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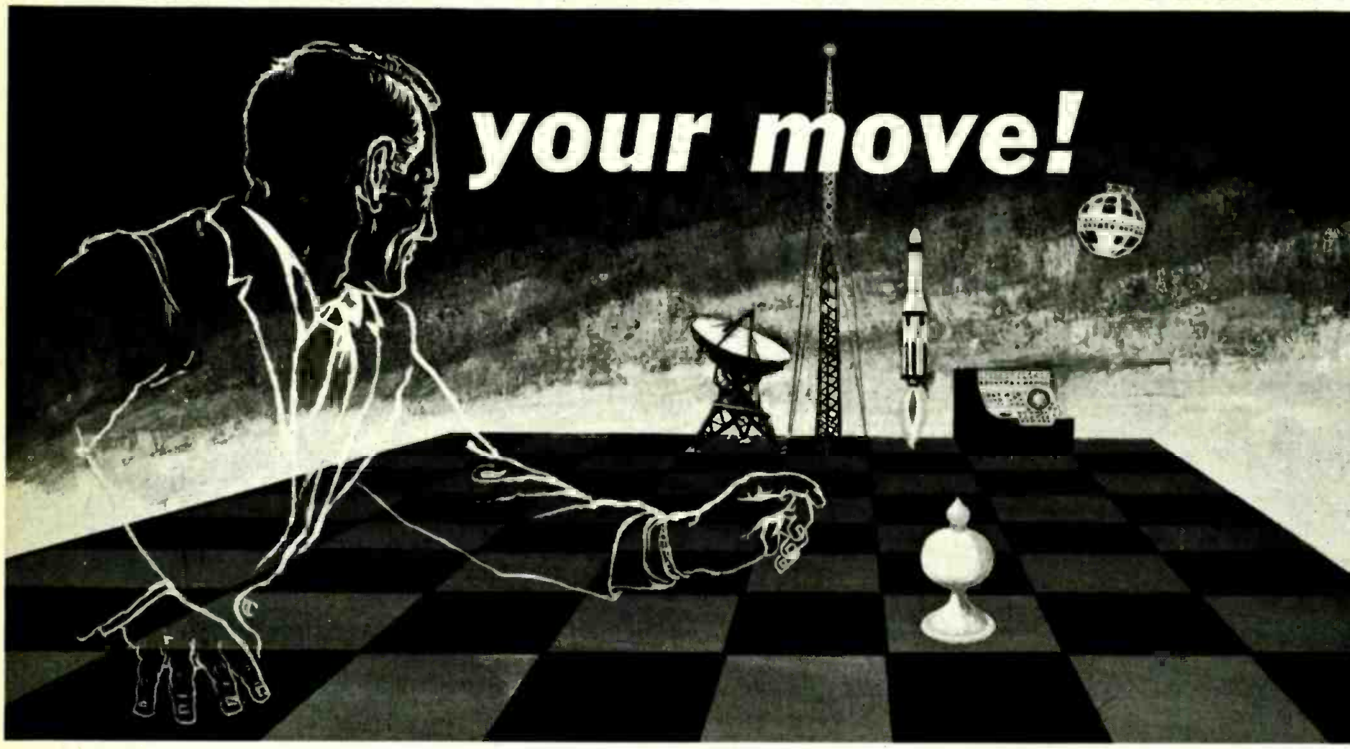

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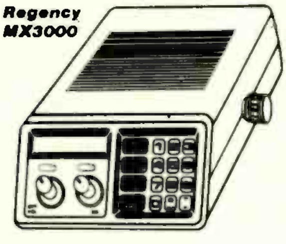

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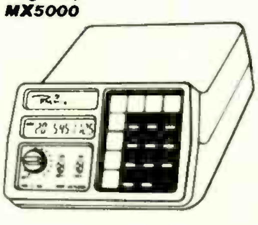

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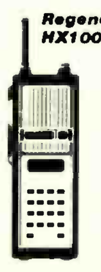

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JULY 1984 Vol. 55 No. 7

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ON THE COVER

You can save money on your air-conditioning bills and stay comfortable at the same time. No, it's not magic—it's what's known as time cycling. The energy miser lets your air conditioner operate more efficiently than it does when it is controlled by just a thermostat. Best of all, you can build the device just in time for the hot weather! The story begins on page 43.

THE TIMEX SINCLAIR 1000 or ZX81 has been described as being worse than a toy. Well, it doesn't have to be. You can put your ZX81 to work as a control computer with as many features as your imagination permits. This month, interfacing basics are discussed, and an interface circuit is presented. The story begins on page 57.

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- **Electronics And The Heart.** The heart may have more in common with electronic devices than you think.
- **An Infrared Transmitter/Receiver.** How many uses for one can you come up with?
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VIDEO ELECTRONICS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

RCA PULLS THE PLUG

RCA's noble experiment with the CED (*C*apacitance *E*lectronic *D*isc) videodisc system came to a sudden end after three years of marketing and $580,000,000 of losses when the corporation's board decided to discontinue manufacturing SelectaVision players. The company will continue to manufacture discs for existing players for at least three years, or as long as there is demand, according to RCA. The videodisc system was a victim of the unexpected success of the VCR, of which RCA is the leading brand in the United States. RCA said the unanticipated demand for VCR's, the constantly dropping prices, and the widespread availability of low-cost program cassette rentals spelled the death of the videodisc system.

RCA had reduced the price of the basic player model to $199.95 and introduced stereo and interactive models at higher prices, but only the cheapest model sold in any volume. RCA said it would continue to sell the remaining players this year, and it expects a total of 700,000 to be in use by year's end. The competing LaserVision optical system, with players being sold by Pioneer, Magnavox, and Sylvania, continues on the market.

THE VCR WINNERS

Once again in 1983, RCA was the most popular VCR brand in the United States, according to a survey by the trade newsletter *Television Digest*. However, RCA won by a slimmer margin this time, with an estimated 16% of 1983's sales, while Panasonic, the No. 2 brand, had 15%. In 1982, RCA held an estimated 22% of the market, to Panasonic's 17.75%. Sony was the No. 3 brand with 7%, followed by General Electric with 5.5%, and Fisher and Sanyo with 5% each.

The two American brands owned by Matsushita Electric, Panasonic and Quasar, accounted a total of 20.6% of all VCR's sold in the United States last year, and taken together they would easily come out in first place. Other brand groupings: North American Philips brands (Magnavox, Sylvania, and Philco) had a total of more than 7.5% of the market, while Sanyo's two brands (Sanyo and Fisher) totaled 10%.

Because total VCR sales in 1983 were more than double those of 1982 (4,091,000 vs. 2,035,000), virtually every brand ended up with greater sales than the year before—even those brands which lost some market share (such as Zenith, which fell from 6% to 2.6% when it temporarily dropped out of the market in preparation for its 1984 switch to VHS from Beta). According to the survey, about 19% of the VCR's sold in the U.S. last year were in the Beta format, a decline from 26% in 1982.

BIG SCREEN, BIG PROSPECTS

Some 143,500 giant-screen projection TV sets were sold in 1983, up from 117,000 in 1982, and in the first quarter of 1984 sales were running about 14% ahead of 1983's pace. U.S. Precision Lens Co., which makes lenses for most of them, sees American homes adding TV projectors in even greater numbers this year, forecasting sales of about 178,000.

The company predicts that 75% of all projection sets sold this year will be rear-projection systems (one-piece types in which the picture is thrown from the inside of the set onto a translucent front-mounted screen) as opposed to 60% last year and 29% in 1981. It sees these advances in projection this year: Improved lenses at lower cost; more compact cabinets; better projection tubes with widespread use of liquid cooling for higher brightness; smaller spot size for better resolution; better phosphors; better screens at lower cost; more sets with optical coupling of tube to lens for higher contrast, and a new generation of chassis designed specifically for projection.

U.S. Precision also spots a trend toward somewhat smaller screen sizes in projection TV. Since a rear-projection set resembles a conventional TV, but with a bigger picture, the company quotes its manufacturing customers as feeling that "projection should more properly be considered an extension of conventional color-TV lines. They argue that we should forget about calling it projection, instead concentrating only on larger screen size."

Meanwhile, some set manufacturers' labs are working on new generations of projection television designed to be used with high-definition widescreen TV of the future. Already in sight, according to inside reports, are projection systems with better contrast, resolution, and brightness than conventional direct-view sets. **R-E**

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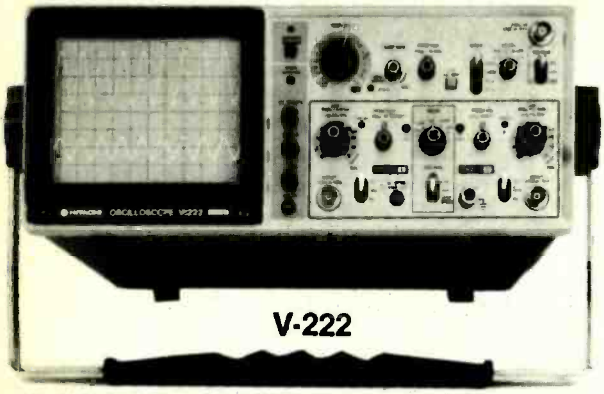
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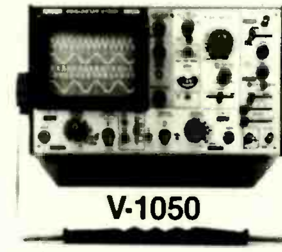
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WHAT'S NEWS

EIA sets new standards for silicon digital IC's

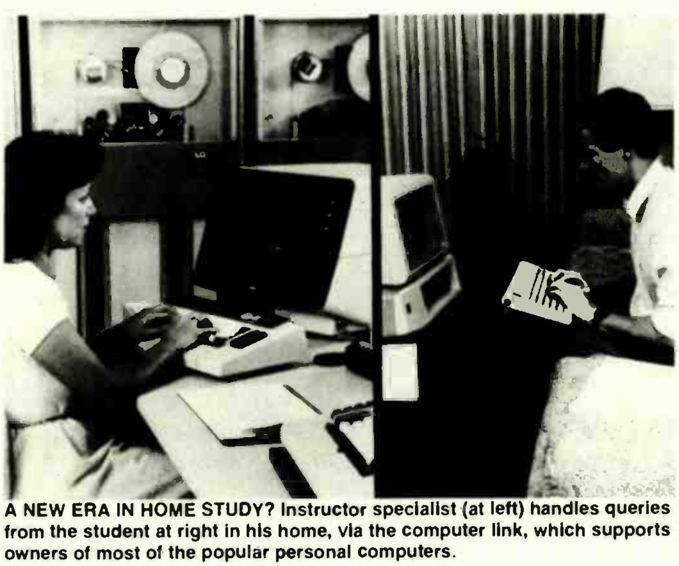
The Engineering Department of the Electronic Industries Association has established JEDEC Standard No. 7, setting industry specifications for three series of new high-speed silicon-gate digital IC's.

The 54/74HC series includes buffered CMOS logic devices with the primary characteristic of V_{IL} (logical low-input voltage) and V_{IH} (logical high input voltage) ratings for good noise immunity in CMOS system designs. The 54/74HCU series includes a limited number of unbuffered (1 active logic circuit) inverters or gates where V_{IL} and V_{IH} ratings are less than those of the HC series. The third series is designated 54/74HCT, having V_{IL} and V_{IH} ratings of 0.8- and 2-volts respectively for direct interfacing with TTL logic IC's.

Computer to interface home student, teacher

A new home-study system, in which student and teacher can be in direct contact, was described to Chicago security analysts by David Bright of the National Education Corp. Mr. Bright reported that the company's computer bank in Scranton, PA—which now handles testing for the company's 60,000 domestic home-study students—has been upgraded to accept on-line computer interfaces.

The new *EdNet* system will be offered to owners of IBM, Apple, Radio Shack, Commodore and Timex computers. The new system, Bright said, will permit independent home students to not only take their testing by computer, but to interface directly with instructional specialists via their home or office computers as well.



A NEW ERA IN HOME STUDY? Instructor specialist (at left) handles queries from the student at right in his home, via the computer link, which supports owners of most of the popular personal computers.

Dr. Maiman member of Inventors Hall of Fame

Dr. Theodore H. Maiman, pioneer in laser research, was inducted into the National Inventors Hall of Fame at the 12th Inventors' Day Expo in Arlington, VA. He was honored for the invention of the ruby laser, the world's first operating laser. The first laser action occurred on May 15, 1960, at the Hughes Research Labs, Malibu, CA.

Dr. Maiman has been elected to both the National Academy of Sciences and the National Academy of Engineers. Among his many awards is the American Physical Society Oliver E. Buckley Prize for "The Most Important Contribution to Solid-State Physics in the Prior Five Years."

The National Inventors Hall of Fame is located in the United States Patent Office in Arlington, VA. and is dedicated to the persons "who conceived the great technological advances which this nation fosters through its patent system."

THEODORE H. MAIMAN LOOKS ON as William Weigel, president of the National Inventors Hall of Fame Foundation, unveils a display honoring him. The display, which includes a replica of the original laser, will be permanently on exhibit in the lobby of the U.S. Patent Office.

The year's other inductees were William M. Burton, for an invention in the refining of gasoline; Wallace H. Carrothers, inventor of nylon, and Philo T. Farnsworth, inventor of the first all-electronic television system.

Japan industry faces semiconductor shortage

Soaring production of VCR's, personal computers, automated office equipment, and other electronics products is hobbling the Japanese electronics industry, according to the influential Japanese newspaper *Yomiuri Shimbun*. At the end of 1983, Japan's largest semiconductor maker, NEC, admitted that "we can supply only about 70 percent of the demand."

Projected production figures are being cut back by some manufacturers. A Sony representative states: "VTR makers are unable to produce as many units as planned, because of the shortage of certain types of semiconductors." A Hitachi official said: "We cannot manufacture as many personal computers as we had planned."

Responding to the situation, NEC, Hitachi, Fujitsu, Toshiba, and other manufacturers are operating 24 hours a day, seven days a week, and are even expanding their production facilities. But they report that a year lead time will be required, and that supplies may remain tight through 1984.

New Orleans will host satellite conference

The sixth annual Satellite Communications Users Conference (SCUC) will be held at the Louisiana Superdome, New Orleans, August 28–30, 1984. Sponsored by the international trade journal *Satellite Communications*, it is the world's largest commercial satellite-communications gathering.

Over 3,000 persons are expected to attend the panel sessions and exhibits. Panel sessions will be directed toward broadcasting, cable, and corporate users, and will cover international satellite services, regulatory policies, and space law. The newest technological advances are being featured by 120 exhibitors.

Additional information on SCUC '84 may be obtained from Kathy Kriner, convention manager, at 303-694-1522.

Optical print reader is held in hand

Oberon International, a London firm, has introduced a hand-held character reader suitable for use with a microcomputer.

Former character-recognizing devices have been extremely expensive and were restricted in the types of characters they could read. Particular problems arose with the operation of the transport and scanning heads. The new device uses manual instead of automatic operation to minimize or eliminate those problems.

The user of an Omni-Reader passes a light-sensitive linear array across a line of type, using a built-in ruler for accurate alignment. The light-sensitive element picks up and stores a series of vertical slices along the line of characters. Those are analyzed by a microprocessor, interpreted, and passed to the computer. Most of the standard fonts can be recognized, and some non-standard fonts can be taught to the software.

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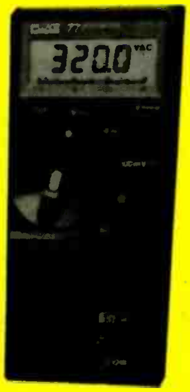

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Growing Demand for Computer Technicians

This is only one of the growth factors influencing the increasing opportunities for qualified computer technicians. The U.S. Department of Labor projects over a 600% increase in job openings for the decade; most of them *new* jobs created by the expanding world of the computer.

(TRS-80 is a trademark of the Radio Shack division of Tandy Corp.)

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SATELLITE/TELETEXT NEWS

GARY ARLEN
CONTRIBUTING EDITOR

CBS, IBM, SEARS TEAM UP

In a move that could speed up nationwide development of videotext—and redefine the nature of videotext technology—Sears, CBS, and IBM have joined forces to develop a new service. The system will use home computers rather than dedicated videotex terminals and could include "true video" pictures rather than the conventional computer-graphic images of today's videotext.

The Sears/CBS/IBM venture will take at least two years to put together, meaning that the first tests will take shape during 1986. All three companies have tested other videotex systems. By teaming up, they bring strong resources to the videotex business. Sears will concentrate on home banking and financial services, along with catalog merchandising. CBS will contribute software and news/information services, while IBM develops computer hardware, software, and networking facilities.

At the heart of the joint venture is a plan to deliver computer software and data-processing power into the home for education, personal productivity, and home management. The triumvirate will recruit other financial and information firms, computer companies, and organizations to offer a variety of services on the system, which doesn't yet have a name.

TELETEXT TRICKLING INTO BIG CITES

Teletext services are popping up around the U.S. this spring—not in the rush that some visionaries might have expected, but rather in a deliberate progression, arriving first in the nation's major markets. Among the developments:

Panasonic, Matsushita, and Sony will begin selling NABTS-format teletext decoders in New York, Los Angeles, and Chicago metro areas, where CBS and NBC both own local TV-stations. Those two networks are in the vanguard of promoting teletext material, and are coordinating their electronic information and ad packages with the decoder introductions. Decoders from all three makers will cost about $900, at first, and will work only with certain late-model component-TV sets.

RCA may introduce TV sets with built-in NABTS teletext decoders as part of the 1985 model line, due out in a few months. Such a move would bring the price of teletext reception down to only a few hundred dollars above the price of a non-teletext set, and would eliminate the need for an add-on teletext decoder.

AMERICAN EXPRESS ENTERS VIDEOTEX

American Express may have to modify its slogan to "Don't *stay home* without us."

The financial-services giant is plunging into videotex services in a big way, preparing to offer at-home shopping, travel-planning, bill-paying, and even insurance and stock brokerage through its subsidiaries. American Express is also repackaging material from its massive worldwide inventory of information—including restaurant reviews, flight schedules, travel tips and business ideas—to put online through various videotex and teletext systems around the U.S.

Working with hotel chains, restaurants, travel firms, and others who accept American Express cards and travelers checks, the company is also creating new systems to deliver travel, entertainment, and business services to videotex customers. In addition, monthly videotex service charges will be billed to your American Express card, just as you can now put your monthly MCI or AT&T long-distance phone bills on a monthly account.

All of American Express' services are being assembled under the trade name "Advance." The first services are now available to Viewtron videotex customers in south Florida, and later this year will go online to Time Mirror Videotex users in southern California.

DBS DEVELOPMENTS

United Satellite Communications Inc., the first-comer in the DBS sweepstakes, began marketing its five-channel service in the Indianapolis area. USCI, which plans to eventually roll out its service nationally, has recruited Radio Shack as its major retail-sales agent—meaning that the DBS service will be sold through Radio Shack stores when the system is offered in other parts of the country. At its start-up, USCI offered two channels of movies, one channel of ESPN all-sports programming, plus two channels that carried a mixture of text news-reports, children's programming, music videos, an electronic program-guide, and other material. USCI, now using a Canadian Ku-band bird (14/12 GHz), is not currently scrambling its signal, although it plans to introduce scrambling later. **R-E**

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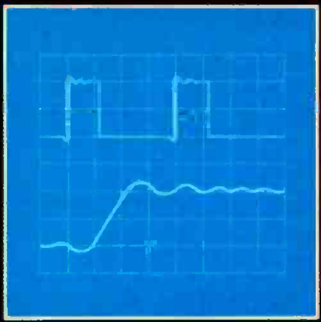

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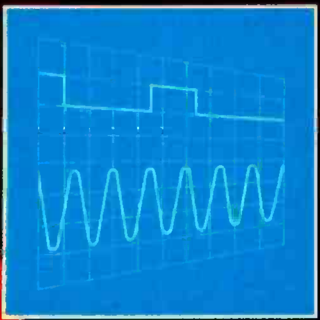

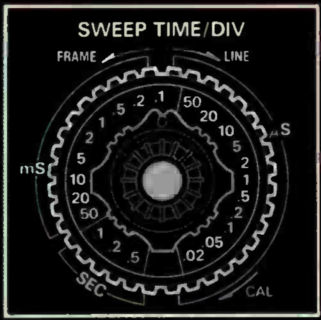

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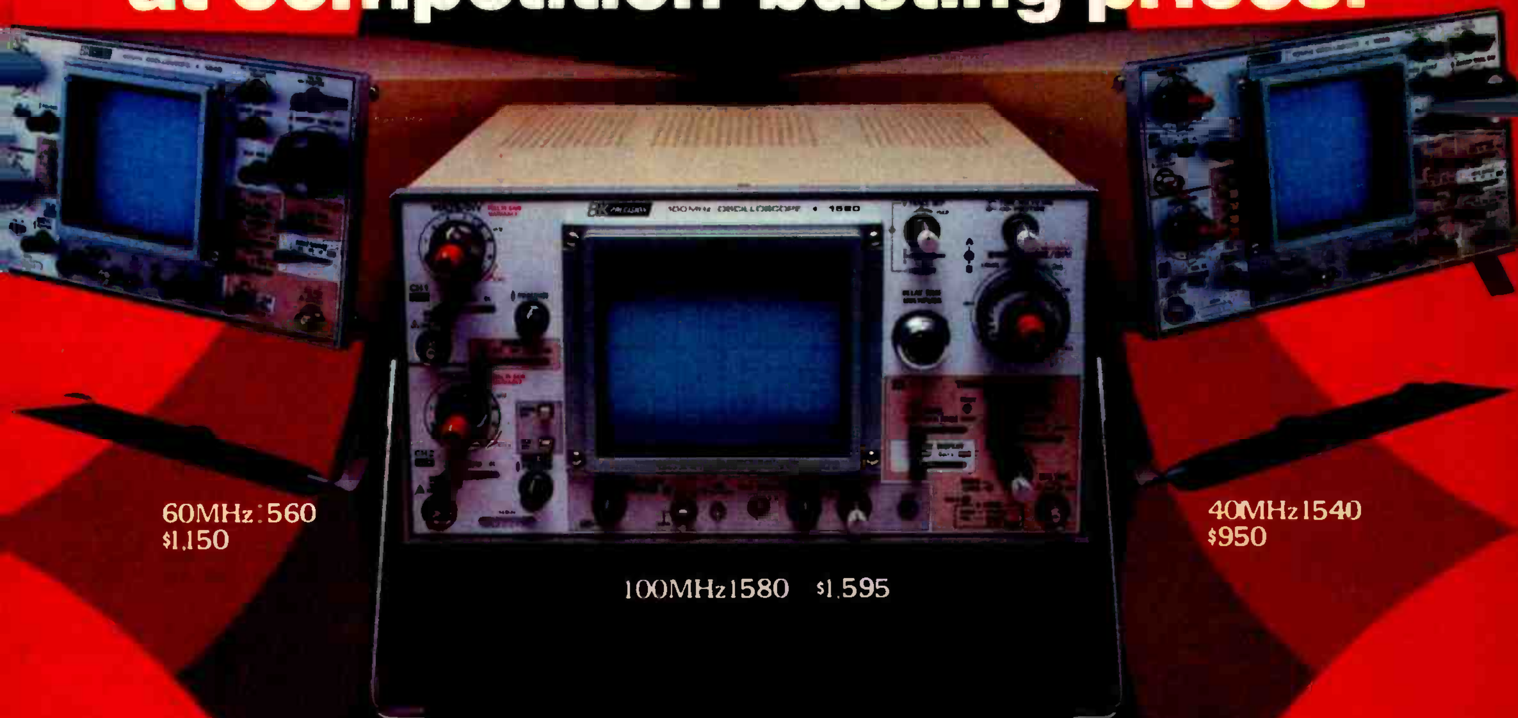

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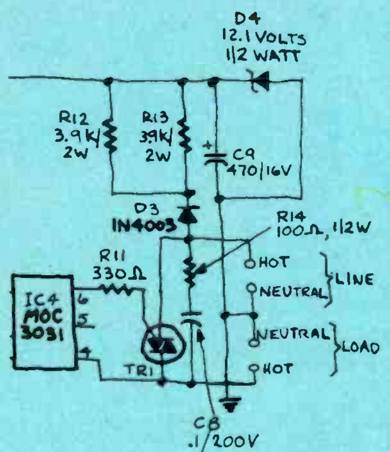
OOOOOPS!

A potentially dangerous error worked its way into the proximity power-switch schematic presented in the "New Ideas" column in the May 1984 issue of **Radio-Electronics**. In the lower right-hand corner of Fig. 1, the neutral line is connected directly to the load's hot line, short-circuiting the output. The neutral line should *not* be connected to the hot line. Instead, it should be connected to the circuit ground.(See figure to right.)—*Editor*



HELP WANTED

Perhaps you can help us or direct us to someone who can. Our problem is this: Recently we purchased a Model *10-40* Electronic Tube Tester. It was manufactured by Precision Apparatus Co., 70-31 84th Street, Glendale, 27 L.I., New York. On one of the old tube supplements it is indicated that Precision Apparatus is a subsidiary of Pacotronics Inc., same address.

The instrument seems to be in fine condition, but the last Tube Supplementary Booklet is dated 1964. What we need are updated Tube Supplements. I wrote to the above named company about eight weeks ago, and as of this writing, have received no response from this.

If you could offer us any information on this

continued on page 16

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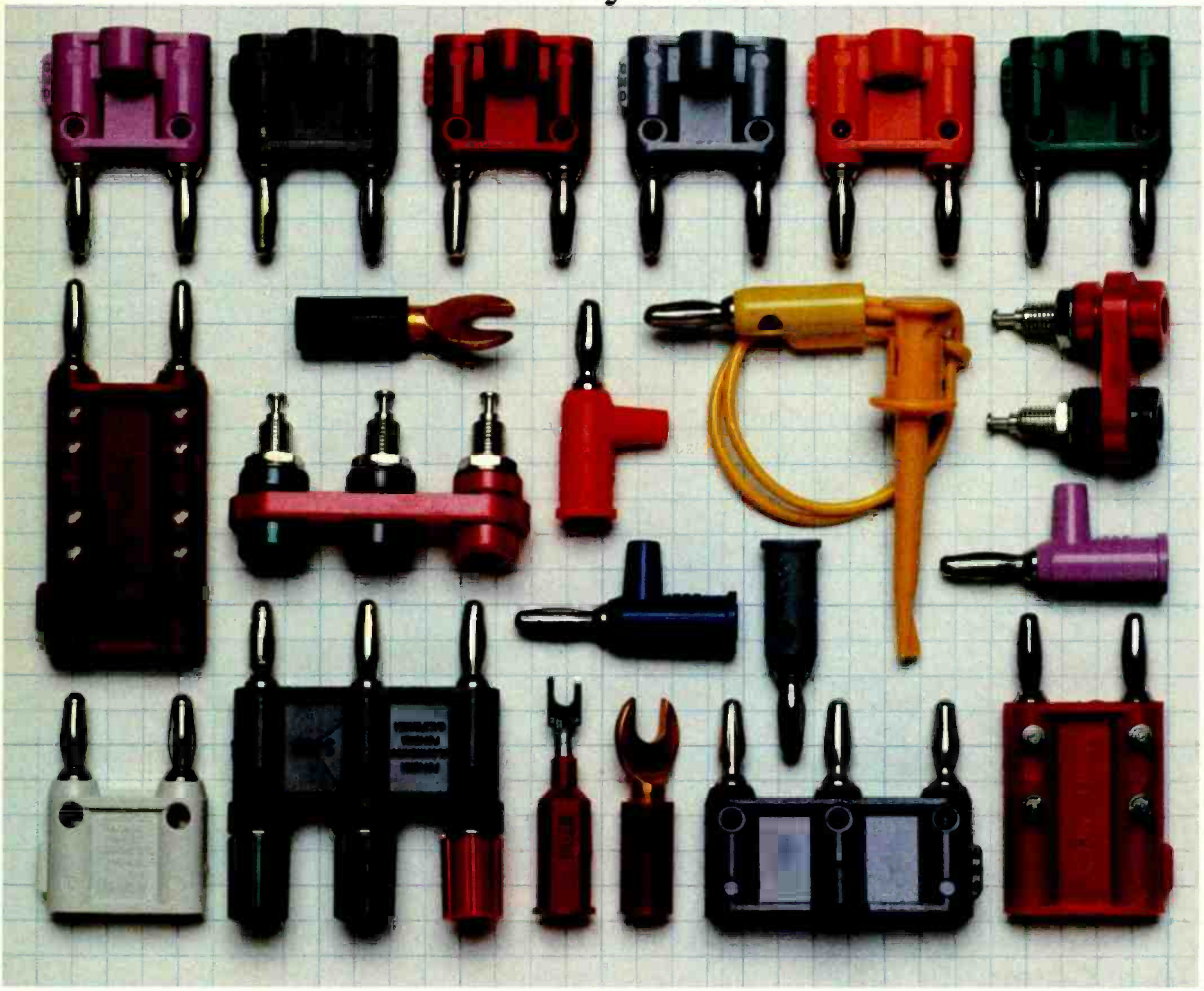

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CIRCLE 72 ON FREE INFORMATION CARD

LETTERS

continued from page 14

subject it would be deeply appreciated.

By the way, the serial number of the instrument is 1347, if that will be of any help.

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CABLE-TV DESCRAMBLING

The article in the February 1984 issue of **Radio-Electronics** on cable-TV descrambling methods has generated quite a bit of reader interest. Many readers are having trouble with the circuit because they cannot find certain parts or acceptable substitutes. That is partly our error, because we did not spell out some of the parts-specifications in the article. Let's take a look at some of the hard-to-find parts.

First of all, coil L1 has an inductance of 12 µH ±10%. It has a minimum Q of 30 measured at 2.52 MHz. Its typical self-resonant frequency is 33 MHz and its DC resistance is about 2 ohms.

Coil L2 has a nominal inductance of 0.071 µH. It is made from 3½ turns of 0.6-mm diameter wire on a 6-mm core. Its unloaded Q is a minimum of 120 at 100 MHz.

The other two coils in the circuit, T1 and T2, have a center frequency of 10.7 MHz with a

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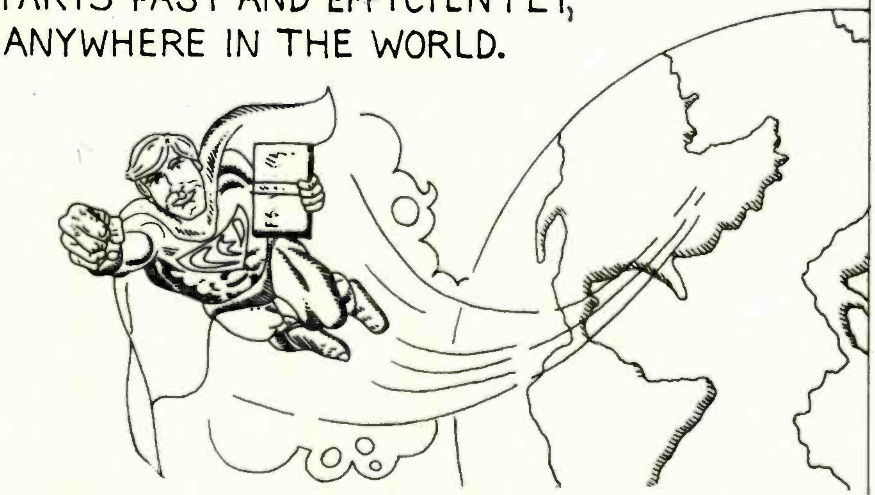

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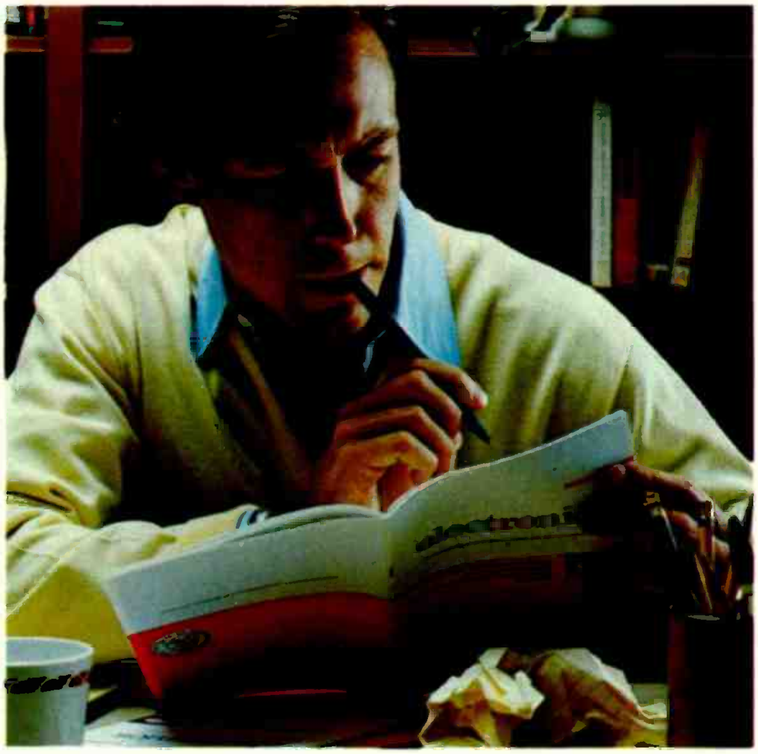

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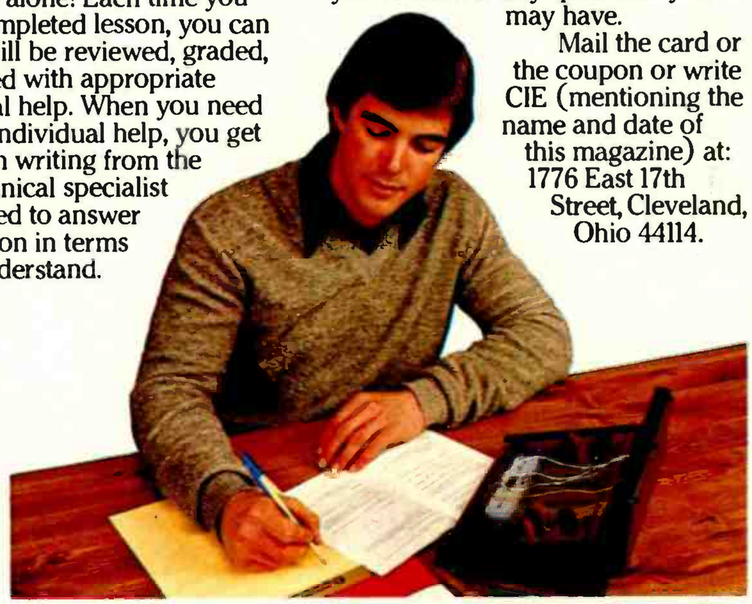

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LETTERS

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tuning range of 1 μH ±6% measured at 7.96 MHz. The unloaded Q is 60 ±20% at 10.7 MHz.

Transistor Q2, the BFQ85, which is no longer manufactured by SGS/ATES has the following absolute-maximum specifications:

Collector-emitter voltage, V_{CE}: 15 V
Collector-base voltage, V_{CB}: 20 V
Emitter-base voltage, V_{EB}: 3 V
Collector current, I_C: 40 mA
Power dissipation, P_D: 200 mW
DC Current gain, h_{FE}: 40 (minimum) to 200
Current-gain-bandwidth product, f_T: 4 (minimum) to 5 GHz
Noise Figure, NF: 3 dB @ 1 GHz.—*Editor*

STAY AS YOU ARE

Your "Stay as you are", comment in the March 1984 issue, expresses my sentiments exactly. I have been a subscriber for a number of years and sincerely hope that **Radio-Electronics** will stay as it is *now* and has been in the past.

ROBERT L. SITLER
Beaver, PA

IDEAL SWITCH

In the "What's News" department of the March 1984 issue, you mention a new General Electric solid-state switch that handles 12,000 watts. I didn't think a switch was suppose to handle any power at all. An ideal switch would handle infinite voltage with no current when open, infinite current with no voltage when closed.

How much is $0 \times \infty$?

JOHN R. SIMPSON
Tampa, FL

What is an ideal switch? If you ever find or build one, let us know so we can both *get rich. Real switches cannot handle infinite voltages—the insulation will break down and the contacts will arc. Real switches also have a finite resistance and cannot pass infinite amounts of current—they will melt. Solid-state switches suffer from similar breakdown problems. The GE insulated-gate transistor (IGT) switch described is rated at 25 amperes, 500 volts continuous, or 12,500 watts. That's not quite infinite, but it's a considerable improvement over earlier IGT's. (Incidently, $0 \times \infty$ is known as an indeterminate form and is undefinable.)*—Editor

OWNER'S MANUAL NEEDED

I purchased a *Precision* R.F. Signal Generator, model *E-200C*. The former owner did not have the owner's manual; it was either lost or misplaced, and the family was unable to find it.

I made several phone calls to the New York area and located the former factory, but the present occupants say that the Precision Company moved several years ago and left no forwarding address.

Will you ask your readers if there is an extra owner's manual for a *Precision* model *E-200C* somewhere in their shops?

R.F. STONEMAN
Roscommon, MI

R-E

Radio-Electronics mini-ADS

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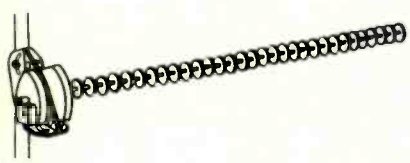

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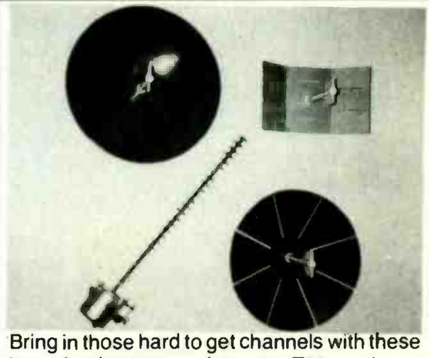

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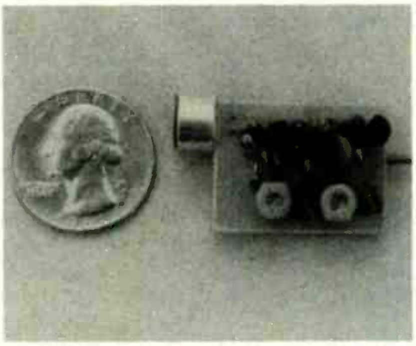

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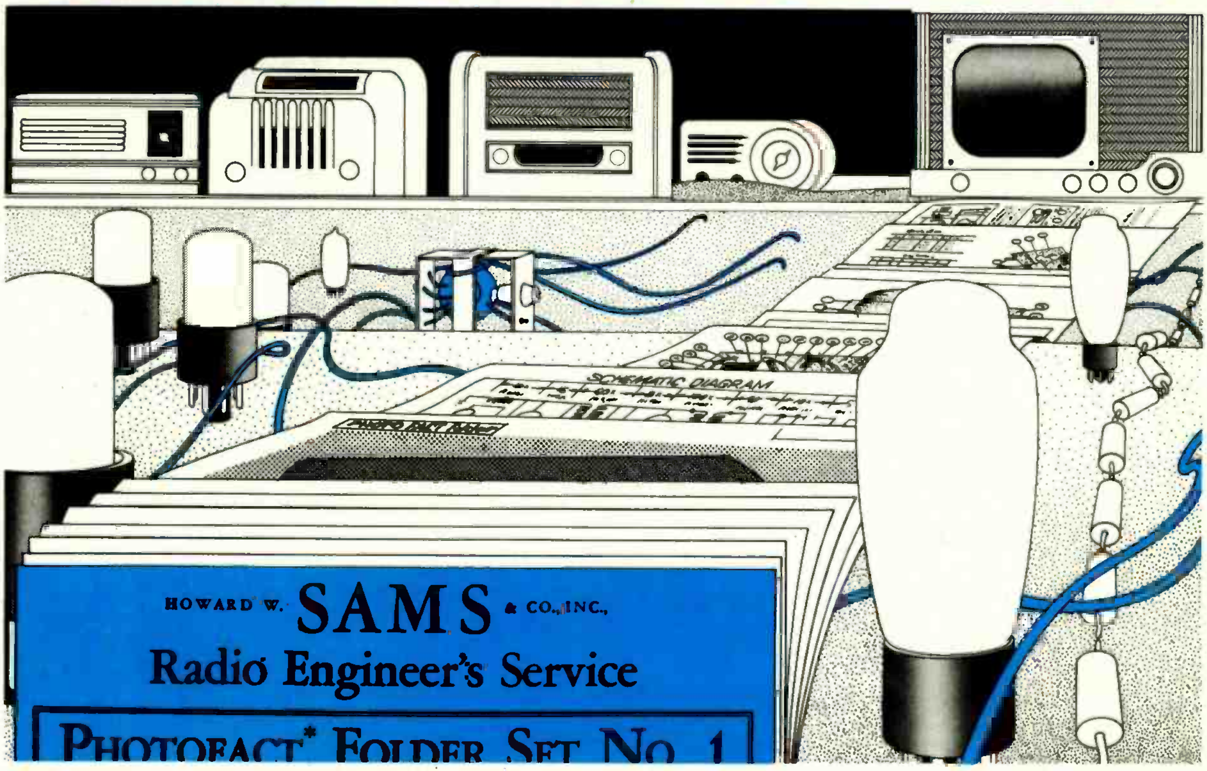

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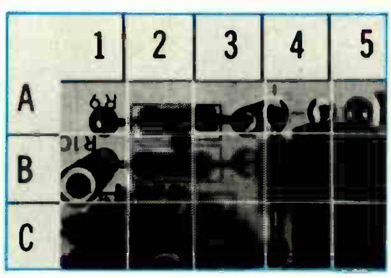

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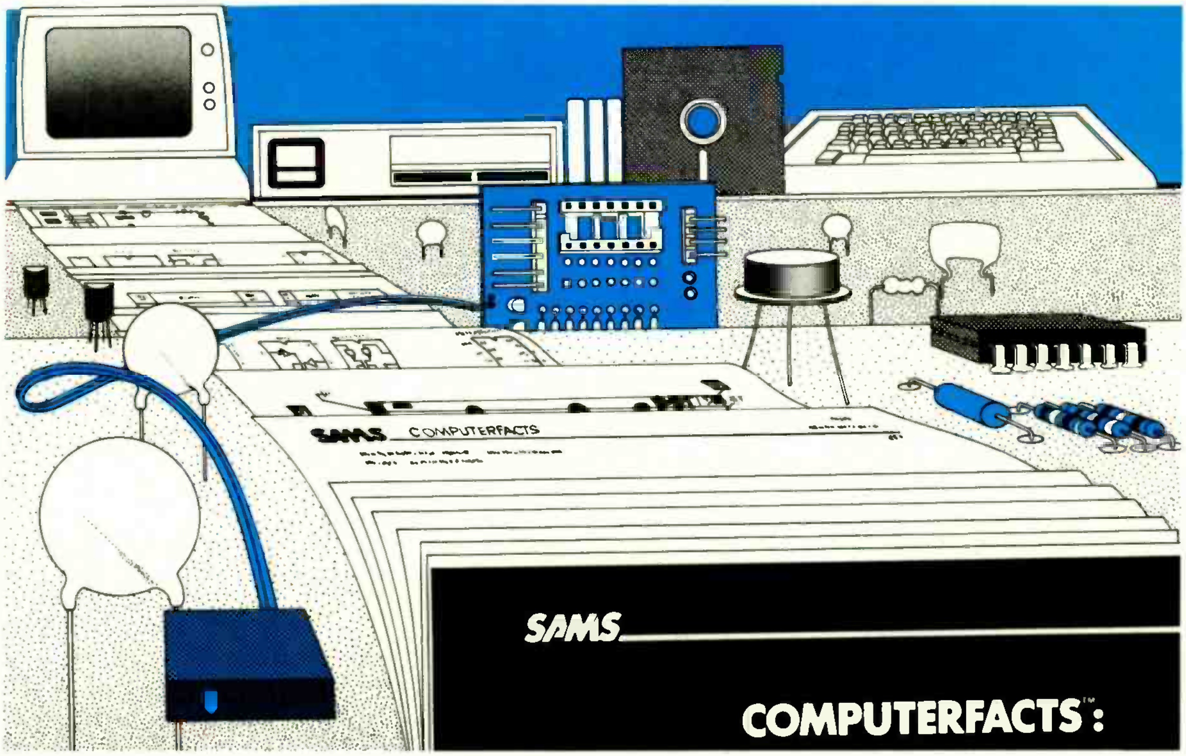

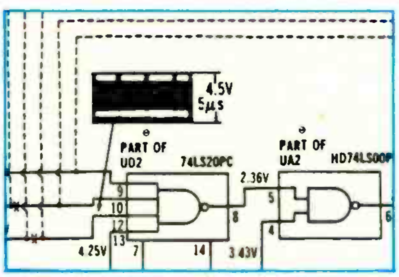

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EQUIPMENT REPORTS

Ungar Electronic Soldering System 9000

This soldering system lets you set the iron temperature precisely

CIRCLE 101 ON FREE INFORMATION CARD

WHETHER YOU ARE BUILDING AN ELECtronics project or repairing a piece of equipment, the most critical part of the job is the soldering. That's because even a single cold solder joint or solder bridge can cause a device to fail, and tracking down the source of that failure can often be next to impossible.

Of course, the most important part of the soldering operation is the iron itself. Well, for those who need or demand the best, Ungar (Division of Eldon Industries, Compton, CA 90220) offers their *Electronic Soldering System 9000*. That unit offers a selectable-temperature precision soldering iron, a built-in iron stand, and a large capacity sponge tray.

The unit is designed for maximum flex-

continued on page 32

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Global Proto-Board products are arrays of solderless sockets and bus strips that emulate PC board layouts while permitting instant insertion and removal of components from the largest DIP to the smallest discretes. With a rugged construction built to provide positive connections and withstand day-in, day-out professional use—even as test fixtures. And mounted on sturdy metal backplanes, for extended high-frequency use and extra durability.

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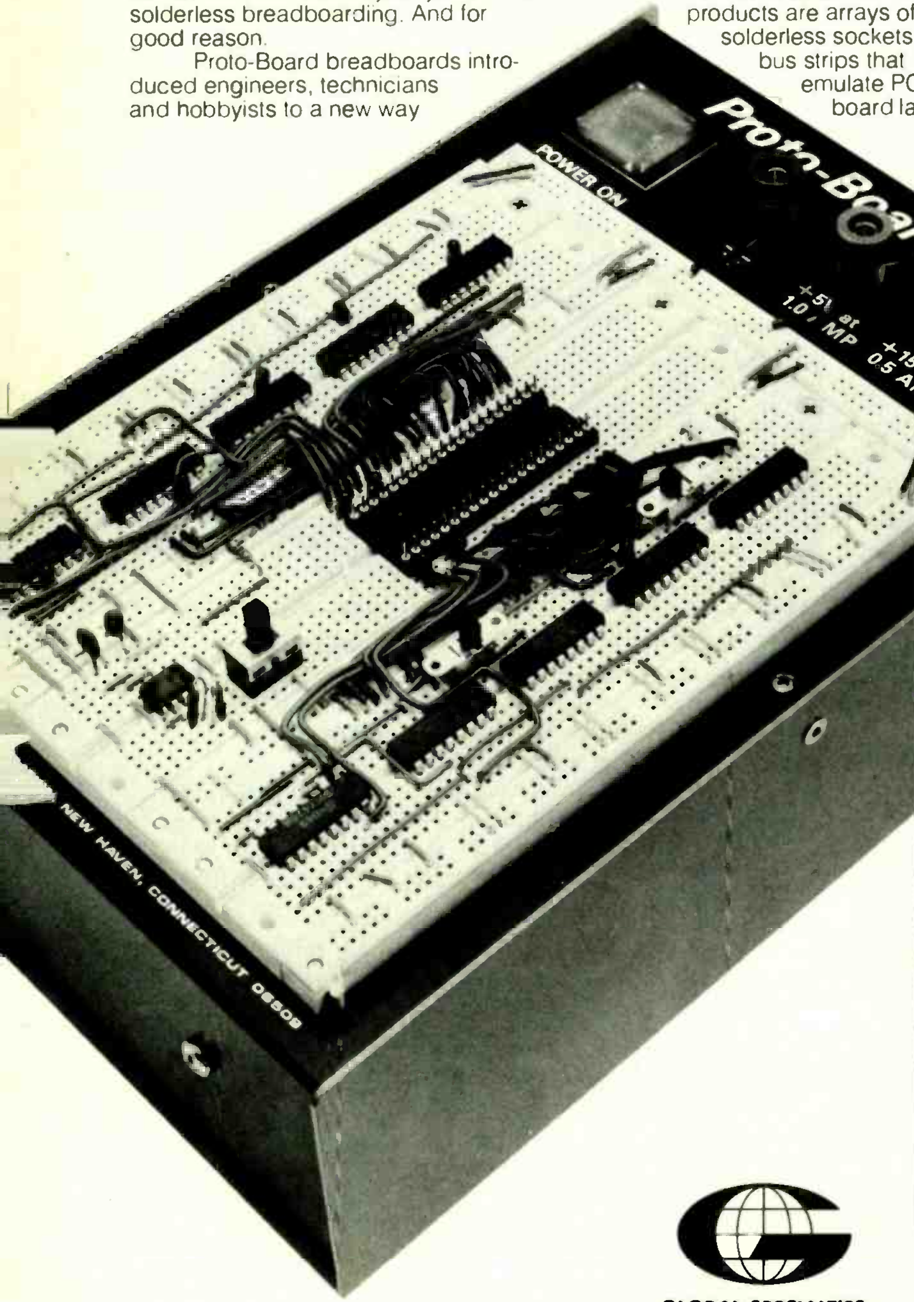

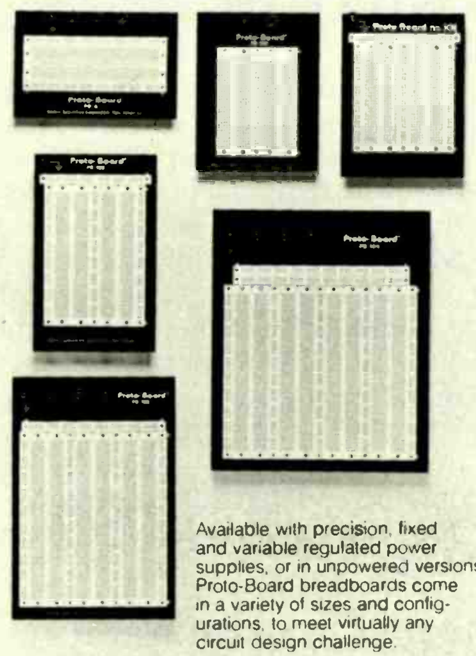

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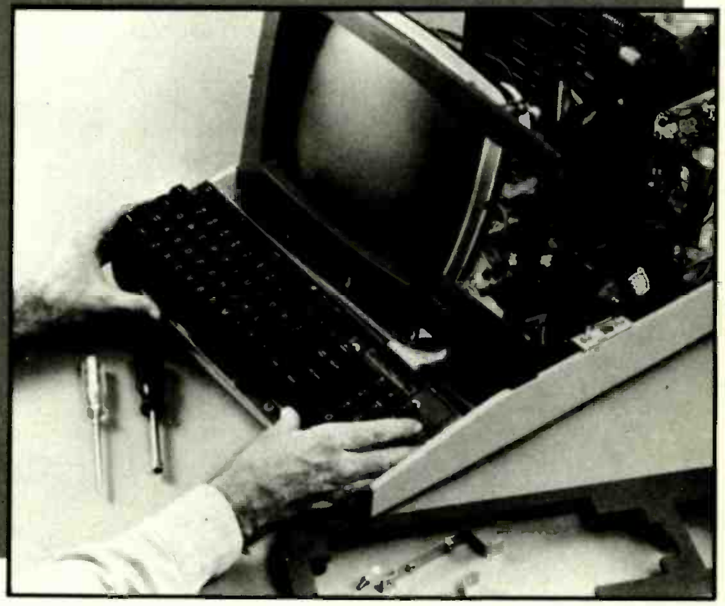

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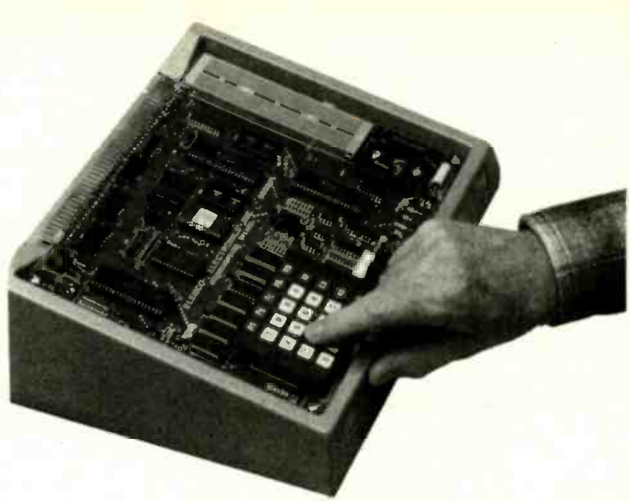
A GROWTH INDUSTRY

High-Technology is a growth industry. The evidence is clear, and most observers predict a steady expansion due to a relatively strong flow of investment capital into computers, electronics and precision instruments. Sales of computers alone will reach an estimated ten million units this year. This means challenges and new employment opportunities, especially in servicing and maintenance. Computer servicing skills can best be learned by working directly on field-type equipment. NTS electronic hardware is selected and developed especially for the training program with which it is associated. You learn by doing, by assembling, by performing tests and experiments, covering principles of computer electronics, microprocessor trouble-shooting, and circuitry.

MICROCOMPUTERS

NTS offers three programs in computer electronics. You will receive training covering solid-state devices, digital logic circuitry, and the fundamentals of the computer itself. Instruction includes micro-control technology and detailed operation of microcomputers. These courses will prepare you for entry-level in many facets of the computer industry such as field service and customer engineering as well as programming. In addition to written texts your course includes the NTS/HEATH disc-drive computer which you assemble as part of the training process. The assembly and use of the computer will serve to reinforce practical application of principles.



MICROPROCESSOR TECHNOLOGY

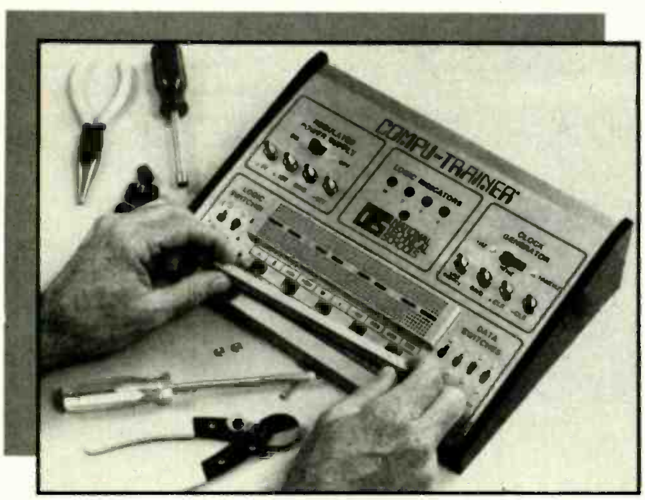
The field of industrial and microprocessor technology encompasses the application of electronic microprocessor control principles. Your course takes you from fundamentals of digital electronics and associated circuitry through the application of the microprocessor as a control device. You will learn how to move and manipulate instructions and information. The microprocessor trainer included in your course is a microcomputer system designed as a practical tool for learning the use of software and hardware techniques utilized in the linking of microprocessors to various systems.

DIGITAL ELECTRONICS

The NTS Compu-Trainer is a fascinating solid-state device which you will build in order to perform over ninety logic circuit experiments. These experiments serve to emphasize an area of electronics which is essential to the understanding of state-of-the-art control equipment; they are also extremely important to those wanting to pursue a career in computer servicing. Separate courses involving the Compu-Trainer are also available in Microcomputer Servicing and Digital/Analog Electronics.

ROBOTICS & VIDEO TECHNOLOGY

Other NTS courses cover a wide range of specialization. In Robotics, the NTS/Heath Hero I is included to train you in robotic applications in manufacturing processes. In Video technology, a new course features the advanced NTS/Heath Z Chassis "Smart Set" color TV with computer space command remote control and space phone. This is an excellent program for those interested in a career in video servicing with microcomputer basics.



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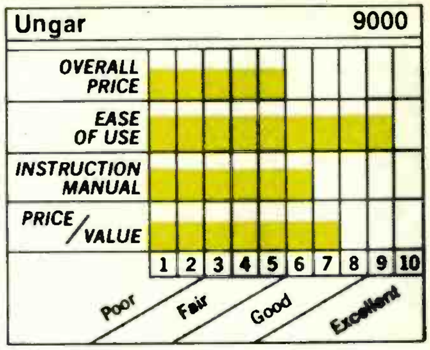
EQUIPMENT REPORTS

continued from page 26

ibility and convenience. The soldering station can be placed directly on a workbench using the base provided, or, if desired, the system control module, which houses the unit's electronics, can be removed from the base and placed under the workbench or on a shelf. The system control module can also be mounted under a shelf or on a wall using an optional mounting bracket. In addition, the iron holder and the sponge tray can be positioned to accommodate either right-handed or left-handed users.

Setting the temperature

But what really sets that unit apart is the adjustable temperature scale. Since the idling temperature can be adjusted over a range of 420°F to 800°F (215.5°C to 426.6°C), the user can set the idling temperature according to the requirements of a specific application. The settings are arranged in increments of 20°F over two ranges. Once set, the system will maintain the temperature to within ±10°F.



An LED-bargraph-type display is used to show the actual iron temperature. That type of display is used so that you can see clearly and directly that the unit has reached or is maintaining the selected temperature. A pulsating LED on the display indicates slight variations in iron temperature.

The system control module and base are made of attractive black and beige plastic. As is appropriate in this type of device, all the plastics are self-extinguishing to reduce any chance of a fire. Also for safety, the system is three-wire grounded, burn-resistant cords are used, and circuit-breaker protection is provided.

Operation of the unit is simplicity itself. The unit is switched on using a front-panel POWER switch, and the desired temperature is selected using the RANGE switch and TEMPERATURE slide control. Once he well-balanced iron with cool grip has reached the proper temperature, you're set to go. All controls and the readout are located on the system-control module.

Calibration of the unit is done against room-temperature. The procedure is done with a cold iron by turning the unit off, placing the RANGE switch in the center CALIBRATION position, and then turning the unit on. Once that's done, the ADJ control is rotated—using a slotted screwdriver—until the temperature readout, disregarding the the last zero, indicates the room temperature. That is, for a room temperature of 70°F, the readout should indicate 700°F.

As you might expect, the instruction manual is really no more than a four-page flyer. It covers some of the features of the unit, and briefly goes over its installation, use, calibration, and maintenance. Also included are some pointers on the preparation and care of soldering-iron tips. There is no information regarding the theory of operation, or a schematic. A list of user-replaceable parts, and their Ungar part numbers, is provided.

With its list price of $190.00, the *Electronic Soldering System 9000* is obviously not aimed at the occasional user. But, if you do a lot of building or repairing, and you are serious about the work that you do, then this unit, with its combination of precision and convenience features, is going to be hard to beat. **R-E**

Sabre Electronics Inc. Calc-U-Dial Automatic Dialer

An automatic call dialer that's also a call timer and a calculator

CIRCLE 102 ON FREE INFORMATION CARD

IN THESE DAYS OF HIGH LONG-DISTANCE phone bills, it's not uncommon to subscribe to one of the independent long-distance telephone services. But using one of those services usually involves entering a long billing or access number. That is an inconvenience, and there is always a chance that you might forget the number or make a mistake entering it. Also, using those services requires a phone that generates DTMF (*Touch-Tone*) tones. If you only have pulse (rotary) equipment you are out of luck. That is, unless you have a device such as the *Calc-U-Dial* from Sabre Electronics (344 El Camino Real, San Carlos, CA 94070). But, as we'll soon see, that device is far more than just a telephone dialer.

A dialer

The unit is a hand-held device that generates DTMF tones. No direct connection to telephone equipment is needed. When dialing a number, the unit's rear speaker is held up to the mouthpiece of the telephone's receiver.

Up to six 16-digit numbers can be stored. The storing process is simplicity itself. The device is turned on and placed in the store mode by pressing the STOR button. Then, using the calculator-type keypad, a storage "location" from one to six is selected and the number entered. Once the number is entered, the store mode is exited and the unit is turned off by pressing the STOR button a second time. So that you don't forget where each number is stored, an area for writing down that information is provided on the back of the unit.

The unit is capable of generating all of the DTMF tone pairs, including * and #. In addition, if you require a pause in your dialing sequence, it can be stored using a P button on the keypad.

As easy as entering a number is, dialing one is even easier. All you do is hold the unit's speaker to the telephone's mouthpiece, press AUTO, and key in the memory location of your number; the dialer does the rest. Once the number has been dialed, it is shown on the unit's 10-digit LCD readout. For stored numbers longer than 10 digits, a ± key can be used to alternately view the first and second part of the number if you wish.

The dialer also has an automatic redial feature. That allows you to redial the last number called by simply pressing the REDL key.

continued on page 36

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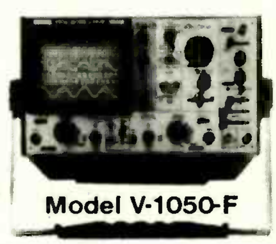

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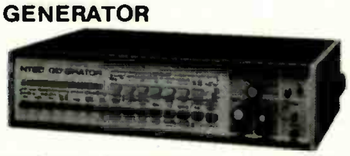

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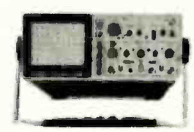

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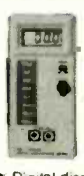

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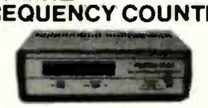

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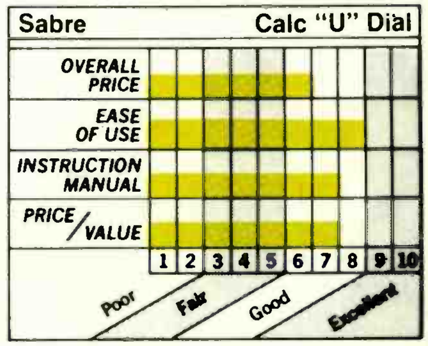
continued from page 33

Finally, numbers that are not stored in memory can be dialed by placing the unit in the manual mode. That's done by pressing the MANL button and keying in the digits. One potential problem in using the device in that manner is that keying in a long number while holding the rear speaker against the telephone's mouthpiece can be inconvenient. Fortunately, the redial feature also works with numbers entered in the manual mode. Thus, all you need do is to enter the number, turn off the unit, then hold the speaker up to the telephone's mouthpiece and press REDL. When used in that manner, the redial feature acts as a seventh storage location.

A call timer

If the *Calc-U-Call* were just a dialer it would still be a handy device. However, the unit does much more. For instance, it is also a call timer. Thirty seconds after a call has been made using either the AUTO or REDL keys, the dialed number display blanks and is replaced by the duration of the call in minutes and seconds. The unit will time calls up to 50 minutes long. After 50 minutes, the unit will turn itself off. The call timer can be turned off before 50 minutes by simply pressing the OFF button.



A calculator

Lastly, but certainly not least, the *Calc-U-Dial* automatic dialer also is an 8-digit calculator. In addition to the normal arithmetic functions (+, −, ×, ÷), the unit can square, do square roots, and take percentages. In addition, the unit can accommodate scientific-notation entry and display. When scientific notation is used, the exponent (power) of 10 is shown at the far right of the display.

The small manual that comes with the *Calc-U-Dial* does a good job of explaining how to use the unit, and detailed examples are given for a variety of circumstances. As you would expect in a consumer unit of this type, no technical information is provided.

All-in-all this is an interesting and useful device that works exactly as claimed. The *Calc-U-Dial* is covered by a 90-day warranty and has a suggested retail price of $49.95. **R-E**

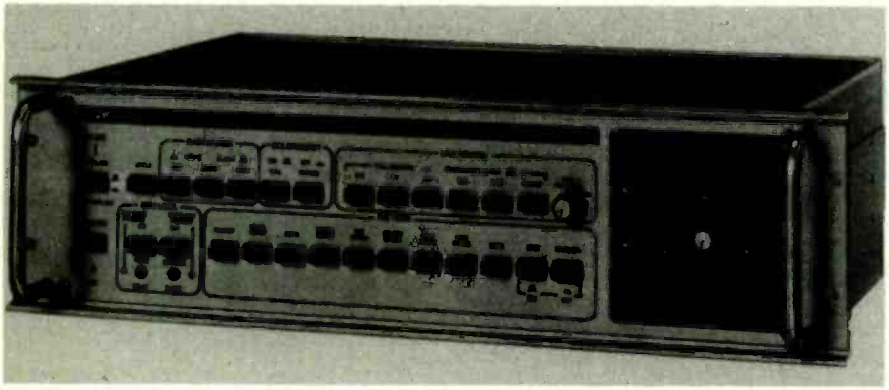
"Sure, they turned off the power. But by ignoring my electric bills, I accumulated enough to buy this unit!"

NEW PRODUCTS

For more details use the free information card inside the back cover

SIGNAL GENERATOR, model *1260* features gen lock; RGB outputs; blackburst; gated or full-field multiburst; a full assortment of convergence patterns and raster colors; NTSC color bars, IWQ and staircase; selectable interlaced or progressive vertical scan, and auxiliary input and output signals.

The model *1260* generates virtually every type of test signal and pattern needed for complete testing, servicing, and adjustment of all types of television and video equipment, including TV receivers, VTR's, VCR's, VDP's, CCTV, MATV, and CATV systems and components. It is priced at $1695.00.—**BK Precision,** 6460 West Cortland Street, Chicago, IL 60635.



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UNINTERRUPTIBLE POWER SYSTEM, the LINE-SAVER™, model *LS-240*, is a standby system for use in the home and small-business computer market. It is available for 120/240 volt, 60/50Hz systems, and has 240-VA, 150 watt capacity. The unit uses pulse-width modulation (PWM) technology to regulate the AC output voltage for greater efficiency to various load conditions. The PWM-AC output will also increase battery efficiency to increase back-up time: 5–10 minutes full load, 20–25 minutes half load, 35–40 minutes ⅓ load.

In addition there is an internal 12-volt sealed rechargeable battery, four voltage-surge protected and EMI/RFI filtered AC outlets, audible and visual power-failure warnings systems, test-mode indicator and switch, and replaceable external fuses.

The unit comes complete with a 6-foot, detachable, 3-prong, heavy-duty cord-set with a CEE-22 connector.

The suggested retail price of the model *LS-240* is $395.00.—**Kalglo Electronics Co., Inc.,** Dept. LS, 6584 Ruch Rd., E. Allen Twp., Bethlehem, PA 18017.

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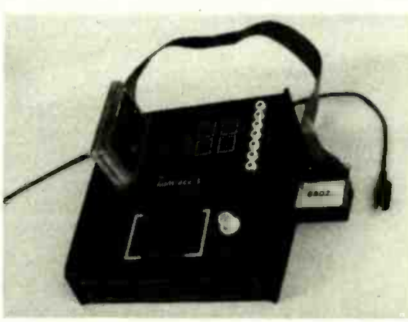

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Intended mainly for applications involving single-board computers, *Addtrace I* is connected directly to the microprocessor IC via a

continued on page 42

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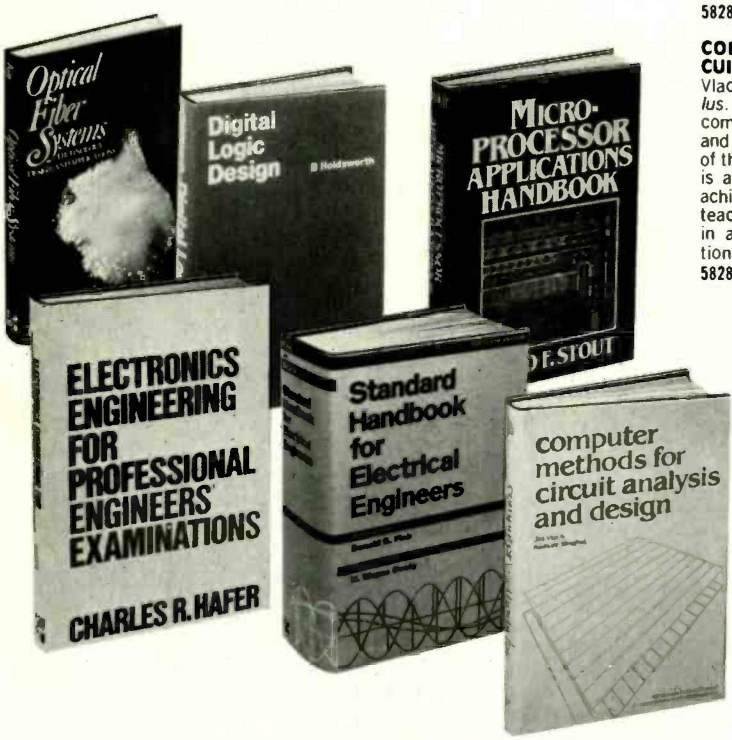

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NEW PRODUCTS

continued from page 37

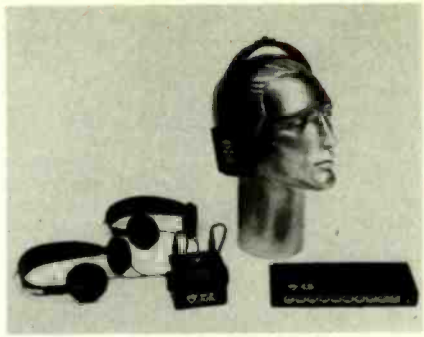
40-pin DIP clip. A special plug-in module adapts the unit so that it is suitable for use with most microprocessors.

There are seven output jacks on the front panel for monitoring pulse duration and timing relationships with an oscilloscope. There are sixteen input lines and six user-definable control lines.

Addtrace I is available in kit form for $199.95. (Factory-wired prices are available on request.)—**BMH Company, Inc.,** 224 Vassar Street, Reno, NV 89502.

CORDLESS STEREO HEADPHONE system works with any audio source: stereo systems, TVs, and radios. It consists of a transmitter and stereo headphone receiver, or transmitter and stereo receiver for use with any headphones.

The components use infrared light to transmit audio information normally carried by wire. The transmitter, *IRT-200*, installs easily; hookup is by phone plug, and adapters are included. With both headphones and receivers, the range is about 35 feet. The system can be used for either stereo or mono.



CIRCLE 114 ON FREE INFORMATION CARD

The stereo headphones, model *IRH-210* have full frequency response, 50-15,000 Hz. The infrared sensor is on top of the headphones for optimum reception. Any number of headphones can be used with the *IRT-200* transmitter.

The *IRSR-220* infrared stereo receiver works with any stereo earphones. Two can listen at once with the unit, which can be placed up to 35 feet from the audio-source/*IRT-200* transmitter hookup.

The system has a retail price of under $100.00.—**Nady Systems,** 1145 65th Street, Oakland, CA 94608.

TWO-WAY FM RADIOS, the basic medium-power Midland *SYN-TECH* mobiles and base stations have had their transmit and receive bandwidths increased.

The bandwidth of the 50-watt low-band (29–54 MHz) VHF models is being doubled from 1 MHz to 2 MHz. The 40-watt mid-band (66-88 MHz) models will have an increased bandwidth from 2 MHz standard to 8 MHz

CIRCLE 115 ON FREE INFORMATION CARD

(transmit) and 3 MHz (receive). The 40-watt high-band VHF bandwidths will increase from 4.5 MHz to 7 MHz (transmit) and 6 MHz (receive). The 30-watt UHF model's bandwidth increases from 10 MHz (transmit) 5 MHz (receive) to l5 MHz (transmit), 8 MHz (receive). All other ratings of the new wider-bandwidth models remain at full published specifications.

Inexpensvie conversions kits are available for field installation on existing units. The total cost of the enhanced-bandwidth conversion kits, including installation, is expected to be under $20.00.— **Midland LMR,** 1690 N. Topping, Kansas City, MO 64120. **R-E**

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BILL OWEN

MANY PEOPLE DREAD THE SUMMER months. It's not because of the heat—it's because of what happens to utility bills once the air conditioner starts running. But as we'll show you, you can keep your bills down while still staying cool. The only requirements are that you have central air conditioning and that the air conditioning uses 24-volt DC control circuits.

When we say we feel hot or cold, we are really describing how comfortable we feel—not necessarily the air temperature. That's because the human body is a poor thermometer: Along with the temperature, it responds to humidity, air movement, and fresh air. For example, we've all heard of the wind-chill factor (a formula which takes into account the effects of air movement on how cold we feel). And all of us have experienced being uncomfortably hot when it's 79°F, and muggy (humid) but quite comfortably cool when it's 78° and dry. (And we've all heard too many times—and we're bound to hear it many more times as the weather heats up—the expression "It's not the heat, it's the humidity.)

Problems with a thermostat

Air conditioning equipment is controlled by a thermostat which, unlike us, can respond *only* to changes in air temperature. If we attempt to economize by increasing the thermostat setting, we will save money. But we'll also reduce the amount of time that the compressor runs, increase humidity, reduce air movement, and allow room air to grow stale. The device that we'll describe uses the proven principal of *time cycling* to keep a comfortable effective air temperature while reducing the actual air-conditioner operating time. It cycles the air conditioner more frequently to reduce humidity, increase air movement and remove stale air. Comfort is maintained with reduced compressor operating-time, resulting in significant savings.

Another problem with a thermostat is that it can respond only to changes in temperature near its location. Because of that, it often cannot provide fine control—it permits the room temperature to vary from uncomfortably cold to uncomfortably hot with no in-between. However, with the flexible COOLING CYCLE control of the device that we'll build, the exact amount of cooling can be easily programmed.

The device that we'll build is effective (and most efficient) when used in conjunction with a ceiling fan. When used that way, you can program the air conditioner to run for minimum-length cycles (to introduce dry, fresh air as needed) but you can still stay comfortable because of the increased air movement that the ceiling fan provides.

Another application for the device is in humid areas where it is necessary to run air conditioning when you are away from home to prevent mildew and damage to furniture, carpets, drapes and artwork. The extended-cycle feature is ideal for unoccupied homes or buildings. In that setting, the "energy mizer" will cycle the air conditioner on for 5 minutes, followed by a 30-minute off period. Valuable furnishings and possessions will be protected because the air conditioner will run at regular, predictable, and economical intervals, where as a thermostat may or may not operate depending upon temperature variations.

A feature normally found only in expensive energy management systems is the fan run-on timer. Normally, when the air conditioner's compressor shuts down, the fan motor stops as well. That leaves cool air trapped in the duct work and cold compressor-coils. However, the fan run-on timer of the device that we'll build lets the fan run for 90 seconds after the compressor stops—allowing the fan to pull cool air into the living space. That feature alone can help you realize significant energy savings, and thus saving you enough money so that you can recoup your investment in a very short time.

A look at the circuit

Figure 1 is the schematic of the cycling-time control circuit. Three monostable timers (IC1, IC2, and IC3) correspond to the three timed intervals. The first timer, IC1, controls the fan-on time—the amount of time that the fan runs on after the compressor shuts off. The second timer, IC2, controls the compressor-on time and the third timer, IC3, controls the compressor-off time. Let's take a look at how it works.

When power is initially applied, the R4-C1 time constant keeps the trigger input (pin 2) of IC2 (which controls the compressor-on time) low enough to ensure triggering. The output from IC2 switches high for a period of time determined by the parallel combination of capacitors C4 and C5 and series resistors R1 and R7. Depending upon the position of control R1 (the COOLING-CYCLE control), the compressor-on time will be between 5 minutes and 20 minutes.

At the end of the on cycle, IC2 pin 3 switches low, triggering IC1 (pin 2) through capacitor C9. Pin 3 of IC1 switches high for 90 seconds (as determined by C11 and R13). At the end of the 90-second fan-on period, IC1 pin 3 switches low, triggering IC3. The output of IC3 (which controls the compressor-off time) will go high for a time interval that is selected by S1. In the CYCLE 1 position, that compressor-off interval is 15 minutes, as determined by C6 and R6. In the CYCLE 2 position, the compressor-off interval is 30 minutes, as determined by C6 and the series combination of R3 and R6.

During the compressor-on interval, IC2 pin 3 is high, which turns on transistor Q1, energizing relay RY1 and the associated LED indicator. Relay RY1 completes the 24-volt control circuit for the compressor-motor contactor. Similarly, during the fan-on interval, relay RY2 and its LED indicator are energized through transistor Q2. During the compressor-off interval, IC2 pin 3 is in its low state, and LED1, the COMPRESSOR-OFF LED, is lighted.

The three timers continue in sequence (compressor on, fan on, compressor off) until power is interrupted. When power is reapplied, the compressor-on timer will begin the sequence.

We don't have to build a power supply for our cycling controller—it obtains its power from the control-voltage transformer inside the air conditioner. One side of that 24-volt AC secondary is brought out directly to the thermostat and is (usually) labeled R. (See Table 1 for some common thermostat markings.) The other side of the secondary is available indirectly through the heater contactor-coil (labeled W).

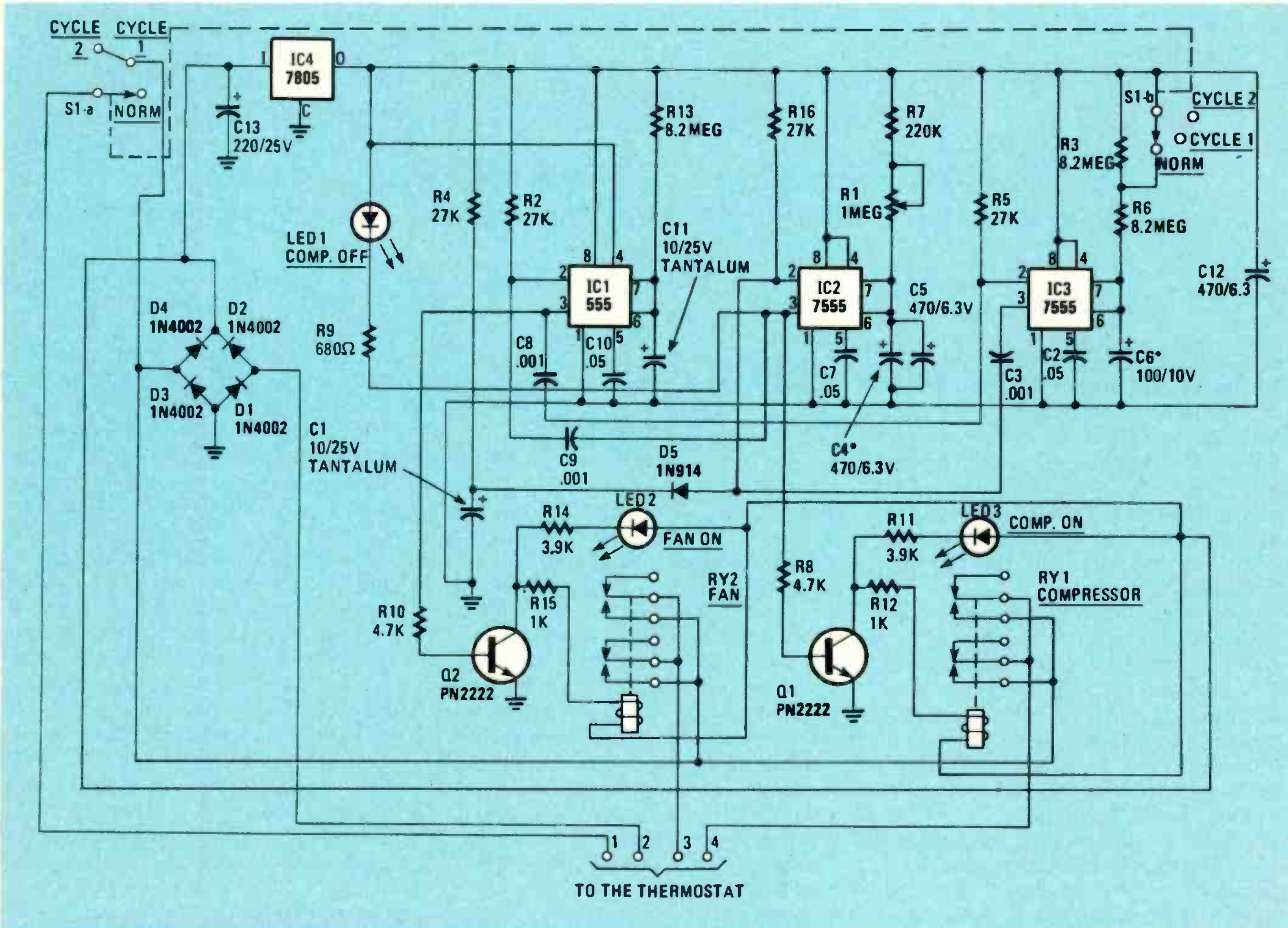


FIG. 1—THREE TIMERS ARE USED to provide compressor-on, compressor-off, and fan-on intervals. Two of the timers are 7555 types because of the long time constants required. Note that the capacitors marked with an asterisk (*) are low-leakage electrolytics.

TABLE 1—HOOKUP

Cable/Color	Possible thermostat-terminal markings				
1/Red	R5	R	RH	4	M
2/White	4	W	W	W	H
3/Green	G	G	G	G	F
4/Yellow	Y6	Y	Y	Y	C

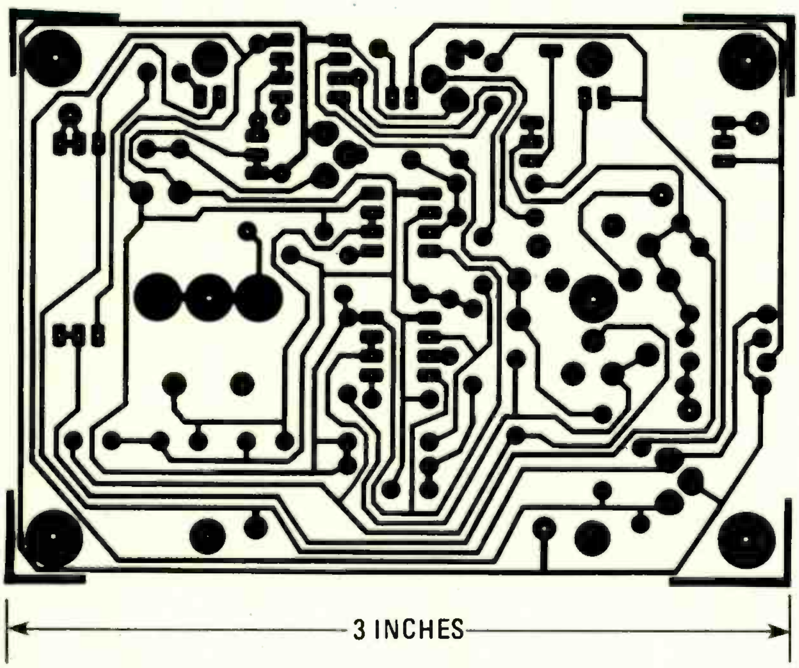


FIG. 2—FOIL PATTERN for a single-sided board is shown full size.

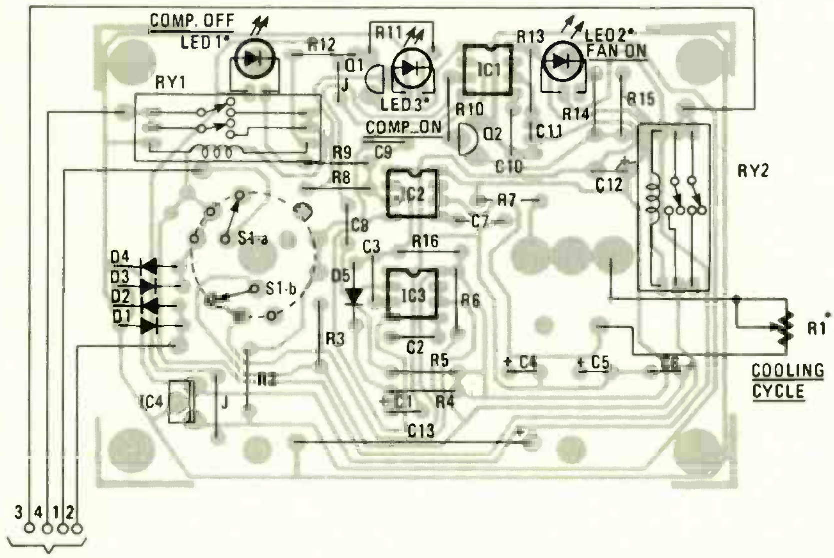


FIG. 3—PARTS-PLACEMENT diagram. The three LED's (marked by *) are mounted on the foil side of the board, as is R1, the COOLING-CYCLE control.

Since the "energy miser" will not be used during reverse-cycle or heat-cycle operation of the air conditioner, we can use a small amount of current (about 50 mA) through the heater contactor (relay) coil. (If more current were drawn through the heater contactor- coil, it might energize the contactor.) Of course, you can use a small transformer instead. Diodes D1 through D4 form a full-wave bridge rectifier. The "R" line from the thermostat is connected to the pole of S1-a (through line 1) and is applied to one bridge input through the switch. The "W" thermostat line is connected to the other bridge input through line 2. The DC output-voltage is filtered by C13 and regulated to five volts by IC4.

PARTS LIST

All resistors ¼-watt, 5% unless otherwise noted.
R1—1 megohm, potentiometer
R2,R4,R5,R16—27,000 ohms
R3,R6,R13—8.2 megohms
R7—220,000 ohms
R8,R10—4700 ohms
R9—680 ohms
R11,R14—3900 ohms
R12,R15—1000 ohms
Capacitors
C1,C11—10 µF, 25 volts, tantalum
C2,C7,C10—.05 µF, ceramic disc
C3,C8,C9—.001 µF, ceramic disc
C4,C5,C12—470 µF, 6.3 volts, low-leakage electrolytic
C6—100 µF, 10 volts, low-leakage electrolytic
C13—220 µF, 25 volts, electrolytic
Semiconductors
IC1—555 timer
IC2,IC3—7555 timer (CMOS version of 555)
IC4—7805 5-volt regulator
D1–D4—1N4002
D5—1N914 or 1N4148
Q1,Q2—PN2222
RY1,RY2—reed-type relay
S1—PC-mount, 3P3T
LED1–LED3—miniature red LED's
Miscellaneous—PC board, cabinet, knobs, machine screws, hookup wire, IC sockets, etc.
The following is available from NRG Electronics, P.O. Box 24138, Ft. Lauderdale, FL 33307; drilled and etched PC board, $9.95; complete kit, $29.95; wired and tested unit, $49.95. Include $1.50 to cover postage and handling and $2.00 for C.O.D. orders.

Assembly

You can easily build this energy-saving device by using a printed circuit board. A PC board isn't essential—point-to-point wiring can be used—but a board is recommended, if only for its neatness and ease of troubleshooting. A suitable foil pattern is shown in Fig. 2. To assemble the project, simply follow the parts-placement diagram of Fig. 3. However, if you plan to mount the board in a cabinet (and that's surely recommended), you should prepare the cabinet before you start soldering. You'll want to mark the locations of R1, S1, and the three LED's on the front panel. Then drill the front panel at those points to fit your components.

Make sure to use good quality rosin-core solder and a fine-tipped pencil-type soldering iron. Place and solder the resistors and diodes first followed by the IC sockets, capacitors and transistors. Be sure to observe polarity with the dipped tantalum and electrolytic capacitors, the transistors, and the diodes. Place and solder potentiometer R1 on the foil side of the PC board. Mount switch S1 on the component side of the PC board and solder. (Figure 4 shows the component side of the

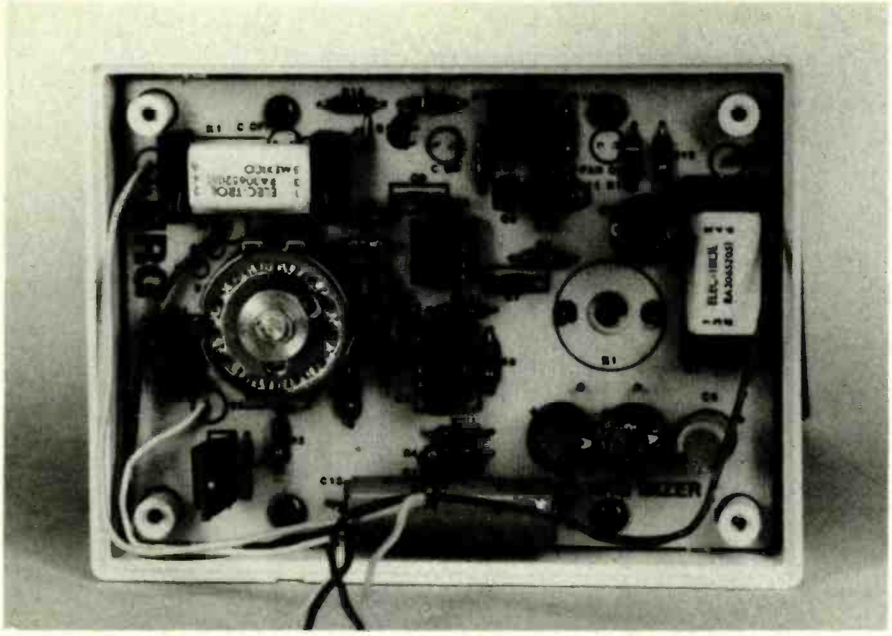


FIG. 4—COMPONENT SIDE. Although the unit is small (about 3×4 inches), the components aren't densly packed.

FIG. 5—USING A PLASTIC case for the project allows you to simply use double stick foam tape to mount it to the wall.

completely assembled PC board.) Next install the three LED's on the foil side of the PC board. Note that the LED's must be polarized correctly. Temporarily fit the PC assembly into the cabinet top and push the LED's into the holes in the cabinet. Clinch the LED leads and carefully remove the PC assembly from the cabinet and—without changing their adjustment—solder the LED leads to the foil. Relays can now be placed at RY1 and RY2 and soldered.

Use excess component leads as wire jumpers and solder at the locations marked "J" on the parts-placement diagram. Finally, install the four wires that you'll use to hook up the device to your thermostat. The leads should be color-coded: The leads marked 1, 2, 3, and 4 on the schematic and parts-placement diagram should be red, white, green, and yellow respectively.

Before installing the unit, it's a good idea to check its operation. Let's now see how to go about doing that:

With controls R1 and S1 set at MIN and NORMAL, connect the red and white wires to an 18-24 volt AC or DC source. (If none is available, two 9-volt transistor radio batteries in series will suffice.) Switch to CYCLE 1 and note that the COMPRESSOR-ON lamp will light.

The proper LED-lighting sequence will start with COMPRESSOR ON, which will stay lit for between 5 and twenty minutes (depending on the setting of the COOLING-CYCLE control) That will be followed by the lighting of the FAN-ON LED for 2 minutes while at the same time "COMPRESSOR OFF" is lit for 15 minutes (in CYCLE 1) or 30 minutes (in CYCLE 2). After IC3 times out, the cycle will begin again when IC2 is triggered again. Remember that those times are approximate and will vary from unit to unit.

If that test shows that something is wrong, you can troubleshoot the unit by "manually triggering" its operating modes. Remove the integrated circuits and, with power applied, make the following jumps using fine gauge wire in the IC sockets. Jumpering IC2 pin 3 to IC2 pin 1, you can test the compressor-off operation and by jumpering IC2 pin 3 to IC2 pin 4, you can test compressor-on operation. To test fan-on operation, jumper IC1 pin 3 to IC1 pin 4.

Installation

During installation, **remove power to the air conditioner at the circuit-breaker panel**. Install the device next to the thermostat. Double-stick foam tape will easily hold the unit on a wall as shown in Fig. 5. Remove the thermostat cover to expose the wire terminals on or behind the wall mounting plate. Cut the wires from the unit to a convenient length and make the connections to the thermostat indicated in Table 1. (It may be necessary to trim some plastic from the thermostat cover or base to allow for wire passage. Switch the "energy mizer" to NORMAL and restore power to the air conditioner. Set the air conditioner to "cool," and the fan to "auto" and set the thermostat high enough so that it does not come on. Set the "energy mizer" to MIN and CYCLE 1. When that's done, the air conditioner should come on and the COMPRESSOR-ON LED should light.

Tips

The thermostat acts as a high limit and will override the device if the room temperature rises above the set temperature. When using the heat cycle, switch the "energy mizer" to NORMAL.

The CYCLE 2 mode provides an extended-off period (about 30 minutes) that is useful for unattended dwellings for humidity control. If the unit is set to MIN and CYCLE 2, the air conditioner compressor will run for 5 minutes followed by a 30 minute off period.

The most economical operation is achieved by setting the fan on auto rather than continuously on. The fan-on timer will keep the fan running for about two minutes after the compressor stops to purge cool air from the duct work and compressor coils. **R-E**

HOW TO

Tune Up Your MDS Downconverter

LEW G. SCHUWEILER

Tuning microwave downconverters can be a real headache—but it doesn't have to be. We'll look at a way to get around some of the problems normally associated with that task.

THE POPULARITY OF MICROWAVE DOWN-converters for use in receiving Multipoint Distribution Service (MDS) signals has grown enormously over the past couple of years. Check the classified section of any electronics magazine and it's sure to have advertisements for downconverter parts and kits. As a result, there are a growing number of kits and home-brew converters in the hands of electronics enthusiasts. The only problem is that once the kit is assembled, the builder is then faced with the awesome task of making sure that the circuit works properly. To understand the proper procedure for tuning and troubleshooting a receiver, it's best to review some background information about downconverter circuits first.

The downconverter system

The main function of a downconverter is to convert microwave signals down to a frequency that's low enough to be received by your television set. As shown in Fig. 1, a typical downconverter consists of a microwave antenna, a mixer, a VCLO (*V*oltage-*C*ontrolled-*L*ocal-*O*scillator), a variable power-supply, and an antenna

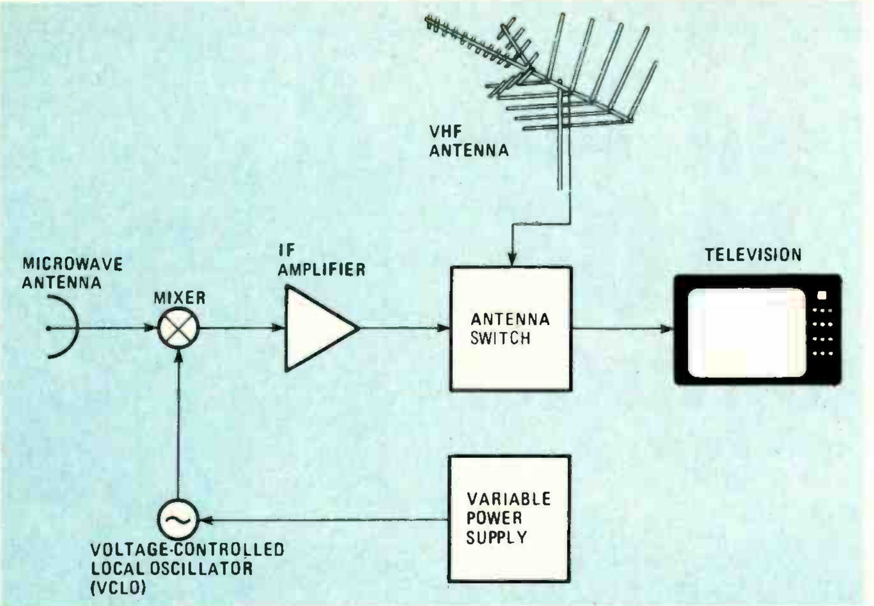


FIG. 1—BLOCK DIAGRAM of a microwave receiver system. The power supply and antenna switch are often enclosed in the same case.

switch. The incoming signal is received by the microwave antenna and fed to a twin-diode mixer. Essentially, what the mixer does is to double the frequency of the VCLO, and then output the difference between that frequency and the received microwave signal to the IF (*I*ntermediate *F*requency) amplifier. That output is usually equal to that of VHF Channel 3 (61.25 MHz). The IF amplifier boosts the signal to a usable level and feeds it to an antenna switch that's used to permit easy switching between the downconverter and the VHF antenna. The VCLO frequency is controlled by a variable power-supply. Adjusting the power-supply voltage causes the VCLO frequency to change, which in turn causes the output (IF) frequency to change. That allows you to fine-tune the downconverter, which can drift somewhat due to temperature changes.

Checking basic circuit operation

After constructing the kit, follow the normal post-construction procedures, which includes making sure that all components are installed in the right position and properly soldered. When checking solder connections, be sure that there are no solder bridges, particularly between the power and ground traces. In addition, the circuit-board layout is critical to the performance of the converter. Board conductors or strip lines behave as inductors and capacitors—altering their size with excess solder changes their values and affects circuit performance.

Also, circuit components such as transistors, diodes, and chip capacitors should be handled with care because they're very fragile. For example, transistor leads can be easily broken off during handling, and chip capacitors can be damaged by excessive heat in soldering—so be careful. Once you are convinced that you have made no construction errors, use a volt/ohm meter (VOM) to check the basic DC operation of the circuit.

When checking the basic operation of the circuit: Make sure that the power supply is operating properly by monitoring its output voltage and making sure that it swings several volts as the tuning knob is rotated back and forth. The next step is to connect the downconverter board to the power supply and place it in a position that allows you easy access to the circuit components. The position of the power-supply's tuning knob isn't important now. Apply power to the system and measure the base-to-emitter (V_{BE}) voltage of each transistor with the VOM—it should be about 0.6 volt.

Figure 2 shows how to distinguish the transistor's collector from its base and emitter. For some transistors, the collector is indicated by the dot directly in front of it—the base is the lead directly across from the collector, and the remaining two tabs are the emitter leads. Transistors with the prefix NEO are set up in much the same way, except that the base (instead of the collector) is designated by an angled lead.

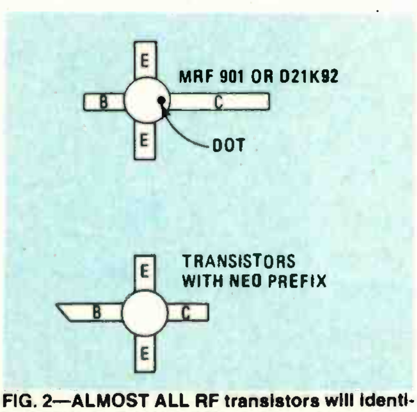


FIG. 2—ALMOST ALL RF transistors will identify their leads in one of these two ways.

If V_{BE} is zero or several volts, check the circuit again for bad solder connections, bridges, or missing components. If everything is soldered in properly but the voltages are incorrect, suspect a bad transistor. If everything thus far is working properly, use the VOM to check the collector-to-emitter voltage (V_{CE}) of the transistors. (Refer again to Fig. 2 if necessary.) The collector-to-emitter voltage should be several volts lower than the power-supply voltage. To make the comparison between the two voltages, measure the supply voltage at the point where it enters the converter board and then measure the base-to-emitter voltages of each transistor. If the collector-to-emitter voltage of any transistor is the same as the power supply voltage, you could have an open collector in that transistor—therefore, it should be replaced. On the other hand, if V_{CE} is zero, the collector of the transistor could either be shorted to ground at some point on the circuit board, or the transistor may be shorted internally and therefore should be replaced. If the voltages are correct, the transistors are operating with the proper DC bias and the circuit is now ready for tuning.

Tuning the downconverter

The normal tuning procedure is a hit-or-miss one, which involves a combination of lengthening or shortening a tuning conductor on the downconverter board and adjusting the variable power-supply.

Adjusting the power supply is no problem; but after each change in the length of the tuning conductor, the downconverter/antenna assembly must be placed in an area where it can receive microwave signals. That's necessary so that you can see whether the changes that you've made have done the trick.

Doing so can be particularly frustrating if you have to hoist the assembly up a 30-foot mast each time! Most people have line-of-sight view of the transmitter from their roof as they stand on it. Even with that ideal situation, a few problems can be encountered, such as having to run up and down a ladder each time you make a correction in the circuit.

To avoid that situation, you'll need a soldering iron on the roof and someone in the house watching the TV while you make the changes. Otherwise, you'll need the variable power-supply and a TV on the roof with you so that you can do it all yourself. Once the circuit is tuned, there's often trouble in positioning the antenna for maximum signal strength. Therefore, it's best not to even consider that problem at this point.

TABLE 1

Frequency—MHz	Use
1690 - 1700	Meteorological satellites
1691.0	GOES satellite
1694.5	METOSAT satellite
1700 - 1710	Space research
1710 - 1850	Government and armed forces
1990 - 2110	Studio-to-transmitter links; intercity relay
2130 - 2150	Point-to-point, fixed
2150 - 2180	Omnidirectional, fixed
2150 - 2156	MDS channel 1
2156 - 2160	MDS channel 2A
2156 - 2162	MDS channel 2
2180 - 2200	Point-to-point, fixed
2200 - 2290	Government and armed forces
2205	NASA space shuttle video
2215	NASA space shuttle video
2217.5	NASA space shuttle audio
2287.5	NASA place shuttle audio
2290 - 2300	Space research
2300 - 2450	Amateur radio operation
2304	Amateur DX
2375	Amateur television
2400 - 2450	Amateur FM repeaters
2450 - 2500	Radar
2500 - 2690	Instructional TV, fixed (ITFS)
2500 - 2506	ITFS ch. A1
2506 - 2512	ITFS ch. B1
2512 - 2518	ITFS ch. A2
2518 - 2524	ITFS ch. B2
2524 - 2530	ITFS ch. A3
2530 - 2536	ITFS ch. B3
2536 - 2542	ITFS ch. A4
2542 - 2548	ITFS ch. B4
2548 - 2554	ITFS ch. C1
2554 - 2560	ITFS ch. D1
2560 - 2566	ITFS ch. C2
2566 - 2572	ITFS ch. D2
2572 - 2578	ITFS ch. C3
2578 - 2584	ITFS ch. D3
2584 - 2590	ITFS ch. C4
2590 - 2596	ITFS ch. D4
2596 - 2602	ITFS ch. E1
2602 - 2608	ITFS ch. F1
2608 - 2614	ITFS ch. E2
2614 - 2620	ITFS ch. F2
2620 - 2626	ITFS ch. E3
2626 - 2632	ITFS ch. F3
2632 - 2638	ITFS ch. E4
2638 - 2644	ITFS ch. F4
2644 - 2650	ITFS ch. G1
2650 - 2656	Operational service, fixed
2656 - 2662	ITFS ch. G2
2662 - 2668	Operational service, fixed
2668 - 2674	ITFS ch. G3
2674 - 2680	Operational service, fixed
2680 - 2686	ITFS ch. G4

TABLE 2

UHF Channel	Local oscillator (MHz)	3rd harmonic (MHz)	UHF Channel	Local oscillator (MHz)	3rd harmonic (MHz)
14	517	1551	49	727	2181
15	523	1569	50	733	2199
16	529	1587	51	739	2217
17	535	1605	52	745	2235
18	541	1623	53	751	2253
19	547	1641	54	757	2271
20	553	1659	55	763	2289
21	559	1677	56	769	2307
22	565	1695	57	775	2325
23	571	1713	58	781	2343
24	577	1731	59	787	2361
25	583	1749	60	793	2379
26	589	1767	61	799	2397
27	595	1785	62	805	2415
28	601	1803	63	811	2433
29	607	1821	64	817	2451
30	613	1839	65	823	2469
31	619	1857	66	829	2487
32	625	1875	67	835	2505
33	631	1893	68	841	2523
34	637	1911	69	847	2541
35	643	1929	70	853	2559
36	649	1947	71	859	2577
37	655	1965	72	865	2595
38	661	1983	73	871	2613
39	667	2001	74	877	2631
40	673	2019	75	883	2649
41	679	2037	76	889	2667
42	685	2055	77	895	2685
43	691	2073	78	901	2703
44	697	2091	79	907	2721
45	703	2109	80	913	2739
46	709	2127	81	919	2757
47	715	2145	82	925	2775
48	721	2163	83	931	2793

Tuning the easy way

There is an easier way to tune your downconverter. You'll need the downconverter along with its power supply, and two television sets. One TV set, which we'll call TV-1, will be used to view the microwave programming. The UHF tuner of the other set (TV-2) will be used as an artificial microwave-signal source. It contains a local oscillator operating a the chosen UHF channel frequency, plus the TV IF (45.75 MHz). TV-2's local oscillator provides enough energy at its third harmonic to serve as a microwave signal. (One of the $69 black-and-white sets will work great.)

In building a downconverter kit, it is important to keep in mind the frequency at which the circuit will be operating. To do so, you must first decide which type microwave transmission you wish to receive, such as one of the NASA space-shuttle frequencies or perhaps one of the MDS channels. Table 1 is a listing of microwave-frequency allocations that can be used for that purpose. Also, whether one of the MDS channels or some other programming is desired, it will be necessary to decide which UHF channel will be used as a microwave-signal source—Table 2 is provided for that purpose. Let's look at an example of what we mean. Suppose, for instance, that you want to receive one of the MDS channels, whose operating frequencies (as shown in Table 1) range between 2150 MHz and 2162 MHz. Selecting a midpoint frequency of 2156 MHz will be accurate enough for the purposes of this tuning procedure. (The reason for that will become more obvious in a moment.)

Now that you've chosen the microwave signal-source, refer to Table 2 to determine the UHF channel that TV-2 is to be tuned to. In the above example, we chose 2156 MHz as our center frequency, so we'll look for that frequency in Table 2 under the "3rd harmonic" heading. As you can see, the closest that we can come to that frequency is either 2145 MHz (Channel 47) or 2163 MHz (Channel 48). Let's use Channel 48. Note: Although this tuning exercise attempts to tune in the desired frequency with the variable power-supply tuned to its mid-voltage point, the converter's actual low-to-high voltage tuning range is extremely broad. Hence, the Channel 48 local-oscillator frequency is accurate enough. Now let's tune the converter by performing the following steps:

1. Connect the equipment as shown in Fig. 3. As you can see, TV-1 is connected to the output of the converter, while TV-2 is connected the antenna/downconverter terminal of the power supply through the feedhorn/downconverter assembly.

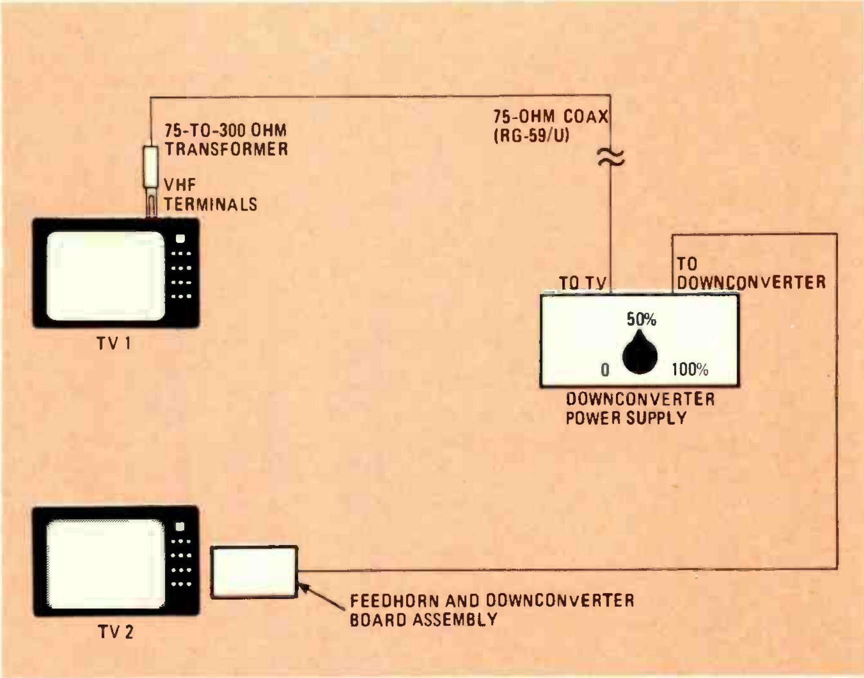


FIG. 3—TEST SETUP for tuning the downconverter. Here the feedhorn assembly is placed close to TV-2 to pick up the artificial microwave signal.

2. Apply power to all equipment.

3. Turn TV-1 to the channel to which the downconverter is to be tuned (2–6).

4. Turn the UHF tuner of TV-2 to the channel chosen from Table 2 (in this case Channel 48). If that channel is an active channel in your area, be sure that there is no antenna connected to TV-2.

5. Place the quarter-wavelength stub or board dipole (antenna) as close as possible to the UHF tuner of TV-2 as shown. (It will probably not be necessary to disassemble the TV—a sufficiently strong signal will be radiated through the case.)

6. Rotate the power-supply control slowly back and forth while watching TV-1. If tuning is possible within the set voltage range, the TV screen will: a) go nearly or completely blank—raster with little or no snow; b) show streaks of color; or c) flicker. The TV's sound will: a) nearly or completely mute; b) buzz; or c) sound like a local radio-station or adjacent television-channel.

7. If tuning is not achieved, set the power supply to its mid-voltage range. Change the VHF tuner of TV-1 in either direction one channel at a time , while adjusting the power-supply voltage back and forth slightly for each channel. If tuning is achieved, proceed to step 10—if not, refer to steps 8 and 9.

8. If tuning cannot be achieved, check the component values of all passive components to see if they are correct and also make sure that they are not damaged. Capacitors can easily be checked for shorts; however, it's a little more difficult to check for open capacitors. Using the highest resistance scale on your meter, carefully observe the meter for a slight deflection just as you touch the test probes to the capacitor leads. If there is no deflection replace that component.

9. The final items to be checked if tuning cannot be achieved are the diodes. To do so, first remove the diodes from the circuit board. Then using the lowest resistance-range on the VOM, connect each diode (one at a time) to your test probes facing in one direction—all anodes to either the black or red lead. Then reverse the leads and check them again. (The anode can be distinguished from the cathode by the stripe at the cathode end.) With the stripe facing in one direction, the diodes should have a low resistance and in the other a high resistance. Replace any defective component, then repeat steps 4 through 8.

10. Once tuning is achieved, set the power supply control to its mid-voltage range and again set TV-2 to the appropriate channel (48 in our example). Add solder to or remove trace material from the tuning conductor on the downconverter circuit board until the converter is tuned. (The tuning conductor is a short length of wire or slug on the converter board.) That gives you the greatest tuning range, so that if the oscillator drifts because of temperature changes you can fine-tune the converter. That concludes the tuning procedure.

Summary

This article has described a simple tuning procedure for microwave downconverters. It can be seen that serveral unnecessary headaches can be avoided by simply following good soldering and wiring practices beforehand. The job is much easier if troubleshooting requirements are kept to a minimum. Also, an important point to note about the procedure is that it can be used for any microwave frequency you choose. In addition, an antenna rotor, such as that available from Radio Shack, mounted with your microwave antenna could be helpful in some cases.

Depending on your location, it might be very interesting to experiment with your downconverter by tuning it to receive things like television studio-to-transmitter links, university instructional TV, or (of course) amateur broadcasts. In any event, it opens up several doors for the inventive microwave experimenter. **R-E**

WHAT IS MDS?

MDS, an acronym for *M*ultipoint *D*istribution *S*ervice, is a local microwave television service. MDS operators are authorized to use microwave frequencies for data communications or television programming within a community.

There are two MDS channels—2150–2156 and 2165–2162 MHz. There is also provision for channel to transmit information from an MDS subscriber's home to the operator, thus leaving open the possibility of an interactive service.

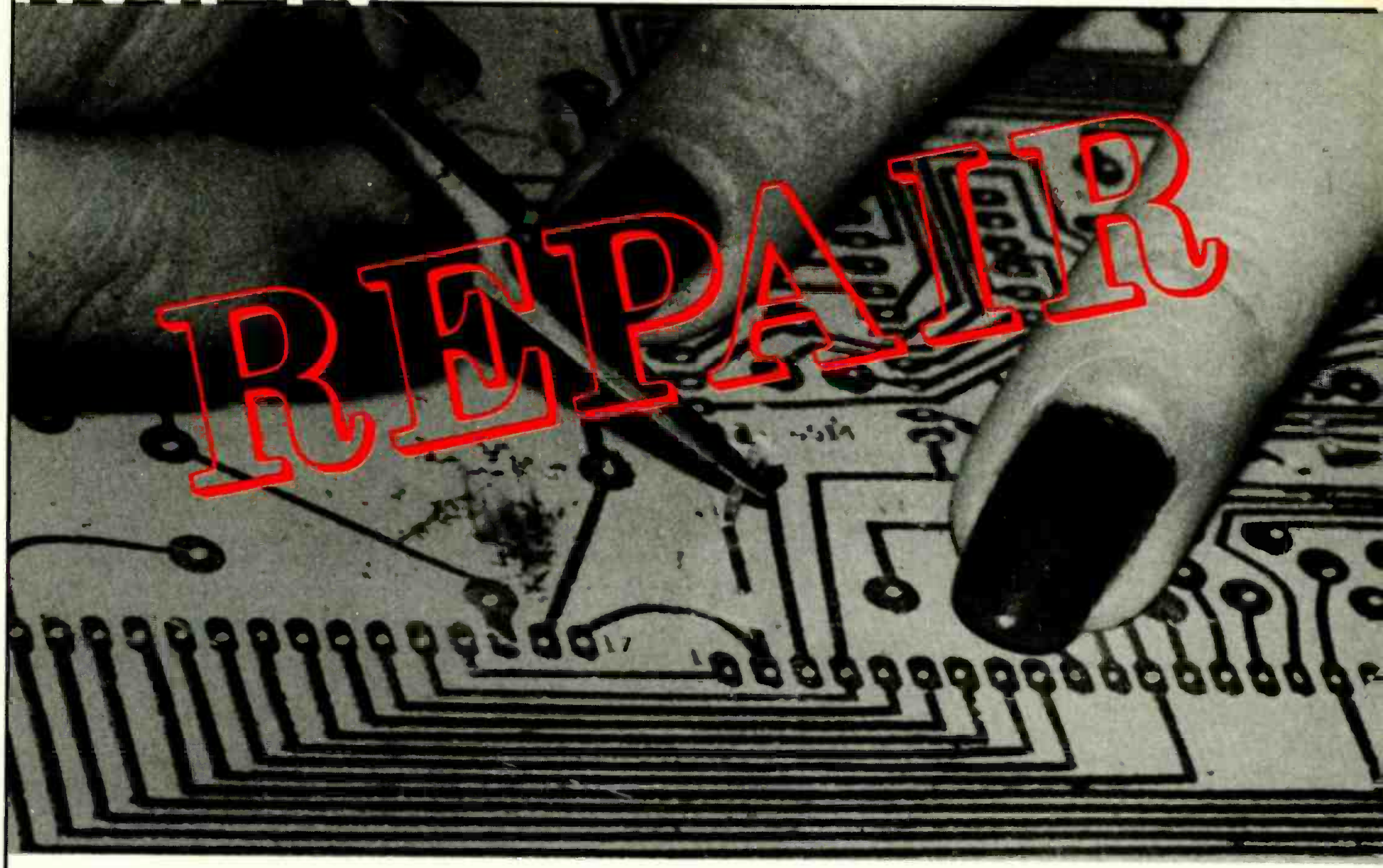
The MDS signal is transmitted in the standard NTSC format but with some differences. The transmission passband is inverted, with the result being lower vestigal-sideband video with the audio carrier being located 4.5 MHz below the video carrier, which in turn is located 1.25 MHz below the top band-edge. That scheme is a mirror image of a standard TV broadcast. The audio and video thus must be inverted by the downconverter before being fed to a TV receiver.

These days, the primary use for MDS is for distribution of pay-TV programming. MDS operates line-of-sight, with only paying subscribers authorized to receive the transmissions. MDS subscription costs are generally lower than other over-the-air forms of pay-TV (i.e. UHF-TV) because the operator's outlay is generally lower. The reason for the lower cost is that an MDS transmitter outputs only a fraction of the power of a UHF pay-TV station—10 to 100 watts as compared to hundreds of thousands of watts.

Because of that, and other cost-related reasons, MDS has become extremely popular. MDS common-carriers lease their transmission facilities to pay-TV programmers in most major markets around the country. Most MDS systems boast between 10,000 and 30,000 subscribers, each paying between $15 and $25 a month for the service.

The FCC does not consider MDS to be a broadcasting service. It instead considers it to be a common carrier and thus the frequencies it uses are not public. Because, in part, of that interpretation, MDS operators have successfully prosecuted manufacturers, sellers, and users of unauthorized reception equipment.

HOW TO REPAIR PC BOARDS



Here are some techniques that can help you rescue that "ruined" board

ROBERT GROSSBLATT

THOSE WHO MAKE THEIR OWN PRINTED-circuit boards know that it's a detailed and painstaking process. It's not hard—just detailed and painstaking. And, as everyone knows, the effects of Murphy's Law are directly proportional to the number of steps in the procedure. Fortunately, printed-circuit boards are one of the few electronics components that can be easily repaired. You can't repair the substrate in an IC and replacing the electrolyte in a capacitor is difficult—even if you use special tools. You can, however, easily correct various PC-board foulups.

If we approach the problem logically, it's immediately obvious that there are really only two things that can possibly wrong with a board:

1. There's copper where there should not be.
2. There's no copper where there should be.

Basically, those problems are the result of either a bad etch or a bad layout.

In the case of a bad etch, before any repair is attempted, you have to ask yourself if it is worth the trouble. A simple repair to a trace on the board is fairly easy to do, but trying to correct catastrophic problems is, quite frankly, more trouble than it's worth. There's no hard and fast rule to help you decide whether or not your board is beyond salvage. If you have vast areas of unetched copper (see Fig. 1) or your traces are hair-thin and grainy looking (see Fig. 2), the board should probably be considered a write-off. If, on the other hand, things aren't that bad and the board is complex and difficult to produce, you're probably looking at a good candidate for a repair.

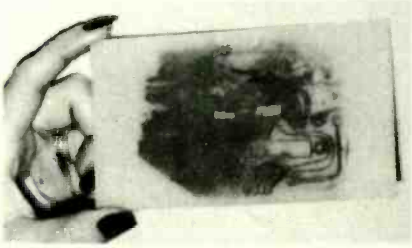


FIG. 1—AN UNDERETCHED BOARD that is beyond repair

Removing excess copper

Removing excess copper is a straightforward operation. If there are a lot of small pieces of copper left on the board between the traces you'll have to cut them out using an X-acto knife. Make sure the blade is sharp, because the copper, even though soft, is still difficult to cut. If you've got a lot of copper to remove, make sure you have a good supply of blades on hand because the edge won't last too long. Remember that you'll be cutting through the copper and into the board material itself. Glass epoxy is hard stuff. If the board material is phenolic your blade will last a little longer but will still dull out pretty quickly.

Cut through the unwanted copper bridge on both sides and carefully lift it up by working the tip of the blade under the corner of the copper at the cut as shown in Fig. 3. Once you lift the corner, you'll find that the copper will peel off the board easily. Make sure you get all the copper off the board—a small piece of loose copper can cause all sorts of terrible problems later on. Longer traces can be removed the same way—just cut them at the ends and peel them off the board.

If you've got large areas of unwanted copper on your board, resist the temptation to remove all of it. Not only do you run the risk of damaging the board, but unconnected copper can come in very handy for all those brilliant last-minute variations that you just have to add to the circuit. And, if all those reasons aren't enough, remember that it's always wiser to *leave well enough alone*. If the excess copper isn't hurting anything, isolate it from the rest of the layout and forget about it. Take your X-acto knife and cut away the traces that connect the unwanted plane of copper to the rest of the foil. Flick the bridges off the board and go on to more important things.

If you feel that you *absolutely* have to get rid of large areas, there are two options—grinding and etching. Large areas of copper that can be easily isolated on the board can be etched away. It's simply a matter of covering the areas of the board you want to protect with waterproof tape, steel-wooling the areas you want to get rid of, and dumping the board back into the etchant. The only important thing to remember here is to make sure that the tape you use is *waterproof*. If it's not, you can be sure that your etchant—and that holds true for all of them from ferric chloride to ammonium persulphate—will ooze its way through the tape with predictable results.


FIG. 2—AN OVERETCHED BOARD that is beyond repair.

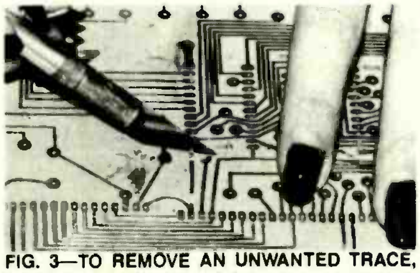


FIG. 3—TO REMOVE AN UNWANTED TRACE, cut it and lift a corner of the copper at the cut.

The best tape to use is that thin plastic packing tape—the kind that can be only cut with a knife. Don't use the tape that has the nylon cords running through it because you can't completely smooth it out on the board. Lay the tape on the board, overlap it at the edges, and rub it to get rid of the air bubbles (see Fig. 4). Take your X-acto knife and cut away the tape wherever you want to remove the copper (see Fig. 5). You can also paint lacquer over the areas you want to protect—that works just as well but it takes a lot longer. If you're anything like the author, the necessity of having to go back and correct mistakes makes you frustrated and impatient. You want *immediate* results. The half hour or so that it takes for the lacquer to dry is just too long—if it only took five minutes it would still be too long. If you do go that route, however, make sure and use a lacquer with a color. Clear lacquer is nice but you can't always be sure which areas are covered—especially when the board is in the etchant. It is the understatement of all time to say that it's disheartening to make a mistake correcting a mistake.

The second way to get rid of copper is to grind it off. It's mentioned here only to give us the opportunity to tell you to avoid it completely. I know it's possible to put a grinding wheel on a small hand tool and pulverize veritable oceans of copper—not only is it fast but it's nice to let electricity do the work. However, *avoid* the temptation to do that! Besides having the board look terrible when you finish (sometimes an important consideration), one slip and you'll grind right through the board itself (always an important consideration).

Replacing copper

Missing copper is a much easier problem to handle. Once again you have to decide whether or not the repairs are worth the trouble. An etch that leaves you with just the ghostly remains of your foil pattern is beyond hope. The same goes for a board that is criss-crossed with cut traces and has doughnuts that are measurable only in angstroms.

There's more at stake here than whether or not two points on the board are connected by copper. The thinner the trace gets, the less current it can handle. If you've got components on the board that use a lot of current, the thickness of the

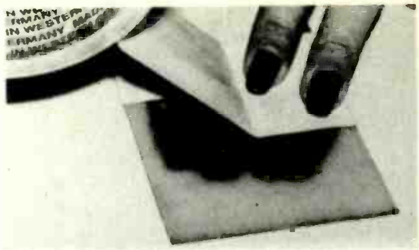


FIG. 4—TO REMOVE LARGE AREAS of unwanted copper, first cover the board with waterproof tape.

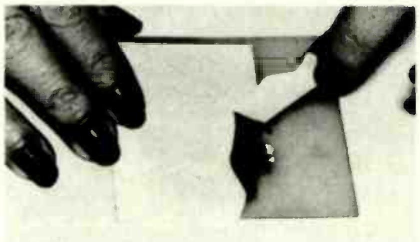


FIG. 5—ONCE THE BOARD is completely covered, use an X-acto knife to remove the tape over the areas you want to re-etch.

trace is one of the things you should have had in mind when you did the layout for the foil pattern. It's always a touchy thing to route relatively serious amounts of current through thin traces. Assuming the copper doesn't burn up (extreme case), it's at least going to get hot (usual case). And when heat rears its ugly head all kinds of nastiness can follow. The conductance of the copper can change and lead to some oscillation and/or other similar nightmares. Linear and TTL circuits draw relatively heavy amounts of current in spurts and those spikes are potential sources of trouble. Thin traces can lead to audio clipping, false triggering, and a whole host of other equally disturbing phenomena—all directly because of current starvation.

When those things occur, the last thing you'll suspect is the traces on the board. Many a board has been ripped apart and many a component has been substituted for over and over before the real source of the problem was found. The moral here is that the problems that can come from thin traces often masquerade as faults in design—you can waste a lot of valuable bench time tracking down the real source of the trouble.

Before ending this soliloquy on the evils of thin traces, there's one more thing you should be aware of. Thin traces can generate heat—and heat can weaken the bond between the copper and the board. And, as we said before, loose copper can do a lot of damage to costly components.

Probably the easiest and most direct way to repair a damaged trace is to solder a piece of wire to the board. You just take a length of wire of the correct thickness and use it to jump the gap in the foil. There are, however, rules that should be followed:

1. Never use uninsulated wire.
2. Never tack solder directly to the foil.
3. Never leave slack in the wire.

Let's take these rules one at a time.

Using uninsulated wire is just asking for trouble. If the foil density of your board is high, it will only take a small shift in the wire's position to short it to another trace. Hook-up wire and cut-off component legs are always lying around your bench but try to avoid using them. It makes a lot more sense to keep a small spool of insulated wire handy just for making repairs to your board. Cut off the length you need and strip the insulation from the ends. If you're using multi-stranded wire, make sure you tin the ends before you solder it to the board. Loose strands of wire are as dangerous as loose bits of copper.

That brings us to our second rule. If you tack solder directly to the foil, you'll be depending on the foil for strength. Just one inadvertent tug on the wire and—you guessed it—the foil is going to lift off the board as shown in Fig. 6 and cause what is referred to in the technical journals as a big problem. The strength in a printed-circuit board comes from the base material, not the foil. Always drill holes for the ends of the wire, regardless of whether your jumper is going to be on the foil or component side of the board. If you put the jumper on the component side treat it like any other component. Put the ends through the holes in the board and solder them to the foil. If you can't drill holes directly through the foil, (if the trace is too thin, for example), locate the holes right next to the trace and bend the ends of the wire over the foil. If your wire has to go on the foil side, drill the holes and let the ends of the wire poke through to the component side. The repair won't be as solid but it will still be better than just tack soldering. Bend the ends of the wire flat against the component side of the board and put a blob of solder on them making sure that it is slightly larger than the hole (see Fig. 7). That jury-rigged strain relief may look strange but it only has to work once to prove its worth.

The most carefully made repair is wasted if you don't pay attention to the third rule. Loose wire will always get snagged on something. If you're lucky, and you've led a good life, *only* the wire will pull loose. More likely, the foil will pull off the board and generate an unnecessary number of gray hairs on your head. If your wire is running on the component side of the board that will be less of a problem, but it's still good practice to make the wire only long enough to span the distance between the two holes. Don't use the same "right angle" principle for the jumpers that you did when you originally laid out the foil pattern. There's absolutely no way the wire repair is going to look as neat as an unbroken trace, so go directly from point A to point B.

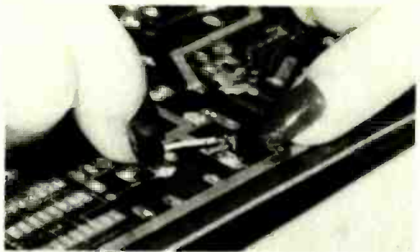


FIG. 6—IF YOU MAKE YOUR REPAIRS by tack soldering wire, lifted foil is likely to be the result.

FIG. 7—MAKING A JURY-RIGGED strain relief using solder.

FIG. 8—USE NAIL POLISH to secure the wire to the board. It works better than any glue we've tried.

FIG. 9—USING SELF-ADHESIVE copper foil to make a repair.

FIG. 10—SILVER PAINT, though expensive, is excellent for repairing hairline cracks in traces.

After you've made the repair, make things even better by securing the wire to the board. The best way to do this is with clear nail polish (see Fig. 8). All the glues we've tried—from two-part epoxy to the cyanoacrylate super glues—don't seem to adhere well to glass-epoxy board. It might be a different story with phenolic board, but we don't use it. The nail polish is strong enough to hold the wire securely to the board but can still be easily removed if you want to make a change later on. Just use a few drops at various points along the length of the wire to keep it from flopping around. Make sure you put some on the solder where the wire is connected to the foil. Since it's the weakest part of the repair, it needs the most help.

There are several alternatives to wire when you have to add copper to the board. For one reason or another they're not as attractive a choice as wire.

Some manufacturers make copper foil sheets with an adhesive back. You just cut out the shape you need with an X-acto knife, peel off the paper covering the adhesive on the back, and stick it on the board as shown in Fig 9. That stuff is really dynamite when you need large areas of copper added to the board but it's difficult to cut out a replacement for a convoluted trace, and more difficult yet if you have to cut out something that's only a sixteenth of an inch thick. Another disadvantage of that method is that the foil doesn't adhere well to an uneven surface. If you do use that stuff to repair your board, don't rely on the adhesive—when your repair is finished, put a few drops of nail polish along its length to hold it to the board. That is really important if the copper is going to handle enough current to warm it up. If you've got a smooth surface, copper foil is a reasonable way to make a repair. If you have to add large planes of copper, it's the only way to make a repair.

Silver paint is a super way to repair hairline breaks in traces (see Fig. 10). If there's room to maneuver on your board, you can also use it to draw in a missing trace. Using it is simplicity itself—you apply it with a thin brush and carefully draw in the traces that are missing or over the ones that are broken. If you happen to slop a bit onto a neighboring trace, it can easily be scraped off when the paint dries. You can repair traces as thin as your artistic ability permits. If your hand is steady enough to follow the serpentine meanderings of a trace, silver paint is the method to use. When it dries it's almost as conductive as the copper it's replacing and you don't have to worry about it getting loose on the board. Now that we've told you why it's so wonderful, we'll tell you why it's not.

To start off with, you can't solder to it and it can't handle as much current as the copper it's replacing. Remember that copper foil comes in different thicknesses—the thicker the copper, the more current it can handle. Traces made from silver paint are thin—certainly much thinner than the copper. You could keep adding layers of silver paint, but that

continued on page 81

DESIGNING WITH LINEAR IC'S

This month, we look at the noninverting follower and some op-amp applications.

JOSEPH J. CARR

Part 3

SO FAR IN THIS SERIES we have introduced you to the basic op-amp, the inverting follower, and some of the more common problems associated with op-amp circuits. This month, we will consider the noninverting follower and look at some applications for op-amps in AC circuits.

Noninverting follower

The inverting follower has one serious drawback—low input-impedance. Since the noninverting input is grounded, the summing junction (the junction of the feedback resistor, input resistor, and the op-amp inverting input) will also be at ground potential. The input impedance is therefore limited to the value of the input resistor. Since input bias currents effectively limit the maximum value of the resistor, they also limit the input impedance. The input impedance of an inverting follower rarely exceeds 1 megohm, with 10 kilohms much more common.

The solution is to turn to the noninverting follower configuration. In that type of circuit, the signal is applied to the noninverting input, so the output will be in phase with the input. The extremely high input impedance of the op-amp (as high as 10^{12} ohms) makes the impedance seen by the signal source equally high.

A simple noninverting follower is shown in Fig. 1. That circuit is called an unity-gain noninverting follower. The output signal is fed back directly to the inverting input. The voltage gain of the circuit, as its name implies, is unity.

The properties of the unity-gain circuit are: extremely high input-impedance, low output-impedance, and a voltage gain of one. Since the output impedance, Z_O, is low, and the output voltage is the same as the input voltage, the *power* gain is greater than one.

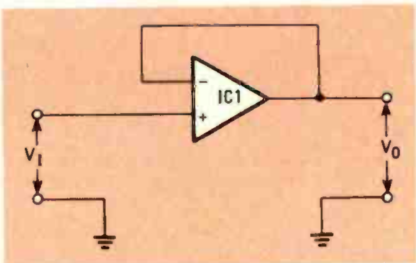


FIG. 1—A SIMPLE unity-gain, noninverting follower.

The unity-gain noninverting follower has at least two main applications: buffering and impedance transformation. A buffer is an amplifier whose job is to isolate an electronic circuit from its load. An oscillator, for example, may use an output buffer to prevent frequency shifts caused by changing load impedances. Often, op-amp-based instruments will use a unity-gain buffer as a matter of good design, so that external factors will not affect the circuit as much.

As for impedance transformation, since the input impedance is very high, and the output impedance is very low, the unity-gain noninverting follower is a high-to-low-impedance converter.

A noninverting follower with gain is shown in Fig. 2. In that circuit, the signal is applied directly to the noninverting input of the op-amp. We must, therefore, treat the inverting input as if it were also at V_I.

The feedback network is the same as for the inverting follower (see part two of this series in the May 1984 issue of **Radio-**

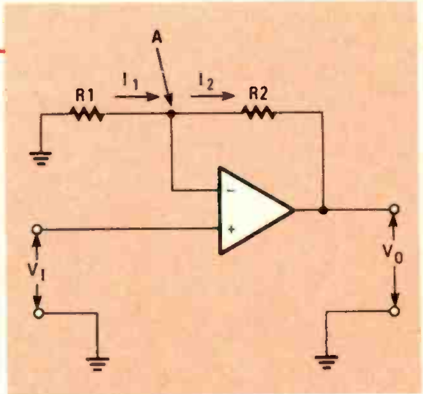


FIG. 2—A NONINVERTING FOLLOWER with gain. If the desired amount of gain is known, the values of R1 and R2 can be found through using equation 7.

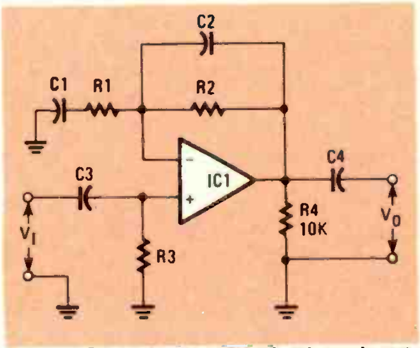


FIG. 3—FOR AC APPLICATIONS, this noninverting follower with gain circuit can be used.

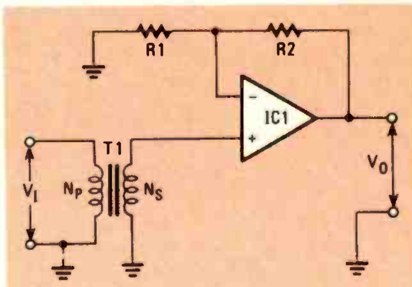


FIG. 4—THIS AC AMPLIFIER provides no frequency shaping, but it can be combined with the circuit that is shown in Fig. 3 if some shaping is desired.

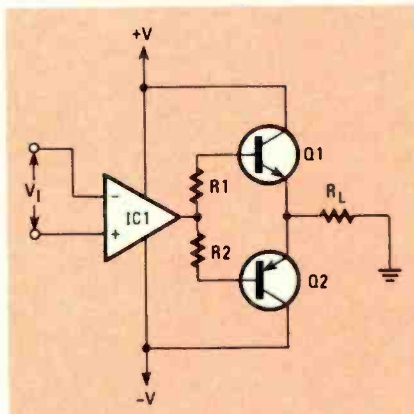


FIG. 5—WHEN AN OP-AMP must drive a load such as a loudspeaker, some means of boosting output power, such as using a complementary symmetry transistor amplifier, is required.

Electronics), except that the "input" side of R1 is grounded. As before, Kirchoff's Current Law (KCL) requires that:

$$I1 = I2 \qquad (1)$$

by ohms Law,

$$I1 = V_I/R1 \qquad (2)$$

and,

$$I2 = \frac{V_O - V_I}{R2} \qquad (3)$$

Substituting equation 2 into 3:

$$\frac{V_I}{R1} = \frac{V_O - V_I}{R2} \qquad (4)$$

Solving for V_O:

$$V_O = \frac{V_I\,R2}{R1} + V_I \qquad (5)$$

$$V_O = V_I\left(\frac{R2}{R1} + 1\right) \qquad (6)$$

Equation 6 is the transfer function for the noninverting follower with gain, and should be committed to memory; the actual gain portion of the equation is:

$$A_V = \frac{R2}{R1} + 1 \qquad (7)$$

We can use equation 7 to set resistor values. That's because that equation can be rewritten so that it can used to find the values of R2 and R1 required for a specified gain. Since we can pretty much set the value of R1 arbitrarily (although the value of that resistor is usually between 100 ohms and 10 kilohms), we should solve for the value of R2:

$$R2 = R1\,(A_V - 1) \qquad (8)$$

One constraint that we should remember is that non-standard value resistors are difficult to come by. We should not, for instance, count too much on obtaining a 29002-ohm unit. The easiest way to proceed, then, is by trial and error, reworking equation 8 several times, using standard values for R1, until a standard-valued R2 is also found. Sometimes, a given gain requirement will not result in a pair of standard values for the two resistors. In that case, a variable resistor, a parallel or series combination of standard-valued resistors that yields the calculated value, or the standard-valued resistor that comes closest to the calculated value, can be used.

If the project has more than one stage, there is another alternative. The total gain is the product of the gains of the individual stages. That means we can work with all of the resistor values in all of the stages until we find a combination that gives us the proper total gain using only standard-valued resistors. There, of course, is no guarantee that such a combination exists, but it is likely that after a bit of searching one can be found.

Like the unity-gain circuit, the noninverting follower with gain circuit will provide buffering and impedance transformation, but also (as its name implies), voltage gain. A noninverting follower with gain circuit, for use in AC applications, is shown in Fig. 3. Note that while four capacitors are used there, one or more of them can, in some cases, be deleted.

Some low-frequency response shaping is performed by capacitors C1 and C3, while high-frequency shaping is done by C2. In all cases, the −3-dB breakpoint is given by equation 9 below (note that that equation is given here in its general form), and the response falls off at a rate of about −6-dB-per octave.

$$f = \frac{1}{2\pi RC} \qquad (9)$$

Another AC amplifier is shown in Fig. 4. That circuit provides no frequency shaping, but it can be combined with the circuit of Fig. 3 if some is needed. The gain of this stage must account for the voltage transformation of T1. The gain of the stage is then

$$A_V = \left(\frac{R2}{R1} + 1\right)\left(\frac{N_S}{N_P}\right) \qquad (10)$$

where N_P is the number of turns in the primary, N_S is the number of turns in the secondary, and all other terms are as defined before.

Here, we can manipulate the transformer's turns ratio as well as the values of the resistors to get the gain we need. Be aware, however, that the turns ratio is multiplicative, so gains get high in a hurry as the turns ratio gets higher. That situation can lead to saturation of the amplifier. If we have a gain of two in the op-amp, and a turns ratio of 10:1, then the overall gain is 100. That is fine, provided that the input-signal amplitudes are small enough. Applying a 1-volt peak signal to the input will cause the amplifier to try outputting 100-volts of signal, which is clearly impossible on a ±15-volt power supply.

Power amplifiers

Operational amplifiers do not usually produce much output power, usually less than 100 milliwatts. When it is necessary to drive a load such as a loudspeaker, then some means of boosting the output power must be found.

One traditional solution is shown in Fig. 5. In that figure, we see a complementary symmetry transistor amplifier being directly driven by an operational amplifier. That power amplifier operates in class B, which means that each transistor conducts over just one-half of the cycle.

The complementary symmetry class-B amplifier works because of the relative natures of NPN and PNP transistors. An NPN transistor turns on harder as the base is made more positive than the emitter, while a PNP transistor turns on harder as the base is made more negative than the emitter. In other words, the NPN device turns on during the positive half-cycle while the PNP one turns on during the negative half-cycle. Thus the bases of the two devices must be connected in parallel.

A major problem with the circuit shown in Fig. 5 is the need for external discrete components (i.e. the transistors), which take up space. In addition, the circuit will not work well without other components to eliminate crossover distortion. Sometimes, the most practical solution is to use a special IC power amplifier. Some of those are special audio devices, while others are merely power op-amps and may be used in a number of applications.

There are a number of special power IC's on the market, so we will pick only one, National Semiconductor's LM379. That 14-pin device can output up to 6 watts-per-channel. The LM379 contains two amplifiers, so it can be used in stereo designs.

A block diagram of the LM379 is shown in Fig. 6. Note that that device has only one power terminal (V_{CC}), so that it is not technically an op-amp. Nonetheless, the device behaves like an op-amp and is as simple to use.

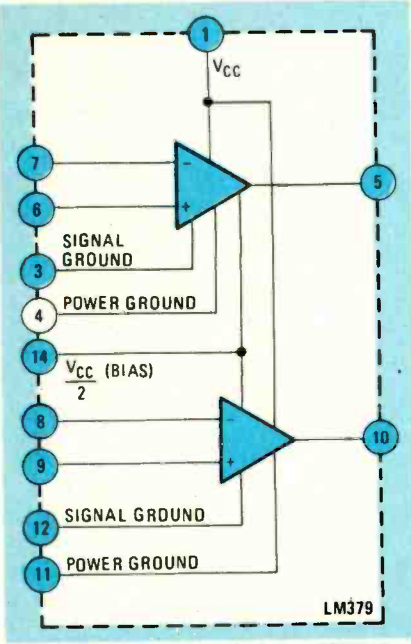


FIG. 6—BLOCK DIAGRAM of the LM379. Note that the device has two amplifiers, so that it can be used in stereo designs.

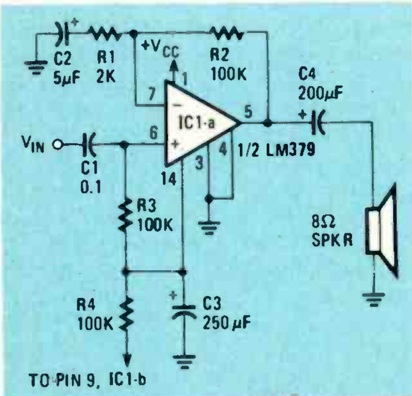


FIG. 7—A TYPICAL AUDIO AMPLIFIER based on the LM379. Note that, aside from the input resistors, only one stage of the two-stage circuit is shown.

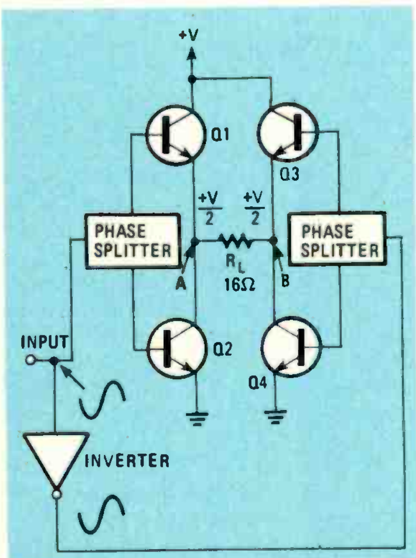


FIG. 8—A SIMPLIFIED SCHEMATIC DIAGRAM of a bridge audio-amplifier.

Note also that the device has two ground terminals—a power ground and a signal ground. Separating those grounds inside of the package prevents ground-loop problems that sometimes occur in power amplifiers. The usual design-layout practice is to connect both of those pins together outside of the package at a single ground point.

Figure 7 shows a typical audio-power amplifier based on the LM379. Note that while that circuit is normally a two-stage one, aside from the input resistors only one stage is shown—for the sake of simplicity; the other stage is identical.

The circuit in Fig. 7 is a noninverting follower. The feedback-voltage divider, R2/R1, sets the gain. The voltage divider also contains a capacitor, C2, which means that that circuit is basically an AC one.

The LM379 operates from a single DC power supply, so the output terminal will have a substantial DC offset. Capacitor C4 is used to block any DC, thus protecting the load (a loudspeaker). Note that C4 is an electrolytic and that its polarity must be observed.

The input resistors for both stages, R3 and R4, are connected to pin 14, which is the $\frac{1}{2}V_{CC}$ terminal that serves as a DC reference point.

The input signal is applied to the noninverting input of the LM379 through capacitor C1. That capacitor affects the upper end of the frequency-response curve, which is calculated using equation 9, substituting R3 for the resistance term.

Bridge audio-amplifier

Several years ago, a major auto manufacturer issued instructions to the car-radio repair trade to not ground one side of the loudspeakers in their product because it might blow the audio-amplifier stage. The instructions came as a bit of a surprise to those who had been routinely grounding one side of an auto-radio speaker for forty years.

The reason for the warning was the bridge audio-circuits used for the output-power amplifiers. Bridge audio-circuits preserve the advantages of a class-B amplifier while eliminating the need for the troublesome output capacitor. That capacitor is not only physically large, but can cause some phase distortion to be added to the output signal.

Figure 8 shows a simplified schematic of a bridge audio-amplifier. Class-B bridge amplifiers such as the one shown are based on the so-called totem-pole circuit. There are two such totem-pole circuits in that figure—Q1/Q2 and Q3/Q4.

Let's first consider the half-bridge case; that uses a normal totem-pole amplifier (here Q1/Q2). In a totem-pole amplifier, the two output transistors are connected in series across the power supply, and the load (the loudspeaker) is connected to the

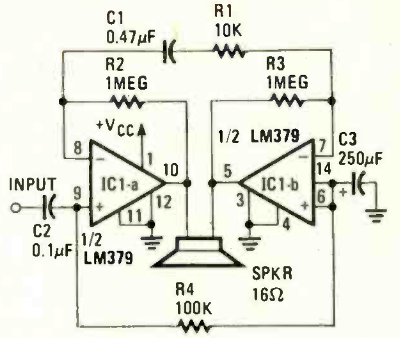


FIG. 9—A PRACTICAL bridge audio-amplifier based on the LM379.

junction between the two transistors and to ground.

The major problem here is that the speaker connection point is at a DC potential equal to one-half the DC supply. Such a potential would blow out the loudspeaker. To avoid that, circuit designers place a large electrolytic capacitor between the junction and the speaker.

We can eliminate the need for that capacitor by using two totem-pole half bridges, as shown in Fig. 8, to form a bridge amplifier. The four arms of the bridge consist of transistors Q1–Q4. The loudspeaker load is connected between the output points of the two totem-pole amplifiers.

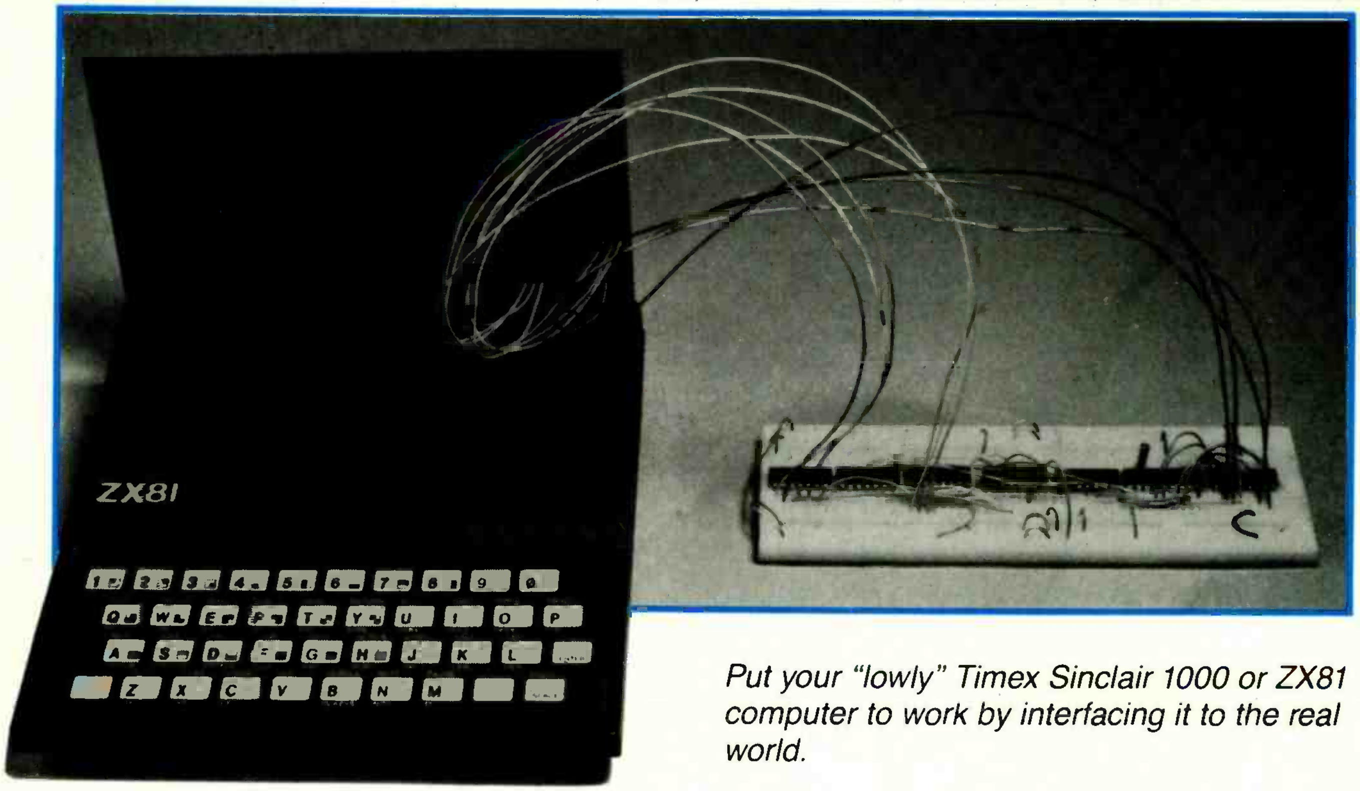
It is necessary to drive the two amplifier halves out of phase with each other. An inverter stage accomplishes the phase inversion in our example (note, however, that real bridge audio-amplifiers use a different method). When the input signal is positive going, the voltage at point A will also be positive going. The voltage at point B, however, will be negative going.

Under quiescent conditions (that is, with no input signal present), the voltage at both points A and B are at $\frac{1}{2}V_{CC}$, so that the differential voltage between the points is zero. That potential increases as the input-signal voltage increases.

Figure 9 shows a practical bridge audio-amplifier circuit based on the LM379. The load (speaker) is connected across the outputs of the two stages.

The input is applied to the noninverting input of IC1-a. From our discussion we know that IC1-b must be driven out-of-phase with IC1-a. Thus the noninverting input of IC1-b is grounded for AC signals through C3. The signal for the inverting input of IC1-b is passed through C1 and R1, but can you spot the signal source? If you will recall, one of the properties of ideal op-amps is that their inputs stick together. Since the input signal is applied to the noninverting input, it will also appear on the inverting input so it can be used to drive the other amplifier!

In the next part of this series we will turn our attention to the DC differential amplifier. **R-E**



Put your "lowly" Timex Sinclair 1000 or ZX81 computer to work by interfacing it to the real world.

Interfacing the ZX81

NEIL BUNGARD

THE SINCLAIR *ZX81* (OR TIMEX SINCLAIR *1000*) was the first computer to be sold for less than $100. It was quite a bargain at that price. Perhaps you're one of the many people who bought one so that you (or your kids) could learn something about computers. Or perhaps you've seen the computer on sale for a very attractive price and have only recently considered buying it just to see what it was like.

If you did buy the machine when it first became available, you may have outgrown it by now. After all, it's not the most practical computer available. Some of its problems—including its membrane keyboard and wobbling 16K RAM extension—can make using the computer almost a chore.

However, the *ZX81* is unbeatable for the hobbyist who wants to experiment—as we will do—with computers, computer interfacing, and Z80 machine language. And now that the computer is no longer being produced, you can often find it selling for as little as $30 (and maybe even less).

Let us note that for the remainder of the article, we'll refer to the Timex-Sinclair *1000* as the *ZX81*, if for no other reason than because it's shorter. There is little difference between the two machines, save that the *1000* has 2K of built-in RAM as compared to the *ZX81*'s 1K.

What we'll do

In this article, we'll show you how to interface the *ZX81* to a clock/calendar integrated circuit, a temperature indicator, a light controller, and a heater controller. You might find use for such devices in photographic dark rooms, home weather stations, and home security systems.

In addition to interfacing those special devices to the *ZX81*, hardware and software interfacing principles will be covered in general. That means that you can make use of the inexpensive *ZX81* for any particular monitor or control application that you have in mind—you won't be limited to the specific applications that we'll discuss. It's true that we won't end up with something as elegant as the home-control computer that was presented in **Radio-Electronics** in April through June. But we will have something to quiet the people who scoff at the *ZX81* and call it a useless machine.

Using a computer for monitoring and control has become much simpler than it once was because of the number of interesting microprocessor-compatible integrated-circuits now available. For example, we'll be using OKI's MSM5832 clock/calendar integrated-circuit (IC).

Where to begin

You will, of course, need a *ZX81* computer and a TV. You should also have a standard cassette-tape player so that you can store your programs. You might also consider building the 8K non-volatile RAM accessory that was described in the July and August 1983 issues of **Radio-Electronics**: It makes storing and using machine code much more convenient.

On the back of the *ZX81* is a card-edge with 44 "fingers." That gives you access to (for all practical purposes) all of the pins of the Z80 microprocessor. Figure 1 shows the pinout of the card edge, while the signals and functions are listed in Table 1. When you interface to the port, you are essentially interfacing directly to the Z80 CPU. To get the most out of the project, you might consider obtaining a Z80 technical manual and other reference material relating to the Z80.

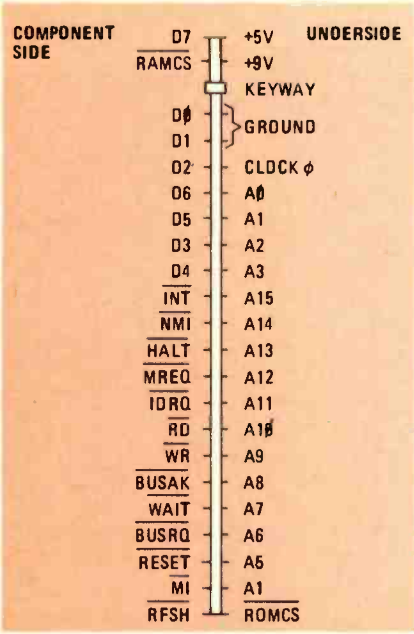


FIG. 1—THE CARD-EDGE PINOUT of the *ZX81*'s expansion port.

sequently doing any type of memory-mapped input/output (I/O) is practically impossible. That leaves you with only the Z80's IN and OUT instructions for getting peripheral data in and out of the microcomputer. Unfortunately, the *ZX81* does not include IN and OUT commands with its BASIC language instructions. That means that all I/O will have to be accomplished from machine-language subroutines that will be incorporated within the BASIC program you write. Fortunately the *ZX81*'s BASIC language does supply you that capability with the "USR" command.

When using the IN and OUT instructions with the *ZX81*, some strange things occur in two specific situations: 1) if you use the OUT machine language instruction with an odd device code (in other words, if A0 = 1), the *ZX81* monitor system will crash. 2) Any input using the IN machine language instruction and an even device code ignores the top two data bits (D6 and D7). As long as those characteristics (that

TABLE 1—TIMEX/SINCLAIR EXPANSION PORT

Description	Signal	Function
Address bus	AØ - A15	Outputs memory-and I/O device addresses
Data bus	DØ - D7	Transmits bidirectional data into/out of CPU
	MREQ	Identifies any memory-access in progress
	IORQ	Identifies any I/O operation in progress
	RD	Indicates that the CPU wants to read data
System control	WR	Indicates that the CPU wants to output (write) data
	MI	Identifies the op-code fetch cycle of instruction Also used withIORQ to acknowledge Interrupt
	RFSH	Synchronizes dynamic-memory refresh
System clock	φ	3.25 MHz clock (output)
	RESET	Resets CPU when pulled low
	INT	Interrupt request input
CPU control	NMI	Interrupt request input; cannot be disabled
	WAIT	Initiates wait state in machine cycle
	HALT	Indicates CPU has executed a HALT instruction
Bus control	BUSRQ	Request to CPU for control
	BUSAK	Acknowledgement of release of control by CPU
RAM/ROM select	RAMCS	If pulled high will disable computer's on board RAM
	ROMCS	If pulled high will disable computer's ROM
Power	+9V	Unregulated
	+5V	Regulated
	GROUND	

Interfacing principles

The procedures for interfacing to a microcomputer are relatively straightforward. Once you learn the techniques, you'll be able to apply what you learn here to other computers. However, the *ZX81* has some unique idiosyncrasies that can give you a real headache unless you are forewarned. We will list those idiosyncrasies now for those that have done some microprocessor interfacing. If you don't understand them now, don't worry—we'll explain later them in more detail when we review general interfacing principles.

The first thing that makes interfacing with the *ZX81* not as straightforward as interfacing with just the Z80 CPU is that the *ZX81* does not use absolute address decoding in its memory scheme. Consequently doing any type of memory-

are unique to the *ZX81*) are known, they can be circumvented. They will not be a problem for our applications. If one is not aware of those characteristics, however, they can be maddening and take weeks to figure out.

Interfacing basics

Interfacing to a microcomputer can be analogous to tossing a baseball. If you try to catch the ball before it is within your reach—or after it has gone past—you will miss it. Data moving in and out of the microprocessor works much the same way. When the microprocessor wishes to input or output data, it always does three operations:

- It places the address of the device with which it wishes to communicate on the eight lower bits of the address bus.
- It places the data it wishes to send to (or receive from) the external device on the data bus.
- After the address and data buses have had time to settle, it sends a control pulse to initiate the data transfer.

The microprocessor does those three operations every time it wishes to communicate. But it is your responsibility to perform the following tasks in response:

- You must decode the address from the address bus and signal the device that its particular address is being sent.
- You must be certain that the communication lines of the device are properly connected to the data bus, and if it is an input device, its communication lines must be disabled (set to a high-impedance) until it receives an input-control pulse from the microcomputer.
- When interfacing to the Z80 CPU, you must decode three control signals to generate the input and output control pulses. Once decoded, you must send the appropriate control pulse to the device to initiate data transfer.

The interface circuit

The schematic of the interface circuit is shown in Fig. 2. Let's take a look at it to see how the principles that we just mentioned apply. Two sections of a quad OR gate, IC1-a and IC1-b, receive three control signals from the microcomputer on its inputs. It decodes those three signals, such that when IORQ and WR are true (low) an OUT control pulse is generated. When IORQ and RD are true (low) an IN control pulse is generated. Those input- and output-control pulses initiate the data transfers. Each of the control pulses goes to a 74LS138 3-to-8-line decoder (IC3 and IC4). Figure 3 shows how the 74LS138 operates: When E1 and E2 are high (logic 1) the logic levels of inputs A, B, and C do not matter. However, if E1 and E2 are low (which is the condition when either IN or OUT is true), the inputs A, B, and C are decoded such that one of the outputs on the 74LS138 goes low. As shown in the table in Fig. 3, the output that goes low depends on the code at the inputs A, B, and C (pins 1, 2, and 3).

Referring back to the schematic in Fig. 2, you will notice that the 74LS138 inputs are connected to A2, A3 and A4 of the *ZX81* address bus. This means that—assuming that A0, A1, A5, A6 and A7 are all logic zeros—the device codes as, shown in Table 2, can be generated by the *ZX81* and will be decoded by the 74LS138.

So with two OR gates and two 74LS138's you have the capability of generating eight output- and eight input-device code pulses. In other words, you have the capability of sending an output to eight separate devices from the *ZX81* and receiving an input from eight separate devices. In the interface circuit in Fig. 2, three of the output-device code pulses (IC4, pins 13, 14 and 15) and one of the

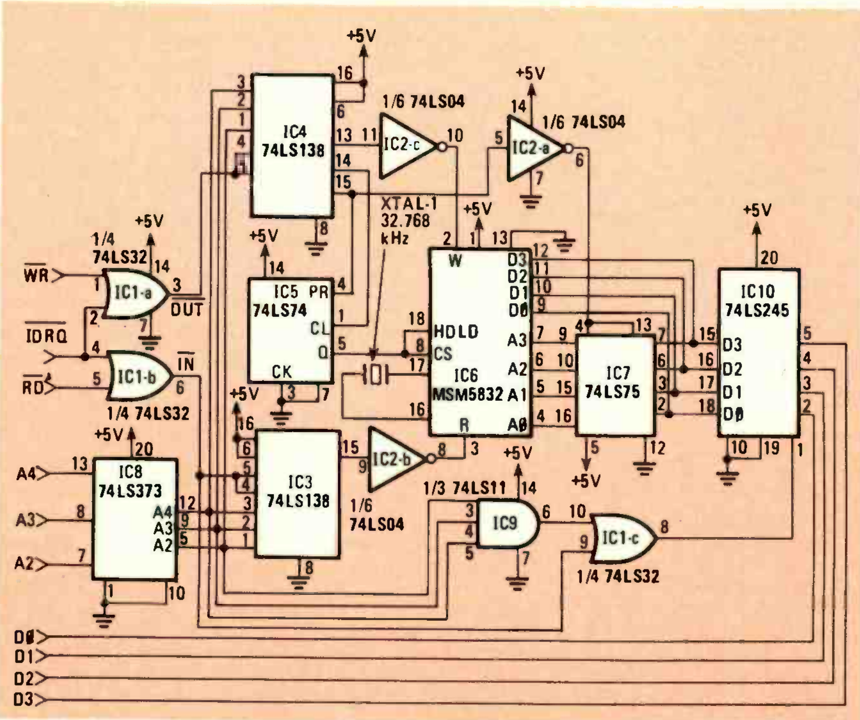


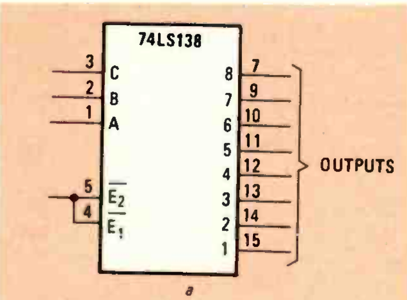
FIG. 2—INTERFACE-CIRCUIT SCHEMATIC. The connections to the computer include three address lines, three control lines, and four data lines. Note that +5 volts can also be taken from the computer.

PARTS LIST

IC1—74LS32 quad OR gate
IC2—74LS04 hex inverter
IC3,IC4—74LS138 3-to-8-line decoder/multiplexer
IC5—74LS74 dual D-type flip-flop
IC6—MSM5832 microprocessor real-time clock/calendar
IC7—74LS75 4-bit bistable latch
IC8—74LS373 octal D-type latch
IC9—74LS11 triple 3-input AND gate
IC10—74LS245 octal bus transceiver
XTAL1—32.768 kHz

Miscellaneous: Card-edge connector for *ZX81*, wire-wrap sockets, universal plugboard, etc.

The following are available from Active Electronics, PO Box 8000, Westborough, MA 01581 (1-800-343-0874): MSM5832 clock/calendar IC, $12.95; 32.7680 kHz crystal, $3.45. Add $3.75 for postage, handling, and insurance.



$\overline{E_1}$ AND $\overline{E_2}$	C	B	A	1	2	3	4	5	6	7	8
1	X	X	X	1	1	1	1	1	1	1	1
0	0	0	0	0	1	1	1	1	1	1	1
0	0	0	1	1	0	1	1	1	1	1	1
0	0	1	0	1	1	0	1	1	1	1	1
0	0	1	1	1	1	1	0	1	1	1	1
0	1	0	0	1	1	1	1	0	1	1	1
0	1	0	1	1	1	1	1	1	0	1	1
0	1	1	0	1	1	1	1	1	1	0	1
0	1	1	1	1	1	1	1	1	1	1	0

(Outputs columns 1–8.) b

FIG. 3—THE 74LS138 3-to-8-line decoder/multiplexer. By using three address lines and two control lines, we can generate 8 input- and 8 output-device codes.

TABLE 2

A4	A3	A2	Device Code (Hex)
0	0	0	00
0	0	1	04
0	1	0	08
0	1	1	0C
1	0	0	10
1	0	1	14
1	1	0	18
1	1	1	1C

Note: A7, A6, A5, A1, and A0 = 0

input-device code pulses (IC3 pin 15) are used. The remaining input and output device code pulses will be used in future interface projects.

Once the device-code pulses are generated via the input and output 74LS138's, they are sent to the clock/calendar circuit to get information into and out of the MSM5832 clock/calendar IC.

The remainder of the circuit in Fig. 2 is specifically for interfacing the MSM5832 to the *ZX81*. For example, when output-device code pulse 00H is generated (at IC4, pin 15), it goes to pin 4 of IC5, a 74LS74 flip-flop. (**Note:** A hexidecimal number is indicated by a capital "H" following the digits.) When the flip-flop receives a low-going pulse on pin 4, it sets its output (pin 5)—and thus the CS and HOLD inputs of the MSM5832 clock/calendar IC—to a logic 1. A logic 1 on those inputs selects the MSM5832 and holds all of its internal registers stable during the input or output operation.

In addition to going to pin 4 of the 74LS74, the device-code pulse is inverted and sent to pins 4 and 13 of a IC7, a 74LS75 4-bit latch. When the 74LS75 receives a high-going pulse on pins 4 and 13, it catches the data present on its inputs (pins 2, 3, 6, and 7). Those input pins are connected (through a buffer) to the four lower-order bits of the data bus of the *ZX81*.

The information transferred from the *ZX81* to the latch is the code or address for the MSM5832 clock/calendar register to which it wishes to send or receive information. A listing of the register options and their codes are shown in Table 3. Once the register code is sent to the 74LS75, it will remain present on its outputs until a new register code is sent.

Once the register code is sent, the MSM5832 is ready for communication and data can be sent to the selected register by generating an output-device code pulse 08H (pin 13, IC4). You may receive information from the selected register by generating an input-device code pulse 00H (pin 15, IC3). When you have completed your input or output operations, an output-device code pulse 04H (pin 14, IC4) is generated to reset the 74LS75 flip-flop output back to a logic zero. That deselects the MSM5832 and allows it to resume normal timing operations—which brings us to an important point: If the MSM5832 is kept on hold (CS and HOLD set to logic 1) for more than 1 second, its normal timing will be interrupted and you will lose a second for each second that those pins are held to a logic 1.

Two IC's in the interface, IC8 and IC10, have not been discussed, yet they are important. Those two IC's are bus buffers—they protect the *ZX81* from damage resulting from wiring errors in the interface circuit. For example, IC8 (74LS373) buffers the address lines and is unidirectional, while IC10 (74LS245) buffers the data-bus lines and is bidirectional. The 74LS245 allows information to flow from the *ZX81* data bus to the interface circuit on all OUT instructions. But it only allows information to flow from the interface circuit to the *ZX81* on certain IN instructions. Those IN instructions are determined by the IN address lines A2 through A4, and a decoder circuit constructed of IC9 (74LS11) and IC1-c (74LS32).

If any address line is a logic 0 and an IN is generated, the 74LS245 allows information to flow from the interface circuit to the *ZX81* data bus. That means that if the *ZX81* is trying to generate an IN instruction with A2, A3, and A4 all logic 1's, an input will not be accomplished.

TABLE 3—MSM5832 REGISTERS

Address Inputs				Internal	Data I/O				Data	*Notes
A3	A2	A1	A0	Counter	D3	D2	D1	D0	Limits	
0	0	0	0	Seconds	X	X	X	X	0–9	Seconds and tens of seconds are reset to zero when write instruction is executed with address selection
0	0	0	1	Tens of seconds	—	X	X	X	0–5	
0	0	1	0	Minutes	X	X	X	X	0–9	
0	0	1	1	Tens of minutes	—	X	X	X	0–5	
0	1	0	0	Hours	X	X	X	X	0–9	
0	1	0	1	Tens of hours	*	*	X	X	0–1/0–2	D2 = 1 for PM; D2 = 0 for AM D3 = 1 for 24-hour format D3 = 0 for 12-hour format
0	1	1	0	Day of week	—	X	X	X	0–6	
0	1	1	1	Days	X	X	X	X	0–9	
1	0	0	0	Tens of days	—	*	X	X	0–3	D2 = 1 for 29 days in Feb D2 = 0 for 28 days in Feb
1	0	0	1	Months	X	X	X	X	0–9	
1	0	1	0	Tens of months	—	—	—	X	0–1	
1	0	1	1	Years	X	X	X	X	0–9	X Indicates data can
1	1	0	0	Tens of years	X	X	X	X	0–9	be either 1 or 0

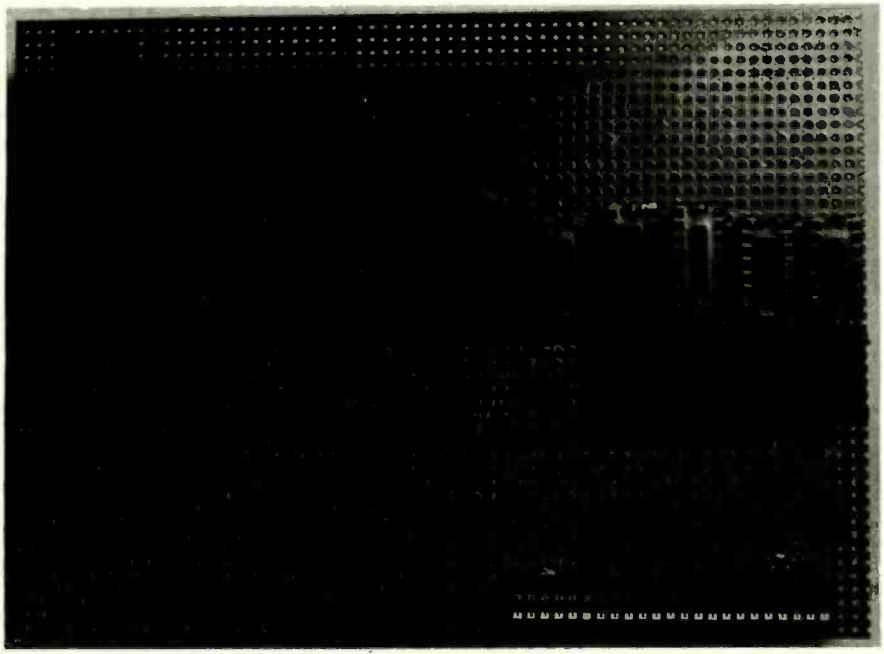


FIG. 4—THE INTERFACE BOARD. Wire wrapping is probably the easiest way to construct the interface. Be sure to leave space between the connector and the lowest IC socket so you can plug the board into the computer.

Even though the 74LS138 can decode and generate a device code pulse for that address when those three address lines are all logic 1's, the 74LS245 will not let the information pass. Keep that in mind when interfacing with the circuit.

Building the interface

To wire anything to the card-edge port of the *ZX81*, you'll need a 44-pin card-edge connector. However, you cannot use a standard 44-pin connector. If you look closely at the card-edge fingers, you will notice that, in addition to the 44 fingers, there is a keyway. That keyway takes up exactly one pin location—it's used so that you won't plug anything in backward. It means that the connector you need is actually a 46-pin type. The problem is that standard connectors are available in 44- and 50-pin configurations but are not available with 46 pins.

You can do one of two things. You can buy a special connector that will fit the *ZX81*. (Such a connector is not too easy to find, but they are available from the "cottage industry" that has sprung up around the *ZX81*.) Your other choice is to buy a standard 50-pin connector and cut it to size. The 50-pin card-edge should have 0.100 by 0.200 inch spacings. It is available from many suppliers, in many different configurations. You'll probably want to buy the wire-wrap type because wire wrapping is easy to use and is easy to modify. But if you're not a wire-wrap fan, feel free to use some other construction method. Whatever method you use, you should make some note of the connector polarity. Either insert a "key" in the keyway or simply label the connector.

Once all the parts for the circuit have been acquired, the card-edge connector and wire-wrap sockets can be place on universal plugboard as shown in Fig. 4. Notice that there is approximately one inch between the top of the card-edge connector and the bottom of the lowest IC socket. If you intend to leave your *ZX81* in its case, be sure to do the same. Otherwise you won't be able to plug the expansion board into the computer. You will also notice that a a 40-pin IC socket has been placed on the plugboard, even though none of the IC's in the circuit requires it. That 40-pin socket has *not* been placed on the board to receive an integrated circuit; its purpose is for breadboarding. As new circuits are developed to interface to the *ZX81* they can be developed on a solderless breadboard and tested. (The photo on the title page of this article shows the clock/calendar circuit under construction before any IC sockets were placed on the plugboard.) When your circuits are working properly, they can be transferred to the plugboard in wire-wrap form. When you need a signal from the *ZX81* all you have to do is bring the signal to the back of the 40-pin IC socket by wire wrapping it from the card-edge connector. Then you can plug one end of a wire into the corresponding hole of the socket, and plug the other end of the wire into the solderless breadboard—very handy!

Another trick that you may find useful when wire wrapping is to use a small amount of quick-setting epoxy glue on the backs of the IC sockets before mounting them. That ensures a sturdy mount which makes wire wrapping easier. Labeling each IC and marking the number one pin of each IC makes the task of wire wrapping much easier; and in addition this aids in reducing wiring errors. Plastic slip-on pin identifiers are recommended.

Now that we have the basic hardware design completed, we can turn to what is often the most time-consuming and least understood aspect of any microprocessor-based project: the software—the program that makes your interface do what it has been designed to do. Next month, after we look at the software, we'll be able to put the interface to work as a temperature sensor, a security system, and more. **R-E**

Clamp-on DC Ammeter

This ammeter uses Hall-effect transducers to let you measure DC current using a clamp-on probe.

HARDIN STRATMAN

THE CONVENTIONAL METHOD OF MEASURING direct current in a circuit is to connect an ammeter in series with the current flow, as shown in Fig. 1. That means that if you want to measure the circuit's current, you have to shut the current off before connecting or disconnecting the ammeter. If the point of current measurement is at a high voltage, the ammeter case must be insulated from ground to prevent arcing. And it also must be insulated from people who might come in contact with it.

Another problem with inserting a conventional ammeter in series with the current flow is that the internal resistance and inductance of the meter can alter some characteristics of the circuit under test in an undesirable manner. For example, it can add inductance in a video circuit or resistance in a high-current circuit. A remote meter-reading at any distance may be difficult to obtain.

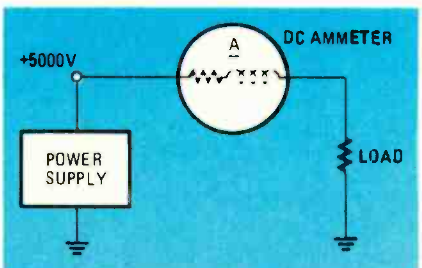


FIG. 1—THE CONVENTIONAL METHOD of measuring current can add undesirable resistance and inductance to the circuit. The ammeter case may also be at a dangerous voltage level.

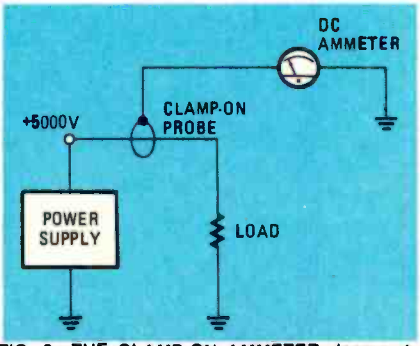


FIG. 2—THE CLAMP-ON AMMETER does not add inductance or resistance to the circuit, and it's isolated from high voltages.

The clamp-on ammeter

With clamp-on ammeters, there's no exposure to dangerous voltages when measuring current; there's no need to disturb the insulation; there's no inserted impedance. Clamp-on ammeters eliminate the undesirable characteristics of DC ammeters because they measure the current flowing in a wire without breaking the circuit connection, as shown in Fig. 2.

Clamp-on ammeters for measuring alternating current have been around for a long time. Those devices are generally low cost, reasonably accurate, and easy to construct since they operate on a mutual-inductance principle the same as a transformer. But there have only been a limited number of DC clamp-on ammeters available. One example of a fine laboratory-type DC clamp-on ammeter is shown in Fig. 3: Hewlett Packard's *HP-428B*, which can measure current from 1 milliamp to 10 amps. Its list price is around $1800. The *HP-428B* first converts the magnetic field around the conductor to an AC voltage that is proportional to the DC current. If you connect a voltmeter or oscilloscope to a front-panel output, you can measure low-frequency (under 400 Hz) AC current, too. The unit's probe needs occasional de-gaussing.

Just recently, some DC clamp-on ammeters that make use of the *Hall effect* principle—as our ammeter will do—have become available. The list price of those instruments is about $200 to $500. Figure 4, for example, shows F.W. Bell's *Current Gun* model *CG-103A*. That is a clamp-on current probe that uses a Hall-effect gen-

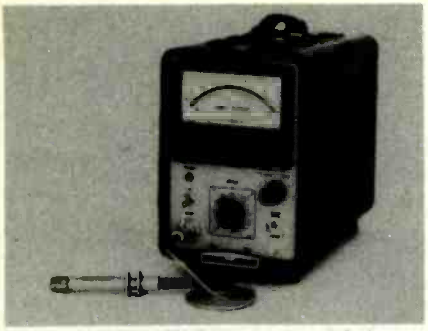


FIG. 3—ONE EXAMPLE OF a lab-type DC clamp-on ammeter: the *HP-428B*.

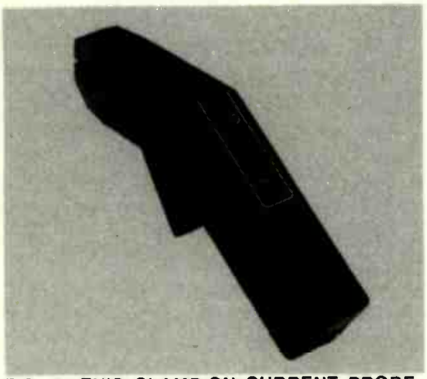


FIG. 4—THIS CLAMP-ON CURRENT PROBE uses Hall-effect sensors.

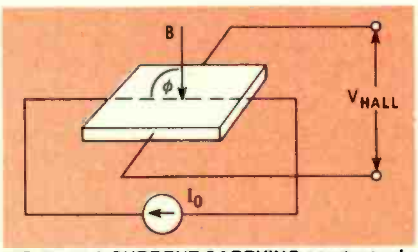


FIG. 5—IF A CURRENT-CARRYING conductor is placed in a magnetic field, a Hall voltage is generated that is perpendicular to both the current flow and the magnetic field.

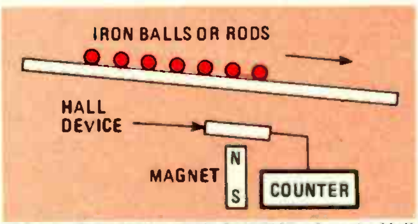


FIG. 6—BECAUSE THE OUTPUT of early Hall transducers varied widely with temperature and pressure variations, their use was limited to acting as switches. Here, the iron balls or rods concentrated the field from the magnet.

erator and lets you read DC and AC currents on a standard voltmeter or oscilloscope. The list price of that probe is about $220.

The Hall effect

The Hall effect is one of those great discoveries that had to wait for its time to come. Edward H. Hall, in 1879, found that if a current-carrying conductor is placed in a magnetic field that is perpendicular to the direction of current flow, a voltage is developed across the material in a direction perpendicular to both the initial current direction and the magnetic field, as shown in Fig. 5. That voltage is now known as the Hall voltage to commemorate the discoverer of the effect.

For close to 100 years, the Hall effect principle was little more than a note in some textbooks and a curiosity for experimenters. That's because there wasn't much practical use for it—the magnitude of the Hall voltage produced in metallic conductors is extremely small. However, experiments with semiconductors showed that some semiconductor materials exhibit a Hall voltage three or four orders of magnitude greater than that of metal. The advances in semiconductor technology permitted the construction of practical Hall transducers.

Early semiconductor Hall transducers had a tendency to drift considerably with vibration, pressure, and changes in temperature. That limited their use to acting as switches in counting devices. An example of how they could be used is shown in Fig. 6.

Using the Hall effect

We no longer have to limit the use of Hall transducers to switches. A useful DC clamp-on ammeter can be built using Hall-effect transducers.

If a Hall generator is placed near a current-carrying conductor, the Hall voltage that's developed is proportional to the magnitude of the magnetic field surrounding the conductor. Since that field is proportional to the current level, the Hall voltage is also proportional to the current level.

For our Hall-effect ammeter to be practical, it should meet some design criteria:

- It must perform accurately on a single, straight wire.
- It should be essentially free of high-voltage dangers.
- It should operate from a single 9-volt battery for a reasonable length of time.
- It should be simple to operate, calibrate, and "zero set".
- It should be fairly low-cost.

We can start with a simple design like that shown in Fig. 7. The voltage induced by the magnetic lines of force around wire generates a voltage that is amplified by the Hall transducer. However that type of circuit is not too practical: It can be used only if the current is extremely large. Figure 8 shows an improved simplified circuit. The first improvement is the use of a *concentrator core*, which increases the magnetic effects by about a factor of four. We'll talk more about that shortly. A second improvement is that two Hall transducers are used. Using two transducers, fastened back-to-back gives us two advantages: First, the Hall voltage is doubled. Second, drifting due to temperature and pressure changes is drastically reduced because each input of the differential op-amp will be effected similarly. The schematic of the final circuit is shown in Fig. 9.

When designing the meter, several Hall transducers were tried. Most of them drifted wildly. A 9SS-series transducer manufactured by the Micro Switch Company (Div. Honeywell, 11 W. Spring St., Freeport, IL) demonstrated considerable improvement over all others and was chosen for the final circuit. Figure 10 shows the Hall transducer.

The output voltage of the 9SS as a function of the magnetic field is linear over an input range of −400 to +400 gauss. The diagram in Fig. 11 shows the four blocks that make up the transducer: Hall-effect element, voltage regulator, amplifier, and output transistor. Its transfer function is:

$$V_{OUT} = (6.25 \times 10^{-4} B + 0.5)V_S$$

where V_S is the supply voltage and B is the magnetic flux density in gauss.

The flux concentrator

The flux density produced by low-level currents is usually not sufficient to allow the use of a Hall transducer to measure the current. However, if a toroidal is used to enclose the conductor and act as a flux concentrator, good results can be obtained, and the basic clamp-on circuit of Fig. 5 can be made into a practical and useful measuring instrument.

Different materials, sizes, and shapes

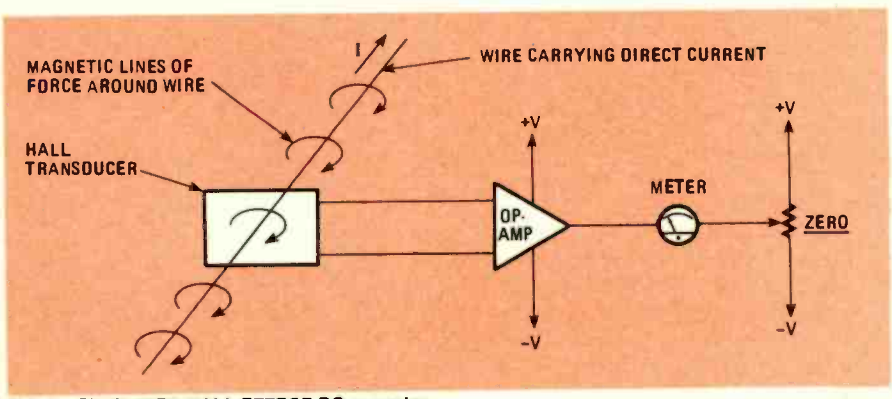


FIG. 7—SIMPLIFIED HALL-EFFECT DC ammeter.

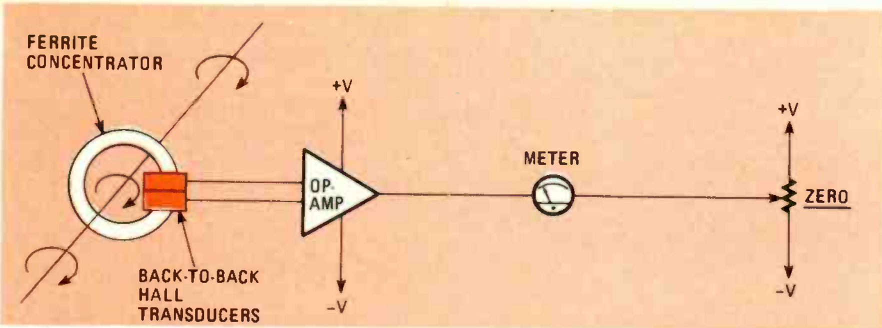


FIG. 8—THIS IMPROVED HALL-EFFECT-AMMETER circuit uses two back-to-back Hall transducers and a ferrite concentrator core.

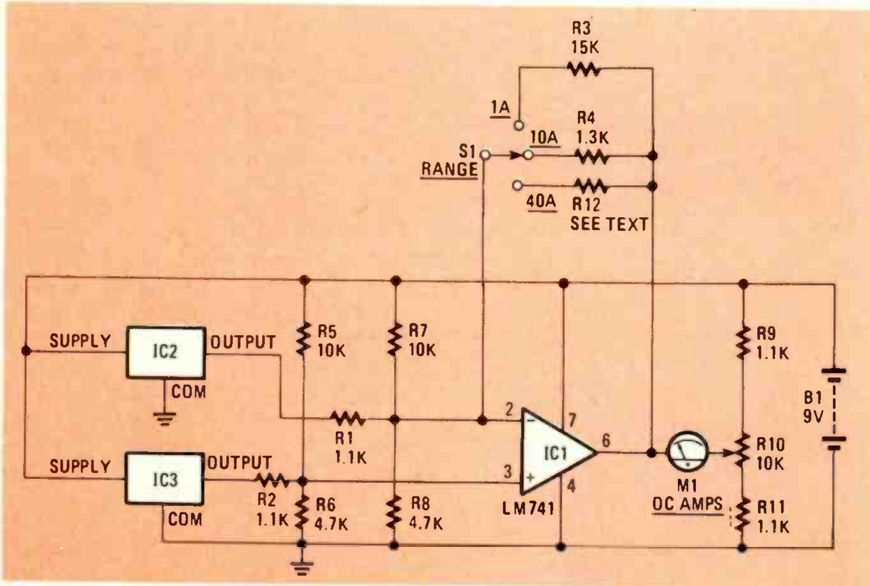


FIG. 9—COMPLETE AMMETER SCHEMATIC. Parts values are not critical, but for more accurate calibration, use variable resistors for R3, R4 (and R12, if you don't use a jumper).

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.
R1,R2,R9,R11—1100 ohms
R3—15,000 ohms
R4—1300 ohms
R5,R7—10,000 ohms
R6,R8—4700 ohms
R10—10,000 ohms, potentiometer
R12—see text
Semiconductors
IC1—LM741 op-amp
IC2, IC3—Hall transducer, sensitivity 3 mV/gauss (Micro Switch 91SS12-2)
Other components
M1—Meter, 100 microamperes movement. (Note that meters with movements up to 1 mA may be used.)
S1—Three-position rotary switch
S2—SPDT toggle or slide switch
B1—Battery, 9 volts, transistor type

Miscellaneous: Concentrator cores, case, wire, solder. Concentrator cores with a permeability of 2500 or greater all performed equally well. It appears that a permeability greater than 2500–3000 fails to capture any additional magnetic flux lines.
The core used in the probe shown in the pictures is a Stackpole 57-3336 type 24B material with a permeability of 5000 and a 0.187-inch gap. These may be obtained from Permag Central Corp., 1213 Estes Ave., Elk Grove Village, IL 60007. The single-unit price is $11 postpaid (IL residents add 7% sales tax).

A pair of Hall-effect transducers (Micro Switch 91SS12-2) is available from Peerless Radio Corporation, 19 Wilbur Street, Lynbrook, NY 11563, for $16 postpaid. (NY residents add 8% sales tax).

were tried for the concentrator for the external probe. The standard of comparison was to pass one ampere of current through a single wire surrounded by the core under test. Ordinary steel, power-transformer steel, silicon steel and "mu" metal all retained enough residual magnetism after the passage of 1 ampere through the wire to upset the zero calibration of the meter after removal of current. The only materials that retained no measurable residual magnetism were ferrite and a special nickel core.

Different core sizes from .5 to 1 inch in diameter were used with no measurable difference in results. Changing the core gap size caused the instrument sensitivity to vary in a linear manner. If the gap size was doubled, the meter reading was reduced to one-half.

The final probe constructed by the writer used a ⅞-inch outside-diameter ferrite core with a 3⁄16-inch gap.

Building the ammeter

You can build the DC ammeter for less than $60, including the case. In addition to being used as an ammeter, you can use the instrument as a gaussmeter—it will

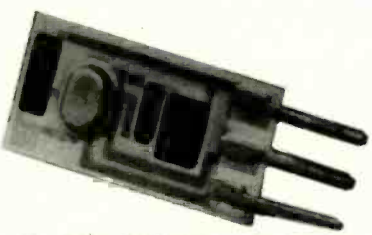


FIG. 10—THE HALL-EFFECT SENSOR from Micro Switch, the *LOHET* (*Linear Output Hall Effect Transducer*).

indicate the presence, relative intensity, and polarity of an external magnetic field.

The probe is the most difficult part of the instrument to build. In the prototype, the Hall transducers were first glued back-to-back with epoxy glue and plastic slides were glued on the sides of the transducers, as shown in Fig. 12. The core was then glued to a piece of 1⁄32-inch fiberglass which slid into the side pieces. That permits the Hall transducers to move into the the gap in the ferrite after the wire has been passed through. When the transducers are properly positioned, their centers should be in line with the core. The closed probe is shown in Fig. 13.

When you build your clamp-on am-

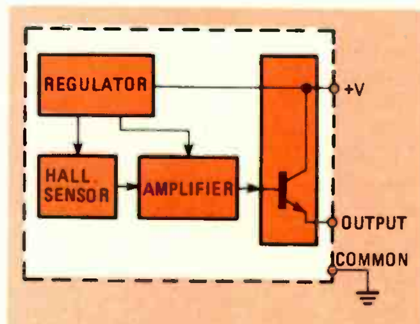


FIG. 11—BLOCK DIAGRAM of Micro Switch's LOHET 91SS12-2.

meter, you may want to use your imagination when constructing a probe for the device. The one shown here works, but is not necessarily the most elegant. You may want to build the entire ammeter into a handheld probe. For example, F.W Bell Inc. (6120 Hanging Moss Rd., Orlando, FL 32807) sells such a meter. They simply added a digital meter to the probe that was shown in Fig. 4.

Cores for the probe should be purchased with a precut gap, because cutting

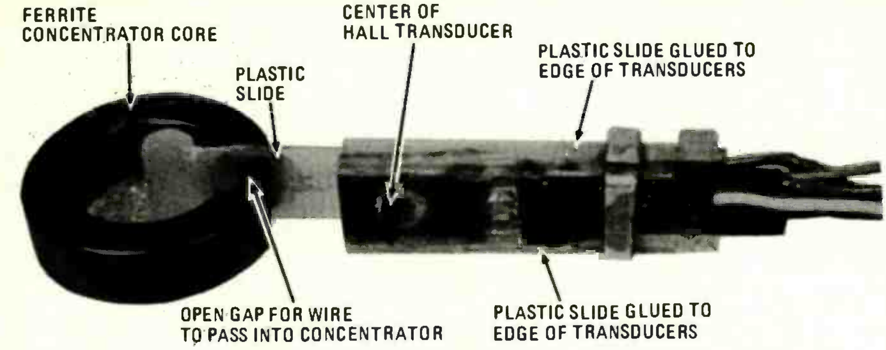


FIG. 12—THE CLAMP-ON PROBE is shown with the gap open.

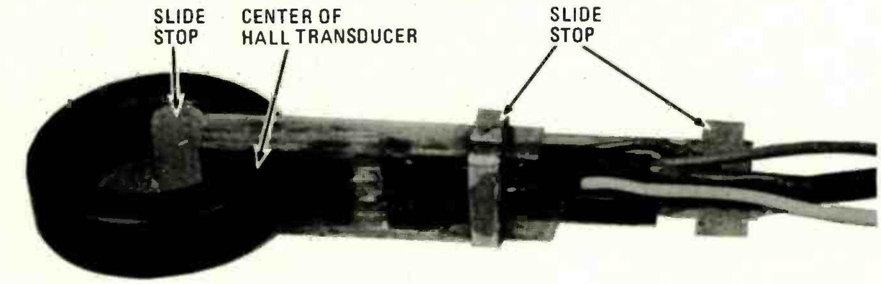


FIG. 13—THE CLAMP-ON PROBE is show here closed. The center of the transducer is in line with the ferrite core.

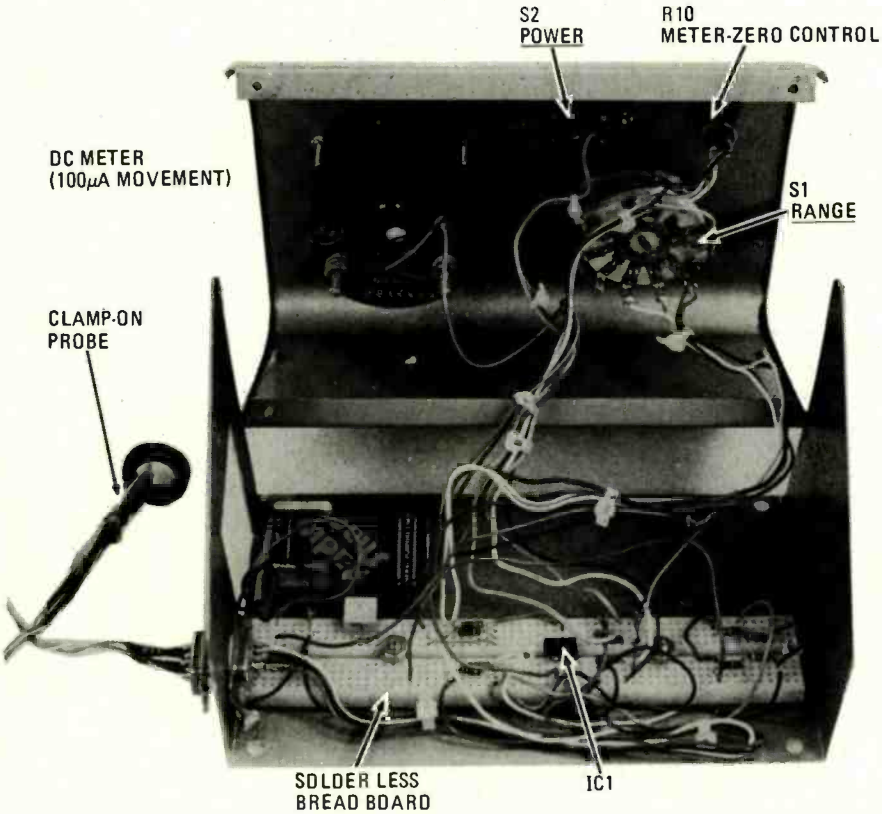


FIG. 14—THE AUTHOR'S PROTOTYPE. The construction method is obviously not critical.

through ferrite material without special tools is extremely difficult.

We won't go into detail on the construction of the rest of the instrument. It is rather straightforward and is not critical. We'll leave it to the ability of the persons wanting to build a clamp-on ammeter. As you can see in Fig. 14, the author's prototype simply used a solderless breadboard for the op-amp circuit.

Calibration procedures

Calibration of the ammeter is determined mainly by the size of feedback resistors R3, R4, and R12 and by the concentrator-core gap. Resistor R12 will generally be zero (a jumper) for the highest current range desired.

Potentiometers should be substituted for R3 and R4 to increase the calibration accuracy. And, of course, the more accurate the standard you use, the more accurate the calibration will be. A one-ampere source of current is most desirable. To calibrate, zero the meter with no current. Then pass one ampere through the wire encircled by the core concentrator with S1 placed in the 0-to-1 amp range. Set R3 for full scale deflection. (Note that current must flow in the proper direction, or the meter will read backward.) Next, make a coil of 10 turns of wire and place a leg of the concentrator through the coil. Set S1 to the 0 to 10 ampere range and zero the meter. Pass 1 ampere through the coil. Set R4 to full scale deflection. Construct a coil of 40 turns of wire and place a leg of the concentrator through the coil. Place S1 in the 0-to-40 amp position and adjust for zero. Pass 1 ampere through the coil and adjust R5 for full scale reading. Please note that the actual full-scale reading of the high current range will vary with core gap size.

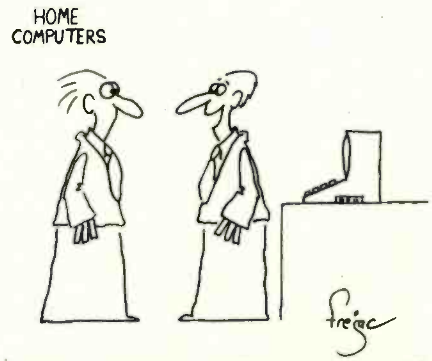
Current drain

The clamp-on ammeter under discussion has a current drain of 21 mA when utilizing an alkaline battery. For the sake of comparison, we'll mention that a *TI-30* calculator draws 9 mA when idling and 50 mA when eight nines are displayed.

This instrument need only use the nine-volt battery for isolated measurements. For ordinary bench measurements, or for installation in an AC driven industrial or commercial device, an AC power-supply (or "battery eliminator") can be used. Those small, low-cost, plug-in devices are capable of delivering 30 to 40 mA. But for best results and drift-free measurements, use a regulated supply.

High voltage warning

One of the advantages of a clamp-on ammeter is the ability to indicate current in a high voltage circuit without insulating the measuring meter. However, the safety factor is only as good as the wire insulation involved. When using the instrument to measure current in a high-voltage circuit make sure the wire insulation has an adequate safety factor to prevent arcing or danger to the operator. **R-E**



"We guarantee that all components will remain state-of-the-art for three hours."

ALL ABOUT

POWER-SUPPLY CIRCUITS

Designing practical power-supply and voltage-regulator circuits is not difficult—but finding practical information on those circuits often is. We'll change that with an in-depth look at practical power supplies and voltage regulators.

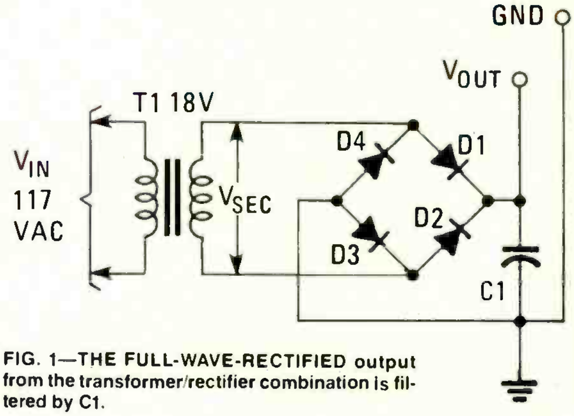


FIG. 1—THE FULL-WAVE-RECTIFIED output from the transformer/rectifier combination is filtered by C1.

RAY MARSTON

TWO OF THE MOST COMMON CIRCUIT DEsign tasks are those of designing basic power-supply circuits and designing voltage-regulator circuits. Both of those design tasks are reasonably simple. A basic power supply consists of little more than a combination of a transformer, rectifier, and filter so all the designer has to do is use a few simple rules to select the component values that will suit his own particular design requirements.

Voltage-regulator circuits may vary from simple Zener networks (designed to provide load currents up to only a few milliamps) to fixed-voltage high-current units (for powering logic boards, etc.), or to variable-voltage, high-current units designed for general-purpose laboratory supplies. We'll look at practical versions of all those examples.

Power supply circuits

Basic power-supply circuits are used so that equipment that requires a DC voltage can safely operate from the AC power lines (rather than from batteries). They are simply designed to convert the AC power-line voltage into an electrically isolated DC voltage with the value required by the actual circuitry of the equipment. The basic power-supply circuitry consists of little more than a transformer-rectifier-filter combination: The transformer is used to convert the AC line voltage into an electrically isolated and more useful (convenient) AC value, and the rectifier-filter combination is used to convert the new AC voltage into a smooth DC value.

Figures 1 through 4 show the three most useful transformer-rectifier-filter combinations that you will ever need. The circuit shown in Fig. 1 provides a single-ended DC supply from a transformer and bridge-rectifier combination. Its performance is virtually identical to the circuit shown in Fig. 2, which uses a center-tapped transformer.

The circuits of Figs. 3 and 4 provide bipolar DC supplies. Note that Fig. 4 is essentially the same as Fig. 3, except that discrete diodes (D1–D4) are used instead of a bridge rectifier. A bridge rectifier can keep things neater, but it can often be cheaper to use discrete diodes in high-current applications. Throughout the remainder of the article, we'll show only circuits that use discrete diodes. Where a bridge rectifier can be substituted, we'll show the diodes in the usual bridge configuration, as we did in Fig. 1.

The rules for designing both the single-ended and bipolar supplies are simple, as you'll see in a moment.

Transformer-rectifier selection

The three most important parameters of a transformer are its *secondary voltage*, its *power rating*, and its *regulation factor*. The secondary voltage is always quoted in volts RMS at full rated power load. The power load is quoted in terms of VA (*V*olt-*A*mps) or watts. Thus, a 15 V, 20 VA transformer has an output of 15-volts

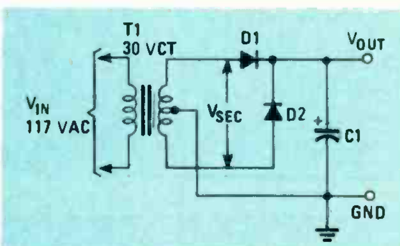


FIG. 2—THIS CIRCUIT, which uses a center-tapped transformer, performs identically to that shown in Fig. 1.

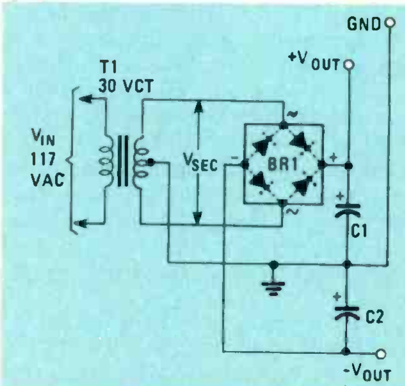


FIG. 3—THIS BIPOLAR SUPPLY uses a bridge rectifier, but separate diodes could be used instead.

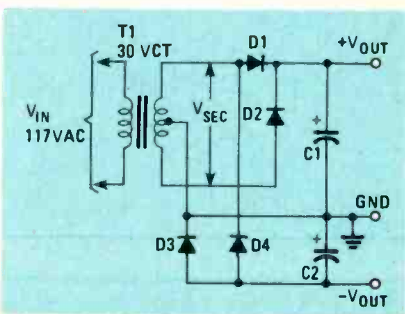


FIG. 4—FOUR DISCRETE DIODES replace the bridge rectifier of the previous circuit. Note, however, that the two circuits are equivalent.

RMS when it is supplying 20 watts. When the load is removed (and the supplied power is reduced to zero) the secondary voltage will rise by an amount specified by the regulation factor. Thus, the output of a 15-volt transformer with a 10% regulation factor (a typical value for the regulation factor) will rise to 16.5 volts when the output is unloaded.

The most important point to notice here is that the RMS output-voltage of the transformer secondary is *not* the same as the DC output voltage of the complete power supply. In fact, the DC output voltage of a full-wave-rectified circuit is 1.41 times the RMS transformer voltage (ignoring rectifier losses) that is feeding the rectifier, as shown in the graph of Fig. 5. Note here that that voltage is equal to 1.41 times the voltage of a single-ended transformer, or 0.71 times that of a center-tapped transformer. Thus, our single-ended, 15-volt RMS transformer with 10% regulation will provide an output of about 21 volts at full rated load (just under 1 amp at 20 VA rating) and an output of 23.1 volts at zero load.

When rectifier losses are taken into account, the output voltages will be slightly lower than shown in the graph. In the "two-rectifier" circuit of Fig. 2, the losses amount to about 600 millivolts, while in the "bridge" circuits of Figs. 1, 3, and 4, the losses amount to about 1.2 volts. The rectifiers should, for maximum safety, have current ratings at least equal to the DC output currents.

Thus, the procedure for selecting a transformer for a particular problem is very simple. Let's see what's involved.

First, decide on the DC output voltage and current that is required: The product of those two values (allowing for slight rectifier losses) determines the minimum VA rating of the transformer. Next, consult the graph of Fig. 5 to find the transformer-secondary RMS voltage that corresponds to the required DC voltage. Simple?

The filter capacitor

The purpose of the filter capacitor is to convert the full-wave-rectified signal of the rectifier into a smooth DC voltage.

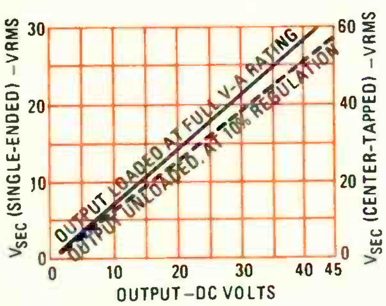


FIG. 5—TO USE THIS GRAPH, determine the required loaded DC output voltage. Then read across to find the corresponding transformer secondary voltage.

The two most important parameters of the capacitor are its working voltage and, of course, the value of its capacitance. The working voltage rating must be greater than the off-load output voltage of the power-supply circuit. The capacitance value determines the amount of ripple that will appear on the DC output when current is being drawn from the circuit.

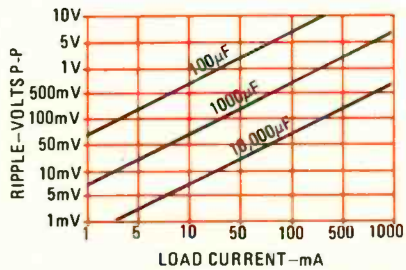


FIG. 6—THE FILTER-CAPACITOR value determines the amount of ripple at the output. This graph relates capacitor value to ripple voltage and load current in a full-wave-rectified, 50–60 Hz powered circuit.

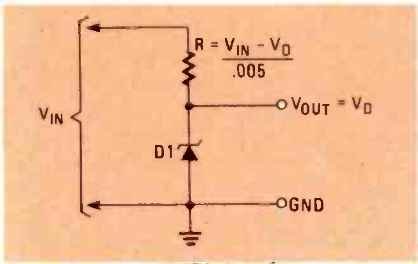


FIG. 7—USING A ZENER DIODE is an easy way to obtain a fixed reference voltage. This reference circuit is biased at about 5 mA.

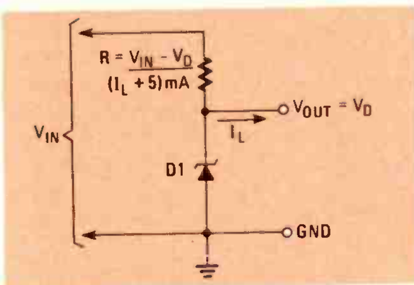


FIG. 8—THIS BASIC Zener regulator circuit can supply load currents of a few tens of milliamps.

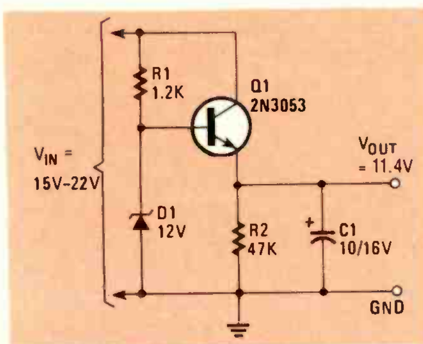


FIG. 9—THE SERIES-PASS Zener-based regulator circuit gives an output of 11.4 volts and can supply load currents up to about 100 mA.

As a rule of thumb, in a full-wave-rectified power supply operating from a 50-60 Hz power line, an output load-current of 100 mA will cause a ripple waveform of about 700 mV peak-to-peak to be developed from a 1000-μF filter capacitor. The amount of ripple is directly proportional to the load current and inversely proportional to the filter capacitor's value. That is shown in the "design guide" of Fig. 6.

In most practical applications, the ripple should be kept below 1–1.5 volts peak-to-peak under full load conditions. If very low ripple is required, the basic power supply can be used to feed a 3-terminal voltage regulator, which can easily reduce the ripple by a factor of 60 dB or so at very low cost.

Voltage-regulator circuits

Voltage regulators may vary from simple Zener-based circuits designed to provide load currents up to only a few milliamps, to fixed-voltage high-current circuits designed around "fixed" 3-terminal regulator IC's, or to variable-voltage high-current circuits designed around "variable" 3-terminal regulator IC's. We'll look at practical versions of all three types of circuits.

Zener-based circuits

A Zener diode can be used to provide a fixed reference voltage by using the simple circuit shown in Fig. 7. In that circuit, a current of roughly 5 mA is passed through the Zener diode from the supply through the current-limiting resistor R. The supply voltage, V_{IN}, may be subject to fairly wide variations, causing the Zener current to vary over a similarly large range. So long as V_{IN} is always more than a few volts greater than the Zener voltage and provided that the Zener power rating is not exceeded, that variation has only a moderate influence on the output voltage of the Zener, which typically has an effective output impedance of only a few tens of ohms.

A Zener can be used as a very simple voltage regulator, providing maximum load currents up to a few tens of milliamps, by merely selecting the value of the resistor R as shown in Fig. 8. When the designed maximum load current is being drawn, only 5 mA flows through the Zener: When zero load current is being drawn, the Zener passes 5 mA plus the full maximum designed load current and thus dissipates maximum power: It is important to ensure that the power rating of the Zener is not exceeded under this no-load condition.

In most practical voltage-regulator applications, the Zener is simply used to apply a reference voltage to a high-gain non-inverting buffer amplifier, which then supplies the required output power. The simplest example of this type of circuit is shown in the series-pass regulator circuit of Fig. 9. Here, Q1 is wired as a voltage follower, its emitter remaining at about 600 mV below its Zener-defined base voltage under all load conditions. The Zener network provides the base-drive current to Q1. That current is equal to the output load current divided by the current gain of the Q1 "buffer" stage. Clearly, the higher the gain of Q1, the better will be the output regulation of the circuit.

One way of improving the regulation of the circuit would be to use a Darlington transistor in place of Q1. An even better solution is to use the op-amp plus transistor buffer stage shown in Fig. 10. There, the op-amp and Q1 are wired as a unity-gain non-inverting DC amplifier with a near-infinite input impedance and near-zero output impedance. The output voltage tracks within a few millivolts of the Zener reference value. The safe output current is limited to about 100 mA by the power rating of Q1. Higher currents can be obtained if Q1 is replaced with a power Darlington transistor.

The circuit shown in Fig. 10 is very versatile. It can be made to generate any desired fixed voltage up to about 30 V maximum by simply using a suitable Zener value and ensuring that the unregulated supply voltage is at least 5 volts greater than the Zener value (up to 36 volts maximum).

The circuit can be used as a variable-voltage supply by simply wiring a potentiometer across the Zener, with its slider taken to the non-inverting input of the 3140 op-amp. That op-amp can accept inputs all the way down to zero volts, enabling (for example) a 0–25 volt supply to be easily implemented.

Fixed 3-terminal regulator circuits

Fixed-voltage regulator design has been greatly simplified in recent years by the introduction of 3-terminal regulator IC's such as the "78xx" series of positive regulators and the "79xx" series of negative regulators. Those IC's incorporate features such as built-in fold-back current limiting and thermal protection. A wide range of 3-terminal fixed-voltage regulator IC's are available: Standard current ratings for those regulators are 100 mA, 500 mA, 1 A and 3 A and standard output voltage ranges for those devices are 5, 6, 8, 12, 15, 18, and 24 volts.

Three-terminal regulators are remarkable easy to use, as shown by the basic circuits in Figs. 11–13, which show the connections for making positive, negative, and bipolar regulated power-supply circuits respectively: The IC's shown in those examples are 12-volt units with current ratings of 1 amp, but the basic circuits are valid for all other voltage ratings, provided that the unregulated input voltage is at least 3 volts greater than the desired output voltage.

Note that a 0.27-μF or greater ceramic disc capacitor should be connected close to the input terminal of the IC, and a 10-μF or greater electrolytic to the output. Also note that those regulator IC's typically provide about 60 dB of ripple rejection, so 1 volt of input ripple will appear as a mere 1 millivolt of ripple on the regulated output.

The output voltage of a 3-terminal regulator is referenced to the "common" terminal of the IC, which is normally (but not necessarily) grounded: Most regulator IC's draw quiescent currents of only a few mA, which flow to ground via that "common" terminal. The regulator output voltage can thus easily be raised above the designed value by simply biasing the "common" terminal with a suitable voltage, making it easy to obtain "odd-ball" output voltages from the regulator. Figs. 14 to 16 show three possible ways of achieving this.

In Fig. 14 the bias voltage is obtained by passing the IC's quiescent current (typ-

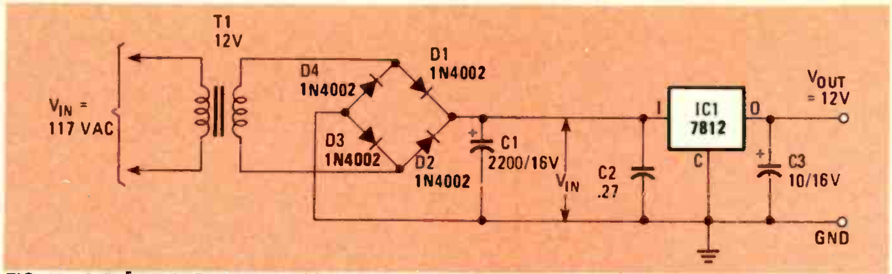


FIG. 11—A THREE-TERMINAL positive regulator circuit.

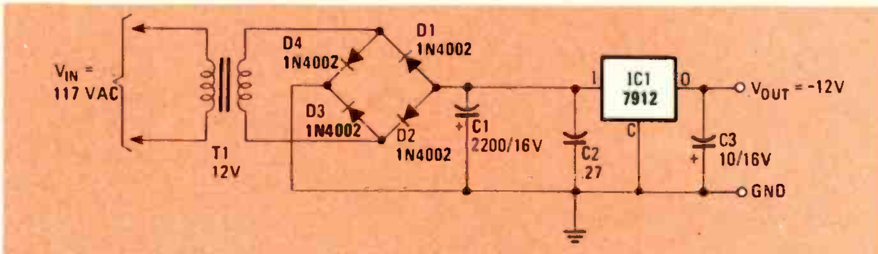


FIG. 12—A THREE-TERMINAL negative regulator circuit.

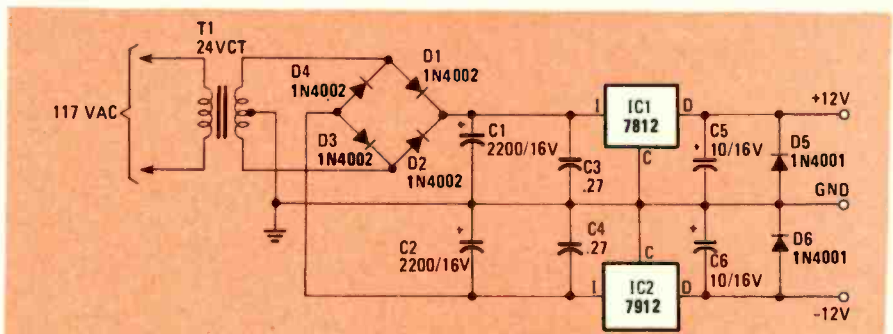


FIG. 13—COMPLETE ±12-volt, 1-amp bipolar power supply using 3-terminal regulator IC's.

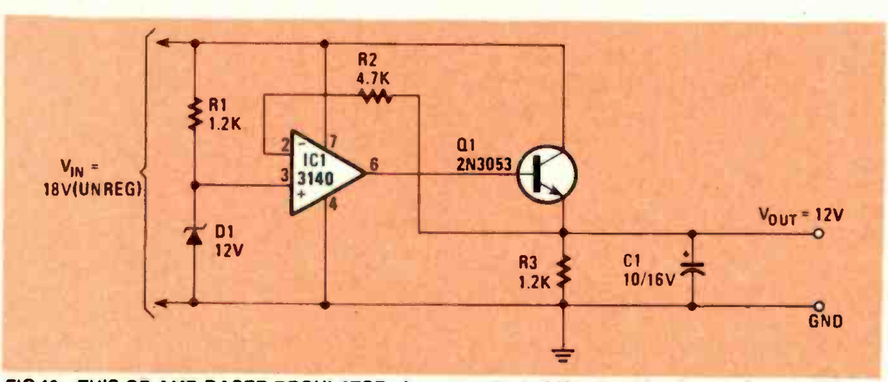


FIG 10—THIS OP-AMP-BASED REGULATOR gives an output of 12 volts at load currents up to 100 mA with excellent regulation.

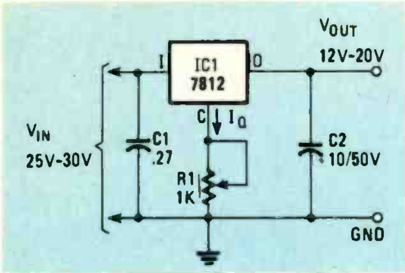


FIG. 14—A SIMPLE WAY to vary the output voltage of a 3-terminal regulator.

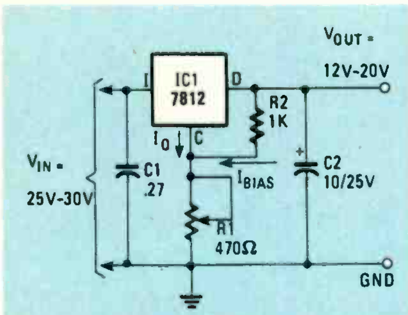


FIG. 15—IMPROVED METHOD of varying the output voltage of a 3-terminal regulator.

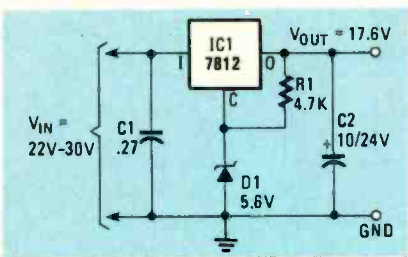


FIG. 16—TO INCREASE THE VOLTAGE output of a 3-terminal regulator, a Zener diode can be wired in series with the COMMON terminal.

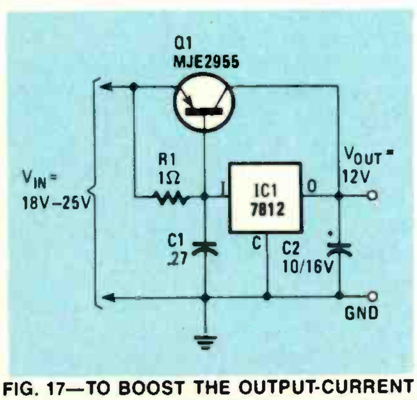


FIG. 17—TO BOOST THE OUTPUT-CURRENT capacity of a 3-terminal regulator, an external transistor can be used, as shown in this circuit that can supply a regulated 12 volts at 5 amps.

ically about 8 mA) through R1. This design is adequate in most applications, although the output voltage obviously shifts slightly with changes in quiescent current. The effects of such changes can be minimized by using the circuit of Fig. 15, in which the R1 bias voltage is determined by the sum of the quiescent current and the bias current set by R2 (12 mA in this example). If a fixed output voltage is required other than the designed value, it can be obtained by wiring a Zener diode in series with the common terminal as shown in Fig. 16, the output voltage then being equal to the sum of the Zener and regulator voltages.

The output current capability of a 3-terminal regulator can be increased by using the circuit of Fig. 17. Resistor R1 is wired in series with the regulator IC. At low currents, insufficient voltage is developed across R1 to turn Q1 on, so all the load current is provided by the IC. At currents of 600 mA or greater sufficient voltage (600 mV) is developed across R1 to turn Q1 on, so Q1 provides all currents in excess of 600 mA.

Finally, Fig. 18 shows how the pass transistor of the above circuit can be provided with overload current limiting via 0.12-ohm current-sensing resistor R2 and turn-off transistor Q2.

Variable 3-terminal regulator circuits

We've already seen that the outputs of "78xx" regulators can be varied over limited ranges by simply applying suitable variable voltages to their "common" terminals, even though these IC's are designed as "fixed" regulators. If, however, you need to vary the output voltages over fairly wide ranges, a far better solution is to use one of the special "variable" 3-terminal regulator IC's, such as the 317K or the 338K.

Figure 19 shows the basic variable-regulator circuit that is applicable to those two devices. Both devices have built-in fold-back current limiting and thermal protection and are housed in TO3 steel packages, the major difference between the devices being that the 317K has a 1.5 amp current rating compared to the 5 amp rating of the 338K.

The major feature of both devices is that their "output" terminals are always 1.25 volts above their "adjust" terminals, and their quiescent or adjust-terminal currents are a mere 50 microamps or so. The 317K has an input-voltage range of 4–40 volts and an output-voltage range of 1.25–37 volts. The 338K has the same input range, but an output-voltage range of 1.25–32 volts.

In the circuit in Fig. 19, the 1.25-volt difference between the "adjust" and "output" terminals causes several mA to flow to ground through R1, thereby causing a variable "adjust" voltage to be developed across R1 and applied to the "adjust" terminal. In practice, the output of the circuit in Fig. 19 can be varied over the approximate range 1.25 to 33 volts via R1, provided that the unregulated input voltage is at least 3V greater than the required maximum output voltage. Naturally, alternative voltage ranges can be obtained by giving R2 and/or R1 alternative values, but it should be noted that

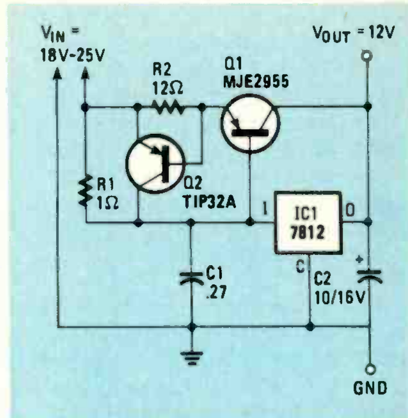


FIG. 18—OVERLOAD PROTECTION has been added to the circuit of Fig. 17.

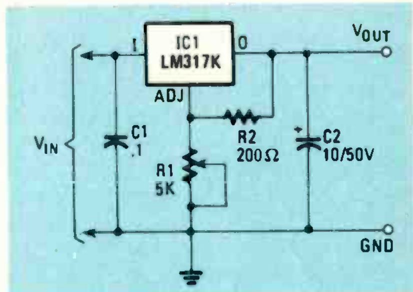


FIG. 19—BASIC APPLICATION of a variable-voltage 3-terminal regulator.

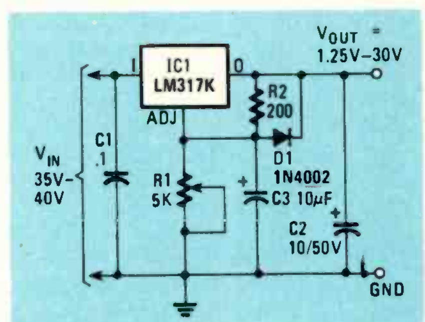


FIG. 20—THIS VARIABLE-VOLTAGE regulator has ripple rejection of 80 dB.

for best stability the R2 current must be at least 3.5 mA.

The basic circuit that we just looked at can be usefully modified in a number of ways. The basic ripple-rejection factor (about 65 dB) be increased to 80 dB by wiring a 10-µF bypass capacitor across R1, as shown in Fig. 20, together with a protection diode connected as indicated, to prevent the capacitor from discharging into the IC if the regulator output is short-circuited.

A further modification is shown in Fig. 21. Here, the transient output impedance of the regulator is reduced by increasing the value of capacitor C2 to 100 µF; diode D2 is used to protect the IC against damage from the stored energy of this capacitor if an input short occurs.

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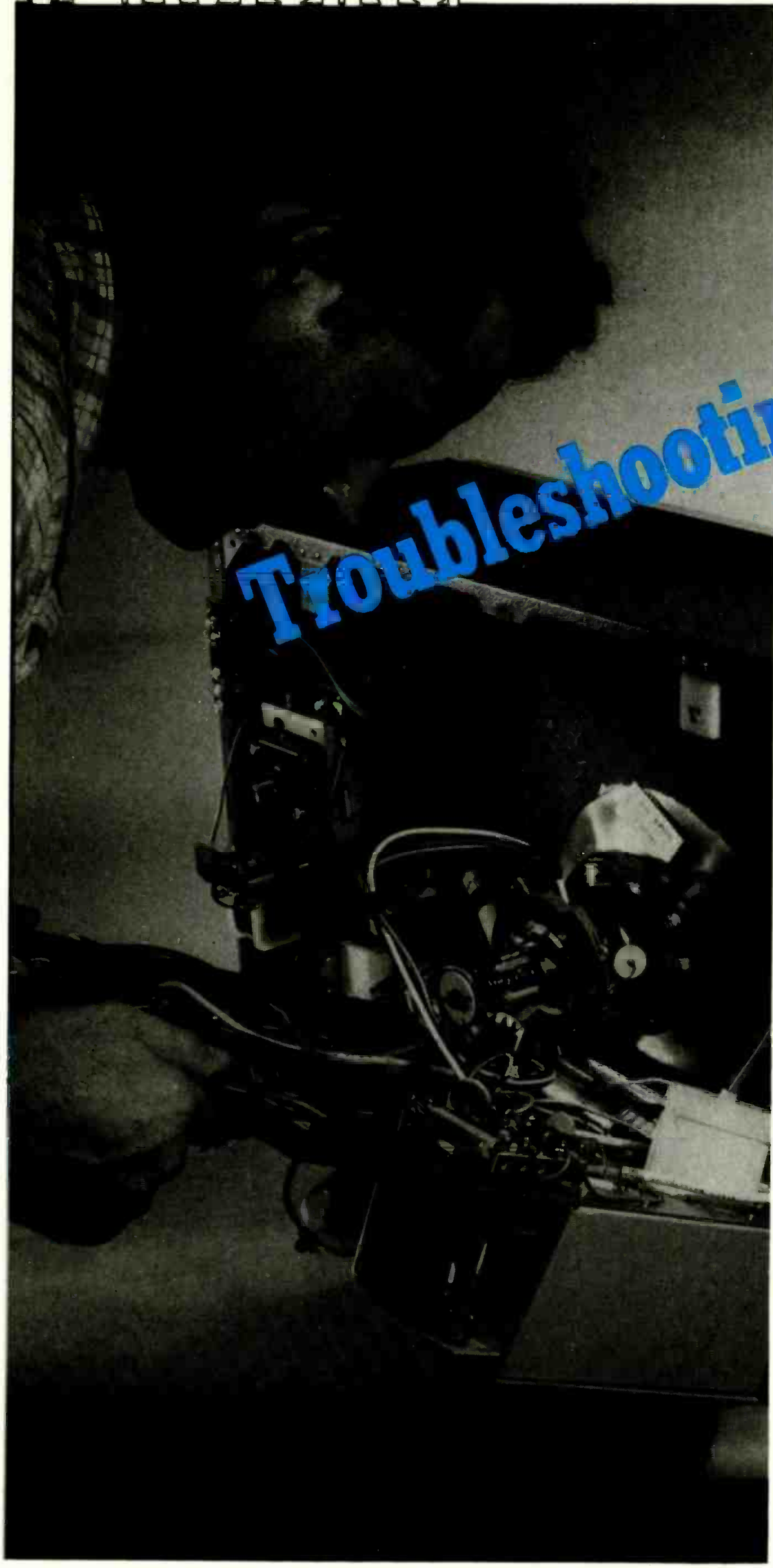

Troubleshooting the Tough Ones

Some TV problems can be fixed in a matter of minutes, with others it can take hours, days, or even weeks. In this article, we'll take a look at some of those "time killers," and see how they were eventually set straight.

FRANK A. SALERNO

PEOPLE WHO PLAY WITH STATISTICS OFTEN come up with numbers that speculate on how many years out of a person's lifetime are spent eating, sleeping, blinking, or whatever. I wonder if someone could estimate how many accumulated years a TV technician might spend working on those nearly impossible sets, doing things like waiting countless hours for those insufferable intermittents to break down. The figure would be astonishing, I'm sure. If we could get paid for all of that time lost, even at two bucks an hour, it would be an awful lot of money.

Let's take a look at some case histories.

The first involves a Zenith 25KC45 that started out routinely enough. The color was supposed to be drifting in and out. After sitting and watching the set for twenty minutes the customer was told that on that particular chassis, and others like it, the modules have a tendency to develop poor contacts. So, the modules were slid off and on again in order to re-establish the contacts and everything seemed fine.

A week later the same call came in. This time the set had been on for a couple of hours when I arrived, and I was lucky to catch it in not-so-living black and white. The act of merely changing channel caused the color to pop back in, and nothing could be done to re-create the problem. I decided to change the 9-86 module, which carries the bulk of the color circuitry, and left confidently. That would not be the first time that that module was found to be the troublemaker.

You guessed it, a few days later another call on that set came in. Once again, the receiver was in its "black-and-white" mode when I arrived. This time, I avoided changing channels and instead gingerly adjusted the fine tuning. The picture remained black and white. Slowly, I felt my way around inside when suddenly the color reappeared—again to stay.

The 9-89 module basically contains the color-output circuitry, and it usually misbehaves by causing changes in one of the primary colors, but still it does process the color signal. So I thought it a good idea to try a new one.

The next call really started to get vexing. There was no doubt about the fact that all of the color circuitry was located on the two modules already changed. Taking the set to the shop, for the time being, was out of the question. That's because that type of problem has an annoying habit of clearing up somewhere between there and here, so I was determined to do everything I could on-site.

In that set all of the customer controls, mounted at the front of the cabinet, are returned to the chassis through molex connectors. I poked around the wire bundle leading to the connectors, and for a brief moment I saw the color fade out and then in again. At last I thought that I was beginning to get somewhere, even though I was unable to repeat what had just happened in that split second. I plugged the molex connectors out and in a few times in the hope of cleaning their contacts up and left once more feeling confident.

For a week there was no news, but then it came. Lost for any more ideas, I was forced to pull the chassis. My reluctance to do so in the first place was well grounded. Once the jig was set up the long process of watching and waiting began. For days nothing happened while the best part of my workbench was being tied up. Still, I used some of the time to record some measurements. I scoped the input of the 9-86 module and made a sketch of what I saw. I did the same with the input, as well as the output, of the 9-89. If and when the color finally disappeared I would then make some comparisons and know where I was losing it.

But the color doggedly stayed put. At one point I was almost ready to give up and return the chassis, but I knew that that would have solved nothing, so I stayed with it, keeping an eye on it as much as I could. One day, upon returning to the shop after walking out for a few minutes, I was happy to see the picture in black and white. Quickly I turned on the scope, afraid that at any moment the color would pop back in and my chance would be lost.

Unfortunately, the scope did not tell me much. The waveforms were changed somewhat; a little crimped in one instance, slightly distorted in the other, but at none of my three test points (see Fig. 1) was there a total lack of signal to give me the clear diagnosis I was looking for.

I went back to the wire bundle. There was a reaction. The bundle was gently pushed to the side, and the color faded away. When the bundle was released the color came back. Back and forth I went, trying to isolate out of this bundle of two dozen or more wires which were the most affected. Being all wrapped together, they all moved together.

Nevertheless, by using a feather touch it started to appear that it was the small group of wires leading to a connector atop the variac tuner that was the most sensitive. Moreover, as it turned out, it was the single wire going to the AFC terminal on the tuner. Tugging slightly on the wire, I was able to cause the color to go in and out at will. Tightening the connector and resoldering it's terminals solved the problem. I still don't know why, it being an AFC problem, resetting the fine tuner did not restore color.

few times. The results were conclusive so the set's tuner was pulled out and sent for repair.

Four days later I reinstalled the tuner, held my breath and pulled the switch. I lost my breath when the picture began to flicker and flash as badly as before. I retraced my steps by hooking up the tuner sub one more time. The picture was then rock solid.

It was time to rethink my diagnosis. Obviously, it was not the tuner itself that was creating the problem, but something that was tied into it: B-plus voltages, antenna transformer, AGC, etc. Taking voltage measurements proved useless since the flickers were of such short duration. Also, with the picture bouncing so wildly there wasn't a stable voltage in the entire set. A better idea, I thought, would be to substitute each of the tuner feeds. First I eliminated the antenna block. Next, I fed the tuner external B-plus voltages. Finally, when I disconnected the AGC line and put a three-volt battery in it's place, the picture firmed up (see Fig. 2). So it was the RF AGC that was the reason for it all. Pushing on, I found the RF-AGC transistor to be the culprit. It had an intermittent junction, causing precisely the symptoms of a defective antenna.

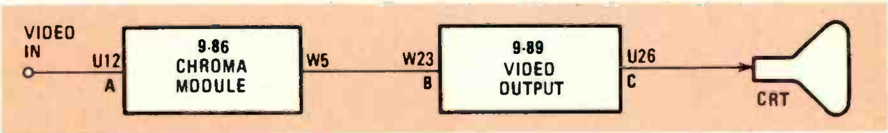

FIG. 1—POINTS A, B, and C were monitored in a hope to find where color was being lost.

Not the antenna

Turning to the next case, a Sony KV1720, hooked up to an external antenna, was flickering and flashing badly. Now and then the picture would get snow and then quickly clear up. Outside, the wind was whipping around, and the rain was coming down in sheets. It was a perfect day for antenna trouble.

I grabbed an umbrella and went outside to have a look. I circled round and round the property looking for the antenna, but it was nowhere to be seen. The lead-in wire went up alongside one wall of the house, but then seemed to just stop at the attic window.

When questioned about it the customer was very vague, saying that there was something up in the attic, but he didn't know what it was. Well, what it was was the antenna, hanging comfortably from the rafters, cozy and dry, not being bothered one bit by the swirling storm outside.

Downstairs again, I removed the external connections and tried the set on it's "rabbit ears." The flickering was still there so I took the set with me.

It was now my belief that the signal was breaking up in either the tuner or the IF strip. By disconnecting the tuner and hooking up a tuner sub, I was able to stabilize the picture. Wanting to be certain, I switched tuners back and forth a

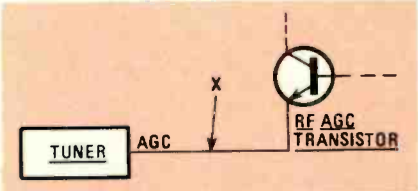

FIG. 2—BY BREAKING OFF the AGC at X and hooking in a three-volt battery, the source of the problem was isolated.

A little luck

Where would we be, in our business, if we couldn't depend on a little bit of luck to step in once in a while. An RCA CTC53X that I serviced recently was a typical case in point, and if it wasn't for the lucky break that came along I might still be bent over that set, looking for the trouble.

The picture was pulling very badly. I studied it for a while, stroking my chin, when I came up with a hunch. A similar chassis that I had serviced some years ago had a thermal condition, causing the picture to pull much like this one was doing now, but only when it was well heated up.

It took several trips to the shop to fix that one, it being one of those nasty now-you-see-it-now-you-don't kind of repairs. In any case, it turned out, at least that time, to be the sync-separator transistor that was developing a leak.

Now, with nothing more than my hunch to go on, I changed the transistor, hoping to save myself the trouble of hauling the set away, but it was not to be. With the new transistor in place the picture wiggled around as badly as before so the set had to go.

On the bench, I put the scope to work. The sync output looked awful, with peaks and humps of video tearing into the sync level. The sync input looked just as bad. In fact, I went farther and farther back, looking for a clean signal, but couldn't find one. Even at the base of the first video amp, where one is accustomed to finding nice straight-edged sync tips, the video content was rolling up and down into the sync, making the whole thing look bent out of shape.

What was going on here? The problem was not likely to be in the filter capacitors, but maybe it was in the AGC. With my voltmeter I went through the whole video/AGC/sync strip, failing to turn anything up. They all checked out. After three hours of looking, I was still not sure of exactly what I was looking for.

Through it all, I was noticing something else besides the pulling. On some channels, not all, there appeared to be some strange-looking interference superimposed over the picture. That interference looked like an odd mixture of corona discharge-radiation, ignition noise, and barkhausen. What was more, when the antenna was removed, instead of the blank, snow-filled raster I had expected to see, I was getting very dark waves of diagonal lines moving across the screen.

Since I was getting nowhere looking for the pulling I decided to leave the antenna off and hunt for the interference instead. Find the cause of that, I thought, and I will find the other. With the scope, I began to poke around the video section, looking for signals, when suddenly, through the corner of my eye I saw a puff of smoke. I quickly yanked the plug. What did I do now, I wondered. Had I shorted something out with the probe? I didn't think so, so I decided to try again.

With the plug back in, I now found myself with no high voltage, and the output tube began to glow red. Working in short steps, so as not to blow the tube, I found that the horizontal oscillator plate voltage was missing. Now I knew where the smoke came from. A 680-ohm resistor, supplying B-plus voltage to the oscillator/sync board was burned open. But the question of what had happened still remained. The ohmmeter told me that there was a low reading from the cold side of that resistor to ground. Checking further, I found what should have been a 180 kilohm resistor that was now white ash. And where did that resistor go? Why, to the sync-separator collector! (See Fig. 3.)

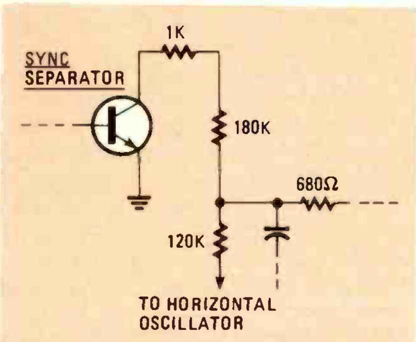

FIG. 3—WHEN THE 180-kilohm resistor changed value, it caused the 680-ohm resistor to burn out, knocking out the horizontal oscillator.

I can only guess at what had taken place. The 180-kilohm unit was probably arcing internally, accounting for the strange interference. With the antenna disconnected, hence no signal, the arcing and interference went into regeneration, causing the resistor to overheat badly until it finally caved in. One thing was certain, once it was replaced the picture straightened out perfectly.

Why didn't the problem show up in my voltage checks? Was it really the removal of the antenna that sped things up? I'll never know.

One big headache

The grandaddy of the marathon intermittents has got to be the one I ran into in Gold Star model *CR-820* that I came to know so well. It was brought to me having sound but no video—just a white raster. For several weeks, the customer told me, the video had been alternating between getting dull and then getting bright, flickering and flashing, until it finally went out altogether.

Naturally, by the time I removed the back cover, turned on my equipment, spread out the schematic, and planned my attack, the picture jumped back in and stayed that way for the first couple of days. Nevertheless, I tucked the set into a corner, belly up, and let it play whenever I was in the shop.

I took as my first area of concentration TP12, which was dead center between the IC101, which contained the first video amp and the IC carrying second video amp, IC501. I kept the scope probe hooked on and waited.

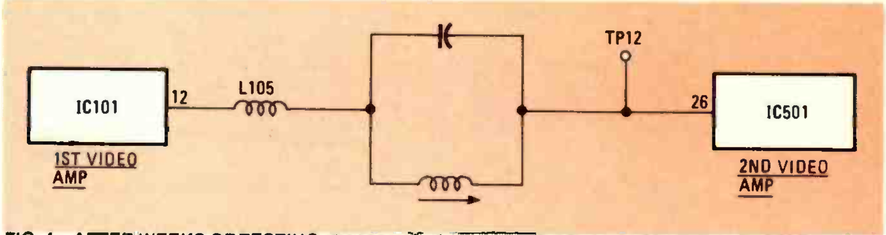

FIG. 4—AFTER WEEKS OF TESTING, the loss of picture was finally traced to an erratic L105.

For days, nothing. A slight flicker here, a flash there, contrast might drop a bit, but nothing to really sink my teeth in. One time I saw the picture fall off about 50 percent, and the waveform do the same, but both quickly recovered. IC501 was a plug-in unit and easy to replace so I went for that one first. Even though it was past TP12 there was the chance that it was loading the signal down.

I thought I had it. For days the set worked fine. I buttoned it up and prepared to call the customer to arrange for pick-up, only to see the flickering return the next time I tried it. So, it wasn't that IC. Perhaps it was the other. Belly up again, scope connected, the wait was on. Occasionally the symptoms turned up briefly, but whenever I moved the scope lead over to another point the picture would lock in place for the next couple of days. After two weeks of that, the picture finally reached a point where it settled down for good.

It was time to let go, I thought. I would have the customer take the set home, live with it until such time when it would quit for good, and make it a little easier to repair. Meanwhile I clipped a memorandum to the schematic for future reference, reminding me that I had a feeling that the video was being lost somewhere between IC101 and IC501. What meager measurements I was able to come up with led to that conclusion. Between them, as shown in Fig. 4, were a small coil, a tuneable transformer, and TP12.

The decision to call the customer having been made, I turned the set on for one last try. That's right—flickering and changes in contrast. In anticipation of that, I had soldered a tiny pigtail wire to the output of IC101 so that I would have something to hold onto with the scope probe. That done, I was ready for some more waiting.

It took two more days before I saw the contrast drop appreciably. The scope pattern stood firm. As had happened so many times before, the moment I moved the probe the picture went solid. Once again, it stayed that way for days.

It was the end of a long and exasperating week. The set was playing well, the scope face steady and bright. I started to

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HOBBY CORNER

Telephones and lines

EARL "DOC" SAVAGE, HOBBY EDITOR

NOW THAT THERE ARE SEVERAL TELEphone companies instead of just one with which to deal, there seems to be increased interest in how telephones work and how to work on them. You may want to do some extra reading on the subject.

William Bass (SC) has asked how he can check his telephone equipment. Like many of us, William has bought his own phone since the "divestiture" of AT&T in January. He foresees a potential problem when he has a breakdown in service. That is, when the telephone company comes to repair his line, he gets a large service charge only to be told that the trouble is in his phone (which they don't repair).

Well, it could happen just that way, and that would be embarrassing—to say nothing of the expense. Contrary to your suggestion William, we would not advise you to stick test equipment on the phone company's line. There is too great a chance that you will create a problem that is even worse than the one you already have. However, you can do the job without any test equipment at all.

The way to go about it is to try another phone on your line. At present, you can buy a neat one-piece phone with a saddle-type holder for about $10. Not only does one of those phones make a good extension; but with two in the house, you can disconnect them one at a time and use it to see if the problem is in the line or the phone itself. It is highly unlikely that two of them would go bad at the same time, barring a lightning strike or something equally catastrophic. And even then, you could check against such a coincidence by disconnecting one of your phones and trying it out at a friend's house.

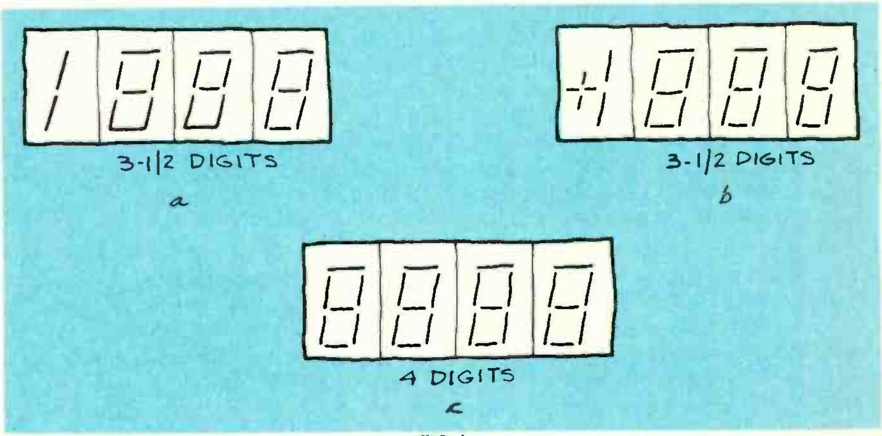

FIG. 1

"Half" digits

Along with others, Robert Reiter (NY) has asked about the "1/2" in display descriptions that say 3 1/2 or 4 ½ digits. That can be confusing, especially when you first run into it. However, it certainly does not mean that you literally have half of a digit. Let's look at an example.

Say, for instance, that a 12-hour clock has four display modules as shown in Fig. 1-a; the left-most digit never displays anything higher than a 1. That is, it is either blank or 1—never 2, 3, and so on. Therefore, that left digit need not contain all the normal segments. If the digit has only the two segments to make a 1, the clock is said to have a 3½-digit readout. The "½" simply means that some of the segments of a digit are missing. Another example would be a digital meter; the left digit may be able to display +1 and −1 but no higher or lower number (Fig. 1-b). It, too, would be called a half digit. On the other hand, if the left position has all the segments (see Fig. 1-c) so that it could be used in a 24-hour clock, for example, the clock has a 4 digit readout. That's all there is to it.

Measuring capacitance, inductance

Every electronics hobbyist is sure to need some type of test (measuring) instrument at one time or another. While, some of you may be satisfied with just a VOM, most of us have additional instruments and would like to have others. The more you are able to check and test and measure, the more likely you are to end up with successful projects.

Having a variety of test equipment does not guarantee success, but it does help. And that can save you a great deal of time, too. Few things are more frustrating than having a project fail because of a component that looks good but is open, shorted, or out of tolerance. It is good to be able to check components one by one whenever necessary.

Test instruments can cost a bundle once you get beyond the basics. And if you are like me, you are attracted to instruments that have more than one use: It's like killing two birds with one stone, so to speak. That's why I am going to give one answer to two different questions.

Robert Blackwell (MD) wants to determine the inductance of coils, and Winston Jones (GA) is looking for a way to measure the value of capacitors. If my original interest in electronics had not been in radio, I might have recommended the traditional instruments for such applications. However, why don't you guys use a *G*rid *D*ip *M*eter (GDM)?

Not least among the many uses of that instrument is the measurement of inductance and capacitance. You are, of course, aware that when a capacitor and a coil are connected in parallel, they have a resonant frequency (f_r). (That's how radios are tuned.) A GDM will enable you to mea-

AN INVITATION

To better meet your needs, "Hobby Corner" has undergone a change in direction. It has been changed to a question-and-answer form. You are invited to send us questions about general electronics and its applications. We'll do what we can to come up with an answer or, at least, suggest where you might find one.

If you need a basic circuit for some purpose, or want to know how or why one works, let us know. We'll print those of greatest interest here in ""Hobby Corner." Please keep in mind that we cannot become a circuit-design service for esoteric applications; circuits must be as general and as simple as possible. Please address your correspondence to:

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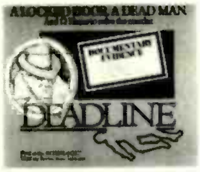

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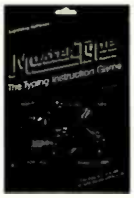

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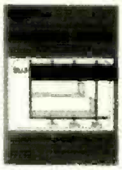

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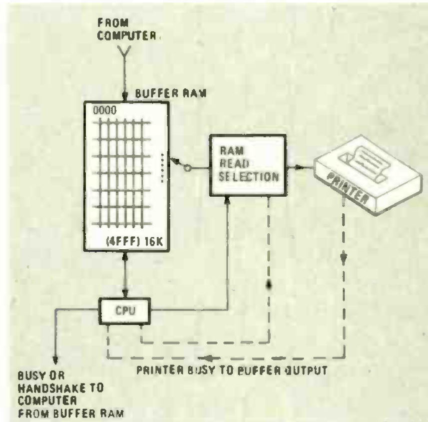

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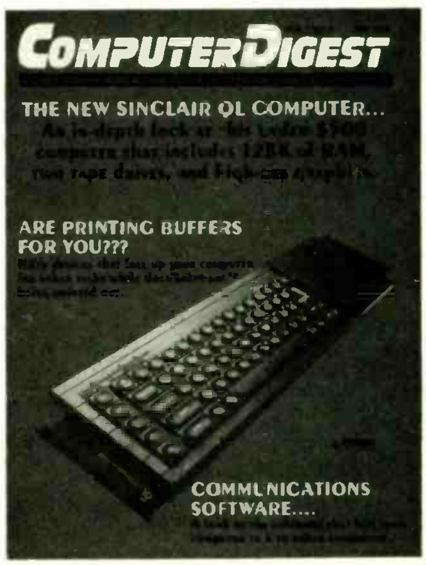
ON THE COVER

Sinclair started many revolutions: He was first with pocket calculators and flat-screen TV's. But perhaps he'll be best remembered for the first under-$100 computer: the ZX81/Timex Sinclair 1000. He is trying to start a new revolution with the Sinclair QL—an office computer for less than $500. The QL comes equipped with 128K RAM, two micro-sized tape drives, and an RS-232 serial port. Integrated software—word-processing, spreadsheet, database, and graphics programs—is also included. ROM-resident SuperBASIC is standard as well. We'll take a look at the machine in detail, starting on page 5.



EDITORIAL

WHY DO YOU READ?

■Most of us read so that we can learn. When we find an article in a magazine that interests us, we read it in the hope that we'll pick up a bit of information that we didn't have before. Naturally, we have to be particular about what we want to learn about—we can't spend our entire lives reading. So we select those magazines that deal directly with our own specific fields of interest. Since we cannot read *everything*, it becomes important that we be selective about who our "teachers" are.

As we all know, there are a great many computer-oriented magazines available. Almost everybody that owns a computer gets a "great" idea for a new computer magazine, and thinks it's the best thing to come down the pike since the invention of sliced bread. Some of those ideas are indeed worthy. Some of the magazines that result will actually last. And some will soon fall by the wayside. How do you select which ones to read?

One of the tests that you can apply, is to look at what magazine editors call a "masthead." That's where they list the names of the people responsible for the publication you are reading. We're rather proud of our masthead, from the publisher right through all of the staff. Those people have been in electronics publishing almost since they learned to write, have worked their way, through the ranks, to the positions they now hold—accumulating years of experience in computers and electronics in the process.

The people who actually write our articles are also experts. (Many of the names, you'll notice, are not new.) They've been writing for many years, and most of our writers are employed in responsible positions at some of the top companies in the computer field. They know what they're talking about, and have learned how to communicate that information in the written word.

What I'm trying to tell you is that **ComputerDigest** is a professionally-developed publication; it's written, edited, and published by professionals for you. We want you to get the most out of it. All *you* have to do is read it! And by all means, let us know what you think.

BYRON G. WELS
EDITOR

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The Sinclair QL

Sinclair started a revolution with his low-priced ZX80 and ZX81 computer. Will his new Sinclair QL have a similar effect on the business-computer market?

MARC STERN

■In the modem world of electronics and microcomputers there are a number of innovators and inventors who keep developing ideas that revolutionize the industry. One of those innovators, whose contributions will continue to be felt for years is Clive Sinclair. In the early 1970's, he took advantage of the four-bit microcomputer technology that was then coming to the fore and developed the first pocket calculator. If that were not enough, later in the 1970's, he was credited with developing the first miniature, flat-screen television set.

In 1981, Sinclair, ever the innovator, apparently looked at how far the cost of the microprocessor had fallen and decided the time was ripe for a low-cost personal computer. Thus, the *ZX80* was born—the first computer under $200. By using a membrane keyboard, plastic case, and a very compact operating system, the price of the computer could be kept down. Sinclair's next machine, the *ZX81* could be sold for even less—it was the first $100 computer. One of the reasons that it could be sold so cheaply was that it contained only four IC's—the Z80 microprocessor, a 2K RAM IC, the 8K operating system, and a custom IC that took the place of 14 TTL IC's that were in the *ZX80*.

Other companies soon realized the potential market for low-priced computers. Commodore Business Machines, Texas Instruments, Atari and a host of other companies all began to produce machines that eventually brought true computing power to home users at well below $200 in cost.

By the end of 1982 and into 1983, the battle in the home computer marketplace became so intense that most of the major manufacturers involved in the dog-fight fell by the wayside and pulled out of the business. Texas Instruments dropped out, as did Mattel Electronics, and Atari suffered major reverses. Even Timex (which had taken over the distribution of the *ZX81* in the U.S.) pulled out, leaving the field to Commodore and Radio Shack.

Despite that, Sinclair proved his point: He showed that microcomputers could be low-cost devices and provide average people with real computing power.

Sinclair does it again

Now that 1984 is half over, it looks as if Sinclair has done it again, but this time in a higher part of the computer spectrum, the desktop segment. Sinclair Research Ltd. (50 Staniford Street, Boston, MA 02114) has developed a home/business microcomputer—the Sinclair QL (Quantum Leap) shown in Fig. 1. The machine includes two breakthroughs in the less-than-$500 category.

The first breakthrough in this $499 small system is its microprocessor: a member of the powerful Motorola MC-68000 series with its 32-bit internal architecture. The second breakthrough in the less-than-$500 category is the use of integrated software. The QL is supplied with a word-processing a spreadsheet, database, and graphics programs. We'll look more closely at the software in a few minutes, but right now let's look at what's inside the QL.

FIG.1—THE NEW SINCLAIR QL: at just $499, a "quantum" leap in computing performance and designed for the serious home, business or educational user.

The MC-68008 microprocessor

After all the media attention given to the Apple *Macintosh* microcomputer, you've doubtless heard of the MC-68000 microprocessor. But you probably haven't heard about its variants, which include the 68008.

The 68008 is a 16-bit microprocessor with an 8-bit data bus. Why did Sinclair go with that device? Most likely because it is cost effective. It has the benefits of a 32-bit internal architecture. But because of its 8-bit data bus, you can use byte-wide memories and peripherals. Bus multiplexing is not necessary, as it is with some 16-bit microprocessors. All those factors help to reduce the cost of a system. The memory-addressing capacity of the 68008 is 1 megabyte.

The hardware

One of the most impressive features of the QL is its size. That a computer this powerful can fit in a 5⅜ by 1¾ by 18¾-inch unit that weighs about 3 pounds is amazing.

Sitting on the QL system board are four Sinclair-designed semi-custom ICs, as well as the microprocessor itself. The first IC, dual-sourced by

Plessey and Synertek, controls the display and memory; the second, dual-sourced by NCR and Synertek, controls other major system-level functions including the Sinclair Microdrive tape-storage units, local area network and RS-232C transmission, and the third and fourth, made by Ferranti, provide analog functions required by the Microdrives.

Standard in the QL is 128K of RAM, which is expandable externally to 640K via a plug-in cartridge available from Sinclair. As shown in Fig. 2, the cartridge plugs in at the left-hand side of the 65-key keyboard.

The keyboard features five special-function keys, as well as separate cursor-control keys. One drawback a user may find is the lack of a separate numeric keypad on the QL, you must use the number keys at the top of the keyboard. The *Microdrives* are found at the far right of the keyboard.

FIG.2—THE NEW SINCLAIR QL shown with a prototype of the forthcoming QL 0.5megabyte RAM pack, connected via the QL's internal expansion slot.

The QL provides two built-in Microdrive units for mass storage. Those tape drives are similar in concept to the tape storage units used in other systems such as the Coleco Adam. Each tiny tape that is inserted into the drive unit—as shown in Fig. 3—has a storage capacity of 100K. Those read-write drives have an access time of 3.5 seconds and a program-loading rate of up to 15 kilobytes-per-second. That's not nearly as fast as a disk drive, but it's a great improvement over cassette-tape storage.

The QL comes with a ROM-resident version of the BASIC programming language called Sinclair SuperBASIC, as well as the QDOS tape-operating system. It is all contained in 32K of ROM.

However, this isn't all that you will find in the QL system. The QL also uses a second processor—the Intel 8048—to handle keyboard I/O, sound, RS-232C reception and real-time clock functions. The inclusion of the second processor means that the 68008 doesn't have to handle housekeeping chores, as well as data-crunching and can thus devote its full capability to handling data.

The QL's video display capabilities are as good as many higher-cost microcomputers on the market. It features built-in high-resolution graphics capability—512 by 256 pixels in eight colors—and allows the user the flexibility of employing either a dedicated color or monochrome monitor or a home television set. Part of the QL's memory serves as dedicated video RAM: 32K

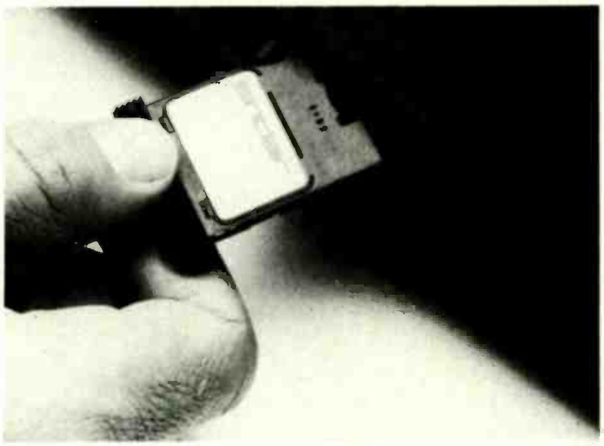


FIG.3—INSERTING THE MICRODRIVE cartridge in the Sinclair QL.

(about 8 pages) of memory, are dedicated to video memory locations. That means that each point on the screen is addressable and has a corresponding location in memory so it can be instantly updated or manipulated by an applications program. The QL normally displays the industry-standard 80 columns by 25 lines on a dedicated monitor and it offers you a choice of character sets. When it is used with a television set, its display is 40 to 60 columns, depending on the software used.

The preceding feature shows the impact the QL is likely to have on the computer market. Like its little relative, the *ZX81* that is still being offered by Sinclair, it will prove to computer users that a computer doesn't necessarily have to cost a bundle to be a "real" device and not a toy. The *ZX81* showed it in the low-end of the market, while the QL will show it in the desktop arena.

The QL also contains nine peripheral/expansion ports. They include one internal expansion port; one microdrive expansion port; a ROM cartridge port; two ports which can be equipped to handle serial interfaces; a local area network port, and two joystick ports. Also included is an RGB-output port and the RF (TV) output.

The software

As was noted earlier, the QL is aimed at the business or home user with sophisticated needs and comes with a standard set of integrated programs that were developed over a period of 18 months by Psion. The applications include comprehensive word-processing, planning, information handling, and graphics capability that are integrated in style, structure, design and in the sharing of information.

The applications—QL Quill; QL Abacus; QL Archive, and QL Easel—all run under the QDOS operating system that is built into the system's ROM. QDOS, developed by Sinclair, has a number of features that are only available on a microprocessor as advanced as the 68000 series. For instance, because it is capable of handling a great deal of data very quickly—depending on the timing and system resource sharing requirements—it can have two or more applications resident at one time, although only one of them can be active at any moment (it's still a single-user system, after all). That allows you to have a degree of multitasking capability (handling two tasks at nearly the same time). For instance, let's say you were receiving a file upload from another QL user, while you were processing text. Because the system is so capable, you could halt the word-processing program, bring up the file transfer program, and begin the transfer. Then, you could go back to your text-processing program as the file was transferred in the background and you could continue working. Or, you could just leave the file-transfer program up in the background and another user could call you and leave the file while you were doing something else.

As in everything, though, there is a catch and that is the more you ask the system to do, the more RAM you need and thus it's quite likely, although the company doesn't indicate this, that you need the full complement of RAM for the QL (640K). That is because multitasking-even for a single-user is still a memory-hungry function. The resident programs and the data that might be manipulated, input or output, all require their fair share of RAM.

QDOS also contains a time-sliced priority job scheduler, as well as display handling for multiple screen windows (here's where the dedicated video RAM becomes especially important because you can manipulate it separately and it shouldn't detract from the overhead needed by other functions). Finally, because of the nature of the operating system and the QL, QDOS provides device-independent input and output.

Also contained within ROM is Sinclair SuperBASIC, a good implementation of the standard programming language. It features procedure structuring; extendability, including syntax; a clean machine-code interface; equal capability for strings and arrays; a full-screen editor, and full error-handling facilities. Since it is an interpreted, rather than a compiled language—the system must interpret the source code before it can be used—it tends to be slower than a compiled language, which is written directly to machine code through a compiler routine. However, interpretation speed is independent of the size of the program, so you have fairly fast program execution. Finally, as in other advanced implementations of BASIC, the operating-system facilities are accessible from BASIC.

As for the rest of the software available which operates under QDOS, the key tenet is usability. The software has been designed to make the word-processing, spreadsheet, database and graphics capabilities available and usable by people with no prior training.

That has been achieved by using several interesting concepts: pyramidal; "do-and-see," and "inform and decide." The pyramidal structure of the software takes you directly to the most commonly used facilities. It enables even the most inexperienced person to perform useful tasks immediately. And, as you become more experienced with the software, you can make the software do more things.

At all times, the software is "do-and-see." In other words, it takes a totally interactive approach and the visual effect is immediately displayed in the video device. For example, the screen always shows exactly what will be output to a printer or plotter. There are no special control characters needed to indicate various type fonts. Instead, the type font itself is shown. In other programs, the only indication of a change in typeface is a special screen symbol.

Finally, the software is self-documented.

Throughout the programs, comprehensive information on the current status and on available actions are displayed. Continuous prompting is directed at the current action being pursued. In addition, a comprehensive help function is available in all the packages at all times.

The integrated software package allows you full text-processing capability, as well as spreadsheet functionality. Further, it allows you to create and manipulate data in a database and it allows you to combine all of the data created into a graphics display.

What does that mean? Suppose you had a report you had to file that needed inputs from a text-processing program; as well as financial data, and other information contained in a database. With an integrated program, you can integrate the text with spreadsheet financial information and database data into a final report and you can also integrate the graphics you need to complete it. Then, if you decide to change something, the report is automatically updated. Isn't it a nice feature? That means you don't need filtration programs and programs that make one data file compatible with a second or third program and it makes your operation more efficient.

The key to this functionality is a common file structure that allows data created under one program to be used by another, which the QL software does.

The future

As you can see from the foregoing, the Sinclair QL is a powerful machine and it shows that you needn't pay a high price for a high performance machine. That is just what the *ZX81* did and it's quite likely that is what this new machine will mean.

The inexpensive pricetag shatters the mystique of the computer marketplace where a high price was equated with quality and functionality. The QL, with its advanced microprocessor, graphics capability and advanced software, has both quality and functionality, but in a price that is lower than $500. And, it offers users one feature that is a costly add-on in many systems, the ability to tie into a *L*ocal *A*rea *N*etwork or LAN. The LAN has been touted as the gateway to information sharing in the electronic office of the future and it shows that Sinclair's thinking is on that office. He aims at giving people a quality alternative for a reasonable price.

PRINTING BUFFERS

No, you don't have to sit there and glare balefully at your computer while you wait impatiently for the printer to play "catch-up."

HERB FRIEDMAN

■Pithy sayings and cliches are endemic to all aspects of life and we have our share of them in electronics. The radio amateurs have "If you can't hear 'em you can't work 'em." Generations of hi-fi enthusiasts have had "The system is only as good as the weakest link" drummed into their ears for years. Computerists have "A computer is only as fast as the slowest peripheral."

Among the very slowest of peripherals is the printer. While the computer is all set to zip through a monstrous database in seconds, the printer is putting it all on paper a letter at a time, tick, tick, tick..,.....tick. And during the time when the printer is doing its tick...tick,..tick, the computer sits idle, waiting for the printer to stop.

Depending on the printer's inherent speed, the idle time can be enormous. For example, consider a 3000-word document, which represents 12 pages of text, 25 lines-per-page, 60 characters-per-line—the defacto standard American business format. One of the modem competitively-priced matrix printers can zip along at about 80–120 characters-per-second. This sounds like *Superman* speed, but first, to create enhanced characters the speed is cut approximately in half, so at best we have 60 characters-per-second, which is 10 words, or one full line of print per second. Exclusive of paper feed or changes, 3000 words will take a minimum of 5 minutes to print. Not bad, you could most likely wait 5 minutes to use the computer.

But you don't want your letters to appear computerized by having matrix characters, so you use a letter-quality daisy wheel printer. A competitively priced daisy printer delivers about 12 characters-per-second. Now we have a whole new ballgame as they say. At 12 characters-per-second, not even allowing for changing the paper or the slower carriage returns and linefeeds it will take 25 minutes to print 3000 words, and that's a lot of time for a computer to be out of service just to print a document.

The spooler

One of the earliest schemes to free the computer from serving as a storage bin for the printer was something called a *spooler*, spooler being an acronym for "Simultaneous Peripheral Operation On-Line," which in plain language means that disk drives and printers can be operational while a program in memory is active with some other function. For example, the spooler might be printing your thesis on perpetual motion while you're composing a letter to the local utility complaining about an electric bill for $1000 during the month you were away on vacation.

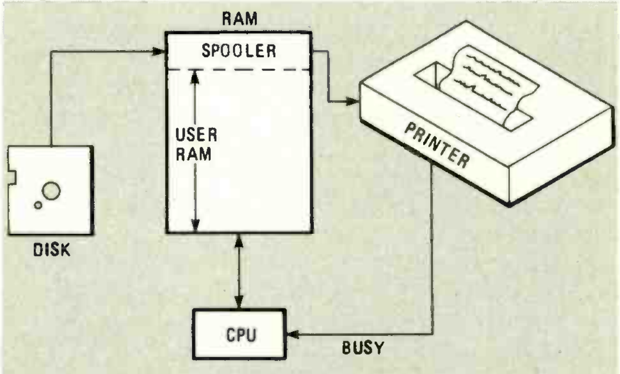


FIG. 1—THERE ARE AS MANY spooler software versions as there are word proccessors. Most of them work this way.

While there are probably as many versions of spooler software as there are word processors, they all more or less work as shown in Fig. 1. The spooler loads itself into high memory. When the computer "looks up" at the top of memory it sees not the actual top of RAM but the bottom of the spooler. Assuming the computer has 64K RAM, if the spooler requires 10K the computer has only 54K RAM available for the user and the computer "sees" 54K as being the top of RAM.

The spooler functions as a pass-thru for blocks of data from the disk to the printer. If the keyboard is activated it takes preference: the spooler holds off calling for a block of information and the computer functions normally; the user can then utilize user RAM for just about anything else.

Programs or functions in the user RAM are said to be in the *foreground*; the spooler function is said to be in he *background*. Only when the foreground is inactive is the background permitted to operate. Actually, because of the small buffer usually built into the printer, and a small buffer of perhaps less than 1K in the spooler (or even larger), the user rarely realizes it's all happening in fits and starts. With a well-written spooler it's almost impossible to detect any interruption in the printer's throughput even though activating the keyboard might delay the spooler by as much as three seconds.

Spooling is sometimes built into word processing software so the user doesn't have to twiddle his or her thumbs waiting for the printer to finish. With a software spooler the printer goes it's merry way—as slow as it wants—while the user powertypes through another document. The only thing the user cannot do is access the disk system while the spooler is active. That is not a problem if you're using the foreground to build a spreadsheet for disk storage after the background spooling is finished, or if you plan to use only non-disk functions until the printing is finished. But, if your foreground task involves the disk system, something's got to give. If you're *boilerplating* a document and the pre-written paragraphs are going to come from disk, the foreground and background tasks are usually going to be mutually exclusive. The few spoolers that can time-share the disk system generally take up so much RAM there's little remaining for the foreground task. So there must always be a compromise of sorts as long as the spooling is done through software.

Hardware spoolers—the printer buffer

When there's no room for compromise, when you want to print and yet have full access to the disk system, you must totally divorce the printing function from the computer. That is done with a hardware spooler, an electronic device usually called a "printer buffer," or a "printer controller," or a "printer optimizer." To avoid confusion, we'll refer to all of the hardware devices as a *printer buffer* regardless of what it's called by the manufacturer.

The basic concept of a printer buffer is a 4-terminal *black box* full of RAM (memory) which is controlled by its own internal CPU (Central Processing Unit). Two input wires connect to the output printer port of the computer, the remaining two output wires connect to the input of the printer. The physical arrangement is shown in Fig. 2. The internal structure of the buffer is such that, to the computer, it appears to be a printer, while to the printer the buffer appears to be the computer.

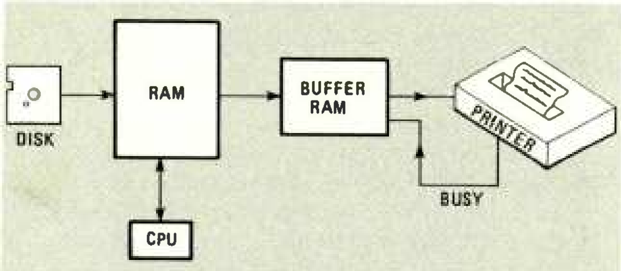


FIG. 2—BLOCK DIAGRAM SHOWS the physical arrangement and interconnections of the printer buffer.

When the computer is given the command to PRINT, it dumps to the buffer, filling the buffer's RAM with a mirror image *of the signals intended for the printer.* Understand this point very clearly: The buffer does not receive a mirror image of the computer's RAM; rather, it receives what is intended for the printer. The data stored in the computer's RAM is what determines the signals sent to the printer, but it is not necessarily the same.

Generally, the buffer outputs immediately to the printer, which thinks it's getting data from the computer. In a matter of seconds—the precise time depending on the amount of data to be transferred from the computer to the buffer—the computer has completed its dump and is free for any other use. The printer chugs along doing its own thing at its own speed using the data from the buffer; it no longer has any effect on the computer.

Now it's entirely possible that the data in the computer exceeds the RAM available in the buffer; you could have a buffer with 16K RAM while your document takes up 18K in the computer. In this instance, the buffer busies-out the computer until there is free RAM available in the buffer.

It works this way: As shown in Fig. 3, when the buffer's RAM is full, the buffer sends a "busy" signal back to the computer through the handshake connection in exactly the same way as the printer would stop output from the computer. The memory in the buffer is arranged in an overwrite stack, that is, it fills from memory location 0000 and transmits to the printer from 0000. As data in RAM is sent to the printer, the RAM is considered empty and available for new data. After a predetermined block of RAM is free the busy signal to the computer is lifted and the free RAM is loaded with fresh data. As soon as the buffer's RAM is full the computer is busied-out until another block of free RAM is available for data storage. Meanwhile, the buffer's CPU is working its way through the stack. When it gets to address 16K it returns to 0000 and sends the new data, once again moving down the stack through the fresh data. Again, when a sufficiently large block of RAM is cleared, the busy is lifted and the computer fills the free RAM.

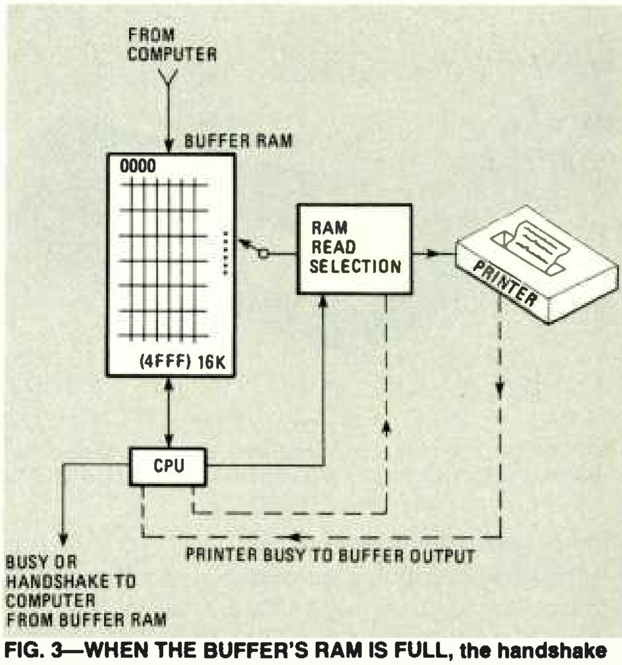
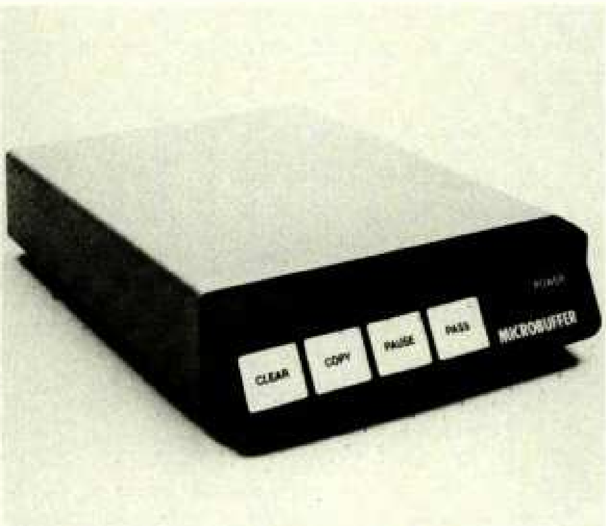


FIG. 3—WHEN THE BUFFER'S RAM IS FULL, the handshake connection sends a "busy" signal back to the computer.

When the computer dumps the remainder of its data, it is free for another purpose even though the buffer is still feeding the printer. So as you see, when the data in the computer's RAM exceeds the capacity of the buffer's RAM it might take somewhat longer than a few seconds to free the computer, but it won't be much longer. Using our previous illustration of 18K of computer data with a 16K buffer, we have 2K of data that cannot be be accommodated by the buffer in the initial "fill." The printer runs at, say, 60-bps (bytes per second). It will take, therefore, an additional 33 seconds for the buffer to release the computer. Actually, 33 seconds is a "nominal value" because the printing commences the instant the buffer's RAM starts to fill, the printer doesn't wait for the RAM to fill. On the other hand, a buffer generally makes its free RAM available to the computer in blocks: it might well accept output from the computer when the first "page" of 256 bytes is free, or 512 bytes,or 1024 bytes, or whatever it's designed to accept as a block of data.

That is really a worst-case scenario because rarely does the computer's stored data exceed the buffer's RAM. In general, few documents exceed 12K bytes, the equivalent of 8 pages of double spaced text at 250 words-per-page. Those who consistently work with larger documents will not use a 16K buffer. More likely, they will use a 64K buffer, which exceeds the total user-available RAM of an 8-bit computer. (In this instance "user-available" means the RAM not used for the computer's operating system and the foreground program.) For example, one of the popular word processors for 64K computers leaves slightly less than 30K available for text storage, so the most the buffer will have to accommodate is 30K of data.



A PRINTER BUFFER, the *Microbuffer* is from Practical Peripherals (31245 La Baya Drive, Westlake Village, CA 91363).

The second computer.

Though we speak in terms of data in and data out when discussing a printing buffer, in actual fact the device is really a somewhat specialized computer, and once something is a computer it's possible to create many diverse functions. The simplest, least expensive buffers serve primarily as RAM storage devices—what flows in flows out unmodified in any way. But the same internal "computer" that handles the data flow can also do things like character and string conversions. For example, assume you are using a Radio Shack *Model 4* computer. This creates a beaut of a problem because Radio Shack's own software assumes a printer that does an automatic carriage return after a linefeed, so Radio Shack's software does not transmit a carriage return after a linefeed. On the other hand, most standard CP/M software that will run on the *Model 4* transmits a line feed after a carriage return. Because of the automatic linefeed of the printer you now have two linefeeds when you want just one. You could probably reprogram the internal switches of the printer each time you changed operating systems (usually requiring some disassembly of the printer), but an easier way is to simply program the buffer (through a keypad) to convert ASCII code 13 (CR) + 10 (LF) to just 13 (CR). The buffer will now straighten out the carriage returns and linefeeds. Each time it comes to a CR + LF command in its own RAM it will output only CR.

Some buffers can also memorize a string of characters, substituting them for a single symbol. For example, an intelligent buffer can be programmed so a single "#" character in a document causes a complete letterhead to print. In effect, # equals: SuperAtenna Repair Co., 12 Howling Wind Rd., Windy City, NH.

When you can't afford to keep your computer tied up just running the printer, or you need some oddball character and string conversions, the easiest way to do the job is most likely to be a printer buffer.

Printer buffers come in all sizes, shapes, and prices that range from about $200 to well over $500. The lowest cost models are esentially RAM storage devices of 16K intended for parallel Centronics-compatible input/output ports. Those models can generally be expanded to at least 64K, possibly even 128K or 256K. Approximately $100 more buys a model with RS-232C serial I/O. For $250 you can get a buffer with 64K of RAM that might have a few extra functions such as a few character conversions, or repeat copy printing from one fill.

At $500 and higher you get full-blown computers that happen to function as a printer buffer. Generally, they have 64K of RAM which is expandable to 128K. They will do multiple character or string conversions, store macros of substantial length, merge stock text with mailing address input, directly drive more than one printer, convert from serial to parallel I/O or vice versa, provide two or three printer outputs for a single input....the list of special functions is seemingly endless.

No buffer that we have seen, regardless of price, has all the functions of every other printing buffer. No matter how sophisticated a buffer might be, if it hasn't got the one single feature that's important to you it's not worth the money. If you work with large documents then you need at least 64K of RAM, that's important. If you have several printers with different printer codes maybe a buffer that does extensive conversions is what you need. If you do a lot of form letter mailing, a highlight feature for the printer buffer you need might be extensive (and long) macros or the ability to stack texts so they print one after the other in perfect sequence.

For personal computers, printer buffers are still in the introductory stage, so advertisements vie for your attention with endless lists of functions and features. A good rule of thumb to use when considering a printer buffer is: "If the function or feature isn't clearly listed—if it's implied or assumed—it probably doesn't have it."

PC: "PERSONAL COMMUNICATIONS"

Your computer's window on the world

HERB FRIEDMAN

■The concept of "personal communications" as applied to personal computers changes so frequently that it's most difficult to keep up with "what's new" both in terms of services and the software needed to access the services.

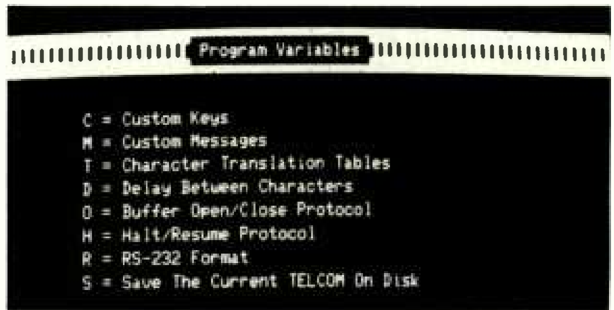
Often, what's new and exciting is not what's efficient and practical but what is fashionable. For example, many of the very same magazines that run "in depth" articles on how to join the revolution in on-line computer services get their author's articles on "hardcopy," *hardcopy* being *technese* for a typewritten sheets. Others, which claim to be computerized, actually request their authors supply the article on a disk specifically formatted for a particular computer that uses one particular kind of word processor, usually WordStar.

On the other hand, **Radio-Electronics**, which is a general electronics publication, has been truly computerized almost from the earliest days of personal computing. R-E gets its columns and features by computer to computer transfer; the hardcopy serves only as a reference backup. Better still, an author can dial-up R-E and dump the manuscript using any preferred word processing program, not just WordStar. Standard, generally-available communications software at R-E automatically modifies the author's upload for R-E's preferred word processor. For example, my files are created with TYPIT, which puts a carriage return after every line in the format that I use for ASCII text transfer. R-E's communications software strips off the linefeeds before they ever get to the storage disk.

Until very recently, that kind of data exchange represented typical personal computer communications: Hobbyists exchanged data and programs (let's be honest and call it "pirating" programs), businesses got information from field offices and salespersons, and college students did their computer work from their dormitories (in those schools with an enlightened administration). However, since personal computers became just another appliance found in many households there has been a dramatic shift in the type and kind of personal communications and the required software.

The communications package.

Today, the fashionable use for personal computer communications is to access the on-line information services, and much of the communications software—what is called the "communications package"—is specifically tailored to access these services.



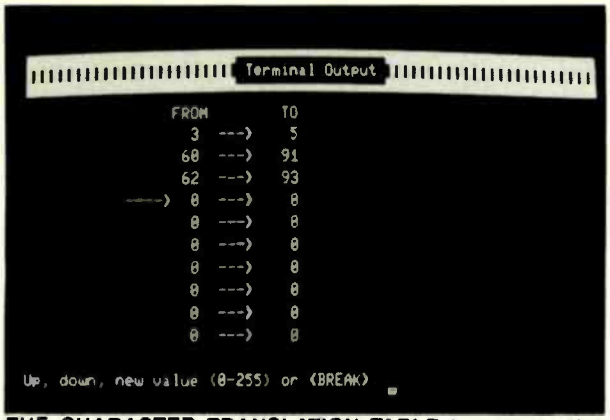
MOST MODERN communications software, even the least expensive, permits customization of program variables of *TELCOM2*, one of the most powerful but least expensive packages.

For those of you not familiar with the term *on-line*, it originally meant equipment and/or software ready for immediate use. By logical extension to personal computing, it means an information service or network which can be accessed by a personal computer through the dial-up telephone system. All that's needed for on-line access of an information service is a personal computer, a modem, and a software package that programs the computer to emulate a "smart terminal."

A smart terminal is one that can store (download) incoming data and transmit (upload) its own tape or disk files, or data stored in its memory. This contrasts with a "dumb terminal," which is only a keyboard and display, or a computer that emulates only a keyboard and a display.

While a dumb terminal can also access computers and on-line information services it cannot store incoming data, nor can it upload its data. As fast as the incoming information scrolls off the sreen it's gone unless fed to a printer. The dumb terminal is simply not adequate for modern on-line or personal communications use, so we will ignore it from here on; we limit our discussion to smart terminals—a full blown computer that also functions for communications.

Dial-up on-line information services—the Source and CompuServe being the best known—have been with us from the early days of personal computing. Today, we also have the Dow Jones·News Service for the Wall Street gamblers, even more specialized services for farmers, information networks only for those with IBM computers, and....you name it. If someone thinks people will pay money for information of any kind they start up an on-line information service.



THE CHARACTER TRANSLATION TABLE has characters specified in decimal ASCII and converts outgoing CONTROL-C (3), < (60), and > (62) to CONTROL-E (5), (91), and (93).

Most communications software provide for easy access to the information services through extensive *macros*, a macro being a complete "message" transmitted by touching only a single key. For example, a macro will transmit the telephone number of an on-line information service (assuming use of an auto-dial modem) and wait to receive the required prompt. On receipt of the prompt, the computer then transmits the required response...and repeats this first-you-then-me exchange several times until the local computer is linked and signed into the information service.

If the software is to be used for several on-line services employing different operating codes (called *protocols*), many communications software packages also provide for automatic translation of transmitted or received ASCII characters. For example, assume that many of the on-line services you access require a CONTROL-C to "bail out," but one service requires a CONTROL-E, and you never can seem to remember the one which is not CONTROL-C. If you have a communications package such as TELCOM (Mumford Micro Systems, Box 400 Summerland, CA 93067) or OMNITERM (Lindbergh Systems, 49 Beechmont St., Worchester, MA 01609), you can create a special version that will automatically translate a CONTROL-C to a CONTROL-E. In this way you always use a standardized keyboard entry which the computer translates to the correct characters for the remote computer or information service.

Introducing E-mail.

In the past year or so there has been a considerable change in the use of personal computers for both on-line information services and what is called E-MAIL (*E*lectronic *M*ail). The use of those services is increasing at such a rapid rate that software is now being tailored more toward specific on-line/E-Mail use than for the kind of conventional data and program exchange of the early users of personal computers.

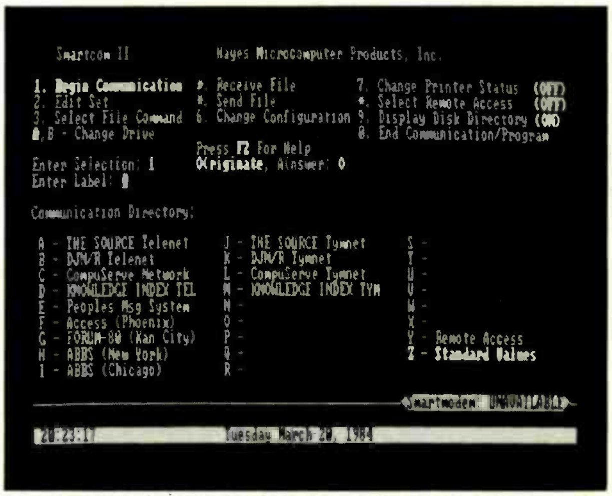
First, popular access to on-line services is no longer primarily for entertainment after prime time when on-line information service rates are lowest. Many on-line services cater to business users and access to the service must be at the touch of a button; no one has time to waste dialing, then punching in strings of access codes, and finally flipping through a menu. So the most modern communications software provides for extended macros; one key dials the service, handles the sign-on protocols, and goes directly to the desired information area of the host computer. True, many older programs had this feature, but the most recent software has macro sign on and automatic E-Mail.

E-Mail is so important a concept to those who can use it efficiently that some New York banks prominently feature E-Mail as one of the highpoints of electronic banking. (Problem is, the pitchman—or is it "pitchperson"—mumbles when they get to the part about how E-Mail can only be sent to other users in the same bank's network.)

One can see the importance of E-Mail by simply looking at the new software packages, such as IBM's "Personal Communications Manager" for the IBM PC/PCjr. Virtually the entire package is oriented towards E-Mail. Like much of the latest communications software, PCM gets involved in unusually sophisticated protocol transfers.

A *protocol transfer* is a method of data transmission that insures an error-free download, upload, or exchange. Until recently, most personal computer protocol transfers involved data and programs, not ASCII text. Instead of exchanging data using ASCII characters, the data is an exact representation of the binary information, and it is transmitted in blocks. Depending on the specific software, error checking is done through a CRC (*C*yclic *R*edundancy *C*heck) or a checksum. Both are means whereby each block of data is followed by a value derived from the data. If a bit gets glitched during transmission the CRC or checksum doesn't match the value of the received data and the host computer automatically requests another transmission. Only when the CRC or checksum matches the data value is the data stored in the computer's memory or written to mass storage.

As a general rule, communications software has some limit on the number of protocol "tries" before it quits and informs the operator there is a data loss.



THE MENU OF *SMARTCOM II* not only lists every function, but also the services programmed for automatic access through the Communications Directory.

Somewhere around 8 to 10 tries is standard before the computer quits and warns the operator that a reliable exchange isn't possible.

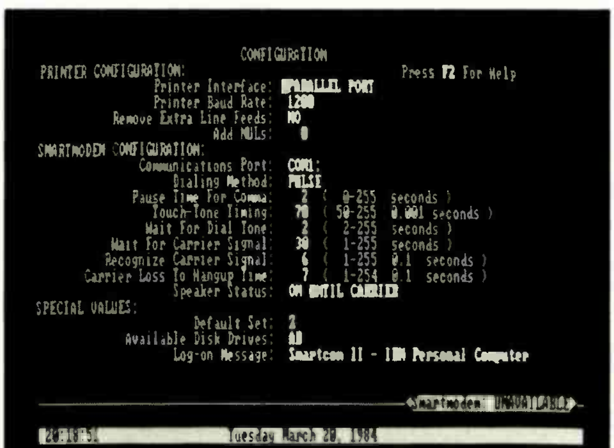
Some software entertains the operator with a running count of the number of blocks transmitted or received, the number of errors, the number of tries, etc. None of this information has any real value, but it beats staring at a blank screen.

The protocols must be compatible.

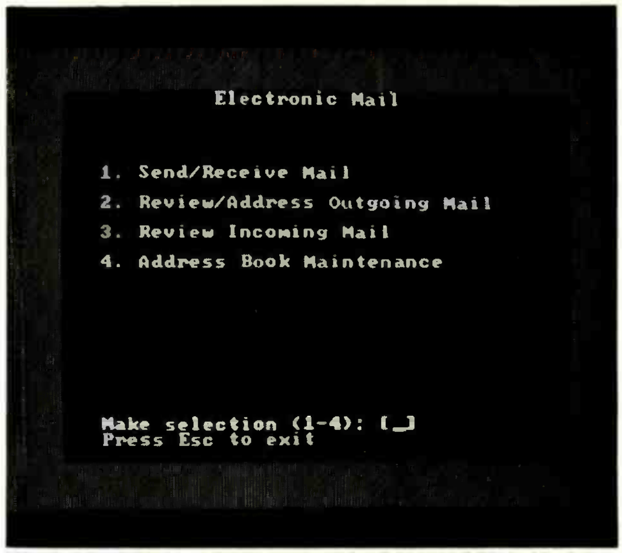
A protocol exchange requires that both computers recognize exactly the same set of control signals—the "protocol." If one computer uses, say, X-ON/X-OFF (CONTROL-Q/CONTROL-S) to start and stop transmission while the other recognizes only ETX/ACK (CONTROL-C/CONTROL-F), or if the computers use different means of calculating the checksum, they will never be able to do a protocol exchange because they will always be searching for control signals that never arrive.

Unfortunately, manufacturers like to insure that people purchase their products, so few communications software packages employ protocols used by other communications software. TELCOM won't do protocol exchanges with CROSSTALK (Microstuff, Inc., 1845 The Exchange, Atlanta, GA 30339), and SOFTCOM (The Software Store, 706 Chippewa Square, Marquette, MI 49855) won't do protocol exchanges with UNITERM (BT Enterprises, 171 Hawkins Rd., Centereach, NY 11720), etc., etc, ad nauseum. About the only outfit that really gives the user a break is MITE (Mycroft Labs, Inc., Box 6045, Tallahassee, FL 32301), which recognizes the CLINK (Crosstalk), XMODEM (public domain), HAYES (Hayes Microcomputer Products, Inc., 5923 Peachtree Industrial Blvd., Norcross, GA 30092) and IBM PC protocols—which encompases the majority of the commonly-used CP/M-IBM personal communications software.

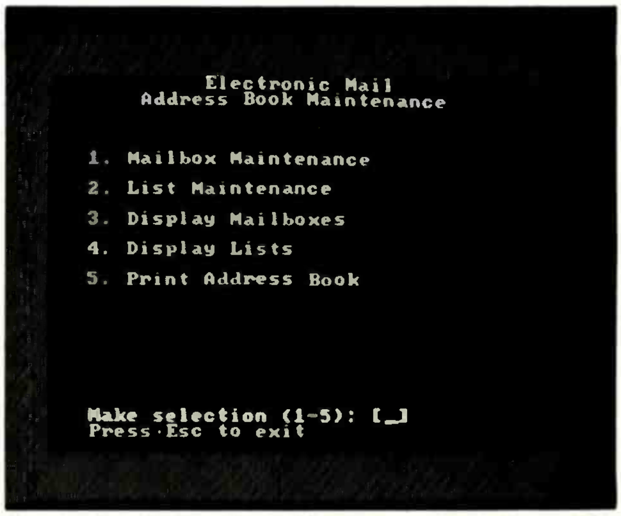
When only interactive text is involved there is usually no need for protocols because the data is exchanged on a character by character basis, not in blocks, and the exchange is continuously viewed. The operator can



THINK OF ANY CONFIGURATION and *SMARTCOM II* will probably let you do it. (Smear of screen is caused by automatic highlighting.)



IBM'S *PERSONAL COMMUNICATIONS MANAGER* is big into E-mail. This sub-menu shows just some of the E-mail options.



If you select Address Book Maintenance, you will see this menu that gives you 5 more choices.

easily recognize a glitch and make an informed guestimate, or ask for a repeat transmission. The data exchange in this instance uses ASCII because the on-line services and hardware all recognize ASCII. If you access the Source, CompuServe, etc., your computer sends and receives ASCII-encoded characters.

Some software does a checksum or CRC check of ASCII text but doesn't interfere with the exchange It just informs the user(s) there was an error.

But modern applications of the personal computer have strained the non-protocol ASCII exchange with which most users of personal computers are most familiar. E-Mail is the wave of the present for many business users, and so communications software must provide for error-free data exchange of text. Why error-free? Imagine sending a construction bid by E-Mail and it arrives as $125,000 instead of $12,500.

E-Mail oriented communications software is more or

YOU NAME THE MAILBOXES in IBM's program. To deliver your mail, just enter the name of the mailbox and the computer will auto-dial the remote location and deliver your message—all unattended.

less the same as any other communications software, but it also includes protocol exchange and has many special features specifically intended for E-Mail. Most important, the E-Mail usually referred to is not the E-Mail of the on-line services whereby you leave a message for another subscriber in an "electronic mailbox" at the Source or CompuServe.

What *is* E-Mail?

E-Mail is a real document, a letter, data, memo or whatever you would normally put down on paper for exchange between two business offices (at least for the present). True E-Mail oriented communications software is clocked and dated; it will automatically transmit your document at a specific date and time. It will go to an internal Address Book, look up the telephone number of the office for which a message is intended, automatically dial the remote telephone and redial until a link is established, transmit the correct remote access codes, compare the return confirmation codes, then go to the data file, locate the desired file and transmit the document using an unusually precise protocol to virtually eliminate any possibility for transmission error, and finally sign off and disconnect.

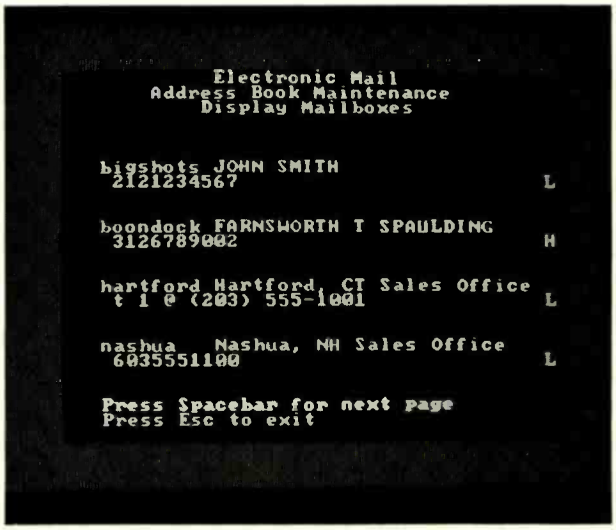
Similarly, true E-Mail software will automatically answer the phone, go on-line, test for protocols, receive and store incoming data using the same precise protocol, and then disconnect. The user can even program what time the computer should auto-answer the telephone line to prevent all callers from being greeted with an answer-tone.

Though many E-Mail features are found in conventional high performance communications software, the major differences are the protocols, internal Address Book access, and header-derived transmissions. As for the protocols, IBM's latest personal computer communications package for home and business, "Personal Communiations Manager," uses the Microcom Networking Protocol. It matters not whether this is the best or worst protocol because today, by popular demand, software must be IBM-compatible, hence, the Microcom Networking Protocol will most likely become the defacto E-Mail standard for home and business, just as the XMODEM protocols are the defacto standard for CP/M bulletin boards.

In a typical E-Mail system each office or location is considered to be a mailbox, identified in the Address Book by a specific codeword or identification. The mailbox file contains the identification, the telephone number and access protocols. For example, Super-Shlock Industries, manufacturers of gold-plated widgets, might be identified by the single word WIDGET, while your own home office might be identified as BIGSHOTS, with a field office identified as BOONDOCK.

You need a header.

Each time you selected a document for transmission you would assign a header to the outgoing log that selects the files to be transmitted. Documents to be transmitted after hours to the home office would have the header BIGSHOTS. Orders and requests for bids to Super-Shlock Industries might have the header



WANT TO SEE WHO PICKS UP THE MAIL at the mailbox? You can call up the list at the touch of a key. The character L or H at the right means low speed (300 baud) or high speed (1200 baud) modem—again automatically selected.

WIDGETS. Five inquiries to the field office asking for information on how many left-handed screwdrivers were in stock would have the header BOONDOCK.

To transmit your document(s) to the field office you would program the communications package to send files coded BOONDOCK at 1:30 AM. At 1:30 in the morning the computer would start up, locate the phone number identified as BOONDOCK in the Address Book, dial the listed telephone number, and after the communications link was established it would search out and upload all files logged as BOONDOCK.

Same thing with the other files. At 3:00 A.M. the computer might "come-up," find itself programmed to transmit WIDGET files, so it would access the telephone circuit associated with the WIDGET identifier in the Address Book, and then upload all logged WIDGET files.

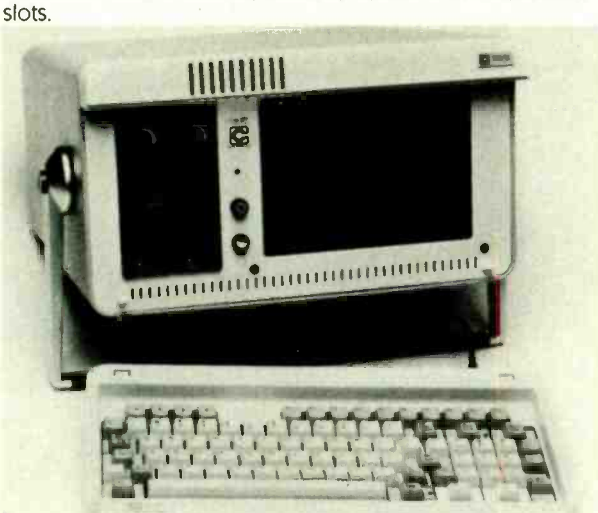
An important component of any business operation is "accountability," which is the business-administrator's way of pinning the blame for mistakes on someone else. While general purpose communications software can be used for E-Mail, true E-Mail software keeps a log of incoming and outgoing traffic. It records who sent what to whom at which telephone number at what time. If the Skyhook Antenna Company claims it never received your order for 25 direct broadcast satellite antennas all you need to do is consult the log, if you sent your order by E-Mail. The log will show the date and time the telephone number was dialed, the protocol identifier exchange (if recorded), the subject or name of the transmitted file (your order), and depending on the particular E-Mail software, the number of tries, failure or success of the protocol exchange, and possibly the disconnect time. It will be difficult for Skyhook Antenna Inc. to deny your order when you have virtually a confirmation in your log.

As with just about everything else in personal computing, new developments are often ready for the marketplace before you even get a chance to become familiar with the hardware and the software you recently purchased. In the field of personal computer communications, be prepared for some startling developments in personal and business E-Mail because it works so well and so easily, and can leave a rather detailed audit trail. Also look at it this way: The junk mail you get through E-Mail doesn't clutter your mailbox and doesn't have to be taken out for the garbage pickup. You get rid of it with the simple command ERASE.

COMPUTER PRODUCTS

For more details use the free information card inside the back cover

IBM-PC COMPATIBLE COMPUTER, the Colby *PC-3*, is a standalone, tansportable computer that incorporates Colby's "high density" IBM-PC compatible motherboard with many functions on the motherboard that would ordinarily require additional plug-in boards, taking up space in the expansion slots.



CIRCLE 121 ON FREE INFORMATION CARD

The unit weights 26 lbs., has a 9-inch amber screen and dual 360K double-sided, double-density floppy-disk drives. It measures 8½ × 16 × 16½ inches, has 3½ IBM-PC expansion slots, and a full-width carrying handle that doubles as a tilt stand. The computer can be stored under an airline seat.

The *PC-3* comes standard with 128K of RAM (but can be upgraded to have as much as one megabyte of RAM on the motherboard), a real-time clock, serial port, parallel port, SASI hard-disk interface, and an 80-column × 25-line display with IBM-fiPC compatible graphics capability. It is priced at $2795.00.—**Colby Computer,** 849 Independence Avenue, Mountain View, CA 94043.

EQUATION-PROCESSING SOFTWARE, *TK!Solver* is an equation-processing program that makes it easy to solve mathematical problems without programming. The user simply enters the model (one or more equations), types in the known values, and presses the action key. The program finds all of the unknown values.

All the tools needed for problem-solving are built into the program, including mathematical functions, facilities for converting units of measurement, and the ability to produce graphs and tables. With the program, the user can create his own mathematical functions and use them along with the built-in functions.

CIRCLE 122 ON FREE INFORMATION CARD

TK!SolverPack applications packages, designed for use with the *TK!Solver* program, solve problems in specific fields. They contain models, which in turn contain the necessary equations, values, and tables for solving a particular problem. The models provided in the applications package can be modified by the user, if desired.

TK!SolverPacks are available for Introductory Science, Mechanical Engineering, Financial Management, and Building Design and Construction. Additional *SolverPacks* are promised in the future, including packages based on educational books published by McGraw-Hill Book Co.

TK!Solver has a suggested list price of $399. The *TK!SolverPack* applications packages are priced at $100. each—**Software Arts,** Borman/Williams, Inc., 156 Fifth Avenue, New York, NY 10010.

DISK FILE, the Rolltop *100,* known as the "Executive" features a silver rolltop enclosure and a textured black high-impact plastic body. It holds 120 diskettes and comes with 10

CIRCLE 123 ON FREE INFORMATION CARD

dividers and color-coded labels. The Executive Rolltop *100* Disk File is priced at $39.95 (model *RT100E*). A locking model for securing valuable programs or data (Model *RT100EL*) is priced at $49.95.—**Microcomputer Accessories, Inc.,** 6721 Buckingham Parkway, Culver City, CA 90230.

COLOR-GRAPHICS TERMINALS, *Graphos II* and *Graphos III* feature shiftable cell architecture and 16 independently

CIRCLE 124 ON FREE INFORMATION CARD

managed screen windows that can smooth-scroll in any direction, be used to compare images, and mix graphics and alphanumerics. The windows have individual color tables and are central to device-independent operation.

Both *Graphos II* and *Graphos III* are well suited for the OEM, systems integrator, and software developer. Each terminal communicates through an RS-232 connector with practically any host computer, and attaches to a variety of monitors. Those terminals can be rack-mounted or used on a desk.

The two terminals differ in memory, speed, and number of colors. *Graphos II* runs at 6.25 MHz and has 16 colors displayable on a TTL-input monitor. It is priced at $3,995.00 (without monitor). *Graphos III* is an enhanced version capable of generating 32,768 colors on an analog RGB monitor, has a speed of 12.5 MHz, and more memory (256K vs 128K graphics RAM; 224K vs 128K local storage RAM). It is priced at $5,485.00 (without monitor). Complete packages with 13" and 19" monitors are available.— **Ithaca InterSystems,** 1650 Hanshaw Road, Ithaca, New York 14850.

PRINTER STAND, *Printer Caddy* is a solid oak-wood container for your printer. The finish comes in light, medium, and dark wood, with the natural markings of the oak wood showing through. There is easy access to printer paper, with two doors front and back; there are also dual fans for cooling,

CIRCLE 125 ON FREE INFORMATION CARD

and an adjustable printer shelf that features ¾" sound-suppression material.

Overall dimensions are 32" × 27" × 44". The printer stand may be moved about easily on four over-size ball-bearing casters. The *"Printer Caddy"* is priced at $490.00.—**Daisy-Net International, Inc.,** PO Box 1152, Northbrook, IL 60062.

sure the resonant frequency.

In order to determine the unknown value of an inductor, place it in parallel with a known capacitor; or for an unknown capacitor, use a known inductor. Measure the resonant frequency with your GDM and you have two of the three values specified in the standard formula:

$$f_r = 1/2\pi\sqrt{LC}$$

Where F is the frequency in hertz; π is equal to 3.1459; L is the inductance in henry's, and C is the capacitance in farads. From that basic formula you can solve for the unknown value. To find the value of an unknown capacitor, for instance, use the equation:

$$C = 1/4\pi^2 f^2 L$$

Let's look at an example: Say that you measure the resonant frequency at 10 kHz and you know the inductance to be 10 μH. Substituting the numerical values for their respective symbols in the above equation will yield a capacitance value of 25.33 μF.

By reversing the positions of L and C in the equation, you can solve for the inductance. Another way, to find the value of an unknown capacitor or inductor would be to use the chart that can be found in any good radio handbook. Also, keep in mind that building a GDM is a good project.

Computer tapes revisited

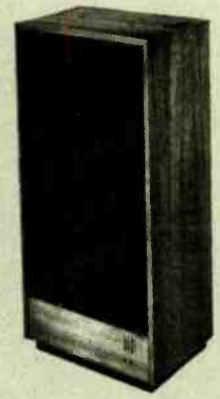
You may recall that the August 1983 Hobby Corner contained a piece about copying computer tapes. The gist of it was that copying from one tape machine to another was an unsatisfactory, if not impossible undertaking. It appears, however, that some of you have had some success with just such copying.

The most informative letter came from Rick Cook (AZ) who is researching this very subject for a book to be published by Sybex. Rick has had the greatest success using relatively inexpensive recorders and high quality tape. He says (as do the others) that finding the right control settings for both machines can require a lot of trial and error. If you are interested in the details, look for Rick's book.

Perhaps my difficulty was a lack of patience in experimenting to get the settings just right. Instead, I got a signal conditioner and then could hardly miss making good copies.

Speaking of signal helpers, P. J. Donnelly (NY) wrote about a passive conditioner for use with Timex/Sinclair tapes. It's call the *Winky Board*, and is available from G. Russel Electronics (RD

continued on page 75



NEW IDEAS

Restoring tube-type car radios

THE INTEREST IN CLASSIC CARS HAS RECENTLY brought several old tube-type six-volt radios into our shop for repair. Most of the trouble with them is not hard to find, but the parts are—most notably the electro-mechanical multivibrators. They were used in DC-to-DC upconverter circuits to provide +300 volts to the vacuum tubes. As I recall, they were not all that reliable, nor were they long-lived, for that matter. Therefore a substitute was needed.

After some experimenting we finally came up with the circuit shown in Fig. 1. The basic circuit is an astable-multivibrator that is used to drive output power-transistors at the same frequency as the old electro-mechanical vibrator.

How it works

The circuit is built around IC1, a 4049 hex inverter/driver. Two of the inverters (IC1-b and IC1-e) are used to form an astable-multivibrator, and the others provide the necessary drive for the output transistors. The rest of the circuit consists of several resistors, capacitors, and diodes, and four transistors.

When power is applied to the circuit a pulse is generated through capacitor C4 and is applied to the cathode junction formed by diodes D1 and D2, causing the inverter outputs to alternately go from low to high.

Each of the multivibrator's two outputs are also fed to two separate drive circuits constructed from the four remaining inverters. We will only look at the upper half of the circuit from this point on, because they both do the same thing—only not at the same time.

When the output of IC1-e is low, it causes the output of the paralleled inverters (IC1-c and IC1-d) to go high. Because diodes D3 and D4 are reverse-biased, they will not conduct. But, when IC1-e's output swings in the positive direction, the output of the parallel inverters goes low, thus causing D3 and D4 to be forward-biased and conduct, turning on PNP transistor Q1. Transistors Q1 and Q3 drive output transistors Q2 and Q4.

With Q2 turned off, its collector voltage will be high. Since the collector of Q2 is tied to center-tapped transformer T1, a high will be across it too. (Remember the same action occurs alternately in the bottom half of the circuit with its output also applied to the primary of T1.) Transformer T1 is used to step up the output voltage from the circuit. The two diodes, D9 and D10, connected across the transformer's output leads form a full-wave rectifier. And capacitors C6 and C7 provide filtering for the rectified output-voltage.

Most of the components were mounted on a small perf-board, about 1½ × 2-1/2 inches. The vacuum-tube multivibrator and rectifier, along with their sockets, were removed from the set to make room for the new circuit. The output transistors, Q2 and Q4, were secured to the chassis using mica insulators and an aluminum heat-spreader plate. Also, ECG 377 transistors may be substituted for Q2 and Q4. Resistor R10 was put were some air could get to it. Also, keep in mind that some old systems require a positive ground. In that case, the hash-choke (L1) should be connected in the negative lead, as was done for the the positive, and tied to the ground point on T1's center-tapped primary. It should also be noted that L1 and T1 are part of the radio's original circuitry. Be sure to check the filter capacitors for shorts before powering up the circuit (sorry to say, we did not).—*Dave Maley*

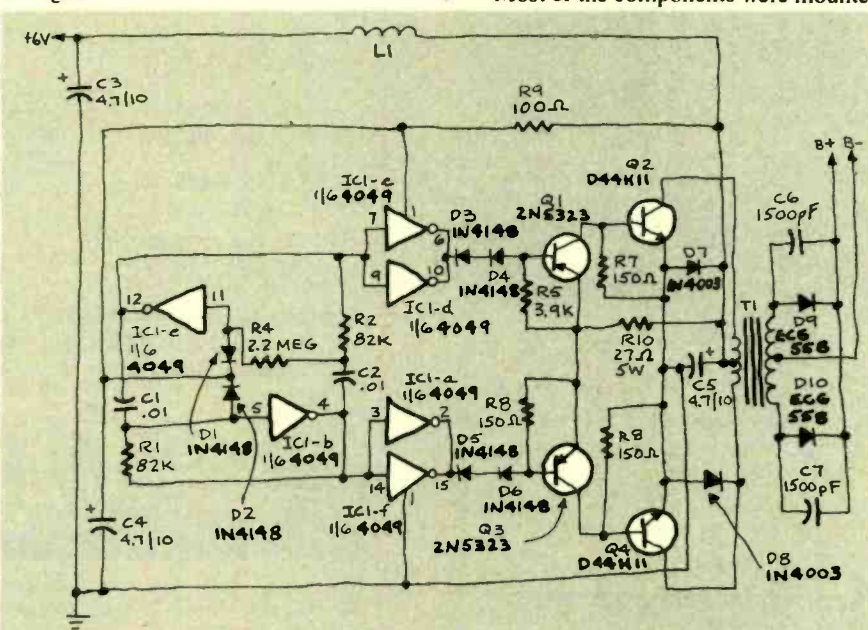


FIG. 1

NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn $25. In addition, for U.S. residents only, Panavise will donate their *model 333*—The Rapid Assembly Circuit Board Holder, having a retail price of $39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working.

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HOBBY CORNER

continued from page 73

1 Box 539, Central Hall, PA 16828). According to P.J., that device works extremely well.

You will notice that the *Winky Board*, like the *Data Dubber*, *AcuData*, etc., is machine-specific. In other words, they cannot be used to copy tapes of computers other than the ones for which they were specifically designed.

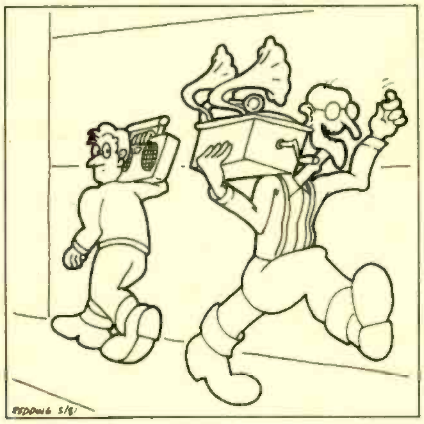
Those of us with little patience need a device that will work with all, or at least several different, types of computer tapes. Have any of you designed such a circuit, or know of such a versatile device?

Larger readouts

Bill Murks (TN) has a receiver with a digital readout, but his vision problem makes it difficult to read the numbers. He would like to add a readout with larger digits to the unit. Well, Bill, you already have all the circuitry needed for the readout, so your best bet is to replace the present one. And since I am not familiar with your receiver, I can do no more than point you in the right direction.

The first thing to do is to determine whether the present readouts are of the common-anode or common-cathode type. Since most display circuits have some "spare" driving capacity, larger digits of the same type should be direct replacements pin-for-pin, even if they do require a bit more current. To be on the safe side, however, you may want to use non-inverting hex drivers between the new digits and the counting circuits.

Here, your greatest problem is likely to be the larger physical size of the readout. A couple of mounting possibilities are: 1) Place the display outside the cabinet in front of the old readout; 2) Mount the readout in a small case and placed it beside or on top of the receiver. **R-E**



DESIGNER'S NOTEBOOK

Frequency multiplication

ROBERT GROSSBLATT

ONE OF THE BIGGEST ADVANTAGES THAT A digital approach to circuit problems has over more traditional analog solutions can be summed up in one word—precision. In fact, some of the stickiest problems that come up when dealing with analog circuitry have been just about eliminated, now that a handful of silicon shavings can replace acres of glass epoxy and miles of wiring.

Certainly the area where that has become most outrageously evident is in the whole field of frequency generation and division. At one time, super-precise frequencies could only be generated by using crystal oscillators, expensive hand-picked components, and then building elaborate divide-by networks with components that had names like 12AX7, 6AU6, and so on.

Of course, we're talking about techniques most commonly used by monks and we know about them through ancient hand-illuminated parchment scrolls. Seriously though, the whole idea of frequency-synthesis and division has undergone a major change with the development of the IC.

One of the first experiments that any newcomer to design encounters is building a simple circuit that can generate several frequencies by dividing down a master oscillator. Not only that, but the whole design can be accomplished using less than three IC's! And if you use a binary ripple-counter, like the 4060, you don't even need an external oscillator—it's built right onto the substrate and can be either an R-C type or crystal based. But enough beating around the bush.

The point here is that while everyone knows twelve-million ways to easily divide any frequency by any number, it's sometimes necessary to do exactly the the opposite. Multiplying a frequency with the same degree of precision that we can get with division is possible by using things like rate multipliers and some exotic special-purpose IC's. And if you have to multiply a frequency by some "oddball" number, special-purpose IC's are the way to go. But suppose your needs are really simple. Just as you can easily divide by two using nothing more exotic than a flip-flop, this month's handy-dandy circuit will multiply a frequency by two just as easily. You can take the same ideas even farther and multiply by four, eight, or whatever, by cascading.

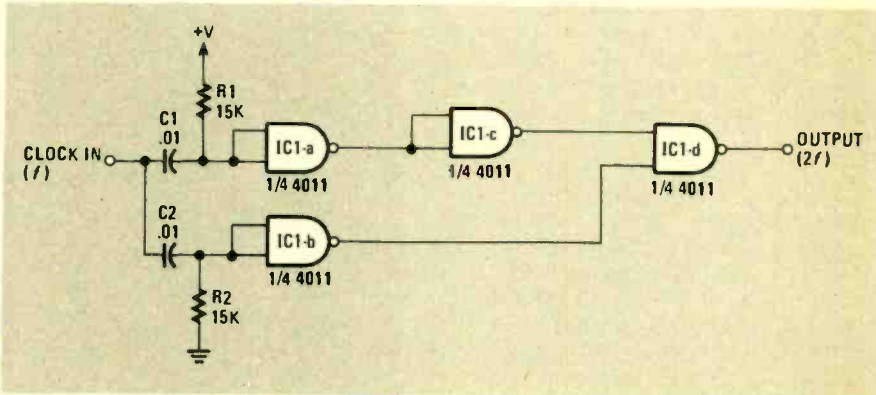


FIG. 1

How it works

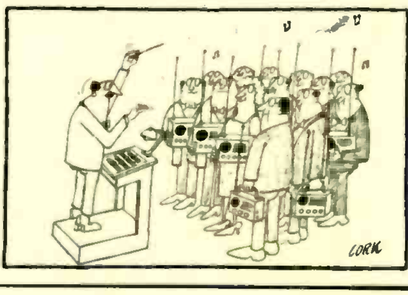
Figure 1 shows a circuit that can be used as a frequency multiplier. The operation of the circuit is so simple it doesn't require much of an explanation. The whole thing is made from a single quad two-input NAND gate! Two gates, IC1-a and IC1-b, are set up as inverters and their inputs are isolated from each other by two capacitors, C1 and C2. Resistors R1 and R2 hold the inverter inputs high and low respectively. Since IC1-c is on the line between IC1-a and IC1-d, both inputs to IC1-d will be high. As long as there's no signal at the clock input, the output of IC1-d is low.

When a clock pulse shows up at the input, the negative edge will charge capacitor C1 and thus change the output state of IC1-a. The output of that IC is then again inverted by IC1-c. As a result, a low is applied to one leg of IC1-d, causing it to output a high. All the IC's will stay in their present state until either the R-C network times-out or the input clock goes high.

When the input clock goes high, capacitor C2 will charge-up and force IC1-b to output a low on the other leg of IC1-d, forcing its output to go low again. The cycle will repeat over and over again, resulting in an output frequency that is exactly double that of the input clock. Just about the only thing to be careful of is to make sure that the R-C time-constant is well above the maximum frequency that you expect to put through the circuit. If the input frequency has a period that is shorter than the time constant of the R-C network, the circuit will hang up.

With the component values shown, you should be OK, provided that you don't apply a frequency to the input that is greater than 500 kHz. Also, be certain that the IC that you are using can handle double the input frequency, since IC1-d will be switching at twice the input frequency. It should also be noted, at this point, that the IC used in the circuit should be compatible with the circuitry that it is to feed. For example, if you are using 7400 series TTL's, use a TTL NAND gate such as the 7402; and as for circuits that contain CMOS or low-power Schottky devices, use a CMOS IC such as a 4011 or 74LS00 series TTL respectively.

You should be able to use the same technique to build circuits that will triple or even quadruple an input frequency. All that you need is more inverters and a final gate with the right number of inputs. There are other, even simpler methods to do the same thing. But the operation of this circuit is very reliable over a wide frequency range. R-E



TROUBLESHOOTING

continued from page 71

shut down the place. It has always been my custom when I have test equipment hooked up to a live set to shut the set first and the equipment last. This time, for no accountable reason, I turned off the scope first. The screen went white, I went limp. I thought I had blown one of the IC's.

But, wait! Turning the scope back on, I went to IC101—perfect signal. Back to TP12—this time it was not going to sabotage me—no signal. Back and forth I went, as though I wanted to savor every delectable moment over and over again. On one side of the coil, a signal; on the other side, none. Finally, when I felt that I had drained out of the moment as much as there was to be drained, I put a jumper across the coil, and there it was—a picture.

It had taken a tiny static discharge that was released when the scope switch was turned off to open the coil for good and get rid of one heck of a headache. **R-E**

SERVICE CLINIC

Electrostatics and electronics

JACK DARR, SERVICE EDITOR

THE HISTORY OF STATIC ELECTRICITY GOES back about 2500 years to ancient Greece. The theory is that someone rubbed a cat with an amber comb or rod, and found that (after rubbing) the comb attracted small lightweight particles such as lint or dust. That phenomenon was called *tribein*, meaning "to rub." Greek philosophers experimented with the force of attraction that amber had on lightweight objects. In fact, our word "electron" comes from "elektron," which was the Greek word for amber.

Since the discovery of the electrostatic phenomenon, many researchers have performed detailed scientific investigations into the property of attraction that many materials display after being rubbed. Among those who performed those experiments was Stephen Grey, an Englishman, who in the 1700's did a considerable amount of work in identifying conductive and nonconductive materials. Other scientists who experimented in this area include Benjamin Franklin, with whom we are all familiar; Alessandro Volta, for whom the volt was named; Charles Augustin De Coulomb, for whom the unit of electric charge was named, and many others.

MATERIALS

INCREASINGLY POSITIVE

AIR
HUMAN HANDS
ASBESTOS
RABBIT FUR
GLASS
MICA
HUMAN HAIR
NYLON
WOOL
FUR
LEAD
SILK
ALUMINUM
PAPER
COTTON
STEEL
WOOD
AMBER
SEALING WAX
HARD RUBBER
NICKEL COPPER
BRASS SILVER
GOLD PLATINUM
SULFUR
ACETATE RAYON
POLYESTER
CELLULOID
ORLON
SARAN
POLYURETHANE
POLYETHYLENE
POLYPROPYLENE
PVC (VINYL)
KEL-F (CTFE)
SILICON
TEFLON

INCREASINGLY NEGATIVE

FIG. 1

MEANS OF STATIC GENERATION	ELECTROSTATIC VOLTAGES	
	10 TO 20 PERCENT RELATIVE HUMIDITY	65 TO 90 PERCENT RELATIVE HUMIDITY
WALKING ACROSS CARPET	35,000	1,500
WALKING OVER VINYL FLOOR	12,000	250
WORKER AT BENCH	6,000	100
VINYL ENVELOPES FOR WORK INSTRUCTIONS	7,000	600
COMMON POLY BAG PICKED UP FROM BENCH	20,000	1,200
WORK CHAIR PADDED WITH POLYURETHANE FOAM	18,000	1,500

FIG. 2

Things went on in much the same way, with little progress being made in that area, until along came a group of dedicated researchers at the 3M Company. They did a complete run-down on the subject of electrostatic discharge (ESD).

ESD

What those researchers found was that a good many materials can develope static charges; those materials, called the *triboelectric series*, are shown in Fig. 1. That figure shows that cotton is the dividing point between the positive and negative. When any two materials in the triboelectric series are rubbed against each other, the materials above the horizontal line lose electrons and those below gain electrons. That transfer of electrons results in a net positive charge for those materials higher up in the series and a negative charge for materials lower in the series.

The level of static electricity generated is directly related to how closely the materials make contact; how rapidly they are separated; their distance from one another in the triboelectric series, and the relative humidity. Look at Fig. 2: It shows that just walking across a carpet while the humidity is low can generate up to 35,000 volts! Most humans cannot feel static electricity until it reaches a level of about 3000 volts.

The voltages generated during normal daily activities are stored on materials in much the same way that a capacitor stores a charge. And those voltages are discharged within 20 nanoseconds after they come çlose to or touch some other material with an unlike charge. That short discharge time causes several watts to be dissipated in a device: And that's not all, the peak current can reach up to 60 amperes! No mistake, we mean amperes! No wonder sensitive devices can arc over internally and be damaged.

The newer generation of semiconductors (such as MOS devices) are faster, more compact, but they are extremely sensitive to heavy static-charges. And when you consider that those devices use single-conductor gate electrodes about a micron wide, it is easy to see why they are so susceptible to ESD damage. For instance, VMOS IC's can be damaged by an electrostatic charge as low as 30 volts. How often have you purchased some static-sensitive device and put it in a circuit only to find that the project or equipment does not work. Very often circuit failure is caused by static charges transferred from the body to sensitive components during handling.

Several types of failure generally occur as a result of ESD. The first and most easily detected is complete component failure. The second and more serious problem is the degraded or intermittent component. Failures caused by ESD happen very quickly and in many cases protective diodes react too slowly to prevent damage.

Computerists are also plagued by ESD. They often find that after hours of punching in data, along comes an electrostatic surge that completely upsets the whole apple cart. For them, protective products such as *Zap Guard* (from Inmac, 2465 Augustine Drive, Santa Clara, CA 95051) have been introduced. That product is nothing more than a conductive mat that, when placed at a computer station, shunts electrostatic charges away from the computer and prevents possible problems from electrostatic discharge.

It was because of such occurrences that we had to find a way to avoid the damage caused by ESD, if only for the sake of not having to replace so many IC's—a job that nobody likes. Electrostatic discharges can be eliminated when the right precautions are taken.

ESD control

Some of the stock devices for the elimination of ESD in a manufacturing environment are really quite simple. One such device is a grounded wrist strap, which must always be worn by the technician while he is in the work area. In that way static charges built up during normal activities can drain off before any damage occurs.

Some other devices used to control ESD are conductive covers for the bench top and mats for the floor in front of the work station. Also, it might be a good idea to ground your bench chair: Note the last item in Fig. 2: "Work chair padded with polyurethane foam."

The problem of generating a static charge can be rendered harmless by running new strips of metal tape across the seat and down the sides to the legs. And then removing any rubber or plastic tips from the legs, so that the chair would be grounded to the conductive floor mat; or, if the chair legs are not metal, the strip can be attached to the mat itself. Let's look at some of the simple actions that generate electrostatic voltages.

Almost anything you do *can* cause a static charge to be developed. For instance, did you know that any relative movement resulting in a rubbing action will generate a static charge? An example of that would be walking, and not necessarily across a carpet. The rubbing of clothing against the body as you walk, or simply taking parts out of a PVC bag, or even picking up such a bag from a workbench can generate ESD!

Materials such as plastics, vinyls, and synthetics can generate charges of 60,000 volts or more because of their high insulating properties. Not only that, but they can also hold their charge for prolonged periods of time. It seems that everything's out to get us, so we have to be extremely careful.

We've mentioned some ESD protective devices, but they are not all that common. However, those items (grounded straps, protective mats, conductive bags, etc.) can be found at NARP CES (North American Philips Consumer Electronics Co., Parts Dept., PO Box 555, Jefferson City, TN 37760). With a few of those protective devices it should be much easier to keep from blowing up sensitive components and equipment. **R-E**

SERVICE QUESTIONS

RASTER PROBLEMS

This Motorola TS-915-D11 has me in circles. I have no raster. All cathode voltages on the kine are at B+, cutting off the tube. Collector voltages of the three video drivers measure .5 instead of 6 volts. The base of the ABL driver is at 30 volts when I turn the ABL adjust to maximum. It should be higher, but I can't figure out why it isn't.—R.L., Johnson City, TN

Although the diagram calls for 34 volts at the ABL driver base, I'm not sure that this is your problem. Still it is an odd circuit, for sure. The ABL adjust is part of a voltage divider that goes back to the screen controls and still further back to the focus control. Stuck in the middle somewhere, you have a 2.7-megohm and a 2.2-megohm resistor. If either of those resistors changes value, you're going to lose some of that voltage. There is DC coupling throughout from the ABL driver through the color outputs, so any off-voltage in that loop could be cutting off the kine. **R-E**

"In technical terms, this is what's known as computer upchuck."

POWER SUPPLY

continued from page 68

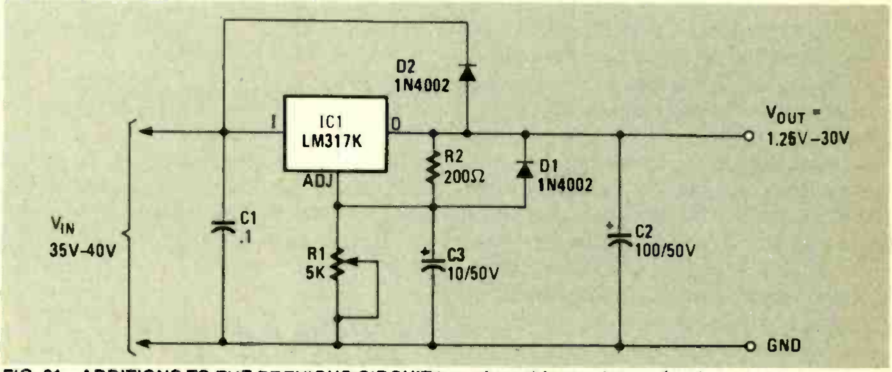


FIG. 21—ADDITIONS TO THE PREVIOUS CIRCUIT has given this regulator a low-impedance transient response and full input and output short-circuit protection.

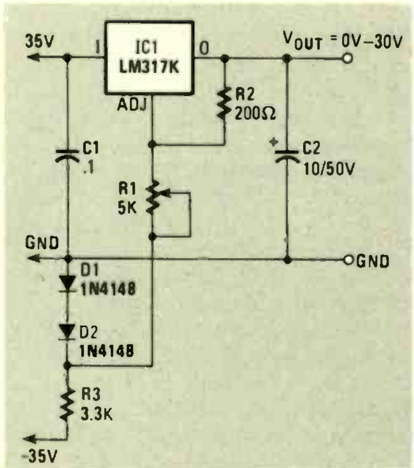


FIG. 22—THE OUTPUT OF THIS REGULATOR is fully variable from zero to 30 volts.

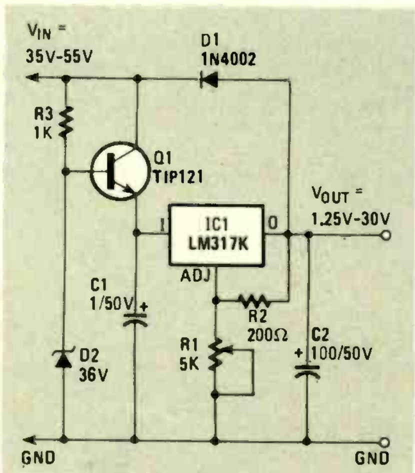


FIG. 23—A PRE-REGULATOR, Q1, is used to give input over-voltage protection and improved ripple rejection.

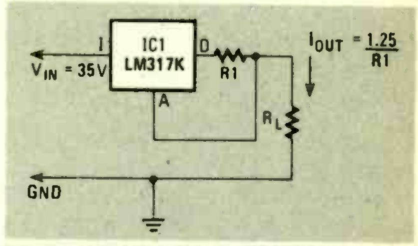


FIG. 24—THE 317K THREE-TERMINAL regulator can be used as a precision current limiter or constant-current generator.

The minimum output voltage of the circuits in Figs. 19–21 is 1.25 volts. If you want the voltage to vary all the way down to zero, the circuits must be configured so that the "adjust" terminal goes to −1.25 volts when R1 is reduced to zero ohms. Figure 22 shows how that can be achieved, using a 35-volt negative rail and a pair of series-connected diodes to clamp the low end of R1 to −1.25 volts.

If you want to get the maximum possible voltage out of one of the these regulators, you'll need to make sure that the input voltage does not exceed the 40-volt rating of the IC. The best way to do that is to use a simple Darlington-plus-Zener pre-regulator circuit, as shown in Fig. 23, which enables you to use any unregulated input in the range 35–55 volts. Note that as well as giving input overvoltage protection, that pre-regulator also gives a further improvement in ripple rejection. If you want to use this circuit with a 5-amp 338K regulator, you may need to reduce the value of R2 and beef up the power rating of the Zener diode.

Finally, to complete this look at regulator circuits, Fig. 24 shows how you can use the 317K as a precision current limiter or constant-current generator in which the output current is determined by R1 and is virtually independent of the external load values. By suitable choice of R1, the constant-current magnitude can be set at any value between approximately 10 mA (R1 = 120 Ω) and 1.25 A (R1 = 1 Ω). The performance is certainly not bad for a two-component circuit. **R-E**

PC BOARDS

continued from page 53

brings us to the next disadvantage—the stuff is very expensive. Still in all, you can't beat it for bridging small breaks in a trace and, to be fair about it, a ½ ounce bottle lasts a long time.

We're mentioning the next alternative only so we can tell you to avoid it. Don't ever leave the leg of a component extra long so you can bend it over to bridge a gap in the trace. You'll run into exactly the same horrors you do when you make a sloppy repair with a piece of wire. In this case, the jumper will only be supported by the board at one end. The other end of the component's leg will still be depend on the adhesion of the copper to the board for strength. As was pointed out before, that's a definite no-no.

You can also try to bridge small gaps in a trace with solder but that is too silly to discuss. What you'll be trying to do is create a solder bridge, and even if you manage to do that successfully, its strength will still depend on the bond between the copper and the board. That is really iffy and the chances are good that even trying to make a solder bridge will lift the copper off the board anyway. To make a long story short, don't ever do that—it creates more problems than it solves.

Changing the pattern

If you have to change the foil pattern because you've discovered that your layout was wrong, the techniques to use are the ones we've already discussed. After all, it's still just a matter of moving the copper around. There are, however, a few other things that should be mentioned.

If you want to change components, you have to remove them from the board without damaging the foil. The ease of removing a component is a direct function of the number of pins it has—the more there are, the harder it will be to remove. Unsocketed IC's are a write-off. There is absolutely no safe way to remove them from the board. If you're faced with that problem, leave the IC where it is and do a cut and paste operation with the traces connected to its pads. However difficult and distasteful that is, it's still better than trying to remove the IC safely.

After the component is removed from the board, the holes have to be cleaned out. Solder will always flow across the hole when the component is removed and it's suicide to try melting the solder and pushing the leg of the replacement part through the hole. The copper will *always* lift off the board. Clean the hole out by melting the solder and pushing a toothpick through the hole from the foil side as shown in Fig. 11. The solder won't stick to the wood and the hole will be nice and clean. You can get rid of the excess solder with a desoldering tool if you're rich or with left-over braided wire if you're not.

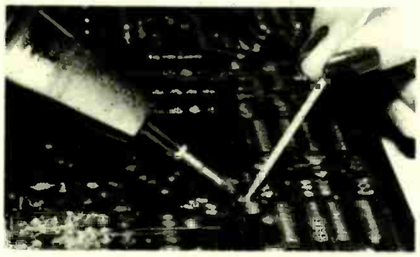


FIG. 11—AFTER A COMPONENT IS REMOVED, solder should be removed from the hole using a toothpick.

We've saved the most horrible sort of repair job for the end. What do you do if you're making a double-sided board and you discover that the two sides are out of register? Well, you cry a lot and bang your head against the wall. There's not much you can do about it—you only have one hope. If things aren't too far off, you can drill through the board at an angle to compensate. If your board is too far off for that, all we have to offer is our deepest sympathy. It's happened to us and if anyone knows a way to solve that problem, please let us know.

A successful repair to a printed-circuit board is any repair that does the job and doesn't affect the integrity of the board. You can use any or all of the techniques we've discussed and you probably know some that haven't been mentioned. The extra time it takes to make a safe, reliable repair is a small enough price to pay to keep acres of valuable silicon from going up in smoke. **R-E**

"It says we'd be in good shape financially if we hadn't bought a computer."

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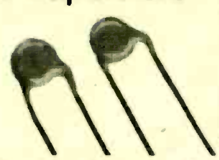

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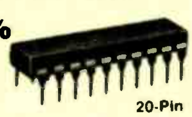

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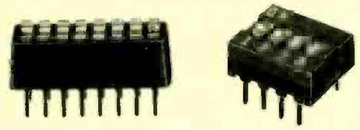

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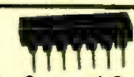

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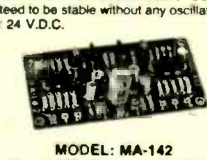

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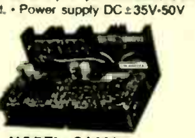

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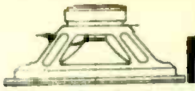

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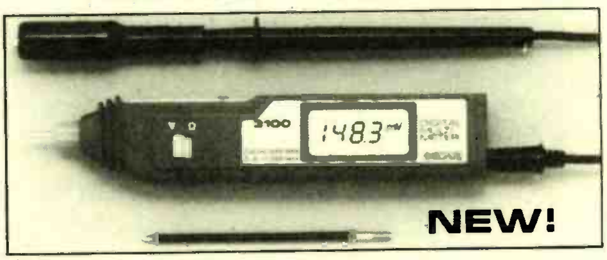

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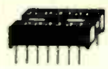

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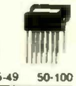

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74S04	.89	74S135	1.15	74S257	1.29
74S05	.52	74S136	1.69	74S258	1.29
74S08	.49	74S138	1.99	74S260	.75
74S09	.49	74S139	1.29	74S280	2.79
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74S11	.42	74S151	1.29	74S288	2.55
74S15	.42	74S153	1.29	74S373	3.10
74S20	.42	74S157	1.29	74S374	3.10
74S22	.42	74S158	1.29	74S387	2.75
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74S112	.72	74S242	2.99	74S940	2.90
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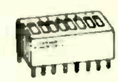

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7413	.29	7494	.69	74177	.69
7414	.49	7495	.50	74179	1.34
7416	Call	7496	.69	74180	.75
7417	Call	7497	2.90	74181	1.75
7420	.19	74100	2.90	74182	.75
7421	.35	74107	.24	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	1.19	74116	1.25		
7425	.29	74121	.29		
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.45	74191	1.15
7429	.45	74125	.39	74192	.75
7430	.18	74126	.44	74193	.75
7432	.29	74128	.59	74194	.75
7437	.25	74132	.45	74195	.68
7438	.29	74136	.75	74196	.75
7439	1.19			74197	.75
7440	.19	74141	.65	74198	1.29
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7442	.45	74143	4.50	74221	1.19
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7444	.65	74145	.59	74273	1.05
7445	.79	74147	1.69	74276	1.89
7446	.79	74148	1.19	74279	.75
7447	.65	74150	1.09	74283	1.40
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7451	.19	74153	.49	74290	.89
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7454	.19	74155	.69	74365	.65
7459	.25	74156	.78	74366	.65
7460	.23	74157	.49	74367	.65
7470	.29	74158	1.65	74368	.65
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74LS04	.69	74LS124	2.75	74LS251	1.40
74LS05	.25	74LS125	.69	74LS253	1.40
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74LS09	.25	74LS132	.59	74LS258	.98
74LS10	.25	74LS136	.49	74LS259	2.95
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74LS83	.59	74LS193	.98	74LS393	1.95
74LS85	.69	74LS194	1.15	74LS395	1.70
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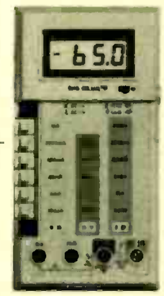

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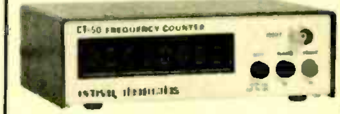

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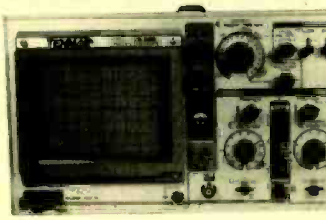

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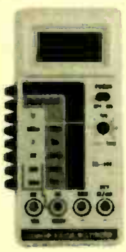

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HFE TEST
0.5" LCD display
DC input impedance 10MΩ
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.5A	5A
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1A	7A
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(NO MIXED QTYS.)
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521	10.98	531	10.45	538	9.84
522	9.50	532	12.40	539	9.84
523	7.75	533	9.90	549	14.55
526A	7.75	534	10.48	550	10.05
528	9.40	535	11.48	556	11.90
529	8.90	536A	13.85	557	11.75
				564	11.55

REPLACEMENT FOR ECG® TYPES

TYPE NO.	YOUR COST	TYPE NO.	YOUR COST
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102A	THREE for .99	159AP	FOUR for .99
123A	FIVE for .99	177	EIGHT for .99
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SUPER SPECIAL (MIN. 5 PC. EACH)

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128	.45	171	.65	506	.55
129	.45	184	.45	500A	8.95
130	.80	185	.45	523	9.95
152	.40	238	2.25	526A	10.20
153	.40	276	6.95	529	13.75
154	.60	291	.95	712	1.25

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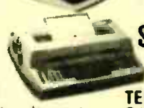

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7400

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SN7403N	14	.25
SN7404N	14	.25
SN7405N	14	.25
SN7406N	14	.45
SN7407N	14	.29
SN7408N	14	.25
SN7409N	14	.25
SN7410N	14	.25
SN7411N	14	.25
SN7412N	14	.49
SN7413N	14	.39
SN7414N	14	.49
SN7416N	14	.25
SN7417N	14	.25
SN7420N	14	.19
SN7421N	14	.49
SN7422N	14	.49
SN7423N	16	.59
SN7425N	14	.29
SN7426N	14	.29
SN7427N	14	.25
SN7428N	14	.59
SN7430N	14	.25
SN7432N	14	.29
SN7437N	14	.25
SN7438N	14	.29
SN7439N	14	.59
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	1.25
SN7444N	16	1.25
SN7445N	16	.69
SN7446N	16	.69
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SN7448N	16	.69
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SN7479N	14	4.95
SN7480N	14	.89
SN7482N	14	1.49
SN7483N	16	.59
SN7485N	16	.59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.79
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.89
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	3.25
SN74100N	24	1.95
SN74104N	14	1.19
SN74105N	14	1.19
SN74107N	14	.29
SN74109N	16	.39
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.69
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.45
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.89
SN74142N	16	3.95
SN74143N	24	3.95
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SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
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SN74157N	16	.59
SN74160N	16	.69
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SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.69
SN74167N	16	2.95
SN74170N	16	1.79
SN74172N	24	4.95
SN74173N	16	.69
SN74174N	16	.69
SN74175N	16	.69
SN74176N	14	.69
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SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.69
SN74196N	14	.89
SN74197N	14	.89
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	14	2.49
SN74279N	16	.79
SN74283N	16	1.49
SN74284N	16	2.95
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SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

74LS

74LS00	14	.25
74LS01	14	.25
74LS02	14	.29
74LS03	14	.25
74LS04	14	.35
74LS05	14	.29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	14	.29
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.39
74LS33	14	.55
74LS37	14	.35
74LS38	14	.35
74LS40	14	.29
74LS42	16	.55
74LS47	16	.75
74LS48	16	.75
74LS49	14	.75
74LS51	14	.25
74LS54	14	.25
74LS55	14	.29
74LS73	14	.39
74LS74	14	.49
74LS75	16	.39
74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
74LS85	16	.89
74LS86	14	.39
74LS90	14	.55

74LS92	14	.55
74LS93	14	.55
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.39
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.89
74LS125	14	.59
74LS126	14	.49
74LS132	14	.59
74LS133	16	.59
74LS136	14	.39
74LS138	16	.89
74LS139	16	.79
74LS151	16	.59
74LS153	16	.59
74LS154	24	1.29
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.69
74LS175	16	.69
74LS181	24	2.95
74LS190	16	.89
74LS191	16	.89

74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.49
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
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74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.89
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.49
74LS374	20	1.49
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
81LS95	20	1.49
81LS97	20	1.49

74S/PROMS*

74S00	14	.35
74S02	14	.35
74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S85	16	2.49
74S86	14	.55
74S112	16	.55
74S113	14	.55

74S114	14	.55
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	16	.85
74S140	14	.55
74S151	16	.99
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74S175	16	1.19
74S188*	16	1.49
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74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49

74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
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CA3083N	16	1.49
CA3086N	14	.69
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CD4012	14	.29
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CD4014	16	1.19
CD4015	16	.39
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CD4017	16	1.19
CD4018	16	.99
CD4019	16	.59
CD4020	16	1.19
CD4021	16	1.19
CD4022	16	1.19
CD4023	14	.29
CD4024	14	.69
CD4025	14	.23
CD4026	16	2.49
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CD4047	14	1.29
CD4048	16	.59
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CD4060	16	1.49
CD4066	14	.59
CD4068	14	.39
CD4069	14	.29
CD4070	14	.39
CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
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CD4078	14	.49
CD4081	14	.29
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CD4512	16	1.19
CD4514	24	2.49
CD4515	24	2.49
CD4516	16	1.19
CD4518	16	1.19
CD4519	16	.59
CD4520	16	1.19
CD4526	16	1.49
CD4528	16	1.49
CD4529	16	1.69
CD4543	16	1.95
CD4562	14	6.95
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Z80A-SIO/1	40	Serial I/O (Lacks DTRB)	12.95
Z80A-SIO/2	40	Serial I/O (Lacks SYNCB)	12.95
Z80A-SIO/9	40	Serial I/O	12.95
Z80B	40	CPU (MK3880N-6) 6MHz	9.95
Z80B-CTC	28	Counter Timer Circuit	12.95
Z80B-DART	40	Dual Asynch. Receiver/Transmitter	19.95
Z80B-PIO	40	Parallel I/O Interface Controller	12.95
Z8001	48	CPU Segmented	44.95
Z8002	40	CPU Non-Segmented	34.95
Z8030	40	Serial Comm. Controller	44.95
Z8036	40	Counter/Timer & Parallel I/O Unit	29.95

6500/6800/68000 SERIES

MC6502A	40	MPU with clock and RAM (2MHz)	6.95
MC6520	40	Peripheral Inter. Adapter	4.95
MC6800	40	MPU	2.95
MC6802CP	40	MPU with clock and RAM	7.95
MC6809E	40	CPU (1MHz) External (Locking)	14.95
MC6821	40	Peripheral Inter. Adapt (MC6820)	2.95
MC6828	24	Priority Interrupt Controller	15.95
MC6830L8	24	1024x8-bit ROM (MC68A30-8)	9.95
MC6850	24	Asynchronous Comm. Adapter	3.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	7.95
MC68000L8	64	MPU 16-Bit (8MHz)	49.95
MC68488P	40	General Purpose Inf. Adapter	9.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661PB	28	Enhanced Prog. Comm. Inf.	9.95
MCM68764	24	64K EPROM (450ns)	24.95
SY6522	40	Peripheral Inter. Adapter	7.95

8080A SERIES

TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8080A	40	CPU	2.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
8156	40	RAM with I/O Port and Timer	6.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	2.95
DP8216	16	Bi-Directional Bus Driver	1.95
DP8224	16	Clock Generator/Driver	2.25
DP8226	16	Bus Driver	2.25
DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	3.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	5.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	8.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.95
DP8307	20	8-bit Bi-Directional Receiver	2.95
DP8308	20	8-bit Bi-Directional Receiver	2.95
DP8310	20	Octal Latched Peripheral Driver	4.95
8741	40	8-bit Univ. Peripheral Interface	29.95
8755	40	16K EPROM with I/O	24.95

DISK CONTROLLERS

INS1771-1	40	Single Density	16.95
FD1791	40	Single/Dual Density (Inv.)	29.95
FD1793	40	Single/Double Density (True)	29.95
FD1795	40	Dual Density/Side Select (Inv.)	29.95
FD1797	40	Dual Density/Side Select True	29.95

SPECIAL FUNCTION

DS0025CN	8	Dual MOS Clock Driver (5MZ)	2.49
DS0026CN	8	Dual MOS Clock Driver (5MZ)	1.95
INS2651	28	Communication Chip	8.95
MC3470P	18	Floppy Disk Read Amp System	4.95
MM58167AN	24	Microprocessor Real Time Clock	8.95
MM58174AN	16	Micro. Compatible Time Clock	7.95
COP402N	40	Microcontroller w/64-digit RAM and Direct LED Drive	5.95
COP402MN	40	Microprocessor w/64-digit RAM & Direct LED Drive w/N Buss Int.	5.95
COP470N	20	32-seg VAC Fluor. Drvr (20-pin pkg.)	3.25
MM5369AA/N	8	Prog. Oscillator/Divider (60Hz)	1.79
MM5369EST	8	Prog. Oscillator/Divider (100Hz)	1.95

DYNAMIC RAMS

Part No.	**Pins			Price
1103	18	1024x1	(300ns)	.99
4027	16	4096x1	(250ns)	2.49
4116N-2	16	16,384x1	(150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1	(200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1	(250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1	(150ns)	6.95 - 8/49.95
4164N-200	16	65,536x1	(200ns)	5.95 - 8/44.95
MM5261	18	1024x1	(300ns)	.49 - 8/1.95
MM5262	22	2048x1	(365ns)	.10
MM5270	18	4096x1	(250ns) MK4096	4.95
MM5280	22	4096x1	(200ns) 2107	3.95
MM5290-2	16	16,384x1	(150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1	(200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1	(250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1	(200ns)	1.69

STATIC RAMS

1101	16	256x1	(650ns)	1.49
2101	22	256x4	(450ns) 8101	2.49
2102	16	1024x1	(350ns)	.89
21L02	16	1024x1	(450ns) L.P.	1.49
2111	18	256x4	(450ns) 8111	2.95
2112	16	256x4	(450ns) MOS	1.95
2114	18	1024x4	(450ns)	1.49 - 8/9.95
2114L	18	1024x4	(450ns) L.P.	1.95 - 8/13.95
2114-2	18	1024x4	(200ns)	1.75 - 8/11.95
2114L-2	18	1024x4	(200ns) L.P.	2.25 - 8/14.95
2147	18	4096x1	(70ns)	4.95
2148	18	1024x4	(70ns)	4.95
TMS4045	18	1024x4	(450ns)	3.95
TMS40L47-45	20	1024x4	(450ns)	2.95
5101	22	256x4	(450ns) CMOS	2.95
MM5257	18	4096x1	(450ns) 4044	4.95
HM6116P-3	24	2048x8	(150ns) CMOS	5.95
HM6116P-4	24	2048x8	(200ns) CMOS	4.95
HM6116LP-4	24	2048x8	(200ns) L.P. CMOS	5.49
HM6264P-15	28	8192x8	(150ns) CMOS	39.95
27LS00	16	256x1	(80ns) L.P.	9.95
7489	16	16x4	(50ns) 3101	2.25
74C920	22	256x4	(250ns)	3.95
74C921	18	256x4	(250ns) CMOS	3.95
74C929	16	1024x1	(250ns) CMOS (6501)	3.95
74C930	18	1024x1	(250ns) CMOS (6518)	3.95
74S189	16	16x4	(35ns) 93405	1.95
74S200	16	256x1	(80ns) 93410	3.95
74S206	16	256x1	(60ns) 93411	3.95
74S289	16	16x4	(35ns) 3101	2.25
82S10	16	1024x1	(50ns) O.C. (93415)	3.95
82S25	16	16x4	(50ns) O.C. (74S289)	2.25

PROMS/EPROMS

1702A	24	256x8	(1us)	4.95
2708	24	1024x8	(450ns)	3.95
2708-5	24	1024x8	(550ns) SM00248	2.95
TMS2516	24	2048x8	(450ns) 2716	5.95
TMS2532	24	4096x8	(450ns) NMC2532	6.95
TMS2564	28	8192x8	(450ns)	14.95
TMS2716	24	2048x8	(450ns) 3 voltage	9.95
2716	24	2048x8	(450ns)	4.95
2716-1	24	2048x8	(350ns)	5.95
27160-5	24	2048x8	(550ns)	4.49
2732	24	4096x8	(450ns)	6.95
2732A-3	24	4096x8	(300ns)	7.95
2732A-4	24	4096x8	(450ns) 21V	6.95
27320-4	24	4096x8	(550ns)	5.95
27580-A	24	1024x8	(450ns)	2.95
2764-4	28	8192x8	(450ns)	9.95
2764-3	28	8192x8	(300ns)	14.95
MM5204Q	24	512x8 (1us)		4.95
MCM68764	24	8192x8	(450ns)	24.95
27128	28	16,384x8	(450ns) 128K EPROM	59.95
74S188	16	32x8	PROM O.C. (6330-1)	1.49
74S287	16	256x4	PROM T.S. (6301-1)	1.95
74S288	16	32x8	PROM T.S. (6331-1)	1.95
74S387	16	256x4	PROM O.C. (6300-1)	1.95
74S471	20	256x8	PROM T.S. (6309-1)	5.95
74S472	20	512x8	PROM T.S. (6349-1)	4.95
74S473	20	512x8	PROM O.C. (6348)	4.95
74S474	24	512x8	PROM T.S. (DM87S296N)	4.95
74S475	24	512x8	PROM O.C. (6340)	4.95
74S476	18	1024x4	PROM T.S.	6.95
74S478	24	1024x8	PROM T.S.	8.95
74S570	16	512x4	PROM O.C. (6305)	2.95
74S571	16	512x4	PROM T.S. (6306)	2.95
74S572	18	1024x4	PROM O.C. (6352)	4.95
74S573	18	1024x4	PROM T.S. (82S137)	4.95
82S23	16	32x8	PROM O.C. (27S18)	2.95
82S115	24	512x8	PROM T.S. (27S15)	9.95
82S123	16	32x8	PROM T.S. (27S19)	2.95
82S126	16	256x4	PROM O.C. (27S20)	2.95
82S129	16	256x4	PROM T.S. (27S21)	2.95
82S130	16	512x4	PROM O.C. (27S12)	3.95
82S185	18	2048x4	PROM T.S. (TBP24S81)	9.95
82S190	24	2048x8	(80ns)	14.95
82S191	24	2048x8	(80ns)	14.95
DM87S180N	24	1024x8	PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8	PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4	PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4	PROM T.S. (82S185)	9.95
DM87S190N	24	2048x4	PROM O.C. (82S190)	14.95
DM87S191N	24	2048x8	PROM T.S. (82S191)	14.95

DATA ACQUISITION

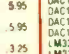
DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0807LCN)	1.49
MC1408L8	16	8-bit D/A Converter (DAC0808LCN)	2.25
ADC0803LCN	20	8-bit A/D Converter (±1/2LSB)	4.95
ADC0804	20	8-bit A/D Converter (1LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
ADC0817	40	8-bit A/D Converter (16-Ch. Multi.)	9.95
DAC1000	24	10-bit D/A Conv. Micro. Comp. (0.05%)	7.95
DAC1008	20	10-bit D/A Conv. Micro. Comp. (0.20%)	6.95
DAC1020	16	10-bit D/A Conv. (0.05% Lin.)	7.95
DAC1022	16	10-bit D/A Conv. (0.20% Lin.)	5.95
DAC1222	18	12-bit D/A Conv. (0.20% Lin.)	8.95
LM334Z		Constant Current Source	1.19
LM335Z		Temperature Transducer	1.40
LM399H		Temp. Comp. Prec. Ref. (.5ppm/C°)	5.00
AY-5-1013A	40	30K Baud Uart (TR1602)	3.95

LOW PROFILE (TIN) SOCKETS

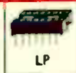
	1-9	10-99	100-up
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.46	.42	.39
40 pin LP	.49	.46	.43

SOLDERTAIL (GOLD) STANDARD

	1-9	10-99	100-up
8 pin SG	.30	.27	.25
14 pin SG	.43	.39	.37
16 pin SG	.47	.43	.41
18 pin SG	.53	.49	.47
24 pin SG	.69	.65	.61
28 pin SG	.81	.76	.72
36 pin SG	1.09	1.03	.97
40 pin SG	1.21	1.14	1.08



LP



SG

ST

WW

SOLDERTAIL STANDARD (TIN)

	1-9	10-99	100-up
14 pin ST	.29	.27	.25
16 pin ST	.34	.32	.30
18 pin ST	.38	.36	.34
20 pin ST	.45	.43	.41
24 pin ST	.49	.46	.43
28 pin ST	.69	.67	.63
40 pin ST	.99	.95	.89

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-9	10-99	100-up
8 pin WW	.49	.45	.42
10 pin WW	.65	.62	.58
14 pin WW	.65	.62	.59
16 pin WW	.69	.65	.61
18 pin WW	.89	.85	.79
20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.29	1.23	1.18
28 pin WW	1.59	1.50	1.45
36 pin WW	1.85	1.75	1.69
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The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences. The "voice" output of the DT1050 is a highly intelligible male voice. Female and children's voices can be synthesized. The vocabulary is chosen so that it is applicable to many products and markets.

The DT1050 consists of a Speech Processor Chip, MM54104 (40-pin) and two (2) Speech ROMs MM52164SSR1 and MM52164SSR2 (24-pin) along with a Master Word list and a recommended schematic diagram on the application sheet.

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Part No. DT1057 .... $24.95 ea.

INTERSIL

* Evaluation Kits

Part No.	**Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	9.95
FE0203D		3½ Digit LCD Display for 7106 & 7116	19.95
7106EV/Kit*	40	IC, Circuit Board, Display	34.95
7107CPL	40	3½ Digit A/D (LED Drive)	11.95
7107EV/Kit*	40	IC, Circuit Board, Display	29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD.	16.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	24	Stopwatch Chip, XTL	14.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL	7.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL	14.95
7216AIJI	28	8 Digit Univ. Counter C.A.	29.95
7216DIPI	28	8 Digit Freq. Counter C.C.	19.95
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	11.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL	74.95

30009 1983 INTERSIL Data Book (1356p.) $9.95

NEW PRODUCT! 74HC High Speed CMOS

74HC00	14	.59
74HC00	14	.59
74HC02	14	.59
74HC03	14	.75
74HC04	14	.59
74HCU04	14	.65
74HC08	14	.59
74HC10	14	.59
74HC11	14	.59
74HC14	14	.85
74HC20	14	.59
74HC27	14	.59
74HC30	14	.89
74HC32	14	.75
74HC42	16	.99
74HC51	14	.75
74HC58	14	.75
74HC73	14	.79
74HC74	14	.79
74HC75	16	.89
74HC76	16	.79
74HC85	16	1.59
74HC86	14	.69
74HC107	14	.59
74HC109	16	.79
74HC112	16	.79
74HC113	14	.79
74HC132	14	.99
74HC137	16	1.95
74HC138	16	1.09

74HC139	16	.99
74HC147	16	1.19
74HC151	16	.89
74HC153	16	.99
74HC154	24	2.49
74HC157	16	.89
74HC158	16	.89
74HC160	16	1.29
74HC161	16	1.29
74HC162	16	1.29
74HC163	16	1.29
74HC164	14	1.29
74HC165	16	2.79
74HC173	16	1.69
74HC174	16	.99
74HC175	16	.99
74HC192	16	1.39
74HC193	16	1.39
74HC194	16	1.09
74HC195	16	1.09
74HC237	16	2.95
74HC240	20	1.95
74HC241	20	1.95
74HC242	14	1.95
74HC243	14	1.95
74HC244	20	1.95
74HC245	20	2.49
74HC251	16	.89
74HC253	16	.99

74HC257	16	.89
74HC259	16	1.49
74HC266	14	1.19
74HC273	20	2.89
74HC280	14	3.95
74HC299	20	4.95
74HC366	16	2.39
74HC367	16	2.39
74HC373	20	2.39
74HC374	20	2.39
74HC390	16	1.49
74HC393	14	1.49
74HC533	20	2.39
74HC534	20	2.39
74HC595	16	3.95
74HC688	20	3.19
74HC4002	14	.59
74HC4017	16	2.19
74HC4020	16	1.39
74HC4024	14	1.59
74HC4040	16	1.39
74HC4060	16	1.39
74HC4075	14	.59
74HC4078	14	.69
74HC4511	16	2.69
74HC4514	24	3.79
74HC4538	16	2.39
74HC4543	16	3.49

74HCU04 is unbuffered. All others are buffered.

74C—C/MOS

74C00	14	.35
74C02	14	.35
74C04	14	.29
74C08	14	.35
74C10	14	.35
74C14	14	.69
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19

74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	1.19
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39

74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.69
80C97	16	.69

LINEAR

TL071CP	8	.79
TL072CP	8	1.39
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.35
LM302H		1.95
LM304H		1.95
LM305H		.99
LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
LM309H		1.95
LM310CN	8	1.75
LM311CN	8	.69
LM312H		2.49
LM317T		1.19
LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320K-24		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
LM320T-24		.89
LM322N	14	1.65
LM323K		5.95
LM324N	14	.59
LM329DZ		.65
LM331N	8	3.95
LM334Z		1.19
LM335Z		1.40
LM336Z		1.19
LM337MP		1.15
LM337T		1.95
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340K-24		1.35
LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
LM340T-24		.79
LM341P-5		.75
LM341P-12		.75

LM341P-15		.75
LM342P-5		.69
LM342P-12		.69
LM342P-15		.69
LF347N	14	1.49
LM348N	14	.99
LM350K		4.95
LF351N	8	.60
LF353N	8	1.00
LF355N	8	1.10
LF356N	8	1.10
LM358N	8	.69
LM359N	14	1.79
LM370N	14	4.49
LM373N	14	3.95
LM377N	14	1.95
LM380CN	8	1.10
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.39
LM384N	14	1.79
LM386N-3	8	.89
LM387N	8	.89
LM389N	16	1.19
LM391N-80	16	1.19
LM392N	8	.69
LM398N	8	3.95
LM399H		5.00
TL494CN	16	3.95
TL496CP	8	1.19
NE531V	8	2.95
NE544N	14	2.95
NE550A	14	1.95
NE555V	8	.35
XR-L555	8	.59
LM556N	14	.69
NE564N	16	2.95
LM565N	14	1.19
LM566CN	8	1.49
LM567V	8	.99
NE570N	16	3.95
NE571N	16	2.95
LM703CN	8	1.19
LM709N	14	.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.55
LM733N	14	1.00

LM739N	14	1.95
LM741CN	8	.35
LM747N	14	.69
LM748N	8	.59
LM1310N	14	1.49
MC1330A1	8	1.95
MC1349	8	1.79
MC1350	8	1.49
MC1358	14	1.95
LM1456V	8	1.95
LM1458CN	8	.59
LM1488N	14	.89
LM1489N	14	.89
LM1496N	14	1.95
LH1605CK		9.95
LM1800N	18	2.49
LM1871N	18	2.95
LM1872N	18	3.25
LM1877N-9	14	2.49
LM1889N	18	2.25
LM1896N	14	2.95
LM2002T		1.95
ULN2003A	16	.89
XR2206	16	3.95
XR2207	14	2.95
XR2208	16	2.49
XR2211	14	3.95
LM2877P		1.95
LM2878P		2.95
LM2901N	14	.59
LM2902N	14	.89
LM2907N	14	2.49
LM3189N	16	1.59
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.99
LM3914N	18	2.95
LM3915N	18	2.95
LM3916N	18	2.95
RC4136N	14	1.25
RC4151NB	8	1.95
RC4194TK		4.49
LM4250CN	8	1.29
LM4500A	16	1.95
NE5532	8	2.49
NE5534	8	1.69
ICL8038B	14	3.95
LM13080N	8	1.19
LM13600N	16	1.19
76477	28	3.95

MORE AVAILABLE

30003 1982 Nat. Linear Data Book (1952 pgs.) . $11.95

CIRCLE 41 ON FREE INFORMATION CARD

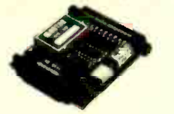
HOME COMPUTER ACCESSORIES

KEYBOARDS

4-Digit Fluorescent Alarm Clock Kit

RS232 ADAPTER FOR VIC-20 AND COMMODORE 64

New! New!



The JE232CM allows connection of standard RS232 printers, modems, etc. to your VIC-20 and C-64. A 4-pole switch allows the inversion of the 4 control lines. Complete installation and operation instructions included.
• Plugs into User Port • Provides Standard RS232 signal levels • Uses 6 signals (Transmit, Receive, Clear to Send, Request to Send, Data Terminal Ready, Data Set Ready).

JE232CM $39.95

VOICE SYNTHESIZER FOR APPLE AND COMMODORE

NEW!

JE520AP

JE520CM

• **Over 250 word vocabulary • affixes allow the formation of more than 500 words • Built-in amplifier, speaker, volume control, and audio jack • Recreates a clear, natural male voice • Plug-in user ready with documentation and sample software • Case size: 7¼"L x 3¼"W x 1-3/8"H**

APPLICATIONS: • Security Warning • Telecommunication • Teaching • Handicap Aid • Instrumentation • Games

The JE520 VOICE SYNTHESIZER will plug right into your computer and allow you to enhance almost any application. Utilizing National Semiconductor's DIGITALKER™ Speech Processor IC (with four custom memory chips), the JE520 compresses natural speech into digital memory, including the original inflections and emphases. The result is an extremely clear, natural vocalization.

Part No.	Description	Price
JE520CM	For Commodore 64 & VIC-20	$114.95
JE520AP	For Apple II, II+, and IIe	$149.95

JE664 EPROM PROGRAMMER

8K to 64K EPROMS — 24 & 28 Pin Packages

Completely Self-Contained — Requires No Additional Systems for Operation

• Programs and validates EPROMs • Checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer interface for editing and program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, less than 10W power consumption • Enclosure: Color-coordinated, light tan panels with molded end pieces in mocha brown • Size: 15⅝"L x 8¾"D x 3½"H • Weight 5¾ lbs

The JE664 EPROM Programmer emulates and programs various 8-Bit Word EPROMs from 8K to 64K-Bit memory capacity. Data can be entered into the JE664's internal 8K x 8-Bit RAM in three ways: (1) from a ROM or EPROM, (2) from an external computer via the optional JE665 RS232C BUS, (3) from its panel keyboard. The JE664's RAMs may be accessed for emulation purposes from the panel's test socket to an external microprocessor. In programming and emulation, the JE664 allows for examination, change and validation of program content. The JE664's RAMs can be programmed quickly to all "1"s (or any value), allowing unused addresses in the EPROM to be programmed later without necessity of "UV" erasing. The JE664 displays DATA and ADDRESS in convenient hexadecimal (alphanumeric) format. A "DISPLAY EPROM DATA" button changes the DATA readout from RAM word to EPROM word and is displayed in both hexadecimal and binary code. The front panel features a convenient operating guide. The JE664 Programmer includes one JM16A Jumper Module (as listed below).

JE664-A EPROM Programmer. $995.00
Assembled & Tested (Includes JM16A Module)

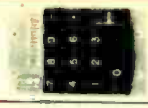
JE665 — RS232C INTERFACE OPTION — The RS232C Interface Option implements computer access to the JE664's RAM. This allows the computer to manipulate, store and transfer EPROM data to and from the JE664. A sample program listing is supplied in MBASIC for CP/M computers. Documentation is provided to adapt the software to other computers with an RS232 port. 9600 Baud, 8-bit word, odd parity and 2 stop bits.

FOR A LIMITED TIME A SAMPLE OF SOFTWARE WRITTEN IN BASIC FOR THE TRS-80* MODEL I, LEVEL II COMPUTER WILL ALSO BE PROVIDED

JE664-ARS EPROM Prog. w/JE665 Option. $1195.00
Assembled & Tested (Includes JM16A Module)

EPROM JUMPER MODULES — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets the JE664 for the proper programming pulses to the EPROM and configures the EPROM socket connections for that particular EPROM.

JE664 EPROM Jumper Mod. No.	EPROM	Programming Voltage	EPROM MANUFACTURER	PRICE
JM08A	2708	25V	AMD, Motorola, NAT, Intel, TI	$14.95
JM16A	2716, TMS2516 (TI)	25V	Intel, Motorola, NAT, NEC, TI, AMD, Hitachi, Mostek	$14.95
JM16B	TMS2716 (3 V's)	-5V, +5V, +12V	Motorola, TI	$14.95
JM32A	TMS2532	25V	Motorola, TI, Hitachi, OKI	$14.95
JM32B	2732	25V	AMD, Fujitsu, NEC, Hitachi, Intel, Mitsubishi, National	$14.95
JM32C	2732A	21V	Fujitsu, Intel	$14.95
JM64A	MCM68764 MCM68L764	21V	Motorola	$14.95
JM64B	2764	21V	Intel, Fairchild, OKI	$14.95
JM64C	TMS2564	25V	TI	$14.95



HI-TEK 14-KEY NUMERIC KEYPAD

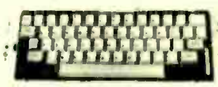
• Great keypad for many home and business computer applications • SPST switching • Mounted on P.C. board • Size 5"L x 3"W x 1⅛"H • Color: Grey • Weight: 1 lb. • Spec available

K-14 . . . . $9.95

MICRO SWITCH ASCII Encoded Keyboards

• **Large selection of keyboards** • Hall effect switching • Some have parallel interfaces • Some have serial interfaces • All have status LEDs and a minimum of 68 keys • Some with numeric keypad capabilities, cursor controls, or both • Styles may vary • Weight: 2 lbs. • No specs available

KB-MISC $9.95



13⅛"L x 4⅛"W x ¾"H

Mitsumi 54-Key Unencoded Matrix All-Purpose Keyboard

• SPST keyswitches • 20 pin ribbon cable connection • Low Profile keys • Features: cursor controls, control, caps (lock), function, enter and shift keys • Color (keycaps): grey • Wt.: 1 lb. • Pinout included

KB54. . . . . $14.95

New!

16-9/16"L x 6⅝"W x 1⅝"H

76-Key Serial ASCII Keyboard

• Simple serial interface • SPST mechanical switching • Operates in upper and lower case • Five user function keys: F1-F5 • Six finger edge card connection • Color (keys): tan • Weight: 2 lbs. • Data incl.

KB76. . . . . $29.95

Nationally Known Manufacturer!

21⅛"L x 9.8"W x 3⅛"H

106-KEY 8-BIT SERIAL ASCII KEYBOARD

• The terminals were designed to be daisy chained around a central host computer and used as individual work stations • Hall effect switching • numeric and cursor keypad • 10 user definable keys • 50" interface cable with 9-pin sub-miniature connector • 7 LED function displays • Security lock • N-key rollover • Automatic key repeat function • Color: (case) white w/black panel—(key caps): grey and blue • Weight: 6½ lbs. • Data included.

KB139 . . . . $59.95

New!

14⅛"L x 5½"W x 1½"H

68-Key Keyboard with Numeric Keypad for Apple II and II+

• Plugs directly into Apple II or II+ motherboard with 16-pin ribbon cable connector • 26 special functions • Color (keys): white/grey • Weight: 2 lbs.

KB-A68. . . . . $99.95

POWER SUPPLIES

TRANSACTION TECHNOLOGY, INC. 5VDC @ 1 AMP Regulated Power Supply

• Output: +5VDC @ 1.0 amp (also +30VDC regulated) • Input: 115VAC, 60 Hz • Two-tone (black/beige) self-enclosed case • 6 foot, 3-conductor black power cord • Size: 6½"L x 7"W x 2¾"H • Weight: 3 lbs.

PS51194 . . . . $14.95

Power/Mate Corp. REGULATED POWER SUPPLY

• Input: 105-125/210-250 VAC at 47-63 Hz • Line regulation: ±0.05% • Three mounting surfaces • Overvoltage protection • UL recognized • CSA certified

Part No.	Output	Size	Weight	Price
EMA5/6B	5V@3A/6V@2.5A	4⅞"L x 4"W x 2⅝"H	2 lbs.	$29.95
EMA5/6C	5V@6A/6V@5A	5⅝"L x 4⅞"W x 2⅝"H	4 lbs.	$39.95

New!

ASTEC SWITCHING REGULATED POWER SUPPLY

• **Apple III Power Supply** • Multiple outputs for bench top uses and other applications • Input: 115VAC, 50-60 Hz @ 3.0 amps • Output: +5VDC @ 1.0 amp, +12VDC @ 1.0 amp, -12VDC @ 1.0 amp, +24VDC @ 2.5 amp, -24VDC @ 2.5 amp • Size: 15"L x 3¾"W x 2⅝"H • Weight: 2½ lbs.

AS1155 . . . . $39.95

POWER SUPPLY +5VDC @ 7.6 AMP, 12VDC @ 1.5 AMP SWITCHING

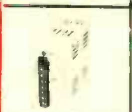
• Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp • Fan volt/power supply select switches (115/230VAC) • Output: 5VDC @ 7.6 amp, 12VDC @ 1.5 amp • 8 foot black power cord • Size: 11½"L x 13¼"W x 3⅛"H • Weight: 6 lbs.

PS94VOS. $39.95

KEPCO/TDK 4-OUTPUT SWITCHING POWER SUPPLY

• **Ideal for disk drive needs of CRT terminals, microcomputers and video games** • Input: 115/230VAC, 50/60Hz • Output: +5V @ 5 Amp, +12V @ 1.8 Amp, +12V @ 2 Amp, -12V @ 0.5 Amp • UL recognized • CSA certified • Size: 7⅞"L x 6-3/16"W x 1⅝"H • Weight: 2 lbs.

MRM 174KF. $59.95



4-CHANNEL SWITCHING POWER SUPPLY

• Microprocessor, mini-computer, terminal, medical equipment and process control applications • Input: 90-130VAC, 47-440Hz • Output: +5VDC @ 5A, -5VDC @ 1A, +12VDC @ 1A, -12VDC @ 1A • Line regulations: ±0.2% • Ripple: 30mV p-p • Load regulation: ±1% • Overcurrent protection • Adj: 5V main output ±10% • Size: 6⅝"L x 1⅞"W x 4-15/16"H • Weight: 1½ lbs.

FCS-604A. . . . . $69.95 each

Switching Power Supply for APPLE II, II+ & IIe*

• Can drive four floppy disk drives and up to eight expansion cards • Short circuit and overload protection • Fits inside Apple computer • Fully regulated +5V @ 5A, +12V @ 1.5A, -5V @ .5A, -12V @ .5A • Direct plug-in power cord included • Size: 9⅝"L x 3½"W x 2⅛"H • Weight: 2 lbs.

KHP4007. . . . . $79.95

NEW!

• AM/PM indicator • Automatic display dimmer • Bright 4-digit 0.5" high display • 10 minute snooze alarm

The JE750 Clock Kit is a versatile 12-hour digital clock with 24-hour alarm. The clock has a bright 0.5" high blue-green fluorescent display. The display will automatically dim with changing light conditions. The 24-hour alarm allows the user to disable the alarm and immediately re-enable the alarm to activate 24 hours later. The kit includes all documentation, components, case and wall transformer. Size: 6⅝"L x 3¼"W x 1⅝"D.

JE750 Alarm Clock Kit. $29.95

DISK DRIVES AND SUPPLIES

5¼" APPLE™ Direct Plug-In Compatible Disk Drive

• Uses Shugart SA390 mechanics • 143K formatted storage • 35 tracks — compatible with Apple controller • Complete with connector and cable — just plug into your disk controller card • Size: 6"L x 3⅞"W x 8-9/16"D • Weight: 4⅛ lbs.

ADD-514...$195.95

+5VDC @ 6 Amps
+12VDC @ 4 Amps
-12VDC @ 0.5 Amps

Microcomputer Power Inc. Regulated Power Supply

13¼"L x 6⅛"W x 5"H

• **Perfect for computer or disk drive systems** • Supply has AMP connectors for direct connection to two 5¼" disk drives • Cooling fan • Input: 100/115/200/230VAC, 47-63Hz • Output (above) • Weight: 9 lbs.

CP167. . . . . $59.95

INDUSTRIES *Protect Yourself...*

DATASHIELD® Surge Protector

• Eliminates voltage spikes and EMI-RFI noise before it can damage your equipment or cause data loss • 6 month warranty • Power dissipation (100 microseconds): 1,000,000 watts • 6 sockets • 6 foot power cord • Normal line voltage indicator light • Brown out/black out reset switch • Weight: 2 lbs.

Model 100. . . . . $69.95

Protect Yourself...

DATASHIELD® Back-Up Power Source

Provides up to 30 minutes of continuous 120 VAC 60Hz power to your computer system (load dependent) when you have a black out or voltage sag • Output rating: 200 watts • Six month warranty • Weight: 24 lbs.

Model 200 (PC200). $349.95

IBM MEMORY EXPANSION KIT COMPAQ COMPATIBILITY

SAVE HUNDREDS OF $$$ BY UPGRADING MEMORY BOARDS YOURSELF!

Most of the popular memory boards allow you to add an additional 64K, 128K, 192K, or 256K. The IBM64K Kit will populate these boards in 64K byte increments. The kit is simple to install — just insert the nine 64K RAM chips in the provided sockets and set the two groups of switches. Directions are included.

IBM64K (Nine 200ns 64K RAMs) $49.95

TRS-80 MEMORY EXPANSION KIT

TRS-80 to 16K, 32K, or 48K

**Model 1 = From 4K to 16K Requires (1) One Kit
Model 3 = From 4K to 48K Requires (3) Three Kits
Color = From 4K to 16K Requires (1) One Kit**

**Model 1 equipped with Expansion Board up to 48K Two Kits Required — One Kit Required for each 16K of Expansion —

TRS-16K3	*200ns for Color & Model III	$12.95
TRS-16K4	*250ns for Model I	$10.95

TRS-80 Color 32K or 64K Conversion Kit

Easy to install kits comes complete with 8 ea. 4164-2 (200ns) 64K dynamic RAMs and conversion documentation. Converts TRS-80 color computers with D, E, ET, F and NC circuit boards to 32K. Also converts TRS-80 color computer II to 64K. Flex DOS or OS-9 required to utilize full 64K RAM on all computers.

TRS-64K2. . . . . $44.95

UV-EPROM Eraser

8 Chips — 51 Minutes

1 Chip — 37 Minutes

Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

DE-4 UV-EPROM Eraser . . . $79.95
UVS-11EL Replacement Bulb . . $16.95

**$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
Shipping — Add 5% plus $1.50 Insurance
*Send S.A.S.E. for Monthly Sales Flyer!***

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CIRCLE 41 ON FREE INFORMATION CARD

CIRCLE 49 ON FREE INFORMATION CARD

2764 8K x 8 EPROM 450 ns $6.95 — 27128-30 16K x 8 EPROM 300 ns $29.95

BARGAIN HUNTERS CORNER

2732A 350ns

- "A" VERSION PROGRAMS AT 21 VOLTS.
- *FAST!* 350ns ACCESS TIME

4.95 EACH **100/4.45** EACH

Z-80 SPECIALS!

Z-80A-CPU 2.95
Z-80A-CTC 2.95
Z-80A-PIO 2.95

SPECIALS END 7/31/84

IC SOCKETS

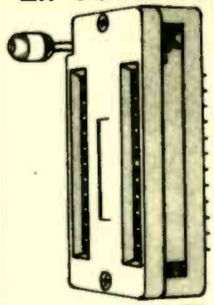
	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call

ST = SOLDERTAIL

8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80

WW = WIREWRAP

ZIF SOCKETS



LEADS	UNIT PRICE
14	5.95
16	5.95
24	7.95
28	8.95
40	10.95

ZIF = Zero Insertion Force

OPTO-ISOLATORS

4N26	1.00	MCA-7	4.25
4N27	1.10	MCA-255	1.75
4N28	.69	IL-1	1.25
4N33	1.75	ILA-30	1.25
4N35	1.25	ILQ-74	2.75
4N37	1.25	H11C5	1.25
MCT-2	1.00	TIL-111	1.00
MCT-6	1.50	TIL-113	1.75

MUFFIN FANS

4.68" Square	14.95
3.125" Square	14.95

HEAT SINKS

TO-3 style	.95
TO-220 style	.35

SWITCHES

SPDT mini-toggle	1.25
DPDT mini-toggle	1.50
SPST mini-pushbutton	.39

DIODES

1N751	5.1 volt zener	.25
1N759	12.0 volt zener	.25
1N4148	(1N914) switching	25/1.00
1N4004	400PIV rectifier	10/1.00
KBP02	200PIV 1.5amp bridge	.45
KBP04	400PIV 1.5amp bridge	.55
VM48	Dip-Bridge	.35

TRANSISTORS

2N918	.50	MPS3706	.15
MPS918	.25	2N3772	1.85
2N2102	.75	2N3903	.25
2N2218	.50	2N3904	.10
2N2218A	.50	2N3906	.10
2N2219	.50	2N4122	.25
2N2219A	.50	2N4123	.25
2N2222	.25	2N4249	.25
PN2222	.10	2N4304	.75
MPS2369	.25	2N4401	.25
2N2484	.25	2N4402	.25
2N2905	.50	2N4403	.25
2N2907	.25	2N4857	1.00
PN2907	.125	PN4916	.25
2N3055	.79	2N5086	.25
3055T	.69	PN5129	.25
2N3393	.30	PN5139	.25
2N3414	.25	2N5209	.25
2N3563	.40	2N6028	.35
2N3565	.40	2N6043	1.75
PN3565	.25	2N6045	1.75
MPS3638	.25	MPS-A05	.25
MPS3640	.25	MPS-A06	.25
PN3643	.25	MPS-A55	.25
PN3644	.25	TIP29	.65
MPS3704	.15	TIP31	.75
		TIP32	.79

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DISK DRIVES

TANDON

TM100-1 5¼" (FOR IBM) SS/DD — 199.00
TM100-2 5¼" (FOR IBM) DS/DD — 219.00

MPI

MP-52 5¼" (FOR IBM) DS/DD — 249.00

TEAC

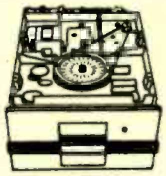
FD-55B ½" HEIGHT DS/DD — 189.00

SHUGART

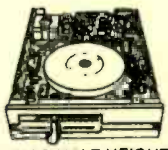
SA 400L 5¼" (40 TRACK) SS/DD — 199.95

8" DISK DRIVE

FD 100-8 BY SIEMENS, SHUGART 801 EQUIV.
SS/DD — 10/$149 EA. — $169.00
FD 200-8 BY SIEMENS, SHUGART 851 EQUIV.
SS/DD — 10/$220 EA. — $239.00



TANDON 5¼"



TEAC HALF HEIGHT

Please include sufficient amount for shipping on above items.

CABINETS FOR 5¼" DISK DRIVES

CABINET #1 $29.95

- ★ Dimensions 8⅝ x 5¹⁵⁄₁₆ x 3¹⁵⁄₁₆"
- ★ Color matches Apple
- ★ Fits standard 5¼" drives, Inc. Shugart
- ★ Includes mounting hardware and feet

CABINET #2 $79.00

- ★ Complete with power supply, switch, line cord, fuse & standard power connector
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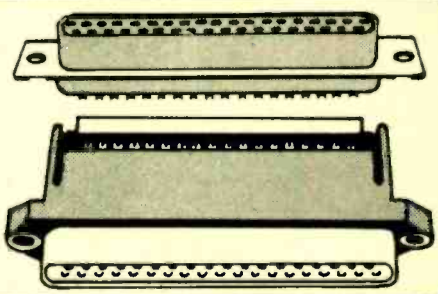
NOTE: Please include sufficient amount for shipping on above items.

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	25	37	50
SOLDER CUP	MALE	DPxxP	2.08	2.69	2.50	4.80	6.06
	FEMALE	DBxxS	2.66	3.63	3.25	7.11	9.24
RT. ANGLE PC HOLDER	MALE	DBxxPR	1.65	2.20	3.00	4.83	—
	FEMALE	DBxxSR	2.18	3.03	4.42	6.19	—
IDC RIBBON CABLE	MALE	IDBxxP	3.37	4.70	6.23	9.22	—
	FEMALE	IDBxxS	3.69	5.13	6.84	10.08	—
HOODS	BLACK	HOOD-B	—	—	1.25	—	—
	GREY	HOOD	1.60	1.60	1.25	2.95	3.50

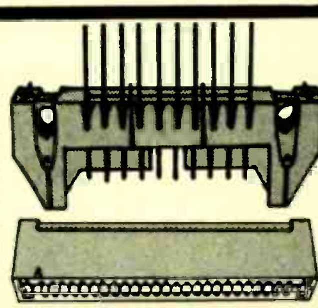
MOUNTING HARDWARE - $1.00 — For order instructions see "IDC Connectors" below.



IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RT. ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RT. ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	1.15	1.86	2.43	3.15	3.73	4.65
RIBBON HEADER	IDMxx	—	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	2.25	2.36	2.65	3.25	3.80	4.74

ORDERING INSTRUCTIONS: Insert the number of contacts in the position marked "xx" of the "order by" part number listed. **Example:** A 10 pin right angle holder style header would be IDH10SR.



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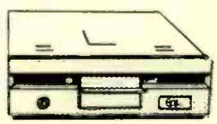

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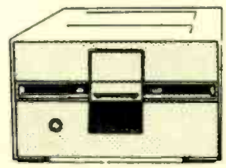

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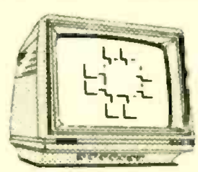

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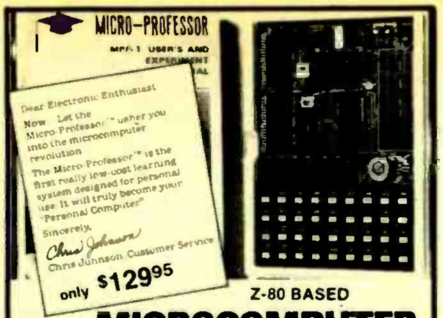

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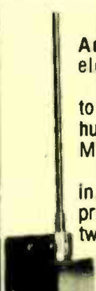

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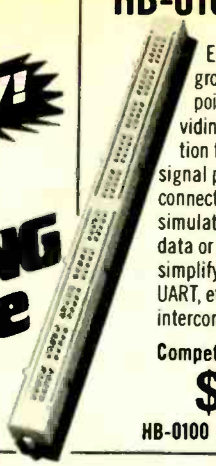

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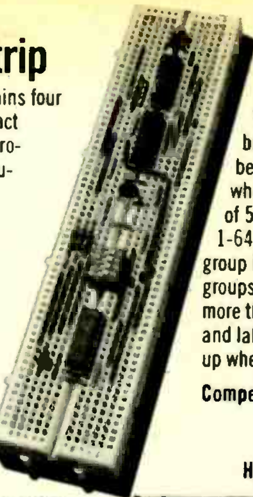

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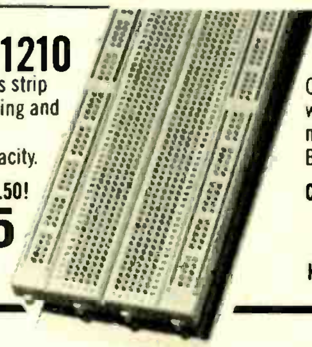

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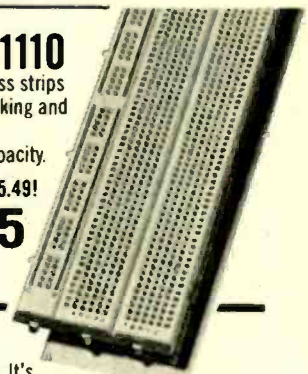

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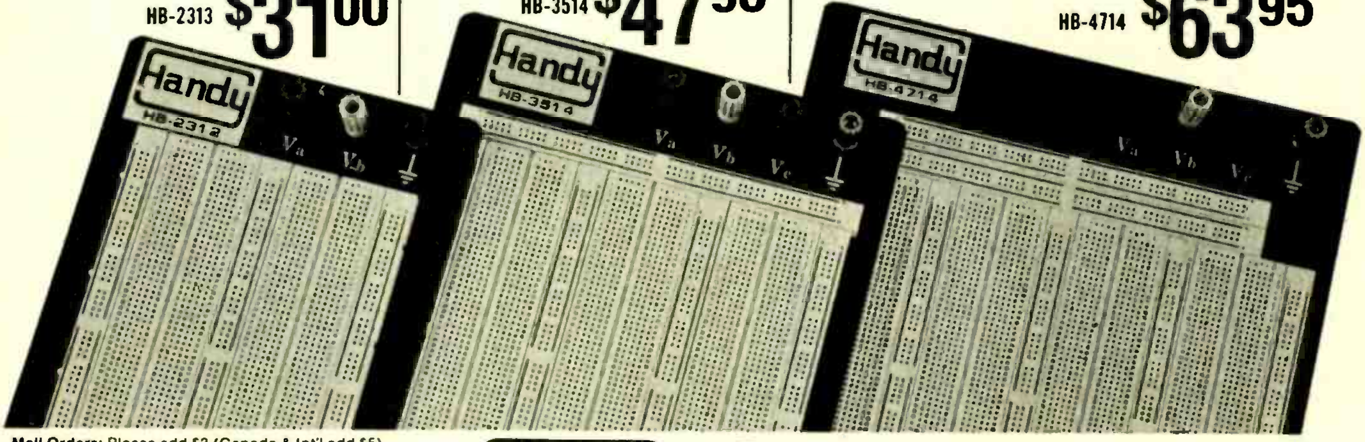

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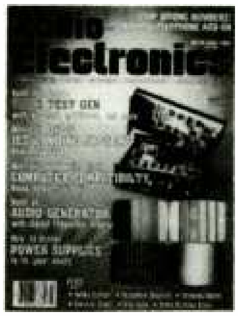

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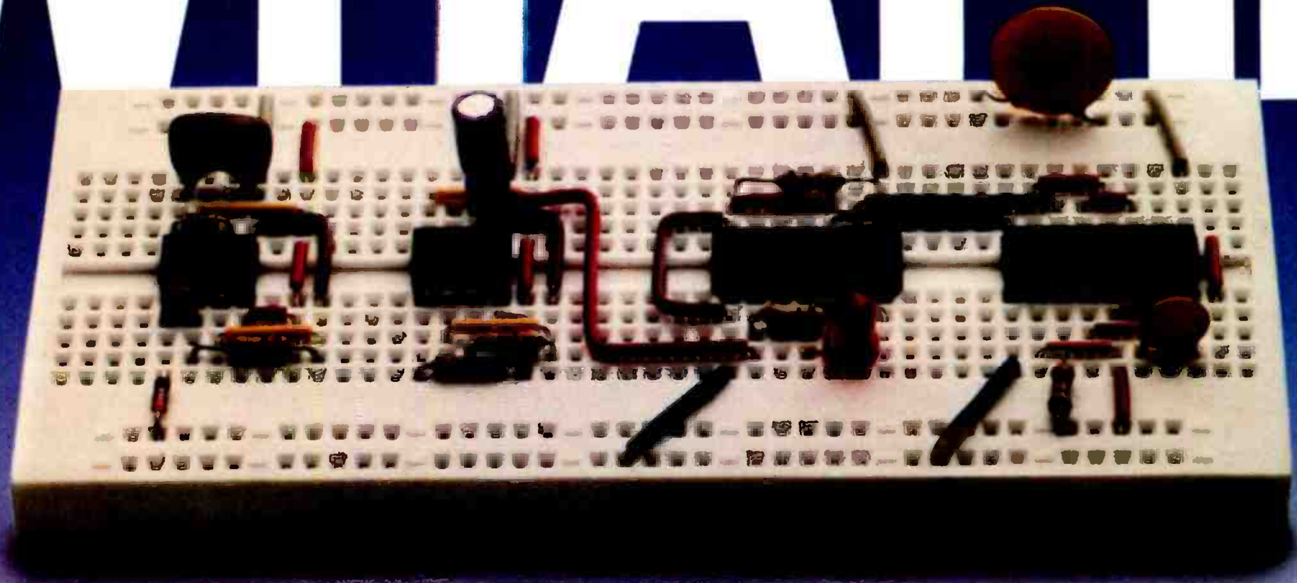

What if there were a faster way to build and test circuits?

There is. Circuit-Strip from AP PRODUCTS makes circuit building a snap, giving you more time to experiment, to create. With a Circuit-Strip solderless breadboard, all you have to do is plug in components and interconnect them with ordinary #22 AWG solid hook-up wire. If you want to make a circuit change, just unplug the components involved and start over. It's just that easy. Circuit-Strips feature 610 plug-in tie-points and have a capacity of up to 6 14-pin DIPs. Four separate distribution buses of 35 tie-points each give you access for power, ground or signal.

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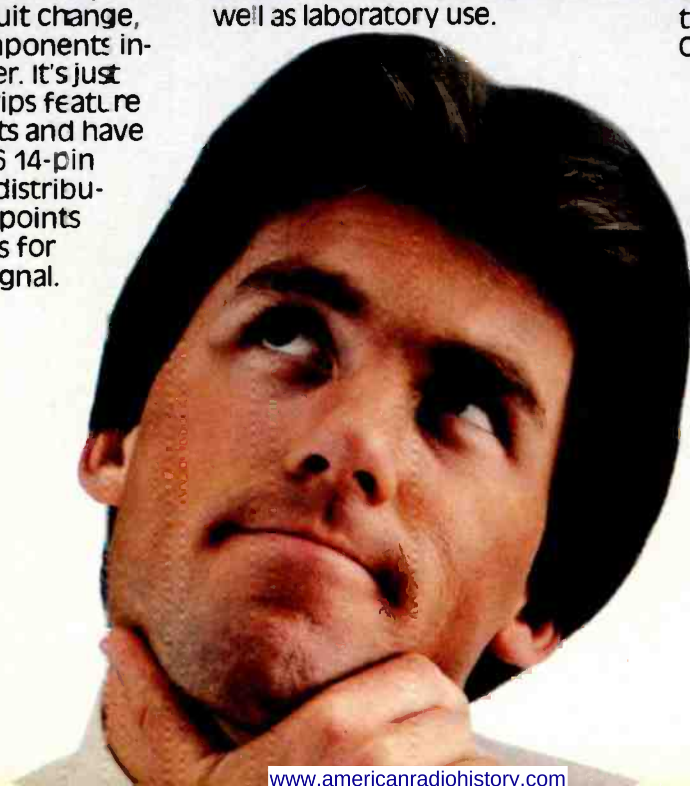

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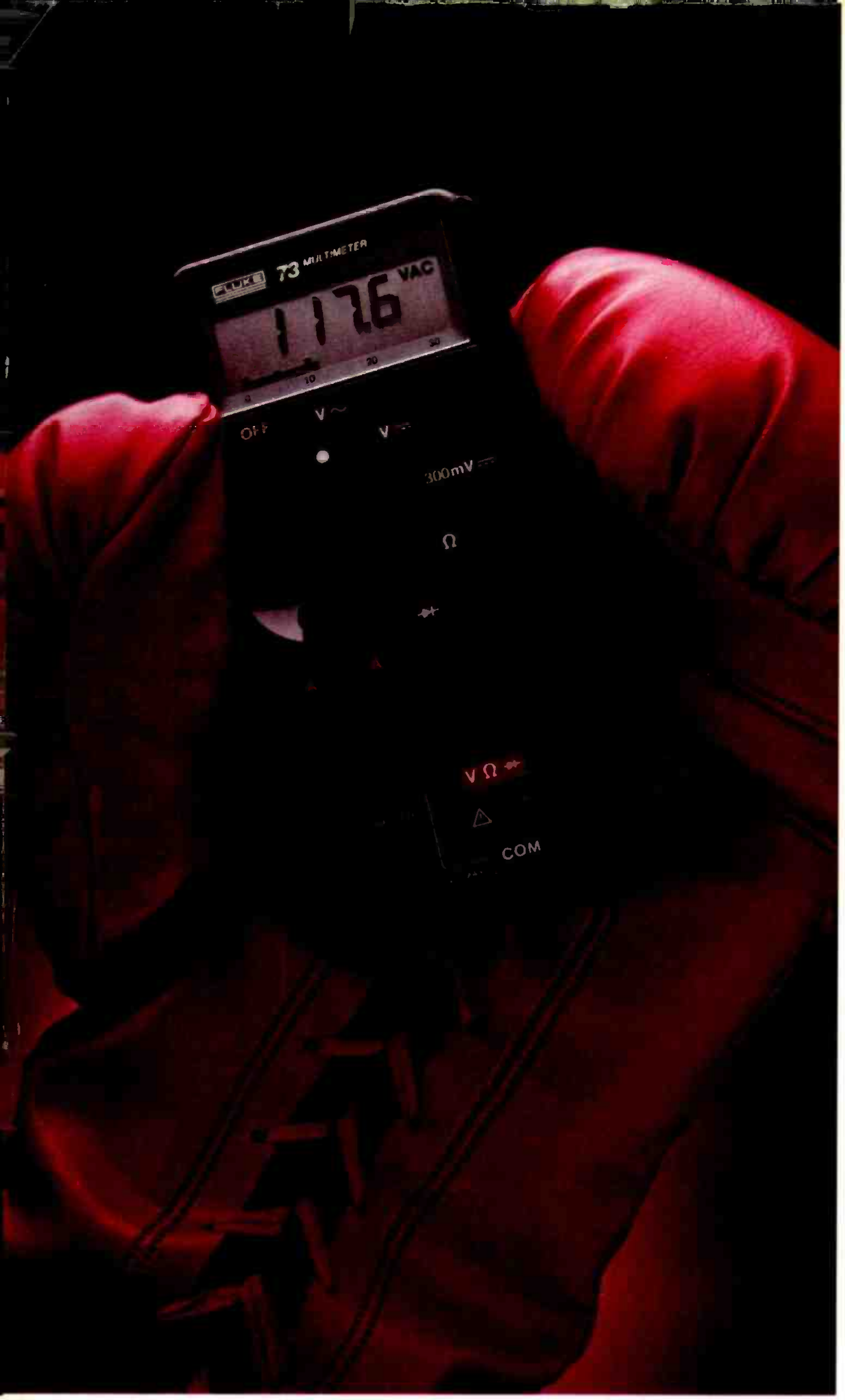

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