THIS MONTH 156 Pages

S100 COMPUTER BOARDS—WHO MAKES WHAT

$1.00 ■ APRIL 1978

Radio-Electronics®

34140

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

pendulums, chimes, displays
UNUSUAL CLOCKS
for your wall and shelf

build for your car
DIGITAL TACHOMETER
with LED display

all about the
S100 BUS
and your microcomputer

for the hobbyist
MODIFY HARDWARE
to suit your needs

how to select a
NEW DMM
more for your money

Video-Tape Recorder Update
New RIAA Equalization Curves
Two Hi-Fi Lab Test Reports
Z-80 Computer Corner
Hobby Corner
State-Of-Solid-State
Service Clinic
XR-2208 Application Note

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A GERNSBACK PUBLICATION

THE SUPERLATIVE SONY.

THE NEW TC-766-2 HAS THE LOWEST WOW AND FLUTTER OF ANY DECK SONY EVER BUILT.

TC-766-2

AN INCREDIBLE 0.018% (WRMS) AT 15 IPS, AND 0.04% (WRMS) AT 7½ IPS. Closed Loop Dual Capstan Tape Drive System. One capstan extends from the motor shaft itself, eliminating intervening gears that can hamper speed accuracy. The other tape drive capstan connects through an extremely steady belt-drive inertia flywheel.

PHASE COMPENSATOR CIRCUIT. The goal of any recording is a "mirror image" of the original signal. Sony's exclusive Phase Compensator Circuit comes closest to achieving this by rectifying phase distortion and producing sound quality virtually identical to the original source.

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SYMPHASE RECORDING. Because of Sony's outstanding **Ferrite & Ferrite Heads,** plus the remarkably precise fabrication and alignment of the head gap, recordings retain exact positioning of signal throughout the stereo field. The "location" of individual sounds won't wander. There's no annoying phase shift.

MORE PROFESSIONAL FEATURES. The TC-766-2 has **4 incredibly durable Ferrite & Ferrite heads** for 2-track recording and playback, 4-track playback and erase, **direct-coupled playback FET amplifier,** flashing **Standby Signal, Punch-In Record** and solenoid-operated **Logic-Controlled Transport Functions** to let you move instantly to and from any mode without stopping. Standard equipment: RM-30 full-function remote control unit with record mute and hinged head cover.

SONY® Brought to you by **SUPERSCOPE**

HATS OFF TO IBM

Printer Break-through

A new 10-digit display calculator with the world's first dual-element integrated printing head will revolutionize the printing calculator.

The full-featured $89.95 Canon P10-D with its one-year parts and labor limited warranty Is the greatest printer value ever offered by JS&A.

Hats off to IBM. Their single-element typing system did away with typewriter keys and started a new technology.

The new Canon P10-D printing calculator starts another new technology. Their dual-element printing system does away with the standard printing head which required a separate disc for each column. The Canon has only two discs–one with digits and the other with symbols.

The P10-D head weighs only ½ ounce compared to 31 ounces in a typical printing head. Its motor weighs only nine ounces–again much less than the heavier conventional motors required to drive larger heads. The Canon motor is smaller, lighter and more efficient because it moves less weight.

THE MOST EFFICIENT SYSTEM

The printing head is controlled by an LSI (large scale integrated circuit). As you press a key, a pulse is generated from this circuit and sent to the motor which does two things: 1) positions the two discs to print the numbers or symbols and 2) glides the numeric disc across the ten column width of the paper.

Conventional printers print from metal discs through thick fabric ribbon onto paper. The Canon system prints directly on paper so each impression is sharp, clear and easy to read. The synthetic polymer disc is first inked by a special cartridge before it prints. Each ink cartridge is easily replaceable. The cartridge lasts for more than 15 rolls of paper at a cost of 17¢ per roll–far less than any other system.

PLAIN PAPER PLUS

Using standard paper tape is only one of several advantages that make the Canon a truly spectacular value. Here are some other exciting new features:

Dual Power Operate the Canon from either your AC outlet or its built-in rechargeable batteries. It's totally portable, yet it also makes a handsome desk calculator.

Dual Display Just flip a switch and the 10-digit large green fluorescent display can be used with or without the printer.

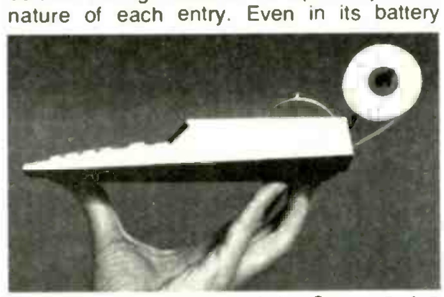
Space-Age Styling Compare the sleek appearance of the Canon with any other printer. It's small enough to fit in your briefcase and large enough to use as a space-saving desk unit. It measures only 1¾" x 4¼" x 8½", weighs only 24 ounces and the paper tucks into the body of the unit–perfect for travel.

Buffered Keyboard If you enter your problems faster than the printer can print them out, don't worry. The unit's memory stores your keystrokes and prints them out in rapid succession.

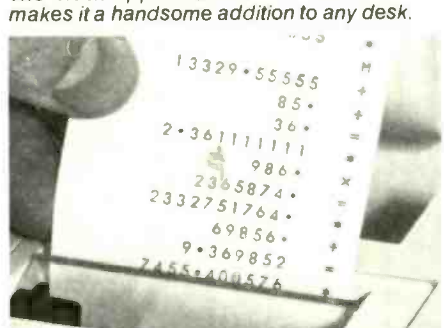
We have always looked at small printers as gimmicks–calculators that lack many important features. We were surprised with the Canon. It has features that far exceed most printers costing hundreds of dollars more.

The following is a list of those features: 10 digit capacity • full four-key memory • addition, subtraction, multiplication and division • percentage key • add-on and discount calculations • power and reciprocal calculations • repeat calculations • add-mode • switch for full-floating or second and third fixed decimal positions • round off or round down switch • paper tape advance.

There are other convenient features that make it perfect for people who spend hours at their calculators. There's a three-digit item counter that counts and prints out the number of entries while printing your total. The symbols on the right side of the tape tell you the nature of each entry. Even in its battery operated position, you could print out more than half a roll of tape before the unit signals you that its batteries are low.



The sleek appearance of the Canon P10-D makes it a handsome addition to any desk.



The direct-impression dual discs print cleaner and sharper on conventional paper tape.

A NEW WAY TO BUY

JS&A offers you a new way to buy your 10-digit Canon P10-D. First we give you the opportunity to use one for 30 days. Carry it in your briefcase. Put it on your desk and see how handy it becomes and how little space it takes up. Check the paper tape and see how clear and easy-to-read it is. Bring it home and let the whole family use it.

Then, within 30 days, decide. If the Canon is not perfect for you, return it for a prompt and courteous refund. And if you do return it, not only will we still consider you one of our good customers, but we will also refund your $2.50 postage, let you keep the paper tape, and thank you for giving us the opportunity of showing it to you. We couldn't be more positive about the quality and value of this incredible new product.

JS&A is America's largest single source of space-age products. We have been in business for over a decade–further assurance that your modest investment is well protected. Canon is one of the world's largest manufacturers of cameras and precision quality instruments and is highly respected as a quality manufacturer of electronic products.

The Canon costs only **$89.95** plus $2.50 for postage and handling and includes a free roll of tape, one ink cartridge, rechargeable batteries and a power cord/charger. It's an incredible value thanks to its new technology. To order, send your check to the address below (Illinois residents add 5% sales tax) or credit card buyers may call our toll-free number.

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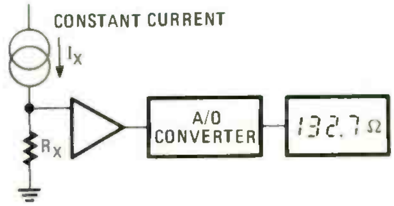
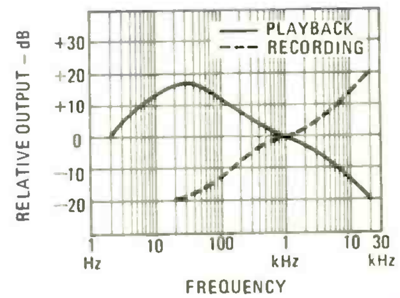
APRIL 1978 Vol. 49 No. 4

ON THE COVER

Ever see electronic clocks with digital readouts equipped with pendulums and tick-tock sound and chimes? We did! And here's a story on how they operate. It's an exploration into interesting circuitry you may not have seen before. The story starts on page 40.



OHMS CONVERTER IS A VITAL section of a digital multimeter. It's only one of many items to be considered when selecting a unit. For full selection data turn to page 63.



NEW RIAA EQUALIZATION CURVES. Note the rolloff in playback response in the low-frequency region. For full details turn to page 52.

Radio-Electronics, Published monthly by Gernsback Publications, Inc., 200 Park Avenue South, New York, NY 10003. Phone: 212-777-6400. Second-class postage paid at New York, NY and additional mailing offices. One-year subscription rate: U.S.A. and U.S. possessions, $9.98, Canada, $12.98. Other countries, $14.98. Single copies $1.00.

Subscription Service: Mail all subscription orders, changes, correspondence and Postmaster Notices of undelivered copies (Form 3579) to Radio-Electronics Subscription Service, Box 2520, Boulder, CO 80322.

looking ahead

Hi-fi TV: Or perhaps I should say higher-fi TV. Anyway, it's good news for people who are always complaining about television sound. The American Telephone & Telegraph Company announced it has converted its entire intercity network-television relay system to an audio bandwidth of 15,000 kHz from the former AM-type bandwidth of 5,000 kHz. AT&T did this by diplexing the audio signal within the television signal, eliminating the former practice of separating television picture from audio and carrying the latter on a standard telephone line. The diplex operation, in addition to producing better sound, is expected to save television networks considerable money by eliminating the need for extra audio lines for TV sound.

Late this year, the AT&T says it will be able to offer stereo sound. Whether it does so or not presumably will depend upon the outcome of an FCC proceeding on stereo sound for TV. Interestingly, the Public Broadcasting System was one of the prime movers originally in working with the AT&T through industry committees on improved TV sound—but it won't share in the new development. PBS will be doing its networking via space satellite, which already provides full 15-kHz sound bandwidth.

CCD color camera: The first complete solid-state tubeless color camera to be demonstrated and announced for production has been developed by RCA Electro-Optics & Devices. The camera uses three tiny silicon charge-coupled devices smaller than a postage stamp with a matrix of 512 × 320 elements, for a total of 163,840 elements. RCA claims it provides sensitivity and other characteristics comparable to those of a high-quality silicon vidicon camera. RCA said it would begin taking commercial orders for the camera in 1979. Initially, it will be offered as an industrial-institutional closed-circuit camera, but eventually it will be offered as a consumer-product accessory for home video recorders. The camera demonstrated weighed 3.6 pounds and measured 4 × 5 × 6 inches, about the same size as its accessory zoom lens. Many companies have been developing CCD cameras, including Bell Telephone Laboratories, Fairchild Camera, General Electric, Eastman Kodak, Nippon Electric, Matsushita (Panasonic) and Sony, and you can expect many more announcements in the near future.

Longer-play videodisc: There's furious competition—at least in the press releases—among the various videodisc systems before the first player hits the market, and this competition recently has centered on playing time. First, RCA announced it had doubled the playing time of its capacitance disc to two hours. Then Matsushita announced in Japan a mechanical disc system which will play for two hours. Now, Philips and MCA Inc., sponsors of the optical system, have announced that they have developed a method to quadruple the playing time of their disc from the original 30 minutes to two hours. The original single-sided disc now has become a two-sided record. But to double the playing time per side, Philips and MCA use a principle which they call "variable angular velocity."

The original optical videodisc spun at a constant 1,800 rpm (for the American television system), storing a single TV frame per revolution. The new longer-play disc varies in playing time depending on the position of the stylus at any given time—so that the speed of the track being played is constant in relation to the laser-beam pickup. The disc, which plays from the inside out, starts at 1,800 RPM, but steadily decreases in speed until it's playing at about 600 RPM by the time the beam reaches the outside track at the end of the selection. Philips says its players will be able to accommodate both the variable-velocity discs and standard 1,800-RPM discs. The former will be known as continuous-play records and designed for such long programs as movies. Because the speed of turntable rotation isn't synchronous with the frame rate, these LP discs will lack some of the specific advantages of the optical system, such as freeze-frame, continually variable forwards and backwards motion, and precise location of a specific frame.

New video products: As the home TV set begins its metamorphosis from a single-purpose appliance to the multi-use home video center, new video products now are coming along rapidly. Projection TV, which in the past has generally been an area left to non-brandname assemblers, is now gaining adherents among major-brand manufacturers. Panasonic and Quasar, both subsidiaries of Matsushita, the world's largest TV maker, plan to market extremely bright and clear single-piece folding three-tube projection sets later this year. Mitsubishi will have a two-piece unit, strongly resembling Advent's projector, with shipments scheduled to start this spring. All three of these are expected to be quite high-priced. At the same time, a nationwide chain of retail stores specializing in projection TV is being formed, starting in California and moving east. It will offer the Projecto-Beam, which is like many other projectors using a single cathode-ray tube as a light source—except that it will be priced at $750, in other words, about the same as a 25-inch color console—and the company's officials think this price break will be what propels giant-screen TV into the bigtime.

With the development of ultra-long-playing home video recorders (a six-hour cassette could come this year), the standard on-off VTR timer is no longer enough. Matsushita has developed an accessory programmer which will turn the recorder on and off and change channels, and is capable of being programmed for an entire week. Another such programmer, this one built into a television set, has been demonstrated by Sharp.

A few television sets, principally those made by GE, automatically adjust themselves to the vertical interval reference (VIR) used by broadcasters to keep color consistent. The GE circuit, which is discrete, uses 180 components and requires adjustment. Now Panasonic has announced development of VIR circuitry on an IC that is being offered to all TV set makers, and this could spread the idea of automatic VIR adjustment.

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

CRT display terminals contribute to eye problems

Add "computer fatigue" to the list of eye complaints some observers feel are becoming more prevalent here and abroad as a result of the increased use of computer display terminals.

Dr. Jeryl Sparks, a Dallas, TX, optometrist, has a number of patients who work at local electronics firms. Even while conceding that soreness and swelling and blurred vision can result from any close-work situation, on-site observations at the firms in question have led him to the conclusion that CRT terminals are the main culprits.

Dot-matrix printouts are particularly hard on the eyes; they require a continual focusing adjustment. A better choice of printout would be light-(illuminated) characters on a dark screen. Other factors contributing to eye problems are glare and the lack of contrast between normal room brightness and the brightness of the screens.

Although these and similar observations are by no means conclusive and opinions vary among eye experts as to the validity of the diagnosis, some commonsense precautions can be taken to guard against potential hazards caused by CRT displays: look up from the work occasionally, take more breaks and blink—full blinking allows oxygen to reach the eyes, thus reducing swelling and soreness.

Cosmic rays believed to cause lightning zigzags

For some time, scientists have questioned the possible link between cosmic radiation and certain kinds of lightning behavior. At a recent meeting of the American Geophysical Union in San Francisco, Dr. James W. Follin of the Applied Physics Laboratory of Johns Hopkins University, presented a paper that bears out the conclusion that without cosmic rays there would be no lightning at all, since there is not enough electrical potential in a thundercloud to generate it.

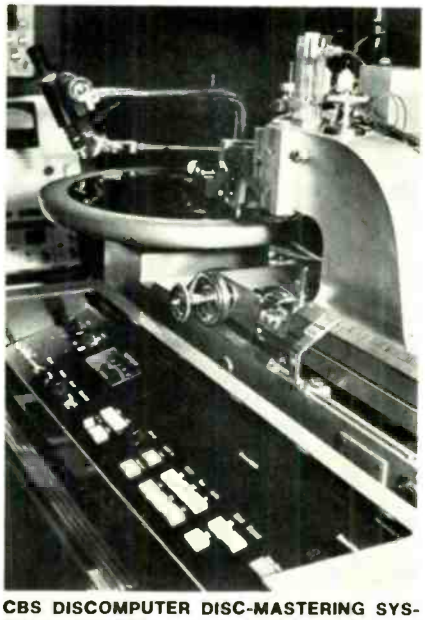
Dr. Bernard Vonnegut, an authority on atmospheric electricity, and other scientists have theorized that the connection between cosmic radiation and lightning could be one of the ways in which sunspots affect the earth's weather. Cosmic rays are composed of highly charged particles, chiefly protons, that are released by the sun and travel at almost the speed of light. When there are many sunspots, the magnetic fields released from the sun's surface protect the earth from the majority of the cosmic rays; but the sun simultaneously increases its output of similar radiation at much lower energy levels.

Those cosmic rays with very high energy, when they strike the upper atmosphere, create cascades of atomic fragments that are then released into our atmosphere as a "cosmic shower." This shower, when it connects with a thunderhead, knocks free electrons from nitrogen and oxygen atoms in the process known as ionization. The electrical charge already present in the cloud is sufficient to accelerate the released nitrogen and oxygen electrons to create a lightning stroke, known as a "step leader." This stroke then travels the path of least resistance to earth, following a series of steps, through segments of air ionized by secondary atomic ray atoms known as muons. Approximately 50 yards from the ground, an electrical discharge jumps up to join the leader stroke, creating a zigzag pattern. The circuit is complete and the return stroke follows the same zigzag path to the sky. This is the first lightning stroke one observes during a storm; the other strokes follow in such quick succession they appear as one.

Computer-operated disc-mastering system improves LP quality

A new disc-mastering system developed by CBS Records called *DISComputer* uses computer technology to improve both the sound and running time of LP records. The system cuts down on distortion and mistracking and contributes significantly to improving the signal-to-noise ratio. The records cut by the new system are also actually louder—by some 2-dB to 5-dB—than those cut by conventional methods.

The computer directs the lathe (with the stylus) to cut grooves according to prerecorded tape sounds and automatically adjusts the size of the groove to accomodate as much sound as possible. It also controls each groove's relationship to the adjacent grooves by providing the correct amount of space. And because more grooves can be fitted into the same space, the record side can be extended up to five minutes longer in some instances.

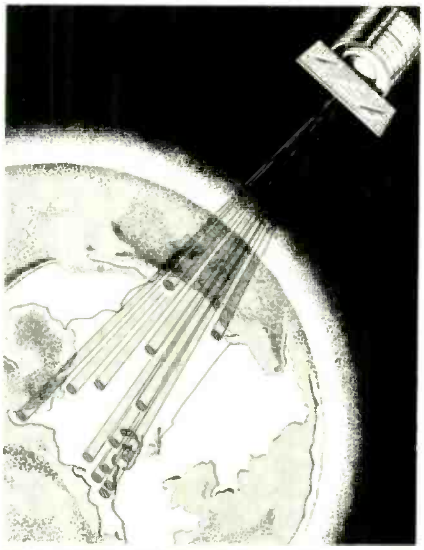


CBS DISCOMPUTER DISC-MASTERING SYSTEM combines computer technology with conventional lathe to cut LP's with improved sound quality and longer playing levels.

The system cost CBS more than $500,000 to develop, and it is at present estimated at $250,000 per unit. The *DIS-Computer* mastering systems are currently being used at CBS studios in New York, Nashville, and in some studios abroad.

Bell microwave-beam technique could increase satellite capacity

Researchers at Bell Laboratories have advanced a totally new concept in satellite telecommunications that is expected to more than double the satellites' present transmission capacity. The scanning/spot beam technique uses narrow microwave beams that are broken into pulses lasting only minute fractions of a second to sweep the U.S. in much the same way as an electron beam sweeps a TV screen. Some fixed beams would be reserved for more densely populated urban areas.



BELL LABS' SCANNING/SPOT BEAM CONCEPT uses about a dozen fixed beams and a narrow, focused microwave beam that would sweep across the U.S., thus increasing satellites' transmission capacity.

The smaller beam size would raise the transmission capacity of each satellite from 15,000 to 50,000 phone calls. This substantial increase in the number of transmissions would be partly effected by transmission frequency reuse, at present feasible only in

continued on page 12

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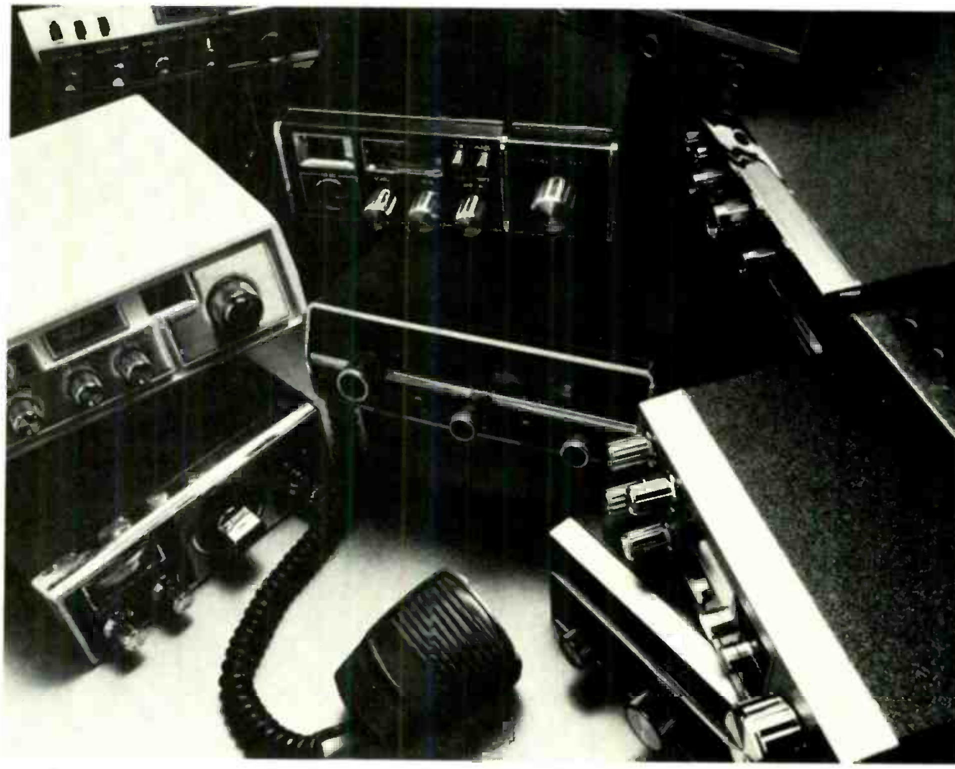

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 continued from page 6

widely separated geographic areas. Raising the number of frequencies would also mean there would be less interference from other microwave transmissions. For instance, at present both terrestrial and satellite communications use 4- and 5-gigahertz channels; the scanning/spot beam satellite would transmit over 11- and 14-gigahertz channels.

Smaller (about 10 feet in diameter), less costly antennas could be used in urban areas, rather than in less developed regions as is present practice. The antennas could be installed on rooftops, thus permitting convenient access by businesses.

The concept, if developed, could go far in reducing the cost of multiple video conferencing and in increasing high-speed data transmission, while also lessening the cost of tie-lines and private communications networks extensively used by corporations.

Magnuson-Moss Warranty Act offers less consumer protection

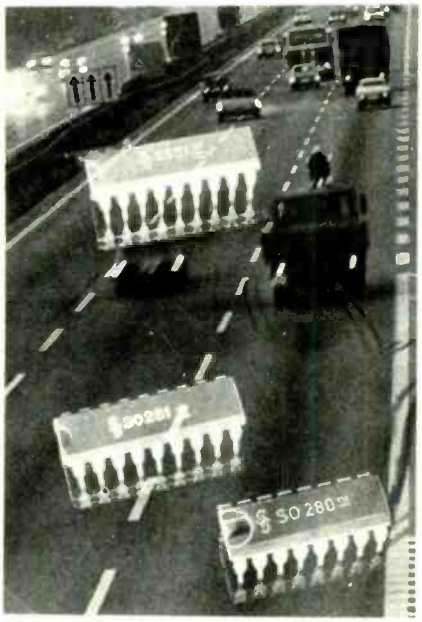
A survey conducted for the FTC by the National Association of Service Managers (NASM) and sent to 83 manufacturers indicates that the 1975 Magnuson-Moss Warranty Act has delivered less than was expected in terms of consumer warranty protection. Originally intended to simplify matters for the consumer by outlining minimum warranty standards and improving warranty protection, the Act has served only to confuse manufacturers (who are not sure what they must do to comply with its provisions) and to limit the amount of protection consumers can expect.

The NASM survey showed that two-thirds of the manufacturers who have over $1 million in gross sales (producing such items as appliances, furnaces, automotive parts, stereos, TV's, CB's, etc.) have switched from full to limited warranties. This means that consumers are now deprived of full warranty protection on their major purchases. Before the Act was passed, these companies tended to be the main providers of full warranties. Thirty-six of the 83 companies indicated they had changed over from full to limited warranties as a *direct result* of the Magnuson-Moss Act.

Announcing the result of the survey, NASM executive director Marvin Lurie said, "We now have solid evidence that the Act has reduced warranty coverage in major sectors of the consumer marketplace . . . We hope that the data NASM has provided to the FTC will permit rapid correction of the situation."

Decoder system for traffic information broadcasts

When you are driving, especially long distances, it is a great convenience to be able to receive periodic traffic information on your car radio. However, when you drive at high speed, the broadcast frequencies change and reception may not always be at optimum.


SIEMENS DECODER SYSTEM uses three IC's to automatically select and tune to traffic information stations.

Siemens AG of Germany has designed a decoder system containing three different IC's that can automatically select and tune to a traffic information station. The ARI decoder system (presently being used in Germany) is based on two special broadcast frequencies that are used by every traffic information station but cannot be heard on any other station: A 57-kHz pilot tone that lets you know you are tuned to a traffic information station and a 125-Hz frequency that is used for the actual broadcast.

The two bipolar S280 and S281 IC's of the ARI decoder respond to the 57-kHz and 125-Hz frequencies; IC S280 and IC S551 recognize the traffic service station by the pilot frequency; and IC S551 also controls the visual indicator, a green LED that tells you you have tuned in correctly. In operation, the system makes sure that the traffic announcements that interrupt regular programming are audible even if a cassette tape recorder is playing simultaneously. And even if the station volume has been lowered, the circuit assures the traffic announcement will come through loud and clear.

The system also warns you when you leave the area so that you can tune into a new station. The decoder drives an automatic station-seeking device until the traffic information program is restored. An optional IC (S552) is also available to identify different travel regions.

Microcomputers to improve U.S. Postal Service

Whenever the U.S. Postal Service must determine when, where and how to shift personnel to take care of special workload requirements, it must generally rely on online analyses, which generally arrive too late to be much use, or else keep a perpetual sharp eye out for potential bottlenecks in the system.

To alleviate this problem and, hopefully, maximize the efficiency of Postal Service operations, a pilot data-gathering system built by Applied Computer Research Company has been installed in a Sacramento, CA, facility. This monitoring system uses microprocessors to interface with conventional electromechanical equipment such as letter sorters and postage-cancelling machines. The microcomputers used in the system are Intel's SBC 80/04 and Zilog's Z-80. The Intel microcomputer board interfaces with the actual equipment, while the Z-80's handle system control. The Z-80, with its 4-MHz clock, hooks up to an on-site minicomputer and interfaces with the Postal Service Data System, a nationwide communications link, which contains all time and attendance records of the Postal System's entire workforce.

It is hoped that the monitoring system will provide postal supervisors with enough information to be able to handle personnel shifts quickly and efficiently. While the Sacramento office is about the smallest postal facility that could expect to receive such a system, larger urban areas, such as Los Angeles and New York, that handle large amounts of mail could benefit from its installation.

FCC proposes eliminating Third Class Operator's license

The Federal Communications Commission's proposed reorganization of radiotelephone operator licensing procedures advises eliminating the Third Class Operator's license. The National Radio Broadcasters Association supports this proposal, citing the fact that in the past the Third Class Operator's exam was not really necessary for a broadcaster to function effectively . . . all that was needed was for the FCC to grant a one-year provisional permit.

The new rules would only require that technicians engaged in installing, repairing or servicing broadcast equipment be *certified* by the FCC—no exam would be needed. If any of the equipment does not fulfill the specifications required by the license, the technician must inform the licensee. **R-E**

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- **Battery or line operation.**
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From the originator of the Digital Voltmeter, Non-Linear Systems comes the MS-15 Miniscope. It is a fine electronic instrument with a great deal of measuring capability and excellent accuracy. Its design is modern, utilizing the latest in low-powered integrated circuits, and it is packaged into the smallest practical size. The instrument fits into many briefcases and tool boxes with room to spare.

Operating characteristics have been chosen so that the MS-15 will make all of the measurements needed in servicing most electronic equipment. It is field-portable so its use is not restricted to the bench.

SPECIFICATIONS:

Y Axis

Vertical Input: x1-10mV/div to 10V/div in four ranges, each continuously variable. x2-20mV/div to 20V/div in four ranges, each continuously variable. x5-50mV/div to 50V/div in four ranges, each continuously variable. Accuracy is 3%.

Input Impedance: 1M ohm shunted by 50 pF

Input Voltage: 350 volts peak

Bandwidth (3 db points): DC/DC to 15 MHz; AC 5 Hz to 15 MHz

Internal Calibrator: 1 .0V (±5%) peak-to-peak square wave at 10-20 kHz

Graticule: 4 div Y by 5 div X; 1 div = 0.25 inch. Viewing area: 1.1"H x 1.35"W.

X Axis

Horizontal Input

Bandwidth (3 db points): OC to 200 kHz

Input Impedance: 1M ohm shunted by 50 pF

Sensitivity: 1V/div, 100V peak maximum input.

Time Base: x1, uS-0.1uS/div to 100 uS/div. x 2, uS-0.2uS/div to 200 uS/div. x5, uS-0.5uS/div to 500 uS/div. x1, mS-0.1mS/div to 100 mS/div. x2, mS-0.2mS/div to 200 mS/div. x5, mS-0.5mS/div to 500 mS/div. all in four ranges, each continuously variable. (Range increments are .1, 1, 10, 100.) With vernier in full clockwise position, calibrated time measurements are possible. Accuracy is 3%.

Triggering

Internal: Sweep triggered from internal trigger source.

Automatic: Trigger source is internal calibrator frequency. To be used if there is no other trigger source available to synchronize the sweep.

Line: Trigger is derived from line frequency when using the battery charger.

Slope: Selects sync to positive- or negative-going waveform

Sensitivity: Less than one division.

External: Controls function as for internal triggering.

Power

Batteries: Three self-contained lead acid "D" cells.

Operating Time: Typically 4 hours.

Charging Time Scope Operating: Will run indefinitely but not reach full charge.

Non-operating: Sixteen hours.

External Power: Battery charger 115 vac (220 vac on request), 50-60Hz, less than 15 watts.

Dimensions: 3.1"H x 6.4"W x 8.0"D.

Weight: Three pounds.

Accessories

Standard: Tilt stand, battery charger, input cable and miniature banana plugs (4).

Options: Leather carrying case and 10-1 attenuating probe, 10M ohm input.

Warranty: One year parts and labor.

MS-15 with Rechargeable Batteries and Charger

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Leather Carrying Case

The leather case has 2 separate compartments. One to hold the scope, the other to hold the charger, probe, shoulder strap, etc. The case can be worn on the belt, or over the neck.

The snaps used on the case are "one way", thus accidental striking of the case against an object will not undo the snaps or let it be pulled off your belt.

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Probe

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editorial

The Real Energy Crisis

Low-cost energy is the problem . . . not a shortage of energy itself.

Sure, at some point in time we will run out of oil, we will run out of natural gas, we will run out of coal. But there are plenty of other energy sources around. They include nuclear, solar, water power, wind, and who knows how many other sources that haven't been discovered yet.

The rising cost of fuel of all kinds is placing quite a hardship on most of us, but it does have a silver lining. It will result in the development of *practical* alternate supplies of energy; because it will pay, be profitable, to develop other sources.

You can buy solar cells today that have an efficiency of 18%, but we've got to get that up to 50%. We have solar hot-water heating systems today that work, but are expensive. What we need is a ruling requiring the installation of such a system in every new home. That would accomplish two aims—get a lot of energy-saving systems into use; and raise the volume of production so the cost of each system is reduced, making it more economical for people with older homes to add one.

Radio-Electronics is interested in our readers' ideas for alternate energy sources. Send me your thoughts. Include diagrams; photos if you have them. We'll publish the more interesting ones . . . remember, if it's built around electronic circuitry, it has an edge.

Larry Steckler

LARRY STECKLER
Editor

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Cover design by Louis G. Rubsamen
Cover photo by Michael Wilson

Radio Electronics is a member of the *Institute of High Fidelity* and is indexed in *Applied Science & Technology Index* and *Readers Guide to Periodical Literature.*

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letters

AN OPEN LETTER TO THE PRESIDENT

Dear Mr. President:

We of the Maryland Electronics and Television Association feel it has become imperative at this time to denounce the foreign import practices allowed for too long by our government. We strongly urge that immediate steps be taken to cause a reversal in this trend of "overseas extortion."

The television Industry, from the manufacturers to the technicians, has been feeling the impact of excessively low-price electronic equipment. In 1977, color TV retail prices are no higher, and in many cases lower, than In 1963, this being the only product that comes to mind that has not Increased with the inflationary trend of these same years. The price of automobiles, for example, has increased 40% in the last five years alone.

True, prices on television sets may be Increased by strong governmental action against importing foreign sets, but it would be more costly for consumers to pay higher unemployment and welfare benefits to more unemployed, while ours decreases.

In recent years, Motorola sold its TV division to foreign interests, as did Magnavox. More and more, foreign countries' employment rates increase, while ours decreases.

We feel that if the government does nothing to combat this serious problem, organizations such as ours (and there are many) must take the initiative in refusing to sell or service foreign-made products. Of course, this would create a hardship on consumers who own such equipment, but we may be left with no alternative.

We appeal to you, Mr. President, to give this subject your earnest attention, and move to restore faith in our Industry and system before we reach a point of no return.

We await your written response to this matter, which is of grave importance both to the Maryland Electronics and Television Association and the entire electronics industry.

EARL REDMAN, President
META Board of Directors

CB TEST GEAR

I am very appreciative of the special feature "What You Need to Know About CB Test Gear" by Forest Belt in your November 1977 issue.

I was especially impressed with Mr. Belt's treatment of the test bench in the last section entitled "Test Systems," in which he gave a very well-defined method of setting up our own comprehensive test bench for servicing radio transceivers.

Please include more articles of this type in future issues as I am sure that I, along with the majority of other readers, will receive great benefit from them.

BYRON McCABE
Tucson, AZ

PARTS HARD TO FIND

I have noted recently some editorial comment in electronics magazines with respect to the trouble people have in construction projects due often to substituting other than specified parts. I would like to point out some problems in this regard.

continued on page 22

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Feature for feature, dollar for dollar, you get more for your money in a Philips scope. These four oscilloscopes, designed for use in service, production or education, are made by Philips to the same quality standards as more sophisticated Philips scopes used in laboratories all over the world. They are light and easy to carry with all controls carefully placed for ease and minimum human errors in operation. Their design and quality of components are your assurance of minimum down time and repair costs.

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John E Cunningham

Special Projects Director
Cleveland Institute of Electronics

My father always told me that there were certain advantages to putting all your eggs in one basket. "John," he said, "learn to do one important thing better than anyone else, and you'll always be in demand."

I believe he was right. Today is the age of specialization. And I think that's a very good thing.

Consider doctors. You wouldn't expect your family doctor to perform open heart surgery or your dentist to set a broken bone, either. Would you?

For these things, you'd want a specialist. And you'd trust him. Because you'd know if he weren't any good, he'd be out of business.

Why trust your education and career future to anything less than a specialist?

You shouldn't. And you certainly don't have to.

FACT: CIE is the largest independent home study school in the world that specializes exclusively in electronics.

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Specialists aren't for everyone.

I'll tell it to you straight. If you think electronics would make a nice hobby, check with other schools.

But if you think you have the cool – and want the training it takes – to make sure that a sound blackout during a prime time TV show will be corrected in seconds – then answer this ad. You'll probably find CIE has a course that's just right for you!

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LETTERS
continued from page 16

1. Have you ever made up a list of exactly what is required and then gone out to the local dealers to try to get these items? Even if I limit my list to Radio Shack parts and catalog numbers, I can visit (and have visited) 10 New York stores without finding 75% of what I need. I now order by mail.

2. You have not provided any help in at least one area where it is badly needed—capacitors. I do not remember any article in your magazine (or any other) discussing what capacitors are suitable substitutions or what cannot be changed to any other type. I refer particularly to ceramic, silver mica, mica, Mylar, tantalum, etc.—also to electrolytics. Why was each type emphasized and what is it really required for?

3. Resistors offer a somewhat simpler problem. So can you point out when you can substitute 5% resistors for 1% resistors, on wire-wound vs. carbon, etc.?

4. How about an update on what items now on the market really require heat-sink protection in soldering.

5. How about some practical specifications for handling static-sensitive AC-field-sensitive solid-state items, MOS, etc.?

R. M. SANFORD
White Plains, NY

DIGITAL CAR CLOCKS

I read with great interest your October and November 1977 articles on "Digital Car Clocks," as I had just recently built James Electronics' Quartz Digital Auto Clock.

It is working very well, but I still want to either convert it or get a similar clock to count in decimal minutes (hundredths) instead of seconds for use in road rallye timing. This appears to require a special IC with a divide-by-100 in place of one divide-by-60 and a 100-Hz frequency. Perhaps you may have discovered such an item during research for your article . . . any ideas? A "split action" timing feature would also be of benefit.

In the October 1977 article you also referred to a Radio Shack *WWV Converter Kit* (No. 28-133 for $5.95). I have inquired at several local Radio Shack outlets, and none of them knows about this kit.

JOHN R. GINGRICH
Massillon, OH

In answer to your first question, if you look in the latest Radio Shack catalog (1978, No. 289) on page 148 at the top, you'll find a super-duper "Quartz Computer Timepiece" for $49.95. I have this identical item, under the Casio brand name, and have had it since it was introduced by Casio about five months ago.

It's terrific! The picture shown in the catalog is just slightly smaller than actual size. In the stopwatch functions it reads decimal seconds, but not *decimal minutes or hours. Real-time is retained when using the elapsed-time function. The AA battery for the display should last for 10 hours or so in regular use as a stopwatch, since the display is always on in that function. It's difficult to adapt this to external power except with the special AC adapter, because the jack is nonstandard (it uses a larger-than-standard center prong). If you could find a mating plug, you could drop the car 12 volts through a resistor (220 ohms, 1 watt should do it nicely, since the display draws about 50 mA). I don't know of any clock that counts minutes in hundredths, although it certainly could be done as you describe.*

Regarding the Radio Shack No. 28-133 WWV Converter Kit, *it has apparently been discontinued. It's not shown in their current catalog.*
FRED BLECHMAN

MAGNETIC SEMICONDUCTOR

During an energy crisis, in desperation, we are apt to seek such far-out solutions as a "magnetic semiconductor" as described by Andrew Fraser in the October 1977 issue.

Even if we should find such a material, Marc Scharf (same issue) also wrote of a basic law of science that has never been violated. If the material is ever found, it will be impossible to improve it or any permanent magnets beyond a certain efficiency. By scientific law the screen must always use more power than the iron block can generate.

It is hoped none of your readers waste their time pursuing John Ecklin's scheme as it is a complete flop unless we can find a "magic semiconductor." Perpetual motion is impossible even with all the many wonders of today's electronics.

A. G. HOLT
Silver Spring, MD

R-E

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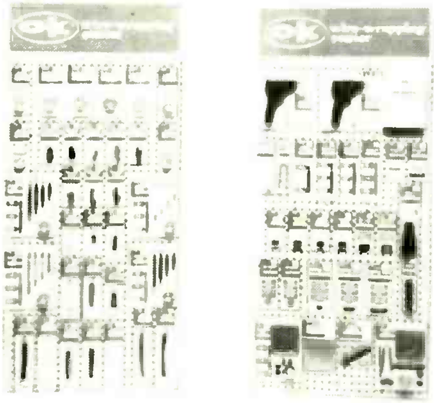

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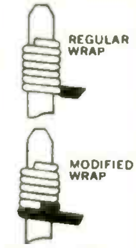

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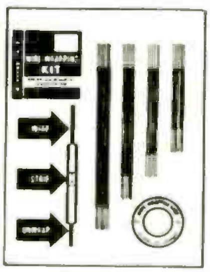

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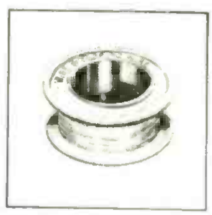

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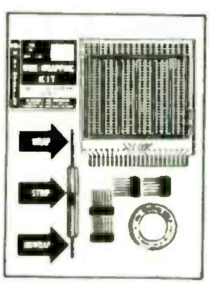
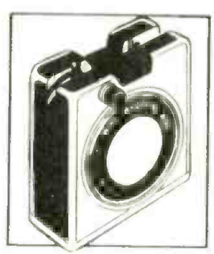


WIRE-WRAPPING KIT

Contains: Hobby Wrap Tool WSU-30, Roll of wire R-30B-0050, (2) 14 DIP's, (2) 16 DIP's and Hobby Board H-PCB-1.

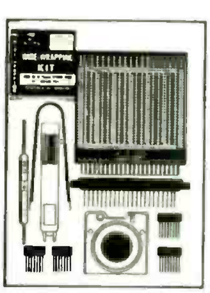
Wire-Wrapping Kit	WK-3B (Blue)	$16.95



WIRE DISPENSER

- With 50 ft. Roll of AWG 30 KYNAR* wire-wrapping wire.
- Cuts the wire to length.
- Strips 1" of insulation.
- Refillable (For refills, see above)

Blue Wire	WD-30-B	$3.95
Yellow Wire	WD-30-Y	$3.95
White Wire	WD-30-W	$3.95
Red Wire	WD-30 R	$3.95



WIRE-WRAPPING KIT

Contains: Hobby Wrap Tool WSU-30 M, Wire Dispenser WD-30-B, (2) 14 DIP's, (2) 16 DIP's, Hobby Board H-PCB-1, DIP/IC Insertion Tool INS-1416 and DIP/IC Extractor Tool EX-1

Wire-Wrapping Kit	WK-4B (Blue)	$25.99

PRE CUT PRE STRIPPED WIRE

Wire for wire-wrapping AWG-30 (0.25mm) KYNAR* wire. 50 wires per package stripped 1" both ends.

30 AWG blue Wire 1" Long	30 B 50 010	$ 99
30 AWG Yellow Wire 1" Long	30 Y 50 010	$ 99
30 AWG White Wire 1" Long	30 W 50 010	$ 99
30 AWG Red Wire 1" Long	30 R 50 010	$ 99
30 AWG Blue Wire 2" Long	30 B 50 020	$1 07
30 AWG Yellow Wire 2" Long	30 Y 50 020	$1 07
30 AWG White Wire 2" Long	30 W 50 020	$1 07
30 AWG Red Wire 2" Long	30 R 50 020	$1 07
30 AWG Blue Wire 3" Long	30 B 50 030	$1 16
30 AWG Yellow Wire 3" Long	30 Y 50 030	$1 16
30 AWG White Wire 3" Long	30 W 50 030	$1 16
30 AWG Red Wire 3" Long	30 R 50 030	$1 16
30 AWG Blue Wire 4" Long	30 B 50 040	$1 23
30 AWG Yellow Wire 4" Long	30 Y 50 040	$1 23
30 AWG White Wire 4" Long	30 W 50 040	$1 23
30 AWG Red Wire 4" Long	30 R 50 040	$1 23
30 AWG Blue Wire 5" Long	30 B 50 050	$1 30
30 AWG Yellow Wire 5" Long	30 Y 50 050	$1 30
30 AWG White Wire 5" Long	30 W 50 050	$1 30
30 AWG Red Wire 5" Long	30 R 50 050	$1 30
30 AWG Blue Wire 6" Long	30 B 50 060	$1 38
30 AWG Yellow Wire 6" Long	30 Y 50 060	$1 38
30 AWG White Wire 6" Long	30 W 50 060	$1 38
30 AWG Red Wire 6" Long	30 R 50 060	$1 38

* KYNAR PENNWALT

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CIRCLE 15 ON FREE INFORMATION CARD

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equipment reports

Wilson Electronics Model WFC-500-S, Model WFC-500-E Frequency Counters

CIRCLE 147 ON FREE INFORMATION CARD

THE WILSON ELECTRONICS CORPORATION (4288 South Polaris Avenue, Box 19000, Las Vegas, NV 89119) has introduced two versions of a new frequency counter, the *models WFC-500-S* and *WFC-500-E*. Both instruments are 6-digit types, with a dual range giving an 8-digit resolution. The frequency range covered by the counters is from 10 Hz up to 500 MHz. The *model WFC-500-S* (shown) has a rated accuracy of 0.0001%, and the *model WFC-500-E* has an accuracy of 0.000002%, or 0.02 PPM. The *model WFC-500-E* uses a TCXO (temperature compensated crystal oscillator) clock.

Both versions can be AC-powered, and have a selector switch that can operate on AC lines of 100, 110, 117, 200, 220 or 234 volts. They can also be powered by 12 volts DC, for mobile use, and both models come with AC and DC input cables, plus an input cable with clips. There are two BNC input jacks on the front panel. Input A is used for frequencies from 10 Hz up to 10 MHz, and it can be switched from a 1.0-megohm impedance to a 50-ohm input. The sensitivity is 25 mV in both switch positions. Input B is used for frequencies from 10 MHz up to 500 MHz, at 50 ohms, with a 100-mV sensitivity at about 20 MHz; this sensitivity reading goes to 25 mV at about 100 to 120 MHz, then gradually rises to about 100 mV at 500 MHz.

The 7-segment red LED readout is plainly visible. An overrange LED on the left-hand side of the readout shows when the input frequency is above the normal readout. Two LED's on the right-hand side show whether the reading is in kHz or MHz. For greater resolution, the initial reading can be displayed in MHz, with the decimal point placed three digits from the left. Incidentally, the counter has lead zero blanking that makes the display simpler to read. For example, if you read 45.75 MHz in the MHz position, all you see is "45.750." When you move this reading to the kHz position, the "45" scoots out of sight to the left, and you then read "750.000" in kHz. The three digits on the right-hand side give you the reading in Hz!

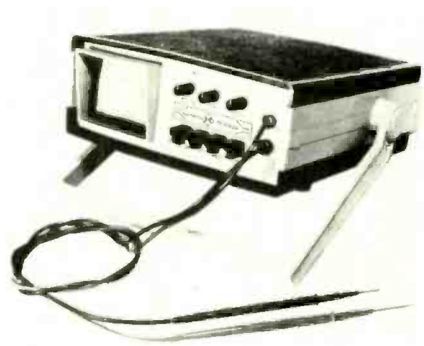
In our bench test, we connected the counter to the color oscillator of a TV set during a network program. The reading was "3.580." Switching to kHz gave a reading of "575.545." The last digit rocked at times, first to "6" and then back, which is normal. We were glad to see that the network's atomic clock was still right on the button. We left the counter and went out for coffee; when we returned it was still reading exactly the same.

When you use the *model WFC-500-E*, which contains the TCXO, a standby LED on the panel lights up as soon as the unit is plugged in. This shows that the crystal oven is operating. The manufacturer recommends leaving the counter on for an hour for greater stability. We didn't warm it up nearly that long, but found it was quite stable within no more than 15 minutes, in the bench test described above and on other frequency standards.

The circuitry of the *model WFC-500-S* and *WFC-500-E* is thoroughly integrated. Standard IC's are used for flip-flops, counter, dividers, etc. The DC power supply is tightly regulated on both AC and DC inputs.

The layout of the front panel is neatly arranged. The input jacks are at the lower right-hand corner, with the selector switches in the middle. All controls are push-push types, with the switch positions plainly marked on the panel. The rear panel contains the 4-pin power-input jack, a line fuse, and a BNC jack for access to the internal 1.0-MHz clock oscillator. The cabinet is made of sturdy metal and comes in two sections for easy access to the counter circuitry. **R-E**

Huntron Tracker Circuit Tester



CIRCLE 148 ON FREE INFORMATION CARD

THE HUNTRON TRACKER IS A NEW VERSION of an old circuit. This circuit is what some call an

continued on page 32

Whatever you're looking for
you'll find it with a price/performance

Put Computer versatility and convenience in your home with the H8 Personal Computer System

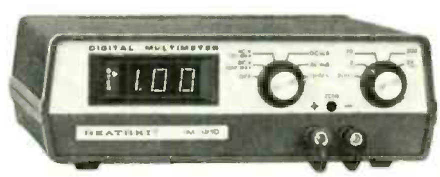
Get into personal computing the right way with a powerful computer system from Heath. Start with the H8. It features 8-bit operation, fully expandable memory, a versatile 8080A CPU, and is the only machine in its price class that, due to its "intelligent" front panel and built in monitor program, can function without peripherals.

Next, add our 12" CRT video terminal. The H9 operates in three different modes, has a 67-key ASCII keyboard, and features a built in interfacing board to make hook-up a breeze.

Add "mass storage" with the ECP-3801 cassette recorder/player and cassette I/O and you've got a system that's ready to go wherever your programming skills take you.

Weigh yourself with electronic precision with our Digital Electronic "Weighing Machine"

Uses solid-state electronics and a strain-gauge transducer element like expensive laboratory scales. The GD-1186 features 300-lb. capacity, can be wired to give weight in pounds or kilograms, and has a bright, easy-to-read 4-digit LED display. It's battery operated so it's safe to use even after a shower. And for extra convenience, the GD-1186 comes with additional cable so you can mount the read-out most anywhere you desire.

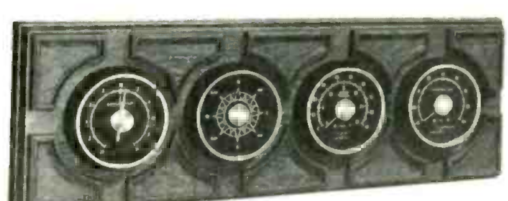


This Low-cost Multimeter gives you digital accuracy at analog prices

The IM-1210 is an economical performer that hobbyists and service techs have been waiting for. Capabilities include AC voltage measurement to 700 volts, DC to 1000 volts, current measurement, and 5-ranges for resistance checks. Accuracy is excellent and the bright digital display gives you readings at a glance.

Our low-cost, effective Microprocessor Course teaches you all about Computers

Using our challenging self-instruction techniques and the optional ET-3400 Trainer, the EE-3401 Microprocessor Course takes you step-by-step through hardware, I/O interfacing, machine language programming, number systems, microprocessor operation, and much more. You'll complete experiments, gain hands-on experience and work directly with the devices that are "taking over" in today's electronics.



Stay "On Top" of the Weather with this Five-function Weather Station

The ID-1290 Weather Station monitors indoor and outdoor temperatures, barometeric pressure, wind speed and direction — all with electronic accuracy and reliability. Ideal for home or office or anywhere accurate, instant weather information is needed.

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advantage in the new Heathkit Catalog!

Smartly-styled Low-Cost Digital Alarm Clock

Unobtrusive and elegant, the GC-1107 is styled in handsome wood grained vinyl, and features an easy-to-read 4-digit blue-green display, 12 or 24 hour format, and automatic dimming to adjust for ambient light conditions. Its "snooze" feature lets you take 9-minute "catnaps" for as long as an hour. And for extra convenience — there's even a handy power failure indicator. A perfect kit for the beginner.

This SSB/CW Receiver is the one the Hams are enthused about!

An excellent, low-cost choice for your first receiver is the HR-1680. With it you'll find total solid-state construction, no-instrument alignment, and a sensitivity figure of less than 0.5 μV. It covers 80, 40, 20, 15 and the lower 1 MHz of 10 meters. And with a MOSFET "front end" and preselector tuning — you'll be digging out the "rare" ones in no time!

Our AR-1515 Stereo Receiver sets new standards in performance, price and features

Undoubtedly the finest AM/FM stereo receiver we've ever designed, the AR-1515 combines distinctive functional styling with excellent tuner performance, and a clean, powerful, amplifier section to give you a home entertainment center of unsurpassed quality. Power output is 70 watts, minimum RMS, per channel into 8 ohms with less than 0.08% total harmonic distortion from 20-20,000 Hz. FM sensitivity is an outstanding 1.8 μV for really clean and clear reception. And the AR-1515 is the only stereo receiver in its price range that provides digital frequency readout!

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CIRCLE 100 ON FREE INFORMATION CARD

EQUIPMENT REPORTS
continued from page 26

"angle tracer." This simple device displays a sharp angle on a scope pattern by feeding an AC voltage across the scope. Huntron Instruments, Inc., 15123 Pacific Highway North, Lynnwood, WA 98036, has really refined and perfected this device, which sells for a suggested retail price of $695.00. State-of-the-art circuitry gives it much more versatility than the original angle tracers.

The *Tracker* has its own scope—a 2 × 3-inch rectangular CRT. The scope controls are at the top of the front panel. Three pushbutton switches at the bottom of the front panel select HIGH, LOW or MEDIUM impedance for matching the circuitry to be tested. A fourth pushbutton is the ON-OFF switch. Also included are two test-lead jacks, and that's all. The test leads used are Huntron *Micro-Probes*. These probes have telescoping points and can be extended to almost 8 inches. The probe tips are quite sharp and are insulated almost to the very end for maximum safety in testing tightly packed circuit boards. You can check practically all parts from their side of PC boards; just push the sharp probe tips down into the holes.

The *Tracker* uses a low AC voltage for tests. This is both voltage- and current-limited by the circuitry. The tests will not damage any solid-state device; even MOSFET's can be safely checked, in-circuit. You can make quick tests on any kind of transistor, from bipolars to FET's, and even Darlingtons, which are hard to check on many transistor testers.

In addition, the *Tracker* can check capacitors of any size, from .0025 μF to 4 μF on the High-Z range, and from 2.0 μF to 5000 μF on the Low-Z range. The display for a good capacitor is a circle or an ellipse; if you see a closed loop, the capacitor is OK. The instrument also checks inductors such as power transformers, vertical output transformers, etc., for shorted windings. If you see a definite *loop*, the winding is OK. If the winding is shorted, you will not see a loop. For a shorted winding, the display will be a vertical line.

Diodes of all types are easy to check. Just touch the test leads to the diode. If you see an angle, the diode is good. You do *not* have to reverse the test leads as in other testing methods. Reversing the leads reverses the angle. If you see the angle, OK. The same thing applies to transistor junctions: If you see the angle, there you are.

The so-called good pattern for all junctions is a *sharp* angle with straight legs. The angle varies, from being quite acute in low-impedance circuits to quite wide in high-impedance circuits; but the key clues will be the same—the sharpness of the angle and the straightness of the legs of the trace. Leakage causes one or more of the legs to bend, and the corner will be rounded, and not sharp.

It is also possible to catch intermittent devices with the *Tracker*. The display flickers at the ends of the trace, or the whole pattern may be erratic and unstable. By monitoring the trace while heating or cooling the device, this test can be speeded up.

All the preceding tests can be made either in-circuit or out-of-circuit. Because you do not have to reverse the test leads, the *Tracker* is ideal for speedy testing! You can use the special test probes to test all discrete transistors, diodes, resistors and capacitors on a typical PC board in only a very short time.

You can make accurate tests on TV modules; all you need is one unit that's known to be good. Just check the same parts (test points, etc.) between the two units, and the defective part will soon be pinned down.

You can even test IC's in the same way. You do *not* have to know the pinout. If you have another IC of the same type, just take readings between the same pins of each IC and the pattern should be the same. These tests can also be made either in- or out-of-circuit, which can save a lot of time taking an IC out and putting it back in.

In some more complex circuits, such as control boards, memories, etc., there are often quite a few identical IC's on the board. You can use the *Tracker* to quickly compare key points between several of these IC's. If the same pattern is repeated on three of them, and an entirely different pattern shows up on the fourth, then the fourth IC should be suspected!

In all cases, the tests can be made with no power applied to the device, PC board, module, etc. The *Tracker*, in effect, feeds its own signal into the device and displays the results on the scope. In-circuit tests show slightly different patterns due to the presence of shunt loading on the junction. However, the key clues still apply: The angles must be sharp and the legs straight. The presence of a closed loop in a test shows there is capacitance in the circuit. However, the key angle will still be sharp. A coil in the circuit may show ringing on the horizontal trace, but, again, the key angle is sharp.

We connected the *Tracker* to a known
continued on page 34

Formerly RCA Instruments

"At last... a digital VOM I can trust."

"I repair electronic equipment from TVs to computers. So I need dependable test equipment. That's why I was unhappy with the first digital VOM I bought — it never worked right and I couldn't trust it.

"Then I bought a VIZ WD-751A for $150. The first thing I noticed was its speed; even on AC (the "problem" scale for most DMMs) the readings come fast — in a second at most. And this DMM is fully protected against overload. Even if I set it on OHMS and put in AC, I can't damage it.

"I like how easy it is to read. Even in the bright sun, it doesn't wash out. And this DMM changed my thinking about LCDs in low light; if there's enough light to plug in the leads, there's enough light to read the display.

"With its LCD readout and low-power CMOS circuits, this meter draws less than 50mA, so its batteries last a long time. And its CMOS large-scale ICs assure me that it'll stay accurate over the long haul.

"I find this same quality built into all VIZ VOMs. Their WD-750A bench-type digital VOM has extra features like an analog reference meter which is center-settable for nulling and peaking; a floating ground; a detachable power cord for complete AC isolation; low-power ohms; and an extra 20 Megohm resistance range. Its metal case provides great rf shielding, and it has the same overload protection as the smaller WD-751A DMM. One service magazine I read just rated it excellent in performance — and I agree; in fact, in their test it even gave very accurate readings on DC having high ripple or pulses, where some DMMs are off by as much as 40%.

"For years I've known that analog VOMs aren't all the same, so why did I ever think that all 3½-digit DMMs would be the same? As my distributor told me, VIZ test instruments work right and they don't come back for repairs.

"These VOMs have convinced me that if VIZ makes it, it's made right."

VIZ Test Instruments Group

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The Circuit Tester line
Accuracy and stability assured

7002

EQUIPMENT REPORTS

continued from page 32

"bad" throw-away TV module (which, of course, I couldn't bring myself to throw out!). This one had two identical IC's. A cross-check between the two showed distinctly different patterns between the same test points on the IC. So, we knew that one of the IC's was bad.

The instruction manual shows all the good and bad traces that can be expected for any type of part—bipolars, FET's, diodes of all kinds, even SCR's and many four-layer devices.

A handy supplementary brochure entitled the "Prober" comes with the *Tracker*. It contains quite a few specialized tests and hints on how to identify patterns, etc. This supplement is expected to be a continuing service; as new *Tracker* applications are discovered, they will be sent out to the users.

If it is properly used, the *Tracker* should be a useful instrument for all kinds of solid-state circuitry. The long *Micro-Probe* test leads make it very easy to get down into tight places, and the sharp probe tips also make it simple to test IC's from the top.

If you *do* repair your own modules, this instrument should be a big help by making fast cross-checking and comparison tests possible. Another good trick: the *Tracker* should make it a lot faster to service those jam-packed, no-schematic little FM/AM radio receivers. You can check all transistors from the top in only a short time. **R-E**

Kager Model KL 3000 Auto-Feed Soldering Pistol

CIRCLE 149 ON FREE INFORMATION CARD

ALL MY WORKING LIFE I'VE KEPT A SHARP EYE out for time-saver tools, those small but useful items that will do only one thing but do it faster or easier.

I've just run into a new one: the Kager *model KL 3000* One-Handed Soldering Pistol manufactured by Kager International, Suite 710, 1180 South Beverly Dr., Los Angeles, CA 90035. The basic model retails for $38. This gun is not a soldering gun, but a solder-feeding "pistol" that weighs less than half a pound, in the box!

It has a good-sized plastic pistol grip. The heating element is mounted in the upper part of the pistol. A guide tube feeds the solder directly onto the joint. The flow is controlled by a trigger that does *not* control the heat, which is on continually.

This tool should be useful for any kind of PC-board work. It should also be a whizz at assembling all kinds of kits, especially those with many closely spaced joints, such as IC's, etc. Normally, you have to hold the board with one hand, hold the part in place with the other,

continued on page 119

CIRCLE 13 ON FREE INFORMATION CARD

Measure resistance to .01Ω at a price that has no resistance at all.

The new B&K-PRECISION Model 2810 may well be the highest resolution 3½-digit DMM available. It is certainly the lowest cost DMM to provide .01Ω resolution. With ohms resolution ten times greater than most DMM's, the 2810 allows you to detect shorted windings in coils, transformers or motors.

You'll also be able to accurately check the low contact resistance of switches, relays, breaker points or connectors. Many poor solder connections or PC board imperfections can also be located.

The 2810 is a full-feature DMM providing selectable high-/low-power ohms, auto-zeroing and 100% overrange reading. Twenty-nine ranges provide maximum readings to 1500 volts DC, 2 amps, and 20 megohms. All ranges are fully overload protected. Typical DC accuracy is 0.5% with resolution to 100μV. And unlike many electronic voltmeters, the 2810 is RFI shielded and can be accurately used in high R-F energy fields.

B&K-PRECISION also has a full complement of optional accessories for the 2810. Accessories include a carrying case, wire tilt stand, AC adapter/charger, high-voltage probe, direct/isolation probe, NiCad batteries and 10-amp current shunt.

At $119.95, the 2810 is a standout value in today's DMM jungle. Don't resist the temptation...contact your local distributor for immediate delivery.

B&K PRECISION DYNASCAN CORPORATION

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BUILD

Automotive/Marine Digital Tachometer

Operate your car or boat at maximum efficiency by monitoring engine speed. This easy-to-build tach lets you keep a finger on your engine's pulse

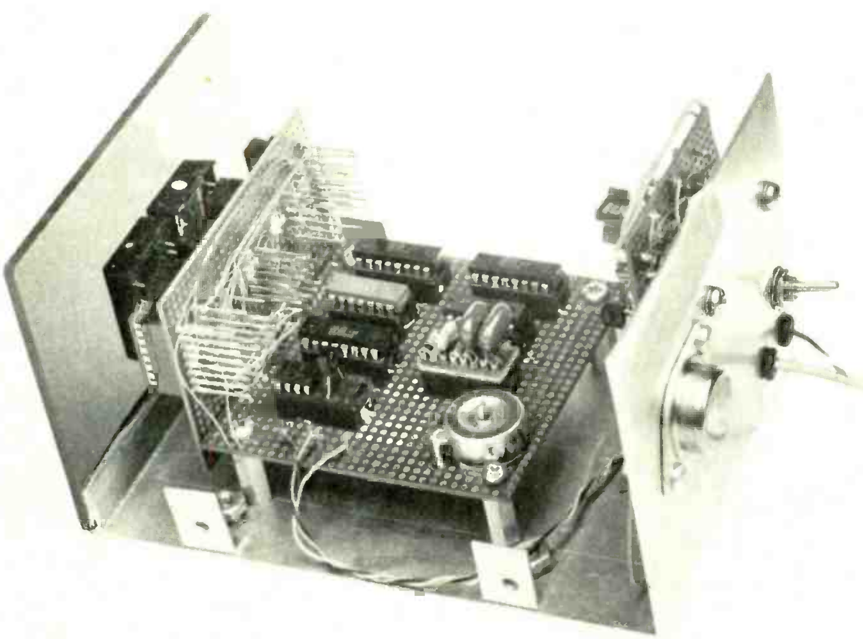
MICHAEL H. KUHN

A CONSTANT AND ACCURATE CHECK ON engine RPM's is essential to the motorboatsman for the following reasons:

1. It is vital if the boat is to be operated at top efficiency and maximum fuel economy. By running a measured course at a constant engine speed, it is possible for the operator to determine fuel consumption per mile and per hour under average conditions.
2. Engine speed can be a valuable navigation aid. Knowing the distance between two buoys or other points, an experienced boatsman can determine the engine speed needed to traverse the two points in a given time.
3. Similarly, knowing the craft's most economical cruising speed, the pilot will be able to estimate the sailing time between two known points.
4. Perhaps the most important reason for knowing the speed of a marine engine is the relationship between RPM's and cruising range. Safety afloat demands that the pilot know how much fuel he must have on board to reach his destination or an intermediate fueling point with an adequate reserve.

An accurate engine-speed indicator is an important instrument for an aware automobile driver. For only by knowing engine RPM's can he obtain most efficient performance with minimum strain on the engine.

This digital tachometer overcomes the ambiguous swing of the analog-meter instrument. It can be used to measure the speed of 2- or 4-cycle automobile and marine engines having from two to sixteen cyclinders. It works on any 12 to 24 volt DC electrical system that has a negative ground. Its 7-segment display is visible in darkness and shaded or dim sunlight and is not bright enough to affect the night-vision of a driver or pilot.



PERF-BOARD AND WIRE-WRAP was used exclusively to build the prototype. A total of three separate perf-boards was used.

How it works

Digital and analog electronic tachometers operate by processing the voltage pulses developed by the make-and-break of the breaker points of an internal combustion engine. These tachometers are basically frequency counters modified to indicate revolutions per minute. Before going further, let's look at the operation of a 4-cycle internal combustion engine. (1) The points open and close once per crank-shaft revolution per cylinder. (2) For all cylinders to fire (regardless of the number of cylinders) the crankshaft makes *two* revolutions. (3) The distrib-

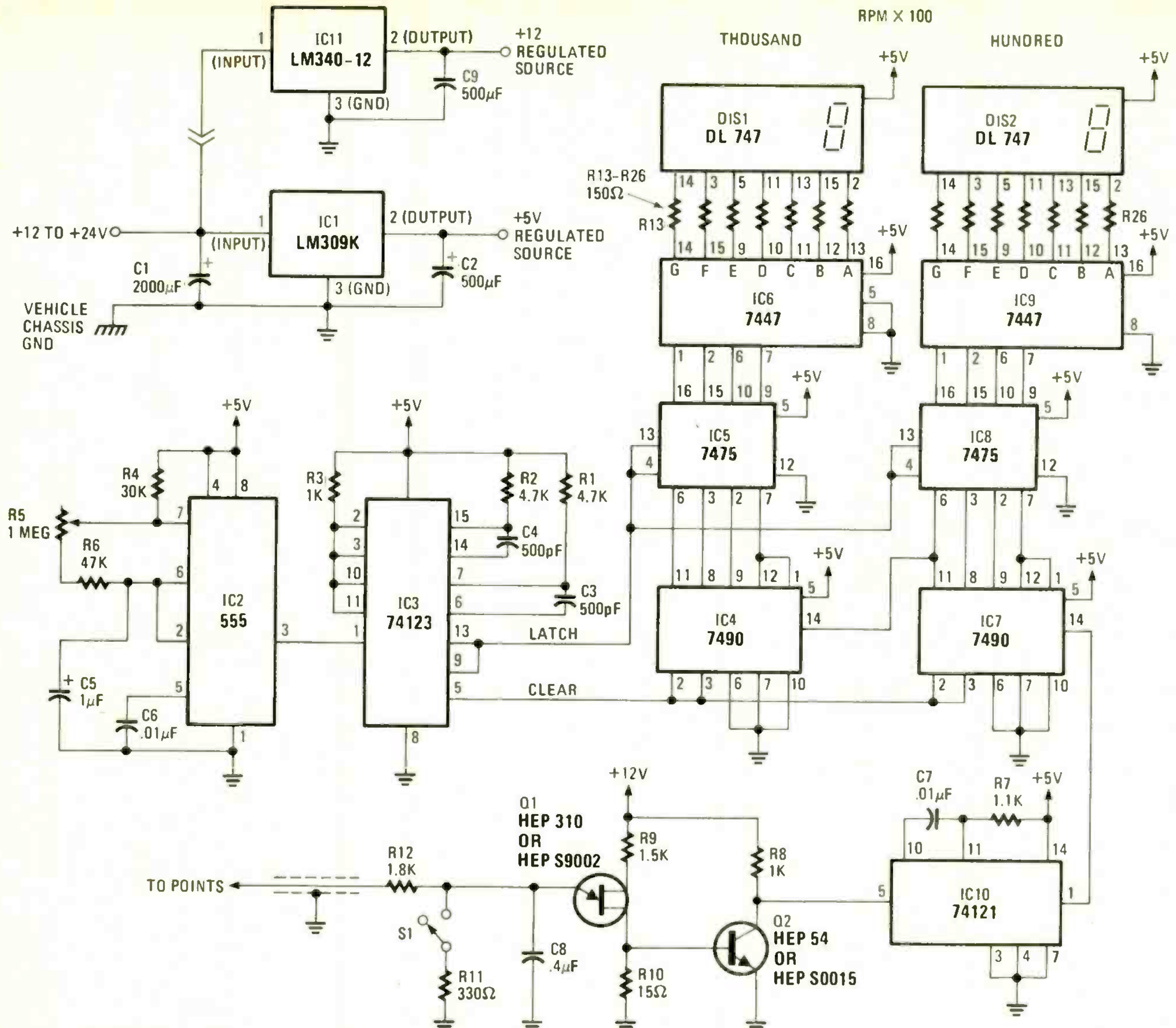


FIG. 1—TACHOMETER provides a direct readout of RPM × 100 on a 2-digit 7-segment LED display.

PARTS LIST

C1—200 μF, 50V, electrolytic
C2, C9—500 μF, 50V, electrolytic
C3, C4—500 μF, 50V, tantalum
C5—1 μF, 50V, electrolytic
C6, C7—.01 μF, 50V, disc
C8—.4 μF, 50V, disc
All resistors are ¼ watt, 5%.
R1, R2—4700 ohms
R3, R8—1000 ohms
R4—30,000 ohms
R5—1 megohm potentiometer
R6—47,000 ohms
R7—1100 ohms
R9—1500 ohms
R10—15 ohms
R11—330 ohms
R12—1800 ohms
R13-R26—150 ohms
Q1—HEP310
Q2—HEP54
IC1—LM309K
IC2—555
IC3—74123
IC4, IC7—7490
IC5, IC8—7475
IC6, IC9—7447
IC10—74121
IC11—LM340-12
S1—SPST toggle
DIS1, DIS2—DL747 common-anode 7-segment LED display

utor makes one-half revolution during each revolution of the crankshaft.

Since the distributor makes one revolution for every two revolutions of the crankshaft (No. 3 above) and since the crankshaft must make two revolutions for all cylinders to fire; the distributor points make-and-break—during each crankshaft revolution—only one-half as many times as the number of cylinders. Thus, in a 6-cylinder engine, the points make-and-break only three times for each engine revolution. Therefore, the tachometer divides the number of pulses picked up from the distributor by half the number of cylinders.

Since a tachometer is calibrated in *revolutions per minute*, it would seem that we would count pulses for a full 60 seconds and then divide by half the number of cylinders to get a RPM reading. However, this is not the case. The tachometer electronics counts pulses for a second or fraction thereof and then multiplies that number by a factor that yields the number of revolutions per minute.

Consider an 8-cylinder engine running at 900 RPM. The breaker points operate 3600 times (900 × 4) per minute. If we divide this by 60 (seconds), we arrive at 60 as the number of pulses developed *per second*. Thus, at 900 RPM, the points generate 60-Hz pulses. Then, for the tachometer to display a "9" (for 900 RPM) we divide 9 by 60 and arrive at 0.15 second or 150 ms. This is the up-date time. If we want to display ten's, we divide 90 by 60 and arrive at a 1.5-second up-date time. Similarly, should we want to display the full 900, we would divide 900 by 60 and come up with 15 seconds as the up-date time. The last two examples are of up-date times that are far too slow to provide accurate instantaneous readings.

The digital tachometer is shown in the schematic in Fig. 1 and block diagram in Fig. 2. Only two decades are used; indicating thousands and hundreds. Tens and units are not displayed as they would wander so much that the distraction would be greater than that of an erratically bouncing needle of an analog instrument. Also, by displaying only thousands and hundreds, we can take advantage of a faster up-date time. For a 4-cycle, 8-cylinder engine, we up-date at 150 ms. This provides a new reading approximately seven times a second.

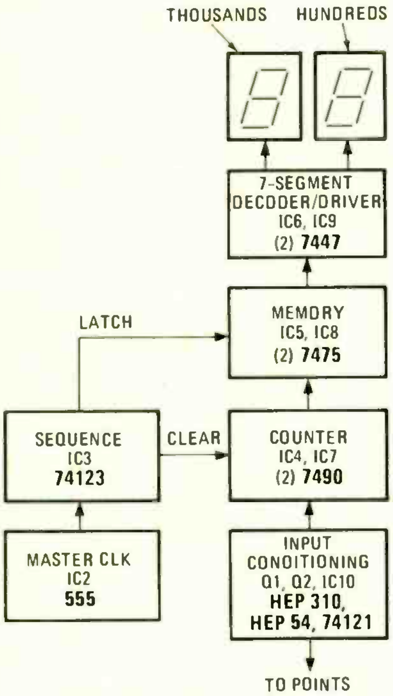
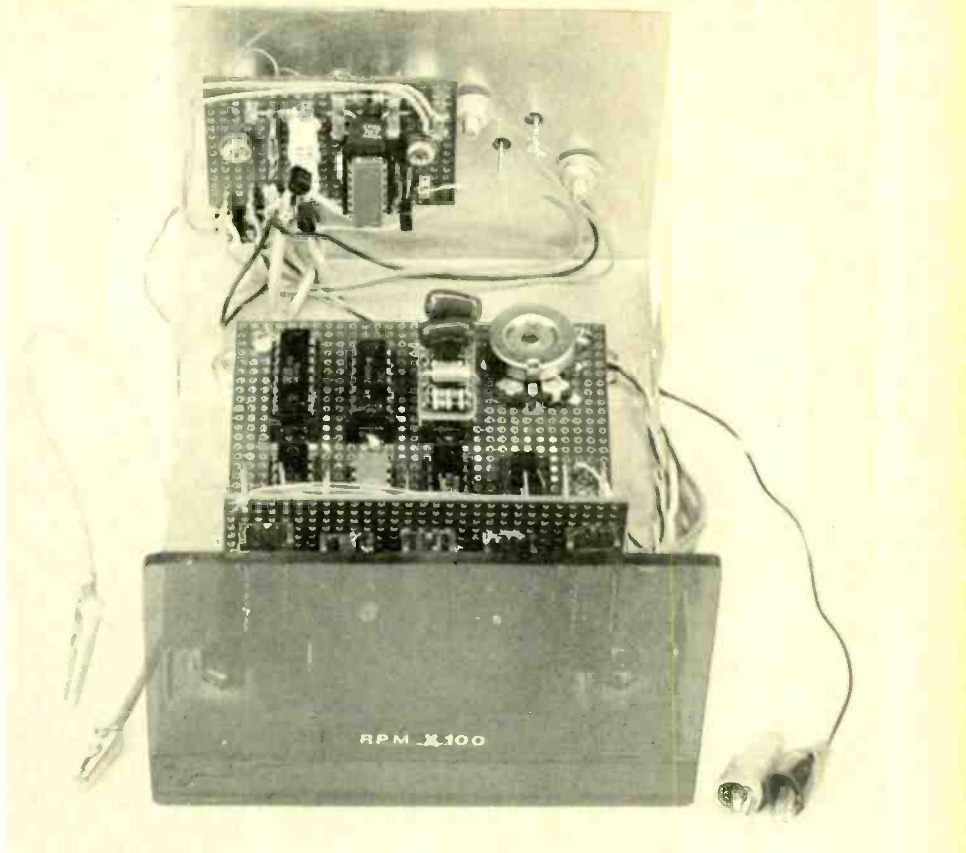


FIG. 2—BLOCK DIAGRAM of tachometer circuit. Master clock signals are provided by a 555-timer IC.



FRONT-PANEL OF TACHOMETER is made of red translucent plastic. Seven-segment LED display is mounted directly behind this.

To convert breaker-point openings and closings to engine RPM, the tachometer electronics performs all the math necessary for a direct read-out. The 555 timer, IC2, is the master clock. Its frequency must be adjusted, by R5, to suit the type of engine being monitored. Once set, this adjustment need not be touched unless the tachometer is switched to an engine of another type.

A dual retriggerable one-shot, IC3, provides the clear pulses for IC4 and IC7 and the latch pulses for IC5 and IC8. Transistors Q1 and Q2 and IC10 condition the input pulses from the distributor to produce a TTL-compatible signal. Switch S1 is used to adapt the tachometer to either standard or electronic ignition systems. Close the switch when the tach is used with electronic ignition.

The TTL devices and the displays operate from a regulated 5-volt DC line fed from regulator IC1. The regulator input is 12 to 24 volts DC. Transistors Q1 and Q2 operate from a 12-volt source so 12-volt regulator IC11 should be installed if you plan to use the tach in a vehicle that has an electrical system supplying more than 12 volts DC. By the same token, do not use IC11 if the tachometer is going in a vehicle with a 12-volt electrical system. Add a switch to bypass IC11 if the tach is to be used in both 12- and 24-volt vehicles.

Construction

I assembled the digital tachometer on perforated board using the wire-wrap method. Sockets were used for the IC's, transistors and most other components. Be sure to use heat sinks on the regulator IC's. Use shielded cable or coax for the hook-up between the tachometer and breaker points.

Calibration and use

Calibrate the tachometer before installing it in the vehicle. For this, you need a low-level 60-Hz signal—6.3 volts AC from a filament transformer (Fig. 3) will do nicely. Connect one lead to the shielded lead marked "to points" and connect the other lead to the shield. Connect the tach to a +12 to +24 volt DC source capable of delivering at least 1 ampere.

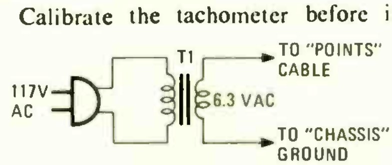


FIG. 3—CALIBRATION of the tachometer requires a low-level 60-Hz AC signal. An inexpensive filament transformer will do nicely.

CALIBRATION TABLE

Engine Type (Stroke/ Cylinder)	Display Readout at 60 Hz (× 100)
2/2 4/4	18
2/3 4/6	12
2/4 4/8	9
2/6 4/12	6
2/8 4/16	4*

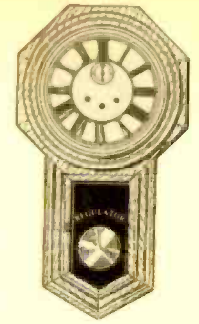
* Halfway between 4 and 5

Refer to the calibration table and adjust trimmer R5 until the read-out displays the number corresponding to the type of engine in your car or boat. For example, when properly calibrated, the tachometer reads "18" for a 4-cycle, 4-cylinder or 2-cycle, 2-cylinder engine.

Now, install the tachometer in your boat or car, hook up the cable and you are set to go. R-E

ROUNDUP

Unusual Electronic Clocks



Pendulums

Displays Chimes

Most of the clocks in earlier articles were table models. Here are details on full-featured wall and mantle models.

FRED BLECHMAN, K6UGT

DIGITAL ELECTRONIC CLOCKS FOR THE home have been available both ready-made and in kit form for several years. More recently, digital clocks for cars have been appearing. Initially these clocks were mechanical, but electronic clocks have been making gains. The latest in sophisticated digital electronic timekeepers, however, are mantel clocks and wall clocks with simulated pendulums and sound. This article discusses three of the more recent designs in detail. An explanation of the circuitry of these timekeepers can teach you a lot about the uses of digital IC's.

Comparison chart

The comparison chart shows the features of each of the clocks covered in this article. The do-it-yourself model is a miniature wall clock 4 inches high and 2 inches wide, using an LCD (*L*iquid *C*rystal *D*isplay) wrist watch.

Some of the terms used in the chart require some explanation. The "pendulums" are electronic and appear to swing as a result of the lighting of the LED's (*L*ight-*E*mitting *D*iodes) in sequence. (Three different ways of doing this will be covered farther on in specific detail.) The "tick-tock" electronic sound simulates the sound of a typical mechanical pendulum clock. The "bongs" are bell-like sounds, produced electronically, that count the hours—two for two o'clock, three for three o'clock and so on. The "chimes" are musical notes arranged in the tune called "Westminster Chimes" that is used by the Big Ben clock in London. The alarms (on those clocks that have them) are 24-hour repeating alarms, so that they can be turned off when they sound and turned back on the next day at the same time.

Grandfather-style clocks

Strictly speaking, none of the clocks described are true "Grandfather" clocks. This is a term that generally describes large hall-type timepieces with chimes, bongs and pendulums. These clocks are all much smaller, and two are wall clocks. However, we call them Grandfather clocks because several have pendulums, sound and early-American-style cases.

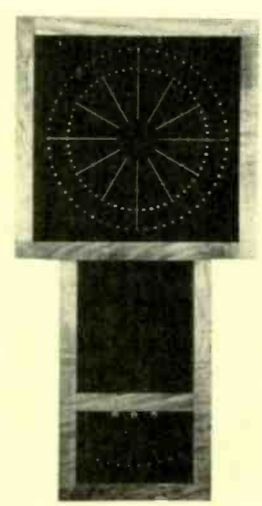
All the clocks have electronic digital displays and use digital circuitry except the Sankyo clock. It is a sort of hybrid instrument and is included because it plays the Westminster Chimes tune. All the clocks have wooden cases except for the Heath *Electronic Clock Chimes* unit, which fits into the case of the *Heath Super-Clock*. All operate from the 117-VAC power line, using the closely regulated 60-Hz frequency for accurate timekeeping, except for the "do-it-yourself" *Micro-Regulator*. It is battery-powered.

When you investigate how these clocks work you will see that no two are alike. Many different approaches have been taken to accomplish essentially the same goal—an accurate digital-display clock in a unique case with unusual conversation-piece features. Since each clock illustrates a different design approach, we'll cover each one in alphabetical order.

Amelect, Inc.

The *model CL7402 Electronic Eye* wall clock has some unique pendulum and timekeeping display circuits; chimes, a tick-tock sound and bongs will soon be added.

The time is read from three concentric circles, with 60 LED's in each of the outer circles and 12 LED's in the inner circle simulating the tips of hour, minute and second hands. The lighted LED in the outer circle shows the seconds, the center circle shows the minutes and the inner circle shows the hours. The black front panel has white lines inscribed 30 degrees apart to represent five minutes, or one hour, as might appear on a conventional clock face. The pendulum at the bottom of the case consists of 10 LED's arranged in arc form. It's fascinating to



AMELECT, INC. CL7402 Grandfather wall-mount clock.

UNUSUAL CLOCKS—COMPARISON CHART

MANUFACTURER OR SOURCE	MODEL (* = BUILT BY AUTHOR)	KIT ($)	ASSEMBLED ($)	DIGITS	SECONDS	PENDULUM	TICK-TOCK	BONG	CHIMES	ALARM	ASSEMBLY INSTRUCTIONS	REMARKS
AMELECT, INC. BOX 367 GOODLAND, IN 47948	CL 7402 GRANDPA WALL MOUNT CLOCK	71.50	95.00	132	√	√	–	–	–	–	GOOD	"ELECTRONIC-EYE" PATENTED READOUT. CHIMES, BONGS AND TICK-TOCK TO BE ADDED. KIT WITHOUT CABINET: $56.25.
BULLET ELECTRONICS BOX 19442E DALLAS, TX 75219	*MG-01 MINI-GRANDFATHER CLOCK	39.95	59.95	4	–	√	√	√	–	–	GOOD	CASE: ADD $14.95 UNFINISHED, $19.50 FINISHED. ASH OR WALNUT.
HEATH COMPANY BENTON HARBOR, MI 49022	GCA-1195-1 ELECTRONIC CLOCK CHIMES	69.95	–	–	–	–	√	√	√	–	EXCELLENT	USE ONLY WITH HEATH MODEL GC-1195 OR GC-1197 "SUPER CLOCKS".
SANKYO SEIKI (AMERICA) INC. 149 FIFTH AVE. NEW YORK, NY 10010	803AL DIGITAL CHIME ALARM	–	59.95	4	√	–	–	–	√	√	–	MECHANICAL-DIGITAL, USING NUMBERED GEARED DRUM. SOUNDS WESTMINSTER CHIMES ON THE HOUR OR ALARM TIME, USING MUSIC BOX.
SOLID STATE TIME BOX 2159 DUBLIN, CA 94566	*ELECTRONIC PENDULUM CLOCK	59.95	69.95	4	√	√	–	–	–	√	FAIR	KIT CASE IS UNASSEMBLED AND UNFINISHED. ASSEMBLED UNIT INCLUDES WALNUT-STAINED CASE. USES PROM FOR REALISTIC PENDULUM ACTION. EASY ASSEMBLY.
"DO-IT-YOURSELF"	*MICRO-REGULATOR	–	–	4	–	–	–	–	–	–	–	BUILD IT FROM BALSA WOOD, LCD DIGITAL WATCH AND INSTRUCTIONS IN THIS ARTICLE.

watch the "seconds" march around the outer circle while the pendulum swings back and forth in exact synchronization—1 second in each direction.

The beautifully made wooden cabinet (available in natural walnut, mahogany, maple or cherry) is shaped like a tall wall clock (the top part is 9½ inches square, and the total height is 19¼ inches); and there is a knick-knack shelf between the clock and pendulum sections. A diagonal version of this clock, *model CL7401A*, without the pendulum is available from Amelect, with or without a base.

Figure 1 is the complete schematic of the *model CL7402* wall clock. Although there are 16 IC's, 142 LED's (132 for the time indication, 10 for the pendulum) and many other parts, assembly is not difficult, just time-consuming. The detailed manual takes you through the assembly step-by-step. Normal assembly precautions should be taken in building this kit and all the others described in this article: Use a small-tip soldering iron, check the solder connections with a magnifier to be sure there are no solder bridges and work slowly and carefully.

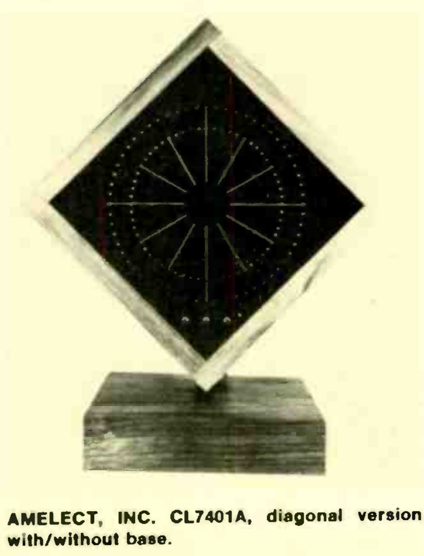
The instructions assume you are building this clock with the optional case. Unless you are a professional cabinetmaker, I recommend ordering the kit with Amelect's preassembled cabinet.

This clock circuitry uses many CMOS (*C*omplimentary *M*etal-*O*xide *S*emiconductor) 4001 Quad 2-input NOR gates. Just to refresh your memory, the positive logic action of a NOR gate can be described thus: The output is logic high *only* when *all* inputs are logic low; if *any* or *all* inputs are logic high, the output is logic low. If you can remember this as you read the circuit explanation, you'll be able to follow the operation of the rather ingenious pendulum and hours-counter circuitry.

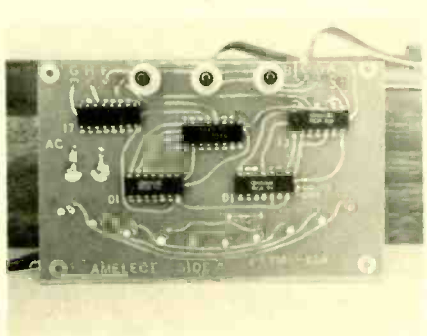
Circuit description

A transformer and full-wave bridge rectifier provide DC voltage. A 60-Hz supply is tapped off the transformer secondary and conditioned to a 60-Hz squarewave by AND gate IC1-b and IC2-a. This conditioned 60-Hz supply is fed to the clock input of divide-by-6 counter IC12. Therefore, the carry output of IC12 is a 10-Hz squarewave ($60 \div 6 = 10$). This 10-Hz output is wired to the clock input of IC14-b, a flip-flop that divides by 2 at output $\bar{Q}$, providing a 5-Hz supply for time-setting the minutes and hours counters.

The pendulum: The 10-Hz output from IC12 is also connected to divide-by-



AMELECT, INC. CL7401A, diagonal version with/without base.



AMELECT CL-7402 pendulum circuit board, front view.

AMELECT CL-7402 time-display circuit board.

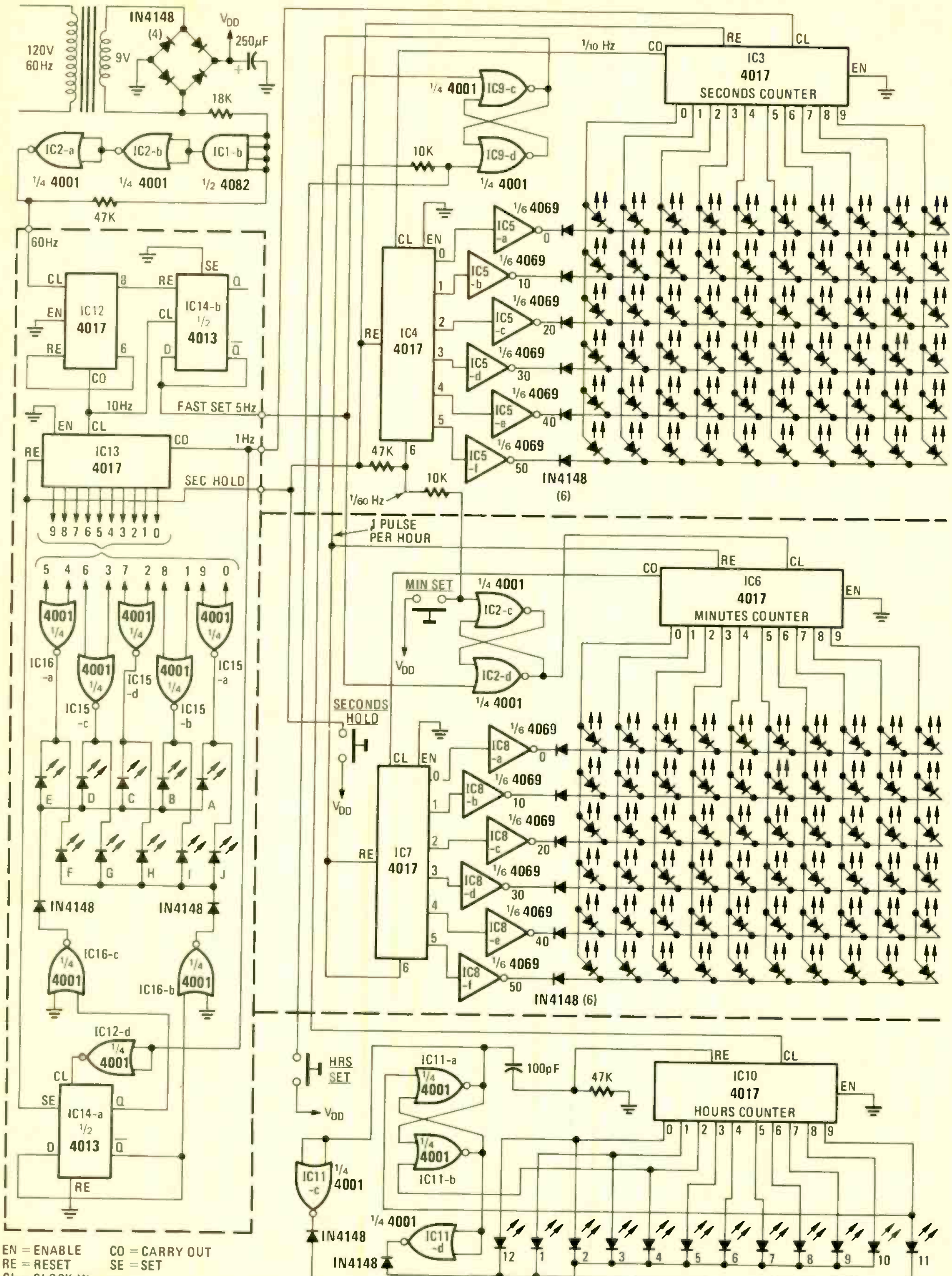


FIG. 1—SCHEMATIC DIAGRAM of the Amelec model CL7402 electronic wall clock. One hundred and thirty-two LED's are for time display and ten simulate the movement of a pendulum.

10 counter IC13. The 0-to-9 counting outputs of IC13 are wired directly to five 4001 2-input NOR gates so that they control 10 LED's one at a time. These LED's form the pendulum (see Fig. 2) that must swing back and forth. To describe this action, assume that IC13's output has just completed a 10-count cycle, so the 0 output is at a logic high. All the other outputs are at logic low, therefore, NOR gates IC15-b, IC15-c and IC15-d and IC16-a all have a logic-high output, thus keeping pendulum LED's B through I off. However, since IC15-a has one logic-high input (from IC13, count 0), its output is at logic low, and this

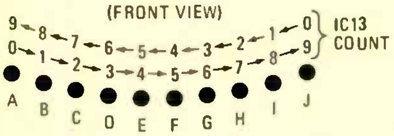


FIG. 2—THE PENDULUM, simulated by twelve LED's, appears to pause at the top of each swing.

enables LED's A and J to light, if they were receiving power from some other source. However, only LED A lights, and here's the reason why:

Referring to IC13, note that the carry output goes to IC12-d. This carry-output pin is at logic high for counts 0 to 4, and at logic low for counts 5 to 9. This polarity is inverted by IC12-d, which clocks flip-flop IC14-a. Because output Q is at logic low at this point, the output of IC16-c is at logic high, providing the current to light LED A. At the next count (1) of IC13, a tenth of a second later, LED B is enabled, then C at count 2, D at count 3 and E at count 4. On count 5, the carry output of IC13 goes to logic low and this is inverted to a *positive-going* edge by IC12-d, thus clocking IC14-a. Instantly, Q goes to logic high and $\overline{Q}$ goes to logic low, which cuts off all the LED's that are connected to IC16-c and enables those that are connected to IC16-b. Therefore, at counts 5 through 9, LED's F, G, H, I and J light in that order.

Here's how to get the pendulum to swing *back* (or have the LED's light in reverse order). Counter IC13 is back to 0, but the IC16-b output remains at logic high. Why? Although the carry output of the counter has gone to logic high, IC12-d has inverted this output to a *negative*-going signal—and IC14-a responds only to *positive*-going signals. So the count progresses, lighting LED's J, L, H, G and F in order on counts 0 through 4. At count 5, however, flip-flop IC14-a sees a positive-going signal and changes state, with Q going to logic low and $\overline{Q}$ going to logic high. This then allows LED's E, D, C, B and A to light in that order on counts 5 through 9, and a complete back-and-forth swing of the pendulum has been completed in 2 seconds. Note that conditions are now exactly as before, so the sequence repeats. Also, LED's A and J each stay lighted for counts 0 and 9, pausing realistically at the top of the swing.

Seconds and minutes counters: The 1-Hz output pulse of IC13 in the pendulum circuitry goes to divide-by-10 counter IC3. Each 0-to-9 output is at logic high for 1 second. These outputs are fed to 60 LED's that are arranged in a 6 × 10 matrix with 6 LED's wired to each of the 10 outputs. However, counter IC4, wired to divide-by-6, is used to ground each LED in the proper sequence. This takes the 0.1-Hz output of IC3 (one pulse every 10 seconds) to operate outputs 0 through 5 of IC4 for 10 seconds each. Whenever any output of IC4 is at logic high, the associated IC5 inverter grounds all 10 LED's in that line—but only the LED that is driven by IC3 for that specific second actually lights.

The output of IC4 in the seconds counter is one pulse every 60 seconds. This supply is fed through NOR gates IC2-c and IC2-d that are arranged as a flip-flop to the minutes counter, which then counts the minutes exactly the same way the seconds are counted.

Hours counter: The output of minutes counter IC7 is 1 pulse-per-hour and is fed through flip-flop IC9-c and IC9-d to hours counter IC10. In this case, however, counter outputs 0 through 9 are wired to four NOR gates (IC11) so that 12 LED's light up in sequence to indicate the hours. Figure 3 shows how this is

HOUR	12	1	2	3	4	5	6	7	8	9	10	11
IC10 COUNT HI OUTPUT	0	1	0	1	2	3	4	5	6	7	8	9
IC11-a OUTPUT	L	L	H	H	H	H	H	H	H	H	H	L
IC11-b OUTPUT	H	H	L	L	L	L	L	L	L	L	L	H
IC11-c OUTPUT	H	H	L	L	L	L	L	L	L	L	L	H
IC11-d OUTPUT	L	L	H	H	H	H	H	H	H	H	H	L

FIG. 3—HOURS ARE INDICATED by LED's lighting sequentially. This is the logic truth table.

accomplished. At midnight or noon, on the count of 0 at IC10, the IC11-a output is at logic low, making the IC11-c output at logic high, disabling LED's 2 through 10. At the same time, the output of IC11-b is at logic high (both inputs are at logic low), making the output of IC11-d low, thus enabling LED 12, which lights, driven by output 0 of IC10. On count 1, LED 1 lights, since the logic gates have not changed state. On count 2, the IC10 output drives IC11-b low at its output (since one input is now low), and this drives the IC11-a output high. The IC11-d output goes high and the IC11-c output goes low. Simultaneously, a positive-going pulse through a 100-pF capacitor resets IC10 to 0 and LED 2 lights. However, LED 12 does *not* light since the low at the IC11-b output makes the IC11-d output high.

Counter IC10 continues counting upward. At the third hour, the count is at output 1 of IC10 and LED 3 lights. The counter output is 2 at the next hour, but reset does *not* occur at this time, since the IC11-a output is already high and LED 4 lights. The count continues up through output 9 which triggers gate IC11-a to a low output, the IC11-b output to high, the IC11-c output to high, thus enabling LED 11 with a low output at IC11-d. This procedure also sets all the logic for hours 12 and 1 until reset by hour 2.

Time setting: A second-hold switch returns the second count to 0 and stops counting at pendulum IC13 by holding the reset at positive voltage. Releasing this switch starts the seconds counting from 0.

Separate switches set the minutes and hours. Both switches use NOR gates for switch debouncing. The "fast-set" 5-Hz signal from the pendulum (IC14-b) advances the LED's around their circle at 5 minutes or 5 hours-per-second when the switch is pressed. Time-setting is thus easy and fast. Amelect, Inc., Box 367, Goodland, IN 47948.

Bullet

Almost all the features one could ask for have been included in this inexpensive Mini-Grandfather Clock. The optional clock case, designed for table or mantel use, is really a necessity for proper packaging of this relatively complex unit. Two large 4½-inch × 6½-inch PC boards are used, interconnected with 17 wires, a special four-position slide switch and a small speaker. The case comes pre-grooved and predrilled; you simply screw it together. No glue is required. A back panel is used to mount the transformer, switch and speaker. You use one large ruby front lens, and the finished clock is 10 inches high, 8 inches wide and 5 inches deep.

The 2-inch-long pendulum is composed of 21 LED's that are arranged in

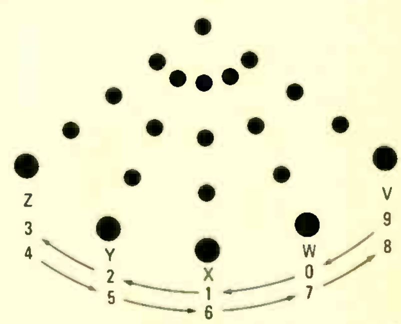


FIG. 4—THE BULLET CLOCK has pendulum simulated by five strings of LED's as radii of the arc.

five "strings" (see Fig. 4). The display has four 0.5-inch-high digits, with a flashing colon and AM-PM indicators. The seconds are not shown but can be set. One PC board contains a conventional-design clock circuit that uses a direct-drive FCM 7010 clock calendar IC. No

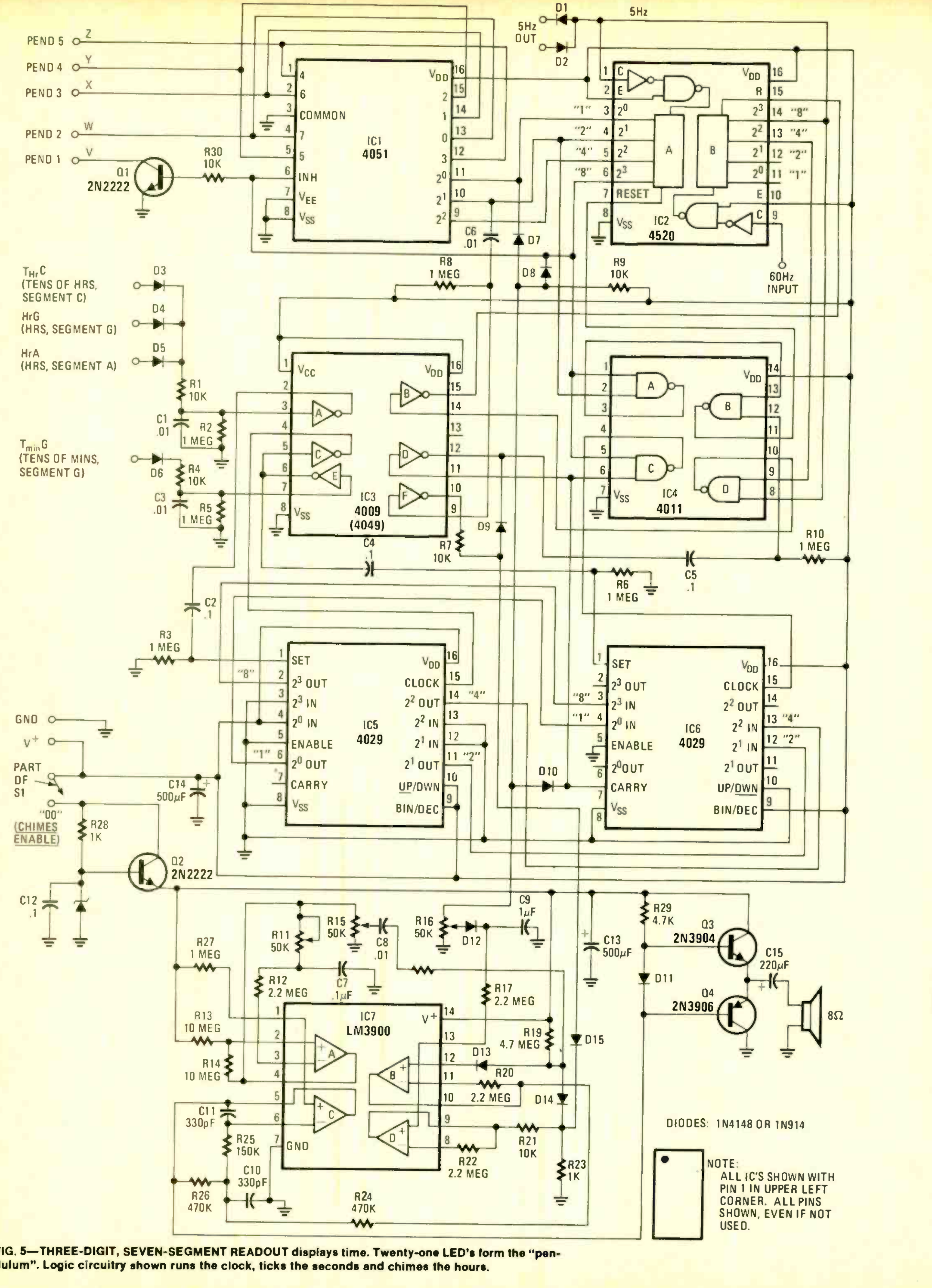
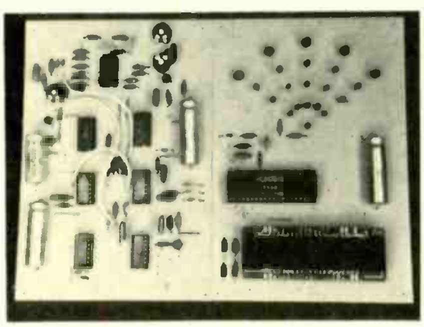


FIG. 5—THREE-DIGIT, SEVEN-SEGMENT READOUT displays time. Twenty-one LED's form the "pendulum". Logic circuitry shown runs the clock, ticks the seconds and chimes the hours.

calendar and alarm functions are provided, however, because they would interfere with the "bong" circuit operation. Resistors are used to connect individual segment outputs of the FCM 7010 to the 4-digit display. The pendulum LED's also mount on this board. To assemble this board is tedious but not difficult. Various points on this board are then connected through wires (ribbon cable) to the logic board, that contains the pendulum, bong and tick-tock circuitry. No chimes are provided. However, a Heath Westminster Chimes is connected to one of these clocks, but this voids Heath's warranty!

BULLET MG-01, completely assembled. Time exposure shows all five pendulum positions.



BULLET MG-01 clock and logic boards side by side before interwiring. The clock board is on the left.

Logic circuitry

If you take time and effort to follow the logic-board circuitry shown in Fig. 5 closely, you will find that it illustrates many basic and inventive uses for IC's.

The logic circuitry shown in Fig. 5 performs three main functions:

1. It "swings" the electronic pendulum;
2. It bongs the hours and counts;
3. It tick-tock's the seconds.

All these functions are performed using the 60-Hz power line, using selected clock-display segment changes to set the bong count and enable function.

The pendulum: The pendulum "strings" shown in Fig. 4 are listed as V, W, X, Y and Z. The object of the pendulum circuitry is to light these strings in sequence so that the pendulum appears to swing back and forth every 2 seconds. The pendulum circuit (Fig. 5) comprises IC1, IC2, and parts of IC3 and IC4. The 60-Hz power supply is received from the clock board, where it has been shaped and has had all negative portions removed. This 60-Hz power supply is fed to pin 9 of IC 2, a dual binary counter. Pin 9 is the input to counter B. Since enable input (pin 10) to this counter is held high, 60 counts-per-second are entered into B which counts up in BCD (*B*inary-*C*oded *D*ecimal). When outputs 4 and 8 of this counter are both high, they trigger gate D (pins 8 and 9) of IC4, a quad 2-input NAND gate. Remember, for a NAND gate the output is low *only* when *both* inputs are high. So, the gate D output is low (pin 10). This low output is fed to inverter B (pin 14) of IC3, a hex-inverting buffer. The inverter B output is therefore high (pin 15), which resets counter B of IC2 through pin 15. Thus, counter B resets on every twelfth pulse (4 + 8), making this a divide-by-12 counter. The 8 output (pin 14) of counter B goes low on every twelfth count. Since 60 counts-per-second are entering, then the counter B output at pin 14 is 60 ÷ 12, or 5 counts-per-second (5 Hz). Through diodes D1 and D2, these high and low states set the clock-display-time hours and minutes, advancing 5 digits-per-second.

The 5-Hz signal is also fed to clock input pin 1 of enabled counter A. It counts up and is reset through NAND gates A and B of IC4 when the count reaches 8 and 2, making this a divide-by-10 counter. Since 5 pulses-per-second enter counter A, it goes through a complete count of 10 in 2 seconds.

The BCD outputs of counter A go directly to IC1, a 1-of-8 decoder, which cycles through eight low outputs—0 through 7. Note that outputs 0 and 7 are connected together and to pendulum string W; outputs 1, 6 and X are also joined, as are outputs 2, 5 and Y and 3, 4, and Z. This makes the corresponding pendulum line low when *either* of the two pins in common goes low as long as inhibit pin 6 is also low. So, for counts 0 through 7, the pendulum LED strings each light for 0.2 seconds in the following sequence: W, X, Y, Z, Z, Y, X, W. But, what about string V? Since IC1 can only count to 8, the next two counts from IC2 counter A light up string V in this manner: On counts 8 and 9, the high on pin 6 (the binary 8 line) drives IC1 inhibit pin 6 high. This stops IC1 from counting. This same high signal simultaneously drives transistor Q1 into conduction, thus grounding pendulum string V. On IC2 count 0, IC1 inhibit pin 6 is released, Q1 is turned off and the sequence repeats, starting with string W again. Note that at each end of the pendulum swing (Z and V), the line stays low for two counts to simulate the pause effect of a real pendulum at the top of its swing.

Now that you're getting confidence in your ability to follow all this logic stuff, let's dive into the bong circuit. Hold on tight and be ready for a rough ride.

Bong circuit: IC7 is a quad op-amp, with sections A, B, C and D. Section A is a squarewave oscillator whose tone is controlled by potentiometer R11. The squarewave is fed to section B through volume control R15. Section B is an AC amplifier whose gain is controlled by a DC voltage supply from section D. Section C is used as a low-pass filter to round off the corners of the squarewave, providing a smoother sinewave-like tone. Transistors Q3 and Q4 amplify the output of section C to drive the speaker. Section D is a DC amplifier, used with potentiometer R16 and capacitor C9 to control the duration of the bong through section B. The four-position switch turns on power to this entire section, so the bong sound may be disabled. Zener diode Z1 and transistor Q2 regulate the voltage. The bong sound is created by IC7 and its associated circuitry, but the digital circuitry controls *when* the bong should sound and how many times it should sound each hour. This is done primarily by IC5 and IC6, with the help of IC3, IC4 and IC2.

Up-down presettable counters IC5 and IC6 do the hours counting, along with IC3 inverters A, C and E, by sensing the time. The tens-of-hours segment C, and hours segments A and G of the clock display are connected through diodes D3, D4 and D5 to inverter A of IC3. When *any* of these segments are high (i.e., lighted), the inverter A input is high and its output is low. When *all three* monitored segments are low (only at 1:00 *AM* or 1:00 *PM*), the inverter output goes high. This charges C2, generating a short pulse to set input pin 1 of IC5. Since a positive voltage is permanently wired to the 2° input (pin 4), the counter clears and presets to 1 (2°) each time the set input receives a positive pulse at 1:00 AM or 1:00 PM. At 20 minutes past the hour, the tens-of-minutes G segment goes high, remaining that way until the beginning of the next hour when it goes low. The high tension at 20 minutes past the hour is detected by D6; changed to a pulse by C3, R4 and R5; double-inverted by inverters E and C; and applies as a positive pulse to clock input pin 15 of IC5. This advances IC5 by one count, since it is wired as an up-counter (pin 10 high). Therefore, at 20 minutes after the hour, an additional count is loaded into IC5. At 1:20, the total count held by IC5 is 2, at 2:20 the count is 3 and so on, until the count resets to 1 at 1:00 AM or 1:00 PM. When segment G of the tens-of-minutes digit goes low at the beginning of each hour, the inverter E output goes high, creating a positive pulse through C4 to set input pin 1 of IC6. Two things happen almost simultaneously: (1) IC6 is loaded with the count existing at the output pins of IC5; and (2) the IC6 carry output of IC6 (pin 7) goes high. Output IC6 is wired to

continued on page 100

BUILD

AM/FM Frequency Display

Part II. *Update your hi-fi with this digital frequency and time display that you can add on or build into a modified AM/FM set. The construction is simple and inexpensive.*

GARY McCLELLAN

IN THE JANUARY 1978 ISSUE, WE WENT step-by-step through the theory of operation and the basic wiring and construction of this time/frequency display that you can add to your AM/FM radio. In effect, it is a 12-hour clock that doubles as a radio frequency indicator.

Now that you have completed the modules, you have two choices in the final packaging. You can build the entire project inside the receiver as I did in a Sansui *model 331* or build the display section as an add-on in an attractive cabinet that sits on top of the radio.

To build everything inside the radio takes a lot of courage. But, if you are an experienced electronics experimenter and constructor and don't mind tearing into a receiver, you should be successful. The advantages are that the finished modification looks very professional. The first thing you must do is to be sure you have room for all the parts. This includes a metal box or enclosure 7 inches high, 4 inches wide and 6¼ inches deep for the display and a box 3¼ inches high, 2⅛ inches wide and 1⅛ inch deep for the interface board. Then, there must be room for transformer T1 and space on the back panel for switches S1 and S2.

Figure 11 shows the additional parts and circuitry needed in the built-in version. The additional parts are mounted using point-to-point wiring on a small piece of perforated board. There are several points of interest in Fig. 11. Display switching is done by taking voltages from the radio function selector switch which selects time, AM or FM. This switch must include a section that switches a positive supply voltage between the AM and FM sections.

The first step is to get the display working properly outside the receiver. Then you connect the switching and modify the receiver mechanically. The switching voltage for the time, AM and FM functions is not critical; it can range from +6 to +24 volts. Interface connections are shown in Fig. 12. This is covered in detail later in this article.

The second, and easier, method is to build the add-on version. This is because you don't have to make extensive mechanical modifications on the receiver. Also, if you have any doubts about your electronic skills, play it safe and build this version. Refer to Fig. 13 for the related wiring on the display board and then to Fig. 12 for the interface connections. Mount the interface board in a type 772 LMB box, or similar enclosure, after punching holes for the RF input and output cables. Then build the display section into a type 463N LMB box or other suitable cabinet.

Connecting to the receiver

Connecting the interface board to the receiver is the toughest part of the project but it's not too hard—you just have to know where to connect several wires. Figure 12 shows the local oscillator sections of a typical radio receiver. Dig out the schematic of your set and locate the local oscillators. In the less expensive sets you may find a single converter section—the same transistor is used for AM and FM. Interfacing is much the same.

Note that you will be working around the tuning capacitor and it is imperative that the interface board be mounted as

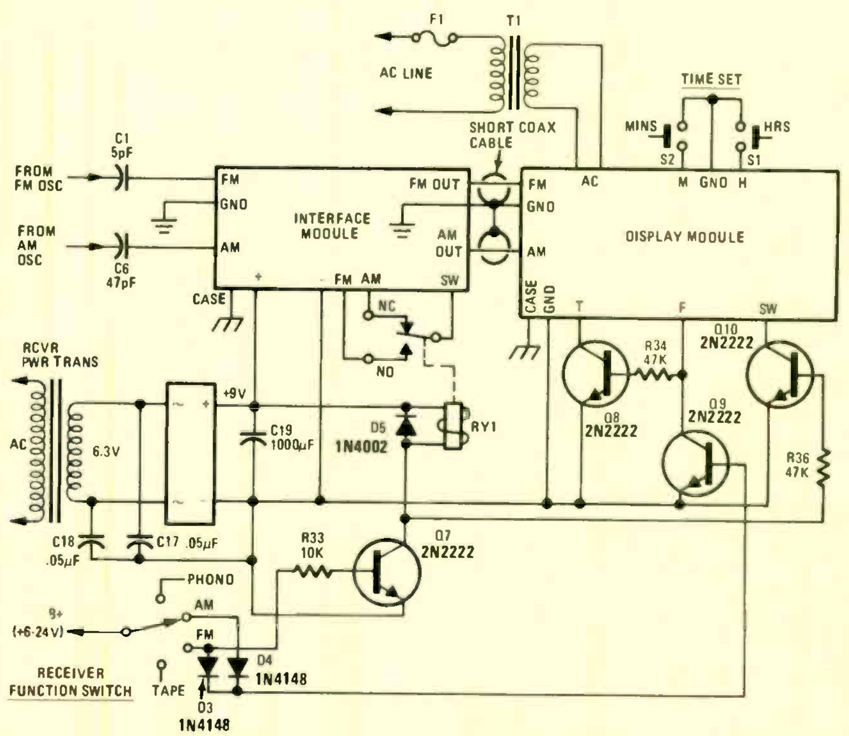


FIG. 11—HOW TIME/FREQUENCY DISPLAY is wired in built-in version. All external parts are mounted on a small piece of perforated circuit board. This arrangement was used in the Sansui receiver.

close as possible to the FM local oscillator. The AM section is not critical—you can even use a short length of coax for the connections.

Back to the schematic, locate the emitter resistor of the FM local oscillator/converter and tie C1 between it and the interface board. Keep the leads under 1 inch in length. Also, be sure to enclose the board in an aluminum utility box as mentioned earlier. Tie a short piece of ground braid from the interface board ground to the radio ground. Repeat this procedure with the AM section. Note that short leads are not as important here.

(For those readers that are concerned about the possibility of detuning the RF circuits caused by the additions, we tried this project with the following results: A slight detuning effect was noticeable only on FM. It was so slight that realignment proved to be a waste of time. In addition to the Sansui model 331, *we tried the time/frequency display on an Arvin receiver, a Radio Shack portable, a Delco AM/FM car radio and a Panasonic table model. All installations worked fine.)*

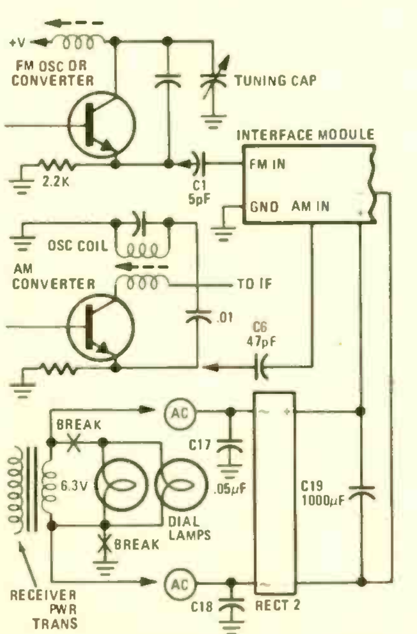


FIG. 12—HOW THE INTERFACE BOARD IS CONNECTED to the receiver. You can use set's dial-lamp supply or separate filament transformer to feed the rectifier.

While you are inside the radio, find a source of 8 volts or more to power the interface board. Usually you can get this voltage by removing the ground from the 6.3-volt AC dial lamp supply and attaching a bridge rectifier and filter capacitor as shown in Fig. 12. This source of power is desirable because it goes off and on with the receiver. If you prefer, substitute a 6.3-volt, 600 mA filament transformer. If you get hum on strong AM stations add capacitors C17 and C18. Route the output cables out of the back and attach a plug PL1 to match the 9-pin tube socket or connector (J1) on the back panel of the main module.

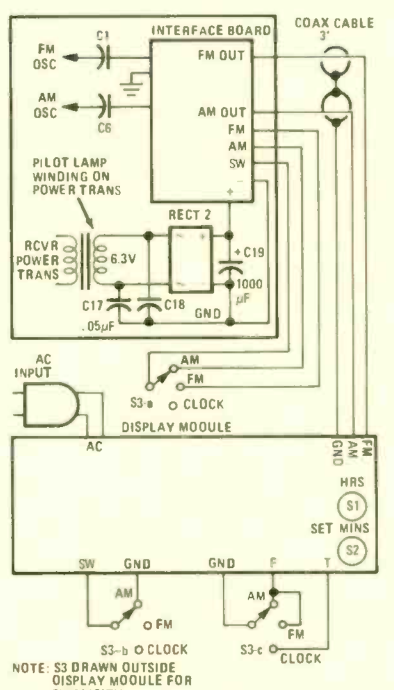


FIG. 13—AUXILIARY CIRCUITRY for the add-on version. Mode switch S3 is installed inside the display module box but is drawn outside for clarity.

Let's try it out

If you used the built-in version, plug in the receiver. The clock colons will light and you will get a reading of 000. Press SET HRS and, after a delay of several seconds, the hours will advance. Do the same with SET MIN and adjust the display for the correct time. Your clock is now working. (Remember the delay whenever you set the clock. This is a built-in feature.)

Turn on the AM radio and you'll get readings such as 640, 1220, 1540 and so on. The last digit will always be 0 in this mode. You should now be able to look up a station, dial its frequency and hear it! Do the same with FM. Note that you get a smooth transition between odd numbers such as 97.3, 97.6 MHz, etc.

The add-on version works the same way, but you must manually change the switch (S3) to read time or radio frequency. You can select the time mode without disturbing the radio—a bonus feature over the built-in version.

There are a few advantages this display has that haven't been mentioned. First, the clock section can be operated as an elapsed-time indicator. When you plug it in—after allowing 5 minutes for the filter capacitor to discharge—the entire clock is zeroed and will begin counting elapsed time in hours and minutes until the interval you are timing has ended. Also, the add-on display will run without the receiver and the receiver can operate without the display so the clock can be handy around the house. **R-E**

All About The S-100 Bus

The 100-line bus that is almost standard equipment in 8080 computer systems. Here we look at the bus and how those 100 lines are used.

WILLIAM BARDEN, JR.

ONE OF THE MOST BENEFICIAL EVENTS IN the microcomputer explosion was the establishment of the S-100 microcomputer bus by MITS, Inc. MITS defined the S-100 bus by the design of the Altair 8800 in 1975. Although they did not intend it as a standard, it soon became one as IMSAI, Polymorphic Systems, Processor Technology, and others brought out microcomputers compatible with the S-100 bus structure. In addition to many microcomputers that use the S-100 bus, there are dozens of manufacturers producing memory boards, I/O boards, speech synthesizers, and other hardware compatible with the S-100 bus structure. This article will explain the basis for the S-100 structure in terms of the microprocessor for which it was designed, the 8080A, discuss the signals of the bus, and describe basic interfacing to the bus.

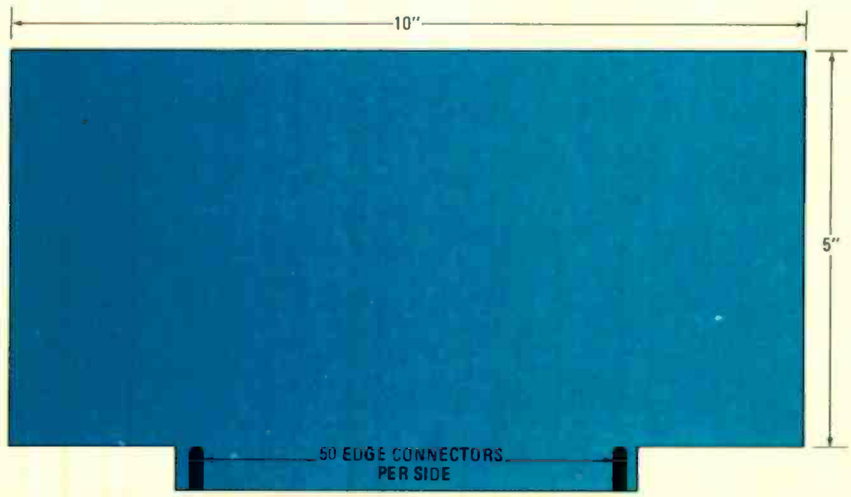


FIG. 1—TYPICAL S-100 BOARD has 100 edge connectors; 50 on each side of the board. These boards are intended to plug into the S-100 mother board.

Physical characteristics

The S-100 bus is a collection of 100 logic and power signals developed from the microprocessor signals. Some signals are logically identical to the signals from the 8080, while others are related, and still others are signals defined by MITS. Physically the bus is represented by a printed-circuit board called a motherboard with 100 parallel foil strips and several 100-pin connectors that are soldered to the foil of the PC board. The typical PC boards that plug into the connectors on the motherboard have 100-pin edge connectors and are the approximate size shown in Fig. 1. A complete S-100 type microcomputer system could consist of the motherboard, power supplies, and a number of S-100 plug-in modules, such as a CPU (*C*entral *P*rocessor *U*nit) module, memory modules, and I/O (*I*nput/*O*utput) modules.

8080 and the S-100

The 8080 microprocessor IC is the heart of most S-100 bus systems, although other microprocessors could be and are being used. Let's first describe the 8080 signals and then see how they relate to the S-100 bus. The pinout of the 8080 is shown in Fig. 2. Most signals are TTL compatible and most are active high.

The 8080 requires three voltages, +5V, −5V, and +12V as indicated. In addition, timing within the 8080 is controlled by a two-phase *non-overlapping* clock represented by Ø1 and Ø2.

Data is transferred bidirectionally between the 8080 and external devices by the data bus, shown as D7 through DO. Data may be instruction data, memory reference data, or input/output data. The 8080 addresses external memory to get the 8 bits of data by means of 16 address lines A15 through A0. Since binary values from 0000000000000000 through 1111111111111111 may be contained on the lines, 65,536 different memory locations can be addressed.

When the 8080 *executes* an instruction, it goes through a predefined *instruction cycle* controlled by the internal logic of 8080. In the course of the cycle, the 8080 first outputs the address of the current instruction on the address bus. It knows the current address from the content of an internal register called a *program counter*. External memory decodes the 16-bit address from the bus and also detects another 8080 signal, DBIN, that indicates that an input (*to* the CPU) operation is to take place. External memory gates the 8 bits of the selected memory location onto the data bus and the CPU strobes in the data some time later in the cycle. During this *fetch* cycle, the

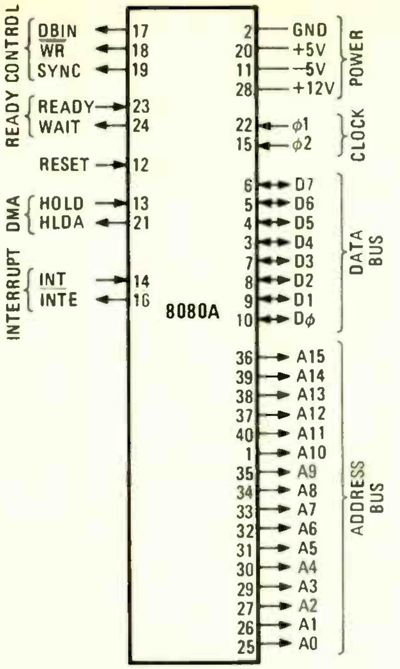


FIG. 2—THE 8080A MICROPROCESSOR IC has the pinout arrangement shown here. Most signals from the IC are TTL compatible.

TABLE 1

Data Bus Bit	Symbol	Description
D0	INTA	Interrupt acknowledge
D1	WO	Indicates a write to memory or output is about to occur
D2	STACK	Indicates the address bus holds stack address
D3	HLTA	Acknowledge for HALT instruction
D4	OUT	Output device address on address bus; data bus will hold output data when WR active
D5	M1	CPU in fetch cycle for first byte of instruction
D6	INP	Input device address on address bus; data bus will accept input data when DBIN active
D7	MEMR	Data bus will be used for memory read data

first byte input represents the complete instruction if the instruction is a one-byte instruction. If the instruction is a two- or three-byte instruction, this first portion of the fetch cycle picks up on the first byte of the instruction. By decoding this first byte (the *operation code*), the CPU knows whether or not to make none, one or two more memory reads to obtain the remainder of the instruction.

When the CPU has the complete instruction, the fetch cycle is completed and the *execution* cycle begins. There are a wide variety of instructions the CPU may execute, but they essentially involve internal functions, reading (again) from memory, writing to memory, reading from an I/O device, or writing to an I/O device.

Reading from memory is similar to the fetch cycle. The address bus holds the memory address of the 8 bits of data to be read and signal DBIN is enabled. If data is to be written to memory, the address bus still holds the memory address of the data to be read, but signal DBIN remains low, and at the proper time signal WR is brought low to strobe the data into external memory. When the CPU executes a read or write (I/O) instruction, the sequence is similar to a memory read or write. The address bus contains the I/O address on lines A7 through A0, as there are only 8 bits available for an I/O address in an I/O instruction.

If data is to be input to the CPU from an external I/O device, signal DBIN is once again high and if an output operation is taking place, DBIN is low and WR is low. How does the I/O device know whether the input or output is from memory or from itself, though? For example, the CPU could read data from memory location 55 and immediately follow that instruction with an input from I/O device 55! To differentiate between I/O addresses and memory addresses, additional signals called status signals are used. There are eight status signals and they are output on the data bus during the beginning of each machine cycle during the time when signal SYNC is high. The status bits and what they represent are shown in Table 1.

The READY signal of the 8080 is an input signal that enables the 8080 to interface with slow memory or I/O devices. If the memory cycle time is not fast enough to allow the memory to respond with data for the CPU, for example, the memory logic may bring down signal READY to a logic 0 level. This causes the CPU to insert an extra clock period in the instruction cycle for as long as READY is low. When in a "not ready" condition, the CPU responds with a WAIT signal that is output to external devices.

The RESET signal is an input that accomplishes what the name describes. It is used before program execution to reset the program counter to zero. Program execution then proceeds from memory location to zero, as previously described for the fetch operation.

The 8080 has the capability, as do most microprocessors, of temporarily suspending instruction execution for *direct-memory-access*, or DMA. DMA permits external memory to be accessed independently of the CPU for high-speed I/O that cannot afford the time required for the CPU to issue a simple byte at a time. When an external I/O device *controller* makes a HOLD request, the CPU responds with an HLDA (Hold Acknowledge), indicating that it has released the address and data buses to the external device. (This is important to avoid the conflict of use of the buses by both the CPU and the external device controller simultaneously.) Normal CPU operation resumes when the external device controller brings the HOLD signal to a logic 0 level.

The remaining two 8080 signals, INT and INTE, are associated with CPU *interrupts*. An interrupt is an external signal that forces the CPU to suspend program execution at the current instruction location and transfer control (or jump) to a predefined address that contains an interrupt program. An example of this might be a CPU dedicated to running a control program that is interrupted when a Teletype key is depressed. The external signal causing the interrupt is INT, which causes an interrupt only if the control program has enabled the interrupt condition by setting an internal interrupt enable flip-flop. The state of the interrupt enable flip-flop is brought out on line INTE.

The above description outlines the 8080 signals necessary to interface external devices to the microprocessor. Now let's see what MITS did with the microprocessor signals to construct a working microcomputer with a control panel, memory and I/O. What they did in the 8800 design defines the S-100 bus.

S-100 bus signals

Power signals: the +8V, +18V and −18V unregulated lines are provided on the S-100 bus. These voltages are regulated to +5 and other required voltages by on-board regulators for each S-100 module.

Data bus: The 8080 data bus is buffered in the S-100 configuration to provide a greater driving capacity. In addition, the data bus is converted from a bidirectional bus to two unidirectional buses. Lines DO7 through DOØ is the data bus coming out from an S-100 CPU while lines DI7 through DIØ is the data bus going into an S-100 CPU. The ouput lines are enabled by S-100 bus signals DO DBS that connects to tri-state buffers (see Fig. 3).

Address bus: Lines A15 through AO of the 8080 are buffered in the S-100 bus system; the tri-state enable signal is ADDR DSBL (see Fig. 3).

The six command and control ouputs described for the 8080—SYNC, DBIN, WAIT, WR, HLDA and INTE—are logically unchanged, but buffered in the S-100 bus system. Their tri-state buffer enable signal is C/C DBS. The six signals are renamed PSYNC, PDBIN, PWAIT, PWR, PHLDA and PINTE (see Fig. 4).

The eight status bits of the 8080 are latched into a status latch, as shown in Fig. 5. The status bits listed in Table 1 now become SINTA, SWO, SSTACK, SHLTA, SOUT, SM1, SINP and SMEMR. Status is disabled by signal STATUS DSBL. A memory write signal MWRITE is developed from SMEMR.

Four inputs to the 8080, READY, HOLD, INT and RESET are either buffered or latched from the S-100 bus signals PRDY/XRDY, PHOLD, PINT and PRESET.

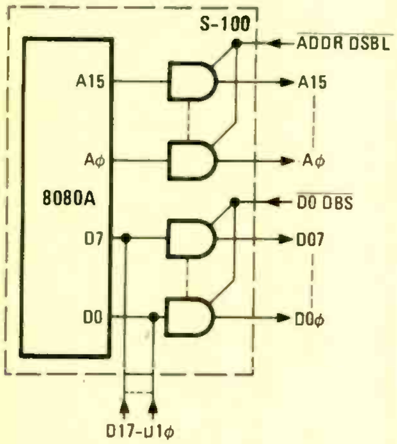


FIG. 3—IN THE S-100 BUS, the data lines from the 8080 are buffered by tri-state buffers as shown in this diagram.

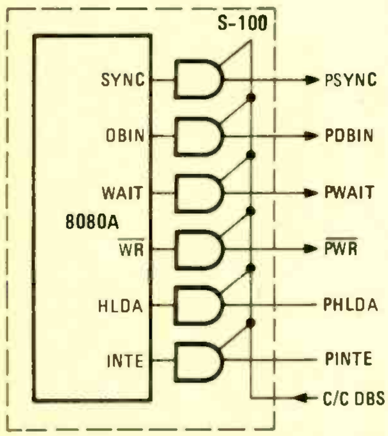


FIG. 4—SIX COMMAND AND CONTROL outputs are also buffered for the S-100 bus. These signals and the buffering can be seen here.

The Ø1 and Ø2 clocks are developed in the S-100 CPU circuitry and routed to the system via S-100 bus outputs Ø1, Ø2 and CLOCK. The latter is Ø2 inverted. Signal POC, Power on Clear, is developed in the power supply logic and indicates when system power is on.

The above signals are S-100 bus signals intimately associated with the 8080, and together with unused pins cover about 80% of the S-100 lines. The remainder of the lines are for the most part associated with *vectored interrupts* and *control panel functions* in the microcomputer.

Signals VI0 through VI7 are eight vectored interrupt lines. The 8080 provides eight *vectors* or pointers to interrupt locations with proper external logic. Signals V10 through V17 are S-100 system signals fed to an interrupt board that would implement these functions.

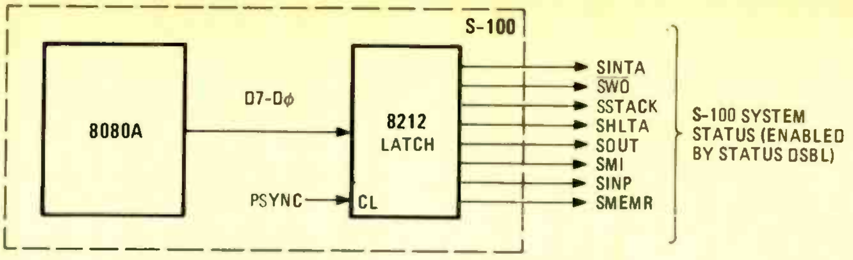


FIG. 5—EIGHT STATUS BITS of the 8080 are latched into a status latch as shown here. When desired, status is disabled by signal STATUS DSBL.

Control panel signals in an S-100 microcomputer system may be present on the S-100 motherboard that *does* have a control panel or they may be strapped to the proper logic level. Some control panel signals may be simply deprived from switch settings. Signals PROT and UNPROT would typically be derived from a switch on a front panel that controls alteration of data in memory. Signals PRESET or EXT CLR may be derived from a momentary switch for system reset and clear of external devices. Signals RUN and SS indicate that the system is running or that a single-step switch is being used to step through a program, respectively. Signal SSWI indicates that a data transfer from the control panel sense switches is to take place, for example, altering memory contents.

Although most manufacturers that make S-100 motherboards have made their boards consistent with the above signals, some incompatabilities do exist, especially in cases where undefined pins have been used to carry required new signals. Boards of this kind are not completely compatible with the S-100 bus and may not be used without some modification.

An S-100 system

Now that we've seen the 8080 signals and their relation to S-100 bus signals, let's look at a typical S-100 bus system. We'll assume that the system uses an 8080 CPU card that contains only the 8080 microprocessor and related logic. This will probably consist of buffering and an 8212 status latch. Many of the S-100 bus signals are generated on this board, such as A15 through A0, the status signals and clock signals. Alternatively, the CPU board might contain a Z-80 or even a 6800 microprocessor. However, if a different microprocessor is used it must generate compatible S-100 signals. In many cases, additional logic will have to be added to the CPU board to create S-100 signals. See Fig. 6 for a look at the kinds of signals that may have to be added.

The memory boards in the system use the 16 address lines as inputs to select the memory location being accessed. If the board is an 8K (or 8192) byte board, 13 lines, A12 through A0, are used to select the specific memory location of the 8K while A15 through A13 are decoded to

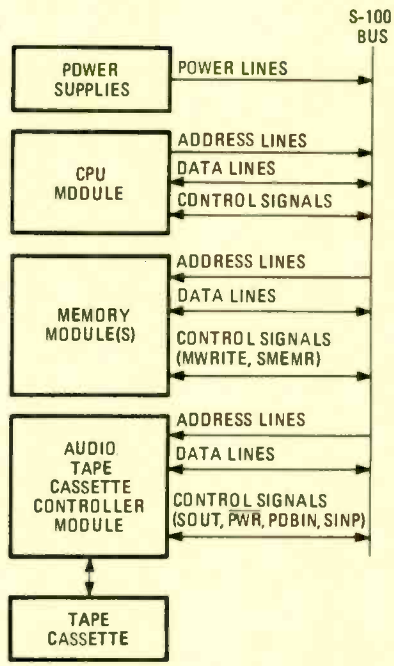


FIG. 6—IF AN 8080 IS NOT USED as the CPU, additional logic may have to be added to create S-100 signals.

select which of the 8K boards is being accessed. Signal MWRITE is used to select the read or write function for the memory IC's on the board, while SMEMR gates the data out to lines DI7 through DIØ on a memory read.

A typical I/O board in the system is an audio tape controller. The address of the controller is decoded from address lines A7 through A2. Address lines A1 and A0 are used to decode functions of the controller such as read and write. Data is output from the controller on lines D07 through DOØ when the controller address is selected on lines A7 through A2, when a write function is specified by A1 and A0 and when SOUT and PWR are logic 1 levels. Signal SOUT indicates "output address available" and PWR indicates "data available." Data is input from the controller from lines DI7 through DI0 by decoding signals PDBIN, SINP and A7 through A0. Signal PDBIN is the 8080 DBIN (input address available).

The above describes some of the rudiments of S-100 bus operation. Although the S-100 bus has lately taken its share of abuse, it does *work*, it's adaptable, it's fairly efficient, and most importantly it is one of the few standards in an otherwise chaotic hobby. **R-E**

ON THE S-100 BUS

This chart is a partial listing of manufacturers of hobby computer products that fit (plug into) the S-100 bus. To conserve space, we have not listed addresses or phone numbers here. **A complete list of addresses and phone numbers is available FREE.** Simply circle **number 120** on the Readers Service Card inside the rear cover of this issue. If we've left anyone out of this directory we'd like to know about it. Send us data on any missing entries so we can include them in the future. This is the first in a continuing series of directories that will cover all aspects of hobby computers. Look for more directories covering other bus systems later this year.

MANUFACTURER	CPU	FRONT PANEL	MEMORY: RAM	MEMORY: PROM	INTERFACE: SERIAL	INTERFACE: PARALLEL	INTERFACE: CASSETTE	INTERFACE: VIDEO	FLOPPY CONTROLLER	MUSIC SYNTH	VOICE SYNTH	MATH	OTHER
Artec Electronics			●										Prototype; Wirewrap
Canada Systems													Real Time Clock; AC Controller
Central Data	●		●										
CMC Marketing	●		●		●	●			●				A/D Converter; D/A Converter
Computalker Consultants											●		
Cromemco Inc.	●		●	●				●	●				A/D Converter; D/A Converter
Cybercom								●					
Dajen Electronics													2708 Programmer
Databyte													Logic Analyzer
DC Hayes Associates					●								
Digital Group, The						●							AC Controller; DC Controller
Digital Research Group			●	●									
Electronic Control Technology	●		●										Extender; Prototyping
Equinox Div.		●	●										
Extensyn Corp.			●						●				
Godbout			●										Mother, Extender, Control, Terminator Boards
Heuristics											●		
Imsai	●		●		●	●	●	●	●				
International Data Systems													Clock; Data Access; Frequency Counter; Modem; Clock; D/A Converter
I.O.R.					●	●							
Ithica Audio	●		●	●									Prototype; Blank
Micropolis									●				
Micro Systems Development								●	●				
MITS	●	●	●		●	●	●	●					
Mountain Hardware													AC Controller
National Multiplex													System Controller
Peripheral Vision					●	●							
North Star Computers	●	●	●						●			●	
Priority One Electronics													Extender; Universal Plugboard
Processor Technology			●		●	●	●	●					
SD Sales	●		●										
Solid State Music										●			
Tarbell Electronics							●		●				
TDL	●		●				●	●					System Controller
Thinker Toys					●	●	●	●					
Trace Electronics			●										
Vector Graphics			●			●	●	●	●				
Vector													Universal Plugboards
Vista Computer									●				
Xitex Corp.													Video Terminal
Xybek				●									

HI-FI

New RIAA Equalization For Records

The playback curve of your hi-fi phono system must be the converse of the equalization curve used by the record maker. New equalization curves promise better overall performance

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

PERHAPS NOT MANY HI-FI ELECTRONICS manufacturers (or even audiophiles) are aware that the Record Industry Association of America (RIAA) has, recently approved a brand-new recording and playback equalization curve. Before you panic and start taking your preamplifier, amplifier or receiver back to the manufacturer for modification, let's review some basic facts regarding record equalization, both at the recording and at the playback ends.

Back in the late 1940's and early 1950's, when long-playing records were first invented, almost every record manufacturer used his own form of record equalization. There were practically as many standards as there were record companies. Manufacturers of preamplifiers (separate hi-fi components were the rule in those days) prided themselves on the number of equalization-switch positions they offered on their products' front panels. Some preamplifiers featured as many as 36 different playback curves, and you had to change the setting every time you played a record from a different company.

Why equalization?

You will understand how equalization works during the recording process by considering how a magnetic cutting head works. Normally, such cutting heads operate as constant-velocity devices; that is, given a flat-frequency response input to the cutting head, the cutting stylus moves with constant velocity regardless of the frequency. However, the lower the frequency to be recorded, the farther the cutting stylus must move to maintain its constant-velocity characteristic, as shown in Fig. 1.

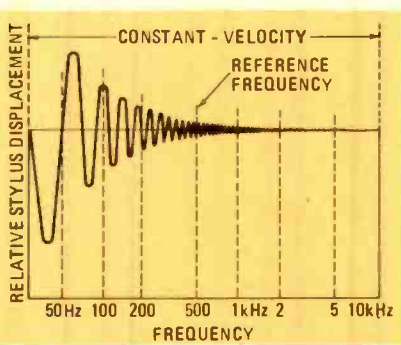


FIG. 1—CONSTANT-VELOCITY CUTTING HEAD requires greater stylus displacement for lower input frequencies.

In the case of a long-playing disc, allowing the cutting head to behave as a constant-velocity device all the way down to the lowest frequency would have meant that grooves would have had to be spaced quite far apart if those high-amplitude, low-frequency undulations were not to cut through from one groove to the next. Early on, it was decided to use a constant-velocity/constant-amplitude characteristic so that below a certain frequency, the cutting stylus moved the same amount from side to side regardless of frequency. Figure 2 shows an idealized constant-velocity/constant-amplitude characteristic with a 500-Hz turnover frequency (the frequency at which stylus motion changes from constant velocity to constant amplitude).

In addition to permitting closer groove spacing by changing the cutting mode at the turnover frequency, recording companies also began to pre-emphasize high frequencies—but for quite another reason. In the high-frequency region, the cutting head again operates in the constant-velocity mode, which means that the *amplitude* of the wiggles in the groove becomes progressively smaller. At very high frequencies, the amplitude of the signal undulations may not be much greater than the inherent surface noise irregularities in the vinyl disc itself. By boosting highs during the recording process, the recording company effectively spreads the distance between signals and noise, or, to put it simply, improves the high-frequency signal-to-noise ratio.

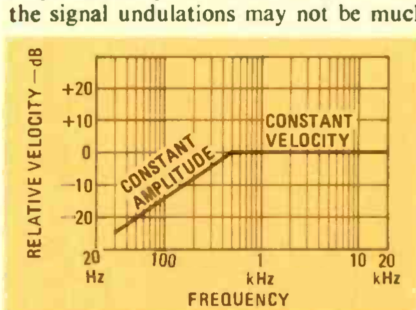


FIG. 2—CONSTANT AMPLITUDE/CONSTANT VELOCITY characteristic used in cutting records.

An idealized two-part recording equalization is shown in Fig. 3. Frequencies below 500 Hz are attenuated, while frequencies above 1 kHz (for example) are boosted. From this basic idea came the

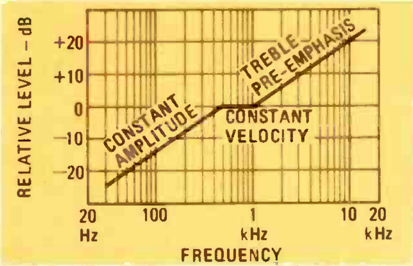


FIG. 3—S/N RATIO at high frequencies is improved by introducing treble pre-emphasis to the constant amplitude/constant velocity characteristic.

many variations of equalization curves that were introduced in early preamplifiers.

RIAA standardization

In June, 1953, the disc recording industry, concerned with the variety of equalization curves required to properly play back recordings from different manufacturers, adopted a standard recording and playback curve that was approved in March, 1964, by both the RIAA and the NAB (*N*ational *A*ssociation of *B*roadcasters). In a very short time, all discs manufactured worldwide were using these standard curves. The official playback curve used at that time is shown in Fig. 4. This characteristic can be obtained by using a circuit consisting of a parallel L/R network having a 3180-μs time constant, a series R/C network having a 318-μs time constant and a parallel R/C network having a 75-μs time constant. "Zero" reference level is taken at 1000 Hz. An actual frequency response plot taken at the output of a precision phono preamplifier shows how closely the playback curve corresponds to the point-by-

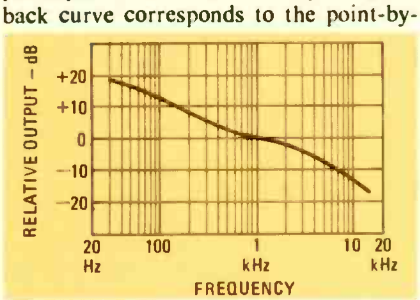


FIG. 4—OLD STANDARD RIAA playback equalization curve has been in use for many years.

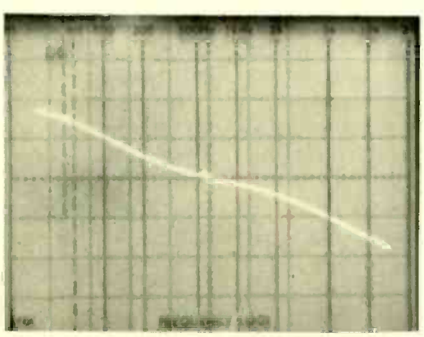


FIG. 5—ACTUAL PLAYBACK EQUALIZATION CURVE of old RIAA standard.

point plot shown in Fig. 4. This plot was stored on the scope face of a spectrum analyzer and is shown in Fig. 5.

In both Fig. 4 and Fig. 5, the frequencies are specified (and shown) only in the 30-Hz to 15,000-Hz range. At the time the RIAA curve was adopted, there were virtually no recordings that contained frequencies beyond those low and high extremes. Even if they did, the likelihood was that home equipment would not have faithfully reproduced such frequency extremes in any case.

However, consider the situation of a typical amplifier manufacturer of the time. Since the low-frequency time constant was set at 3180 μs, in theory at least, if a manufacturer's amplifier (or preamplifier) had a response below 30 Hz, the bass boost continued to rise, as shown by the extended curve in Fig. 6. If the manu-

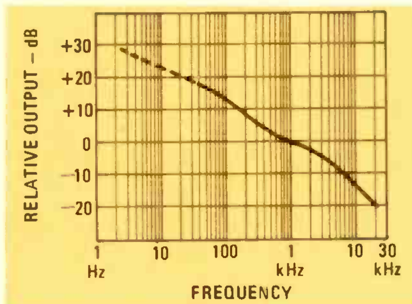


FIG. 6—MANY EQUALIZATION CIRCUITS provide bass boost below the low frequency limit of the old RIAA curve.

facturer did nothing to rolloff the bass response of his product, bass boost provided in the preamplifier-equalizer circuit would be around 20 dB at 20 Hz, 23.0 dB at 10 Hz and, if the amplifier response continued to be even lower (for instance, to 5 Hz) the bass boost would be around 26 dB at that ultra-low subsonic frequency.

Most early records did not contain frequencies below 30 Hz, and amplifiers and preamplifiers did not have uniform response much below 20 Hz either. Therefore, in most cases, there was a natural rolloff in response caused by the amplifier circuit itself rather than by any specific equalization circuitry built into the preamplifier section.

But now, consider what has been happening in amplifier and preamplifier technology in the past few years. Today, it is not uncommon to find amplifiers, preamplifiers and even receivers that have a flat response all the way down to 10 Hz or even lower. Some new so-called DC amplifiers can amplify signals as low as "0 Hertz," or DC! Such amplifiers, when combined with preamplifiers whose low-end equalization rises at a 6-dB-per-octave rate below the RIAA-specified 30-Hz point, can amplify subaudible tones at an increasing rate.

Rumble

Consider what this extreme bass boost does to turntable rumble. In the early days, most turntables used 4-pole motors that were coupled to the turntable platter either via an idler wheel or via a belt. A 4-pole synchronous motor rotates at 1800 rpm. This translates to 30 revolutions-per-second, or a fundamental vibrational rate (based on the premise that the worst rumble occurs at a once-per-revolution rate of the motor shaft) of 30 Hz. This frequency is, of course, well within the audible range and there isn't much you can do about it.

Today, however, many turntables use motors that rotate at a slower speed. A 16-pole motor (commonly used in a popular line of turntables) has a 450-rpm speed, which translates to a fundamental rotational vibration of only 7.5 Hz. If there is significant vibration transmitted from the motor to the cartridge via the pickup arm, that frequency will be needlessly amplified by some 24 dB referenced to a 1000-Hz signal if the amplifier has flat response down to that low frequency.

Not surprisingly, many amplifier and preamplifier manufacturers have been aware of this problem for some time and have incorporated so-called subsonic cutoff filters that rolloff response beginning at some frequency at or below 20 Hz. While it is true that you cannot hear rumble that occurs at frequencies below 20 Hz, you have only to remove the front grill of one of your speakers while playing a silent groove of any record on your turntable with the volume turned up high to see what such low frequencies do to the woofer cone. You may find that it is wobbling wildly in and out at some subsonic rate that, although inaudible, places the speaker cone in its nonlinear operating range during much of the time that it is trying to reproduce the *music* that you *do* want to hear.

For these reasons, the RIAA has adopted a revised playback curve as well as a slightly revised recording curve. Both new curves are shown in Fig. 7. Note that

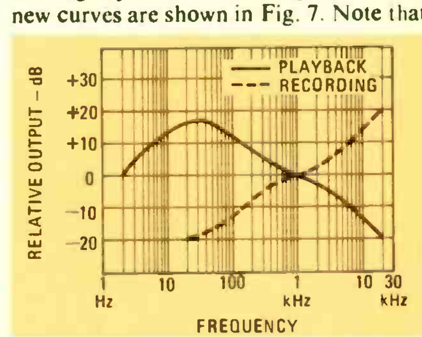


FIG. 7—NEW RIAA EQUALIZATION CURVES. Note the rolloff in playback response in the low frequency region.

the response peak for the bass section of the playback curve now occurs at 31.5 Hz and begins to rolloff below that frequency. The rolloff occurs by introducing a fourth R/C network with a 7950-μs time constant to the three existing networks that make up the equalization circuit. The high end of the equalization curve is

Should your career in electronics go beyond TV repair?

CREI prepares you at home for broader and more advanced opportunities in electronics— plus offers you special arrangements for engineering degrees

There is no doubt television repair can be an interesting and profitable career field. TV repair, however, is only one of the many career areas in the fast growing field of electronics.

As an indication of how career areas compare, the consumer area of electronics (of which TV is a part) makes up less than one-fourth of all electronic equipment manufactured today. Nearly twice as much equipment is manufactured for the communications and industrial fields. Still another area larger than consumer electronics is the government area. That is the uses of electronics in such areas as research and development, the space program, and others.

Just as television is only one part of the consumer field, these other fields of electronics are made up of many career areas. For example, there are computer electronics, microwave and satellite communications, cable television, even the broadcast systems that bring programs to home television sets.

As you may realize, career opportunities in these other areas of electronics are mostly for advanced technical personnel. To qualify for these higher level positions, you need college-level training in electronics. Of course, while it takes extra preparation to qualify for these career areas, the rewards are greater both in the interesting nature of the work and in higher pay. Furthermore, there is a growing demand for personnel in these areas.

Unlike most other home study schools, CREI programs are devoted exclusively to preparing you for careers in advanced electronics. All of CREI programs are college level. And CREI gives you both theory and practical experience in advanced electronics.

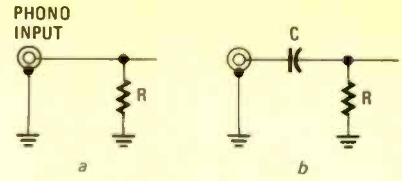
Unique Design Lab

A unique feature of CREI training is its Electronic Design Laboratory Program, which trains you to actually design circuits. It also helps you understand the theories of advanced electronics and gives you extensive practical experience in such areas as tests and measurements, breadboarding, prototype construction, circuit operation and behavior, characteristics of electronic components and how to apply integrated circuits.

Frequency*	Relative level (dB referenced to 1 kHz) "Old" RIAA	"New" RIAA	Net Difference
100	+13.11	+12.9	−0.21
80	—	+14.2	—
70	+15.31	—	—
50	+16.96	+16.3	−0.66
40	—	+16.8	—
30	+18.61	+17.0**	−1.60
20	—	+16.3	—
16	—	+15.4	—
8	—	+11.2	—
4	—	+5.7	—
2	—	−0.2	—

*For frequencies above 100 Hz, old and new curves are the same.
**Actually listed as 31.5 Hz in new RIAA curve.

TABLE I—COMPARING THE OLD AND NEW RIAA EQUALIZATION curves at specific frequencies.



VALUES FOR 7950 TIME CONSTANT

IF R IS NOW	CAPACITOR ADDED SHOULD BE
22K OHMS	0.36μF
47K OHMS	0.17μF
100K OHMS	0.08μF

FIG. 8—TYPICAL PHONO INPUT JACK arrangement in the preamplifier stages is shown in *a*. Simple modification to obtain new RIAA playback equalization is shown in *b*.

extended to 20 kHz because recording at this frequency is not only practical but is, in fact, taking place on many current discs. At the high end of the playback curve, however, no change in preamplifier equalization circuitry is required, since the existing 75-μs rolloff network does the job out to 20 kHz and beyond. The curve has simply been extended to recognize points out to 20 kHz.

With respect to the low end of the playback curve, adding the fixed rolloff network will make a difference. Table I shows the old and new RIAA bass-boost values from 100 Hz down. Next to these values are listed the *difference* (in dB) between the old and new equalization curves. Note, for example, that while at 100 Hz the difference is hardly significant (0.2 dB), at 50 Hz it amounts to 0.66 dB, and at 30 Hz (the previous end point of the old curve) it is more than 1.6 dB!

Such a difference in response may not seem significant, but when you compare the subsonic region of Fig. 6 with the now specified subsonic response of the new RIAA curve, the importance of this change becomes apparent.

In a very real sense, the use of the new playback curve in preamplifiers, integrated amplifiers and receivers should significantly reduce turntable rumble quite audibly. Using the rumble frequency of 7.5 Hz cited earlier, we have already noted that an amplifier not equipped with any form of subsonic rolloff would provide about 24 dB of boost at that low frequency. Based upon the new RIAA curve, boost at the 7.5-Hz frequency will be down to only around 11.0 dB—*an improvement of 13 dB* at that particular rumble frequency.

Older equipment

Equalization circuit values differ from manufacturer to manufacturer and from product to product (usually, equalization constants are included in a negative-feedback network around the two or three amplification stages contained in the low-level preamplifying section of a preamplifier or amplifier). It would therefore be impossible to advise what new resistor and capacitance values to add to your present preamplifier circuitry so that it conforms with the new RIAA curve. A simpler modification can be made, assuming that the manufacturer of your equipment has no other suggestions or recommendations. As you know, most phono input jacks are terminated with a 47,000-ohm resistor, which magnetic cartridge manufacturers recommend as the optimum load resistance. By adding a high-quality miniature Mylar capacitor of appropriate value, you can easily obtain the rolloff characteristic required by the new RIAA curve. Figure 8-a shows the typical phono input jack arrangement, with the load resistor wired directly across the phono input cartridge. In some instances, you may have to follow the shielded cable to its other end if no resistor is directly wired across these jacks. Figure 8-b shows a small capacitor added in series with the signal side of the load resistor, and the accompanying table in Fig. 8 shows values of capacitance to be used with commonly found load-resistor values.

It is to be hoped that designers and manufacturers of preamplifiers, amplifiers and receivers will quickly incorporate the new RIAA playback curve in their future products, since it will benefit record reproduction (regardless of turntable equipment). This is an improvement that has been a long time coming. **R-E**

CCD memories will replace MOS and core RAM's

Charge-coupled device (CCD) memories, while in some cases still being lab-tested, will be the next device adopted by the computer industry. CCD's will replace fixed-head disc storage, particularly low-end floppy discs. The CCD format of storing data is similar to that of mechanical discs, which will simplify its adaptation to present systems.

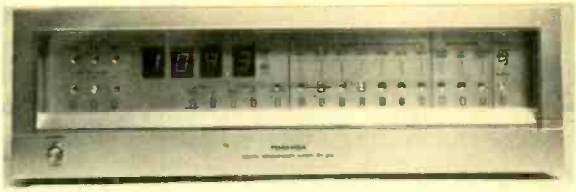
Texas Instruments and Fairchild are presently shipping samples of 65K-bit devices, while Intel Corporation and Motorola have devices that are still in the planning stage. Users will have a choice of three different CCD's, with the first size (65K) large enough to be a cost-effective replacement for mechanical storage units. However, it is expected that the main use for the CCD's will be in auxiliary or main-storage applications, completely replacing MOS and core RAM's. Before this can happen, however, entire systems will have to be redesigned to incorporate the CCD's.

Texas Instruments introduced its 65K IC last March; Fairchild produced a scaled-up version on its earlier 16K devices; and Intel Corporation plans to introduce samples of its 65K device this spring. Motorola will produce a similar device, using Fairchild masks. The Fairchild and TI devices are organized in 16 × 4K × 1 format (or 16 randomly accessible shift registers, each one 4,096-bits-long and arranged in an interleaved serial-parallel-serial structure that keeps power low and operating rate high). The Intel part looks like a RAM, with 256 loops of 256 bits each . . . to shorten latency time . . . and is also completely TTL compatible.

All manufacturers agreed that although CCD's will be harder to use than dynamic RAM's, the low-cost factor will dictate the success of the anticipated changeover to CCD's. It is estimated that the de. ces will have a minimum 4:1 cost advantage over RAM's.

The real key, however, to the final acceptance of CCD's, according to one spokesman, will be in *standardization* of design. At present, both Fairchild and TI use 16-pin devices and 16 × 4K × 1 arrays; Fairchild's unit comes in the standard 0.3-inch-wide package, TI's in a 0.4-inch-wide configuration. And Intel uses an 18-pin device in a 0.3-inch-wide package.

Radio-Electronics Tests Toshiba ST-910 FM Tuner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CIRCLE 101 ON FREE INFORMATION CARD

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

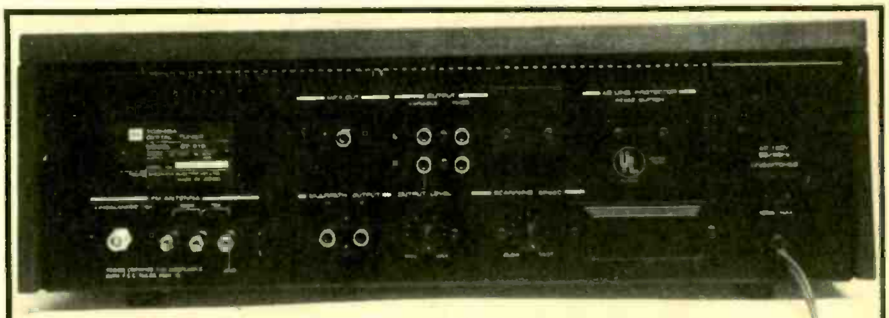
THE TOSHIBA *MODEL ST-910* IS THE MOST UNusually configured FM tuner we have ever seen or tested. The front panel (shown in Fig. 1) is completely devoid of knobs and conventional switches, except for a single mechanically operated power on-off pushbutton switch at the lower left of the front panel. Nor is the tuner equipped with a conventional type of frequency dial scale. So, to operate this handsome tuner, you simply touch appropriate points on the large screened glass surface that occupies about two-thirds of the front panel. Along the bottom edge of this glass area are no less than 19 small rectangular areas, each of which contains a touch switch composed of invisible, transparent electrodes. When you touch one of these areas, a small "hum" voltage is developed that signals the all-electronic switches to perform the various tuner functions.

The first three touch-switch areas determine the muting-threshold level. Touch one of these areas and a green light illuminates just above the area. Directly above these three green lights are three tiny red lights, each illuminating at a prescribed signal-strength input. If only the leftmost muting-level switch is touched, then any signals equal to or greater than the level needed to light the first signal-level light can overcome the muting circuitry. If the third muting-level switch is touched, then only those signals that are strong enough to light up all three red signal-level lights can overcome the muting-threshold level. When power is first applied, the first (lowest signal level) muting-level light comes on automatically, and, as we later learned, signals above around 7 μV (22.1 dBf) will be received. All muting can be defeated (for ultra-weak signal reception) by touching the first already-illuminated muting-level switch area, at which time the green light goes out and the tuner is "wide open" regardless of incoming signal strength. However, interstation noise will also be heard when you tune up or down the frequency band.

The four darkened windows to the right of the signal-level indicators display tuned-to frequencies in bright red digits. The tuning range is from 87.5 MHz to 107.9 MHz in 100-kHz (0.1-MHz) increments. Increments of 100 kHz were chosen because even though FM stations in the U.S. are always assigned at 200-kHz intervals (i.e., 88.1, 88.3, etc.), this is not the case in Europe and other foreign countries.

Manual tuning is accomplished by means of four touch-switch areas located beneath the frequency readout windows. The first two switch areas are labeled UP and DOWN, and touching either of them shifts the receive frequency in 1-MHz increments (either up or down). The second pair of touch switches shifts the tuned-to frequency in 100-kHz increments, again either up or down, each time the appropriate switch is touched.

Next in line is a touch switch labeled MEMORY. Touching this switch turns on a red light above the switch. You then have approximately three seconds to enter the displayed frequency into one of the seven available "sensor" or memory channels by touching one of the available touch-switch areas numbered from 1 through 7. A green light above the selected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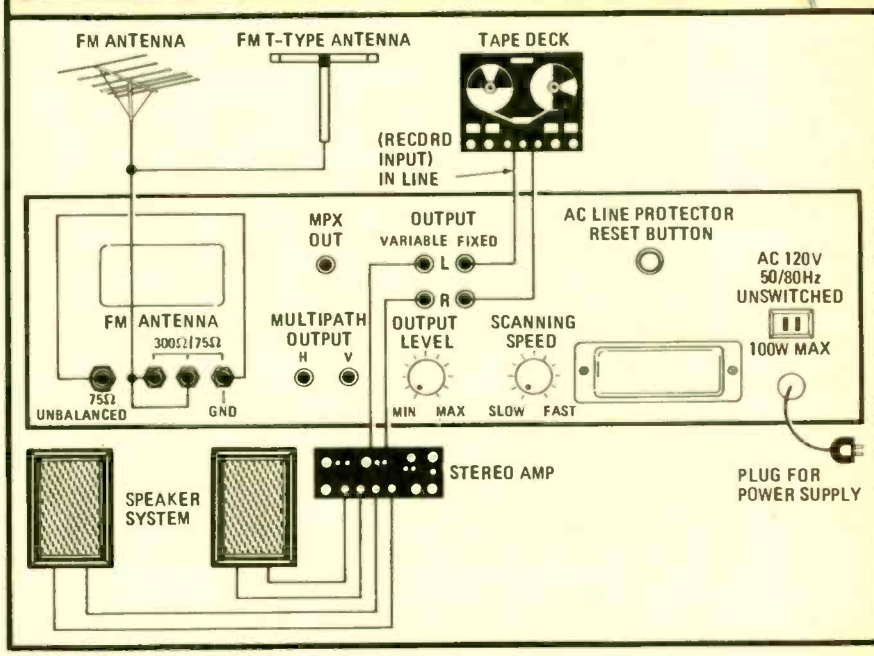

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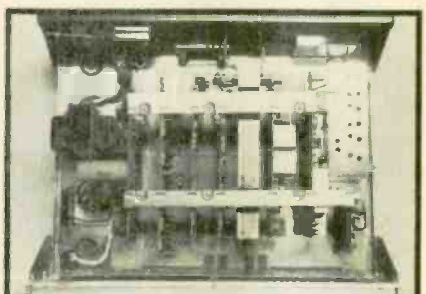
MANUFACTURER'S PUBLISHED SPECIFICATIONS:

Usable Sensitivity: mono, 1.8 μV. **S/N Ratio:** mono, 75 dB. **Total Harmonic Distortion** (400 Hz, 100% modulation): mono, 0.15%; stereo, 0.2%. **Frequency Response:** 20 Hz to 15 kHz, ±0.5 dB. **Alternate Channel Selectivity:** 85 dB. **Image Rejection:** 100 dB. **IF Rejection:** 100 dB. **Spurious Rejection:** 100 dB. **AM Suppression:** 65 dB. **Capture Ratio:** 1.5 dB. **FM Stereo Separation:** 40 dB at 1 kHz. **Rated Output Level:** fixed, 650 mV (400 Hz, 100% modulation); variable, 0 to 2.0 V (400 Hz, 100% modulation). **Output Impedance:** 1000 ohms. **Power Requirements:** 120V, 60 Hz, AC. **Power Consumption:** 30 watts. Dimensions: 450 mm W × 143 mm H × 340 mm D. **Weight:** 8 kg (17.64 lbs.). **Suggested Retail Price:** $1800.

channel switch comes on, the red light above the MEMORY switch flashes brightly and is extinguished, and the selected frequency is permanently stored in the channel memory of your choice. In the future, to recall that frequency, just touch the appropriate touch switch again, and the frequency is recalled and appears in the readout. The frequency remains in memory even if the power is shut off and the set turned on at another time, just as long as the power plug remains connected to the wall outlet.

There is a third tuning method called AUTO TUNING. Two more touch-switch areas, labeled UP START and DOWN START are located to the right of the seven memory switches. When either the UP START or DOWN START switch is touched, the tuner starts scanning frequencies (either up or down) until a signal is received that is equal to or greater than the previously selected muting-level threshold. Another switch area next to these two areas labeled STEREO ONLY permits only stereo signals to overcome the muting circuitry. Activating this switch causes a light to come on just above it, to remind you that this mode has been selected. Finally, a touch-switch area labeled MONO, at the extreme lower right-hand corner of the panel, permits you to deliberately alter stereo reception to the monophonic mode, in case stereo signals are too weak and noisy. A stereo indicator above this last switch lights up when stereo signals are received. To return to stereo reception or to automatic mono/stereo switching, simply touch the MONO switch a second time and the light above it goes out.

The rear panel shown in Fig. 2 has screw-type antenna terminals for 300-ohm or 75-ohm transmission-line connection, along with a standard coaxial connector for using 75-ohm coaxial lead-in cable with an appropriate mating connector. Also provided are output jacks for connection to horizontal and vertical oscilloscope inputs for observing multipath reception (and properly orienting an antenna for least multipath interference), and an output jack that delivers a composite detector-output signal. (The latter might be needed if the FCC ever approves four-channel discrete FM broadcasting.) Next come output jacks that deliver fixed and variable audio levels, and below them



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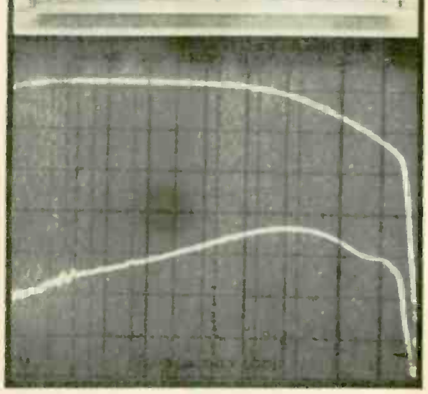


TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Toshiba** Model: **ST-910**

FM PERFORMANCE MEASUREMENTS

SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE	R-E Measurement	R-E Evaluation
IHF sensitivity, mono: (μV) (dBf)	1.8 (10.3)	Good
Sensitivity, stereo (μV) (dBf)	3.6 (16.3)	Very good
50-dB quieting signal, mono (μV) (dBf)	2.8 (14.1)	Excellent
50-dB quieting signal, stereo (μV) (dBf)	40.0 (37.3)	Fair
Maximum S/N ratio, mono (dB)	80	Excellent
Maximum S/N ratio, stereo (dB)	70	Very good
Capture ratio (dB)	1.6	Good
AM suppression (dB)	65	Excellent
Image rejection (dB)	100+	Superb
IF rejection (dB)	100	Excellent
Spurious rejection (dB)	100+	Superb
Alternate channel selectivity (dB)	85	Excellent
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz (±dB)	0.5	Excellent
Harmonic distortion, 1 kHz, mono (%)	0.08	Excellent
Harmonic distortion, 1 kHz, stereo (%)	0.085	Superb
Harmonic distortion, 100 Hz, mono (%)	0.18	Good
Harmonic distortion, 100 Hz, stereo (%)	0.17	Very good
Harmonic distortion, 6 kHz, mono (%)	0.17	Fair
Harmonic distortion, 6 kHz, stereo (%)	0.10	Excellent
Distortion at 50-dB quieting, mono (%)	1.4	Fair
Distortion at 50-dB quieting, stereo (%)	0.45	Good
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV) (dBf)	3.6 (16.3)	Very good
Separation, 1 kHz (dB)	39	Good
Separation, 100 Hz (dB)	48	Excellent
Separation, 10 kHz (dB)	29	Good
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV) (dBf)	7, 60, 500 (22, 40.8, 59.2)	Excellent
Dial calibration accuracy (±kHz at MHz)	"Perfect"	Perfect
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Control layout		Excellent
Ease of tuning		Superb
Accuracy of meters or other tuning aids		Perfect, see text
Usefulness of other controls		Excellent
Construction and internal layout		Excellent
Ease of servicing		Good
Evaluation of extra features, if any		Excellent
OVERALL FM PERFORMANCE RATING		Very good

TABLE II

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Toshiba** Model: **ST-910**

OVERALL PRODUCT ANALYSIS

Retail price	$1800
Price category	High
Price/performance ratio	Good
Styling and appearance	Excellent
Sound quality	Excellent
Mechanical performance	See text

Comments: There is no doubt that a good deal of the cost of this unusual FM tuner has been apportioned to its sophisticated touch-switch operation, its all-electronic operation and its seven-station memory capability. The audio purist may regard some or all of these features as pure "gimmickry," but at least one aspect of the novel design *does* contribute to audibly improved FM reception. That is the frequency-synthesized tuning. While it is true that other tuners we have measured can deliver as low distortion as this one (some do even better at the low- and high-frequency extremes), you must bear in mind that those ultra-low distortion results are obtained in our laboratory using a distortion analyzer hooked up to the tuner that enables us to tune to such minimum-distortion points. The home user rarely, if ever, has that advantage and must usually depend upon less-than-accurately calibrated center-tune meters. Even slight tuning errors create great increases in distortion. In the case of the *model ST-910*, no such tuning errors are possible. What you read on the digital readout is what you get—in frequency, that is. As for the novel touch-switch operation, it certainly does lend an air of elegance to the tuner and, as Toshiba points out, purely electronic switching of this type is not subject to wear or "dirty contacts" with extended use. On the other hand, such refinements do not, in and of themselves, contribute to better FM sound. At this price level, too, we would have expected to find some built-in means for indicating multipath distortion rather than having to use an externally connected oscilloscope.

is an output-level control. A second matching knob varies the scanning speed of the auto-tuning mode, as described previously. A line circuit-breaker pushbutton and an unswitched convenience AC outlet with 100-watt capacity complete the rear-panel layout. The dual pairs of output jacks permit you to connect a tape deck directly to the fixed output jacks, while the variable output jacks can be connected to the amplifier, as shown in Fig. 3.

Internal construction and circuitry

Figure 4 shows the internal layout of the *model ST-910* and, as might be expected, the parts density is extreme. To give you some idea of the complexity of the frequency-synthesis tuning system and its associated memory circuits, the *model ST-910* contains 32 transistors, 9 FET's, 100 diodes, 11 linear IC's, 85 digital IC's and 24 LED's!

The linear portions of the tuner include two RF stages using cascaded FET's and varicap diodes for front-end tuning. The IF section contains LC filtering (multipole) and a broad-band ratio detector. Phase-locked-loop circuitry is used in the multiplex decoder section.

Performance measurements

Table I summarizes major laboratory performance measurements, only a few of which can be compared with the manufacturer's specifications that are quite sparse for a tuner of this quality. Nevertheless, in absolute terms, the tuner's measured performance, although not quite as good as that of the highest-quality conventionally designed tuners we have measured, is more than adequate for good reception under most listening conditions. Distortion at midfrequencies was, in fact, excellent in both the mono and stereo modes, but tended to rise a bit too rapidly at the low- and high-frequency extremes. AM suppression and other rejection specifications were superb, however, and it is these lesser specifications that often make the difference between a very good tuner and an excellent one.

A plot of separation-versus-frequency is shown in Fig. 5, with the upper trace representing the response of the tuner to the "desired" channel (including 75-μs de-emphasis) and the lower trace showing the output from the opposite stereo channel under the same modulating conditions.

Use and listening tests

The *model ST-910* is a joy to use. On occasion, we did note that touching certain touch-switch areas did not immediately activate the corresponding switching function. However, we found that this problem was immediately corrected by gripping the front panel with the other hand. In any case, it takes only a few minutes to become familiar with the unit's novel switching arrangement and memory capabilities. The transition from muting to receiving is completely without the accompanying noise, clicks or pops so often associated with some muting circuits.

A summary of this product will be found in Table II, together with our overall product evaluation. Certainly, the *model ST-910* is a great engineering accomplishment and we can easily understand why it is so costly. The well-heeled audio hobbyist may find this tuner hard to resist, especially after playing with its touch switches for a while. The less-affluent audiophile will have to settle for lower-cost tuners that receive FM broadcast signals as well (and sometimes better) than the *model ST-910*.

R-E

U.S. Pioneer RT-707 Tape Deck

CIRCLE 102 ON FREE INFORMATION CARD

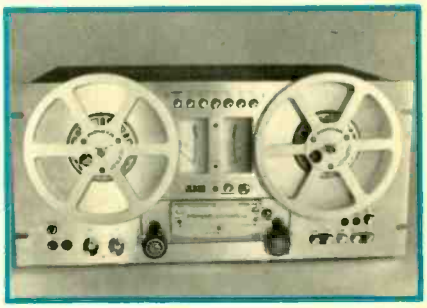
LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

THOSE READERS WHO ARE OLD ENOUGH TO remember some of the first open-reel tape decks designed for home use many years ago will experience a feeling of *déja vu* when they see the new U.S. Pioneer Electronics *model RT-707* open-reel tape deck shown in Fig. 1. The wide, rack-mountable square shape resembles some of the old Magnecord decks popular some time back, and lends itself beautifully to home installation on a shelf or table top, unlike some tall, top-heavy open-reel units presently on the market. Don't be misled by appearances, however. The *model RT-707* is a modern and sophisticated open-reel machine, and, at its unusually low suggested price, may appeal to those serious home recordists who might otherwise purchase a cassette deck.

The tape deck's low profile does, of course, limit reel size to a 7-inch reel (even these reels project a bit above the top of the unit). But with the available speeds of 7½ ips and 3¾ ips, maximum recording time is as great as might be obtained with 10-inch reels at twice the speed. With the excellent frequency response and high signal-to-noise ratio available at the 7½-ips speed, there is really no important loss in performance compared with the higher professional 15-ips speed machines—especially in view of the low wow-and-flutter figures obtainable at the 7½-ips speed.

Controls near the top of the deck (between the reels and surmounting the twin record-level meters) include a power ON-OFF pushbutton, a speed selector pushbutton, a TAPE/SOURCE monitor pushbutton, BIAS and EQ pushbuttons and individual left- and right-channel record pushbuttons. Wide-throw meters are calibrated from −20 dB to +3 dB. Between the meters are RECord and PAUSE indicator lights; while below the meters are a four-digit counter, a RESET control, a REPEAT-play pushbutton and a pitch-control knob that varies playback speed by approximately ±6%. Since this machine can be operated in either direction, it comes with four tape heads (record, erase and *two* playback heads). The playback heads and the record head are made of hard Permalloy, while the erase head is made of ferrite. The heads are protected by a metal cover, with screw holes provided for azimuth adjustment of both playback heads and the single record head. Quarter-track configuration is supplied.

Beneath the supply reel are two microphone input jacks, a stereo headphone output jack, a dual concentrically mounted microphone input and line input-level controls. Beneath the take-



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up reel on the right are a a PAUSE pushbutton, fast-forward and fast-rewind pushbuttons, STOP pushbutton, PLAY and RECORD pushbuttons, and a pair of pushbuttons with arrow lights indicating the direction of tape travel.

Drive system

The *model RT-707* uses three separate drive motors: A frequency-generating AC servomotor drives the single-capstan tape-drive system while two 6-pole inner-rotor induction motors handle reel rotation in both the play and fast-wind modes. A large flywheel is associated with the tape-drive motor. The motor is controlled by logic circuitry so that it is possible to switch from mode to mode without going through STOP. This same feature also permits you to rock the transport system between fast forward and fast rewind for locating specific points on a tape smoothly.

MANUFACTURER'S PUBLISHED SPECIFICATIONS:

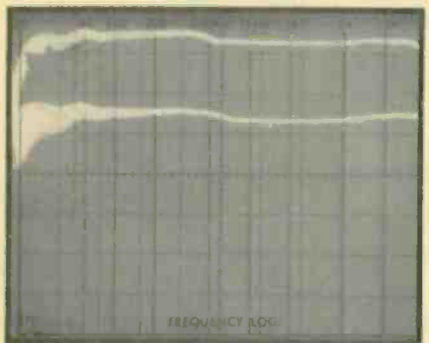
Maximum Reel Size: 7 inches. **Speeds:** 7½ ips and 3¾ ips. **Speed Accuracy:** ±0.5%. **Fast Rewind Time:** 1200 feet, approximately 100 seconds. **Wow and Flutter:** 7½ ips, 0.05% WRMS; 3¾ ips, 0.08% WRMS. **S/N Ratio:** better than 58 dB (referenced to a +6-dB record level). **Harmonic Distortion:** less than 1.0% at 7½ ips. **Frequency Response:** measured at −20-dB record level, 30 Hz to 24,000 Hz, ±3 dB at 7½ ips; 30 Hz to 16,000, Hz ±3 dB at 3¾ ips. **Crosstalk and Stereo Separation:** better than 50 dB. **Erase Coefficient:** 70 dB. **Bias Frequency:** 125 kHz. **Input Sensitivity:** mike, 0.25 mV (125 mV maximum); line, 50 mV (25 volts maximum); DIN, 16 mV. **Output: at 0-dB reference:** line, 450 mV; headphone, 70 mV into 8-ohm loads. **Power Requirements:** 120 volts, 50 to 60 Hz, 120 watts maximum. **Dimensions:** 18²⁹⁄₃₂ W × 9¹⁄₁₆ H × 14¹⁄₃₂ D. **Net Weight:** 43 lbs., 10 oz. **Suggested Retail Price:** $575.

Laboratory measurements

We made all our measurements using 1200-foot reel lengths of *Scotch 206* recording tape because Pioneer's own published specifications are referenced to this tape. The results of our measurements are shown in Table I.

Figure 2 is a scope photo of the record/playback response at the 7½-ips speed, using record levels of 0-dB (upper trace) and −20-dB (lower trace). Note that even at the high 0-dB record level, response just begins to roll off at the 20-kHz extreme, while at the lower, −20-dB record level, the response is flat to beyond the 20-kHz sweep limit. Of course, this is one of the key advantages of an open-reel machine as compared with even the best tape cassettes. In the latter, any attempt to record a 20-kHz frequency sweep at 0-dB record level results in extreme tape saturation and extensive rolloff at the high end.

Figure 3 shows some evidence of this effect. In this test, the slower 3¾-ips speed was used, and three frequency sweeps were measured and displayed on the scope face. The upper trace shows the 0-dB sweep, −10 dB and −20 dB (in the bottom trace). When this slower speed is used, the greater amount of treble equalization during recording does result in tape saturation at the higher record levels, but at the −20-dB record level, the response extends to above 16 kHz.



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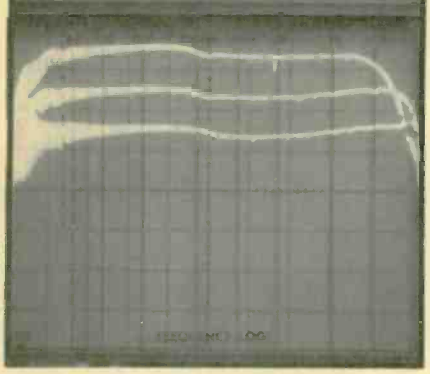

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Harmonic distortion was generally much lower than would be obtained at equivalent record levels using a high-quality cassette deck. And, of course, the 64.5-dB signal-to-noise ratio (referenced to the 3% THD record level, or +10 dB) was observed *without* the aid of any separate noise-reduction system such as Dolby.

Summary

Our overall product evaluation together with comments are shown in Table II.

Pioneer has produced a fine open-reel machine at a relatively modest price that gives the serious home recordist on a limited budget a real choice between a cassette and an open-reel instrument. **R-E**

TABLE 1
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **U.S. Pioneer Electronics** — Model: **RT-707**

OPEN-REEL TAPE DECK MEASUREMENTS

FREQUENCY RESPONSE MEASUREMENTS	R-E Measurements	R-E Evaluation
STANDARD TAPE		
Frequency response at 15 ips (Hz-kHz, ± dB)	N/A	N/A
Frequency response at 7½ ips (Hz-kHz ± dB)	21–21, 3	Excellent
Frequency Response at 3-3/4 ips (Hz-kHz ± dB)	29–16, 3	Very good
CrO_2 TAPE		
Frequency response at 15 ips (Hz-kHz, ± dB)	N/A	N/A
Frequency response at 7½ ips (Hz-kHz, ± dB)	N/A	N/A
Frequency response at 3¾ ips (Hz-kHz ± dB)	N/A	N/A
	(See Figs. 2,3)	
DISTORTION MEASUREMENTS (RECORD/PLAY)		
Harmonic distortion at −3 VU (highest speed) (%)	0.6	Very good
Harmonic distortion at 0 VU (highest speed) (%)	0.7	Excellent
Harmonic distortion at +3 VU (highest speed) (%)	0.8	Excellent
Record level for 3% THD (dB)	+10.0	Excellent
SIGNAL-TO-NOISE RATIO MEASUREMENTS		
Best S/N ratio, standard tape (dB)	64.5	Excellent
Best S/N ratio, CrO_2 tape (dB)	N/A	N/A
MECHANICAL PERFORMANCE MEASUREMENTS		
Wow and flutter at 15 ips (% WRMS)	N/A	N/A
Wow and flutter at 7½ ips (% WRMS)	0.045	Excellent
Wow and flutter at 3¾ ips (% WRMS)	0.06	Superb
Rewind time, 1200-foot tape (seconds)	65	Good
COMPONENT MATCHING CHARACTERISTICS		
Microphone input sensitivity (mV)	0.2	
Line input sensitivity (mV)	44	
Line output level (mV)	440	
Phone output level (mV or mW)	73 mV/8 ohms	
Bias frequency (kHz)	125	
TRANSPORT MECHANISM EVALUATION		
Action of transport controls		Superb
Tape guidance system		Very good
Absence of mechanical noise		Excellent
Tape head accessibility		Very good
Construction and internal layout		Excellent
Evaluation of extra features, if any		Excellent
OVERALL TAPE DECK PERFORMANCE RATING		Excellent

TABLE II
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **U.S. Pioneer Electronics** — Model: **RT-707**

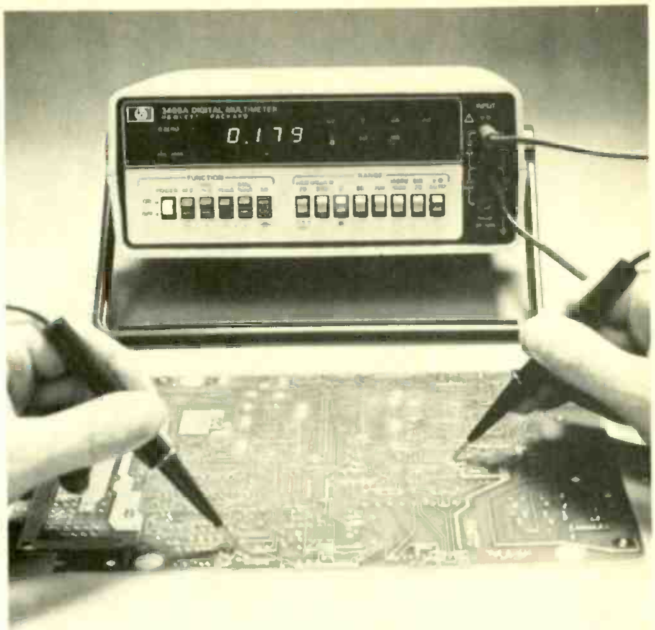
OVERALL PRODUCT ANALYSIS

Retail price	$575
Price category	Low
Price/performance ratio	Excellent
Styling and appearance	Superb
Sound quality	Very good
Mechanical performance	Excellent

Comments: In recent years, most open-reel tape deck manufacturers have been catering to supposed needs of semiprofessional home recordists; those who simply want to record and listen to music on tape just for sheer listening pleasure have had to opt for better-quality cassette decks. High-priced open-reel decks of rather large proportions have generally been the rule. Pioneer has changed all that with this unusual open-reel machine. The *model RT-707* fits nicely on a shelf along with other components. All the advantages of an open-reel unit (easy editing, higher dynamic range and better signal-to-noise ratio compared with even the best cassettes) are retained, plus a few extra features that may be received with indifference by the "pro" recordist but will be much appreciated by the home user. These include the auto reverse playback feature, the repeat-play option (using sensing tape at one end of the tape and the 0000 setting of the tape counter as cues for the logic control system) and the pitch control, which insures in-tune playback of tapes made on other, less-than-perfect-speed recorders. Considering the going prices of competitive open-reel decks, we found it almost unbelievable that Pioneer was able to provide three-motor direct drive logic-actuated transport systems for the relatively low price indicated. Separate control of left- and right-channel recording provides even more flexibility and permits sound-on-sound recordings (by changing rear-panel amplifier patching). With response to well beyond 20,000 Hz in the high-speed mode, this open-reel machine outperforms cassette decks costing considerably more. Its mechanical and electrical performance, as well as its imaginative physical configuration, is likely to prompt many a prospective recordist to consider going back to open reel instead of settling for a cassette deck.

Selecting A DMM—

What you should look for



If you think you know everything about DDM's, you probably don't. So, let's follow the trials and tribulations of George Tinkerer after he's bought one.

MARSH FABER*

THE LOUD RING OF THE DOORBELL BREAKS the silence.

"I'll get it!"

George Tinkerer bounds down the stairs, throws open the door and greets the mailman like a long-lost brother.

"It's here, Blanche! It's here!"

"What's here, George?" his wife answers.

"My new DMM! My new Whoopeetronics automatic dual-sensing, parametrically perambulating, 65-function, three-phase voltmeter."

"You mean you spent $294.68 of Junior's future college fund for that?"

George ignores his wife's subtle prod as his trembling fingers unveil the prize. George savors every second with superhuman restraint. Ever so slowly, he uncoils the power cord and dramatically inserts the plug into the wall receptacle. The box responds with an impressive display of red zeros.

"Big deal, George. What does it do?"

"It measures volts, ohms and amperes."

"Fantastic. So what's a volt, George?"

"A volt is one of those things that comes out of the wall. I'll show you."

"Don't you think you better read the manual first, George?"

"Nah! Manuals are for amateurs. Look, you just take these probes and stick them in the wall socket, like this."

Of course, George Tinkerer's Whoopee-tronics prestidigitator isn't ready to read 115 volts AC. In fact, it is eagerly looking forward to telling him what value resistor he might have in his hand.

As George applies his house current to the ohms input, the DMM responds predictably by smoking, arcing, hemorrhaging internally; it raises itself three inches off the bench and self-immolates. George is thrown to the floor. Blanche is scared out of three inches of baby fat and the new toy lies groaning and smoldering on George's blackened workbench.

Following the $294.68 holocaust, George regains his wife's good graces by babysitting eight Saturdays in a row, dropping out of the bowling league and cleaning up the garage—not once, but twice. George's true cost of owning a DMM is more than any man should have to pay.

George's plight is less fantasy than fact. The initial purchase price of a DMM may be irrelevant compared to the cost and hassle resulting from the abuse of poorly designed protection circuitry.

George is a charter member in the most difficult customer group that a DMM manufacturer must cater to. As recently as ten years ago, DMM's were available only to a select few people supported by corporate research budgets. They were expensive and hardly portable; and they were designed for the sophisticated user who demanded the ultimate in accuracy.

Today, DMM manufacturers cater to George. They produce small, portable instruments, at reasonable prices with the emphasis on durability. George may not have as much training and experience as a man in a standards lab, but he is much more demanding. When he makes a mistake in using his DMM, he expects the instrument to shrug off the overload and "keep on ticking."

In order to design a multimeter that is within George's price range, the manufacturer must make engineering tradeoffs. The consumer must therefore beware of enticingly low price tags and consider the compromises that may have been made. The initial cost, usability, serviceability and dependability must all be considered.

Initial cost

The most obvious cost in owning a DMM is the purchase price, which is the amount that usually headlines the advertisement for the instrument. However, this amount may not include the cost of necessary options or attachments.

Always obtain a data sheet before ordering any piece of equipment. Often an accessory is listed on the data sheet that you must add to the instrument before it is capable of performing your desired measurement.

Such options and accessories include batteries, chargers, carrying cases, various probes and test leads. External accessories, such as probes, are easy to order at a later date, but some options may be

* Design Engineer, Hewlett-Packard

factory-installed in the main body of the instrument and should be considered carefully at the time of purchase. Field installation of certain options may not be possible.

Usability

George Tinkerer had a specific application in mind when he bought his multimeter. Had he not destroyed it upon receipt, he would have eventually judged its usefulness by how well it performed in his measurement application. George wanted a DMM that met his requirements, but he didn't want to pay extra money for capability that he would never use.

In order to receive the best return on his investment, George should have scrutinized and understood the data-sheet specifications. The most fundamental data-sheet specifications are often misinterpreted. Resolution, sensitivity and accuracy characterize the fundamental capability of any DMM.

The overrange capabilities of DMM's vary widely, and their labeling can often be ambiguous. Technically, the number of digits a DMM can display is the logarithm of the maximum reading (number of counts). For example:

Maximum reading	Log_{10} X	Advertised resolution
1000	3	3 digits
1099	3.04	3½ digits
1999	3.30	3½ digits
2999	3.48	3½ or 3¾ digits

Some definitions take the ± sign into account, which doubles the number of total counts and adds 0.3 digits to the Log_{10} X value. Thus, a ±1999-count DMM becomes a 3998-count DMM, and Log_{10} 3998 = 3.6 digits.

This is all delightfully confusing and of little interest until you attempt to measure a 15-volt supply with some accuracy and find that the reading is 15.0 on one DMM when it could be 15.00 on another DMM, the latter instrument having better accuracy.

The solution to the "number-of-digits" enigma is to look only at the total number of counts, or the overrange specification.

In a 3-digit DMM, 1000 counts is full scale and any count above that figure is considered to be overrange.

	Maximum reading	Overrange
3 digits	1000	0
3½ digits	1999	100%
3¾ digits	2999	200%

While the labels are not necessarily exact, the total maximum reading will always give the true resolution—the ability to detect a small incremental change in a signal. If a 3½-digit DMM displays 0 to 1999 counts, the resolution (one count) represents one part in 2000, or .05%.

Sensitivity is the quantity measured by the least-significant digit on the lowest range. If the full-scale reading on the most sensitive range is 199.9 mV, the sensitivity is .1 mV, or 100 μV. Similarly, if the lowest ohms range is 19.99 ohms, the sensitivity is .01 ohms, or 10 milliohms.

There are many cases where accuracy is not a prime consideration, but in those special instances where it is, it is useful to know the difference between full-scale accuracy and one-tenth-scale accuracy. Even a specification as fundamentally important as accuracy can be ambiguous. Here are two examples:

DMM (A)—Accuracy = 0.1% + 0.1% range

DMM (B)—Accuracy = 0.1% reading + 1 count

For a 1000-count DMM, both specifications are identical, but assume both are 2000-count instruments, and look at the error for a 15.0-volt input on the 200-volt range:

DMM (A)—Error = 150 counts × 0.1% + 2000 counts × 0.1%
= 0.15 counts + 2 counts
= 2.15 counts
= 0.215 volt

DMM (B)—Error = 150 × 0.1% + 1 count
= 150 × 0.1% + 1 count
= 0.115 volt

Expressed as a percent of reading, which is the true measure of accuracy for any input, the errors are:

$$\text{DMM (A)—\% error} = \frac{0.215 \text{ volts}}{15.0 \text{ volts}} = 1.43\% \text{ of reading}$$

$$\text{DMM (B)—\% error} = \frac{.115 \text{ volts}}{15.0 \text{ volts}} = 0.77\% \text{ of reading}$$

Clearly, the percent-of-range error has a drastic effect upon the accuracy of a low-level measurement. Conversely, for best accuracy, the DMM range switch should be set to display the maximum number of counts. In the worst case shown above, DMM (A), which netted a 1.43%-of-reading error, assume the DMM is set to a lower range, from 200 volts to 20 volts.

Range = 20 volts
Reading = 15.00 volts = 1500 counts
Error = 1500 × 0.1% + 2000 × 0.1%
= 1.5 + 2 = 3.5 counts = .035 volt

As a percent of reading, this becomes:

$$\% \text{ reading error} = \frac{.035 \text{ volt}}{15.00 \text{ volts}} = 0.233\%$$

This percent-of-reading error is a considerable improvement over 1.43%. It is interesting to note that the most accurate reading that can ever be made by either DMM (A) or DMM (B) is 0.2% of reading. At any voltage below full scale, the effective accuracy decreases. This is particularly true for AC voltage measurements. The most common AC converters use either logging amplifiers or diode switches; both techniques exhibit poor performance near zero. Again, the most accurate measurements are made at full scale.

Features

Once decisions regarding resolution, sensitivity and basic accuracy were made, George Tinkerer was faced with a new set of choices labeled "convenience factors." He went over the list and checked off "current," "autoranging," "battery power" and "LCD." George mistakenly thought that "LCD" stood for "liquid crystal display" when, in fact, it meant "lizard crossing detector." (This option proved to be of marginal value to George who was a strict vegetarian!)

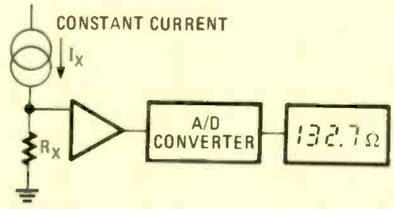


FIG. 1—OHMS CONVERTER consists of constant current source feeding the unknown resistor.

Preposterous? Yes, but some features appear better on paper than they do on the bench. Autoranging is an example. Some DMM's incorporate a switchable ×1 or ×10 amplifier that allows autoranging on only two ranges. This reduces the number of manual range-switch positions, but it does not offer full autorange capability.

Full autoranging almost guarantees input protection. Some manually ranged DMM's offer limited overvoltage protection on the lower voltage ranges, but an autoranged instrument, by the very nature of the design, must accept the full input voltage (for instance, 1000 volts) on the lowest range.

Fully autoranged current function, with a separate shunt for each range, is rarely found in low-cost instruments. The high currents, low-voltage drops and low-leakage currents do not lend themselves to inexpensive solid-state switching. For this reason, some DMM designs autorange all functions except current. Those that do autorange current usually use a 1-ohm or a 1000-ohm resistor across the input. Reading voltage on the 100-mV and 1-volt ranges then allows two ranges of current with voltage drops of 100 mV and 1 volt, respectively.

The ohms conversion offers more opportunity for confusion. The ohms converter is the circuit (see Fig. 1) that supplies a constant current to an unknown resistor. Its output is a voltage that is measured by the A/D converter and displayed as an ohms reading.

In an analog meter, the current source does not have to be constant because any arbitrary linearity function can be displayed by simply changing the markings on the meter scale. However, a DMM uses a linear A/D converter, so the current must be constant.

Sometimes an ohms converter will be specified as having a "5-volt maximum output." This does not mean that the ohms converter can send 5 volts across a low impedance. On the contrary, it simply means that the current-source output is limited to 5 volts. In no case will the current source supply more than its listed current on any given range.

The somewhat arbitrary 5-volt maximum specification was actually instituted when DMM's were manufactured for the armed forces. Because most active devices are damaged by current and not by voltage, the most important specification to consider is not the maximum output voltage, but the maximum output current that the ohmmeter can supply.

Display

When George checked off LCD on the data sheet, he really wanted a liquid crystal display. He was probably interested in long battery life. Liquid crystals offer exceptionally low current drain, and they can be manufactured with any number of different display characters. Some LCD's are very slow at cold temperatures, sometimes taking as long as half a second to change states completely, and certain other types encounter reliability problems in humidity at elevated temperatures. Since LCD's are slow, they are hard to multiplex, so the number of interconnections becomes quite high. They must be back-lighted to be seen in a dark room and certain types suffer from a narrow viewing angle.

Light-emitting diode displays (LED's) are fast enough to multiplex, and they offer more consistent temperature performance than liquid crystals. The LED is difficult to read in very bright sunlight, while the LCD is not. The LED is fast, but it also consumes more power. In order to reduce power requirements, LED's are sometimes made smaller and placed behind a lens, but this also restricts the viewing angle. LED displays are manufactured in predetermined sizes and shapes, and do not offer the display-character flexibility afforded LCD's. However, LED's are reliable under adverse environmental conditions.

In addition to obtaining accurate readings, George is also concerned with interpreting those readings. He wants full annunciation to lessen possible error. If an instrument is properly annunciated, the user should be able to glance at the display and know immediately that he has chosen the correct function and range, and that he has committed no error setting up the front-panel controls. A reading that exceeds the full-scale range input should be displayed so distinctively that it cannot be interpreted as a valid reading. Smoke pouring from the front panel is generally considered an unsporting way of indicating overload.

TYPICAL LED DISPLAY is easier to read than LCD display but it consumes more power.

Service

The day is bleak . . . the wind is cold . . . the sky is overcast. George is overcast. He steps off the bus and pulls his collar high to fend off the freezing rain. Under his left arm, he carries the decimated remains of his DMM. Every slippery footstep on the rain-slicked sidewalk brings him closer to the Whoopee-tronics service center. He recalls the embarrassment of that infamous day when his DMM failed him. In his mind's eye, he can envision the Whoopee-tronics showroom full of ex-used car salesmen in checkered sport coats and polka-dot ties with big toothy grins that seem to say, "hello, sucker."

By the time he reaches his destination, George is livid. White knuckles squeeze the doorknob into submission as his wet shoes soil the polished tile floor. His temples start to pound and his already crimson neck starts turning purple as he approaches the service desk.

"Hi, pops. You look like a drowned rat." After making the remark, the service technician notices blue flames emanating from George's nostrils and decides to back off. Finally, George speaks.

"You turkeys sold me this blankety-blank instrument and it blew up, and I want to know what you're going to do about it!" The technician manages a weak smile as he extracts the DMM from George's midsection.

"Hmmmm, looks like the ohms converter. I can tell because there's a little puddle of metal where the protection transistor used to be. Heh, heh." The levity goes unanswered. "Well, let's just try a new input module." As he applies power, the DMM returns like a phoenix to the living world. "Now, I'll calibrate it for you." The technician adjusts the controls, returning the instrument to its original condition. George is impressed, but still defensive.

"O.K., what's this gonna cost me?"

"Oh, nothing. We've corrected a design flaw in our ohms protection circuit, and we now list an ohms overload specification in our data sheet. I'm glad you bought our DMM instead of an analog meter. An ordinary analog meter needle would have wound around like a pig's tail and it would have been cheaper to replace the whole instrument than to pay for the repair. Imagine how many pointers you could corkscrew around the stop in, say, five years. At $70 apiece, you could easily justify buying a dandy self-protected, accurate autoranging DMM. Of course, we can't promise ours will never fail, but we are doing everything possible to make ours dependable. In any case, please try to be more careful in the future."

George feels like the guy who was under the bleachers ordering a hot dog when Hank Aaron hit his 714th homer. He came prepared for a fist fight and couldn't find an opponent. Suddenly, his opinion of Whoopee-tronics is reversed. He starts thinking about why the service is so good. He notices the quiet efficiency of the service center and recalls the service technician's skill. George realizes that the technician hardly looked at the manual when he calibrated the DMM because the order of adjustments and their relationship to each function had been clearly marked on a piece of sheet metal inside the DMM. The workmanship was excellent, and a drawing of the PC board in the manual allowed instantaneous component location. The manual contained detailed schematics and troubleshooting aids.

George is impressed with the service he obtained and appreciates the time and effort that go into making a product serviceable, but he wonders now how dependable his DMM will be in the future. He asks the service technician what steps Whoopee-tronics takes to guarantee reliability.

The technician first explains that George's mishap will be less likely to occur in the future due to some new abuse tests recently implemented by Whoopee-tronics. He proudly recites the company viewpoint on dependability:

Dependability

"Dependability is the characteristic that separates the quality instrument from the average instrument. It is a direct measure of design forethought.

"Even the most knowledgeable user will err at times in his application and unintentionally subject his multimeter to adverse conditions. A properly designed multimeter would have survived your debut into the rewarding world of electronics without so much as a whimper.

"There are some unavoidable adverse conditions, such as physical and electrical environments. Most 'expensive' multimeters undergo a strenuous series of environmental tests before designs are finalized, and the designs are often changed as a direct result of these tests.

"The more common environmental tests include operating temperatures like

−20°C and +55°C, 95% relative humidity (rain is 100%), shock and vibration tests to determine mechanical integrity, and operation in strong electrostatic and electromagnetic fields. Although these representative tests are difficult, they are by no means new, and they do not take into account the most difficult environment of all—your workshop and workbench.

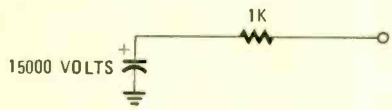


FIG. 2—STATIC DISCHARGE from the human body can be represented by this equivalent circuit.

"An entirely new set of tests has been devised to counteract the possible mishandling of a DMM. Every possible misuse of the product is simulated. Instruments are subjected to a current-limited static discharge of 15,000 volts to any exposed terminal. Voltages of over twice the input rating are applied to the input terminals, and extremely high currents are applied to ampere terminals to check for safety and fire hazards. A 230-volt supply is applied to the 115-volt line input as well as to the ohms input to see that no damage occurs. High voltage is applied to the input while selecting every conceivable combination of pushbutton or rotary-switch positions to insure that turning on a switch between positions or pushing buttons in illegal combinations will not cause damage to the instrument or to your circuit.

"High voltages are applied between circuit low and safety ground to check the transformer and all mechanical spacings for dielectric strength. If you wonder why we subject the voltmeter to inputs as extreme as 15,000 volts, this voltage simulates the static discharge from a human body.

Static discharge

"When MOS (*M*etal *O*xide *S*emiconductor) devices first became available, it was found that they had a high failure rate with respect to other semiconductor technologies. Some clever detective work revealed that the failures were due to static discharge. Since the FET gates had extremely low leakage currents, they could accumulate charge to the point that internal breakdown occurred, destroying the device. Vast improvements have since been made in MOS circuit protection, but these devices are still susceptible to static discharge.

"Contrary to popular belief, MOS integrated circuits are not the only semiconductors that are susceptible. Junction FET's and even bipolar transistors are frequent victims of this phenomenon. This is especially true in voltmeter input circuitry. In order to provide good common mode rejection and minimum voltage drift with changing temperature, DMM manufacturers use differential transistors in input amplifiers. Temperature tracking dictates a small junction area, which makes the device vulnerable to static discharge destruction.

"If you've ever lived in a dry climate, I'm sure you've experienced walking across a carpet and drawing an arc to the nearest grounded object. The potential static discharge from your body can reach 15,000 volts under such conditions. Many electrical models have been used to simulate the human body during static discharge. For example, here's one widely accepted model."

The technician draws the schematic shown in Fig. 2 for George.

"Theoretically, 15 amperes of instantaneous short-circuit current can be supplied by this circuit."

George breaks in: "Fifteen amperes? Hogwash! Why, you would die every time you touched a doorknob!"

"Certainly, 15 amperes of continuous current passing through your heart would cause instant fibrillation. However, the current is not continuous and it doesn't pass through your heart.

"The charge is stored on your body's surface and is discharged over that surface. The only place that the charge penetrates the skin to any extent is at the point of contact with the grounded object, where the increased current density causes pain. Since the time constant of the equivalent circuit is only 300 ns, the energy released is relatively small, but it is enough to damage a semiconductor.

"The design engineer must create an input amplifier that measures microvolts but not be damaged by tens of kilovolts. One method of controlling static is to intentionally design spark gaps around the input circuitry.

"A spark gap can be formed by the jagged ends of two hookup wires or by the blades of a switch wafer. A needle gap arcs at a voltage that is about one-tenth that of two equally spaced smooth surfaces. Because of the physical variations in designing spark gaps and the unpredictability of static discharge, circuit layouts must nearly always be modified empirically. In the early stages of designing to avoid static damage, this 'lightning bolt test' may destroy a large section of input circuitry. Troubleshooting and replacing the zapped circuit can involve considerable time and effort."

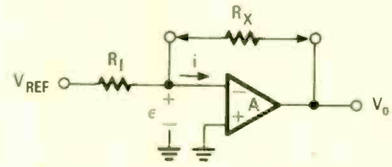
"Gosh," George comments, "I didn't know a static discharge could cause so much damage. But what about my multimeter? Why did it blow up?"

The technician casts a suspicious eye at George. "You probably applied the line voltage directly to the ohms terminals."

George's sheepish grin gives him away. "Yeah, I guess I wasn't very careful," he confesses.

The technician pats him reassuringly on the shoulder. "I wouldn't be too ashamed. All of us have done it at one time or another. That's exactly what we try to avoid with our new testing program. Our new ohms converter can take the full-line voltage without being destroyed.

"Let me show you a simple ohms converter." The technician draws the circuit shown in Fig. 3.



LET R_X REPRESENT THE UNKNOWN RESISTOR, AND R_I REPRESENT THE RANGE RESISTOR INSIDE THE DMM. FOR AN IDEAL OPERATIONAL AMPLIFIER,

$$i = 0$$
$$A = \infty$$

THEN $\frac{V_{REF} - \epsilon}{R_I} = \frac{\epsilon - V_0}{R_X}$

BUT $\epsilon = \frac{V_0}{A} = \frac{V_0}{\infty} = 0$

SO $V_0 = V_{REF}\left(\frac{-R_X}{R_I}\right)$

FIG. 3—SIMPLE OHMS CONVERTER provides output voltage proportional to unknown resistance.

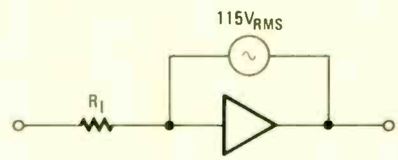


FIG. 4—APPLYING LINE VOLTAGE to input terminals of circuit in Fig. 3 will destroy amplifier.

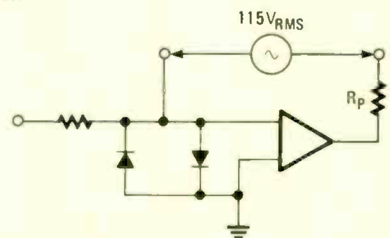


FIG. 5—DIODES PROTECT ohms converter circuit against application of line voltage.

"The voltage is proportional to the unknown resistor. Now, assume you apply 115 volts RMS across the ohms terminals. The circuit looks like this." (See Fig. 4.)

"An ordinary operational amplifier would be reduced to cinders, therefore, some protection circuitry is added." (See Fig. 5.)

"Resistor R_p protects the op-amp to some extent. However, R_p itself now becomes subject to burnout. The value of R_p must be small enough to allow the op-amp to supply high current on the lowest resistance range, but this small value means it will dissipate a lot of power if 115 volts AC is accidentally applied to the ohms input. High power usually means a metal-film resistor should be used, but in this case a carbon-composition resistor would probably perform

continued on page 118

Make Your Own CUSTOM HARDWARE

These days, it appears that the active electronics experimenter needs a greater variety of hardware just as sources seem to be drying up. Why not make the hardware you can't find or afford?

JAMES E. TEMPLE

LIKE MOST READERS OF RADIO-ELECTRONICS, I WANT TO build 50% of all construction projects described in each issue, within their specifications and with "hardware to suit." But, to suit what? Certainly not my pocket book. If I buy a minimum quantity, I have to pay a king's ransom to complete the project; if I purchase the standard quantities all that extra hardware sits in my parts boxes. Ah, then the idea lamp lights up: I'll modify the hardware to suit special purposes. So I'd like to share my experiences on how I successfully modify specialty hardware and make it twice as versatile.

Some necessary tools

The Dremel Motor tool and its many accessories is very versatile. The 1-inch-diameter cutoff wheel with its mandrel holder is a fantastic item. The wheel is no more than a ¹⁄₁₆-inch thick, made of a carbide material and a powerful cutter. It is somewhat brittle, especially with any side pressure. Yet it will cut through stainless steel as if it were butter. When it comes to cutting epoxy boards, the cutoff wheel again acts very smoothly. I am impressed with how quickly it cuts, and I try to grind each wheel down to the smallest possible size without breaking the disc. Wear safety glasses as a precaution. Since the tool travels at 24,000 rpm, a breaking disc can send particles all over the place, especially toward your face and eyes.

Jewelers' files also come in handy, as well as a miniature anvil along with a small vacuum vise, emery cloth, pliers, cutters, and any other time-saving tool.

Star No. one

(I refer to any item that cuts down on time and expense as a "star," and feel perhaps you might agree.) The miniature tubular terminal, *model 1236* by Keystone Electronics Corporation, 49 Bleeker St., New York, NY, is able to hold securely wires from 0.010 to 0.050 in diameter, discrete components that can be inserted from either side of the terminal. They mount in a ¹⁄₁₆-inch hole (0.062 to 0.067) with a special insertion tool for hand usage. The terminal comes in quantities of 100 and 1000 and is ideal for both printed circuits, rats'-nest-type of building and even Wire-Wrap setups. Figure 1 shows how it would normally be used when inserted into a board.

To modify this little gem, drill the hole and insert the terminal with the tool. Figure 2 shows what happens when you cut it flush with the board, with the cutoff disc. The dotted lines indicate the material removed by cutting. There is no excessive material above the board and the top section has been hammered tightly down to the board (use a light tack hammer). The burrs have been cleaned out with a round jewelers' file, so the miniature tubing has been made even smaller.

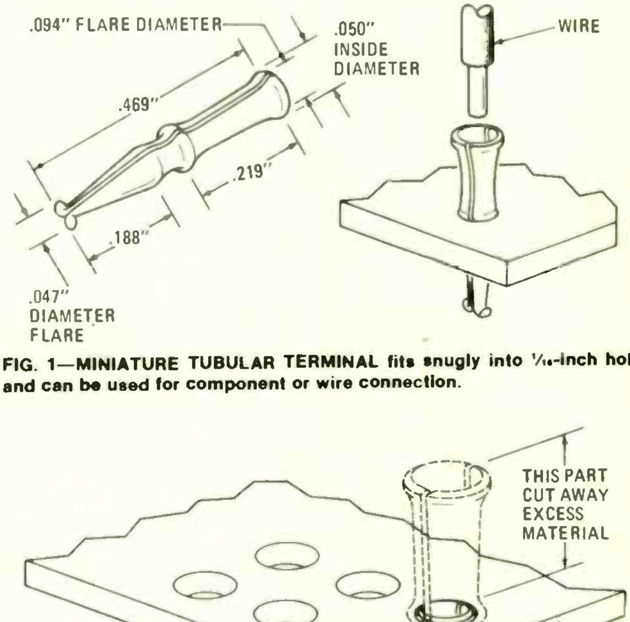


FIG. 1—MINIATURE TUBULAR TERMINAL fits snugly into ¹⁄₁₆-inch hole and can be used for component or wire connection.

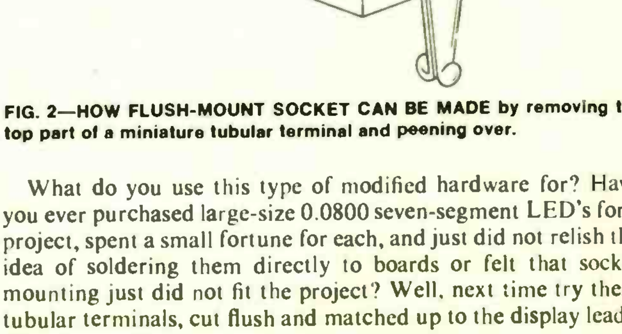


FIG. 2—HOW FLUSH-MOUNT SOCKET CAN BE MADE by removing the top part of a miniature tubular terminal and peening over.

What do you use this type of modified hardware for? Have you ever purchased large-size 0.0800 seven-segment LED's for a project, spent a small fortune for each, and just did not relish the idea of soldering them directly to boards or felt that socket mounting just did not fit the project? Well, next time try these tubular terminals, cut flush and matched up to the display leads;

each display is held firmly as if in a socket. With leads A to G, you can now use a minimum number of displays mounted without soldering to avoid possible damage. You can even remove them quite freely to use in another circuit without too much trouble.

Another use for this terminal (cut flush again) is to mount individual LED's without soldering the LED's directly to the board. You will need Vector's T-46 push-in pins, which are crimped to hold securely to the boards and sold in packs of 50. This pin has a rounded head, a crimped flange and fits a 0.042 drill hole. Remember the special tool to insert the tubular terminals? When you mount it in a vise upside down, it becomes a miniature setting tool supporting the PC board around the drill hole that will have a pin inserted into it. Merely place the board over the tool, line up the hole, insert the pin and, using a light hammer, hammer it home securely. Solder the round head to the circuit on either side to be sure of circuit continuity. Soldering is an easy way to set these pins. You can also try pushing the pins into the board holes with a pair of pliers. But the pins bend too easily this way.

With this type of LED mounting use the LED lens produced by James Electronics of 1021 Howard Ave., San Carlos, CA. This lens holds the LED securely, and the LED leads can be tied into the circuits. The holder fits a ¼-inch hole, and does indeed hold the LED snugly. However, the LED leads must still be soldered to the circuit in which it will be used. Now we have the three parts that can be combined to make a neat and easily dismantled unit: the LED lens and holder, the Vector pins and the miniterminals.

Figure 3 shows a 1-inch long by ⅜-inch wide LED mounting

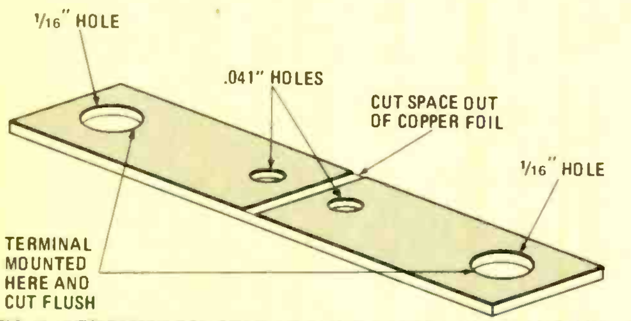


FIG. 3—LED MOUNTING STRIP made from a small piece of single-sided printed-circuit board. Mini-terminals fit the outer holes.

board made of copper foil. At the outermost points of the strip, drill two 1/16-inch holes, one on each end. In the direct center, drill two 0.041 holes spaced 0.100 apart. In between the holes, cut the copper foil in the center to make upper and lower sections that are electrically isolated from each other. Mount the miniterminals in the 1/16-inch holes. Use an anvil as a support to the board when you insert the terminals and push them all the way in. Cut off the excess tubing except for at least 1/16 of an inch, which can be spread apart with a nail and hammered flush with a tack hammer. Clean the holes for burrs with a jewelers' file and insert a wide needle to be sure the holes are open all the way. Where you want to mount a discrete LED, take the pattern strip and mark the centers of the 1/16-inch holes where the mini-tubes are. On the printed circuit board drill a 0.042 hole. At the dead center of these two holes, mark the board and drill a ¼-inch hole (see Fig. 4). Leave room for the current-dropping resistor for the LED in the vicinity of the 0.042 holes, and be sure of the polarity of the line the resistor connects to; positive or negative. You can even install this resistor on the strip, but this will require an additional ¼-inch length to accomodate it.

The Vector pins are placed into the 0.042 holes facing the same direction as the LED lens. Solder these pins on either the head side or the shaft side, or both sides, making the pin a part of the circuit. You even have enough space to wire-wrap and jump to another part of the circuit board, but it is best to keep the wrapping to only five turns. Mount the LED lens in the ¼-inch hole, push the LED into the lens until it clicks into place;

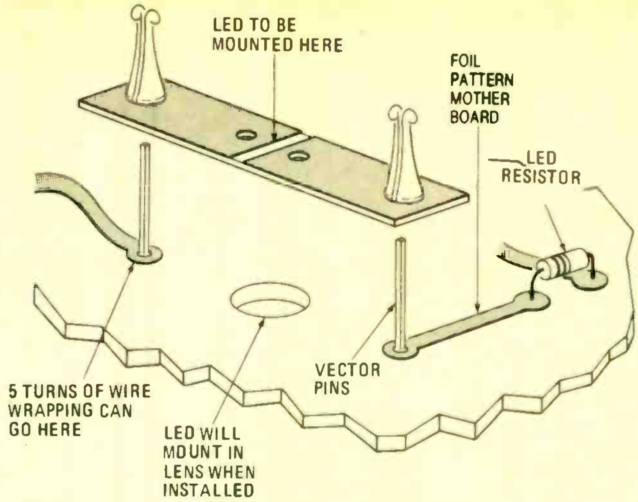


FIG. 4—HOW LED MOUNTING STRIP forms a plug-in connector when mated to suitable pins inserted into the PC board.

pass the LED leads through the holes in the mounting strip, making sure of the lead polarity; and push the strip down over the leads and the Vector pins until the strip fits snugly. To finish off, solder the LED leads to the mounting strip, and cut off the excess leads. You now have a removable LED from the lens that makes contact with the board circuit yet can be quickly replaced by another strip with a mounted LED of another color, a brighter output, etc. This system also lets you mount the LED lens on a front panel, not directly on the printed circuit board. Drill a ⅜-inch hole in the PC board behind the front panel. The lens will then pass through the PC board, and by using the LED

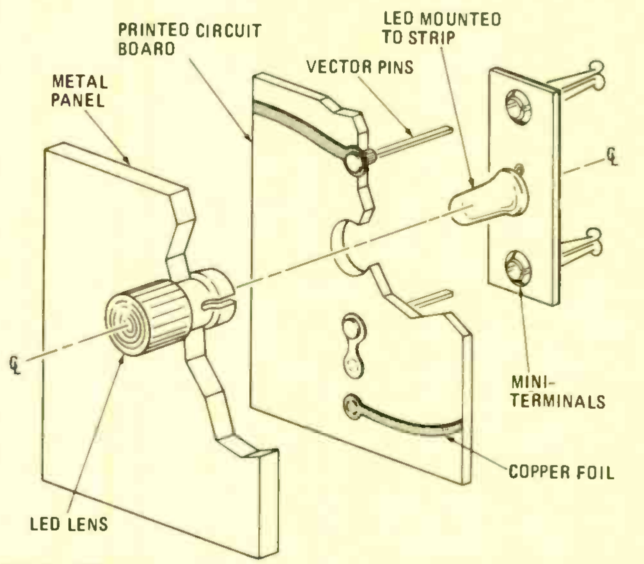


FIG. 5—LED LENS ON THE FRONT PANEL mates with the PC board and the LED on its mounting strip.

strips you can easily mount the removable LED's in the lens and show color through to the front panel. A front panel can now be serviced easily in case of trouble. Figure 5 shows the assembly.

Star No. two:

The No. K32 J-pin, marketed by Vector, is a perfect square wire used for wire-wrap connections or soldering into a printed circuit. It provides two points of contact, can be cut flush, bent at right angles, left as-is, can mount IC packages as if it were a socket, etc. (see Fig. 6).

To mount IC's directly without a socket, place J-pins one to each lead, and pass them through the mounting holes in the board; the pins will fit tightly against an IC lead in a 0.042 hole. The J-pin can face in either direction when it is installed next to the lead either up or down, depending where the lead will do the most good for the circuit. Using the J-pin as a socket, you can remove the IC and place it back into the circuit if necessary.

A J-pin is used for terminal or tie points, in wire-wrap or PC systems and even in a rats' nest setup. This pin can be modified to take the place of many other hardware items, thereby saving money.

If you want a special IC socket, do the following: Take some Molex *Soldercon* IC pin connectors (another "star") and some J-pins; together they can be made into an IC socket of any pin size. Insert the Molex socket pins; push the J-pins next to the Molex lead; solder the Molex lead to the J-pin, top side and bottom; and you have a useful socket for wire-wrap circuits or

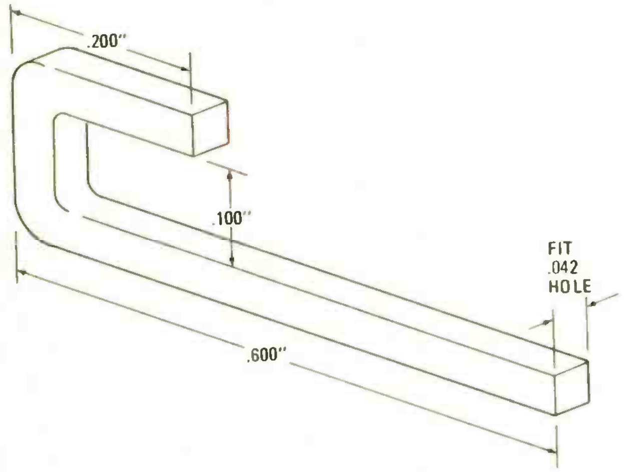


FIG. 6—THE VECTOR J-PIN is one of the more versatile of small hardware components. It's just over a half inch long.

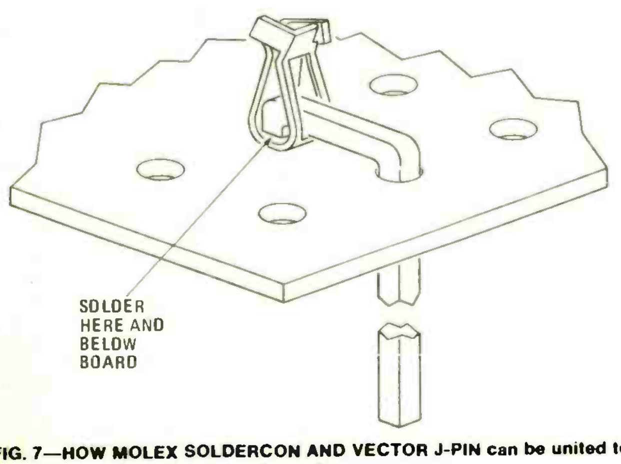


FIG. 7—HOW MOLEX SOLDERCON AND VECTOR J-PIN can be united to form one terminal of a socket for an IC.

rats' nests. Figure 7 shows J-pin and Molex *Soldercon* units used together to make a socket point. Using a miniature tubular terminal and a J-pin in pairs on a printed circuit board results in a mounting point for any discrete component. You have set up a specialty socket for wire-wrap circuits for the large seven-segment displays, which are now easily removed or replaced into the circuits.

Have you ever designed a PC board and found you needed to add several more IC's not provided for in the original layout, but you lack the room to add them directly to the board? Set some J-pins into the circuit board, trying to take off the power connections and the input or output connections of the original circuit. Try to keep the J-pin pattern as square as possible. Take a second copper board, make it match up to the square, mark off the J-pin points where they will come in contact with the second board, drill 0.042 holes, and check out the pin alignment. If it looks OK, either use these holes to mount the second board directly or set up your miniterminals to have a removable second board in case the original board needs servicing. The second PC board will mount the needed IC's to the first circuit. Be sure to allow additional space for other possible circuits. For added security provide for some 2-56 nut-and-bolt holes to hold the two boards together securely in place. Duplex circuit boards are very neat and take little effort to produce.

Want to try a right-angle connection instead of a duplex set-up? If the original board has enough space for a second board mounted at a right angle, the J-pins can be modified to act as a push-in connector to the new board, which will have PC finger leads coming to the end of the board, similar to an edge connector (see Fig. 8.) If the original board has a blank area, you

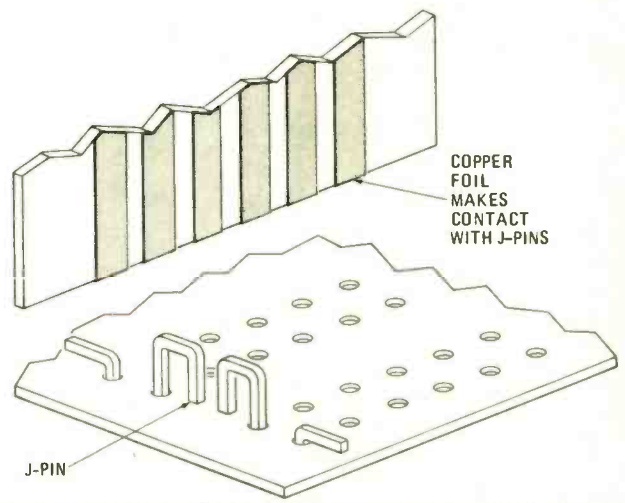


FIG. 8—HOW J-PINS CAN BE USED as edge-connector socket pins for a PC board.

can use a *Quik-Circuit* IC pattern to set up the pins. *Quik-Circuits* are copper foil, set up on a mounting strip with adhesive backing; they will stick securely to any clean portion of the board, have three holes for each contact point, and come in 36-lead strips. Note if only one IC is added to the original board, use the *Quik-Circuit* to make the connections.

If you decide to set up the right-angle second board to the first, then, using the *Quik-Circuit* pattern for the necessary number of contact points, press the pattern to the first board. Drill out three holes per lead for each lead. Place the J-pins as shown in Fig. 8; this will take up two holes. Then make the circuit connections to the third hole to the original board. You now have the edge connector for the second board match up to its outer copper leads. Also be sure to securely mount the right-angle board, using nuts and bolts. You can even twist some wire tightly to the two boards, but it will have to be cut if you have to separate the boards.

J-pins can be used as edge connectors in a motherboard setup. It is a little time-consuming to use them up in this manner, but they can save quite a bit of money. If you have time plan your next motherboard using J-pins. Then Star No. Four is a third type of edge connector you can use for these motherboard setups.

Star No. three

Figure 7 shows how the standard-size Molex *Soldercon* can be made into a wire-wrap type of connector using J-pins. Here are some other modifications you may want to try out:

Want to mount something to the end of a PC board that would require some form of right-angle connector? Merely set up the holes in the PC board, insert the Molex sockets, solder them securely to the board, and bend them to a right angle to the board. You don't have to mount them in a vertical position only. You can also use these sockets as edge connectors. Put a Molex socket on one board, and matching J-pins on the second board bent parallel with the board after soldering. The result is two boards that can be connected and taken apart from the ends without having to purchase special hardware.

Now for the best use. To add a piggyback IC, that is to mount a second IC directly to the first one, you can now mount two IC packages in the space of one by using the following method: This setup works nicely with memory IC's, since most of the leads are common to others in nature, except for the data lines or enable line if two circuits are separated. Start by drilling the IC holes for the base IC unit; then drill a second row of holes parallel to the base IC holes (see Fig. 9 for the pattern and spacing). Now

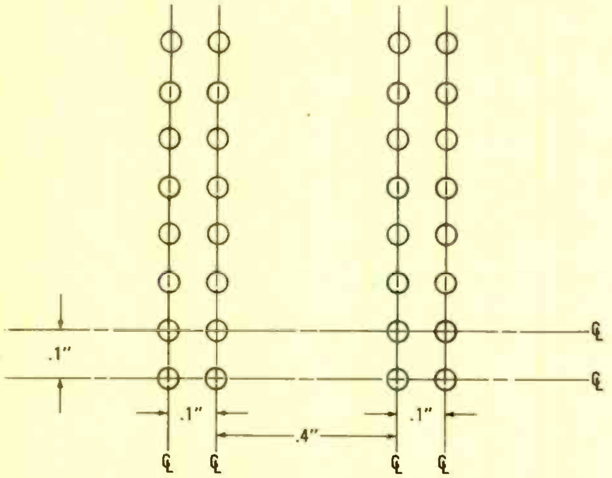


FIG. 9—THE STARTING POINT as you lay out PC board to take piggy-backed dual-in-line integrated circuits.

set up the printed circuit pattern to accommodate the common lines, the separate input and output data lines, and others needed for the two IC's. Figure 10 shows a pattern for a 2102 duplex-mounted memory IC. After etching the circuit, mount the first memory IC by soldering directly to the board. Then take a piece

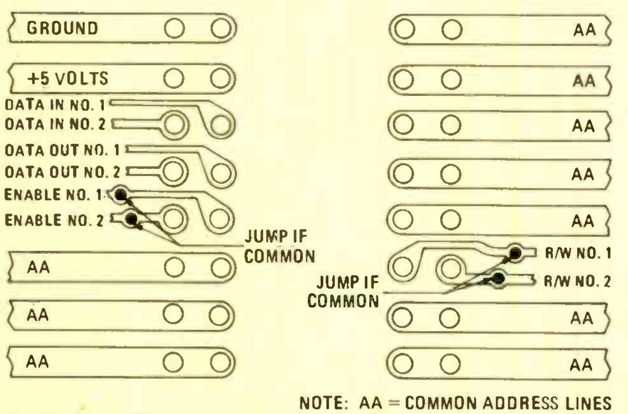


FIG. 10—HOW CONNECTIONS ARE MADE to the pins of piggy-backed IC's. Leads can be etched or Quik Circuit types.

of masking tape cut just to the lead size and place over the outside of the uncommon leads (data or enable lines). This is done to be sure no accidental connections will be made after the next step. Then insert a row of Molex *Soldercons*, solder in to all points of the copper foil, and bend the row as close as possible to the mounted IC in the board. The second IC, with its leads slightly bent outward, is then inserted into the Molex connectors and pushed firmly in (see Fig. 11).

Inspect for possible uncommon-lead shorting because these leads must be kept separate from each other. Common-lead shorting is OK as the circuit does this anyway. Just be sure of those leads requiring separate data information lines. It would be a good idea to paint these particular leads on the first IC after mounting it for additional protection and lead identification.

You now have two IC packages in the space of almost one. Consider also directly soldering a third IC to the uppermost IC mounted to the Molex pins. What a space saver this can be if you are hard pressed for room. If stackable IC sockets were

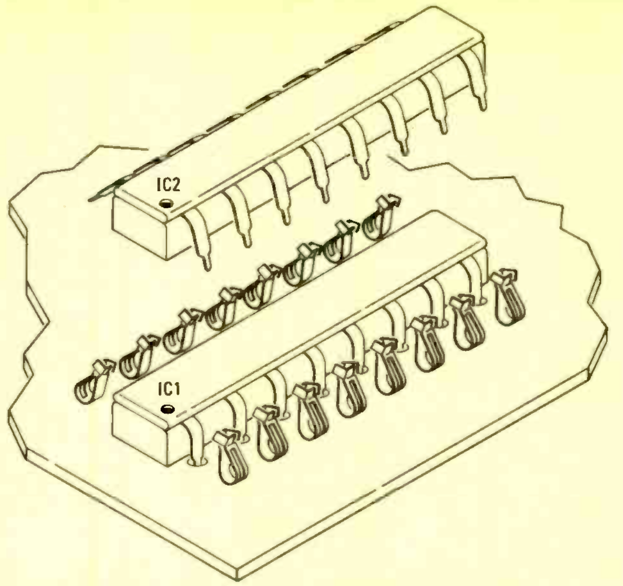


FIG. 11—HOW IC'S ARE PIGGY-BACKED. Pins on the top device are spread outward and then inserted into the Molex socket.

available you could avoid this type of modification. However, as yet they are not on the market, or if they are, a darn good secret has been kept from us "home-brew" users and builders.

Star No. four

This is a simple way to drill all those precision-spaced holes in the PC boards: Using predrilled perforated board with 0.100 × 0.100 spacing, place some double-sided Scotch-brand tape onto the perforated board section you will use as a drill guide. Press the perforated board over the PC board area, mark the drill holes, and just drill them as straight as you can directly by using the guide, the motor tool and the right drill-bit size. Remove the guide and, using blade No. 17 of an *X-acto* knife, you can easily remove any burrs left by drilling the board. No need to use any clamps as the sticking action of the double-sided tape holds the guide securely when you are drilling.

Star No. five

Are you tired of buying expensive edge connectors and wiring them to the motherboard to provide a backplane circuit? Here is a better way: AP Products, Box 110-Q, Painesville, OH, and Robinson-Nugent, 800 E. Eighth St., New Albany, IN, make and market male and female headers, both straight and some right-angle male headers (the female headers are not right angle). These 36-connector-wide headers can be broken into lesser sizes if needed. They match up beautifully when properly mounted in the PC boards and provide continuity of circuits from one board to another, without separate use of cable and connectors.

To use these headers to make a backplane board, use a board (made by Vero Electronics) which has 36 lines running about 18 inches long. If the Vero board is used with the female headers, two additional holes will have to be drilled for each header installed into the board. Just insert the female header and solder in place all 36 tabs, or less if all 36 lines are not used. Use as many female headers in this backplane board as needed for the circuit cards that will be made using the right-angle male header to mate with the header on the motherboard. I use this system in place of the standard 22-pin edge connectors. All I do is set up the general pattern for the motherboard, consider how many individual cards will use this board, install the headers as I go and work on my individual cards with the idea of matching up the circuits to the backplane motherboard. I also provide additional space on the motherboard for possible revisions or additions. Figure 12 shows the headers set up to the Vero board and how the individual male-header cards are to be inserted so circuits on the card and motherboard are interconnected.

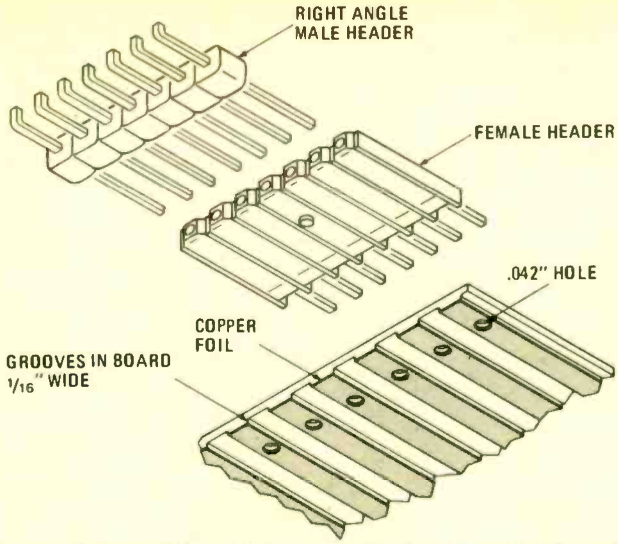


FIG. 12—HEADERS FORM CONNECTORS as auxiliary boards are plugged into the motherboard or main-frame.

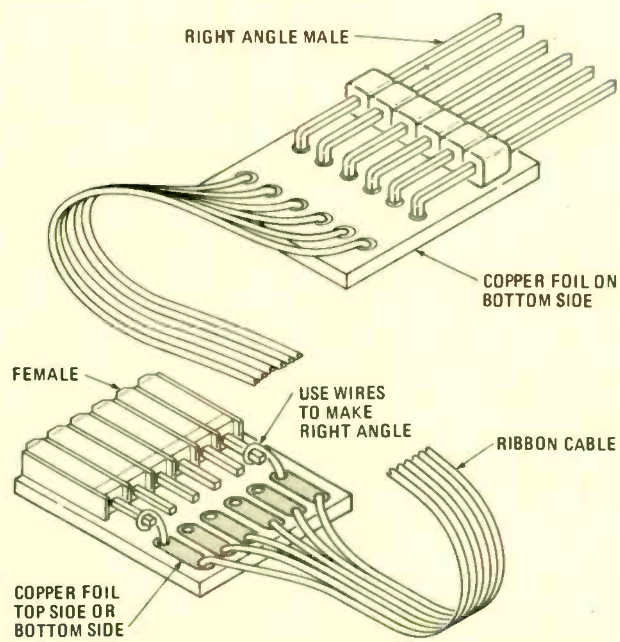


FIG. 13—RIBBON-CABLE CONNECTORS can be made from either male or female headers and small pieces of Veroboard.

Also I find I can make flat wire connectors with these headers. The female headers do require a slight modification, since they do not come with right-angle leads. Figure 13 demonstrates how to attach a female header at a right angle to a board using wires. All you need to build these cable assemblies is the Vero board (or equivalent); the necessary lines—8, 10, or up to 36; the flat ribbon cable; and male and female headers. Solder in the male or female header on one end of the strip, solder in the ribbon cable, and tape it securely; this completes one end of the cable assembly. Do the same at the opposite end of the wire cable or solder the wire directly to the circuit where it is to be attached. A matching male or female header will have to be provided in the circuit that has the cable connection attached to it. The foregoing method is an inexpensive way to use detachable cable assemblies in PC board layouts without buying special hardware. It is especially useful when you want to use cable between a main circuit board and a display panel.

Male and female headers can also be used as end board connectors, keeping in mind the right-angle modification for the females. The use for these headers is unlimited. Some readers who work with them will come up with other uses and modifications. From a simple motherboard and card connectors to cable assembly, they can help to keep overall hardware costs down.

Star No. six

Vector's No. T-44 pins. Normal usage is to mount these pins in perforated board with a 0.042 hole, and use for mounting discrete components; the extra long lead can be wire-wrapped or soldered. Do you want to mount discrete devices to an IC socket? Consider this setup:

In the PC board install an IC socket or Molex pins. Then, take some perforated board with 0.100 × 0.100-hole spacing, cut it to fit the socket, and insert the T-44 pins where the IC leads would go. Now you can solder any device into the parallel pins, cut the T-44 pin lead to fit the socket snugly, and you have an inexpensive base to mount these discrete devices. A ready-made base for this purpose would cost a hundred times as much. Also you can modify the T-44 pin by cutting off the component mounting portion to make a T-pin (see Figs. 14 and 15). This modified T-44-pin to a T-pin can replace the Vector T-46 pin.

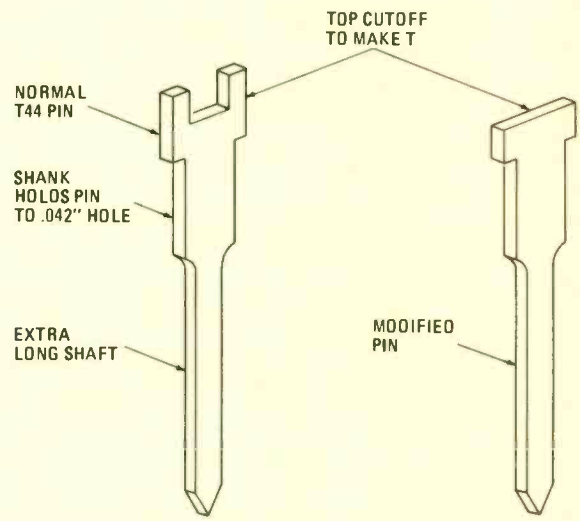


FIG. 14—MODIFIED T-44 PIN has notch section cut off forming a "T" pin substitute for the type T-46.

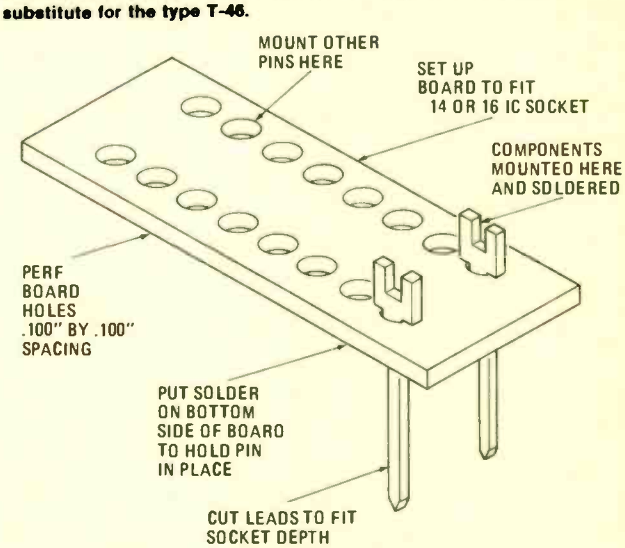


FIG. 15—VECTOR T-44 PINS AND PERFORATED BOARD can be used as a plug-in terminal strip for discrete components.

The T-section makes an excellent soldering base to hold the pin securely, and the extra long shaft length comes in handy.

A money-saving way to use IC test clips is to take the clip and carefully solder wires to each test terminal. After soldering and marking test lead No. 1, wrap up this end with electrical tape to strengthen the wire connections just made. Take a piece of perforated board, put in the T-44 pins, match up the wires to the

continued on page 121

All About Audio Oscillators

The audio oscillator of today ranges from the simplest audio source for signal tracing to the more precise and sophisticated lab-grade instruments. This story is about the latter type.

CHARLES M. GILMORE*

THE MODERN AUDIO OSCILLATOR ORIGINATED when electronic products were simple. It has since developed into a complex instrument with sophisticated specifications. The electronics world it serves has increased in sophistication so much that the original audio oscillator would no longer suffice in the areas of design, service or research.

The audio oscillator's low-distortion, low-noise signals are mainly used in the design and service of high-quality audio equipment. These are by no means the only uses. Design, service and research measurements in frequency response, attenuation, amplifier and system gain, distortion, noise and impedance are all made possible or simplified by using high-precision audio oscillators.

In the literature on the history of low-frequency signal sources, the terms "generator" and "oscillator" are used virtually interchangeably. A decade ago, these terms were truly interchangeable; generator or oscillator had little independent meaning. Today oscillator and generator indicate different technologies used to produce the fundamental signal. The term "oscillator" is applied to a circuit having a natural resonance and able to produce a pure sinusoidal signal. On the other hand, the term "generator" normally indicates some other form of electronic circuitry. For example, a constant-current source and a capacitor can be used to generate a triangle wave as the fundamental signal, and various electronic shaping networks process the triangle to produce the different waveforms.

A prime requirement for much audio work is a high-purity signal—a signal of extremely low harmonic content and low noise. The oscillator is the logical circuit for a signal source meeting these needs.

Changes in the state of the art, especially in audio equipment, have resulted in a need for great improvements in audio oscillator specifications. Ten to fifteen years ago, the sine/square generator producing a sinusoidal signal with a 0.25% total harmonic distortion (THD) was entirely acceptable for audio equipment design and service. Today, to maintain increasingly sophisticated audio equipment, the audio oscillator must have THD specifications of less than 0.05%, and preferably less than 0.25%. This change has brought the audio oscillator to the forefront, and will soon make the sine/square generator obsolete.

Basic oscillators

Figure 1 is a block diagram of a typical audio oscillator. The major sections are: oscillator (the signal source), output amplifier and output attenuator. Occasionally, additional circuitry can be found to drive the oscillator to provide phase-locking or some form of frequency synchronization. Squarewave shaping circuits are used if squarewave output is also furnished, and meeting circuits are added to some audio oscillators to display output amplitude. Of course, all these instruments have some form of electronically regulated power supply: either battery or line, depending upon the application for which the instrument was designed.

Oscillator circuits

A number of basic oscillator circuits are used to generate fundamental signals. Each has attributes that make it popular in particular situations. The Wien bridge is one of the most used audio oscillator circuits. Figure 2-a is a simplified schematic of a Wien-bridge oscillator. The twin-T oscillator (Figure 2-b) is a variation of the Wien bridge and has other derivatives known as the bridged-T oscillator (Figs. 2-c and 2-d).

The Wien bridge and the bridged-T (capacitive) are usually continuously tuned by a variable capacitor, and ranges are changed by changes in resistance. The

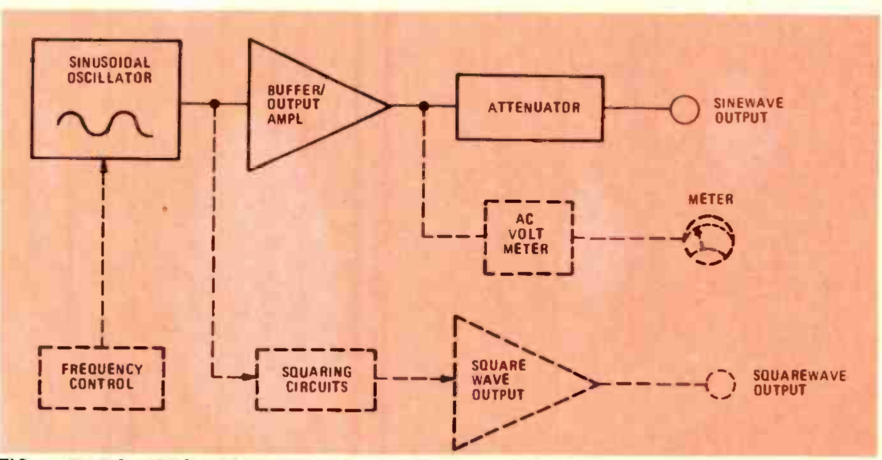


FIG. 1—BASIC AUDIO OSCILLATOR. The simplest type will include the sinusoidal wave generator, buffer amplifier and output attenuator. Other types may include meters, and squaring and electronic control circuits.

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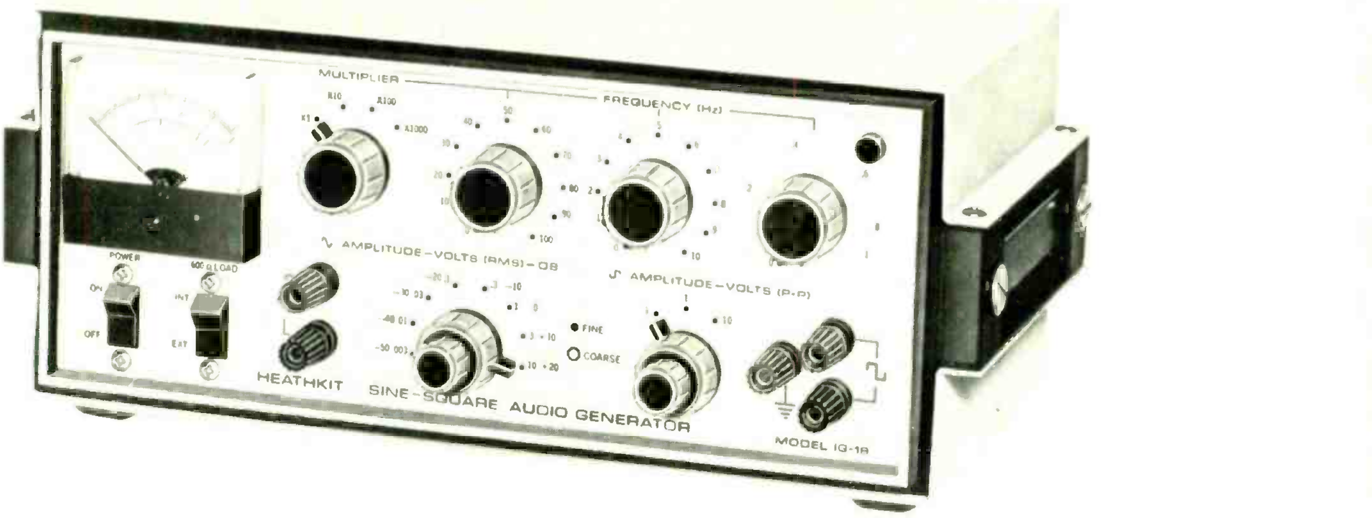

bridged-T (resistive) is usually continuously tuned by varying one resistance (often by pushbuttons) and range-changed with fixed capacitance values. The twin-T circuit is not often used for continuously variable oscillators, since three elements must be changed to change the frequency. Such oscillator circuits typically operate over the span of a few hertz to 10 MHz.

The Wien-bridge oscillator operates when the net phase shift of the two R–C (resistance-capacitance) combinations is zero. Therefore, a two-stage amplifier that provides a 360° phase shift is necessary for proper operation. Amplitude variations with changes in frequency are removed by a compensating element in one leg of the bridge. A thermistor, or more popularly, a tungsten lamp filament, is used for this amplitude compensation.

The phase-shift oscillator (Fig. 3) is another R–C circuit. Having approximately the same frequency range as the Wien-bridge oscillator series, the phase-shift oscillator derives its operation from successive 60° phase shifts at each of the R–C stages. This shift oscillator has two major disadvantages: The three R–C elements must be varied to change the frequency, and the oscillator output is amplitude-sensitive to the R–C ratio.

The frequency of both the phase-shift and Wien-bridge oscillators depends directly on the value of the capacitance. Therefore, a 10:1 change in the capacitance value produces a 10:1 change in the oscillator frequency. This characteristic of R–C oscillators makes them particularly popular.

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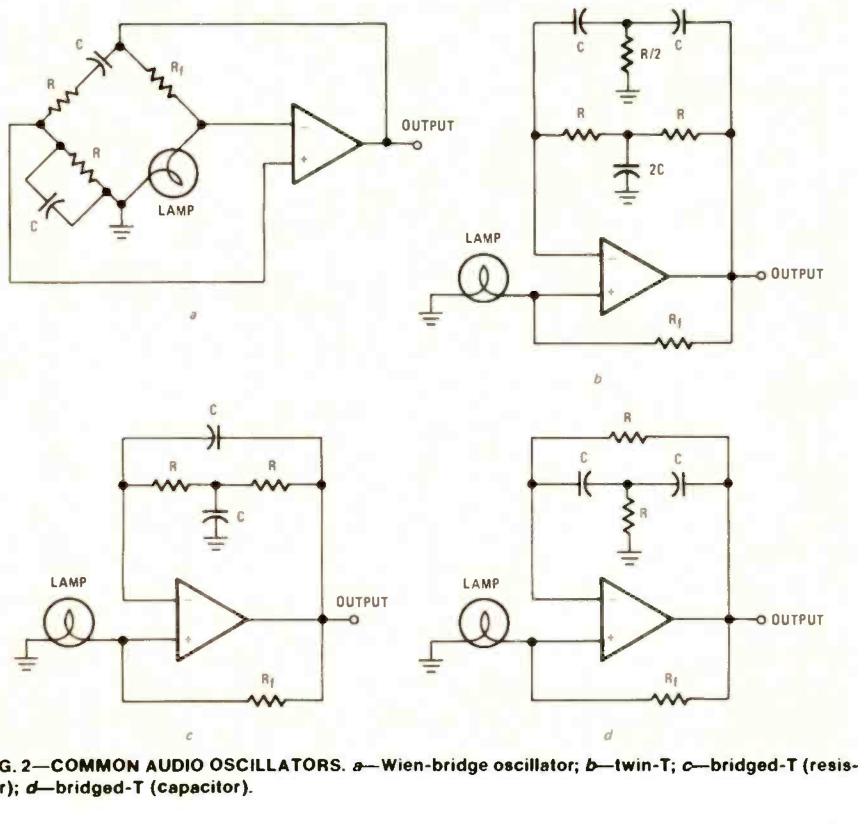


FIG. 2—COMMON AUDIO OSCILLATORS. ***a*—Wien-bridge oscillator; *b*—twin-T; *c*—bridged-T (resistor); *d*—bridged-T (capacitor).**

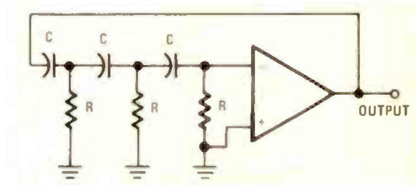


FIG. 3—PHASE-SHIFT OSCILLATOR. Each R-C section shifts the phase 60 degrees.

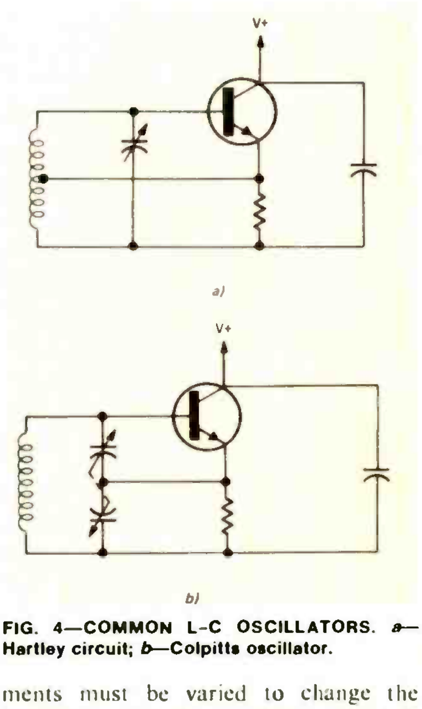


FIG. 4—COMMON L-C OSCILLATORS. *a*—Hartley circuit; *b*—Colpitts oscillator.

ic application of the month

XR-2208 Operational Multiplier

GENERAL DESCRIPTION

The XR-2208 operational multiplier combines a four-quadrant analog multiplier (or modulator), a high frequency buffer amplifier, and an operational amplifier in a monolithic circuit that is ideally suited for both analog computation and communications signal processing application. As shown in the functional block diagram, for maximum versatility the multiplier and operational amplifier sections are not internally connected. They can be interconnected, with a minimum number of external components, to perform arithmetic computation, such as multiplication, division, square root extraction. The operational amplifier can also function as a preamplifier for low-level input signals, or as a post detection amplifier for synchronous demodulator applications. For signal processing, the high frequency buffer amplifier output is available at pin 15. This multiplier/buffer amplifier combination extends the small signal 3-dB bandwidth to 8 MHz and the transconductance bandwidth to 100 MHz.

The XR-2208 operates over a wide range of supply voltages, ±4.5V to ±16V. Current and voltage levels are internally regulated to provide excellent power supply rejection and temperature stability. The XR-2208 operates over a 0°C to 75°C temperature range. The XR-2208M is specified for operation over the military temperature range of –55°C to +125°C.

FEATURES

- Maximum Versatility
  - Independent Multiplier, Op-Amp, and Buffer
- Excellent Linearity (0.3% typ.)
- Wide Bandwidth
  - 3 dB B.W. – 8 MHz typ.
  - 3° Phase Shift B.W. – 1.2 MHz typ.
  - Transconductance B.W. – 100 MHz typ.
- Simplified Offset Adjustments
- Wide Supply Voltage Range (±4.5V to ±16V)

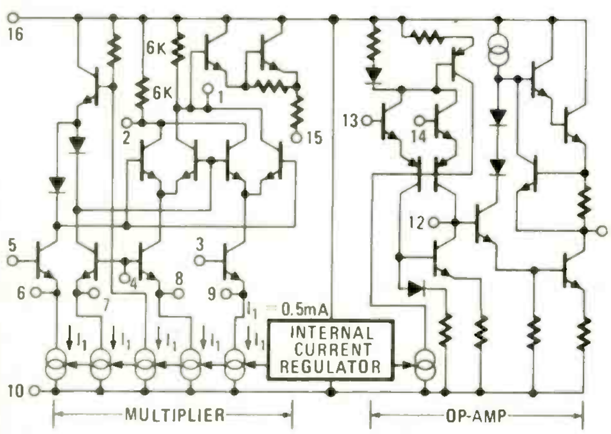
APPLICATIONS

- Analog Computation
  - Multiplication
  - Division
  - Squaring
  - Square Root
- Signal Processing
  - AM Generation
  - Frequency Doubling
  - Frequency Translation
  - Synchronous AM Detection
  - Triangle-to-Sinewave Converter
  - AGC Amplifier
  - Phase Detector
- Phase-Locked Loop (PLL) Applications
  - Motor Speed Control
  - Precision PLL
  - Carrier Detection
  - Phase-Locked AM Demodulation

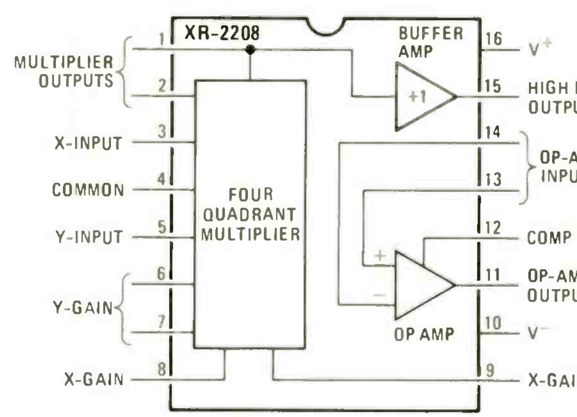
ABSOLUTE MAXIMUM RATINGS

Power Dissipation	
Ceramic Package	750 mW
Derate above +25°C	6 mW/°C
Plastic Package	625 mW
Derate above +25°C	5.0 mW/°C
Power Supply V+	+18 Volts
V–	–18 Volts
Storage Temperature Range	–65°C to +150°C

SIMPLIFIED SCHEMATIC DIAGRAM



FUNCTIONAL BLOCK DIAGRAM



EXAR INTEGRATED SYSTEM, INC.
750 Palomar Ave., P.O. Box 62229, Sunnyvale, CA 94088
(408) 732-7970 TWX 910-339-9233

AVAILABLE TYPES

Part Number	Package	Temperature Range
XR-2208M	Ceramic	−55°C to +125°C
XR-2208N	Ceramic	0°C to +75°C
XR-2208P	Plastic	0°C to +75°C
XR-2208CN	Ceramic	0°C to +75°C
XR-2208CP	Plastic	0°C to +75°C

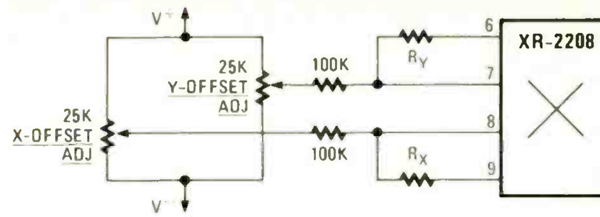


FIG. 1–OFFSET ADJUSTMENT

DESCRIPTION OF CIRCUIT CONTROLS

MULTIPLIER INPUTS (PINS 3, 4, AND 5)

The X- and Y-inputs to the multiplier are applied to pins 3 and 5 respectively. The third input (pin 4) is common to both X- and Y-portions of the multiplier, and in most applications serves as a "reference" or ground terminal. The typical bias current at the multiplier inputs is 3 μA for the X- and Y-inputs and 6 μA for the "common" terminal. In circuit applications such as "synchronous AM detection" or "frequency doubling" where the same input signal is applied to both X- and Y-inputs, pin 4 can be used as the input terminal since it is common to both X- and Y-sections of the multiplier.

MULTIPLIER OUTPUTS (PINS 1 AND 2)

The differential output voltage, V_o, across these terminals is proportional to the linear product of voltages V_x and V_y applied to the inputs. V_o can be expressed as:

$$V_o \approx \left(\frac{25}{R_x R_y}\right)\left(V_x V_y\right)$$

where all voltages are in volts and the resistors are in kΩ. R_x and R_y are the gain control resistors for X- and Y-sections of the multiplier.

The common-mode DC potential at the multiplier outputs is approximately 3 volts below the positive supply. One of the multiplier outputs (pin 1) is internally connected to the unity-gain buffer amplifier input for high frequency applications.

In most analog computation operations, such as multiplication, division, etc., pins 1 and 2 are DC coupled to the op-amp inputs (pins 13 and 14). The final output, V_z, is then obtained from the op-amp output at pin 11, as shown in Fig. 2.

X AND Y GAIN ADJUST (PINS 6, 7, 8, AND 9)

The gains of the X- and Y-sections of the multiplier are inversely proportional to resistors R_x and R_y connected across the respective gain terminals. The multiplier conversion gain, K_m, can be expressed as:

$$K_m \simeq \frac{25}{R_x R_y} \quad (\text{volts})^{-1}$$

where R_x and R_y are in kΩ.

X- AND Y-OFFSET ADJUST (PINS 7 AND 8)

Two of the gain-control terminals, pins 7 and 8, are also used for adjusting X- and Y-offsets. Fig. 1 shows the typical adjustment circuitry which can be connected to these pins to null-out input offsets.

OP-AMP INPUTS (PINS 13 AND 14)

Pin 13 is the noninverting and pin 14 the inverting inputs for the op-amp section. In most multiplier applications, these terminals are connected to the multiplier outputs (pins 1 and 2). Note: When the op-amp section is not used, these terminals should be grounded.

OP-AMP COMPENSATION (PIN 12)

The op-amp section can be compensated for unconditional stability with a 20 pF capacitor connected between pin 12 and pin 11. For op-amp voltage gains greater than unity, this compensation capacitance can be reduced to improve slew rate and small signal bandwidth.

OP-AMP OUTPUT (PIN 11)

This terminal serves as the output for the op-amp section. It is internally protected against accidental short circuit conditions, and can sink or source 10 mA of current into a resistive load. In most multiplier applications, pin 11 is the actual XR-2208 output, with the op-amp inputs being connected to the multiplier outputs.

BUFFER AMPLIFIER OUTPUT (PIN 15)

The buffer amp is internally connected to the multiplier section. The buffer amp has unity voltage gain, and provides a low-impedance output at pin 15 for the multiplier section. The buffer amp is particularly useful for high frequency operation since it minimizes the capacitive loading effects at the multiplier outputs.

The buffer amplifier is activated by connecting a load resistor, R1, from pin 15 to ground. When it is not used, pin 15 can be left open circuited. However, since the buffer amplifier output is a low-impedance point, reasonable care should be taken to avoid burnout due to accidental short circuits. The maximum DC current drawn from pin 15 should be limited to 10 mA. The DC voltage at pin 15 is typically 4.5 volts below V^+.

APPLICATIONS INFORMATION

PART I: ARITHMETIC OPERATIONS

Multiplication

For most multiplication applications, the multiplier and op-amp sections are interconnected as shown in Fig. 3 to provide a single-ended analog output with a wide dynamic range. The circuit of Fig. 2 provides a linear output swing of 10V for maximum input signals of 10V, with a scale factor K = 0.1. The trimming procedure for the circuit is as follows:

1. Apply OV to both inputs and adjust the output offset to OV using the output offset control.
2. Apply 20V P-P at 50 Hz to the X-input and OV to the Y-input. Trim the Y-offset adjust for minimum peak-to-peak output.
3. Apply 20V P-P to the Y-input and OV to the X-input. Trim the X-offset adjust for minimum peak-to-peak output.

4. Repeat step 1.
5. Apply +10V to both inputs and adjust scale factor for V_o = +10V. This step may be repeated with different amplitudes and polarities of input voltages to optimize accuracy over the entire range of input voltages, or over any specific portion of input voltage range.

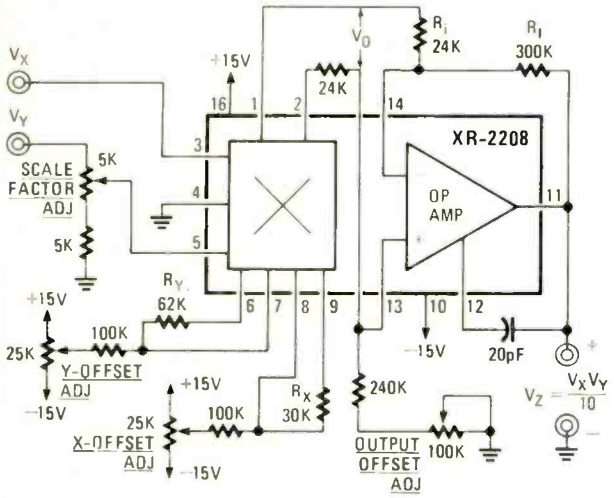


FIG. 2-MULTIPLICATION CIRCUIT

Squaring Circuit

The recommended circuit connection for squaring applications is shown in Fig. 3. This circuit is the same as the basic multiplier circuit with both inputs tied together, except only one input offset adjustment is necessary. Trimming procedure for the squaring circuit is as follows:

1. Apply 0 volts to the input and adjust the output offset to zero.
2. Apply 1.0V to the input and adjust the Y-offset until V_o = 0.10V.
3. Apply 10V to the input and adjust the scale factor until V_o = +10V.
4. Apply −10V to the input and check that V_o = +10V. If not, repeat steps 1 through 3. Some compromise may be necessary in scale factor adjustments given in steps 3 and 4.

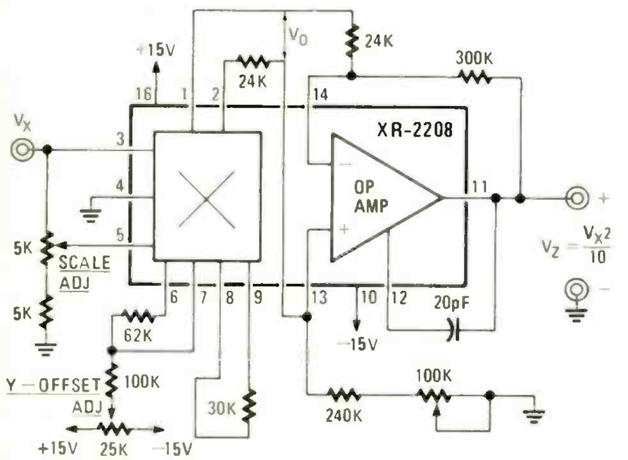


FIG. 3-SQUARING CIRCUIT

Dividing Circuit

Recommended circuit connection for performing analog division is shown in Fig. 4. This circuit uses the multiplier in the feedback path of the op-amp. For the circuit shown, $V_o = +10\ V_Z/V_X$ where $V_X < 0$ and V_Z can have either sign. Positive values of V_X are not allowed, causing positive feedback and latchup.

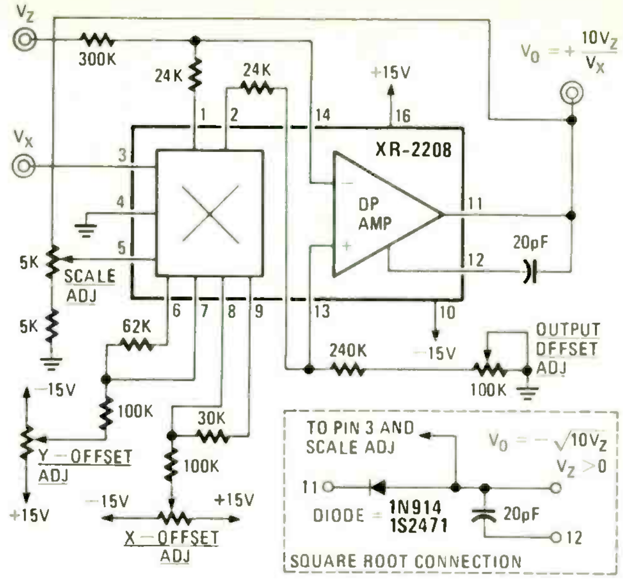


FIG. 4-DIVIDING CIRCUIT

This latchup mode is nondestructive to the XR-2208, and is common to all analog division circuits. The divide circuit is trimmed as follows:

1. Apply V_Z = 0 and trim the output offset adjustment for constant output voltage as V_X is varied from −1V to −10V.
2. Keeping V_Z = 0, and applying V_X = −10V, trim the Y-offset adjust until V_o = 0.
3. Let $V_Z = V_X$ and/or $V_Z = -V_X$ and trim the X-offset adjustment for constant output voltage as V_X is varied from −1V to −10V.
4. Repeat steps 1 and 2 if step 3 required a large initial adjustment.
5. Keeping $V_Z = V_X$, adjust the scale factor trim for V_o = −10V as V_X is varied from −1V to −10V.

Square Root Circuit

This is essentially the dividing circuit with the X-input tied to the output. Thus, the voltage on the Z-input is divided by the output voltage, i.e. the output is proportional to the square root of the input. A diode is included in series with the output to prevent a latchup condition which would result if V_Z were allowed to go negative. The square root circuit may be trimmed as a divider by disconnecting the X-input from the output, keeping $V_Z > 0$ and $V_X < 0$. The square root circuit may also be trimmed in the closed-loop mode by the following procedure:

1. Apply V_Z = +0.10V and trim the output offset adjust for V_o = −0.316V.
2. Apply V_Z = +0.9V and trim the X-offset adjust for V_o = −3.0V.
3. Apply V_Z = +10V and trim the scale factor adjust for V_o = −10V.
4. Repeat steps 1 through 3 until desired accuracy is achieved.

PART II: SIGNAL PROCESSING

AM GENERATION

Figure 5 is the recommended circuit connection for generating double sideband (DSB) or suppressed carrier AM signals. Modulation and carrier inputs are applied to the X- and Y-inputs respectively. The carrier level at the output can be adjusted by the DC voltage applied to pin 3. For suppressed carrier operation, the carrier feedthrough can be further reduced by using the X- and Y-offset adjustments. In this application, the unity-gain buffer amplifier section will provide a low-impedance output if desired. If the buffer amp is not used, pin 15 should be open circuited to reduce power dissipation.

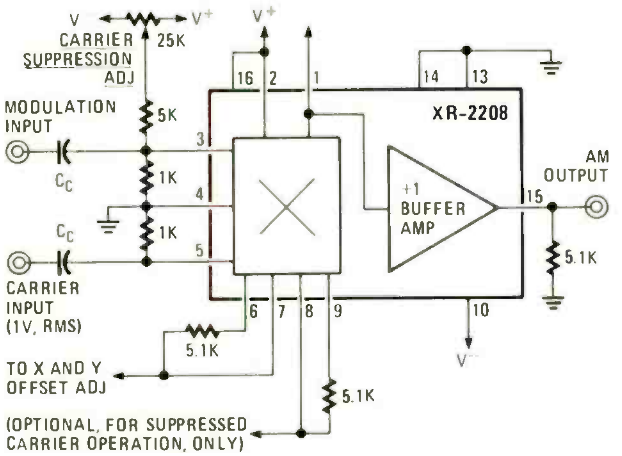


FIG. 5-AM GENERATION

Typical carrier suppression without offset adjustment is 40 dB for frequencies up to 1 MHz, and 30 dB for frequencies up to 10 MHz. For low frequency applications ($f < 10$ kHz), carrier suppression can be reduced to 60 dB by using the offset adjustment controls.

SYNCHRONOUS AM DETECTION

Figure 6 is a typical circuit connection for synchronous

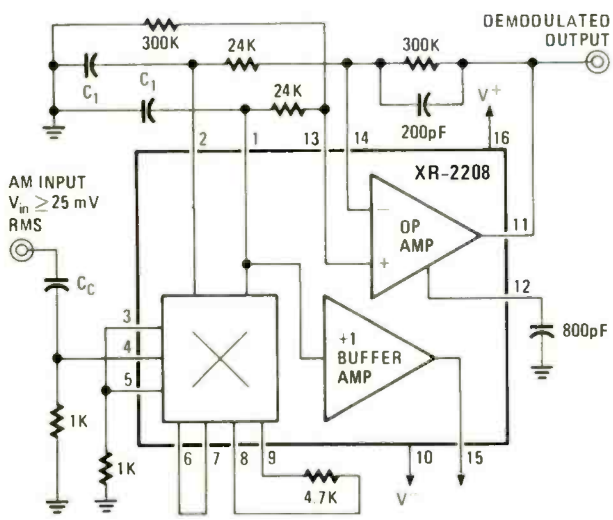


FIG. 6-SYNCHRONOUS AM DETECTOR

AM detection for carrier frequencies up to 100 MHz. The AM input signal is applied to the multiplier "common" terminal (pin 4). The Y-gain terminals are shorted, and this section of the multiplier serves as a "limiter" for input signals $\geq$ 50 mV RMS; the X-section of the multiplier operates in its linear mode. The low-pass filter capacitors, C1, at pins 1 and 2 are used to filter the carrier feedthrough. If desired, the op-amp section can be used as an audio preamplifier to increase the demodulated output amplitude.

TRIANGLE-TO-SINEWAVE CONVERSION

A triangular input can be converted into a low distortion (THD < 1%) sinusoidol output with the XR-2208. A recommended connection for this application is shown in Fig. 7.

The triangle input signal is applied to the X-input (pin 3). The multiplier section rounds off the peaks of this input and converts it to a low distortion sinewave. For the component values shown in Fig. 7, the recommended input signal level at pin 3 is $\simeq$ 300 mV P-P in order to obtain a 2V P-P sinewave output at pin 15. This waveform can be further amplified using the op-amp section to provide high level (10V P-P), low distortion output at pin 11.

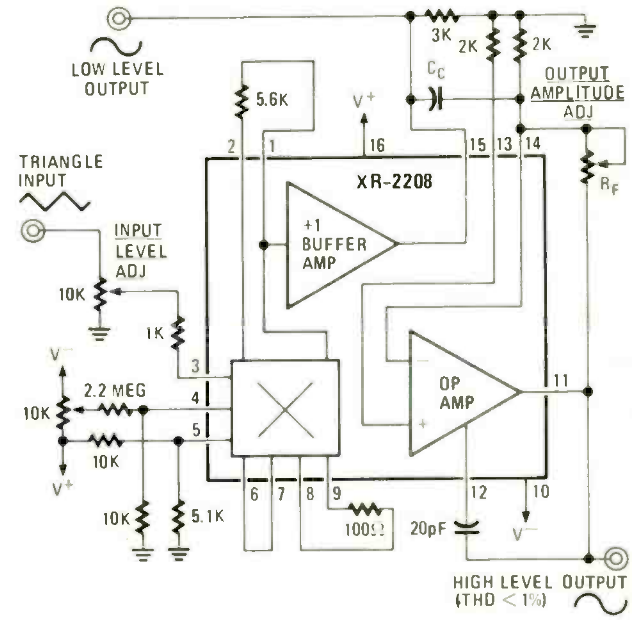


FIG. 7-TRIANGLE-TO-SINE CONVERTER

PHASE DETECTION

The multiplier section can be used as a phase detector. A recommended circuit connection is shown in Fig. 8. The reference input is applied to pin 5, and the input signal whose phase is to be detected is applied to pin 3. The differential DC voltage, V_ϕ, at the multiplier outputs (pins 1 and 2) is related to the phase difference, ϕ, between the two input signals, V_1 and V_2, as:

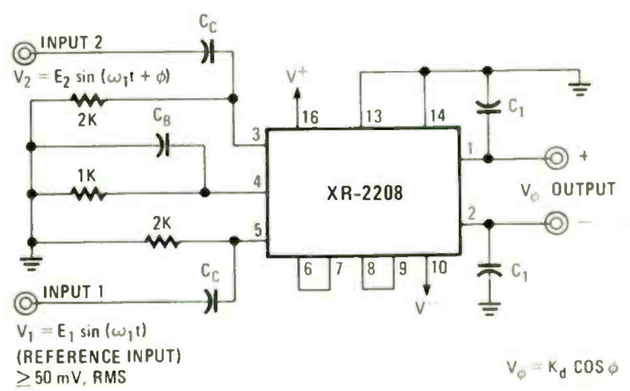


FIG. 8-PHASE-DETECTOR CIRCUIT

$$V_\phi = K_d \cos \phi$$

where K_d is the phase detector conversion gain. For input signals $\geq$ 50 mV RMS, K_d is $\approx$ 2V/radian and is independent of signal amplitude. For lower input amplitudes, K_d decreases linearly with the decreasing input level. The capacitors C1 at pins 1 and 2 provide a low-pass filter with a time constant T1 = R1 C1, where R1 = 6 kΩ is the internal impedance level at these pins.

If needed, the phase conversion gain can be increased by using the op-amp section of the XR-2208 to further amplify the output voltage, V_ϕ. The XR-2208 operational multiplier is suitable for phase detection of input frequencies up to 100 MHz.

PART III: PHASE-LOCKED LOOP APPLICATION

MOTOR SPEED CONTROL

A motor speed control where the frequency of the motor is "phase-locked" to the input reference frequency, f_r, is shown in Fig. 9. The multiplier section of the XR-2208 is

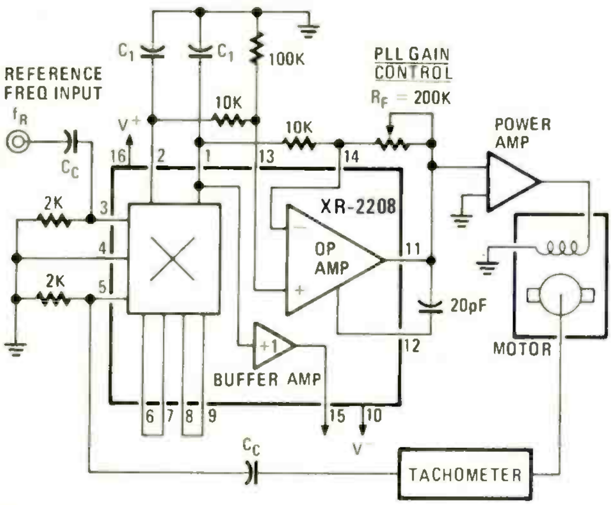


FIG. 9-MOTOR SPEED CONTROL CIRCUIT

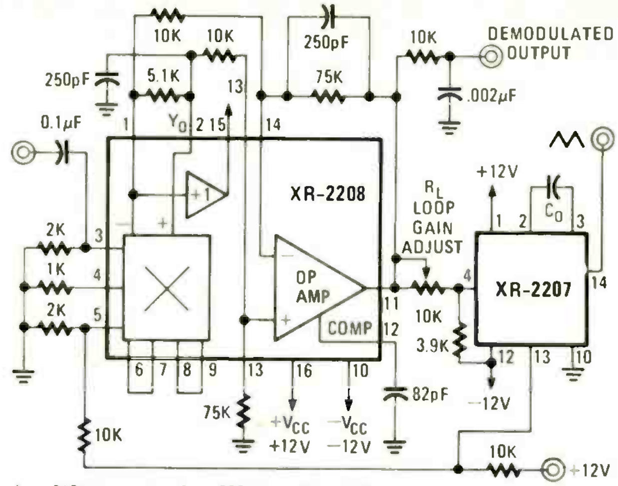
used as a phase comparator, comparing the phase of the tachometer output signal with the phase of the reference input. The resulting error voltage across pins 1 and 2 is low-pass filtered by capacitors C1 and amplified by the op-amp section. This error signal is then applied to the motor field-winding to phase-lock the motor speed to the input reference frequency.

PRECISION PLL

A precision phase-locked loop may be constructed using an XR-2207 voltage controlled oscillator and an XR-2208. (See Fig. 10.) Due to the excellent temperature stability and wide sweep range of the XR-2207 this PLL circuit exhibits especially good stability of center frequency and wide lock range. In this application the XR-2208 serves as a phase comparator and level shifter. Resistor R_L adjusts the loop gain of the PLL, thus varying the lock range. Tracking range may be varied from about 1.5:1 up to 12:1. For large values of R_L, temperature stability of center frequency is better than −30 ppm/°C.

PHASE-LOCKED AM AND CARRIER DETECTION

The XR-2208 can be used as a "quadrature detector" in conjunction with monolithic PLL circuits to perform phase-



f_0 = 840 kHz for Co = 200pF and RL = 1.6K
SWEEP RANGE = 120kHz TO 1.4MHz

FIG. 10-PRECISION PLL

locked AM demodulation and for carrier-level detection. Fig. 11 shows a recommended circuit connection for such applications. The XR-210 or XR-215 monolithic PLL circuits can be adjusted to lock on the desired input AM signal and regenerate the unmodulated carrier. This carrier frequency appears across the timing capacitor, CO, of the PLL and is used as the "reference input" to the XR-2208 multiplier. The AM signal is applied simultaneously to the PLL input and to the XR-2208 multiplier input (pin 3), as shown in Fig. 11.

The demodulated signal is then low-pass filtered by capacitor C1 at the multiplier output, and can be amplified further to the desired audio level by using the op-amp section of the XR-2208.

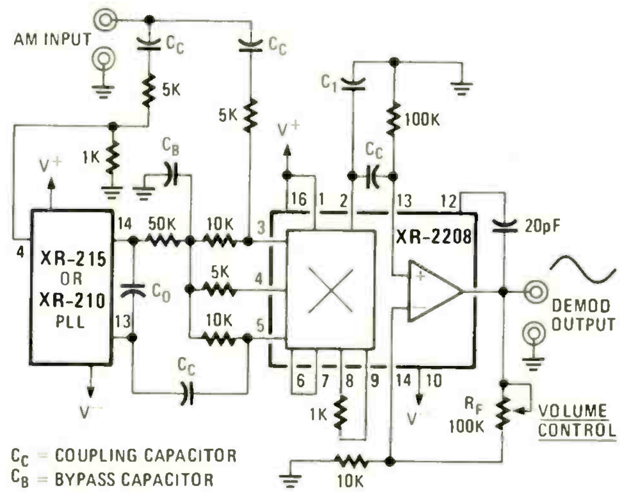


FIG. 11-PHASE-LOCKED AM DEMODULATION OR CARRIER DETECTION

In the carrier detector applications, the op-amp is used as a voltage comparator and produces a "high" or "low" level logic signal at the op-amp output when the input carrier level reaches a detection threshold level set by an external potentiometer. The output from the carrier detector can then be used to enable the "logic-output" stage of the XR-210 FSK modem.

The phase-locked AM or carrier detector system of Fig. 11 shows a high degree of frequency selectivity, as determined by the monolithic phase-locked-loop "capture" bandwidth. R-E

VTR Update

A look at the latest equipment introduced since our February 1978 videotape recorder roundup

FRED PETRAS

ONE OF THE PERILS OF DOING A "WRAPUP" or "roundup" type of feature article in the fast-moving world of home electronics is that by the time it appears in print it is outdated to some degree. **Radio-Electronics** has run into this situation again, this time with our feature on Home Video Tape Recorders (HVTR's) that appeared in the February 1978 issue. Even as the presses were rolling, a half-dozen changes had taken place, and by the time the issue hit the newsstands and the Post Office mailing circuit, a lot more had happened. This article, then, is meant as an update piece, to bring you as close to the whole story as possible within the framework of press deadlines.

New HVTR entries

As noted, several companies were poised to enter the HVTR market. And some have done so. Among them is Akai, which revealed it will market VHS decks (two- or four-hour not specified at presstime). Aiwa and Pioneer, both strong in audio tape recorders, have announced plans to sell Beta 2 units in the United States. Quasar, marketer of the VX-2000 system, is branching out to additionally market a VHS-4 unit priced at $995. And Montgomery Ward has gone the VHS-4 route with a Panasonic-brand-name unit at $995. (That price will be dropped to $947 in its spring-summer catalog, according to trade reports.) Competitor mass-merchant J.C. Penney is going with an RCA-brand-name VHS-4 at $1000.

Another company, not mentioned in our feature article, announced that it is entering the U.S. HVTR market this year. It is Shin-Nippon Electric Company, home electronics arm of Nippon Electric Company, Tokyo. The firm will market two-hour Beta models "sometime this year" under the NEC brand name. Initially, Shin-Nippon will offer Sony-made units, but later will offer its own models.

And, just as we finished writing the above, word came that Philco is about to enter the HVTR field with a VHS-4 model in May.

At the same time we learned that Magnavox is coming up with related HVTR products—25-inch color TV consoles with compartments to accommodate HVTR decks. A vertical armoire with *Star* tuning chassis is priced at $1300; a horizontal console with *Touch-Tune* chassis at $995; and a horizontal console with regular TV chassis at $799.

As noted in our February article, HVTR pricing has been in a state of transition. Sony recently dropped its Beta 2 list price from $1300 to a more competitively viable $1095, as did Toshiba, both on the heels of Zenith, which triggered the drops by cutting its price from $1300 to $995. (This move by Zenith was reportedly done to be competitive with RCA, Zenith's arch-enemy in the color TV field.) JVC came up with a price cut on its two-hour VHS from $1280 to $1050.

Thus, manufacturer pricing of the three main contenders—Beta-2, VHS-2 and VHS-4—is in the $995 to $1095 range. This $100 differential is usually smaller in terms of pricing at the retail level. With HVTR products still in a somewhat short-supply/heavy-demand state, retail pricing has stabilized to a notable degree. *At the moment*, no one is talking about or expecting any additional severe price cutting, either at the manufacturer level or at the retail level.

Relative to playing times, the battle continues. As noted, Sony, with two-hour capability, in an attempt to take the edge off the four-hour capability of competitors, came up with a "long-play" videotape that extends Beta running time to three hours, and a cassette changer to permit up to six hours of operation. Subsequently, JVC announced it would soon offer a three-hour cassette for its VHS-2 system.

This capability for long operation time poses a problem, namely, timers to enable its full use primarily in the area of automatic "absentee" recording. Manufacturers are reportedly at work on the matter and may possibly have LP timers in the marketplace by fall.

Heretofore, HVTR owners had three basic, relatively low-priced color TV cameras to choose from—a JVC unit at $1500, a GBC unit at $1595 and a model from Toshiba at $1700. Now Zenith is offering a two-tube Akai color camera at $2895, and Sony is promoting a Trinicon color camera at $2995.

A source at Akai said the company expects to offer a high-performance color model at a "breakthrough price" sometime this year. Meanwhile, other companies have spurred their research and development departments to devise lower-priced color cameras for HVTR use. Among them is Sony, which recently entered a technical pact with NEC (Nippon Electric Company) with a view to developing low-cost color cameras.

Videotapes

At presstime, **Radio-Electronics** was still hearing reports that blank video tapes have been in short supply in many parts of the country, namely in VHS form. The word from tape suppliers is that this situation will ease off shortly. Key manufacturers are stepping up their efforts on behalf of HVTR users by increasing production in some cases, or by adding new tapes production facilities. An example of the latter is Sony, which built a $50 million tape plant in Alabama to assure adequate supplies of Betamax cassettes.

As predicted in our February article, recorded HVTR tapes are growing in abundance as more and more companies get into the field. The latest development is the formation of Video Club of America, Farmington Hills, MI 48024, which sells (via mail-order) two-hour movies from 20th Century Fox Studios at $39.95, and longer features at $59.95, in the major HVTR formats. The club also offers a trade-in program under which consumers who bought a $39.95 videotape can return it for a 50 percent credit on their next purchase. **R-E**

computer corner

Z-80 How to interface the Z-80 to other devices and the associated timing

WILLIAM BARDEN, JR.

LAST MONTH, WE LOOKED AT THE THREE different ways the Z-80 can be interrupted. This month, we'll take a look at how the Z-80 can be interfaced to other devices.

Before discussing some real-world examples of interfacing, we'll look more closely at the interface timing diagrams and interfacing signals involved. The Computer Corner in the December 1977 issue briefly discussed CPU timing for the operation code-fetch portion of instruction execution. The timing for a memory read or memory write is similar except that the M1 cycle (operation code fetch) is not active during the read or write memory operation.

Figure 1 shows the timing diagram for a memory read and Fig. 2 shows the timing diagram for the memory write operation. They are usually three clock-

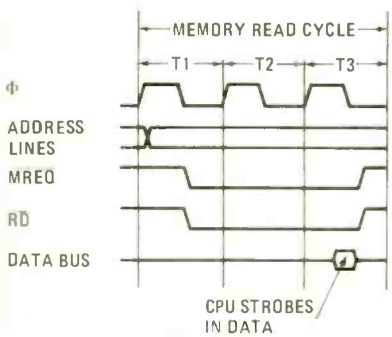


FIG. 1

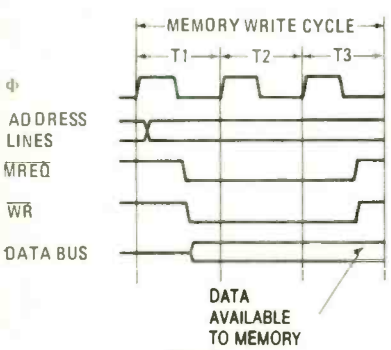


FIG. 2

periods long, unless slow memories are being used, in which case additional *wait* clock cycles can be activated by the slow external memory. The MREQ signal is used to signal the external memory that a valid memory address is on address bus lines A0–A15. If a memory read is being performed, signal RD is brought down to a logic 0. If a memory write is being performed, RD is a logic 1 and signal WR is a logic 0. Data is strobed into the CPU register during read operations at the indicated time, or is available for a memory write during most of the three write cycles.

Provision is made in the Z-80 microprocessor for interfacing to slower memories by the WAIT signal input to the Z-80. Bringing this signal down to a logic 0 informs the Z-80 CPU that external memory is not ready to transfer data. Figure 3 shows the result: It simply stretches the memory read or write time as long as required by slow memory.

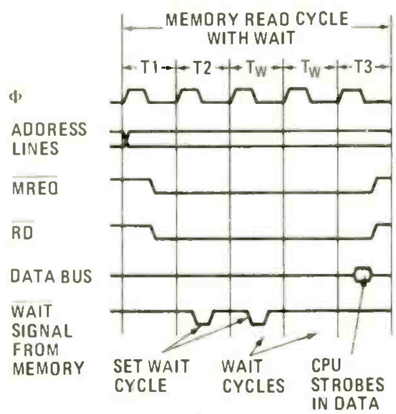


FIG. 3

I/O routines

Input and Output data transfers are initiated by unique I/O instructions. The CPU decodes these instructions and issues a special signal to indicate that data will be transferred to an I/O device, rather than a memory device. The Z-80 and the 8080 are different from most microprocessors in this respect since many microprocessors do not differentiate between memory addresses and I/O device addresses. Address decoding for many other microprocessors is done by the memory and I/O devices in a *memory-mapped* I/O scheme. The net effect is that some of the address range of this type of microprocessor must be dedicated

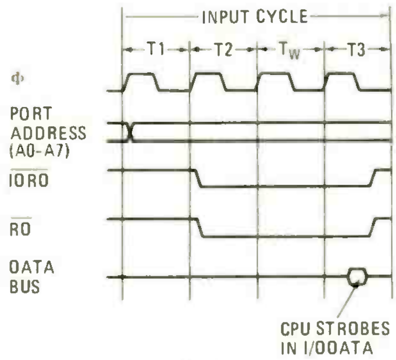


FIG. 4

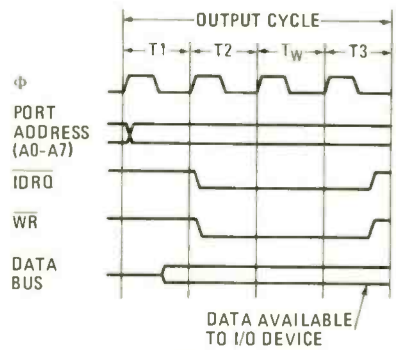


FIG. 5

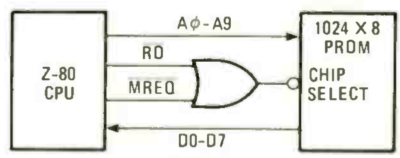


FIG. 6

to I/O device addresses, rather than to memory addresses alone.

Figure 4 shows the Input and Fig. 5 shows the Output cycles on the Z-80. Note that the major difference is in the IORQ signal that notifies the external I/O device that a valid I/O device address is present on address bus lines A0 through A7. The RD and WR signals are used in the same sense as in memory read and write operations. Note that input and output cycles are four clock cycles long, because the CPU automatically inserts an additional wait cycle to provide more time for the I/O device to respond. The I/O devices can also use the wait state capability provided by the wait input to synchronize slow-speed I/O devices with CPU execution of Input or Output instructions.

Figure 6 shows the operation of a Z-80

CPU with a 1024-by-8 bit PROM. This simple example allows for no I/O device interfacing and is for demonstration purposes only. Address lines A0–A9 are brought into the PROM to provide 10 bits of address (0–1023). Since presumably no write operations to the PROM will be performed in the program, the signals RD and MREQ are OR'ed together to provide a chip select signal to the PROM. Signal RD is not really necessary since every memory access is a memory read.

Figure 7 shows the same PROM storage with additional RAM storage to supplement the somewhat limited RAM storage of the CPU registers in the first example. Here, it is assumed that the RAM will not contain a program, and that it will provide storage for program variables computed in the course of program execution. In addition, the PROM memory is located at addresses 0000 through 03FF (ϕ through 1023_{10}), while the RAM addresses are 0400 through 04FF (1024–1279_{10}). Address-line 10 can therefore be used to decode whether PROM or RAM is being addressed. While RD and WR must both be provided to the RAM memory, only RD is used for the PROM. As in the first example, RD is a redundant signal for the PROM since a MREQ with address line A10 = 0 will guarantee that only the PROM is being addressed.

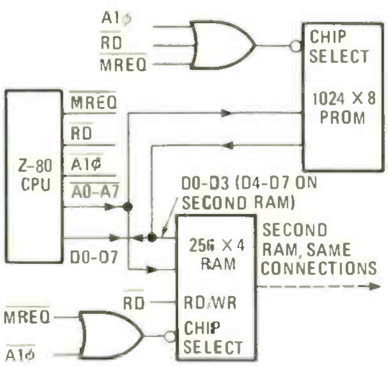


FIG. 7

In Fig. 8, an I/O device is added to the system. Since only one I/O device is used, signal IORQ alone is sufficient to inform the I/O device that it is being addressed. A second simplification here is that the I/O device is a read-only device and that no decoding of read-versus-write is necessary. Anytime the I/O device is addressed, the IORQ line is brought to a logic 0, and the device will output eight bits of data on the data bus. No address decoding is necessary either, since only one I/O device is used in this type of configuration.

The above examples are simple, workable interfacing examples for memory and I/O devices. Additional address decoding would be necessary in larger configurations, in addition to further gating and buffering of Z-80 outputs and inputs.

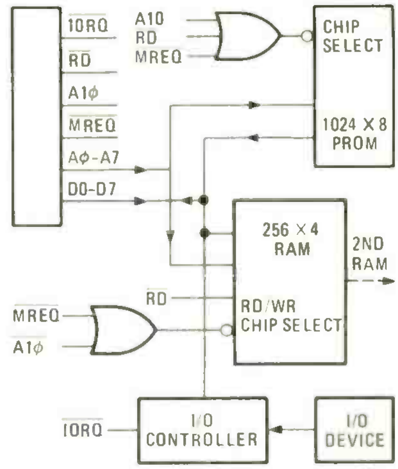


FIG. 8

While the 8080 microprocessor and updates to the 8080, such as the 8085, remain extremely popular and usable microprocessors, the Z-80 offers many advantages over the 8080. The Z-80 appears to be the microprocessor of the future, as short-lived as the future is in the world of microprocessors. We will be watching for up-dates and will keep you advised. **R-E**

hobby corner

A look at the various breadboarding and prototyping systems available (including a brand-new one) for building your own circuits from scratch. **EARL "DOC" SAVAGE, K4SDS,** HOBBY EDITOR

BACK IN THE OLD DAYS, THE HOBBYIST HAD two choices of procedure when he wanted to design or test a circuit. He could tack-solder the parts together on a breadboard (literally, a pine plank), or hard-wire it right on the chassis and hope for the best. Even so, that wasn't too bad—all the components were large and few were fragile, so it was no great problem to put them in and take them out.

Later on, things got better. At one time I was fortunate enough to have a small Vector breadboarding outfit for tubes. It was quite revolutionary because it provided for temporary circuit building and a relatively easy change of components.

Today, a hobbyist without a modern breadboarding and prototyping system is at a great disadvantage. With subminiature (sometimes even microminiature) parts that are often sensitive to heat and/or physical handling, how can he work at all? He must throw a lot of time *and* a lot of parts.

Happily, that struggle is not necessary. There are some good breadboarding and prototyping systems available that are effective and efficient. They are time-saving, component-saving, temper-saving and money-saving. Best of all, they are not costly—in fact, you can start inexpensively, then add on when and if you have the need and the means.

Before taking a look at these systems, let's make sure we are talking about the same things. The terms *breadboard, circuit board* and *prototype board* have been used so much lately they have become quite confusing. Right or wrong, here's how we'll use them.

A *breadboard* is any device that allows circuit elements to be electrically connected and disconnected by applying pressure on the component leads. Usually, these temporary connections are made by using spring clips embedded beneath the surface of a perforated block.

A *prototype board* allows circuit elements to be electrically connected in a physically stable manner. While components can be removed and exchanged, the connections are not considered temporary and are usually soldered or wire-wrapped. Furthermore, a prototype board accommodates a wide variety of circuits. One kind of board is called a *universal* printed-circuit (PC) board, as opposed to a *dedicated* PC board.

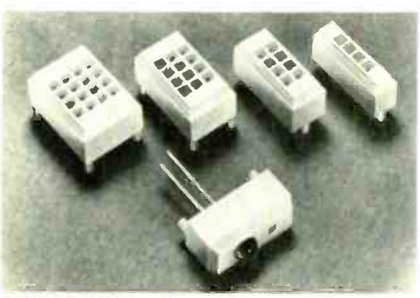
The term *circuit board* encompasses several types of boards—in fact, all boards *except* breadboards. Therefore, to avoid confusion, we will not use this term.

A *dedicated* PC board is one that has been designed for one particular circuit only, and cannot normally be used for any other. It can be constructed by attaching stick-on pads to a nonconducting board, by etching a copper-clad board or by grinding a copper-clad board.

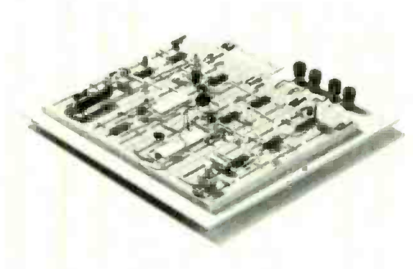
First, we'll look at the characteristics of each of the major breadboarding systems and then, we'll do the same for prototyping systems. Next, we'll examine how some of these systems match for combination use, particularly a new system just being introduced in this country. Finally, we will suggest ways to help you decide when and how to do what.

Breadboards

Table 1 shows five breadboarding systems along with the major characteristics of each. The prices indicated in the table and in this article are approximate suggested list prices.



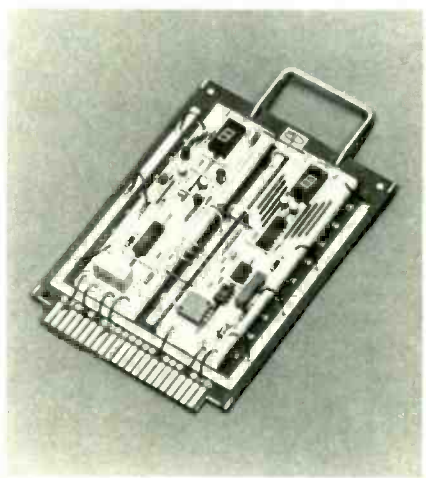
TIE-POINT BLOCKS by AP; one with an LED.



ALL-CIRCUIT EVALUATOR model ACE 236.

A breadboard is considered to be *indexed* if it is marked in such a way that each tie point can be identified by a number-letter (or any other) combination. (The full significance of indexing will become apparent later.) The wire size listed is not necessarily that claimed by the manufacturer but represents the maximum gauge that can be easily inserted into the tie points. Our breadboarding experience indicates that the maximum size of wire accepted is of greater significance than the minimum size.

The AP Products system features small *Tie-Point Blocks* that contain various tie-point configurations, and there is one block that holds an LED. These blocks are available in packages of 20. In addition, the *All-Circuit Evaluators*, available in kit form or assembled, contain different groups of terminal and distribution strips mounted on a metal plate with binding posts and bumper feet ($19–$80). AP Products also manufactures *Unicards*. These are breadboard strips mounted on cards for modular card-rack construction ($32–$56). Also available are various special boards, a jumper wire kit ($10), as well as connectors, sockets and ribbons for interboard connections.



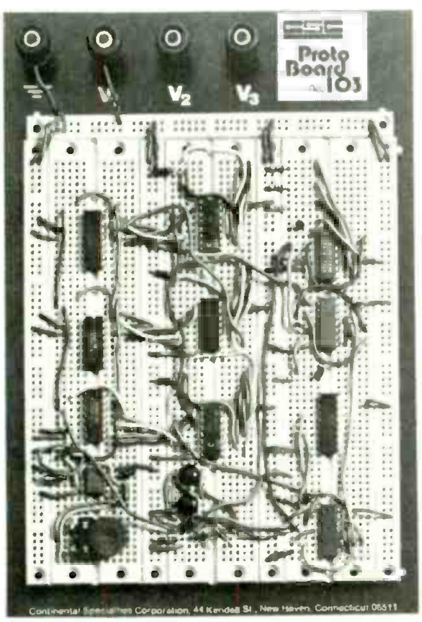
UNICARD by AP plugs into external circuitry.

The Continental Specialties breadboards interlock so that you can make larger layouts with ease. Continental Specialties QT sockets and strips are also available as various *Protoboards* on plates with binding posts and feet ($16–$80) and mounted on boxes with internal power supplies ($55–$120). Useful accessories include a function generator ($70) and an R–C bridge ($60).

TABLE I—BREADBOARDING SYSTEM CHARACTERISTICS

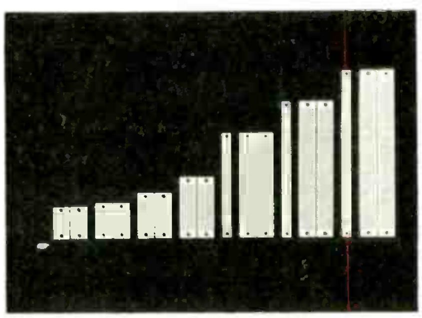
Manufacturer	Hole Pattern	Size	Indexed	Component Sockets Required	Bus	Wire Size	Other	Name(s)
AP Products, Inc. Box 110-Q Painesville, OH 44077	Standard .1" × .1"	34 × 5TP* to 128 × 5 15 to $19**	No	No	Attached and/or separate 12 × 4 to 36 × 4 $2 to $4**	to No. 20	Tie Point Blocks 1 × 4 to 4 × 4 and LED's 20 at $4 to $10	Terminal strips Distribution strips Unicards All-circuit evaluators
Continental Specialties Corp. Box 1942 New Haven, CT 06509	Standard .1" × .1"	14 × 5 to 118 × 5 $3 to $13**	Some models	No	Attached and/or separate 12 × 5 to 40 × 4 $2 to $4**	to No. 20	See text	QT sockets & bus strips Experimentor Protoboards
E & L Instruments, Inc. 61 First Street. Derby, CT 06418	Standard .1" × .1"	16 × 5 to 128 × 5	No	No	Attached	to No. 22	See text	SK sockets Mini-board Universal breadbox
Saxton Products, Inc. 215 N. Rte. 303 Congers, NY 10920	3 special types, see text	3 × 5-in. modules 70 to 208 TP $5 to $20	Yes	Yes/No, see text	Attached	to No. 18	Detachable control panels	*S-DeC* *T-DeC* *U-DeC*
Vector Electronic Co., Inc. 12460 Gladstone Ave. Sylmar, CA 91342	Standard .1" × .1"	8 × 4 to 24 × 4 (for mounting on .1" × .1" board)	Yes	No	Separate 1 × 4 to 1 × 8	to No. 20	Can use both sides, see text	*Klip-Blok* *Klip-Strip* *Klip-Bus* *Patchboard*

* 34 units of five tie points each.
** Approximate suggested list prices.

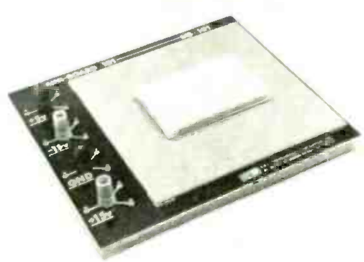


CONTINENTAL SPECIALTIES 103 ProtoBoard.

The E & L Instruments system includes a *Mini-board* with binding posts and feet. Self-adhesive hook and loop fasteners hold the SK sockets and large components so that they can be mounted or removed with ease. The base of the *Mini-board* is somewhat more flexible than others we've seen. E & L also makes a *Universal Breadbox* consisting of SK sockets, binding posts and BNC connectors mounted on a sloping-top box. There's enough space inside the box to build such things as power supplies.



SERIES QT SOCKETS AND STRIPS by CSC.



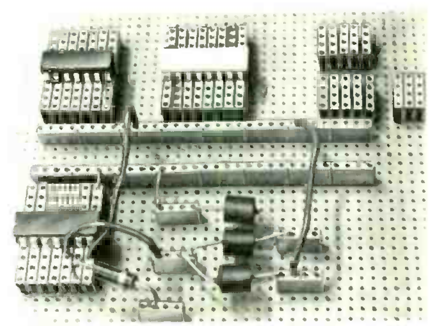
MINI-BOARD 101 by E & L Instruments.

E & L's model BB-IV Universal Breadbox.

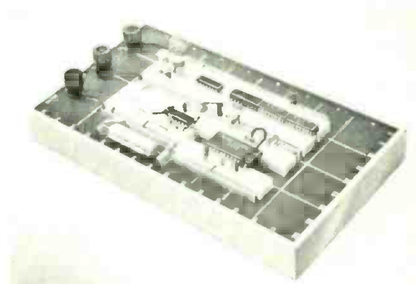
Vector and Saxon approach breadboarding somewhat differently. Let's consider the two systems in reverse alphabetical order since the Vector system is based upon .1 × .1-inch hole spacing. That spacing, by the way, conforms to the pin spacing of practically all IC's. This is why it is not necessary to use IC sockets with these systems.

The Vector system differs from the others in two significant respects: First, the .1 × .1-inch patterned tie-point blocks (called *Klip-Blok's*) are designed to be mounted on .1 × .1-inch perforated boards. The *Klip-Blok's* and *Klip-Strip's* can then be shifted around at will and placed in almost any position on the perforated *Patchboard*.

The second big difference in the Vector system is that the tie points are constructed so that wires can be inserted *from either side* or even all the way through them. In fact, since the *Klip-Blok's*, *Klip-Strips* and *Patchboard* all have the same hole pattern, and since the *Patchboard* is mounted on an open-bottom frame, components can be placed on both sides of the system. Although not necessary, of course, you have the option of using this system in this manner to



VECTOR's Klip Strips and Bus Strips.



VECTOR 51X Klip-Blok DIP Patchboard.

continued on page 103

state of solid state

Delta modulation is finding many useful applications. A new integrated circuit from Motorola performs both the decode and encode functions. **KARL SAVON,** SEMICONDUCTOR EDITOR

TRANSMITTING DIGITAL DATA OVER RAdio, telegraph or telephone channels is one of the most reliable methods of communication. Analog signals, whether audio, video or control waveforms, can be transmitted with similar reliability if they are first digitized into binary equivalents. If the instantaneous analog levels are first converted into a binary series of ones and zeros, they can then be routed through a digital communication channel and then decoded or reassembled into the original waveform.

Binary transmission is inherently reliable because it is simple to distinguish between only two different levels. The two levels can be represented by two DC voltages, two frequencies, two phases, or other more complicated schemes.

Motorola Semiconductors has developed the XC3417 and XC3418 IC's to perform the modulation and demodulation functions of a CVSD (*C*ontinuously *V*ariable *S*lope *D*elta) modulation scheme.

Delta modulation, developed about 30 years ago, approximates an analog signal by using line segments. It is a digital coding system that performs well considering it requires relatively few components. The system is asynchronous and, therefore, does not require the transmission of sync signals. Delta modulation is somewhat less efficient in bandwidth than pulse-code-modulation (PCM) for speech and video. However, its characteristics are just about right for telephone-quality speech. For many telemetry and control applications, delta modulation uses less bandwidth than PCM.

How it works

Figure 1 shows the block diagram of a CVSD encoder. The analog input signal is compared against a waveform that is approximately the same as the one that will eventually be decoded at the receiver. Based on the result of this comparison, the system then reduces the error between the two comparator inputs. At specific clock-cycle intervals, the comparator output is sampled to determine the direction and magnitude of the slope of the next segment of the approximated waveform.

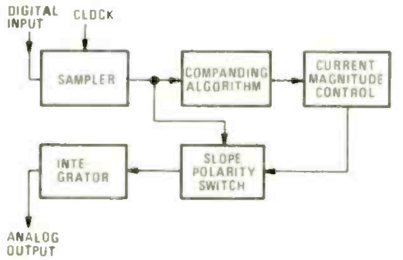


FIG. 1—CVSD ENCODER compares the input signal against a waveform that is approximately the same as the decoded signal and reduces the error between them.

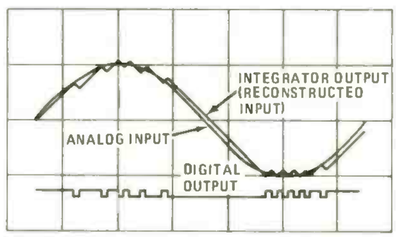


FIG. 2—WAVEFORMS showing how the CVSD encoder tracks the analog input.

Figure 2 shows that when the approximated signal exceeds the input waveform, the comparator changes the polarity of the slope. The sampler output operates the slope polarity switch, which directs current into an integrating capacitor. Since the integrated voltage is too great in this case, the current is switched so that the output discharges towards a lower voltage.

At each comparison interval, if the approximated signal still exceeds the input, the negative slope is maintained; or if the approximated signal is less than the input, the slope is switched to a positive value.

Some modified delta-modulation systems use a resistor to discharge the integration capacitor at a relatively high rate. This modification further simplifies the circuit but increases the channel bandwidth.

The digital output of the system, the same output that is transmitted over the communication channel, is the input to the slope polarity switch. By transmitting the slope polarity of the approximated signal, an integrator in the decoder, similar to the one used in the encoder, reconstructs the same approximated signal. Approximate filtering smoothes out the discontinuities to produce a close copy of the original analog input.

The companding algorithm and current-magnitude control blocks in Fig. 1 make the system even more interesting and useful. To optimize system performance, the integrator-output slope is changed to compensate for the range of input-signal slope variations. Constant-slope line segments may be too shallow to follow, or so steep that they overshoot the input waveform.

An algorithm to solve this problem was developed that was easy to implement in the circuit. A shift register keeps track of the slope polarity for a fixed number of clock pulses. If the slope polarity does not change for a number of clock pulses, it is possible that the output waveform is not keeping up. Under these conditions the slope is increased or decreased, accounting for the term, "continuously variable."

Figure 3 shows that the decoder has circuit blocks in common with the encoder. In fact, it is possible to switch a couple of leads around on the IC to change the circuit from an encoder to a decoder. You can do this in simplex operation when only one station transmits at a time. Wherever full-duplex operation is required (simultaneous transmission and reception), separate modulators and demodulators are needed.

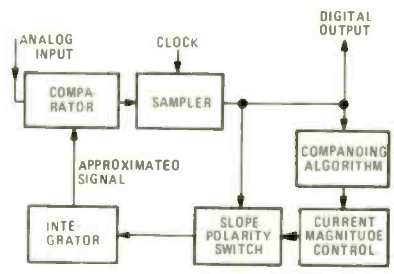


FIG. 3—CVSD DECODER contains the same functional blocks as the encoder.

Figure 4 shows the schematic of a simplex voice CVSD using the XC3417 integrated circuit; all the functions discussed are included on the single IC.

The encode function is enabled by closing the push-to-talk switch, transfer-ring the solid-state encode/decode switch to its upper encode position.

The analog input is shown AC-coupled to the inverting comparator input. The other input to the comparator is the reconstructed waveform reproduced at the receiver's demodulator. The comparator output continuously shows whether the input waveform is lower or higher than the reconstructed waveform.

The comparator output feeds the serial input of a three-stage shift register. Clocked by a 16-kHz signal, the shift register reads the comparator output on the falling edge of each pulse. The output of the first shift-register stage is the sampled output of the comparator and becomes the digital output.

The slope polarity switch sets the direction of the current that feeds integrator network R6–C2. The current integrated by capacitor C2 is equal to the voltage across R_X divided by the resistance of R_X (13K). Because the resistor connects to high-input impedance op-amp A2, essentially all the current in R_X flows into the polarity switch and then into integrator network R6–C2. The op-amp forces the voltage of the inverting and noninverting inputs to be equal. Controlling the voltage on pin 3 controls the voltage on pin 4 and also the value of the integrator current. Filter capacitor C_S is connected between pin 3 and V_{CC}, and R_S

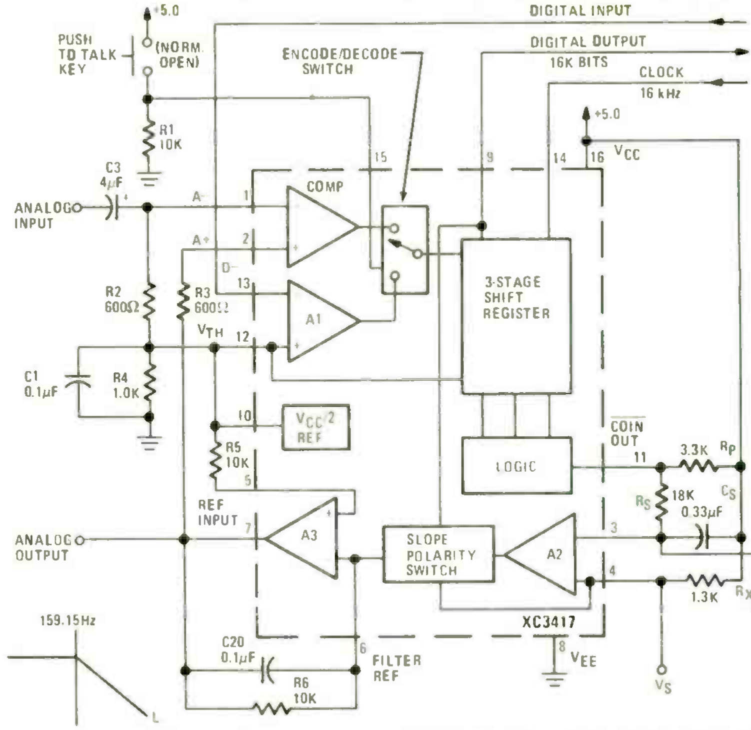


FIG. 4—SIMPLEX VOICE CVSD built around the XC3417. Encode and decode functions are controlled by the push-to-talk switch.

couples the inverted coincidence output to pin 3.

A logic circuit connected to the parallel outputs of the three shift-register stages detects when the three outputs are either all ones or all zeros. If the output-signal polarity has been equal for three consecu-

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service clinic

Troubleshooting horizontal sweep circuits in solid-state television sets.

JACK DARR, SERVICE EDITOR

EVER SINCE TV BEGAN, WE HAVE SEEN one very familiar symptom: "Thin horizontal line across screen." This cause is easy: there's no vertical sweep. The problem is usually quite simple to find and fix. With the advent of solid-state TV, a new one has turned up: "Thin *vertical* line on screen." This shakes up us old tube-type technicians! I do not remember ever seeing this on a tube set—that is, for more than a few milliseconds when the damper blew up or something similar. This is because any problems in the horizontal deflection yoke killed the boost, which, in turn, killed the sweep, high voltage and the whole works in one fell swoop.

Most of the solid-state sets have an entirely different basic circuit. The horizontal deflection coil and the flyback are in shunt across the horizontal output transistor. If the horizontal deflection coil opens, the high voltage is often unaffected. There are also other differences in the deflection yoke circuitry as compared with the tube sets. Let's see how a couple of solid-state deflection circuits work, so that you'll know what to look for if this kind of symptom occurs.

Figure 1 shows a basic circuit, stripped to its bare essentials. The horizontal output transistor provides a current pulse that is fed to the flyback (which works just like other flybacks). This signal is also fed into the horizontal deflection coils, which are in parallel with the flyback. The current pulse flows through the yoke windings, then *returns* to ground through a yoke-return capacitor. The pulse actually charges and discharges this capacitor, thus completing the AC circuit for the horizontal deflection coils.

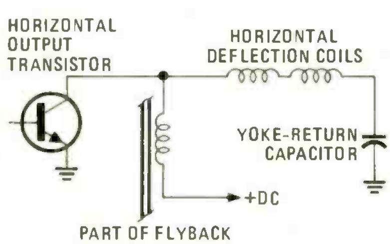

Fig. 1

What happens if this capacitor opens? A thin vertical line. There is a dandy quick check for this, just scope the yoke-return capacitor. If the yoke-drive pulse appears on the hot side but there is obviously no horizontal sweep, there's your answer. Tack another capacitor across the original (with the power off) and check.

In actual sets, the circuits include a lot more components than the one in Fig. 1.

The complete horizontal-deflection-coil circuit for one popular chassis is shown in Fig. 2. Let's follow the signal through the circuit starting at the collector of Q401. The signal goes to the flyback and also to the deflection yoke socket,

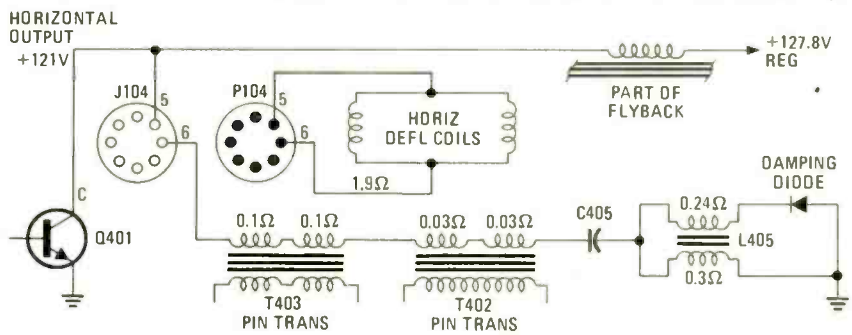

Fig. 2

J104 pin 5. From here it proceeds through the paralleled horizontal yoke windings (others are in series; it makes no difference) through the primary windings of T402 and T403 and two pincushion transformers. From T402, the signal goes *through* C405, a 0.55-μF capacitor (there's the yoke-return capacitor; I knew we'd find it in here somewhere!); and on through L405 to ground.

This complete path for the horizontal deflection yoke currents is easy to check out with an ohmmeter. Start with one ohmmeter lead on pin 6 of the deflection yoke socket (J104). (You did check the yoke? Good.) You can check both pin transformers by reading the resistance from J104 pin 6 to the top of capacitor C405. Both of these windings measure only 0.26 ohm total. From the bottom end of C405, the other pin transformer measures only 0.3 ohm. If there is continuity at these points and still no horizontal sweep, the capacitor is apt to be open.

In a case at point, a Service Clinic reader wrote that he had no horizontal sweep in an RCA CTC-71J. I recommended checking the points as described above, and he found an open conductor on the PC board on the PW400 horizontal deflection and pincushion board. All test points are easily accessible in this chassis, and capacitor C405 is right out in the open! In any other chassis, you might not be this lucky, but the troubleshooting principles will still be the same.

In another set, the circuit is basically similar. But instead of returning to DC ground, the horizontal deflection yoke returns to a horizontal-centering control with a pair of diodes. The horizontal-centering control is connected to the +145-volt line. However, it seems as though the AC return path is made at this point through a 30-μF electrolytic capacitor that's connected to ground on the centering control. The +145-volt source in the DC power supply had *better* be at AC ground if the filter capacitors aren't open! This small difference in the circuit won't affect the basic diagnosis, of course.

So, if this symptom appears in a solid-state TV set, you can immediately eliminate a couple of things; namely the horizontal output stage, flyback, low voltage DC power supplies, and high-voltage rectifier. Also, you know the drive pulses are present or the other stages wouldn't be working either. If you follow the horizontal deflection coil circuit from the output transistor all the way to ground, the faulty part should show up pretty fast.

As I said, this can't happen in tube TV sets. I have never seen a genuine case like it. However, once I thought I did on an Admiral chassis that was brought in for service. Like most of the sets manufactured in those days, it had a large flat pan-type chassis with the picture tube strapped to it. I set it up on the bench, with the picture tube on top, and applied power. Lo and behold, a thin vertical line *did* show up on the screen! I tested the horizontal sweep circuits, but this showed absolutely nothing wrong. There was plenty of high voltage, the drive waveforms were all fine, etc. After some head scratching, the reason finally dawned on me. This was one of the rare sets with the chassis mounted *vertically* on the side of the cabinet so that the picture tube was not on the top but on the *side*! Placing the tube in this position made it look better; now I had a thin horizontal line. I fixed the problem in the vertical sweep, and took it home (blushing a little, but happy). The moral of this story is: "Don't get too much exercise by jumping to conclusions!" Make a complete analysis first.

R-E

service questions

MULTIPROBLEM TV

This is a tale of a tough dog—a Muntz AS-9015. This set had: a dim picture, poor focus, vertical shrinking. I checked the focus voltage; it didn't read right. Then I recalibrated the high-voltage probe, and now had 6 kV so that wasn't it! Checked the voltage-dependent resistor in the vertical circuit. The vertical-input grid resistor and the 150K resistor in the height-control circuit were off-value; changed them, but no help. Round and around!

Finally, I read the +1050 boost-boost voltage: I'd replaced the boost rectifier first—ZERO. I replaced it again . . . WHAM-O! Bright, full picture, no focus problem. The boost rectifier I used the first time around wasn't marked, and I guess I managed to get it in backward! (I've also run across some top hat diodes with markings reversed, so check these before installation.) Thank you for the help in solving this dog.

(Actually, about all I gave him was sympathy. Thanks to George Welker, George's TV, Spokane, WA, for this tale of woe.)

CROWBAR SHORT

I've really got a dead short in a Zenith 12CB12X. The fuse blows so fast that I can't find it! I've checked everything and found nothing. I'm pulling my hair out.—L. A., Franklin Furnace, OH.

Don't do that . . . when you get to my age, you'll need it!

Now, you have two loads on the AC line; one is the heater circuit, the other, the DC power supply. You say that a slow-blow fuse makes the heater rectifier blow out. This is a clue. Disconnect the heater rectifier and then turn it on, connecting a 25- to 50-watt lamp across the fuse holder. If the lamp lights up, there's a short in the DC power supply (diode, input-filter capacitor, etc.). If the lamp doesn't light up, the short is in the heater circuit. The likely suspects are: the protective diode to the common ground or a wiring short in the input to the heater circuit. The trouble is not likely to be in the middle of the line, or some of the tubes would light very brightly.

"PUMPING" SPEAKERS

Here's a funny one: I've got a Harman-Kardon 930 receiver that has a very low-frequency pulsation, and the pilot light dims if the speakers are connected. After much searching, I found that this can be stopped by disconnecting the left preamp. The DC voltages at the preamp outputs are different. What have I overlooked?—D. B., San Jose, CA.

I think you've found it. Something in that left preamplifier is causing a feedback to make the speakers "pump" and take excessive current. Disconnect both preamplifiers and feed a signal into the power amplifiers; see if their output signals are equal. If so, connect the right-hand preamplifier, and feed a signal into it. If this works, take that left preamplifier apart and you'll find something in there that's way off.

SCREEN BLACKOUT

This problem on an RCA CTC-35 has me stumped! The screen goes dark, but it

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SERVICE QUESTIONS

continued from page 87

does so only once every three or four weeks. When it does, the high voltage is still up. Then, I can turn it off for five minutes, turn it back on and it works for three to four weeks more. Something is biasing-off the picture tube, right?—R. D., Springfield, VA.

Right. There are a couple of things that cause this. One is a bad heater contact on the 12BY7 video output tube socket. If the heater contact is bad, this kills the tube, there's no plate current, the plate voltage rises to +405 supply voltage and out goes the screen. Similarly, it could also happen with the jumper on the PC board in the heater circuit to the two difference-amplifier tubes; if there's a bad solder joint here, these tubes go out and their plate voltage goes up, biasing the tube to heavy conduction and out goes the screen. It's more likely to be the video output tube in this case, since the difference amplifiers cause the high voltage to pull down just a little or, in some cases, a lot.

HIGH-VOLTAGE SHUTDOWN

I had a Quasar TS-938 with a peculiar symptom: If it was turned on in the evening, nothing came on. However, if it was turned on in the morning, it would play all day until turned off at night.

You gave me some hints from the Quasar Field Engineers, and they worked. When I reset the DC voltage to get +100 volts on pin 16 of the JA panel, everything worked fine. I didn't know that some of these voltage controls would shut down on *low* line voltage! When they write "sealed at the factory" on that high-voltage adjust control, they aren't kidding. The stuff they use could seal safes!

(Thanks to George Senn, Red Bank, NJ, for this feedback. Here's another way of resetting that voltage control: Quasar says to remove the original control, replace it, adjust it and then reseal it. A lot easier than trying to get that cement off!)

DEFLECTION YOKE

I need some help in getting a new deflection yoke for a Bradford TV, model WTG-61059. The original part number is 490V017C01. Do you have the company's address?—F. C., Victory, NY.

Sorry, Bradford isn't with us any more. However, here's one good clue: That part number is obviously a Westinghouse part number. Westinghouse is one of 15 firms that built Bradfords that are listed in my J. W. Miller Company *Catalog No. 175*. With a little head scratching and a lot of cross-checking, I found a substitute listed for this yoke: a Triad YT-103-1.

NO BRIGHTNESS CONTROL

There's a brightness problem in this Sharp C-922 that I can't find. The raster is

continued on page 94

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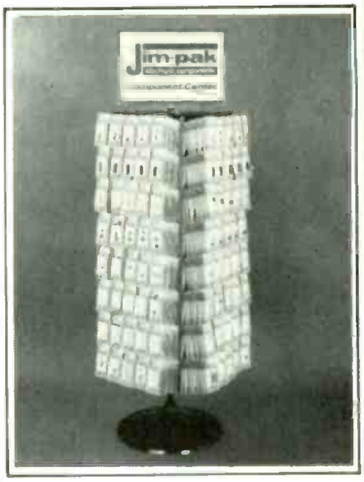

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Morgantown	*Electro Distributing Co.*

CIRCLE 52 ON FREE INFORMATION CARD

SERVICE QUESTIONS

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too bright, there are retrace lines, etc., and the brightness control has no effect. I found +55 volts on the common control grids of the picture tube. This should be only −1.5 volt. When I shunt this to ground with a resistor to give zero volts, the brightness control works! Where does this small negative voltage come from?—E. F., Baltimore, MD.

The picture-tube grid circuit is a bit complicated. Apparently the bottom end of the high-voltage multiplier goes to the grids and then (somehow) to ground, possibly through the DC power supply.

This is some kind of beam-current control circuit. The small amount of voltage that is developed from the high-voltage multiplier return would be positive. However, there's a diode in the circuit marked "Isolation": this current flows in pulses that may develop enough negative voltage to cancel the positive voltage fed through those resistors. Since the problem seems to be somewhere in this area, check all resistors and the diode.

HIGH-VOLTAGE SHUTDOWN

I need an idea on this Magnavox T989-01. The high-voltage shutdown works too fast. If I unhook the reference voltage, disabling the shutdown, everything works perfectly. The high-voltage is 29.5-kV, the +120-volt line regulates nicely, and so on. However, when I rehook the reference voltage, it works for quite a while, then away it goes again!—C. F., Iola, KS.

Since the high voltage and everything else seem to be normal, I agree that the problem is in the high-voltage shutdown. I looked through my Magnavox file and found a *Service Note* on "Nuisance Tripping of High-Voltage Shutdown"! The note says: Try setting the high-voltage to 28.0 kV at zero beam current. If this does not clear up the problem, then install Magnavox Kit No. 18138-2. This kit contains a new high-voltage bleeder resistor, a new Z301 and a new high-voltage limiter adjust control, along with instructions.

OPEN CEILING HEATER WIRING

Lloyd F. Bazant, Design Engineer with Western Instruments, 4714 S. W. Willetta St., Albany, OR 97321, writes that his company makes a special "locator" device for finding open circuits in built-in ceiling heating wires. [A reader in Rossville, GA, wrote (**Radio-Electronics**, November, 1977) asking about the subject.] Oddly enough, this instrument is called a "Ceil-Heat Fault-Finder," which is exactly what it does. Thanks for the data.

FAULTY REMOTE CONTROL

I have a problem in the remote control of a Philco 13J42 chassis. I can make it work on the channel selector or on the volume control, but they won't work together. It's either one or the other. What's happening?—M. B., Las Vegas, NV.

This sounds very much as if you have an alignment problem in the receiver. You have two tuned transformers on the limiter output. The 38-kHz transformer is the channel selector. Align each of these transformers and make sure the adjustment shows a definite peak. It is possible one of the ringer bars in the transmitter is broken, or something is damping it and throwing it off-frequency. Use the alignment procedure in *Sams Photofact 650-2A* that covers this receiver.

VIDEO PROBLEM

Recently, I wrote you for ideas on an AC problem in the video of this Zenith 8Y4B36. I got the schematic after I wrote you. As soon as I saw the schematic, I knew what was wrong. I had replaced a diode in the 24-volt source. This diode turned out to be a Zener and I had used an ordinary diode that wasn't well marked to replace the Zener. That cleared up the problem.—C. C., Chicago, IL

Good!

continued on page 96

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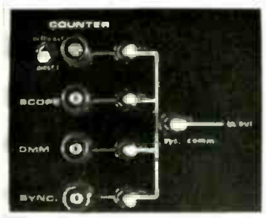

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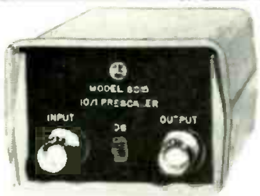

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Requires 3 "AA" batteries (not supplied).

LM-300 .... $99.50
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SERVICE QUESTIONS
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LOSS OF WIDTH

I can't get enough width on this Philco 18QT85A. It's shrunk in about 2 inches on each side of the screen. The high voltage is low too; it drops to about 14 kV if I turn up the brightness, and the raster blurs. The low brightness is about 22 kV. I've checked and changed a lot of things and can't find it.—M. D., Willimantic, CT.

Step one: Read the control grid voltage on the 6KD6 horizontal-output tube. The normal reading is −57 volts. If this reading is quite a bit more negative than it should be, try a new VDR. This resistor is the one that's used in the 6KD6 control grid and return circuit. It's apparently the only high-voltage regulation used in this chassis. If this resistor is bad it can develop too much negative bias and reduce the output of the 6KD6. Note that both sweep and high voltage are down. Just for luck, check the boost voltage. If this is low, you'll have these symptoms.

SYNC-AGC PROBLEMS

I'm having an odd problem in this CTC-36H RCA. When it's turned on, the horizontal sync goes. Then, the whole picture starts to fade after about 15 seconds, starting from the corners and working to the middle! Inside of 10 minutes, it goes "click," and then works perfectly! What's the matter with this thing?—K. B., Brooklyn Park, MN.

There is one part that can, and does, cause weird symptoms like this—an intermittently open filter capacitor! If this capacitor is open or away down in capacitance at turn-on, it can cause a feedback signal through the B+ line that can give you almost any kind of symptom you want. Then, when the chassis has warmed up enough, the open joint heals, the set returns to normal and you sit there wondering what happened.

Clue: At turn-on, *scope* the B+voltage lines, especially around the horizontal oscillator and/or the AGC stages. Look especially for pulses at horizontal frequency. If you see these pulses, that's probably what it is.

TRANSIENT SPIKES

You answered a reader's question in the July 1977 issue, saying that his trouble could be transients in the car's electrical system. I agree! I'm a Motorola two-way radio technician and the Motorola service bulletins state that in many cases, solenoids (and similar devices) in cars can cause spike transients of up to 400 volts peak when de-energized.

All Motorola's new equipment uses a dual Zener diode across the 12-volt input—i.e., 25-volt Zeners back to back. I have seen these transient pulses hit hard enough to blow the diodes completely. The idea is to shunt off any pulse above 25 volts, and it does.

Thanks to Brian S. Hansen of Killingworth, CT for this information.

NO HORIZONTAL SWEEP

This RCA CTC-71J chassis has only a vertical line down the center of the screen. I've checked and changed the yoke; still no horizontal sweep. There's no yoke-return capacitor that I can see. Any help?—J. R., Detroit, MI.

I think you've done what I just finished doing—getting lost in that horizontal-yoke return circuit! The brown wire from the horizontal yoke is the return, and it goes all around the barn (through the pincushion circuitry), but it *does* go through a 0.55-μF yoke-return capacitor C405. Capacitor C405 is on the right-hand side of the PW400 board, just below the toroid transformer. The capacitor is easy to get at, *after* you find it. Check all the connections and continuity through the pin circuits, as well as the capacitor.

WEAK COLOR

There's a color problem in this Admiral 4H12 chassis. The color signal is weak, and everything is all right up to the 6LE8 demodulator input, as far as the color signals are concerned. The colors are all

normal, they're just low in amplitude. Is there anything in your notes on this?—R. C., Pacoima, CA.

We have found problems in sets using high-level demodulators, with tubes similar to the 6LE8 and others. The key clue is in the plate voltages; if these voltages are off, try a new tube. We've fixed several sets having this problem, using a new tube. Try a new 6GH8 in the 3.58-MHz oscillator socket just for luck. A low oscillator signal can also cause weak color.

HIGH-VOLTAGE DROP

I have no high voltage on a Webcor 4012 TV. (All parts are made by Toshiba.) If I unhook capacitor C411 from the flyback, I can read +250 volts on all its terminals. When C411 is connected, this voltage drops to less than +100. I hope you can help.—F. C., Seminole, FL.

So do I. Capacitor C411 is the boost capacitor, and the symptoms indicate it is very *leaky*. Note that your B+ voltage should be only +135, and you are reading +250 volts with the capacitor unhooked. Therefore, you are receiving a little "boost" from stray capacitance. Substitute a new capacitor for C411 (which is marked only for 400 volts). Try using at least a 600-volt capacitor here. The normal boost should be +350 volts. **R-E**

STATE OF SOLID STATE
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tive clock edges, pin 11 switches low. Since one end of C_S is returned to the V_{CC} supply, the capacitor charges toward V_{CC} during periods of no coincidence. The voltage across the capacitor increases as does the voltage on pin 4 and the integrator current. This is how the companding algorithm is used to correct for insufficient or excessive slope. Time constants of the coincidence filter (also known as syllabic filter) are selected between 6 and 50 ms. In this particular application, it is equal to $(R_P + R_S) \times C_S = 7$ ms.

For decoding, the push-to-talk switch is released so that the analog switch drops to its lower position and the shift register is fed from the digital sense amplifier instead of the modulator comparator. Other than that, everything works exactly as before. The same integrator circuitry and coincidence companding algorithm insure that the reconstructed signal is similar to the one approximated at the transmitter. Low-pass filtering removes the quantizing noise.

To design the circuit shown in Fig. 4 around the XC3417 or XC3418 integrated circuit, values must be assigned to a number of components to optimize the signal-to-noise ratio and distortion. As with all communication channels, bandwidth and amplitude limits require using filters and clock rates that are consistent with the limitations of the particular medium being used.

In *conventional* delta modulation systems, the clock rate is normally selected to be greater than the highest frequency to be sampled. Limited-integration delta modulation systems approach pulse-rate modulation (PRM) when the integration time actually becomes smaller than the period of the lowest signal frequency. Clock frequencies in the range of 9.6 to 64 kHz can be used to drive the circuit shown in Fig. 4. The higher the clock rate the greater the bandwidth needed for the channel, and the greater the signal-to-noise ratio. Voice channels are limited to a 9,600-Hz clock frequency, some radio systems can reach 12 kHz, and commercial telephone circuits will handle 37.7 kHz. Clock rates above 15 kHz work better with a longer shift register, which is how the four-bit XC3418 differs from the three-bit XC3417.

The value of R_X is selected so that the system can follow the input signal with companding ratios (the time the coincidence circuit is activated) that do not exceed about 25%.

With no analog input to the system, the digital output is an alternating sequence of ones and zeros. Although certain modified delta systems benefit from nonsymmetrical one-zero patterns, the one shown in Fig. 4 is designed for perfect balance. Because of circuit imperfections, the alternating ones and zeros should have a minimum step size of 20 mV (at 16 kHz) to guarantee the proper idle channel condition. The value of R_{min} determines the idle channel step size.

The XC3417 and XC3418 integrated circuits are available in ceramic or plastic 16-pin dual-in-line packages. The logic and analog functions are implemented with a combined I^2L/Linear Bipolar processing technology. A data sheet is available from Motorola Semiconductor Products, Inc., Box 20912, Phoenix, AZ 85036.

AM/FM radio circuit

One of the primary design motivations for the Fairchild μA721 IC was the severe space limitations in automobile AM/FM radio/CB transceiver combinations. This IC along with a two- or three-transistor FM front end, a couple of diodes, some tuned circuits and an audio-output stage makes a complete AM/FM radio.

Figure 5 shows the AM/FM radio IC, which includes a bias circuit, two amplifiers, an IF limiter and detector and an oscillator mixer.

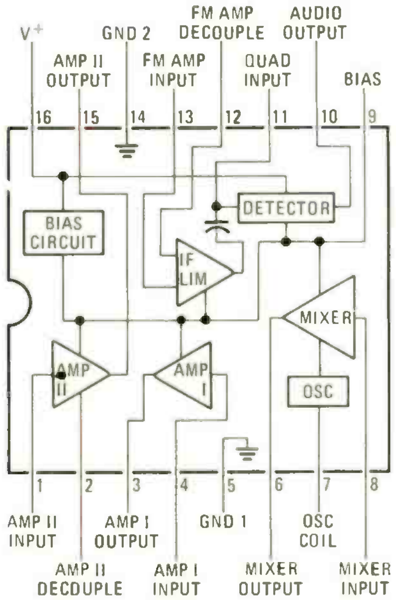

FIG. 5--μA721 PERFORMS most of the functions required for a complete AM/FM radio.

For additional details, write to Fairchild Camera and Instrument Corporation, 464 Ellis Street, Mountain View, CA 94042.

Another radio circuit

SGS-ATES Semiconductor Corp. also has AM/FM integrated circuits—the TDA1220 and TDA1230. The TDA1220 has an FM IF amplifier-limiter, an FM detector, and an AM RF amplifier, mixer, oscillator, IF amplifier and detector. The FM limiting sensitivity is 30 μV, the amplitude modulation rejection (AMR) is 50 dB and the S/N ratio is better than 60 dB.

The TDA1230 goes further with an AF power amplifier that is driven from the on-chip FM detector or from an external audio source.

Voltage regulator

Silicon General's SG1532, SG2532 and SG3532 precision general-purpose regulators are substantially improved versions of the industry standard SG723. The SG1532 has a minimum required input voltage of 4.5 compared with the SG723's 9-volt specification. Lower voltages can be sustained across common 5-volt regulators, reducing the dissipation.

The SG1532 has thermal shutdown and current-limit protection. The IC is protected even if an external pass transistor fails. A sense voltage of only 89 mV is needed to current-limit the SG1532 compared with 650 mV for the SG723. A series-current sense resistor is inserted in the output current path to trigger the current-limit protection circuit. At 650 mV and, for example, 10 amps, the sense resistor dissipates 0.65 × 10 or 6.5 watts—a lot of wasted energy. Eighty mV reduces the number to 0.08 × 10, or only 800 mW.

The older SG723 design uses a Zener

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UNUSUAL CLOCKS

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count down (pin 10 low) from its loaded count each time the clock (pin 15) receives a positive-going signal.

The carry output of IC6 turns off D10 (which has been grounding the bong DC amplifier, section D of IC7) and puts a high input on NAND gate C (pin 6) of IC4. At the count of 8 of IC2 counter A, the other input to pin 5 of gate C goes high, its output goes low and D8 stops conducting. On the ninth count of counter A (8 and 1), diodes D7 and D8 are both reverse-biased and the bong generator is allowed to strike by enabling section D of IC7. On the very next count (0), diodes D7 and D8 are grounded, disabling the bong generator. Also, line 8 of counter goes low, so the gate C output goes high, clocking IC6. This subtracts one count from the preset total loaded in from IC5. Each time the pendulum swings into position V on count 8, the bong strikes once until the IC 6 count has gone down to 0. At this point, the carry line goes low, D10 conducts and the bong generator is disabled.

To achieve the bong sound, the bong DC amplifier (IC7-d) is enabled only when diodes D7, D8 and D10 are all turned off (with positive voltage on the cathode). When this happens, capacitor C9 is allowed to charge through R9, a portion of R16 and D12 to a voltage level controlled by duration potentiometer R16. The charge on capacitor C9 controls the output of section D, which, in turn, controls the gain of section B through D14, R21 and R23. As the charge bleeds off capacitor C9, the section B output drops proportionally, giving a sustain effect and creating a bell-like sound through the speaker.

Tick-tock circuit

In regular operation, each time the pendulum swings to position Y on the count of 2 from counter A, capacitor C6 receives a positive charge. This charge remains on C6 during the count of 3, but on the count of 4 (the second count in position Z), C6 is suddenly grounded. This negative-going transition is inverted by IC3-f, and a short positive pulse is applied through D15, which turns on AC amplifier B of IC7, allowing a short tone-burst to pass into the audio output section. The resulting sound resembles a tick. Similarly, on counts 6 and 7, the counter line 2 is high and capacitor C6 charges; on count 8 (the first count of pendulum position V) line 2 goes low, capacitor C6 discharges and causes another tick. There is actually no tock sound—just two ticks spaced 0.8 second and 1.2 seconds apart in the 2 seconds it takes for the pendulum to swing back and forth.

The tick-tock is disabled when the bong is about to sound so that the bong sound is clean. The tens-of-minutes segment G transition on the hour triggers the set input of IC6 described earlier, and the carry output goes high. Since the 60-Hz count from the power line may result in the pendulum being anywhere in its swing at this instant, the carry-output high is inverted by section IC3-d and this negative-going transition is passed through C5 as a negative-going pulse to one input of NAND gate B of IC4. This results in a momentary high output of gate B, which resets counter A of IC2 to 0. Also, because inverter D now has a low output, diode D9 conducts, grounding the tick command from inverter F until IC6 completes the bong counting and the carry output goes to its normal low state.

Although the instructions are detailed and complete, this is not a kit for beginners, and it will take an experienced builder at least 10 hours to assemble it. But you really *have* something when you're finished—a large mantelpiece clock that displays the time digitally, has a swinging pendulum and tick-tock, and a bong that counts out the hours. Bullet Electronics, Box 1944E, Dallas, TX 75219. *(continued next month)*

OVERHEATING RESISTORS

I do get the weird ones! This Sanyo 51C51R came in with no picture and no sound. The voltage on collector Q931, the votlage-regulator pass transistor, is +131; on the emitter it is only -7.7. I checked, and nothing seemed wrong. With the set on, resistors R982 and R983 became hot enough to melt solder. (There are shunt resistors across the regulator transistor.) Error amplifier Q921 was bad. I replaced it, but now the circuit breaker cuts off! The rectifier diode is OK, etc. What's going on?—J. N., Houston, TX.

Everything is OK up to that regulator transistor. The shunt resistors overheat because collector Q931 obviously is not conducting at all. In normal operation, the transistor should carry most of the current. Disconnect the load on the +120-volt source. Remove the 1-amp fuse and connect a current meter across it. The normal current is 700 mA.

Check the error-amplifier circuit. It contains two transistors, and when that one went bad it could have damaged the bias resistors, etc. Also check the horizontal-output transistor to see if it has shorted.

AGC LOCKOUT

This Zenith 14N29Z showed an AGC lockout when the channels were changed. It stayed out for 3 to 5 seconds and then it came on. The AGC voltages read strangely. The AGC goes to +25 volts and then slowly drops back. Checking the resistors in the AGC line gave no results. The AGC control showed hardly any range; the picture remained light. Checking the AGC keying pulse showed it was OK. The control grid voltage of the AGC tube showed far too much positive. Oh, oh! This voltage comes through a VDR.

When I freeze-sprayed the VDR the voltage jumped back to normal. I heated it, off we went again. Just for fun, I checked the resistance of the VDR—it varied (hot and cool) from 20 megohms to infinity. When I replaced the VDR, the set worked. This is Zenith part No. 63-5494, and you must be sure to get the right one! For a test, I replaced it with a 7.5-megohm resistor, and the set worked much better.

(This is a condensation of a page and a half of lab notes from my own bench!—Service Editor)

PROBLEMS GALORE

Here's an astonishing assortment of coincidences in a good old chassis:

In this Zenith 16Z25, cathode current in the 17DQ6 is 20 mA. The tube is good, the grid is very sensitive when touched with VTVM, and the 470,000-ohm grid resistor is open.

The raster shows a short, narrow, heavy shading from left to right. Is the filter open? Yes. This is a 10 μF on B+ voltage. I replaced it. Result: a full blank raster but no sound.

The second IF voltages are all off. Resistor R32 (120,000 ohms) to ground is open. The voltages are now OK. But there's no picture! I traced this to the radio-frequency AGC. Grounding the AGC on the tuner overloads the picture. Checking the RF amplifier shows that two 120,000-ohm resistors are up to more than 500,000 ohms each. The set works now, but warms up very slowly. I finally find that a 3CB6 tube was used instead of a 4CB6 tube in the IF. End of story!

BREAKER TRIPS, RESISTOR BURNS

When I turn on this Magnavox T-995-02, I get audio and the high voltage starts to come up. Then the breaker trips out and the 2200-ohm resistor R20 on the video board begins to burn up. I can't leave it on long enough to find out anything. Any ideas or tests?—J. S., Levittown, PA.

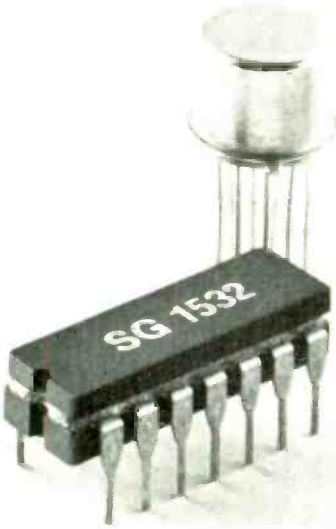
We've got one clue: Resistor R20 is burning up. This resistor is in the supply to the ABL (*A*uto *B*right *L*imiter) circuit, *and* it comes from the return lead from the high-voltage tripler. Obviously, this voltage is far too high; it should be about +24 volts. Here's a check: connect the voltmeter to terminal 11 on the video board and turn the set on. If this voltage reads way above 24, this will confirm your guess.

It sounds very much as if the high-voltage tripler breaks down when the high voltage reaches a given value. Disconnect the black lead from the flyback to the tripler and recheck. If everything else works try a new tripler.

STATE OF SOLID STATE
continued from page 99

diode reference, while the SG1532 has a lower noise band-gap reference.

Line regulation is 0.01%-per-volt maximum, and the output current capacity is

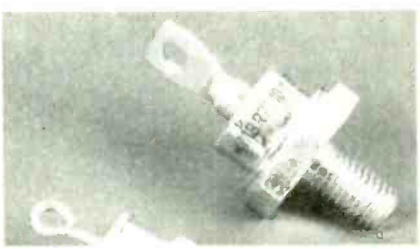


SILICON GENERAL'S SG1532 VOLTAGE REGULATOR

a minimum of 100 mA. The price is $1.10 per unit in quantities of 100. Silicon General, Inc., 7382 Bolsa Avenue, Westminster, CA 92683.

Schottky rectifiers

Schottky rectifiers are ideal for power rectification because of their lower forward voltage and the resulting lower power dissipation. The 17-device MBR7520 family from Motorola has a greater trans-



SCHOTTKY RECTIFIERS FROM MOTOROLA

ient capacity than other rectifiers on the market. The diodes have a forward-current rating from 25 to 75 amp and have reverse voltage ratings up to 45 volts. Most devices in the series have dV/dt ratings of 100 volts-per-μs.

At a 100°C case temperature, 70-amp forward current and 45 volts, test units have been subjected to 8.3-ms, 1300-amp pulses once-per-minute, with no failures. The diodes recover from transients above the operating voltage specifications that drive them into temporary avalanche breakdown.

The rectifiers are mounted in DO-4 and DO-5 stud packages. Additional data is available from Motorola Semiconductor Products, Inc., Box 20912, Phoenix, AZ 85036. R-E

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increase board density and/or duplicate a double-sided PC board. This is the only system we have seen with this capability. Some of the possible Vector system variations are quite interesting, and among the available accessories are adapter pins for larger lead-wire sizes and a jumper wire kit.

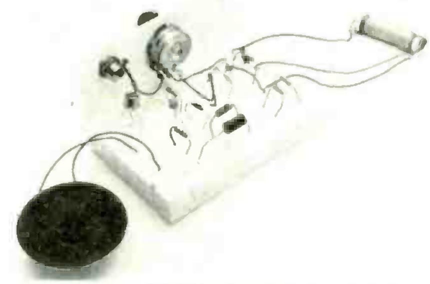
The final breadboard system to be examined is new in the United States. Having been used for some time in England, it is being imported and distributed by Saxton Products. This system is based upon modules called DeC's, and does *not* follow the usual .1 × .1-inch tie-point spacing. Each DeC module measures about 3 × 5 inches, and is constructed so that two or more DeC's can be locked together to form a single unit of any size.

T-DeC WITH IC SOCKET mounted on adapter.

There are three types of DeC's in this system: The *S-DeC* is for discrete circuits and has 70 tie points. The *T-DeC*, with 208 tie points, is used for discrete circuits with some IC's and requires IC sockets mounted on a special adapter sockets that have the correct pin spacing to fit the *DeC* boards. The *Micro-* or *U-DeC* is used for IC circuits, and comes in Type A (requiring IC sockets) and Type B (built-in IC sockets).

The Saxton DeC's are sturdy and well constructed. They do not permit as high-density breadboarding as the other systems. However, their unusual tie-point pattern permits a somewhat simpler transition from schematic to breadboarded circuit. They also have another advantage, which we'll see when we get to the prototyping section in this article. Several accessories are also available.

Systems with indexed boards provide a facility that becomes more useful as the complexity of the circuit increases. For example, you can note on the schematic exactly where connections are made just by jotting in B3 or K48, etc. This can save time when you are modifying the circuit as you go along. It is also possible to code the index indicators on the schematic *before* you assemble the circuit. In addition to this advantage, the indexing also helps to eliminate wiring errors.



S-DeC PROTOTYPING BOARD for discrete circuits.

Finally, you should note especially the wire kits that are available. I had a little box of random length and color wires and thought this was as good as anything. More recently, however, I have been using one of the jumper-wire kits. These jumper wires come in various colors and lengths (in 0.1-inch multiples) and they can be used to connect one tie-point to another without wandering all over the board or arcing through the air.

Next month, we'll take a look at the various prototyping systems and wiring techniques. We will also discuss how to select the best method for building your own circuits. **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 back cover.

FUNCTION GENERATOR, *model 301*, is a versatile lab instrument for engineers, students and hobbyists. Unit provides three basic waveforms—sine, square, and triangular waveforms over a 1-Hz to 100-kHz range. Operates with

either a single 12-volt supply or ±6-volt supplies. A squarewave output is available at the sync output terminal for oscilloscope synchronization or for driving logic circuits. Price: $119, postpaid.—**Printronix,** 1361 Flatbush Ave., Brooklyn, NY 11210.

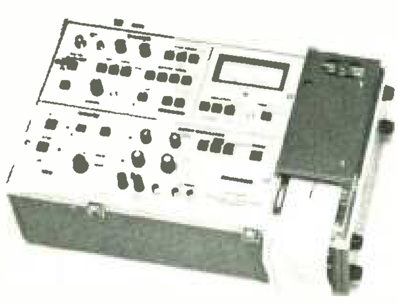
CIRCLE 109 ON FREE INFORMATION CARD

WIRE TOOL, *model 908-G*, is five tools in one: wire stripper, bolt cutter, wire cutter; long-nose plier for pulling wire, loosening and tightening

small nuts; and wire crimper for solderless connections. Tool measures 8¼ inches long and has blue, plastic cushion-gripped handles. Price: $8.90.—**Channellock, Inc.,** Meadville, PA 16335.

CIRCLE 110 ON FREE INFORMATION CARD

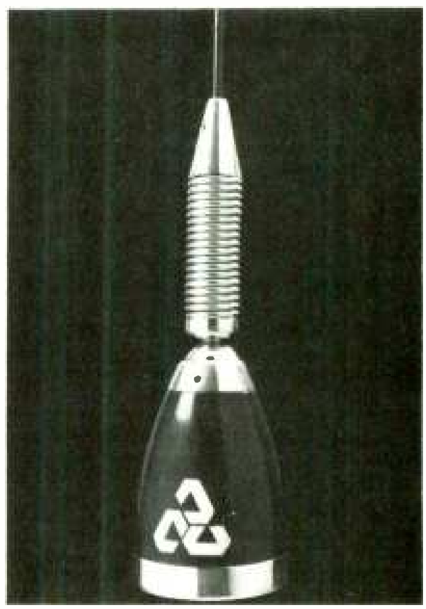
FREQUENCY RESPONSE RECORDER, *model LFR-5600*, measures and plots frequency re-



sponse, wow & flutter, drift, voltage and temperature for a wide range of audio equipment. Unit consists of two sections: an audio sweep oscillator (with 20-dB and 40-dB attenuation for high-sensitivity tests), and a pen recorder. Oscillator can also be used separately for direct-frequency-response readout on an oscilloscope. Chart section also serves as a DC reader to 10 mV-per-cm. The meter doubles as a sweep-frequency indicator. Unit contains standard 1-kHz and 333-Hz signal frequencies for reel-to-reel or cassette checks; selectable 25 dB, 50 dB or linear scales; external signals for response checks. The *model LFR-5600*, which comes in a sturdy built-in carrying case, costs $2995.—**Leader Instruments Corp.,** 151 Dupont St., Plainview, NY 11803.

CIRCLE 115 ON FREE INFORMATION CARD

BASE-LOADED ANTENNA is designed for flexibility, efficiency and long life. Quick-disconnect unit available with either trunk-lip, surface or magnetic mounts. Other features are: *Uni-Axis* ball joint, 500-watt pretuned coil, shielded coax

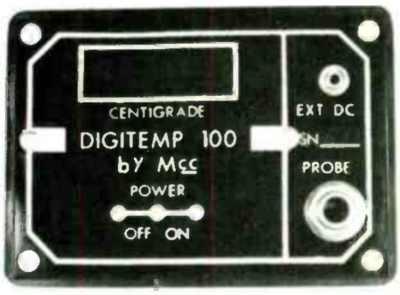


cable and in-line connector, and stainless steel whip. Suggested retail prices: trunk-lip mount, $32.50; surface mount, $28.50; magnetic mount, $32.50.—**Armstrong & Associates,** 3635 First Ave., S.E., Cedar Rapids, IA 52402.

CIRCLE 111 ON FREE INFORMATION CARD

TEMPERATURE METER, *Digitemp 100*, is a lightweight instrument with easy-to-read 0.33-in. LED display and adaptable to both hand-held operations and bench work (using optional adapter/charger). With standard probes, unit measures a range of −55°C (−67°F) to +150°C (+302°F) within ±0.5 degrees accuracy. CMOS technology minimizes display drift to less than 0.1°C per 15-degree change. Meter operates on standard 9-

volt battery; optional NiCad battery pack available. Other options include 3 standard probes—surface probe, for measuring semiconductor and heat-sink temperatures, etc.; bolt-down probe for monitoring chassis and heavy machinery; and submersible probe for measuring liquids. Also available are adapter/charger and two sizes of



cable. Unit measures 4 × 2⅞ × 1⁹⁄₁₆ in. and weighs 8 oz. Prices: *Digitemp 100*, $155 less probe; surface probe, $25; bolt-down probe, $27; submersible probe, $25; adapter/charger, $10; cables, $16 and $22; and battery pack, $10.—**Mid-Continent Communications Co.**, 1103 Broadway, Oak Grove, MO 64075.

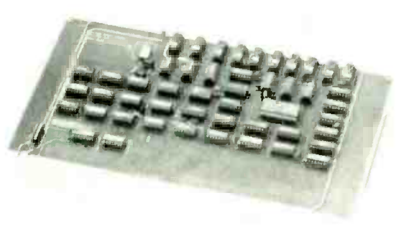
CIRCLE 114 ON FREE INFORMATION CARD

55-CHANNEL MARINE VHF-FM TRANSCEIVER, *Key/Com 55*, is totally synthesized to provide keyboard entry of any VHF channel (domestic and foreign) without crystals. Unit can receive 34 additional police, fire and ambulance monitoring

channels and four weather stations. Contains loudspeaker, LED readout, dimmer switch, battery meter, indicator light. *Key/Com 55* measures 3 × 8 × 9 inches and costs $659.95.—**SBE, Inc.**, 220 Airport Blvd., Watsonville, CA 95076.

CIRCLE 112 ON FREE INFORMATION CARD

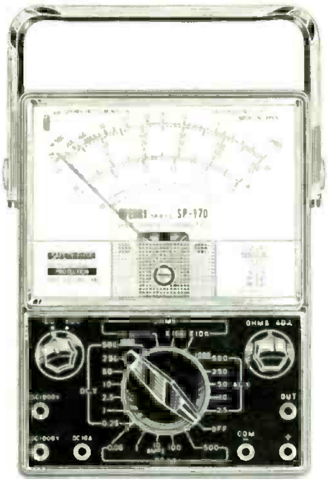
HARDWARE FLOATING POINT BOARD, *model FPB-B*, is compatible with the Z-80 microprocessor and is specially designed for applications needing fast floating decimal calculations. Board is compatible with SBC-80 bus. The *model FPB-B* uses BCD enumeration to perform add, subtract,



multiply and divide with selectable precision up to 14 digits. Included is a paper tape version of extended BASIC. Prices: kit, $299; assembled, $399.—**North Star Computers, Inc.**, 2465 Fourth St., Berkeley, CA 94710.

CIRCLE 118 ON FREE INFORMATION CARD

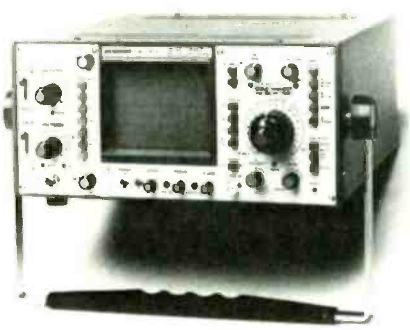
MULTI-TESTER, *model SP-170*, comes in a rugged plastic case with convenient carrying handle. Multimeter ranges are: 2.5–1000 VAC; 0.25–1000 VDC; 0.05–500 mA DC; 10 amps DC; 2K–20 megohms and −20, +56 dB. Sensitivity is 20,000 ohms/VDC and 5000 ohms/VAC. Contains 21-position selector switch, two-color scale, safety front panel, polarity selector switch. Unit is fuse-protected on all ranges except 10 amps DC. The *model SP-170* is battery-powered—uses one C-cell and one 9-volt transistor battery. Comes with



test leads, fuses, batteries, instructions. Weight: under 2 lbs. Prices: *model SP-170*, $73.50; optional carrying case, *model C-11*, $14.75.—**a.w. Sperry Instruments, Inc.**, 245 Marcus Blvd., Hauppauge, NY 11787.

CIRCLE 117 ON FREE INFORMATION CARD

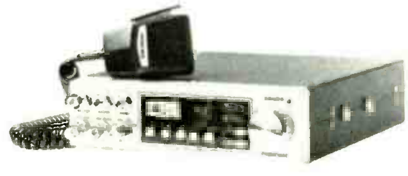
DUAL-TRACE OSCILLOSCOPE, *model LBO-515*, is a dual-channel, 25-MHz instrument with a built-in variable delayed sweep of from 1 μs to 5 sec. Offers a 5 mV-per-division vertical sensitivity; rectangular CRT with internal graticule; selectable sync; auto, normal, single-trace and



reset modes with 20 Hz–10 kHz rejection. Features include beam rotator, Channel 1 & Channel 2 trigger with polarity inversion for Channel 2, front-panel astigmatism control, × 10 magnification and 14-ns risetime. Finger-contoured handle doubles as locking bale. Priced at $1395, the *model LBO-515* comes complete with probes and accessories.—**Leader Instruments Corp.**, 151 Dupont St., Plainview, NY 11803.

CIRCLE 116 ON FREE INFORMATION CARD

CB TRANSCEIVERS, *Old Hickory, Adams* (shown) and *Madison*, are 40-channel units all



providing 4-watt power output and 100% modulation capability plus standard controls. Budget-

continued on page 110

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NEW PRODUCTS

continued from page 105

priced model *Old Hickory* AM mobile radio features an S/RF meter and ANL switch. The *Adams* AM/SSB unit (shown) has three-channel scan; S/RF, modulation and SWR meters; RF noise blanker and gain control switches. The key features of the top-of-the-line *Madison* AM/SSB base station are: digital clock, S/RF meter, noise blanker and RF gain control. Prices: *Old Hickory*, $129.95; *Adams*, $369.95; *Madison*, $499.95.—**President Electronics, Inc.**, 16691 Hale Ave., Irvine, CA 92714.

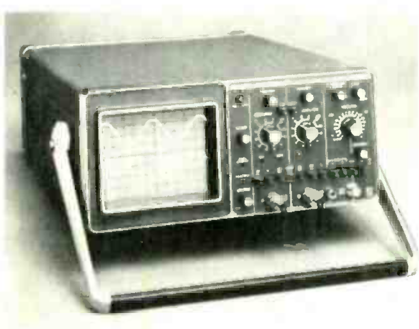
CIRCLE 125 ON FREE INFORMATION CARD

AEROSOL BOOSTER, *Vibra-Jet*, attaches to any can of solvent/degreaser or cleaner to reach into tight areas. Rigid-construction 12-in. probe on 26-in. flexible tubing. Useful for TV servicing, and

large-scale industrial use as well as in the home. *Vibra-Jet* is available through electronics dealers, distributors and hardware outlets. Suggested retail price: $1.98.—**Chemtronics, Inc.**, 45 Hoffman Ave., Hauppauge, NY 11787.

CIRCLE 119 ON FREE INFORMATION CARD

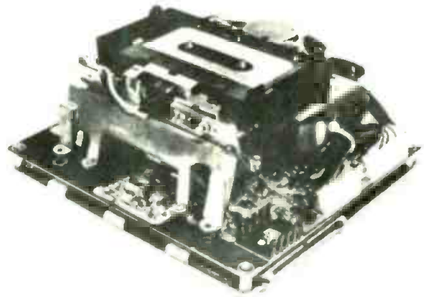
PORTABLE OSCILLOSCOPE, *model PM 3211*, is a 15-MHz, 2-mV instrument designed for general lab, shop and field service applications. It features a comprehensive display on an 8 × 10-cm screen, measures 300 × 135 × 445 mm and weighs 7.5 kg. Contains a double-insulated pow-



er supply, automatic or level-set triggering, 18-speed timebase with vernier control. Channel B doubles as X-input and can also be inverted with ADD function to display A ± B. Price: $875, including two probes.—**Philips Test & Measuring Instruments, Inc.**, 85 McKee Dr., Mahwah, NJ 07403.

CIRCLE 122 ON FREE INFORMATION CARD

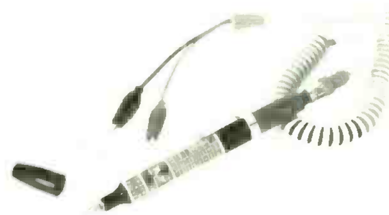
DIGITAL CASSETTE RECORDER, *model STR-150*, is designed for use with micro- and minicomputers, controllers and other devices requiring full remote-signal control of all tape-drive functions. Unit includes read-write electronics, control and timing logic and motor control logic. Accepts any asynchronous 8-bit parallel data word. Speed Tolerate Technique (STR) assures



total unit-to-unit *model STR-150* tape compatibility as well as compatibility with all tapes recorded on STR-type recorders.—**Triple I,** 4605 N. Stiles, Oklahoma City, OK 73118.

CIRCLE 123 ON FREE INFORMATION CARD

LOGIC PROBE, *Catch-A-Pulse Experimentor*, has pulse accumulator; responds to single pulses up to 20 μs and accumulates multiple pulse trains. Probe is compatible with RTL, DTL, TTL, CMOS, MOS and microprocessors using a 3.5- to



15-volt power supply. Thresholds are automatically programmed. LED readout displays HI, LO, bad or open-circuit logic and pulse levels. Probe comes with protective cap and detachable cord. Price: $22.95.—**AVR Electronics,** Box 19299, San Diego, CA 92119.

CIRCLE 121 ON FREE INFORMATION CARD

DIP SOCKETS in 14- and 16-pin configurations for wire-wrapping SSI, MSI and LSI integrated circuits. Pins are three-level wire-wrap, gold-plated, .015 in. square on .100-in centers; spring

contacts are phosphor bronze leaf; and socket bodies are made of glass-filled thermoplastic.—**OK Machine & Tool Corp.,** 3455 Conner St., Bronx, NY 10475.

CIRCLE 124 ON FREE INFORMATION CARD

HI-FI SPEAKERS AND EQUIPMENT TABLES are designed like furniture—all units are constructed of solid cherry, oak or walnut, have carefully selected veneers, and are sanded, sealed and stained. Both speakers and tables come matched in four different styles (shown is Mediterranean). Tables have a wire-capturing feature that eliminates unsightly wires. Speakers are available in 10-, 12- and 14-inch sizes. Tables measure 30 or 60 inches long; the larger size accommodates most color TV sets. Suggested retail prices: tables, \$125–\$180; speakers, \$180–\$360.—**Wrightwood Engineering,** Div. Wrightwood Enterprises, Inc., 818 Evergreen Ave., Chicago, IL 60622.

CIRCLE 113 ON FREE INFORMATION CARD

TOOL DISPLAY, *90205*, is designed to take the maximum advantage of floor space and minimizes set-up time. A wide variety of most-wanted tools can be displayed to full advantage; handy out-of-stock and free catalog cards are included. Also available is separate nutdriver-screwdriver shelf (*90206*) with metal frame that holds drivers securely.—**Hunter Tools,** 9674 Telstar Ave., El Monte, CA 91731.

CIRCLE 126 ON FREE INFORMATION CARD

CIRCLE 44 ON FREE INFORMATION CARD

CIRCLE 69 ON FREE INFORMATION CARD

CIRCLE 20 ON FREE INFORMATION CARD

new lit

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TEST INSTRUMENTS, 42-page illustrated catalog includes CB testers, DMM's, frequency counters, multimeters, oscilloscopes, semiconductor and transistor testers, power supplies and many other test instruments. Specifications and features of each unit are included. Separate price schedule.—**B&K-Precision,** Dynascan Corp., 6460 W. Cortland Ave., Chicago, IL 60635.

CIRCLE 128 ON FREE INFORMATION CARD

MICROCOMPUTER SYSTEM CATALOG, *Byte Shopper*, features all kinds of microcomputer schemes, from the simplest home setup to large timesharing, multi-user systems. Each product described includes not only specifications but a complete discussion of how it works and its application. More than 50 manufacturers are represented, and almost all products are S-100 bus-compatible. Catalog is available for $2.50.—**Byte Shopper,** Byte Shop of Arizona, Box 28106, Tempe, AZ 85282.

COMPONENTS CATALOG, 64 pages, contains a wide variety of more than 100 components and kits and features listings of surplus and replacement semiconductors. A transistor reference data listing is also included in the back of the catalog. Other items include bridge rectifiers, function generators, IC's, LED's, microprocessors, PC boards, switches, solar cells, Zeners. Also describes kits for radios, a signal injector, a timer, TV games, counters, and psychedelic lights. A handy order form is included in the back, and a separate catalog flyer with additional products is also available.—**J. & J. Electronics, Ltd.,** Box 1437, Winnipeg, Man. R3C 2Z4.

CIRCLE 129 ON FREE INFORMATION CARD

ELECTRONIC INSTRUMENT CATALOG contains 32 pages of test equipment, burglar/fire alarm systems, CB accessories and hobby projects. Test instruments include oscilloscopes, frequency counters, logic testers, DMM's, VOM's, tube testers and an IC color generator. Also described are such devices as smoke detectors, heat/fire sensors, and a complete home-protection security system. Solid-state circuitry kits feature AM/FM radios, an electronic organ, an ESP tester, a stereo amplifier and many more.—**EICO Electronic Instrument Co.,** 108 New South Rd., Hicksville, NY 11801.

CIRCLE 130 ON FREE INFORMATION CARD

INSTRUCTIONAL BOOKLET, *A Brief Guide to Microphones*, 15 pages, uses a step-by-step approach to a basic understanding of different microphone types and features. Eight basic microphone terms are described, and an additional section deals with mike accessories.—**Audio-Technica U.S., Inc.,** 33 Shiawassee Ave., Fairlawn, OH 44313.

CIRCLE 131 ON FREE INFORMATION CARD

FREQUENCY COUNTERS, *Freq. Out.*, is a 4-page, full-color description of manufacturer's *Max-100*, a portable, 8-digit, 100-MHz frequency counter with a suggested resale price of $134.95.—**Continental Specialties Corp.,** 70 Fulton Terrace, New Haven, CT 06509. **R-E**

CIRCLE 132 ON FREE INFORMATION CARD

books

BUGBOOKS V AND VI, by Peter R. Rony, David G. Larsen and Jonathan A. Titus. E&L Instruments, Inc., 61 First St., Derby, CT 06418. *Bugbook V*, 493 pp.; *Bugbook VI*, 490 pp. 6× 9 in. Softcover $9.50 each.

These two volumes combine a course in introductory digital electronics with programming and interfacing an 8080A-based microcomputer. Designed for study and guidance in performing "hands-on" experiments with a low-cost microcomputer, breadboards and available components.

Bugbook V covers programming and instruction basics, as well as digital codes, register, logic gates and truth tables. Instruction and experiments with the 7400-series TTL IC's, including flip-flops and latches, decoders, counters, digital signal gates and multivibrators.

Bugbook VI contains detailed instructions and lab experiments with instruction set, three-state busing techniques, and accumulator and memory-mapped I/O techniques. This volume also covers advanced I/O concepts and interrupt servicing. Complete appendices for both volumes are contained in the back of *Bugbook VI*.

GROUNDING AND SHIELDING TECHNIQUES IN INSTRUMENTATION, Second Edition, by Ralph Morrison. Wiley-Interscience, Div. of John Wiley & Sons, 605 Third Ave., New York, NY 10016. 146 pp. 6 × 9 in. Hardcover $15.50.

This is a revised and updated version of an earlier popular book for engineers, technicians, designers, and anyone concerned with electronic equipment. Notice has been taken of more recent developments in electronics, such as digital circuits, and schematics have been revised to reflect these developments. Electrostatic concepts are outlined in simple fashion so that the reader can come away with a clear understanding of the common shielding errors and how to avoid them. The text is well illustrated with block diagrams and halftones.

LOGIC DESIGNER'S MANUAL, by John D. Lenk. Reston Publishing Co., Div. of Prentice-Hall Co., Reston, VA 22090. 504 pp. 6 × 9 in. Hardcover $18.95.

This book introduces the reader to commercially available IC's that can be used for specific applications. The text and illustrations show how these IC's can be interconnected to form logic systems. Chapter 1 is an introduction to logic design; Chapter 2 describes how decoders, counters, etc., work; the remaining chapters cover such subjects as A/D and D/A converters, arithmetic units, memories, interface and other logic circuits.

SECURITY ELECTRONICS, Second Edition, by John Cunningham. Howard W. Sams & Co., Inc., 4300 W. 62nd St., Indianapolis, IN 46268. 192 pp. 5½ × 8½ in. Softcover $5.95.

This book takes a look at how various electronic security devices and systems work, and suggests what type of system is best for specific applications.

Chapter 1 is an introduction to the various types of systems available. Modes of operation, antishoplifting devices, metal detectors, the use of computers in alarm systems and debugging devices are just some of the topics covered in other chapters. Included in the back of the book is a glossary of terms and definitions as approved by the U.S. National Bureau of Standards Law Enforcement Standards Lab. R-E

AUDIO OSCILLATORS

continued from page 73

Figure 4 shows another popular circuit—the L–C (inductance-capacitance) combination. Figure 4-a is the Hartley oscillator, which uses a tapped inductor and Fig. 4-b is the Colpitts oscillator, with a split capacitor. The natural frequency of either of these oscillators depends on the square root of L × C. Therefore, for a 10:1 tuning range, the value of C (or L) must vary by 100:1. This is one of the major disadvantages of the L–C oscillator. Another major disadvantage lies in the size of the inductance and capacitance required to reach low frequencies. The advantage of the L–C oscillator lies in the ease with which a high-Q (high-selectivity) tuned circuit, which results in extremely pure sinewaves, can be obtained.

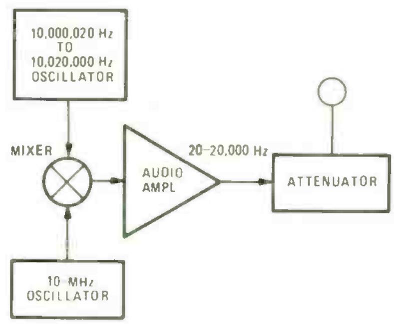

FIG. 5—THE BEAT-FREQUENCY TYPE. The audio signal is the difference—or beat—between two separate radio frequencies.

Today an L–C circuit is not often used. However, it was commonly used in heterodyning or beat-frequency oscillators, as shown in Fig. 5. This arrangement has an extremely wide frequency range. For instance, the oscillator in Fig. 5 can cover a 20-Hz to 20-kHz range, while the L–C 10-MHz oscillator frequency changes by only 2%. (Such oscillators often have frequency stability problems.)

Tuning

Two forms of frequency selection are common. One is switch-selectable decade ranges, with a continuously variable frequency adjustment within the selected decade. Such oscillators are continuously tunable and usually have a ganged variable capacitor that is adjusted to produce changes within each decade. Ranges are changed by changing sets of resistors. The L–C oscillator ranges can be changed by adjusting taps on the inductor or switching in new inductors.

Selection of discrete frequencies by switches is the other frequency selection method. Although not as common as continuous tuning, it has many operational advantages. When switched frequency selection is used, ranges are changed by selecting sets of fixed capacitors whose capacitance increases in decade steps.

Within a particular decade, frequency is adjusted by selecting appropriate resistors. In other words, the switched tuning technique usually inverts the role of capacitance and resistance as compared with continuous tuning.

Designing an oscillator suitable for generating fundamental audio oscillator signals involves many techniques for reducing distortion and noise to the lowest possible levels. The amplifier in the basic oscillator circuit must have extremely high gain over the entire frequency range used. The higher the gain, the greater the feedback and the lower the distortion. This amplifier must not introduce any appreciable phase shift over the oscillator's entire frequency range. Amplifier noise and hum must be reduced to the lowest possible levels. Frequency stability with component aging and temperature variations must be carefully considered. Any effect that would tend to modulate the basic oscillator signal in either amplitude or frequency must be removed, as all these effects contribute to total distortion.

Output amplifier

The output amplifier has three purposes. First, it supplies some gain to increase the oscillator output amplitude to the maximum level required. Second, the amplifier serves as a buffer, isolating the oscillator from load changes at the output. Third, it serves to reduce the output impedance of the oscillator stage to the required impedance (usually either 50 or 600 ohms). Most amplifiers used for this type of work consist of one or more Class A amplifier stages. The amplifier in common use consists of a number of stages connected to form a high-gain, wideband, low-noise circuit.

Normally, the gain of the output amplifier must be in the range of one to five. Large amounts of negative feedback are introduced to reduce the gain to this required range, which tends to improve amplifier frequency response, phase and distortion characteristics. Frequently, the amplifier output impedance, which has been reduced to an extremely low value by the large amount of feedback, is significantly lower than required at the output. A series resistor at the amplifier output yields the desired impedance. Although this limits the maximum power transfer capabilities of the amplifier, it does insure a reflectionless signal source.

Designing the output amplifier for the audio oscillator requires great care to avoid introducing hum, noise or amplitude modulation. Low noise techniques and careful shielding are routinely applied to such amplifiers. Other more advanced techniques, such as special isolating transformers, are not uncommon. Additional leveling techniques can be applied at the output amplifier, although they are more commonly applied at the oscillator.

Output attenuator

Output attenuators may vary in complexity from the very simple to the exotic. Figure 6 shows an extremely simple attenuator. The output impedance of the audio oscillator varies with the setting of the 400-ohm variable attenuator. The output impedance of this circuit may drop to nearly zero at the minimum setting.

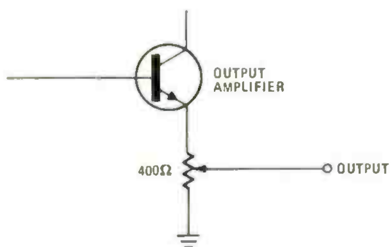

FIG. 6—AN OUTPUT ATTENUATOR that is commonly used on low-priced audio oscillators.

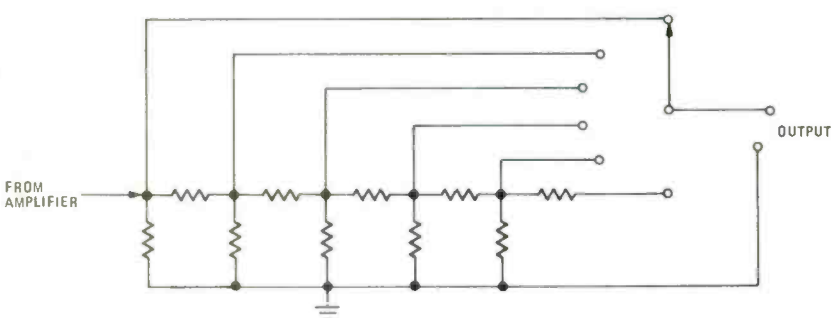

FIG. 7—THE LADDER ATTENUATOR operates in steps and maintains a constant impedance throughout its range.

Attenuators like the one shown in Fig. 7 are common in more sophisticated oscillators. The continuous variable attenuation is inserted before the amplifier stages. Therefore, the output impedance does not vary as the continuously variable attenuator is adjusted. The step attenuator is of the constant-impedance type, with either 10-dB or 20-dB steps, and maintains either a 600-ohm or 50-ohm output impedance regardless of attenuator setting.

The design of the output attenuator

turn page

must insure identical performance at high and low frequencies. This becomes especially important if squarewaves are included; they contain components of much higher frequency than the sinusoidal waveforms of the same frequency. Equal attenuation of the high-frequency and low-frequency components is necessary to reproduce the squarewave faithfully.

Metering circuits

Many audio oscillators display the exact output signal amplitude on a meter. Normally, the metering circuit monitors the signal applied to the fixed attenuator, and the attenuation supplied by the fixed (step) attenuator is presumed to be constant and accurate. Metering circuits require a rectifier that is flat over the entire frequency range of the oscillator. The rectifier-circuit output drives the meter; a typical circuit is shown in Fig. 8.

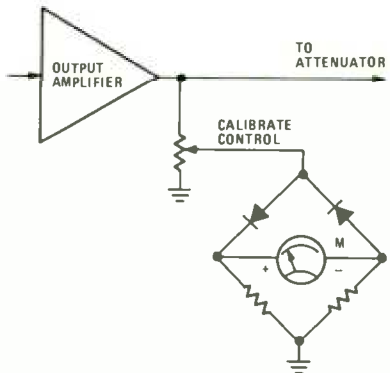

FIG. 8—TYPICAL OUTPUT METER. The audio frequency is rectified and measured.

Squaring circuits

The Schmitt trigger is the circuit most commonly used to generate a squarewave from the internal sinewave of the audio oscillator. The Schmitt trigger circuits are usually designed to avoid fast rise-times to keep noise from entering the sinewave output. The input to the squaring circuit must be buffered so it does not affect the sinewave characteristics by loading. The squarewave output of the Schmitt trigger is passed through a simple amplifier, reducing the output impedance to drive an attenuator.

Frequency control

Some audio oscillators offer auxiliary circuitry giving a few percent frequency variation. This feature permits locking to an external standard for more precise frequency control. Depending upon the basic oscillator circuit chosen, the external frequency control circuitry consists of an electronically variable capacitor to shunt the oscillator capacitance, or electronically variable resistors to shunt the oscillator resistance elements. Light-dependent resistors or Varicaps are used.

Specifications

The specifications of an electronic instrument are usually provided briefly in advertising, and in more detail in the operator's manual. Audio oscillator specifications, like those of most other instruments, vary from a simple listing covering less than a page to detailed listings covering a number of pages (generally found on more expensive units). Frequently, such specifications vary from manufacturer to manufacturer and at times even among instruments sold by the same manufacturer. It is therefore important that the user be able to organize the specifications in one common format to compare audio oscillators so he can decide on which one to buy.

Frequency range

The frequency range specification indicates the lowest frequency generated, as well as the highest frequency generated. This specification also indicates the number of ranges over which the oscillator must be tuned to cover its complete frequency range.

A note of caution: It is common to advertise only those performance specifications that lie within the classic audio frequency range (20 Hz to 20 kHz). Low-frequency limits for audio oscillators may run from a fraction of a hertz for the most sophisticated oscillators to 10 Hz for the lower-cost units. In higher-priced models, upper frequency limits of 1 MHz to 2 MHz are common. Lower-cost units may extend to an upper limit of only 100 kHz. All extend beyond the classic audio spectrum, and one cannot assume that a specification holds over this entire range. Read *all* the specifications to determine the capabilities of the audio oscillator at *any* particular frequency.

Frequency setting accuracy

Frequency accuracy, given as a percentage of the operating frequency, varies from a precise ±0.5% on switch-selected incremental oscillators to an error of ±5% on the less expensive units. For most work, a ±5% accuracy is entirely acceptable. Accuracy specifications for oscillators with switched incremental frequency tuning are given with any vernier frequency control in a fixed calibrate position. On oscillators with an exceptionally wide frequency range, a reduction in accuracy should be expected at the extreme ends of the range.

Audio oscillators are not intended to be used as frequency standards, and a high accuracy level is not generally necessary. Applications such as measuring the band-pass characteristics of extremely sharp filters, or measurements in such cases where legislation requires compliance to a frequency tolerance, may require an external frequency meter for ultimate accuracy.

to be continued

next month

MAY 1978

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SELECTING A DMM
continued from page 66

best. The reason is that when high voltage is applied to a metal-film resistor, it typically fails by opening up until the metal film melts, then it shorts and finally opens. This, of course, defeats the desired protection. A carbon-composition resistor under the same conditions will typically open without the interim short.

"Another way to implement ohms protection is to use an active protection device. This is used in our new ohms circuit." (See Fig. 6.)

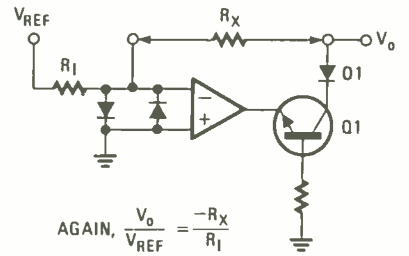

FIG. 6—ACTIVE PROTECTION CIRCUIT used in the ohms circuit of the digital multimeter.

"In normal operation, transistor Q1 is saturated and diode D1 is on. Consider the two opposite polarity cases (Fig. 7):

"The input to the op-amp is limited to −0.7 volts, causing the output to go positive which turns off Q1 (Fig. 7-a). Transistor Q1 is a 450-volt switching transistor, so nearly all the 163 volts appear at its collector. Since Q1 is off, virtually no collector current flows, and Q1 does not dissipate a large amount of power.

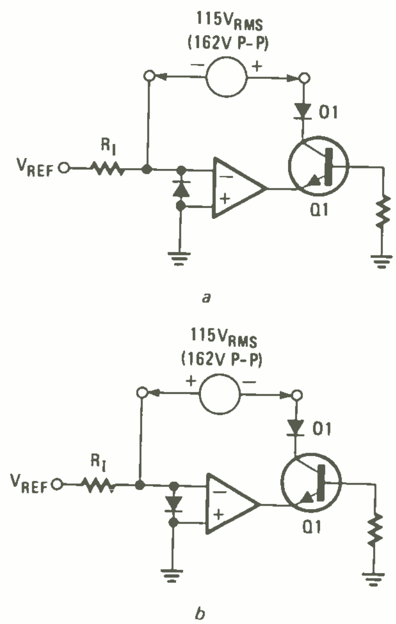

FIG. 7—ACTIVE CIRCUIT PREVENTS external voltage from damaging the DMM ohms circuit. Diode D1 and Q1 are the basic components.

"In Case 2 (Fig. 7-b), the op-amp output is negative, which forces transistor Q1 on. The input is limited to +0.7 volts, and diode D1 is off.

"So now we have an ohms converter that is protected, even if a 220-volt line is connected to it. I think you'll agree that we make our product rugged."

George is visibly impressed. "I had no idea you people spent so much time with reliability and customer satisfaction. I wish I had known before I bought my first DMM. Of course, I probably would still have purchased your product."

George now realizes the forethought and extra testing effort that went into the design of his DMM. He will gladly pay more for a DMM whose usability he can verify from careful scrutiny of the data sheet. He wanted a "quality" DMM, and the service reputation of the manufacturer has already paid for itself. With renewed confidence in his DMM, he steps out of the Whoopee-tronics service center into the bright sunshine and hurries off to reenlist in the summer bowling league. **R-E**

EQUIPMENT REPORTS

continued from page 34

use the other hand to hold the soldering iron and feed solder with the fourth hand! With the *model KL-3000*, you can hold the board and part with one hand, and use the other hand to solder it.

The soldering pistol uses small-gauge solder, .031- and .050-inch in diameter. In the standard *model KL 3000*, the feed-reel is mounted on the top of the grip at the back, almost flush with the grip. Enough of the small solder can fit on this reel for quite a lot of joints. If a larger capacity is needed for production-line work, etc., you can mount a larger solder reel that holds three times as much as the standard reel. For making many joints without stopping, you can even obtain a bench-mounted reel that holds 2.2 lbs. of solder, or one kilogram!

The *model KL 3000* comes in 20-, 30-, 40- and 60-watt sizes. The heating elements are interchangeable and can all be used in the same handle. The solder feed must match the size of the solder used, but this only requires changing the feed tube, which is not hard to do.

A great many soldering tips are available: 10 different 4-mm tips for the three lower heats, and 16 tips in the 6-mm size for the 60-watt unit. The tips are all specially coated so that you never file them. You just wipe them off with a wet sponge, and you're ready to go again. A bench stand is available that holds the pistol in the recommended upright position. And you can use any stock solder-gun holder.

The four stock pistol sizes are 115-volt AC-powered. A 24-volt unit, powered by a step-down transformer, is rated at 40 watts. By changing taps, this unit can be used at 20 or 30 watts. An electronic temperature-controlled unit is also available for precision control of tip temperature.

We found a small junked PC board, put some parts in it and tried the pistol out. After only a little practice, we could make really smooth professional-looking joints with ease. A thumbscrew under the barrel can be used to adjust the amount of solder that is fed out when you press the trigger. The trigger also has click-stops that you can use. One squeeze delivers enough solder to make any average-sized joint, with one or two leads.

You can obtain the solder from Kager or use any stock solder. The sizes are standard.

For all IC work or for very closely spaced joints, this pistol is a very useful tool. **R-E**

Hickok Model 266 CB Signal Generator

THE HICKOK ELECTRICAL INSTRUMENT COMPANY, 10514 Dupont Avenue, Cleveland, OH 44108, have been manufacturing RF signal generators for a long time. (Other things too, of course!) There's a *model 188* generator on my bench that's been there since 1935! It works, too.

The company's latest entry is a real state-of-the-art instrument that can do many things accurately and make many tests easily. This instrument is the *model 266* CB signal generator. It uses the latest technology to develop all

turn page

the different signals needed for present-day CB work. The suggested retail price is $495.

The heart of the *model 266* is a digital phase-locked loop (PLL). A highly accurate reference oscillator together with the PLL generates an RF output signal exactly on-

CIRCLE 133 ON FREE INFORMATION CARD

frequency for all 40 CB channels. In our tests, the most deviation was about 20 Hz, which is far tighter than the average CB radio. The PLL uses an IC programmable divider to change CB channels. You just punch the two numbers in on the 12-button keyboard, and then press one of the two ENTER pushbuttons. The RF output locks tightly onto the reference, and a bright LED pilot labeled PHASE-LOCK lights! The channel number appears instantly on the two-digit LED readout. An IC memory remembers the correct divisor for the channel.

If you press the wrong pushbuttons, and the LED readout gives you a number that is not one of the 40 channels (such as Channel 46 or Channel 95), this number shows up on the readout, but the PHASE-LOCK light stays out. You must press a 0 pushbutton for the first nine channels—i.e., "01," "06," etc. Hickok states that the PLL can be programmed for any extra channels in the 27-MHz band that may be added later.

The RF signal output is monitored by a panel meter, which reads directly in microvolts. The meter can be set in six steps, from ×1 to ×100K, and has a continuously variable level control. You can obtain any signal strength needed, from 100-mV RMS down to microvolt levels. The attenuator is also calibrated in dBm, and there is a dBM scale on the meter. (Example: 0 dBm = 1 mV, or 1000 μV.) This is especially useful for measuring adjacent sideband rejection, squelch setting, etc., that must be a certain dB below a reference level.

You can generate both AM and SSB signals. On AM, the RF signal can be unmodulated (or modulated) with an accurate 1.0-kHz signal. Pressing a button adjusts the modulation percentage from 0% to 100%; you can then read this on the meter.

For SSB tests, set the *model 266* to the CB channel desired without modulation. Set the CB rig to the same channel and to either upper sideband (USB) or lower (LSB). Now just press the USB or LSB pushbuttons on the front panel. The PLL moves exactly 1 kHz in either direction. The resulting RF signal is the same as a sideband signal with 1000-Hz modulation. The modulation percentage is also adjustable.

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MAKE YOUR OWN CUSTOM HARDWARE
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IC lead pin, solder the wire to the T-44 pins, put in a strain relief, and again mark pin No. 1 on this socket connector. The Glomper clip now can fit itself to an IC socket, yet still has testing points as handy as the original unmodified Glomper test

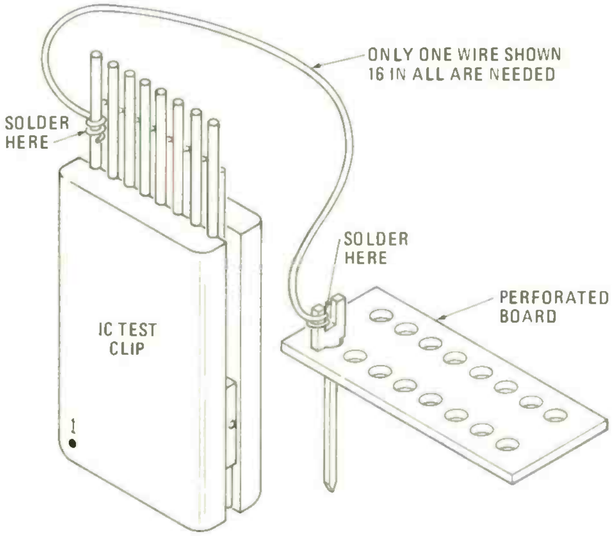

FIG. 16—IC TEST CLIP can be modified with a piece of cable and a home-brew jig to plug directly into an IC socket.

clip (see Fig. 16). The wire cable should be kept to under 36 inches, and 24 inches seems to work nicely. This same test clip prewired would cost a small fortune at the electronic shop, and for only pennies you have made the same unit.

Star No. seven

Just a helpful tip to those who use a great deal of solder wick to remove IC's and other components from boards. The cost of this wick is quite expensive. So, if you have some old zip cord, why not save some hard cash? Simply strip the cord to the braided wire, smear on some flux and use this in place of the solder wick.

Throughout this article I have given the names and addresses of makers of the special hardware stars I have introduced you too. Why not write them for their catalogs and try some of the ideas presented in the article next time you need a special situation device. Don't be afraid to try your hand at some modification of your own making, and let's hear from you through **Radio Electronics;** us home brewers have to stick together just to keep out of hot water. **R-E**

EQUIPMENT REPORTS

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This test is a fast check for upper or lower sideband rejection, RF sensitivity and centering of any fine-tuning or clarifier controls on the CB transceiver.

A noise generator circuit is also included that produces a standard pulse-train noise, with a width of 1.0 μs and a 100-PPS repetition rate. This noise is superimposed on the RF output signal. It can be used to check the receiver's noise blanking, noise limiter, etc., circuits on either AM or SSB.

For IF alignment and many other tests, the *model 266* has a crystal-controlled 455-kHz signal that is 30% modulated and variable. For dual-conversion receivers, a crystal on the first IF frequency can be plugged into a crystal socket, and used to check this stage.

The IF test is also useful for checking a CB rig with a frequency synthesizer. Feed an unmodulated RF signal into the input of the CB rig and then press the 455-kHz IF signal output pushbutton. Couple the 455-kHz IF signal into the second IF stage. If the CB isn't exactly on-frequency, you'll hear an audible beat note in the speaker. Just tune the synthesizer for zero beat, and the job is done. A mistuned synthesizer can cause low sensitivity, etc. You can use the crystal function to check crystals for activity and frequency. Just plug the crystal into the *model 266*, select the crystal via the front-panel pushbutton and read the frequency on a counter connected to the IF output of the *model 266*. Crystals in the 1- to 20-MHz range can be checked out. Third overtone crystals, used in many CB's, oscillate on the fundamental frequency, at one-third the RF frequency.

The *model 266* has an RF signal output of up to 100,000 μV, and an IF output signal of 150 mV. This output is sufficient to operate a frequency counter directly. The step attenuator on the RF signal output uses precision resistors and careful shielding, and the output signal can be adjusted down to a level of 1.0 μV or a bit less. If fractional-microvolt signals are needed for an especially sensitive CB, you can construct a simple 20-dB attenuator that divides the RF output signal down by the necessary amount. The manual contains full construction details for this.

Amplitude-modulated CB's, as well as SSB's, can be easily checked for adjacent-channel rejection. Measure the sensitivity of the CB rig and then switch the PLL to the next channel in either direction. Increasing the RF output signal level until the output meter shows the same reading provides the adjacent-channel rejection ratio in dB instantly.

SSB tests are equally simple. For adjacent-sideband rejection, just measure the sensitivity on the USB, set the meter, then switch the *model 266* to the LSB setting. Bring the signal level up until the meter shows the same reading, and read it off the RF meter in dBm.

Even the receiver's audio stages can be checked for maximum power output as well as for frequency response. For power tests, just read the RMS voltage across the speaker voice coil or a dummy load with a high signal input. Two charts in the instruction manual show the signal voltage for any power level—from 0.1

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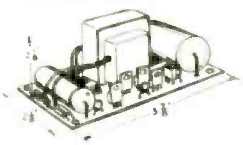

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max .062" panel thickness $1.75
140-4 cut-out 1.160" x 4.375"
max .125" panel thickness $2.75

DIODES

Silicon SW diode assorted 400 mw	$.05ea
1N4148 (1N914) Silicon diode 400 mw	.10
1N3064 Silicon SW diode 400 mw	.10
1N4006 Silicon rect. diode 600V 400mw	.10
Zener diode 400 mw - 2.4V, 3.6V, 5.1V, 6.5V, 6.8V, 10V, 12V, 14.5, 15V, 120V	.15
Germanium diode 400 mw	.08

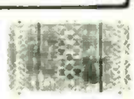
ELECTRONIC BUZZER

Miniature, Solid State
6V 15ma (4-9V oper.) $1.69 ea.
12V 15ma (8-20V oper.) $1.69 ea.

TANTALUM CAPACITOR KIT
60 solid dipped capacitors
12 values, 5 capacitors each

.1uf/35V	1/35	4.7/16	10/25	22/16	47/25
.33/35	2.2/35	6.8/16	15/20	33/10	56/6

UNIVERSAL BREADBOARD



Silver placed copper circuits fits any IC and related components. 2 triple rows of 27 holes for DIP. 3-3/16"x5-1/16" $1.00

TANTALUM CAPACITORS - solid dipped

.1u/35V	$.20	6.8/6	$.25	15/50	$.40
.22/35	.20	6.8/16	.25	22/16	.40
.33/35	.20	6.8/50	.30	33/10	.50
1/35	.20	10/16	.30	47/6	.50
2.2/20	.25	10/25	.35	47/25	.55
2.2/35	.25	10/50	.35	56/6	.65
3.3/35	.25	15/10	.35	150/15	1.25
4.7/16	.25	15/20	.35		

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LD110/111 chip set - 2V, 20V, 200V ranges auto zero, auto polarity, .3" LEDs. All components, PC voards, power supply for 115V use. Case not included.
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Checks gain & band width of the Y ampl & attenuators and freq. calibration of timebase. Build into any scope. All parts, PC board & instructions..$3.80

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VU meter uses a column of LEDs to indicate signal level. Designed as a 2 channel meter Uses separate rectifier and display boards. +15V supply required. All components, PC boards and instructions........$32.50

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I & II - Logic, memory text & experiments $17.00 /set
Instructors Manual (for 1 & 2) $ 3.00 ea.
IIA - Introduction, use of UART $ 5.00 ea.
V & VI- Experiments in Digital 8080A programming & interfacing $ 9.50 ea. 19.00 /set
555 - Timer applications, experiments $ 6.95 ea.
CMOS - Designers primer and handbook $ 6.00 ea.
SK10 - E & L Solderless Breadboard $16.50 ea.

TANTALUM CAPACITOR KIT
solid dipped, 12 values, 5 each

.1uf/35V	2.2/35	10/25	33/10
.33/35	4.7/16	15/20	47/25
1/35	6.8/16	22/16	56/6

capacitors only......$14.95
supplied in styrene utility box.. ....$19.95

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Silver plated copper circuits holds 5 - 16 pin DIP IC's and interconnection holes. $1.00

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2N2222A	NPN Low Power Trans TO-18	.29
2N2223	NPN Low Power Trans. TO-5	.69
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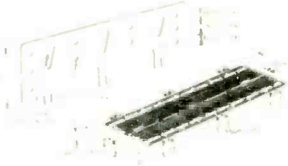
2N2904	PNP Low Power Trans TO-5	.49
2N2905A	PNP Low Power Trans TO-5	.76
2N3227	NPN Low Power Trans TO-18	.69
2N3904	PNP Low Power Trans TO-92	.17
2N3906	NPN Low Power Trans TO-92	.17
SCA 13572	NPN Pwr Trans - 200V TO-5	1.75

BIMBOARD - BREADBOARD KIT



Solderless breadboard section has 94 breadboard strips of 5 sockets each. 2 bus strips of 40 sockets each. Component bracket for switches lamps etc., accepts leads .01" to .035" diameter. $11.95 ea.

Zener Diode Handbook - Motorola $ 3.00 ea.
Switching Transistor Handbook - Motorola $ 2.50 ea.
CMOS Data Book - Solid State Scientific $ 3.00 ea.
Micro Computor Application Hdbk.- IASIS- 8080 microcomputor debugging, architecture and instruction set. $ 6.95 ea.

TRIMPOT - 25 turn
Bourns - Cermet 3299W
PC Mount, vert. adj.
2K, 10K, 20K $1.75 ea

SOLDER
60/40 w/rosin.in dispensor
13 fit of .040" dia. $1.95

TRIMPOT - Single Turn
Mepco - Cermet 8014
.5w, + 100 PPM/°C + 20%
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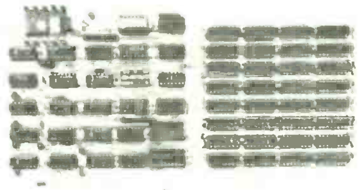
MEMORY CAPACITY
MEMORY ADDRESSING
MEMORY WRITE PROTECTION
8K, 16K, 24K, 32K using Mostek MK4115 with 8K boundaries and protection. Utilizes DIP switches. PC board comes with sockets for 32K operation. Orders now being accepted. Allow 6 to 8 weeks for delivery.



INTERFACE CAPABILITY
Control, data and address inputs utilizes low power Schottky devices.
POWER REQUIREMENTS
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+18VDC 400MA DC
−18VDC 30MA DC
on board regulation is provided. On board (invisible) refresh is provided with no wait states or cycle stealing required.
MEMORY ACCESS TIME IS 375ns.
Memory Cycle Time is 500ns.

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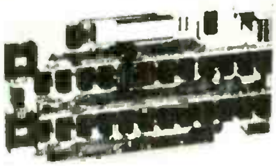

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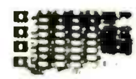

The Whole Works - $79.95

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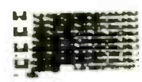

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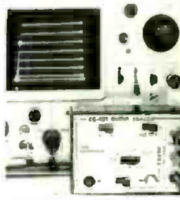

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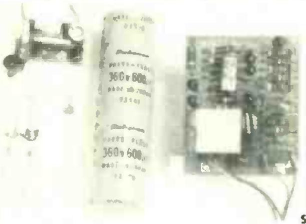

We have all the parts to custom design your own automatic photo graphic strobe. These individual modules may be put together in several different ways, depending on how powerfull, or whether you want automatic shut off. We have a DC to DC power supply, that raises the output of 4 NICADs from 4.8 volts, to 320 volts. We have the trigger coil, to fire the flash tube. We have 2 flash tubes, a straight tube 2" long, and a horseshoe tube 1½" long. a small, high voltage, high capacity capacitor, rated at 360 V, 600 mfd. 38 watt seconds., an electronic cut off device that shuts of the flash tube when the exposure is correct. You may make up your own kit by choosing the parts you wish. We list the price of each part, but when 3 or more parts are chosen, you may deduct 10% from the total. We suggest that only one capacitor be used if the the straight flash tube is used. With the horseshoe tube, 2 capacitors may be used for greater output. Use of the cut off module is optional. We provide circuitry for the entire system.

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Horseshoe flash tube	9941R	$3.00
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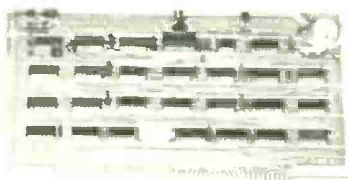

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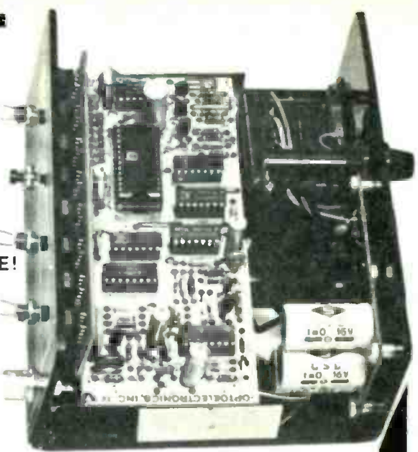


TAKE ADVANTAGE OF THIS NEW STATE-OF-THE-ART COUNTER FEATURING THE MANY BENEFITS OF CUSTOM LSI CIRCUITRY. THIS NEW TECHNOLOGY APPROACH TO INSTRUMENTATION YIELDS ENHANCED PERFORMANCE, SMALLER PHYSICAL SIZE, DRASTICALLY REDUCED POWER CONSUMPTION [PORTABLE BATTERY OPERATION IS NOW PRACTICAL], DEPENDABILITY, EASY ASSEMBLY AND REVOLUTIONARY LOWER PRICING!

KIT #FC-50 C	60 MHZ	COUNTER WITH CABINET & P.S.	$119.95 COMPLETE!
KIT #PSL-650	650 MHZ	PRESCALER [NOT SHOWN]	29.95
MODEL #FC-50WT	60 MHZ	COUNTER WIRED, TESTED & CAL.	165.95
MODEL #FC-50/600 WT	600 MHZ	COUNTER WIRED, TESTED & CAL.	199.95

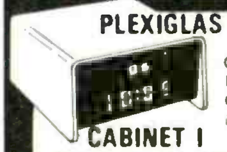
SIZE:
3" High
6" Wide
5½" Deep

FEATURES AND SPECIFICATIONS:

DISPLAY: 8 RED LED DIGITS .4" CHARACTER HEIGHT
GATE TIMES: 1 SECOND AND 1/10 SECOND
PRESCALER WILL FIT INSIDE COUNTER CABINET
RESOLUTION: 1 HZ AT 1 SECOND, 10 HZ AT 1/10 SECOND.
FREQUENCY RANGE: 10 HZ TO 60 MHZ. [65 MHZ TYPICAL].
SENSITIVITY: 10 MV RMS TO 50 MHZ, 20 MV RMS TO 60 MHZ TYP.
INPUT IMPEDANCE: 1 MEGOHM AND 20 PF.
[DIODE PROTECTED INPUT FOR OVER VOLTAGE PROTECTION.]
ACCURACY: ± 1 PPM [± .0001%]; AFTER CALIBRATION TYPICAL.
STABILITY: WITHIN 1 PPM PER HOUR AFTER WARM UP [.001% XTAL]
IC PACKAGE COUNT: 8 [ALL SOCKETED]
INTERNAL POWER SUPPLY: 5 V DC REGULATED.
INPUT POWER REQUIRED: 8-12 VDC OR 115 VAC AT 50/60 HZ.
POWER CONSUMPTION: 4 WATTS

KIT #FC-50C IS COMPLETE WITH PREDRILLED CHASSIS ALL HARDWARE AND STEP-BY-STEP INSTRUCTIONS. WIRED & TESTED UNITS ARE CALIBRATED AND GUARANTEED.

PLEXIGLAS CABINETS



Great for Clocks of any LED Digital project. Clear-Red Chassis serves as Bezel to increase contrast of digital displays.

CABINET I 3"H, 6¼"W, 5½"D
CABINET II 2½"H, 5"W, 4"D

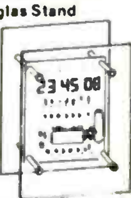
Black, White or Clear Cover
$6.50 ea.

RED OR GREY PLEXIGLAS FOR DIGITAL BEZELS 3"x6"x1/8" 95¢ ea. 4/$3

SEE THE WORKS Clock Kit

Clear Plexiglas Stand

- 6 Big .4" digits
- 12 or 24 hr. time
- 3 set switches
- Plug transformer
- all parts included



Plexiglas is Pre-cut & drilled
Kit #850-4CP
Size: 6"H, 4⅓"W, 3"D
$23.50 ea. 2/$45. Assembled $29.95

60 HZ. XTAL TIME BASE

Will enable Digital Clock Kits or Clock-Calendar Kits to operate from 12V DC.
1"x2" PC Board
Power Req: 5-15V (2.5 MA. TYP.)
Easy 3 wire hookup
Accuracy: ± 2PPM
#TB-1 (Adjustable)
Complete Kit $4.95
Wir & Cal $9.95

SPECIAL PRICING!

PRIME - HIGH SPEED RAM

21L02-3 400 NS

LOW POWER - FACTORY FRESH

1-24	$1.75 ea.	100-199	$1.45 ea.
25-99	1.60 ea.	200-999	1.39 ea.

1000 AND OVER $1.29 ea.

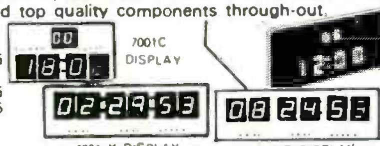
6-DIGIT LED CLOCK CALENDAR KIT

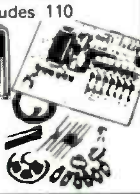
DATE-TIME-SNOOZE ALARM & MORE... KIT 7001

FOR THE BUILDER THAT WANTS THE BEST. FEATURING 12 OR 24 HOUR TIME — 29-30-31 DAY CALENDAR. ALARM. SNOOZE AND AUX. TIMER CIRCUITS

Will alternate time (8 seconds) and date (2 seconds) or may be wired for time or date display only, with other functions on demand. Has built-in oscillator for battery back-up. A loud 24 hour alarm with a repeatable 10 minute snooze alarm, alarm set & timer set indicators. Includes 110 VAC/60Hz power pack with cord and top quality components through-out.

KIT - 7001B WITH 6 - .5" DIGITS	$39.95
KIT - 7001C WITH 4 - .6" DIGITS & 2 - .3" DIGITS FOR SECONDS	$42.95
KIT - 7001X WITH 6 - .6" DIGITS	$45.95





KITS ARE COMPLETE (LESS CABINET)
ALL 7001 KITS FIT CABINET I AND ACCEPT QUARTZ CRYSTAL TIME BASE KIT # TB-1

JUMBO DIGIT CLOCK

A complete Kit (less Cabinet) featuring: six .5" digits, MM5314 IC 12/24 Hr. time, PC Boards. Transformer, Line Cord, Switches and all Parts. Ideal Fit in Cabinet II

Kit #5314-5 $19.95 2/$38.

JUMBO DIGIT CONVERSTION KIT $9.95 ea.

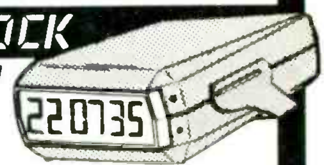
Convert small digit LED clock to large .5" displays. Kit includes 6 - LED's, Multiplex PC Board & Hook up info.
Kit #JD-1CC For Common Cathode
Kit #JD-1CA For Common Anode

PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout.
Specify for 7001 B, C or X - $7.95

MOBILE LED CLOCK

12/24 HR .4" DIGITS!

MODEL #2001
12 VOLT AC or DC POWERED

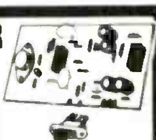


- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM
- SET TIME FROM FRONT VIA HIDDEN SWITCHES • 12/24-Hr. TIME FORMAT
- STYLISH CHARCOAL GRAY CASE OF MOLDED HIGH TEMP. PLASTIC
- BRIDGE POWER INPUT CIRCUITRY — TWO WIRE NO POLARITY HOOK-UP
- OPTIONAL CONNECTION TO BLANK DISPLAY [Use When Key Off in Car, Etc.]
- TOP QUALITY PC BOARDS & COMPONENTS - INSTRUCTIONS.
- MOUNTING BRACKET INCLUDED

KIT #2001 COMPLETE KIT $27.95 EA. 3 OR MORE $25.95 ea. 115 VAC Power Pack #AC-1 $2.50 EA.

ASSEMBLED UNITS WIRED & TESTED ORDER #2001 WT [LESS 9V. BATTERY] Wired for 12-Hr. Op. If not otherwise specified. $37.95 EA. 3 OR MORE $35.95 ea.

AUTO BURGLAR ALARM KIT



AN EASY TO ASSEMBLE AND EASY TO INSTALL ALARM PROVIDING MANY FEATURES NOT NORMALLY FOUND KEYLESS ALARM HAS PROVISION FOR POS & GROUNDING SWITCHES OR SENSORS WILL PULSE HORN RELAY AT 1HZ RATE OR DRIVE SIREN KIT PROVIDES PROGRAMMABLE TIME DELAYS FOR EXIT ENTRY & ALARM PERIOD UNIT MOUNTS UNDER DASH REMOTE SWITCH CAN BE MOUNTED WHERE DESIRED CMOS RELIABILITY RESISTS FALSE ALARMS & PROVIDES FOR ULTRA DEPENDABLE ALARM DO NOT BE FOOLED BY LOW PRICES! THIS IS A TOP QUALITY COMPLETE KIT WITH ALL PARTS INCLUDING DETAILED DRAWINGS AND INSTRUCTIONS OR AVAILABLE WIRED AND TESTED

KIT #ALR-1 $9.95
#ALR-1WT WIRED & TESTED $19.95

VARIABLE REGULATED 1 AMP POWER SUPPLY KIT

- VARIABLE FROM 4 to 14V
- SHORT CIRCUIT PROOF
- 723 IC REGULATOR
- 2N3055 PASS TRANSISTOR
- CURRENT LIMITING AT 1 Amp

KIT IS COMPLETE INCLUDING DRILLED & SOLDER PLATED FIBERGLASS PC BOARD AND ALL PARTS (Less TRANSFORMER) KIT #PS-01 $8.95

TRANSFORMER 24V CT will provide 300MA at 12V and 1 Amp at 5V. $3.50

ORDER BY PHONE OR MAIL
COD ORDERS WELCOME

OPTOELECTRONICS, INC.

5821 N.E. 14th AVENUE,
FORT LAUDERDALE, FLA. 33334
PHONE (305) 771-2050 / 771-2051

ORDERS TO USA & CANADA ADD 5% FOR SHIPPING, HANDLING & INSURANCE. ALL OTHERS ADD 10%. ADDITIONAL $1.00 CHARGE FOR ORDERS UNDER $15.00 - COD FEE $1.00. FLA. RES. ADD 4% STATE TAX.

master charge
BANKAMERICARD

CIRCLE 59 ON FREE INFORMATION CARD

SOCKET JUMPERS

Mates with two rows of .025" sq. or dia. posts on patterns of .100" centers and shielded receptacles. Probe access holes in back. Choice of 6" or 18" length.

Part No.	No. of Contacts	Length	Price
924003-18R	26	18"	$ 5.38 ea.
924003-06R	26	6"	4.78 ea.
924005-18R	40	18"	8.27 ea.
924005-06R	40	6"	7.33 ea.
924006-18R	50	18"	10.31 ea.
924006-06R	50	6"	9.15 ea.

JUMPER HEADERS

Solder to PC boards for instant plug-in access via socket-connector jumpers. .025" sq. posts. Choice of straight or right angle.

Part No.	No. of Posts	Angle	Price
923863-R	26	straight	$1.28 ea.
923873-R	26	right angle	1.52 ea.
923865-R	40	straight	1.94 ea.
923875-R	40	right angle	2.30 ea.
923866-R	50	straight	2.36 ea.
923876-R	50	right angle	2.82 ea.

INTRA-CONNECTOR

Provides both straight and right angle functions. Mates with standard .10" x .10" dual row connectors (i.e. 3m, Ansley, etc.) Permits quick testing of inaccessible lines.

Part No.: 922576-26 No. of contacts: 26 Price $6.90 ea.

INTRA-SWITCH

Permits instant line-by-line switching for diagnostic or QA testing. Switches actuated with pencil or probe tip. Mates with standard .10" x .10" dual-row connectors. Low profile design. Switch buttons recessed to eliminate accidental switching.

Part No.: IS-26 No. of contacts: 26 Price $13.80 ea.

CRYSTALS

THESE FREQUENCIES ONLY

Part	Frequency	Case Style	Price
CY1A	1.000 MHz	HC33/U	$5.95
CY2A	2.000 MHz	HC33/U	$5.95
CY2.01	2.010 MHz	HC33/U	$5.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

CONNECTORS

PRINTED CIRCUIT EDGE-CARD

156 Spacing-Tin-Double Read-Out

Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100A (.100 Spacing)	PINS (Wire Wrap)	$6.95

25 PIN-D SUBMINATURE (RS232)

DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95
DB51226-1	COVER FOR 25S/25P	$1.75

LOTS OF POTS

Untested 3/8" square Spectrol Trimpots. Single-turn Printed Circuit Potentiometers

GB134	3 ea. of:	10-20-25-50 100-200-250-500 ohm	= 24 pcs.	$2.95
GB135	3 ea. of:	1K-2K-2.5K-5K 10K-20K-25K-50K	= 24 pcs.	$2.95
GB136	3 ea. of:	100K-200K-250K-500K 1Meg-2Meg-2.5Meg-5Meg	= 24 pcs.	$2.95

(Values subject to substitution within each group.)

'EXTRA SAVINGS' Buy all 3 (GB134, 135 & 136) for only $7.49

SWITCHES

1/4" mounting holes

	Part No.			1-9	10-
TOGGLE (sub-miniature)	JMT121	SPDT	on-off-on	$1.95	$1.43
	JMT123	SPDT	on-none-on	1.65	1.21
	JMT221	DPDT	on-off-on	2.55	1.87
	JMT223	DPDT	on-none-on	2.15	1.58
TOGGLE (Printed Circuit)	MPC121	SPDT	on-off-on	$2.05	$1.53
	MPC123	SPDT	on-none-on	1.75	1.31
	MPC221	DPDT	on-off-on	2.65	1.97
	MPC223	DPDT	on-none-on	2.25	1.68
PUSH BUTTON	PB123	SPDT	maintained	1.95	1.47
	PB126	SPDT	momentary	1.95	1.47
PUSH BUTTON Miniature	MS102	DPST	momentary open	.35	.30
	MS103	SPST	momentary closed	.35	.30
DIPSWITCH SPST	206-4	8 pin dip	4 switch	1.75	1.65
	206-7	14 pin dip	7 switch	1.95	1.85
	206-8	16 pin dip	8 switch	2.25	2.15

1/16 VECTOR BOARD

0.1 Hole Spacing, P-Pattern

	Part No.	L	W	Price 1-9	10 up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062WE	4.50	6.50	2.07	1.86
	84P44 062WE	4.50	8.50	2.56	2.31
	169P44 062WE	4.50	17.00	5.04	4.53
	169P84 062WE	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062WEC1	4.50	17.00	6.80	6.12

INSTRUMENT/ CLOCK CASE

Injection molded unit. Complete with red bezel. 4 1/2" x 4" x 1-9/16"

$3.49

MICROPROCESSOR COMPONENTS

8080A	CPU	$10.95	CDP1802	CPU	$19.95
8212	8 Bit Input/Output	4.95	MC6800	8 Bit MPU	19.95
8214	Priority Interrupt Control	7.95	MC6820	Periph. Interface Adapter	7.95
8216	Bi-Directional Bus Driver	4.95	MC6810AP1	128 x 8 Static RAM	5.95
8224	Clock Generator/Driver	5.95	MC6830L8	1024 x 8 Bit ROM	15.00
8228	System Controller Bus Driver	5.95	Z80	CPU	24.95

CPU'S

8080A	Super 8008	$10.95
2650	8 Bit MPU	26.50
P8085	CPU	29.95

SR'S

2504	1024 Dynamic	$3.95
2518	Hex 32 BIT	7.00
2519	Hex 40 BIT	4.00
2522	Dual 132 Bit SSR	2.95
2524	512 Dynamic	.99
2525	1024 Dynamic	3.00
2527	Dual 256 BIT	3.95
2529	Dual 512 BIT	4.00
2532	Quad 80 BIT	3.95
2533	1024 Static	5.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	3.95

UART'S

AY-5-1013	30K Baud	$5.95

ROM'S

2513(2140)	Char. Gen. upper case	$9.95
2513(3021)	Char. Gen. lower case	9.95
2516	Char. Gen.	10.95
MM5230	2048 BIT (512 x 4 or 256 x 8)	1.95
MM5262	2K x 1 Dynamic RAM	3 for 1.00

RAM'S

1101	256 x 1	Static	$1.49
2101	256 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107/5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
TMS4044-45NL	4K	Static	14.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	5.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
21L02/91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
UPD414(2104)	4K	Dynamic 16 Pin	5.95
UPD416	16K	Dynamic	49.95

PROMS

1702A	2048	Famos	$5.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95
2708	8K	Eprom	10.95
2716	16K	Eprom	29.95
6301-1	1024	Tri-State Bipolar	3.49
6330-1	256	Open Collector Bipolar	2.95

SPECIAL REQUESTED ITEMS

FCM3817	$5.00	11C90	19.95	7205	19.95	9368	3.95
AY-3-8500-1	7.50	4N33	3.95	ICM7045	24.95	LD110/111	25.00/set
AY-5-9100	17.50	8T20	7.50	ICM7207	7.50	95H90	11.95
AY-5-9200	14.95	8T97	2.00	ICM7208	22.00	MC3061P	3.50
AY-5-9500	4.95	HD0165	7.95	ICM7209	7.50	MC4016 (74416)	7.50
AY-5-2376	14.95	MCM6571	13.50	MK50240	17.50	MC1408L7	8.95
9374	1.95	MCM6574	13.50	DS0026CH	3.75	MC1408L8	9.95
82S115	25.00	MCM6575	13.50	TIL308	10.50	74C922	9.95

CLOCK CHIPS

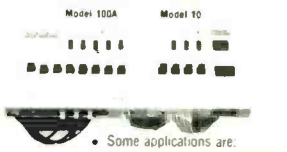
MM5309	$9.95
MM5311	4.95
MM5312	4.95
MM5314	4.95
MM5316	6.95
MM5318	9.95
MM5369	2.95
MM5841	9.95
CT7001	5.95

PARATRONICS

Featured on February's Front Cover of Popular Electronics

Logic Analyzer Kit Model 100A

$229.00/kit



- Analyzes any type of digital system
- Checks data rates in excess of 8 million words per second
- Trouble shoot TTL, CMOS, DTL, RTL, Schottky and MOS families
- Displays 16 logic states up to 8 digits wide
- See ones and zeros displayed on your CRT, octal or hexadecimal format
- Tests circuits under actual operating conditions
- Easy to assemble — comes with step-by-step construction manual which includes 80 pages on logic analyzer operation.

(Model 100A Manual - $4.95)

- Some applications are:
  - Troubleshooting microprocessor address, instruction, and data flow
  - Examine contents of ROMS
  - Tracing operation of control logic
  - Checking counter and shift register operation
  - Monitoring I/O sequences
  - Verifying proper system operations during testing

PARATRONICS TRIGGER EXPANDER - Model 10

Adds 16 additional bits. Provides digital delay and qualification of input clock and 24-bit trigger word. — Connects direct to Model 100A for integrated unit).

Model 10 Kit - $229.00
Baseplate — $9.95
Model 10 Manual — $4.95

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 50-40C 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

- 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:

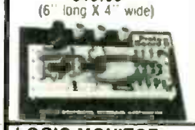
Mobile Charger Eliminator — use power from car battery — Model 100 — CLA $3.95

Charger Eliminator — use 110 V AC — Model 100 — CAI $9.95

CONTINENTAL SPECIALTIES

PROTO BOARD 6

$15.95 (6" long X 4" wide)



Other CS Proto Boards

PB100 - 4.5" x 6"	$ 19.95
PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6½ x 2¾	80.00
PB203A - 9.75 x 6½ x 2¾ (includes power supply)	129.95

PROTO CLIPS

14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50
40 PIN	13.75

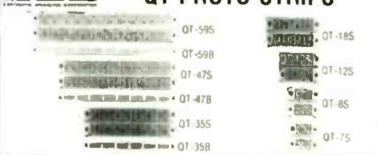
DESIGN MATES

DM1 - Circuit Designer $69.95
DM2 - Function Generator $74.95
DM3 - RC Bridge $74.95

LOGIC MONITOR

for DTL, HTL, TTL or CMOS Devices **$84.95**

CSC QT PROTO STRIPS



QT type	# holes	price
QT-59S	590	12.50
QT-59B	bus strip	2.50
QT-47S	470	10.00
QT-47B	bus strip	2.25
QT-35S	350	8.50
QT-35B	bus strip	2.00
QT-16S	180	4.75
QT-12S	120	3.75
QT-8S	80	3.25
QT-7S	70	3.00

Experimentor 300	$ 9.95
Experimentor 600	$10.95

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

Spec Sheets - 25¢ — Send 35¢ Stamp for 1978 Catalog
Dealer Information Available

NOW OPEN SATURDAYS

James ELECTRONICS

1978 CATALOG NOW AVAILABLE

1021-A HOWARD AVE., SAN CARLOS, CA. 94070
PHONE ORDERS WELCOME — (415) 592-8097
Advertised Prices Good Thru April

The Incredible "Pennywhistle 103"

$129.95 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 for the deaf. 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 = 2025 space, 2225 mark.
Receive Sensitivity	−46 dbm acoustically 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.

The Original the 3rd Hand

$9.95 each

- Leaves two hands free for working
- Clamps on edge of bench, table or work bench
- Position board on angle or flat position for soldering or clipping
- Sturdy, aluminum construction for hobbyist, manufacturer or school rooms

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One: Times Single Event — Split & Taylor
- Size 4.5" x 2.15" x .90" (4½ ounces)
- Uses 3 Penlite Cells

Kit —	$39.95
Assembled —	$49.95
Heavy Duty Carry Case	$5.95

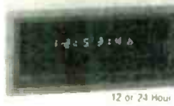
Stop Watch Chip Only (7205) $19.95

IMC 3½ DIGIT DPM KIT

- New Bipolar Unit
- Auto Zeroing
- .5" LED
- Auto Polarity
- Low Power
- Single IC Unit

Model KB500 DPM Kit	$49.00
Model 311D-5C-5V Power Kit	$17.50

JE700 CLOCK



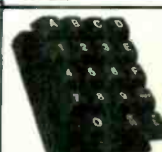
The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6 x 2½ x 1. It utilizes a MAN72 high brightness readout, and the MM5314 clock chip.

12 or 24 Hour

115 VAC

KIT ONLY **$16.95**

HEXADECIMAL ENCODER 19-KEY PAD

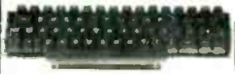


- 1 - 0
- ABCDEF
- Shift Key
- 2 Optional Keys

$10.95 each

New 63 KEY KEYBOARD

$29.95 IN STOCK



This keyboard features 63 uncoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13 x 4 base suits most applications.

HD0165	Encoder Chip (encodes 16 keys)	$7.95 ea.
AY-5-2376	Encoder Chip (encodes 88 keys)	$14.95 ea.

JE803 PROBE

The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols (HI) 1 (LOW) 0 (PULSE) P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit

printed circuit board

T²L 5V 1A Supply

This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only

$9.95 Per Kit

CIRCLE 53 ON FREE INFORMATION CARD

DIODES/ZENERS

1N914	100v	10mA	.05
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N753A	6.2v	z	.25
1N758A	10v	z	.25
1N759A	12v	z	.25
1N4733	5.1v	z	.25
1N5243	13v	z	.25
1N5244B	14v	z	.25
1N5245B	15v	z	.25

SOCKETS/BRIDGES

8-pin	pcb	.25	ww	.45
14-pin	pcb	.25	ww	.40
16-pin	pcb	.25	ww	.40
18-pin	pcb	.25	ww	.75
22-pin	pcb	.45	ww	1.25
24-pin	pcb	.35	ww	1.10
28-pin	pcb	.35	ww	1.45
40-pin	pcb	.50	ww	1.25

Molex pins	.01	To-3 Sockets	.45
2 Amp Bridge		100-prv	1.20
25 Amp Bridge		200-prv	1.95

TRANSISTORS, LEDS, etc.

2N2222A	NPN (2N2222 Plastic .10)	.15
2N2907A	PNP	.15
2N3906	PNP (Plastic)	.10
2N3904	NPN (Plastic)	.10
2N3054	NPN	.35
2N3055	NPN 15A 60v	.50
T1P125	PNP Darlington	.35
LED Green, Red, Clear, Yellow		.15
D.L.747	7 seg 5/8" High com-anode	1.95
XAN72	7 seg com-anode (Red)	1.25
MAN71	7 seg com-anode (Red)	1.25
MAN3610	7 seg com-anode (Orange)	1.25
MAN82A	7 seg com-anode (Yellow)	1.25
MAN74A	7 seg com-cathode (Red)	1.50
FND359	7 seg com-cathode (Red)	1.25

C MOS

4000	.15
4001	.15
4002	.20
4004	3.95
4006	.95
4007	.35
4008	.95
4009	.45
4010	.45
4011	.20
4012	.20
4013	.40
4014	.95
4015	.90
4016	.35
4017	1.10
4018	1.10
4019	.50
4020	.85
4021	1.00
4022	.85
4023	.25
4024	.75
4025	.30
4026	1.95
4027	.50
4028	.95
4030	.35
4033	1.50
4034	2.45
4035	1.25
4040	1.35
4041	.69
4042	.95
4043	.95
4044	.95
4046	1.75
4049	.45
4050	.45
4066	.95
4069	.40
4071	.35
4081	.70
4082	.45
MC14409	14.50
MC14419	4.85

– T T L –

7400	.15	7473	.25	74176	1.25	74H72	.45	74S133	.40
7401	.15	7474	.30	74180	.75	74H101	.75	74S140	.55
7402	.20	7475	.35	74181	2.25	74H103	.75	74S151	.30
7403	.20	7476	.40	74182	.95	74H106	.95	74S153	.35
7404	.15	7480	.55	74190	1.75			74S157	.75
7405	.25	7481	.75	74191	1.05	74L00	.25	74S158	.30
7406	.35	7483	.95	74192	.75	74L02	.25	74S194	1.05
7407	.55	7485	.75	74193	.85	74L03	.30	74S257 (8123)	1.05
7408	.25	7486	.25	74194	1.25	74L04	.30		
7409	.15	7489	1.35	74195	.95	74L10	.30	74LS00	.25
7410	.10	7490	.55	74196	1.25	74L20	.35	74LS01	.35
7411	.25	7491	.95	74197	1.25	74L30	.45	74LS02	.35
7412	.30	7492	.95	74198	2.35	74L47	1.95	74LS04	.30
7413	.35	7493	.35	74221	1.00	74L51	.45	74LS05	.45
7414	1.10	7494	.75	74367	.85	74L55	.65	74LS08	.25
7416	.25	7495	.60			74L72	.45	74LS09	.35
7417	.40	7496	.80	75108A	.35	74L73	.40	74LS10	.35
7420	.15	74100	1.15	75110	.35	74L74	.45	74LS11	.35
7426	.30	74107	.35	75491	.50	74L75	.55	74LS20	.25
7427	.45	74121	.35	75492	.50	74L93	.55	74LS21	.25
7430	.15	74122	.55			74L123	.85	74LS22	.25
7432	.30	74123	.55	74H00	.15			74LS32	.40
7437	.30	74125	.45	74H01	.25	74S00	.35	74LS37	.35
7438	.35	74126	.35	74H04	.20	74S02	.35	74LS40	.45
7440	.25	74132	1.35	74H05	.20	74S03	.30	74LS42	1.10
7441	1.15	74141	.90	74H08	.35	74S04	.30	74LS51	.50
7442	.45	74150	.85	74H10	.35	74S05	.35	74LS74	.65
7443	.65	74151	.65	74H11	.35	74S08	.35	74LS86	.65
7444	.45	74153	.75	74H15	.45	74S10	.35	74LS90	.95
7445	.65	74154	.95	74H20	.30	74S11	.35	74LS93	.95
7446	.95	74156	.95	74H21	.25	74S20	.35	74LS107	.85
7447	.95	74157	.65	74H22	.40	74S40	.20	74LS123	1.00
7448	.65	74161	.85	74H30	.20	74S50	.20	74LS151	.95
7450	.25	74163	.85	74H40	.25	74S51	.25	74LS153	1.20
7451	.25	74164	.60	74H50	.25	74S64	.20	74LS157	.85
7453	.20	74165	1.50	74H51	.25	74S74	.35	74LS164	1.90
7454	.25	74166	1.35	74H52	.15	74S112	.60	74LS367	.75
7460	.40	74175	.80	74H53J	.25	74S114	.65	74LS368	.75
7470	.45			74H55	.20			74C04	.25
7472	.40							74C151	2.25

9000 SERIES

9301	.85	95H03	1.10
9309	.35	9601	.45
9322	.75	9602	.45

MICRO'S, RAMS, CPU'S, ETC.

74S188	3.00
1702A	4.50
MM5314	3.00
MM5316	3.50
2102-1	1.45
2102L-1	1.75
TR1602B	4.50
TMS 4044-45NL	14.50
8080AD	12.00
8T13	1.50
8T23	1.50
8T24	2.00
8T97	1.00
2107B-4, A	4.00
2708	11.50

LINEARS, REGULATORS, etc.

MCT2	.95						
8038	3.95	LM320T5	1.65	LM340K15	1.25	LM723	.50
LM201	.75	LM320T12	1.65	LM340K18	1.25	LM725N	2.50
LM301	.45	LM320T15	1.65	LM340K24	.95	LM739	1.50
LM308 (Mini)	.95	LM324N	.95	78L05	.75	LM741 (8-14)	.25
LM309H	.65	LM339	.95	78L12	.75	LM747	1.10
LM309K (340K-5)	.85	7805 (340T5)	.95	78L15	.75	LM1307	1.25
LM310	1.15	LM340T12	1.00	78M05	.75	LM1458	.95
LM311D (Mini)	.75	LM340T15	1.00	LM373	2.95	LM3900	.50
LM318 (Mini)	.95	LM340T18	1.00	LM380 (8-14 PIN)	.95	LM75451	.65
LM320K5 (7905)	1.65	LM340T24	.95	LM709 (8, 14 PIN)	.25	NE555	.50
LM320K12	1.65	LM340K12	1.65	LM711	.45	NE556	.95
						NE565	.95
						NE566	1.75
						NE567	1.35

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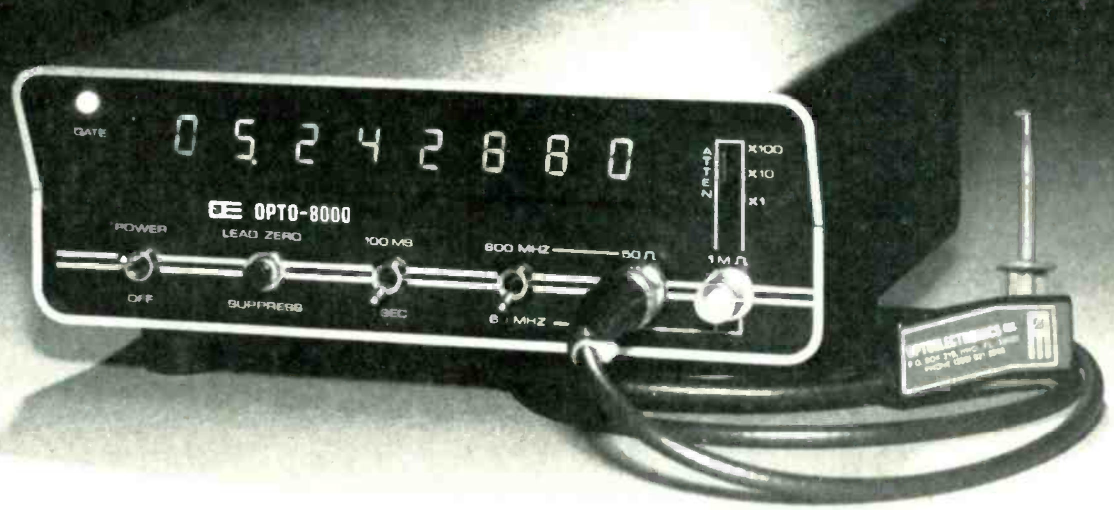
OPTO-8000.1



This new unit has taken a giant step in front of the multitude of inexpensive counters made recently available. The Opto-8000.1 boasts a combination of features and specifications found only in units costing several times its price. Accuracy of ± 0.1 PPM or better—*Guaranteed*—with a factory-adjusted, sealed TCXO (Temperature Compensated Xtal Oscillator). **Even kits require no adjustment for guaranteed accuracy!** Built-in, selectable-step attenuator, rugged and attractive, black anodized aluminum case (.090" thick aluminum) with tilt bail. 50 Ohm and 1 Megohm inputs, both with amplifier circuits for super sensitivity and both diode/overload protected. Front panel includes "Lead Zero Blanking Control" and a gate period indicator LED. AC and DC power cords with plugs included.

SPECIFICATIONS:

Time Base—TCXO ± 0.1 PPM GUARANTEED!
Frequency Range—10 Hz to 600 MHz
Resolution—1 Hz to 60 MHz; 10 Hz to 600 MHz
All IC's socketed (kits and factory-wired)
Display—8 digit LED
Gate Times—1 second and 1/10 second
Selectable Input Attenuation—X1, X10, X100
Input Connectors Type—BNC
Approximate Size—3"h x 7½"w x 6½"d
Approximate Weight —2½ pounds
Cabinet—black anodized aluminum (.090" thickness)
Input Power Required—9-15 VDC, 115 VAC 50/60 Hz or internal batteries

OPTO-8000.1 Factory Wired	**$299.95**
OPTO-8000.1K Kit	**$249.95**

ACCESSORIES:

Battery-Pack Option—internal Ni-Cad Batteries and charging unit	**$19.95**
Probes: P-100—DC Probe may also be used with scope	**$13.95**
P-101—LO-Pass Probe, very useful at audio frequencies	**$16.95**
P-102—High Impedence Probe, ideal general purpose usage	**$16.95**
VHF RF Pick-Up Antenna-Rubber Duck w/BNC #Duck-4H	**$12.50**
Rt. Angle BNC adapter #RA-BNC	**$ 2.95**

FC-50—Opto-8000 Conversion Kits:
Owners of FC-50 counters with #PSL-650 Prescaler can use this kit to convert their units to the Opto-8000 style case, including most of the features.

FC-50→Opto-8000	**Kit $59.95**
*FC-50→Opto-8000F	**Factory Update $99.95**
FC-50→Opto-8000.1 (w/TCXO)	**Kit $109.95**
*FC-50→Opto-8000.1F	**Factory Update $149.95**

*Units returned for factory update must be completely assembled and operational

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p.o. box 212 Burlingame CA 94010

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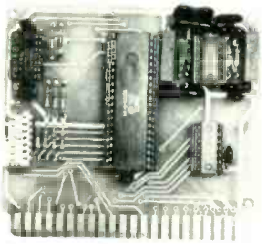


UART & BAUD RATE GENERATOR

Part no. 101

- Converts serial to parallel and parallel to serial
- Low cost on board baud rate generator
- Baud rates: 110, 150, 300, 600, 1200, and 2400
- Low power drain +5 volts and -12 volts required
- TTL compatible
- All characters contain a start bit, 5 to 8 data bits, 1 or 2 stop bits, and either odd or even parity.
- All connections go to a 44 pin gold plated edge connector
- Board only $12.00; with parts $35.00

RS-232/TTL INTERFACE

Part no. 232

- Converts TTL to RS-232, and converts RS-232 to TTL
- Two separate circuits
- Requires -12 and +12 volts
- All connections go to a 10 pin gold plated edge connector
- Board only $4.50; with parts $7.00

DC POWER SUPPLY

Part no. 6085

- Board supplies a regulated +5 volts at 3 amps., +12,-12, and -5 volts at 1 amp.
- Board has filters, rectifiers, and regulators
- Power required is 8 volts AC at 3 amps., and 24 volts AC C.T. at 1.5 amps.
- Board only $12.50

TAPE INTERFACE

Part no. 111

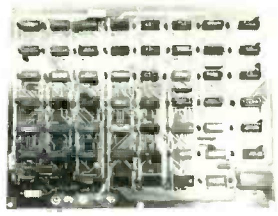
- Play and record Kansas City Standard tapes
- Converts a low cost tape recorder to a digital recorder
- Works up to 1200 baud
- Digital in and out are TTL-serial
- Output of board connects to mic. in of recorder
- Earphone of recorder connects to input on board
- Requires +5 volts, low power drain
- Board $7.60; with parts $27.50
- No coils

Part no. 107

RF MODULATOR

- Converts video to AM modulated RF, Channels 2 or 3
- Power required is 12 volts AC C.T., or +5 volts DC
- Board $4.50; with parts $13.50

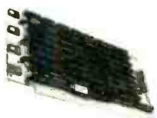
TELEVISION TYPEWRITER



Part no. 106

- Stand alone TVT
- 32 char/line, 16 lines, modifications for 64 char/line included
- Parallel ASCII (TTL) input
- Video output
- 1K on board memory
- Output for computer controlled curser
- Auto scroll
- Non-distructive curser
- Curser inputs: up, down, left, right, home, EOL, EOS
- Scroll up, down
- Requires +5 volts at 1.5 amps, and -12 volts at 30 mA
- Board only $39.00; with parts $145.00

8K STATIC RAM



Part no. 300

- 8K Altair bus memory
- Uses 2102 Static memory chips
- Memory protect
- Gold contacts
- Wait states
- On board regulator
- S-100 bus compatible
- Vector input option
- TRI state buffered
- Board only $22.50; with parts $160.00

TIDMA

Part no. 112

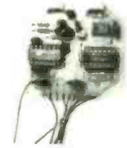
- Tape Interface Direct Memory Access
- Record and play programs without bootstrap loader (no prom) has FSK encoder/decoder for direct connections to low cost recorder at 625 baud rate, and direct connections for inputs and outputs to a digital recorder at any baud rate.
- S-100 bus compatible
- Comes assembled and tested for $160.00

APPLE I MOTHER BOARD

Part no. 102

- 10 slots — 44 pin (.156) connectors spaced ¾" apart
- Connects to edge connector of computer
- Pin 20 and 22 connects to X & Z for power and ground
- Board has provisions for bypass capacitors
- Board cost $15.00

MODEM



Part no. 109

- Type 103
- Full or half duplex
- Works up to 300 baud
- Originate or Answer
- No coils, only low cost components
- TTL input and output-serial
- Connect 8 ohm speaker and crystal mic. directly to board
- Uses XR FSK demodulator
- Requires +5 volts
- Board $7.60; with parts $27.50

To Order:

VISA master charge

Mention part number and description. For parts kits add "A" to part number. Shipping paid for orders accompanied by check, money order, or Master Charge, BankAmericard, or VISA number, expiration date and signature. Shipping charges added to C.O.D. orders. California residents add 6.5% for tax. Parts kits include sockets for all ICs, components, and circuit board. Documentation is included with all products. Dealer inquiries invited. 24 Hour Order Line: (408) 374-5984.

E21

CIRCLE 56 ON FREE INFORMATION CARD

CIRCLE 62 ON FREE INFORMATION CARD

CIRCLE 105 ON FREE INFORMATION CARD

THIS SPECIAL ONE CENT SALE IS FOR MAGAZINE ADS ONLY

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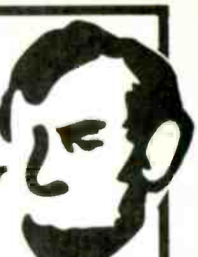

THIS NEW LIST OF "ONE-CENTERS" HELPS FIGHT INFLATION!

LEDS!

YOUR CHOICE 5 for $1.00
1¢ SALE 10 for $1.01

Order by Cat. No.

- ☐ #4R2135 JUMBO RED LEDS
- ☐ #4R2137 MICRO RED LEDS
- ☐ #4R2790 JUMBO RED CLEAR LEDS
- ☐ #4R2792 JUMBO TAPERED AMBER
- ☐ #4R2140 MICRO GREEN LEDS

1.5 AMP BULLET RECTIFIERS!

Order by Cat. No. 4R60B84 and voltage

☐ 50V	10 for $.59	20 for $.60
☐ 100V	10 for .69	20 for .70
☐ 200V	10 for .79	20 for .80
☐ 400V	10 for .89	20 for .90
☐ 600V	10 for 1.09	20 for 1.10
☐ 800V	10 for 1.19	20 for 1.20

1¢ SALE

OP AMP 1¢ GIVEAWAYS

Order by Type Number

Type	Sale	1¢SALE
☐ LM308V	2 for $1.00	4 for $1.01
☐ LM311V	2 for 1.00	4 for 1.01
☐ LM558V	3 for 1.19	6 for 1.20
☐ LM709H	10 for 1.19	20 for 1.20
☐ LM741V	5 for 1.19	10 for 1.20
☐ LM1800N	1 for .99	2 for 1.00
☐ LM3900N	2 for 1.00	4 for 1.01

MICRO MINI TOGGLE SWITCHES!

3 Amps. 125 VAC contacts. with chrome handles. complete with mounting hardware.

Cat. No	Type	Sale	2 for
☐ 4R3936	SPDT	$1.29	$1.30
☐ 4R5085	SPDT*	1.39	1.40
☐ 4R4037	DPDT	1.45	1.46
☐ 4R5087	4PDT*	1.95	1.96

BUY 1 AT OUR SALE PRICE
GET 2 FOR 1¢ MORE

4 DIGIT FLUORESCENT CLOCK BASIC KIT

12 or 24 hours! .57" bright blue digits! Easy to breadboard, uses MM5316 clock chip and minimum of external components! AM—PM indicator, includes options for alarm, clock-radio, snooze, and more! Basic kits include readouts, ICs, sockets, transistors & all necessary components! (case, PC board, transformer, line chord not included). Requires 12VCT transformer.

- ☐ #4R3791 Fluorescant Basic Kit $9.95, 2 kits $9.96
- ☐ #4R3792 Components for optional alarm $2.95 (No 1¢ sale)
- ☐ #4R3686 12VCT "pluggable" transformer 1.95 (No 1¢ sale)

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Honest Abe Penny Sale!

Order By Cat. No.2M1981 & Type No.

Type	Each	2 for
☐ SN7400	$.19	$.20
☐ SN7401	.19	.20
☐ SN7403	.19	.20
☐ SN7404	.25	.26
☐ SN7405	.19	.20
☐ SN7406	.19	.20
☐ SN7408	.21	.22
☐ SN7410	.19	.20
☐ SN7413	.39	.40
☐ SN7414	.65	.66
☐ SN7416	.29	.30
☐ SN7420	.19	.20
☐ SN7423	.29	.30
☐ SN7426	.25	.26
☐ SN7427	.25	.26
☐ SN7430	.29	.30
☐ SN7432	.25	.26
☐ SN7437	.25	.26
☐ SN7438	.29	.30
☐ SN7440	.19	.20
☐ SN7442	.69	.70
☐ SN7443	.69	.70
☐ SN7444	.65	.66
☐ SN7445	.99	1.00
☐ SN7446	1.35	1.36
☐ SN7447	1.25	1.26
☐ SN7448	1.35	1.36
☐ SN7450	.19	.20
☐ SN7451	.19	.20
☐ SN7453	.19	.20
☐ SN7454	.19	.20
☐ SN7455	.19	.20
☐ SN7460	.19	.20
☐ SN7462	.19	.20
☐ SN7464	.19	.20
☐ SN7465	.19	.20
☐ SN7470	.25	.26
☐ SN7471	.25	.26
☐ SN7472	.25	.26
☐ SN7473	.55	.56
☐ SN7474	.29	.30
☐ SN7475	.79	.80
☐ SN7476	.59	.60
☐ SN7478	.59	.60
☐ SN7480	.29	.30
☐ SN7482	.39	.40
☐ SN7483	.99	1.00
☐ SN7485	1.49	1.50
☐ SN7486	.39	.40
☐ SN7488	1.95	1.96
☐ SN7490	.69	.70
☐ SN7491	.79	.80
☐ SN7492	.45	.46
☐ SN7493	.49	.50
☐ SN7494	.69	.70
☐ SN7495	.69	.70
☐ SN7496	.69	.70
☐ SN7498	.69	.70
☐ SN74100	1.49	1.50
☐ SN74107	.39	.40
☐ SN74112	.25	.26
☐ SN74113	.19	.20
☐ SN74114	.25	.26
☐ SN74121	.49	.50
☐ SN74123	.69	.70
☐ SN74125	.59	.60
☐ SN74126	.39	.40
☐ SN74132	1.25	1.26
☐ SN74140	.99	1.00
☐ SN74141	1.49	1.50
☐ SN74145	1.25	1.26
☐ SN74148	1.75	1.76
☐ SN74150	.99	1.00
☐ SN74151	.99	1.00
☐ SN74153	.99	1.00
☐ SN74154	1.75	1.76
☐ SN74155	.79	.80
☐ SN74156	.69	.70
☐ SN74157	.99	1.00
☐ SN74158	.99	1.00
☐ SN74160	1.25	1.26
☐ SN74161	1.25	1.26
☐ SN74163	1.19	1.20
☐ SN74164	.99	1.00
☐ SN74165	1.25	1.26
☐ SN74166	1.25	1.26
☐ SN74173	1.25	1.26
☐ SN74174	1.49	1.50
☐ SN74175	.99	1.00
☐ SN74177	.79	.80
☐ SN74179	1.49	1.50
☐ SN74180	.49	.50
☐ SN74182	.69	.70
☐ SN74190	1.49	1.50
☐ SN74191	1.75	1.76
☐ SN74192	.85	.86
☐ SN74193	.85	.86
☐ SN74194	1.25	1.26
☐ SN74195	.49	.50
☐ SN74197	.75	.76
☐ SN74199	1.75	1.76
☐ SN74200	5.50	5.51
☐ SN74251	1.75	1.76
☐ SN74284	4.50	4.51
☐ SN74285	4.25	4.26

POP-AMPS AT "CENT-CIBLE" PRICES

Buy ONE At Sale Price, Get 2ND For Only 1¢ More - Order By Type No.

Type	Each	2 for
☐ LM300H	$.49	$.50
☐ LM301H-V	.45	.46
☐ LM308V-H	.79	.80
☐ LM309K	1.29	1.30
☐ LM311H-V	.79	.80
☐ LM318V	1.29	1.30
☐ LM320H-5, 12, 15	1.29	1.30
☐ LM320K-15	1.29	1.30
☐ LM320T-6, 5	1.29	1.30
☐ LM322N	1.19	1.20
☐ LM324N	1.75	1.76
☐ LM339N	1.09	1.10
☐ LM340K-5, 6, 8, 12, 15, 18,	1.29	1.30
☐ LM340T-5, 6, 8, 12, 15, 18, 24	1.29	1.30
☐ LM350N	.59	.60
☐ LM370N-H	1.29	1.30
☐ LM374H	1.79	1.80
☐ LM376V	.29	.30
☐ LM377N	2.25	2.26
☐ LM381N	1.69	1.70
☐ LM531H	1.49	1.50
☐ LM532H-N	.29	.30
☐ LM555V	.75	.76
☐ LM558V	.79	.80
☐ LM561N	1.00	1.01
☐ LM565N	.99	1.00
☐ LM703H	.49	.50
☐ LM704H	.29	.30
☐ LM709N-H	.25	.26
☐ LM710N	.39	.40
☐ LM733N	.79	.80
☐ LM739N	.89	.90
☐ LM741V-H	.30	.29
☐ LM1304	.80	.79
☐ LM1310	1.00	.99
☐ LM1312	2.00	1.99
☐ LM1414V	.80	.79
☐ LM1458V	.70	.69
☐ LM1800N	1.00	.99
☐ LM3028H	.66	.65
☐ LM3900N	.50	.49
☐ LM3909V	1.76	1.75
☐ LM4195	1.96	1.95
☐ LM4250	1.20	1.19
☐ LM75451	.40	.39
☐ LM75453	.40	.39
☐ LM75491	.80	.79
☐ LM75492	.80	.79
☐ LM75494	.60	.59
☐ PA263	1.50	1.51

PENNY SALE PRICES LISTED ARE GOOD TILL MAY 15, 1978
WE RESERVE THE RIGHT TO LIMIT QUANTITIES!!!!!!

Mail your order in & save many dollars!

Quan.	Description (Order by Cat. No. in parenthesis)	Sale	1¢SALE
☐ 10	CALCULATOR KEYBOARDS, 20 keys and more (4R3524)	$2.00	20 for $2.01
☐ 15	SLIDE VOLUME CONTROLS, asstd values (4R3057)	2.00	30 for 2.01
☐ 10	CRYSTALS, may include CB, Ham & more (4R3250)	2.00	20 for 2.01
☐ 150	MOLEX IC SOCKETS, on a strip, cut to length (4R3144)	2.00	300 for 2.01
☐ 100	TERMINAL STRIPS, from 2 lugs up (4R3136)	2.00	200 for 2.01
☐ 30	NE-2NEON LAMPS, all 100% good (4R2613)	2.00	60 for 2.01
☐ 40	SHIELDED CABLE, 1 cond, mikes, phonos (4R3577)	2.00	80 for 2.01
☐ 50	TRANSISTOR ELECTROS, asstd values, styles (4R2747)	2.00	100 for 2.01
☐ 3	SOUND TRIGGERS, sound triggers scr w/amp (4R3625)	2.00	6 for 2.01
☐ 15	6V TEST INDICATORS, leads, grain-o-wheat (4R3526)	2.00	30 for 2.01
☐ 100	CAPACITOR SPECIAL, discs, mylar, lytics, more (4R2738)	2.00	200 for 2.10
☐ 30	MINI TRIMPOTS, to 1 meg, 1 turn, ¼W (4R3345)	2.00	60 for 2.01
☐ 10	VOLTAGE REGULATORS, hobby LM320, 340, TO-3 (4R3330)	2.00	20 for 2.01
☐ 30	PANEL SWITCHES, slides, roteries, mod. etc (4R3268)	2.00	60 for 2.01
☐ 200	RESISTOR SPECIAL, ⅛ to 1W, carbon, metal (4R3054)	2.00	400 for 2.01
☐ 200	HALF WATTERS, resistors, carbon, metal (4R3046)	2.00	400 for 2.01
☐ 100	NATIONAL IC BONANZA, linears, 7400s ROMS (4R2860)	2.00	200 for 2.01
☐ 40	HOBBY LEDS, asstd types, mostly useable (4R2859)	2.00	80 for 2.01
☐ 15	LM340T VOLTAGE REGULATAORS, 5 to 24V, TO-220 (4R2635)	2.00	30 for 2.01
☐ 100	TWO WATTERS, resistors, carbon-metal marked (4R2735)	2.00	200 for 2.01
☐ 100	POLYSTYRENE CAPS, asstd values, voltage, hi-Q (4R2729)	2.00	200 for 2.01
☐ 50	THERMISTORS, resistors that change with temp (4R4089)	2.00	100 for 2.01
☐ 20	BRIDGES, untested, 2, 4, 6, 10, amp. full wave (4R4022)	2.00	40 for 2.01
☐ 25	LAMP'N'SOCKET SETS, micro, 1.5V, T2 (4R3957)	2.00	50 for 2.01
☐ 15	MIXED READOUTS, hobby, untested, .127, .3, .5, etc. (4R3619)	2.00	30 for 2.01
☐ 150	QUARTER WATTERS, resistors, metal film, marked (4R3413)	2.00	300 for 2.01
☐ 100	PLASTIC TRANSISTORS, untested, RO-92 (4R2604)	2.00	200 for 2.01
☐ 200	PREFORMED RESISTORS, ¼, ½, 1W, marked, asstd (4R2608)	2.00	400 for 2.01
☐ 200	PRECISION RESISTORS, ¼, ½, 1W, 1%, 2% marked (4R2428)	2.00	400 for 2.01
☐ 60	DIPPED MYLARS, shiny finish, asst values (4R2597)	2.00	120 for 2.01
☐ 30	VOLUME CONTROLS, audio, linear, asstd values (4R2421)	2.00	60 for 2.01
☐ 5	7.5 VOLT ZENER DIODES, 1 watt (4R5187)	1.00	10 for 1.01
☐ 5	9.1 VOLT ZENER DIODES, 1 watt (4R5188)	1.00	10 for 1.01
☐ 30-FT.	WIRE WRAP WIRE, 30 gauge (4R3803)	1.19	60-ft for 1.20
☐ 5	TANTALUM CAPS, 2.2uF, 25V (4R5189)	1.00	10 for 1.01
☐ 1	TV GAME SWITCH, choose TV or game, 75 pr 300 ohms (4R3970)	1.50	2 for 1.51
☐ 1	ALARM CLOCK CHIP, MM5316, 4-digits (4R1759)	2.95	2 for 2.96
☐ 5	PANCAKE PHOTOCELLS, 600 to 15K ohms (4R2939)	1.00	10 for 1.01
☐ 1	100KHZ MARKER CRYSTALS, approx for marker gen. (4R3896)	1.95	2 for 1.96
☐ 1	MOTHERBOARD EDGE CONNECTOR, 106 pins, .125" (4R3987)	3.50	2 for 3.51
☐ 1	48-PIN EDGE CONNECTOR, .156" spacing (4R3963)	1.95	2 for 1.96
☐ 1	JOYSTICK, two 10K pots, for computers, TV games (4R5037)	2.95	2 for 2.96
☐ 1	CHARACTER GENERATOR, 5 × 7 Mostek MK 2002P (4R3898)	4.95	2 for 4.96

READOUTS!

		ONE CENT SALE
☐ 3½ DIGIT LCD WRISTWATCH DISPLAY, (#4R3960)	3 for $1.19	6 for $1.20
☐ GE FLUORESCENT NIXIES, 7-seg, blue (#4R3684)	1 for 1.00	2 for 1.01
☐ SPERRY FLAT NIXIES, orange dual digit (#4R5014)	2 for 1.19	4 for 1.20
☐ SPERRY FLAT NIXIES, orange, .3", 1½-dig (#4R5015)	2 for 1.19	4 for 1.20
☐ MAN-3 BUBBLE READOUT, .19" red, com cath. (#4R3338)	6 for 1.00	12 for 1.01
☐ MAN-4 READOUT, bubble, red, com anode (#4R1503)	2 for 1.00	4 for 1.01
☐ FND-10 BLOCK READOUT, .122" com cathode (#4R2082)	2 for 1.19	4 for 1.20
☐ 8-DIGIT READOUT, led, com cathod, red (#4R5190)	1 for 1.95	2 for 1.96

SPEAKERS!

	Each	2 for
☐ 6" TWIN CONE SPEAKER, hi-fi, for car'n'home (#4R5059)	$4.50	$4.51
☐ 2¾ × 5" OVAL SPEAKER, 8 ohms (#4R2553)	1.49	1.50
☐ 2 × 6" OVAL SPEAKER, 8 ohms (#4R3454)	1.49	1.50

MICROPHONES!

	Each	2 for
☐ CONDENSOR MIKES, sensitive, 500 ohms, 1½V (#4R3178)	$4.95	$4.96
☐ COMMUNICATIONS MIKE, 500 ohms, CB-HAM (#4R4074)	4.50	4.51
☐ NOISE CANCELLING MIKE, Ham-CB, 500 ohms (#4R3902)	6.95	6.96

RELAYS!

	Each	2 for
☐ SPDT 12V BLOCK RELAY, 5A contacts (#4R4032)	$1.98	$1.99
☐ SPDT 12V REED RELAY, 1A contacts (#4R4094)	1.49	1.50
☐ SPDT 12V SENSITIVE, 2000 ohm coil (#4R3044A)	1.95	1.96

AMPLIFIERS!

	Each	2 for
☐ 8 WATTS ON A BOARD, with built-in preamp (#4R5040)	$5.95	$5.96
☐ 9 WATTS ON A CHIP, Toshiba TA7205 (#4R5057)	4.95	4.96
☐ 3 WATTS ON A CHIP, G-E PA 263 (#4R1522)	1.50	1.51

TRANSFORMERS!

	Each	2 for
☐ 12V TRANSFORMER, 300ma, pc leads, 110pri. (#4R3412)	$1.49	$1.51
☐ 12V TRANSFORMER, 1A, 110/220pri, open frame (#4R4040)	2.95	2.96
☐ 24VCT TRANSFORMER, 300ma, open frame, 110pri. (#4R3323)	1.95	1.96

DIP SWITCHES!

	Each	2 for
☐ 2 SWITCHES ON A DIP (#4R3668)	$ .77	$ .78
☐ 3 SWITCHES ON A DIP (#4R3669)	.88	.89
☐ 6 SWITCHES ON A DIP (#4R3671)	1.29	1.30

IC SOCKETS!

☐ 8-PIN MINI-DIP (#4R2123)	4 for $1.19	8 for $1.20
☐ 14-PIN DIP (#4R1308)	3 for 1.19	6 for 1.20
☐ 16-PIN DIP (#4R1309)	3 for 1.19	6 for 1.20
☐ 18-PIN DIP (#4R3378)	6 for 1.19	12 for 1.20
☐ 24-PIN MSI/DIP (#4R3886)	2 for 1.19	4 for 1.20
☐ 28-PIN MSI/DIP (#4R3887)	2 for 1.19	4 for 1.20
☐ 8-PIN TO-5 (#4R1307)	4 for 1.19	8 for 1.20

FULL WAVE 10 AMP BRIDGE RECTIFIERS!

Order by Cat. No. 4R2447 & voltage

PRV	Sale	2 for
☐ 50	$1.29	$1.30
☐ 100	1.49	1.50
☐ 200	1.69	1.70
☐ 400	1.99	2.00
☐ 600	2.25	2.26
☐ 800	2.50	2.51

RIBBON CABLE!

Order by Cat. No. 4R3939 and Conductors

Cond.	Sale	1¢ Sale
☐ 20	7-ft. $1.98	14-ft. $1.99
☐ 26	4-ft. 1.98	8-ft. 1.99
☐ 34	3-ft. 1.98	6-ft. 1.99
☐ 40	3-ft. 1.98	6-ft. 1.99

2-Amp Epoxy BRIDGE RECTIFIERS!

PENNY SALE! BUY ONE AT SALE PRICE, GET 2ND FOR ONLY 1¢ MORE

• Full Wave!! • TO-5 case!

Order by Cat. No. 1346 and PIV

PIV	Sale Each	2 for
☐ 50	$.59	$.60
☐ 100	.69	.70
☐ 200	.79	.80
☐ 400	.89	.90
☐ 600	.99	1.00
☐ 800	1.19	1.20
☐ 1000	1.29	1.30

10 AMP - POWER TABS! SCRS! TRIACS! QUADRACS!

Order by Cat. No. and voltage!
#4R1448 - TRIACS #4R730 - SCRS
#4R1590 - QUADRACS

PRV	Sale	2 for
☐ 50	$ .55	$ .56
☐ 100	.69	.70
☐ 200	.88	.89
☐ 300	1.19	1.20
☐ 600	1.59	1.60

SPECTROL "SKINNY-TRIMS"

Ohms: ☐ 10** ☐ 50** ☐ 100** ☐ 200** ☐ 500* ☐ 1K* ☐ 2K** ☐ 5K* ☐ 10K* ☐ 20K** ☐ 50K** ☐ 100K**

3/8" square, screwdriver shaft, 2% tol, 1/4 watt Cermet PC leads. Order by Cat. No. and value.

Your Choice 2 for $1

- ☐ No. 3R3863 25 turn upright, type 64
- ☐ No. 3R3866 single turn, flat, type 63

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MA1003 MOBILE CLOCK MODULE (National)
$18.95 complete

Attaches directly to 9-12V Battery. Automatic Nighttime Dimming. Fluorescent Display gives Color Choice (Red, Blue, Green or Yellow) when used w/corresponding Color Filter. Includes — Module, Switches, & Filter

ALUMINUM CASE WITH FILTER. (switches included with clock kit). In Silver, Bronze, Black and Gold. Filter colors — red, blue, green, or yellow. **$5.75**

Complete Clock Kit $9.95
4 DIGIT 12 24 HOUR
Includes: PC Board, 5316 Clock Chip, all components and Power Supply.
Displays hours and minutes ... Switch to minutes and seconds ... AM-PM Indicator ... Elapsed Timer ... Fluorescent Display
Options: If alarm function desired add $2.50 (includes speaker and all components)
Plexiglas Case Kit (red or blue) $2.00

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6.3 volts at 1.2 amps

Capacitors
500 MFD at 50V .... 4/$1.00
500 MFD at 15V .... 6/$1.00

Clock Chips
MM5314 or MM5316 .... $3.50

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Positive — To 220 Pkg $1.00
7805, 7806, 7812, 7815, 7824
Negative — To 220 Pkg $1.25
7905, 7912, 7915
To — 3 Pkg. — LM309K $1.25

Dry Reed Switch Capsules .... 25/$1.98
Glass Sealed 5 amp 115 VAC

1C Sockets $1.00
8, 14, 16, 18 Pin .... 5/$1.00

Bridges
1.5 amp, 200v .... 3/$1.00
3 amp, 200v .... 3/$1.25

Bridges

VOLT	2 AMP	4 AMP	6 AMP	25 AMP
50	$ .60	$ .70	$ .80	$1.30
100	.70	.80	.90	1.40
200	.80	.90	1.00	1.60
400	1.00	1.10	1.20	
600	1.25	1.35	1.40	

250 K Slide Volume Controls .. 4/$1.00
By Mallory

2 Amp Circuit Breaker .... 2/$1.00
Front Panel Mount through ½ dia. hole. 120 VAC, 32 VDC. Trips at 2.7 amps.

Grain of Wheat type chic. min. Display Lamp — red or white .... 10/$1.00

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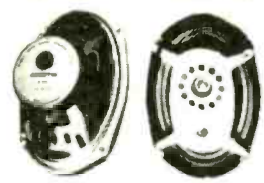
Use with Digital Clocks for 12 VDC or Portable Operation.
Kit includes: PC Board, 5369 Divider Chip, 3.5795 MHZ XTAL and all other parts plus complete instructions.

70 Volt Line Transformer $2.90
Power Rating — 10 watts. Model TR-1
Primary Volts: 70.7 — Primary Taps: 0.63, 1.25, 2.5, 5, and 10 W. Secondary Impedance: 4 & 8 ohms. Primary and Secondary Terminations: 8" color coded leads. 1⅝" H, " 16D, 2" W, Base 2⅜" W

6" Pioneer Pincushion Speakers
3.2 ohms, 7½ watts .... $3.95 pair

Heavy Duty Alligator Clip Test Lead Set $2.49
Set of 10 color coded leads with insulated alligator clip on each end.

3-WAY AUTO SPEAKER STEREO SYSTEM



3-WAY Concert Hall Sound

Two 6"x9" 20 ounce 3-Way Speakers complete with chrome accents padded vinyl grills, mounting cables and hardware, **Only $49.95**

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AC/DC Wall Plug Adaptor-Charger $1.00
120 volt input/6VDC 130 MA output.

Sound Actuated Switch .... $.85

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DL741 Jumbo Displays $1.35
7 Segment-Common Anode

Diffused LED's, Jumbo Red LEDs 0.2", and Factory Prime 7/$1.00, 100/$11.00

7 SEG LED Displays $.59 ea., 10/$5.00
33" Type 707/MAN-1 14 Pin Dip, Common Annode or Cathode.

Jumbo Red LED's .... 10/$1.00, 100/$9.00

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3A3C	2.50
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6FQ7 6CG7	1.60
6LB6	4.00
6GF7A	2.50
6BK4C 6EL4A	4.00
8FQ7 8CG7	2.00
6JS6C	4.00
12GN7A 12HG7	3.00
6GJ7 ECF801	2.00
17JZ8	2.00
5GH8A	2.50

Plug-In Component Oven $1.75
Used in housing crystals, I.C.'s etc. — for stable operation. Temp.: 65 C-3 C, ½ C. Regulation 24V. Bi Filar Winding. Cold Resistance: 110 ohms 10%. 2.4 watts @ 25 C 6.5 watt max.

6 Digit LED Alarm Clock Kit and Elasped Timer Indicator ... $13.95
Red Display
Complete kit includes: National 5375AB Clock Chip, Transformer; PC Boards, Drilled and Silk Screened; SLA-7 Red .33 High Brightness Displays; All components; Instructions and pictorals.
Features: Hrs., Min., and Sec. ... 12 Hr. format with 24 hr. Alarm ... Snooz Feature ... AM PM Indication ... 60 min. elapsed Timer ... Freeze Capability ... Power Fail Indicator.
Options: Wood grain case $4.00 when purchased with kit.

Potentiometer Assortment . 12/$1.00
Includes 1K to 100K. Tab mounts, printed circuit, duals, push-pulls, nylon and metal shafts (long and short)

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Factory prime, taped and reeled

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Asst. of outputs 1" square

15 Trimmers & Sensitivity Controls .... 5/$1.00
2.5 meg central cermet trimmers and miniature wire wound rheostats.

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8 mil x ¾" x 66'

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1 pound, assorted sizes

C106 SCR to 202 Package .... $.99
300 V, 4 amp

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- Q-BUS—FULLY STATIC
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- MODULAR
- PROM COMPATIBLE
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- MAPPABLE IN 4K INCREMENTS

ASSEMBLED, TESTED & BURNED IN $1249.00 COMPLETE KIT $1159.00

LARGEST & FASTEST STATIC MEMORY AVAILABLE

S-100 32K STATIC MEMORY BOARD

features:

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2. BUFFERED - with noise suppressed control inputs
3. MODULAR - populated in 1K increments
4. RELIABLE - single source +5V. regulator
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COMPLETE KITS or
ASSEMBLED UNITS which have been fully tested and burned in

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16K	$468	$515
24K	$648	$695
32K	$800	$845

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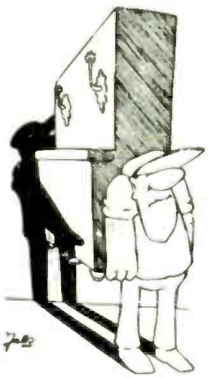
MM1403AH 2x512 BIT $1.95



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IN5340	6.0	IN5349	12	IN5358	22
IN5341	6.2	IN5350	13	IN5359	24
IN5342	6.8	IN5351	14	IN5360	25
IN5343	7.5	IN5352	15	IN5361	27
IN5344	8.2	IN5353	16	IN5362	28
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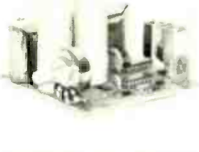

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200	.07	.20	.35	1.15	4.25	6.50
400	.09	.25	.50	1.40	6.50	9.50
600	.11	.30	.70	1.80	8.50	12.50
800	.15	.35	.90	2.30	10.50	16.50
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TTL IC SERIES

7400	13	7445	65	74151	.61
7401	13	7446	68	74153	.61
7402	13	7447	58	74154	.94
7403	13	7448	68	74155	.58
7404	15	7450	15	74157	.55
7405	13	7472	25	74161	.55
7406	16	7473	28	74163	.55
7407	20	7474	28	74164	.85
7408	18	7475	45	74165	95
7409	18	7476	30	74170	1.68
7410	.13	7480	31	74173	1.20
7411	18	7483	65	74174	.95
7412	.13	7485	87	74175	85
7413	.36	7486	28	74176	.75
7414	.60	7490	42	74177	75
7416	.22	7491	58	74180	65
7417	25	7492	43	74181	1.90
7420	.13	7493	43	74190	1.00
7425	.25	7494	67	74191	1.00
7426	22	7495	65	74192	79
7427	19	7496	65	74193	79
7430	13	74107	28	74194	.80
7432	22	74121	29	74195	.85
7437	.21	74122	38	74196	86
7438	.21	74123	.45	74279	55
7440	13	74125	40	74367	.65
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200	.75	1.25	2.00
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600	1.20	1.75	4.00

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68UF 35V	5/$1.00	22UF 25V	$ .40
1UF 35V	5/$1.00	15UF 35V	3/$1.00
2.2UF 20V	5/$1.00	30UF 6V	5/$1.00
3.3UF 35V	4/$1.00	47UF 20V	$ .35
4.7UF 15V	5/$1.00	68 UF 15V	$ .50

74LS SERIES				LINEAR CIRCUITS	
74LS00	21	74LS126	47	LM 101	75
74LS02	21	74LS132	80	LM 301/748	29
74LS03	21	74LS136	39	LM307	.30
74LS04	28	74LS138	70	LM 308	75
74LS05	28	74LS139	70	LM 311	75
74LS08	21	74LS151	70	LM 318	1.20
74LS09	28	74LS153	70	LM 319	95
74LS10	21	74LS155	70	LM 324	1.05
74LS11	21	74LS156	70	LM 339	1.10
74LS13	44	74LS157	72	LM 358	1.40
74LS15	25	74LS160	88	LM 370	1.15
74LS20	24	74LS161	85	LM 377	2.50
74LS21	26	74LS162	85	LM 380	.95
74LS22	26	74LS163	85	LM 381	1.25
74LS26	32	74LS168	88	LM 382	1.25
74LS27	32	74LS169	85	LM 537	2.50
74LS30	26	74LS170	1.68	LM 553	2.50
74LS32	32	74LS173	1.10	LM 555	39
74LS37	32	74LS174	1.00	LM 556	85
74LS38	32	74LS175	80	NE540L	2.25
74LS40	.26	74LS190	95	560	2.00
74LS42	65	74LS191	95	565	95
74LS47	79	74LS192	95	566	1.25
74LS51	26	74LS193	95	567	1.30
74LS54	26	74LS195	95	703	90
74LS90	95	74LS196	.95	709	25
74LS74	.35	74LS197	95	710	35
74LS76	35	74LS221	1.25	741C or V	31
74LS90	55	74LS257	70	747	65
74LS92	55	74LS258	70	LM 1310	2.50
74LS93	55	74LS279	55	1456	95
74LS109	.38	74LS365	.55	1458	50
74LS112	38	74LS366	55	CA3046	75
74LS113	38	74LS367	55	3900	49
74LS114	38	74LS368	55	8038CC	3.90
74LS125	47	74LS390	1.40	791 Power op amp	1.95

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PRV	TRIACS 1A	TRIACS 10A	TRIACS 25A	SCR'S 1.5A	SCR'S 6A	SCR'S 35A
100	.40	.70	1.30	.40	.50	1.20
200	.70	1.10	1.75	.60	.70	1.60
400	1.10	1.60	2.60	1.00	1.20	2.20
600	1.70	2.30	3.60		1.50	3.00

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7401 .21	74199 1.49	74LS266 .39	LF13741 .76
7402 .21	74221 .86	74LS273 1.28	LM301AN .44
7403 .21	74251 1.09	74LS279 .62	LM307N .64
7404 .21	74279 .55	74LS283 .79	LM308N 1.00
7405 .21	74298 .94	74LS290 .65	LM309K 1.80
7406 .25	74365 .67	74LS293 .65	LM311N .90
7407 .25	74366 .67	74LS295 1.12	LM317T 3.00
7408 .21	74367 .67	74LS298 .90	LM317MP 1.90
7409 .21	74368 .67	74LS365 .67	LM318N 2.70
7410 .21	**74LS00**	74LS366 .67	LM320MP-5 1.30
7411 .21	74LS00 .28	74LS367 .67	LM320MP-6 1.30
7412 .21	74LS01 .28	74LS368 .67	LM320MP-8 1.30
7413 .25	74LS02 .28	74LS377 1.50	LM320MP-9 1.30
7414 .89	74LS03 .28	74LS386 .39	LM320MP-12 1.30
7416 .25	74LS04 .29	74LS395 1.74	LM320MP-15 1.30
7417 .25	74LS05 .29	74LS670 2.34	LM320MP-18 1.30
7420 .21	74LS08 .29	81LS95 .77	LM320MP-24 1.30
7421 .25	74LS09 .29	81LS96 .77	LM323K 7.50
7423 .35	74LS10 .28	81LS97 .77	LM324N .72
7425 .25	74LS11 .28	81LS98 .77	LM325N 2.70
7426 .25	74LS12 .28	**INTERFACE**	LM326N 2.70
7427 .33	74LS13 .47	8093 .40	LM327N 2.70
7428 .28	74LS14 1.02	8094 .40	LM339N 1.15
7430 .21	74LS15 .28	8095 .67	LM340T-5 1.25
7432 .25	74LS20 .28	8096 .67	LM340T-6 1.25
7433 .30	74LS21 .28	8097 .67	LM340T-8 1.25
7437 .25	74LS22 .28	8098 .67	LM340T-10 1.25
7438 .25	74LS26 .33	75450 .88	LM340T-12 1.25
7439 .50	74LS27 .33	75451 .61	LM340T-15 1.25
7440 .21	74LS28 .33	75452 .61	LM340T-18 1.25
7442 .53	74LS30 .28	75453 .61	LM340T-24 1.25
7445 .70	74LS32 .33	75454 .61	LM341P-5 .98
7446 .70	74LS33 .33	75491 .81	LM341P-6 .98
7447 .70	74LS37 .33	75492 .84	LM341P-8 .98
7448 .70	74LS38 .33	75493 1.09	LM341P-12 .98
7450 .21	74LS40 .28	75494 1.19	LM341P-15 .98
7451 .21	74LS42 .67	MC1488N .90	LM341P-18 .98
7453 .21	74LS47 .79	MC1489N .90	LM341P-24 .98
7454 .21	74LS48 .77	**4000 CMOS**	LM348N 1.60
7460 .21	74LS51 .28	4000 .23	LM349N 1.60
7470 .30	74LS54 .28	4001 .23	LM358N .77
7472 .30	74LS55 .28	4002 .23	LM1310N .84
7473 .30	74LS73 .39	4006 1.23	LM1800N .94
7474 .30	74LS74 .39	4007 .23	LM1801N 1.70
7475 .49	74LS75 .53	4008 .79	LM1812N 4.80
7476 .32	74LS76 .39	4009 .44	LM1830N 1.30
7480 .70	74LS78 .39	4010 .44	LM1889N 2.00
7483 .70	74LS83 .79	4011 .23	LM2111N 1.25
7485 .89	74LS85 .49	4012 .23	LM2907N 1.50
7486 .28	74LS86 .39	4013 .40	LM2917N 1.50
7489 2.19	74LS90 .57	4014 .96	LM3089N 1.30
7490 .44	74LS92 .57	4015 .96	LM3900N .88
7491 .70	74LS93 .57	4016 .40	LM3900N .88
7492 .44	74LS95 .88	4017 1.05	LM3905N 1.40
7493 .44	74LS96 .88	4018 1.05	LM3909N .69
7494 .70	74LS107 .39	4019 .23	LM3911N 1.50
7495 .70	74LS109 .39	4020 1.14	MC1456V 1.00
7496 .70	74LS112 .39	4021 1.14	MC1458V .53
74100 1.28	74LS113 .39	4022 .96	MC1496N .70
74107 .30	74LS114 .39	4023 .23	MC3302P 1.15
74109 .33	74LS125 .49	4024 .84	NE536T 2.50
74116 1.26	74LS126 .49	4025 .23	NE540L 2.04
74121 .35	74LS132 .81	4026 1.68	NE555V .48
74122 .44	74LS136 .39	4027 .40	NE556A .88
74123 .61	74LS138 .73	4028 .89	NE558N 2.40
74125 .40	74LS139 .73	4029 1.14	NE559N 2.40
74126 .40	74LS151 .75	4030 .43	NE560B 2.50
74128 .48	74LS153 .75	4033 1.51	NE561B 2.50
74132 .70	74LS154 1.10	4034 3.50	NE562B 2.50
74141 .88	74LS155 .75	4035 1.14	NE565A 1.25
74145 .70	74LS156 .75	4040 1.14	NE566V 1.28
74147 1.63	74LS157 .75	4041 .79	NE567V 1.36
74148 1.30	74LS158 .75	4042 .79	UA709CV .44
74150 1.16	74LS160 1.02	4043 .79	UA710CA .44
74151 .70	74LS161 1.02	4044 .79	UA711CA .53
74153 .65	74LS162 1.02	4046 1.86	UA723CA .60
74154 1.03	74LS163 1.02	4049 .40	UA733CA .75
74155 .70	74LS164 1.02	4050 .40	UA741CV .44
74156 .70	74LS168 1.14	4051 1.26	UA747CA .79
74157 .70	74LS169 1.14	4052 1.26	UA748CV .49
74160 .88	74LS170 1.73	4053 1.26	UA7805CU 1.25
74161 .88	74LS173 1.34	4060 1.58	UA7806CU 1.25
74162 .88	74LS174 1.06	4066 .79	UA7808CU 1.25
74163 .88	74LS175 .84	4069 .23	UA7812CU 1.25
74164 .96	74LS181 2.50	4071 .23	UA7815CU 1.25
74165 1.15	74LS190 1.18	4072 .23	UA7818CU 1.25
74166 1.15	74LS191 1.18	4073 .23	UA7824CU 1.25
74170 2.64	74LS192 .98	4075 .23	UA78L05ACZ .40
74174 .98	74LS193 1.18	4081 .23	UA78L08ACZ .40
74175 .93	74LS194 .88	4082 .23	UA78L10ACZ .40
74176 .79	74LS195 .86	4510 1.14	UA78L12ACZ .40
74177 .79	74LS196 .86	4511 1.05	UA78L15ACZ .40
74180 .70	74LS197 .86	4514 2.80	UA78L18ACZ .40
74181 2.15	74LS221 1.06	4515 2.80	UA78L24ACZ .40
74182 .79	74LS240 1.90	4516 1.23	UA7905CU 1.70
74184 2.15	74LS241 1.90	4518 1.14	UA7906CU 1.70
74185 2.19	74LS242 1.70	4520 1.14	UA7908CU 1.70
74189 3.50	74LS244 1.70	4527 1.68	UA7909CU 1.70
74190 1.23	74LS247 .79	4528 .88	UA7912CU 1.70
74191 1.23	74LS248 .79	4585 1.23	UA7915CU 1.70
74192 .88	74LS249 .79	74C00 .23	UA7918CU 1.70
74193 .88	74LS251 .84	**LINEAR**	UA7924CU 1.70
74194 .88	74LS253 .84	CA3046 .75	**MISC IC**
74195 .88	74LS257 .75	CA3086 .50	MM5314N 3.75
74196 .88	74LS258 .75	LF351N .76	
74197 .88	74LS260 .34	LF356N 1.20	

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20 PIN SOLDER	.30	2.85/10	25.25/C
22 PIN SOLDER	.33	3.15/10	27.75/C
24 PIN SOLDER	.38	3.60/10	32.25/C
28 PIN SOLDER	.45	4.25/10	38.25/C
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18 PIN W-W	.60	5.70/10	51.00/C
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.0022	.14	1.15/10	9.00/C	.047	.15	1.25/10	10.00/C
.0033	.14	1.15/10	9.00/C	.068	.15	1.25/10	10.00/C
.0047	.14	1.15/10	9.00/C	.1	.17	1.35/10	11.00/C
.0068	.14	1.15/10	9.00/C	.22	.23	1.85/10	15.00/C
.01	.14	1.15/10	9.00/C	.33	.30	2.50/10	20.00/C
.022	.15	1.25/10	10.00/C	.47	.36	3.00/10	24.00/C

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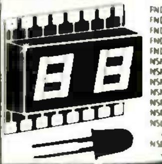
VALUE	RADIAL LEADS			AXIAL LEADS		
.47/50V	.08	.65/10	5.41/C	.11	.90/10	7.65/C
1/50V	.08	.65/10	5.41/C	.11	.90/10	7.65/C
2.2/50V	.08	.65/10	5.41/C	.12	.90/10	7.82/C
3.3/50V	.08	.65/10	5.41/C	.12	1.00/10	8.31/C
4.7/35V	.08	.65/10	5.41/C	.12	.95/10	7.91/C
4.7/50V	.08	.68/10	5.75/C	.12	1.00/10	8.31/C
10/16V	.08	.65/10	5.41/C	.11	.90/10	7.65/C
10/25V	.08	.65/10	5.66/C	.12	1.00/10	8.31/C
10/35V	.09	.70/10	6.12/C	.13	1.10/10	8.94/C
10/50V	.10	.75/10	6.58/C	.13	1.15/10	9.56/C
22/16V	.08	.67/10	5.66/C	.12	1.00/10	8.31/C
22/25V	.09	.70/10	6.09/C	.13	1.05/10	8.74/C
22/35V	.11	.85/10	7.29/C	.15	1.19/10	9.98/C
22/50V	.12	1.00/10	8.48/C	.17	1.32/10	11.22/C
33/16V	.09	.75/10	6.90/C	.12	1.00/10	8.48/C
33/25V	.10	.81/10	7.50/C	.14	1.15/10	9.56/C
33/35V	.13	1.05/10	9.65/C	.15	1.34/10	11.23/C
33/50V	.14	1.13/10	10.41/C	.19	1.52/10	12.89/C
47/10V	.09	.71/10	6.52/C	.13	1.10/10	9.50/C
47/16V	.10	.81/10	7.47/C	.14	1.15/10	9.56/C
47/25V	.13	1.05/10	9.65/C	.17	1.30/10	11.22/C
47/35V	.14	1.13/10	10.41/C	.19	1.51/10	12.89/C
47/50V	.15	1.21/10	11.16/C	.21	1.71/10	14.55/C
100/10V	.10	.77/10	6.58/C	.14	1.13/10	9.56/C
100/16V	.11	.85/10	7.28/C	.17	1.30/10	11.22/C
100/25V	.13	1.10/10	9.15/C	.20	1.55/10	13.30/C
100/35V	.17	1.47/10	11.85/C	.21	1.93/10	16.50/C
100/50V	.21	1.71/10	14.55/C	.29	2.30/10	19.70/C
220/10V	.13	1.08/10	9.15/C	.18	1.42/10	12.05/C
220/16V	.15	1.16/10	9.86/C	.20	1.55/10	[illegible]
220/25V	.21	1.71/10	14.55/C	.29	2.35/10	19.96/C
220/35V	.25	2.03/10	17.26/C	.35	2.79/10	23.70/C
220/50V	.29	2.35/10	19.96/C	.40	3.23/10	27.44/C
330/6V	.14	1.12/10	9.50/C	.19	1.48/10	13.71/C
330/10V	.15	1.16/10	9.83/C	.21	1.64/10	15.13/C
330/16V	.21	1.66/10	14.14/C	.31	2.45/10	22.70/C
330/25V	.23	1.86/10	15.79/C	.38	3.07/10	28.38/C
330/35V	.33	2.66/10	24.59/C	.43	3.43/10	31.68/C
330/50V	.54	4.30/10	39.73/C	.60	4.81/10	44.45/C
470/6V	.15	1.21/10	11.16/C	.20	1.64/10	15.13/C
470/10V	.21	1.71/10	14.55/C	.31	2.45/10	22.70/C
470/16V	.23	1.81/10	15.39/C	.33	2.66/10	24.59/C
470/25V	.29	2.35/10	19.96/C	.43	3.43/10	31.68/C
470/35V	.43	3.43/10	30.26/C	.47	3.78/10	34.96/C
470/50V	.54	4.30/10	39.73/C	.75	6.03/10	55.80/C
1000/6V	.22	1.90/10	16.50/C	.35	2.76/10	25.54/C
1000/10V	.24	1.96/10	16.62/C	.38	3.07/10	28.38/C
1000/16V	.29	2.35/10	19.96/C	.43	3.43/10	31.68/C
1000/25V	.42	3.33/10	28.27/C	.68	5.42/10	50.13/C
1000/35V	.60	4.81/10	44.45/C	.75	6.03/10	55.81/C
2200/6V	.36	2.86/10	26.48/C	.43	3.43/10	31.68/C
2200/10V	.42	3.33/10	28.27/C	.60	4.81/10	44.45/C
2200/16V	.54	4.30/10	36.58/C	.68	5.42/10	50.13/C

LED DIGITS AND LAMPS



FND357 .375" Single Digit CC Red	$1.35
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FND507 .5" Single Digit CC Red	1.35
FND800 .8" Single Digit CC Red	2.50
FND807 .8" Single Digit CA Red	2.50
NSN373 .3" Dual Digits CC Red	2.20
NSN374 .3" Dual Digits CA Red	2.20
NSN583 .5" Dual Digits CC Red	2.60
NSN584 .5" Dual Digits CA Red	2.60
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¼ WATT RESISTOR ASSORTMENTS

Catalog Number	Description	PRICE
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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 RESISTOR 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
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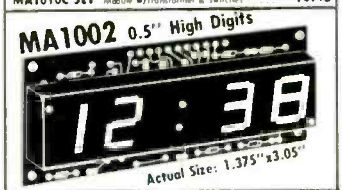
MA1010C	.84" LED 24 Hour Clock Module	$13.00
MA1010C SET	Module w/Transformer & Switches	$16.45



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1N5228B	3.9V	1N5244B	14V
1N5229B	4.3V	1N5245B	15V
1N5230B	4.7V	1N5246B	16V
1N5231B	5.1V	1N5247B	17V
1N5232B	5.6V	1N5248B	18V
1N5233B	6.0V	1N5249B	19V
1N5234B	6.2V	1N5250B	20V
1N5235B	6.8V	1N5251B	22V
1N5236B	7.5V	1N5252B	24V
1N5237B	8.2V	1N5253B	25V
1N5238B	8.7V	1N5254B	27V
1N5239B	9.1V	1N5255B	28V
1N5240B	10V	1N5256B	30V
1N5241B	11V	1N5257B	33V

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MPS3393	.16	1.55/10	13.60/C	130.00/M
MPS3393	.16	1.55/10	13.60/C	130.00/M
MPS3394	.16	1.55/10	13.60/C	130.00/M
MPS3395	.16	1.55/10	13.60/C	130.00/M
MPS3563	.16	1.55/10	13.60/C	130.00/M
MPS3565	.16	1.55/10	13.60/C	130.00/M
MPS3638A	.16	1.55/10	13.60/C	130.00/M
MPS3640	.16	1.55/10	13.60/C	130.00/M
MPS3641	.16	1.55/10	13.60/C	130.00/M
MPS3643	.16	1.55/10	13.60/C	130.00/M
2N3904	.16	1.55/10	13.60/C	130.00/M
2N3906	.16	1.55/10	13.60/C	130.00/M
2N4124	.16	1.55/10	13.60/C	130.00/M
2N4126	.16	1.55/10	13.60/C	130.00/M
2N4401	.16	1.55/10	13.60/C	130.00/M
2N4403	.16	1.55/10	13.60/C	130.00/M
2N4410	.16	1.55/10	13.60/C	130.00/M
2N5087	.16	1.55/10	13.60/C	130.00/M
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2SC 184	.59
2SC 281	.59
2SC 284	1.40
2SC 367	.90
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2SC 373	.59
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2SC 562	2.15
2SC 563	1.10
2SC 619	.59
2SC 620	.59
2SC 632A	.70
2SC 644	.59
2SC 645	.70
2SC 650	1.30
2SC 668	.59
2SC 680	2.80
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2SC 693B	.59
2SC 696	1.95
2SC 708A	1.90
2SC 710	.59
2SC 711	.59
2SC 712	.59
2SC 717	.59
2SC 730	4.40
2SC 732	.59
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2SC 799	3.60
2SC 815	.59
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2SC 871	.59
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2SC 983	1.00
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2SC 1060	2.25
2SC 1061	1.40
2SC 1080	4.40
2SC 1096	1.00
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2SC 1115	3.40
2SC 1116	4.40
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2SC 1124	1.30
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2SC 1166	.59
2SC 1173	.90
2SC 1175	.90
2SC 1177	14.00
2SC 1189	1.40
2SC 1211D	.70
2SC 1213	.70
2SC 1222	.45
2SC 1226	1.00
2SC 1237	4.25
2SC 1239	3.50
2SC 1279	.70
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2SC 1307	4.90
2SC 1312	.59
2SC 1313G	.59
2SC 1317	.59
2SC 1318	.59
2SC 1327	.59
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2SC 1362	.59
2SC 1364	1.40
2SC 1377	4.90
2SC 1383	.59
2SC 1400	.59
2SC 1402	3.70
2SC 1403	3.70
2SC 1419	1.10
2SC 1444	2.80

2SC 1448	1.10
2SC 1449	1.00
2SC 1451	1.60
2SC 1475	1.40
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2SD 224	1.90
2SD 227	.59
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2SD 235	1.00
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CIRCLE 7 ON FREE INFORMATION CARD

EQUIPMENT REPORTS

continued from page 122

watt to 10 watts. You can even read the audio frequency response of the receiver. An AF signal generator can be connected to the external modulation jack on the front panel. Set up a reference level at 1000 Hz, then vary the frequency above and below this level.

You can use the variable RF signal output to check squelch threshold, control action, the signal needed to break squelch, etc. The same setup also checks out the automatic gain control on any CB receiver. Just inject the AM signal at 30% modulation into the input, then set the *model 266* for a high RF signal, at 50,000 μV. Connect an output meter across the external speaker jack, and note the reading. Now reduce the RF output signal slowly to about 1.0 μV. The audio output signal should drop slowly and smoothly without dips or peaks. The audio output at the lowest signal level should be no more than 30 dBm below the reference level set up with the high RF signal. This procedure will also check and calibrate the S-meter on the CB, if one is used; this should read maximum at the high signal output and then drop to zero at the lowest RF signal.

The *model 266* CB signal generator is a versatile piece of test equipment that is surprisingly easy to set up and use. The RF step attenuator is a 6-position switch; the RF modulation and IF levels are variable controls, and everything else is done with pushbuttons.

The instruction manual contains full setup data (including all the control positions for both generator and CB) for every kind of test imaginable. The manual is actually like a good CB troubleshooting handbook. Full checking and recalibration instructions are given. There's even a complete list of CB channel frequencies, which is nice because I'm sure not going to ever remember 'em! **R-E**

Philips/MCA, Inc. announce two-hour videodisc format

A new two-hour playing format for optical videodiscs was announced recently by Philips and MCA, Inc., that will enable the viewer to enjoy full-length feature films and programs of up to hours in length on a single double-sided disc.

The optical videodisc player will not only accomodate the two hour format using variable angle velocity, but also play programs recorded at the present 1800 RPM format. Magnavox will market the player and the videodisc will be handled by MCA Disco-Vision.

Ion implantation improves FET's, optical couplers and solar cells

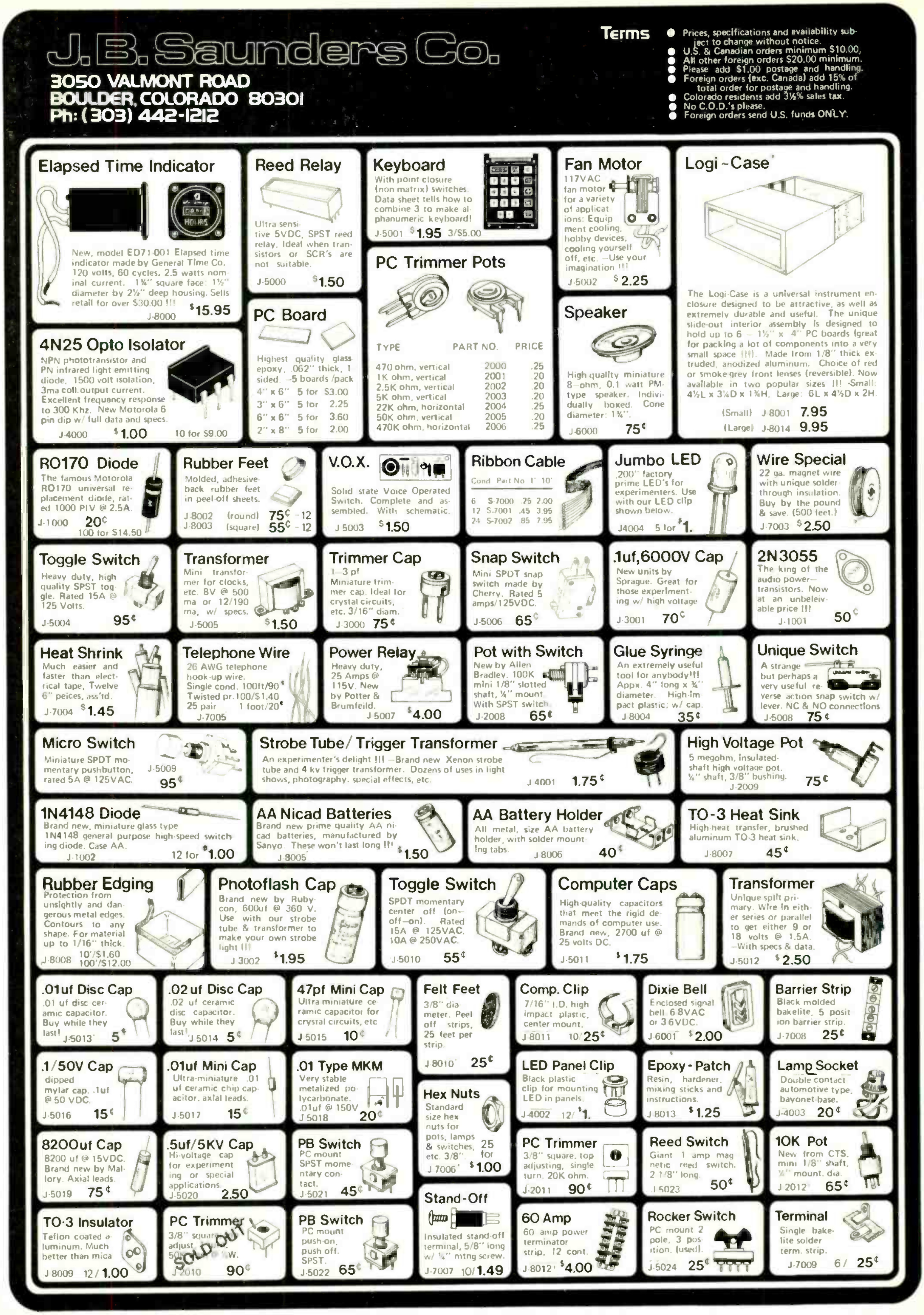
Several ion-implantation methods are presently being developed that are expected to improve the performance of microwave FET's, create new optoelectronic devices for use in telephone couplers and fiber-optic communications, and increase the efficiency of solar cells.

Hewlett-Packard has built an ion-implanted FET that, as a result of its planar construction, promises greater reliability than conventional crystalline devices. The company sees the potential application of these FET's in GaAs IC's. With a 5-dB gain, HP researchers have been able to obtain an output power of more than 1 watt at 6 GHz and a power-added efficiency of 34%. Avantek, Inc., has also been working with low-noise microwave FET's; silicon implanted into a GaAs semi-insulating substrate results in a shallow but steep profile.

On the optoelectronic front, Bell Labs has developed two semiconductors—one, a bilateral phototransistor to be used as an optical coupler in telephone switching, and an optically switched LED to interface between digital logic circuits and glass fibers. Bell researchers believe this LED has application in a tap and-repeater circuit.

With the possibility of having an effect on the national energy crisis, the efficiency of solar cells has been improved by a special chemical process developed by the Jet Propulsion Lab of the California Institute of Technology at Pasadena. The oxide surface layer of the gallium-arsenide MOS cell is formed by physical deposition, and pulsed-laser evaporation is used to improve the antireflecting coating of the solar cell surface. This has pushed the efficiency of the GaAs MOS solar cell to 17%.

Texas Instruments has also created a tandem-junction thin-film solar cell with collecting junctions on both the dark and illuminated sides of the cell. So far, experimental solar cells have yielded an open-circuit voltage of 600 mV, a short-circuit current of 50 mA per-square-centimeter and an 18% efficiency at 25°C.



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2SA497	1.44	2SC517	3.60	2SC1239	3.50	2SD188	2.70
2SA634	1.00	2SC634A	.60	2SC1306	3.50	2SD234	.85
2SA636	1.25	2SC710	.49	2SC1307	4.75	2SD235	.85
2SA673	.70	2SC711	.49	2SC1377	4.80	2SD313	1.05
2SA678	.65	2SC735	.49	2SC1383	.50	2SD314	1.50
2SA682	1.49	2SC756A	2.40	2SC1448	1.00	2SD315	1.20
2SA683	.60	2SC778	3.50	2SC1449	.85	2SD358	1.10
2SA699	1.30	2SC781	2.50	2SC1678	2.00	2SD360	1.05
2SA699A	1.45	2SC789	1.00	2SC1728	1.85	2SD427	2.55
2SA733	.49	2SC798	3.95	2SC1760	1.60	2SD525	1.50
2SA777	.99	2SC799	3.25	2SC1816	3.50	2SK19	1.25
2SB54	.49	2SC1000	.49	2SC1908	.49	2SK30A	.75
2SB56	.95	2SC1013	.95	2SC1909	3.75	2SK33	.90
2SB186	.49	2SC1014	.95	2SC1957	1.00	2SK55	1.00
2SB187	.55	2SC1017	1.20	2SC1973	.90		
2SB324	.60	2SC1018	1.00	2SC1975	3.50	3SK22Y	2.20
2SB370	.65	2SC1061	1.25	2SC2028	.80	3SK40	2.00
2SB405	.60	2SC1079	3.95	2SC2029	3.40	3SK45	2.20
2SB415	.65	2SC1096	.80	2SC2091	2.50	3SK49	2.20
2SB461	1.60	2SC1098	1.00	2SC2092	3.25		
2SB463	1.40	2SC1115	3.00				
2SB507	1.40	2SC1170B	4.95	2SD72	.80	4004	3.00
2SC371	.49	2SC1172	5.25	2SD77	1.50	4005	3.00
2SC372	.49	2SC1173	.75	2SD88	4.80	40081	1.50
2SC481	1.50	2SC1209	.75	2SD118	3.00	40082	3.00

JAPANESE CIRCUITS

AN136	2.90	LA4400FS	3.40	TA7055P	3.00	UPC20C	3.75
AN214	3.35	LA4400FR	3.40	TA7060P	1.40	UPC41C	2.80
AN239	6.50	LD3120	2.40	TA7061P	1.50	UPC563H2	8.00
AN241	2.40	M5115PR	7.80	TA7063P	1.50	UPC566H	1.25
AN315	3.50	PLL01A	13.50	TA7075P	3.75	UPC575C	2.60
BA511	3.00	PLL02A	8.50	TA7089P	2.90	UPC595C	2.95
BA521	3.40	PLL02A-G	8.50	TA7120P	1.50	UPC1001H2	3.50
HA1202	2.20	SG613	6.75	TA7150P	3.75	UPC1008C	5.75
HA1306	4.90	STK011	7.50	TA7153P	6.90	UPC1020H	3.25
HA1308	4.50	STK015	6.50	TA7203P	4.25	UPC1025H	3.50
HA1322	4.20	STK032	14.20	TA7204P	3.70	UPC1166H	4.50
LA1201	4.25	STK050	24.50	TA7205P	3.60	UPD277C	4.50
LA4031P	3.20	STK056	11.35	UH1C003	6.50	UPD857C	15.50
LA4032P	4.20	STK415	8.50	UH1C004	6.50	UPD858C	9.50
LA4051P	3.20	TA7045M	3.25	UPC16C	2.50	UPD861C	18.50

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7401	.21	7448	1.15	74121	.55
7402	.21	7450	.26	74122	.49
7404	.21	7451	.27	74123	1.05
7405	.24	7453	.27	74125	.60
7407	.45	7454	.41	74126	.81
7408	.25	7460	.22	74132	3.00
7409	.25	7472	.39	74141	1.15
7410	.20	7473	.45	74150	1.10
7411	.30	7474	.45	74151	1.25
7413	.85	7475	.80	74153	1.35
7416	.43	7482	1.75	74154	1.50
7417	.43	7483	1.15	74157	1.30
7420	.21	7485	1.12	74161	1.45
7422	1.50	7486	.45	74164	1.65
7425	.43	7489	2.49	74165	1.65
7427	.37	7490	.69	74166	1.70
7428	.35	7491	1.20	74174	1.95
7430	.26	7492	.82	74175	1.95
7432	.31	7493	.82	74180	1.05
7437	.47	7494	.91	74181	3.55
7438	.40	7495	.91	74191	1.50
7440	.21	7496	.91	74195	1.00
7441	1.10	74100	1.25	74197	1.00

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1N34	.25	2N2905A	.30	2N3903	.16
1N60	.25	2N2906	.25	2N3904	.16
		2N2906A	.30	2N3905	.16
1N270	.25	2N2907	.25	2N3906	.16
1N914	.10	2N2907A	.30	2N3954A	3.75
2N173	1.75	2N2913	.75	2N3955	2.45
2N404	.75	2N2914	1.20	2N3957	1.25
2N443	2.50	2N3019	1.00	2N3958	1.20
2N508A	.45	2N3053	.30	2N4037	.60
2N718	.25	2N3054	.70	2N4093	.85
2N930	.25	2N3055	.75	2N4124	.16
2N956	.30	2N3227	1.00	2N4126	.16
2N1302	1.25	2N3247	3.40	2N4141	.20
2N1305	.75	2N3250	.50	2N4142	.20
2N1540	.90	2N3393	.20	2N4143	.20
2N1544	.80	2N3394	.17	2N4220A	.45
2N1560	2.80	2N3414	.17	2N4234	.95
2N1605	1.75	2N3415	.18	2N4400	.16
2N1613	.50	2N3416	.19	2N4401	.16
2N1711	.50	2N3417	.20	2N4402	.16
2N2102	.70	2N3442	1.85	2N4403	.20
2N2160	.70	2N3553	1.50	2N4409	.16
2N2218	.25	2N3563	.20	2N4410	.16
2N2218A	.30	2N3565	.20	2N4441	1.00
2N2219	.25	2N3638	.20	2N4442	1.15
2N2219A	.30	2N3642	.20	2N4443	1.35
2N2221	.25	2N3643	.20	2N4852	.55
2N2221A	.30	2N3645	.20	2N5061	.30
2N2222	.25	2N3646	.14	2N5064	.50
2N2222A	.30	2N3731	3.75	2N5130	.20
2N2270	.40	2N3740	1.00	2N5138	.15
2N2369	.25	2N3771	1.75	2N5296	.50
2N2484	.32	2N3772	1.90	2N5306	.20
2N2712	.18	2N3773	3.00	2N5400	.40
2N2904	.25	2N3819	.40	2N5401	.50
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2N2905	.25	2N3866	1.25	2N5458	.30

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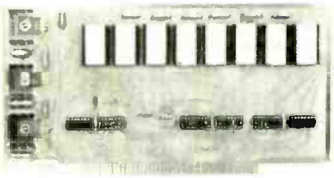

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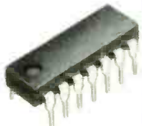

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7448	276-1816	99¢
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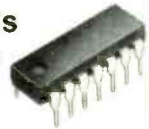

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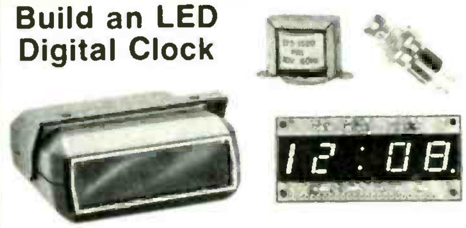

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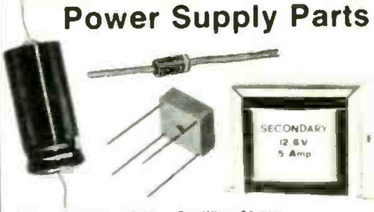

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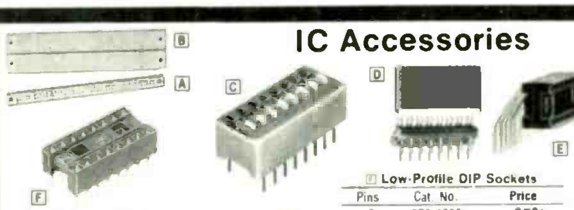

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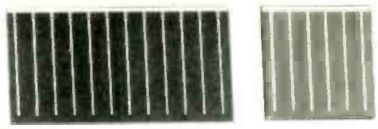

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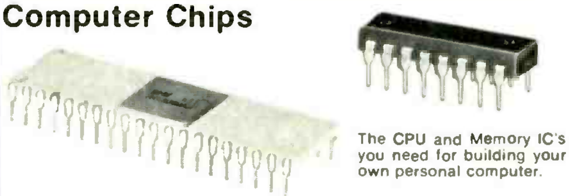

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service questions

HOPELESS PROBLEM

This Zenith D3720L is a hopeless problem! There's no high voltage and the horizontal output tube isn't conducting. The drive waveform checked good as did the DC supply voltage, deflection yoke, etc. I replaced the flyback—no change. I note that the DC voltage on pins 3 to 11 of the 20LF6 drops from +300 to only +60—A. H., New York, NY.

Nothing is hopeless if you attack the problem systematically. There are 17 different things you must eliminate in this kind of problem, and there may be more. You've already eliminated quite a few. Now, the one significant reaction is the high-voltage drop in the 20LF6 *screen* grid voltage when the set warms up. I've seen this before.

There are two possible causes for the voltage drop. One is that the top cap on the 20LF6 may not be making contact, so there is actually no plate voltage. The screen does have voltage, so it tries to act as the plate and the resulting high current causes the voltage to drop. Check the continuity between the 20LF6 plate cap lead and the damper cathode; this should read only a very few ohms. Also check the solder joint between the lead and cap.

The other cause is even rarer, but it has shown up lately. Try another 20LF6 tube. We've run into this before, and there is some weird defect in the tube itself, showing up even in new tubes. Open the 20LF6 cathode and read the current to find out whether the tube is taking excessive current or not enough.

Here's another rare cause for your problem. Place a DC voltmeter on the damper cathode and turn the set on. You should read the full B+265 volts here as soon as the damper tube warms up. If you do not, try a new damper tube; sometimes the cathode ribbon in some of these tubes opens up.

HORIZONTAL RADIATION

A reader recently wrote about some incorrect answers to Reader Questions in the November 1977 issue. His letter contained one remark that I'd like to correct. Referring to a question dealing with horizontal radiation from one TV set into another, he wrote "your answer is more theoretical than practical," etc. And claimed this radiation was due to co-channel interference!

Not so. This answer was the result of actual personal observations of real sets, as well as many letters from readers with the same problem. For instance, in the first case I ever saw years ago, an old Dumont 301 in a two-set home would tear up the picture on a portable in the next room! The cause: one of the 5U4 rectifiers was very gassy. Whenever possible, which is most of the time, the published answers in Reader Questions have been verified by reader feedback.

COLOR PROBLEM

I've got a lulu of a problem here. This set was vandalized by an angry husband who had to turn it over to his wife as a part of the settlement! I found and fixed all the missing and broken parts, and got it working. The set came back with a focus problem; I fixed that. Now I've got a fine sharp black and white picture, but no color at all! With the set working, all I can get in the color circuits is a big flattened horizontal pulse. If I open the cathode of the horizontal-output tube, the color waveforms come back, all the way to the picture tube grids! What the Sam Hill is this?—R. M., Kensington, MD.

From the symptoms you describe, this color problem is being *caused* by the presence of the horizontal *blanking* pulse! When you kill the horizontal output, you kill these pulses. Since the color-signal circuits are obviously working, something in the blanking circuitry is causing the color to be blanked out. **R-E**

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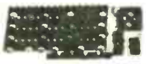

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21L02/250 ns	[illegible]	[illegible]	[illegible]	4402	[illegible]	[illegible]	[illegible]
2102	[illegible]	[illegible]	[illegible]	5101	[illegible]	[illegible]	[illegible]
2102 1	[illegible]	[illegible]	[illegible]	74C89	[illegible]	[illegible]	[illegible]
91L02APC	[illegible]	[illegible]	[illegible]	7489	[illegible]	[illegible]	[illegible]
2111 1	[illegible]	[illegible]	[illegible]	8599	[illegible]	[illegible]	[illegible]
2111 1	[illegible]	[illegible]	[illegible]	74S189	[illegible]	[illegible]	[illegible]
2112 1	[illegible]	[illegible]	[illegible]	74S200	[illegible]	[illegible]	[illegible]
21L01	[illegible]	[illegible]	[illegible]	74S201	[illegible]	[illegible]	[illegible]
2101 1	[illegible]	[illegible]	[illegible]	3101A	[illegible]	[illegible]	[illegible]
2114/650 ns	[illegible]	[illegible]	[illegible]	3107	[illegible]	[illegible]	[illegible]

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LS195	.52	74367	.79
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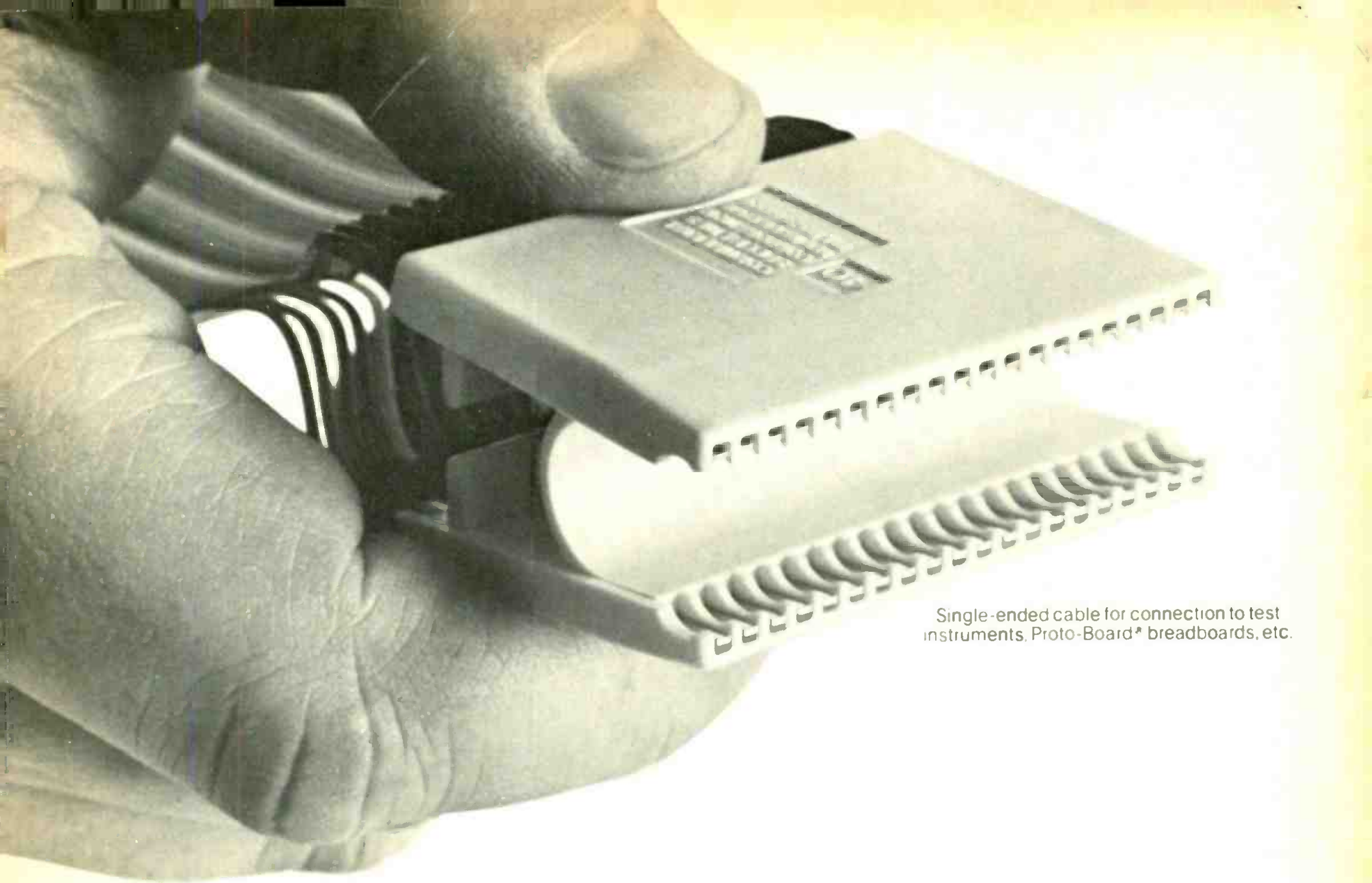

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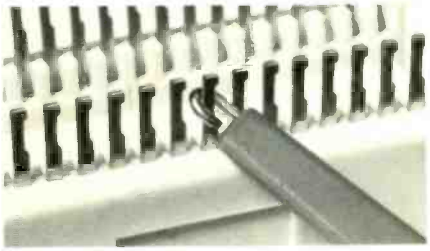

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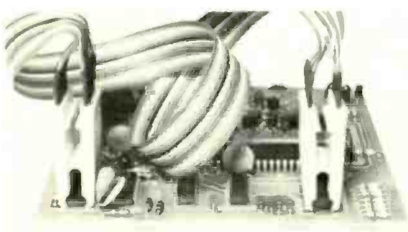

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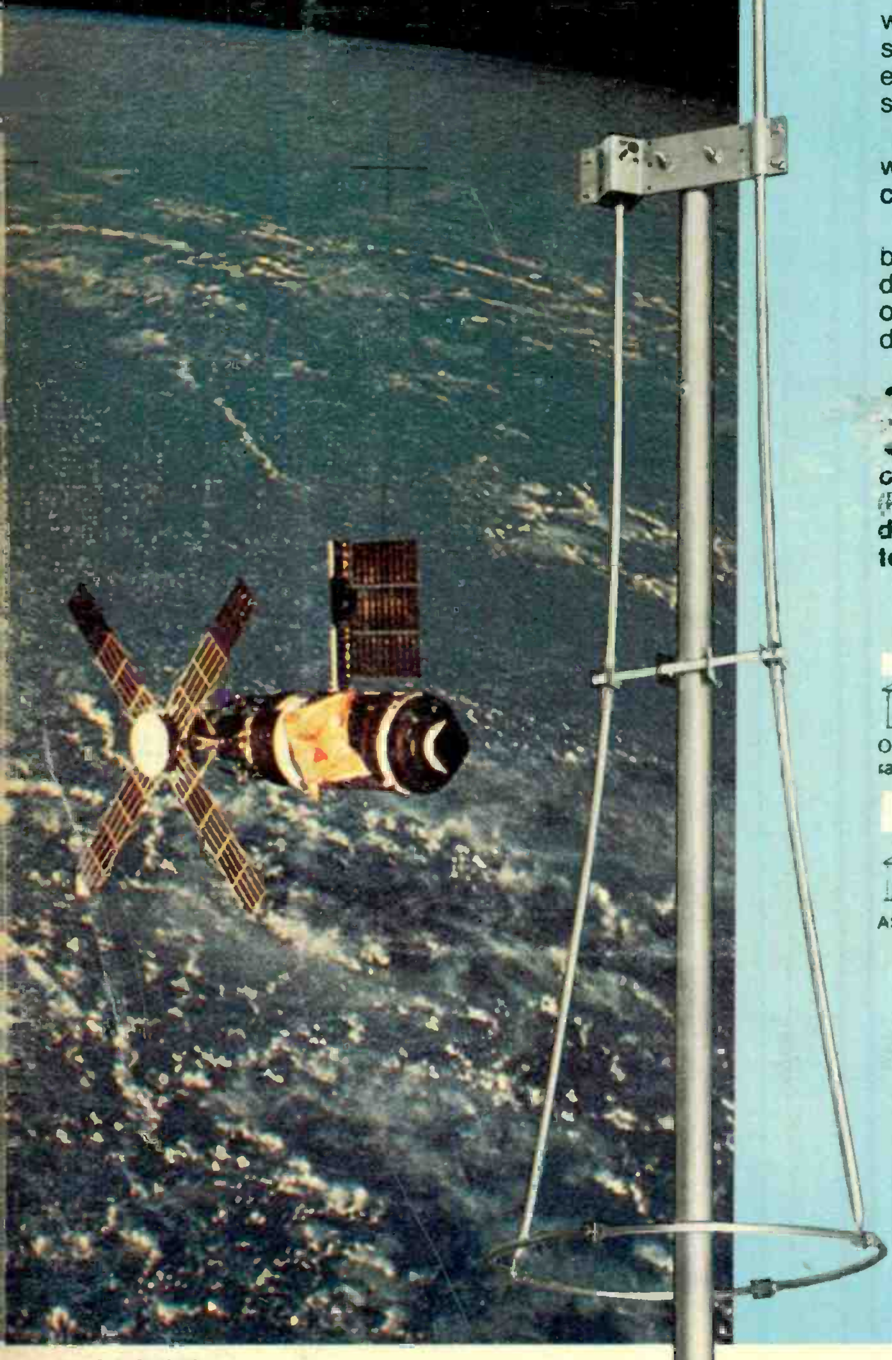

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CO-INDUCTIVE design of this patented antenna gives long range, noise free performance.

The result of years of research & development, the ASTRO PLANE has top radiation which means that your signal gets out from the highest part of your antenna. Your signal radiates about 15 feet higher than with other antennas which radiate near the bottom.

The ASTRO PLANE has a lower angle of radiation which makes more efficient use of the radiated signal by allowing it to hug the curvature of the earth instead of shooting your power up into the sky.

The ASTRO PLANE has 4.46 db gain over isotropic which gives you a stronger signal and better, clearer reception.

You'll get long lasting, trouble free performance because it is compact in design — without long drooping radials, without coils to burn or short out, and with direct ground construction to help dissipate static charges and lightning.

• Stainless steel radials concentrate signal power on top • Rigid heavy-duty aluminum tubing • No long drooping radials to ice up or break off • So unique it's backed by a U.S. patent (Patent #3587109) • No coils to burn out or detune • Easy assembly • Lightweight — easy to install on simple pipe mast

Ordinary collinear or ground plane antenna signals are blocked...they radiate from the bottom.

ASTRO PLANE gets its signal over obstacles...it radiates from the top.

SPECIFICATIONS

Total Length — 12 feet	Vertical Polarity
Weight — 4 lbs.	Aircraft Quality Aluminum
Power Gain — 4.46 db	SWR — Pre-tuned — Less than 1.2:1
Impedance — 50-52 ohms	band width — full 40 channels
Omnidirectional — needs no rotor	

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