only) drill eight holes into the extended portion of the traces, insert eight terminal pins and solder the pins. For the eight foil traces on the bottom side of the board, cut the socket terminals short right up to the solder connection, all except for the top row of terminals. This row of terminals is now used for wire-wrap connections to the traces on the bottom side of the board. Make sure not to cut the data-in or data-out pins on the sockets since these pins will be paralleled to the other data-in and data-out pins and finally wire-wrapped to the input for the cable connections to the card.

On the component side of the card, you can use PC lines to make edge-connector fingers, the type of fingers or number of lines will depend upon the type of bus to which the card will be connected. Or, you can make a provision for wiring in a cable to connect to the bus lines. (Wires should be soldered in, and you can use the wire-wrap pins that allow wire-wrapping to the lower side of the wire cable.) Finally, for the fingers or the wire cable, insert the wire-wrap terminal pins, solder them firmly to the card, and finish the PC board by wire-wrapping the connections to the appropriate pinouts for the particular bus structure.

What you have just constructed is a compact tri-level PC board. Redundant or similar lines have been connected by foil traces, soldered to the sockets (modified for solder connections to the PC board), and all that remains is to wire-wrap the end terminal pins of each row of IC's. The few wire-wrap wires you have used can be taped to the card to secure them; changes made to the circuit are easier as each line is accessible, both top and bottom. With an 8½- by 4½-inch card, there is no reason why 64 DIP IC's cannot be located on it. It is possible that on a 9- by 16-inch-wide card you can cram in four times the number of IC's, and in terms of memory for computers, provide a 32K board. What we have not provided for on this type of memory board is bank-select in 1K increments, nor did we buffer the memory address lines or buffer the data lines. However, this problem is easily overcome by a second memory control and select card of appropriate design.

What we have demonstrated are the principles of combining the best of two worlds in project construction; that is, using PC layouts (to eliminate many redundant lines to the various IC's) and using wire-wrap sockets modified to the card for solder and wire-wrap connections. Using this technique you can fit a great many IC's in a highly crowded space, and wire-wrapping the final connections is made simple. Less than one-half of the wire-wrap connections will be required by this type of construction, yet all lines are accessible if changes or additions to the circuit are required. **R-E**

New IHF Amplifier Specifications

Amplifier comparisons made more realistic for the layman by a new IHF testing standard that provides a closer correlation between what he hears and what the lab technician measures.

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

AFTER NEARLY THREE YEARS OF DELIBerations, the Institute of High Fidelity (IHF) has published and approved a new standard entitled "Methods of Measurement for Audio Amplifiers." This standard (IHF-A-202, 1978) supersedes an earlier IHF standard that had been used since 1966 but rendered obsolete in 1974 when the Federal Trade Commission ruled that the continuous power rating of an audio amplifier intended for home entertainment had to be specified in a somewhat different manner than had been done using the old standard.

One of the major new measurements incorporated in the new standard is dynamic headroom. This measurement was designed to help consumers select one of two amplifiers having the same *continuous* power-output ratings but achieving significantly different loudness levels when fed with the same short-term dynamic musical signals.

An amplifier having a very "stiff" power supply may produce very little more output power than its rated continuous power level under such conditions, whereas an amplifier with a "soft" or less-regulated supply may, under the same conditions, deliver power greater than its continuous rated level. The dynamic headroom dB specification may therefore vary from 0 (for the stiffly regulated power-supply amplifier) to +3.0, or even more.

Now that the new standard has become officially recognized by the IHF, let's look at some of the other new measurement methods it describes. The new standard attempts to correlate more accurately what the consumer *hears* when listening to an amplifier and what the technician *measures* for that amplifier during lab tests. Equally important, the new standard insures that *all* manufacturers that publish amplifier or preamplifier specs make all measurements in identical fashion and report their findings uniformly so that prospective purchasers are not comparing "apples and oranges" when looking at competing products.

Since **Radio-Electronics** publishes complete high-fidelity test reports on audio amplifiers and preamplifiers, in future reports, we will adopt the new measurement techniques described in the standard. While to detail every one of the new measurements is beyond the scope of this article, we'll try to explain those major changes in measurement techniques that will affect the test reports. Those interested in obtaining the complete standard may do so by sending a check or money order to The Institute of High Fidelity, 489 Fifth Avenue, New York, NY 10017, in the amount of $7.50. Ask for Standard IHF-A-202, 1978.

New reference levels

One of the most confusing factors found in published amplifier specifications has been the lack of uniformity in the reference levels used to make sensitivity and signal-to-noise ratio measurements. For instance, let's consider two

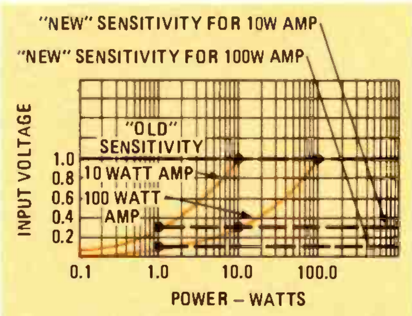


FIG. 1—NEW IHF SENSITIVITY rating specifies the input voltage required to produce a 1-watt output.

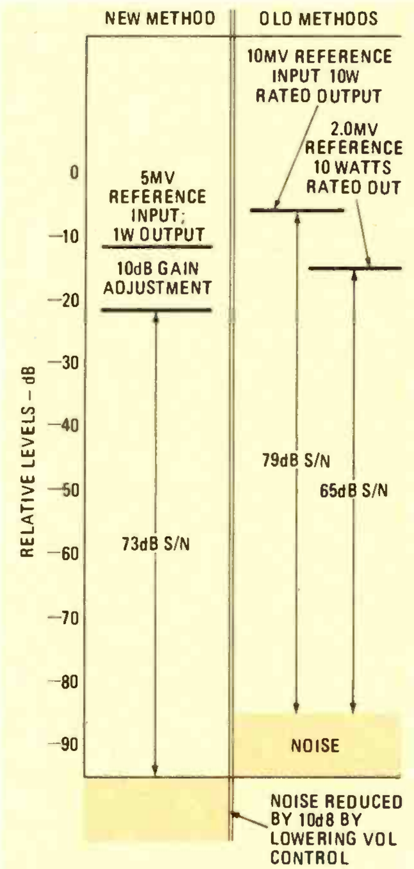


FIG. 2—NEW IHF S/N RATIO STANDARD specifies reference input level and output level. The volume control is adjusted to obtain the specified 1-watt output level. The old standard required S/N to be measured at full-rated output.

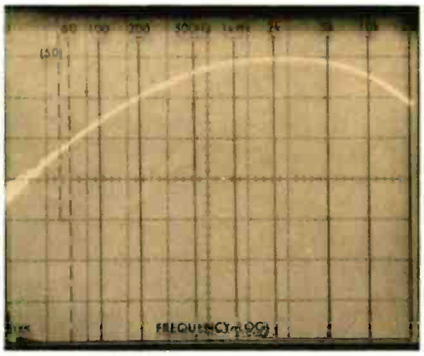


FIG. 3—RESPONSE of A-weighting network used in hum measurements.

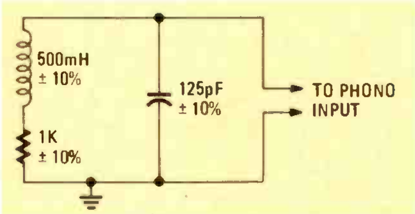


FIG. 4—NETWORK approximates the impedance of a magnetic phono cartridge. To comply with new IHF standard, network must be connected to phono preamp for S/N measurements.

audio amplifiers, one with a 10-watt power-output rating and the other with a 100-watt-per-channel rating. An amplifier's input sensitivity has traditionally been measured so as to describe how much input-signal amplitude is required for the given amplifier to deliver its *rated* output (with the volume control turned all the way up to maximum). Suppose each of the two amplifiers in our example requires an input signal of 1.0 volt to deliver its rated output. This implies that both amplifiers have "equal sensitivity." Yet, if 1 volt is fed into the 100-watt-per-channel amplifier, it will *sound* 10-dB louder than if it were fed to the 10-watt-per-channel amplifier! It is therefore clear that the *gain* of the two amplifiers is not identical.

In the new standard, amplifier sensitivity is still measured with the volume control turned up fully, but now it is specified as the voltage required to produce *1.0 watt* at the speaker-output terminals (or 0.5 volts in the case of a separate preamplifier), regardless of the full power (or voltage output) rating. Using that reference output level in the two examples, the input sensitivity of the 10-watt amplifier is now 0.316 volt (for a 1-watt output), while the input sensitivity of the 100-watt-per-channel amplifier is 0.1 volt (for a 1-watt output). These concepts are shown in Fig. 1, in which power output for the two amplifiers is plotted against input voltage.

S/N reference levels

Even more confusing were previous methods of measuring signal-to-noise (S/N) ratios.

Again, let's look at two hypothetical amplifiers. One integrated amplifier has a phono-input sensitivity of 2.0 mV (i.e., 2.0 mV applied to the phono-input terminals at 1 kHz drives the amplifier to its full rated output if the volume control is turned up all the way). Let's assume that the S/N measurement (when the signal is removed and the input jacks are shorted) is 65 dB.

Another amplifier manufacturer, whose phono preamplifier is just as noisy as the first, decides that a 65-dB value does not look "good enough" in print. So, he chooses an input reference level of *10 mV*. But, of course, when 10 mV are applied to this amplifier, the amplifier will overload (since it, too, would produce full rated output from a 2.0-mV signal with the volume control turned up fully). Therefore, the manufacturer *lowers* the volume-control setting until rated power output is obtained once more. And he would have to lower it by approximately 14 dB! Assuming that the residual noise is a function only of the phono preamplifier, the manufacturer now reads a S/N ratio of 79 dB, even though the preamp section in his unit is no less noisy than that of his competitor!

In order to establish uniform S/N readings, the new standard dictates that the input-signal level be fixed at 5.0 mV for a magnetic phono section, and at 0.5 volt for a high-level input such as the tuner, auxiliary, or tape input on a preamplifier or integrated amplifier. In addition, the *output* reference level must be adjusted (as in the case of sensitivity measurements) to a 1.0-watt level (for a power amplifier) or 0.5 volt (for a preamplifier). This adjustment is made by using

PRIMARY SPECS FOR POWER AMPLIFIERS:
1. Continuous Average Power Output ....
2. Dynamic Headroom ....
3. Frequency Response ....
4. Sensitivity ....
5. A-Weighted Signal-To-Noise Ratio ....

PRIMARY SPECS FOR PREAMPLIFIERS:
1. Frequency Response ....
2. Maximum Voltage Output ....
3. Total Harmonic Distortion ....
4. Sensitivity ....
5. A-Weighted Signal-To-Noise Ratio ....
6. Maximum Input Signal ....
7. Input Impedance ....

PRIMARY SPECS FOR INTEGRATED AMPLIFIERS:
1. Continuous Average Power Output ....
2. Dynamic Headroom ....
3. Frequency Response ....
4. Sensitivity ....
5. A-Weighted Signal-To-Noise Ratio ....
6. Maximum Input Signal ....
7. Input Impedance ....

TABLE 1—PRIMARY SPECS that must be provided by manufacturer to comply with new IHF standards.

1. Clipping Headroom ....
2. Output Impedance ....
3. Wideband Damping Factor ....
4. Low-Frequency Damping Factor ....
5. CCIR/ARM Signal-To-Noise Ratio ....
6. Tone-Control Response ....
7. Filter Cutoff Frequency ....
8. Filter Slope ....
9. Crosstalk ....
10. A-Weighted Crosstalk ....
11. CCIR/ARM Crosstalk ....
12. SMPTE Intermodulation Distortion ....
13. IHF Intermodulation Distortion ....
14. Transient-Overload Recovery Time ....
15. Slew Factor ....
16. Reactive Load ....
17. Capacitive Load ....
18. Separation ....
19. Difference of Frequency Response ....
20. Gain-Tracking Error ....
21. Tone-Control Tracking Error ....

TABLE 2—SECONDARY SPECS that may be provided at manufacturer's discretion.

TABLE 3

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Model:

AMPLIFIER PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
POWER OUTPUT CAPABILITY		
RMS power/channel, 8-ohms, 1 kHz (watts)		
RMS power/channel, 8-ohms, 20 Hz (watts)		
RMS power/channel, 8-ohms, 20 kHz (watts)		
RMS power/channel, 4-ohms, 1 kHz (watts)		
RMS power/channel, 4-ohms, 20 Hz (watts)		
RMS power/channel, 4-ohms, 20 kHz (watts)		
Frequency limits for rated output (Hz-kHz)		
Dynamic headroom (dB)		
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)		
Intermodulation distortion, rated output (%)		
Harmonic distortion at 1-watt output, 1 kHz (%)		
Intermodulation distortion at 1-watt output (%)		
DAMPING FACTOR AT 8 OHMS, *50 Hz*		
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ± dB)		
Maximum input before overload (mV)		
Hum/noise, "A"-weighted, referenced to 1W or 0.5V output, for 5-mV input (dB)		
HIGH-LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ± dB)		
Hum/noise, "A" wt'd, re 0.5 or 1W out, 0.5V in (dB)		
Residual noise, "A" wt'd, minimum volume, re 1W out (dB)		
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig.	
Action of secondary tone controls	See Fig.	
Action of high- and low-frequency filters	See Fig.	
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, PH-1/PH-2, re 1W or 0.5V out (mV)		
Input sensitivity, high-level, re 1W or 0.5V out (mV)		
Output level, tape outputs, at rated output (mV)		
Output level, headphone jack, at rated output (mV or mW)		
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		
Adequacy of input facilities		
Front panel layout		
Action of controls and switches		
Design and construction		
Ease of servicing		
OVERALL AMPLIFIER PERFORMANCE RATING		

the master volume control. This makes a lot of sense since it places the master volume control at a setting that approximates that which a consumer would normally use in actual music listening. No one ever listens to a hi-fi stereo system with the volume control turned up fully (in most cases, this would overdrive the amplifier or preamplifier into severe clipping, since amplifier *gain* has nothing to do with maximum amplifier power or voltage output).

Figure 2 shows the old and the new methods of measuring signal-to-noise; it is assumed that other amplifier stages do not affect overall noise. Actually, we have already discovered that very often you cannot compute new S/N values from the old values (even taking into account new reference input and output levels) since, as the new input and output reference levels are set up (by the volume control and by varying signal-input levels), other noise-producing stages affect the measurement. Thus, it is next to impossible to convert from the old measurement method to the new by simply juggling dB and gain figures.

A-weighting

In the past, some manufacturers used a weighting network in signal-to-noise measurements while others did not. A weighting network recognizes the fact that the human hearing system does not respond equally to all audible frequencies, especially at low listening levels. Our ears are less sensitive to line frequency or hum than to mid-frequencies, and are also less sensitive to ultra-high frequencies. In the past some manufacturers used an A-weighting network to take into account the subjective aspects of residual noise. This network has a frequency-response characteristic that is shown in Fig. 3, in which you will note that much less importance is given to 60-Hz noise (about 20-dB less) than to noise at, say, 1 kHz. Similarly, noise at 10 kHz is given approximately 5-dB less importance than noise at mid-frequencies.

The new standard is in conformance with those manufacturers who have used an A-weighting network in making S/N measurements, and requires that type of network to be inserted between the output of the amplifier and the meter used to measure the noise voltage or residual noise.

Most manufacturers have traditionally measured phono signal-to-noise ratios by inserting a shorting plug in the phono-input jacks. In the case of many phono-preamplifier circuits, this test method does not reflect what actually happens when you connect a magnetic cartridge to those same phono inputs. A magnetic cartridge has a certain amount of DC resistance, plus a finite amount of inductance. Instead of inserting a shorting plug, the new standard requires using a network that approximates the complex impedance "observed" by the phono inputs when a cartridge is actually connected; a diagram of this network is shown in Fig. 4.

For making S/N measurements of the high-level inputs on an amplifier or preamplifier, a 1000-ohm resistor will be used to terminate the input jacks.

Primary amp/preamp ratings

To rate amplifiers according to the new IHF standards, the manufacturer must list certain primary ratings in order of their importance. For a basic power amplifier, five basic ratings must be shown; while for an integrated amplifier or a preamplifier, seven primary ratings must be given. Table 1 lists the primary ratings in each case.

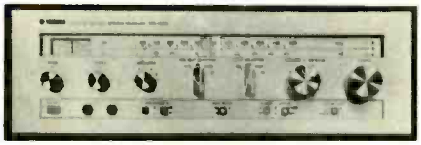
At least 21 other secondary ratings and how to measure them are included in the IHF standards, and can be listed (in part or in whole) by the manufacturer at his own discretion. Table 2 shows these secondary ratings.

Future test reports

It has been **Radio-Electronics'** practice to publish tabular listings of measured results on amplifiers, receivers and preamplifiers in its high-fidelity test reports. Table 3 shows the form that will be used in future test reports. The italicized items in this table represent either new specs not previously reported on, or those that have been reported on using earlier techniques and that will now be measured in accordance with the new standards. Since it will probably take some time before all manufacturers begin to use the standards, it may be somewhat difficult to compare their published specifications with those measured according to the new standard. For example, signal-to-noise ratios may seem poorer or lower than those specified using older methods.

In time, however, it is hoped that most serious high-fidelity manufacturers will adopt the new measurement techniques and ratings; this will make it that much easier for an audio consumer to select good hi-fi amplification equipment. **R-E**

Radio-Electronics Audio Lab Tests



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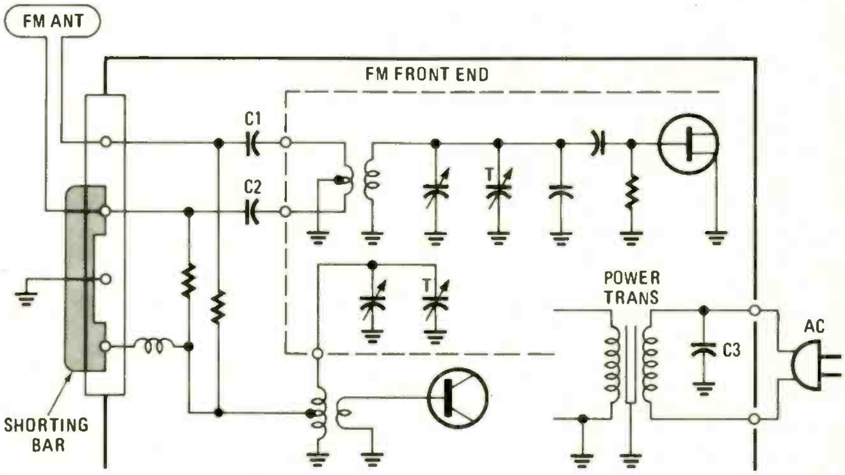
CIRCLE 130 ON FREE INFORMATION CARD

Yamaha CR-420 AM/FM Receiver

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

THE PUBLISHED SPECIFICATIONS FOR YAMAHA'S relatively low-powered *model CR-420* receiver contain one term you may not have seen before. This is the NDCR specification (*N*oise *D*istortion *C*learance *R*ange). Yamaha (6600 Orangethorpe Avenue, Buena Park, CA 90622) developed this specification in the belief that it tells more exactly what you can expect from the product in terms of combined noise and distortion during actual use. When you read this claim, you'll note that, with the volume control turned down 20-dB below its maximum (typical of normal use), the *model CR-420* receiver produces no more than 0.1% *combined* noise and distortion at any listening level from 100 mW to the full rated output of 22 watts-per-channel. While it can be argued that distortion at a −60-dB level (compared with output level) is far less annoying than noise at that same level, this extra specification gives you some idea of what you can expect in the way of dynamic range.



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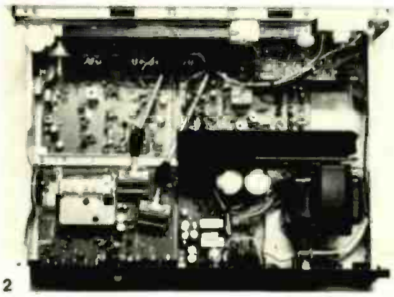

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The NDCR specification is only one of several innovative features associated with this low-cost receiver. The front panel of the *model CR-420* is shown in Fig. 1. To the left of the long and narrow dial calibration area is a single tuning meter that serves as a signal strength meter in the AM mode and as a center-of-channel tuning meter for the FM mode, with FM frequencies calibrated at every half-MHz. Three tiny LED indicators to the right of the scales inform you whether you are listening to AM, FM, or stereo FM. Step-type BASS and TREBLE controls are located just below the tuning meter, and next to them is an independent loudness control. This control is used to change listening levels after the main volume control has been adjusted to realistic listening levels, depending upon the program source selected. The control covers a range (downward in level) of around 20 dB, and as it is rotated away from the flat or maximum clockwise position, this introduces just the right amount of loudness compensation. This arrangement works far better than the usual combination volume/loudness-control-plus-switch found on many competitive receivers.

Recording-output and program-source selector switches are also operated independently of each other. This makes it possible to feed one program to an associated tape deck while

MANUFACTURER'S PUBLISHED SPECIFICATIONS:

FM TUNER:
Usable Sensitivity (mono): 1.8 μV (10.3 dBf). **50-dB Quieting:** mono; 3.5 μV (16.1 dBf); stereo, 43.5 μV (38 dBf). **S/N Ratio:** mono, 77 dB; stereo, 71 dB. **Capture Ratio:** 1.0 dB. **Selectivity:** 65 dB. **Image Rejection:** 50 dB. **AM Suppression:** 56 dB. **IF and Spurious Rejection:** 75 dB. **Harmonic Distortion:** mono, 0.15% at 100 Hz and 1 kHz, 0.3% at 6 kHz; stereo, 0.25% at 100 Hz and 1 kHz, 0.8% at 6 kHz. **Stereo Separation:** 40 dB at 1 kHz, 30 dB at 50 Hz and 10 kHz. **Frequency Response:** 30 Hz to 15 kHz, +1.0, −3.0 dB. **Muting Threshold:** 5.0 μV (19.2 dBf).

AM Tuner:
IHF Sensitivity: 18 μV per meter. **Selectivity:** 20 dB. **S/N Ratio:** 50 dB. **IF and Image Rejection:** 40 dB. **Harmonic Distortion:** 0.6%.

Amplifier:
Power Output: 22 watts-per-channel, 8 ohms, 20 Hz to 20 kHz. **Harmonic Distortion:** 0.05%. **IM Distortion:** 0.05%. **Damping Factor:** 40. **Input Sensitivity:** phono, 2.0 mV; high level, 120 mV. **Frequency Response:** phono, RIAA ±0.5 dB; high level, 20 Hz to 20 kHz, ±1.5 dB. **S/N Ratio:** phono, 91 dB (referenced to a 10-mV input); high level, 97 dB. **Noise Distortion Clearance Range:** for 0.1% THD, 20 Hz to 20 kHz with volume control at −20 dB; phono to speakers, from 100 mW to 22 watts. **Bass Range:** ±12 dB at 50 Hz. **Treble Range:** ±11 dB at 20 kHz. **High Filter Cutoff:** 6 dB-per-octave above 10 kHz. **Low Filter Cutoff** (built-in): 12 dB-per-octave below 10 Hz.

General Specifications:
Power Consumption: 130 watts, 120 volts 60 Hz. **Dimensions:** 17¾W × 6⅜H × 12¾ inches D. **Weight:** 19 lb. **Suggested Retail Price:** $280.

TABLE 1

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Yamaha — Model: CR-420

FM PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE		
IHF sensitivity, mono: (μV) (dBf)	1.7 (9.8)	Excellent
Sensitivity, stereo (μV) (dBf)	8.0 (23.3)	Good
50-dB quieting signal, mono (μV) (dBf)	2.5 (13.2)	Excellent
50-dB quieting signal, stereo (μV) (dBf)	33.0 (35.6)	Very good
Maximum S/N ratio, mono (dB)	76	Excellent
Maximum S/N ratio, stereo (dB)	70	Excellent
Capture ratio (dB)	1.0	Excellent
AM suppression (dB)	58	Good
Image rejection (dB)	52	Fair
IF rejection (dB)	75	Good
Spurious rejection (dB)	78	Good
Alternate channel selectivity (dB)	65	Good
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz ($\pm$dB)	0.3	Excellent
Harmonic distortion, 1 kHz, mono (%)	0.06	Superb
Harmonic distortion, 1 kHz, stereo (%)	0.07	Superb
Harmonic distortion, 100 Hz, mono (%)	0.06	Superb
Harmonic distortion, 100 Hz, stereo (%)	0.075	Superb
Harmonic distortion, 6 kHz, mono (%)	0.12	Excellent
Harmonic distortion, 6 kHz, stereo (%)	0.15	Excellent
Distortion at 50-dB quieting, mono (%)	0.4	Very good
Distortion at 50-dB quieting, stereo (%)	0.35	Very good
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV) (dBf)	8.0 (23.3)	Good
Separation, 1 kHz (dB)	54	Superb
Separation, 100 Hz (dB)	45	Excellent
Separation, 10 kHz (dB)	43	Superb
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV) (dBf)	5.0 (19.2)	Very good
Dial calibration accuracy ($\pm$kHz at MHz)	50-overall	Excellent
EVALUATION OF CONTROLS CONSTRUCTION AND DESIGN		
Control layout		Excellent
Ease of tuning		Very good
Accuracy of meters or other tuning aids		Excellent
Usefulness of other controls		Excellent
Construction and internal layout		Very good
Ease of servicing		Excellent
Evaluation of extra features, if any		Very good
OVERALL FM PERFORMANCE RATING		Excellent

you listen to a completely different program source. Volume and balance controls are concentrically mounted, and next to them is the tuning knob.

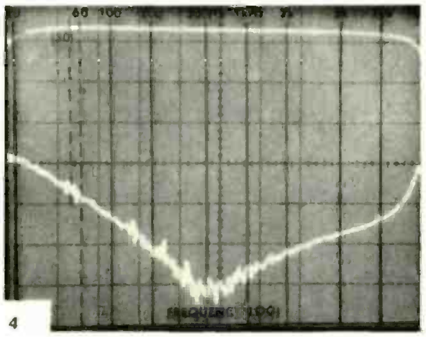
The bottom of the panel contains a pushbutton power on-off switch; two phone jacks (for dual stereophonic headphone listening); speaker selector pushbuttons for choosing one or both pairs of speaker systems (which can be connected to the *model CR-420*); a high-cut filter switch; an AM/FM selector pushbutton; a mono/stereo mode selector; and an FM muting switch which, when pressed to OFF, also switches the FM reception into the monophonic mode, regardless of the incoming FM signal.

The rear panel of the *model CR-420* contains terminals for 75-ohm, 300-ohm FM and external AM antennas. Nearby are the phono and auxiliary input jacks as well as the tape-out and tape-in jacks and a chassis ground terminal. Two rows of spring-loaded color-coded speaker terminals are next, followed by a pair of convenience AC receptacles (one switched, the other unswitched). A wide variety of additional components can be connected to the *model CR-420* receiver.

Circuit highlights

An internal view of the chassis is shown in Fig. 2. The power-supply circuitry is well isolated from low-level and RF circuits, and the two major rotary switches are connected to front-panel knobs via long coupling shafts and swivel joints. This design places the actual switches close to the circuits they must select.

The front-end section of the receiver uses a three-gang tuning capacitor and a junction FET for the RF amplifier stage. The IF section uses a four-element ceramic filter, a two-stage



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direct-coupled amplifier and a three-stage differential amplifier with a current limiter. The FM demodulator is a wideband balanced-type ratio detector; and a phase-locked-loop IC is used for multiplex stereo decoding.

A special circuit allows the external FM antenna to serve for AM reception thus eliminating the need for a bar antenna. During AM reception, the FM antenna acts as a whip antenna because of the high impedance provided by capacitors C1 and C2 (see Fig. 3). Using capacitor C3 to bypass the power-transformer primary side, the ground side of the AM antenna coil is grounded via the power-line cord; this provides a whip antenna effect. To increase the antenna's sensitivity, the shorting bar shown in Fig. 3 bridges the terminals as shown. If overloading results, the bar can be removed.

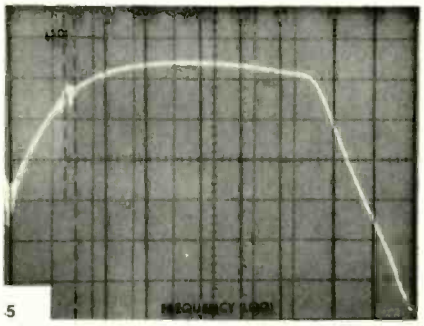
The power-amplifier section of the *model CR-420* is direct-coupled and consists of a differential amplifier stage with constant-current circuitry, a Class-A driver stage with two-stage thermal compensation, a Darlington pair full complementary single-ended push-pull DC-coupled output stage, and a power-consumption limiter-type protection circuit.

A speaker protection relay separates the amplifier and speakers when the power switch is turned on or whenever more than ±2 volts DC is present at the speaker output terminals.

FM measurements

Table 1 summarizes measurements made for the FM tuner section. The results can be compared with the manufacturer's published specifications shown elsewhere in this report. Almost every performance specification was either equalled or exceeded, except for the monophonic and stereophonic signal-to-noise claims, which were nontheless excellent. The 1-kHz distortion readings of 0.06% in mono and 0.07% in stereo are about as low as we have ever read, even when lab testing the very highest-priced separate tuners. Stereo FM separation of better than 50 dB at mid-frequencies and above 40 dB at 10 kHz is also unusual in receivers in any price or power category.

Figure 4 is a scope analysis of FM frequency response and separation. Note that FM de-



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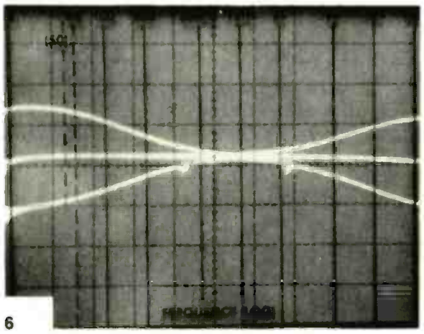
emphasis no longer plays a part in these measurements since in our lab we now use a signal processor ahead of our FM generator, which applies the required pre-emphasis to the swept modulating test signal to achieve a flat "net" response.

Figure 5 is a scope photo of AM response and, as is true of most stereo receivers providing AM reception, response began to fall off at around 3 kHz.

Amplifier measurements

Table 2 contains a summary of all amplifier/preamplifier-control measurements made on the *model CR-420*. The performance of this section was consistent with that of the tuner. Power ratings are conservatively stated since we obtained an output of 34.0 watts-per-channel at mid-frequencies and 31 watts-per-channel at 20 kHz, as opposed to the 22-watt-per-channel FTC power rating claimed. At an actual rated output of 22 watts-per-channel (at mid-frequencies), harmonic distortion was an extremely low 0.008% while IM distortion was almost equally low, with readings of only 0.009%. Distortion readings at the 1-watt level were largely distortion plus noise (with the noise component contributing more to the single-meter reding than the distortion), but they were well below Yamaha's 0.1% NDCR index figure and well below the rated 0.95% THD figure, even ignoring that noise was a contributing factor to the total reading.

The range of the BASS and TREBLE controls of the *model CR-420* is shown in Fig. 6. Note that turnover frequencies are positioned lower (for the BASS) and higher (for the TREBLE) than is usual with simple feedback-type controls. This design feature makes it possible to augment extreme bass or extreme treble that might be deficient.



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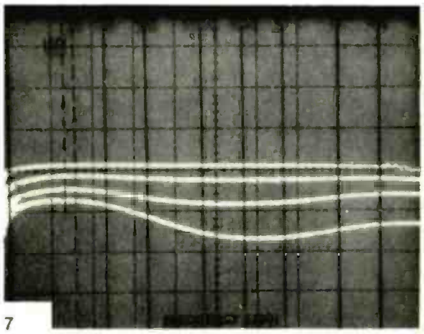

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Figure 7 shows the system response at various loudness control settings. When these measurements and sweep-frequency analyses were made, the volume control remained at a fixed setting and only the separate loudness control setting was altered. At mid-frequencies, this control provides up to 20 dB attenuation, but as can be seen from the progressively lower amplitude sweeps, compensation at the bass end of the spectrum increases as the control setting is lowered.

Summary

Table 3 contains an overall product evaluation together with our positive conclusions regarding the *model CR-420*. Although in the past we have tested more costly Yamaha receivers and other components, this is our first experience with one of their lower-priced products. We have had an opportunity to use the receiver for better than two weeks, and it is easy to see why these receivers are well accepted. Yamaha has brought as much care and thoughtful engineering to "beginner" sets as to its sophisticated separate components. **R-E**

TABLE 2
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Yamaha Model: **CR-420**

AMPLIFIER PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
POWER OUTPUT CAPABILITY		
RMS power/channel, 8-ohms, 1 kHz (watts)	34.0	Excellent
RMS power/channel, 8-ohms, 20 Hz (watts)	33.0	Superb
RMS power/channel, 8-ohms, 20 kHz (watts)	31.0	Excellent
RMS power/channel, 4-ohms, 1 kHz (watts)	N/A	N/A
RMS power/channel, 4-ohms, 20 Hz (watts)	N/A	N/A
RMS power/channel, 4-ohms, 20 kHz (watts)	N/A	N/A
Frequency limits for rated output (Hz–kHz)	Below 10–45	Superb
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.008	Excellent
Intermodulation distortion, rated output (%)	0.009	Excellent
Harmonic distortion at 1-watt output, 1 kHz (%)	0.025	Very good
Intermodulation distortion at 1-watt output (%)	0.02	Very good
DAMPING FACTOR, AT 8 OHMS	51.4	Very good
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ± dB)	+0.5 −0	Very good
Maximum input before overload (mV)	140	Very good
Hum/noise referred to full output (dB) (at rated input sensitivity) ("A" weighted)	80	Excellent
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz–kHz, ± dB)	13–41, 1.0	Very good
Hum/noise referred to full output (dB) ("A" weighted)	102	Excellent
Residual hum/noise (minimum volume) (dB) ("A" weighted)	103	Excellent
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 7	Good
Action of secondary tone controls		N/A
Action of low-frequency filter(s)		N/A
Action of high-frequency filter(s)		Good
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	2.1	
Input sensitivity, auxiliary input(s) (mV)	105	
Input sensitivity, tape input(s) (mV)	105	
Output level, tape output(s) (mV)	105	
Output level, headphone jack(s)	125 mV	
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		Very good
Adequacy of input facilities		Very good
Arrangement of controls (panel layout)		Excellent
Action of controls and switches		Excellent
Design and construction		Very good
Ease of servicing		Very good
OVERALL AMPLIFIER PERFORMANCE RATING		Excellent

TABLE 3
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Yamaha Model: **CR-420**

OVERALL PRODUCT ANALYSIS

Retail price	$280
Price category	Low
Price/performance ratio	Superb
Styling and appearance	Excellent
Sound quality	Very good
Mechanical performance	Very good

Comments: Yamaha is an audio component manufacturer that does not sacrifice control or quality when "stepping down" to its lowered power receiver designs. The tuner section (at least the FM) of the *model CR-420* exhibited performance characteristics as good as those of higher-priced models, and, even though the unit is not equipped with selectable IF bandwidth, a high-enough alternate channel selectivity was balanced with an adequate bandwidth, so that the distortion levels observed during our tests (at full 100% modulation levels) were incredibly low—often limited by the capabilities of our test equipment. Stereo separation in FM was very high.

Perhaps more important than the measured test results was the intelligent control layout. The separate record-out switch and program source switch are a welcome innovation in a receiver at this low price and permit you to record one program source while listening to another. Yamaha retained the center-of-channel tuning mode for the single meter when it is used for FM tuning. We wish that the MUTING switch had been made independent of the stereo/mono FM mode, since the present arrangement prevented us from checking out some weak-signal stations in the stereo mode.

At (or even slightly above) its rated power-output level, the *model CR-420* delivers good tight sound that is well balanced and uncolored. With so many new speaker systems requiring no more power than the receiver can supply, it's nice not to have to opt for a super-powered unit just to obtain other high-quality features.

Radio-Electronics Audio Lab Tests

1

CIRCLE 131 ON FREE INFORMATION CARD

SAE Model 4100 Time Delay System

MOST SERIOUS AUDIOPHILES KNOW THAT ANY stereo component system, no matter how superior its music-reproduction capabilities, still falls short of recreating the total musical experience of attending a live concert in an acoustically proper environment. When you attend a live concert in a large auditorium, much of the sound reaches you not from the stage, but as reflections from the walls, ceiling and other areas of the auditorium. This reverberant sound is delayed in time in amounts that depend upon the hall's dimensions. The duration of the sound reflections can also vary greatly, depending upon the hall size and the reflective nature of its surfaces. These effects are called the acoustics or reverberance of the concert hall and it is this reverberant effect with its associated time delay that the Scientific Audio Electronics (701 E. Macy, Los Angeles, CA 90012) *model 4100* attempts to recreate in a home listening room.

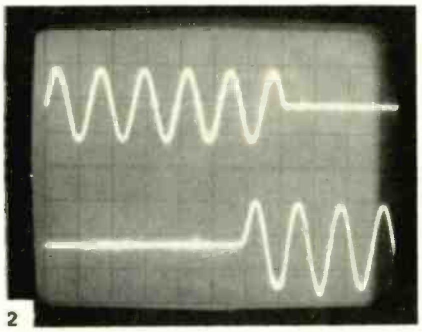
The *model 4100* (see Fig. 1) requires another stereo amplifier and another pair of speakers in addition to itself and your present stereo component system. The unit is designed to be used between the preamplifier output and the power amplifier input of an existing stereo system.

Performance measurements

The *model 4100* requires relatively few static bench measurements. The few we did make are summarized in Table 1. Lest you become dismayed at the seemingly poor frequency response obtained from the rear-channel outputs, a few words of explanation are needed.

Long ago it was established that reverberant or reflected sound in a concert hall does not contain very much high-frequency content. This is because the highs are more readily absorbed by the structural surfaces of the concert hall than the low and mid-frequencies that are more easily reflected from surfaces. In addition, our outer ear is so shaped that high frequencies reaching us from behind are not as readily perceived as treble frequencies reaching us from the front. If the rear channels reproduced all the frequencies with uniform intensity, the effect would be unreal and we would perceive the rear speakers as being primary producers of program content, which is not the purpose of a time-delay system.

The effectiveness of a device such as the *model 4100* is more easily determined by listening tests than by static bench measurements, and our comments and overall product analysis in Table 2 confirm that the *model 4100* produces the desired effect in a home music system very successfully. Nevertheless, to give you some idea of what is taking place inside the "black box," we fed a series of burst tones into the inputs of the *model 4100*. In the scope photo of Fig. 2, the upper trace represents the tone-burst input, while the lower trace represents the signal obtained by using only the "short" time-delay slide control set to its maximum setting. The signal has clearly been delayed by the requisite amount (sweep rate was 2 μs-per-horizontal division).



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Summary

The *model 4100* Time Delay Ambience System will appeal to those audio purists who are willing to add the necessary additional stereo amplifier and extra speakers to their hi-fi systems to achieve total realism in home music-reproduction systems. This system should enable a user to duplicate every kind of listening environment. **R-E**

MANUFACTURER'S PUBLISHED SPECIFICATIONS:

Total Harmonic Distortion: 0.5%. **Intermodulation Distortion:** 0.5%. **Signal-to-Noise Ratio, referred to rated output:** front outputs, 95 dB; rear outputs, 60 dB. **Frequency Response:** rear outputs only, 50 Hz to 5 kHz, ±1.0 dB. **Weight:** 15 lb. **Dimensions:** 2¾ H × 15 W × 8 inches D. **Suggested Retail Price:** $500.

TABLE 1

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Scientific Audio Electronics — Model: 4100

AUDIO TIME DELAY PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
Total harmonic distortion, 1 kHz (%)	0.3	Good
IM distortion (%)	0.2	Very good
S/N ratio, front (dB)	90	Excellent
S/N ratio, rear (dB)	77	Excellent
Frequency response, rear (Hz–kHz)	36–5.0, −1.0 dB	See text

TABLE 2

OVERALL PRODUCT ANALYSIS

Retail price	$500
Price category	Medium
Price/performance ratio	Very good
Styling and appearance	Excellent
Sound quality	Excellent
Mechanical performance	Very good

Comments: The merits of a time-delay unit such as the SAE *model 4100* are directly proportional to the degree of flexibility it affords. The greater the number of variables in time delay and reverberation, the more likely the unit will be able to duplicate the sonic environment that best fits the music reproduced in your listening room. The *model 4100* excels in this respect, thanks to the three time-delay levels and its ability to introduce continuously variable amounts of short, medium and long delay. SAE engineers and listening panel must have done a great deal of listening before choosing these delay times since, in our extended listening tests, we were always able to find some combination of delays and regeneration (reverberation) that resulted in an apparent room-size enlargement just about perfect for the particular program source.

However, as with all such devices, the effect can be overdone, and you are cautioned to adjust it with care. If you can "hear" sound coming from the rear speakers, the rear sound level is probably too high and should be backed off. The BLEND pushbutton, in which a delayed sound signal is fed back to the front speakers as well as to the rear speakers, did not prove to be useful in our setup, although it might prove effective if you simply want to add some reverberation to "dry" program sources recorded with close-microphone techniques.

A device such as the *model 4100* should not be confused with any 4-channel reproduction scheme. But, in its own way, this time-delay unit offers one of the chief advantages of 4-channel sound—the feel of a concert hall—that was almost entirely ignored in the early 1970 attempts at quadriphonic sound reproduction.

Troubleshooting Communications Receivers

The right signal generator, good diagnostic ability and precise bench techniques lead to rapid repair of 2-way radios.

FOREST BELT

MANY OF THE ARTICLES ON TEST EQUIPMENT tend to be of the "what it does" variety. Some of them, like lab reports, provide a list of specifications and comments on the conformance or nonconformance to the specs by the instrument being examined. This special section takes a different approach.

We will take an in-depth look at communications signal generators and how to properly use one to troubleshoot. We will also look at what instrument features make the job easier and which instruments have those features. The following pages of this article will attempt to bring you this knowledge, along with explanations and illustrations.

Using the best available information, all data has been checked and rechecked. Some test equipment manufacturers did not respond to our requests for detailed information. We have either omitted their instruments or told you what we could learn about them by other means. In either case, there is a lot of information here to insure successful two-way-receiver troubleshooting, no matter what kind of land/mobile, marine, or CB outfits you should run across.

Troubleshooting communications receivers

You can approach diagnosing two-way radios from two standpoints: First, and probably most common, you can analyze a symptom or set of symptoms, then track down the specific defect causing those symptoms.

Or—and I consider this the better approach—you can start a procedure that takes you all the way through the transmitter-receiver. Along the way you virtually cannot miss encountering any defect that exists. Moreover, checking the entire set this way anticipates many minor troubles, and helps you correct them before they cause a breakdown. Best of all, you put the transmitter and receiver in tip-top condition, right up to specifications.

An approach like this proves effective whether you're troubleshooting CB radios, FM two-way radios, aircraft transceivers, marine radio-telephones, or ham gear. The result is thorough servicing, mixed with what is commonly called preventive maintenance—grade-A insurance against most callbacks.

This special section deals with signal generators, with the emphasis on receivers and the receive function of transceivers. Obviously, certain transmit functions can also be traced with communications signal generators: mainly in microphone amplifiers and modulators.

For a start, let's examine in more detail this overall troubleshooting approach. The block diagram of Fig. 1 shows the receive stages in a typical FM two-way radio. Receive stages in CB transceivers differ somewhat, since they receive AM or SSB signals.

The receive stages shown in Fig. 1 represent those of a recent model single-conversion UHF-FM receiver. Not long ago, UHF receivers needed a second conversion, down to 455 kHz. Only filters at that low IF frequency could confine bandwidth or selectivity enough for narrowband FM (5-kHz deviation). But technology never stands still. Now, sharply selective crystal filters at 10.7-MHz (especially in tandem as shown here) can hold IF selectivity tightly to the necessary

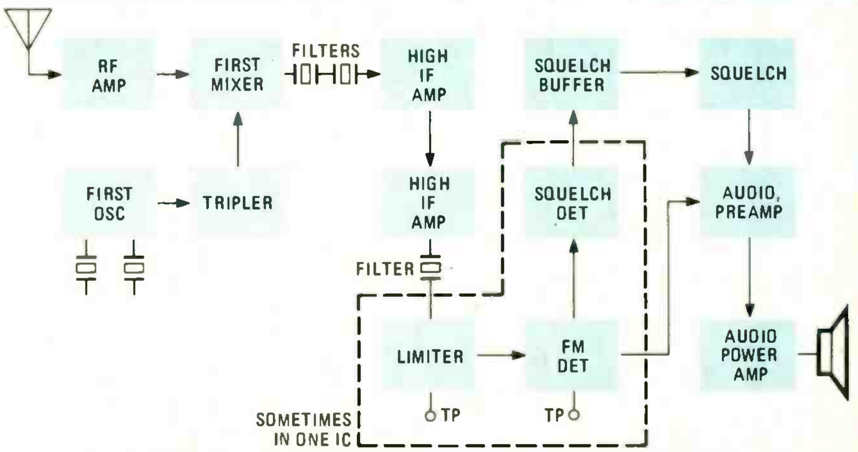


FIG. 1. RECENT MODEL UHF-FM RECEIVER reflects single-conversion design. Older UHF sets used dual conversion, and did not contain IC's.

20-kHz bandwidth. The need for a second oscillator and mixer is eliminated.

This changes very little the way you approach overall troubleshooting. As you will see later, dual-conversion receivers require a generator that reaches accurately down into the submegahertz frequencies.

First things first

An excellent place to begin troubleshooting is around the discriminator. You need an accurate 10.7-MHz signal source, unmodulated. Of course, if the discriminator comes after a series of low-IF amplifiers, let's say, the 455-kHz variety—that's the signal source to use.

The important thing to remember is *accuracy*. Today's more expensive signal generators have plenty of accuracy. However, you should not attempt a discriminator adjustment with just any old signal generator. One of exceptional accuracy and tight stability is a must. Lacking an expensive generator, you may have to make do with one that has less stability; if so, *always* monitor its output with a frequency counter.

Once the discriminator is calibrated, turn your attention to the IF stages immediately preceding it. In the Fig. 1 example, this means you test the IF amplifier and limiter stages at a frequency of 10.7 MHz. In a dual-conversion receiver, this step deals with 455-kHz stages.

Go to the limiter first. You'll discover that a quick meter check of the action in this stage indicates some things about the operation back towards the front end of the receiver, without even injecting a signal. Monitoring the effects, at the limiter, of an input signal tells you even more.

After checking the limiter, assess the operation of the IF amplifiers and the associated selectivity filters. Again, certain tests reveal whether or not these stages and components perform the way they are intended to. If they don't, correct the trouble before you proceed. Some later tests will depend on the proper operation of these IF stages.

Alignment tells a story

Knowing that transmitter troubleshooting responds well to an alignment procedure in diagnosis, smart technicians apply similar techniques for the IF and RF sections of communications receivers.

Therefore, if the receiver is a dual-conversion set, you next switch your signal generator to the high intermediate frequency and test those stages. As you will discover, you can verify the accuracy of your signal generator by two measurements—one using your frequency counter, and another made at the discriminator of the receiver. (Details will follow later in this article.)

The same procedure works when you check the receiver's RF sections. If the previous tests have been performed correctly, you can quickly zero-beat the receiver to a base transmitter or to a tightly controlled signal generator. (Today's generators (see Table 1) with digital settings have an accuracy that exceeds the FCC requirement for transmitters.)

TABLE 1—FM SIGNAL GENERATORS[1]

Brand	Model	Frequencies	Accuracy (ppm)[2]	Output (mV)	Tone-Squelch Frequencies (Hz)
Cushman	CE-4B CE-5	0.01-999.9999 0.05-519.999	3 9	100 100	10.0-9999.0
ifr	FM/AM 1000A	0.03-1000.0	5	5	5.0-9999.9
Lampkin	107C 109 303	0.001-1000.0 2.0-512.0	5 10	100 50	 10.0-9999.0
Singer/ Ailtech	FM-10CS	0.05-1300.0	10	1	
Wavetec	3001 3002	1.0-520.0 0.001-520.0	100 100	1000 1000	

NOTES:

1—All but Waveteck are part of FM communications service monitors.
2—ppm = parts per million, each part equivalent to 0.00001% of dialed frequency.
3—Dual-tone generator, with variable delays and durations.

Next on the agenda

It may come as a surprise that audio-and-squelch diagnosis *follows* the IF and RF troubleshooting procedure. Yet, using a meter to check most two-way radios makes it easy to check out most of these sections—up to and including the FM detector—without having to listen to the receiver.

Furthermore, only if all these tests come out as they should are squelch-system tests meaningful. This is because FM two-way radios depend on noise-operated squelch. Squelch problems in these sets often arise from defects in the RF or IF sections. Anything that reduces the amount of front-end circuit noise at the discriminator can cause "soft or erratic squelch." You could drive yourself crazy trying to track it down in the squelch section.

For this and other reasons, therefore, we suggest getting the discriminator, the low and high IF sections, and the RF and oscillator/mixer stages all in tip-top shape before you worry about squelch or audio.

Also, you can then check out the squelch and audio without having to use an audio generator. Simply feed a frequency-modulated signal (again, most modern generators can be frequency-modulated as well as amplitude-modulated) through the front end of the set (which you have proved OK) and proceed with testing.

This possibility becomes even more important when tone-coded squelch is involved. In these systems, receiver squelch opens up and "hears" only messages with an accompanying subaudio tone from the transmitter.

First, of course, you must understand how these squelch systems work. Second, you must be able to check the way squelch turns the audio on and off. Finally, you test how the squelch is opened up by the subaudio tone. This last requirement involves using a rather special audio generator, which is beyond the scope of this Special Section.

Final checks

One other important circuit within a receiver is the power supply: Certain DC voltages are regulated.

Before you undertake any other procedures, measure and verify that these regulated DC voltages are where they are supposed to be.

Not many mobile sets use electromechanical relays nowadays. Yet you may come across older gear that does use such relays.

Ordinarily, there are only two answers to relay problems: Either burnish the contacts or replace the relay. Only the most experienced relay expert is truly successful in trying to "bend the contacts" so they make and break in proper sequence. Considering the time you might spend on this procedure, and the likelihood of an early failure, your money is better spent on a new part.

Finally, do the customary final touch-ups. If a pilot light looks a little dark, it should be replaced because it will probably burn out soon. Dust out the chassis and clean up the front panel. Use a little alcohol on a *Q-Tip* to clean almost any corner. Remove knobs so you can clean behind them rather than leave a "ring around the collar."

Most important of all, service the set thoroughly. Whether you use the procedures described in this Section or ones of your own, check the set thoroughly. That's the only way to do the job conscientiously.

FM Detector And Filter Tests

Proper operation of FM detectors is vital to reliable operation of 2-way radio communication. Here's how they work and how to fix 'em.

BEFORE EMBARKING ON TESTS, YOU should understand how an FM demodulator works. Three basic types are used—discriminator, ratio detector and quadrature detector. Each is different, yet the principle of operation is roughly the same.

A frequency-modulated IF signal goes to the primary of a demodulator transformer. The signal is coupled inductively to the secondary. However, capacitance coupling also feeds the signal into the same circuits that are driven by the transformer secondary. This mixes inductively coupled and capacitively coupled signals, 90 degrees out-of-phase with each other.

A pair of diodes, connected in series-opposing at each end of the transformer secondary, act as detectors. However, the 90-degree phase difference causes them to conduct equally under one condition only—when the signal entering the transformer primary is precisely at the resonant frequency of the transformer primary and secondary circuits.

However, during frequency modulation, the signal deviates above and below the center frequency *at an audio rate*. Imbalance caused by the quadrature signals is proportional to the *amount of frequency deviation*.

Demodulators in double-conversion receivers center on a 455-kHz frequency. In others, the demodulator centers at whatever IF has been chosen; 10.7 MHz is usual.

Figure 1 shows an example of a basic FM discriminator that is used in many G-E two-way receivers. When the frequency swings above resonance, diode D1 conducts the most current. The voltage across the 220-pF capacitor becomes positive at the junction of D1. The farther the frequency deviates from center, the greater the positive voltage. When the frequency swings below resonance, diode D2 conducts the most current, and diode D1 conducts less. Voltage becomes positive at the junction of the capacitor and diode D2. Polarity across the capacitor thus alternates back and forth in step with the frequency deviation.

LAMPKIN LABORATORIES MODEL 107C

If you remember your frequency-modulation theory, you know that deviations occur at an audio or voice-frequency rate. The resulting alternating voltage across the 220-pF capacitor corresponds exactly with those voice frequencies. The RF is eliminated by the 220-pF capacitor. The demodulator thus recovers audio or voice modulation from the IF signals.

The discriminator shown in Fig. 2 differs only in how the quadrature or phase-shifted signal is fed to the secondary circuits. A "phantom center tap" is set up by a capacitive divider across the secondary.

The overall effect is identical. A signal precisely at resonance (of the transformer) results in the two diodes conducting equally and developing an equalized potential (0 volt) across the load capacitor. You can measure this zero voltage through a metering circuit—in Fig. 2, the 15K resistor and 0.01-μF decoupling capacitor.

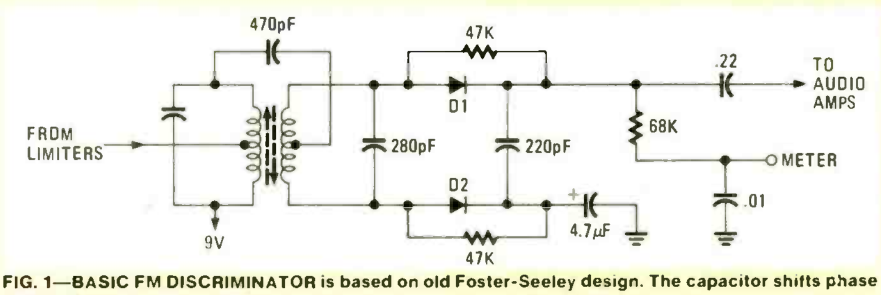


FIG. 1—BASIC FM DISCRIMINATOR is based on old Foster-Seeley design. The capacitor shifts phase by 90 degrees.

Either of two things can move this DC "output" voltage away from zero. First, if the center frequency fed to the transformer is slightly off—that is, not exactly at 455 kHz—the resting meter voltage reads slightly positive (above frequency) or slightly negative (below frequency). Second, with an exact incoming frequency, any misalignment of the transformer resonance, particularly secondary misadjustment, drastically alters the meter reading. In other words, the discriminator meter reads zero only when the incoming frequency is exactly 455 kHz, *and* when both transformer coils are adjusted to resonate precisely at 455 kHz.

From this, you can determine how to "calibrate" a discriminator; i.e., set it accurately at zero. Feed an accurate 455-kHz signal into the transformer from the limiter stages, and adjust the transformer coils for a zero reading at the discriminator metering point.

Just one precaution: The accuracy of this 455-kHz test signal is crucial. Use a crystal-controlled source, or a highly accurate synthesized generator, or keep a frequency counter on the generator you use. This is the only way you can truly calibrate the discriminator.

Figure 3 shows another type of demodulator. Note how the quadrature signal passes between two capacitive dividers, one across the primary and another across the special three-winding secondary of the discriminator transformer. This particular discriminator is used in Motorola two-way radios. Sometimes it is called a *phase discriminator;* some technicians call it a *capacitance discriminator*. The bottom part (inset) of Fig. 3 restructures the usual diagram to help you understand the operation of the demodulator a little better.

Diode D2 grounds the bottom end of the transformer secondary on the half-cycles in which the top end of the winding is negative (and the bottom end is positive). During that half-cycle, R1 is the load. Diode D1 couples the other end of the secondary to R2 on the other half-cycles. At resonance, D1 and D2 conduct almost identically. The DC voltages they develop show up across capacitor C4. Since these voltages are equal, they cancel each other. Therefore, the voltage at the metering point is exactly 0 (to ground).

Let the frequency being fed to the transformer deviate even slightly from

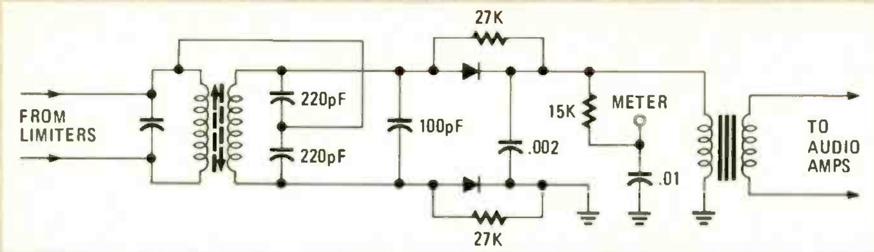


FIG. 2—DIFFERENCE IN SHIFTING PHASE does not alter the operation of this FM detector.

the transformer's resonant frequency and one diode conducts slightly more than the other. The voltage developed across C4 becomes something other than zero. If the frequency goes up, D1 conducts the most and the voltage at the metering point swings positive. Below resonant or center frequency, D2 conducts more and the voltage at the meter point is negative.

Hence, as frequency modulation deviates the signal up and down from the center frequency, the voltage across C4 follows the deviations closely and frequency demodulation occurs.

One thing you will discover when you examine the functional block diagram of almost any two-way radio is that a stage or two of *limiting* precedes the FM discriminator. *Limiters* are saturated stages that level out any amplitude variations that exist in a signal. It is important, for the recovered voice signals to be clear, that a discriminator type of demodulator be fed a pure FM signal. Many factors between the transmitter modulator and the receiver demodulator can vary the signal level, in effect adding some amplitude modulation. Most discriminators are sensitive to amplitude modulation, so limiters are necessary.

Once a limiter is saturated, it develops a base current that is somewhat proportional to the signal fed into the stage. Consequently, connecting a meter across a base resistor will indicate whether the limiter works or not. Virtually all commercial FM two-way radios contain at least one metering point for evaluating the limiter, which is why it's handy as an alignment indicator.

Broadcast FM receivers and some older communications receivers contain a variant called a *ratio detector*. The most notable circuit variation is that the diodes are connected as series-aiding rather than as series-opposing. Capacitors still produce a quadrature phase shift and the same results are obtained as with a discriminator; that is, frequency deviations cause a change in voltage across an output or a load capacitor and voice signals are recovered from a frequency-modulated IF signal.

A ratio detector effectively cancels the amplitude modulations that accompany the IF signal to the detector. Therefore, less limiting is needed. Nevertheless, you almost never find a communications receiver without limiters between the low-IF amplifier and the FM demodulator.

Modern systems

Figure 4 shows a modern-day FM demodulator. Instead of a discriminator transformer, a fixed-frequency ceramic filter couples the IF signal from the limiters to the diodes. Designed especially for this purpose, this unique filter offers an extra advantage: high selectivity. Aging seldom changes the filter's resonant frequency more than a few Hertz, so you never have to adjust it; it either works or it doesn't.

The 90-degree phase difference occurs in the discriminator filter itself. Two output voltages develop across R1 and R2, and are fed to diodes D1 and D2. Because they are connected in series-aiding, diodes D1 and D2 deliver a combined DC output voltage that is precisely zero when the frequency that is fed to the filter exactly matches its center resonance. Deviations up or down from the center frequency produce a net positive or negative voltage across R3. Capacitor C3 provides a time constant with this load fast enough to respond properly to voice frequencies, and yet slow enough to eliminate most of the IF component. Network L1 and C5, together with bypass capacitor C4, filter out any remaining 455-kHz signal. As a result, capacitor C6 couples voice signals onto the audio-amplifier stages.

As always in communications discriminators, there is a test point across the DC output. In this design, since you cannot adjust the quadrature circuit, this test point serves mainly to help you judge whether the filter discriminator is good or bad, or adjust the conversion oscillators.

State-of-the-art two-way radios use an IC for the limiter/discriminator sections. Even with these circuits, a 90-degree phase shift is necessary. So, you will find an adjustable quadrature transformer connected to two pins of the IC. This tunable coil serves the same purpose (insofar as adjustment is concerned) as the secondary of a discriminator transformer.

Figure 5 shows a simplified representation of an integrated-circuit FM demodulator system, with limiters and a quadrature detector contained in one IC.

The quadrature coil is located externally. Tuning it is similar to tuning the secondary of a discriminator or ratio detector, but with one significant difference. You do not align for a zero-centered

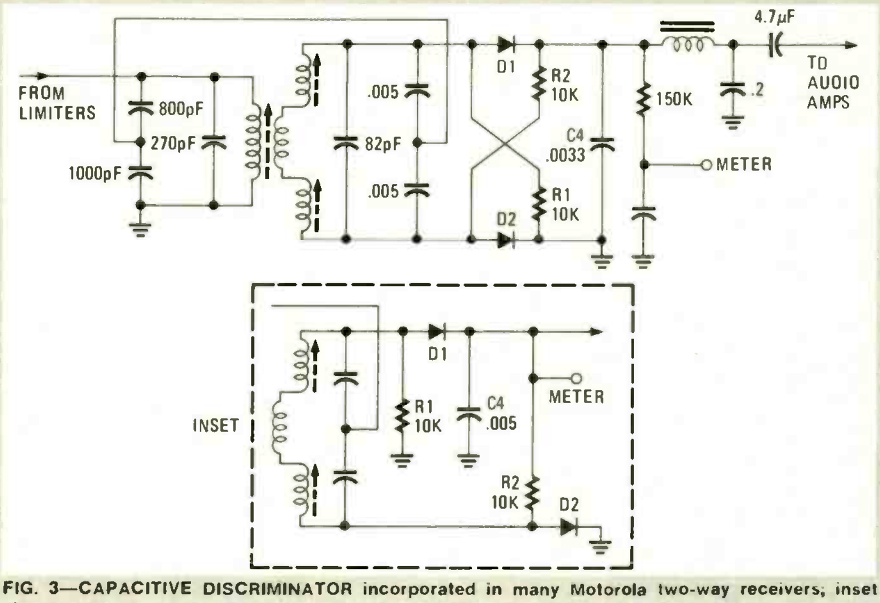


FIG. 3—CAPACITIVE DISCRIMINATOR incorporated in many Motorola two-way receivers; inset shows restructured circuits so you can understand how demodulators work.

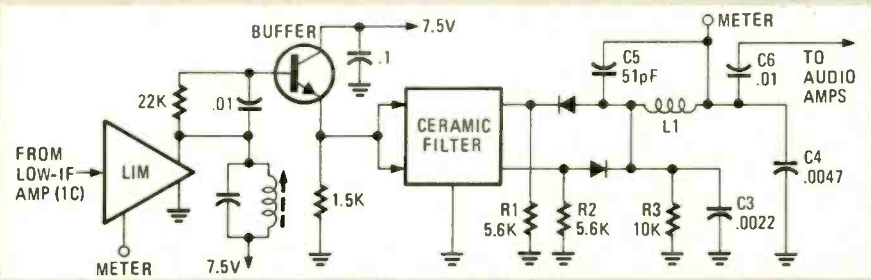


FIG. 4—FM DETECTOR (from marine VHF set) is driven by ceramic filter; it features high selectivity and cannot be adjusted.

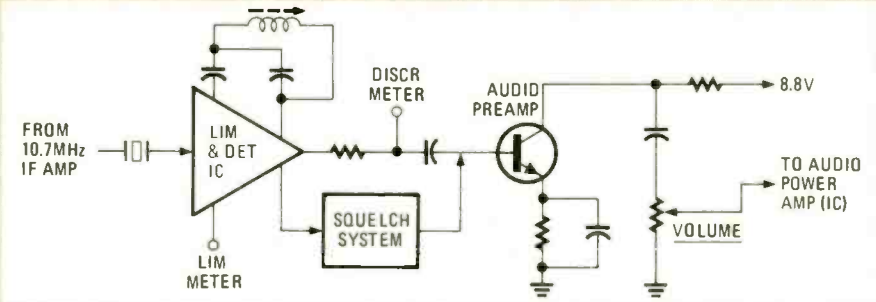


FIG. 5—IC'S IN MODERN DESIGN often combine a limiter and FM detector; the alignment coil is still external.

meter reading. Instead, with a very precise IF signal fed in from the IF amplifiers, you align for an exact 24-μA meter reading. This happens to be "zero-center" on this quadrature-detector S-curve. Naturally, the circuit includes a detector metering point.

Limiter stages are part of the same IC. As is common practice, there is a metering point for measuring the limiter current. You can use limiter metering to adjust for RF and IF alignment.

The Fig. 5 set has an IF of 10.7 MHz. To calibrate the discriminator, use only a signal source that is synthesized with a digital readout, or is tightly crystal-controlled.

Testing FM detectors

The first test for a discriminator is whether or not it will zero-center properly. This is called "calibrating" the discriminator. (Earlier we stressed the necessity for signal-source accuracy.)

Another important point: DO NOT try calibrating the discriminator from the front end or, in double-conversion sets, with a high-IF signal. Why? If either oscillator happens to be off-frequency, you would zero-center the discriminator incorrectly, or you would unknowingly use an incorrect signal. Perform this part of troubleshooting using only an unmodulated IF signal.

Feed a precisely accurate 455-kHz low-IF signal into the base of the second receiver mixer. If the receiver is single-conversion, use whatever frequency the IF and discriminator take, but feed in the signal at the mixer base. The mixer stage thus isolates any capacitive effect the generator cable has on tuning of subsequent stages.

The signal should be very strong for this test and adjustment procedure. Set the generator-output level high—for at least 500 mV of IF signal.

Connect your DC meter at the discriminator test point. If the meter reads either side of zero, adjust the discriminator coil (the secondary—usually the bottom slug) to center the discriminator as closely to zero as possible. Make sure again that the test signal is precisely at the right IF; otherwise, any later adjustments will be incorrect. Also remember that, in some sets, zero center is at some specified meter reading.

If you can't zero the discriminator, this means trouble, and diodes are the most frequent offenders. Diodes should be fairly well matched: that is, forward resistance should be about the same in both. There should be almost *no* leakage. A faulty coil or capacitor can also prevent zeroing. Get this corrected before proceeding any further.

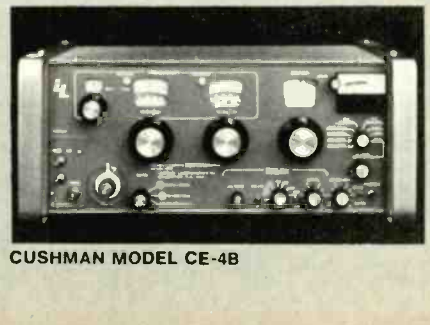
Next, test the discriminator for balance. This is where a decade-type generator frequency control comes in handy.

With the discriminator accurately zeroed, reset the generator frequency for 1 kHz *above* the center frequency. Note the new discriminator meter reading. Then, reset the generator frequency to 1 kHz *below* the center frequency. The meter reading should move in the opposite direction from zero and exactly the same amount. In other words, equal frequency swings above and below center frequency should result in equal but opposite voltage swings.

Diodes again are your prime suspect when a discriminator fails to show balance. Sometimes, however, a badly mistuned *primary* coil creates this effect, even when the secondary seems to zero normally. However, go easy: all primary tuning requires that you readjust the secondary for zero. Capacitor values that have shifted (as a result of age or heat) can also cause unbalance. In addition, check the decoupling for the primary winding and the discriminator secondary.

Poor discriminator balance can be caused by a faulty ceramic or crystal IF filter. Although this is not the usual symptom of a bad selectivity filter, don't overlook it. (In a moment we'll tell you how to test filters.)

Connect your DC meter at the metering point in the limiter stage nearest the discriminator. Adjust all low-IF transformer and limiter coils for a maximum reading at the limiter.



CUSHMAN MODEL CE-4B

For this check, don't feed in too much IF signal. Set the signal generator attenuator at zero and turn it up until you see the limiter reading rise slightly. If, when you align the IF and limiter coils, the reading goes higher, keep reducing the generator-output signal. If you oversaturate the limiters, these adjustments will be too broad and you won't obtain accurate alignment.

Broad adjustments in any case signify trouble. Look for a leaky transistor, a faulty transformer or an open decoupling capacitor. Eliminate the trouble before proceeding to any other part of the receiver.

Finding filter defects

Check out low-IF filters when you have your instruments connected for IF alignment. Keep the generator set exactly at the discriminator's center frequency. Feed in just enough signal to quiet some of the circuit noise heard in the speaker. Meter the limiter at the same time. You will note that slight quieting occurs after the limiter reading starts rising.

Now, set the generator-output high so the receiver is almost but not completely quieted. This signal level brings the limiter reading up to about halfway between threshold limiting and "flattening out" or oversaturation. It is important to hear a tiny bit of circuit noise, and note the limiter meter reading.

Now, raise the generator frequency exactly 1 kHz *above* the center frequency. Pay close attention to the increased noise level of the receiver and the exact degree of reduction in limiter reading.

Next, shift the generator frequency to 1 kHz *below* center. The meter reading should fall off almost exactly the same amount as for 1 kHz above the center frequency. Speaker noise increases.

You can make and interpret this test in a matter of seconds. If you have any doubts, swing the generator frequency 2 kHz above and below center. Again, the noise levels on either side of center should be the same, with matching reductions in the limiter reading.

If there had been any earlier unbalance in the discriminator or quadrature detector, this test indicates whether you can blame it on defective filters.

Sometimes, when a discriminator zeroes OK but cannot be balanced exactly, some careless folks settle for a compromise balance, with the discriminator resting a little off-center. This results in audio distortion, especially during full signal modulation from another station or transmitter. Always test both the discriminator *and* filter balance to be sure.

Where filters are ganged, you may wonder which one is bad. Try injecting the test signal between the two filters. Isolate the signal generator with a 50-pF capacitor in series with the cable. Injection tracing lets you isolate which filter has changed characteristic. **R-E**

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Chapter 5 questions, electronic components & circuits

1. Which of the following statements regarding the circuit shown in Fig. 1 is true:

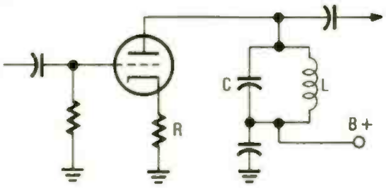

FIG. 1

( ) a. will pass all frequencies except one band near the resonant frequency of the L—C circuit.

( ) b. will reject all frequencies except one band near the resonant frequency of the L—C circuit.

( ) c. the value of R will determine the resonant frequency of the L—C tank circuit.

( ) d. resistor R provides regeneration for the circuit.

2. In the circuit shown in Fig. 2:

( ) a. R and C act as a tone control.

( ) b. R varies the frequency of oscillation.

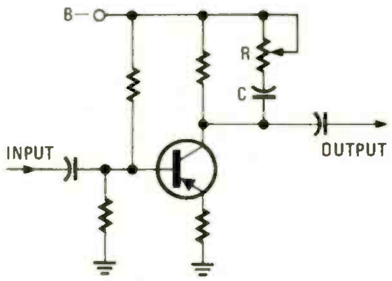

FIG. 2

( ) c. R varies the collector voltage.

( ) d. R varies the DC voltage on C.

3. In the Fig. 3 circuit:

( ) a. D will conduct when the voltage at E1 is lower than its breakdown potential.

( ) b. D is a protective device which will cause R to open if E2 voltage rises above D breakdown voltage.

( ) c. D will conduct when E1 voltage is

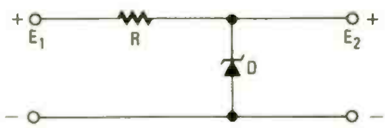

FIG. 3

higher than its breakdown potential.

( ) d. the circuit is that of a simple half-wave power supply.

4. Regarding the circuit shown in Fig. 4:

( ) a. the circuit cannot work as D1 and D2 cancel any signal at E.

( ) b. the circuit could work as a regulated power supply.

( ) c. the position of the pointer at R

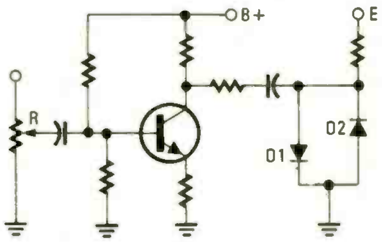

FIG. 4

would determine the DC voltage at E.

( ) d. D1 and D2 are noise limiters.

5. Regarding the circuit shown in Fig. 5:

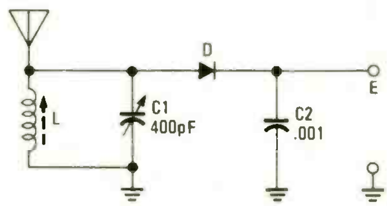

FIG. 5

( ) a. it will work best if a high impedance headset is connected at E.

( ) b. it cannot work without a power supply connected at E.

( ) c. it cannot operate over the entire AM broadcast band unless both the L and C1 are variable.

( ) d. the value of C2 will determine the station to be received.

6. The circuit shown in Fig. 6:

( ) a. could be used to turn on an alarm.

( ) b. is a sound-operated relay circuit.

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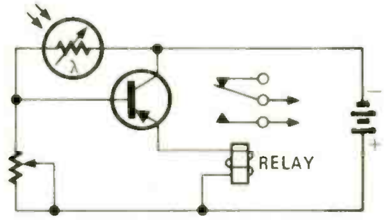

FIG. 6

( ) c. can be used to measure fluid flow.

( ) d. is an overload protector.

7. What type of circuit is shown in Fig. 7?

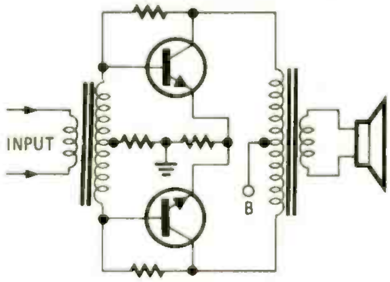

FIG. 7

( ) a. a complementary symmetry amplifier circuit.

( ) b. a push-push amplifier.

( ) c. a push-pull amplifier.

( ) d. an emitter-follower amplifier circuit.

8. The circuit in Fig. 8 is a:

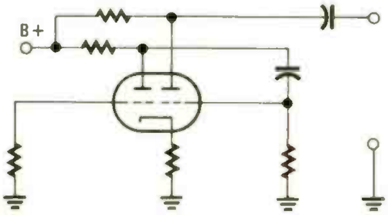

FIG. 8

( ) a. multivibrator.

( ) b. blocking oscillator.

( ) c. Armstrong oscillator.

( ) d. Hartley oscillator.

9. Figure 9 is a:

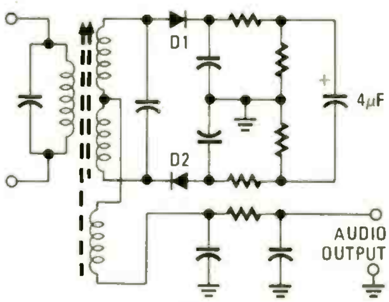

FIG. 9

( ) a. ratio detector.

( ) b. quadrature detector.

( ) c. discriminator.

( ) d. full-wave bridge.

10. In Fig. 10, pins 3, 4, 5, 7, 10, 11, & 12 of the IC might be used for:

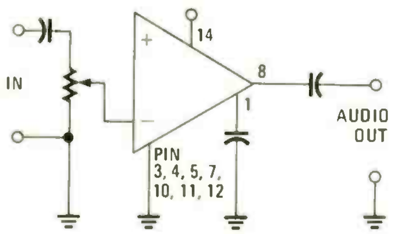

FIG. 10

( ) a. heat sinks.

( ) b. optional input level connections.

( ) c. optional output level connections.

( ) d. they have no purpose.

Be sure to keep this month's issue of **Radio-Electronics** so you can check your answers in the next CET test. **R-E**

Answers To Prior Quiz

Correct answers to Chapter 4 questions on transistors and semiconductors

Here are the answers to the questions on transistors and semiconductors that appeared in the November 1978 issue.

1. Correct answer is "b." Collector and emitter DC voltages on transistors vary widely. Determining that either of these elements has a DC voltage is useful in troubleshooting but the most useful check is to see if the bias voltage (emitter-to-base) is in the range that will permit the semiconductor to operate.
2. Correct answer is "d." The collector of an NPN transistor is positive in relation to the base and emitter. The emitter would be approximately 0.6 volt more negative than the base.
3. Correct answer is "a."
4. Correct answer is "a."
5. Correct answer is "d."
6. Correct answer is "c": A tunnel diode is unique in that it will oscillate at UHF frequencies.
7. Correct answer is "c."
8. Correct answer is "a."
9. Correct answer is "b" (an N-channel JFET).
10. Correct answer is "c."

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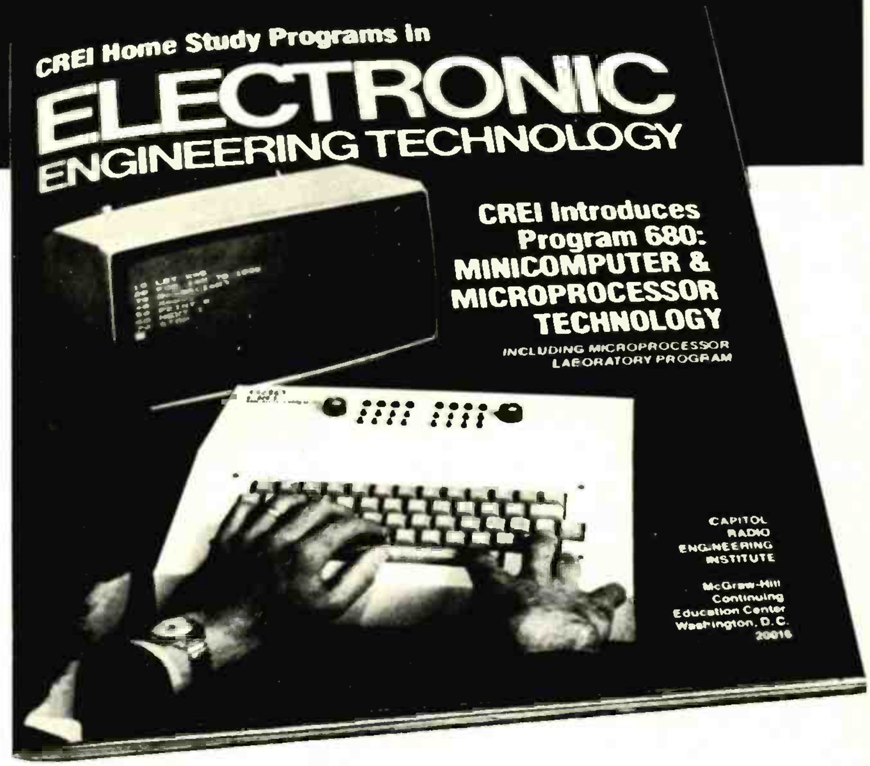

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HOBBY CORNER

Learn solid-state circuitry as you complete your monophonic music maker.

EARL "DOC" SAVAGE, K4SDS, HOBBY EDITOR

DID YOU GET YOUR MULTIPLE-TONE GENerator and note selector assembled and operating (see "Hobby Corner," **Radio-Electronics**, January 1979)? This month it's time to add an automatic control system. We'll build a push-one-button-to-play circuit and then add triggers.

The push-to-play circuit calls for a pulse generator and a counter. Figure 1 shows a basic 555 astable multivibrator used as a variable-rate pulser. The rate and, therefore, the length of each note in the tune is determined by R1, R2 and C1. You can increase or decrease any of those components to change the available range of lengths.

Pressing switch S1 removes pin 4 from ground; this enables the 555 pulser that puts out (pin 3) a string of pulses for as long as the switch is open. The 7493 binary counter counts the pulses and encodes them to binary 0–15 for the 74154 note selector. This arrangement, of course, replaces the four manual switches that were added temporarily to the 74154 input, as described last month.

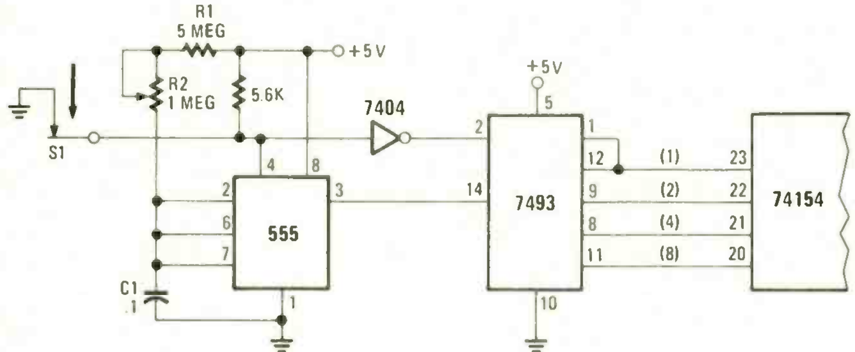


FIG. 1—PUSH-TO-PLAY circuit.

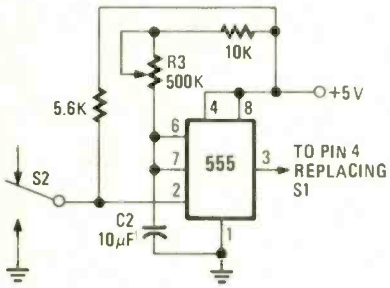


FIG. 2—MONOSTABLE controller circuit.

The 7404 inverter between pin 4 of the 555 and pin 2 of the 7493 does two jobs. It returns the counter to zero when the 555 is disabled, thus insuring (1) that the tune starts at the beginning regardless of where it stopped, and (2) that zero output pin 1 (74154) is activated. Since no tone was connected to the pin 1 output, the device is silent when S1 is *not* pressed.

You can use switch S1 to turn on a doorbell, as an alarm clock output or any other device of your choice. As long as the switch is activated, the tune plays. The circuit now plays as much of your tune as there is time for. That's OK, but it seems unfinished!

So let's add another 555 to make the circuit play the tune in whole multiples only—no more part tunes. The 555 monostable shown in Fig. 2 will do just that.

Remove the pin 4 line from the pulser and connect it to the controller output, pin 3. Now just a quick tap on S2 starts the tune, and it plays until the controller times out. Adjust R3 until the time-out occurs right at the end of the tune. (Depending upon how long each note sounds, you may have to change the value of R3 and/or C2 to get into the correct timing range.)

Now you have a doorbell, clock alarm or whatever other device you like that plays *your* tune through to the last note regardless of how long S2 is closed. Of course, it may play it five or 10 times if your visitor has a heavy finger, but this feature is good to have on a clock alarm if you are a heavy sleeper!

Why not use a 556 dual timer in place of the two 555's? Sure, you can do that, but right now we're going to talk about adding even more controller timers.

Control timers

Suppose, for example, that you would like to use your tune player in place of a doorbell, and you have *two* doors. If you use two switches on one controller timer, it won't be possible to know whether your visitor is at the back or the front of the house. To solve this problem, set up another controller 555, as shown in Fig. 2. Adjust the timing so that one controller plays one-half the tune and the other controller plays the whole tune, or the whole tune once and twice. If your home has three doors, just use three controllers.

When you use more than one 555 controller, you cannot simply tie all the outputs together. The most direct method is to use one or more OR gates (see Fig. 3). If one or more inputs goes high, then the output also goes high and activates the pulser.

There is one more potential problem: Perhaps a heavy-handed visitor or some other occurrence triggers and re-triggers a controller when you don't want it to repeat. For example, suppose you want the alarm clock to repeat until you turn it off but you don't want to activate the on-the-hour chime. The circuit shown in Fig. 4 causes the controller to trigger once and *only once* for each closing of switch S3 no matter how long it is closed.

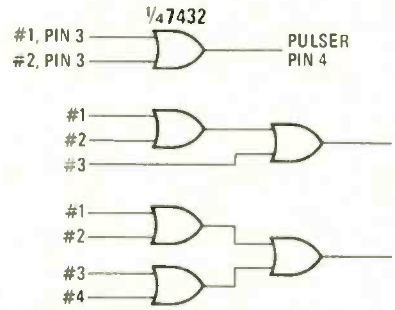


FIG. 3—CONTROLLER COUPLERS.

The single trigger circuit is a little tricky. In fact, you can provide different effects by changing the values of R4 and C4 and even by taking out the diode across the capacitor. These possibilities are available: (1) a single trigger when S3 is closed and another when it is opened; (2) a single trigger on closing and another available as soon as the first time-out is completed; and (3) a single trigger on closing following by a "dead-time" of from several seconds to several minutes during which the switch will not re-trigger. The values given in Fig. 4 put my prototype in case (2) above, but much depends upon the *quality* of C4 and how much leakage it has.

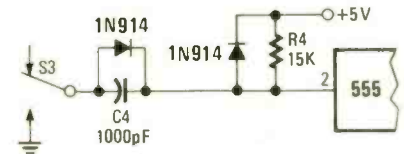


FIG. 4—SINGLE-TRIGGER (time-out) circuit.

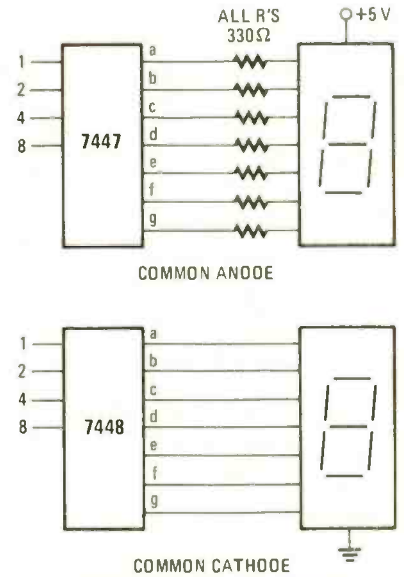


FIG. 5—TWO READOUTS AND DRIVERS.

There are many variations that you can make in these circuits. Build a tune-maker to suit your needs and, then, package it accordingly. Here are just four more ideas:

1. Use gates to detect the 15, 30, 45 and 00 minutes on your digital clock and trigger tune-maker chimes.
2. Put in a second 74154 and 7493 to give you a 30-note capability.
3. Drive the 74154 with an 8573 or an 8574 (256 × 4 PROM) for 256 variations of your 16 notes.
4. Take a fistful of 1N914's and build a diode matrix to select any number of notes.

Let us know what you have done with the tune-maker, and we'll share as many ideas with other readers as possible. Have fun! **R-E**

computer corner

8085 *A look at one memory IC that is among the 8085 family of devices.*

J. TITUS, C. TITUS, D. LARSEN AND P. RONY

IN A PREVIOUS COLUMN (JANUARY 1979), we described the new Intel 8085 microprocessor IC. This is an upgraded type of 8080 microprocessor, since it has features that are not found on the 8080 device. One of the advantages in using the 8085 is the availability of "family" devices that can be used with little or no additional external logic. This makes the 8085 and its family ideal for small controllers, instruments and games, where expansion and the ability to run large programs such as BASIC may not be required.

This month we will describe one of the 8085-family devices, the 8155 read/write memory.

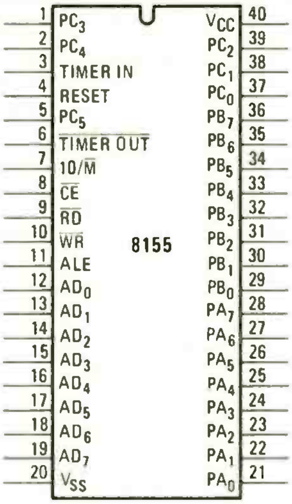
8155 RAM

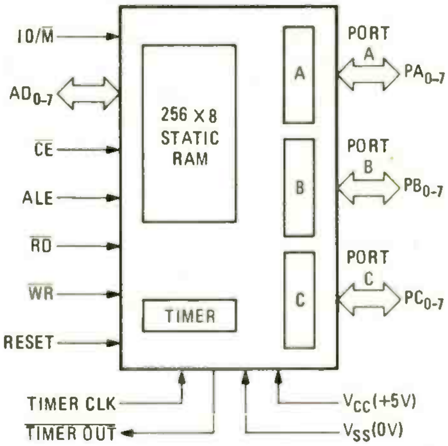
The 8155 read/write memory IC contains 256 bytes of memory, which is probably more than enough for a small system. In most cases, the read/write memory will be used for temporary storage of data or results, as well as register and address information. The 8155 is also bus-compatible with the 8085 system through the use of the bidirectional address-data bus and standard control signals. In this case, only the $IO/\overline{M}$, $\overline{RD}$ and $\overline{WR}$ signals are necessary for memory control. The ALE, CLOCK and RESET signals from the 8085 are also provided for internal control of the IC.

The 8155 has some I/O lines—in fact, there are two 8-bit I/O ports and one 6-bit I/O port. The two 8-bit I/O ports can be operated in either the input or output mode; individual bits cannot be selected. These two ports are called ports A and B. The 6-bit I/O port (port C) can be operated in several ways, but these are beyond the scope of this article. Let us just say that these operations allow the I/O ports to perform in a manner similar to that provided by the mode 1 and mode 2 operation of the 8255 programmable peripheral interface.

The 8155 read/write memory also contains a 14-bit programmable counter, re-

*This article is reprinted courtesy American Laboratories. Dr. Rony, Department of Chemical Engineering, and Mr. Larsen, Department of Chemistry, are with the Virginia Polytechnic Institute & State University. Both Mr. J. Titus and Dr. C. Titus are with Tychon, Inc.





ferred to as a timer. The timer uses either the 8085's clock output or an externally applied clock signal. The timer's output is available as a pin on the 8155 IC, and it can be used several ways, depending on your requirements. It could be connected to the Serial Input Data (SID) pin 5 to be sensed by the RIM instruction, or connected to one of the 8085's interrupt pins (RST 7.5, for example) so that the end of the timer's period could be detected via an interrupt. The timer's output is fairly flexible, being programmed to operate in one of four ways:

Control Bits M2	M1	Mode Of Operation
0	0	Output a logic 0 during the second half of the count.
0	1	Output a squarewave, same as 00 above, but reload and restart the count at the end of each count sequence.
1	0	Output a single short pulse at the end of the count sequence.
1	1	Output a single pulse at the end of the count, but reload and restart the count at the end of each count sequence.

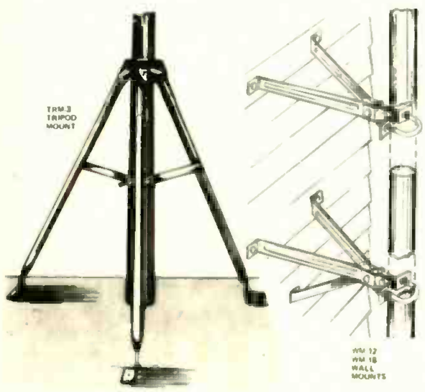
Control bits M2 and M1 are the most significant ones in the 16-bit value programmed into the counter. Since the counter is only 14-bits-long, the control bits are not included in the count itself, but are used by the control logic to determine the counter-output state when the count has been finally decremented to zero. Whenever a new 14-bit count value is reprogrammed into the counter, these two control bits must also be included in the new 16-bit word.

The 8155 read/write memory also has an internal control register that is loaded with an 8-bit byte that is used to determine operation of the I/O ports and the 14-bit counter. **R-E**

communications products

More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside the back cover.

ANTENNA MOUNTS, *model TRM-3, model WM-12, model WM-18.* The heavy-duty *model TRM-3* is a 3-foot-high tripod that accomodates TV, FM, CB and antenna masts to 1¾ inches in diameter. It can be roof-mounted or used in the field without bolting the legs. Comes fully assembled, with cap screws and hex nuts for securing the mast.



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The *models WM-12* and *WM-18* are 12-inch and 18-inch wall mounts, respectively; both include brackets, U-bolts and hardware for up to 1¾-inch diameter masts. List prices: *model TRM-3,* $16.90; *model WM-12,* $9.50; and *model WM-18,* $13.45.—**RMS Electronics, Inc.,** 50 Antin Place, Bronx, NY 10462.

TWO-METER TRANSCEIVER KIT, *model HW-2036A,* has a 143.5-MHz—148.5-MHz operating range and features a phase-locked synthesizer/VCO loop and choice of ±600-kHz split operation. Features tone encoding, built-in 5- and 11-VDC regulators, hash filter/regulator and gimbal mount. The *model HW-2036A-1* (with

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Micoder II mike/auto patch) costs $289.95; the *model HW-2036A-2* (with standard PPT mike) costs $269.95.—**Heath Co.,** Dept. 350-640, Benton Harbor, MI 49022.

CB MULTIMONITOR, *model CB MM6,* is designed for 23- or 40- channel mobile/base station equipment and offers six functions in a single unit: An antenna-matching network to adjust SWR; an SWR bridge and reflected power indicator; a built-in low-pass filter (to eliminate second and third harmonics); a complete antenna monitoring system with warning light; a built-in dummy load with modulation indicator; and a choice of

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using a regular mobile CB antenna or AM/FM antenna for CB communications. The unit comes with two antenna inputs. Other specifications include a 26.5-MHz to 27.5-MHz frequency range, handles 5 watts of input power, 50-ohm input impedance, up to 4:1 VSRW mismatch correction, and spurious signal suppression of −25 dB. The *model CB-MM6* measures 2¾ W × 4 L × 1¼ inches H, and lists for $49.95.—**RMS Electronics, Inc.,** 50 Antin Place, Bronx, NY 10462.

AM/FM POWER ANTENNA, *model FA-80,* features a 10-pole motor and is fully shielded against noise transmission and reception. The antenna is completely automatic—it is activated and deactivated by the vehicle's ignition system; as an option it can be connected to car radio's on-off

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switch. The flush-mounted head protects against theft.—**Harada Industry of America,** Dept. P, 145 E. Albertoni St., Carson, CA 90746. **R-E**

AUDIO TEST STATION

continued from page 48

Rotary switch S3 selects the integrating capacitor, and the charging current is determined by the networks connected to IC201 pins 4 through 7. Small-value capacitors charge faster than larger capacitors for the same charging current so a smaller capacitor selected by S3 will produce a higher frequency. Also for a given capacitor, increasing the charging current by varying R1 and R2 also increases the frequency.

The comparator or squarewave output from pin 13 is applied to Q201, an external buffer. The buffer is necessary because the internal squarewave buffer is an open collector, and the output impedance on the positive edge of the squarewave is equal to R201. Therefore, any significant change in the external load on pin 13 alters the amplitude of the positive edge of the squarewave.

The two resistor networks connected to pins 4 through 7 each control a separate current source for charging the integrating capacitor. These sources can be used singly or in pairs. When used in pairs, the currents of each are added. The voltages applied to IC201 pins 8 and 9 determine which of these current sources is active.

The outputs of both pins 13 and 14 are approximately symmetrical around 0. The output of Q201 ranges from approximately 0 to +V (+6 volts). With S4 in the SYMM position, IC201 pin 8 is at level 0 and pin 9 at +V. This enables both pins 6 and 7 and, therefore, the charging current from the integrating capacitor for both the positive and negative ramps is the total current drawn from pins 6 and 7. When the wiper of R1 is at ground, only a very small current is drawn from pin 7, and the charging rate, or frequency, is determined by R204. Resistor R204 therefore determines the low frequency point when R1, the front panel frequency-adjust slide pot is at the minimum setting. When the wiper of R1 is at −V (−6V), most of the charging current is provided by R205, since it is much smaller than R204. Resistor R205 then determines the high frequency limit when R1 is at the maximum setting. With these values for R204 and 205, the frequency range of R1 is 100:1. The reason that R204 and R205 are not also 100:1 is because even with R1 at ground, R205 contributes slightly to the charging current and therefore R204's contribution must be reduced to compensate. When R1 is at −V, the R204 contribution is negligible compared with that of R205.

When S4 is in the RAMP position and the output from IC201 pin 13 is high, pin 8 is also high. In this case, pins 4 and 5 are activated and they perform exactly as do pins 6 and 7. Remember that the squarewave output of pin 13 is at a constant voltage during rise of the ramp voltage of pin 14. Therefore, during the positive-going ramp of pin 14, the current is controlled by pins 6 and 7. During the negative portion of the ramp, current is controlled by pins 4 and 5; or, as viewed from the front panel, R1 controls the time of the positive-going ramp and R2 controls the time of the negative-going ramp. If R1 and R2 are in extreme opposite positions, the result is positive and negative ramps with a 100:1 time ratio. With S4 in the ground (symmetrical) position, R1 controls the time of a symmetrical triangular waveform. The result of all this (looking at the front panel), is that R1 and R2 provide a 100:1 change of frequency, and each step of S3 provides a 100:1 change.

We know that the timebase section derives its name from the fact that its primary function is to sweep the audio generator and the time (actually the inverse of time—frequency) base of an X–Y display. To accomplish this, the timebase only has to provide a variable-symmetry triangle wave at low frequency. However, once the basic oscillator is established, it is relatively easy to let it provide other useful functions.

For instance, an effective way to check the proper action of a mixer is to apply two triangle waves, one, high-amplitude at a low frequency; the second, a lower amplitude at a higher frequency. If the mixer is functioning properly, each input retains its individual characteristics at the output, but one input will be riding on the other. The timebase section was designed to provide the three basic waveforms over at least the full spectrum of needed audio frequencies.

A piece of test equipment that many classify as "nice to have" but difficult to justify as a separate purchase is a pulse generator. Again, however, since there is already a basic oscillator in the timebase section, it is relatively simple to shape it into a pulse output. Therefore, the total frequency range of the timebase oscillator is made as wide as the capabilities of the basic oscillator can provide.

You then have a three-function generator with a useful frequency range of 0.002 Hz to 100 kHz and a pulse repetition rate of 0.002 Hz to about 800 kHz. The pulse-shaping section will be covered next month.

To provide the maximum possible versatility to the timebase oscillator, the range of integrating capacitors has been made as wide as practical. There is no DC bias across the integrating capacitor, and the manufacturer of IC201 has specified that the capacitors be nonpolar. This requirement is easily implemented for small-value capacitors; however, large-value nonpolar capacitors are rare and usually large sized.

The problem with using a polarized-type capacitor in a bipolar circuit is that the polarized capacitor tends to leak when you try to charge it in the reverse direction. If the leakage represents a significant portion of the charging current, the voltage rise across the capacitor (and hence across the output triangle wave) will be an exponential rather than a linear rise. This is because the leakage current increases with the charging voltage. If the leakage is significant, then at some voltage level, the leakage current and charging current will be equal, the voltage will cease to rise and oscillation will also cease. Additionally, some types of polarized capacitors can be damaged by reverse voltage.

Actually, this circuit works quite well with some aluminum electrolytic capacitors. With a supply voltage of ±7, the charging voltage is only about ±1.5. Aluminum electrolytic capacitors can tolerate the 1.5-volt reverse voltage. However, low-leakage capacitors, and only those with the lowest voltage ratings, should be used in this circuit.

Note that the integrating capacitors are all evenly spaced one decade apart except for the largest and smallest capacitors. The 470-μF value capacitor is simply the largest value that will consistently work in this circuit. Also note that the smallest capacitor (C203) must be reduced from its nominal value by an amount that is equal to the stray capacitance of the board and switch circuit.

continued on page 82

service clinic

Troubleshooting starter circuits in pulse-width modulated power supplies.

JACK DARR, SERVICE EDITOR

THE AUGUST 1978 SERVICE CLINIC, WE discussed pulse-width modulation (PWM) power supplies, and briefly mentioned the starter circuit. Now let's explain this circuit in more detail. This circuit is absolutely indispensable because it gives the horizontal *oscillator* circuit a swift kick to get it started. The PWM circuit *must* receive gate pulses from this circuit to operate. So, all PWM power supplies use some form of starter circuit. Keep in mind that all this activity takes place in a fraction of a second! When power is applied, the B+ voltage comes up very quickly in all solid-state circuits. Oscillator, driver and horizontal-output circuits start just as quickly.

So, all it takes is a short pulse of DC voltage, somewhere near the right value to get the oscillator going. Once the oscillator is running, the horizontal-output stage starts, as well as the PWM supply, and everything takes off. Some of these stages use quite complex circuits, but basically they're all similar. For example, the RCA CTC-85 color chassis circuitry looks complicated but isn't (see Fig. 1).

The B+line (unregulated) is provided by a nonisolated bridge rectifier, from the AC line through L201—an AC line choke. At turn-on, a current pulse comes from the + terminal of the bridge and flows through the primary of start-up transformer T201. The current flows through this transformer because a large electrolytic 800-μF capacitor, C304, is connected to it (C304 later becomes a filter capacitor).

When a capacitor of this size is discharged, it resembles a short circuit to a current source. Translation: the current flows into the capacitor until it is fully charged. While this is flowing, we get a *pulse* of current through the primary of T201. The transformer's secondary develops the two DC voltages needed—+22 and +27 VDC through the rectifier diodes and filter capacitors. These DC voltages now feed the horizontal oscillator, driver and buffer stages. When these stages start operating, they generate drive pulses to feed the horizontal-output stage and the PWM circuitry (this is on the regulator-control module). The PWM circuit feeds a regulated B+ voltage to the horizontal-output stage.

Now that we've got our starting kick and things are going, we have to disable the starter circuit or it might interfere with the normal DC supplies, which are all developed by the flyback. The following method is used in all the starter circuits I've seen so far.

In Fig. 1, note D301 and D304, which are connected to the starting DC lines feeding the oscillator, driver, etc. During start-up, these two-diodes are reverse-biased and do nothing. There is a +DC voltage on their cathodes but no voltage at all on the anodes. This is because the normal supply voltage is not working *yet*. (Remember this is taking place in a very short time!)

Shortly thereafter, the oscillator circuit and other stages are fed their normal supply voltages, so that they continue operating. Now, the starter circuit has no AC supply to keep it running. The start voltage drops. The *starter* diodes are now reverse-biased and cut off (there is a + voltage on the cathodes, and no voltage at all on the anodes). This isolates the starter transformer from the DC lines, which stays inactive until the set is turned off again. This diode reaction is used for all the starter control circuits I've seen so far.

An interesting test, mentioned in the RCA *Technical Manual*, can be performed. If the starter circuit is not working, nothing happens. After checking the starter diodes, the filter capacitors, transformers, etc., for shorts and opens, you *can* start the horizontal oscillator by momentarily connecting a +22 VDC supply to the +27-volt input. All it takes is a very short current pulse somewhere near the normal voltage. (Although I haven't tried this, it looks as if you could do this with a bias box. The RCA manual suggests using a 22.5-volt battery, but these batteries are not very common.)

Check the starter circuit for a short DC pulse just as the set is turned on. It is best to use an analog meter because even a small kick of the needle is detectable. Set the meter to approximately the 15-volt scale so that the motion of the needle is easier to observe.

Most problems in these circuits can easily be located with the standard tests—checking diodes, filter capacitors, transformers, etc., for shorts or opens. In the RCA CTC-85 chassis, the entire B+ supply is isolated from the AC line by

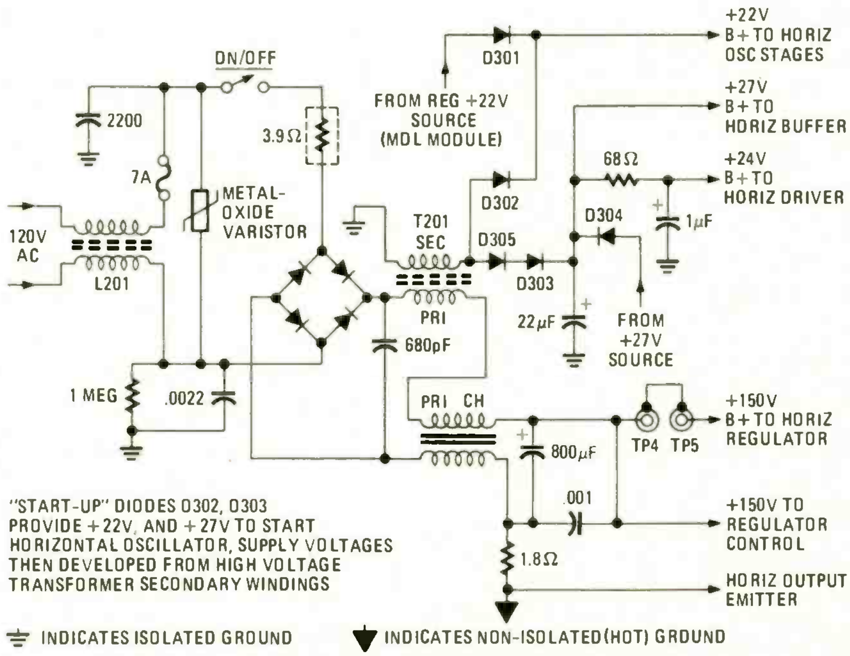

FIG. 1

the horizontal-output transformer; the unregulated B+ supply is not. This leads to the use of two "grounds," one isolated, the other "hot." However, this ground lead isn't really very hot, since it's only a very little way (one diode drop and a 1.8-ohm resistor) away from the isolated ground, or B− line. So little, in fact, that the hot ground can be used as the test equipment ground lead for voltage and waveform checks.

The starter circuit is not difficult to troubleshoot if you know what it does and how it does it. It's just that trying to explain the procedure isn't easy! The PWM won't work till the oscillator starts, the output stage won't work till the oscillator starts, but the output stage must be running to feed the oscillator! Something like the mythological worm with its tail in its mouth!

Thanks to RCA for the CTC-85 *Color Chassis Technical Manual*, which provided Fig. 1 and much data. **R-E**

service questions

HEATER STRING SHORT

There's a short in a Sears 19-inch color set that I can't find. The 5-amp fuse in the heater string blows quickly. The 40KD6 tube was bad, as well as the 12BY7 tube. Any ideas?—M. R., E. Chicago, IN.

A common cause of this kind of trouble is a heater-to-cathode short in one of the tubes, perhaps one in the middle of the series circuit. (Note: The cathode of the tube must be directly grounded to cause this particular short.) When it happens, the heater circuit is grounded in the middle; this raises the heater voltage on all tubes between the short and the source, and it will usually blow some of the tubes.

(Feedback: "Bulls-eye! I found a 6GH8 tube with the heater-to-cathode short, and another 12BY7 tube was open.")

VERTICAL BLACK LINES

I've had problems in several TS-934 Quasar chassis with one or two small vertical dark lines at the left side of the screen. So far all I've done is try new damper and horizontal-output tubes until I find some that help. Do you have any data on this?—L. J., Eveleth, MN.

Quasar's booklet, *6 Years of Servicing*, says that this problem can be caused by damaged insulation on the red wire between pin 5 of the high-voltage transformer and pin 9 of the damper tube. The cure is to place heavy plastic sleeving over this lead to prevent leakage to the edge of the chassis. (This lead is on the socket side of the chassis under the damper/output tube, and goes to a terminal strip and hash choke L502.) **R-E**

AUDIO TEST STATION
continued from page 79

Accuracy and stability are mainly dependent on the components' cost and the amount of care taken during calibration. The oscillator is quite stable, and the timing components can be stable and either precision or trimmable. We decided that the components should be stable but that absolute accuracy was not important. The frequency counter can read down to approximately 1 Hz. By noticing the last digit bobble, it is even possible to interpolate to a sensitivity of less than 1 Hz. Frequencies of less than 1 Hz should perhaps be selected as subjective rather than absolute values. Therefore, the resistors, similar to most of the resistors throughout the rest of the system, are 5% carbon film; the capacitors are as temperature stable as readily available with the tolerance of the smaller values at ±5% and that of the electrolytic capacitors at ±20%.

Timebase output circuitry

The output of Q201 serves four functions: One has already been discussed; the other functions will be covered as they apply to other circuits. Transistors Q202 and Q203 form a triangle-to-sinewave converter. Each transistor logarithmically clips one peak of the triangle wave. Resistor R212 determines the degree of rounding of the peak, and R213 makes sure that the peaks are clipped equally. Transistor Q204 buffers the common-collector output of Q203.

Trimmer resistors R224, R223 and R227 as selected form the input resistor to inverter IC202. Each of the three basic waveforms are generated with different signal levels; therefore, these resistors provide that each waveform has the same amplitude at the output of IC202. Trimmers R225, R221 and R240 provide offset nulling for each waveform, with R226, R222 and R239 controlling the sensitivity of those adjustments.

Switch S5 selects one of the three signal lines to be applied to IC202. Note that the squarewave line when it is not selected is grounded through the other half of switch S5. This minimizes squarewave crosstalk into the sinewaves or triangle waves at time of selection. The rise- and falltimes of the squarewave are fast enough to cause a spike waveform to propagate across the contacts of S5 or across the circuit board.

The output of IC202 goes to IC203, which is connected as a unity-gain inverter. Switch S8 then inverts at the output whatever waveform was selected by S5. This is valuable for interfacing with certain other types of equipment and can also help provide a stable scope-trigger for internal calibrations.

Resistor R3 is the front-panel-amplitude slide pot, and IC204 is one-half of an LM377. This device is generally considered only as a driver for low-power speaker systems, to be used with a single power supply. However, it is far more versatile and actually easier to implement with a split power supply than with a single power supply. Also, from the speaker-driver applications it is not always obvious that this is an operational amplifier suitable for op-amp applications. It is fast enough for the full audio spectrum.

One of the most powerful audio applications for an operational amplifier is as a mixer. The negative inputs of IC204 and IC201–IC203 are connected as a summing junction. This creates a perfect mixer; that is, several independent signals can be added together each with independent gain or loss, without any signal affecting any other signal.

A first encounter with this circuit is often rather mysterious. When you troubleshoot a signal-processing system, you often take an oscilloscope, start at the input and then walk through node-by-node to the output, observing the waveforms and watching for any change from node to node. Normally, the only change from input to output is a change in amplitude. If a node in the chain does not have a signal, you can generally assume that something has either interrupted or grounded the signal since you checked the previous node; also you would not

continued on page 84

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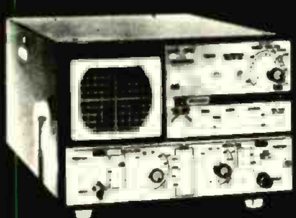

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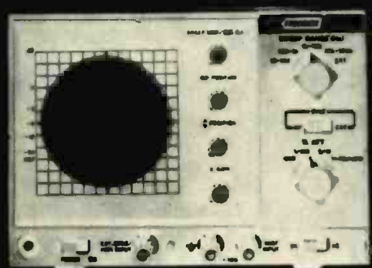

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AUDIO TEST STATION
continued from page 82

observe that signal in any subsequent node. However, in this circuit (if R3 is not at ground) there is a signal at the left side of R234, but the right side of R234 shows just 0 volt.

This phenomenon is called a *virtual* ground. The input impedance of IC204 (as seen from the wiper of R3) is simply R234. For any signal from R3 that might attempt to pass back through R235, it's as if the right side of R235 were grounded. Turning up the sensitivity control on the scope may reveal a very severely clipped remnant of the signal. However, the output of IC204 is the original signal with a gain of R237 divided by R234.

In addition, there is a DC level that is the voltage at the left of R233 times R237 divided by R233. In this case, the voltage should be zero since R233 provides the offset null of IC204. Front-panel DC offset is applied through R235.

Resistor R236 is necessary for frequency compensation. OP-amp IC204 is internally compensated to be stable at gains greater than 10 (the gain being determined by the ratio of feedback resistor R237 to input resistors R234, etc.). Resistor R236 can be calculated, but is most easily determined empirically. Substitute a variable resistor for R236, set S5 to the squarewave position, observe the output of IC204, and adjust R236 for both minimum risetime and minimum overshoot at 1 kHz.

Resistor R4 is the front-panel DC offset. With S9 in the SWEEP position, the R4 output mixes with the signal from R3 to provide a ±5-volt DC offset of that signal.

Switch S9 provides the manual timebase mode. With S9 in the SWEEP position, the triangle-wave output of the oscillator is used to sweep the frequency of the audio sweep generator as well as the timebase of an X–Y display. Setting S9 switch to the MANUAL position opens the direct connection between R4 and IC204. The triangle wave is removed from its sweep function, and R4 is substituted for it—both for the sweep circuitry and for the timebase output. Switch S5 must be in the TRIANGLE position. Resistors R209 and R206 adjust the output of IC204 so that the signal from R4 that arrives at the upper half of S9 will exactly replace the triangle wave at switch S9.

The LM377 IC has both overcurrent and thermal shutdown. It can apply at least ±5 volts to a less than 10-ohm load. If a higher signal or power level is required, an LM378 or an LM379 can be substituted, as these IC's are equivalent.

The LM377 is rated at a total supply voltage of 26. The LM378 and LM379 are both rated at 35 volts. The only way to differentiate between those devices that can tolerate a higher voltage from those that can't is to experiment. (The premium price of the LM378 pays for destroying a lot of good LM377's to locate some of the higher voltage units we need.) The LM379 is an LM378 with a metal heat sink on top. A tab at each end lets you solder it into a circuit board; the device is also drilled and tapped so that you can mount an additional heat sink or mount the unit to a chassis.

Although the LM377 is quite immune from self-destruction, it can be damaged by applying a large external voltage at J1. Overvoltage sensor OV201 protects the output of IC204 from external damage. If ±10 volts or more is applied to the output terminal, OV201 shorts to ground and prevents the external voltage from reaching IC204. If this voltage is present for any significant time, F201 blows, thereby protecting OV201 from excess dissipation.

The external overvoltage protection is optional. There are several devices on the market designed to limit voltage, and the PC board is set up to accept several different types. The recommended LA10 device costs approximately $20. Even though this $20 is there to protect a $3 output amplifier, **the value lies in eliminating repair costs and downtime.**

Resistor R299 establishes the output impedance. The jumper around R299 is on the circuit board. Normally, R299 is omitted in which case the output impedance is less than 1 ohm. If some other output impedance is desired, it is inserted as R299 and the jumper on the board is cut. The jumper is on the reverse side of the board readily accessible in a finished unit, which makes it easy to attach R299.

Timebase calibration

Connect a reasonably well-calibrated oscillator scope to J1. (The scope is the only calibration standard that will be used and it is assumed that amplitude calibrations are not critical.)

Set the scope input to DC.
Set all trimming resistors to their center positions.
Turn on master power switch S1 and S2.
Set S5 to TRIANGLE and S8 to NOT INVERT.
Set R3 to maximum and R4 to 0.
Set S3 to 1 kHz.
Set S4 to symmetrical.
Set R1 to lower position.
The output should show a clean triangle wave at about 1 kHz.
Set R3 to zero.
Make sure that R4 is at 0.
Adjust R232 for zero offset.
Set R3 to maximum.
Adjust R227 for 16 volts peak-to-peak.
Adjust R240 for zero offset.
Switch S5 to squarewave.
Adjust R224 for 16 volts peak-to-

peak.
Adjust R225 for zero offset.
Switch S5 to sinewave.
Adjust R223 for approximately 16 volts peak-to-peak and R222 for approximately zero offset. Both these resistors will be readjusted later.
Switch the scope input to AC.
Adjust R212 for slight clipping.
Adjust R213 for symmetrical waveform.

With the scope set to AC, adjusting R213 will cause the average level of the waveform to shift; therefore, symmetry is achieved when the positive-going and the negative-going peaks are exactly the same distance from the center line on the scope.

Adjust R212 for minimum sinewave distortion. A sinewave plotted on the face of the scope can greatly assist in this. Use an 8 × 8-centimeter overlay, and a harmonic distortion analyzer can be used if one is available.
Adjust R223 for 16 volts peak-to-peak.
Switch the scope input to DC.
Adjust R222 for zero offset.
Set S5 to triangle wave.
Check the waveform quality at each position of S3.

At the 10K position, the waveform will be distorted; however, the 10K position is only intended to trigger the pulse generator. When you initially check the low-frequency ranges, set R1 to 100 F. Any deviation from strict linearity indicates a leaky capacitor. A slight curving of the waveform is acceptable for most applications. However, if curving is severe, the circuit may not oscillate at all at low currents. For the lowest positions of S3, set the horizontal timebase of the scope to external; this will produce just a vertical trace. Then, follow the oscillator through at least a couple of cycles to insure there is no excessive leakage. At the 0.002 setting of switch S3, a single cycle is approximately 8 minutes. If the scope beam stops while approaching one peak, increase R1 slightly. This increases the charging current. The beam should continue slightly, which indicates excessive leakage. Increasing R1 past some point should cause the oscillator to restart. Replace the capacitor that is leaky.

Then,
Set R3 to maximum.
Set S9 to manual.
Set R4 to zero.
Set R206 for zero output.
Move R4 to +5 volts.
Set R209 for a +8-volt output.
Move R4 to −5 volts.

The output should be approximately −8 volts. Resistors R206 and R209 will be fine-tuned later on.

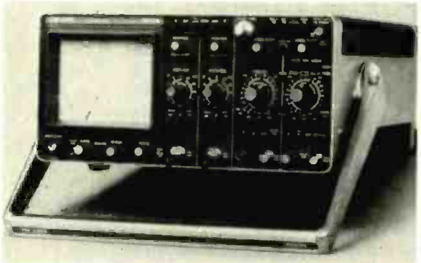
The combination of 50K (R3) and 16K (R234) produces a taper similar to the audio taper in most controls.

That's it for now. Next month, we'll cover the pulse generator, sweep shaper and audio sweep generator. **R-E**

new products

More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside the back cover.

DUAL-TRACE 100-MHz SCOPE, *model PM3262*, is a dual-channel, 100-MHz instrument that provides both a main timebase and an alternate timebase to display trigger signals simultaneously. Offers a 5- to 10-mv-per-division sensitivity, rectangular CRT with internal graticule, pushbutton-selectable trigger modes, ×10 magnification, ±3% accuracy, and X-Y operation. Unit operates on 140 VAC; 200-264 VAC, 440 Hz; and 250 VDC. It comes with probes, filters, cover, adapters, and manual, with other optional accessories available. The *model PM3262* measures 12.5 × 6.1 × 16.2 in., weighs 21.1 lb., and costs $2345.—**Philips Test & Measuring Instruments, Inc.**, 85 McKee Drive, Mahwah, NJ 07430.



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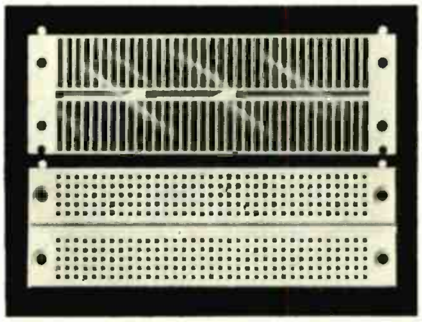
SOLDERLESS BREADBOARD COMPONENTS, *Quick Test* (*QT*) sockets and bus strips, are spring-clip arrays behind a series of small holes on a molded plastic surface that can accommodate AWG Nos. 22–30 wire sizes. Sockets comprise 5-tie-point spring-clip terminals on either side of a 0.3-inch channel, and can be used either alone or ganged with jumper leads for larger arrays. Bus strips contain twin rows of interconnected tie-points to provide 35, 47 or 59 tie-point terminals. The sockets come in 7 lengths with from 14 to 118 terminals; the bus strips measure from 4.1 to 6.5 inches long, with twin buses of 35, 47, 59 tie points each. Prices: QT sockets, $3-$12.50; bus strips, $2-$2.50.—**Continental Specialties Corp.**, 70 Fulton Terrace, New Haven, CT 06509.



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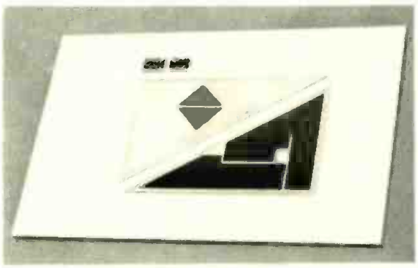

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the board. Also contained is a *Paramatic Line Guide* to permit drawing horizontal parallel lines without moving the triangle from position. *Paramatic Drafting Set* with 13-inch by 21-inch board costs $45; with 20-inch by 26-inch board, $85.—**Design Instrument Mfg. Co., Inc.**, 9849 Belfast Dr., Garden Grove, CA 92644.

COMPUTER GAME, *Merlin*, offers 6 games of chance for 1 or 2 players from age 7 to adult. Games range from simple "Tic-Tac-Toe" to advanced "Mindbender." The unit uses a TI microprocessor with 2K-byte memory and is battery

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operated. *Merlin* can counter moves with its own strategy, and uses electronically synthesized sounds to communicate wins and losses. Approximate retail price, $33.—**Parker Brothers,** 50 Dunham Rd., Beverly, MA 01915.

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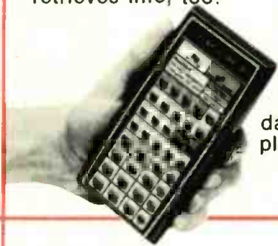

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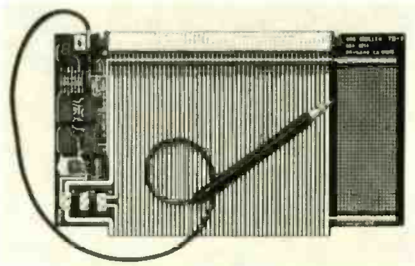
computer products

More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside the back cover.

S-100 BUS EXTENDER BOARD KIT, *model TB-2*, is an S-100 bus-compatible card with several new features: A built-in logic probe with 7-segment display; a pulse catcher with LED; and a "kluge board" (with holes on a 0.1-inch grid) that aids in assembling debug or test circuits. Power is provided by an on-board 5-volt regulator. Other features include power-supply links for current measurement and independent supply switching; edge connector label; and gold-plated edge connectors. List price, $35.—**Mullen Computer Products,** Box 6214, Hayward, CA 94545.



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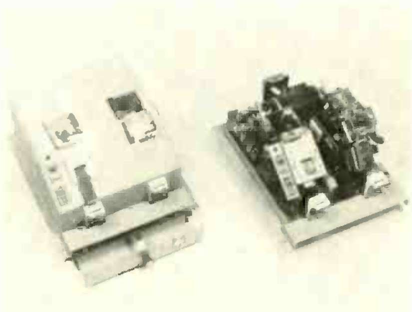

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COMPUTER SOFTWARE is packaged on mini-diskettes in North Star format, ready for implementation in any S-100 8080/Z80 system. The applications programs include: financial, mathematical analysis, statistical and miscellaneous, games (including Trap, Taxman, Calendar, Civil-war, Lunar Lander), backorder and mailing list (using disc data files), plus North Star DOS for Centronics printer (retail sales reporting and pro-file, both using disc files). Price: $35 each.—**MicroAge Mail Order,** 1425 W. 12th Place # 101, Tempe, AZ 85281.

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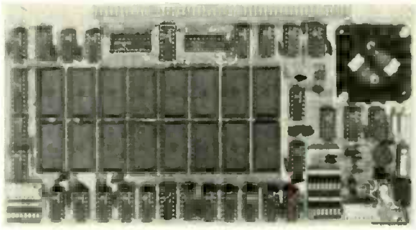
MEMORY BOARD, *32K Bytesaver*, comes assembled or in kit form, and is compatible with the S-100 bus and with *System Two* and *System Three* computers. The board contains a 2716 PROM programmer, compatible with Intel 2716 PROM's or equivalent. Fast data storage is implemented by a single write into an erased PROM. The board also provides a 32K-byte ROM capability. Switches are provided to protect and unprotect ROM's, shadow ROM sockets, select card addresses and control Bank-Select or DMA I/O features. Prices: *32K Bytesaver*, kit, $195; assembled, $295.—**Cromemco, Inc.,** 280 Bernardo Ave., Mountain View, CA 94040.



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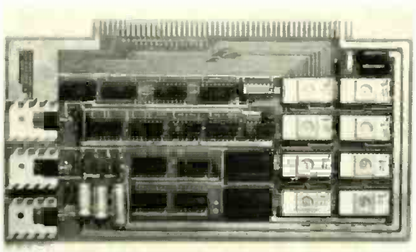
S-100 BUS PROM BOARD, *model 8K Plus 2*, is available in kit form (plus sockets) or fully assembled. The board is designed for use with eight 2708 EPROM's, and has two provisions for either 2716's or pin-compatible 8316 ROM's. The board's circuitry can pull Ready-Line low for use with low-speed ROM's, and three extra 16-pin pads are included for TTL PROM's, power-on jump, etc. The board is made of epoxy glass with solder-tinned pads and buses and gold-plated edge connectors. Prices: kit, $59.95; assembled, $109.95.—**Mini Micro Mart,** 1618 James St., Syracuse, NY 13203.



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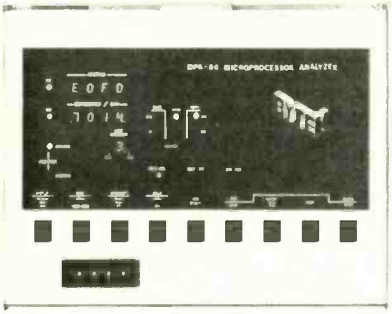
COMPUTER TAPE CASSETTES, *Microsettes,* are designed for microcomputer use (Apple, Heath, IMSAI, MITS). Each cassette tape comes in hard plastic box with two labels. The 50-foot tape length is suitable for from 8K-byte to 40K-byte memory storage of most personal computers. Available in sample size, $1; 10-pack, $7.50; 100-pack, $58.—**Microsette Co.,** 777 Palomar Ave., Sunnyvale, CA 94086.

CIRCLE 118 ON FREE INFORMATION CARD

MICROPROCESSOR ANALYZER, *model MPA-80,* is designed for use with 8080- or 8085-based systems. The unit provides real-time analysis of processor operations and can single-step the program either by machine or instruction cycle. Its features include hardware breakpoint capability, a reverse trace mode, hexadecimal displays that display optimum information for each type of instruction (opcode, 1 or 2 data bytes, memory or branch addresses), and status indicators. Recommended applications are for engineering, production, test and field service. Personality modules provide the interface to your system. Prices: $845; personality modules (8080 or 8085), $145.—**BYTEK,** Box 3026, Burbank, CA 91504.

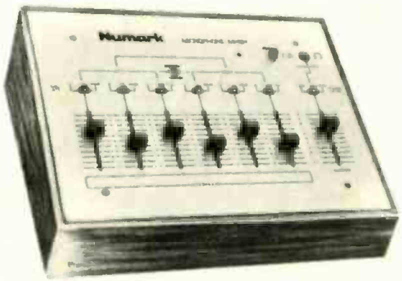


CIRCLE 119 ON FREE INFORMATION CARD

stereo products

More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card is inside the back cover.

MICROPHONE MIXER, *model MX3000,* is a sound-studio unit designed to handle any high-power amplifier without using external preamp. It has provisions for 6 mike inputs and 2 stereo line inputs. Other controls include individual mike attentuators, and stereo/mono switches, a master control switch and headphone monitor. Specifications are: input sensitivity (mike), 0.5 mV, (line) 65 mV; output impedance, 100 ohms; hum and noise (mike), −52 dB, (line) −65 dB; frequency response (mike) 20 Hz-18 kHz (1 dB); (line) 10 Hz-30 kHz (−1 dB). The unit measures 12¾ W × 9¼ H × 3½ inches D, and weighs 6½ lb. Suggested retail price: $149.95.—**Numark Electronics Corp.,** 503 Raritan Center, Edison, NJ 08817.



CIRCLE 109 ON FREE INFORMATION CARD

TAPE RECORDER CARE KIT provides a flexible way to clean tape heads in hard-to-reach spots. The kit contains various plug-together plastic tools, a mirror, a variety of felt applicator tabs, and a bottle of tape head cleaner. Price: $8.95.—**Maxell Corp. of America,** 130 Commercial Way, Moonachie, NJ 07074.

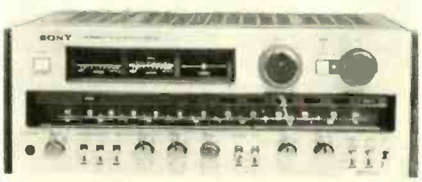
CIRCLE 110 ON FREE INFORMATION CARD

SIGNAL PROCESSOR/PREAMPLIFIER, *model SP4002,* contains two separate phono preamps with a 0- to 150-pF variable cartridge loading capability and a variable impedance of 100 mV at 47,000 ohms; both accept any cartridge with a 0.28- to 300-mV output capability. Each preamp contains inputs and outputs, and provides a variable ±20-dB gain, 97-dB S/N ratio, 300-mV overload capability, plus the newly approved RIAA equalization curve. Front-panel controls include signal processing switches (including subsonic filter, external loops, equalizer, monophonic mixer for Channels A and B and tape-record switches); volume and balance control switches; power on-off switch; and source selection switch. Built into the preamplifier unit is a graphic equalizer providing from 15-dB to 22-dB boost-per-octave and a better than 114-dB S/N ratio. Also included on the front panel are headphone jacks and an extra tape recorder jack. Price: $699.—**Soundcraftsmen,** 1721 Newport Circle, Santa Ana, CA 92705.

CIRCLE 111 ON FREE INFORMATION CARD

AM/FM STEREO RECEIVER, *model STR-V7,* is a top-of-the-line unit that provides 150 watts-per-channel RMS into 8 ohms from 20 Hz to 20 kHz, with no more than 0.07% THD and IM distortion. Its features include tape monitors and dubbing; stepped-attenuator volume control; bass and treble controls; high-cut and low-cut filter switches; and a loudness-compensation switch. The receiver also includes an FM bandwidth switch, linear dial calibration, flywheel coupling, FM muting switch, center tuning and signal-strength meters.

The tuner front end contains a MOSFET RF amplifier, 4-gang tuning capacitor and oscillator; the IF stage comprises 4-element ceramic filters, a differential amplifier and 5 banks of limiters. A phase-locked-loop multiplex IC provides 48-dB at 1-kHz stereo separation. The amplifier section contains a toroidal-coil transformer and two 15,000-μF capacitors; and the preamp features RIAA phono equalization and provides 25-mV overload protection. Suggested list price: $820.—**Sony Corp. of America,** 9 W. 57th St., New York, NY 10019.



CIRCLE 112 ON FREE INFORMATION CARD

next month

■ Your Own Computer

A special section devoted to personal computing with the accent on peripheral devices, including printers, terminals and floppy discs. You won't want to miss the many hints on selecting and setting up a system and the round-up listings of peripheral devices.

■ Rechargeable Batteries—Past, Present And Future

A look at the improvements that have taken place in the last 10 years and what may take place in the next 10 years, with a special look at lithium cells.

■ Build A String Synthesizer

Part 2—Construction details for a professional-quality music synthesizer that can be built for many times less than commercially available instruments.

new lit

More information on new lit is available from the manufacturers of items identified by a Free Information number. Use the Free Information Card inside the back cover of this issue.

ELECTRONICS CATALOG, 48 pages of discounted items for electronics hobbyists, educators, dealers. Includes hundreds of items from basic components to TV and hi-fi equipment, a radar warning system, telephone keyboard, clock assembly, etc. Catalog also includes a 16-page wholesale supplement listing items of special interest to dealers and volume users.—**ETCO Electronics Corp.,** North Country Shopping Center, Rte. 9 North, Plattsburgh, NY 12901.

CIRCLE 105 ON FREE INFORMATION CARD

BRADFORD COMPONENTS CATALOG, 8 pages listing components for servicing Bradford TV's and appliances. Included are resistors, VDR's, transistors, diodes, electrolytics, semiconductors; several parts kits are featured, as are Bradford service manuals. Price: $1.50 (refundable with first purchase).—**The Marcel Companies,** Parts Division, 57 Enfield St., Enfield, CT 06082.

TROUBLESHOOTING GUIDE, *Common Production Soldering Problems: Causes and Cures,* is a four-page article detailing the most common soldering defects and can be used as a reference for assembly and production personnel. Some of the problems discussed are insufficient or excessive solder on joints, solder joint discoloration and solder bridges, nonwetting and dewetting conditions, measling and cold joints. Possible causes for solder defects plus suggested solutions accompany each section.—**Multicore Solders,** Westbury, NY 11590.

CIRCLE 106 ON FREE INFORMATION CARD

QUARTZ CRYSTALS catalog contains 7 pages describing high-quality crystals for a wide variety of equipment applications—from replacement units to new, modified or experimental equipment. Crystals are available for Motorola, GE, E.F. Johnson, Comco and other manufacturers. Complete descriptions and specifications are given along with technical information for all crystal sizes and types—from microminiature to large and cold-weld varieties.—**Savoy Electronics, Inc.,** 1175 N.E. 24th St., Fort Lauderdale, FL 33310.

CIRCLE 107 ON FREE INFORMATION CARD

ELECTRONIC WIRE/CABLE CATALOG, *Catalog No. 878,* 180 pages of multi-conductor cables, computer cables, hookup wires, coax cables, wire and cable assembly packages, and shielded/unshielded cords and portable cordage. Catalog includes such products as power-limited low-energy cable (UL-approved); bus-cable assemblies for IEEE-488 interconnections; and CEE color-coded wire. Construction details, specifications and electrical characteristics are given in both conventional and metric units. Price: $2.50.—**Belden Corp.,** 2000 S. Batavia Ave., Geneva, IL 60134.

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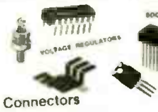

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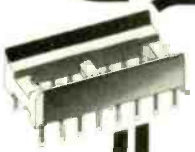

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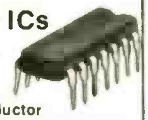

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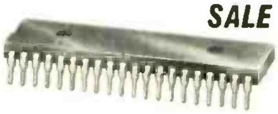

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8208 Bus Driver. 8-bit bidirectional. 276-2508. Reg $5 95 **Sale 4.95**

8154 128x8-Bit RAM I/O. 40-pin DIP. 276-2511. Reg. $9 95 **Sale 7.95**

8212 I/O Port. Data latch and buffer. 276-2512. Reg $4 95 **Sale 3.95**

8224 Clock and Generator Driver. 276-2524. Reg $3 95 **Sale 2.95**

8228 System Controller and Bus Driver. 276-2528. Reg $6 95 **Sale 5.95**

8251 Programmable Communication Interface. 276-2551. Reg. $9.95 **Sale 7.95**

8255 Programmable Peripheral Interface. 276-2555. Reg. $9.95 **Sale 7.95**

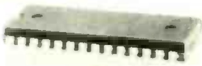
RAM Memory ICs

Under 450 nS Access Time

2102 1024 x 1 Array. Low-cost static memory chip. 16-pin DIP. Buy 8 and save! 276-2501 2.49 Ea. or 8/14.95

2114L 1024 x 4 Array. NMOS static RAM. 18-pin DIP. 276-2504. Reg. $12 95 **Sale 10.95**

SN-76477 Sound/Music Synthesizer IC



2.99 Featured In Oct. Popular Electronics

Creates almost any type of sound — music to "gunshots!" Built-in audio amp. Includes 2 VCO's. LF osc., noise gen., filter, 2 mixers, envelope modulator, logic circuit. 28-pin DIP. With data/applications circuits. 276-1765 .... 2.99

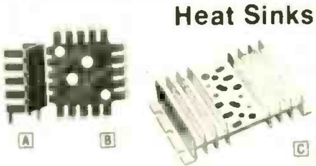
Analog Audio Delay IC MN 3002

10.95

For Phase-Shifter, Reverb & Delay Circuits

"Bucket Brigade" device uses 512 shift registers to provide a continuously variable electronic delay for complex audio signals. Includes data sheet and applications circuits. 276-1760 .... 10.95

Heat Sinks

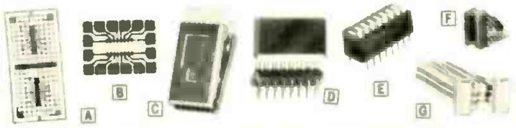


[A] **TO-220.** For PC board-mounted power semiconductors in TO-220 cases. Anodized aluminum. 276-1363 .... 79¢

[B] **TO-3 Sink.** For PC or chassis mtg. 276-1364 .... 1.39

[C] **Universal.** Mounts 2 devices, accepts 9 case styles. 276-1361 .... 2.69

Top-Quality IC and PCB Accessories



[A] **PC Board.** Mounts two 14 or 16-pin ICs or sockets for bread boarding. Copper clad. 2½x5x1¹⁄₁₆". 276-151 .... 2.99

[B] **PC Board.** Mounts single 14 or 16-pin IC or socket. 276-024 .... Pkg. of 2/99¢

[C] **16-Pin IC Test Clip.** 276-1951 .... 3.99

[D] **16-Pin DIP Header.** With snap-on cover 276-1980 .... 1.29

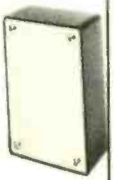
[E] **8-Rocker 16-Pin DIP Switch.** 276-1301 .... 1.99

[F] **Vertical 16-pin Socket.** For LED displays 276-1986 .... 1.49

[G] **16-Pin DIP Jumper Cable.** 18" long. 276-1976 .... 3.99

Project Boxes

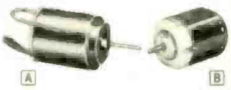
Aluminum Cover



The popular, low-cost way to house your electronic experiments.

3¼x2⅛x1⅛". 270-230 .... 1.19
4x2¼x2¼". 270-231 .... 1.29
5¹⁄₁₆x2⅛x1⅝". 270-233 .... 1.49
6¼x3¾x2. 270-627 .... 1.79
7¾x4⅜x2⅜". 270-232 .... 2.49

Miniature Hobby Motors



High-torque permanent magnet type. ¹⁄₁₆" dia. shaft.

[A] 12VDC. 350mA. 2x¹³⁄₁₆". 273-210 .... 69¢

[B] 6-9VDC. 500mA. 1⅝x¾". 273-209 ..... Pkg. of 2/99¢

PC Potentiometers

[A] Vertical

[B] Horizontal

Ohms	¼ W. (Fig A) Cat No	¼ W. (Fig A) Ea	⅛ W. (Fig B) Cat No	⅛ W. (Fig B) Ea
500	271-226	49¢	—	—
1k	271-227	49¢	271-333	39¢
5k	271-217	49¢	—	—
10k	271-218	49¢	271-335	39¢
25k	—	—	271-336	39¢
50k	271-219	49¢	—	—
100k	271-220	49¢	271-338	39¢
500k	271-221	49¢	—	—
1 Meg	271-229	49¢	—	—

Switches

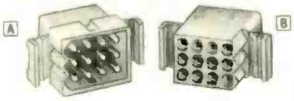
[A] **Miniature Toggle.** 6A @ 125VAC
SPDT. 275-662 .... 2.49
DPDT. 275-663 .... 2.89
DPDT. Center-Off. 275-664 .... 2.99

[B] **Momentary SPST.** 275-609 .... 1.89

[C] **Momentary SPDT.** 275-1549 .... 1.99

[D] **SPST Mercury.** 275-027 .... 99¢

Molded Connectors



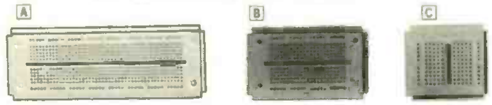
Molded nylon body. Each circuit rated 8A @ 250V. Standard .093" pin diameter

[A] **4-Pin Male.** 274-224 .... 99¢
6-Pin Male. 274-226 .... 1.19
9-Pin Male. 274-229 .... 1.39
12-Pin Male. 274-232 .... 1.49

[B] **4-Pin Female.** 274-234 .... 99¢
6-Pin Female. 274-236 .... 1.19
9-Pin Female. 274-239 .... 1.39
12-Pin Female. 274-242 .... 1.49

2-Pin Male & Female. (Not Shown.) 274-222 .... Pair 89¢

IC Breadboard Sockets



Modular boards snap together and feature standard 0.3" center. Accept 22 through 30-gauge solid hookup wire.

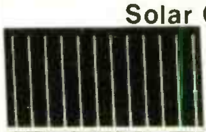
[A] 550 connections in 2 bus strips of 40 tie points each with 47 rows of 5 connected tie points. 2⅛x6". 276-174 .... 9.95

[B] 270 connections in 2 bus strips of 40 tie points each with 23 rows of 5 connected tie points. 2⅛x3⅝". 276-175 .... 5.95

[C] **Mini-Socket.** 22 rows of 5 tie points each, plus 2 bus strips with 10 connections each. 2⅛x1⅞". 276-176. Reg. $3.95 **Sale 2.99**

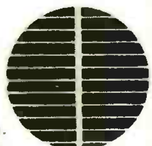
Solar Cells

Electricity from Light



4cm x 2cm Silicon Cell

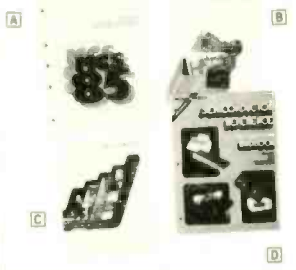
Silicon-type cell converts light to electrical power, delivering up to 100 mA at 0.5V. Use several in series-parallel for higher voltage or current. 276-120 .... 2.99



2¼" Dia. Silicon Cell

Highly efficient! Delivers up to 400 mA at 0.5V. Ideal for solar power projects, battery charging and operating electronic equipment. 276-121 .... 5.99

Computer Data Manuals and Semiconductor Handbook



[A] **Intel® 8080/8085 Programming Manual.** Handy reference for programming with Intel's assembly language. 62-1377 .... 3.95

[B] **Intel Memory Design Handbook.** Explains use of Intel's memory components and support circuits in systems. 62-1378 .... 3.95

[C] **Intel Data Catalog.** 928 pages of specifications on most of Intel's standard microcomputer-related products. 62-1379 .... 4.95

[D] **Semiconductor Reference and Application Handbook.** Complete specs and applications for popular IC transistors, diodes. 276-4002 .... 1.95

Low-Cost Plug-In PC Boards

For 22-pin connectors. 4½x4" ¹⁄₁₀" grid. 3 styles available.
Standard. 276-152 .... 3.49
Digital. 276-154 .... 3.49
Op-Amp. 276-153 .... 3.49
22-Pin Dual Connector. 276-1551 .... 2.99

WHY WAIT FOR MAIL ORDER DELIVERY? IN STOCK NOW AT OUR STORE NEAR YOU!

Radio Shack®

A DIVISION OF TANDY CORPORATION • FORT WORTH, TEXAS 76102
OVER 7000 LOCATIONS IN NINE COUNTRIES

Prices may vary at individual stores and dealers

THE MOST ADVANCED TIMEPIECE OF ITS KIND IN THE WORLD!

LCD Quartz Alarm Chronograph with calendar and dual time zone!! Watch is the same as Seiko but you pay a lot more for the name! Features:

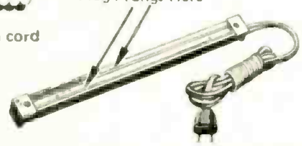
- 24 hour alarm
- Chronograph counts up to 12 hrs., 59 mins. 59.9 sec.
- Precision of chrono up to 1/10 sec indicated by 10 moving arrows!!
- Lap time (with chrono running uninterrupted)
- Time displays by LCD for hour, min, sec, day, date of the week and AM/PM.
- Calendar gives out date-day
- Dual time zone for any two cities of the world at your own choice.
- With light switch to allow you to see the time in the dark!

$65.50

ONE YEAR FULL WARRANTY!

TAP-A-LINE

It is a multi-plug extension cord for 110V AC
Maximum 12 plugs
$3.50 EA.



3-579 MHz Color TV Crystal

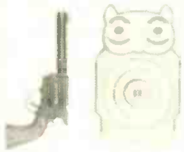
ON SALE
$1.25 EA.
10 for $11.00

6V 2AMP Rechargeable Battery

for moped, backup light system, alarm system, CB or other purpose. All brand new, never charged!
SPECIAL PRICE
$4.25 EA

WHAT A SAFE WAY TO SHOOT!

Electronic shooting game for all ages. Target uses photo electric cell and pistol shoots light beams. Range approx. 10 ft. and target makes sound. Not a kit! Battery not included.



$13.50 per set

SANYO HYBRID

Audio power amplifiers I.C. Max. hi-fi output power, minimum ext. components needed.

15 Watts	STK-028	$ 8.50
23 Watts	STK-054	$13.50
30 Watts	STK-056	$17.50
50 Watts	STK-050	$26.50
10W + 10W (stereo)	STK-040	$14.50
15W + 15W (stereo)	STK-041	$25.50
20W + 20W (stereo)	STK-043	$31.50

*data sheet comes with purchase

JUMBO 1" LED ALARM CLOCK MODULE

Assembled — not a kit!
Features:
- 1" 4 digits red LED display
- 12 hours real time format
- 24 hours alarm audio output (just add speaker)
- Power failure indicator
- Count down timer 59 mins.
- 12-16V AC 50/60 Hz input
- 10 min. snooze control

$8.50 EACH
FCM 701

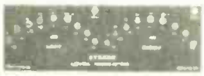
Transformer
$1.75

THE MOST POPULAR MM5314 CLOCK KIT

Features:
- 12/24 Hours Display
- 50/60 Hz Input
- 6 Digits Bright Orange Readouts

Kit includes plastic case, MM 5314 I.C. One set transistor drivers, P.C. Board, gas discharge displays, all other electronic parts and transformer. Catalog no. DC-8SP
SPECIAL PRICE
$17.95 PER KIT

NEW MARK III 9 Steps 4 Colors LED VU



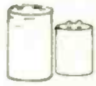
Stereo level indicator kit with arc-shape display panel!! This Mark III LED level indicator is a new design PC board with an arc-shape 4 colors LED display (change color from red, yellow, green and the peak output indicated by rose red). The power range is very large, from -30dB to +5dB. The Mark III indicator is applicable to 1 watt — 200 watts amplifier operating voltage is 3V — 9V DC at max 400 MA. The circuit uses 10 LEDs per channel. It is very easy to connect to the amplifier. Just hook up with the speaker output!

IN KIT FORM $17.50

9 STEPS LED LEVEL INDICATOR KIT

for most stereo amplifiers
This new project works as a pair of VU meter to indicate the output level of your amplifier from -20dB to +3dB. Kit includes all LED, transistors, electronic components, P.C. Board and instructions.
Easy to build and fun to see.
ONLY $12.50 EA.

COMPUTER GRADE CAPACITORS



All capacitors are Brand New U.S. made in standard size

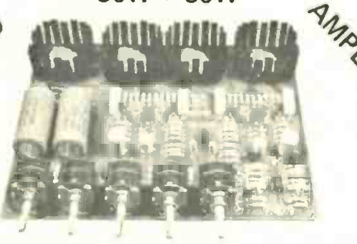
6000MFD	50V	$2.60 EA.
9000MFD	50V	$3.25 EA.
11000MFD	35V	$3.20 EA.
14500MFD	40V	$3.40 EA.
23000MFD	20V	$3.00 EA.
58000MFD	20V	$3.20 EA.
100,000MFD	6V	$2.50 EA.

ELECTRONIC DUAL SPEAKER PROTECTOR

Cut off when circuit is shorted or overload to protect your amplifier as well as your speakers. A must for OCL circuits.

KIT FORM
$8.75 EA.

60W + 60W STEREO AMPLIFIER

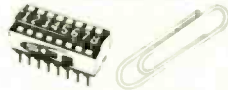


COMPLETED UNIT—NOT A KIT!

OCL pre amp. & power stereo amp. with bass, middle, treble 3-way tone control. Fully assembled and tested, ready to work. Total harmonic distortion less than 0.5% at full power. Output maximum is 60 watts per channel at 8Ω . Power supply Is 24 - 36V AC or DC. Complete unit

*Kit form $37.50	Assembled $49.50 ea.
Power transformer	$ 8.50 ea.

DIP SWITCHES



(On-Off Contacts)

4 positions	$1.50
5 positons	$1.60
6 positions	$1.70
7 positions	$1.70
8 positions	$1.80
10 positions	$2.00

ELECTRONIC WHEEL OF FORTUNE KIT!

With 10 numbers split into black and white on dial. The LED turns when you hit the play switch, then it slows down and stops on one number. It sounds like a motor inside, but there is none. Lots of fun and easy to build. Kit comes with nice looking case, all electronic parts, P.C. Board and LEDs. Battery not included.

$12.50

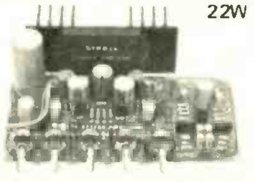
It is not a pack of cigarettes. It is a new FM wireless mic kit! New design PC board fits into a plastic cigarette box. (case included) Uses a condensor microphone to allow you to have a better response in sound pick-up. Transmits up to 350 ft! With an LED Indicator to signal the unit is on.

KIT FORM
$7.95
FMM2

AN AIR HORN!

Good for anything needing sound. This Is not electronic, but we bought them with some other deals. They are all brand new in boxes. $2.50 EA.

22W + 22W STEREO HYBRID AMPLIFIER KIT



It Works in 12V D.C. As Well! Kit includes 1 PC SANYO STK-024 stereo power amp. IC LM 1458 as pre amp, all other electronic parts, PC Board, all control pots and special heat sink for hybrid. Power transformer not included. It produces ultra hi-fi output up to 44 watts (22 watts per channel) yet gives out less than 0.1% total harmonic distortion between 100Mz and 10KHz. **$32.50 PER KIT**

POWER TRANSFORMER $6.50 EACH

CIRCLE 13 ON FREE INFORMATION CARD

SUPER 15 WATT AUDIO AMP KIT

Uses STK-015 Hybrid Power Amp

Kit Includes: STK-015 Hybrid IC, power supply with power transformer, front Amp with tone control, all electronic parts as well as PC Board. Less than 0.5% harmonic distortion at full power ½dB response from 20—100,000 Hz. This amplifier has QUASI—Complimentary class B output. Output max is watt (10 watt RMS) at 4Ω.

ONLY $23.50 each

FM WIRELESS MIC KIT

This new model FM wireless MIC kit uses 3 high freq. transistors, works in the FM range (88-108 MHz). It transmits the sound wave fidelity clearly over long distances (up to 250 ft.). Kit comes with all electronic parts, P.C. Board and mini microphone!

$6.95 EACH KIT

WE FOUND THE CASE FOR THE FM MIC!! Small nice looking aluminum case size like a pack of cigarettes. It is an intercom. Audio amp inside with a mic jack, a mini toggle sw on top, can be used for many projects. We give you the circuit data as well.
VERY SPECIAL PRICE 2 for $4.99

63 KEYS ASC11 DECORDED COMPLETE KEYBOARD

by Honeywell

with dual color key tops, uses TMS 5000 decorder LSI. (schematic data included)

SPECIAL $56.50 NOT A KIT!

PROFESSIONAL CASE

for our 0-30V Power Supply. It is a nice looking metal cast case with giant 4" volt/amp meter; output blinding post and fuse holder, on/off switch and line cord! ONLY $21.50 EA.

CASE 030

Sub-Mini Size Condenser Microphone

$2.50 each

FET Transistor Built-In

MANY SOUND DECISIONS!

Solid state sound indicator operating voltage 6V DC 30μ A. Small size approximately ¾" X 1¼".

Model EB2116 (Continuous)
Model EB2126 (Slow Pulse)
Model EB2136 (Fast Pulse)

$3.60 EACH

Continuous — Slow pulse — Fast pulse

POWER SUPPLY KIT

0-30V D.C. REGULATED

Uses UA723 and ZN3055 Power TR output can be adjusted from 0-30V, 2 AMP. Complete with PC board and all electronic parts.

0-30 POWER SUPPLY $10.50 each

Transformer for Power Supply, 2 AMP 24V x 2 $6.50
30V DC Panel Meter $4.20

FLUORESCENT LIGHT DRIVER KIT

12V DC POWERED

Lights up 8～15 Watt Fluorescent Light Tubes. Ideal for camper, outdoor, Auto or Boat.

Kit includes high voltage coil, power transistor, heat sink, all other electronic parts and PC Board, light tube not included!

ONLY $5.50 PER KIT

12V DC MINI RELAY

P.C. Board Solder Type

2AMP Contact SPDT $1.30 EA
2AMP Contact DPDT $1.75 EA
5AMP Contact 4PDT $2.20 EA

12V D.C. AUTO DIGITAL CLOCK

Complete Unit. Not a Kit!

0.4" blue color 4 digits display. Turn off readouts when car is not running. X'tal controlled time base for time accuracy. Special designed case for easy mounting on top of your dashboard. Ideal for car, boat and campers.

ONLY ~~$28.60~~ ea. SALE! $24.50

HEAVY DUTY CLIP LEADS

10 pairs — 5 colors. Alligator clips on a 22" long lead. Ideal for any testing.

$1.85/pack

1Watt AUDIO AMP

All parts are pre assembled on a mini PC Board. Supply Voltage 6～9V D.C.

SPECIAL PRICE $1.95 ea.

ELECTRONIC SWITCH KIT

CONDENSER TYPE

Touch On Touch Off, uses 7473 I.C. and 12V relay

$5.50 each

MINI-SIZED I.C. AM RADIO

Size smaller than a box of matches! Receives all AM stations. Batteries and ear phone included.

Only $8.50

"FISHER" 30 WATT STEREO AMP

MAIN AMP (15W X 2)

Kit includes 2 pcs. Fisher PA 301 Hybrid IC all electronic parts with PC Board. Power supply ± 16V DC (not included). Power band with (KF 1% ± 3dB). Voltage gain 33dB. 20Hz — 20KHz.

Super Buy Only $18.50

AA SIZE NI-CD BATTERY

6 in a pack (1.2V X 6) 500 MA/HR

$4.80 PER PACK

AUTO ALARM KIT

The Crimefighter Auto Alarm is an electronic, self-controlled auto protection system, normally mounted within the glove box of an automobile. Two minutes after turning off the ignition, the alarm automatically turns itself "on". When auto is re-entered, the horn will sound after a 10-45 second entry delay. The automobile owner, by inserting the ignition key, will activate the alarm. Once activated, the alarm will sound for two minutes before automatically turning off. The alarm then resets and is ready to again protect the vehicle from unwanted entry.

FEATURES: Simple installation: 5 wires. Automatically turns on when auto is parked. Adjustable entry time. Extended exit time to allow for unrushed exit from vehicle. Numerous applications include protection of boats, campers, trailers, motorcycles, trucks. Cannot be deactivated by "hot wiring" an auto. Cannot be turned off without ignition key. Negative ground only.

ONLY $14.00 PER KIT

BRAND NEW EVEREADY CH15 AA size NI-CD 500 MA/HR.

4 for $5.50

Only limited quantity available

5W AUDIO AMP KIT

2 LM 380 with Volume Control. Power Supply 6～18V DC

only $5.00 ea.

Sub Mini Size PANEL METER

500 UA

ONLY $1.20 ea

MINI-MINI TOGGLE SWITCH

Half size of submini toggle switch rated 3 amp 125V AC contact

		1-9	10-99
MS 244	SPDT	1.00	0.90
MS 245	DPDT	1.20	1.10

LARGE QUANTITY AVAILABLE FOR OEM

TIMER KIT

Time Controlled from 1-100sec. Ideal to be used as timer delay unit for burglar alarm, photo service, and other purposes. Max. loading 110V, 2 AMP. Supply voltage 12-18V DC.

FT-10 ELECTRONIC IC TIMER $11.50 each

PANEL METER (D.C. Type)

Size 60MM X 66MM. White Face Type

$5.50 ea.

0-50 UA	0-30V
0-1MA	0-50V
0-5MA	0-100V
0-100MA	

ELECTRONIC ALARM SIREN

COMPLETE UNIT

Ideal for use as an Alarm Unit or hookup to your car back up to make a reverse indicator. Light Output up to 130dB. Voltage Supply 6～12V

AU—999 $7.50

4 DIGITS ALARM CLOCK

COMPLETE UNIT NOT A KIT

- 0.5" RED LED READ OUT
- 24 HRS. ALARM SET
- 10 MINS. SNOOZE SET
- AM/PM ALARM INDICATORS
- SECOND DISPLAY SWITCH
- AUTOMATIC BRIGHTNESS CONTROL
- COMPACT AND HANDSOME PACKING
- 110V AC 60HZ INPUT

$17.50 EACH

TRANSFORMERS

ALL 117 VOLT INPUT

30V	4AMP	$7.50 EA.
36V CT	3AMP	$6.50 EA.
48V CT	3AMP	$6.50 EA.
24V CT	3AMP	$6.50 EA.
24V CT	0.8AMP	$1.80 EA.
12V CT	0.8AMP	$1.80 EA.
12V CT	120MA	$1.25 EA.

AC POWER SUPPLY

Wall Type Transformer

12V AC	Output	200MA	$2.75 EA.
16V CT AC	Output	100MA	$2.10 EA.
6V DC	Output	120MA	$1.90 EA.
12V DC	Output	100MA	$1.90 EA.

SUBMINIATURES TOGGLE SWITCHES

SPDT	On-Off	$1.30 ea
DPDT	On-Off	$1.50 ea
3PDT	On-Off	$1.75 ea

Mini size Rocker Type. Also available at the same price

SOUND ACTIVATED SWITCH

All parts completed on a PC Board. SCR will turn on relay, buzzer or trigger other circuit for 2～10 sec. (adjustable). Ideal for use as door alarm, sound controlled toys and many other projects. Supply voltage 4.5V～9V D.C.

$1.75 ea./2 for $3.00

MINI SIZE REED RELAY

Approx. 1" square. SPST Normal Open. Contact rated 1AMP. Coil 6～12V DC. All brand new by AMF

3 for $2.00

LINEAR SLIDE POT 500KΩ SINGLE

Metal Case 3" Long

2 FOR $1.20

2¼" ROUND SPEAKER

8Ω 0.25W for most sound projects

SPECIAL 3 for $2.00

WIDE ANGLE PANEL METER

1¾" x ¾". IMA Full Scale (scale marks 0-100)

$1.50 each

PUSH-BUTTON SWITCH

N/Open Contact. Color: Red, White, Blue, Green, Black. 4/$1.00. N/Close also Available 50¢ ea.

LARGE QTY. AVAILABLE

DIGITAL ELECTRONIC LOCK KIT

for auto ignition, entry door, burglar alarm, etc. 4 Digits Programmable to Any Combination

$6.50 ea. CMOS I.C. IN CIRCUIT

400Ω RELAY AND KEY PAD NOT INCLUDED

I.C. TEST CLIPS

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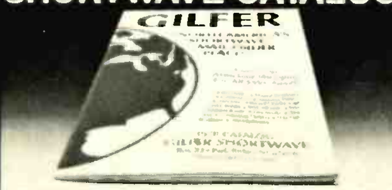

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	Description	Sale	2 For
5646R	26V or 29V @ 1.0A	$7.95 Ea.	$15.00
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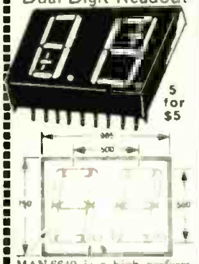

5 for $5

MAN-6640 is a high performance, compact DOUBLE DIGIT readout having a bright orange display with a right hand decimal (and is Common Cathode). Each digit is .560 x .320" for easy reading. Ideal for digital readout displays, instrument panels, digital clocks, TVs, radios, etc. Complete with data and pin out. No. 1103R **1.25**

DELTA Burglar ALARM

Only **$24.50**

MOTION DETECTOR

When there is a new development in electronics, it takes some time before that development is available to hobbyists and experimenters, especially at surplus prices. This time we have reversed the trend, and announce a DELTA EXCLUSIVE, the DELTA MOTION DETECTOR. This device detects any motion or movement for a minimum distance of 8-ft. The secret is in the ultra complex custom LSI chip, which combines the latest in linear & digital circuitry. The device is completely self-contained, in a case 6 x 3 x 2 ¼", and operates from four "AA" NICad batteries. Nothing else is needed, for the device to perform its basic function, motion detection. When motion or movement is detected, a "whoop" alarm is sounded. The MOTION DETECTOR is designed to provide either an audible or silent alarm. The silent alarm is controlled by a timer, which delays the alarm up to 30 seconds. The silent alarm activates a relay, whose contacts are brought out to plug, and will activate ANY device, such as siren, horn, tape recorder, telephone dialer, etc.

The Motion Detector works on a CHANGE OF LIGHT. Any change of +5% or more, triggers the detector. Works within a range of 0.1 candlepower (almost dark), to 100 candlepower, (quite brite), a range of 1000 to 1. NO external light source is needed.

When left in a darkened or semi-darkened room, the Motion Detector acts as a fantastic FIRE ALARM. The light from a single match, anywhere in the room, triggers the alarm, so that the device becomes an intrusion alarm and fire alarm, all in one.

Delta No.	Description	Sale
5611R	Complete motion detector kit (less batteries	$24.50
1072R	Motion Detector Chip only, with data	8.95
5611R	P.C. boards, set of 2	6.50
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5635R	Completely assembled kit, w/batteries & charger	69.50

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CT-50

SPECIFICATIONS:
Frequency range 6 Hz to 65 mHz. 600 mHz with CT-600
Resolution 10 Hz @ 0.1 sec gate, 1 Hz @ 1 sec gate
Readout 8 digit, 0.4" high LED, direct readout in mHz
Accuracy, adjustable to 0.5 ppm
Stability 2.0 ppm over 10° to 40° C, temperature compensated
Input BNC, 1 megohm 20 pf direct, 50 ohm with CT-600
Overload 50VAC maximum, all modes
Sensitivity less than 25 mv to 65 mHz, 50-150 mv to 600 mHz
Power 110 VAC 5 Watts or 12 VDC @ 400 ma
Size 5" x 4" x 2", high quality aluminum case, 2 lbs
ICS 13 units, all socketed.

The CT-50 is a versatile and precision frequency counter which will measure frequencies to 60 mHz and up to 600 mHz with the CT-600 option. Large Scale Integration, CMOS circuitry and solid state display technology have enabled this counter to match performance found in units selling for over three times as much. Low power consumption (typically 300-400 ma) makes the CT-50 ideal for portable battery operation. Features of the CT-50 include: large 8 digit LED display, RF shielded all metal case, easy pushbutton operation, automatic decimal point, fully socketed IC chips and input protection to 50 volts to insure against accidental burnout or overload. And, the best feature of all is the easy assembly. Clear, step by step instructions guide you to a finished unit you can rely on. **Order your today!**

CT-50, 60 mHz counter kit	$89.95
CT-50WT 60 mHz counter, wired and tested	159.95
CT-600, 600 mHz scaler option, add	29.95
CB-1, Color TV calibrator-stabilizer	$14.95
DP-1, DC probe, general purpose probe	12.95
HP-1, High impedance probe, non-loading	15.95

CAR CLOCK

The UN-KIT, only 5 solder connections

Here's a super looking, rugged and accurate auto clock which is a snap to build and install. Clock movement is completely assembled—you only solder 3 wires and 2 switches, takes about 15 minutes! Display is bright green with automatic brightness control photocell—assures you of a highly readable display, day or night. Comes in a satin finish anodized aluminum case which can be attached 5 different ways using 2 sided tape. Choice of silver, black or gold case (specify).

DC-3 kit, 12 hour format	$22.95
DC-3 wired and tested	$29.95
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Under dash car clock

12/24 hour clock in a beautiful plastic case features: 6 jumbo RED LEDS, high accuracy (1 min/mo.), easy 3 wire hookup, display blanks with ignition, and super instructions. Optional dimmer automatically adjusts display to ambient light level.

DC-11 clock with mtg. bracket	$27.95
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Extend the range of your counter to 600 mHz. Works with any counter. Includes 2 transistor pre-amp to give super sens. typically 20 mv at 150 mHz. Specify ÷ 10 or ÷ 100 ratio.

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OP-AMP SPECIAL

741 mini dip	12/$2.00
B1-FET, mini dip, 741 type	10/$2.00

VIDEO TERMINAL

A completely self-contained, stand alone video terminal card. Requires only an ASCII keyboard and TV set to become a complete terminal unit. Two units available, common features are: single 5V supply, XTAL controlled sync and baud rates (to 9600), complete computer and keyboard control of cursor. Parity error control and display. Accepts and generates serial ASCII plus parallel keyboard input. The 3216 is 32 char. by 16 lines, 2 pages with memory dump feature. The 6416 is 64 char. by 16 lines, with scrolling, upper and lower case (optional) and has RS-232 and 20ma loop interfaces on board. Kits include sockets and complete documentation.

RE 3216, terminal card	$149.95
RE 6416, terminal card	189.95
Lower Case option, 6416 only	13.95
Power Supply Kit	14.95
Video/RF Modulator, VD-1	6.95
Assembled, tested units, add	60.00

CALENDAR ALARM CLOCK

The clock that's got it all: 6-.5" LEDs, 12/24 hour, snooze, 24 hour alarm, 4 year calendar, battery backup, and lots more. The super 7001 chip is used. Size: 5x4x2 inches.
Complete kit, less case (not available)
DC-9 $34.95

30 Watt 2 mtr PWR AMP

Simple Class C power amp features 8 times power gain. 1 W In for 8 out, 2 In for 15 out, 4 W In for 30 out. Max. output of 35 W, incredible value, complete with all parts, less case and T-R relay

PA-1, 30 W pwr amp kit	$22.95
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FM MINI MIKE KIT

A super high performance FM wireless mike kit! Transmits a stable signal up to 300 yards with exceptional audio quality by means of its built in electret mike. Kit includes case, mike, on-off switch, antenna, battery and super instructions. This is the finest unit available.

FM-3 kit	$12.95
FM-3 wired and tested	16.95

CLOCK KITS

our Best Seller your Best Deal

Try your hand at building the finest looking clock on the market. Its satin finish anodized aluminum case looks great anywhere, while six .4" LED digits provide a highly readable display. This is a complete kit, no extras needed, and it only takes 1-2 hours to assemble. Your choice of case colors, silver, gold, bronze, black, blue (specify).

Clock kit, 12/24 hour, DC-5	$22.95
Clock with 10 min. ID timer, 12/24 hour, DC-10	27.95
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12V DC car clock, DC-7	27.95

For wired and tested clocks add $10.00 to kit price.

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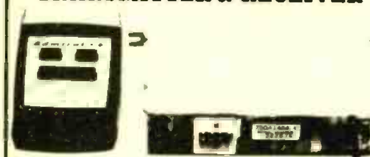

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DJ14-1-14	1 ft.	2-14 Pin	2.79 ea.
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- Thousands of applications
- Operates on +6 to +9 VDC
- Output Frequency 800 Hz
- Draws only 15 MA @ 600 ohms
- Size 1¼" x ⅝"

PART NO. MB-1

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Use as a warning Device or Audible Reminder

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- dBA: 68 (Min) — 80 (Max)
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Ideal for use with clocks, power supplies or any other type of AC application.

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Regulated Power Supply

- Uses LM 309K
- Heat sink provided
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- Provides a solid 1 amp @ 5V
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- Sizes: 3-1/2" x 5" x 2" high

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MM504H	Dual 16 Bit Static	.50
MM506H	Dual 100 Bit Static	.50
MM510H	Dual 64 Bit Accumulator	.50
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2528	Dual 250 Static	4.00
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2533	1024 Static	2.95
3341	Fifo	6.95
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A-Y-5-1013	30K BAUD	5.95

MICROPROCESSOR MANUALS

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

ROM'S

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

RAM'S

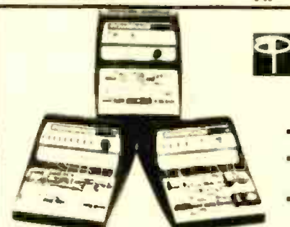
1101	256X1	Static	$1.49
1103	1024X1	Dynamic	.99
2101(8101)	256x4	Static	3.95
2102	1024X1	Static	1.75
21L02	1024X1	Static	1.95
2111(8111)	256X4	Static	3.95
2112	256X4	Static MOS	4.95
2114	1024X4	Static 450ns	9.95
2114L	1024X4	Static 450ns low power	10.95
2114-3	1024X4	Static 300ns	10.95
2114L-3	1024X4	Static 300ns low power	11.95
5101	256X4	Static	7.95
5280/2107	4096X1	Dynamic	4.95
7489	16X4	Static	1.75
74S200	256X1	Static Tristate	4.95
93421	256X1	Static	2.95
UPD414 (MK4027)	4K	Dynamic 16 pin	4.95
UPD416 (MK4116)	16K	Dynamic 16 pin	14.95
TMS4044-45NL	4K	Static	14.95
TMS4045	1024X4	Static	14.95
2117	16,384X1	Dynamic 350ns (house marked)	9.95
MM5262	2KX1	Dynamic	4/1.00

PROM'S

1702A	2048	FAMOS	$5.95
TMS2516 (2716)	16K*	EPROM(Intel 2716)	49.95
	*Requires single +5V power supply		
TMS2532	4KX8	EPROM	89.95
2708	8K	EPROM	10.95
2716 T.I.	16K**	EPROM	29.95
	**Requires 3 voltages, —5V, +5V, +12V		
5203	2048	FAMOS	14.95
6301-1(7611)	1024	Tristate Bipolar	3.49
6330-1(7602)	256	Open C Bipolar	2.95
82S23	32X8	Open Collector	3.95
82S115	4096	Bipolar	19.95
82S123	32X8	Tristate	3.95
74186	512	TTL Open Collector	9.95
74188	256	TTL Open Collector	3.95
74S287	1024	Static	2.95

NEW!! IN STOCK... POWERACE

ALL-CIRCUIT EVALUATORS WITH POWER



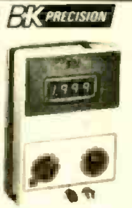
- 1680 solderless, plug-in tie points ... will hold up to 18 14-pin DIP's.
- Breadboard elements accept all DIP sizes ... including RTL, DTL, TTL and CMOS devices. TO-5's and discretes with leads up to .032" dia.
- All connections to/from switches, indicators, power supplies and meters are made via solderless, plug-in, tie-point blocks on control panels.
- Interconnect with any solid 20 to 30 AWG wire.
- Breadboard elements are mounted on ground planes ... ideal for high-frequency and high-speed low-noise circuits.
- Short-circuit-proof fused power supplies.
- Operate on 110 to 130 VAC at 60 Hz
- Space-age compact styling and high-grade components permit convenient, organized and quick prototyping.
- All models are 7.5" wide 11.5" deep and 4.0" high (rear) 0.75" high (front) and weigh approx. 2.5 lbs.

POWERACE 101 -General purpose model for prototyping all types of circuit.
#923101 $84.95

POWERACE 102 -Complete digit prototyping lab with built-in logic probe
#923102 $114.95

POWERACE 103 -Triple-output power supply for prototyping both linear and digit circuits.
#923103 $124.95

B+K PRECISION 3½-Digit Portable DMM



- Overload Protected
- 3" high LED Display
- Battery or AC operation
- Auto Zeroing
- 1mV, 1Va, 0.1 ohm resolution
- Overange reading
- 10 meg input impendence
- DC Accuracy 1% typical

Ranges: DC voltage - 0-1000V
AC Voltage 0-1000V
Freq. Response 50-400 HZ
DC/AC Current 0-100mA
Resistance 0-10 meg ohm
Size 6.4 x 4.4 x 2

Model 2800
$99.95

Comes with test leads, operating manual and spare fuse

Accessories:

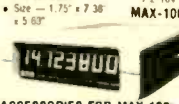
AC Adapter BC-28	$9.00
Rechargeable Batteries BP-26	20.00
Carrying Case LC-28	7.50

CSC 100 MHz 8-Digit Counter

CONTINENTAL SPECIALTIES CORPORATION

- 20 Hz-100 MHz Range
- .6" LED Display
- Crystal-controlled timebase
- Fully Automatic
- Portable — completely self-contained
- Size — 1.75" x 7.38" x 5.63"
- Four power souces, i.e. batteries, 110 or 220V with charger 12V with auto lighter adapter and external 7.2-10V power supply

MAX-100 $134.95



ACCESSORIES FOR MAX 100:

Mobile Charger Eliminator use power from car battery — Model 100 — CLA $3.95
Charger/Eliminator use 110 V AC — Model 100 — CA1 $9.95

New CSC Mini-Max 6 Digit 50MHz Frequency Counter

- Guaranteed frequency range of 100 Hz to 50 MHz
- Full 6 digit display with antiglare window
- Fully automatic-range, polarity, slope, trigger, Input level switching not required.
- Lead-zero blanking—All zeros to the left of the first non-zero digit are blanked. Kilo Hertz and Mega Hertz decimal points automatically light up when the unit is turned on.
- Built in input overvoltage protection.
- Use 9V Battery or 110/220V power.
- Complete with mini antenna.
- Lightweight — Only 8oz.

MINI-MAX $89.95

Accessories For Mini-Max

Part No.	Description	Price
MM-A4	Antenna	$ 3.95
MM-C5	Carrying case	5.95
MM-IPC	Input cable with clip leads	3.95
MM-AC2	110V adapter	9.95
MM-AC3	220V adapter	9.95

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets — 25¢
1979 Catalog Available—Send 41¢ stamp

NEW 1979 Catalog

Jameco ELECTRONICS

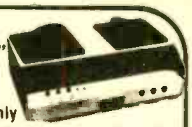
A division of JAMES ELECTRONICS of California

PHONE ORDERS WELCOME (415) 592-8097

MAIL ORDER ELECTRONICS — WORLDWIDE
1021 HOWARD AVENUE, SAN CARLOS, CA 94070

ADVERTISED PRICES GOOD THRU FEBRUARY

The Incredible *"Pennywhistle 103"*



$139.95 Kit Only

The Pennywhistle 103 is capable of recording data to and from audio tape without critical speed requirements for the recorder and it is able to communicate directly with another modem and terminal for telephone "hamming" and communications. In addition, it is free of critical adjustments and is built with non-precision, readily available parts.

Data Transmission Method	Frequency-Shift Keying, full-duplex (half-duplex selectable).
Maximum Data Rate	300 Baud
Data Format	Asynchronous Serial (return to mark level required between each character)
Receive Channel Frequencies	2025 Hz for space, 2225 Hz for mark
Transmit Channel Frequencies	Switch selectable: Low (normal) = 1070 space, 1270 mark; High = 025 space, 2225 mark
Receive Sensitivity	−46 dbm accoustically coupled
Transmit Level	−15 dbm nominal. Adjustable from −6 dbm to −20 dbm.
Receive Frequency Tolerance	Frequency reference automatically adjusts to allow for operation between 1800 Hz and 2400 Hz
Digital Data Interface	EIA RS-232C or 20 mA current loop (receiver is optoisolated and non-polar).
Power Requirements	120 VAC, single phase, 10 Watts.
Physical	All components mount on a single 5" by 9" printed circuit board. All components included

Requires a VOM, Audio Oscillator, Frequency Counter and/or Oscilloscope to align

TRS-80 16K Conversion Kit

Expand your 4K TRS-80 System to 16K. Kit comes complete with:

- 8 each UPD416 (16K Dynamic Rams)
- Documentation for conversion

TRS-16K $115.00

Special Offer - Order both your TRS-16K and the Sup'R' MOD II Interface kit together (retail value $144.95) for only $139.95

COMPUTER CASSETTES

- 6 EACH 15 MINUTE HIGH QUALITY C-15 CASSETTES
- PLASTIC CASE INCLUDED 12 CASSETTE CAPACITY
- ADDITIONAL CASSETTES AVAILABLE #C-15-$2.50 ea

CAS-6 $14.95
(Case and 6 Cassettes)

SUP 'R' MOD II

UHF Channel 33 TV Interface Unit Kit

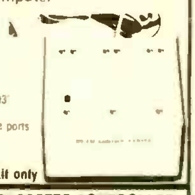
Wide Band B/W or Color System

- Converts TV to Video Display for home computers, CCTV camera, Apple II, works with Cromeco Dazzler, SOL-20, TRS-80, Challenger, etc.
- MOD II is pretuned to Channel 33 (UHF).
- Includes coaxial cable and antenna transformer.

MOD II $29.95 Kit

RS-232 CONTROL CENTER

Plug in your modem, computer prom programmer, terminal, printer, etc. and selectively control data flow.



- Same Contour as Pennywhistle 103
- Totally self-contained
- Includes 2 master ports and 3 slave ports

PART NO. RS-232CC $89.95 kit only

CASSETTE CONTROLLER

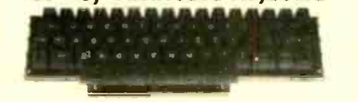
Ideal for use with the TRS 80 and others

"Plug/Jack interface to any computer system requiring remote control of cassette functions"

The CC100 controls cassette motor functions, monitors tape location with its internal speaker and requires no power. Eliminates the plugging and unplugging of cables during computer loading operation from cassette.

#CC-100 $29.50

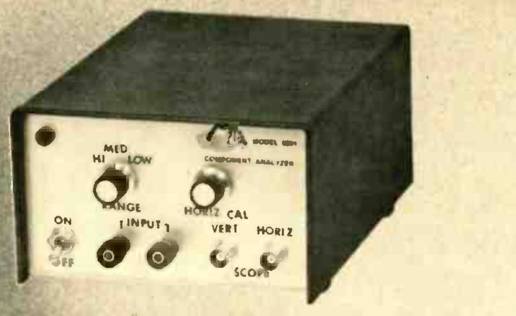
63-Key Unencoded Keyboard



This is a 63-key, terminal keyboard newly manufactured by a large computer manufacturer. It is unencoded with SPST keys, unattached to any kind of PC board. A very solid molded plastic 13 x 4" base suits most application. IN STOCK **$29.95/each**

Hexadecimal Unencoded Keypad

19-key pad includes 1-10 keys, ABCDEF and 2 optional keys and a shift key. **$10.95/each**



PTS 8001 Component Analyzer

Solid state component tester works in or out of circuit. Simple hook-up to any standard oscilliscope. High, medium and low range switch for matching the impedance to the component being tested.
Dealer Net $54.95

See the Yellow Pages for the PTS Servicenter Nearest You or Contact:

PTS ELECTRONICS, INC.
P.O. Box 272 Bloomington, IN 47401 812-824-9331

CIRCLE 66 ON FREE INFORMATION CARD

12V 8A POWER SUPPLY $44.50

Handles 12A with 50% duty cycle. Hams and CBers use it for powering mobile transceivers in the home, techs use it for a bench supply, hi-fi stores use it to power car stereo equipment, and computer owners use it to power bunches of floppy disc drives. Features crowbar overvoltage protection, foldback current limiting, adjustable output 11-14V, custom heavy-duty transformer, RF suppression, and easy assembly (all parts except xfrmr/filter caps/diodes mount on circuit board). With complete assembly instructions. Does not include case.

TRS-80 CONVERSION KIT $109 (3/$320)

Includes DIP shunts, 250 ns chips for 4 MHz operation, and 1 year guarantee. Upgrades 4K TRS-80 to 16K, or populates Memory Expansion Module — our novice level instructions show you how. **Also suitable for APPLE computers.**

H8 COMPATIBLE 12K X 8 MEMORY BOARD UNKIT $200

Comes with sockets and bypass caps pre-soldered in place for easy assembly. Fully static, buffered, and includes on-board regulation. With easy-to-follow instructions.

MEMORY SPECIAL: 2101-L1 (high speed/low power) **1K STATIC RAM NOW ONLY 99¢ EACH**
(sorry, only good for orders of 10 or more)

GODBOUT
BILL GODBOUT ELECTRONICS
BOX 2355, OAKLAND AIRPORT, CA 94614

TERMS: Orders under $15 add $1. Cal res add tax. VISA®/Mastercharge® ($15 min) call (415) 562-0636, 24 hrs. Allow 5% shipping, excess refunded. COD OK with street address for UPS.

SEND FOR OUR FREE FLYER

CIRCLE 28 ON FREE INFORMATION CARD

REGULATED POWER SUPPLIES

POWER SYSTEMS # PS1111
115-230V 50/60 cy. in VAC at 35A out.
6"x 16¾"x 15¼" 26 lbs. shipping weight $85.00

POWER SYSTEMS # PS1106
115-230V 50/60 cy. In 12 VAC at 15A out.
5"x 16¾"x 5" 19 lbs. shipping weight. $75.00

C/MOS (DIODE CLAMPED)

4001	18	4019	.37	4049	.35	74C74	45
4002	18	4020	90	4050	.35	74C83	1 15
4006	95	4021	90	4053	1 10	74C86	40
4007	.18	4022	90	4055	1.25	74C93	75
4009	37	4023	18	4066	.70	74C151	1 40
4010	37	4024	75	4071	18	74C160	1 05
4011	18	4025	18	4076	97	74C161	1 05
4012	.18	4027	.37	4520	70	74C174	1 05
4013	29	4028	80	74C00	22	74C175	1 05
4014	75	4029	95	74C02	.22	74C192	1 20
4015	75	4030	.33	74C04	24	74C193	1 20
4016	29	4035	97	74C08	22	74C901	48
4017	90	4042	65	74C10	27	74C902	48
4018	90	4046	1 35	74C73	65	74C914	1.70

1488 RS232 INTERFACE	$ 1 40	2114 4K STATIC RAM (450 ns)	$ 9 50
1489 RS232 INTERFACE	$ 1 75	4116	$ 15 [illegible]
2509 TRI STATE STATIC SR	$ 1 35	5280 2107B 4K DYN RAM	$ 3 40
2513 CHARACTER GEN UP.	$ 6 75	TMS 4050L	$ 3 95
2518 HEX 32 BIT SR	$ 2 70	5204 4K PROM	$ 4 95
2522 STATIC SHIFT REG	$ 1 95	82S23	$ 1 95
[illegible] EPROM (450 ns)	$ [illegible]	82S129	$ 3 25
[illegible]	$ [illegible]	AY 5 1013 UART	$ 5 25
2716 [illegible]	$2[illegible]	[illegible]	$ 4 95
2102 1 (450 ns)	$ 99	8701C TELEDYNE 8 BIT A D CONVERT	$ 4 95
21L02 1 (450 ns)	$ 1 25	[illegible]	$ 1 75
MM5270 4K [illegible]	$ 1 45	8224	$ 3 95
[illegible] 4008P	$ 1 95	8228	$ 3 95
2101 1 256 × 4 STATIC	$ 2 45	[illegible]	$ [illegible]
2111 1 256 × 4 STATIC	$ 3 45		
2112 1 256 × 4 STATIC	$ 2 75		

CRYSTALS $3.45 ea.
4 000 MHz
5 000 MHz
6 000 MHz
8 000 MHz
10 000 MHz

RIBBON CABLE
FLAT (COLOR CODED)
#30 WIRE
26 cond. - .50/per foot
40 cond. - .75/per foot
50 cond. - .90/per foot

CTS 206-8 eight position dip switch $1.60
CTS-206 4 four position dip switch $1.45
LIGHT ACTIVATED SCR's
TO 18 200V 1A $ .70

SILICON SOLAR CELLS
2¼" diameter .4V at 500 ma $4.00

LED READOUTS
FND 359 C.C. .4" $ .50
FCS 8024 4 digit
C.C 8" display $5.95
FND 503 C.C. 5" $ 85
FND 510 C.A 5" $ 85
DL 704 3" C.C. $ 85
DL 704 C.A. 3" $ .75
DL 747 C.A. 6" $1 75
FND 803 C.C .8" $1 95
FND 810 C.A. .8" $1.95

PRINTED CIRCUIT BOARD

4 1/2" × 6 1/2" SINGLE SIDED EPOXY BOARD 1/16" thick, unetched
$ 60 ea. 5/$2.60

7 WATT LD-65 LASER DIODE IR $8.95

2N 3820 P FET $ 45
2N 5457 N FET $ 45
2N2646 UJT $ .45
ER 900 TRIGGER DIODES 4 $1 00
2N 6028 PROG UJT $ 65

MINIATURE MULTI-TURN TRIM POTS
100, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 500K, 1Meg, 2Meg, $.75 each 3/$2.00

CHARGED COUPLE DEVICES

CCD 201C 100x100 Image Sensor $95.00
CCD 202C 100x100 Image Sensor $145.00

VERIPAX PC BOARD $4.00
This board is a 1/16" single sided paper epoxy board, 4½"x6½" DRILLED and ETCHED which will hold up to 21 single 14 pin IC's or 8,16 or LSI DIP IC's with busses for power supply connector.

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TIL-118 OPTO-ISOLATOR $ .75
MCT-6 OPTO ISOLATOR $ .80
1 WATT ZENERS: 3.3, 4.7, 5.1, 5.6, 9.1, 10, 12, 15, 18, or 22V 6/$1.00
MC6860 MODEM CHIP $9.95
MCM 6571A 7 × 9 character gen $10.75

Silicon Power Rectifiers

PRV	1A	3A	12A	50A	125A	240A
100	06	14	30	.80	3 70	5.00
200	07	20	35	1 15	4 25	6.50
400	09	25	50	1.40	6 50	9.50
600	11	30	.70	1 80	8 50	12.50
800	15	35	90	2.30	10.50	16.50
1000	20	45	1 10	2 75	12.50	20 00

SAD 1024 a REDICON 1024 stage analog "Bucket Brigade" shift register. $14.95

1N 4148 (1N914) 15 $1 00

RS232 CONNECTORS
DB 25P male $2.25
DB 25S female $2.95
HOODS $1.00

REGULATORS
309K $ 1.20
723 $ .50
LM 376 $ .60
320T 5, 12, 15 or 24 $1 25
340K-12,15 or 24V $ 95
340T-5, 6, 8, 12, 15,18 or 24V $ 95
78 MG $1.35
79 MG $1.35

TRANSISTOR SPECIALS

2N6233 NPN SWITCHING POWER $ 1.95
MRF-8004 a CB RF Transistor NPN $ .75
2N3772 NPN Si TO 3 $ 1.00
2N1546 PNP GE TO-3 $ .75
2N4908 PNP Si TO 3 $ 1 00
2N6056 NPN Si TO-3 Darlington $ 1 70
2N5086 PNP Si TO 92 4 $ 1.00
2N3137 NPN Si RF $ .55
2N3919 NPN Si TO 3 RF $ 1 50
2N1420 NPN Si TO 5 3/$ 1.00
2N3767 NPN Si TO 66 $ 70
2N2222 NPN Si TO-18 5 $ 1.00
2N3055 NPN Si TO 3 $ .50
2N3904 NPN Si TO 92 6/$ 1.00
2N3906 PNP Si TO 92 6/$ 1.00
2N5296 NPN Si TO-220 $ 50
2N6109 PNP Si TO 220 $ .55
2N3638 PNP Si TO 5 5 $ 1 00
MPSA 13 NPN Si 4/$ 1.00

TTL IC SERIES

7400	.13	7445	65	74151	61
7401	.13	7446	68	74153	61
7402	.13	7447	58	74154	94
7403	.13	7448	68	74156	.58
7404	.15	7450	.15	74157	.55
7405	.13	7472	.25	74161	.55
7406	.16	7473	.28	74162	.79
7407	.20	7474	.28	74163	.55
7408	.18	7475	.45	74164	.85
7409	.18	7476	.30	74165	.95
7410	.13	7480	.31	74170	1 68
7411	.18	7483	.65	74173	1.20
7412	.13	7485	.87	74174	.95
7413	.36	7486	.28	74175	.85
7414	.60	7489	1.25	74176	.75
7416	.22	7490	.42	74177	.75
7417	.25	7491	.58	74180	.65
7420	.13	7492	43	74181	1.90
7425	.25	7493	43	74190	1.00
7426	.22	7494	.67	74191	1.00
7427	.19	7495	.65	74192	.79
7430	.13	7496	.65	74193	.79
7432	.22	7497	90	74194	.80
7437	.21	74107	.28	74195	50
7438	.21	74121	.29	74196	86
7440	.13	74122	.38	74279	.55
7441	.70	74123	.45	74298	.90
7442	37	74125	.40	75325	1.50
		74126	.40	75491	50
		74150	94	75492	50

DATA CASSETTES 1/2 HR $ 95

22/44 Pin Solder Tail .156" Conn. $1.95

MM 5387AA new clock chip which will directly drive LED's 12/24 hrs., 1 supply & alarm $5.95

NO. 30 WIRE WRAP WIRE SINGLE STRAND 100' $1.40

ALCO MINIATURE TOGGLE SWITCHES
MTA 106 SPDT $ .95
MTA 206 DPDT $ 1 70
MTA 206 P DPDT CENTER OFF $ 1.85
MSD 206 P DPDT CENTER OFF LEVER SWITCH $ 1.85

Full Wave Bridges

PRV	2A	6A	25A
100			1.30
200	.75	1.25	2.00
400	.95	1.50	3.00
600	1.20	1.75	4.00

DIP SOCKETS

8 PIN .17 24 PIN .35
14 PIN .20 28 PIN .40
16 PIN .22 40 PIN .60
18 PIN .25

SANKEN AUDIO POWER AMPS

Si 1010 G 10 WATTS $ 7.80
Si 1020 G 20 WATTS $15.70
Si 1050 G 50 WATTS $28.50

TANTULUM CAPACITORS

22UF 35V	5 $1 00	6 8UF 35V	4 $1 00
47UF 35V	5 $1 00	10UF 10V	$ .25
68UF 35V	5 $1 00	22UF 25V	$ 40
1UF 35V	5 $1 00	15UF 35V	3/$1.00
2 2 UF 20V	5 $1 00	30UF 6V	5/$1.00
3 3UF 20V	4 $1 00	47UF 20V	$ .35
4.7UF 15V	5/$1.00	68 UF 15V	$ .50
		100 UF 10V	$ .40

74LS SERIES

74LS00	19	74LS132	.70
74LS02	19	74LS138	70
74LS03	19	74LS139	70
74LS04	21	74LS151	59
74LS05	21	74LS153	59
74LS08	21	74LS155	62
74LS09	21	74LS156	62
74LS10	20	74LS157	59
74LS11	20	74LS160	79
74LS13	40	74LS161	79
74LS14	80	74LS162	79
74LS15	21	74LS163	79
74LS20	21	74LS168	80
74LS21	21	74LS169	80
74LS22	21	74LS170	1 40
74LS26	29	74LS173	95
74LS27	25	74LS174	72
74LS28	26	74LS181	2 00
74LS30	21	74LS190	88
74LS32	25	74LS191	88
74LS37	28	74LS192	88
74LS38	28	74LS193	88
74LS40	21	74LS195	50
74LS47	73	74LS196	75
74LS51	25	74LS197	75
74LS54	25	74LS244	1 75
74LS73	35	74LS266	39
74LS74	34	74LS257	68
74LS75	50	74LS258	68
74LS76	35	74LS265	25
74LS85	75	74LS279	50
74LS86	35	74LS290	60
74LS90	50	74LS293	58
74LS92	50	74LS365	49
74LS93	50	74LS366	49
74LS109	35	74LS368	49
74LS112	35	74LS375	60
74LS113	35	74LS386	35
74LS114	35	74LS390	1 45
74LS125	45	74LS670	2 00
74LS126	45	81LS97	1 15
		81LS98	1 15

LINEAR CIRCUITS

LM 101	75
LM 301/748	25
LM307	30
LM 308	75
LM 311	75
LM 318	1.20
LM 324	70
LM 339	1.10
LM 358	70
LM 370	1 15
LM 377	1 60
LM 380	.95
LM 382	1.25
LM386	80
LM 387	1 75
LM 537	2.50
LM 553	2.50
LM 555	.39
LM 556	85
NE540L	2.25
560	2 00
565	95
566	1.20
567	1.10
703	90
7331l	75
592H	95
709	25
710	.35
741C or V	25
747	.50
LM 1310	2 50
1456	95
1458	50
3900	.40
8038CC	3 90
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LF356H	1.20

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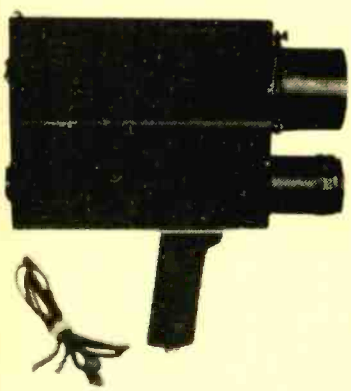

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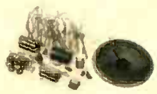

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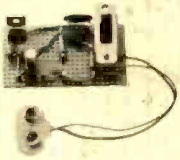

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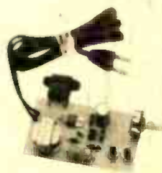

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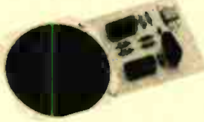

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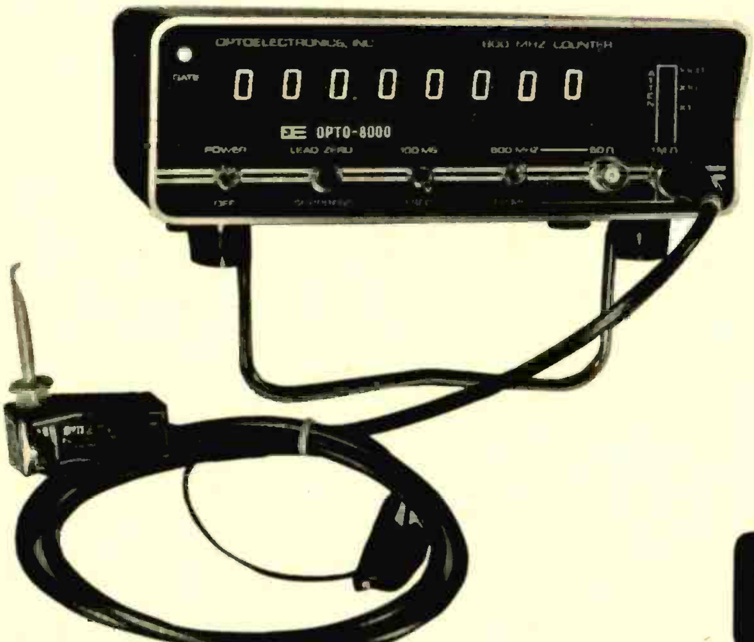

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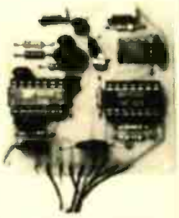
MODEM *



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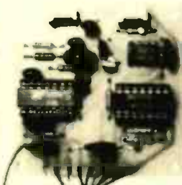
TAPE INTERFACE *



Part no. 111
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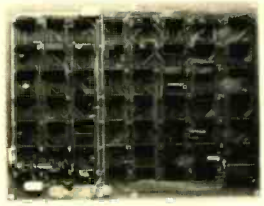

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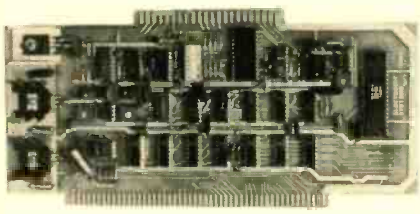

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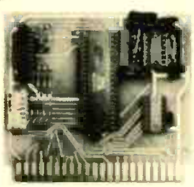

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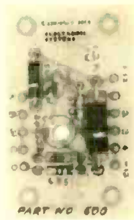

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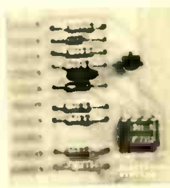

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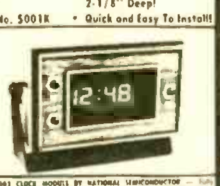

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2N4124	.22	1.83	16.45	146.00
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2N4401	.21	1.80	16.00	140.00
2N4403	.21	1.80	16.00	140.00
2N4410	.24	2.00	18.00	160.00
2N5087	.24	2.00	18.00	160.00
2N5089	.24	2.00	18.00	160.00
2N5210	.27	2.25	20.25	180.00
MPF102	.54	4.50	40.50	360.00
2N5457	.51	4.25	38.25	340.00
MPSA13	.27	2.25	20.25	180.00
MJ2955	1.47	12.25	110.25	980.00
TIP120	1.17	9.75	87.75	780.00

5% CARBON FILM RESISTORS

¼ WATT RESISTOR ASSORTMENTS

Catalog number	Description	PRICE
RS125	Set of 5 each of the 73 standard 5% ¼ watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 megohm (365 total pcs.)	$9.90
RS225	Set of 5 each of the 72 standard 5% ¼ watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through 910 kilohm (360 total pcs.)	$9.90

½ WATT RESISTORS ASSORTMENTS

Catalog Number	Description	PRICE
RS150	Set of 5 each of the 73 standard 5% ½ watt carbon film resistors in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc., through 1.0 megohm (365 total pcs.)	$9.90
RS250	Set of 5 each of the 72 standard 5% ½ watt carbon film resistors in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc., through [illegible]	$9.90

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STRIPS — WRAPS — UNWRAPS

PANAVISE — Call or Write for the Digi-Key Catalog for Panavise Details

NEW! THE MA1023 by NATIONAL SEMICONDUCTOR

THE "PROGRAMMABLE" CLOCK MODULE

0.7" HIGH DIGITS — RED LED DISPLAY

The MA1023 Clock Module offers a degree of flexibility not available in conventional clock modules. This has been accomplished by manufacturing into each MA1023 Module a set of options over which you, the user, has total control. In a very real sense, this control allows you to program the MA1023 to fit your specific application.

It is the MA1023 user that determines whether his module will operate in a 12 or 24 hour mode. It is the user that selects his preference for a fixed or flashing colon. And, by the simple introduction of a potentiometer, the user gains continuous control over the module display brightness.

But probably the ultimate feature offered by the MA1023 Module is the unique back-up oscillator option that allows for continuous time keeping during power failures with a single 9 volt battery and an external 5M potentiometer. This means that when other clocks grind to a halt, the MA1023 runs on.

And if an alarm is your delight, the MA1023 makes it easy. Simply connect the buzzer to the alarm circuit and you're ready to go. Finally, an alarm circuit that calls for no complex intervening circuitry. The large 0.7" red led display, low power consumption, leading zero blanking and many other excellent features are offered at this remarkably low cost.

After reading through the features, we are confident that you will agree that there is no question that the MA1023 "Programmable" clock module is truly unique.

And to enhance the MA1023 kit even more, Digi-Key is introducing a specially designed switching panel kit complete with standoffs and hardware for "sandwich mounting" with the MA1023 module. But if your preference or needs dictate remote mounting of the switching panel — no problem. You will still enjoy the straight forward one to one pin connection offered by the Digi-Key switching panel kit and MA1023 module. Furthermore, the printed circuit board that provides the basis for the switching panel incorporates circuitry that will speed and simplify completion of the project. In addition to the simplicity offered by the Digi-Key switching panel, the low profile, light touch panasonic switches utilized will add quality and professionalism to your finished product. Order your MA1023 "Programmable" clock module and specially designed Digi-Key switching panel today.

DIGI-KEY SWITCHING PANEL KIT MA1023P

(Shown assembled and "sandwich mounted" to MA1023 Clock Module)

Catalog	Description	COST
MA1023M	MA1023 Clock Module Only (Assembled and tested)	$9.95
MA1023P	Digi-Key Switching Panel Kit for MA1023 (Includes P.C. Board, Switches, Wrappers, Standoffs, Hardware, Components)	6.95
MA1023T	Special Transformer for MA1023	2.95
MA1023B	Alarm Buzzer for MA1023	2.25
MA1023K	Includes MA1023M, P, T, & B	19.95
MA1023C	Conventional switch set for applications where MA1023P [illegible] 501PB and [illegible] 502PB	[illegible]

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Y4	30 AWG Yellow Wire 4" Overall Length	1.07
W4	30 AWG White Wire 4" Overall Length	1.07
R4	30 AWG Red Wire 4" Overall Length	1.07
B5	30 AWG Blue Wire 5" Overall Length	1.16
Y5	30 AWG Yellow Wire 5" Overall Length	1.16
W5	30 AWG White Wire 5" Overall Length	1.16
R5	30 AWG Red Wire 5" Overall Length	1.16
B6	30 AWG Blue Wire 6" Overall Length	1.23
Y6	30 AWG Yellow Wire 6" Overall Length	1.23
W6	30 AWG White Wire 6" Overall Length	1.23
R6	30 AWG Red Wire 6" Overall Length	1.23
B7	30 AWG Blue Wire 7" Overall Length	1.30
Y7	30 AWG Yellow Wire 7" Overall Length	1.30
W7	30 AWG White Wire 7" Overall Length	1.30
R7	30 AWG Red Wire 7" Overall Length	1.30
B8	30 AWG Blue Wire 8" Overall Length	1.38
Y8	30 AWG Yellow Wire 8" Overall Length	1.38
W8	30 AWG White Wire 8" Overall Length	1.38
R8	30 AWG Red Wire 8" Overall Length	1.38

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The NIBBLER is Digi-Key's new low cost personal/hobby computer. Based on National Semiconductor's SC/MP-II microprocessor, the NIBBLER includes 4K NIBL Basic in ROM and 2K of RAM. The NIBBLER requires 5 volts at ½ amp providing 110 baud serial ASCII I/O which is easily interfaced with a CRT or Teletype. And our low price of $149.95 is for an assembled and tested system! Software/Hardware manual included with NIBBLER or available separately for $5.00.

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- It Speaks Basic Beautifully
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THE "NIBBLER" POWER SUPPLY	PS11-ND	39.95
22/44 PIN EDGE CONNECTOR	3776PS-ND	2.50

DATA BOOKS

TTL DATA BOOK, 592 P, NAT. SEMI	9010B	$4.00
LINEAR DATA BOOK, 1978, 981 P	9027B	$5.00
CMOS DATA BK, 77 EDIT, 555 P, NAT. SEMI	9012B	$3.00
POWER TRANSISTORS, 151 P, NAT. SEMI	9014B	$3.00
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[illegible]

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250 VDC plus/minus 10% TOLERANCE

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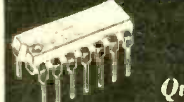

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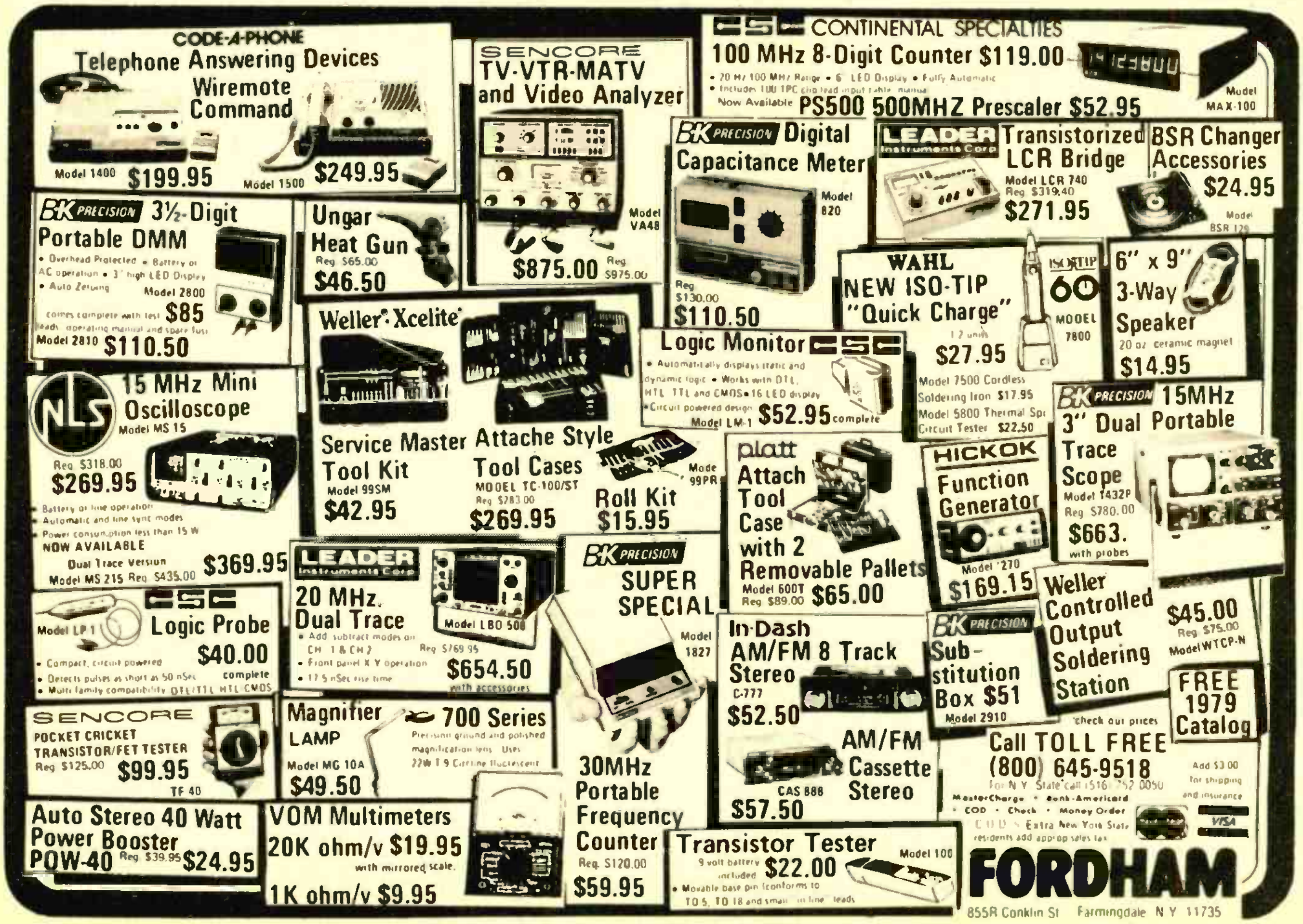

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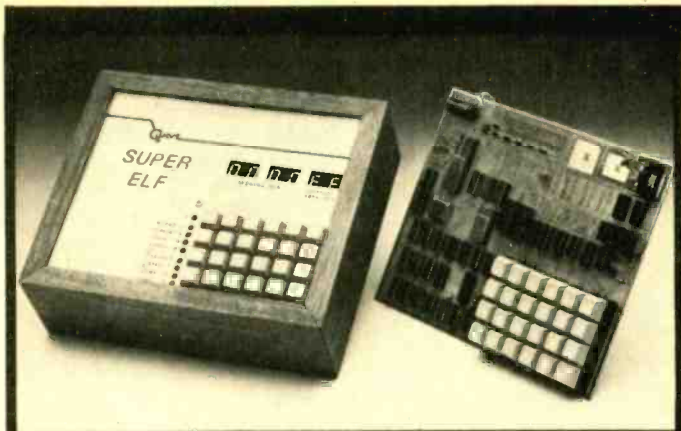

QUEST Cosmac Super Elf Computer $106.95

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

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

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

A 24 key **HEX keyboard** includes 16 HEX keys plus **load, reset, run, input, memory protect, memory select, monitor select** and **single step.** Large, on board displays provide output and optional **high and low address.** There is a 44 pin standard connector for PC cards and a 50 pin connector for the **Quest Super Expansion Board.** Power supply and sockets for **all** IC's are included in the price plus a detailed 90 page instruction manual.

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

Remember, other computers only offer Super Elf features at additional cost or not at all. **Compare before you buy. Super Elf Kit $106.95, High address option $8.95, Low address option $9.95. Custom Hardwood Cabinet** with drilled and labelled front panel **$24.95. NiCad Battery Backup Kit $4.95.** All kits and options also come completely assembled and tested.

Questdata, a 12 page monthly software publication for 1802 computer users is available by subscription for $12.00 per year. New 100 page software manual Vol.1 $4.95.

Tiny Basic for ANY 1802 System

Cassette $10.00. On ROM Monitor $38.00. Super Elf owners, 30% off. **Object code listing or paper tape with manual $5.50. Original ELF Kit Board $14.95.**

Super Expansion Board with Cassette Interface $89.95

This is truly an astounding value! This board has been designed to allow you to decide how you want it optioned. **The Super Expansion Board comes with 4K of low power RAM** fully addressable anywhere in 64K with built-in memory protect and a **cassette interface.** Provisions have been made for all other options on the same board and it fits neatly into the hardwood cabinet alongside the **Super Elf.** The board includes slots for up to 6K of **EPROM** (2708, 2758, 2716 or TI 2716) and is **fully socketed** ($12.00 value). EPROM can be used for the monitor and Tiny Basic or other purposes.

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

Other on board options include **Parallel Input and Output Ports with full handshake.** They allow easy connection of an ASCII keyboard to the input port. **RS 232 and 20 ma Current Loop** for teletype or other device are on board and if you need more memory there are two **S-100** slots for static RAM or video boards. A Godbout 8K RAM board is available for $135.00. **Parallel I/O Ports $9.85, RS 232 $4.50, TTY 20 ma I/F $1.95, S-100 $4.50. A 50 pin connector set** with ribbon cable is available at $12.50 for easy connection between the **Super Elf** and the **Super Expansion Board.**

The **Power Supply** for the Super Expansion Board is a 5 amp supply with + 8v ± 18v + 12v − 5v. Regulated voltages are ±5v & +12v $29.95. −12 volt optional. Deluxe version includes the case at $39.95.

INTEGRATED CIRCUITS

7400TTL	
7400N	17
7402N	17
7404N	.19
7409N	23
7410N	.17
7414N	63
7420N	.17
7422N	1 39
7430N	.20
7442N	.50
7445N	.69
7447N	.60
7448N	.69
7450N	17
7474N	29
7475N	.49
7485N	88
7489N	2 00
7490N	.43
7492N	.43
7493N	.43
7495N	69
74100N	90
74107N	29
74121N	34
74123N	.59
74125N	39
74145N	.69
74150N	.95
74151N	69
74154N	1.00
74157N	.69
74161N	.87
74162N	.87
74163N	.87
74174N	.96
74175N	.90
74190N	1.15
74192N	.87
74193N	.85
74221N	1.55
74298N	1 65
74365N	66
74366N	66
74367N	66

74LS00 TTL	
74LS00N	.25
74LS02N	25
74LS04N	.25
74LS05N	.25
74LS08N	.25
74LS10N	.25
74LS13N	.40
74LS14N	90
74LS20N	25
74LS22N	.25
74LS28N	.41
74LS30N	.25
74LS33N	39
74LS38N	30
74LS74N	.35
74LS75N	.47
74LS90N	.51
74LS93N	.51
74LS95N	1.89
74LS107N	.35
74LS112N	35
74LS113N	.35
74LS132N	72
74LS136N	35
74LS151N	.67
74LS155N	.67
74LS157N	.67
74LS162N	.91
74LS183N	.91
74LS174N	.95
74LS190N	1.06
74LS221N	1 95
74LS258N	.67
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LM309H	1.15
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LM323K-5	6.95
LM320K-12	1.35
LM320K-15	1.35
LM320T-5	1.60
LM320T-8	1 60
LM320T-12	1 50
LM320T-15	1.60
LM324N	1.15
LM339N	1.55
LM340K-5	1.10
LM340K-8	1.10
LM340K-12	1.10
LM340K-15	1.10
LM340K-24	1.10
LM340T-5	1.10
LM340T-8	1.10
LM340T-12	1.10
LM340T-15	1.10
LM340T-18	1.10
LM340T-24	1.10
LM343H	4.50
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LM377	4.50
LM379	5.00
LM380N	1.00
LM381	1 60
LM382	1 60
LM703H	.40
LM709H	.28
LM723H/N	.50
LM733N	.67
LM741CH	.35
LM741N	.25
LM747H/N	.62
LM748N	.35
LM1303N	.82
LM1304	1.10
LM1305	1.27
LM1307	2.00
LM1310	2.75
LM1458	.47
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LM3905	1.75
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NE570B	5.00
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CD4001	.21
CD4002	.21
CD4006	1.10
CD4007	.21
CD4008	.21
CD4009	.39
CD4010	.39
CD4011	.21
CD4012	.21
CD4013	36
CD4014	.86
CD4015	86
CD4016	36
CD4017	.94
CD4018	94
CD4019	.21
CD4020	1.02
CD4021	1.02
CD4022	.86
CD4023	.21
CD4024	.75
CD4025	.21
CD4026	1.51
CD4027	.36
CD4028	.79
CD4029	1.02
CD4030	.21
CD4035	1.02
CD4040	1.02
CD4042	.71
CD4043	63
CD4044	.63
CD4046	1.67
CD4049	.36
CD4050	36
CD4051	1.13
CD4060	1.42
CD4066	71
CD4068	.40
CD4069	.40
CD4070	.40
CD4071	.21
CD4072	.21
CD4073	.21
CD4075	.21
CD4076	1.75
CD4078	.40
CD4081	.21
CD4082	21
CD4116	.47
CD4490	5.50
CD4507	1 00
CD4508	4.25
CD4510	1.02
CD4511	.94
CD4515	2.52
CD4516	1.10
CD4518	1.02
CD4520	1.02
CD4527	1.51
CD4528	.79
CD4553	5.75
CD4566	2.25
CD4583	4.50
CD4585	1.10
CD40192	3.00
74C00	.28
74C04	33
74C10	.28
74C14	2 10
74C20	.28
74C30	.28
74C48	1 95
74C74	.75
74C76	1.40
74C90	1.15
74C93	1.40
74C154	3.00
74C160	1.44
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74C192	1.65
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74C923	5.50
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74C926	6 95
74C927	6.95

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8T23	3.10
8T24	3.50
8T25	3.20
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MM5262	.40
MM5280	3.00
MM5320	9.95
MM5330	5.94
PD411D-3	4.00
PD411D-4	5 00
P5101L	13.95
4200A	9.95
82S25	2.90
91L02A	1.75
HD0165-5	6.95
MM57100	4.50
GIAY38500-1	9.95
MCM6571A	9 95
9368	3.50
4100	10.00
416	16 00

CLOCKS	
MM5309	3 00
MM5311	3.60
MM5312	4.80
MM5313	3.60
MM5314	3 90
MM5315	4 00
MM5316	5.00
MM5318	3 60
MM5369	2.10
MM5841	14.45
MM5865	7.95
CT7001	5.80
CT7002	8.95
CT7010	8.95
CT7015	7.25
MM5375AA/N	3.90
MM5375AB/N	4 90
7205	16.50
7207	7.50
7208	15.95
7209	4.95
DS0026CN	3.75
DS0056CN	3.75
MM53104	2.50

MICROPROCESSOR	
6800	17 50
6802	24.95
8080A with data	8.95
8085	27.00
Z80A	24.50
8212	2 90
8214	8 00
8216	2 90
8224	2 90
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8251	8 50
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8255	9.25
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8259	19.50
CDP1802CD	19.95
CDP1802D	25.00
CDP1861	12.95
6820	9.95
6850	12.95
6502	12.50

IC SOCKETS

Solder Tin Low Profile

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

3 level wire wrap gold
14 pin 25 16 pin 27
2 level 14 pin ww 20

WIRE WRAP LEVEL 3

PIN		PIN	
14	25	24	.86
16	.27	28	1.00
18	.57	40	1.23

UART/FIFO	
AY5-1013	5 50
AY5-1014	7.50
3341	6.95

PROM	
1702A	3.95
N82S23	2 95
N82S123	3 50
N82S126	3.75
N82S129	3.75
N82S131	3.75
N82S136	8.75
N82S137	8 75
2708	10.50
DM8577	2.90
8223	2.90
2716TI	22.50
2716 Intel	48 00

CRYSTALS	
1 MHz	4.50
2 MHz	4.50
4 MHz	4.25
5 MHz	4.25
10 MHz	4.25
18 MHz	3 90
20 MHz	3 90
32 MHz	3 90
32768 MHz	4.00
1 8432 MHz	4.50
3 5795 MHz	1 20
2 0100 MHz	1.95
2 097152 MHz	4 50
2.4576 MHz	4.50
3 2768 MHz	4.50
5 0688 MHz	4 50
5 185 MHz	4.50
5.7143 MHz	4.50
6.5536 MHz	4.50
14.31818 MHz	4.25
18.432 MHz	4.50
22.1184 MHz	4.50

CONNECTORS	
44 pin edge	2.00
100 pin edge	4.50
100 pin edge WW	4.50

KEYBOARD ENCODERS	
AY5-2376	$12.50
AY5-3600	13 50
74C922	5.50
74C923	5.50
HD0165-5	6 95

IC Test Clips

	1	10
Red	55	.47
Black	.55	.47

Keyer 8043 14.50
comp. w/spec./sock

TRANSISTORS	
2N1893	.40
2N2222A	.18
2N2369	.30
2N2904A	20
2N2907A	.25
2N3053	.40
2N3638	.25
2N3643	25
2N3904	18
2N3906	18
2N3055	.69
2N4400	25
2N4401	.75
2N4402	20
TIP31	.60
TIP33A	1.00

CLOCK MODULES Complete alarm clocks ready to hook up with transformer and switches. Very compact with .50" and .84" digits.

MA1002A, C or E .50"	8.95
102P3 Transformer	2.25
MA1010A, C or E .84"	11.95
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Special transformer and six switches when purchased w/module	2.95
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RESISTORS ¼ watt 5%
10 per type .03 1000 per type .012
25 per type .025 350 piece pack
100 per type .015 5 per type 6.75

KEYBOARDS	
56 key ASCII keyboard kit	$62.50
Fully assembled	72.50
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Green, Orange, Yellow TO18	20
Jumbo Red	20
Green, Orange, Yellow Jumbo	.25
Clipite LED Mounting Clips	8/$1.25

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Model 150 Bus Grabber Kit	$369.00

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12V CT 250 ma wall plug	3.50
24V CT 400 ma	3.95
10V 1.2 amp wall plug	4.85
12V 6 amp	12.95

DISPLAY LEDS			
MAN1	CA	.270	2.90
MAN3	CC	.125	.39
MAN72/74	CA/CA	.300	1.00
DL704	CC	.300	1.25
DL707/DL707R	CA	.300	1 00
DL727/728	CA/CC	500	1 90
DL747/750	CA/CC	600	1.95
DL750	CC	.600	1.95
FND359	CC	.357	.70
FND500/507	CC/CA	500	1.35
FND503/510	CC/CA	500	.90
FND800/807	CC/CA	.800	2.20
3 digit Bubble			.60
4 digit bubble			.80
DG8 Fluorescent			1.75
DG10 Fluorescent			1.75
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7520 Clairex photocells			.39
TIL311 Hex			9 50

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1600	mfd	200V	4.50
2000	mfd	45V	2.50
3200		50V	2 50
5500		25V	2.50
5800		40V	3.00
6100		40V	3.00
6100		50V	3.00
7700		50V	2.50
8000		55V	2.50
9400		65V	3 00
10000		20V	2 50
12000		30V	3.50
35000		25V	5.00
55000		25V	5 00
82000		15V	6 00
160000		10V	6 00

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DC clock with 4-.50" displays. Uses National MA-1012 module with alarm option. Includes light dimmer, crystal timebase PC boards. Fully regulated, comp. instructs. Add $3.95 for beautiful dark gray case. Best value anywhere.

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