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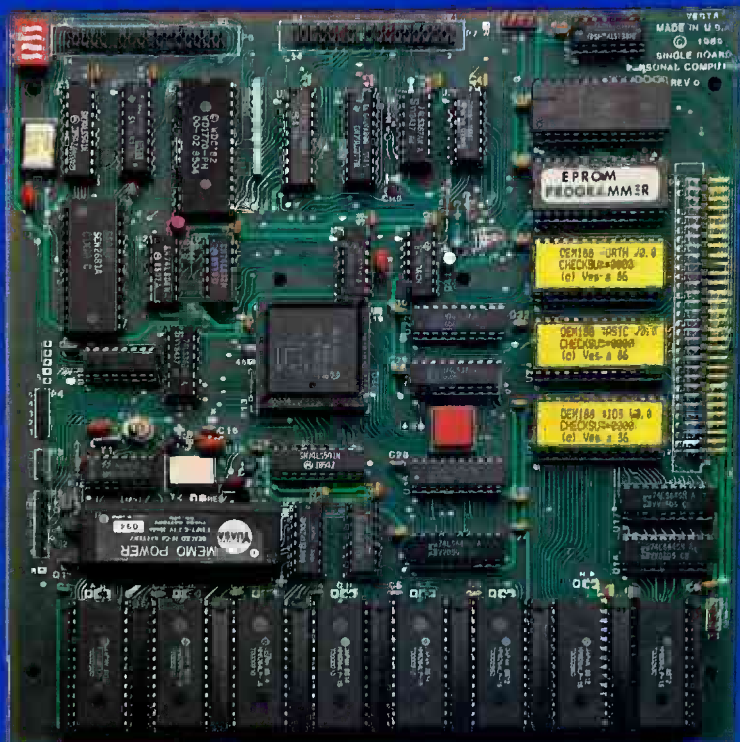

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Vol. 58 No. 4

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TECHNOLOGY

CIRCUITS AND COMPONENTS

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EQUIPMENT REPORTS

DEPARTMENTS

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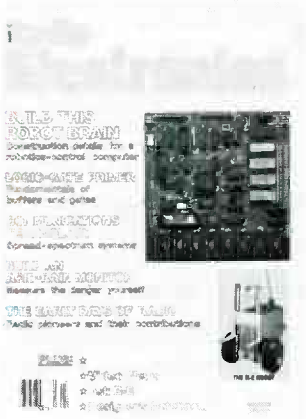
COVER 1



The past few months we've described a versatile robot that you can build. Up to now, much of the discussion has been devoted to the logic behind the design, and some of the goals we'd like the robot to achieve. What construction details we did present were pretty much confined to the mechanical systems.

Now it's time to get to the heart of the matter. Or, to be a bit more precise, the brain. If our robot is to be a useful servant, an on-board computer is a necessity. The one we've designed for our robot offers great power and flexibility; it is built around an upgraded version of the microprocessor used in the IBM *PC*. To find out more about the computer, turn to page 39.

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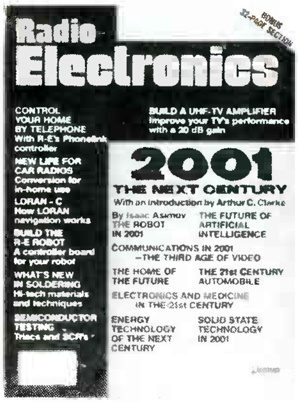

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Advertising Sales Offices listed on page 128.

WHAT'S NEWS

New broadcast stations coming

In 1979, WARC (the *World Administrative Radio Conference*) allocated or reallocated the 1605–1705-kHz band to radio Region 2 (the Western Hemisphere). An Expanded-Band Conference was scheduled to plan the broadcast use of that band. The FCC made two proposals to that Conference: One was that allotment planning be used; the other was that station power be limited to 10 kW.

Allotment planning has several advantages over assignment planning, the alternative. In assignment planning, each signatory country must submit its complete and detailed requirements, pinpointing each prospective station and stating power, antenna systems, and other characteristics for each.

Under allotment planning, designated frequencies are made available for designated areas. Although the allotment of frequencies is based on the presumption of stations with defined characteristics within defined areas, the signatories are not bound to follow the exact details of the plan and may depart from the plan provided that the radiation toward other signatories does not exceed what would have resulted from operating stations with the presumed characteristics.

As to the proposed 10kW power limit, the FCC believes that such a maximum power provides for adequate service range for each station, while making it possible to have enough stations to meet the requirements of the area.

The first session of the Conference, held in the spring of 1986, approved both the allotment system and the 10-kW power limit. Unless unexpected difficulties crop up at the second and final session, to be held near the end of 1988, it is expected that the portion of the band between 1665 and 1705 kHz will be opened July 1, 1990. Some stations in the 1605 to 1665 portion of the band may be actually on the air well before that date.

Under present allocations, a small part of the 1605-1705 kHz band is in use for broadcasting. The rest of that band is divided between fixed and mobile stations; those stations chiefly are used for navigational aids. **R-E**

"Unmanned" warfare due in the future?

General Electric researchers are engaged in a project to improve the image-understanding abilities of machine-vision systems. The purpose is to permit an unmanned vehicle to recognize objects in its range of "vision" and to take appropriate action—steer around an obstacle, stop at a body of water, or turn and flee from a hostile tank.

To do that, it is necessary to teach the vehicle's computer "geometric reasoning;" that is, to train it to recognize objects by matching their geometric features (lines and corners) with those of images stored in memory. Hundreds of images will have to be remembered, including those of landmarks, vehicles, and other objects the vehicle may encounter.

To store the images, the computer is "shown" photos, drawings, or mockups of objects from several viewpoints, including front views, side views, three-quarter views, etc. That is done with a TV camera that converts the images into digital data that the computer can deal with. The computer then manipulates the data to create a model of the object, which is filed away in memory.

When the vehicle's camera spots an unidentified object in its path, the computer starts processing the image to extract rough geometric data, looking for lines and vertices where there are sharp changes. That produces a two-dimensional representation (resembling a crude line drawing) showing the boundaries of the object. That is compared with all the possible two-dimensional orientations of the three-dimensional models in the computer's memory. If several features of any rotation of the 3-D model agree with the computer's 2-D image, the computer assumes a tentative identification. It then examines finer details to confirm or reject the identification.

MODEL MAKING. General Electric scientist Daniel Thompson is preparing one of the many images required to make the three-dimensional model from which the jeep could be identified.

The project is supported by a $1 million contract from DARPA (the U.S. *Defense Advanced Research Projects Agency*), and is aimed at evaluating the potential of unmanned vehicles for military operations, such as surveillance and reconnaissance missions, or shuttling supplies to front lines.


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VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **EDTV.** A new program in Japan has as its goal a major change in television transmission standards by 1988. The new standard will produce a sharply-improved picture, but will maintain compatibility with existing standards and TV sets.

The Broadcasting Technology Association, a Japanese government-industry association, has announced that it established the following guidelines for its proposed new *E*xtended *D*efinition *TV* (EDTV) system:

- Complete compatibility with existing receiving equipment and standards.
- Picture quality that is sufficient for viewing at a distance of four times tube height (rather than the existing optimum of 10 times the tube height). Therefore, under the standard, a 30-inch tube (tubes of that size are expected to be common in the near future) would be ideally viewable from eight feet away.
- Horizontal resolution of 450 lines (compared with today's approximately 330 lines) and vertical resolution of 450 lines compared with today's 300 lines) by using a progressive non-interlaced scanning system.
- Reduction of cross-color and cross-luminance to unnoticeable levels.
- Ghost cancellation, possibly by means of a reference signal transmitted along with the TV program.

The details of the proposed specifications are scheduled to be released this summer, after which it will be the responsibility of Japan's Ministry of Posts and Telecommunications to implement the new standards.

The Broadcasting Technology Association currently has 38 member companies, 19 of which are manufacturers, including the Japanese subsidiaries of Philips and RCA. The association is maintaining liaison with the U.S.'s Advanced Television Systems Committee, which is working on similar proposals, but with less well-defined deadlines.

• **HDTV.** Another study in Japan, this one by an affiliate of NHK (Japan Broadcasting Company), is developing specifications for a reasonably priced VCR system for Japan's *H*igh *D*efinition *TV* (HDTV) system, which uses an 1,125-line widescreen picture. Existing videotape recorders for the system cost between $250,000–$300,000 and use open-reel one-inch videotape.

The proposed new system would use half-inch tape, probably metal coated, in a cassette similar to that used by the VHS format. Nine Japanese electronics manufacturers have agreed to use the new standard that is developed as the result of the study. The HDTV VCR's could be used for projection in motion picture theaters, closed-circuit performances of various kinds, and high-quality electronic publishing. Japan is preparing for the direct satellite broadcasting of high-definition TV to theaters and to specially equipped homes.

• **Electronic still camera.** The first electronic still camera to be introduced for the consumer market has been announced by Casio. It will go on sale in the United States and Japan around the middle of 1987. The camera uses the standard two-inch "video floppy" developed for electronic still photography; the video floppy can hold up to 25 full frames or as many as 50 fields of color pictures.

The camera has an MOS image sensor capable of 280,000-pixel resolution. Shutter speeds range from 1/8 to 1/1000 of a second. It differs from other such cameras shown to date in that it includes playback capability; a recorded image can be played back on any television set without the need for a separate player. Other features include erase capability and the ability to shoot five fields continuously in one second.

Furthermore, the price announced for the two-pound camera in Japan is by far the lowest reported for any proposed such camera to date: $650, although it may be somewhat higher in the U.S. Although electronic still cameras have been developed and tested by many manufacturers, the only other one currently on the market is a professional model by Canon, which sells at $2,400. Casio says it also will offer a color printer for about $1,250. **R-E**

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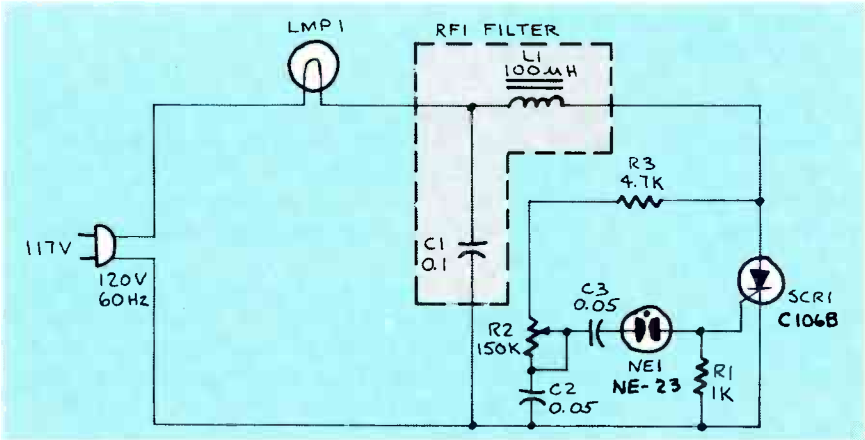

FIG. 1

INTERFERENCE FROM LIGHT DIMMERS

How can I prevent electronic light dimmers from interfering with reception on my AM radios? Whenever I use a dimmer-controlled light, a loud buzz makes reception impossible.—P.B., Gustavus, AK

Literally thousands of the early electronic light dimmers were marketed before the manufacturers realized that there was a problem. Those dimmers used a Triac or an SCR as the control device. What they failed to account for was that Triacs and SCR's produce harmonic-rich squarewaves that cause RFI (*R*adio-*F*requency *I*nterference) unless steps are taken to prevent it. Later dimmers have built-in filters and shielding to prevent the harmonic interference from feeding back into the power line, or use zero-crossing control switching to eliminate the noise. Figure 1 shows the schematic of one of the newer versions; it was developed by General Electric. The RFI filter in that circuit is enclosed in the dashed box.

As for do-it-yourself remedies, you could connect a 0.0047-µF capacitor across the dimmer to reduce the interference. But if not done carefully, making such a modification could produce a shock or fire hazard. In the interest of safety, the best approach would be to simply replace the noisy dimmers with models that incorporate an RFI filter.

MORE ON MOTOR-SPEED CONTROL

In a recent column, I replied to queries from C.S., TX and J.C., TN. One reader wanted to reverse a small universal fan motor and the other wanted to vary the speed of a drill-press motor. I was not able to give specific advice to either reader. Well, if you guys are still "listening" both problems were solved over twenty years ago in a *Popular Mechanics* article entitled "Electronic Drill-Press Drive."

In the article, the author describes how he replaced his drill-press motor with a 1-horsepower universal motor salvaged from a Hoover canister-type vacuum cleaner. He shows how to reverse that motor by shifting the pole and field coil assemblies to the opposite side of the brush-holder centerline. Further, he used an SCR in a conventional circuit to vary the speed of a drill-press from below 1000 rpm to 10,000 rpm. If you want more information, the article appeared on pages 188 through 193 of the February 1964 issue of *Popular Mechanics*. Back issues are often available at larger public or university libraries.

WHAT IS THIS IC?

I have a Fairchild 40-pin IC marked "3805." I'm not sure if it is a UART or a microprocessor. Can you tell me what it is compatible with and where I can get a data sheet?--T.A., Logansport, IN

The type number is unknown to anyone I've been able to contact at Fairchild. One person suggested that the device was probably made for an equipment manufacturer who specified that his own part number be used. Another wondered if you had transposed the last two figures while copying the numbers off of the device. In that case, possibly the device is a 3850 CPU (*C*entral *P*rocessing *U*nit) for the Fairchild F8 microprocessor system. For information on the 3850 and its applications, refer to the F8 User's Guide and/or write to Fairchild, Microcomputer Division, 464 Ellis St., Mountain View, Ca 94042

SOLID-STATE TUBE SUBSTITUTES

In my job I service U.S. Army electronic equipment that uses vacuum tubes. I've heard that there are solid-state replacements for vacuum tubes such as the 12AT7, 12AU7, 6AL5, 6AK5 and 6SN7. Is that true? If so, where can I find them?--R. L., Anaheim, CA

Back in the mid-1960's, several manufacturers attempted to de-

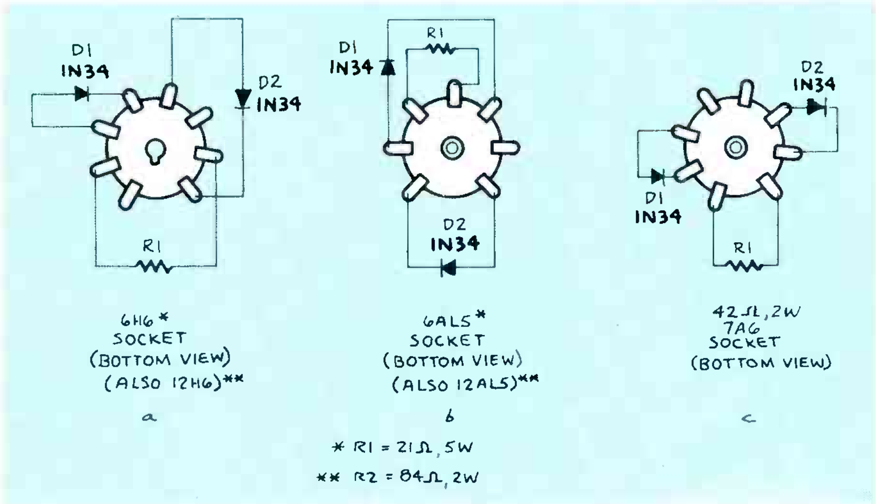

FIG. 2

velop lines of universal semiconductor replacements for vacuum-tube diodes and tridoes. Their efforts were short-lived because substituting a semiconductor device for a tube usually meant that the adjacent circuitry had to be extensively modified.

One approach was using two transistors connected in a cascode arrangement as a plug-in replacement for a triode voltage-amplifier tube. Similarly, semiconductor diodes were offered replacements for vacuum-tube diodes. To my knowledge, none of the solid-state replacements for tubes included a resistor as the equivalent of the tube's heater. A resistor would have to be hard-wired into the circuit to take the place of the heater in series heater-string sets.

Of all the plug-in solid-state replacements tried, the most practical and successful were those for power rectifiers. For a short period in the 1960's, five IN-type silicon rectifier assemblies were offered as replacements for some popular vacuum-tube rectifiers. Those were the IN1237 for the 0Z4, the IN1238 for the 5U4-GB, the IN1239 for the 5R4, the IN1262 for the 6AU4-GTA, and the IN2637 for the 866-A.

If you are permitted to make permanent modifications in the equipment you are servicing, then you might consider hard-wiring 1N34 semiconductor diodes as replacements for small-signal detector tubes.

Figure 2 shows how to do that for 5 popular tubes. The scheme for replacing a 6H6 or 12H6 is shown in Fig. 2-*a*, the scheme for replacing a 6AL5 or 12AL5 is shown in Fig. 2-*b*, and the scheme for replacing a 7A6 is shown in Fig. 2-*c*. The resistors shown need only be installed in circuits where the tube heaters are wired in series. **R-E**


Components and Adaptors


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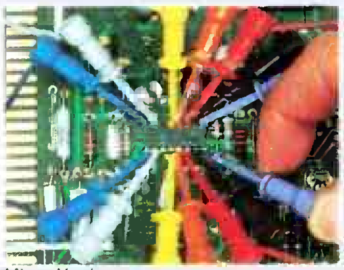
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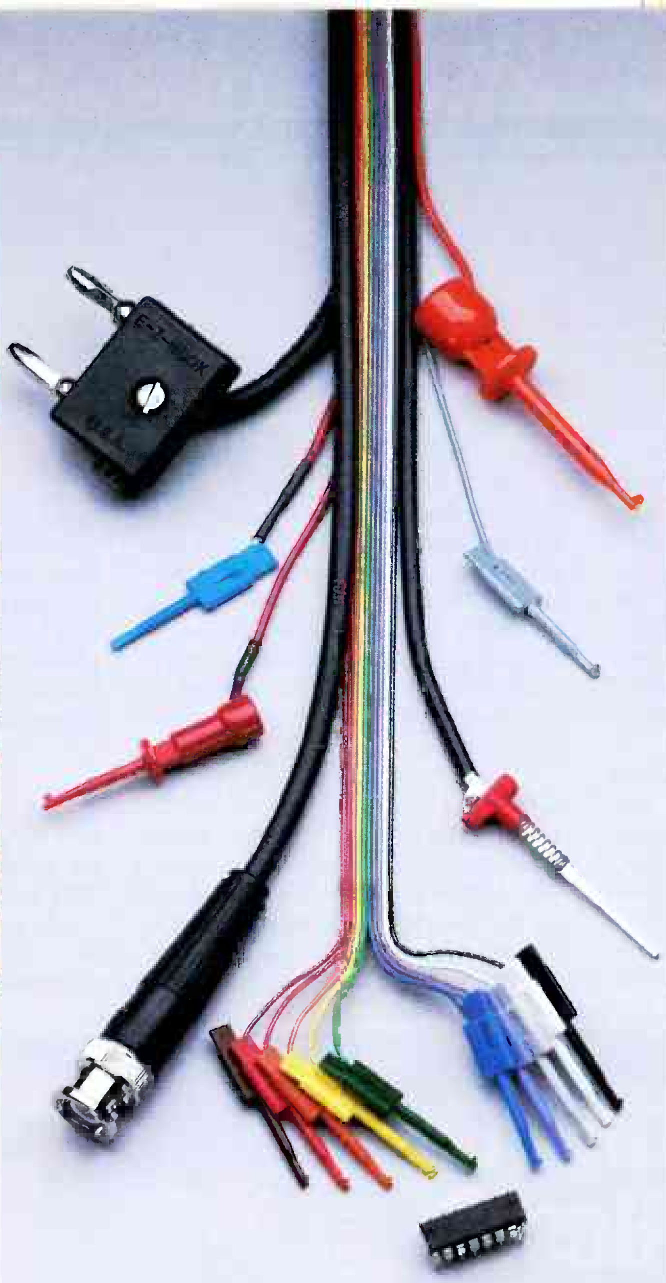
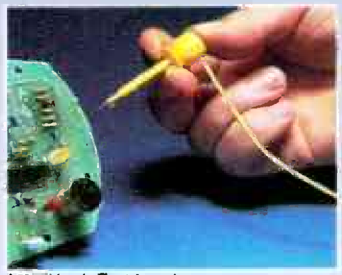
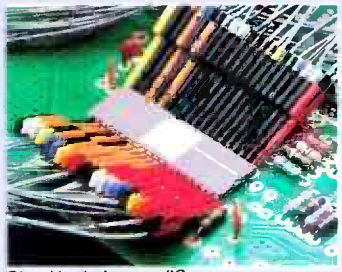



Mini Hook Test Leads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LETTERS

RAZOR-BLADE DETECTOR

I enjoyed, and have just finished reading, the "Letters" department in the December 1986 issue of **Radio-Electronics**. Matthew Kleinmann of Binghampton, NY, mentioned the "razor-blade detector," which was used in the first radio that I constructed.

The razor blade *must* be a blue blade *(quench-type, not lacquered—Editor)*. It is the bluing process which, in conjunction with the lead, allows the detection of radio waves.

Mount the blade flat. Take a medium-size safety pin and bend the latch so that it may be mounted flat to the board, with the point of the pin facing the center of the razor blade. Sharpen a No. 2 pencil, and carefully cut away enough wood so that you can break off about an inch of lead. Then affix the lead so that it extends past the point of the pin.

I fastened mine together by wrapping some fine wire tightly around the pin and the lead. (That operation may require a helper. The end of the pin where it fastens to the board, and the end of the blade are the connecting points of the detector.) The pin must be bent to where the lead makes good contact with the blade. It is then moved around like the "cat whisker" until a spot is found where it will detect radio waves. Have fun.

DON SMITH
Perrysburg, OH

CASSETTE FIDELITY

I am an old-time audio research and development engineer, and an audio buff dating back to the '30's and '40's, now retired.

I have been highly skeptical of the flowery advertising claims made about the fidelity that can be had nowadays on prerecorded audio cassettes. As a consequence, I resisted getting any such equipment until recently.

Unfortunately, the cassettes I have obtained left a great deal to be desired. I found that the high-end response depended on which deck it was played back on. Further, that response seemed to vary from one playing to another, and often it changed in the middle of a program. On decks in which the high frequency response seemed deficient, I could lift or twist the cartridge slightly and have the highs fade in and out. That discovery put me on a two-week personal fact-finding project, in the interest of my own education. My discoveries have convinced me, positively, that my skepticism was well founded.

Applying my old R and D experience, I recorded a full-track-width cassette with a 5-kHz audio tone for a head-alignment test. (I first tried to buy such a cassette, but was unable to find one for sale anywhere. I suspect that the deck manufacturers do not want such cassettes available, because such a test is too severe for the playback equipment available on the consumer market.)

On twenty decks I plugged my tape into, barely four of them had the heads aligned properly. Most of the rest were well down at 5 kHz, one of them to almost zero. I could put a very slight pressure, one way or the other, on any of them and bring my test signal up to full output.

Another problem: The guides on most decks are welded directly to the heads. When the head is tilted when aligning, the tape is also forced to track higher or lower on the head. That causes the output level to vary at the same time that the high-end response is maximized. Furthermore, the tape-tracking within the cartridges is so loose and sloppy that the tape tends to walk up and down on the head, depending on a slight tipping up or down of the cartridge. Also, the springs behind the pressure pads are often not perfectly flat, or the pad itself is tipped or twisted slightly, causing an unbalanced pressure against the face of the head. That causes the tape to

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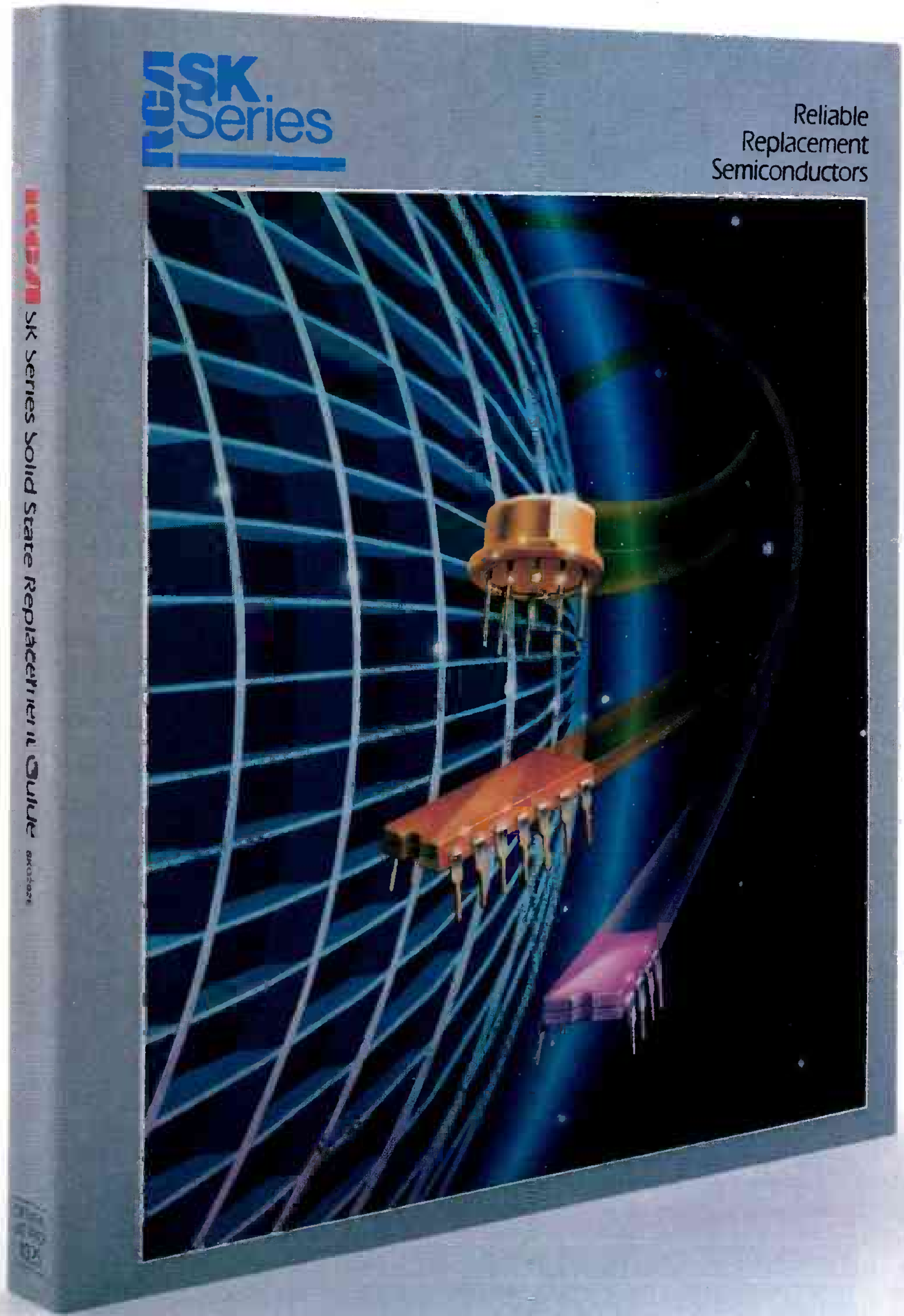

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RCA SK Replacement Solid State

wander up or down, or twist ever so slightly, but more than enough to wipe out the high-end response.

In addition to the above, the pressure rollers were frequently not square with the capstan. That also tended to make the tape walk up or down with the capstan, forcing the tape to twist out of alignment.

I suspect that the only way that you can realize frequency response at 5 kHz or higher is when you record and play back on the same machine. I did that, however, and I still had a problem some of the time, due to the internal cartridge slop, which caused the tape to screw up or down, depending on room temperature, whether the tape had just been fast-forward or reverse wound, and other impossible-to-control variables.

I challenge anyone to record 5 kHz on his or her best machine, using the highest quality cartridge, and then see what it looks like when played back and viewed on one's own scope. The dropouts, semi-dropouts, and volume fluctuations are quite unbelievable. After that, try your recording on a few other machines and see what happens.

My conclusion? Fortunately, the average listener does not have a "golden ear." And the dropout problem is hard to detect by ear on music, rather than on a sustained pitch. The average listener, on hearing 3- or 4-kHz tones interprets them as "super" high-frequency response. If all recorded music on cassettes were to be given a boost at 3 or 4 kHz, and then chopped off above 5 kHz, I suspect that everyone would be pleased, and fully convinced of his or her listening quality. I sort of suspect that the cassettes being sold now are so recorded, and that very few listeners out in the real world know the difference.

JACOB ANTHES
Glidden, WI

You have either purchased some really low-priced junk, or have managed to acquire manufacturing rejects. All high-fidelity type machines and tapes that we have tested here over a period of many years can easily record to 15 kHz (not 5 kHz) and will hold its alignment within tolerable limits from 12 kHz and higher. In fact, the cassette system is so good, including its resistance to dropouts, that even rock-bottom priced machines and tapes are popular as low-cost data storage systems for personal computers.—Editor

ATTENTION: MR. MICHAEL HARDY

First, let me compliment **Radio-Electronics** for an excellent magazine. I have been an avid cover-to-cover reader for several years. I have never found another publication that covers *all* conceivable interests and subject matters within its range. Please keep up the good work; don't change a thing.

Second, an open reply to Mr. Michael Hardy, of Massillon, OH, and other interested job-candidates in the electronics field.

I suggest that you pick up a copy of the *Sunday Atlanta Journal-Constitution* at your local library.

continued on page 20

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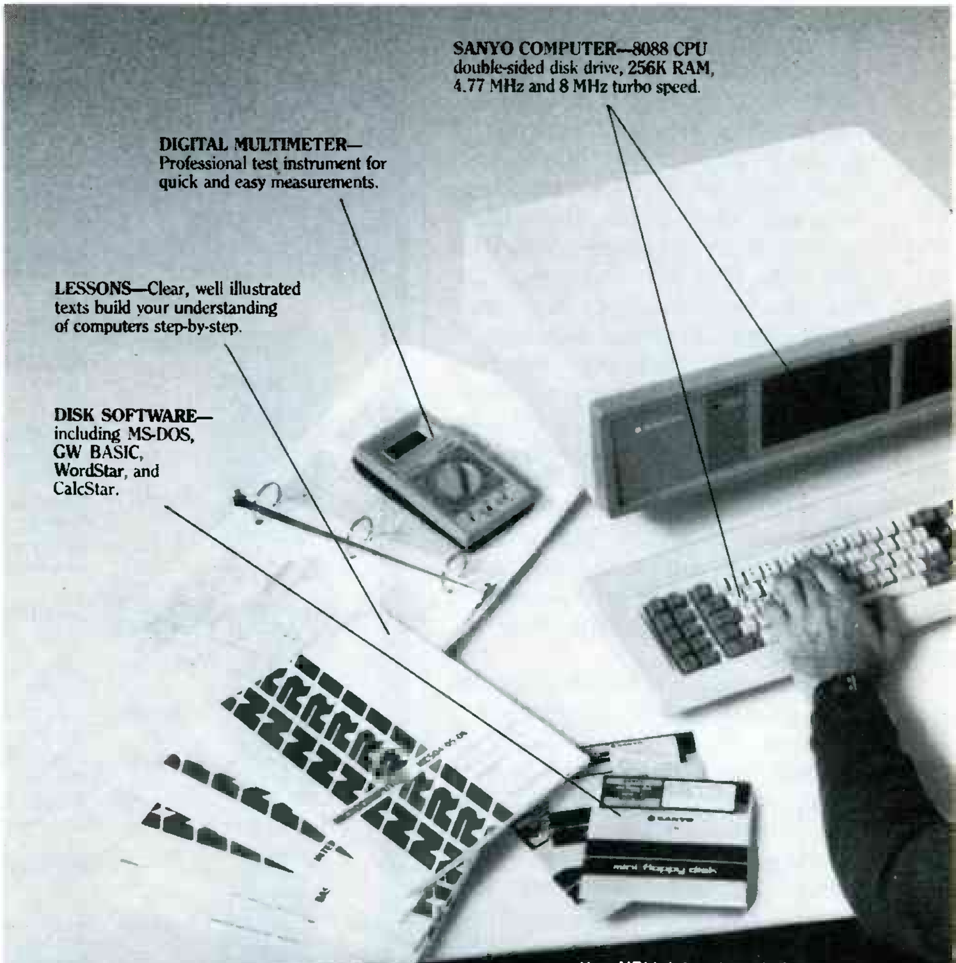

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The North-Atlanta area is covered with high-tech industry. In fact, the entire North-Georgia area is booming. We have the factories; all we need is more technicians. I am sure that most manufacturers in this area will tell you that they can't find enough techs. If you don't want to go to Georgia, try Florida. With firms like Harris Semiconductor (Gates Radio) there I am sure that you'll be satisfied.

The point, Mr. Hardy, is that jobs *are* available. They might not be down the street from your house, but if you are serious about your profession, there is work to be had. Right in your home state, the Cleveland Institute of Electronics publishes a newspaper called the *Electron*. Many, many jobs are listed there, and not just open to CIE graduates.

I wish you the best of luck. It took me three months to find the right position, but I have never gone hungry since.
MICHAEL MALLORY
Carrollton, GA

PATENT COSTS

I enjoyed reading Dave Sweeney's article, "How to Apply for a Patent," in the January 1987 issue of **Radio-Electronics**. The information is very good, with the exception of the cost of obtaining copies of already issued patents. Like the 5-cent cigar, 28-cents-per-gallon gasoline, and 10-cent Coca-Cola, the day of the 50-cent patent copy is long gone. The current price is $1.50 per copy from the Commissioner of Patents and Trademarks, Washington, DC 20231. Provide the patent number with your fee and, in 6–8 weeks time you'll get your copies. If you need faster service, many large cities have patent depositories where you can even make copies yourself.

Being an inventor with three recent patents, I have used the Boston Public Library for obtaining copies of relevant patents. If any reader writes to me and encloses a self-addressed, stamped envelope (SASE), I'll provide the location of the nearest patent depository in his or her area. Also, if requested, I'll include information about using expired patents that saved me time and money in conducting my own patent search.

I am confident that the information I provide regarding the cost and process for obtaining patent copies will expedite ordering.
JOSEPH R. BIRKNER, President
Star Research Co.
P.O. Box 2121,
West Peabody, MA 01960.

ON SAMS PHOTOFACTS

I should like to comment on your answer to D.D., in the "Ask R-E" section of the December 1986 **Radio-Electronics**.

You were unquestionably correct when you told the reader that the Philco service data that he needed could be found in *Sams Photofact #794–8*, and then you gave him the telephone number of the company.

But you failed to mention that most of the old "Photofacts" are out of print, and that those that are available cost $9.95 per set.

And you failed to tell him that

Regency "Scanner Answer" Giveaway

Here's your chance to win a complete monitoring package from Regency Electronics and Lunar Antennas. 18 scanners in all will be awarded, including a grand prize of the set-up you see above: the Regency HX1500 handheld, the Z60 base station scanner, the R806 mobile unit, and a Lunar GDX-4 Broadband monitoring/reference antenna.

55 Channels to go!

When you're on the go, and you need to stay tuned into the action, take along the Regency HX1500. It's got 55 channels, 4 independent scan banks, a top mounted auxilliary scan control, liquid crystal display, rugged die-cast aluminum chassis, covers ten public service bands including aircraft, and, it's keyboard programmable.

Compact Mobile

With today's smaller cars and limited installation space in mind, Regency has developed a new compact mobile scanner, the R806. It's the world's first microprocessor controlled crystal scanner. In addition, the R806 features 8 channels, programmable priority, dual scan speed, and bright LED channel indicators.

Base Station Plus!

Besides covering all the standard public service bands, the Regency Z60 scanner receives FM broadcast, aircraft transmissions, and has a built-in digital quartz clock with an alarm. Other Z60 features include 60 channels, keyboard programming, priority control, digital display and permanent memory.

Send in a photo (like this one of Mike Nikolich and his Regency monitoring station) and receive a free gift from Regency. Be sure to include your name, address and phone number.

Lunar Antenna

Also included in the grand prize is a broadband monitoring/reference antenna from Lunar Electronics. The GDX-4 covers 25 to 1300 MHz, and includes a 6 foot tower.

Regency® ELECTRONICS INC.
7707 Records Street
Indianapolis, IN 46226

Grand Prize (1 awarded)
1—Regency Z60 Base station scanner
1—Regency HX1500 Handheld scanner
1—Regency R806 Mobile scanner
1—Lunar GDX-4 Antenna

First Prize (5 awarded)
1—Regency Z60 Base station scanner
1—Regency R806 Mobile scanner

Second Prize (5 awarded)
1—Regency HX1500 scanner

Contest rules: Just answer the questions on the coupon, (all answers are in the ad copy) fill in your name and address and send the coupon to Regency Electronics, Inc., 7707 Records Street, Indianapolis, IN 46226. Winners will be selected from all correct entries. One entry per person. No purchase necessary. Void where prohibited by law. Contest ends June 30, 1987.

1. The Regency Z60 is
   ☐ a digital alarm clock ☐ an FM radio
   ☐ a scanner ☐ all of the above
2. The Regency R806 is the world's first ________ controlled crystal scanner.
3. The Regency HX1500 features
   ☐ 55 channels ☐ Bank scanning
   ☐ Liquid crystal display ☐ all of the above
4. The Lunar GDX-4 antenna covers ____ to ____ MHz.

Name: ________

Address: ________

City: ________ State: ________ Zipcode: ________

I currently own ________ scanners.

Brands owned: ________

CIRCLE 185 ON FREE INFORMATION CARD

Radio-Electronics has a constant advertiser (me) who sells previously-owned individual folders for $3.00 or $5.00 each, and has a stock that is more than 99% complete up to set #1600, plus many later numbers.

They are genuine Sams folders (not copies). Many of them are unused, and all are complete and clean. There is also an equally complete stock of Sams specialized books on auto radios, tape recorders, CB sets, modular hi-fi, etc.

ALLEN J. LOEB
414 Chestnut Lane,
East Meadow, NY 11554.

FILAMENT CHECKER

The filament checker in the "Antique Radio" section of **Radio-Electronics**, December 1986, should use a 1.5-volt battery and a #49 lamp. Using the #14 bulb and a 3-volt source could blow out old battery tubes with 1.4-volt, 50-mA filaments. Ignoring the inrush resistance of a #14 lamp, 2.3 volts would be applied to a 1.4-volt filament. A fresh, new tube might stand that, but not a 40-year-old relic. (Of course, your local distributor probably has a shelf full of 1A7's worth $1.25 each.)

STEVE DOW
Powell River, BC, Canada

POWER-SUPPLY OVERLOAD

Your "Service Clinic" and "Service Questions" are my favorite parts of **Radio-Electronics,** and I am very disappointed when either or both do not appear, as happens occasionally.

This letter is occasioned by the letter from A.H., Eureka, CA, entitled "Power-Supply Overload." Your reply is fine, but I want to call to your attention another possible explanation, because I have encountered similar problems at least a couple of times in the past.

The most recent was a TV set in which the TV filament was supplied from the horizontal-output transformer, but rectified by a single diode. There was no picture, and I found that there was no voltage at the socket's filament terminals. However, I checked with the socket removed from the tube and found that the full voltage was present.

After some searching and testing, I discovered that one of the diode (rectifier) connections had resistance that did not affect the reading without the tube, but was high enough to drop the voltage with the load of the tube filament. Present-day meters use so little current that that can easily happen with a poor solder joint.

CHARLES W. MARTEL
Belmont, MA.

MEMORIES

I read with interest the query concerning razor-blade radio detectors in the December 1986 section of "Letters" in **Radio-Electronics**. It brought back memories of the sets built when I was just a teenager, using scraps and junk scrounged from the junkbox of a local radio repairman.

RON E. CASH
Pierre, SD

continued on page 29

EQUIPMENT REPORTS

Sencore LC75 "Z Meter II"

Measure inductance and capacitance at the touch of a button!

CIRCLE 9 ON FREE INFORMATION CARD

BECAUSE THE MODERN IC-BASED CIRcuit usually has tighter parameters than the older vacuum-tube and transistor designs, the inductors and capacitors used in the circuit must likewise have tighter parameters, or at the very least, be tested within a narrower range of tolerances. Much, if not all of the older service-grade LCR test equipment has neither the precision nor the testing capabilities needed to ensure proper performance from the capacitors and inductors used in modern circuits.

Critical parameter tests of capacitors and inductors require new techniques of measurement, and that is precisely what's to be found in *Sencore's "Z meter II."*

The Z Meter II uses an autoranging 3½ × 0.5-inch LED display to indicate: capacitor and inductor values; capacitor leakage, inter-element capacitor leakage, capacitor effective series resistance, capacitor "memory," and air-core coil shorted turns and opens.

No bridges

Unlike conventional C and L meters that employ some kind of bridge configuration to determine reactance (which is then interpolated to capacitance and inductance values), the Z-meter measures both directly. Capacitance is determined by measuring how long it takes to charge an unknown capacitor to +5 volts through a precision resistor. (Remember: t = RC.) Inductance is determined by measuring the *emf* caused by a constantly-varying current in the coil being tested.

The capacitance test range is 1 pF to 200,000 µF in 10 automatically-selected ranges. Accuracy is ± 1% of reading + resolution error ± 1 pF to 1000 µF, with the reading error increasing to ± 5% above 1000 µF.

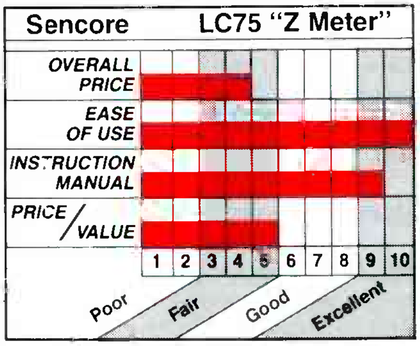
The inductance test range is 10 µH to 2 H in 6 automatic ranges. Accuracy is ± 2% of reading + resolution error.

In addition to capacitance value, a stepped variable output voltage range of 3- to 600-VDC permits capacitors to be tested for leakage at their operating voltage (not necessarily their rated voltage); charts are provided showing the leakage limits for various capacitor types and test voltages. The stepped variable output voltage can also be used to "reform" electrolytic capacitors.

Unusual tests

Two other unusual Z-meter capacitor tests are those for *dielectric absorption* and *ESR* (*E*quivalent *S*eries *R*esistance). Dielectric absorption is the inability of a capacitor to completely discharge. It is often referred to as "memory," or "battery action," and all capacitors have some amount of dielectric absorption. Until the age of critical solid-state circuits, high values of dielectric absorption passed unnoticed. Unfortunately, modern circuits can be disabled by unusually high dielectric absorption, which usually goes undetected by conventional service-grade capacitor tests. (It's the unseen force that can "blow" computer components if you fool with the circuit even after the powerline has been disconnected.) The Z-meter, on the other hand, will uncover excessive capacitor "memory."

All electrolytic capacitors have ESR—equivalent series resistance—which is not usually a problem in non-critical circuits. When it is a problem, it usually can't be determined by conventional test equipment. The Z-meter has a one-button test for ESR.



Two inductor tests

The Z-meter actually has two kinds of inductor tests. The conventional kind determines the value of an unknown inductor. The second test is a "ringing current" test used to determine the condition of non-iron-core coils, such as TV yokes and flybacks. Basically, the ringing test measures the coil's "Q."

It works this way. The Z-meter applies a single pulse to a coil and then digitally counts the number of ringing cycles produced by the pulse until the signal is damped to the reference level. For most non-iron-core coils, 10 ringing cycles is considered "normal," or "good." A shorted coil will lower the Q and produce less than 10 ringing cycles, while an open coil will produce no ringing. So, less than 10 rings, or no rings, means a bad yoke or flyback.

Actually, any air-wound coil can be ring-tested; however, because of their low impedance, coils of less than 10 μH usually display only 2 to 4 rings.

Tracing defective cables

Both the capacitance and inductance functions can be used to determine cable lengths, or the distance to either a short-circuit or an open in a length of cable. Open coaxial cable is capacitive. To determine the length of a cable or the distance to an open you simply measure the capacitance of one foot of cable, then measure the input capacitance of the open cable. Divide the open-cable reading by the 1-foot value and you'll be very close to the distance to the end of the cable, or the distance to the open.

The same technique is used for shorted cable. However, a shorted cable appears inductive rather than capacitive. Measure the inductance of a one-foot length of cable that is shorted at the far end and use the indicated value as a reference. Then measure the inductance of a length of cable that you believe has an internal short-circuit. Divide the total cable-reading by the 1-foot value and you are within inches of the short-circuit's location.

How do we get within inches of an open or a short? It works this way. Assume the problem is an open length of RG-59. You measure an exact one-foot length and find it has a capacitance of 27 pF. You measure the defective cable and find its capacitance is 859 pF. Dividing 859 by 27 give you 31.8. In other words, the open is 31.8 feet from the input to the cable. Since 0.8 foot equals almost 10 inches (actually 9.6), the open is 31 feet, 10 inches from the input to the cable. Allowing for assorted measurement errors, the open will be near, but probably not precisely, 31.8 feet.

Measuring very small values

A logical question is "What happens when capacitor and inductor values get so small they are actually less than those of the test leads and wires." Good question, but the Z-meter has a good answer. A front panel control that is normally used to balance out the test lead inductance or capacitance can be used as an offset for small values. For example, it is no problem to balance out the inherent capacitance of the test leads by using the front panel *LEAD ZERO* control. However, that doesn't solve the "window" problem of digital measurement—a small area that must be overcome before the instrument reads. For example, a 2-pF capacitor won't push the reading off zero because of the window's inertia; but the basic reading can be offset to perhaps 10 pF by the *LEAD ZERO* control. Connecting a 1-pF capacitor will result in a reading of 11-pF. Since you know that 10 pF is an offset value, the true value must be 11 pF less 10 pF, or 1 pF. The offset measurement procedure is used the same way when measuring very small inductor values

While the intricacies of the measurement systems give an appearance of complexity, the Z-meter is notably easy to use because the readings themselves are autoranging, thereby restricting function selectors to only a few switches and controls. Stepped selectors are provided for the *DC leakage/capacitor reform* output voltages and the inductance ringing tests. Rocker switches are provided for *leakage range* (aluminum electrolytics or all other types) and power. A conventional potentiometer is used for the test-lead zeroing. Five push-buttons are used for: capacitor leakage, value, and ESR: and inductor value and the ringing tests.

For the infrequent times when you must hold down a button—such as when using the leakage test to reform an electrolytic capacitor—a small spring-loaded device is provided that slips between the handle and the button, which keeps the function button depressed as long as needed.

User calibration

Non-laboratory (user) calibration of the digital reading is made possible by three screwdriver adjustments (located on the rear apron) for *Zero Meter Reading*, Capacitor Zero (with test leads open), and *ESR zero*.

The Z-meter has a fused BNC input connector. It is supplied with a test cable terminated in miniature-hook test clips: Adapters are provided for making connection to capacitors having screw terminals.

The Z-meter is list-priced at $995. For additional information on the instrument, write to Sencore, 3200 Sencore Drive, Sioux Falls, SD 57107. **R-E**

NEW LIT

INFORMATION BOOKLET, the *Surface Mount Technology Handbook*, is 24 pages, letter size, on coated stock, and is fully illustrated with photos, tables, and diagrams.

Among the points covered are: board retention, strain relief, housing insulators, thermal mismatch, materials, lead design, automated PC-board assembly, and solder-reflow methods.

The handbook includes a glossary of SMT terms, and a description of the surface-mounting process. Last but not least, the handbook contains a catalog of Molex's surface-mount connectors. Available free on request from **Molex Incorporated,** 2222 Wellington Ct., Lisle, IL 60532.

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CIRCLE 71 ON FREE INFORMATION CARD

LETTERS

continued from page 22

GATED SYNC DESCRAMBLER

We've made a number of modifications to the gated-sync descrambler that was featured in the February 1987 issue of **Radio-Electronics**. In addition, several errors crept in.

Starting with the modifications, resistor R1 has been deleted. Resistor R3 is now connected between R2 and the cathode of D1. C15 has been replaced by a 3–40-pF trimmer connected in parallel with a 47-pF fixed unit. L2 is now 18 µH fixed unit.

Also, if you require AM detection of the sound subcarrier, the following modifications can be performed: Connect C27 to pin 4 of IC2 (rather than pin 12 of IC4). Increase C11 to 100 pF. Remove three turns from L1; it will now be 5½ turns on an 8-32 screw. When tuning L2, it should be adjusted for the appropriate sound subcarrier (65.75 MHz for Channel 3 or 71.25 MHz for Channel 4) as you now want to pass sound and reject video. If you have trouble rejecting the video, you can also try adding a trap to IC2. That trap should consist of a 100-pF NPO capacitor and 5½ turns of No. 22 enamelled wire on an 8-32 screw. Connect the trap in series between pin 7 of the MC1330 and ground. For more information see *Video Scrambling and Descrambling for Satellite and Cable TV* (H.W. Sams), by the authors.

Turning to the errors. There are several mis-identified components on the PC board (Fig. 2). There are two C5's; the one located between C18 and L2 is actually C15. There are two R20's; the potentiometer located below switch S1 is actually R30. There are two R21's; the one located above C3 is R29. There are two C14's; the one located between R14 and R15 is actually C19. There are two C20's; the one located below IC5 is actually C30.

Finally, C13 and C22 should both be 0.1-µF units and C24 should be a 39-µF unit; a 47-pF unit can also be used for C24.

RUDOLF F. GRAF and WILLIAM SHEETS **R-E**

NEW PRODUCTS

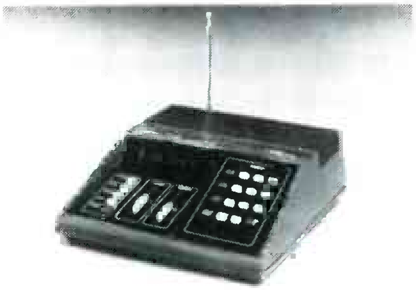
CIRCLE 30 ON FREE INFORMATION CARD

SOUND SENDER, is a device that makes it possible to play a portable cassette player, Walkman, or CD player through an FM auto-sound system by merely plugging it in to the cigarette lighter of a car, truck, van, RV, or boat. There is no extra wiring needed.

The device elimiates the need for earphones while driving, which are prohibited by law in many states. It also reduces the possibility of theft, because the cassette radio in the dashboard is usually the target of thieves.

The *Sound Sender* weighs 2 ounces and consists of a small plastic housing (4½" × 1¾" × 1⅜") and a wire with a cigarette-lighter plug at one end and a jack for a cassette player at the other. The suggested retail price is under $30.—**Dynasound Organizer,** a Division of Hartzell Manufacturing, Inc., 2516 Wabash Ave., St. Paul MN.

SCANNER, the Regency model *R1070*, has ten channels, and can receive more than 15,000 frequencies over six of the most popular public-service bands, including VHF-low (30–50 MHz), VHF-amateur (144–148 MHz), VHF-high (148–174 MHz), UHF-amateur (440–450 MHz), UHF (450–470 MHz), and UHF-T (470–512 MHz). No crystals are required, and the scanner is pre-programmed with 10 of the most-popular frequencies.



CIRCLE 31 ON FREE INFORMATION CARD

Programmed frequencies can be changed or added by touching the fingertip controls. A dual-level vacuum-fluorescent digital display flashes messages to aid in programming; and once a frequency is entered into a channel, a special test key automatically verifies the frequency, while checking all microprocessor functions.

In addition to scanning as many as 10 channels, the scanner can search an entire frequency range to find active frequencies. Other features include a channel lockout for skipping channels that are not of current interest, manual search and scan controls, and sliding volume and squelch controls. During a power failure, a built-in capacitor will save the frequencies in memory for several hours, without the need for batteries.

The Regency model *R1070* comes complete with an AC power-supply cord, telescopic antenna, and an easy-to-follow instruction manual. The suggested retail price is $159.95.—**Regency Electronics, Inc.,** 7707 Records Street, Indianapolis, IN 46226.

MINIATURE HANDHELD DMM, the Circuitmate model *DM78*, is designed for the electronics hobbyist, but is also convenient for computer and field technicians to carry as a supplement or backup to their larger DMM.

CIRCLE 32 ON FREE INFORMATION CARD

The model *DM78* has 0.7% accuracy: It includes diode test, continuity test, and autoranging capabilities. The meter weighs 3½ ounces, including the supplied carrying case. It can measure AC or DC voltages over the four ranges of 2-, 20-, 200-, and 450-volts, full scale. Resistance ranges on the model *DM78* are 2K, 20K, 200K, and 2000K, full scale. Bandwidth is specified as 40–500 Hz. There is overload protection to 650-volts DC or peak AC, and the battery life is 70 hours. Test leads are included.

The model *DM78* is priced at $29.95.—**Beckman Industrial Corporation,** 630 Puente Street, Brea, CA 92621.

CD-PLAYER ADAPTOR, the Sparkomatic model *CDA50,* will allow portable compact-disc players to be played through a car-stereo system. It operates by inputting a standard FM-stereo signal having a carrier frequency of 90.1 MHz into the antenna input of the car radio.

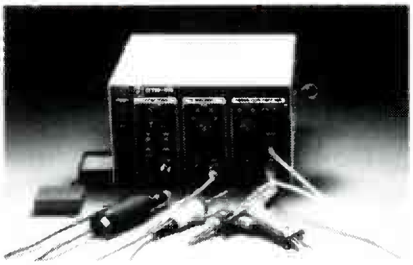
A switch is incorporated into the adaptor that turns on the unit; power-on status is indicated by an LED. The switch also disconnects the external antenna so that the only signal reaching the car radio will be that of the model *CDA50.*

CIRCLE 33 ON FREE INFORMATION CARD

In addition to compact-disc players, the unit can be used for playing portable cassette players that have a line out or headphone jack. The unit also provides a 9-volt output that is suitable for powering audio equipment requiring that voltage. The unit is intended for under-dash mounting, and appropriate mounting brackets are supplied. The model *CDA50* has a suggested retail price of $19.95.—**Sparkomatic Corporation,** Milford, PA 18337.

REPAIR STATIONS, the OK Industries model *BTR-55,* (shown), the model *BTR-35,* and the model *BTR-25,* are self-contained repair stations specifically developed to meet the requirements of delicate multilayer PC-board rework.

The desolder section of the model *BTR-55* features a 100-watt desoldering tool; spike-free operation; pistol-grip handpiece; accurate temperature indication via thermocouple tip-temperature sensing; temperature adjustable 280°C – 470°C (535°F – 800°F); heavy duty, quick-rise diaphragm pump; adjustable hot-air blower; 24-volt handpiece; long-life desolder nozzles.



CIRCLE 34 ON FREE INFORMATION CARD

The solder section features: spike-free operation; 48-watt, heavy-duty soldering iron with thermocouple tip-temperature sensing; and temperature control adjustable from 280°C – 470°C (535°F – 880°F).

The hand-tool section features: 12-volt DC drill and grinder; variable power output, continuously adjustable up to 16,500 rpm, and 3-volt AC output.

The model *BTR-35* combines the same performance features as the model *BTR-55* but without the hand-tool section. The model *BTR-25* contains the multi-layer desolder section of the model *BTR-55*.

The BTR series systems start at $565.00.—**OK Industries,** 3455 Conner Street, Bronx, NY 10475.

DMM, the A.W Sperry Instruments model *DM-1* "Pocket Pro" is a miniature, 3½ digit, ultra slim digital multimeter that provides the measurement capabilities of a 14-range digital instrument in a pocket-calculator size.

CIRCLE 35 ON FREE INFORMATION CARD

The model *DM-1* measures a mere 4.2" in height, is 2.0" wide, 0.4" deep, and weighs 3.5 ounces. It features autoranging, manual ranging, electronic overload protection on all ranges, auto-polarity, and audible-continuity indication.

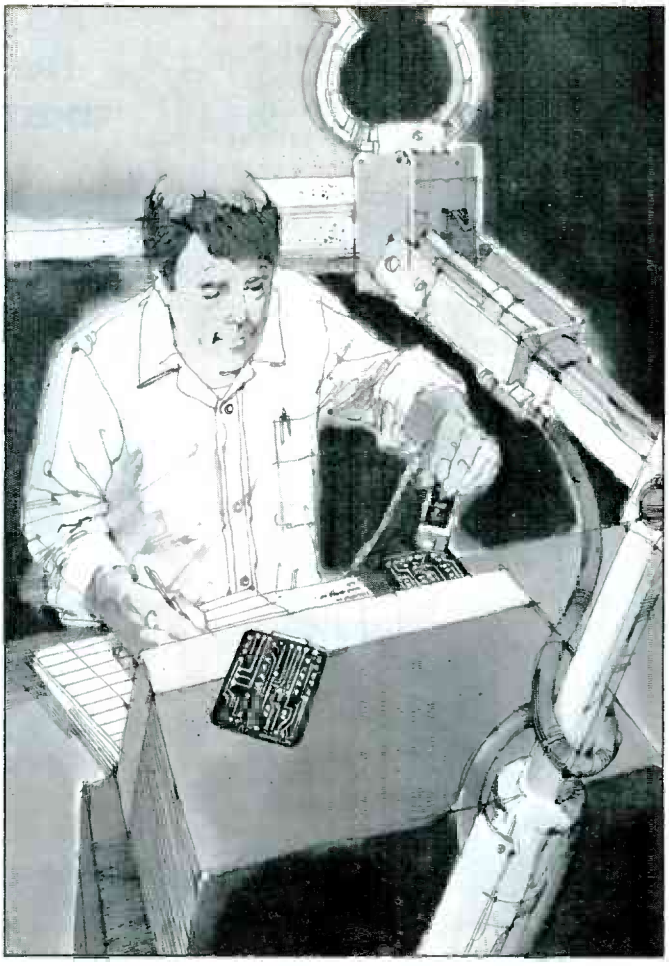
The model *DM-1* comes with two 1.5-volt LR-44 button-type batteries, a carrying case, built-in test leads, and one-year warranty; it is priced at $29.95.—**A. W. Sperry Instruments, Inc.,** 245 Marcus Boulevard, Hauppage, NY 11788.

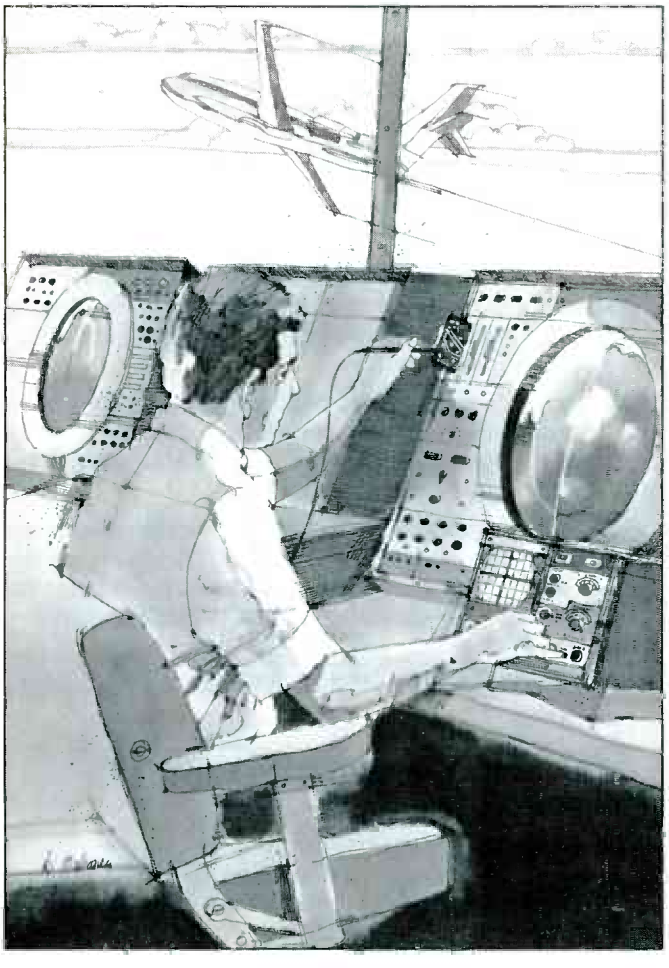
SCREWDRIVER, the model *T-15* Torx driver, features an extra-long 9¾" blade. It makes servicing difficult-to-reach areas of MacIntosh and other personal computers a

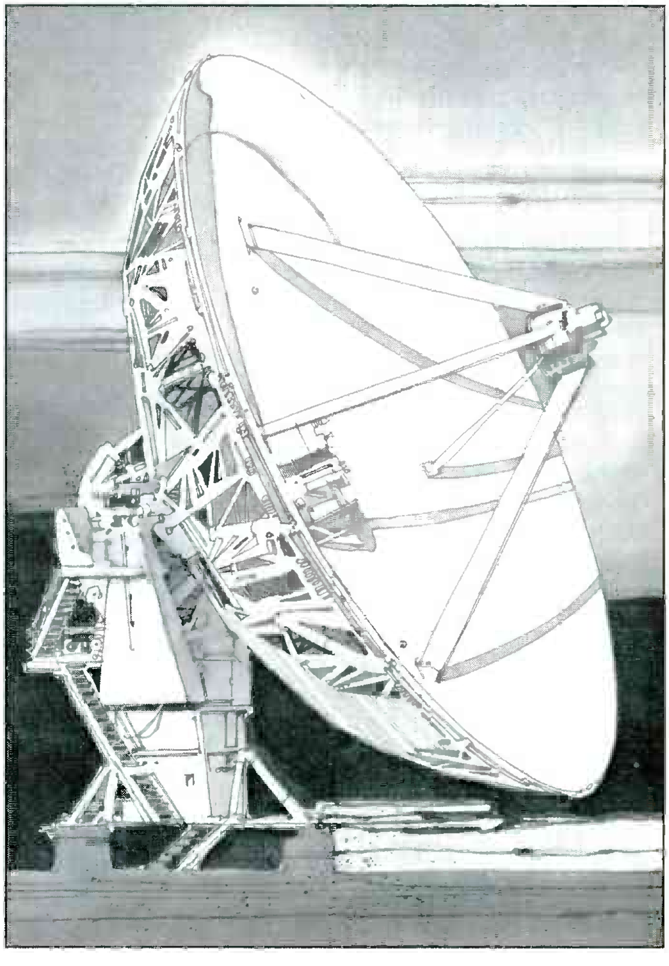
CIRCLE 36 ON FREE INFORMATION CARD

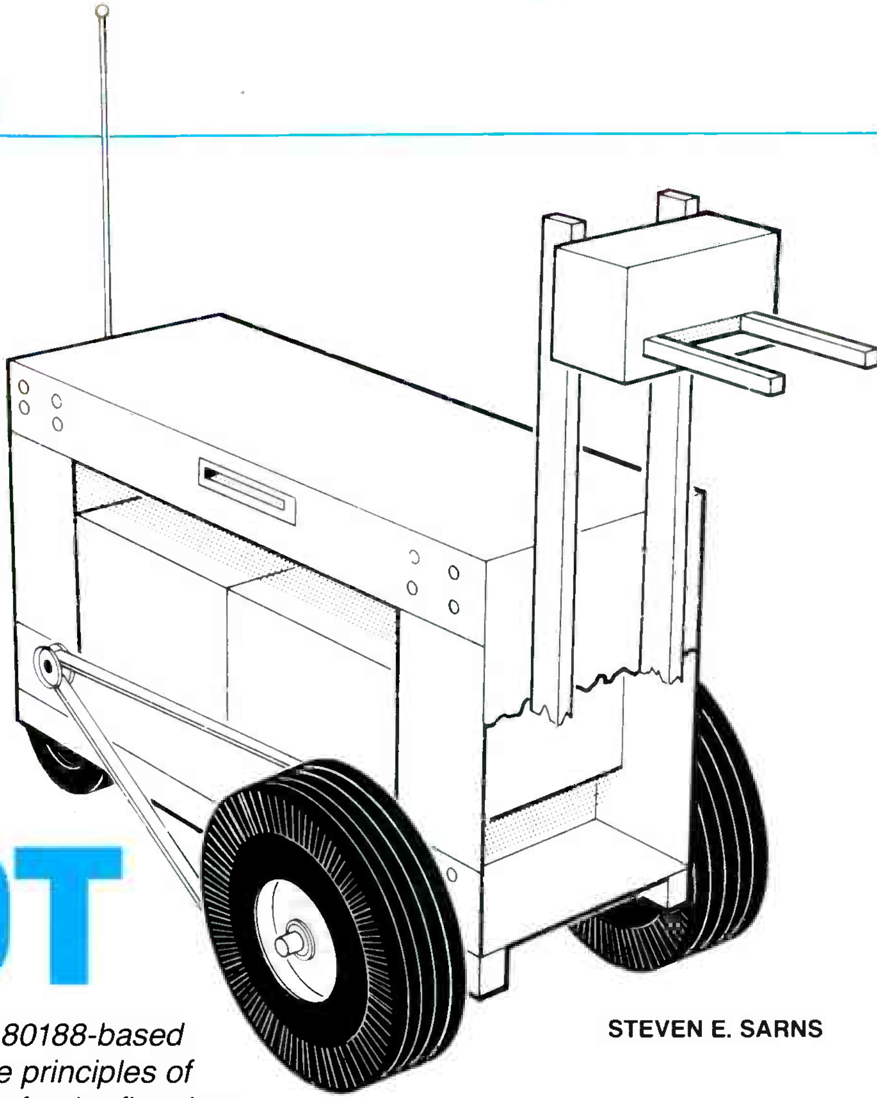
far-easier task. The overall length is 13¼", with a break-resistant plastic handle. The model *T-15* is priced at $6.95.—**Jensen Tools, Inc.,** 7815 South 46th Street, Phoenix, AZ 85044. **R-E**

CIRCLE 181 ON FREE INFORMATION CARD









R-E ROBOT

Here are the hardware details of the 80188-based computer board. We also discuss the principles of bringing up a microprocessor system for the first time.

STEVEN E. SARNS

THE ROBOTIC PERSONAL COMPUTER (RPC) was introduced in the January 1987 issue. To gain an overall understanding of how the board works, see the block diagram (Fig. 1), and the memory (Fig. 3) and I/O maps (Fig. 4) presented in that issue. Now we'll discuss the basics of how the separate sub-sections function, and then go on to discuss construction and debugging.

Data buses

To begin, note that three functionally equivalent but electrically isolated data buses exist on the RPC. The data-bus outputs of the 80188 feed IC14, which feeds the three buses: the expansion bus (see Fig. 1), the memory bus (through IC16, shown in Fig. 2), and the auxiliary bus (through IC17, shown in Fig. 3).

The microprocessor's address bus is buffered by IC15, IC22, and IC21; the outputs of those octal latches feed the expansion connector and all on-board IC's that need access to the address bus.

The 80188's major control signals are buffered by IC13, which also buffers the microprocessor's timer output, which in turn feeds the resulting signal through C18 to speaker SPKR1. The 8259 interrupt controller connects to the auxiliary data bus through IC17. Three-to-eight line decoder IC41 decodes the microprocessor states for the expansion bus.

Memory interface

The RPC provides decoding for sixteen RAM/ROM sockets in two 64K banks (ØØØØ:ØØØØ to ØØØØ:FFFF and 1ØØØ:ØØØØ to 1ØØØ:FFFF). However, due to PC-board space limitations, the upper bank (IC44–IC51), if used, must be mounted physically above the lower bank (IC1–IC8). Only the chip-enable ($\overline{CE}$) pins (pin 20 of each IC) are routed to separate pads. The parts-placement diagram, which appears along with the PC pattern in PC service, indicates how those pins are connected.

Otherwise, the memory interface is fairly straightforward. Octal transceiver IC16 provides an isolated bus for the low-memory RAM (IC1–IC8, and IC44–IC51). The two three-to-eight line decoders (IC11 and IC12) provide the $\overline{CE}$ signals for the low-memory IC's. In a similar manner, half of two-to-four line decoder IC39 provides the $\overline{CE}$ for the BIOS and language ROM's (IC23, IC24, IC30, IC31).

Several jumpers (JU1, JU2, JU10–JU13) allow you to provide a different decoding scheme, or to accommodate RAM IC's of other sizes. Jumpers JU3–JU9, when connected as shown, allow you to provide battery backup for selected (or all) low-memory RAM IC's. Note that the jumpers enable and disable battery backup in pairs (IC1 and IC44, IC2 and IC45, etc.). If battery backup is not desired (for example, if EPROM's are used in low-memory sockets), the appropriate jumper(s) should be grounded.

Clock and disk controller

As shown in Fig. 3, gates IC28-a–IC28-c, IC27-a, and IC26-d decode the 80188's peripheral select, read, and write lines, to enable the WD1770 disk controller (IC34) when appropriate. Data-bus buffering is provided by IC17 (which also feeds most of the RPC's peripheral circuits); IC37 provides outputs for selecting one of four drives. One bit (Q4, pin 12) of IC37 drives an LED that indicates disk drive activity; another bit (Q3, pin 9) provides the $\overline{STROBE}$ signal for the parallel printer interface (shown in Fig. 4).

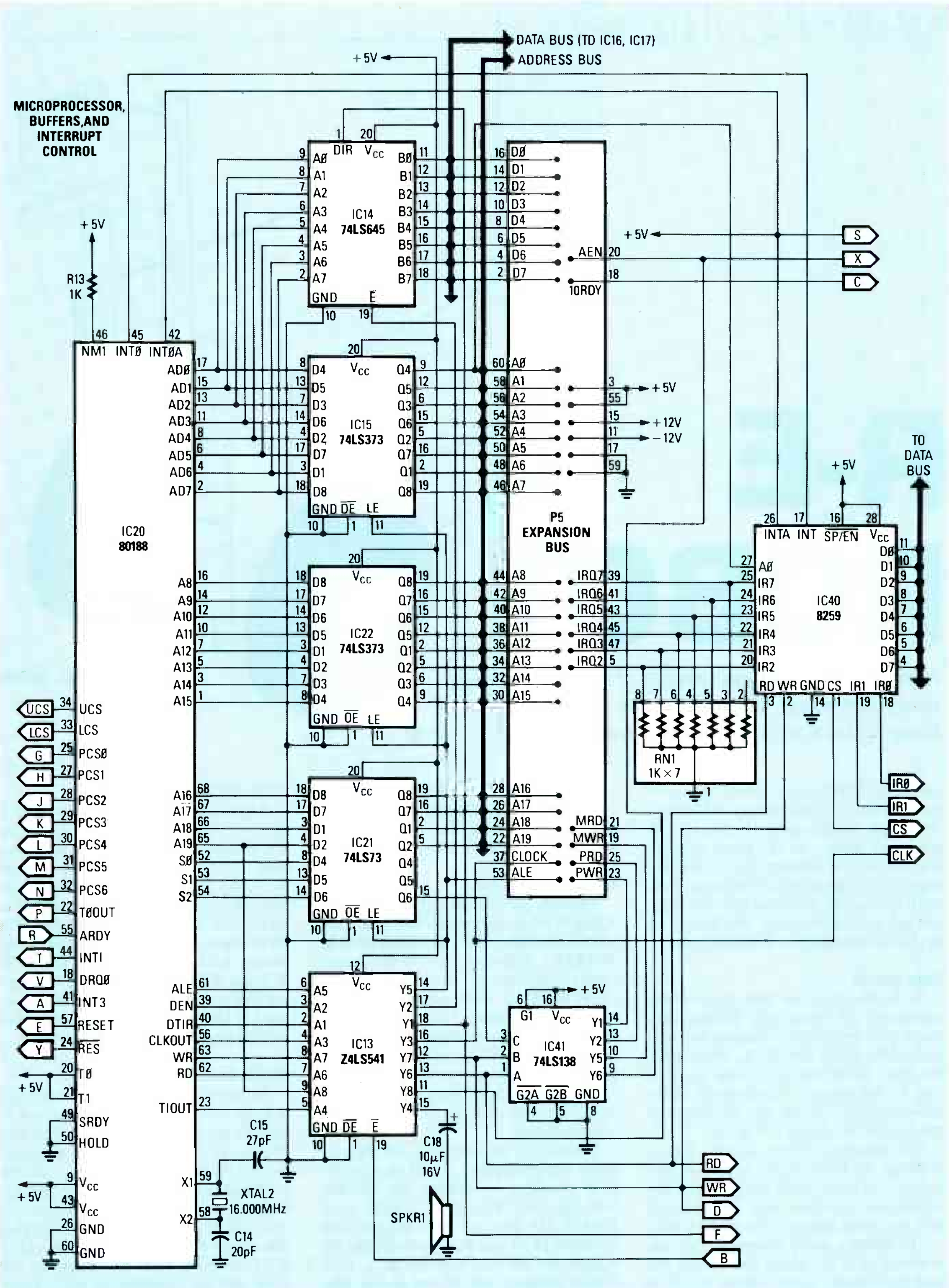


FIG. 1—THREE OCTAL LATCHES, IC15, IC21 and IC22 buffer the microprocessor's address line. The output of those latches feed the expansion bus and any on-board IC's that need access to the address line.

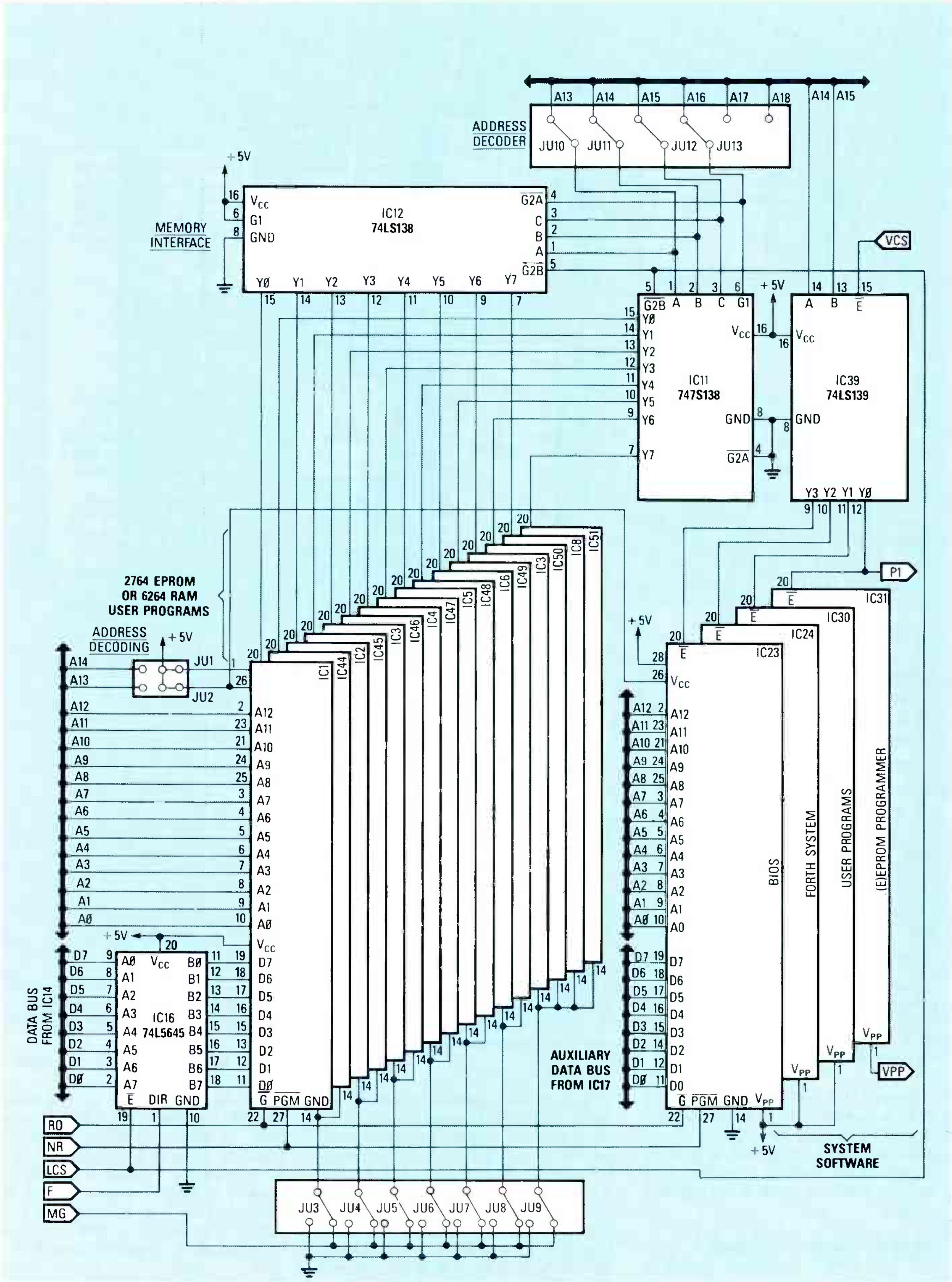


FIG. 2—DECODING FOR 16 RAM/ROM SOCKETS, in two 64K banks, is provided by the Robotic Personal Computer.

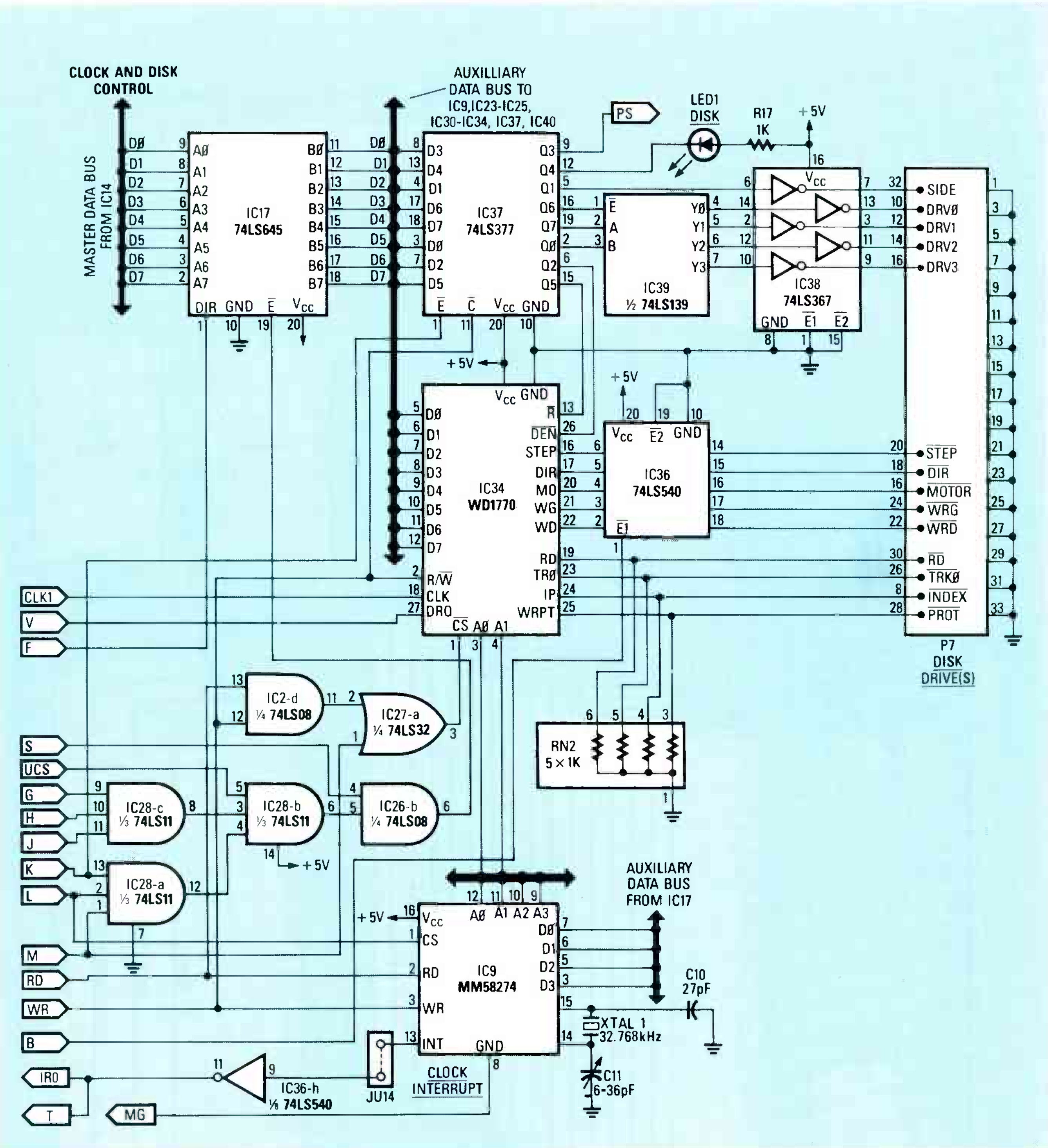


FIG. 3—SIX GATES are used to decode the microprocessor's peripheral select, read, and write lines to enable the disk controller when appropriate.

The clock IC is a National MM58274; it can be programmed to provide one interrupt or continuous interrupts at one of seven selected intervals, ranging from 0.1 second to 60 seconds. Jumper JU14 provides hardware defeat of the interrupt output.

Serial and parallel interfaces

A dual UART, the 28-pin version of Signetics' 2681, is used for serial communications; the IC has a built-in software-programmable baud-rate generator. As shown in Fig. 4, Channel A of the DUART, accessed through P1, is dedicated for use by a standard ASCII terminal. Channel B, accessed through P2 (for RS-232 signal levels) or P4 (for TTL levels), is an auxilliary port for use with a serial printer, modem, etc. Level translator IC18 converts the +5-volt outputs of the DUART to RS-232 levels. Jumper JU16 allows you to defeat the "busy" input of DUART channel B; JU17 allows you to select TTL or RS-232 input to Channel B.

The data lines of the parallel printer port (P6) are driven by IC33, an eight-bit latch. As mentioned above, the STROBE signal for latching data in the printer is provided by IC37 (shown in Fig. 3). The printer's BUSY and ERROR outputs are buffered by IC32, as are the separate positions of DIP switch S1. Table 1 shows the meanings of the various settings of S1.

Power supply

The RPC requires only +5 volts at

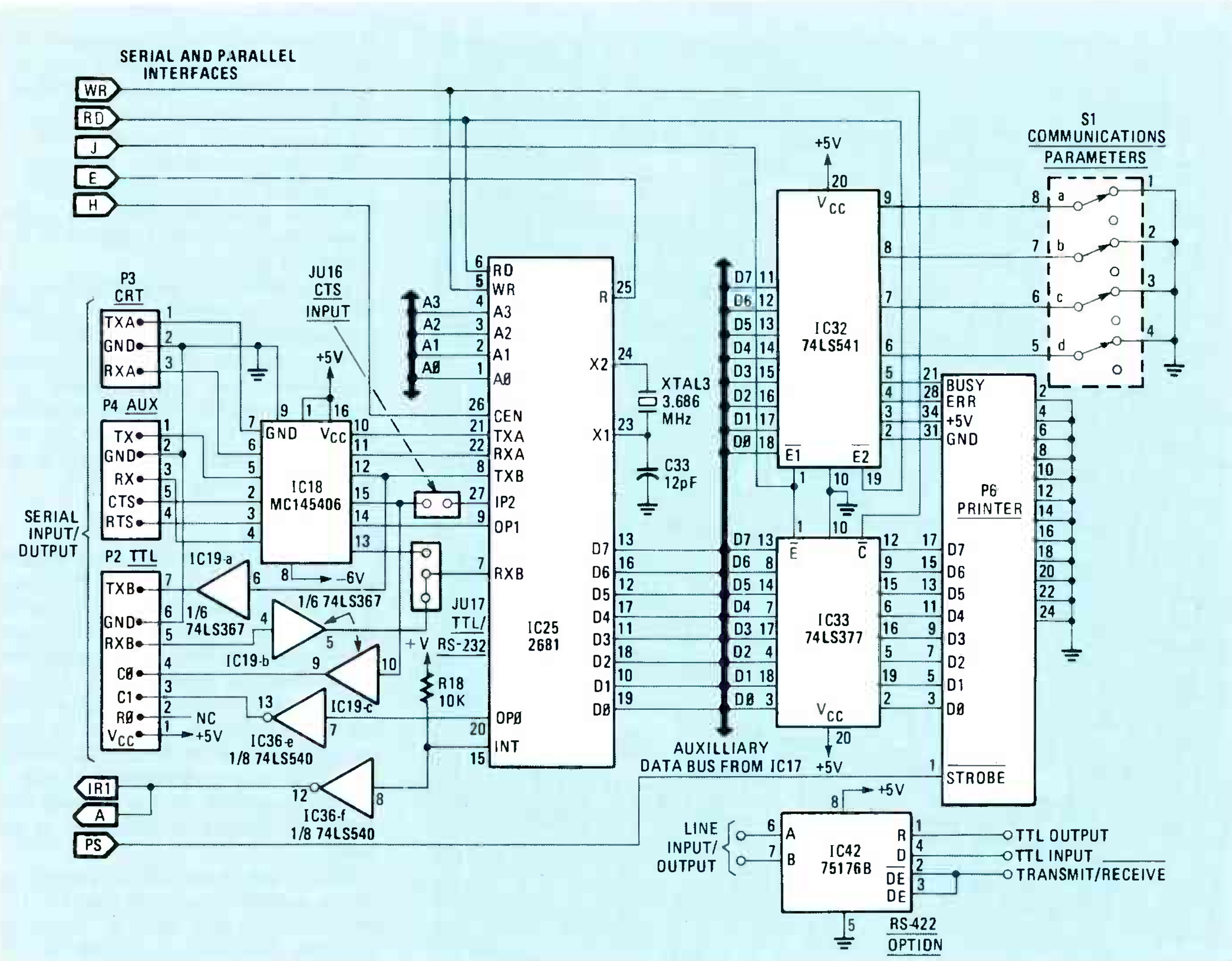


FIG. 4—A DUAL UART is used for serial communications. The IC used, a 28-pin Signetics 2681, has a built-in programmable baud-rate generator.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.

R1, R8, R10, R15, R18, R21—10,000 ohms
R2, R3, R9, R11, R13, R14, R17—1000 ohms
R4, R6, R7—100,000 ohms
R5, R20—unused
R12—1 megohm
R16—10,000 ohms, trimmer potentiometer
R19—15 megohms
RN1—1K × 7 SIP resistor pack
RN2—1K × 5 SIP resistor pack

Capacitors

C1, C34—unused
C2–C9, C12, C19–C32, C35–C38, C40, C42–C50, C52, C53—0.1 µF, bypass
C10, C15, C33—27 pF, disk
C11—6–36 pF variable trimmer capacitor
C13, C18—10 µF, 16 volts, electrolytic
C14—20 pF, disk
C17, C39—100 pF, disk
C41—4.7 µF, 16 volts, electrolytic
C51—1 µF, 35 volts, tantalum

Semiconductors

IC1–IC8, IC44–IC51—6264 RAM or 2764 EPROM
IC9—MM58274, clock
IC10—LM393, op-amp
IC11, IC12, IC41—74LS138, 3-to-8 line decoder
IC13, IC32—74LS541, octal buffer
IC14, IC16, IC17—74LS645, octal transceiver
IC15, IC21, IC22—74LS373, octal latch
IC18—MC145406, RS-232 line driver/receiver
IC19, IC38—74LS367, hex buffer
IC20—80188, microprocessor
IC23, IC24, IC30, IC31—BIOS and language EPROM's (see text)
IC25—SCN2681AC1N28—Dual UART (Signetics)
IC26—74LS08, quad two-input AND gate
IC27—74LS32, quad two-input OR gate
IC28—74LS11, triple three-input AND gate
IC29—TL497, switching regulator
IC33, IC37—74LS377, octal latch
IC34—WD1770, floppy disk controller
IC35—LM336-2.5, precision voltage reference (2.5 volt)
IC36—74LS540, octal buffer
IC39—74LS139, dual 2-to-4 line decoder
IC40—8259A, interrupt controller
IC42—SN75176B, RS-422 controller (optional)
IC43—7555, CMOS 555 timer
D1–D3—1N4148 switching diode
D4—1N759 6.8-volt Zener diode
LED1—standard
Q1, Q2, Q4—2N3906, PNP transistor
Q3—2N3904, NPN transistor

Other components

L1, L2—56 µH coil
P1, P3—3-pin 0.025" post connector
P2—7-pin 0.025" post connector
P4—5-pin 0.025" post connector
P5—60-pin dual-row 0.025" post connector
P6, P7—34-pin dual-row 0.025" post connector
P8—4-pin 0.025" post connector
S1—four position DIP switch
S2—normally-open pushbutton switch
XTAL1—32.768 kHz crystal
XTAL2—16.000 MHz crystal
XTAL3—3.6864 MHz crystal

Note: The RPC is available from Vesta Technology, 7100 W. 44th Ave., Suite 101, Wheatridge, CO 80033; 303-422-8088

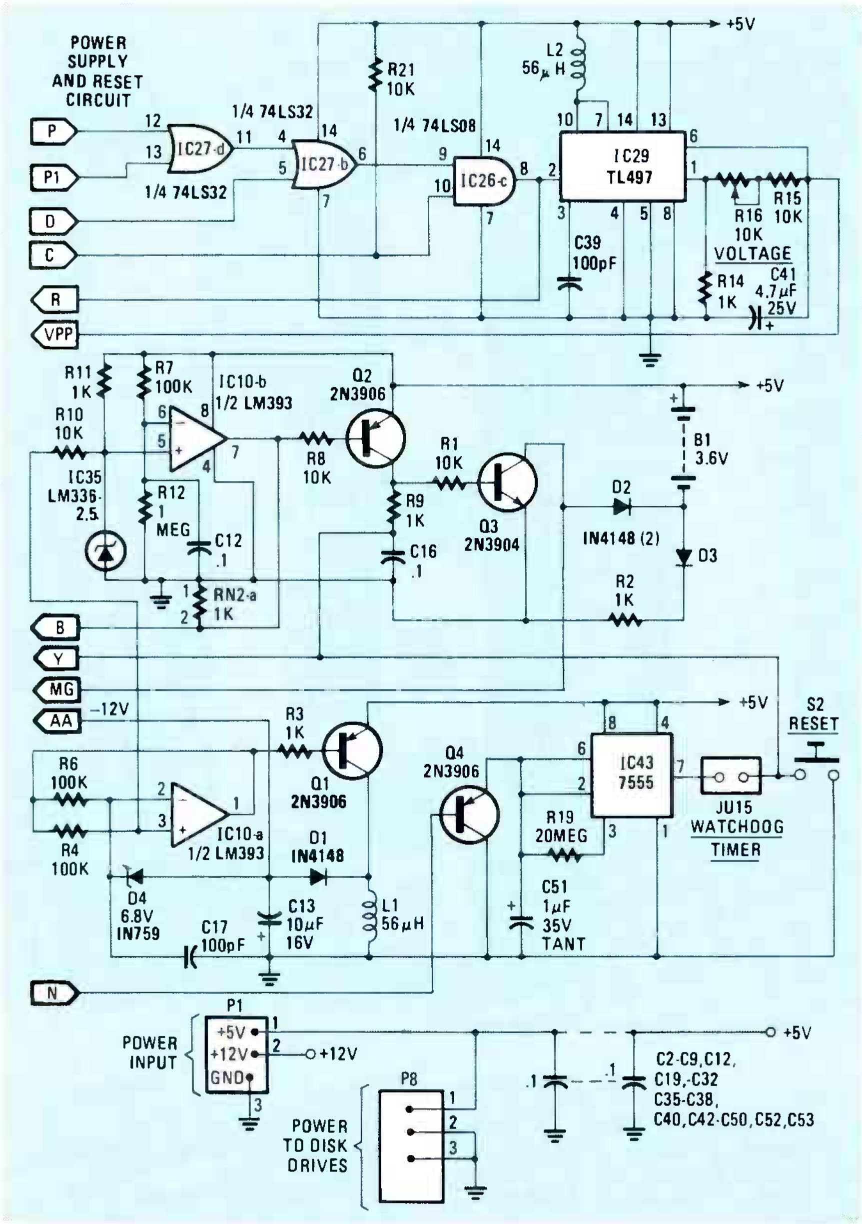


FIG. 5—THE COMPUTER CAN BE RESET using switch S2. Further, when jumper JU15 is installed, IC43 can provide reset pulses at fairly long intervals—30 seconds with the component values shown.

TABLE 1—S1 COMMUNICATIONS PARAMETERS

Positions a	b	c	d	Baud rate	Double-stacked memory socket
0	0	0	0	150	Yes
0	0	0	1	300	Yes
0	0	1	0	600	Yes
0	0	1	1	1200	Yes
0	1	0	0	2400	Yes
0	1	0	1	4800	Yes
0	1	1	0	9600	Yes
0	1	1	1	19200	Yes
1	0	0	0	150	No
1	0	0	1	300	No
1	0	1	0	600	No
1	0	1	1	1200	No
1	1	0	0	2400	No
1	1	0	1	4800	No
1	1	1	0	9600	No
1	1	1	1	19200	No

about 850 mA. The power connector (P1) also routes +12 volts to the disk-drive connector (P7) and the expansion connector (P5). The RPC does not itself use +12 volts; other necessary voltages are generated on-board. As shown in Fig. 5, IC29 is a switching regulator that provides the EPROM programming voltage (V_{PP}). Both 12- and 21-volt EPROM's can be accommodated by adjusting R16.

Op-amp IC10-a functions as an oscillator that generates the −6-volt supply for the RS-232 output; IC10-b provides a low-power detection circuit that applies power from battery B1 to the RAM IC's shown in Fig. 2.

The computer's reset function is handled by S2; in addition, IC43, a CMOS 555 timer, can provide reset pulses at fairly long intervals—30 seconds with the component values shown. Jumper JU15 must be installed for those pulses to have effect. As we'll see, resetting the processor periodically can be useful in debugging the hardware.

Construction

Due to the complexity of this project, we recommend that you use a PC board. A double-sided board with plated-through holes is available from the source mentioned in the Parts List; foil patterns for that board are presented in PC Service. If you etch your own board, allow some method of soldering each and every pad on both sides of the board. You should pass a thin jumper wire through all pads in which components are *not* mounted, and solder the jumper on both sides of the board.

Mount and solder all components as shown in the diagram in PC service. Use sockets for all IC's, but don't insert the IC's yet. We recommend that the PC board be wave soldered for several reasons:

- Solder will fill the plated-through holes, thereby increasing their reliability.
- The solder wave will cause the traces under the solder mask to reflow, thereby forming a better circuit.
- Wave-soldered joints are more reliable.

A local electronics assembly shop may be able to wave solder the board for you. After soldering, remove all solder flux and check all work carefully.

Testing and debugging

The next step is the most exciting—and the trickiest. Bringing up an untested microprocessor system is a difficult task, especially without the aid of sophisticated test equipment. However, the following has served us many times, using only a 50-MHz dual-channel oscilloscope.

The first task is to check power distribution. Use an ohmmeter to confirm that the +5-volt line is not shorted to ground. Next, apply power, and check all sockets for power at the correct pins.

The next step is to try to execute code. Install the microprocessor and all of the support circuits required to read from ROM (IC11–IC17, IC21, IC22, IC39). In-

continued on page 102

BUILD THIS

COMMERCIAL ZAPPER FOR YOUR RADIO

MARK RUMREICH

Bothered by commercial interruptions on FM? Kill 'em with this zapper.

MANY SMALL OFFICES USE FM EASY-LISTENING stations to supply background music. Often, the commercials broadcast by those stations are unobjectionably loud. If you'd like to restore peace and quiet to your office, just connect our commercial killer in your receiver's tape-monitor loop. The circuit automatically senses large changes in volume and reduces output accordingly. In addition, it's easy to build, and inexpensive.

How it works

The commercial killer monitors the incoming signal and reduces output according to how much the input resembles a commercial (we'll discuss how it makes its decision in a moment). In reducing output, the commercial killer takes account of the past few seconds of signal in determining how much to reduce output. Doing so reduces the number of errors and creates a smoother overall effect as it fades out of commercials and fades into music. It is less objectionable to miss the first few seconds of music than to hear the first few seconds of a commercial, so the commercial killer has different attack and decay times.

Whether a signal is "commercial-like" is determined by the rate of large volume transitions. Because music (especially that on "light" stations) is typically composed of a number of instruments playing more or less continuously, the volume (or envelope) stays fairly constant over a short period of time. In a typical commercial, however, the instantaneous volume changes rapidly over time as the announcer pauses between words, and as various additional sound sources are mixed in and out.

Music with much dynamic range (rock and roll, for example) has a high rate of large volume transitions, so the commercial killer probably will trigger erroneously with that type of music.

Figure 1 shows a block diagram of the commercial killer. A summing amplifier adds the left- and right-channel inputs. The summing amp has adjustable gain so that you can find the optimum signal level for the station you use the commercial killer with.

Next comes an envelope detector, which produces a waveform that represents the instantaneous volume of the signal. A comparator (with hysteresis) produces a transition whenever the output of the envelope detector goes either above or below pre-set thresholds. The output of the comparator is conditioned via the transition converter, which produces a pulse of fixed width and amplitude for each transition of the comparator. Those pulses feed a "leaky integrator," whose output determines the gain of the left and right VCA's (*V*oltage *C*ontrolled *A*mplifiers). The output of the leaky integrator is a DC voltage whose value depends on the pulse rate from the transition converter.

The VCA's are what actually reduce the output signals during commercials. An LED connected to the VCA's provides a visible indication of the amount of volume reduction taking place.

Figure 2 shows the schematic of the circuit. Diodes D5–D8 form a bridge rectifier that feeds Zener diode D9, which provides a regulated single-ended 16-volt supply for the circuit. Because a single-ended supply is used, a reference voltage (V_{REF}) is generated via the voltage divider composed of R36 and R37 and transistor Q3. That reference voltage is used to bias the op-amps precisely.

Op-amps IC1-a and IC1-b function as buffers that drive both the summing amp (IC2-a) and the VCA's (IC1-c and IC1-d). The outputs of IC1-a and IC1-b are, of course, biased to the reference voltage. To achieve maximum dynamic range, a positive envelope detector follows the

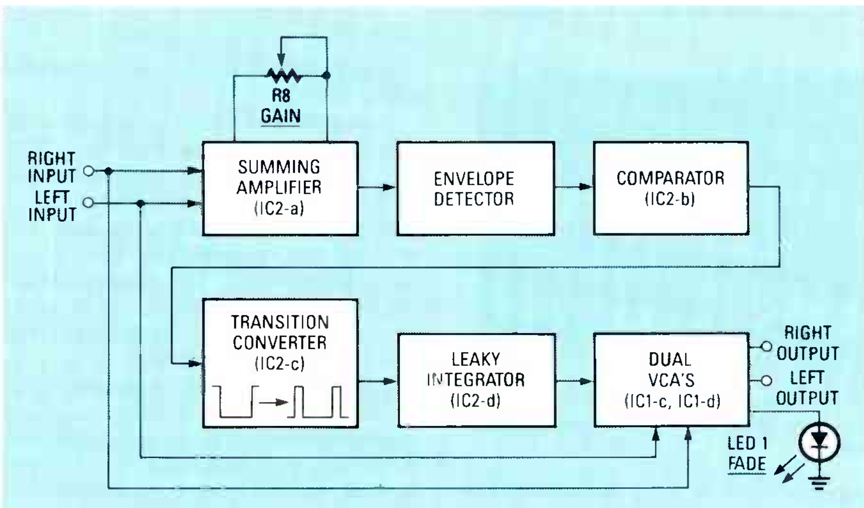


FIG. 1—BLOCK DIAGRAM OF THE COMMERCIAL KILLER: The envelope of the signal is used to vary the pulse rate from IC2-c. The pulses are integrated; the resulting signal controls the gains of a pair of VCA's.

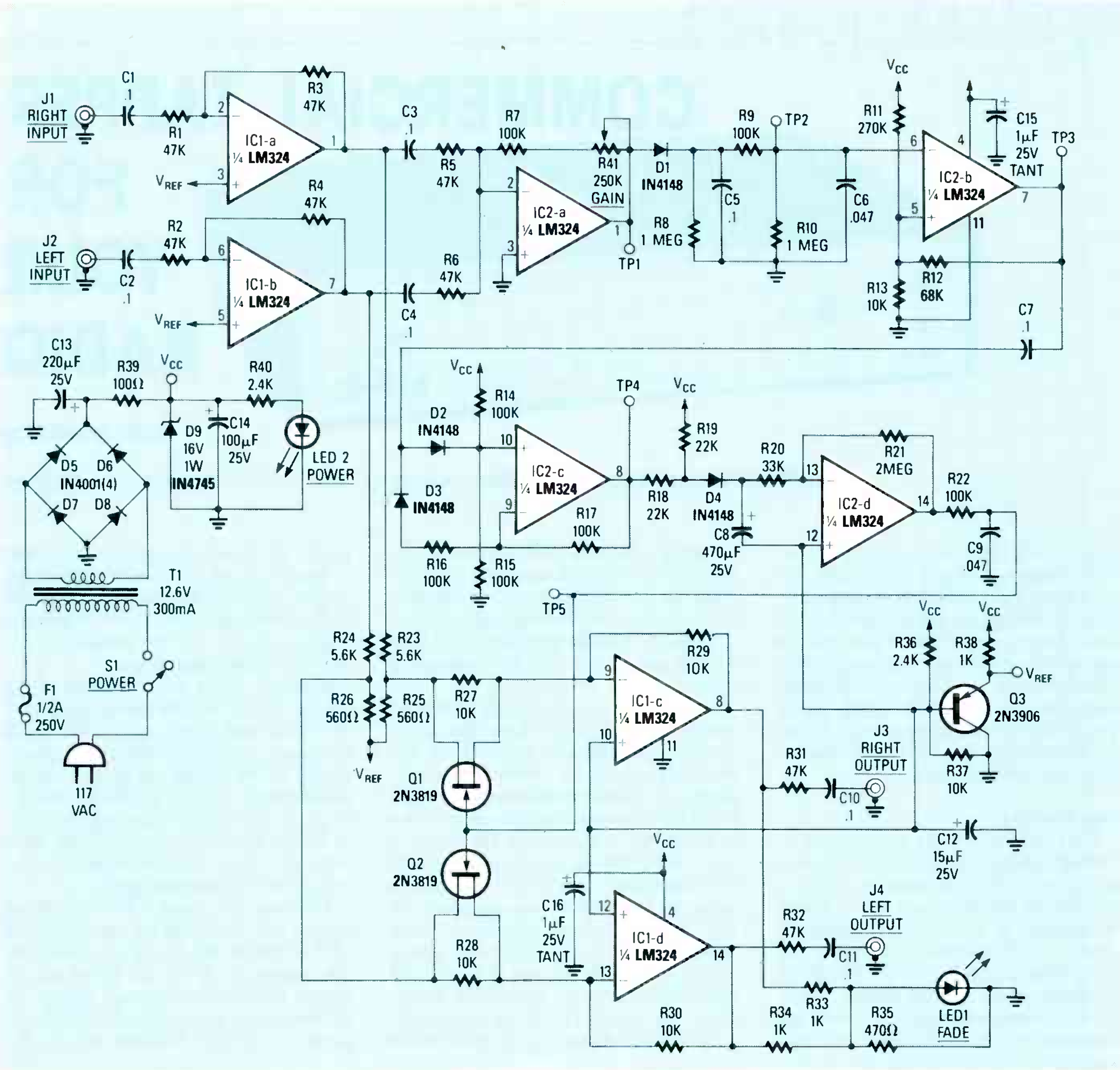


FIG. 2—THE COMMERCIAL KILLER'S SCHEMATIC: Q3 provides a reference voltage for the op-amps; Q1 and Q2 control the gain of IC1-c and IC1-d.

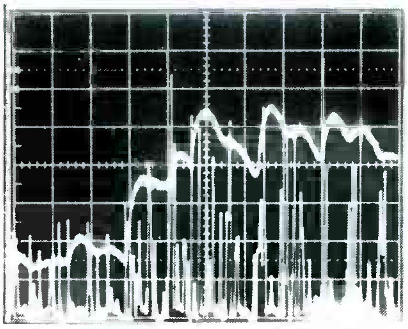


FIG. 3—THE SPIKES represent L + R audio, and the smooth trace, the output of the envelope detector.

summing amp (IC2-a); that allows the summer to be referenced to ground (not V_{REF}). The envelope detector has a second-order network optimized for normal audio material.

Figure 3 shows typical waveforms at the output of the summing amplifier (TP1), and the corresponding waveform at the output of the envelope dectector (TP2). The spiked traces represent the audio signal, and the smooth trace riding above them, the envelope. The summer's channel is set for 1 volt/division, and the envelope detector for 0.5 volt/division. The timebase is 20 ms/division.

Referring back to the schematic (Fig. 2), IC2-b is used as a comparator. As mentioned earlier, the comparator has two thresholds; the signal must cross both before the output changes from positive to negative (or vice-versa). The equations describing the lower and upper threshold voltages (V_{LO} and V_{HI}, respectively) as functions of the supply voltage and bias resistors are as follows:

$$A = (R12 \times R13) / (R12 + R13)$$

$$V_{LO} = (A \cdot V_{CC}) / (A + R11)$$

$$B = (R11 \times R12) / (R11 + R12)$$

$$V_{HI} = (R13 \cdot V_{CC}) / (R13 + B)$$

In this case, $V_{LO} \approx 0.5$ volts and $V_{HI} \approx 2.48$ volts.

Figure 4 shows the envelope-detector's output (TP2) at 0.5 volts/division and the comparator's output (TP3) at 2 volts/division (both at 20 ms/division). The square waveform in the center of the photo is the comparator's output; the other waveform is the envelope detector's output. Notice that the comparator does not respond to

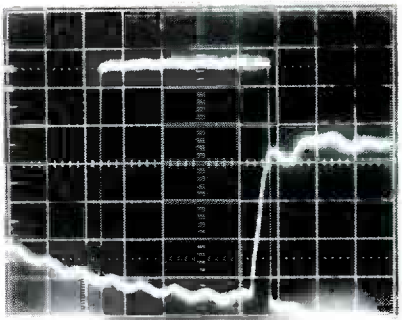


FIG. 4—THE SQUARE WAVEFORM represents the output of the comparator; the other waveform is the output of the envelope detector.

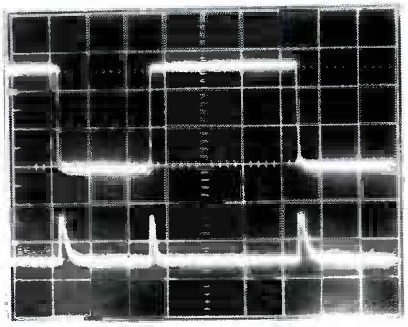


FIG. 5—THE COMPARATOR'S OUTPUT is shown in the upper trace; the output of the transition converter is shown in the lower trace. Every time the comparator changes state, another pulse is generated.

the minor transitions in the early part of the waveform; the comparator's output changes state only after both thresholds have been crossed.

Because the inverting input of the comparator is used for threshold detection, the output is inverted with respect to the input. The comparator responds to specifically designed threshold levels, so it is important that the output of the summing amp provide that level. We'll show how to make the adjustment later.

Figure 5 shows a typical output of the transition converter (TP4) along with the corresponding input from the hysteresis comparator, in the upper and lower traces, respectively. The transition-converter waveform is shown at 5 volts/division, with the bottom graticule at 0 volts; the timebase is 100 ms/division. Notice that the baseline is approximately eight volts ($V_{CC}/2$); that is due to the bias at the non-inverting input of IC2-c.

The leaky integrator (IC2-d) produces a DC voltage that depends on the pulse rate from the transition converter. When no pulses are present, diode D4 is reverse-biased, and the output of IC2-d will be equal to the voltage present at its non-inverting input, V_{REF}. When pulses arrive, diode D4 is forward-biased, so the voltage across capacitor C8 increases. The output of IC2-d then decreases by a factor of about 60 (R21/R20). When the pulse rate is high, the output voltage will be between six and nine volts, thereby providing minimum gain from the VCA's. But when the pulse rate is low, capacitor C8 will discharge through resistor R20 to V_{REF}, thereby restoring the gain op-amp to maximum.

The trick about the VCA circuits is that a matched pair of N-channel JFET's act as voltage-controlled input resistors. When gate-to-source voltage (V_{GS}) is near 0 volts, the FET acts as a small resistor, and gain is maximum—about 5 dB with respect to the output of the buffer stages (IC1-a and IC1-b).

However, when V_{GS} is less than -3 volts, the FET acts as a large resistor, so the gain of the op-amp is minimized—it provides about 20 dB of attenuation. In order to provide good left/right matching, the two FET's should have similar voltage and current characteristics, especially at drain-to-source voltages of 0.6 volts.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.

R1–R6, R31, R32—47,000 ohms
R7, R9, R14–R17, R22—100,000 ohms
R8, R10—1 megohm
R11—270,000 ohms
R12—68,000 ohms
R13, R27–R30, R37—10,000 ohms
R18, R19—22,000 ohms
R20—33,000 ohms
R21—2 megohms
R23, R24—5600 ohms
R25, R26—560 ohms
R33, R34, R38—1000 ohms
R35—470 ohms
R36, R40—2400 ohms
R39—100 ohms
R41—250,000 ohms, trimmer potentiometer

Capacitors

C1–C5, C7, C10, C11—0.1 µF, ceramic disc
C6, C9—0.047 µF, ceramic disc
C8—470 µF, 25 volts, electrolytic
C12—15 µF, 25 volts, electrolytic
C13—220 µF, 25 volts, electrolytic
C14—100 µF, 25 volts, electrolytic
C15, C16—1 µF, 25 volts, tantalum

Semiconductors

IC1, IC2—LM324 quad op-amp
D1–D4—1N4148 signal diode
D5–D8—1N4001 rectifier diode
D9—Zener diode, 16 volt, 1 watt (1N4745 or similar)
LED1, LED2—standard
Q1, Q2—2N3819 N-channel JFET
Q3—2N3906 (or similar)

Other components

J1–J4--Chassis-mount RCA connectors
F1—Fuse, 0.5 amp, 125 volts AC
S1—SPST, 1 amp, 125 volts AC
T1—Transformer, 12.6 volts, 300 mA (Radio Shack 273-1385 or similar)

NOTE: The following are available from MFR Engineering, 5333 N. Guilford, Indianapolis, IN 46220: Etched and drilled circuit board, $11; matched set (Q1 and Q2) $2.50 All prices postpaid. Indiana residents must add applicable sales tax.

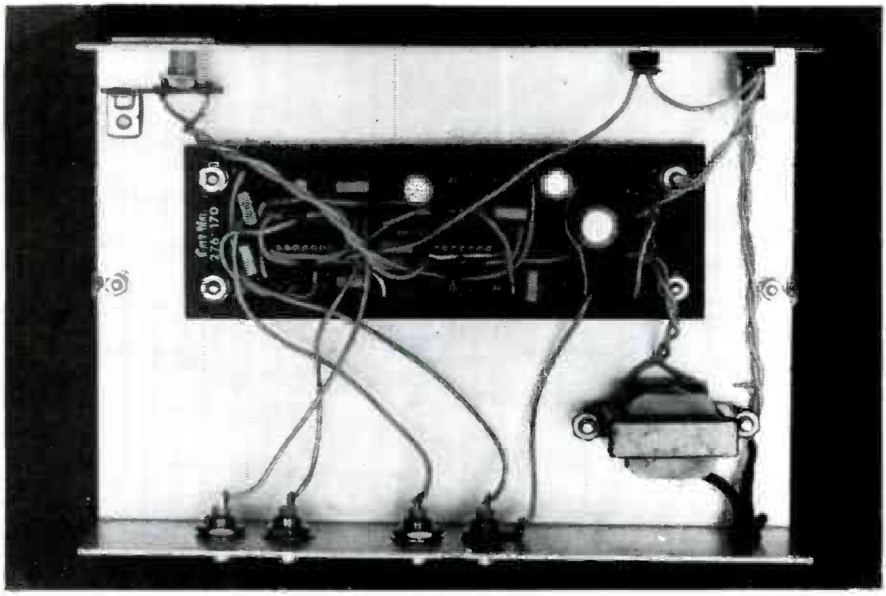


FIG. 6—THE AUTHOR'S PROTOTYPE was built on a piece of perfboard using point-to-point wiring. Keep your lead lengths short, and be careful with the 117-volt primary circuit.

Construction hints

Figure 6 shows the author's prototype, which was built on a piece of prototype board. The author used two LM324 quad op-amps, because they're inexpensive and easy to obtain. However, slightly better frequency response and signal-to-noise ratio may be obtained by replacing the op-amps with low-noise JFET op-amps (TL074's, for example). Whichever op-amps you use, make sure that the buffer amps (IC1-a–IC1-d) are not in the same physical package as the processing amps (IC2-a–IC2-d). Also, be sure to connect a good decoupling capacitor, near the IC, from the V_{CC} pin to ground.

Alignment and troubleshooting

To align the commercial killer, adjust the detector-gain potentiometer (R41) to

continued on page 75

BUILD THIS

Concerned about acid rain? This inexpensive monitor will keep you informed.

WALTER D. SCOTT

ACID RAIN MONITOR

THE EFFECTS OF ACID RAIN HAVE BEEN widely debated, often with little hard evidence to back up either side's point of view. Actually, it's not difficult to provide hard evidence. A simple one-transistor circuit can be used to sense the acidity of local rainfall (and other liquids). Accuracy is as good as the source used to calibrate the meter. The project can be built for about $30 using all new parts; many of the parts are of the junkbox variety, so with just a little bit of luck the cost could be even less.

The sensor can be mounted in a remote location; it has a built-in solenoid-operated drain valve. The meter indicates acidity in terms of pH, which refers to the concentration of hydrogen ions in a solution. The meter's range is from 7 (neutral) to 2.5 (highly acidic).

How it works

The schematic diagram of the circuit is shown in Fig. 1. A simple bridge rectifier and 12-volt regulator powers the MOSFET sensing circuit. The unregulated output of the bridge rectifier operates the drain solenoid via switch S1. The sensor itself is built from two electrodes, one made of copper, the other of lead. In combination with the liquid trapped by the sensor, they form a miniature lead-acid cell whose output is amplified by MOSFET Q1. The maximum output produced by our prototype cell was about 50 μA.

MOSFET Q1 serves as the fourth leg of a Wheatstone bridge. When sensed acidity causes the sensor to generate a voltage, Q1 turns on slightly, so its drain-to-source resistance decreases. That resistance variation causes an imbalance in the bridge, and that imbalance is indicated by meter M1.

Construction

The circuit is simple, but the sensor must be built exactly as shown for calibration to be accurate. As shown in Fig. 2 and Fig. 3, the electrodes must have a diameter of ¼ inch, and they must be spaced ⅜ inch apart in a plastic funnel with a handle to ensure accurate calibration. The positive electrode is a 1½" length of ¼" copper tubing. The negative electrode is a strip of lead that is formed to the same size and shape as the copper electrode. You should be able to get lead strip from a sporting-goods store; it's used to make fishing sinkers. Otherwise, try a junkyard.

Use flux-less solid-core solder to make connections to the electrodes, and waterproof all exposed joints and wiring. Seal the electrodes in the bottom of the funnel by melting the plastic with a soldering iron, or plug the funnel with epoxy putty. Use a good-quality waterproof cable to connect the electrodes and solenoid to the control box.

The solenoid assembly must be waterproof, otherwise, water may leak into the solenoid housing and cause a short. But first, remove the valve and coat the plunger with grease, preferably silicone, for temperature resistance. Also, coat all metal solenoid parts with acrylic spray or clear lacquer. Then epoxy the solenoid's valve to the funnel stem through a 1" washer with a drain hole. Mount the solenoid in a 35mm film canister or other waterproof container. It may be necessary to trim off some of the valve's exit tube in order to fit it inside the 35mm film canister.

The method of fitting the solenoid to the cap of the film canister and the mount-

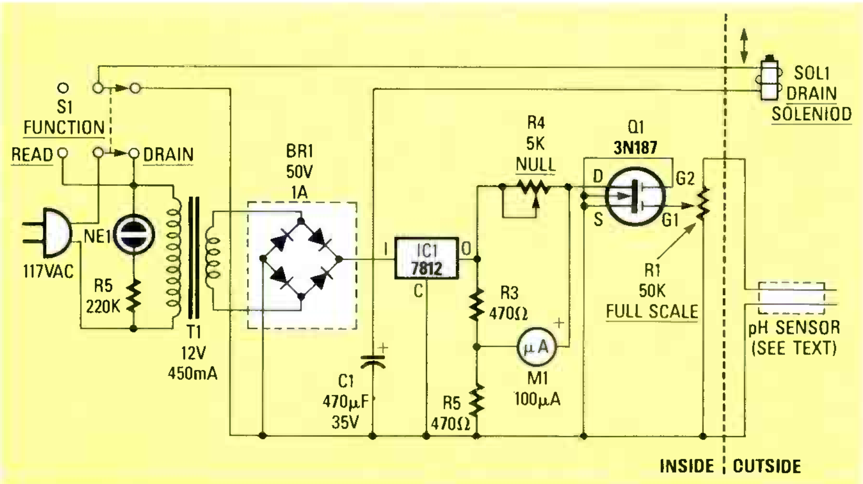


FIG. 1—THE DRAIN-TO-SOURCE RESISTANCE of Q1 varies depending on the acidity of the sample presented to Q1's gate circuit. That variable resistance varies the current flowing through the bridge; that current is proportional to pH.

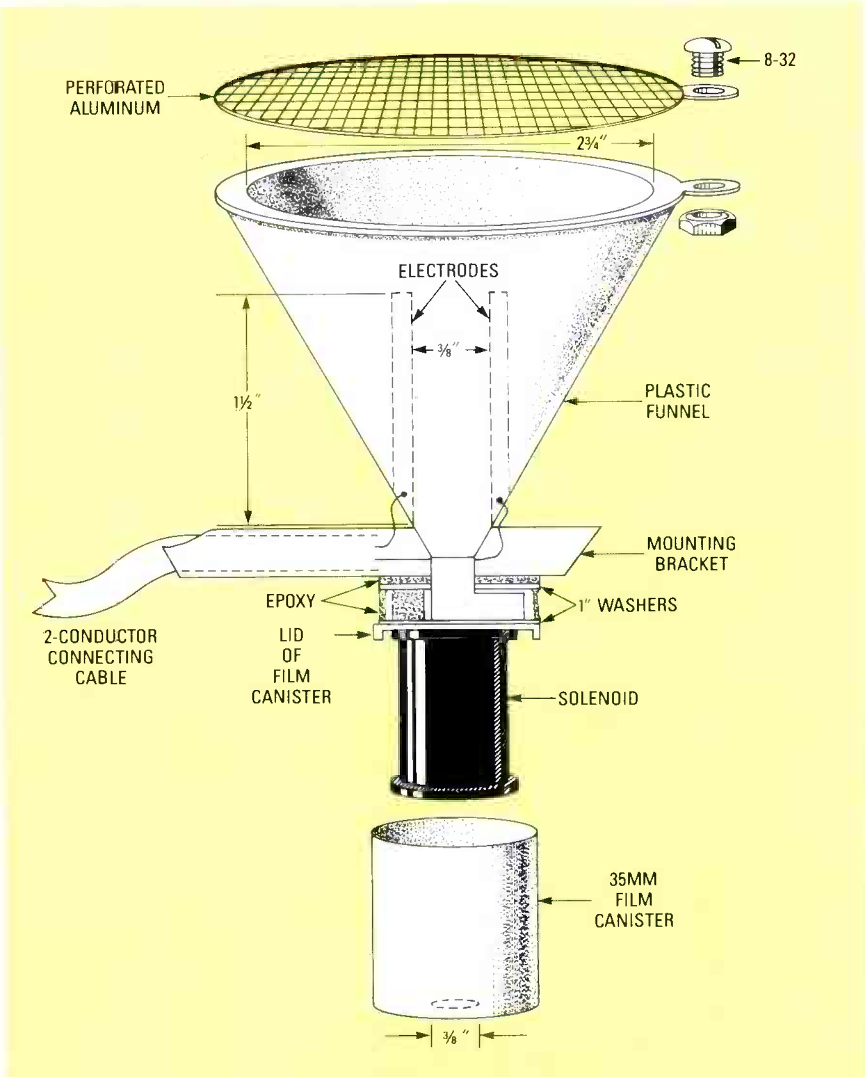


FIG. 2—TWO ¼-INCH ELECTRODES, made of copper and lead, are mounted inside the funnel, spaced ⅜-inch apart. A solenoid valve attached to the mouth of the funnel is used to drain it as necessary.

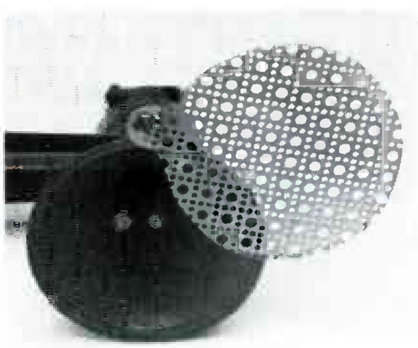


FIG. 3—CLOSE-UP OF THE FUNNEL assembly: the screen keeps foreign matter, which could affect pH, out of the funnel.

ing bracket will depend on the type of solenoid you have. Use epoxy, screws, or both.

As shown in Fig. 4, a swing-away filter cut from perforated sheet aluminum is bolted to the funnel's handle. In addition to preventing drain-clogging or electrode-shorting by air-borne particles, the screen prevents false pH readings that might be caused by pine needles, oak leaves, or other acidic contaminants. You should also coat the filter with lacquer to prevent aluminum-oxide contamination. Plastic screening is also available and may be used.

All parts were mounted and wired point-to-point on a piece of perfboard; the perfboard was then mounted in a case, as shown in Fig. 5.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.

R1—50,000 ohms, pc-mount, linear potentiometer
R2, R3—470 ohms
R4—5000 ohms, PC-mount, linear potentiometer
R5—220,000 ohms

Capacitors

C1—470 µF, 35 volts, electrolytic

Semiconductors

IC1—7812, 12-volt regulator
Q1—3N187 MOSFET transistor
BR1—50-volt 1-amp bridge rectifier

Other components

M1—100-µA panel meter
NE1—Neon lamp
S1—DPDT, 117-volt, toggle, center off
SOL1—12-volt DC solenoid valve
T1—12-volt 450-mA power transformer

TABLE 1—CALIBRATION

pH	µA
3	82
3.5	76
4	68
4.5	64
5	61
5.5	59
6	56
6.5	53

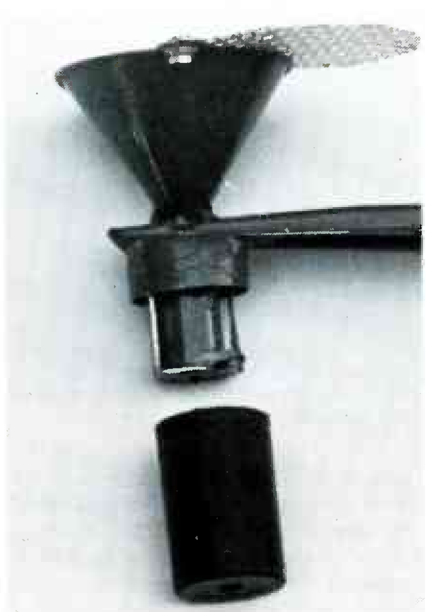


FIG. 4—A 35mm FILM CANISTER provides a water-tight enclosure for the solenoid valve.

Calibration

Our prototype was calibrated against a professional pH meter using precisely-diluted sulphuric acid (which is, by the way, a major ingredient of industrial pollution.) After setting the zero and full-scale points, you can calibrate the meter using Table 1. Otherwise, you can, as we did, measure known solutions with your meter and a professional meter, and mark your meter's scale accordingly.

The first step is to null the meter; 0 µA represents neutrality, a pH of 7. With the sensor connected through the same cable that will be used for the final installation, set R1 for lowest resistance and fill the receptor funnel with distilled water. Adjust R4 until the meter reads exactly zero.

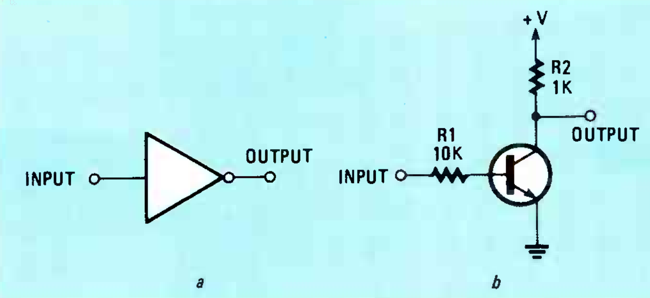
You'll need to connect a 1.5-volt battery in series with a 5,000-ohm linear potentiometer to calibrate the remaining

continued on page 73

LOGIC-GATE FUNDAMENTALS

A small group of simple logic elements is at the heart of all digital circuitry. We discuss how each element works in detail.

RAY MARSTON



INPUT	OUTPUT
0	1
1	0

c

FIG. 1—SHOWN HERE ARE THE INVERTER (*a*), a resistor-transistor implementation of it (*b*), and its truth table (*c*).

AND, NAND, OR, NOR, XOR, XNOR—ARE those the words to some children's song? No, they're the basic building blocks of digital electronics. And you have to understand how they work before you can tackle the microprocessor that controls your car, your stereo receiver, your VCR, even your dishwasher.

Logic elements come in many different forms, and they're built from both integrated circuits and discrete components. Many logic circuits may be designed in more than one way; a detailed understanding of the basic logic elements can help you optimize your design based on the materials at hand. We'll give specific examples of how that's done later; for now let's get our feet wet.

The inverter

Shown in Fig. 1 is the most basic element of digital electronics: the inverter. The symbol for an IC inverter is shown in Fig. 1-*a*; an inverter may also be built from discrete components, as shown in Fig. 1-*b*. However it's built, it functions according to the truth table shown in Fig. 1-*c*.

In any digital circuit, all input and output signals can be at only one of two levels, high or low. A logic high is usually represented by a "1," and a logic low by a "Ø." When the inverter's input is low (Ø), its output is high (1), and when its input is high (1), its output is low (Ø).

In the resistor-transistor circuit (Fig. 1-*b*), when the input is low, the transistor is cut off, so the output floats high. When the input is high, the transistor goes into saturation, so the output is pulled low.

In a sense, the inverter is the most versatile of all logic elements. As we'll see, it can be used to convert one type of logic gate to another (an OR gate, for example, to a NOR gate). A pair of inverters can be used to make a bistable latch, a monostable or astable multivibrator, etc. Also, the real-world inverter usually has a high input impedance and a low output impedance, so it can be used as an impedance buffer.

However, not all buffers are of the inverting type. Figure 2-*a* shows the standard circuit symbol of a non-inverting buffer, which can be made by cascading two inverters, as shown in Fig 2-*b*. The truth table in Fig. 2-*c* shows how the non-inverting buffer works: When the input is low, the output is low, and when the input is high, the output is high.

Of course, both inverters and buffers are available in IC form. For example, the 4049 and the 4069 are hex inverters, and the 4050 is a hex (non-inverting) buffer. The 4069 is especially useful, because it has high output-drive capacity, so it can drive TTL loads. In addition, its inputs can accept signals far greater than the supply voltage, so the gates can be used to translate signals between circuits operating at different voltages (a ten-volt CMOS circuit to a five-volt TTL circuit, for example).

The 4041 also has high output-drive capacity and can be used to drive TTL circuits. However, the 4041 cannot accept input signals greater than the supply voltage. The device is a quad inverting/non-inverting buffer, in which each input has both a true and an inverted output.

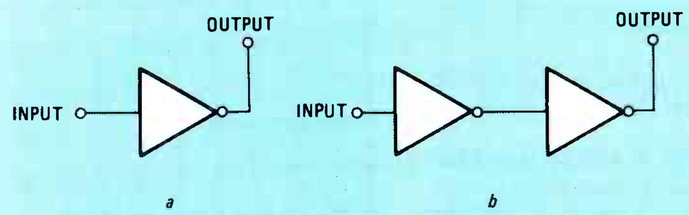
The 5402 is a hex inverting buffer capable of driving TTL loads. It has a controllable three-state output and an INHIBIT control (pin 12), which is normally held low, but which grounds all outputs when pin 12 is forced high.

OR and NOR gates

Figure 3-*a* shows the standard symbol of a two-input OR gate, and Fig. 3-*b* shows its truth table. As indicated by its name, the output of the OR gate goes high if any of its inputs goes high.

The simplest way to make an OR gate is with several diodes and a single load resistor, as shown in Fig. 4. The diode-based OR gate is reasonably fast, very cost effective, and can readily be expanded to accept any number of inputs by adding a diode to the circuit for each new input.

Closely related to the OR gate is the NOR gate. Figure 5-*a* shows the standard symbol of a two-input NOR gate, and Fig. 5-*b* shows its truth table. Note that the output is high only when both inputs are low.



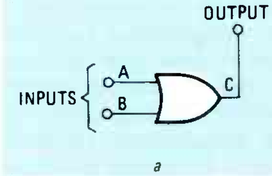
INPUT	OUTPUT
0	0
1	1

c

FIG. 2—SHOWN HERE ARE THE NON-INVERTING BUFFER (*a*), a dual-inverter implementation of it (*b*), and its truth table (*c*).

It's easy to convert an OR gate to a NOR gate; Fig. 6 shows several methods. As shown in Fig. 6-*a*, the diode-based OR gate can be followed by a transistor inverter to produce a NOR gate. Or, as shown in Fig. 6-*b*, a digital inverter can produce the same effect.

In fact, OR and NOR gates can function in a variety of other ways. As shown in Fig. 7-*a*, following an OR gate with an



A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

b

FIG. 3—THE TWO-INPUT OR GATE (*a*) and its truth table (*b*).

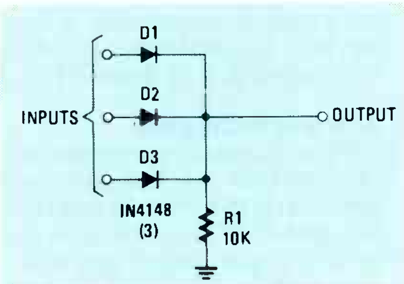
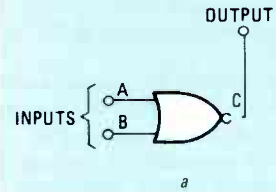


FIG. 4—A THREE-INPUT OR GATE may be built from several diodes and a resistor.



A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

b

FIG. 5—THE TWO-INPUT NOR GATE (*a*) and its truth table (*b*).

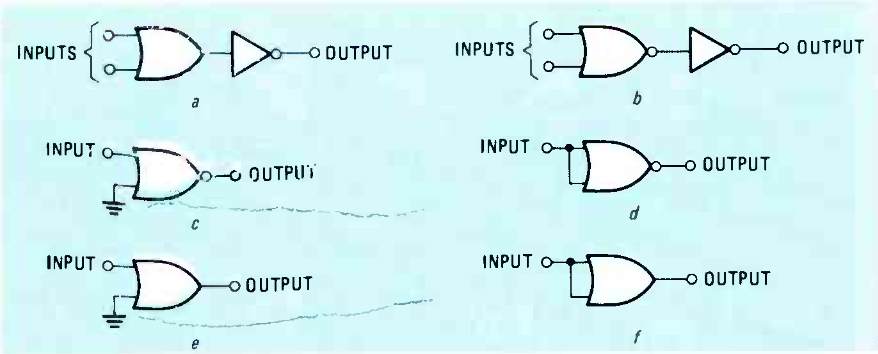


FIG. 7—BY COMBINING A NOR OR AN OR GATE WITH AN INVERTER, you can convert an OR gate to a NOR gate (*a*), or a NOR gate to an OR gate (*b*). To use a NOR gate as an inverter, ground the unused input(s) (*c*) or connect the inputs together (*d*). To use an OR gate as a buffer, ground (*e*) or short (*f*) the unused inputs.

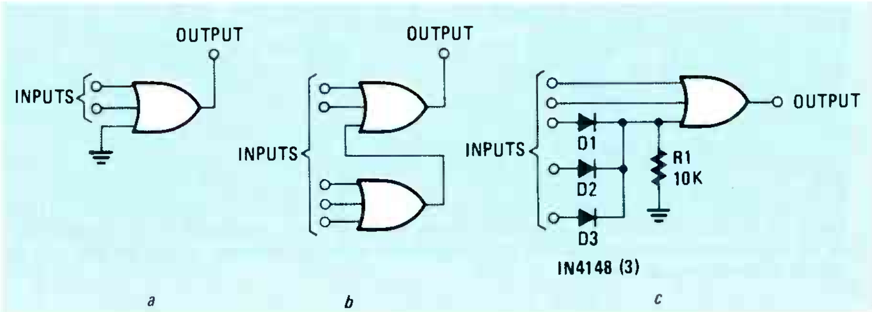


FIG. 8—GROUND UNUSED OR-GATE INPUTS (*a*); to increase the number of inputs, cascade gates (*b*), or use diode-resistor logic (*c*).

inverter produces a NOR gate. Similarly, following a NOR gate with an inverter produces an OR gate (Fig. 7-*b*). The NOR gate can also function as a simple inverter. Figure 7-*c* and Fig. 7-*d* show several ways of configuring a NOR gate as an inverter. Likewise, the OR gate can function as a simple buffer, as shown in Fig. 7-*e* and Fig. 7-*f*.

Sometimes a circuit requires more or fewer inputs than the available gates provide. For example, as shown in Fig. 8-*a*, you could ground an unused input of a multi-input OR gate. To expand the number of inputs, you can cascade gates, as shown in Fig. 8-*b*, or you can add resistor-diode logic to one input, as shown in Fig. 8-*c*.

You might think it's wasteful to use a multiple-input gate as a simple buffer or inverter. In general, that's true, but there are occasions when doing something of that nature is desirable. For example, assume that a design requires an inverter for some function, but that no inverters are available. If there is a spare NOR gate available in another IC it could be used instead.

A practical example

Suppose you want to build a low-power tone generator that can be activated by any one of four inputs. A non-optimal version of such a circuit is shown in Fig. 9-*a*. For the oscillator composed of IC3-a and IC2-b to work, the pin-2 input of IC3-a must be low. Therefore, the output of the input OR gate must be inverted, so IC2-a is used.

To simplify the circuit, it quickly becomes apparent that IC1-a and IC2-a simply form a NOR gate, so they can be replaced by a single four-input NOR gate,

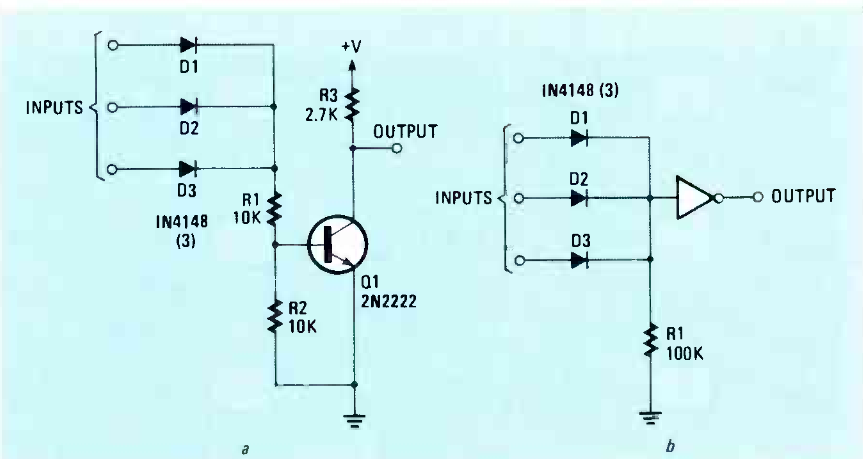


FIG. 6—SEVERAL IMPLEMENTATIONS OF A THREE-INPUT NOR GATE: a diode-transistor version is shown at (*a*), and a diode-inverter version at (*b*).

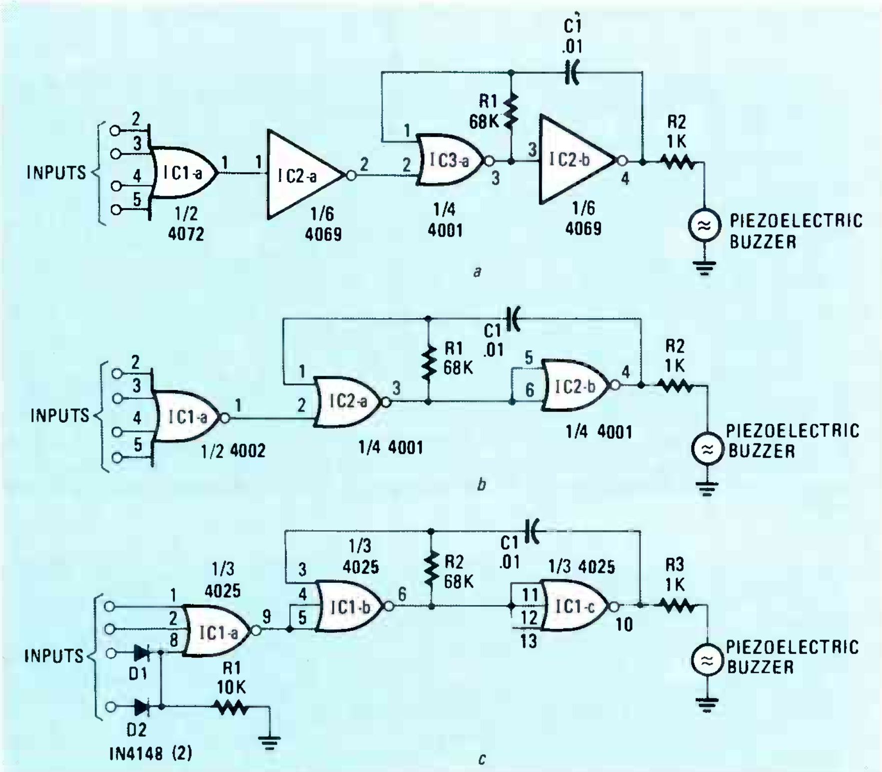
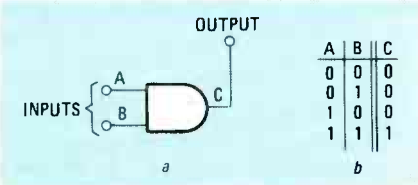


FIG. 9—A GATED TONE OSCILLATOR can be built in several ways, depending on the materials at hand. At (*a*) is an un-optimized version; at (*b*) is a partially optimized version; and at (*c*), the final circuit, which is based on just one IC.



A	B	C
0	0	0
0	1	0
1	0	0
1	1	1

FIG. 10—THE AND GATE schematic symbol (*a*) and its truth table (*b*).

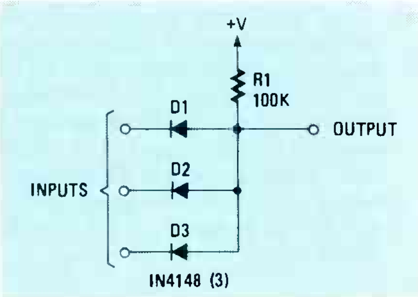


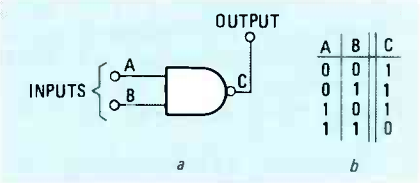
FIG. 11—BUILD AN AND GATE from diodes and a resistor.

as shown in Fig. 9-*b*. Further, one of the extra two-input NOR gates in IC2 can be used instead of IC2-b, further simplifying the circuit.

However, a little work can reduce the entire circuit to a single IC, as shown in Fig. 9-*c*. In that circuit three three-input NOR gates are used. The first, IC1-a, is expanded to a four-input gate with resistor-diode logic. The second, IC1-b, functions as a two-input gate. And the third, IC1-c, functions simply as an inverter.

AND and NAND gates

Figure 10-*a* shows the standard symbol, and Fig. 10-*b*, the truth table, of a two-input AND gate. As indicated by its name, the output of the AND gate is high only when both of its inputs are high. As shown in Fig. 11, the simplest way to make an AND gate is with several diodes and a resistor. Like the OR gate, additional inputs may be obtained by adding an extra diode for each new input.



A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

FIG. 12—THE NAND GATE schematic symbol (*a*) and its truth table (*b*).

Figure 12-*a* shows the standard symbol of a two-input NAND gate; its truth table is shown in Fig. 12-*b*. As you can see, the output of the NAND gate is low only when both inputs are high.

You can convert a NAND gate to an AND gate or an AND gate to a NAND gate using an inverter, as shown in Fig. 13-*a* and Fig. 13-*b*, respectively. To use a NAND gate as an inverter, connect the unused input(s) to the positive voltage source (as shown in Fig. 13-*c*), or to each other (as shown in Fig. 13-*d*). Likewise, to use an AND gate as a buffer, connect the unused input(s) to the positive voltage source (as shown in Fig. 13-*e*) or to each other (as shown in Fig. 13-*f*).

To reduce the number of inputs to a NAND gate, connect the unneeded input(s) to the positive voltage source, as shown in Fig. 14-*a*; to expand the number of inputs, use a second gate, as shown in Fig. 14-*b*.

XOR and XNOR gates

Figure 15-*a* shows the standard symbol of a two-input XOR (for eXclusive *OR*) gate, and Fig 15-*b* shows its truth table. As you can see, the XOR gate has the unusual property that its output goes high only when its inputs are different. That property gives the XOR gate unusual flexibility; by connecting its unused input to ground or to the positive supply voltage, it can function as an inverter (as shown in Fig. 16-*a*) or as a buffer (as shown in Fig. 16-*b*), respectively.

Figure 17-*a* shows the symbol and Fig. 17-*b* shows the truth table of a two-input XNOR (for eXclusive *NOR*) gate. The XNOR gate is equivalent to an XOR gate with an inverted output. The XNOR gate gives a high output only when both inputs are identical; it's very useful in logic-comparator applications.

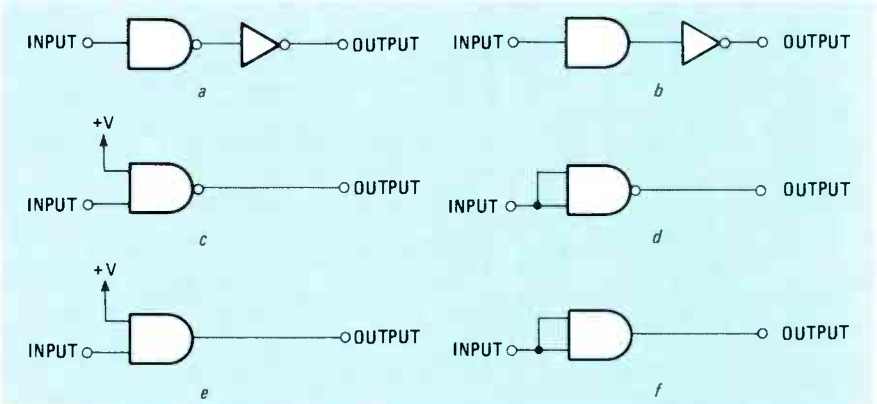


FIG. 13—BY COMBINING A NAND OR AN AND GATE WITH AN INVERTER, you can convert a NAND gate to an AND gate (*a*), or an AND gate to a NAND gate (*b*). To use a NAND gate as an inverter, tie the unused input(s) high (*c*) or connect the inputs together (*d*). To use an AND gate as a buffer, tie the unused input(s) high (*e*) or short (*f*) the inputs.

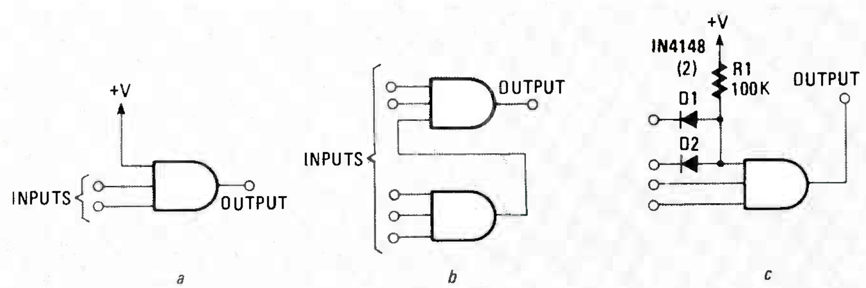


FIG. 14—TIE UNUSED AND-GATE INPUTS high (*a*); to increase the number of inputs, cascade gates (*b*) or use diode-resistor logic (c).

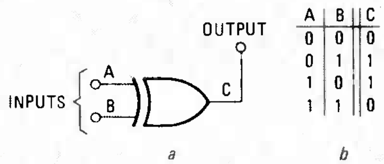


FIG. 15—THE XOR GATE schematic symbol (*a*) and its truth table *(b)*.

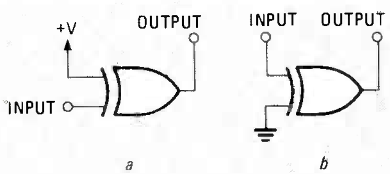


FIG. 16—USE THE XOR GATE AS AN INVERTER (*a*) or as a buffer (*b*).

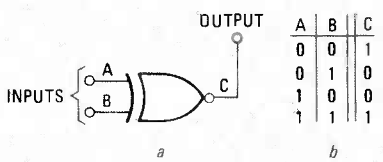


FIG. 17—THE XNOR GATE schematic symbol (*a*) and its truth table *(b)*.

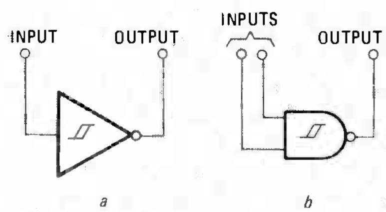


FIG. 18—AN INVERTING SCHMITT TRIGGER (*a*) and a NAND-gate Schmitt trigger. Use a Schmitt trigger to square up slowly changing input signals.

The Schmitt trigger

CMOS inverters and gates are generally intended to be driven by logic signals, signals that are either fully high (logic 1) or fully-low (logic Ø). If inputs linger between those two states for more than a few microseconds, there is a danger that the inverter/gate will become unstable and act as a high-frequency oscillator, thereby generating false output signals. So if slow signals are present at one or more of CMOS inputs, those signals should be "conditioned" (given fast rise and fall times) before being applied to the actual logic circuitry.

The most useful conditioning element is the Schmitt trigger. Schmitt triggers come in many forms; Fig. 18-a and Fig. 18-b illustrate one section of a hex Schmitt inverter (the 40106) and one section of a quad NAND gate (the 4093), respectively. Schmitt-type gates logically function the same as regular CMOS and TTL gates; only the electrical switching and current-drive characteristics vary.

Programmable logic

Most logic IC's are dedicated devices.

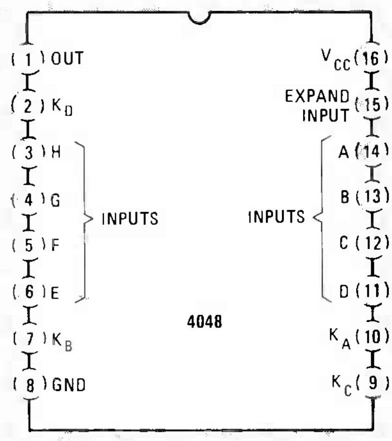


FIG. 19—THE 4048 EXPANDABLE, PROGRAMMABLE eight-input logic gate. Eight logic functions are possible (see Table 1).

TABLE 1—4048 FUNCTIONS

Output Function	Control Inputs K_A	K_B	K_C	Unused Inputs
NOR	Ø	Ø	Ø	Ø
OR	Ø	Ø	1	Ø
OR/AND	Ø	1	Ø	Ø
OR/NAND	Ø	1	1	Ø
AND	1	Ø	Ø	1
NAND	1	Ø	1	1
AND/NOR	1	1	Ø	1
AND/OR	1	1	1	1

K_D = 1 FOR NORMAL ACTION
K_D = Ø FOR HIGH-Z OUTPUTS
EXPAND INPUT = Ø

Without external components, a NAND gate, for example, can't function as anything else. There are, however, special logic elements that can be programmed to function as any one of a variety of gates, in various configurations.

One such gate is the 4048, a multifunction programmable eight-input gate. Its pin-out is shown in Fig. 19. The IC has two groups of four logic inputs (A–H), an expansion input, and four control inputs (K_A–K_D) that allow you to select the mode of operation.

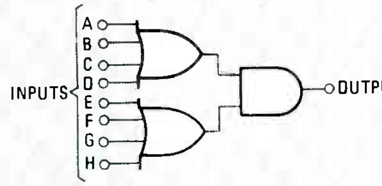


FIG. 20—THE 4048 MAY BE CONFIGURED as a dual four-input OR/AND gate.

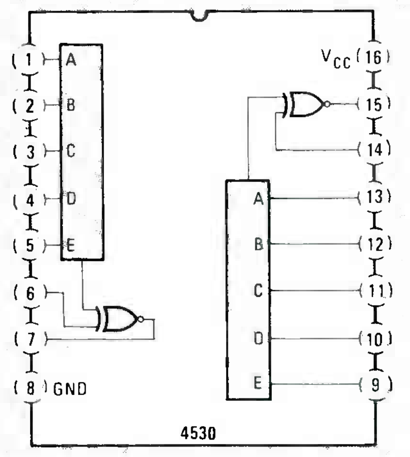


FIG. 21—THE 4530 MAJORITY LOGIC IC. Its output becomes active when more inputs are high than low.

Control input K_D allows you to select operation of the outputs: either normal or three-state. The remaining control inputs (K_A, K_B, and K_D) enable one of eight different logic functions to be selected, as shown in Table 1.

Operation in the AND, OR, NAND, and or NOR modes is conventional, but operation in the other modes (OR/AND, OR /NAND, AND/OR and AND/NOR) is slightly more complex. In the latter cases, the inputs are broken into two groups of four, which provides the first logic function. Those outputs are then combined according to the second function. So, for example, to use the 4048 as an eight-input OR /AND gate (as shown in Fig. 20), K_A and K_C would be connected to ground, and K_B would be connected to the positive supply voltage.

The EXPAND input of the 4048B allows IC's to be cascaded, so that, for example,

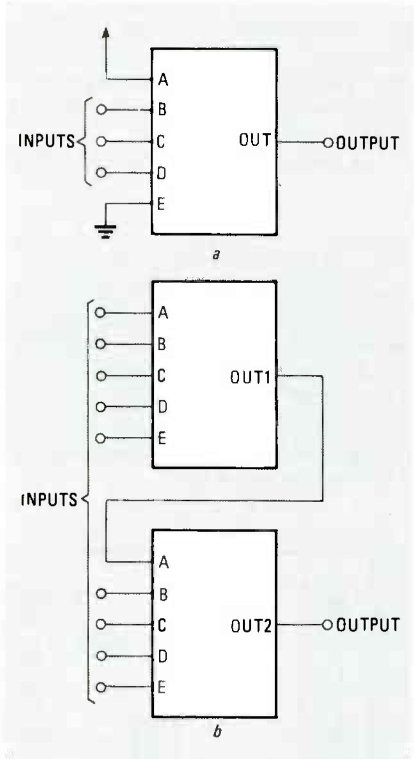


FIG. 22—UNUSED INPUTS must be tied high and grouded in pairs (*a*). To expand the number of inputs, connect the output of one element to one input of another (*b*).

TABLE 2—4048 EXPAND LOGIC

Combined Output Function	Function needed at EXPAND input	Ouput expression
NOR	OR	$J = \overline{(A + B + C + D + E + F + G + H) + (EXP)}$
OR	OR	$J = (A + B + C + D + E + F + G + H) + (EXP)$
AND	NAND	$J = (ABCDEFGH) \cdot \overline{(EXP)}$
NAND	NAND	$J = \overline{(ABCDEFGH) \cdot \overline{(EXP)}}$
OR/AND	NOR	$J = (A + B + C + D) \cdot (E + F + G + H) \cdot \overline{(EXP)}$
OR/NAND	NOR	$J = \overline{(A + B + C + D) \cdot (E + F + G + H) \cdot \overline{(EXP)}}$
AND/NOR	AND	$J = \overline{(ABCD) + (EFGH) + (EXP)}$
AND/OR	AND	$J = (ABCD) + (EFGH) + (EXP)$

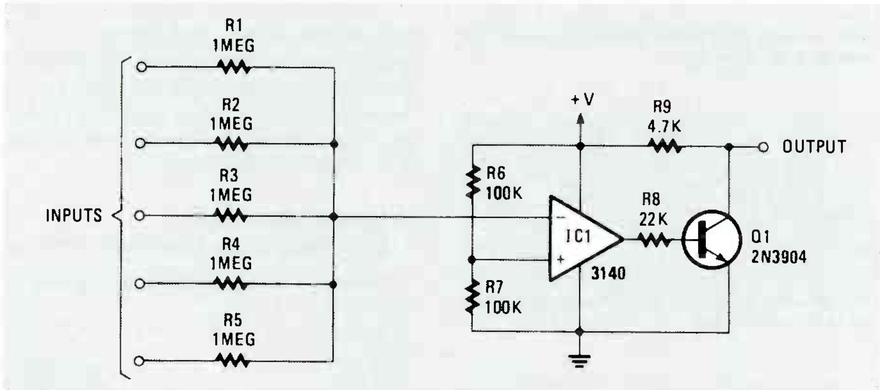


FIG. 24—THE OUTPUT OF THIS MAJORITY- LOGIC circuit swings from ground to within 50 mV of the positive supply voltage.

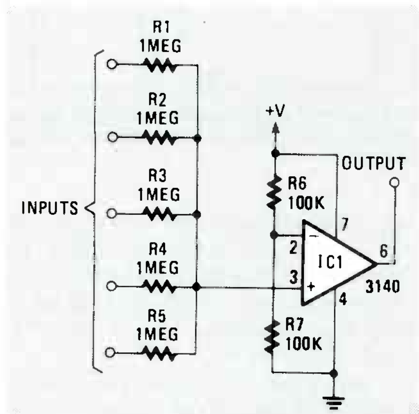


FIG. 23—BUILD A MAJORITY-LOGIC function from discrete components as shown here. The output swings from ground to several volts below the positive supply voltage.

two IC's could function as a single 16-input gate by feeding the output of one IC into the EXPAND input of the other. Note that, when using expanded logic, the overall logic functions of the two IC's may differ; Table 2 summarizes the configurations and their output expressions.

Majority logic

Less well known than the logic families we've already discussed is *majority* logic, which, as the name implies, gives an output when the majority of an odd number of inputs are high, irrespective of which inputs are active.

The best known CMOS majority-logic IC is the 4530, a dual 5-bit unit shown in Fig. 21. The output of each element feeds one input of an XNOR gate; the other XNOR input is externally available, enabling it to be wired as either an inverting or a non-inverting stage.

As shown in Fig. 22-*a*, the effective number of inputs of a 4530 can be reduced by wiring half of the unwanted inputs high and the other half low. On the other hand, the effective number of inputs can be increased by cascading elements, as shown in Fig. 22-*b*.

Majority-logic IC's can be difficult to find, but it's easy to simulate majority logic with an op-amp, as shown in Fig. 23. In that circuit the op-amp functions as a voltage comparator; voltage-divider R6–R7 applies one-half the supply voltage to the inverting input (pin 2) of the op-amp, and the five input resistors (R1–R5, each of which must be connected either to ground or to the positive supply voltage) form a voltage divider that supplies a fraction of the supply voltage to the op-amp's non-inverting input (pin 3).

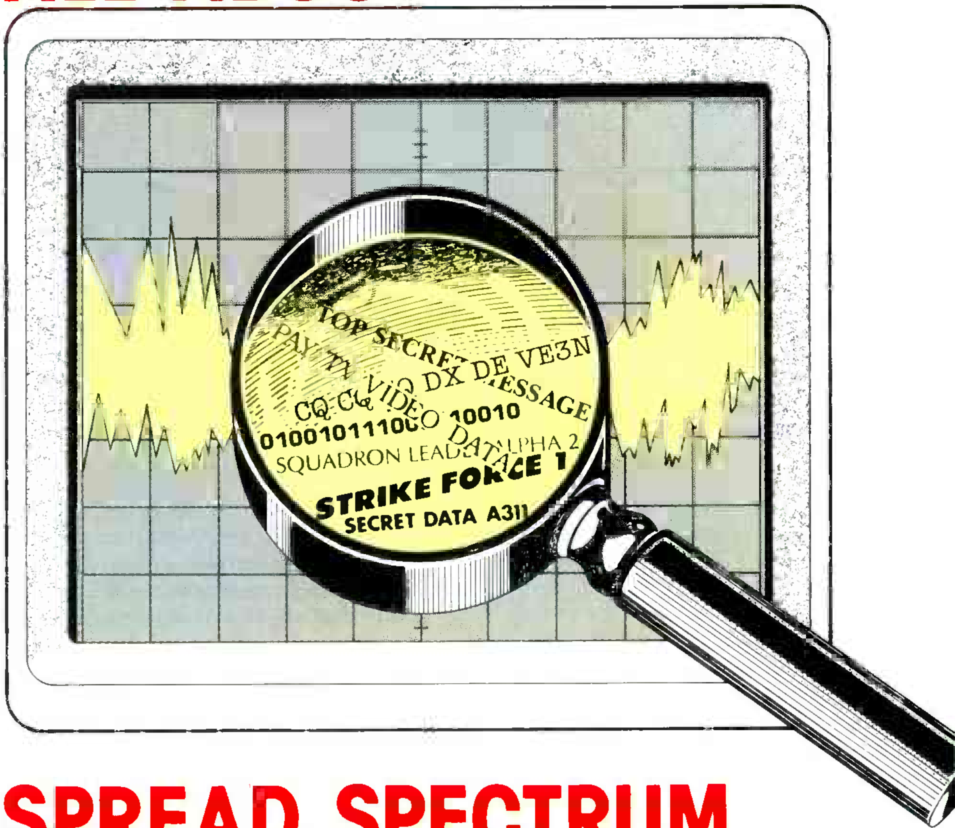
To understand how it works, suppose that two input resistors are connected to ground and that three resistors are connected to the positive supply voltage. The three logic-1 resistors have a combined (parallel) impedance of 333K, and the two logic-0 resistors have a combined impedance of 500K. Therefore the resulting voltage on pin 3 is greater than one-half the supply voltage, so the output goes high.

If, on the other hand, only two of the five inputs go high, the resulting pin-3 voltage at the non-inverting input is below one-half the supply voltage, so the output of the op-amp goes low.

If 5% resistors are used, that circuit can have as many as eleven inputs, simply by adding additional one-megohm input resistors. The output of the circuit goes all the way to ground, but it only rises to within several volts of the value of the supply voltage when the output is high. In many applications that's of little importance; it does, however, mean that elements cannot be cascaded to increase the total effective number of inputs.

That defect can be overcome by using the "compound" circuit shown in Fig. 24. In that circuit, the output is inverted and level-shifted by Q1, and the op-amp inputs are transposed. The output of that circuit swings to within 50 mV of either supply rail, enabling circuits to be cascaded without limit. **R-E**

ALL ABOUT SPREAD SPECTRUM COMMUNICATIONS



Learn about the methods used by the government and others to achieve reliable communications under the most difficult conditions.

JAMES E. McDERMOTT

A NOCTURNAL BAT EMITS WEAK ULTRASONIC chirps as it bobs and weaves through a maze of obstacles; a deep-space probe accurately broadcasts its position to an earth-based tracking station; and a military radio link is maintained despite powerful enemy jamming signals. In all of those situations, a modulation technique known as *spread spectrum* is used.

As its name implies, in spread spectrum a communications signal is spread over a wide frequency range. Among the potential advantages offered by spread-spectrum communications are message privacy, signal invisibility, noise rejection, and accurate signal timing.

In this article we will look at some of the various spread-spectrum techniques in use today. Among them are frequency hopping, time hopping, chirping, and direct sequence. But before we can fully understand those techniques and their applications in space, military, and commercial communications, some necessary groundwork must be laid.

Time *vs.* frequency

A signal can be represented in one of two ways. Most often, a signal is represented as a function of time (change in amplitude *vs.* change in time). That is also called a *time-domain* representation. But signals can also be represented as a function of frequency (change in amplitude *vs.* change in frequency). That is called a frequency-domain representation.

In Fig. 1 are two common signals; both are shown in the time and the frequency domain. In Fig. 1-*a* is the time-domain representation of a wide data pulse; the frequency-domain representation of that signal is shown in Fig. 1-*b*. A narrow pulse or spike is shown in the time domain in Fig. 1-*c*; the frequency-domain version of that signal is shown in Fig. 1-*d*.

Any signal can be shown in either the time or the frequency domain. It is also possible to convert a time-domain representation to a frequency-domain representation, and vice versa, using a mathematical operator called a *transform*. The most familiar of those, at least to advanced students of electronics, are the *Fourier* and the *Laplace* transforms. As a meaningful discussion of transforms requires a working knowledge of calculus, we will not go into further depth on that subject here. Consult your local library for more information on the subject.

Bandwidth

The most familiar type of frequency-domain representation shows us the *bandwidth* or spectrum of a signal at an instant of time. Such a representation is called an *instantaneous bandwidth* and can be thought of as a snapshot view of a signal's frequency spectrum. Instantaneous bandwidth is most useful when discussing pulsed signals.

In some spread-spectrum techniques, the bandwidth of a signal changes significantly over time. For instance, in a frequency-hopping system (such systems will be discussed later on in this article) the instantaneous bandwidth may be narrow; but over time, signal components may be present over a wide frequency range. For such signals, the concept of *hopped bandwidth* is useful. Hopped bandwidth is analogous to time-lapse photography and describes the full extent of the frequency spectrum covered by the signal.

A spread-spectrum signal, by definition, occupies a larger bandwidth than necessary to convey information. The minimum bandwidth required to convey the information contained in the signal is called the *information bandwidth*. For example a voice signal requires approximately 2000 Hz of bandwidth to be faithfully reconstructed; a television signal may require 6 MHz. A typical spread-spectrum signal carrying a single voice message may occupy a hopped bandwidth of 100 MHz, or an instantaneous bandwidth of 10 MHz or more.

For a signal-processing technique to be useful it must offer some gain over an unprocessed signal. That gain is called *process gain*. In spread-spectrum systems, the process gain is the ratio of the spread-spectrum bandwidth to the information bandwidth; it can be expressed in decibels by the formula:

$$G_P = 10 \text{ LOG } (BW_{RF}/BW_I)$$

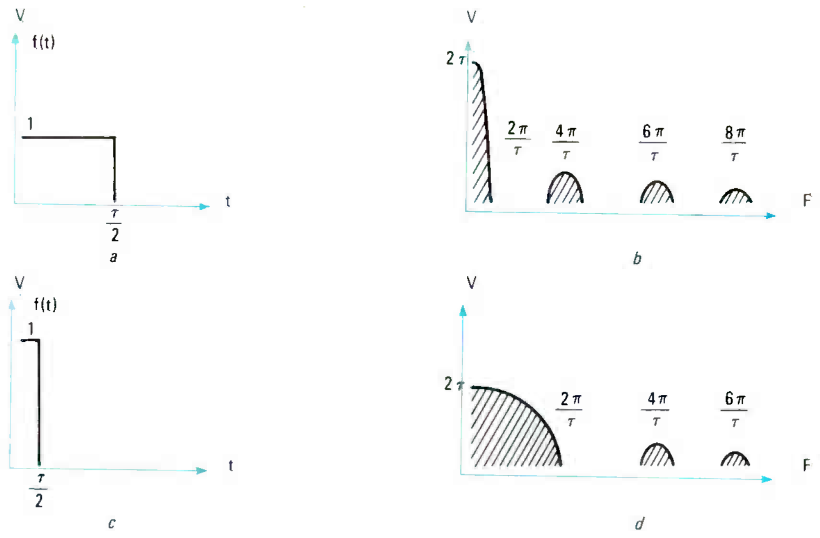


FIG. 1—FREQUENCY DOMAIN *VS.* TIME DOMAIN. A wide pulse is shown in the time domain in *a* and in the frequency domain in *b*. A narrow pulse is shown in the time domain in *c* and in the frequency domain in *d*.

where BW_{RF} is the spread-spectrum bandwidth and BW_I is the information bandwidth.

Noise

Noise can be considered as all RF energy other than the signal of interest; it is the most significant limiting factor for all communications systems. For a signal to be received, its level must be greater than the noise level. A useful quantity in determining whether a signal will be received, and how well, is the *S*ignal-to-*N*oise *R*atio (SNR). The SNR can be expressed in dB's using the following formula:

SNR = 10 LOG (signal-power/noise-power)

In designing a communications system, the goal is to maximize the effective SNR. When increasing the signal strength is either impractical or illegal, the only recourse is to minimize the effects of the noise degrading the signal. Depending on the nature of the signal and the noise, there are various techniques that can be used to achieve that goal.

When faced with white or flat noise, narrowband signals are transmitted so that effective filtering can be done at the receiver. A bonus is that the use of narrow bandwidths allows for greater use of the crowded communications bands.

Willful interference, especially from narrowband, high-power jammers, is quite another story, however. Spread spectrum is a powerful weapon in combating that type of interference.

Some history

As early as the 1920's, engineers proposed using broadband signals, primarily to counteract the effects of fading on communications links. The idea was to spread the signal energy over a wide range of frequencies, then to reconstruct the signal by gathering all the frequency components at the receiver. Then when one part of the band suffered from fading, the combined signal in the receiver would only be diminished slightly. Unfortunately, technology was far behind insight, so those proposed systems remained largely theoretical.

World War II brought an urgent need for secure communications as engineers confronted man-made problems in the form of high-power jammers. Engineers tackled the problem using that era's more-advanced technology. Before the war's end both sides were using sophisticated communications systems, many of which used bandspreading techniques.

By occupying large bandwidths, spread-spectrum signals increase their ability to withstand interference by improving what is referred to as *jamming margin*. For example, if a narrowband signal is marginally readable under a certain level of jamming or interference, and 20 dB of G_P is added by using a spread-spectrum technique, then the signal can withstand 20 dB, or 100 times, more jamming power.

A useful byproduct of the bandwidth spreading process is a proportional reduction in signal density, making the signal virtually undetectable by an uninformed receiver. That has a particular appeal in tactical and strategic systems; today the military is one of the largest users of spread-spectrum systems.

A communications shell game

A frequency hopper is a communications signal in which the carrier frequency is continuously changed to one of a great many frequency *slots*. The resulting signal has a large hopped bandwidth, often in the hundreds of MHz. Figure 2-*a* shows the resulting spectrum for a 10-slot system, although typical systems in use today may have 1000 or more such "hop slots." A noise source, usually a digital *P*seudo*N*oise (PN) sequence generator, is used to determine the current hop slot. A typical hop sequence for a ten-slot system is shown in Fig. 2-*b*. A typical frequency-hopper system is shown in block diagram form in Fig. 3.

Frequency hoppers can be subdivided into fast hoppers, which can change frequency in less than a microsecond, and slow hoppers, which may use each slot frequency for several seconds at a time. Fast hoppers are generally used in tactical military environments where jammers can quickly home in and swamp a slow-hopping signal. Such a system is usually based around expensive state-of-the-art frequency synthesizers. Fast hoppers are limited by the speed at which the synthesizer can be effectively switched, al-

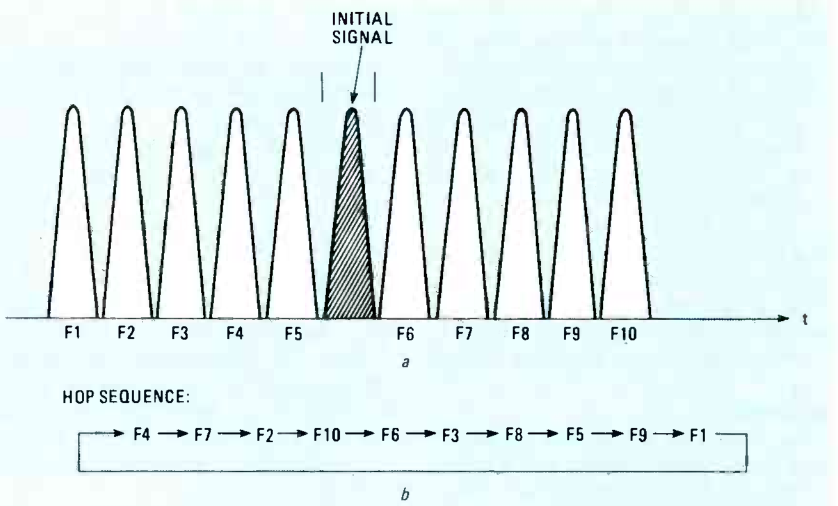


FIG. 2—A FREQUENCY HOPPER will jump from one frequency slot to another over time. The spectrum of a simple 10-slot system is shown in *a*. One possible hop sequence for the system shown in *a* is shown in *b*.

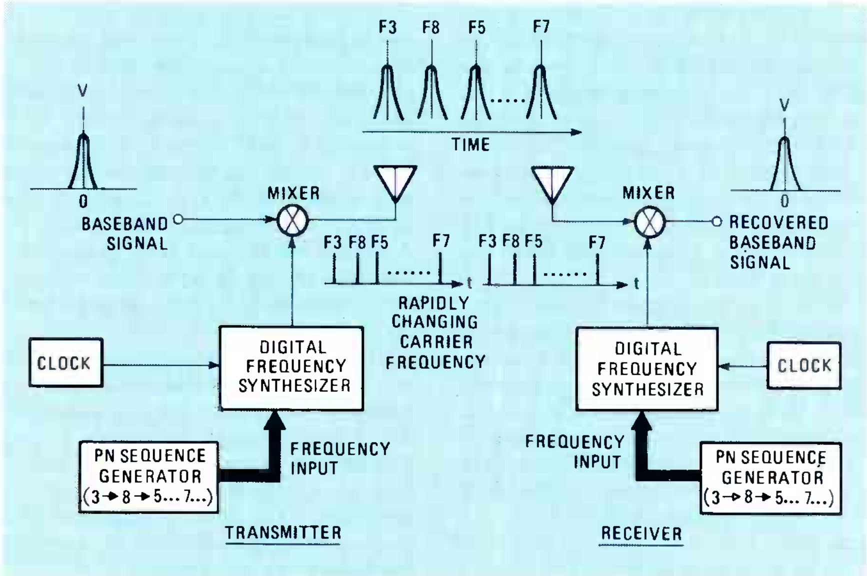


FIG. 3—BLOCK DIAGRAM of a typical frequency-hopper system. The pseudo-random noise-sequence generators at both the transmitter and receiver are set up to output the same sequence.

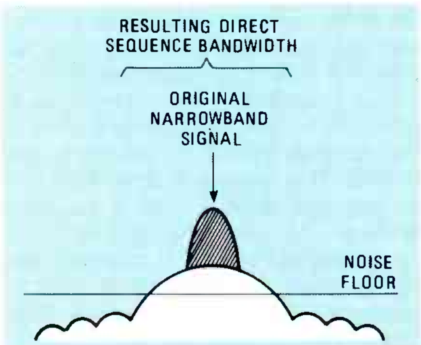


FIG. 4—WHEN AN RF SIGNAL IS MODULATED by a digital pulse, the carrier widens. If that pulse were replaced with a chip sequence, extremely wide bandwidths would result.

though many can hop over a 1-GHz range in less than 1 μs.

Slow hoppers are normally used where low cost is important and where any expected jamming lacks sophistication. Slow hoppers are also used as an inexpensive way to share a band among many users. By carefully selecting the hopping sequences or codes to prevent overlap, several slow-hopped systems can co-exist in the same band and in so doing increase band efficiency. A jammer attempting to interfere with a specific signal is now even less effective since it may be impossible to isolate that signal from the rest of those using the band. (Of course, a jammer could always just knock the entire band out of service.)

Signal shredders

Imagine shredding an important message into a million pieces and then scattering them into a tornado. A thousand miles away someone gathers up all or almost all of the snippets and reconstructs the original message. If you substitute communications signals for the paper you have the essence of the most sophisticated and exciting of the spread-spectrum techniques: direct-sequence spreading.

In the direct-sequence technique, bandspreading is accomplished by exploiting the inherent properties of digital modulation. That is, whenever a pulse stream is mixed with a carrier signal, a slight broadening of the RF carrier occurs. However, if instead of a single bit, a long code sequence, called a *chip sequence*, is sent in the same time interval, large instantaneous bandwidths can be produced, as shown in Fig. 4. The wide bandwidths are a direct consequence of the extremely narrow pulse widths of the bits in the chip sequence.

In the receiver, the RF signal must be *correlated*; that is the signal must undergo a de-spreading or bandwidth-collapsing procedure. First, the signal is converted back to baseband by mixing it with an appropriate carrier signal. The resulting baseband signal contains noise as well as the chip sequence. That noise, which includes willful interference, must be removed. That task can be handled in many ways, but one design makes use of a *matched filter*, a circuit that compares the received chip sequence with a predetermined sequence and looks for a match.

One popular matched-filter design is built around an analog shift register, as shown in Fig. 5. As each bit in the chip sequence is received, it is fed into the input of the register. As the bits are cycled through the register, the contents of each cell are sampled and summed. The output of the filter is a current that is proportional to the degree of the match. The filter shown in Fig. 5 is set up to look for a sequence of 1101101. When the bits in each cell match that sequence exactly, the out-

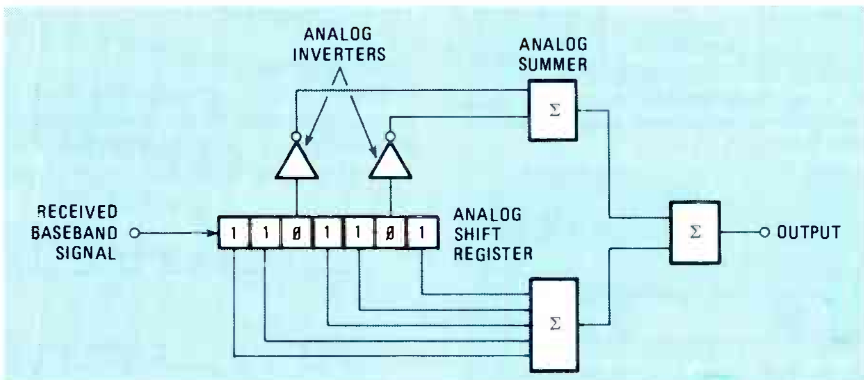


FIG. 5—MATCHED FILTERS are used to search for particular chip sequences. The one shown here, which is built around an analog shift register, searches for the sequence 1101101.

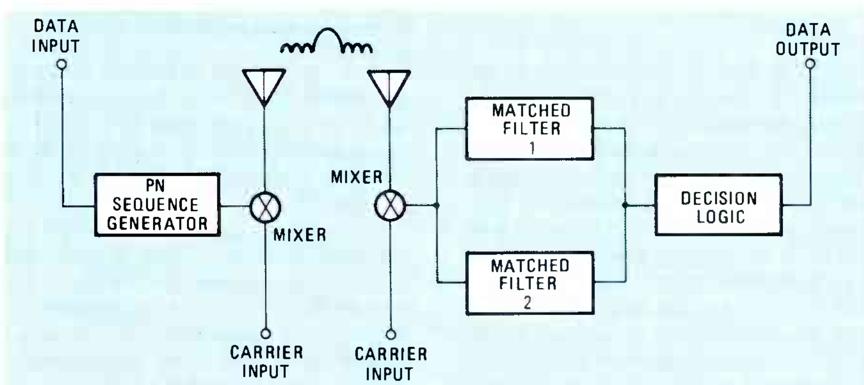


FIG. 6—MULTIPLE MATCHED FILTERS are used in direct-sequence receivers to increase the likelihood of successful correlation. Decision logic is used to select the filter output that is most likely to be correct.

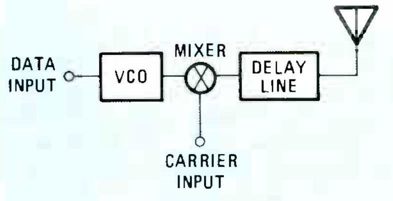


FIG. 7—A CHIRP-SYSTEM transmitter is shown here in block diagram form.

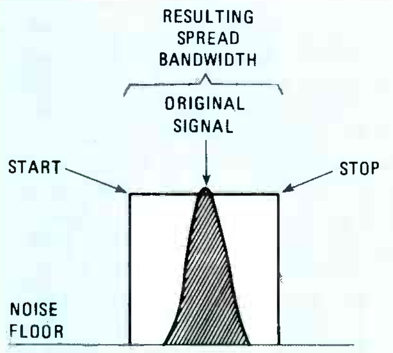


FIG. 8—THE CHIRP SIGNAL'S carrier frequency is continuously swept through part of a band. Intelligence is conveyed by the direction of the sweep.

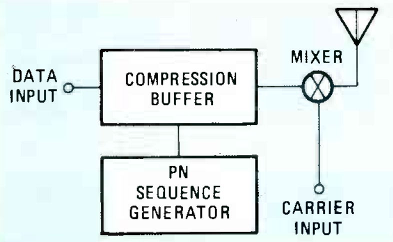


FIG. 9—IN A TIME-HOPPER TRANSMITTER data is compressed and buffered, and then transmitted in burst form.

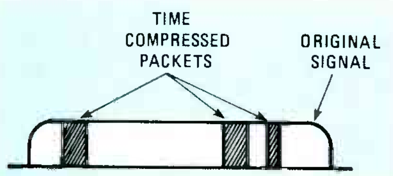


FIG. 10—TIME-DOMAIN REPRESENTATION of a time-hopped signal. In the frequency domain, the resulting spectrum would be similar to that of a direct sequence signal.

put of the filter is a maximum. As the degree of match, or correlation, decreases, the output decreases. If the bits in none of the cells match, the output is zero.

Some receivers will make use of two or more matched filters to increase the likelihood of successful correlation. Decision-logic circuitry is used to select the most likely filter output. The output of the correlator is then fed to a demodulator, etc. for processing by conventional means. A block diagram of a typical direct-sequence system, up to the output of the correlator at the receiver, is shown in Fig. 6.

Chirp systems

Similar to signals used in radar applications, chirped signals are formed by sweeping or sliding the frequency of the signal over a wide range during a pulse interval. The block diagram of a circuit for a chirp transmitter is shown in Fig. 7.

When used in a communication application, the data input determines the direction of the chirp: frequency is shifted up the band for a logic 1 and down the band for a logic Ø.

Receiving chirp signals involves using matched filters in much the same way as they are used in direct-sequence systems. The structure of the filters themselves do differ, however, because in chirp systems frequency rather than amplitude patterns are of interest. Multiple filters are usually used, with the filter producing the most unambiguous output identifying the data sent.

Chirp systems usually use a linear frequency sweep instead of a noise source and so in strict terms don't qualify as a spread spectrum signal. However, as you can see in Fig. 8, they do have larger than required bandwidths and so produce processing gain. See Fig. 8.

Although many experimental wartime systems used some form of chirping, it is not often used today for communications—at least not for *human* communications. However, it is believed that dolphins use complex chirp signals for communications; bats use similar signals for ranging and navigation.

Time hopping

Time-hopping schemes are used in conjunction with frequency-hopping or direct-sequence spreading to provide multiple-channel access or data security in the form of "randomly" scheduled transmission times. As shown in Fig. 9, time hopping requires that data be stored or compressed and then transmitted in high-speed bursts during the allotted time slot. See Fig. 10.

The processing gain of time hopping is achieved by virtue of the shorter time taken to transmit the information, since the narrower the pulse in the time domain the larger the bandwidth in the frequency domain. Since scheduling can be derived from a random or pseudo-random source, time-hopping systems are bonafide members of the spread-spectrum family.

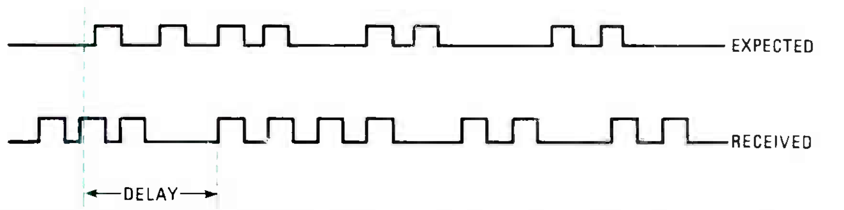


FIG. 11—IN THE GPS RANGING SYSTEM, distance to the transmitter is determined by the time delay between expected and received signals.

Applications

Frequency hopping can be added to either digital or analog communication systems since it is only the carrier that is affected. The U.S. Air Force has retrofitted many of their existing analog UHF radio links with frequency-hopping capability as an interim step while more sophisticated digital systems are being developed. That interim system, which the Air Force has branded *Have Quick*, uses the time of day to select the currently active frequency slot from among a set of 7000 possible slots.

The *G*lobal *P*ositioning *S*ystem (GPS) is a satellite system that makes use of a basic direct-sequence ranging technique. As of this writing, the system is only partially in place. When fully implemented, GPS could allow subscribers anywhere in the world to determine their position to within a few meters, therefore revolutionizing navigation.

The GPS will consist of a fleet of 18 satellites in low-altitude circular orbits that allow contiguous coverage of the entire globe with direct-sequence microwave signals. Virtually every spot on the globe will be able to receive signals from at least 4 satellites. When decoded, each signal can be used to determine the linear distance from a particular satellite to the receiver. That distance is proportional to the propagation delay; that is the time difference between when the signal is transmitted and when it is received. See Fig. 11. Three of the signals are used to triangulate the receiver's position. The signal from the fourth satellite is used to correct clock drift and other error effects.

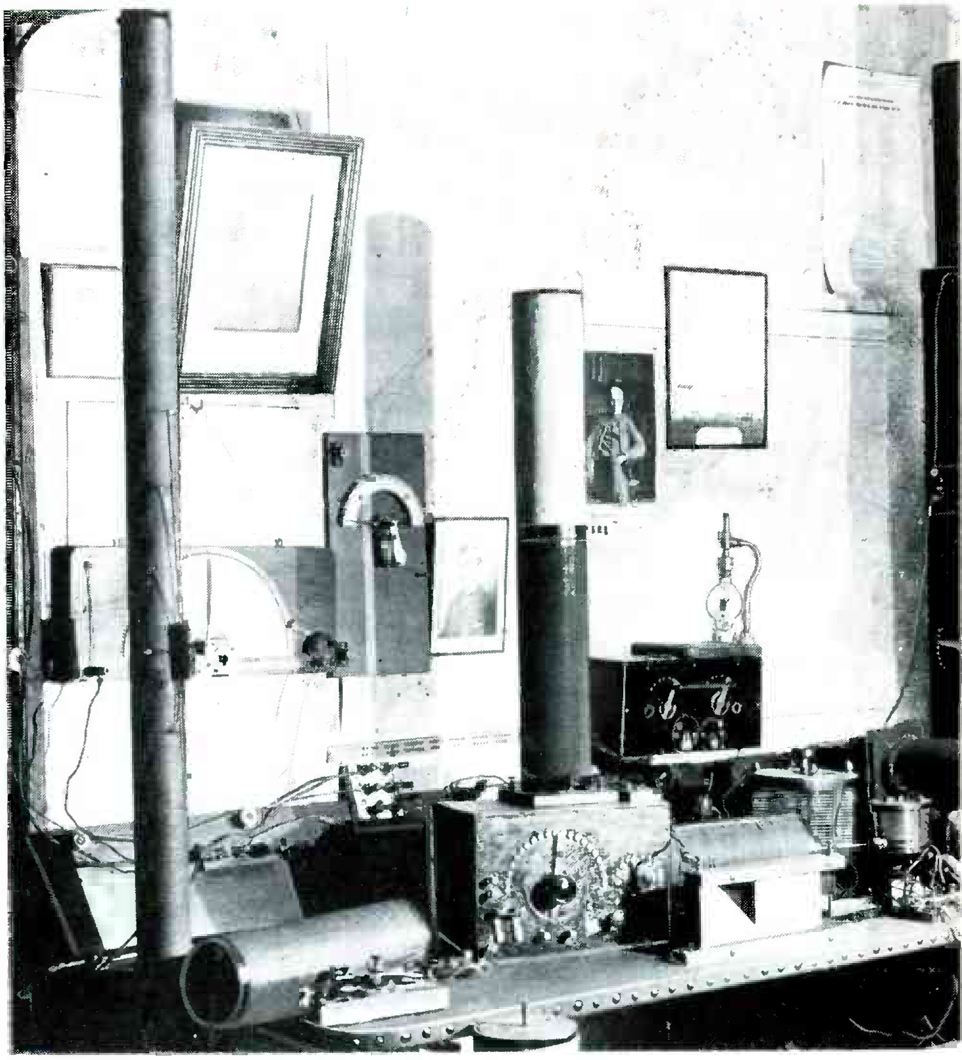
The *J*oint *T*actical *I*nformation *D*istribution *S*ystem (JTIDS) is designed primarily for military use. Using frequency-hopped, direct-sequence modulation the system provides communication, navigation, and control facilities to air-, land-, and sea-based subscribers. The system uses a 5-MHz wide MSK (*M*inimum *S*hift *K*eying, which is closely related to frequency shift keying) direct-sequence signal. The signal is then frequency hopped over a 52-frequency set, with 3 MHz of separation between hopped frequencies. After a user synchronizes with the system, which is done using special preamble signals, data can be exchanged with any other authorized user within a range of 500 nautical miles. **R-E**

HISTORY

The Early Days of RADIO

MARTIN CLIFFORD

Learn about the many discoveries and inventions that led to the development of radio.



Part 3 TWO GREAT TECHnological "revolutions" have changed the nature of civilization. One was the Industrial Revolution, which is commonly agreed to have begun in 1750. It was a revolution in the invention, design, and use of machinery for mass manufacturing.

Perhaps less renowned (at least in some circles), though no less important, was the "electronics revolution." It can be considered to have begun with the article "A Dynamical Theory of the Electromagnetic Field," written by James Clerk Maxwell, a Scottish physicist. That article was published in *Philosophical Transactions* in 1865.

The most significant result of the electronics revolution was radio. But, as is so often the case, radio was not the brainchild of a solitary inventor. Instead, numerous developments by independent researchers and teams led to the evolution of radio.

Remember also that many laws of radio that we take for granted now were only developed during the second half of the 19th century. For instance, by the Civil War, telegraphy was well established and telegraph wires crisscrossed the countryside. Even so, experimenters were hard at work looking for some way of communicating without wires. However, their work was severely hindered by some of the misconceptions of the time.

For one, most people were convinced that there had to be some connecting mechanism between the transmitter and receiver. Around the middle of the 19th century, Samuel F.B. Morse, the inventor of wired telegraphy, tried a wireless system that substituted water for wire over part of a telegraph loop. The system is illustrated in Fig. 1. Note that there is no wired connection between the receiver on one bank and the key on the other. Instead, the link is provided by the water in the stream.

Morse and others also experimented with inductive schemes. In 1885, Sir William Preece, Engineer-In-Chief of the British Post Office, tried using the circuit shown in Fig. 2. He was able to establish communications over a distance of about 1000 yards, using loops of wire that each were hundreds of feet long.

The antenna

Electricity and the possibility of wireless communications attracted enthusiasts and experimenters of all kinds. One of those was Dr. Mahlon Loomis. Dr. Loomis was a prominent Philadelphia dentist who, at the age of 28, had patented a process for making false teeth.

Dr. Loomis is also credited with making the first wireless transmission, in West Virginia in 1865. As shown in Fig. 3, the Loomis "transmitter" consisted of a telegraph key that was connected in series

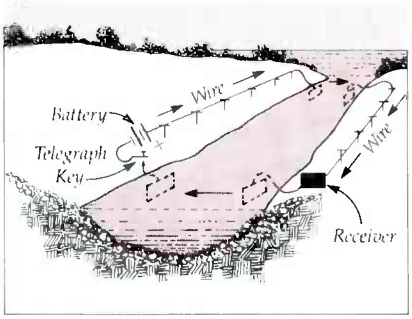


FIG. 1—THE MORSE SYSTEM of transmitting signals through space. Water served as the link between transmitter and receiver.

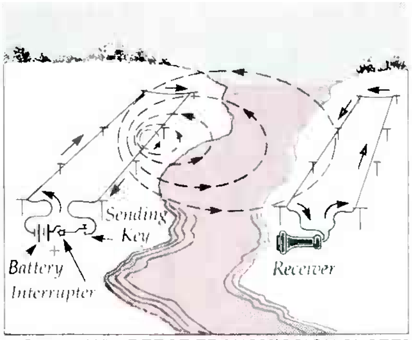


FIG. 2—THE PREECE TRANSMISSION SYSTEM used two loops of wire, each over a hundred feet long. One loop (for transmitting) had a battery and telegraph key; the other loop, a telephone handset.

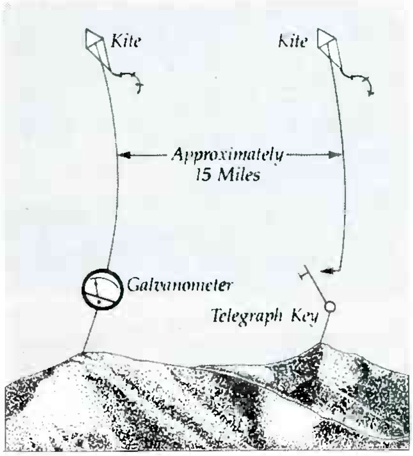


FIG. 3—DR. LOOMIS' transmitting and receiving system. The copper wires were held aloft by kites.

with a long length of fine copper wire. The wire was held aloft by a kite in which a small section of wire mesh was embedded. The receiver, which was located some 15 miles away was similar, except that the key was replaced by a galvanometer that was used to indicate signal reception.

Dr. Loomis was the first to use the word "aerial;" it was the term he used to describe the copper wire. He received a patent for his scheme in 1872. It was the first patent ever issued for wireless telegraphy. Dr. Loomis' wireless system was demonstrated publicly in Philadelphia in late 1879.

Despite Dr. Loomis' work, Marconi is

SO THEY SAID

- While working for the Marconi Wireless Telegraph Co, Ltd. in 1916, David Sarnoff, who subsequently became President and Chairman of the Board of RCA, proposed to his superiors that the company become involved in the manufacture and sale of what Sarnoff called "music boxes." They would be used for the reception of not only music but educational programs that would be broadcast by radio.

Sarnoff was advised that there was no merit to his suggestion.

- In 1882, Professor Amos E. Dolbear applied for a patent for his invention of a wireless transmitter that used an inductive technique. The patent application was rejected by the patent office on the grounds that it was "contrary to science."

- On November 12, 1913, Dr. Lee de Forest went on trial in New York on the charge of using the mails to defraud. The indictment stated that his patents were for "a strange device, like an incandescent lamp, which he (de Forest) called an Audion, and which device had proven to be worthless."

Acording to the Federal District Attorney, "de Forest has said in many newspapers and over his signature that it would be possible to transmit the human voice across the Atlantic before many years. Based on these absurd and deliberately misleading statements, the misguided public, your honor, has been persuaded to purchase stock in his company, paying as high as $10 and $20 a share for the stock.

De Forest was aquitted by the jury, but the judge advised him to "get a common garden variety of job and stick to it."

- Charles Babbage, the designer of a calculating machine that can be regarded as the ancestor of today's computers, was asked in 1843 by British Prime Minister Robert Peel to use the machine to "calculate the time at which it will be of use." **R-E**

widely recognized as the inventor of the antenna, even though Edison also held a prior patent in the field. Edison's method, shown in Fig. 4, used large metal plates at the transmitter and receiver. Those plates formed what was essentially a huge capacitor. Electrostatic charges at the transmitter plate induced a charge at the receiver plate. The system was suitable for short-distance communications only, and Edison subsequently sold the antenna patent rights to Marconi.

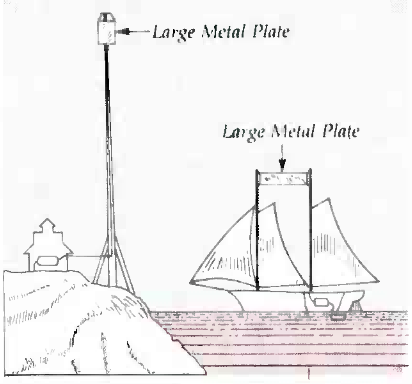


FIG. 4—THE EDISON capacitor antenna used a large plate for transmitting and a similar large plate for receiving.

In 1895, while experimenting with the oscillator circuit developed by Hertz, Marconi decided to ground one side of the oscillator and extend a lead at the other side of the oscillator into the air. That lead somewhat resembled the antennae of an insect, hence the word "antenna" was soon applied to that arrangement. It was quickly noted that the use of an antenna allowed communications over far greater distances.

The detector

Wireless telegraphy introduced several problems that were of no concern to the developers of wired telegraphy. For instance, a wired system operates on DC. Signals were sent by interrupting the current flow. At the receiving end, those interruptions were made audible by an electromechanical sounder.

With a wireless system, however, some means of extracting or detecting a signal is required. That task is handled by a rectifier, which is a device that allows current to flow in only one direction. Because of the function they serve, rectifiers are also called detectors.

We discussed crystal detectors in the first installment of this occasional series. (See the July 1986 issue of **Radio-Electronics**.) However, early detectors used other schemes. One of the first detectors consisted of two metal electrodes that were immersed in an electrolytic or acid solution. Initially developed in the late 1850's, years later detectors of that type, which by then were called electrolytic interrupters, became extremely popular with amateur experimenters and wireless-telegraphy hobbyists. See Fig. 5 for an example of an electrolytic detector.

Another early detector was the coherer. The basic principal behind that device was discovered first in 1850 by Guitard. He noted that particles of dust in electrically charged air tended to adhere to each other. Later, in 1883, Sir Oliver Lodge noted that metallic dust, which is normally a poor conductor, becomes a good conductor when exposed to high frequencies.

Those discoveries led Edouard Branly to develop the Branly coherer, which was also called the Branly wave detector. See Fig. 6. The coherer consists of a small glass tube filled with metal filings. In 1894 Lodge used the coherer to detect signals from a transmitter located 150 yards away.

The coherer was not without its problems. Perhaps the most significant problem was that the filings would adhere to each other each time a signal was passed through them; that is, after each dot or

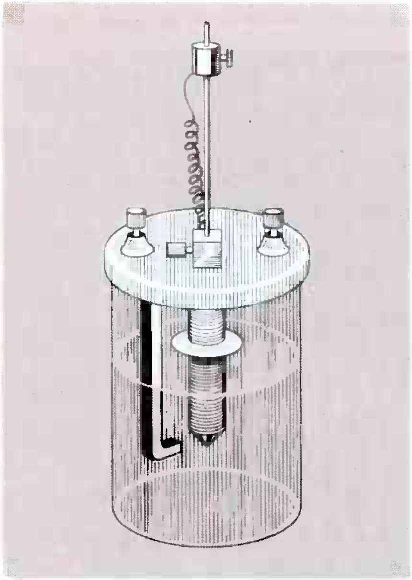


FIG. 5—THE ELECTROLYTIC DETECTOR consisted of two metal rods submerged in an electrolyte or acid solution. Such detectors eventually were very popular with hobbyists and experimenters.

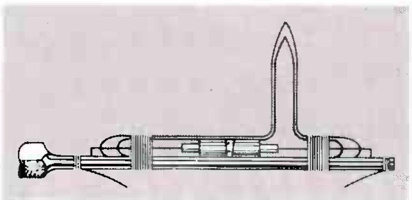


FIG. 6—THE BRANLY COHERER. One drawback was that the metal filings in the glass tube tended to stick to each other.

dash. To separate the filings some type of automatic tapping device was required to mechanically tap or shake the tube after each signal passed.

Marconi used an improved version of the Branly coherer in some of his work. Marconi's coherer used filings made from a nickel-silver alloy. Although a tapping device was still required, the coherer was able to detect signals from a transmitter located two miles away.

Marconi, with the assistance of Lodge and Dr. John Ambrose Fleming, also developed the electromagnetic detector shown in Fig. 7. That detector consisted of a moving band of iron wire (A) mounted on a pair of wheels (E). The band passed through a coil (B) that was connected to the antenna. As a section of the band passed through a pair of permanent magnets (D), it was magnetized. When that section later passed through coil B, a magnetic field that varied with the signal applied to the coil via the antenna was created. That field was electromagnetically coupled to coil C, which was connected to a telephone receiver. In many ways, Marconi's detector resembled the wire recorder, which would not be developed until over four decades later.

Edison and radio

Edison's work in developing the electric light also played an important part in the development of radio. That's because it led to the invention of the vacuum-tube diode, and later to the triode.

Edison was not the first person to turn his attention to developing an electric light, however his work was the most successful. One problem with earlier efforts, like that of W. Edward Staite, was that the filament was exposed to the atmosphere, allowing rapid oxydation. Once Edison hit upon the idea of placing the filament in an evacuated globe, he was on the way to success. But there were still obstacles to overcome.

Edison's difficulties with his electric light are well documented. One of the most significant was that one side of the

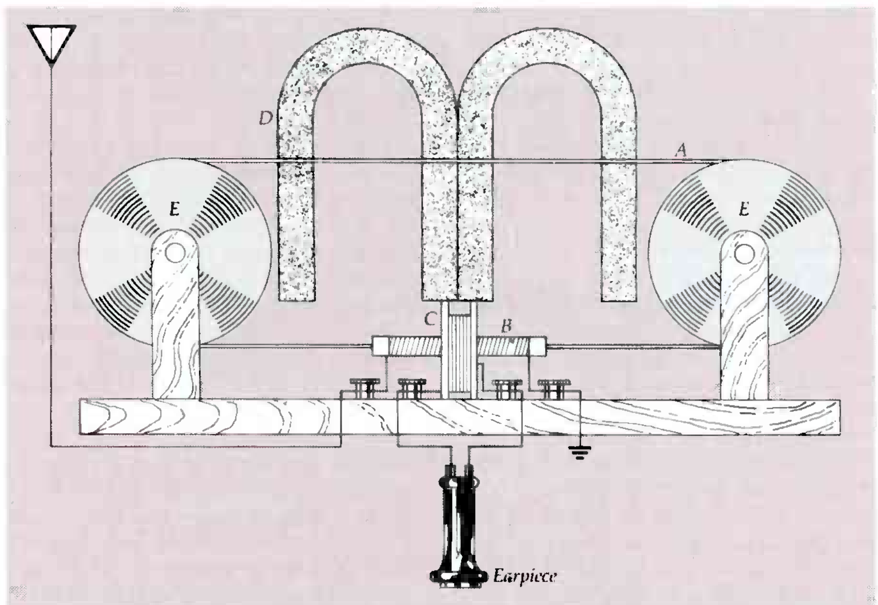


FIG. 7—MARCONI'S MAGNETIC DETECTOR used electromagnetic induction to produce an audible signal in the earpiece.

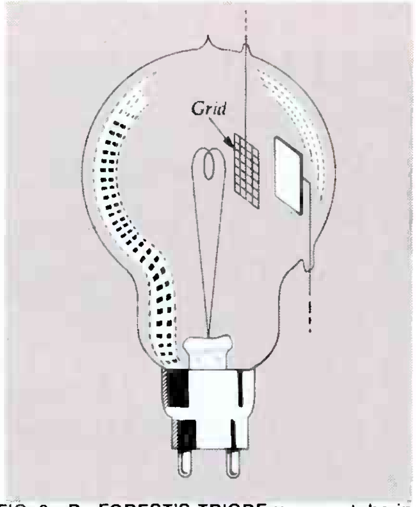


FIG. 8—De FOREST'S TRIODE vacuum tube in its final form. The tube was designed for both signal rectification and amplification.

filament behaved in a different manner than the other side. As a result, the glass envelope of the light would blacken. Edison tried various schemes to eliminate the problem. In 1883, as an experiment, Edison inserted a metal plate between the filament wires. By connecting the plate to the positive terminal of a battery he was able to measure the current between the filament and that plate. Although the information did not lead to an answer to the blackening problem, he deemed the discovery significant enough to obtain a patent for it.

Fleming felt that Edison's discovery might be the answer to the ongoing problem of signal detection. In 1904, Fleming modified Edison's design by replacing the metal plate with a metal cylinder that completely surrounded the filament. Also, the filament was designed to carry a larger current than was required by Edison's bulb. That was made possible by the development of the thoriated tungsten filament by Irving Langmuir in 1900. (adding theorium to a filament improves a filament's emission.)

The triode

De Forest's invention of the triode vacuum tube was a major step forward for radio. It was the first device that had the ability to amplify. De Forest tried many approaches before finally meeting with success. In one of the earliest designs tube was actually a duo-diode—two diodes within a single envelope. In another approach, de Forest tried to influence current flow by wrapping wires around the outside of the envelope.

Eventually the design shown in Fig. 8 took shape. That tube was actually a diode/triode, since the device was used to both rectify and amplify. Rectification was done by using the grid and the filament as a diode.

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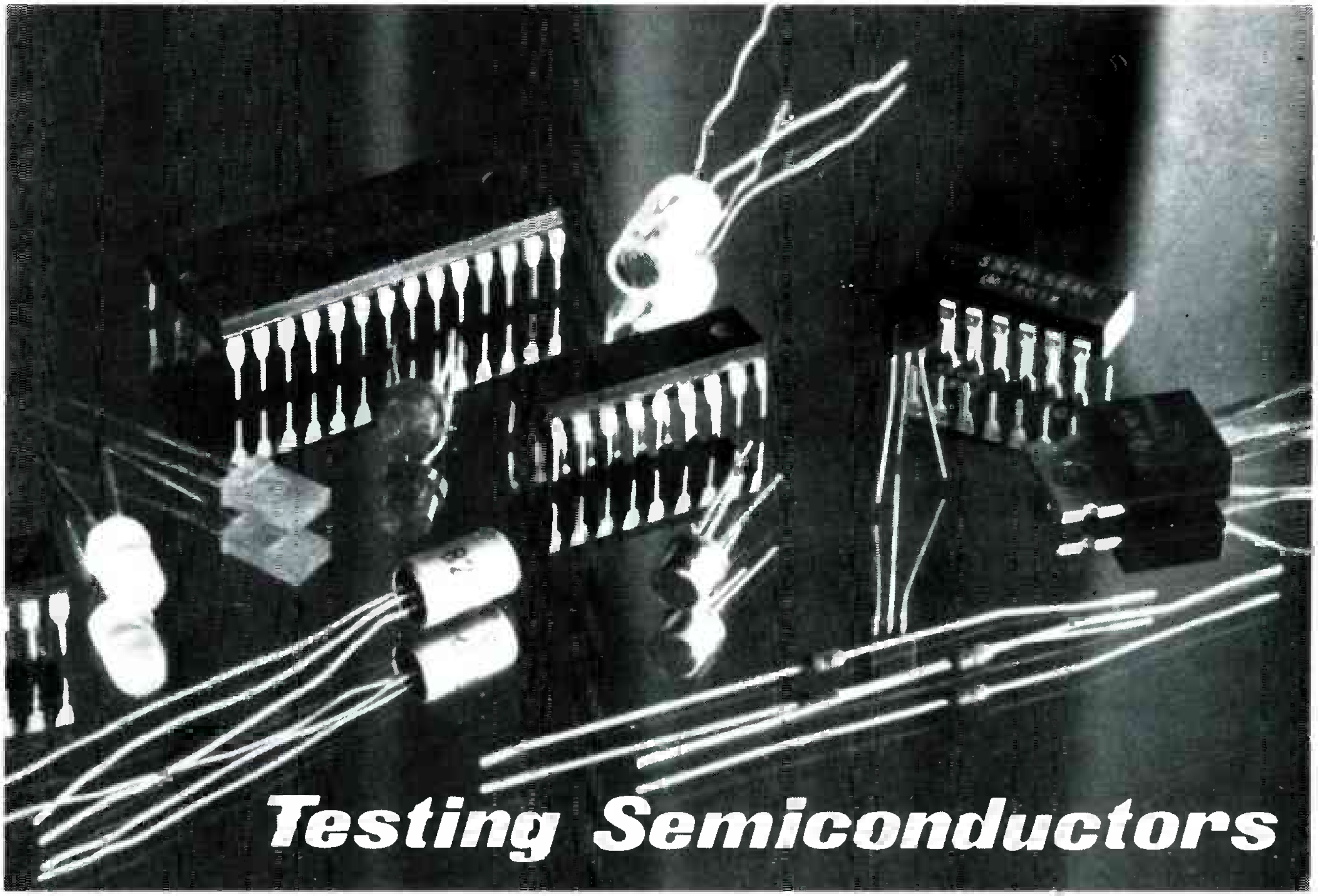

Testing Semiconductors

Our back-to-school series continues this month with a discussion of diodes and their characteristics.

TJ BYERS

BY NOW YOU SHOULD HAVE A GOOD UNderstanding of semiconductor junctions and their behavior. We have explored the relationship between leakage current and breakdown voltage, looked into transistor construction, and shown how different voltage and current combinations affect the performance of bipolar transistors and FET's.

However, transistors were not the only products of the semiconductor revolution. Other devices with such unlikely names as silicon-controlled rectifier, tunnel diode, and Triac were introduced, and are still very useful. As exotic as they may sound, you are now in a position to deal with them intelligently. Armed with the information from the first two parts of this series, we're ready to perform static measurements on just about any semiconductor device we happen to run across. This month we turn our attenton to semiconductor diodes.

Diodes

It can be said that diodes are the forerunners of the semiconductor revolution. We had diodes long before we had transistors. They come in a variety of shapes, sizes, and, most important, voltage and current ratings. Some are used for very special purposes; others are used in a wide variety of circuits. Whether general- or special-purpose, all diodes have three important characteristics: breakdown voltage, reverse leakage current, and forward voltage drop.

Breakdown voltage

Undoubtedly, the most important characteristic is the junction's breakdown voltage. It is at that voltage that the diode ceases to be a one-way electronic valve; at and above the breakdown voltage, current can flow freely in both directions.

Breakdown occurs when a reverse-biased diode junction goes into avalanche, a condition that is normally fatal to the device if it is allowed to continue unchecked. Data sheets list diode breakdown voltage as V_R or P_{RV} (which stand for *R*everse *V*oltage and *P*eak *R*everse *V*oltage, respectively), depending on the type of diode and its intended function. For all intents and purposes, though, the terms are interchangeable.

Breakdown voltage can be determined in one of two ways: It can be mathematically interpolated from leakage currents and charts, or it can be measured directly.

In the first method, we take a number of diodes and subject each to increasing amounts of reverse voltage, taking note of the leakage currents (I_R) as we do. We continue increasing voltage until the junction goes into avalanche. By following that procedure with a number of similarly manufactured diodes, we can correlate leakage currents and breakdown voltages, and thereby derive a family of curves that shows how breakdown voltage varies with leakage current.

Those results can be used to test other diodes with identical construction. By applying a voltage that is one-half to two-thirds the expected breakdown potential across the device under test and by measuring the resultant I_R current, we can predict the diode's breakdown voltage.

In fact, that's how many semiconductor

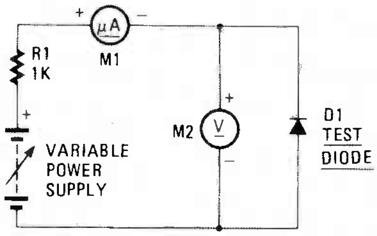

FIG. 1—REVERSE LEAKAGE CURRENT (I_R) may be measured at various voltages with this set-up.

manufacturers test their diodes. By specifying a maximum allowable current at a given voltage, the manufacturer can guarantee that the actual breakdown voltage of a diode equals or exceeds the specified breakdown voltage. Any diode that fails the leakage test will more than likely also fail to sustain the maximum voltage; therefore it's rejected.

Figure 1 shows a setup for measuring I_R and predicting V_R. The power supply is adjusted to a specific reverse voltage as indicated by the voltmeter, and the leakage current is noted on the milliammeter. Then the appropriate chart (supplied by the manufacturer) would be consulted to predict V_R.

While we're on the subject of reverse leakage current, let's emphasize the importance of I_R in several different applications. Leakage, for example, plays an important part in signal-diode circuits, particularly when the diode is used for purposes of isolation or modulation. Many times diodes must be matched—and that can be expensive. Measuring the value of I_R of a handful of general-purpose samples, however, often will yield a matched pair for about one tenth the price of a commercially matched set.

Peak reverse voltage

It's true that V_R and P_{RV} are often interchangeable, but there actually is a distinction between them. Both define the voltage at which the diode junction fails. However, P_{RV} is usually used in connection with rectifier diodes that are subjected to AC voltages, rather than DC.

The distinction is made because of the different ways AC voltages are specified. A 110-volt rms AC signal can accomplish the same amount of work as 110-volts DC. In truth, though, the AC signal only has a value of 110 volts for a brief moment during each cycle. As shown in Fig. 2, for a sinewave to have an *rms* value of 110 volts, the *peak* voltage must reach 166—nearly one-third more than you might expect.

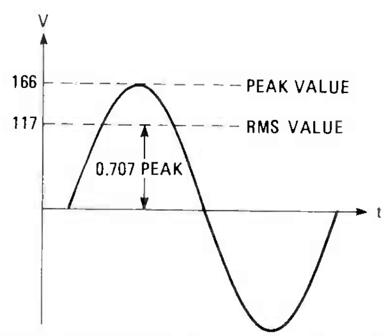

FIG. 2—A SINEWAVE with an rms voltage of 110 has a peak voltage of 166. A diode with a breakdown voltage of 125 volts would fail when subjected to a 110-volt rms signal, because the peak voltage exceeds the rating of the diode, even though the rms value doesn't.

Consequently, if you place a diode with a breakdown voltage of 125 volts in a 110-volt AC circuit, it would fail because the peak voltage exceeds the diode's rating, even though the rms value doesn't. The same diode in a 110-volt DC circuit would survive. Hence, the industry adopted the term P_{RV} as a means of indicating that peak—not rms—voltage is the important breakdown characteristic.

In a true P_{RV} test, the diode junction is forced into avalanche and voltage is measured. Usually, however, P_{RV} is tested using a pulse generator, rather than a steady DC source. The peak pulse voltage exceeds the P_{RV} rating of the diode, thereby forcing the junction into avalanche. Voltage is then measured with an oscilloscope. The test procedure has the advantage that it subjects the diode to operating conditions like those normally found in actual service, and it reduces the possibility of destroying the diode junction by allowing the heat to dissipate between test pulses. The test circuit is shown in Fig. 3.

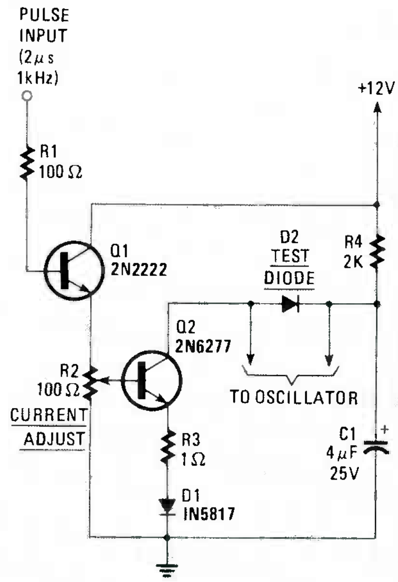

FIG. 3—P_{RV} IS NORMALLY MEASURED using pulsed voltages.

Forward voltage drop

The third characteristic that all diodes share is forward voltage drop (V_F). It is the amount of voltage you would measure across the diode during normal operation. The value of V_F is generally a fixed quantity and is largely determined by the quantum gap in the semiconductor junction.

More simply put, it is a function of the semiconductor material itself. Silicon diodes, for example, typically have a V_F of 0.7 volts. The V_F of a germanium diode, on the other hand, is 0.3 volts.

If semiconductor type was the only factor affecting V_F, its measurement would be academic, indeed. However, junction shape, ambient temperature, and current flow all affect forward voltage drop. Consequently, V_F must be measured for each type of device. It is measured by passing a specific current through the diode and measuring the voltage drop across it. A representative circuit is shown in Fig. 4.

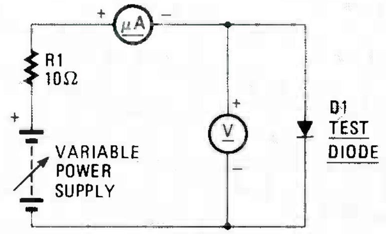

FIG. 4—FORWARD VOLTAGE DROP is measured using the same basic circuit as shown in Fig. 1. However, the polarity of the diode is reversed, and the resistor's value is reduced.

Forward current flow is an important characteristic that is related to forward voltage drop. Normally, the diode displays a fixed voltage drop. A point is reached, however, where the junction becomes saturated with electrons, and the bulk resistance of the junction affects current flow. Higher currents also increase power dissipation, which in turn increases junction temperature, which increases the voltage drop, which results in greater power dissipation . . . and so on.

It is not unusual to find a two- or three-volt drop across a high-power rectifier operating near its rated current limit. And, in low-voltage designs, the power lost due to V_F can be appreciable.

The Schottky diode

One way to reduce V_F losses is to alter the construction of the junction. The Schottky-junction diode, named for its inventor, is just such a device.

As shown in Fig. 5, the Schottky diode consists of a junction made of metal on one side and a semiconductor on the other. The junction forms a barrier that acts like a one-way valve. The forward conduction mechanism uses hot-carrier electrons, as opposed to hole migration in bipolar junctions, to bridge the gap. That mechanism has led to the nickname *hot-carrier diode*.

Since the diode is composed of a single

semiconductor material, its quantum voltage gap is very small: typically on the order of 0.3 volts or less. The method of testing for V_F or P_{RV} in a Schottky device is identical to the procedures outlined earlier. Because of the way the junction works, however, the Schottky diode typically has a lower reverse-voltage breakdown value than that found in the bipolar diode.

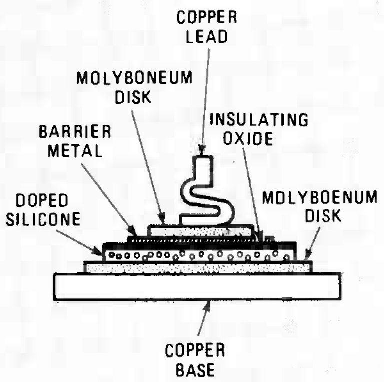

FIG. 5—THE SCHOTTKY DIODE is built from a single semiconductor material, unlike typical PN-junction diodes.

The Schottky diode also has smaller series resistance (V_F/I_F), less inductance, and faster recovery time than bipolar devices. Those features (and the nearly ideal voltage-current characteristics of the Schottky junction) make it attractive for use in applications other than power rectifiers. In fact, Schottky diodes are commonly found in microwave devices and TTL integrated circuits.

The Zener diode

The avalanche effect characteristic of bipolar semiconductor junctions is the basis of the Zener diode. Basically, it is a bipolar diode that operates in the reverse-breakdown mode. Breakdown voltage is largely independent of current, temperature, and age; therefore the Zener often replaces battery-resistor voltage-reference circuits.

The Zener diode is built much like a bipolar junction diode—with one difference. As we have noted throughout this series of articles, avalanche current often destroys a semiconductor junction because of the excessive heat that is generated. That problem is avoided in the Zener diode by enlarging the junction and providing external heat sinking when necessary (usually for diodes with power ratings greater than one watt).

The Zener's breakdown voltage (V_Z) is measured using the same current-limited avalanche-producing procedures described several times in this series. There is one difference, however: the test current used. Until now we've been careful to maintain the avalanche current at a very low level to prevent damage to the junction. Zener diodes, however, need to be tested near the limits of their operating range—in other words, well beyond the knee—for the test to be accurate.

For ½- and 1-watt Zeners, that current is typically 20 mA. In other words, the test is performed with a constant-current power supply adjusted to provide 20 mA of current. Then, with the diode under test attached to the current source, voltage is measured across the diode. The voltage read is V_Z for that Zener.

Higher-powered Zeners are tested at higher currents, as defined by their data sheet. You will find, though, that V_Z is stable over a wide range of current values. Therefore, it is of little concern whether the diode is tested at 20 mA or at 24 mA—as long as the current remains within the safe operating limits of the Zener.

Dynamic resistance

Because Zener diodes frequently substitute for batteries, dynamic resistance (R_Z) is an important characteristic. Basically, dynamic resistance is the AC impedance of the diode; it is equivalent to the internal resistance of a battery.

R_Z is measured by first applying a DC current and then passing an AC current through the diode. The Zener's opposition to the passage of AC is its dynamic resistance.

Both V_Z and R_Z can be determined using the test circuit shown in Fig. 6. First the constant-current source is adjusted until the rated DC current flows through the Zener diode, as described above. At that point, V_Z may be read from the voltmeter.

R_Z is determined by measuring the peak-to-peak voltage (V_1) across the Zener, and that across R1 (V_2). Then those values are inserted into the following equation:

$$R_Z = 100 \times V_1/V_2$$

Note that R_Z will vary as the DC current through the diode varies.

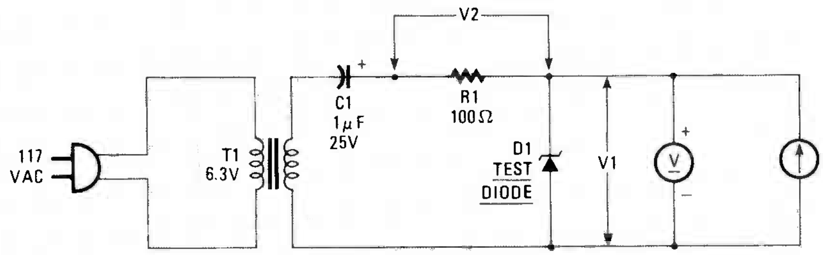

FIG. 6—DYNAMIC RESISTANCE (R_Z) and Zener voltage (V_Z) can be measured using this circuit.

The tunnel diode

The last diode we'll examine this month is the tunnel diode. Although not as popular as it used to be, the tunnel diode is still used in high-frequency circuits.

The tunnel diode is a two-terminal device that differs from other diodes in the level of doping used in the semiconductor materials. The impurity concentrations in both the N-type and the P-type materials is 1000 times greater than that normally found. That high concentration results in an extremely thin depletion region at the junction—something on the order of 1 micron (0.000001 cm).

Normally, a forward voltage of a 0.5 or more is required to overcome the electrical barrier formed by the P-N junction. Quantum theory, however, predicts that upon occasion an electron will violate classical physics and sneak through the P-N barrier to appear mysteriously on the other side of the junction. That process is called tunneling. If the junction is made thin enough, as in the tunnel diode, the likelihood of tunneling increases.

Tunneling is important in that it occurs at very low voltages, typically 100 millivolts or less. Because the active region of a tunnel diode occurs at a much lower voltage than that of a conventional diode, the tunnel diode is an extremely low-power device. Such diodes have been used

continued on page 102

MEASURING V_Z

A quick-and-easy way to measure a Zener's V_Z is to place a current-limiting resistor in series with any stable power source—it needn't be regulated—and measure the voltage across the diode. For

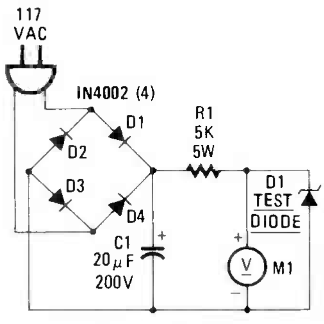

FIG. 1

Zeners with power ratings of less than one watt and voltage ratings less than 24, the circuit shown in Fig. 1 proves quite accurate. For safety, build the circuit in an insulated housing. And don't connect it to any line-powered equipment! **R-E**

PC SERVICE

BECAUSE THE CIRCUIT BOARD FOR THE robotics-control computer will not fit on the pages of Radio-Electronics, the component side is shown here half sized. The solder side of the board will be shown next month. For those interested in receiving full-size photostats of both sides of the board, simply send a self-addressed, stamped envelope to:

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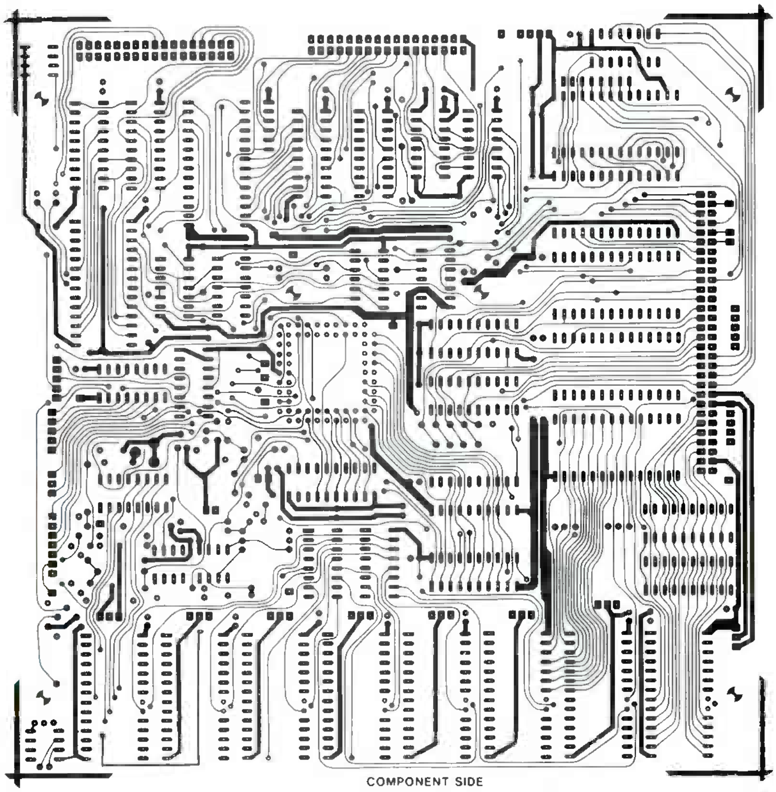

COMPONENT SIDE

7¾ INCHES

THE COMPONENT SIDE of the robotics-control computer is shown here half size. Note that it is not a mirror image, and it cannot be used to directly etch a board.

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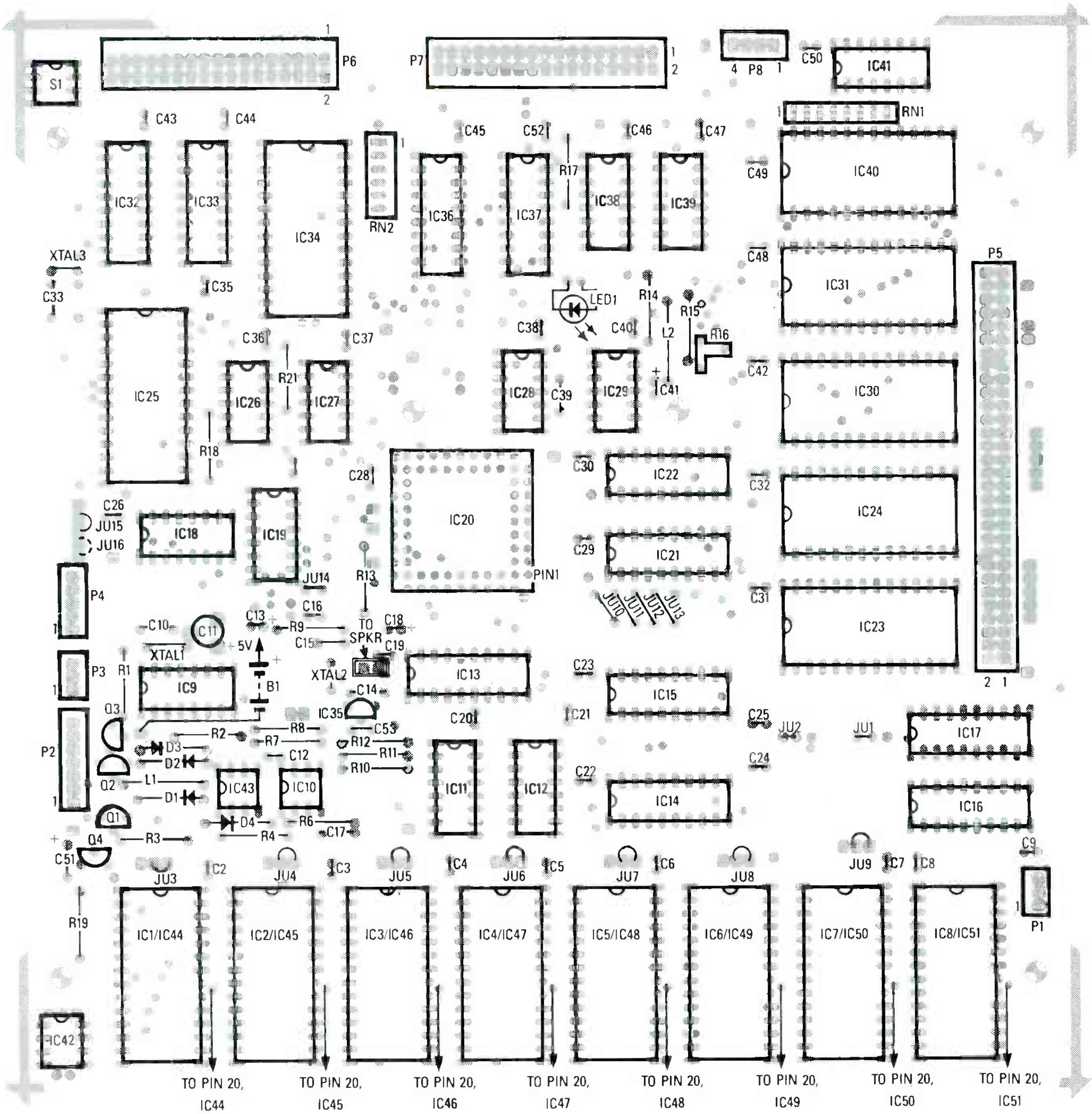


THE PARTS-PLACEMENT PATTERN for the robotic control computer. For clarity, the parts are shown over the board's *pad master*. The interconnecting traces are not shown.

NEW IDEAS

Headlight alarm

IT'S 5:00 P.M., AND YOU'VE JUST finished a long day at the office. You climb into your car, turn the ignition switch on, and nothing happens. That's when you suddenly realize the problem: You left your headlights on this morning. Unfortunately, the realization has come about eight hours too late and now your battery is dead.

The preceding incident has probably happened to you at least once; in my case it has happened more often than I care to remember. Or at least it used to. Now, I have installed the simple circuit shown in Fig. 1 in my car. Of course, the circuit is a headlight alarm. It has saved me from embarrassment and aggravation on several occasions.

The circuit

While many cars are equipped with a headlight alarm, many more, unfortunately are not. For those cars, the circuit in Fig. 1 offers a low-cost way to add that valuable feature. Let's see how it works.

The base of Q1 is connected to the car's ignition circuit; the easiest point to make that connection is at the ignition switch fuse in the car's fuse panel. Also, one side of the piezoelectric buzzer is connected to to the instrument-panel light fuse; remember that when the headlights or parking lights are on, the instrument panel is lit too. When the headlights are off, no current reaches the buzzer and therefore nothing happens. What happens when the headlights are on depends on the state of the ignition switch. When the ignition switch is on, transistors Q1 and Q2 are biased on, effectively removing the buzzer and the LED from the circuit.

When the ignition switch is turned off but the headlight switch remains on, transistor Q1 is turned off, but transistor Q2 continues to be biased on. The result is that the voltage across the piezoelectric buzzer and the LED is sufficient to cause the buzzer to sound loudly and the LED to light. Turning off the headlight switch will end the commotion quickly.

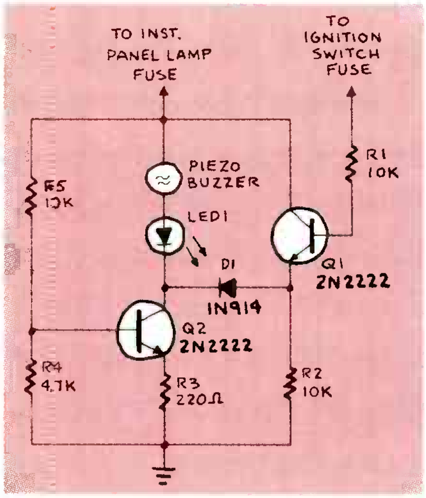


FIG. 1

Construction

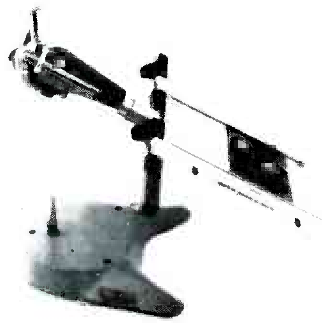
The circuit can be wired together on a piece of perforated construction board. The buzzer I used was a Radio-Shack 273-065 PC-board mounting type, but almost any similar buzzer will do. Circuit parameters are not critical, so feel free to make appropriate substitutions from your junk box to further reduce the cost.

When you are finished, house the circuit in a small, plastic experimenter's box and locate the unit on or under the dash of your car. You could also locate most of the unit behind the dash were it will be out of the way and mount only the LED where it can be seen easily. One good place would be next to the headlight switch on your dash; that will provide more of a custom look.—*Charlie Lowell*

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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Audio Update

Why stereo doesn't work

LARRY KLEIN,
AUDIO EDITOR

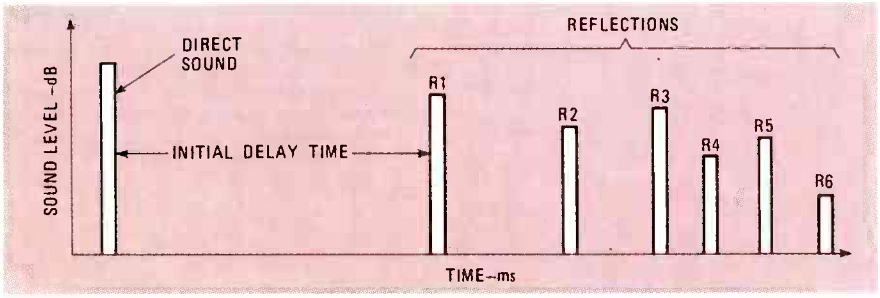

FIG. 1

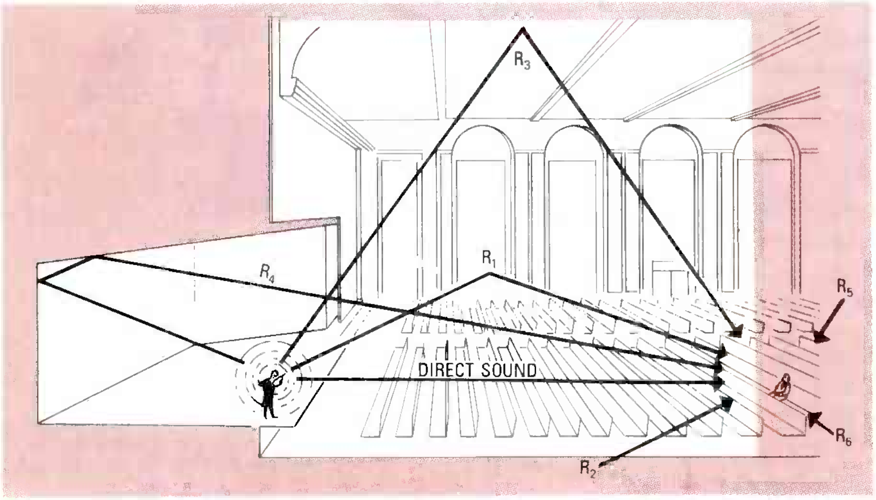

FIG. 2

DESPITE MORE THAN 35 YEARS IN PURsuit of the "Holy Grail of Hi-Fi" (i.e. *perfect* sound reproduction), I've experienced it something less than a dozen times. By "perfect" I mean that with my eyes closed, I sonically seem to be in the same room or hall with the performers. Aside from a few impressive experiences with binaural headphone listening, which is another acoustic ballgame altogether, the only times I've experienced the "I am there/they are here" phenomena have been when there was specially recorded program material and/or when two or more extra channels have been involved.

For some of us, quadraphonic sound reproduction, which was introduced in the early 1970's, had a potential that was never fully realized. A combination of bad marketing, bad engineering, and bad demonstrations condemned quadraphonic sound to an early demise, despite the fact that the basic concept was valid.

Live *vs.* reproduced sound

To appreciate the reasons why multichannel sound is, by its very nature, far superior to the best that conventional stereo has to offer, it's necessary to understand the differences between live sound heard in a hall and recorded sound reproduced in a living room.

There are few acoustic similarities between the two listening environments. The sheer size of most live-performance venues means that the sound reflected and re-reflected from the boundary surfaces (walls, floor, ceiling) are going to reach a listener's ears substantially later than the sound coming directly from the performers. See Fig. 1. Since sound travels roughly 1,100-feet-per-second, or 1.1-feet-per-millisecond, time delays of more than 50 milliseconds between the direct and reflected sound are not uncommon. And when the sonic environment is both large and hard surfaced, such as in a church, the reflections multiply, blend, and take several seconds to die away. Furthermore, the reflected and reverberant energy, which can account for better than 80 percent of the total sound impinging on the audience, comes at the listeners from all directions. See Fig. 2.

Even when perfectly set up in a normal listening room, a conventional high-quality stereo system is functioning with a host of handicaps. First of all, the sound comes from a more or less flat plane whose area is roughly defined by the location of the two speakers. Whatever hall reverberation is captured by or synthesized into the recording is also coming from the same space.

Of course, there are reflections of the speaker sound taking place

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within the listening room, but compared to any live recording environment, the listening room walls are usually much too close. That means that the reflections arrive much too quickly (have too short a delay time), and the reverberant sounds that would normally be heard from the sides and rear essentially all come from the front. In fact, unless the chosen speaker systems are very carefully set up with due consideration for their specific dispersion characteristics and their proximity to the adjacent room surface, early room reflections are likely to distort the stereo image and to introduce frequency-response irregularities through cancellation and reinforcement of the direct signal.

To my ears, most speakers sound best when at placed least three or four feet away from any reflecting surface, including the back wall, and are, in general, situated in a fairly absorptive part of listening room. Carpeting in front of the speakers, wall hangings behind and between the speakers, and soft chairs flanking the speakers are all means to that end.

In my view, it is the audible, but usually only unconsciously perceived disparity between the acoustic environment embodied in the recording and the actual acoustic environment of the listening room that is primarily responsible for the lack of sonic realism of even the best stereo system.

My theory is supported by the fact that a good system almost always sounds more realistic when heard from an adjacent room, where you hear a blend of the two contradictory acoustic environments. A very large listening room can give rise to the same effect; when you listen far enough away from the speakers some of the same acoustic blending can take place. But in no case does the recorded early and late reflections (reverberations) surround the listener in the same way it does under live conditions.

The sound field

From the psychoacoustic viewpoint of a single listener, the complex acoustic interactions taking place throughout the concert hall or listening room don't really matter. What is significant is the ever-changing sound field occurring directly at the listener's two ears. Even an untrained listener hearing a well-recorded live performance for the first time has a sense of the size and the nature of the recording space. Assuming that the engineers were competent, the acoustic ambience of a recording of Orff's *Carmina Burana* performed in a church is going to sound quite different from that of a small jazz group playing in a night club. Our ear/brain computers are constantly analyzing the similarities and differences in phase, timing, amplitude, and frequency occurring in the sounds reaching our two ears. That information is used unconsciously to construct a mental image of the acoustic environment in which the sound is taking place. I say "unconsciously" because we are not talking about a deliberate mental process. But the fact that we are

continued on page 82

ACID RAIN

continued from page 49

points. Connect the circuit to a VOM, and adjust the potentiometer for a reading of 94 µA. Then disconnect the sensor assembly from the main circuit and connect the battery-potentiometer combination in its place. Adjust R1 until the meter reads exactly 100 µA, which corresponds to a pH of 2.5.

The other pH points are established by feeding a known current to the circuit and noting the position of the needle. Those positions correspond to the pH's shown in Table 1. If you want to interpolate in-between values, keep in mind the fact that the scale is not linear.

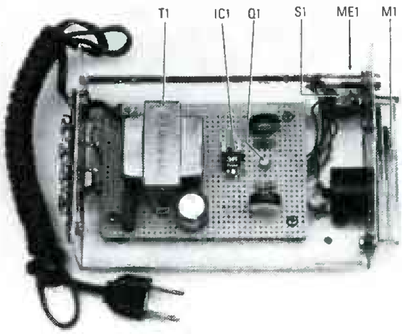


FIG. 5—THE ELECTRONIC COMPONENTS mount on a piece of perfboard; they are connected by point-to-point wiring. The terminal strip provides connections to the remote-mounted sensor and solenoid.

Installation and use

The best location for the sensor assembly is on a post, as shown in Fig. 6, away from trees and buildings. If it's mounted on the side of a house, be sure that the bracket you use is long enough to place the funnel beyond roof or eave run-off.

Don't be alarmed if the meter indicates some acidity. A pH of 6.0 to 6.5 is normal and unharmful. However, environmentalists warn of dire consequences for continuously higher readings.

For example, at continuous pH levels of 5.0 to 5.5, lawns and garden plants will begin to turn brown, and soil will need added lime. A pH of 4.5 in ponds and lakes will start killing fish, and, when pH reaches a level of 4.0, a clear blue appearance, although beautiful, will indicate a "dead" body of water. A pH of 3.5 will cause rapid deterioration of painted surfaces. A continuous pH of 3.0 will result in erosion of structural limestone, and entire forests will die. Last, if the meter indicates 2.5 or less, you may be living near an active volcano!

After taking readings from accumulated rainfall, the funnel should be drained, leaving S1 in the DRAIN position only long enough to drain the funnel, as most inexpensive solenoid valves are not designed for continuous duty. Inspect the electrodes several times a year, and if any corrosion forms, swab it off with a weak ammonia-water solution, and then flush the electrodes with distilled water.

For studying the long-term effects of acidity, the output of the meter could be connected to a chart recorder. And the meter may also be used to test your local tap, pond, and stream water by pouring a sample into the funnel. **R-E**

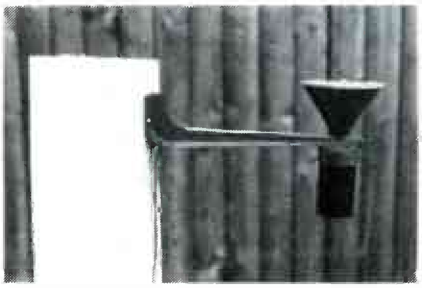
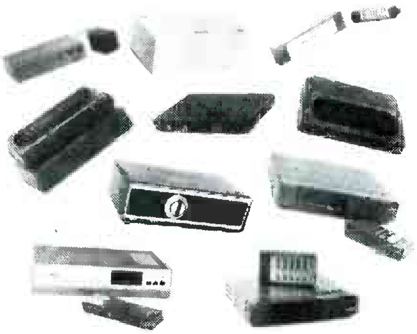


FIG. 6—THE SENSOR ASSEMBLY should be mounted on a long bracket that is screwed to a post. The post should be mounted away from overhanging eaves; and don't mount it under a tree.

Radio-Electronics mini-ADS



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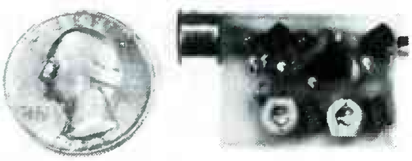

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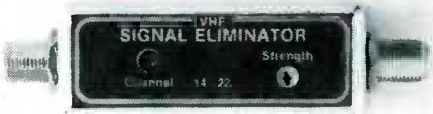

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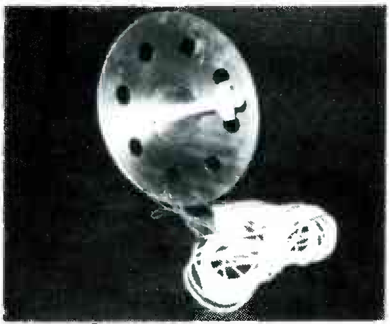

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Radio-Electronics mini-ADS

COMMERCIAL ZAPPER

continued from page 47

maximize the number of comparator transitions during commercials. Begin by connecting the commercial killer to the stereo receiver's tape-monitor loop. Set the receiver to FM and select the tape-monitor mode. Because the audio level may vary from station to station, tune to the station of greatest intended use. And remember, the commercial killer works best with easy-listening formats. During commercials, adjust R41 to maximize attenuation by watching the FADE LED. Slight readjustment may be necessary to provide the fewest zapping errors without performance degradation.

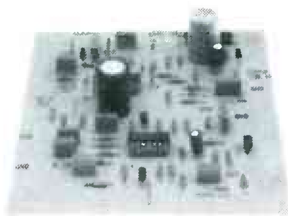

FIG. 7—THE COMMERCIAL ZAPPER circuit is shown here assembled on a PC board.

If the commercial killer fails to work, make sure that the power supply is providing the correct voltage, and that V_{REF} is about 13.5 volts.

If the voltages are correct, then verify that you can obtain waveforms like those shown in Fig. 3–Fig. 5. If the peak signal level at the inverting input of IC2-b cannot be adjusted (via R41) to exceed 2.5 volts, the signal level out of the receiver may be unusually low, so the value of R41 may need to be increased.

If the rate of transitions at TP4 is low during music and high during commercials (but attenuation is not proportional to the rate of transitions), verify the following.

- When there is no signal present, the voltage at TP5 should be within 0.2 volts of the voltage at the non-inverting input of IC1-c.
- During a commercial, the voltage at TP5 should be at least three volts less than the voltage at the non-inverting input of A7.

If the first condition is not met, there will be attenuation during music. Diode D4 should be reverse-biased with no signal present. If it is not, and if the voltage at TP4 is about eight volts, it may be necessary to reduce R18.

If the second condition is not met, there will be insufficient attenuation during commercials. If TP4 is approximately eight volts with no signal present, it may be necessary to decrease R19 or R20.

Last, if fading occurs, but the LED does not light, it may be connected to the circuit backwards. **R-E**

DRAWING BOARD

ROBERT GROSSBLATT

An output decoder

BELIEVE IT OR NOT, WE'RE ALMOST finished putting together our DTMF transmitter-receiver. All we have to do is add a few bits and pieces and we can start the easy part—looking around for some good applications for the circuit. As it stands now, we can point the transmitter at the receiver, push one of the transmitter's sixteen buttons, and see a DTMF tone pair at the outputs of the receiver's 3525, with the high and low group tones already conveniently separated for us. The last thing we have to do is translate the DTMF tones back into binary so we can do something with the output. Fortunately, that's the easiest part of the design.

As was the case with splitting the high and low groups, you could put together a circuit that converted DTMF data to binary using only standard parts. But then again, if you put your mind to it you could probably build a light bulb that way as well. This happens to be one of those times when it makes a lot of common sense to use an IC designed specifically for the job.

Although several companies make DTMF decoder IC's, we decided to use Mostek devices. That company makes a range of decoders, so you can pick an IC that really suits a particular application. Since we're not trying to do anything fancy, any of their decoder IC's will do. The MK5102 is a nice choice since it's easy to find and use. That IC is very similar to the MK5103, and the pinouts are identical, so one can be freely substituted for the other. The only difference between the parts is that the MK5103 is a slightly higher-grade device. The signal-to-noise ratio is 4 dB better, the tones can be detected 3 milliseconds faster, and it only uses about half the current when it's working (2 mA as opposed to 5 mA). But in many applications, those improvements will not make a difference.

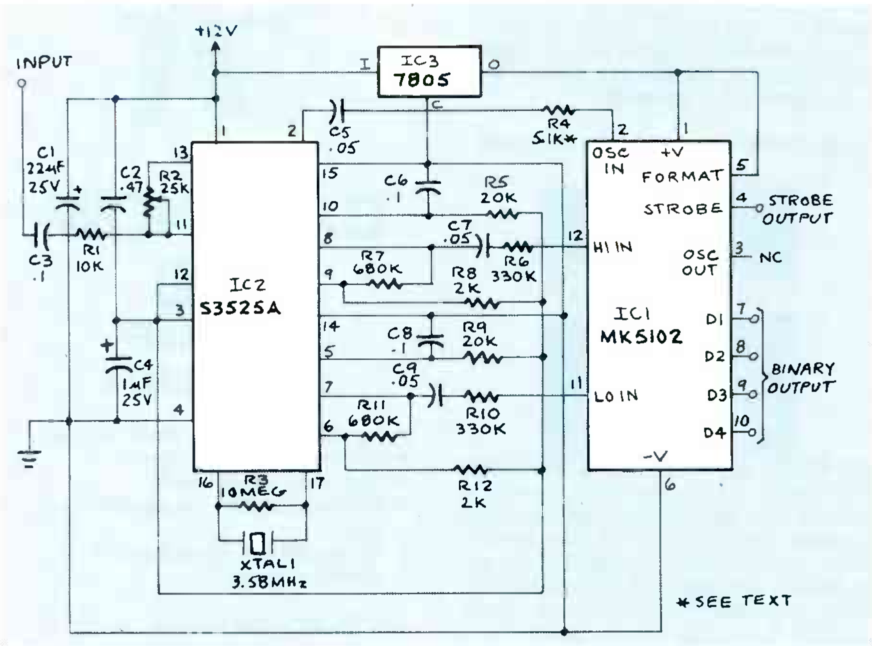

FIG. 1

Hooking it up

Getting the S3525 to talk to the MK5102 is simple. The only thing that might be the least bit tricky comes about because the two devices want different supply voltages: +5 volts for the MK5102 and +12 volts for the S3525. Since the MK5102 is a CMOS part it doesn't need a lot of current so the supply voltage can be chopped down to size with nothing more than a Zener.

Getting the signals from the S3525 outputs to the MK5102 inputs also takes a bit of thought since the voltage levels have to be translated there as well. That's because the CMOS outputs of the S3525 swing to within ½ volt of the supply voltage, which means that a

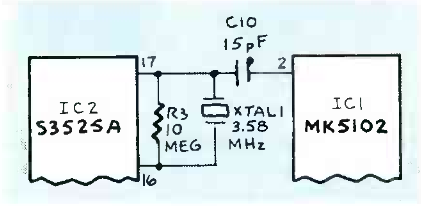

FIG. 2

high will be at about 12 volts. That's a definite no-no for the inputs of the MK5102. Figure 1 shows a circuit that takes care of the problem and gets the two IC's talking to each other.

One thing you should notice right away is that we're making use of the buffered 3.58-MHz oscillator output that the folks at AMI have so conveniently put in the architecture of the S3525. (The buffered 3.58-MHz signal is exactly what we need to drive the MK5102.) Using one crystal for both IC's is a good idea since it eliminates one possible source of error. Of course we have to take care of the voltage differences there as well, but that's handled in the same manner as the outputs.

If you look at the outputs of the S3525, you'll see that C9 and C7 decouple each of them from the MK5102 inputs. Resistors R6 and R10 are there to do the level translation so the 12-volt outputs can safely drive the MK5102's 5-volt inputs. Much the same kind of level shifting is done at the crystal output as well with C5 and R4. The value you arrive at for R4 depends on the exact supply voltages at each IC but the value used in Fig. 1 should work as long as you're using supply voltages that are within 0.2 volts of 12 volts for the S3525 and of 5 volts for the

MK5102 OUTPUT CODES

INPUT	OUTPUT							
	PIN 5 HIGH				PIN 5 LOW			
	D1	D2	D3	D4	D1	D2	D3	D4
1	Φ	Φ	Φ	1	Φ	1	Φ	1
2	Φ	Φ	1	Φ	Φ	1	1	Φ
3	Φ	Φ	1	1	Φ	1	1	1
4	Φ	1	Φ	Φ	1	Φ	Φ	1
5	Φ	1	Φ	1	1	Φ	1	Φ
6	Φ	1	1	Φ	1	Φ	1	1
7	Φ	1	1	1	1	1	Φ	1
8	1	Φ	Φ	Φ	1	1	1	Φ
9	1	Φ	Φ	1	1	1	1	1
Φ	1	Φ	1	Φ	Φ	Φ	1	Φ
*	1	Φ	1	1	Φ	Φ	Φ	1
#	1	1	Φ	Φ	Φ	Φ	1	1
A	1	1	Φ	1	Φ	1	Φ	Φ
B	1	1	1	Φ	1	Φ	Φ	Φ
C	1	1	1	1	1	1	Φ	Φ
D	Φ	Φ	Φ	Φ	Φ	Φ	Φ	Φ

FIG. 3

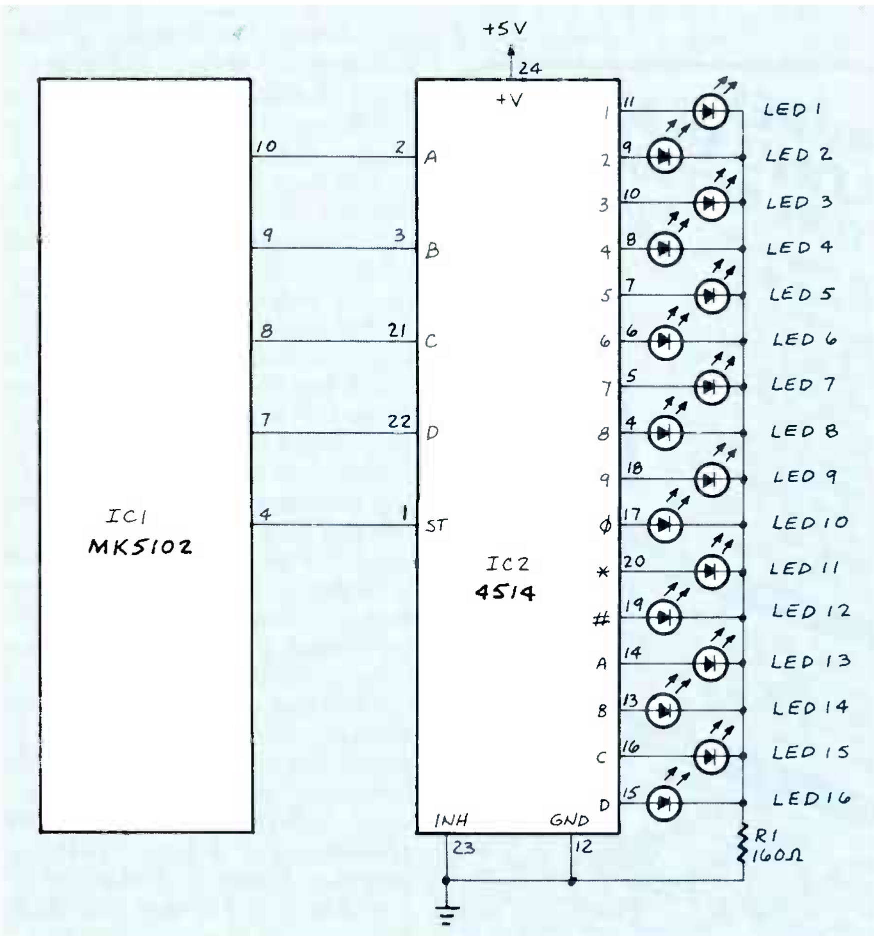

FIG. 4

MK5102. If your voltages are different, you'll have to adjust the value of the resistor.

That problem comes about because the S3525 will work over a wider supply voltage range than the MK5102. The S3525 is happy with anything from 9.5 to 13.5 volts while the MK5102 will choke if you don't stay within ½ volt of 5 volts. You can work out R4 with a lot of math, but this is one of those times when it's a lot easier (and a lot smarter) to measure the voltage at pin 2 of the MK5102. Using the appropriate *DC* range on your voltmeter or DMM, adjust the value of R4 until you've got a reading of 2.5 volts. That's not a super-accurate way to get the job done since the voltage at that point is actually AC, but it yields satisfactory results.

If you still have problems, you can modify the circuit as shown in Fig. 2. There, both C5 and R4 have been eliminated and the output of the oscillator on the S3525 is used to drive both IC's directly. Although that circuit appears simpler, it will put more of a load on the S3525. Experiment with both circuit configurations and see which one works best for you. If there is no apparent difference, stay with the configuration shown in Fig. 1.

Believe it or not, that's just about all there is to connecting up the MK5102. The only other thing worth discussing is the format-control pin, pin 5. The MK5102 can output data two different ways: two-of-eight or straight binary. The difference between those outputs is shown in Fig. 3. When pin 5 is high, the output is straight binary; when pin 5 is low, the output is in two-of-eight format. Since we're feeding in binary in at the transmitter, we want binary out at the receiver and we can get that by tying pin 5 high.

Seeing the output

The last step in building our remote-control system is to devise some way of examining the binary output of the receiver. A simple way to look at it is to use a 4514 in a circuit setup that's exactly the opposite of the one we used at the transmitter. The appropriate circuit is shown in Fig. 4. By tying pin 23 of the 4514 low, we're permanently enabling the outputs. The input enable pin, pin 1, is controlled by the strobe output of the MK5102. As soon as the MK5102 detects a valid input, it puts a high on the strobe input and valid data on the output. The 4514 will only accept input as long as the MK5102 strobe is active. When the strobe drops low the data will be latched in the 4514 and the selected output will remain high.

There are no end to the uses for the remote-control circuit. If you use the outputs properly, you can control a lot more than 16 devices with the 16 keys on the transmitter keypad. How to go about doing it we'll leave as an exercise for you.

As a matter of fact, let's make a contest out of it. The first two readers who send me a working circuit schematic and an explanation will have their idea published and get a year's subscription to **Radio-Electronics**—not a bad deal! Remember, I want an add-on to our remote-control system that will let you use it to control more than 16 devices. **R-E**

DESIGNER'S NOTEBOOK

A battery backup for CMOS-based circuits

ROBERT GROSSBLATT
CIRCUITS EDITOR

ONE OF THE BIGGEST ADVANTAGES OF CMOS-based circuit design is the ability to run everything off batteries. Not only does that make the circuit completely portable, but it simplifies the overall design process as well. Powering a device from a wall socket means that you have to use transformers and rectifiers. It also means that you have to deal with ripple, regulation, and a lot of other stuff that has nothing to do with the circuit you're trying to build.

Of course, there are two sides to every story. Batteries simplify a lot of problems, but they also have one big one of their own: They go dead. And if power is drawn by a circuit to retain memory, those batteries will fail a lot sooner.

Memories like the 5101, 6116, 6264, and the other members of the CMOS low-power series require only about 10 µA at 2 volts to retain their contents. That makes it possible to use a battery backup with those devices.

Battery backup circuit

If a battery backup is to be of any use, you need a circuit that will automatically switch from the main supply to the battery backup with an absolute minimum of glitching. That's the purpose of the circuit shown in Fig. 1. Designed for use with rechargable Ni-Cd units, it charges the batteries whenever power is applied to the +V terminal, and supplies power from B1 when power is absent from that terminal. The circuit is easily modified for use with non-rechargeable batteries.

The first thing you should notice about the circuit is its simplicity.

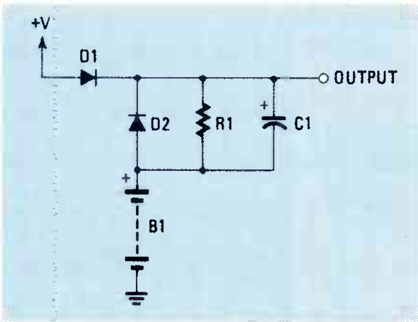

FIG. 1

The circuit's operation is straightforward. When power is supplied to +V, D1 conducts and, since D2 is reverse-biased, current flows into the batteries through current limiter R1. When the power is removed from +V, D2 is forward-biased and current flows from the battery to the output and on to the low-power voltage input of the CMOS device. Since D1 is reverse-biased at that time, no current can leak out via the +V terminal to the main part of the circuit. Capacitor C1 is included to filter out any glitches that may pop up during the change over from main power to battery backup, or when you replace the battery.

Component selection

Diode D2 can be a 1N914 unit since only small amounts of current will ever flow through it. Choosing a unit for D2 presents more of a problem; its selection depends on how much current is expected to flow through that diode. Chances are, if you're powering a CMOS IC, that the operating current is so low that you can use a 1N914 there as well. It is a simple matter to measure the current needs of the device to be powered; that should be done before making a decision about which diode to use for D2.

Resistor R1 is the current limiter for the battery. Its value will depend on the battery's charging current and the voltage that's available from +V. The value can be found from:

$$R1 = (+V - 0.6 - V_B)/I_C$$

where +V is the voltage available at the +V terminal, 0.6 is the voltage drop across diode D1, V_B is the nominal voltage of the battery, and I_C is the charge current required by the battery. For I_C use the battery's 14-hour charge rate. The value of I_C might be different for batteries from different manufacturers. The value for the battery you will use may be marked on the battery itself. Otherwise it can be obtained from the battery's data sheet or from the manufacturer. You can modify the circuit for use with lithium or other non-rechargeable units by deleting R1.

Stabilizing control lines

One precaution you should take when using the circuit is to make sure that the memory control lines are stable before switching from main power to backup. If the control lines are enabled during the switch over, you stand a good chance of generating a write pulse and scrambling the data. In most cases, it's possible to three-state the appropriate inputs on the IC, which will take care of the problem. Otherwise, extra circuitry can be added that will perform the same function. If there's enough interest in that topic, we'll talk about it in more depth in a future column. **R-E**

STATE OF SOLID STATE

Tone generator IC's

ROBERT F. SCOTT
SOLID STATE EDITOR

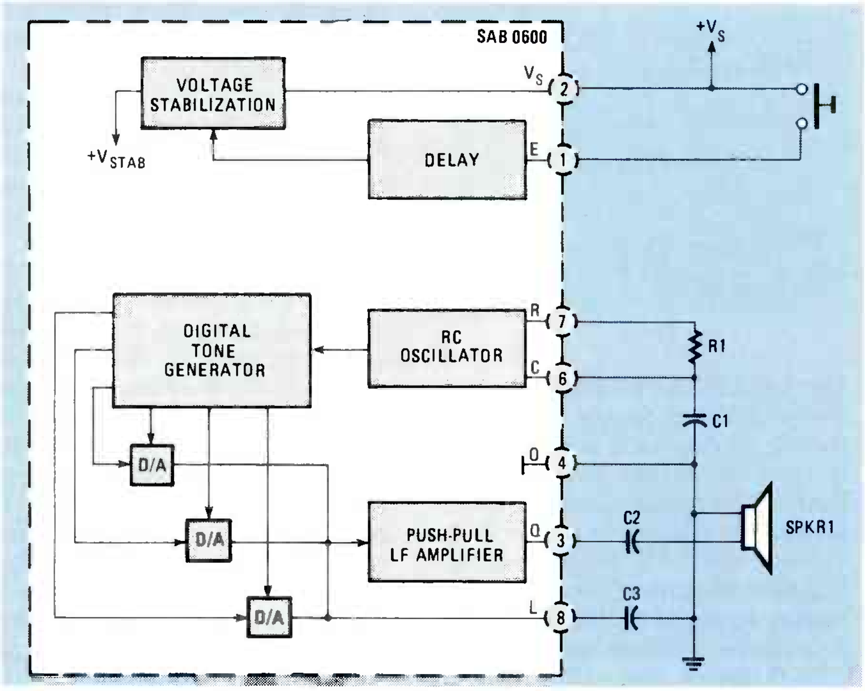

FIG. 1

THREE NEW IC TONE GENERATORS ARE available from the Integrated Circuits Division of Siemens Components. They are well suited for replacing the electromechanical gongs and doorbells in home installations and have countless applications as alarms and annunciators in timers, clocks, and automobiles. The devices are the SAB 0600, the SAB 0601, and the SAB 0602. The first develops a three-tone chime, the second generates a single tone, and the third produces two notes in succession. The SAB 0601 and the SAB 0601 are developed from the SAB 0600; the former by suppressing the last two tones, the latter by suppressing only the last note. Since all three IC's are simply variants of the SAB 0600, the circuits and discussion we will present will be centered on the latter.

A block diagram of the SAB 0600 is shown in Fig. 1. The SAB 0600 can be used to build a three-tone melodious chime, which in its simplest form requires only one resistor, three capacitors, and an 8-ohm speaker as external components as shown in the figure. The chime sequence is produced by three harmonically related frequencies: they are fed into a summing point and their amplitudes are allowed to decay individually.

The master oscillator generates a 13.5-kHz signal that is controlled by external components R1 and C1, which are connected to the R and C terminals of the tone generator. That 13.5-kHz signal is divided to produce the 660-, the 550- and the 440-Hz tones. One of those frequencies is divided down and used to control the timing and decay of the sequentially-produced tones. A 4-bit D/A (*D*igital-to-*A*nalog) converter in each tone path acts on the three tones in such a way that they overlap as they decay.

The push-pull output stage can deliver approximately 160 mW to an 8-ohm speaker. The shrill tones produced by the squarewave voltages can be mellowed by shunting some of the higher harmonics to ground through a capacitor tied to pin 8 (C3 in Fig. 1); the value of that capacitor is typically 0.1μF. Volume can be controlled by inserting a 100-ohm potentiometer between the speaker and the output blocking capacitor (C2 in Fig. 1).

The chimes are sounded by momentarily applying a 1.5- to 11-volt (maximum) pulse to the trigger terminal, E. To at least somewhat protect against false triggering by interference on the control line, a trigger pulse shorter than 2 ms will not activate the circuit. The SAB 0600 requires a source of 7- to 11-volts DC for operation, but it can be triggered by either an AC or a DC voltage. For DC triggering, the switch or pushbutton is connected between pins 1 and 2.

An electronic doorbell

The fact that the electronic chime can be activated by an AC pulse simplifies using it as an add-on to conventional doorbell systems powered by a 16- to 25-volt bell transformer; it simply takes the place of an electromechanical

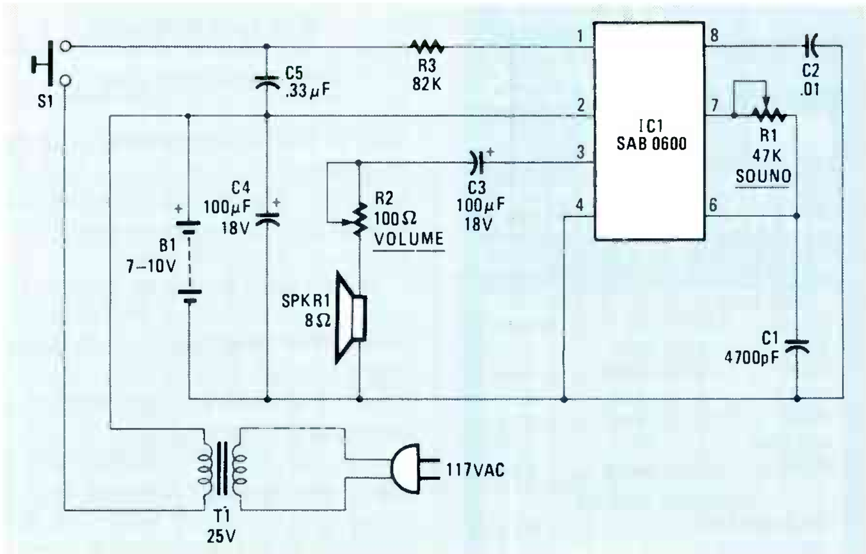

FIG. 2

sounder in the system. Figure 2 shows the required circuitry. An internal diode in the SAB 0600 shunts the negative half-cycles of the AC voltage to ground. The peak value of the positive half-cycles adds to the value of $+V_S$, so a resistor (R3) must be inserted in series with the trigger terminal to prevent the voltage at pin 1 from rising above the maximum level permitted for $+V_S$ (11 volts). Let's calculate its value.

The minimum permissible input current at pin 1 is 500 μA. Resistor R3 must drop the AC peak voltage so that the voltage at pin 1 never exceeds 11 volts. Assuming that the bell transformer has a 25-volt secondary:

$$R3_{(MIN)} = (V_{RMS} \times 1.41)/500\mu A$$
$$= (25 \times 1.41)/0.0005$$
$$= 35/0.0005$$
$$= 70{,}000 \text{ ohms}$$

For reliable triggering, the maximum value of R3 is determined by the minimum value for V_S (6 volts) while applying 1.5 volts at 50μA to pin 1 for triggering. So:

$$R3_{(MAX)} = (V_{S(MIN)} - 1.5)/50$$
$$= (6 - 1.5)/0.00005$$
$$= 90{,}000 \text{ ohms}$$

The suggested value of 82,000 ohms shown in Fig. 2 will provide triggering by battery or AC-peak voltages up to 35.

Note well that no conventional electromechanical bell or chime can be connected in parallel with the electronic chime pushbutton. Otherwise the electronic chime will sound continuously as the bell or gong will form an electrical connection between the V_s and the trigger terminals (pins 1 and 2).

The SAB 0600 and the others in the series are $2.30 each, in lots of 1 to 24. Write to **Siemens Components, Inc., Integrated Circuits Division,** 186 Wood Avenue South, Iselin, NJ 08830. **R-E**

AUDIO UPDATE

continued from page 72

able to make judgments about the recording environment when listening to a good stereo recording is a far cry from experiencing an I-am-there sonic illusion.

If we could perfectly record and store the two separate sound fields that impinge on a listener's right and left ears at some specific seat in a concert hall and then accurately reproduce the two fields directly at another set of ears, the second listener should experience exactly what the first listener heard. Many such recordings have been made using carefully constructed dummy heads with wide-range microphones implanted in the equivalent of their ear canals. Of course, the material has to be listened to through headphones to prevent the introduction of a confusing intervening acoustic environment. I've heard many such binaural recordings, and while they are a definite step towards realism, for obscure reasons they don't achieve quite the I-am-there perfection that theory seems to promise.

A practical approach

Late last year, I was asked by Yamaha to participate in the introduction of their *DSP-1* digital sound-field processor. I was particularly interested in the device because it used a completely new approach to recreating "concert-hall realism" in the home. It was neither an updated quadraphonic synthesizer nor a time-delay system, although in a sense it could be said to draw on both techniques in its digital manipulation of the signal.

After some discussion, Yamaha and I agreed on a presentation technique; I would first discuss the acoustic and psychoacoustic differences between the live musical experience and recordings reproduced at home—very much as I have done in my column. I would then introduce the *DSP-1* as one company's approach to enhancing the reality of home music reproduction. I'll discuss the specifics of Yamaha's digital processing techniques next time. **R-E**

VOL. 5 NO. 4 APR. 1987

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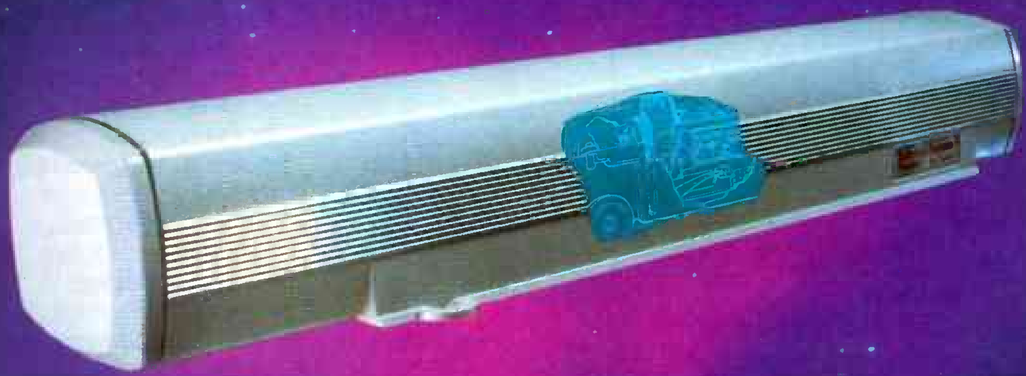
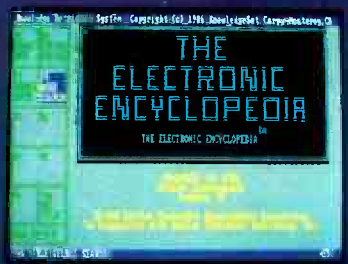
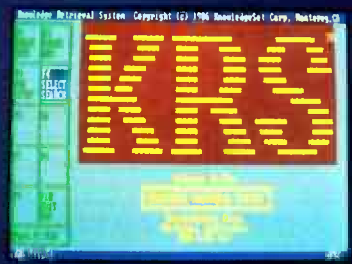


GROLIER'S ELECTRONIC ENCYCLOPEDIA





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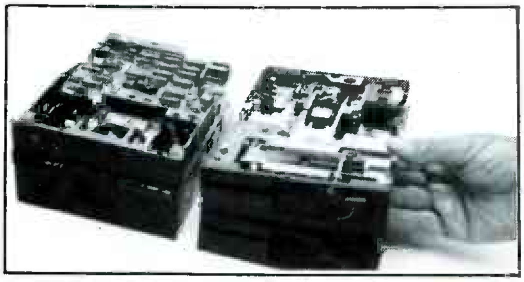

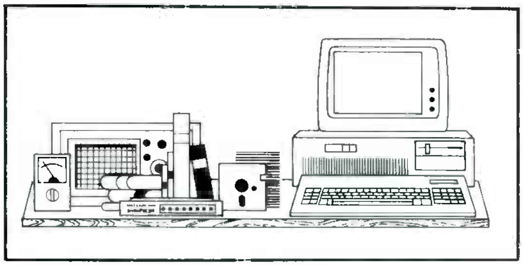

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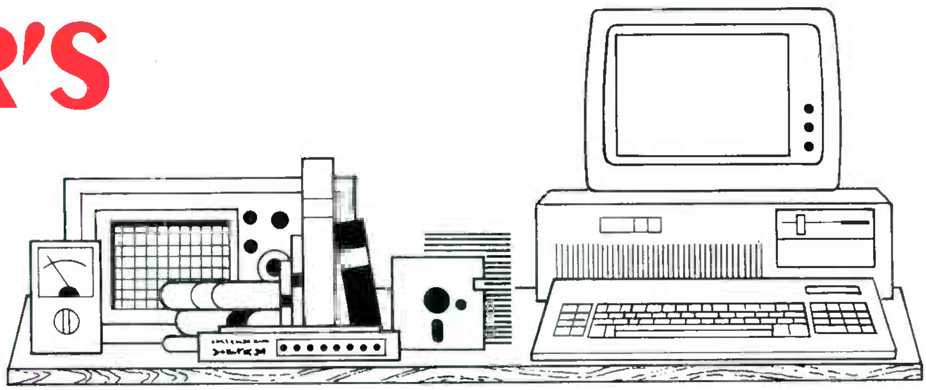

HERCULES GRAPHICS CARD PLUS

At a time when color-graphics systems for the IBM-PC are more prolific than ticks on a hound, one would hardly expect to see a monochrome graphics board squaring off with the competing color-graphics heavyweights. But into the midst of the fray comes the new Hercules card (Hercules Computer Technology 2550 Ninth St., Berkeley, CA 94710).

Like the old Hercules card, the new *Plus* supports both monochrome text and 720-by-348 pixel graphics on the IBM monochrome display monitor or its equivalent. The *Plus* is hardware and software compatible with all applications developed for the original card, including tough customers like Lotus 1-2-3, Flight Simulator, and SubLogic's Jet. Anything and everything that ran on the old card comes off without a hitch on the new one.

RamFont

What sets the *Plus* card apart from the original is something called RamFont, a hardware-based graphics mode that enables the PC to display multiple fonts and limited graphics on the screen as easily as older graphics cards displayed standard monochrome text. (See Fig. 1)

Actually, in addition to the original two modes, there are two RamFont modes: 4K RamFont and 48K RamFont. Each uses the indicated amount of display memory, and each serves a different purpose.

The 4K RamFont mode is essentially a superset of the standard text mode. Traditionally, text screens have been limited to one type and style of displayed text; the patterns of which are indelibly etched into the BIOS ROM IC of the computer. With the *Plus*, Hercules provides a number of diskette-based fonts, including Bold, Greek, "Medieval," Sans Serif, "Future," and about 25 others, any one of which can replace the standard character set, thereby allowing you to customize the display to your liking. The selected font is accessible by any and all text-mode software in the normal fashion. Hercules provides a font editor so that you can create your own fonts, or modify theirs.

The 48K RamFont mode is completely new and totally revolutionary. In this mode, each character is defined by twelve bits, rather than the customary eight. So programs can display as many as 3,096 characters in different sizes, shapes and typefaces.

FIG. 2

Using drivers supplied by Hercules, the 48K RamFont mode can also be used to display graphics screens from Lotus 1-2-3 (Version 2) and Symphony. (Lotus' new scientific word processor, Manuscript, makes use of the 48K RamFont mode; watch for a review in an upcoming issue.—*Editor*). The drivers actually replace the standard eight-

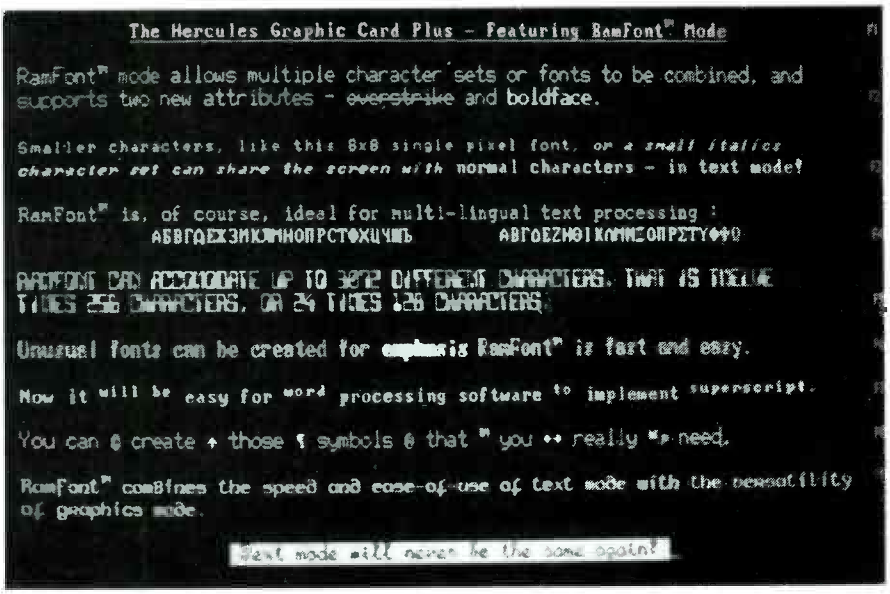

FIG. 1

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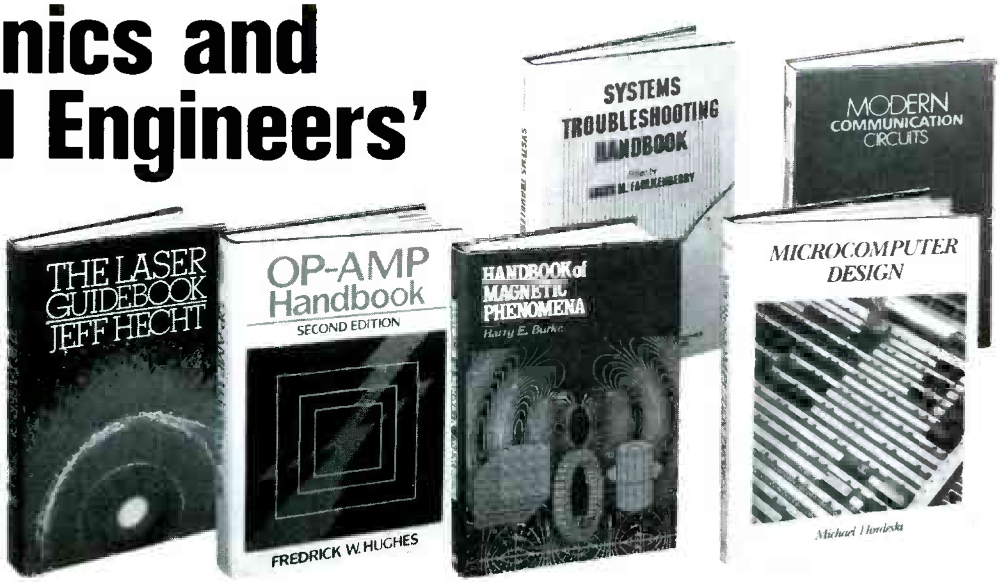

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bit ASCII character codes with the 12-bit character codes required by RamFont. And through careful definition and manipulation of the character patterns involved (lines and solids included), complex graphic imagess can be created on-screen. Vendor software support for the new 48K RamFont mode is expected.

A point to consider, however, it that none of the 4K or 48K RamFont characters can be printed on paper. They are screen images only, and remain that way. Calls to the printer result in standard ASCII characters.

Printer port

Overshadowed by RamFont's glitter is a unique parallel-printer port. It's unique in that it is controlled by a single, proprietary IC that replaces about 18 standard TTL IC's. It is configured to function only as LPT1; to disable it, you must remove the IC.

Priced at $299—a full $200 less than the original Hercules card—the Hercules *Graphics Card Plus* is a winner. If you're in the market for a monochrome graphics card, check this one out first.

GROLIER'S ELECTRONIC ENCYCLOPEDIA

What is the value of information? The answer to that question depends on the kind of information—and on whether it's accessible. If it's inaccessible, it's worth just about what it would be if it didn't exist at all: Nothing. That may seem obvious, but there's more to the idea than may appear at first glance. Our age has already been called the Information Age, but technologies that are here now, albeit in rather primitive form, promise to eclipse previous advances in both the storage and processing of information.

In fact, it's already happening in several areas. Almost everyone is familiar with optical storage technology, because the audio compact disk is one example of that technology. You may have heard of the CD-ROM—it's physically the same as an audio CD, but it usually carries information that is to be processed by computer.

We discussed the organization of the audio compact disk in the August 1986 issue; an upcoming issue in 1987 will discuss CD-ROM technology. Meanwhile, we've been discussing CD-ROM products as they've been released. For example, see our review of the PC-SIG CD-ROM in the March issue. That CD-ROM contains the equivalent of more than 600 diskettes of programs and data files for the IBM-PC.

Another CD-ROM product, *The Electronic Encyclopedia,* has been released by Grolier Electronic Publishing, Inc. (Sherman Turnpike, Danbury, CT 06816), in cooperation with Activenture Corp. (Monterey, CA). If you've ever used a computer with the CP/M operating system, you may be interested to know that its inventor, Gary Kildall, is head of Activenture.

The encyclopedia is contained on a single CD-ROM; an auxilliary diskette contains Activenture's Knowledge Retrieval System (KRS), installation software, and drivers for several popular CD-ROM drives (Hitachi, Phillips, and Sony models). Unlike some CD-ROM products, KRS does not require the hardware drivers to be included in your CONFIG.SYS file, so there is little possibility for conflict with other programs or devices. The program requires 256K of RAM, and it can run on any monochrome or color IBM-PC display.

What is it?

The encyclopedia itself is based on Grolier's *Academic American Encyclopedia,* which was first published in 1980. The text of *The Electronic Encyclopedia* has been available electronically through on-line networks since 1982. The CD-ROM contains a two-part 110-megabyte database. One part, comprising about 60 megabytes, contains the text of the encyclopedia; the other, comprising about 50 megabytes, is an index that pinpoints every occurance of every word in the main database. The database contains about nine million words and thirty thousand entries. In

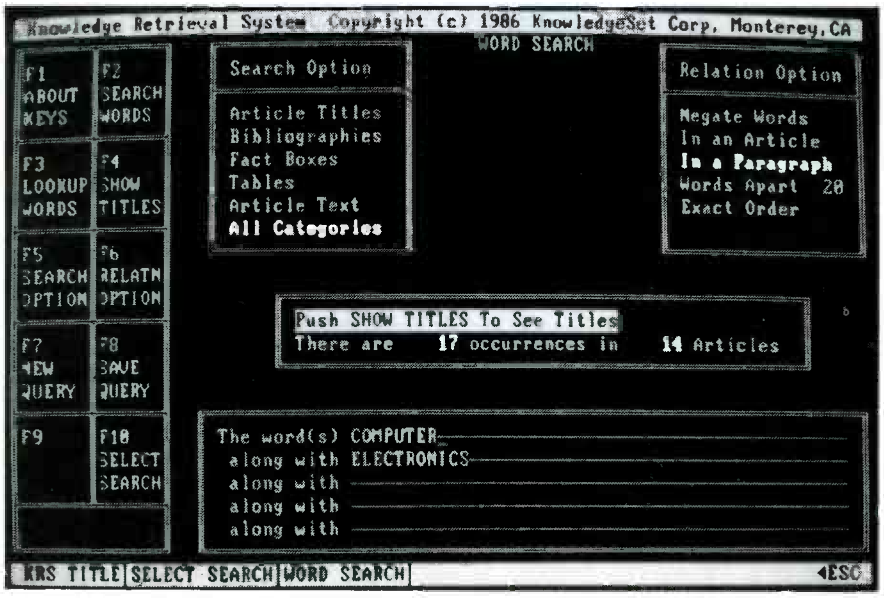


FIG. 3

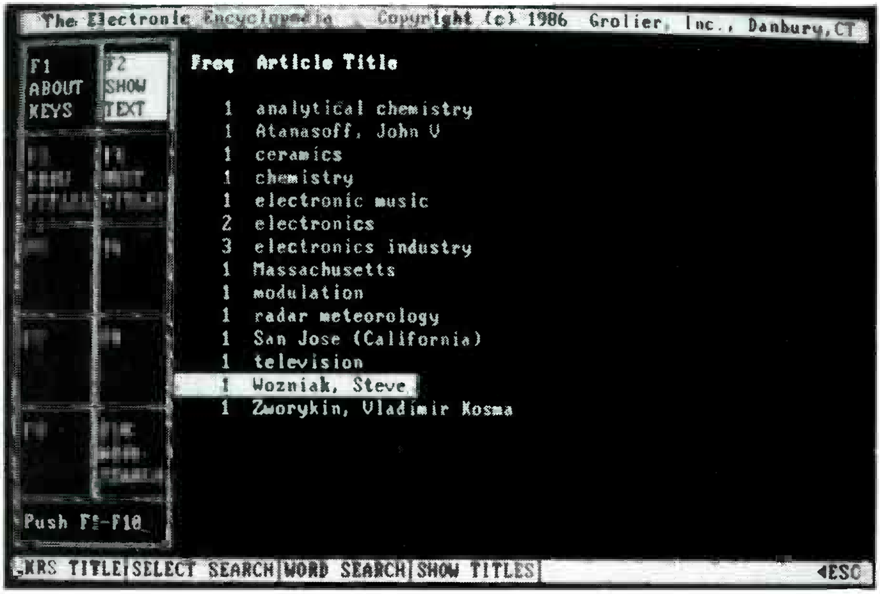


FIG. 4

printed form it takes ten thousand pages, or about two feet of shelf space, to hold the entire encyclopedia. About 35% of the entries concern science and technology; about 36% concern the humanistic disciplines; the remainder concern the social sciences, geography, sports, and contemporary life.

Enough statistics—what's it like to use the encyclopedia, and how is the encyclopedia itself?

Purpose and implementation

To begin with the latter, let's quote Grolier's three stated purposes for *The Electronic Encyclopedia* as they appear in the *User's Guide:*

- To provide quick access to definitive, factual information.
- To provide a readily intelligible general overview of a subject that does not compel the reader to grasp intricate subtleties or wade through drawn-out historical analysis.
- To provide a starting place for further research by isolating key concepts, outlining the structure of the subject, and directing the reader to more specialized primary and secondary sources of information.

Does *The Electronic Encyclopedia* meet those goals? In general, yes. If you wanted graduate-level information on computer science or Shakesperean drama, the encyclopedia wouldn't help. In fact, as encyclopedias go, *The Electronic Encyclopedia* is rather weak; it's certainly no *Brittanica*. But if you need a quick overview of a subject, or simply a place to start, it can be valuable.

The real strength of *The Electronic Encyclopedia* arises from its electronic form and from the indexing and collating abilities that form provides. It would be extremely difficult with any printed encyclopedia to find all articles containing both the words *computers* and *electronics*. But with *The Electronic Encyclopedia* it's simple, as shown in Fig. 3.

After choosing a search topic, you're presented with a list of articles, as shown in Fig. 4, which you may examine one by one. You do so by moving the highlight bar with the cursor keys, and then pressing F2. The text display appears as shown in Fig. 5. In addition, complicated articles can be viewed in outline format.

When you find an interesting article, you can print the text or save it to a standard ASCII text file, for inclusion in a word-processing document.

A separate KRS screen allows you to set the screen colors, type of CD-ROM drive, and operating parameters. See Fig. 6.

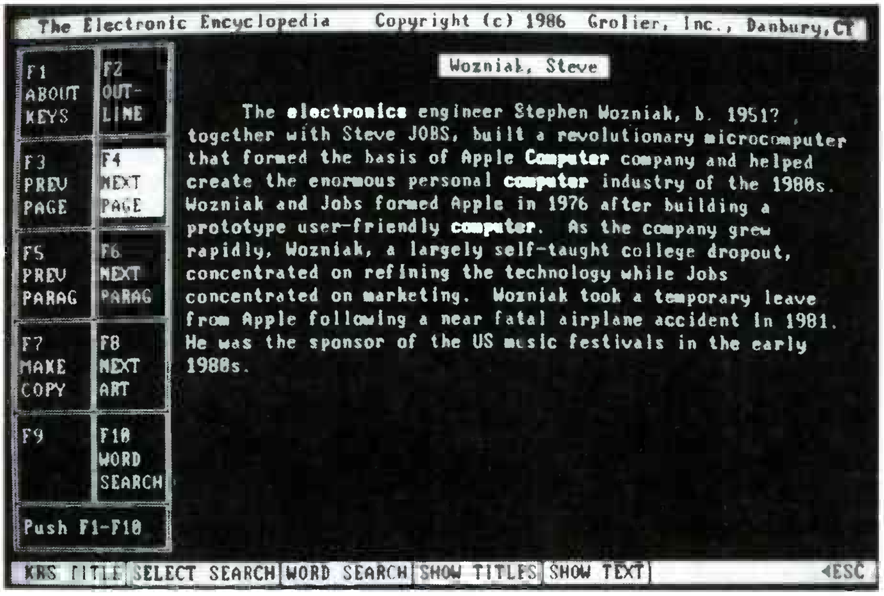


FIG. 5

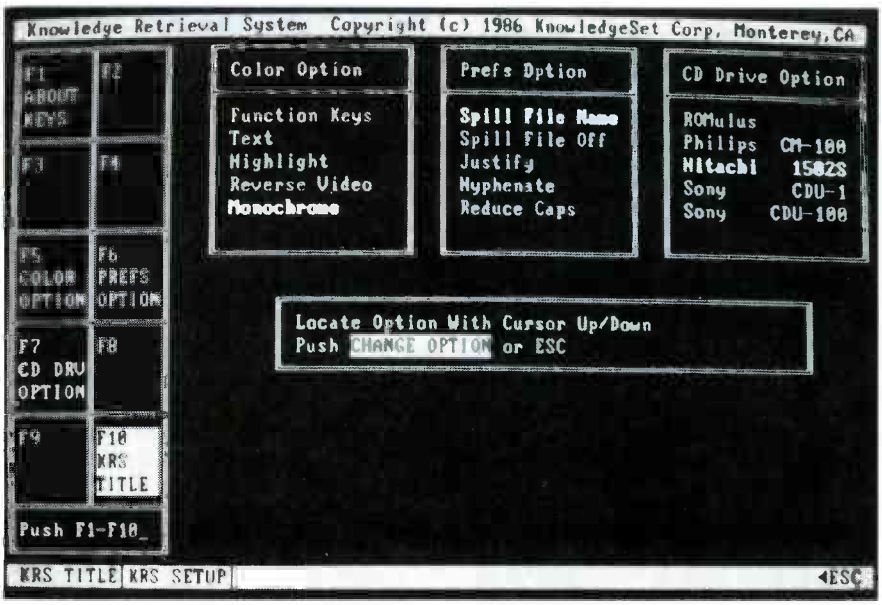


FIG. 6

Evaluation

The KRS software works fairly well in helping you to extract information from the encyclopedia, but it does have a few rough edges. For example, we wanted to open a file and collect all information on a topic in that file for perusal later. It turns out that you must assign a new output file name each time you enter a new article. Doing so requires you to traverse several levels of menus and to wait an appreciable amount of time.

In addition, some menu choices are not obvious, and it takes either some experimentation or a close study of the manual to learn how to accomplish simple tasks.

Last, although it's obvious that *The Electronic Encyclopedia* was designed not for the power user, but for the masses, a command-driven mode that bypasses the menus would have been nice, especially if it could be run from DOS in batch mode.

However, we think the real importance of *The Electronic Encyclopedia* lies not in what it itself can do, but in the avenues of design it opens for those to follow. KRS has become a standard by virtue of being first; others will emulate its good points and correct its faults.

The situation reminds us of what happened to Kildall's earlier brainchild, CP/M. Indeed, we would be surprised if some product didn't surpass KRS just as MS-DOS surpassed CP/M. We just hope that Kildall will gain the recognition and rewards he deserves for being a true pioneer, not just another copy-cat imitator.

Our methods of dealing with information are going to have a drastic effect on how we work, on the way we live, and even on the way we play. KRS and *The Electronic Encyclopedia* provide us a glimpse into the kind of information-processing systems our children will take for granted while wondering how earlier ages managed to accomplish anything.

Thanks to Amdek Corporation (2201 Lively Blvd., Elk Grove Village, IL 60007) for use of their *Color 722* EGA monitor, which was used for our color cover shots.

HALL-COMSEC'S WIRETAP, HAYES' TRANSET 1000, DISC INSTRUMENTS' μLYNX TRACKBALL, AND FINOT GROUP'S KEEP TRACK

If you've ever connected any two pieces of computer gear together, you know that the so-called RS-232 standard is really just a myth. Many companies manufacture devices designed to help you conquer a troublesome RS-232 hook-up, but a device called the *WireTap*, from Hall-Comsec, Inc. (901 Sandy Cove Lane, Ft. Collins, CO) is inexpensive ($37.50), and it can save you much grief. It's shown in Fig. 7.

The *WireTap* is a module with male and female DB-25 connectors on either end. Between them is a nine-position DIP switch, two rows of socket connectors, and two rows of LED's. Near the male end, and connected to pins 2–8, 12, 20, and 22, are red LED's; at the female end, and connected to the same pins, are green LED's. The red LED's light on high signals; the green on low. Pin 7 is connected straight through; no other pins are accessible.

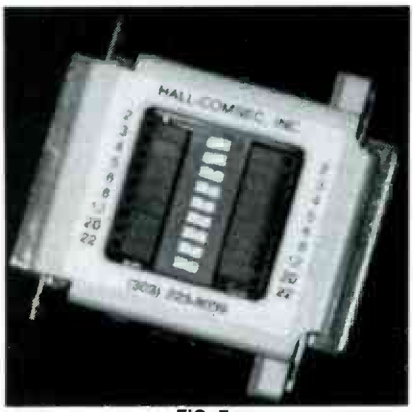


FIG. 7

To connect a pin on one end to the pin opposite it (pin 2 to pin 2, for example), just close the appropriate switch. To connect a pin to a different pin (pin 2 to pin 3, for example) use the appropriate socket connectors and a short length of solid wire. Hall-Comsec has thoughtfully provided several such wires.

The *WireTap* is small enough to tuck away in a corner of your briefcase and carry with you wherever you go. It's helped us out of more than one jam.

KeepTrack Plus

Maintaining the files on a hard disk can be a real pain; many programs on the market profess to help ease the task. One of the better ones is called *KeepTrack Plus*. In operation, the program gives a tree-structured view of your directories and files. You can tag files across multiple directories, and then view, copy, delete, and back them up. You can copy an entire directory (with all subdirectories, if desired) by a single keypress. *KeepTrack Plus* will create the appropriate tree structure in the target drive, if necessary. You can back up files to two diskettes simultaneously, and create lists of files not to back up. The screen shot in Fig. 8 should give you an idea of how easy it is.

KeepTrack Plus comes with two manuals. One teaches the fundamentals of DOS, including filenames, directory structure, batch files, etc. The other manual is for users who are ready to start using *KeepTrack Plus* without training. At only $79 (plus $5 shipping), it's a real bargain. Contact The Finot Group, 2390 El Camino Real, Suite 3, Palo Alto, CA 94306.

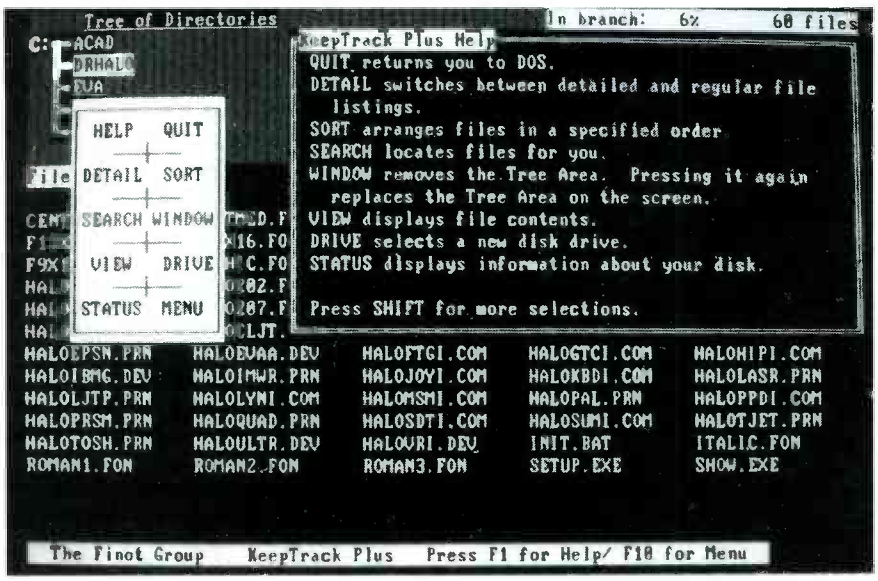


FIG. 8


FIG. 9

Hayes *Transet 1000*

There are printer buffers and then there are printer buffers like the one shown in Fig. 9. The *Transet 1000* from Hayes Microcomputer Products, Inc. (5923 Peachtree Industrial Blvd., Norcross, GA 30092) is a printer buffer—but it's also a whole lot more. You can use it to buffer data from a computer to a printer while simultaneously (or separately) buffering data from a modem. You can use it to connect two computers to one printer, or one computer to two printers. You can even design your own "communication paths" through it.

The *Transet 1000* has two bi-directional serial ports and an output-only parallel port. It comes in two versions: with 128K and 512K of RAM, which have suggested retail prices of $399 and $549, respectively, and many dealers discount both versions.

As a printer buffer, you can set it to print multiple copies, as well as to format raw ASCII text as well as most word processing programs.

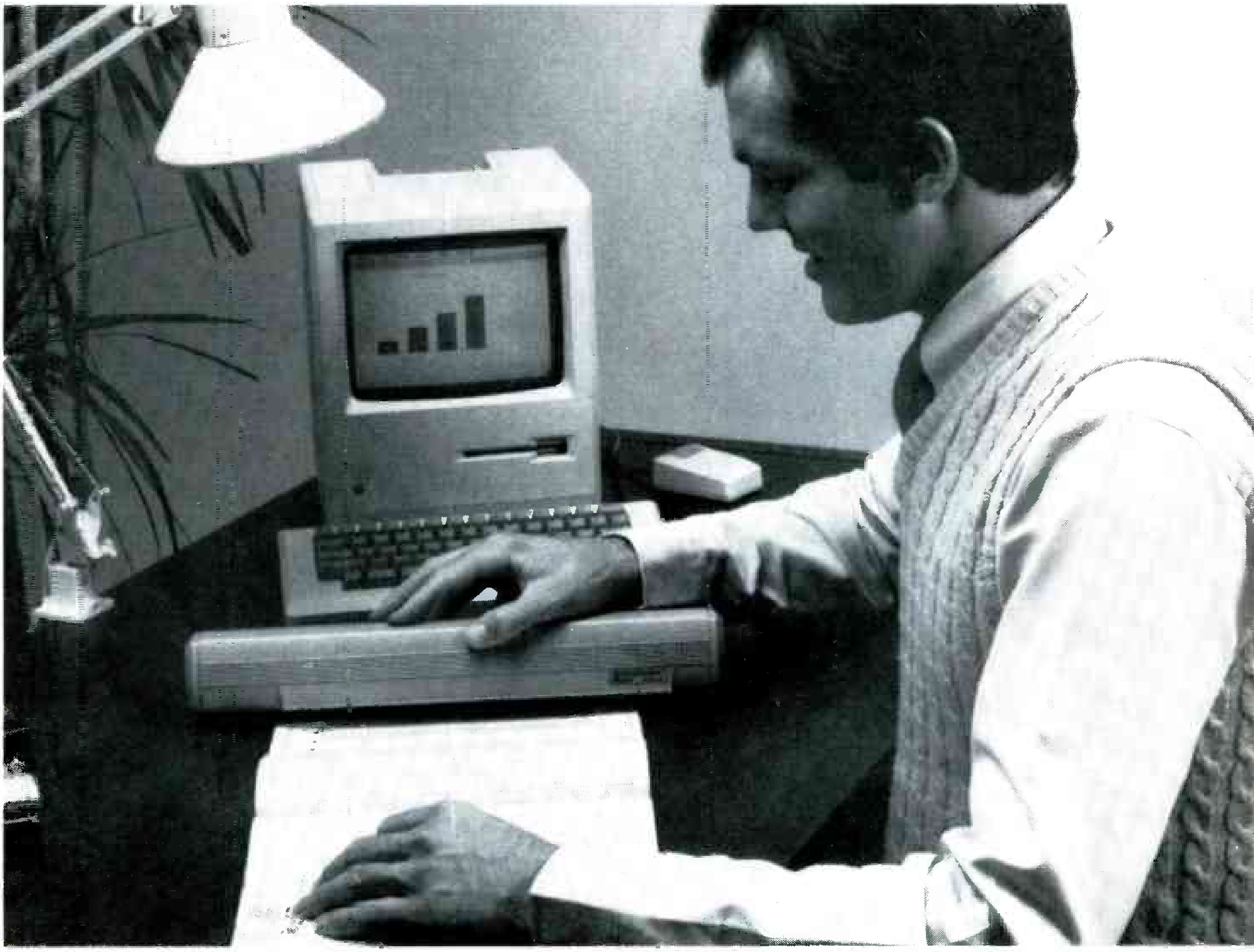
Disc Instruments μLynx

Around the computer shack bugs are bad, but rodents can be good. Some people swear by mice; others hate them. A compromise, and a good one, is sold by Disc Instruments (102 East Baker Street, Costa Mesa, CA 92626), a subsidiary of Honeywell. It's called the μLynx (pronounced microlynx), and it provides the convenience features of a mouse without the hassle.


FIG. 10

Its biggest selling point is that you don't need to clean your desk—a rolling ball in the top of the unit performs the "mouse" functions. In addition, you don't need to dedicate a serial port to it; through a special dual connector, it hooks up between your keyboard and your computer. No separate power supply is necessary.

In operation, it greatly speeds cursor movements in programs like AutoCAD, Dr. Halo, etc. And it should be compatible with most programs, because it emulates operation of the Microsoft mouse.



THE CAUZIN SOFTSTRIP SYSTEM

A new storage technology promises to revolutionize the way computer programs and all sorts of other data are distributed.

JEFF HOLTZMAN, TECHNICAL EDITOR

Personal computers have proven themselves extremely valuable to scientists, engineers, students, office workers, writers, musicians, artists and many others. But one problem that has often plagued personal computer users is the dissemination of information. Typing program listings (from **ComputerDigest** and other magazines) into a computer is time consuming and prone to error. Not only is time wasted in typing, but time is also wasted in debugging one's typing errors.

The Cauzin system is what the publishing industry has been looking for: an inexpensive yet reliable means of printing the software programs that eat up so much valuable page space. Bar codes were touted several years back as a possible solution. But bar codes never caught on because of their low data density, and because no low-cost, reliable bar-code reader became generally available for personal computers. However, a new technology that is similar, but vastly superior, to bar codes hopes to revolutionize the way that computer programs and other data are distributed.

Cauzin Systems, Inc. (a division of Kodak) has devised this new technology. Long narrow strips called Datastrips are the heart of this technology.

As shown in Fig. 1, each strip is about 0.78 inches wide; the length depends on the amount of data a strip contains. The maximum length of a strip is about 9 inches. Different strips can contain different amounts of data, depending on the printing process, and on the paper and ink used for printing. Low-density strips, which can be printed on any Epson *MX* or *FX* printer, contain about 1500 bytes; high-density strips, which must be reproduced photographically, can contain as many as 5500 bytes.

High-density strips printed on good paper with the proper ink can hold 60,000 bytes on a single 8-1/2 × 11 inch sheet of paper. Each strip can hold as many as 10 files; conversely, a long file can extend across as many as 255 strips. A file can contain anything that can be represented in eight-bit bytes: program code, ASCII text, graphic images, spreadsheet workfiles, data bases, etc.

The reader required by the system contains a highly-integrated mechanical, optical and electronic system, all under control of a custom microprocessor (a TMS7040) and a custom VLSI IC. An internal view of the reader is shown in Fig. 2. In addition to the eight scanning lenses, 160 lenses are used for speed control.

The Softstrip

The physical makeup of a Softstrip is shown in Fig. 3. As you can see in Table 1, each strip contains 20 fields comprising a header area and a data area. Every strip contains fields 1 through 10; only the first strip of a file (or a group of files that extends across two or more strips) contains fields 11 through 18. Field 19 is the data area, and field 20 is an optional two-byte CRC (Cyclic Redundancy Check) code for error checking.

Each strip may contain from 2 to 6 bytes horizontally, plus one parity bit at each end of a line. Each line can be between ten and 40 mils high. Since each scan covers an area 2.5 mils high, the maximum resolution of the reader is 400 lines per inch. And since the thinnest data line is ten mils high, each data line is scanned a minimum of four times. Low-density strips with 40-mil lines are scanned 16 times.

Communicating with the reader

Cauzin has written communications programs for several popular microcomputers: the Apple *IIe*, the Apple *IIc*, the *Macintosh*, and the IBM-*PC*. Those programs can be used to read data strips automatically. However, if you want to read a data strip into a computer for which Cauzin has written no communications program, or if you're interested in getting at data strip files directly, here's some information that will help.

All you need is an interface cable, a computer with a serial port, and a communications program that can run at 4800 baud with 1

TABLE 1—CAUZIN SOFTSTRIP™ FIELD LAYOUT

Field	Length	Contents
1: Horizontal Sync		
2: Vertical Sync		
3: Data Sync	1	\$00
4: Expansion Bytes	2	\$00 See \$00 Extended Description
5: Length	2	Two byte Hex length of total bytes following this field
6: Checksum	1	Binary Add with carry
7: Strip I.D.	6	A mandatory 6 byte ID field (preferably ASCII)
8: Sequence No.	1	Binary
9: Strip Type	1	Binary
10: Software Expansion	2	\$0000 Binary (reserved)
11: Op. Sys. Type	1	Binary
12: Number Files	1	Binary
13: Cauzin Type	1	Binary
14: O.S. File Type	1	Binary
15: File Length	3	Binary lsb, nsb, msb order
16: Filename	Var.	ASCII Variable length name
17: Terminator	1	\$00/FF Filename Terminator
18: Block Expand	Var.	\$00 defaults 1 byte no info.
19: Data	Var.	File data information in consecutive blocks based on previous file lengths.
20: CRC	2	optional at strip end

NOTES: Fields 1 thru 10 occur on every strip
Fields 11 thru 18 are contained on Strip 1 only
File Directory Repeated Fields 13 thru 18
End of repeated file directory fields

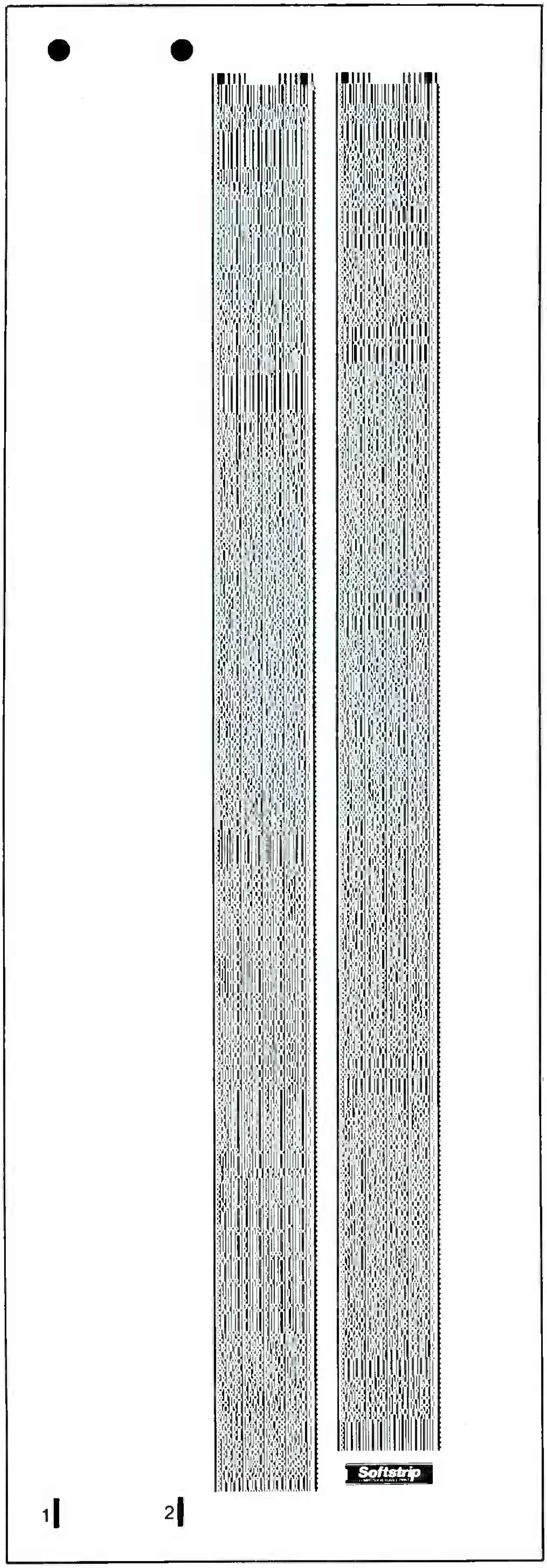


FIG. 1—SAMPLE DATA STRIP contains a 6K BASIC program for printing a calendar for any year with a custom message. The program is also available on RE-BBS.

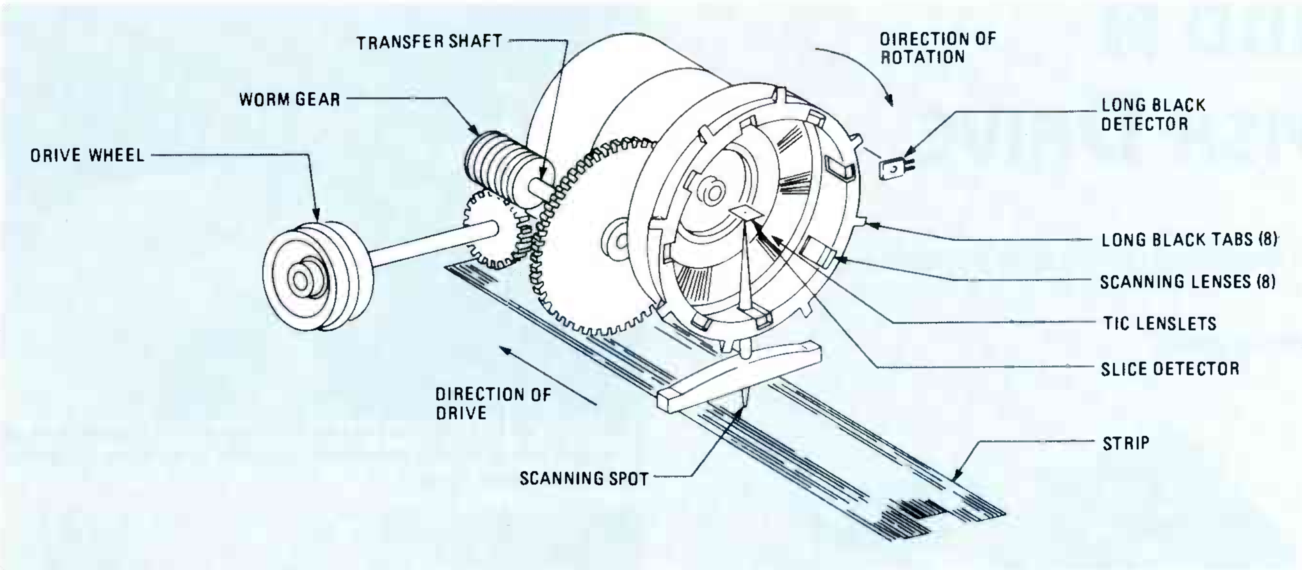


FIG. 2—INTERNAL VIEW OF THE READER: the eight black tabs provide horizontal-sync-like pulses for synchronizing the reader. All operations are controlled by a custom microprocessor.

start bit, 1 stop bit, and no parity bits.

The pinout of Cauzin's 6-pin modular plug is shown in Fig. 4. The reader can provide two-kinds of outputs: ±5-volt RS-232, and 25-mv Apple *II* cassette compatible. Pin 3 of the output connector determines whether RS-232 or cassette mode is active. The reader has a built-in pull-up to enable cassette mode; to enable RS-232 mode, just ground pin 3 (by connecting it to pin 6). Pin 1 provides a separate ground for the data input line in cassette mode; pin 4 provides a special signal we'll discuss below. To connect the reader to an IBM-PC, a *Macintosh*, or an *Apple*, follow the wiring diagrams shown in Fig. 5.

To read a Softstrip into a non-supported computer, you'll use the TERMINAL mode. Position the reader by aligning the circle and the bar by the Softstrip with the corresponding points on the reader. Then use your communications program to send the reader a "T" or a "t." The reader does not transmit an acknowledgement; rather the reader goes directly into the read mode. Use your communications program to capture the contents of the file in memory and then write the file to disk when transmission is complete. You can capture a file that extends across more than one strip simply by reading each strip in turn.

The Terminal mode is most useful for ASCII file transfers, because some file-header "garbage" may end up in the file. That garbage could create havoc in a binary object-code file. The communications program supplied by Cauzin transfers files cleanly, makes sure you read the strips in proper order, and performs other error checking.

Hacker mode

Notice in Fig. 4 that pin 4 of the reader's connector is labeled "Slice." Slice is a direct digital representation of the output of the scanner. By capturing the output of slice, you can digitize a rectangular region measuring about 0.78 by 0.5 inches. Possible applications include fingerprint analysis, digitization of musical scores, and handwriting analysis.

Note that the reader provides only the digitized signal; it's up to you to write the appropriate pattern-recognition software. However, Cauzin has written a special demonstration program that captures a digitized image in the memory of an Apple II computer. After an image has been captured, it can be saved to disk, printed, or displayed on screen. The hacker demo program is available from Cauzin.

The signal provided by Slice is purely digital: When the scanner is focused on a black spot, slice will be high (+5.0 volts). When the

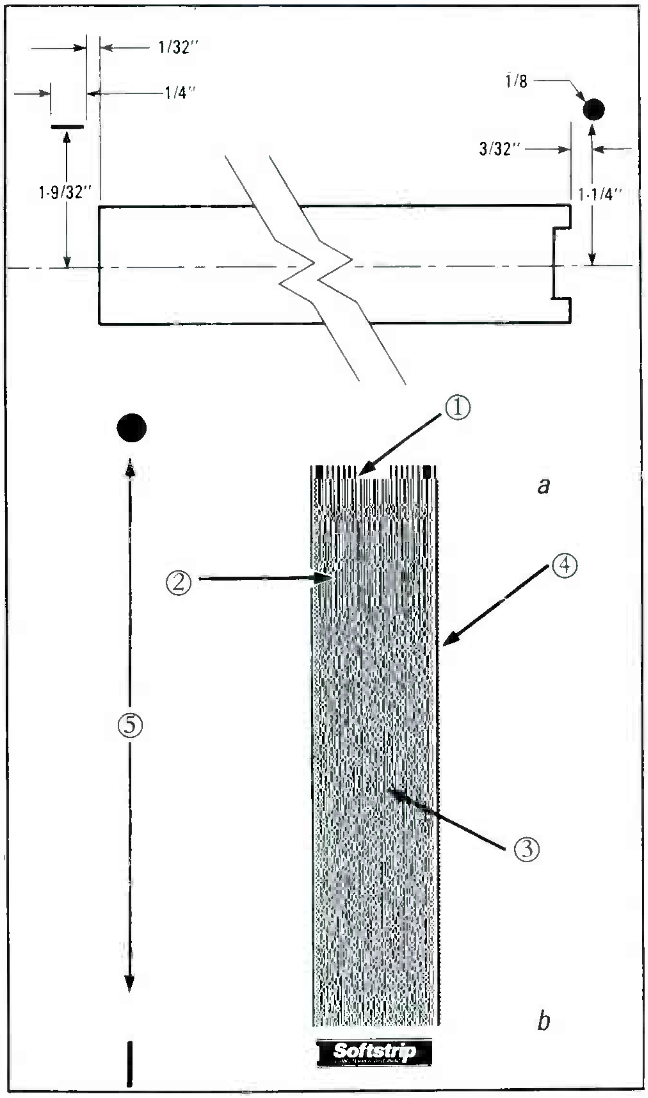
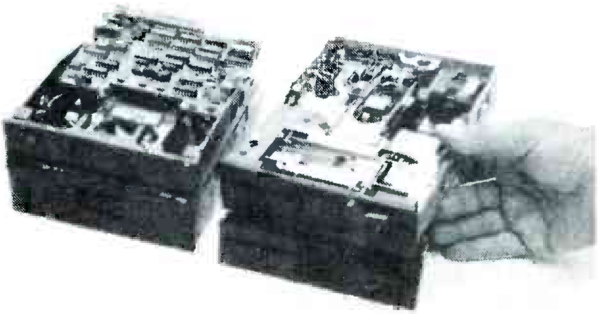


FIG. 3—THE SOFTSTRIP DIMENSIONS are shown in *a*. Its major areas are shown in *b*: (1) the header, which indicates paper and ink quality, number of bytes per line, and alignment; (2) the data section, which contains directory information; (3) the file section, which contains all data; (4) boundary lines, which keep the reader aligned and synchronized; (5) alignment marks.

ADD A DISK DRIVE

For improved computing performance.

Herb Friedman



NOT ONLY DO TWO half-height drives take up exactly the same amount of space as a full-height drive, their power requirements are half that of the full-height drive.

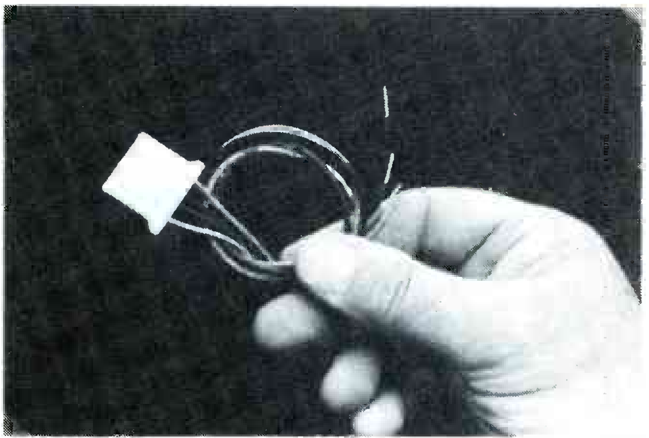
There are so many "surplus" 5-¼ inch disk drives flooding the marketplace that a modern fast-access drive which sold for well over $200 a little more than a year ago can now be purchased for less than $60. Many of these surplus drives are half-height and IBM-compatible, which means they are dual-sided with 40 tracks per side, so that two will fit in exactly the same space as a full-height drive while using only as much power as a single full-height drive, and they will work in IBM-compatible, Radio Shack, Heath, and Zenith computers, as well as any other computer whose original drive was machanically and electrically compatible with the Shugart SA-400 5-¼ drive.

Although a half-height IBM-compatible disk drive is double-density, 40 tracks per side, with a track access of 6 milliseconds, it is downward-compatible with earlier single-density, 35 track drives having 30 ms. track access. If the original drive(s) for your computer, such as a Radio Shack Model I, use single-density, 35 track, single-sided drives, the IBM-compatible dual-sided 40 track half-size drive will work just fine. The computer simply ignores the extra 5 tracks per side and the second side. If your computer is a Heath H8, which uses hard-sectored single-sided, 40-track 20-ms drives, you can again substitute an IBM-compatible drive because a drive having faster track access can replace one of slower access. Also, an IBM-compatible drive automatically works in the hard or soft-sectored mode. (The hard or soft sector mode is determined by the disk controller.)

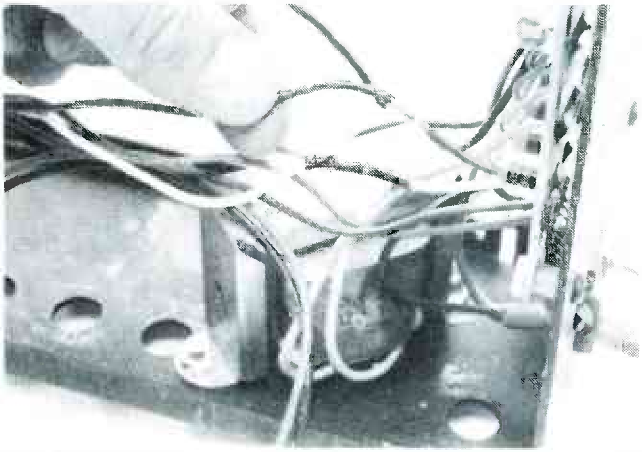
Satisfied?

Maybe you're satisfied with your present drive(s) but would like to use modern software which requires additional disk drives for maximum throughput; or maybe you want to increase the number of drives without installing outboard accessories. Either is accomplished by substituting two half-height drives for one or more internal full-height drives. If you have a Color Computer disk drive accessory it has 35 tracks, and 20- or 30-ms track access. The same cabinet and cable will accommodate two 40-track 6-ms drives. Since much modern software for this computer allows the user to select both the number of tracks and the track access time, you can almost double the track acess speed. If you have an IBM PC-compatible computer you could replace the A: drive with two half-height drives (A: and B:) and use the space (from the original drive B:) for an internal hard disk drive.

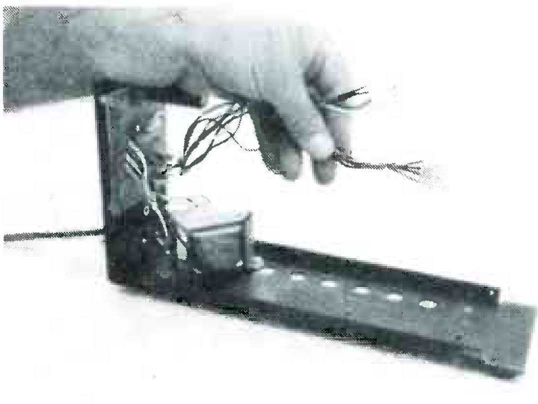
The physical installation of two half-height drives presents no problems because the power and signal connectors are "standard." You might have to drill new holes in the cabinet for the half-height's connectors. Simply flip the drive over so the connections are in the clear—there are mounting holes on both sides of the drive.



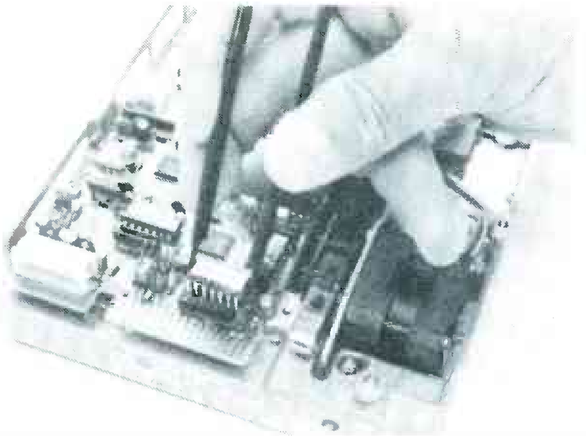
THE ONLY REQUIRED wiring modification will be the addition of a second power supply connector, which is always supplied with factory-installed wires.



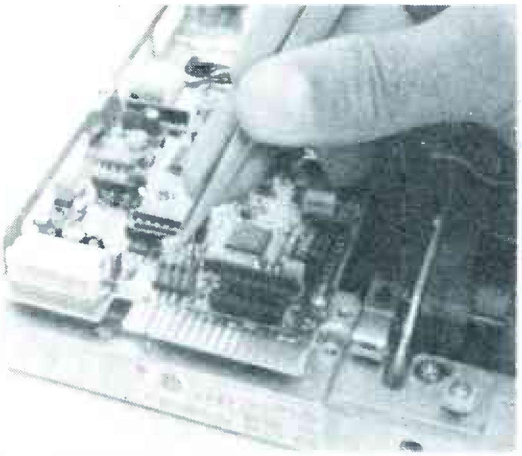
YOU WILL AVOID the possibility of damage to the power supply's printed circuit board if you splice the new power connector to the original wiring. Cut the tape to 3/16 inch so you can wrap several turns around the splice.



THE COMPLETED SUPPLY looks the same, but now there are two power connectors. Solder neatly, and don't remove unnecessary insulation.



NEXT TAG and remove the resistor block from all drives except the one that uses the last connector on the signal cable. Then mark the block.



USING TWEEZERS or needle-nose pliers, set each drive's DS *drive select* jumper to correspond to the jumper of the older drive being replaced, or to the required jumper pair if you're just adding an extra drive.

INSTALL THE DRIVE(S) and the signal and power connections. Make sure that matching power connector terminals are spliced together. One or more drives will probably be damaged if you reverse the end wires of a single connector.

Power connections

You will need to install an extra power connector for the extra drive. Do not remove the power supply assembly and drill new holes in the printed circuit board for the extra power wires because you can end up damaging the printed circuit board or one of the heat-sinked voltage regulators. A better way is to splice the wires for the new power connector into the wires leading to the original power connector. Don't attempt to match colorcoded leads because there is no color standard for a disk drive's power connector: Every color in the rainbow has been used. Since the connector is polarized, orient the old and new connectors in the same direction and then match the individual connections. To splice in the new wires, scrape about ¾ inch of insulation off an original wire, wrap the new wire around the old, solder, and cover with tape. If you offset each splice about one inch there will be no possiblility of a short if a strand of wire slips out from under the tape.

Since it's almost impossible to program one of the half-heights when two are substituted for a full-height drive, make sure you program the drive before it's installed in the cabinet. Programming means setting the drive select jumper and possibly pulling a termination resistor block. Older drives programmed drive selection through pins shorted by a jumper plug. Also, most no longer have HS and HL head-loading programming, nor a MUX connection. If they exist they are factory set at other pin-jumper terminals—which should never be changed by the user. If you don't know what a jumper is for, don't touch it.

SECURE THE CABINET COVER and you now have two drives that occupy the space of one, both using the original cabinet and power supply.

The drive select programming for any 5-¼ inch disk drive is almost always located adjacent to the card-edge signal connections, which are easy to locate because they are labled DS0, DS1, DS2, and DS3. To program a half-height, look at your old drive and determine which one of the drive select jumpers isn't cut open. Then move the half-height's jumper to the same set of terminals, but keep in mind that the physical location might be different; on your old drive DS1 might be the third set of terminals, on the half-height it might be the first or second set of terminals. You are only interested in matching the DS connections, not their physical location. If your old drive also has HS, HL or MUX jumpers forget them. If your old drive has all DS jumpers set (Radio Shack does this for some computers because the selection is actually made by the pins of the signal cable's connector), you either must determine which is the one that's actually used, or short all DS pairs on the half-height drive.

Finally, there is the terminating resistor block. All drives are supplied with a terminating resistor, which resembles a socketed integrated circuit. It is generally located near the drive select jumpers. (If you can't locate the terminator block, phone the store that sold you the drive.) Only one drive per set of drives on a signal cable—usually the one at the end of the signal cable from the computer—can have the terminator; often, drives won't work if two or more drives are terminated. Pull the unwanted resistor block, but use an IC extractor tool so you don't damage the pins. You might need the block in the future. Not all resistor blocks are alike; a Brand X drive won't necessarily work with a resistor block from a Brand Y drive, so place a small label on each block before it's pulled so you know which block goes into which drive.

Basically, it takes longer to describe how to swap or retrofit half-height disk drives than it takes to do the job. The photographs show how easy it is to do a 2-for-1 half-height retrofit. If you plan your work carefully and solder neatly, soon you'll enjoy the convenience of dual disk storage.

BUILD THIS IBM INCOMPATIBLE

Build your own fully functional computer from discrete components.

JEFF HOLTZMAN

Like the early settlers of this country, the pioneers of the personal-computer revolution built their own. Legendary machines like the Altair 8800 and the SWTPC 6800 were built, like settler's houses, from whatever materials were at hand. There was no going into the local Computerland and saying "Yea, I wanna buy a machine to do the bills and maybe play a few games—just for the kids, you know. . ." If one of those pioneers wanted to balance his checkbook, he had to write a program to do it—and in assembly language at that!

Nowadays people say that that pioneering spirit is dead, and that no one in his right mind would attempt to build his own computer. Well we think differently. We think that you can learn an enormous amount about computers (and, possibly, about psychiatry) by building your own computer. In fact, we think that, for the engineering or technical student interested in digital design, there is no better way to learn than by building your own computer.

So, in this 463-part series, we are going to teach you everything you need to know—from the ground up—about building your own computer. With the information we'll provide, you'll be able to put together a fully functional version of anything from an Apple II to an IBM-PC to a Cray I. So stay tuned.

Basic electricity

To begin our foray into the world of computers, let's discuss the basics of electricity. As everyone knows, there are two basic kinds of electricity, positive and negative. (See Fig. 1.) Due to the nature of the Earth's orientation with respect to the sun, electricity in the northern hemisphere is positive. If you're from "down unda," you have negative electricity. You can see for yourself how the two types of electricity differ by standing on the equator, extending your arms from your sides, and holding a large plastic pail in each hand. (See Fig. 2.) You must use a plastic pail, because a metal one would conduct electricity and allow it to leak out on the ground. Anyway, after a while, you'll find that the pail in the northern hemisphere is much heavier than the one in the southern hemisphere.

For our circuit examples we'll use positive electricity. Later on (in part 367) we'll show you a simple means of converting positive to negative (and negative to positive) electricity. But for now, if you live down unda, just reverse the orientation of all polarized components (diodes and capacitors), and substitute PNP for NPN transistors.

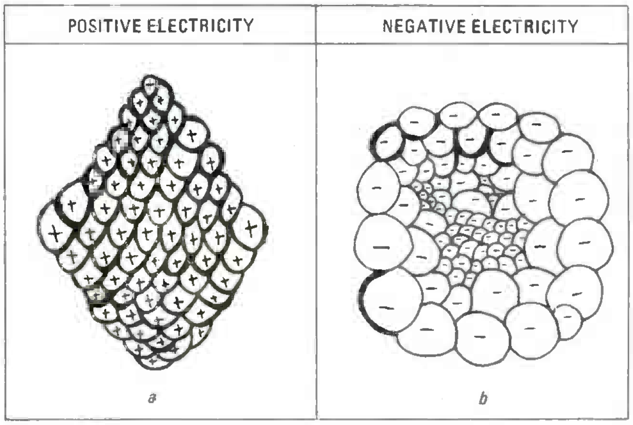


FIG. 1—THE TWO MAJOR KINDS OF ELECTRICITY. Other less-common types are not shown.

FIG. 2—POSITIVE ELECTRICITY falls on the northern hemisphere; negative electricity falls on the southern hemisphere.

Basic logic

Just as there are two basic kinds of electricity, there are two basic kinds of logic. Your choice of positive or negative logic, however, depends not on which hemisphere you live in, but on how obscure you want your circuit designs and programs to be. Due to the nature of the human mind, positive logic is inherently more comprehensible than negative logic. Positive logic is used more often than negative logic, but negative logic certainly has its uses. Sometimes, for example, if you're having trouble resolving a circuit into its proper logic elements, merely thinking about it in the opposite set of terms may suggest a solution. Or, if you're a student, you may be able to impress your professor by casting a circuit with negative logic elements. Or you may be able to confuse him so much that he'll have to admit you're a genius and place you on the dean's list. As we said, negative logic does have its uses.

There are three basic kinds of logic operations; it has been shown that many logic problems can be solved by combining them in various ways. The operations are the NOT, the AND, and the NAND. Their truth tables are shown in Fig. 3-*a*–Fig. 3-*c*.

NOT

INPUT	OUTPUT
1	0
0	1

a

AND

INPUTS A	INPUTS B	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

b

NAND

INPUTS A	INPUTS B	OUTPUT
0	0	1
0	1	1
1	0	1
1	1	0

c

FIG. 3—TRUTH TABLES OF THE MAJOR LOGIC ELEMENTS. The NOT and the AND combine to form the NAND..

The NOT gate

The operation of the NOT gate will be familiar to anyone who is married. For lack of anything better to do, couples often take up opposite sides of an argument. It doesn't matter which side each person takes; in fact, often, the partners may in fact agree, or each may actually believe in the point of view the other represents. The important point is that for every "yes" there is a corresponding "no," and for every "no" there is a corresponding "yes." That is the essence of the NOT gate.

The AND gate

By contrast, the operation of the AND gate will be totally unfamiliar to anyone who is married. A two-input AND gate has the following property: for the output to be "yes," both inputs must be yes. Just as the two partners of a marriage almost never agree on the same thing at the same time, the AND gate is seldom used in practical circuits.

The NAND gate

The operation of the NAND gate should be somewhat more familiar. It is a combination of a NOT gate and an AND gate. For the output of a NAND gate to be "no," both inputs must be "yes." However, the output will be "yes" if either input is "yes." That is a very useful property.

Let's consider an example: suppose you want to buy a new computer, and your wife says no. If you had signed a marriage

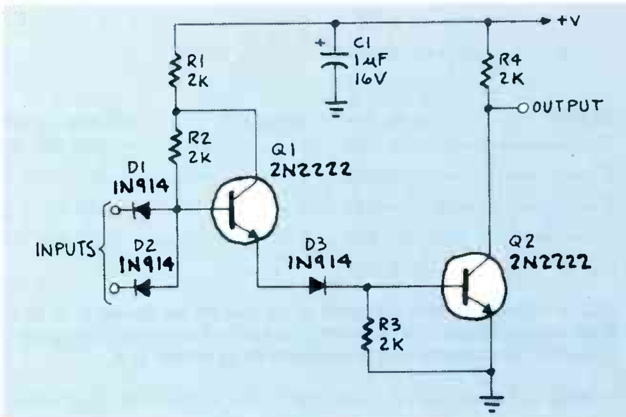


FIG. 4—A DISCRETE-COMPONENT NAND GATE. Build several hundred for next time.

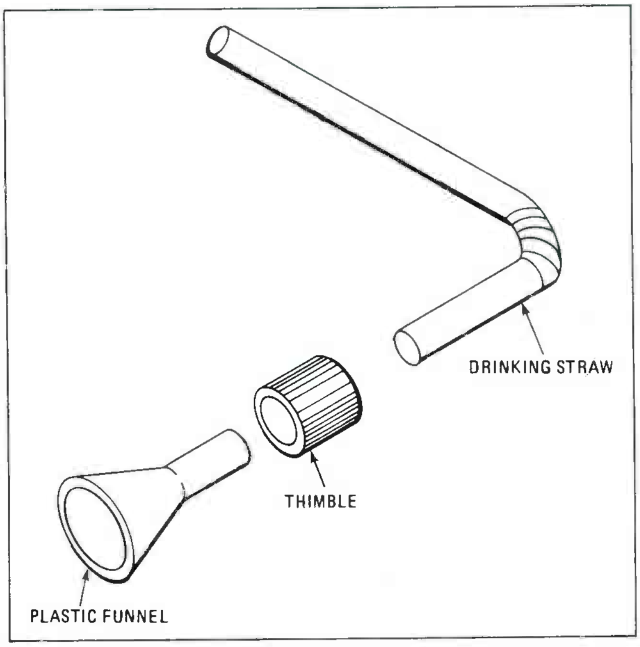


FIG. 5—POSITRON CATCHER. To decrease loss due to leakage, all components should be non-metallic. Use non-conductive epoxy to attach the parts together.

THE CAUZIN SOFTSTRIP SYSTEM

continued from page 95

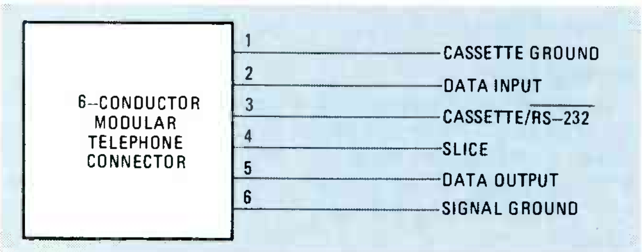


FIG. 4—READER PINOUT: A six-conductor telephone cord provides all connections. See Fig. 5 for connections to typical computers.

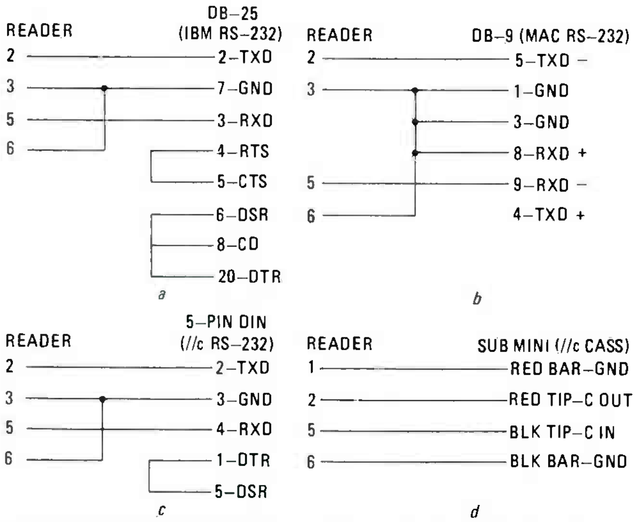


FIG. 5—CONNECT THE READER to an IBM-PC as shown in *a*, to a Macintosh as shown in *b*, to the RS-2323 port of an Apple IIc as shown in *c*, or to the cassette port of an Apple IIe as shown in *d*.

scanner is focused on a white spot, slice will be low (0.0 volts). To use slice, you'll also have to monitor pin 5, data out. Valid data appears at slice only when data out is high. In Hacker Mode, data out carries the signal that Cauzin calls Long Black. Long Black is similar to a TV's horizontal-sync signal.

To get into hacker mode, send an "H" to the reader, and wait for the reader to transmit a CTF (Command To Follow) followed by an "H." CTF is Cauzin's designation for a BREAK-type signal, not an ASCII character; CTF is a single pulse that goes low for 74 ms and then high for 74 ms. After receiving the "H," your program must send three 0E characters, at which point the reader will begin scanning. From that point on, it's up to you to capture and analyze the data.

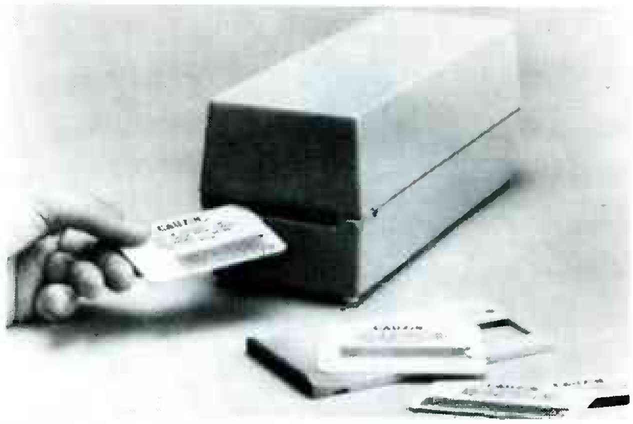


FIG. 6—HOSPITAL ADMISSIONS INFORMATION is contained in a Datastrip on a credit-card size piece of plastic. A special reader reads the data.

Other Uses

Datastrips can be printed in other forms. For example, they can be printed on credit card-like pieces of plastic and used for emergency-room admissions and other applications. For instance, all of a patient's relevant medical statistics could be printed on a small card. Use of the card, rather than a lengthy interview, can speed the admission process, and could mean the difference between life and death for a critically ill patient. A card and a special reader are shown in Fig. 6.

Softstrip datastrips can also be used to archive any sort of information. They are ideal for long-term storage because paper and ink are much more secure over long periods of time than magnetic media (disks and tape) and microfilm.

Conclusions

As you can see, Cauzin has packed a lot of smarts into a very small package. Whether the Softstrip system will catch on remains to be seen. However, many book publishers (Addison-Wesley, Houghton Mifflin, McGraw Hill, and many others) and many newspapers and magazines (including *The Village Voice, Byte, Keyboards, Computers and Software, MacUser, Nibble, Nibble Mac, Dr. Dobbs,* and many others) have already begun to print software in strip form, and we're considering it too. Let us know what you think. If reader response warrants it, you'll soon see much of our software in that form.

---

agreement with her stating that both of you would abide by the rules of NAND logic, you would be able to buy the computer. Of course, simple NAND logic can be detrimental, too. For example, if she wants to buy a new hair dryer, you're stuck. But by combining several logic elements, you could develop an equation like this: $\overline{T}$ = H AND (W OR $\overline{W}$).

The equation shows that T will be "yes" only when H says "yes," regardless of what W says. If you think that the term (W OR $\overline{W}$) is irrelevant, then you don't understand completely the psychology of marriage.

Other logic elements

There are many other logic functions (OR, NOR, XOR, XNOR, MAYBE, SORT-OF, KIND-OF, YES BUT, and so on), but, in order to reach our goal of building our own computer, we needn't discuss them here. Consult any elementary textbook on digital logic for more information. In the meantime, let's turn to something of a more practical nature.

Basic NAND circuit

A two-input NAND gate is shown in Fig. 4. As we stated above, both inputs must be "yes" for the output to be "no." We're using positive logic, so a "yes" corresponds to a high, and a "no" corresponds to a low (ground). The values of the resistors will depend on the voltage you use to power the circuit. We'll show you how to build your own positron catcher (for generating positive electricity) below. But for experimental purposes, you could use a nine-volt battery and 2K resistors.

Project goals

The NAND gate is the basic building block of many digital computers. Whatever kind of computer you want to build, you can be certain of one thing: you'll need many NAND gates. You can start building now, and, if you change your mind later on, that's OK. Provided you use a reliable interconnection scheme, you can always reuse the gates you build. Of course, if you're sure you want to build, say, a Cray, you can get much better prices for the parts you buy, by buying in large quantities. Here are our estimates for the number of gates you'll need to build various computers. To build a Cray supercomputer, about 10^{50} gates. To build an IBM-PC, about 10^{10} gates. To build an Apple II, three or four dozen gates should suffice.

If you have a different computer in mind, that's just great. We encourage experimentation, and would welcome design details. Send your ideas to the Managing Editor.

Construction

After verifying that your circuit works, you'll want to start duplicating it. Each gate could be built on a separate piece of perfboard, using spring-loaded terminals for connections. You'll need five terminals per gate (two for inputs, one for the output, and two for power and ground). However, if you're planning to build one of the larger computers, you may want to build many circuits (hundreds, or even thousands) on each card. The connections between the gates on each card could be soldered, and the cards might be interconnected via spring-loaded terminals.

The size of the positron catcher you'll need also depends on the computer you'll build. A filled household bucket will provide several hours of experimentation using several hundred gates. You can use a funnel, a thimble, and a drinking straw, as shown in Fig. 5. Drill a ⅛-inch hole in the thimble, and then use epoxy to glue the thimble to the funnel, and the straw to the thimble. Be careful not to clog the straw!

If you're planning to build a Cray, try to obtain a 10,000-gallon fiberglass tank. You may be able to buy one cheaply from an out-of-business gasoline station. For the sake of efficiency, you should use something larger than a household funnel to catch positrons. If you can locate your catcher on top of a mountain, you'll avoid the dissipating effect the atmosphere has on positron energy.

Conclusion

The power of simple digital logic elements can be surprising at times. And that is the goal of our series—to show you just how much you can do with a few (or many) simple gates. For next time, start building gates. You should have at least several hundred on hand so that we can start building the most important part of any computer: the ALU (Arithmetic Logic Unit).

One problem you may run into is time. While the gates are easy to build, it's tough to build several hundred in just a month. So that we don't leave anyone behind, we'll delay publishing Part 2 until April, 1988. See you then.

R-E ROBOT

continued from page 44

stall the watchdog timer (IC43) and JU15, and set the timeout for approximately 1 second (by substituting a 1-megohm resistor for R19). Do not install any other IC's. Apply power and confirm that the oscillator is operating by observing the signal at pin 56 of the microprocessor. Pin 24 of the microprocessor should go low each time S2 is pressed and each time IC43 times out. If those operations appear normal, remove power and install a ROM with a simple JMP – 1 instruction where the reset vector normally goes (FØØØ:FFF Ø). Now, if all is well, you should see a nice tight loop by observing the address bus on an oscilloscope.

You can trigger your scope easily on that signal and actually use your scope as a poor-man's bus analyzer. Observe the RD line and select a cycle for analysis. Note the exact position of the RD strobe on your scope. Now probe the DØ line. Is it high or low when RD is low? Write it down. Do the same for all of the data and address lines. You have just decoded the entire state of the microprocessor for that RD cycle: the address being read and the next instruction in the ROM.

Next, fill a ROM with NOP's (Ø9Øh) and execute a jump to the beginning of the ROM. Scope the address lines. You should see a Ø1Ø1 sequence on AØ, a ØØ11 sequence on A1 and so on. Each address line will appear at half the frequency of the preceding line.

What if things are not as they should be? This is where the watchdog timer (IC43) comes to our rescue. Set it for a timeout of a few milliseconds, trigger your scope on the reset pulse from the microprocessor (pin 57), and observe the first few RD cycles at the ROM. Here are a few things to look for:

1. Is the chip select line to the ROM (pin 20) active? If not, there could be a problem in the address-decoding circuitry or the address latches. Perhaps one or more of the microprocessor signals ALE, DEN, DT/R, RD, or WR are lost.

2. Are the address lines correct? They should all be high except for AØ–A3; those lines will toggle. Watch for voltage levels that are neither high nor low; two lines may be shorted, or the address decoder may not be functioning correctly.

3. Decode the first few instructions on the data bus. Do they accurately represent the contents of the ROM? Are the voltage levels correct? Incorrect voltage levels are caused by bus contention, shorted traces, ungrounded IC's, unpowered IC's, capacitors attached to data lines, and many others we have not (yet) had the pleasure of encountering.

continued on page 108

EARLY RADIO

continued from page 61

The end of spark

Another important milestone in the development of radio was the development of a generator capable of producing a high-frequency, continuous-wave carrier. That is, a carrier that could be modulated by sound.

Early radio transmitters were of the spark type. They could produce only a damped wave, which is very broadband and electrically noisy. Because of those characteristics, spark was suitable only for wireless telegraphy.

In 1889, Elihu Thomson of General Electric produced a high-frequency dynamo. Later, Nikola Tesla also produced such a dynamo. However, both had a maximum frequency of only about 5,000 cycles.

By 1903, Charles Steinmetz had built a 10,000-cycle alternator. In 1904, Reginald A. Fessenden conceived the idea of an alternator that would be capable of reaching a frequency of 100,000 cycles. Assigned to the project by General Electric, Ernst F. W. Alexanderson attempted to build such a device. He was eventually successful, although only after repeated failures.

The first transmission of a human voice took place on Christmas Eve, 1906. The continuous-wave carrier was generated by an alternator with an operating frequency of 50,000 Hz and a power of 1 kW. The microphone was a water-cooled unit. The historic event was not accompanied by much publicity, and 14 years would elapse before the beginning of scheduled radio broadcasting in the U.S. in 1920.

Tuned circuits

Spark did have one advantage: receivers did not need any type of tuning mechanism. For continuous-wave signals to be useful, some means of tuning would be required. Sir William Crookes' article, "Some Possibilities of Electricity" published in the *Fortnightly Review* in 1892, called attention to the need for tuned circuits. He wrote, "What remains to be discovered is a means of generating waves of any desired wavelength, and receivers which will respond to wavelengths between certain defined limits and be silent to all others."

That idea was put into action by Sir Oliver Lodge, who started experimenting with tuned receivers and transmitters in 1897. He called his method "syntonized tuning achieved through the use of capacitors." With the development of continuous-wave transmitters, and tuned receivers that could receive their signals, the first stage of the electronics revolution was complete. R-E

SEMICONDUCTOR TESTING

continued from page 64

as high-current rectifiers in low-voltage applications.

As the forward bias on the tunnel diode is increased, however, something interesting happens. As shown in Fig. 7, the current peaks and then drops into a deep valley, only to increase exponentially in traditional fashion.

The dip constitutes a region of negative

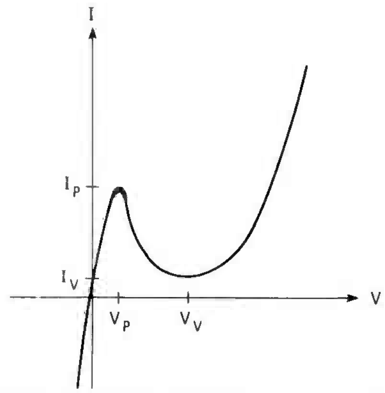


FIG. 7—THE TUNNEL DIODE is characterized by a rapid rise in current followed by a dip; when operated in the latter region, the diode can function as an oscillator.

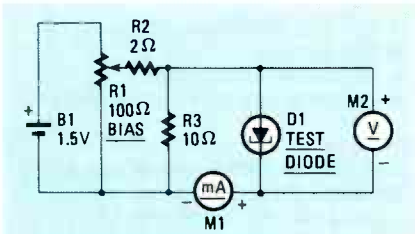


FIG. 8—MEASURE TUNNEL-DIODE characteristics using this circuit.

resistance, i.e., increased voltage leads to decreased current. By exploiting that characteristic, the tunnel diode can be made to oscillate in the relaxation mode. The small physical size of the tunnel diode permits oscillation into the hundreds of megahertz with simple circuitry and minimum power dissipation.

Tunnel-diode characteristics can be measured easily with a voltmeter and a current meter, as shown in Fig. 8. Bias voltage is increased with R1, and the rise in current noted. At some point (V_P), current will plunge suddenly, and voltage will increase by several hundred millivolts. Those characteristics represent valley current (I_V) and valley voltage (V_V), respectively. Typical readings are 100 mV at 1 mA for the peak values, and 350 mV at 0.1 mA, for the valley values. The I_P to I_V ratio should be no less than 6 to 1.

That's it for this month; next time we'll look at thyristors. R-E

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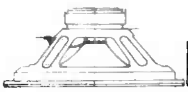

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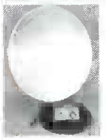

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R-E ROBOT

continued from page 102

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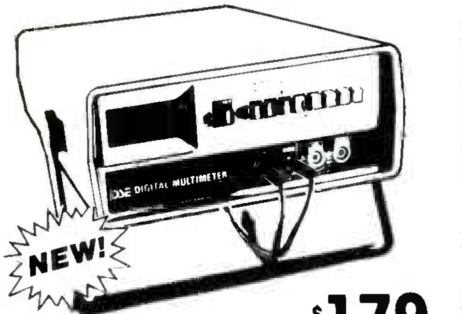

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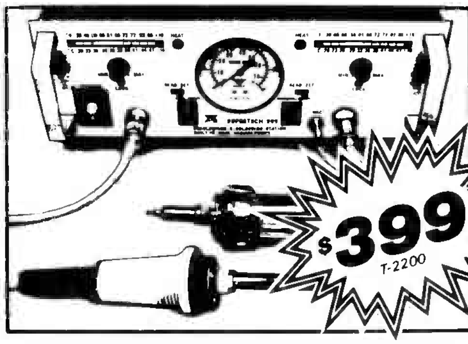

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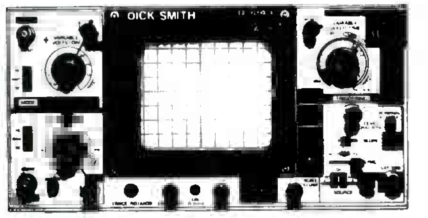

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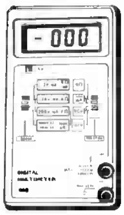
$21.95 Q-1440

Features full overload protection & diode check! Comes with probes and battery.

Specifications: DCV -0.20,100,200V ● ACV -0.200,500V (RMS) ● DC current-0,2,20,200mA ● Resistance - 0.2K, 20K,200K, 2M ohms ● 200 hour battery life.



Resistance Substitution Wheel

Values from 5 ohms to 1M ohm in 36 steps using most common divisions. 2½" dia. easy to read. Includes leads and insulated alligator clips. Maximum power .25W.

$7.95 Q-1410

35 MHz Dual Trace

$599 Q-1241

With high brightness CRT; includes 2 probes & schematic

Specifications: NORMAL, AUTO, & SINGLE sweep modes with 5x mag. (±10%) ● TIME BASE -0.1 us - 0.5s/div (±3%); 21 ranges ● 3% LINEARITY Delayed trigger: INTEN'D: Delay, time become dim/DELAY'D; sweep starts at time delayed. Delayed time: 10 msec to 1 usec ● TRIGGERING - Sensitivity: Int. < 1 Div/Ext <100mV p-p for 10MHz, <0.2V p-p for 35 MHz; Source: INT (CH-A, CH-B,ALT), LINE,EXT, 1/10 EXT TV LINE, FRAME).

R-E Reader's Special

Type-right™

was $34.95

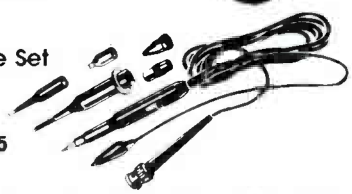
SAVE 29%

$24.95 Y-1021

Everyone should know how to type and anyone can learn with Type-right™! You get a full-sized 47-key color coded keyboard with an 8 character LCD screen and a 56-page course manual. The instructional program leads students step-by-step from basic finger positions to 45 w.p.m. proficiency. Speed & accuracy readouts after each lesson.

Offer good from 3/1/87 thru 4/30/87 or while supplies last.

CRT Probe Set



$29.95 Q-1245

Versatile probe suits virtually any 'scope. It features built in x1/x10 switch, 4' of SHIELDED cable with BNC connector, and wandering earth lead with alligator clip, insulating shroud.

Specification: Working voltage - 600V Pk (or 600V DC) ● Bandwidth - x1: DC-10MHz/z10: DC-100MHz ● input resistance - x1: 1M ohm/x10: 10M ohm ● Input capacitance -x1: 40pF ±CRO input c/x10: 10-60pF ● REF position -probe grounded via 9M resistor.

20 MHz Dual Trace

$399 Q-1240

Includes 2 probes & schematic

Specifications: VERTICAL FREQUENCY & DEFLECTION - AC 10 Hz/ DC to 202 MHz; 5mV to 20V/ div on 12 ranges in 1-2-5 step (-3dB) 28 MHz (-6dB) ● 17.5 nsec RISETIME ● 3% OVERSHOOT ● MODES CH1, CH2, DUAL ADD X-Y ● INPUT IMPEDANCE - 1M/20pF±3pF, MAX INPUT - 600V p-p or 300VDC ± peak AC ● CHOP FREQUENCY - 200kHz ● CHANNEL SEP - 160dB of 1 kHz ● TIME BASE - Auto or triggered ● SWEEP TIME - 0.2 to 0.5 sec/div ● TRIGGERING - Sensitivity: Int. < 1 div/Ext. <1V p-p.

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Great introduction to the use of oscilloscopes.
Specially extended to 4/30/87

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1 Year Test Equipment Warranty

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NEW!

AT Compatible Computer Kit

Get more power & speed at substantial cost savings with this fully IBM AT compatible computer system!

The superior engineering of this system ensures reliability and performance as well as full compatibility with the IBM AT. Like the IBM, it is based on the Intel 80286 microprocessor, but the stable, 4-layered main system board gives better reliability than the IBM. The AT Turbo's efficient design uses fewer chips but packs all the AT power onto a smaller board to fit XT systems as well. All boards and components are available indivdually to upgrade your current system, but you'll get even greater savings by buying our custom kit. Complete instructions are included, so you'll have the satisfaction of building your own superb AT computer.

AT Turbo Computer System

(See below for complete component descriptions)

80286 AT Baby Motherboard-6/10MHz	(X-1050)	$499.00
2x 256K Upgrade Kit	(X-1190)	69.90
Hard/Floppy Disk Controller Card	(X-1052)	199.00
1.2MB Floppy Disk Drive	(X-7502)	135.00
200W Power Supply	(X-1111)	99.00
84-key Keyboard	(X-1122)	59.95
Heavy-duty Steel Case	(X-1120)	39.95

Individual Components Total $1101.80

$975 X-1152

SAVE $125

off individual component prices

DSE 1 YEAR WARRANTY on Computer Products

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Intel 80286, 80287 are trademarks of Intel Corp

Hercules Graphics Card is a trademark of the Hercules Graphics Corporation.

80286 AT Baby Motherboard — $499 X-1050 NEW

- Intel 80286 CPU/80287 Math Coprocessor Socket 24 bit addressing; 16 bit data path; 16 level interupts; 7 channel DMA
- Socketed for up to 1MB memory
- Speed 6/10 MHz, software switchable
- Real clock time; built-in battery
- Standard speaker, keyboard, & power connectors
- 7 expansion slots (4 dual 62/36 pin; 3x62 pin for PC/XT adapter cards)
- BIOS made in USA - legal and 100% IBM AT compatible

256K Upgrade Kit — NEW $34.95 X-1190

- IBM AT compatible ● 120 nsec
- contains 9 x 256K D/RAM (Z-9315)

Hard/Floppy Drive Controller Card — $199 X-1052

- IBM AT compatible
- Supports two hard disk drives
- Supports two 1.2 MB floppy drives

360 KB/ 1.2 MB Floppy Drive Controller Card — $79 X-1051 NEW

- IBM AT compatible

I/O Card — $79 X-1060

- IBM AT compatible
- RS-232 & Parallel Game ports

1.2 MB Floppy Disk Drive — NEW! $135 X-7502

- IBM AT compatible ● 15 sectors/track

200W Power Supply — NEW $99 X-1111

- IBM AT compatible
- Input: 117V AC, 50Hz
- Output: 200W DC

84-key Keyboard — $59.95 X-1122

- IBM AT/XT compatible
- Keyboard angle adjusts from 7-15°
- Mechanical key switch with strike rate 20 million
- LED indicator shows lock key status
- Ergonomic design: adjustable height, tactile feel

Heavy-Duty Steel Case — $39.95 X-1120

- IBM XT/AT Baby Board Compatible
- Easy internal access
- Includes hardware for expansion slots & power supply mounting
- Weight approximately 17 lbs.

IBM AT-style case — NEW $79 X-1121

Dynamic RAMs (IBM AT compatible) — NEW

				9 & Up
64K 150 nsec	(Z-9312)	$1.29		$1.19
64K 120 nsec	(Z-9313)	1.95		1.75
256K 150 nsec	(Z-9314)	2.99		2.89
256K 120 nsec	(Z-9315)	4.29		3.99

More AT-compatible Accessories

MONOPAK Card — $169 X-1054 NEW!

- IBM AT/XT PC compatible ● Hercules compatible
- Monochrome graphic adapter with 80 x 25 text mode, 720 x 348 graphic mode & 64 KB buffer
- Parallel printer port with Centronic compatible interface
- Serial & game ports; light pen interface

Monographics Card — $89.95 X-1012

- IBM AT/XT/PC compatible
- 80 x 25 text mode; 720 x 348 graphic mode
- Parallel printer port

Enhanced Graphics Card — $209.00 X-1008

- IBM AT/XT compatible
- 256K Video RAM ● Light pen interface
- RAM-loadable character generator
- Full 16-color support for 640 x 350 graphics

Color Graphics Adaptor Card — $69.95 X-1007

- IBM AT/XT compatible ● 40/80 col x 25 rows
- 320 x 200 med-res color; 640 x 200 hi-res b&w

2MB Memory Expansion Card — NEW $139.00 X-1056

- IBM AT compatible
- Fully socketed memory with parity check
- Select/split among Conventional, Extended or Expanded Memory
- Use up to 4 cards for up to 8MB expansion memory
- Includes software to enhance system performance

3MB Multifunction Card — NEW! $159.95 X-1058

- IBM AT compatible
- Fully socketed memory with parity check
- True 16-bit architecture for memory
- RS-232 serial port; parallel printer port; game adapter port
- Includes serial & joystick interface cables

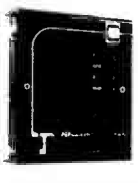
Amber Monitor — NEW! X-1133 $119.00

- IBM AT/XT compatible

Green Monitor — X-1132 $99.95

- IBM/AT/XT compatible

Get great values on Computer Accessories at Dick Smith Electronics



$129 X-4020 NEW!

PEPswitch

Electronic Printer Switch

Tired of messing with cables and juggling hardware? PEP switch is the smart printer switch that lets you switch between printers from your keyboard! Use it to select between draft and final copy printers, between printers with different paper types (e.g.) invoices and picking slips), etc.

PEPswitch is compatible with any printing device with a Centronics parallel interface. The desired printer can be selected from your keyboard by a simple ASCII command sequence or by a mechanical switch on the PEPswitch cover. Multiple PEPswitches may be used to select from as many as five printers attached to one P.C.

It's so good, we use PEPswitch on *our* office system!

GENDER CHANGERS

- Centronic M/M (X-4006) — $9.95
- RS-232 M/M (X-4009) — $4.95
- Centronic M/F (X-4010) — $9.95
- RS-232 M/F (X-4002) — $4.95
- Multiport RS-232 Gender Changer (X-4003) — $14.95

MODEM SALE *SAVE UP TO 27%!*

Voyager 1200B *was $140* X-1100 — $109
- Plug-in card ● 0-300 & 1200 bps

Challenger 1200 *was $169* X-1102 — $129
- Free-standing ● 0-300 & 1200 bps

Discovery Hi-Speed *was $379* X-1104 — $299
- 0-300,600,1200,2400 bps

25 Pin Adapter $9.95 RJ-11 to RS-232 X-4005

Null Modem $4.95 X-4007

Keyboard Extension Cable $4.95 X-3597
5 pin to 5 pin DIN; 10' length

PRINTER CABLES

Parallel Printer Interface (X-3595) $9.95
For use on a large range of computers

IBM Parallel Interface (X-3590) $9.95
Fully RFI and EMI shielded; 6' length

IBM Parallel Interface (X-3591) $11.95
Fully RFI and EMI shielded; 10' length

IBM Serial Interface
25 pin Male/Male; 10' length (X-3592) $9.95
25 pin Male/Female; 10' length (X-3593)

Macintosh Serial Interface (X-3594) $7.95
6 foot length

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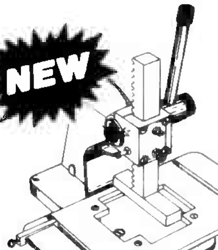
Electronics hobbyists & professionals all over the world have relied on DSE for more than 18 years!



Now! Custom cables are quick & easy!

IDC BENCH ASSEMBLY PRESS

$139
T-5260

Mass terminate up to 64-conductor cable in seconds without wire stripping or soldering! This quarter-ton manual press is a rugged, practical installation tool for low volume, mass termination of various IDC connectors on flat (ribbon) cable. Interchangeable base plates accomodate a broad range of IDC connectors.

PRESS ACCESSORIES

Cutters
- Flat (Ribbon) Cable (T-5261) **$54.95**
- Strip Header (IDC) (T-5262) **$49.95**

Base Plates $29.95 each
- Female Socket Transition Connectors (T-5263)
- Card Edge Connectors (T-5264) ● DIP Plugs (T-5265)
- D-Sub Connectors (T-5266)

Jetset AIRDAPTER

$34.95
C-4125

Frequent Fliers, Take Note!

Why rent lo-fi, uncomfortable airline earphones when you can own your own high quality stereo headphones to tune into inflight entertainment any time? Comfy & convenient, Airdapter works on all aircraft with standard airpipe connectors or in personal stereo jacks in club & 1st class. Latest circuitry filters out hiss and amplifies signal.

Make Your Own Professional Quality PCB's!

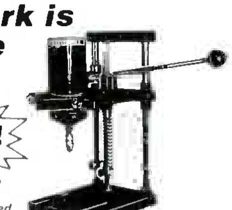
Photo-Etch™ PRINTED CIRCUIT KIT **$37**
H-5700

All the chemicals necessary to make any circuit up to 5" x 6" - from original or magazine art! For larger circuits, we carry a range of PCB-making accessories - check our catalog or call to inquire!

Contains: 5" x 6" steel frame; Pos-Neg film; film processing pack; yellow filter; 4oz. negative-acting etch resist; 16oz. resist developer; blank copper circuit boards; dry concentrated etchant; 1:1 resist patterns & tapes; complete instructions.

Developing trays & exposure light not included. Trays available at camera supply houses. DSE exposure light (S-3905) $11.95.

Precision work is easy with the right tools!



Mini-Drill Stand NEW!

$12.95
T-4753

Drill not included (see below)

Clean, accurate holes are a cinch with this sturdy mini-drill stand. It's a perfect accessory for the mini-drill kit below.

Mini-Drill Set

$9.95
T-4751

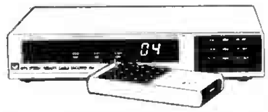
For hobbyist, toolmaker, technician. **Contains:** 4 high-speed twist drills with 3 collets, grinding bit, wrench, tommy bar, and DC power cable (for 12-35V DC) in a plastic case.

Get a whole new source of TV!

Dual polarity, multi-channel wideband microwave TV tuner receives 1.9-2.7 GHz. System includes 19" parabolic dish, DC, LNC, cable, transformers & 90 day warranty. Use with any TV!

MICROWAVE Receiver System **$99.95**
D-6350

WARNING! *Although this system receives descrambled pay TV signals (like HBO), such usage is ILLEGAL! DSE offers this product with the express understanding that it will be used for lawful purposes only!*



Cordless Remote for ANY TV!

These stylish video components install easily in minutes & replace the existing tuner with 139 channel cable-ready capability controlled by a 19-button cordless remote with many features.

TV Remote Scan **$139** Y-8530
MTS Stereo Remote Scan **$199** Y-8531

VIDEOTAPE REWINDERS **$39.95 each** VHS C-3813 Beta C-3814

IC Substitution Manual (B-4001) **$29.95** ***NEW!***

Hard to find TORX screwdrivers?

We have 'em!

NEW!

SIZE	CAT. NO.	SINGLE PRICE	10 & UP
#08	T-4208	$2.70	$2.60
#10	T-4210	3.15	3.05
#12	T-4212	3.40	3.30
#14	T-4214	3.60	3.50

INSTRUMENT CASES NEW!

$6.95 H-2506 ***NEW SIZE!***

6"W x 6¼"D x 2½"H
Includes mounting slots & posts

Try these other useful sizes:

10"W x 7½"D x 3¼"H H-2507 **$9.95** 8"W x 6¼"D x 2½"H H-2505 **$7.95**

Musicians! Make Notes!!

AUDIO MIXER NEW!

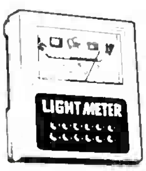
$129
F-3050

Here's a pro-quality mixing board in a compact package at an incredible low price! Mix 2 mics and up to 4 other stereo inputs (from 8 separate sources) and output to a recorder or amplifier. Features include 5-band graphic equalizer, VU meters, Master, Fader & Monitor Controls; Talkover, Headphone Jack.
Specifications: Input sensitivity: 1mV-150mV; Output 0.775V at 1KHz sinewave; Distortion <0.05%; S/N ratio > 60dB; Frequency response 20-20000KHz ±2dB; Equalizing frequencies: 60Hz, 250Hz, 1KHz, 3.5KHz, 12KHz ±5%; Control range ±12dB; Headphone power: 100mW (max) at 32 ohm; Power source: 220V AC, 50Hz; Size: 13⅜"W x 9½"D x 2½"H(1) x 1⅜"H (2)

DIGITAL PANEL METERS

3.5 Digit LCD **$29.95** Q-2200
High input impedance; 9V battery required

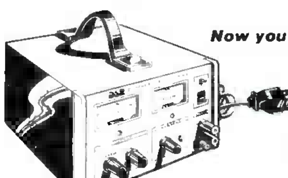
4.5 Digit LCD **$59.95** Q-2202
Low power dissipation, guaranteed zero reading for 0 volts input on all scales; 9V battery required.



POCKET LIGHT METER NEW

$8.95
Q-1050

0-3000 lux, accurate ±15%. For incandescent, flourescent. No batteries required.



Now you can afford a **VARIABLE POWER SUPPLY**

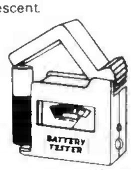
$149.95
M-9548

Lab standards at a hobbyist's price! Variable voltage and current output with panel meters for each; coarse & fine voltage controls; hi/low amp scales; banana-type outputs.
Specifications: 0-30V DC Supply; 0-5A Output; 0.5mV rms Ripple Regulation; 0.01% 2mV Line; 0.01% 3mV Load

NEW!

POCKET BATTERY TESTER

For all sizes: D,C,AA,AAA, N,9V & Button **$7.95** Q-1052



PHONE BUG ALERT **$14.95** F-1008
Alerts you to eavesdropping on any phone system. Easy to install. No batteries required.

NEW

ATTENTION AUSTRALIS 1 OWNERS!

The AUSTRALIS STEREO UPGRADE Kit is *NOW IN STOCK!* **$29.95** K-6317

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COMMODORE PRINTER/PLOTTER
Commodore Model # 1520
Four color X-Y plotter. Standard VIC serial interface allows easy connection to Commodore 64 computers. Up to 80 characters per line in four sizes.
4 inch paper
CAT # COM-1520
$49.95 each
EXTRA pen sets $1.50 per set.

2K 10 TURN
MULTI-TURN POT
SPECTROL
#MOD 534-7161
$5.00 EACH

SOLID STATE BUZZER
Star #SMB-06L
6 vdc
TTL compatible.
$1.00 each
10 for $9.00

POLARITY SWITCH
Designed to control an external coaxial relay on a satellite TV system. IDEAL FOR THE EXPERIMENTOR AS PARTS. Heavy chassis box containing a 5 Vdc relay, CA 358 op amp and other parts.
Catalog # RDPS $1.75 each 10 for $15.00

EDGE CONNECTORS
ALL ARE .156" SPACING.

22 EDGE CONNECTOR $1.25 ea
solder lug style 10 for $11.00
22/44 EDGE CONNECTOR
$2.00 ea P.C. style 10 for $18.00
22/44 EDGE CONNECTOR
solder lug style $2.50 each
28/56 EDGE CONNECTOR
P.C. style $2.50 ea
36/72 EDGE CONNECTOR
P.C. style $3.00 each
43/86 EDGE CONNECTOR
P.C. style $4.50 each

COMPUTER GRADE CAPACITORS
1,400 mfd. 200 Vdc
3" X 2" dia. $2.00
6,400 mfd 60 Vdc
4 1/4"x1 3/8"dia.$2.50
7,500 mfd 200 Vdc
5 3/4" x 3" dia. $4.00
12,000 mfd 40 Vdc
4 1/4" x 2" dia. $2.50
22,000 mfd 25 Vdc
4 3/4" x 2" dia. $2.50
48,000 mfd 10 Vdc
3" x 2 1/2" dia. $2.50
66,000 mfd 15 Vdc
3 3/4" x 3" dia. $3.00
72,000 mfd 15 Vdc
4" x 2" dia. $3.50
100,000 mfd 10 Vdc
6" x 2 1/2" dia. $1.00

MICRO-CASSETTE MECHANISM
Micro-cassette tape transport for standard MC60 or MC45 micro-cassettes. 3 Vdc operation. Contains: drive motor, belt, head, capstan, pinch wheel and other components. 3 1/2" X 2 1/4" X 5/8"
CAT# MCMEC $3.00 each 10 for $27.50

WALL TRANSFORMER
11.5 Vdc
1.95 Amp.
INPUT: 120 Vac
SIZE: 3 3/4" X 2 7/8" X 2 5/8"
CAT # DCTX-11519
$6.50 each

48 KEY ASSEMBLY FOR COMPUTER OR HOBBYIST
NEW T.I. KEYBOARDS. Originally used on computers, these keyboards contain 48 S.P.S.T. mechanical switches. Terminates to 15 pin connector. Frame 4" x 9"
CAT # KP-48 $3.50 each

TRANSISTORS
2N706	4 for $1.00
2N2222A	3 for $1.00
PN2222A	4 for $1.00
2N2904	3 for $1.00
2N2905	3 for $1.00
MJ2955	$1.50
2N3055	$1.00
PMD 10K40	$1.00
TIP 121	75¢
TIP 125	75¢

3rd TAIL LIGHT ?
Sleek high-tech lamp assembly. Could be used as a third auto tail light, emergency warning light, or special-effects lamp. Red reflective lens is 2 3/4" x 5 1/2" is mounted on a 4" high pedestal with up-down swivel adjustment. Includes 12v replaceable bulb.
CAT# TLB $3.95 each.

RELAYS
10 AMP SOLID STATE
CONTROL: 3 - 32 vdc
LOAD: 140 vac 10 amp
SIZE: 2½" x ¾" x ⅞"
$9.50 EACH 10 FOR $90.00

ULTRA-MINIATURE 5 VDC RELAY
Fujitsu # FBR211NED005M20
High sensitivity
COIL: 120 ohms
CONTACTS: 1 amp
Mounts in 14 pin DIP socket
$1.25 each 10 for $10.00

MINIATURE 6 VDC RELAY
Aromat #RSD-6V
Super Small
S.P.D.T. relay
GOld colbalt contacts rated
1 amp @ 30 vdc. Highly sensitive. TTL direct drive possible. 120 ohm coil.
Operate from 4.3 - 6 vdc.
COIL: 120 ohms $1.50 each
$^{13}/_{16}$ x $^{13}/_{32}$ x $^{7}/_{16}$ 10 for $13.50

13 VDC RELAY
CONTACTS: S.P.N.C.
10 amp @ 120 vac
Energize coil to open contact...
COIL: 13 vdc 650 ohms
SPECIAL PRICE $1.00 each

4PDT RELAY
14 pin KH style...
3 amp contacts...
USED but fully tested ... $1.70 each
Specify coil voltage desired
Either 24 vdc or 120 vac
LARGE QUANTITIES AVAILABLE
SOCKETS FOR KH RELAY
75¢ each

3½" SPEAKER
8 ohm impedance. Full range speaker. 8 oz magnet 4" diagonal mounting centers
$2.50 each 10 for $20.00

TELEPHONE COUPLING TRANSFORMER
Stancor # TTPC-8 or Triad # TY-304 P
600 ohms c.t. to 600 ohms c.t.
P.C. board mount
3/4" x 5/8" x 3/4" $1.25 each

PHOTO-FLASH CAPACITORS
170 MFD 330 Volt
CAT# PPC-170
75c each
400 MFD 330 Volt
CAT# PPC-400 $1.00 ea

SPRING LEVER TERMINALS
Two color coded terminals on a sturdy 2¾" x 3¾" bakelite plate.
Great for speaker enclosures or power supplies.
75¢ EACH 10 for $6.00

XENON FLASH TUBE
3/4" long X 1/8" dia. Flash tube designed for use in compact camera flash units. Ideal for experimentors.
CAT# FLT-1 2 for $1.00

TRANSFORMERS
120 volt primaries

5.6 volts @ 750 ma.	$3.00
6.3 volt @ 600 ma.	$1.75
12 V.C.T. @ 200 ma.	$2.00
12 V.C.T. @ 400 ma.	$3.00
12 V.C.T. @ 1 amp	$4.00
12 V.C.T. @ 2 amp	$4.85
12 V.C.T. @ 4 amp	$7.00
18 volts @ 650 ma.	$2.00
24 V.C.T. @ 200 ma.	$2.50
24 V.C.T. @ 1 amp	$4.85
24 V.C.T. @ 2 amp	$6.75
24 V.C.T. @ 3 amp	$9.50
24 V.C.T. @ 4 amp	$11.00

LIGHT ACTIVATED MOTION SENSOR
This device contains a photocell which senses sudden changes in ambient light. When an object or person passes within it's field of view (about 15') it beeps for several seconds then resets. Could be used as a door annunciator or modified to trigger other devices. 5 1/2" X 4" X 1". Operates on 6 Vdc. Requires 4 AA batteries (not included).
Catalog # LSMD $5.75 per unit

MINIATURE TOGGLE SWITCHES
ALL ARE RATED 5 AMPS @ 125 VAC

S.P.D.T. (on-on)
P.C. style non-threaded bushing.
75¢ each
10 for $7.00

S.P.D.T. (on-on)
Solder lug terminals.
$1.00 each
10 for $9.00
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S.P.D.T. (on-off-on)
Solder lug terminals.
$1.00 each
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P.C. style non-threaded bushing
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S.P.D.T. (on-on)
P.C. lugs threaded bushing.
$1.00 each
10 for $9.00
100 for $80.00

D.P.D.T. (on-on)
Solder lug terminals.
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100 for $180.00

WALL TRANSFORMERS
all plug directly into 120 vac outlet

4 VDC @ 70 ma.	$2.00
6 VAC @ 500 ma.	$3.50
6 VDC @ 750 ma.	$4.50
9 VDC @ 500 ma.	$5.00
12.5 VAC @ 265 ma.	$3.00
18 VAC @ 18 VA and 8.5 VAC @ 1.28 VA	$3.50
24 VAC @ 250 ma.	$3.00
MULTI-VOLTAGE @ 500 ma. 3,4½,6,7½,9 or 12 VDC	$7.50

TI SWITCHING POWER SUPPLY
Compact, well-regulated switching power supply designed to power Texas Instruments computer equipment.
INPUT: 14 - 25 vac @ 1 amp
OUTPUT: + 12 vdc @ 350 ma.
+ 5 vdc @ 1.2 amp
− 5 vdc @ 200 ma.
SIZE: 4¾" x 4¼" x 1¼" high
* SPECIAL PRICE $3.50 each

13.8 VDC REGULATED POWER SUPPLY
These are solid state, fully regulated 13.8 vdc power supplies. Both feature 100% solid state construction, fuse protection, and L.E.D. power indicator. U.L. listed.
2 amp constant, 4 amp surge $20.00 each
3 amp constant, 5 amp surge $27.50 each

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AAA SIZE	1.25V 500mAH	$1.85
AA SIZE	1.25V 500mAH	$1.85
AA	with solder tab	$2.00
C SIZE	1.2V 1200mAH	$3.50
SUB-C SIZE	solder tab	$3.50
D SIZE	1.2V 1200mAH	$3.50

LED'S
STANDARD JUMBO DIFFUSED T 1-3/4
RED 10 for $1.50
100 for $13.00
GREEN 10 for $2.00
100 for $17.00
YELLOW 10 for $2.00
100 for $17.00

FLASHER LED
5 volt operation
red jumbo T 1¾ size $1.00 each
NEW GREEN FLASHER
CAT # LED-4G $1.00

BI-POLAR
jumbo T 1¾ size
2 for $1.70

D.P.S.T. LIGHTED ROCKER SWITCH
115 vac lighted rocker, snap mounts in ⅞" x 1⅛" hole. Orange lens. 16 amp contact.
$1.50

MINI-PUSH BUTTON
S.P.S.T. momentary normally open ¼" bushing. Red button.
35¢ each
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SNAP ACTION SWITCH
Cherry elect. #E-21. N.O. or N.C. 0.1A contacts. Suitable for alarms and other low energy circuits. 1⅛" lever.
45¢ EACH 10 FOR $4.20

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Pomona #2104.
$1.00 EACH
Heavy-duty black phenolic project box with cover and screws. 2⅜" X 1½" X 1½"

FUSES
3AG (AGC) SIZE
1, 1½, 2, 2½, 3, 4, 5, 6 AMP
GMA SIZE
1, 2, 3, 4, 5 AMP
5 of any ONE amperage 75¢

8" 15 WATT SPEAKER
C.T.S Model 8B3079
Full range speaker, 100-10,000Hz;
Ideal for PA systems.
Mounting holes for line-matching transformer.
CAT#SK-815
$3.50 ea. Case of 8 pcs. $25.00 per case

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ROTRON # MX77A3
Muffin XL
220 Vac
4 1/8" square metal frame fan.
CAT# CF-220 $6.50 ea
10 for $60.00 / 100 for $500.00

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Will charge most every size Ni-cad battery available.
Cat # UNCC-N $12.50

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Two piece holder for jumbo LED
10 for 65¢ 100 for $5.00

CLEAR CLIPLITE LED HOLDER
Make LED a fancy indicator. Clear.
4 for $1.00

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CARLING (on-off)
RATED: 10 amp @ 125 Vac.
All plastic body and toggle.
CAT# STS-1
$1.00 ea.
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100 for $7.50
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7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	.29	.19	7485	.65	.55
7402	.29	.19	7486	.45	.35
7404	.35	.25	7489	2.05	1.95
7405	.39	.29	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.45	.35
7408	.35	.25	74123	.59	.49
7410	.35	.25	74125	.55	.45
7414	.49	.39	74126	.75	.65
7416	.45	.35	74143	4.05	3.95
7417	.45	.35	74150	1.35	1.25
7420	.35	.25	74154	1.35	1.25
7430	.35	.25	74158	1.59	1.49
7432	.39	.29	74173	.85	.75
7438	.39	.29	74174	.65	.55
7442	.55	.45	74175	.65	.55
7445	.79	.69	74176	.99	.89
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	2.05	1.95
7448	2.05	1.95	74193	.79	.69
7472	.75	.65	74198	1.85	1.75
7473	.45	.35	74221	.99	.89
7474	.45	.35	74273	2.05	1.95
7475	.49	.39	74365	.69	.59
7476	.45	.35	74367	.69	.59

74LS

Part No.	1-9	10+	Part No.	1-9	10+
74LS00	.29	.19	74LS165	.75	.65
74LS02	.29	.19	74LS166	.99	.89
74LS04	.35	.25	74LS173	.59	.49
74LS05	.35	.25	74LS174	.49	.39
74LS06	1.09	.99	74LS175	.49	.39
74LS07	1.09	.99	74LS189	4.59	4.49
74LS08	.29	.19	74LS191	.59	.49
74LS10	.29	.19	74LS193	.79	.69
74LS14	.49	.39	74LS221	.69	.59
74LS27	.35	.25	74LS240	.79	.69
74LS30	.29	.19	74LS243	.79	.69
74LS32	.35	.25	74LS244	.79	.69
74LS42	.49	.39	74LS245	.89	.79
74LS47	.99	.89	74LS259	.99	.89
74LS73	.39	.29	74LS273	.89	.79
74LS74	.35	.25	74LS279	.49	.39
74LS75	.39	.29	74LS322	4.05	3.95
74LS76	.55	.45	74LS365	.49	.39
74LS85	.59	.49	74LS366	.49	.39
74LS86	.35	.25	74LS367	.49	.39
74LS90	.49	.39	74LS368	.49	.39
74LS93	.49	.39	74LS373	.79	.69
74LS123	.59	.49	74LS374	.79	.69
74LS125	.49	.39	74LS393	.89	.79
74LS138	.49	.39	74LS590	6.05	5.95
74LS139	.49	.39	74LS624	2.05	1.95
74LS154	1.09	.99	74LS629	2.29	2.19
74LS157	.45	.35	74LS640	1.09	.99
74LS158	.45	.35	74LS645	1.09	.99
74LS163	.59	.49	74LS670	1.09	.99
74LS164	.59	.49	74LS688	2.05	1.95

74S/PROMS*

74S00	.29	74S188*	1.29
74S04	.35	74S189	1.69
74S08	.35	74S196	2.49
74S10	.29	74S240	1.49
74S32	.35	74S244	1.49
74S74	.45	74S253	.79
74S85	1.79	74S287*	1.49
74S86	.35	74S288*	1.49
74S124	2.95	74S373	1.49
74S174	.79	74S374	1.49
74S175	.79	74S472*	2.95

74ALS

74ALS00	.35	74ALS138	.89
74ALS02	.35	74ALS174	.89
74ALS04	.39	74ALS175	.89
74ALS08	.39	74ALS240	1.49
74ALS10	.39	74ALS244	1.49
74ALS27	.39	74ALS245	1.49
74ALS30	.39	74ALS373	1.69
74ALS32	.39	74ALS374	1.69
74ALS74	.49	74ALS573	1.69

74F

74F00	.39	74F139	.89
74F04	.39	74F157	.95
74F08	.39	74F193	3.95
74F10	.39	74F240	1.39
74F32	.39	74F244	1.39
74F74	.49	74F253	.99
74F86	.59	74F373	1.39
74F138	.89	74F374	1.39

CD—CMOS

CD4001	.19	CD4076	.65
CD4008	.89	CD4081	.25
CD4011	.19	CD4082	.25
CD4013	.29	CD4093	.35
CD4016	.29	CD4094	.89
CD4017	.55	CD40103	2.49
CD4018	.59	CD40107	.69
CD4020	.59	CD40109	1.49
CD4024	.49	CD4510	.69
CD4027	.35	CD4511	.69
CD4030	.29	CD4520	.75
CD4040	.65	CD4522	.79
CD4049	.29	CD4538	.79
CD4050	.29	CD4541	.69
CD4051	.59	CD4543	.79
CD4052	.59	CD4553	4.95
CD4053	.59	CD4555	.79
CD4059	3.95	CD4566	2.49
CD4063	1.95	CD4572 (MC14572)	.39
CD4066	.29	CD4583	.89
CD4069	.25	CD4584	.39
CD4070	.25	CD4585	.89
CD4071	.25	MC14411P	8.95
CD4072	.25	MC14490P	4.49

COMMODORE CHIPS

Part No.	Price	Part No.	Price	Part No.	Price
WD1770 Disk Cont.	19.95	6545-1 CRTC	2.49	8701 Clock Chip	9.95
SI-3052P 5V Pos Reg 2A	5.95	6551 ACIA	3.29	*8721 PLA	14.95
6504A CPU	1.95	6560 VIC-I	10.95	8722 MMU	9.95
6507 CPU	4.95	6567 VIC-II	14.95	*251104-04 Kernal ROM	10.95
6510 CPU	9.95	6569 VIC PAL	14.95	*325572-01 Logic Array	24.95
6520 PIA	1.75	6572 VIC PAL-N	14.95	*82S100PLA (906114-01)**	13.95
6522 VIA	2.95	6581 SID	14.95	901225-01 Char. ROM	11.95
6525 TPI	7.95	8360 Text Editing	10.95	901226-01 BASIC ROM	11.95
6526 CIA	14.95	8501 MPU	10.95	901227-03 Kernal ROM	11.95
6529 SPI	4.95	8502 MPU	7.95	901229-05 Upgrd. ROM	15.95
6532 128x8 RAM, I/O, Tim Ar	6.49	8563 CRT Contr	15.95	*No spec. available	
		8564 VIC	15.95	**NOTE: 82S100PLA = U17 (C-64)	

NEC V20 & V30 CHIPS

Replace the 8086 or 8088 in Your IBM-PC and Increase Its Speed by up to 40%!

Part No.	Price
UPD70108-5 (5MHz) V20 Chip (Replaces the 8088)	$ 9.95
UPD70108-8 (8MHz) V20 Chip (Replaces the 8088-2)	$11.95
UPD70116-8 (8MHz) V30 Chip (Replaces the 8086 or 8086-2)	$14.95
UPD70116-10 (10MHz) V30 Chip (Replaces the 8086 or 8086-2)	$34.95

MICROPROCESSOR COMPONENTS

MISCELLANEOUS CHIPS

Part No.	Price
D765AC	4.49
WD1770	19.95
CDP1802CE	4.95
2661-3	5.95
WD9216	9.95

Z80, Z80A, Z80B SERIES

Part No.	Price
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Z80-CTC	1.79
Z80-DART	4.95
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Z80A-CTC	1.49
Z80A-DART	4.95
Z80A-PIO	1.49
Z80A-SIO/0	4.95
Z80B	2.95
Z80B-CTC	3.49
Z80B-PIO	4.29

6500/6800/68000 SER.

Part No.	Price
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65C02 (CMOS)	8.95
6520	1.75
6522	2.95
6532	6.49
6551	3.29
6800	1.75
6802	3.49
6810	1.25
6821	1.29

6500/6800/68000 Cont.

Part No.	Price
6840	3.95
6843	2.95
6845	2.95
6850	1.49
6852	3.95
6875	8.95
68000L8	11.95
68661PB	5.95

8000 SERIES

Part No.	Price
8031	2.95
80C31BH	14.95
8035	1.49
8073	29.95
8080A	2.49
8085A	2.29
8086	6.95
8086-2	8.95
8087 (5MHz)	125.00
8087-2 (8MHz)	159.95
8088	6.49
8088-2	8.95
8116	4.95
8155	1.95
8155-2	2.49
8156	2.49
8202	9.95
8203	14.95
8212	1.49
8224	2.25

8000 SERIES Cont.

Part No.	Price
8228	2.49
8237-5	4.95
8243	2.25
8250A	5.49
8250B (For IBM)	6.95
8251A	1.75
8253-5	1.95
8254	2.95
8255A-5	1.69
8257-5	2.49
8259-5	1.95
8272	4.49
8279-5	2.95
8741	10.95
8748	7.95
8749	9.95
8751	39.95
8755	14.95

DATA ACQUISITION

Part No.	Price
ADC0804LCN	3.19
ADC0808CCN	5.95
ADC0809CCN	3.95
ADC0816CCN	14.95
ADC0817CCN	8.95
DAC0808LCN	1.95
DAC1008LCN	6.49
AY-3-1015D	4.95
AY-5-1013A	3.95

DYNAMIC RAMS

Part No.	Function		Price
4116-15	16,384 x 1	(150ns)	.89
4128-20 (Piggyback)	131,072 x 1	(200ns)	4.49
4164-150	65,536 x 1	(150ns)	1.15
4164-200	65,536 x 1	(200ns)	.95
TMS4416-12	16,384 x 4	(120ns)	4.25
8118	16,384 x 1	(120ns)	.69
41256-150	262,144 x 1	(150ns)	2.95
50464-15	65,536 x 4	(150ns) (4464) (41464)	4.95

STATIC RAMS

Part No.	Function		Price
2016-12	2048 x 8	(120ns)	1.69
2102	1024 x 1	(350ns)	.89
2102-2L	1024 x 1	(250ns) Low Power (91L02)	1.95
2114N	1024 x 4	(450ns)	.99
2114N-2	1024 x 4	(200ns)	1.05
2114N-2L	1024 x 4	(200ns) Low Power	1.49
21C14	1024 x 4	(200ns) (CMOS)	.49
2149	1024 x 4	(45ns)	4.95
5101	256 x 4	(450ns) CMOS	1.95
6116LP-2	2048 x 8	(120ns) Low Power CMOS	2.95
6116P-3	2048 x 8	(150ns) CMOS	1.89
6116LP-3	2048 x 8	(150ns) Low Power	1.95
6264P-12	8192 x 8	(120ns) CMOS	3.89
6264LP-12	8192 x 8	(120ns) Low Power CMOS	4.25
6264P-15	8192 x 8	(150ns) CMOS	3.59
6264LP-15	8192 x 8	(150ns) Low Power CMOS	3.75
6514	1024 x 4	(350ns) CMOS (UPD444C)	4.49
43256-15L	32,768 x 8	(150ns) Low Power	24.95

PROMS/EPROMS

Part No.	Function		Price
1702A	256 x 8	(1µs)	6.95
TMS2516	2048 x 8	(450ns) 25V	4.95
TMS2532	4096 x 8	(450ns) 25V	5.95
TMS2564	8192 x 8	(450ns) 25V	8.95
2708	1024 x 8	(450ns)	4.95
TMS2716	2048 x 8	(450ns) 3 voltage	9.95
2716	2048 x 8	(450ns)	3.75
2716-1	2048 x 8	(350ns) 25V	4.95
27C16	2048 x 8	(450ns) 25V (CMOS)	6.49
2732	4096 x 8	(450ns)	3.95
2732A-20	4096 x 8	(200ns) 21V	4.25
2732A-25	4096 x 8	(250ns) 21V	3.95
2732A-45	4096 x 8	(450ns) 21V	3.75
27C32	4096 x 8	(450ns) 25V (CMOS)	6.49
2764-20	8192 x 8	(200ns) 21V	4.25
2764-25	8192 x 8	(250ns) 21V	3.75
2764A-25	8192 x 8	(250ns) 12.5V	4.25
2764-45	8192 x 8	(450ns) 21V	3.49
27C64	8192 x 8	(450ns) 21V (CMOS)	5.49
27128-20	16,384 x 8	(200ns) 128K 21V	4.95
27128-25	16,384 x 8	(250ns) 128K 21V	4.25
27128A-25	16,384 x 8	(250ns) 12.5V	4.95
27C128-25	16,384 x 8	(250ns) 21V (CMOS)	5.95
27256-25	32,768 x 8	(250ns) 256K (12.5V)	5.95
27C256-25	32,768 x 8	(250ns) 256K (CMOS) (12.5V)	8.95
27512-25	65,536 x 8	(250ns) 512K (12.5V)	19.95
68764	8192 x 8	(450ns) 25V	15.95
68766	8192 x 8	(350ns) 25V	16.95
74S387	256 x 4	PROM O.C.	1.29
74S471	256 x 8	PROM T.S.	4.95
N82S123	32 x 8	PROM T.S.	2.49

SATELLITE TV DESCRAMBLER CHIP

The MM5321 is a TV camera sync generator designed to supply the basic sync functions for either color or monochrome 525 line/60Hz interfaced and camera video recorder applications. COLOR BURST GATE & SYNC ALLOW STABLE COLOR OPERATION

MM5321N. $11.95

INTERSIL Also Available!

74HC HI-SPEED CMOS

Part No.	Price	Part No.	Price
74HC00	.25	74HC175	.69
74HC02	.25	74HC221	.99
74HC04	.29	74HC240	.79
74HC08	.29	74HC244	.79
74HC10	.29	74HC245	.89
74HC14	.49	74HC253	.59
74HC30	.29	74HC259	.65
74HC32	.29	74HC273	.79
74HC74	.39	74HC373	.79
74HC75	.39	74HC374	.79
74HC76	.45	74HC393	.75
74HC85	.79	74HC595	1.19
74HC86	.39	74HC688	.79
74HC123	.89	74HC4040	.89
74HC125	.49	74HC4049	.59
74HC132	.49	74HC4050	.59
74HC138	.49	74HC4060	1.09
74HC139	.49	74HC4511	1.29
74HC154	1.19	74HC4514	1.19
74HC163	.65	74HC4538	.89
74HC174	.69	74HC4543	1.19

74HCT — CMOS TTL

74HCT00	.29	74HCT139	.59
74HCT02	.29	74HCT157	.69
74HCT04	.29	74HCT174	.69
74HCT08	.29	74HCT175	.69
74HCT10	.29	74HCT240	.99
74HCT32	.29	74HCT244	.99
74HCT74	.49	74HCT245	1.19
74HCT86	.49	74HCT373	1.19
74HCT138	.59	74HCT374	1.19

74C—CMOS

74C00	.29	74C174	.79
74C02	.29	74C175	.79
74C04	.29	74C221	1.49
74C08	.35	74C240	1.29
74C10	.35	74C244	1.29
74C14	.49	74C373	1.49
74C32	.35	74C374	1.49
74C74	.59	74C912	7.95
74C85	1.39	74C915	1.39
74C86	.35	74C920	9.95
74C89	5.19	74C921	9.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

LINEAR

DS0026CN	1.95	LM1458N	.39
TL074CN	.89	LM1488N	.49
TL084CN	.99	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.49
LM307N	.45	DS14C89N (CMOS)	1.19
LM309K	1.25	LM1496N	.85
LM311N	.45	MC1648P	4.95
LM317T	.79	LM1871N	2.95
LM318N	.99	LM1872N	2.95
LM319N	.99	LM1896N-1	1.59
LM323K	3.95	ULN2003A	.99
LM324N	.39	XR2206	3.95
LM338K	4.95	XR2211	2.95
LM339N	.39	XR2243	1.95
LF347N	1.79	DS26LS29CN	4.49
LM348N	.69	DS26LS31CN	1.19
LM350T	2.95	DS26LS32CN	1.19
LF351N	.39	DS26LS33CN	1.95
LF353N	.49	LM2901N	.49
LF355N	.79	LM2907N	2.49
LF356N	.79	LM2917N (8 pin)	1.55
LF357N	1.09	MC3419CL	9.95
LM358N	.49	MC3446N	2.95
LM360N	2.19	MC3450P	2.95
LM361N	1.79	MC3470P	1.95
LM380N-8	.99	MC3471P	4.95
LM386N-3	.99	MC3479P	4.79
LM387N	.99	MC3486P	1.69
LM393N	.39	MC3487P	1.69
LM399H	2.95	LM3900N	.49
LF411CN	.79	LM3905N	1.19
TL497ACN	2.69	LM3909N	.99
NE540H (C540H)	2.95	LM3914N	1.95
NE555V	.29	LM3916N	1.95
XR-L555	.75	NE5532	.89
LM556N	.49	NE5534	.69
NE558N	.89	7805K (LM340K-5)	1.29
LM565N	.99	7812K (LM340K-12)	1.29
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LM741CN	.29	7812T (LM340T-12)	.49
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MC1350	1.19	7905K (LM320K-5)	1.35
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MC1377P	3.19	75472	.99
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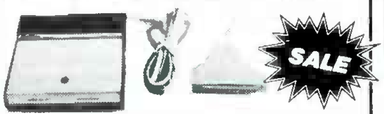

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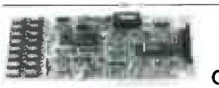

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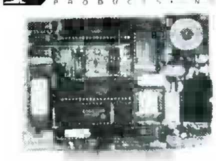

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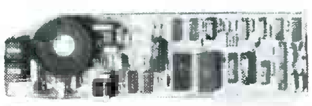

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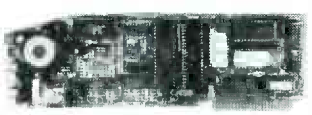

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Universal 64K/256K Printer Buffer
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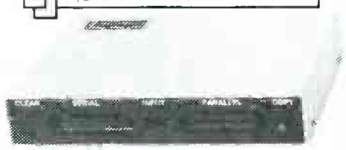

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5V=Single 5 Volt Supply 21V PGM=Program at 21 Volts

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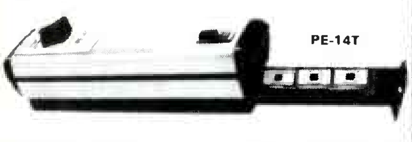

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1.0 MHz

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10.0	1.95
10.738635	1.95
12.0	1.95
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5.0688	4.95
6.0	4.95
6.144	4.95
8.0	4.95
10.0	4.95
12.0	4.95
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18.432	4.95
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74LS00

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74LS01	.18	74LS166	.95
74LS02	.17	74LS169	.95
74LS03	.18	74LS173	.49
74LS04	.16	74LS174	.39
74LS05	.18	74LS175	.39
74LS08	.18	74LS191	.49
74LS09	.18	74LS192	.69
74LS10	.16	74LS193	.69
74LS11	.22	74LS194	.69
74LS12	.22	74LS195	.69
74LS13	.26	74LS196	.59
74LS14	.39	74LS197	.59
74LS15	.26	74LS221	.59
74LS20	.17	74LS240	.69
74LS21	.22	74LS241	.69
74LS22	.22	74LS242	.69
74LS27	.23	74LS243	.69
74LS28	.26	74LS244	.69
74LS30	.17	74LS245	.79
74LS32	.18	74LS251	.49
74LS33	.28	74LS253	.49
74LS37	.26	74LS256	1.79
74LS38	.26	74LS257	.39
74LS42	.39	74LS258	.49
74LS47	.75	74LS259	1.29
74LS48	.85	74LS260	.49
74LS51	.17	74LS266	.39
74LS73	.29	74LS273	.79
74LS74	.24	74LS279	.39
74LS75	.29	74LS280	1.98
74LS76	.29	74LS283	.59
74LS83	.49	74LS290	.89
74LS85	.49	74LS293	.89
74LS86	.22	74LS299	1.49
74LS90	.39	74LS322	3.95
74LS92	.49	74LS323	2.49
74LS93	.39	74LS364	1.95
74LS95	.49	74LS365	.39
74LS107	.34	74LS367	.39
74LS109	.36	74LS368	.39
74LS112	.29	74LS373	.79
74LS122	.45	74LS374	.79
74LS123	.49	74LS375	.95
74LS124	2.75	74LS377	.79
74LS125	.39	74LS378	1.18
74LS126	.39	74LS390	1.19
74LS132	.39	74LS393	.79
74LS133	.49	74LS541	1.49
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74LS139	.39	74LS645	.99
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74LS151	.39	74LS683	3.20
74LS153	.39	74LS684	3.20
74LS154	1.49	74LS688	2.40
74LS155	.59	74LS783	22.95
74LS156	.49	81LS95	1.49
74LS157	.35	81LS96	1.49
74LS158	.29	81LS97	1.49
74LS160	.29	81LS98	1.49
74LS161	.39	25LS2521	2.80
74LS162	.49	25LS2569	2.80
74LS163	.39	26LS31	1.95
74LS164	.49	26LS32	1.95

HIGH SPEED CMOS

A new family of high speed CMOS logic featuring the speed of low power Schottky (8ns typical gate propagation delay), combined with the advantages of CMOS: very low power consumption, superior noise immunity, and improved output drive.

74HC00

74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.59	74HC148	1.19
74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.59	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.85
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.99
74HCT74	.85	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.15	74HCT373	2.49
74HCT154	2.99	74HCT374	2.49
74HCT157	.99	74HCT393	1.59
74HCT158	.99	74HCT4017	2.19
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.69
74F02	.69	74F86	.99	74F253	1.69
74F04	.79	74F138	1.69	74F257	1.69
74F08	.69	74F139	1.69	74F280	1.79
74F10	.69	74F157	1.69	74F283	3.95
74F32	.69	74F240	3.29	74F373	4.29
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CMOS

4001	.19	14419	4.95
4011	.19	14433	14.95
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4013	.35	4511	.69
4015	.29	4516	.79
4016	.29	4518	.85
4017	.49	4522	.79
4018	.69	4526	.79
4020	.59	4527	1.95
4021	.69	4528	.79
4024	.49	4529	2.95
4025	.25	4532	1.95
4027	.39	4538	.95
4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.75
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4056	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	2.49
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C905	10.95
4085	.79	74C911	8.95
4086	.89	74C917	12.95
4093	.49	74C922	4.49
4094	2.49	74C923	4.95
14411	9.95	74C926	7.95
14412	6.95	80C97	.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74155	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.29	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.50
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S15	.49	74S196	2.49
74S30	.29	74S197	2.95
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.49	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
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74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.59	7905K	1.69
7812K	1.39	7912K	1.49

TO-93 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	1.49

OTHER VOLTAGE REGS

LM323K	5V	3A	TO-3	4.79
LM338K	Adj.	5A	TO-3	6.95
78H12K	12V	5A	TO-3	8.95

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.69
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	6.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320	see 7900	XR2206	3.95
LM322	1.95	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.79	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	6.95	CA3089	1.95
LM339	.59	CA3130E	.99
LM340	see 7800	CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3914	2.39
LM393	.45	MC4024	3.49
LM394H	5.95	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

DATA ACQ — INTERFACE

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

	1-99	100+
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.16
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49
ST=SOLDERTAIL		
8 PIN WW	.59	.69
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		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL (ZERO INSERTION FORCE)

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDCEN36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

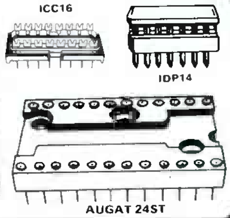
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.95	.95	---	---	---	1.75	---	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW



DIODES/OPTO/TRANSISTORS

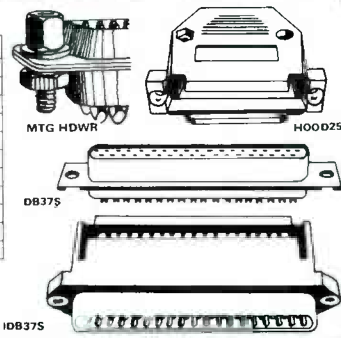
1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP02	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	---	1.95	2.65	---
	FEMALE	DBxxSR	1.25	1.55	---	2.00	2.79	---
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	2.70	2.95	---	3.98	5.70	---
	FEMALE	IDBxxS	2.92	3.20	---	4.33	6.76	---
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	---	---
	GREY	HOODxx	.65	.65	---	.65	.75	.35

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.
EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR.

MOUNTING HARDWARE $1.00



LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN-72	COM ANODE	.3"	.99
MAN-74	COM CATHODE	.3"	.99
MAN-8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
TIL-311	4x7 HEX W/LOGIC	.270"	9.95

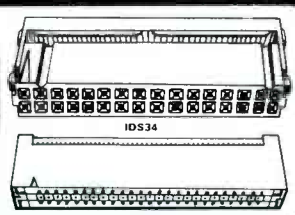
DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

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
RIGHT 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
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	2.75	3.80	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
BCD OUTPUT	10 POSITION 6 PIN DIP	1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.95
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

HARD TO FIND "SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER. ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE	1.49
2x40	STRAIGHT LEAD	2.49
2x40	RIGHT ANGLE	2.99

SHORTING BLOCKS

GOLD CONTACTS SPACED AT .1" CENTERS

5/$1.00

As a highly satisfied customer, I wish to praise the speedy and efficient ways in which my previous orders were handled. The quality of your merchandise is excellent and the prices are set to suit my budget. I have already reccomended your company to many of my colleagues and associates.

Lloyd Lynch

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.18	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

CALL FOR VOLUME QUOTES

CIRCLE 189 ON FREE INFORMATION CARD

1200 BAUD MODEM FOR IBM WITH PC TALK III SOFTWARE $109^{95}

BARGAIN HUNTERS CORNER

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5150 STYLE OEM KEYBOARD
* IMPROVED KEYBOARD LAYOUT
* 83 KEYS, FULLY IBM COMPATIBLE
* LED INDICATORS FOR CAPS & NUMBER LOCK

MITSUBISHI $129^{95}

HIGH DENSITY DRIVE
* IBM PC/AT COMPATIBLE
* 1.2 MEGABYTE, ½ HEIGHT FDD
* READS DS/DD OR DS/DH DISKETTES
* QUIET & RELIABLE

SPECIALS ENDS 4/30/87

PAGE WIRE WRAP WIRE

PRECUT ASSORTMENT IN ASSORTED COLORS $27.50

100ea: 5.5", 6.0", 6.5", 7.0"
250ea: 2.5", 4.5", 5.0"
500ea: 3.0", 3.5", 4.0"

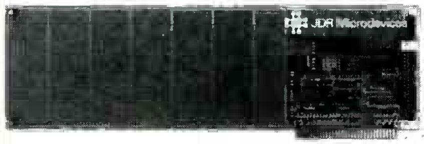
SPOOLS

100 feet	$4.30	250 feet	$7.25
500 feet	$13.25	1000 feet	$21.95

Please specify color: Blue, Black, Yellow or Red

WIRE WRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE WITH GOLD-PLATED EDGE-CARD FINGERS



IBM-PR2

IBM

BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

IBM-PR1	WITH +5V AND GROUND PLANE	$27.95
IBM-PR2	AS ABOVE WITH DECODING LAYOUT	$29.95

S-100

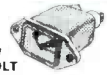
P100-1	BARE - NO FOIL PADS	$15.15
P100-2	HORIZONTAL BUS	$21.80
P100-3	VERTICAL BUS	$21.80
P100-4	SINGLE FOIL PADS PER HOLE	$22.75

APPLE

P500-1	BARE - NO FOIL PADS	$15.15
P500-3	HORIZONTAL BUS	$22.75
P500-4	SINGLE FOIL PADS PER HOLE	$21.80
7060-45	FOR APPLE IIe AUX SLOT	$30.00

EMI FILTER $4.95

* MANUFACTURED BY CORCOM
* LOW COST
* FITS LC-HP BELOW
* 6 AMP 120/240 VOLT



6 FOOT LINE CORDS

LC-2	2 CONDUCTOR	.39
LC-3	3 CONDUCTOR	.99
LC-HP	3 CONDUCTOR W/STD FEMALE SOCKET	1.49

MUFFIN FANS

3.15" SQ	ROTRON	14.95
3.63" SQ	ETRI	14.95
3.18" SQ	PAPST	16.95

SOCKET-WRAP I.D.™

* SLIPS OVER WIRE WRAP PINS
* IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
* CAN WRITE ON PLASTIC; SUCH AS IC #

PINS	PART#	PCK. OF	PRICE
8	IDWRAP 08	10	1.95
14	IDWRAP 14	10	1.95
16	IDWRAP 16	10	1.95
18	IDWRAP 18	5	1.95
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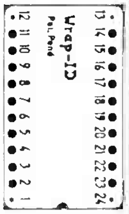

ID WRAP 24

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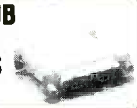

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* ONE YEAR WARRANTY

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PS-130 $99.95
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* 90 DAY WARRANTY

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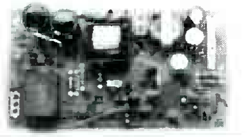

PS-1558

PS-1558 $34.95
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CAPACITORS

TANTALUM

1.0μf	15V	.35	.47μf	35V	.45
6.8	15V	.70	1.0	35V	.45
10	15V	.80	2.2	35V	.65
22	15V	1.35	4.7	35V	.85
.22	35V	.40	10	35V	1.00

DISC

10pf	50V	.05	680	50V	.05
22	50V	.05	.001μf	50V	.05
27	50V	.05	.0022	50V	.05
33	50V	.05	.005	50V	.05
47	50V	.05	.01	50V	.07
68	50V	.05	.02	50V	.07
100	50V	.05	.05	50V	.07
220	50V	.05	.1	12V	.10
560	50V	.05	.1	50V	.12

MONOLITHIC

.01μf	50V	.14	.1μf	50V	.18
.047μf	50V	.15	.47μf	50V	.25

ELECTROLYTIC

RADIAL			AXIAL		
1μf	25V	.14	1μf	50V	.14
2.2	35V	.15	10	50V	.16
4.7	50V	.15	22	16V	.14
10	50V	.15	47	50V	.20
47	35V	.18	100	35V	.25
100	16V	.18	220	25V	.30
220	35V	.20	470	50V	.50
470	25V	.30	1000	16V	.60
2200	16V	.70	2200	16V	.70
4700	25V	1.45	4700	16V	1.25

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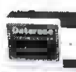

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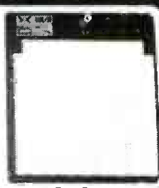
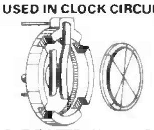


WBU-208

LITHIUM BATTERY

AS USED IN CLOCK CIRCUITS



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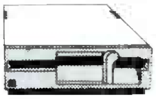

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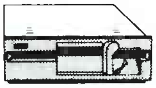

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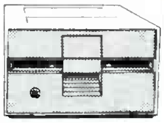

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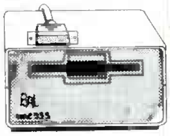

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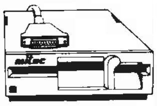

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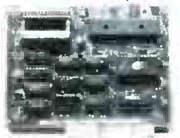

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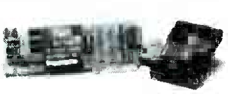

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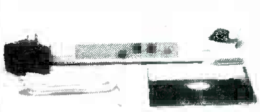

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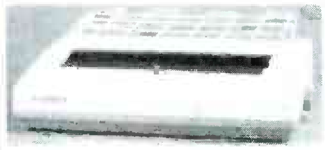

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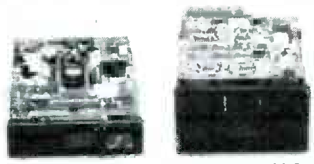

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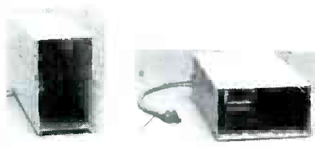

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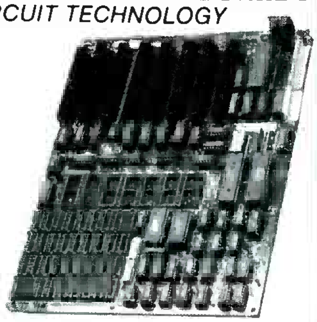

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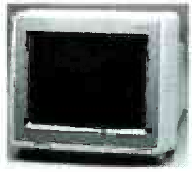

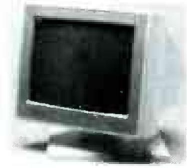

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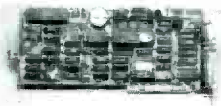

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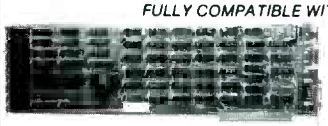

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PLEASE NOTE: THIS CARD WILL NOT RUN LOTUS GRAPHICS AND DOES NOT INCLUDE A PARALLEL PORT

FLOPPY DISK DRIVE ADAPTOR $34.95

- INTERFACES UP TO 4 STANDARD FDDs TO IBM PC OR COMPATIBLES
- INCLUDES CABLE FOR TWO INTERNAL DRIVES
- STANDARD DB37 FOR EXTERNAL DRIVES
- RUNS QUAD DENSITY DRIVES WHEN USED WITH JFORMAT

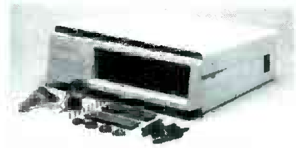
HALF HEIGHT HARD DISK SYSTEMS
Includes half height hard disk drive, hard disk drive controller, cables and instructions. All drives are pre-tested and are backed with a full one year warranty.

10 MEGA BYTE HDD	MMI 212	$289.95
20 MEGA BYTE HDD	SEAGATE ST-225	$369.95

BUILD YOUR OWN 256K XT COMPATIBLE SYSTEM

XT MOTHERBOARD	$109.95
PRO-BIOS (A $20 VALUE)	FREE!
256K RAM	$26.55
130W POWER SUPPLY	$69.95
FLIP-TOP CASE	$39.95
MCT-5150 KEYBOARD	$59.95
½ HT TANDON DRIVE	$79.95
FDD CONTROLLER	$34.95
MONOCHROME ADAPTOR	$49.95
CENTER MONITOR	$99.95
TOTAL:	$571.15

IBM STYLE COMPUTER CASE
AN ATTRACTIVE STEEL CASE WITH A HINGED LID FITS THE POPULAR PC/XT COMPATIBLE MOTHERBOARDS



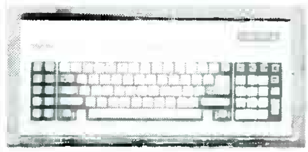
- SWITCH CUT-OUT ON SIDE FOR PC/XT STYLE POWER SUPPLY
- CUT-OUT FOR 8 EXPANSION SLOTS
- ALL HARDWARE INCLUDED

$39.95

IBM COMPATIBLE KEYBOARDS

MCT-5150 $59.95
- "5150" STYLE KEYBOARD
- FULLY IBM COMPATIBLE
- LED STATUS INDICATORS FOR CAPS & NUMBER LOCK
- LARGE, EASY TO REACH SHIFT & RETURN KEYS
- 83 KEY TYPEWRITER LAYOUT

MCT-5151 $79.95
- REPLACEMENT FOR KEYTRONICS KB-5151™
- SEPARATE CURSOR & NUMERIC KEYPAD
- CAPS LOCK & NUMBER LOCK INDICATORS
- IMPROVED KEYBOARD LAYOUT



MCT-5060 $59.95
- IBM AT STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE

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- IBM ENHANCED STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- 12 FUNCTION KEYS
- EXTRA LARGE SHIFT & RETURN KEYS
- LED INDICATORS FOR SCROLL, CAPS & NUMBER LOCK
- AUTO REPEAT FEATURE
- SEPARATE CURSOR PAD

1200 BAUD MODEMS BY EASYDATA
HAYES COMPATIBLE, AUTO-DIAL, AUTO-ANSWER, AUTO RE-DIAL ON BUSY, POWER-UP SELF TEST, FULL ONE YEAR WARRANTY

MODEL 1200B*
- INTERNAL DESIGN
- 10 INCH CARD
- SERIAL PORT INCLUDED

$119.95

MODEL 1200H*
- INTERNAL DESIGN
- HALF LENGTH (5") CARD
- INCLUDES SPEAKER

$109.95

EASYDATA-12
- EXTERNAL DESIGN
- WITH POWER SUPPLY
- LED STATUS INDICATORS

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*FOR IBM, INCLUDES PC TALK III COMMUNICATIONS SOFTWARE

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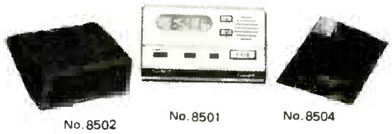
CALL OR WRITE FOR A **FREE CATALOG** — OVER 60 HOT & WELL-QUALIFIED ITEMS FOR YOUR SELECTION!

TALKING CLOCK

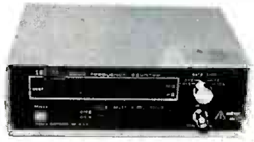


No.8502 No.8501 No.8504

1. Talk: push button for voice announcement of time.
2. Read out: twelve hours system display for hour, minute, second (by colon flash), AM & PM.
3. Display: three display modes of time, alarm time & date
4. Alarm: on/off switch with thirty seconds voice alarm.
5. Snooze: reminder voice alarm of thirty seconds after 4 minutes of first voice alarm
6. Volume: two level of voice output.
7. Language available: English.

PARROT 8501 .... $17.75
COCKATOO 8502 .... $15.90 NOT A KIT!
MYNAH 8504 .... $16.90

150MC Universal Digital Frequency Counter SM-100

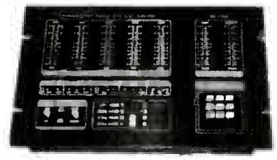


FREE AC ADAPTOR * AVAILABLE UNTIL STOCK LAST *

Frequency Range: 10Hz – 150MHz
Event Counter: 0 to 99999999 counts. (8 Digit)
Input sensitivity: KHz range 10Hz – 10MHz 50mVrms.
MHz range 1MHz – 150MHz 40mVrms.
Response time: 0.2 second.
Hold Function: Hold the last input signal.
Power Supply: DC6V Battery or DC9V 250MA Adaptor.
Dimension: 9⅞" x 6$^{11}/_{16}$" x 2¾"
Assembled with tested $99.00

PROFESSIONAL COLOR LIGHT CONTROLLER SM-328

NEW FOR '87'



FEATURES:
1. FOUR GROUPS OF INDEPENDENT OUTPUT SYSTEM 1000W/CH. MAX. 4680W (100-117V) 2. PROFESSIONAL COLOR CONTROL SYSTEM (KEY-BOARD TYPE) 3. INDEPENDENT INPUT SIGNAL ADJUSTMENT 4. FOUR GROUPS OF INDEPENDENT DIMMER CONTROL 5. SPEED CONTROL CHASER 6. AUTOMATIC CHASING CONTROL SYSTEM 7. FOUR KINDS OF SPECIAL CHASING PROGRAM 8. COMBINATION OF PROGRAM AND MUSIC CHASING EFFECT 9. FORWARD/BACKWARD CHASING CONTROL

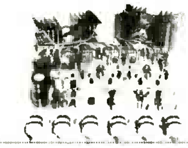
SM–328 color light controller is specialized for ballroom, night club, disco and advertisement lighting. It consorts with several color control characteristics, which employ professional color control system and keyboard program selection. Therefore, it is capable of producing lighting effects by using chasing program and fluctuating music signal.

There are two kinds of lighting effects. The first type is controlled by 'music' signal. In order to adjust the brightness of four groups of lightings, each music signal will be separated into high, medium low A, and low B frequency range. Furthermore, each group of lightings is incorporated with an independent signal adjustment.

The second kind is composed of electrical circuits and this is the main part for creating a special lighting effect. It has four chasing programs.

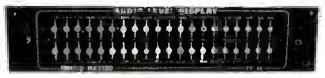
DIMENSION: 14 5/16" X 8 15/16" X 3 3/16"
Ass. with tested $120.00

TA–1500 100W + 100W NEW CLASS 'A' DC STEREO PRE-MAIN AMPLIFIER



KIT .... $ 67.00
METAL CABINET/X'FORMER .... $ 26/$ 16.80

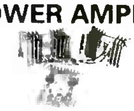
TY–45 BAR/DOT AUDIO LEVEL DISPLAY



Kit $34.95

100W DYNAMIC CLASS "A" MAIN POWER AMPLIFIER

TA-1000A



KIT .... $ 51.95
METAL CABINET/X'FORMER .... $26/$16.80

CORDLESS SOLDERING IRON RECHARGEABLE

No. 620

New

Each set $22.80

TA–2400A ELECTRONIC ECHO AND REVERBERATION AMPLIFIER

REMIX records yourself!

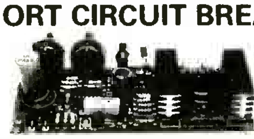
Ass. with tested $99.85

NF-CR BI-FET PRE-AMP TA–2800

Kit $44.50

0-50V/3A POWER SUPPLY W/SHORT CIRCUIT BREAK

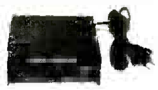
TA–503



Kit $12.30

STEREO SIMULATOR

TA–3000



SPECIAL KITS OFFER!

KIT ONLY $25.00

You can own a stereo TV from today! This simulator is a special design of using the most advanceable monoploised L.S.I. It produced a superior analog stereo effect since the L.S.I. Is equalled 60 pcs. of LOW NOISE FET & TRANSISTOR. The simulator can even help you to promote your television from a normal one to a special one with a Hi-Fi STEREO function. Our simulator is also applicable to any other 'mono sources' in covering it to ANALOG STEREO. Undoubtedly, it is the most advanced equipment for every family, while it should contribute to your listening pleasure.

Ass. with tested $30.00

HIGH QUALITY MULTIPURPOSE PRE-AMPLIFIER

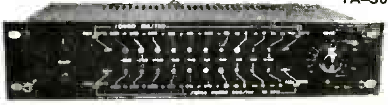
TA–2500

GREAT VALUE

Assembled with tested $82.00

60W VERSATILE STEREO POWER BOOSTER

TA–302



KIT .... $ 50.00
ASS. with tested .... $ 60.00

80W + 80W DC LOW TIM PRE-MAIN AMPLIFIER

TA–800

Kit .... $ 49.85
METAL CABINET/X'FORMER .... $ 26/$ 16.80

Model No.	Description	Kit/Assembled	Unit Price
TA-001	1W Mini Amplifier	Kit	$3.90
TA-006	6W Mini Amplifier	Kit	$4.92
TA-007	12W Stereo Power Booster	Kit	$8.00
TA-008	AC/DC SHOULDER AMPLIFIER	Ass	$48.00
TA-10	STEREO PRE-AMPLIFIER WITH MAGNETIC MIC AMP	Kit	$6.00
TA-50 A, B	MULTI-PURPOSE MELODY GENERATOR	Kit	$10.76
TA-120	PURE CLASS"A" MAIN POWER AMPLIFIER	Kit	$25.00
TA-202	20W AC/DC STEREO AMPLIFIER	Ass	$60.00
TA-300	30W Multi-Purpose Single Channel Amp.	Kit	$11.07
TA-302	60W Stereo Power Booster	Kit/Ass.	$50.00/60.00
TA-323A	High Quality 30W+30W Stereo Amplifier	Kit	$24.60
TA-322i	60W IC Stereo Pre-Amplifier & Power Amplifier	Kit	$29.50
TA-400	40W TRANSISTORIZED MONO-AMPLIFIER	Kit	$13.84
TA-477	120W MOSFET POWER AMPLIFIER	Kit	$61.28
TA-800	80W+80W DC LOW TIM PRE-AMPLIFIER & POWER AMP.	Kit	$55.38
TA-802	80W+80W PURE DC STEREO POWER AMP. (W/SPEAKER)	Kit	$39.95
TA-820A	60W+60W OCL DC PRE-MAIN & STEREO AMPLIFIER	Kit	$43.00
TA-1000A	100W DYNAMIC CLASS"A" MAIN POWER AMP (MONO)	Kit	$51.95
TA-1500	100Wx2 NEW CLASS"A" DC STEREO PRE-MAIN AMP	Kit	$67.00
TA-2400A	ELECTRONIC ECHO ANO REVERBERATION AMP	Ass	$99.85
TA-2500	HIGH QUALITY MULTI-PURPOSE PRE-AMPLIFIER	Ass	$90.00
TA-2200	DC FET SUPER CLASS"A" PRE-AMPLIFIER	Kit	$38.00
TA-2800	NF-CR BI-FET PRE-AMP (WITH 3WAY TONE CONTROL)	Kit	$44.50
TA-3000	STEREO SIMULATOR	Kit/Ass.	$25.00/30.00
SM-43	3 1/2 MULTI-FUNCTIONAL LED D.P.M.	Kit/Ass.	$29.23/35.00
SM-48	4 1/2 HI-PRECISION D.P.M.	Kit/Ass.	$38.00/43.00
SM-100	8 DIGIT 150MC FREQUENCY COUNTER	Ass	$99.00
TY-43	3 1/2 DIGITAL PANEL METER	Kit	$28.00
TR-355 A, B	3-5A REGULATED DC POWER SUPPLY	Kit	$8.90
TR-503	0-15V/3A POWER SUPPLY WITH SHORT CIRCUIT BREAK & OVERLOAD PROTECTOR	Kit	$10.25
TR-100	0-15V 2A REGULATED DC POWER SUPPLY	Kit/Ass	$59.50/69.50
TY-1A MK4	BATTERY FLUOPESCENT LIGHT	Kit	$3.99
TY-7	ELECTRONIC TOUCH SWITCH	Kit	$5.50
TY-11A	MULTI-FUNCTIONAL CONTROL RELAY	Kit	$3.99
TY-12	DIGITAL CLOCK WITH TWO TIMER	Kit	$13.86
TY-13	COLOR LED VU METER	Kit	$17.50
TY-14	ELECTRONIC SHOCK	Kit	$3.00
TY-18	HIGH PRECISION SOUND CONTROL SWITCH	Kit	$7.68
TY-20	SUPER SENSITIVE COLOR POWER LEVEL INDICATOR	Kit	$19.50
TY-23B	COLOR LIGHT CONTROLLER	Kit/Ass	$65.00/75.00
TY-25	SPEAKER PROTECTOR	Kit	$9.50
TY-35	FM WIRELESS MICROPHONE	Kit	$7.68
TY-36	AC/DC QUARTZ DIGITAL CLOCK	Kit	$16.92
TY-38	SOUND OR TOUCH CONTROL SWITCH	Kit	$10.00
TY-41 MKIII	INFRARED REMOTE CONTROL UNIT	Kit/Ass.	$25.00/30.00
TY-42	BAR/OOT LEVEL METER	Kit	$21.00
TY-45	BAR/DOT AUDIO LEVEL DISPLAY	Kit	$34.95
TY-47	SUPERIOR ELECTRONIC ROULETTE	Kit	$16.92
YAMATO 4001	3½ DIGITAL MULTIMETER	@ SET	$33.80
T1	LCD THERMOMETER CLOCK W/IN/OUT DOOR SENSOR	@ SET	$20.00
T2	LCD THERMOMETER CLOCK W/F°/C° MEASURING	@ SET	$18.00
8501	TALKING CLOCK (PARROT)	@ SET	$17.75
8502	TALKING CLOCK (COCKATOO)	@ SET	$15.90
8504	TALKING CLOCK (MYNAH, GOLDEN OR BLACK)	@ SET	$16.90
NO. 620	COROLESS SOLDERING IRON RECHARGEABLE	@ SET	$22.80

METAL CABINETS WITH ALUMINIUM PANEL

LG1273	3"x 12"x 7"	@ SET	$18.00
LG1684	4"x 16"x 8"	@ SET	$22.00
LG1924	4"x 19"x 11.5"	@ SET	$24.00
LG1925	5"x 19"x 11.5"	@ SET	$26.00

WE CAN SUPPLY HIGH POWER TRANSFORMERS FOR OUR KITS, PLEASE REFER TO OUR CATALOG!

TERMS: Minimum order: $10.00. Charge card order $20.00. No C.O.D.! Check & Money order, phone order accept. CA. residents must include 6.5% sales tax. Prices are subject to change without notice. All merchandise subject to prior sale. Shipping & handling: Inside L.A. 5% of total order (Min. $1.50). Outside L.A. 10% of total orde (Min. $2.50), Outside U.S.A. 20% of total order (Min. $5.00). Shipped by UPS ground.
HOURS: Mon-Fri 9:30 to 5:00, Sat 9:30 to 1:00 (PACIFIC TIME)
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We warehouse 60,000 items at American Design Components — expensive, often hard-to-find components for sale at a fraction of their original cost!

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THERE'S NO RISK.
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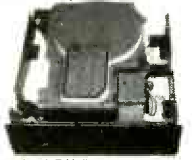
PC 8300 HOME COMPUTER
(Advanced version of the Timex 1000)

42-key mechanical keyboard (not membrane). Contains 2K of RAM.** Reverse video, Z80A, 6.5 MHz processor, ROM 8K BASIC. Graphics capability/sound-music, TV or monitor. Joystick input operates on 115 VAC. Includes: AC adapter, TV cable, and pair of cassette cables. Will run all prerecorded tapes for Sinclair/Timex 1000-ZX81. Mfr — Power 3000.
Item #10336 **$29.95** New (in orig. boxes)

****16K RAMPACK upgrade**
(1 available per each customer.)
Item #10337 **$10.00** New

3½", 10Mb HARD DISK DRIVE
(IBM® Compatible)



Fits standard 5¼" spacing. Shock mounted. High speed, low power. Mfr — MMI #MM212
Item #9217 **$179.00** New
Controller Card for above
Item #9984 **$99.00**

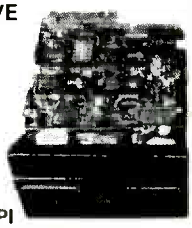
5¼", 1.2 Mb. AT HALF HT. DISK DRIVE

48/96 TPI (IBM® Compatible)
Double sided, single/double density; 80 track.
Mfr — Panasonic #JU-475
Item #10005 **$129.00** New

5¼" FULL HT. DISK DRIVE

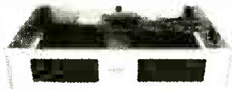
48 TPI (IBM® Compat.)
Double sided/double density, full height drive. 48 T.P.I., 80 tracks.
Mfr — MPI-52S
Item #7928 **$79.95**
2 for **$150.00**

5¼" FULL HT. DISK DRIVE

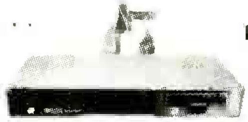


96 TPI DS/QUAD DENSITY
Mfr — CDC #9409T
Item #1893 **$99.00**

3¼" DISK DRIVE EXPANSION MODULES . . .



IBM PC Jr.
Side-by-side mounting (PC Jr. mounts on top). With floppy disk drive controller board. Contains: 2 Tabor TC-500 3¼" disk drives. Total capacity 360K. Item #8825
~~$199.00~~ **$99.00** New



APPLE
Side-by-side mtg. with disk storage space in front. Floppy disk controller board capable of handling 4 disk drives. Contains: 2 Tabor TC-500 3¼" disk drives. Total cap. 360K. Item #8826
~~$199.00~~ **$99.00** New

IBM PC/XT

Stacked mounting, replaces old-fashioned 5¼" disk drives. Contains: 2 Tabor TC-500 3¼" disk drives. Total capacity 360K. Plugs right into your controller. Item #8827
~~$169.00~~ **$99.00** New

Each unit supplied with two 3¼" flexible diskettes.

190W DISK DRIVE POWER SUPPLY

Input: 115V
Output: +12V @ 4.13A, +5.1V @ 3.04A } x 3
Contains 3 sets of dual outputs, allowing for simultaneous operation of 3 disk drives. Originally designed for the AT & T computer.
Dim.: 11"W x 4½"H x 7"deep
Item #10006 **$59.95** New

IBM® COMPATIBLE 3¼" DISK DRIVE

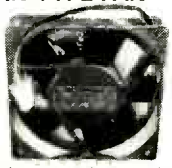
Tabor TC-500 drivette. Single-sided, quad density. Capacity: 164K bytes. Will work with any 5¼" disk controller.
Item #8824 ~~$79.95~~ **$49.95** New
*Total cap. 500K bytes with special software.

3¼" DISKETTES (Pack of 5)
Item #9495 **$9.95** New

12 VDC SPRINT® FAN 27 CFM

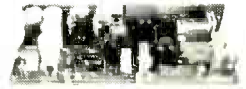
Polarity protected. Can be mounted for cooling or exhaust.
Dim.: 3⅛" sq. x 1¼" deep
Mfr — Rotron - DAYNA
Item #9218 **$12.95** New

12/24 VDC, 1" THIN MUFFIN-TYPE FAN 55/100 CFM



8W. Can be mounted for blowing or exhaust. 5 plastic blades with feathered edges, aluminum housing. Brushless, ball-bearing type.
Dimen.: 4¹¹⁄₁₆" sq. x 1" deep
Mfr — Centaur CUDC24K4-601
Item #8541 **$19.95** New

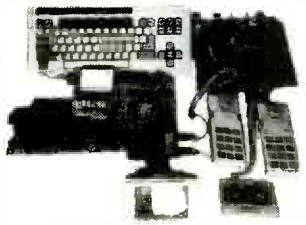
HI-POWER SWITCHING POWER SUPPLY



Output: +5.15V @ 70A, +12V @ 4A, +12V @ 4A, +5.2V @ 5A
Input: 115/230V nominal, .725KW cont. 47–63Hz. Enclosed in metal housing.
Dim.: 15"W x 2½"H x 6" deep.
Mfr — Todd Prod. #4XS8151A
Item #9749 **$29.95** New

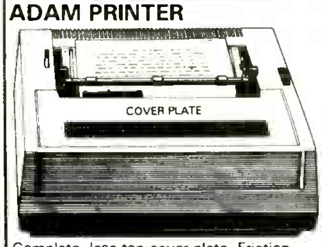
PUMPS – COMPRESSORS – BLOWERS – MOTORS – POTENTIOMETERS – COUNTERS TIMERS – RELAYS – VOLTAGE REGULATORS – POWER SUPPLIES – SWITCHES

ADAM COMPUTER KIT!
(Less printer & w/o cabinet)



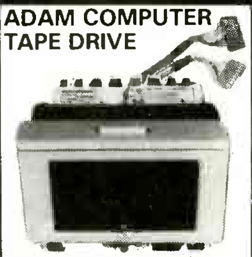
Build it yourself from subassemblies. No wiring necessary (just plugs together). Hook-up diagram included. Includes: Keyboard, 1 cassette digital data drive, 2 game controllers, power supply, all memory boards, and one cassette. Is capable of running CP/M, has built-in word processor.
Item #7410 **$99.00** (complete)

ADAM PRINTER



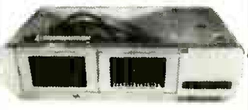
Complete, less top cover plate. Friction feed. Takes standard paper 8½" x 11". (Customer returns; tested — operational.)
Item #8839 **$69.50**

ADAM COMPUTER TAPE DRIVE



Serial format. Search 80IPS — Read/Write 20IPS. 12V motor, 5V logic, 8 & 9 pin connector cables. Originally designed for the Adam.
Dim: 5"W x 3¾"H x 4" deep
Item #6641 **$9.95** New

COLECOVISION to ADAM EXPANSION KIT



This expansion module just plugs into your ColecoVision. With Printer Power Supply and data drive (both included), you will have a working Adam Computer. Adam Keyboard, one Smart basic cassette and hook-up diagram also included.
Item #9918 **$59.50**

ADAM CASSETTES
(Assorted)

Consists of Smart Basic, Buck Rogers, and blank cassettes (all can be easily erased).
Item #7786 — Bakers Dozen
13 for **$19.95** New

ADAM ACCESSORIES . . .

ASCII KEYBOARD
Item #6643 **$19.95**

PRINTER POWER SUPPLY
Item #6642 **$14.95**

CONTROLLERS (set of 4)
Item #7013 **$9.95**

LOGIC BOARD*
Item #7231 **$9.95**

GAME BOARD*
Item #7679 **$6.95**

*Parts Only

ADC KITS . . .

ROBOTICS KIT
(Springs, Belts, Pulleys & Gears)
Consists of:
9 Timing Belts (7.5" to 13")
2 Roung Belts (12" to 15")
15 Nylon & Plastic Spur & Drive Gears
22 Torsion Springs
6 Compression Pulleys
19 Tension Springs
Item #5306 **$14.95** New

IC SOCKET KIT
100 Ass't. Sockets — Consisting of 100 assorted IC sockets. From 14 to 40 Pin.
Item #5309 **$9.95** New

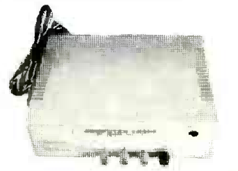
COMPONENTS PARTS KIT
Hundreds of components! — Consisting of Heat Sinks, Capacitor, Trimpots, Resistors, and MORE!
Item #7230 **$15.00** New

SWITCH KIT
35 Ass't. Switches — Consisting of 35 assorted: Dip, Toggle, Slide, and Sensitive Miniature and Standard Size Switches.
Item #5307 **$9.95** New

RELAY KIT
15 Assorted Relays — Consisting of 15 asst. AC & DC Relays, 5V, 12V, 24V, & 115V. All types.
Item #5308 **$9.95** New

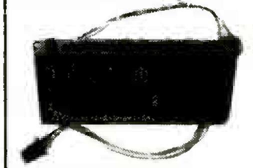
TOY MOTOR KIT
For Robotics — Consists of: 18 assorted toy motors, from 1.5V to 12VDC.
Item #7229 **$9.95** New

COMPUTER GRADE POWER SUPPLY



Other uses–runs CB & car radios. Comes ready to plug in!
DC Output: −5V @ .5 amp, +5V @ 3 amp, +12V @ 6 amp.
Input 115V/60H. Dim.: 9¼"W x 3¾"H. (Rubber ft. incl.)
Item #9501 **$24.95** New

SWITCHING POWER SUPPLY

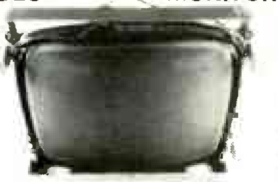


115 & 230V, 47–440 Hz.
Input: 90–135V/180–270V
Output: 5VDC @ 5.5A, +12VDC @ .4A, −12VDC @ .3A
Perforated metal case enclosure.
Dim.: 9½"L x 3½"W x 2"H.
Mfr — General Instrument
Item #7983 **$14.95** New

CIRCLE 178 ON FREE INFORMATION CARD

"The First Source"— for electromechanical & electronic equipment and components — AMERICAN DESIGN COMPONENTS!

15" COMPOSITE VIDEO MONITOR



15", green phosphor, high resolution (12 lines center) and bandwidth from 10Hz to 30Hz ± 3dB. Operating volt.: 120/240VAC, 50/60Hz., 65VA max. Mfr — Motorola – Alpha Series

Item #10044 **$34.95** New

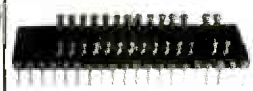
MECHANICAL KEYBOARDS . . .

48-KEY — Timex Z81/1000
Item #6712 **$5.95** New

66-KEY — Commodore C-16
Item #9394 **$5.95** New

75-KEY — Timex or Adam
For computer upgrade. . .
Item #7429 **$5.95** New

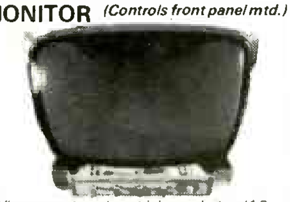
NS 87P50D-11 MICROCOMPUTER



8-bit single chip microcomputer units; emulates: 8048/49/50. Piggy-back configuration allows you to plug in an eprom 2758 and 2716, 2732. Features: XMOS, 5V, 8-16 bit, 4K directly accessible memory. 256 bits on chip ROM, 11 MHz. max. freq.

Item #8899 **$24.95** New

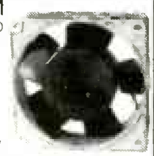
12" COMPOSITE VIDEO MONITOR *(Controls front panel mtd.)*



12", green phosphor, high resolution (12 lines center) and bandwidth from 10Hz to 30Hz ± 3dB. Operating voltage: 120/240VAC, 50/60Hz., 65VA max. Mfr — Motorola – Alpha Series

Item #10043 **$29.95** New

115 CFM MUFFIN® FAN



SPECIAL!
115 VAC/60 Hz., 21W., 28A., 3100 RPM; 5-blade model, aluminum housing. Can be mounted for blowing or exhaust. Dim.: 4$^{11}/_{16}$"sq. x 1½"deep.

Item #5345 **$5.95** RFE

With Speed Control
Item #5345S **$8.95**

150 CFM SUPER VENTURI FAN

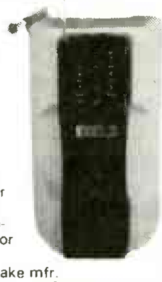
Ball bearing; 115 VAC, 60 Hz.; .195/178 amps. Has 2 sets of mtg. holes (fits standard rack or larger). Can be mtd. for blowing or exhaust. Dim.: 5" sq. x 1½" deep. Mfr — Rotron

Item #1866 **$19.95** New

CORDLESS TELEPHONE

700 ft. Range

Wall or Base Mount



Full duplex: talk & listen simult. Auto redial: last number dialed recall. Comes with attachments for both types of mtg.; incl. AC power adaptor & battery indicator light. Color: brown w/cream. Famous make mfr.

Item #9997 **$29.95** New

Rechargeable NICAD BATTERY BACKUPS

12V @ 450 ma
Contains 10 AA cells. Recharge rate: 45 ma. 16–18 hours. Case with tab output connections. Dim.: 2$^{1}/_{16}$"H x 1¼"W x 2$^{15}/_{16}$"L Mfr — GE 123233 or equiv.
Item #5443 **$5.95** New

13.2V @ 1.65 AH
Contains 11 C cells. For model boats, toys, etc. Mfr — GE #41B035BB00101
Item #5444 **$15.95** New

GEL-CELL BATTERIES

(Rechargeable)
For use with model cars, trains, boats, planes etc.—

6V @ .9 AH
Dim.: 2"W x 2"H x 1⅝"D. Mfr — Globe GC610.
Item #9304 **$3.95** New

6V @ 9.5 AH
Dim.: 5½"H x 4⅛"W x 2⅝"deep. Mfr — Elpower #695
Item #7039 **$14.95** New

INTEGRATED CIRCUITS . . .

Linear. . .

Part	Price
LH0002CN	$5.35
LM10CLH	2.65
LH0070-OH	3.55
TL071CP	.53
TL072CP	.71
LM301N	.32
LM307N	.41
LM310N	1.16
LM311N	.41
LM317K	2.65
LM317LZ	.62
LM317MP	.80
LM317T	.90
LM318N	1.07
LM319N	1.07
LM324N	.35
LM334Z	1.07
LM336Z	.98
LM337MP	1.03
LM337T	1.34
LM338K	3.55
LM339N	.44
LF347N	.90
LM348N	.62
LM350K	3.55
LF353N	.53
LF356N	.80
LM358N	.44
LM380N	.80
LM380N-8	.98
LM381N	1.16
LM383T	1.34
LM385Z	1.70
LM386N-4	.80
LM389N	.90
LM393N	.41
LF398N	2.15
LF411CN	.71
TL494CN	1.75
TL496CP	1.34
TL497ACN	1.97
NE555V	.26
XR-L555	.62
LM556N	.53
NE558N	1.07
NE564N	1.75
LM565N	.90
LM566CN	1.25
LM567V	.80
NE570N	2.24
NE571N	1.75
NE592N	.80
LM709N	.44
LM709CH	.80
LM710N	.62
LM711N	.62
LM723CN	.41
LM725CN	2.24
LM733CN	.62
LM739N	2.30
LM741CN	.26
LM741CH	.53
LM741-14N	.53
LM747CN	.53
LM748CN	$ .53
DS8T28N	1.57
LM1456V	1.75
LM1458N	.44
LM1488N	.62
LM1496N	.90
LM1899N	1.43
ULN2003A	.90
DS26LS31CN	1.34
DS26LS32CN	1.34
LM2901N	.53
LM2903N	.53
LM2907N	1.75
LM2917N	1.39
LM2917-14N	1.34
LM2931CT	1.07
MC3346P	.90
MC3486	1.34
MC3487	1.34
SG3524	1.75
LM3900N	.53
LM3914N	1.75
RC4136N	.80
RC4151NB	.90
RC4193NB(DE)	2.65
7805K	1.21
7812K	1.21
7815K	1.21
7818K	1.21
7824K	1.21
7805T	.44
7812T	.44
7815T	.44
7818T	.44
7824T	.44
78S40	1.75
7905K	1.21
7906K	1.21
7912K	1.21
7915K	1.21
7918K	1.21
7924K	1.21
7905T	.53
7912T	.53
7915T	.53
7918T	.53
7924T	.53
79L12AC	.53
79L15AC	.53
LF13201N	2.33
LM13600N	1.07
LM1889	1.85
75107N	.90
75108N	.90
75110A	1.34
75115	1.07
75123N	1.34
75124N	1.34
75138N	2.65
75154N	1.25
75450N	.53
75451CN	.44
75452CN	.44
75453CN	.44
75463N	.53
75472	.80
75492N	.71
76477	3.55

Z8000 Series. . .

Part	Price
Z80	$1.57
Z80-CTC	1.61
Z80-DART	4.45
Z80-DMA	4.45
Z80-PIO	1.61
Z80-SIO/1	4.45
Z80A	1.66
Z80A-DART	4.72
Z80A-DMA	5.35
Z80A-PIO	1.75
Z80B	3.55
Z80B-CTC	4.45
Z80B-PIO	4.45

Eproms. . .

Part	Price
2708	$3.55
2716	2.24
2732A-4	2.95
2764-25	2.95
68701	9.95
68766	16.25

6800 Series. . .

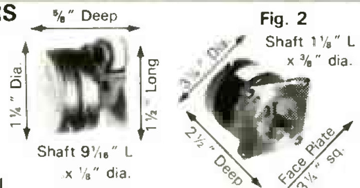
Part	Price
6800	$2.12
6821	2.72
68A09EP	5.95

COMPUTER & GAME EQUIPMENT – ACCESSORIES – MODULES
ELECTRONIC COMPONENTS – INTEGRATED CIRCUITS – OPTICS

STEPPING MOTORS for ROBOTICS

Precision steppers with increments from 1 to 7.5 degrees. Speeds up to 5,000 steps.

Fig. 1



Item No.	Step Angle	Volts DC	Stall Torque oz/in	Type	Mfr. & Part No.	Fig	Price
5431	1	5	17	PM	N.A. Phillips A82310-M2	1	$9.95 ea. 2/$14.95
7630	1.8	3.0	200	PM	Superior Electric M092-FT-402	2	$34.50 ea. 2/$59.50
5275	1.8	1.8	72	PM 2 Ø	Superior Electric M061-FF-6201B	2	$19.95 ea. 2/$37.50

RECORDING TAPE 7½" Reel, 2400 ft.

Bulk erased. Major mfrs.: Ampex, Scotch, etc.
Item #6711 — ¼ Mil.
79¢ ea.; 3 for **$2.00**

MINI MICRO-COMPUTER REGULATOR

140 VA

Provides voltage regulation and ultra-isolation for microprocessor-based equipment. Contains less than 3% harmonic distortion, better than 60 dB traverse noise rejection. Contains dual outlet for CPU & monitor, and 6 ft. line cord.
Input: 95 — 130V, 60Hz.
Output: 120V @ 1.17A
Dimensions: 11⅝"L x 4⅜"H x 5⅝"W
Mounted on metal base with rubber feet.
Mfr — Sola #63-13-114
Item #9999 **$99.00** New

AMERICAN DESIGN COMPONENTS, 62 JOSEPH STREET, MOONACHIE, N.J. 07074

MINIMUM ORDER $15.
RE-47

YES! Please send me the following items:

Item No.	How Many?	Description	Price	Total

Total
Shipping & handling, we ship UPS unless otherwise specified. Add $3 plus 10% total. Canadian: $3 plus P.O. cost. Charge only.
Sales Tax (N.J. residents only, please add 6% of total)
ORDER TOTAL

FREE 1987 CATALOG sent with every order.

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Tenma 15MHz Dual Trace Portable Oscilloscope

■ Internal rechargeable battery ■ Built-in battery charger ■ Two 10:1 probes included ■ 5x horizontal magnifier ■ Front panel electrical trace rotation ■ High brightness CRT with internal graticule ■ For additional specifications see MCM Catalog #14

Two Year Limited Warranty

#72-335 **$489.90** (ea.)

Tenma LCR Meter

■ Measures inductance from 1μH-200H in six ranges ■ Measures capacitance from .1pF-200μF in seven ranges ■ Measures resistance from .01ohm-20Mohm in seven ranges ■ Carrying case included

One Year Limited Warranty

#72-370 **$149.95** (ea.)

Tenma Regulated Power Supply

■ Output: Regulated 13.8V ■ Input: 120VAC ■ Fuse protected ■ With easily accessible fuse holder ■ Neon light indicator ■ Heavy duty binding posts ■ Effective heat sinks for more power dissipation ■ 90 day warranty

3.5 Amp (5 Amp Surge) #72-280 .... **$29.95** (ea.)

7 Amp (10 Amp Surge) #72-290 .... **$59.95** (ea.)

Tenma Resistance Selector Box

■ This device allows the user to quickly substitute a resistor in a circuit with any value between 1ohm and 11Mohm ■ Constructed entirely of ½ watt resistors with 1% tolerance ratings ■ 90 day warranty

#72-405 **$28.50** (ea.)

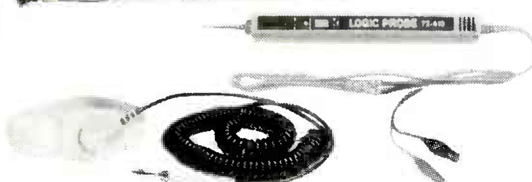
The Name You Can Trust In Electronic Test Equipment

TENMA

Tenma Anti-Static Work Mat

■ A must for the modern service shop ■ Used in conjunction with our #21-660 wrist strap to help eliminate static related problems ■ 18" x 26"

#21-655 $37.60 (1-4) **$33.45** (5-up)



Tenma Anti-Static Wrist Strap

■ Silver-plated monofilament fibers are woven into a comfortable elastic wrist strap, that gently conforms to the user's wrist for reliable contact to ground

#21-660 $10.25 (1-9) **$9.45** (10-up)

Tenma Soldering Station

■ Adjustable temperature range of 150°-420° (300°-790°F) ■ Grounded tip for soldering static sensitive devices ■ LED power, heater and temperature indicators ■ See MCM Catalog #14 for additional information

#21-147 $49.95 (1-3) **$44.80** (4-up)

Tenma Logic Probe

■ Working voltage: 4-16VDC ■ Frequency response: Maximum 20MHz ■ Detectable pulse width: Longer than 25nsec ■ Input impedance: 1Mohm minimum ■ Input overload protection: ±250V DC/AC ■ 90 day warranty

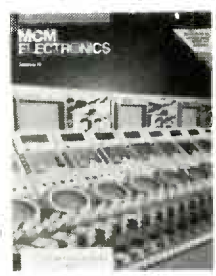
#72-415 **$14.95** (ea.)

Tenma RS-232 Break Out Box

■ Monitors individual communication interface lines ■ Detects the presence or absence of activity ■ Rewire RS-232 interfaces ■ Line powered ■ Dual-state LEDs monitor both positive and negative signal levels ■ 48 test points ■ For additional information see MCM Catalog #14

#72-440 **$49.80** (ea.)

Call Toll Free 1-800-543-4330 (In Ohio 1-800-762-4315 In Alaska and Hawaii 1-800-858-1849)



Terms: MasterCard VISA

- $10 minimum order. $1.00 charge for orders under $10.
- $20 minimum charge card order.
- Orders shipped UPS C.O.D.
- Most orders shipped within 24 hours.
- Sales office open 8:30 am to 7:00 pm Saturdays 10:00 am to 3:00 pm EST.
- For prepaid orders add $2.75 for shipping and handling.
- Should shipping and handling charges exceed $2.75, the balance due will be sent C.O.D.

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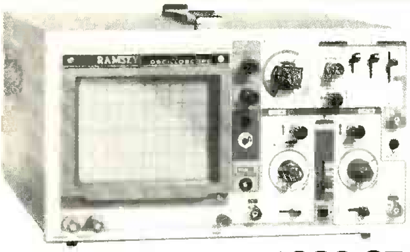
SOURCE NO. RE-31

RAMSEY

RAMSEY ELECTRONICS

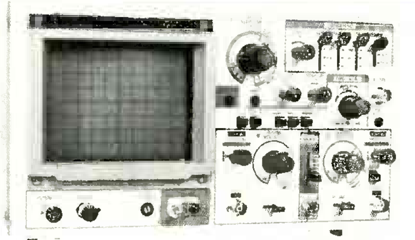
QUALITY TEST GEAR YOU CAN COUNT ON



INCLUDES 2 HOOK-ON PROBES **$369.95***

20 MHz DUAL TRACE

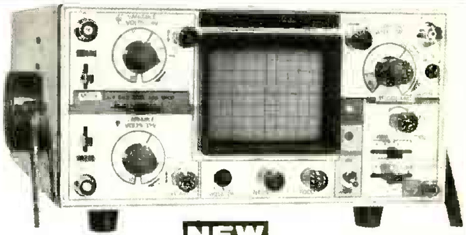
Features component testing circuit for resistors, capacitors, digital circuits and diodes—TV sync filter—high sensitivity—Z axis—XY mode—built-in calibrator—5X horizontal magnifier



INCLUDES 2 HOOK-ON PROBES **$499.95***

35 MHz DUAL TRACE

wide frequency bandwidth—optimal sensitivity —delayed triggering sweep—hold off—ALT trigger—single sweep TV sync 5X magnification—XY or XYZ operation— HF/LF noise reduction



NEW

INCLUDES 2 HOOK-ON PROBES **$449.95***

15 MHz DUAL TRACE PORTABLE

Field/bench applications—built-in charger and battery pack—up to 2 hours operation per charge—5X horizontal magnification—high brightness CRT—front panel trace rotator

RAMSEY OSCILLOSCOPES

All Ramsey oscilloscopes feature unsurpassed quality at an unbeatable price. Of heavy duty construction, they are suitable for hobby, service and production applications.

*Add an additional $10.00 for each unit for shipping.

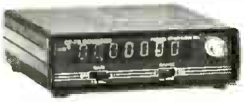
MODEL	BAND WIDTH	# TRACES	CRT SIZE	VERTICAL SENSITIVITY	MAXIMUM TRIG FREQ	USEABLE MAXIMUM BANDWIDTH
2200	20 MHz	(2)	8x10CM	5 mV per div	35 MHz	30 MHz
2500	15 MHz	(2)	3.5 inch	2 mV per div	30 MHz	25 MHz
3500	35 MHz	(2)	8x10CM	1 mV per div	50 MHz	60 MHz

All include high quality 1:1, 10:1 hook on probes, instruction/service manual with schematic and component layout. 1 year warranty.

MINI-100 COUNTER

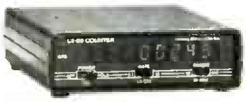
$119.95 CHARGER, NICAD BATTERIES, AC ADAPTER INCLUDED

CT-70 7 DIGIT 525 MHz



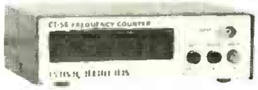
$139.95 WIRED, INCLUDES AC ADAPTER

CT-90 9 DIGIT 600 MHz



$169.95 WIRED INCLUDES AC ADAPTER

CT-50 8 DIGIT 600 MHz



$189.95 WIRED INCLUDES AC ADAPTER

CT-125 9 DIGIT 1.2 GHz

$189.95 WIRED INCLUDES AC ADAPTER

MODEL	FREQ RANGE	SENSITIVITY	ACCURACY	DIGITS	RESOLUTION	PRICE
MINI-100	1-500 MHz	Less than 250mv	1 PPM	7	100 Hz, 1 KHz	119.95
CT-70	20 Hz-550 MHz	< 50mv To 150 MHz	1 PPM	7	1Hz, 10Hz, 100Hz	139.95
CT-90	10 Hz-600 MHz	< 10mv To 150 MHz < 150mv To 600 MHz	1 PPM	9	0.1Hz, 1Hz, 10Hz	169.95
CT-50	5 Hz-600 MHz	LESS THAN 25 mv	1 PPM	8	1Hz, 10Hz	189.95
CT-125	10 Hz-1.25 GHz	< 25mv @ 50 MHz < 15mv @ 500 MHz < 100 mv @ 800 MHz	1 PPM	9	0.1Hz, 1Hz, 10Hz	189.95
CT-90 WITH OV-1 OPTION	10 Hz-600 MHz	< 10mv To 150 MHz < 150mv To 600 MHz	0.1 PPM	9	0.1Hz, 1Hz, 10Hz	229.90

RAMSEY FREQUENCY COUNTERS

Ramsey Electronics has been manufacturing electronic test gear for over 10 years and is recognized for lab quality products at breakthrough prices. Our frequency counters have features and capabilities of counters costing twice as much.

RAMSEY D-4100 COMPACT DIGITAL MULTITESTER

$24.95

test leads and battery included

Compact sized reliability and accuracy. This LCD digital multitester easily fits in your pocket, you can take it anywhere It features full overload protection • 3½ digit LCD readout • recessed input jacks • safety probes • diode check function • 2000 hours battery life

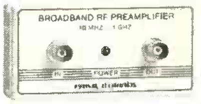
NEW

RAMSEY D-5100 HANDHELD DIGITAL AUTORANGING METER

$49.95

Includes Probes
1 Year Warranty

Has TOUCH-HOLD feature to allow readings to be logged or referred to before making the next reading. Up to 10 AMP current capability and a continuity function which beeps on zero Ohms.

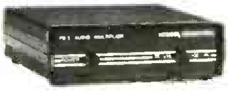


$44.95 wired includes AC adapter

PR-2 kit **$39.95**

PR-2 COUNTER PREAMP

The PR-2 is ideal for measuring weak signals from 10 to 1,000 MHz • flat 25 db gain • BNC connectors • great for sniffing RF • ideal receiver/TV preamp



$69.95 wired

PS-2 kit **$49.95**

PS-2 AUDIO MULTIPLIER

The PS-2 is handy for high resolution audio resolution measurements, multiplies Up in frequency • great for PL tone measurements • multiples by 10 or 100 • 0.01 Hz resolution & built-in signal preamp/conditioner

$89.95 wired includes AC adapter

PS-10B 1 GHz PRESCALER

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Complete kit, TD-1 **$5.95**

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PA-1, 40 W pwr amp kit **$22.95**
TR-1, RF sensed T-R relay kit **6.95**

COLOR ORGAN
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FM-1 Kit **$3.95**
FM-2 Kit **$4.95**

SIREN
Produces upward and downward wail. 5 W peak audio output, runs on 3-15 volts, uses 3-45 ohm speaker.
Complete kit, SM-3
$2.95

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A super sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as general purpose amplifier. Full 2W rms output, runs on 6 to 15 volts, uses 8-45 ohm speaker.
BN-9 Kit **$5.95**

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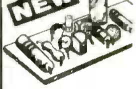

NEW

FM RECEIVER
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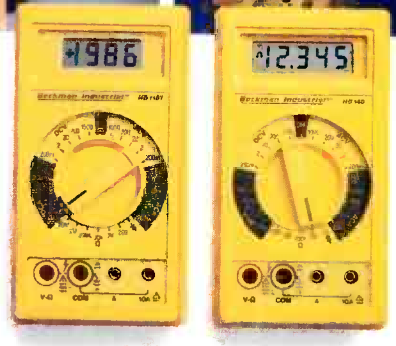

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