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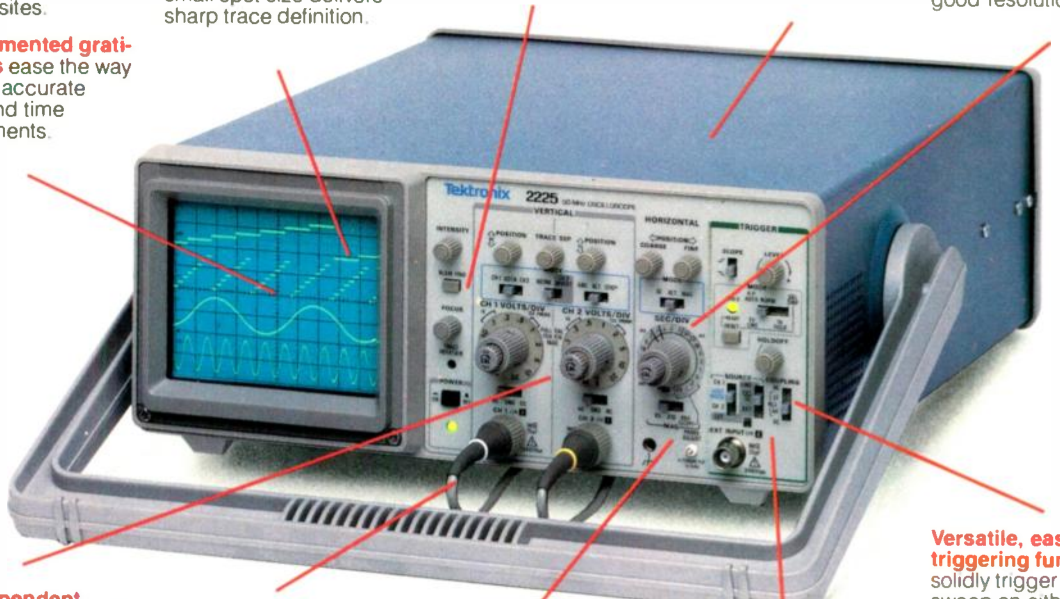

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CIRCLE 92 ON FREE INFORMATION CARD

December 1987 Radio-Electronics

Vol. 58 No. 12

BUILD THIS

TECHNOLOGY

CIRCUITS AND COMPONENTS

DEPARTMENTS

PAGE 86

PAGE 47

AND MORE

ON THE COVER

Copy protection is commonplace in today's movie industry. The *Macrovision* encoding process is used on many new video tape releases, and some cable companies have expressed interest in it as well. Its advocates claim that *Macrovision* affords unimpaired viewing of the original tape while making it impossible to copy it. However, many sets are unable to process the encoded signal correctly—resulting in a clouded picture that might also roll or flash. If your TV is one of those that can't handle the encoded picture, our Macro-Scrubber can help. It eliminates only the *Macrovision* encoding, with no effect on normal video signals. For a clean picture all the time, build the Macro-Scrubber. The story begins on page 49.

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How to test TTL devices.

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Get your PT-68K up and running.

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HANDHELD DIGITAL IC COMPARATOR/ TESTERS FEATURE 20 CHANNEL LOGIC MONITOR

B&K-PRECISION's Model 550 and 552 IC Comparator Tester/Logic Monitors test IC's by comparison to a known good reference in one simple operation. As logic monitors, they simultaneously indicate the logic states of up to 20 IC pins. They test most 14 to 20 pin, 54 and 74 Series TTL (Model 550) or 4000 and 74C Series CMOS (Model 552) devices. Both models are available from distributors at $395. Contact your local distributor or: B&K-PRECISION, Dynascan Corp., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

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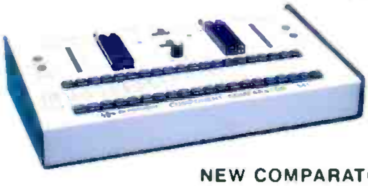

NEW COMPARATOR ADDS IC/COMPONENT TESTING TO SCOPE

Test virtually any type of passive or active component or module with B&K-PRECISION's new 541 Component Comparator. The 541 is designed for use with the 540 component tester or virtually any x-y oscilloscope. It is well suited for both in-circuit and out-of-circuit tests. It's fast and easy to use. Unlike single function testing, the 541 can be used on series, parallel or series/parallel circuits. $395. Contact your local distributor or: B&K-PRECISION, Dynascan Corp., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

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NEW COMPONENT TESTER LOCATES FAULTS ON UNPOWERED BOARDS IN FIELD OR PLANT

The new Model 540 component tester is an extremely cost effective, highly flexible trouble-shooting aid that can assist in rapidly locating faults on unpowered boards. Faults can be traced to the component level without specific circuit knowledge. Individual components can also be tested. Test results are displayed as a curve on a built-in CRT display. Curve tracing allows matching of components. Two channels allow production testing against known good boards. Ideal for field service or production testing. $995. Contact your local distributor or: B&K-PRECISION, Dynascan Corp., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

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PROGRAMMABLE IC TESTER TESTS TTL, CMOS, RAM AND ROM IC'S, IN OR OUT-OF-CIRCUIT

Called the "first cost-effective way to test IC's both in and out-of-circuit," the new B&K-PRECISION Model 560 fills the void between basic component testers and costly ATE systems. Over 1500 different 14 to 24 pin devices can be tested, including TTL and CMOS digital IC's, RAMs and ROMs. The 560 speeds testing, simplifies diagnostics and doesn't require prior test skills. Plain-English user prompts guide every step of operation. Test results are displayed as positive "pass" or "fail." Test results can be fed to a printer. Applications include incoming inspection, QC, production line testing and troubleshooting faulty products. $3,500. Contact your local distributor or: B&K-PRECISION, Dynascan Corp., 6460 W. Cortland St., Chicago, IL 60635. (312) 889-9087.

EDITORIAL

Where is ComputerDigest going?

It's been almost four years since the first issue of **ComputerDigest** appeared inside **Radio-Electronics.** We have proven wrong the thousands of readers who felt that we would soon become "just another computer magazine." We have proven that Radio-Electronics is dedicated to covering the entire scope of electronics from satellite TV to antique radio, from digital audio tape to computers.

We hope you've noticed that **ComputerDigest** has changed during the last year. We've been taking our coverage of computers more seriously, and we've been covering more serious computers.

We've seen how computers can be used to design printed-circuit boards, and we've seen how graphics coprocessors work to make CAD programs faster and more powerful. We've looked at the computers of tomorrow with reports on IBM's PS/2. And, although we got off to a false start, we've begun to show you how to build a computer based on Motorola's powerful 68000 microprocessor.

Our hands-on reviews have kept you on top of the latest hardware and software. And we hope that our in-depth product comparisons have helped make your buying decisions easier by keeping you informed.

The construction projects have ranged from a clock board for your PC to a complete, powerful, yet low-cost 68000-based machine. We have also shown you how to install a 3-1/2-inch disk drive, and how you can dramatically increase the performance of your PC.

But that's enough talk about 1987. As we prepare our first issue for next year, we wonder how we can make **ComputerDigest** better. What type of articles do you want to see in 1988? More reviews? More construction? More industry news? Only *you* know how **ComputerDigest** can serve you better. Please don't keep it to yourself—we need to know. Write to us at 500-B Bi-County Blvd., Farmingdale, NY 11735. Let us know what computers you use and how you use them, and share your views with us..

Thanks for making 1987 a successful year for Radio-Electronics. We hope your holiday season is happy, and we wish you all the best for the new year.

BRIAN C. FENTON
Managing Editor

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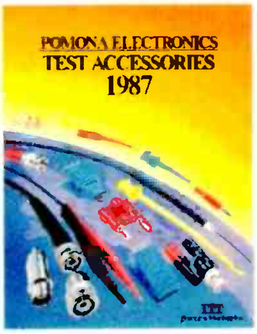

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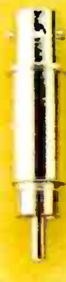

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CIRCLE 101 ON FREE INFORMATION CARD

WHAT'S NEWS

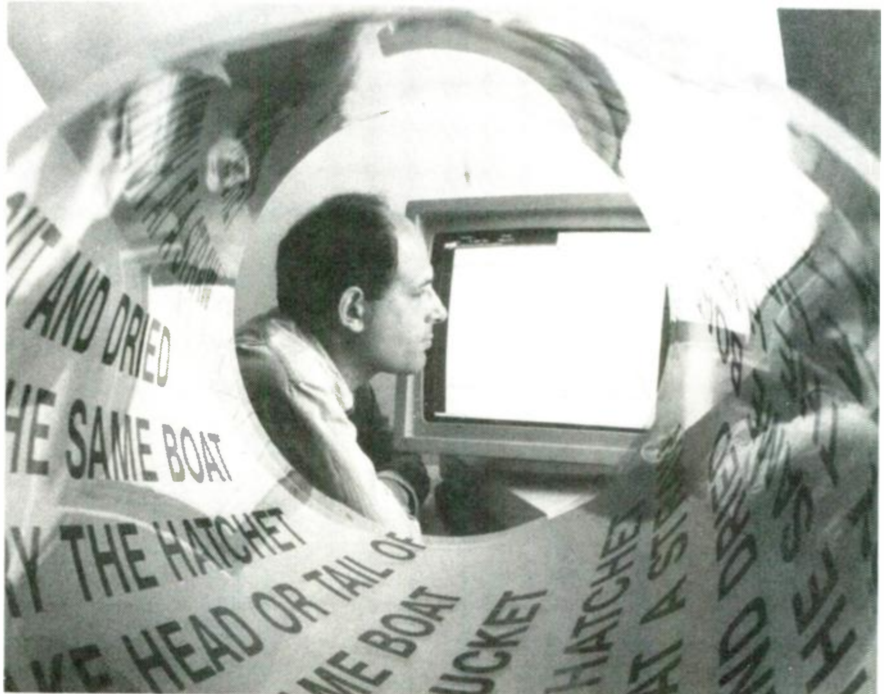
Novel developments in artificial intelligence

In spite of fantastic advances, computers remain remarkably stupid about certain things. In particular, their language level is below that of a two-year-old child. And they are notoriously poor at finding things only slightly different from those asked for. Another weakness of computers is overprecision—without the exact information the computer cannot reach a conclusion. (An officer on the battlefield, on the other hand, must make instant decisions based on incomplete—and sometimes conflicting—information.)

Scientists at the General Electric Research and Development Center recently presented eight papers aimed at those problems at the Tenth International Conference on Artificial Intelligence, held in Milan, Italy. Possibly the most topical were two papers by Dr. Urik Zernik of the Center. Both of them were based on attempts to answer two questions: How do human beings learn language?" and "How can the process be taught to computers?"

Past computer-language programs have followed academic models—the computer is "taught" a vocabulary (or fitted with a "dictionary") and given a set of grammatical rules. But humans don't learn a language that way, says Dr. Zernik. They learn with everyday experience with new words, phrases, and idioms.

His solution is to equip his program (called RINA) with a "dynamic lexicon" containing entire phrases (including idioms). RINA is also equipped with a set of mathematical instructions that tell the computer how to work with the lexicon and how to use it to gain new knowledge.



DR. URI ZERNIK, General Electric scientist, with a few of the idioms that his language, RINA, helps the computer to figure out.

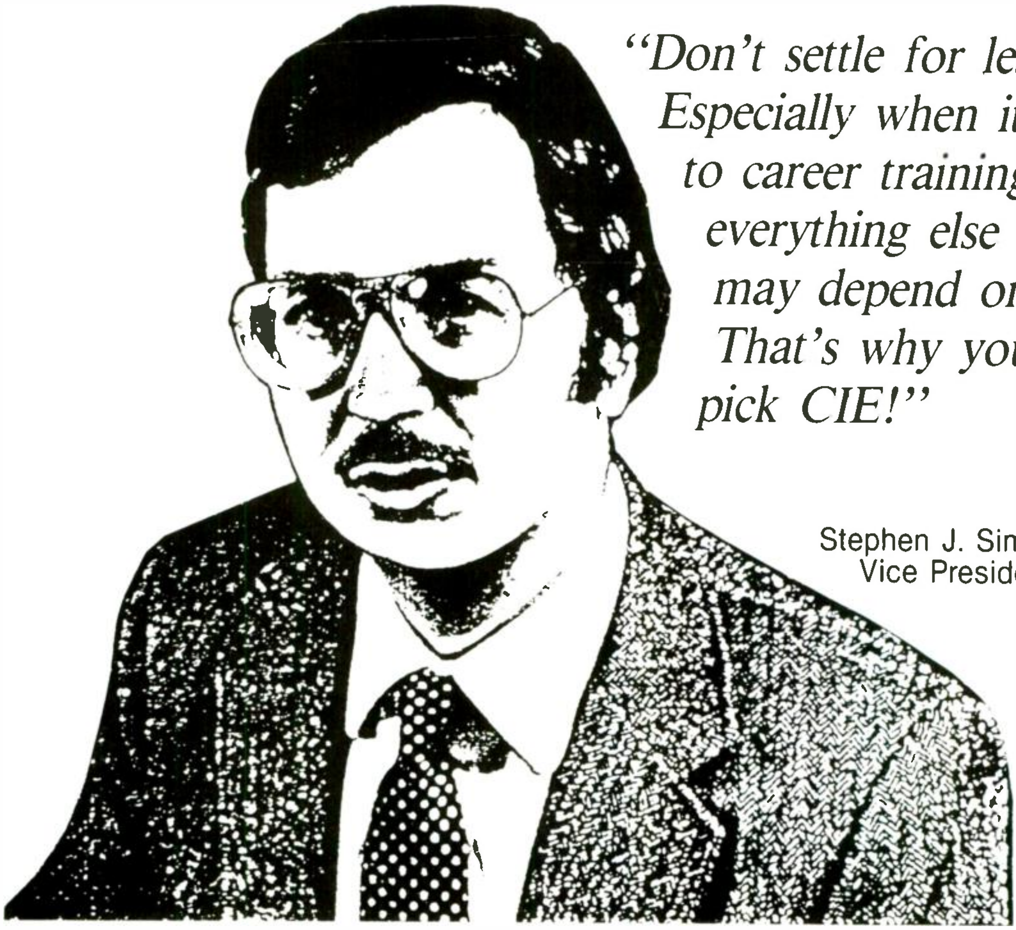
As an example, the computer was given the statement: "Israel and Egypt buried the hatchet." The computer interpreted that as "The nations buried a knife", but it rejected the phrase; in its experience, nations do not bury physical objects. The user helped out: "Israel and Egypt were in a long conflict, they signed a peace agreement." The computer, correctly deducing the meaning of the idiom, then replied: "They buried the hatchet; they terminated the conflict." Later, given the idiom in a totally different context, it responded correctly by applying what it had learned.

A system that is designed to enable a computer to make decisions based on incomplete information was described by Dr. Piero Bonissone, in a paper detailing RUM (*R*easoning with *U*ncertainty *M*odule). The system helps the computer to make sense out of fuzzy terms, like "almost" or "probably" and to weigh the similarities and differences of the current situation against a previous one.

Another paper, by GE scientist Van-Duc Nguyen, describes advances in image understanding—a computer's ability to recognize objects shown by the lines and angles of their outlines. (See "What's News" **Radio-Electronics**, April 1987). That process of "line labeling", or identification, is improved by adding information showing all lines as either concave, convex, or occluding. **R-E**

PC 22

"If you're going to learn electronics, you might as well learn it right!"



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Especially when it comes
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may depend on it.
That's why you ought to
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Stephen J. Simcic
Vice President, Academic Affairs

VIDEO NEWS

DAVID LACHENBRUCH,
CONTRIBUTING EDITOR

• **What's in a name?** Not much, evidently. Take RCA, for example: In 1986, it was sold to General Electric, which was one of the original founders of RCA. General Electric then sold off RCA Records to German publisher Bertelsmann, which not only continues to use the RCA name but has restored the old RCA "meatball" trademark—R, C, and A in a circle, with a lightning bolt at the bottom of the A. Then GE proceeded to sell both GE and RCA consumer electronics to France's giant Thomson combine. Now the RCA initials will be used on records by a German company and on TV's by a French one. The David Sarnoff Research Center (once called RCA Laboratories) was donated to SRI International, which still calls it by the name of RCA's guiding genius.

Or take Philips, the worldwide tradename of the Dutch electronics giant. In the early days of electronics, the company reached an agreement to keep the Philips name out of the United States because it might be confused with Philco, which was here first. Philco was sold to Ford, Ford sold it to GTE, and GTE sold it to North American Philips, which in turn was absorbed by Dutch Philips. So Philips ended up owning Philco, which, not surprisingly, no longer had any objection to the use of the Philips name. Thus, the Philips name finally has come to America on lightbulbs and appliances, and soon on electronics, including TV sets.

Good old names never seem to die; but sometimes they go to sleep for a while. That's what's now happening to Pilot, a historic name. It was Pilot Radio that introduced the first big-selling component FM tuner, the *Pilotuner*. Then in 1948 Pilot brought out the first portable TV (it was in a large suitcase and had a 3-inch picture); that was also the first TV set with a list price under $100. Pilot went through a number of permutations, and eventually when audio marketer Morse sold out to Curtis Mathes, Pilot was one of the names that went with it. Curtis Mathes tried selling Pilot audio equipment for a while, but phased out the line this year. So Pilot is now in limbo, but the brand will probably make a comeback sometime soon, like oldtimers such as Capehart, Emerson, Symphonic, and DuMont; all of those are still around, but the equipment is being manufactured by companies that have no connection to the brand's originator.

• **Zenith goes digital.** Apparently encouraged by the success of its original digital offerings last year, Zenith has introduced 15 new TV sets with all-digital signal processing, in 20- and 27-inch sizes, all with built-in TV stereo and teletext reception. That's far more digital models than any other TV manufacturer will be selling in the U.S. In other introductions, Zenith became the first American manufacturer to offer a TV set with a 35-inch tube (the tube is Japanese). Also, Zenith has introduced a new vertical VCR about six-inches wide by 12-inches tall, designed for bookshelves and other tight places. One 27-inch TV set has a removable panel that conceals a compartment just the right shape to hold Zenith's vertical VCR—and nobody else's. For its lower-priced sets, Zenith has introduced the new highly automated *Duratech* chassis, which contains 46% surface-mount parts, 80% machine-inserted components, 20% fewer connectors, and is 100% computer tested and aligned.

• **Compact disc-video postponed.** If you've been looking for those *C*ompact *D*isc-*V*ideo (CD-V) records and players (**Radio-Electronics**, August 1987), you'll have to wait a little longer. Although they were formally "introduced" last summer, nothing has come on the market, and they're now scheduled for a new launch early in 1988. The CD-V format is an overall name given to the old Laservision videodisc, as well as the new five-inch discs that play five minutes of analog video and 20 minutes of digital audio. Pioneer has introduced combination players that will play the 5-inch discs as well as 8- and 12-inch ones, and others are due soon. CD-V's sponsors want to go through the hoopla of a launch after they have about 200 music-video titles in the 5-inch size. At press time, fewer than 100 selections had been committed to the short audio-video singles. **R-E**

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3.5 DIGIT DMM / MULTITESTER

Our best model. A highly accurate, full function DMM loaded with many extra features. Audible continuity, capacitance, transistor, temperature and conductance all in one hand-held meter. Temperature probe, test leads and battery included.

- Basic DC accuracy: plus or minus 0.25%
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- Resistance: 200 ohms — 20M ohms 6 ranges
- AC/DC current: 200uA — 10A, 6 ranges
- Capacitance: 2000pf — 20uf, 3 ranges
- Transistor tester: hFE test, NPN, PNP
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3.5 DIGIT FULL FUNCTION DMM

High accuracy, 20 amp current capability and many range settings make this model ideal for serious bench or field work. Tilt stand for hands-free operation. 2000 hour battery life with standard 9v cell. Probes and battery included.

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- AC voltage: 200mv — 750v, 5 ranges
- Resistance: 200 ohms — 20M ohms, 6 ranges
- AC/DC current: 200uA — 20A, 6 ranges
- Fully over load protected
- Input impedance: 10M ohm
- 180 x 86 x 37mm, weighs 320 grams

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3.5 DIGIT AUTORANGING DMM

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- Resistance: 200 ohms — 20M ohms, autoranging
- AC/DC current: 20mA — 10A, 2 ranges
- Fully over-load protected
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- Input impedance: 10M ohm
- 150 x 75 x 34mm, weighs 230 grams

DMM-100 $29.95

3.5 DIGIT POCKET SIZE DMM

Shirt-pocket portability with no compromise in features or accuracy. Large, easy to read .5" LCD display. 2000 hour battery life with standard 9v cell provides over two years of average use. Probes and battery included.

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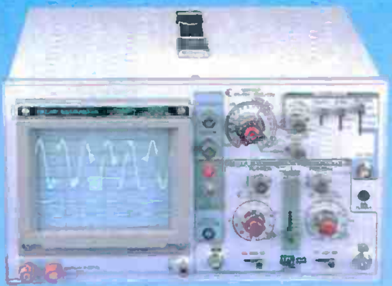
- DC voltage: 2v — 1000v, 4 ranges
- AC voltage: 200v — 750v, 2 ranges
- Resistance: 2k ohms — 2M ohms, 4 ranges
- DC current: 2mA — 2A, 4 ranges
- Fully over-load protected
- Input impedance: 10M ohm
- 130 x 75 x 28mm, weighs 195 grams



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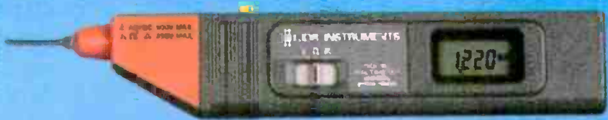
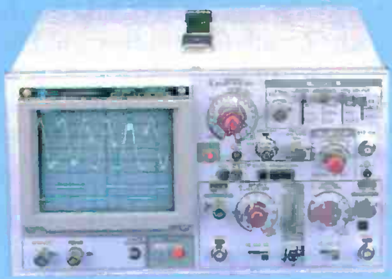


DPM-1000 $54.95

3.5 DIGIT PROBE TYPE DMM

Autoranging, pen style design for the ultimate in portability and ease of use. Custom 80 pin LSI chip increases reliability. Audible continuity tester and data hold feature for added convenience. Case, test leads and batteries included.

- Basic DC accuracy: plus or minus 1%
- DC voltage: 2v — 500v, autoranging
- AC voltage: 2v — 500v, autoranging
- Resistance: 2k ohms — 2M ohms, autoranging
- Fully over-load protected
- Input impedance: 11M ohm
- 162 x 28 x 17mm, weighs 75 grams



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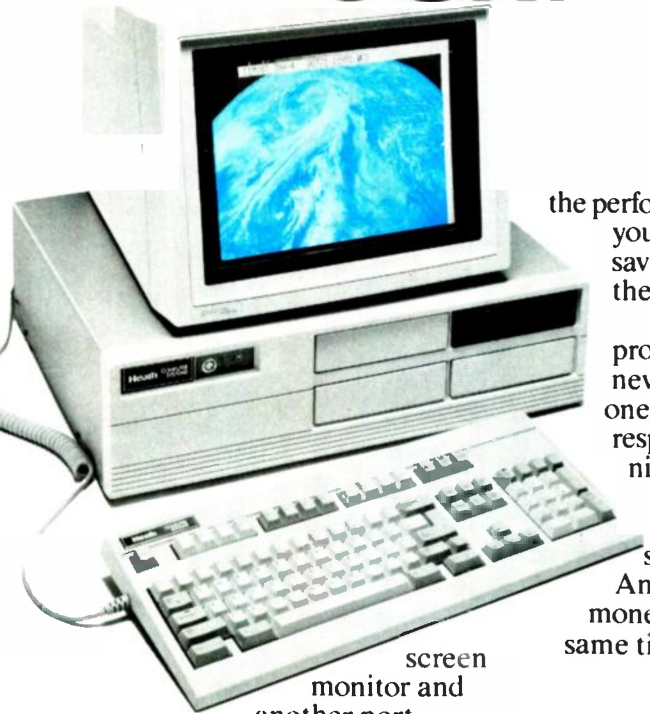

Heath makes building the powerful 386 computer quick, fun, easy... and a great value.

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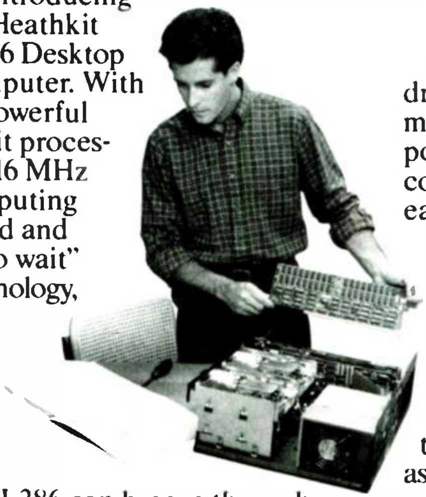
Introducing the Heathkit H-386 Desktop Computer. With its powerful 32-bit processor, 16 MHz computing speed and "zero wait" technology,



the H-386 can breeze through complex calculations in seconds.

Every INTEL 80386 microprocessor used in our H-386 is 100% tested for all functions. And you get superb graphics because one video port provides dazzling 640-by-480 color on Zenith's new flat screen monitor and another port drives EGA, CGA and TTL monochrome monitors. Both ports automatically emulate common video formats for easy system configuration.

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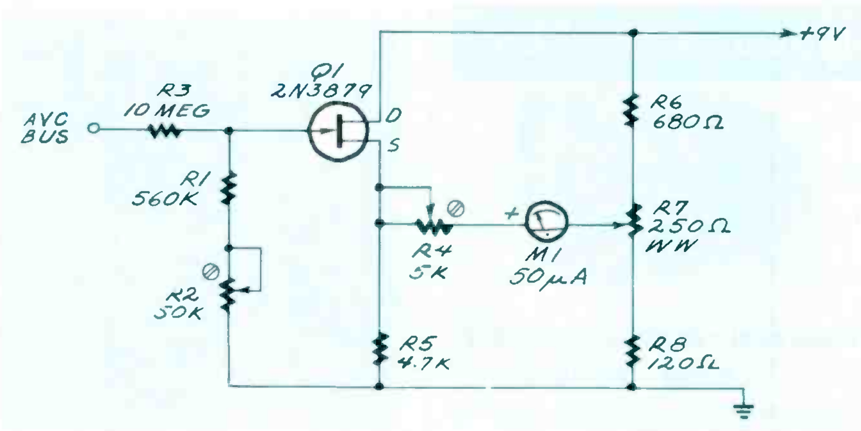


FIG. 1

S-METER AND HEADPHONE JACK

Please show the circuit of a signal-strength meter for an AM radio. Also describe how I can add a headphone jack that will automatically silence the speaker when the phones are plugged in.—J.D., Turnersville, NJ.

I don't know anything about the radio you're modifying, so the best bet for a signal-strength indicator is an FET DC voltmeter (Fig. 1) connected to the set's AGC bus. As shown, the meter reads upward when connected to a positive-going AGC. If the radio uses tubes or has a negative-going AGC, completely isolate the voltmeter's positive and negative leads from the receiver and then reverse the meter movement's connections so it responds to a negative voltage input. Or, do as was often done on communications receivers: Turn the meter upside down so a declining voltage input will cause the meter to appear to read up-scale.

Figure 2 shows how low-impedance headphones can be connected into the audio output circuit of the radio. Inserting the phone plug connects the phones across the audio output while disconnecting the speaker.

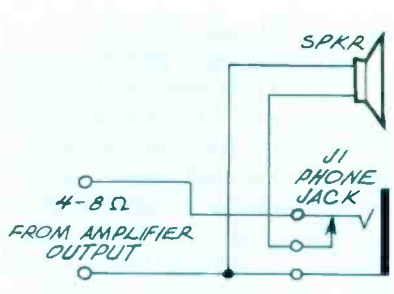


FIG. 2

PRECEDENCE DETECTOR

We are planning to update the indicator system used in our "Scholastic Bowl" events. The present system uses relays and we want to use solid-state circuitry.

The moderator or quiz-master asks a question and the first contestant to believe that he has the answer presses a pushbutton switch that causes his indicator lamp to light, and, at the same time, locks out the indicators of the other contestants. The judge determines the winner and then resets the system.—J.R., Cuba, IL.

Our files contain a number of precedence-detector circuits that indicate which of two pushbuttons is pressed first. One circuit, which uses incandescent lamps for high visibility, is shown in Fig. 3.

The circuit, which was described by M. Jennings in the English magazine *Radio & Electronics Constructor*, is designed for SCR switching. The SCR's, of which there is one per "player," remain off until one of them is turned on when a player momentarily closes his pushbutton switch. The switch

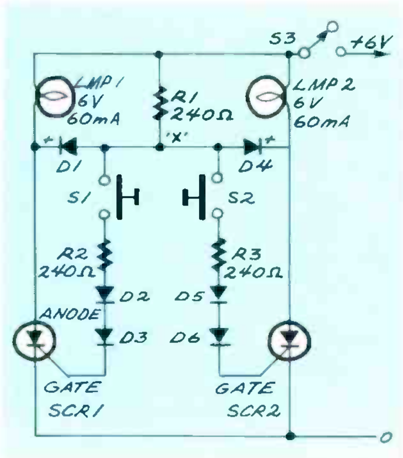
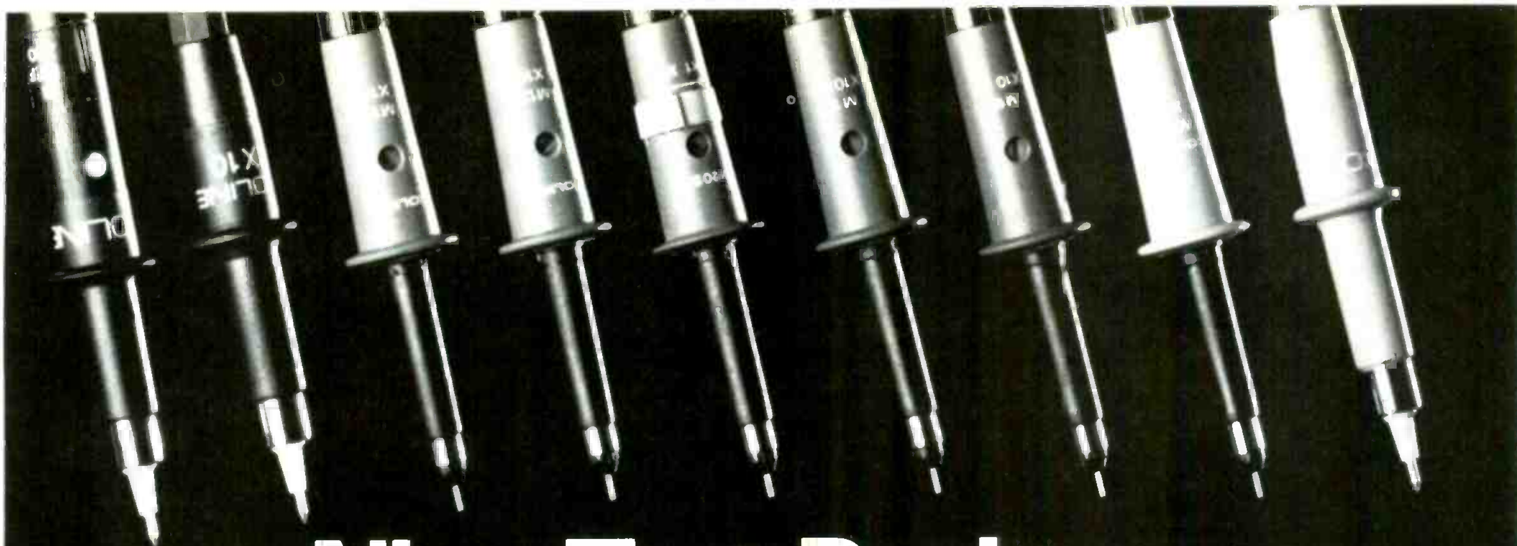


FIG. 3

closure produces a positive trigger pulse on the gate of the corresponding SCR, turning it on. As soon as one SCR turns on, its corresponding indicator lamp lights and the other SCR is locked out so that it cannot fire.

Any number of switching circuits can be added to the detector by duplicating the circuitry to the right of point "X. The SCR's are low-power types such as the Radio Shack *276-1020* and the diodes are silicon rectifiers such as the 1N4002. Switches S1 and S2 are normally-open pushbuttons. Switch S3 is used by the judge or referee to apply power and to reset the precedence detector. That switch may be a single-pole push-on/push-off type.

The precedence detector works this way: Even with S3 closed to energize the detector, the SCR's do not conduct because their gates are isolated from a positive voltage source. Assume that two (or more) players hit their pushbuttons at almost the same instant, but contestant No. 1 closes his switch (S1) a fraction of a sec-



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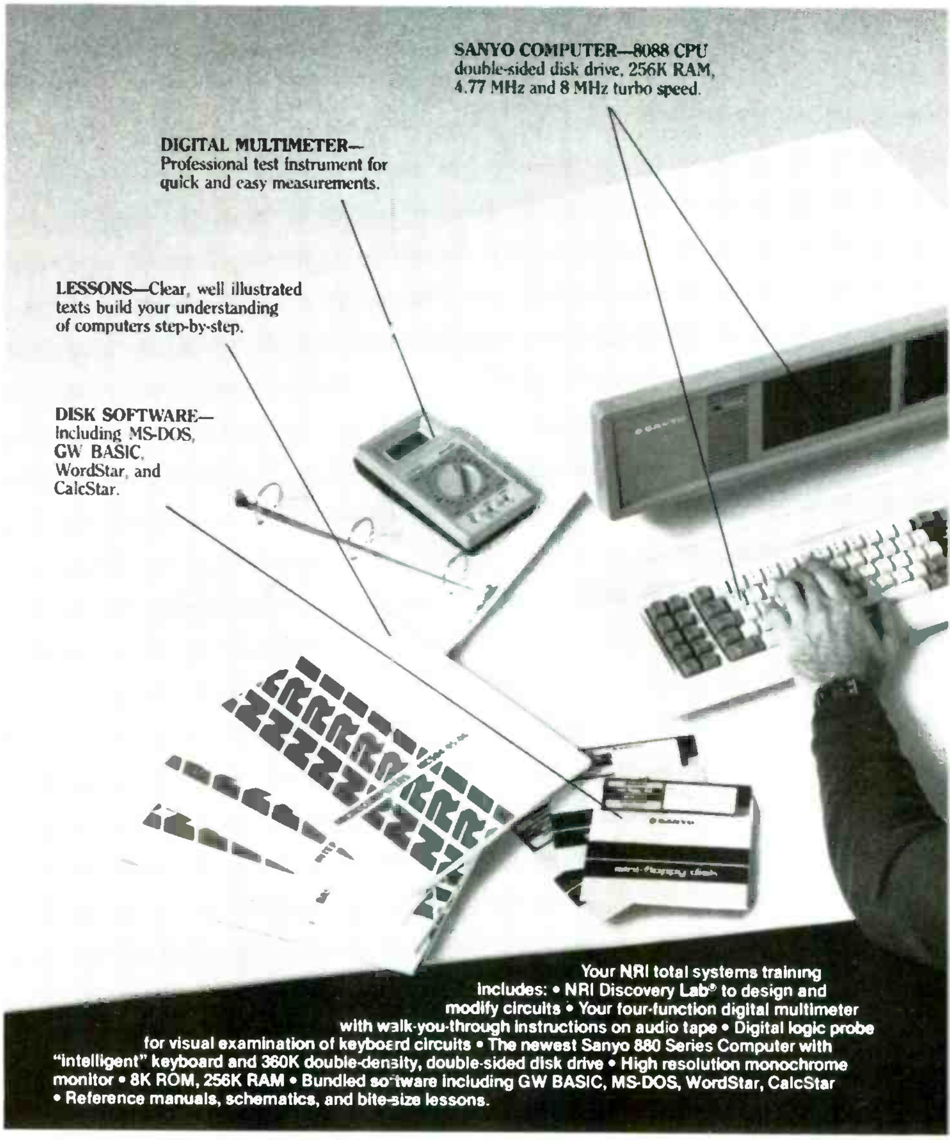

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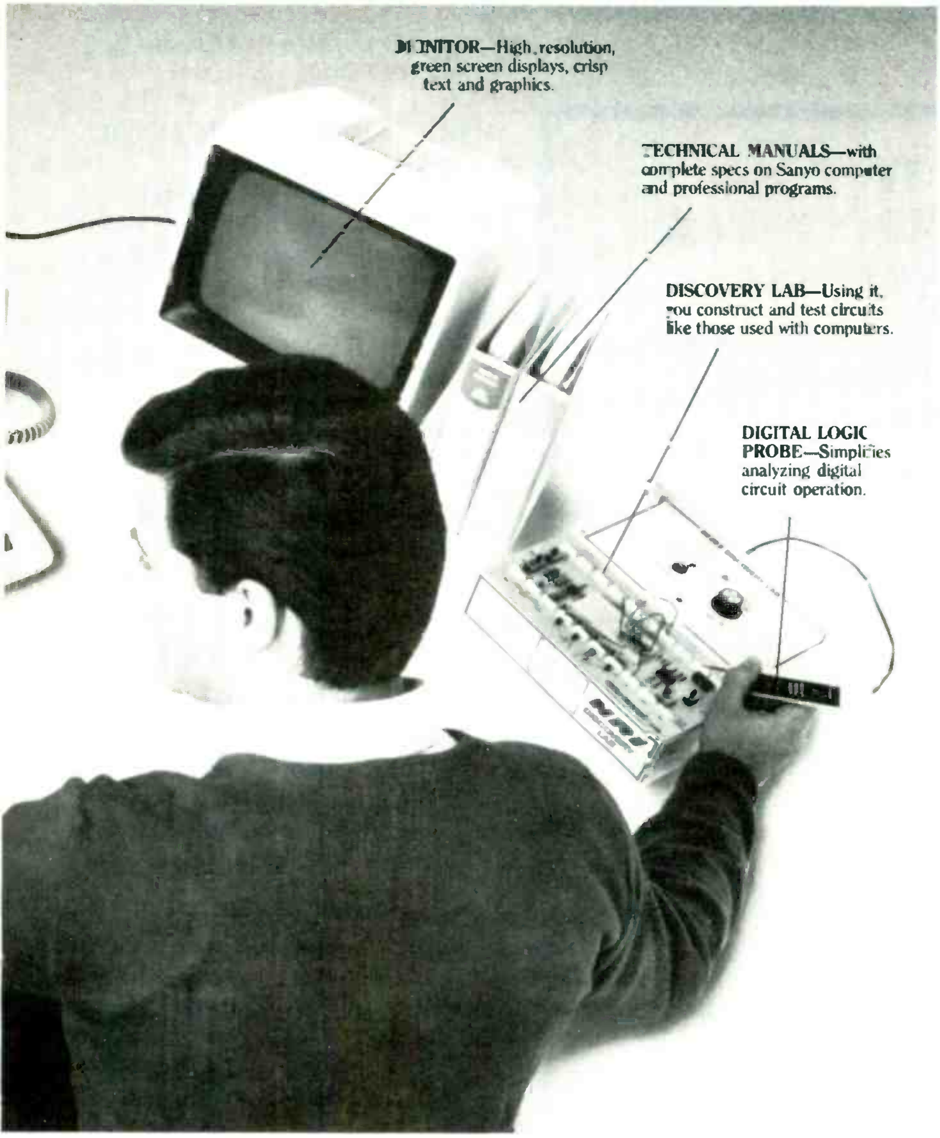

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ond before any of the others. At the instant S1 closes, gate current flows through R1, S1, and diodes D2 and D3, so SCR1 conducts. Its anode current flows through indicator lamp LMP1, and the anode voltage falls to around 0.6 volt—the anode-cathode voltage drop across SCR1. That causes D1 to be forward-biased, so it also conducts, dropping point X to 1.2 volts—the sum of the diode-voltage drops across SCR1 and D1.

With point X at 1.2 volts, all the other circuits are locked out, because when any other pushbutton is pressed, the two series-connected silicon diodes (D5, D6, etc.) are not sufficiently forward-biased to pass the gate current needed to fire the associated SCR. After determining the winning contestant, the umpire resets the board by pushing S3 once to turn off the conducting SCR, and again to restore power.

The indicator lamps should be low-current types—drawing approximately 60 mA or so. If you use higher current types make sure that their cold resistance (as measured with an ohmmeter) is high enough to limit the initial inrush of lamp current to the maximum surge-current rating of the SCR.

If you need something more elaborate, consider building the "Electronic Umpire" described in the December 1970 issue of **Radio-Electronics**. It handles two teams of three players each, and indicates the order of response for the first four contestants.

USING AN OPTOELECTRONIC COUPLER

I am trying to design a circuit that uses a Motorola MOC7811 slotted opto-coupler as a sensor, but I can't locate any applications data. Can you help?—B.J.D., Peoria, AZ .

Slotted couplers in that series consist of an infrared-emitting diode and a photodetector facing each other across a slot in the housing, as shown in Fig. 4. The slot provides a means of interrupting the path between the infrared source and its detector.

We don't have any idea as to what you want to accomplish, so your best bet is to seek applications data from Motorola Semiconductors, 616 West 24th St., Phoenix, AZ 85282. For typical circuits and additional applications information, see one or more of the following: *General Electric Optoelectronics Manual*, the Motorola *Optoelectronics Device Data* book, or *The Optoelectronics Data Book for Design Engineers* from Texas Instruments.

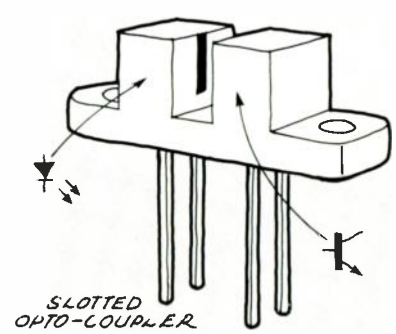


FIG. 4

WHAT KIND OF RESISTORS

I'm interested in resistors and want information on the differences

between a thermistor, thermister, thyristor, and varistar. I have found some definitions, but they are conflicting. I'm particularly interested in the thermistor because one is used in my oscilloscope's power supply.—B.C., San Diego, CA.

The word "thermistor" is an acronym for *Thermally-Sensitive Resistor.* A thermistor is a ceramic semiconductor whose resistance varies greatly with changes in its temperature. The change in temperature may be due to internal heating due to current flow, or to heat from an external source. Thermistors are available with either positive or negative temperature coefficients. The NTC (*Negative Temperature Coefficient*) device is one that exhibits a *decrease* in resistance with *increases* in body temperature. A PTC device is one that develops an *increase* in resistance with an *increase* in temperature.

"Thermister" is a misspelling or corruption of the correct spelling.

I never heard of a "varistar." Perhaps the word you are looking for is "varistor"—meaning a two-terminal voltage-sensitive semiconductor whose resistance decreases rapidly as the applied voltage is increased.

A thyristor is a stable (two-state) semiconductor device having three or more junctions. It can be rapidly switched between its *off* and *on* states. The term "thyristor" is often used to include SCR's and gate-controlled switches.

UNLOADED VACUUM-TUBE AMPLIFIERS

I've serviced car stereo and home hi-fi equipment for more than ten years. Occasionally, an old tube-type amplifier is brought in for service. Recently, a new service manager "hit the roof" when he found me working on a vacuum-tube power amplifier when I had not connected a load to its outputs. He says that I could have destroyed the amplifier, but won't explain how or why. What's the problem?—B.F., Mamaroneck, NY.

Solid-state power amplifiers can be run without a load on their outputs but can be damaged if a short circuit is inadvertently connected across the output terminals. Conversely, a vacuum-tube power amplifier can be damaged if you "crank up the power" before connecting a speaker or resistor load across the secondary of the output transformer.

Here's what happens: Without a load on the secondary winding, the primary winding appears as a very-high impedance and the audio voltages across it can rise to very-high values. The peak voltages can be high enough to cause arcing in the output tubes or cause a breakdown in the insulation between turns in the primary winding.

Whether the voltage peaks do or don't cause catastrophic tube or transformer failure depends on such factors as the transformer's design and the amplifier's output power. You have been lucky thus far, so follow the service manager's instructions and always keep a load on the output of a vacuum-tube power amplifier. **R-E**

LETTERS

ON ARTIFICIAL INTELLIGENCE

I read your article, "Artificial Intelligence," in the May 1987 issue of **Radio-Electronics**, and I was amazed that nothing was mentioned about the following:

Democratic electronic circuits or systems would consist of not only series/serial circuits, but parallel as well. That type of system would also include analog chips and circuits, which convey data based on the degree that a circuit is on—in short, waveforms—and not just based on electronic switching chips or circuits. Those analog chips would simulate how the neurons work in the brain. They would probably be called *almost* and *nalmost* chips, or *maybe on* and *not maybe on* chips. Chips and circuits such as those would make it possible for a computer to learn, memorize, and understand, and to relate or think—to *know*.

Interface data bridges would allow the thousands of neuronic microprocessors in the computer to have the same data stored in each one as the entire computer has stored in its memory bank overall. Those would make it possible for the computer to have a hologramic memory bank, just as the brain has.

A circuit that performs like an electronic mirror, composed of a simulated *data-constructed model* of reality, would enable a computer to compare incoming data with that data model for analysis and interpretation. Within that index memory bank should be a form of self-consciousness, so that the

computer can know itself better and have an identity. That would allow it to relate itself better to the outside world.

Circuits such as those would enable a computer to mimic the brain realistically. They would be able to modify and re-program themselves relative to outside circumstances and basic built-in programming, for survival and the expansion or evolution of consciousness. The circuits would be flexible and therefore capable of change and growth.

Today's computers are nothing more than inert slave mechanisms—like electronic slide rules, card catalogs, or books. We need computers that have more feedback in them.

HERBERT D. STAFFIERI
Bridgeport, CT

MICRO-FLOPPY RETROFIT

Before I read the article, "Microfloppy Retrofit," in the August 1987 **ComputerDigest**, I converted my XT B: drive to 3½ inch, using the Toshiba *ND-354A* with their "Universal Kit." The kit is very inexpensive and complete, with accessories for the PC, XT, AT, Compaq2, AT&T PC6300, and compatibles. Besides costing less than the IBM kit, the Toshiba kit has the advantage of not requiring the IBM's 37-pin D-connector.

My original configuration was one half high 5¼ FDD and one half-height 20-megabyte hard disk. The half height 3½-inch disk drive fits very nicely on top of my A: drive.

I am using PC DOS 3.2, and to format 3½ inch disks at 720K I used the undocumented DOS command called DRIVPARM in my CONFIG.SYS file. The complete command is DRIVEPARM = /D:1/F:2, where /D:1 is the drive number (B:) and /F:2 indicates the 3½-inch drive type.

Having a 3½ inch drive is necessary for me to maintain compatibility with the new IBM computers at work—and it is nice to have 720K floppy storage.

RICHARD F. PELLY
Huntington Beach, CA

AMPLIFIER DESIGN

I enjoy **Radio-Electronics** very much—in fact, I can barely wait for the next issue. I want to thank you for including computer program listings with some of your articles. I find them almost as much fun as the projects.

The article, "Transistor Amplifier Design," by Jack Cunkelman in the August 1987 issue was a great source of information on common emitter amplifiers. Maybe he could do more on common-base and common-collector amps.

Line 280 in the program listing reads:

R2 = IZ*RE*100/((RE*100) − IZ)

Two problems were solved when I changed line 280 to read:

R2 = INT(IZ*RE*B/((RE*B) − IZ))

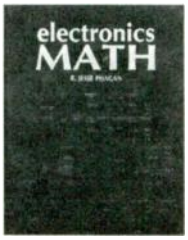
First, the formula now considers the "input" value for beta. And I no longer get a negative result for R2 with certain "input" data.

I hope that is useful to other readers, and thanks again.

MICHAEL H. PERKINS
Louisville, KY

continued on page 37

Please note: some books count as 2 selections



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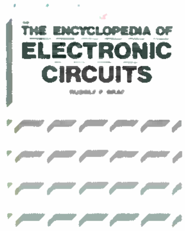

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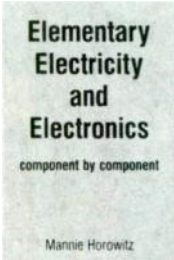

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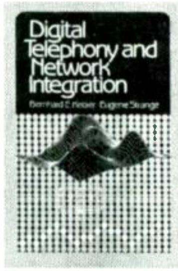

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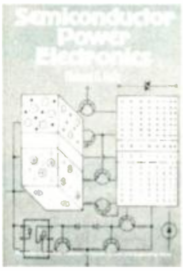

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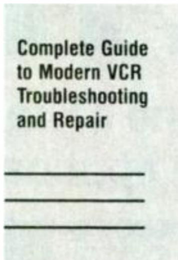

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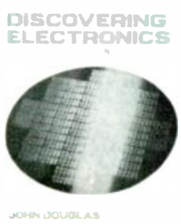

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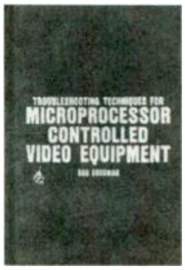

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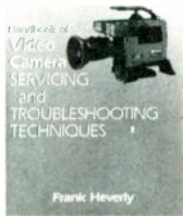

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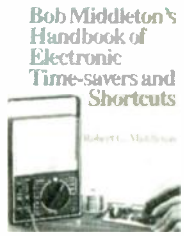

Bob Middleton's Handbook of Electronic Time-savers and Shortcuts
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NEW PRODUCTS

CIRCLE 10 ON FREE INFORMATION CARD

FM DUAL-BAND TRANSCEIVER. The Kenwood *TW-4100A* is rated for 45 watts on 2 meters and 35 watts on 70 cm. It features selectable fullduplex cross-band ("telephone-style") operation. Cross-band repeater operation is also possible. (A control operator is needed for repeater operation.) In addition, there are programmable band scan and memory scan with memory-channel lock-out features.

The model *TW-4100A* is 5.9 × 1.97 × 7.87" and weighs less than four pounds. Frequency coverage is 142–149 MHz (allows operation on certain MARS and CAP frequencies), and 440–449.995 MHz. The suggested price is $649.95.—**Kenwood,** 2201 E. Dominguez Street, Long Beach, CA 90810.

DIGITAL MULTIMETER. The Beckman *DM71* is a handheld pen-type meter that features a 3½-digit display with 0.7% accuracy (2-mV DC range) and auto-ranging; it fits easily into a shirt pocket.

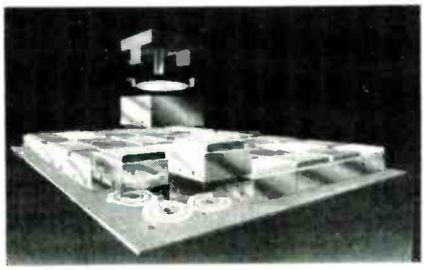
The meter has been designed for ease of use, having a rotary function dial instead of the usual combination-pushbutton operation. A DATA HOLD function allows the user to manually freeze the display so that it can be read without rushing, or under better lighting conditions. The unit features a 90-hour battery life.

The model *DM71* has a suggested retail price of $49.94.—**Beckman Industrial Corporation,** 3883 Ruffin Road, San Diego, CA 92123-1898.

CIRCLE 11 ON FREE INFORMATION CARD

SWITCH MODULE. The Tec *SNAP-TEC* is a new approach to mounting data-entry switches directly onto a printed-circuit board without the need for soldering.

Designed for low- to medium-speed switching applications, the *SNAP-TEC* uses a stainless-steel snap-dome mounted in a plastic housing along with a plastic keycap/actuator. The switch module snaps into two holes in a .062-inch



CIRCLE 12 ON FREE INFORMATION CARD

PC board directly over mating contact circuitry.

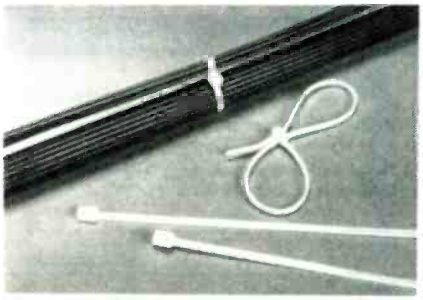
Available in a variety of colors and keycap styles, the *SNAP-TEC* can be mounted on .500-inch centers. Custom-designed keycaps are also available. Actuation force is 220 grams with a 0.015-inch nominal travel. The price per unit is under $0.30 each when purchased in quantities of 1000.—**Tec, Incorporated,** 2727 North Fairview Avenue, P.O. Box 5646, Tucson, AZ 85703.

CABLE TIES. Two new cable ties from Panduit, the *PAN-TY* (shown) and the *STA-STRAP*, are double-loop ties whose bent tips provide faster orientation.

Both types are made of natural 6/6 nylon (white), which is U.L. 94-V2 self-extinguishable. They are also available in heat-stabilized nylon (black) and weather resistant outdoor nylon (black). Temperature ranges are −40°F to +221°F for heat-stabilized materials and −40°F to +185°F for the other two materials.

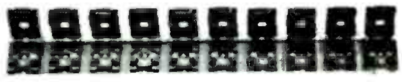
PAN-TY double-loop cable ties are one-piece construction; two sizes are available for up to a maximum combined bundle diameter of 3.8". They have a minimum loop tensile strength of 50 pounds. Prices, which depend on size, start at $10 per 100.

STA-STRAP double-loop cable ties have a two-piece design, which allows the first loop to be released prior to final tensioning. That design has zero insertion force and can be hand-installed only. Maximum combined bundle diameter is 1.25"; minimum loop tensile strength is 30 pounds. Pricing depends on size. —**Panduit Corp.,** 17301 Ridgeland Avenue, Tinley Park, IL 60477-0981.



CIRCLE 13 ON FREE INFORMATION CARD

DEDICATED ADAPTER. The Program Automation *Surface Mount Adapter,* for Data I/O's *120/121A* programmers, can program 10 devices at a time on the upper and/or lower 10 sockets of the programmer, and uses all standard programmer instructions and readouts. For added throughput, two adapters can be used to program 20 devices at a time.



CIRCLE 14 ON FREE INFORMATION CARD

Features include: easy drop-in lock-in adapter; pop-out ejector after programming; vertical sockets for ease of handling and insertion; sockets designed to meet manufacturer's specs and ensure coplanarity; small footprint for ease of handling.

The *Surface Mount Adapter* can be used for production planning of OTP PLCC EPROMS, for incoming inspection of preprogrammed parts, and in a maintenance environment for checking questionable parts. It is priced at $2000.00—**Program Automation, Inc.**, 22706 Aspan, Suite 308, El Toro, CA 92630.

PRECISION ALIGNMENT KIT. The Jensen *Y23B840* kit contains a selection of precision tools that are manufactured to extremely fine tolerances and are designed for adjustments of VHS and Beta video-cassette recorders.

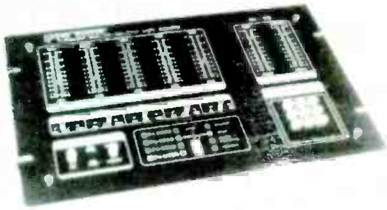
The kit includes a base-plate reference jig and a height gauge (used for precision height adjustment of the reel discs, guide posts,

continued on page 38

EQUIPMENT REPORTS

Mark V SM-328 Professional Color Light Controller

Control your lights for excitement



CIRCLE 20 ON FREE INFORMATION CARD

IF YOU ARE A PROFESSIONAL DJ—OR IF you just want to pretend you are—you'll be interested in the SM-328 professional light controller from Mark V Electronics, Inc. (248 E. Main Street, Suite 100, Alhambra, CA 91801). The SM-328 can be used for dance-hall lighting, to add chasing lights to advertising displays, or just to add a new dimension to your parties.

The 4-channel controller is a distant relative of the color organs you might remember from the 1960's. It has a power output of better than 1000 watts per channel, so it can be used to control more than forty 100-watt spotlights or more than 800 5-watt bulbs! But whatever lighting array you choose, there are three main ways that the SM-328 can control it: It can run its own chaser programs, it can control the lights based on an external audio signal, or it can use a combination of the input signal and the chaser program.

Chaser programs

The SM-328 can run four chaser programs, which can be used for dramatic displays of chasing lights. The first program lights each channel in sequence, with one channel active at a time. The second program does the opposite. It darkens each channel in sequence, while the other three channels appear lighted. The third program lights two channels at a time and alternates back and forth between them. Finally, the fourth program also lights two channels at a time, but in a sequence of 1-2, 2-3, 3-4, 4-1. The speed of the chasing is controlled by a lighted slide potentiometer.

The chaser program and its operating modes are selected via a 9-button keypad. For example, an AUTO control mode can be selected to automatically vary the time that each channel remains lighted; or, a slide potentiometer can be used to manually control the on-off timing. The direction of the chase is also controlled from the keypad.

Music control

By connecting the SM-328 in parallel with one of your loudspeakers, you can use the audio signal fed to the speaker as the controlling source for the lights. The actual audio level is unimportant because the SM-328 will accept signals ranging from 100 millivolts to 28 volts (or a maximum of 100 watts of audio power). Since the SM-328 has a high impedance (bridging) input it has no affect on either the speaker or its associated amplifier.

A MASTER LEVEL control allows the user to adjust the overall brightness of the lamps in proportion to the volume of the music input. Alternately, the user can create unusual or customized lighting effects, even "ride gain" on the effects, because each channel has its own level control—a lighted slide control.

The output of each channel's level control feeds an op-amp filter that determines the channel's frequency response. One channel responds to treble frequencies, one to midrange frequencies, and two channels respond equally to bass frequencies. The op-amps, in turn, control optically-coupled Triacs. In addition to a level control, each channel features a three-position slide switch that can be used to instantaneously dim or cut the light.

Some of the most interesting and eye-catching lighting displays can be obtained by using a music signal to control the execution of the light-chaser programs.

Good layout

The front panel is specifically designed to be used in dim lighting—even in virtual darkness. For example, only those potentiometers that can be used in a given mode are lighted in that mode. Also, the brightness of the level-control potentiometers changes with the music signal in its channel. But while the LED's that illuminate the potentiometers can be used for quick set-up adjustments, they aren't adequate for use as an overall lighting guide; for *precise* lighting control it's still necessary to view the actual lights.

We found the keypad switches difficult to use. Their tactile feedback was very poor, and the keys did not always do what they were supposed to. However, we were able to clear up the problem by disassembling the case and cleaning the switch contacts. Other than the keypad, the SM-238 is solidly constructed, and its solid metal 14-inch rack-mount case can take a good amount of abuse. The controller carries a suggested list price of $150. R-E

LETTERS

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SCA RECEIVER

I'm glad to see that **Radio-Electronics** is showing an interest in FM subcarriers, with "Build This SCA Receiver" in the August 1987 issue. The authors mention that SCA is inherently "noisy." However, with the Signetics' 565 PLL (whose basic design the authors follow) most of the noise is due to the unnecessarily wide bandwidth inherent in the SCA receiver design published in the Signetics' application notes.

Ironically, that wide-bandwidth noise shows up mostly in more advanced SCA receivers, such as the one featured in **Radio-Electronics**, that amplify the signal before input to the PLL. Below 100 mV, the lock range (thus, the capture range as well) decreases with decreasing input voltage. Therefore, a simple receiver accepting a weak SCA signal of 10-20 mV has build-in bandwidth limiting. In general, however, increased input voltage will improve the 565's demodulation characteristics (AM reception, etc.).

Fortunately, there is a simple solution to the wide-bandwidth-noise problem in advanced SCA receivers: reduce the lock range by connecting a 25K potentiometer between pins 6 and 7 of the 565. While some people will enjoy having direct control of the bandwidth from the "front panel," it turns out that simply shorting pins 6 and 7 (minimum lock range) gives acceptable results.

I have one more suggestion: substituting a 470-pF capacitor for C43 and a 4.7K resistor for R55 will give the 10K potentiometer (R72) sufficient range to tune both the 92-kHz and the 67-kHz SCA subcarriers.

The above discussion notwithstanding, designing an SCA receiver with the Signetics 565 is much more straightforward than with Exar's XR2211. But I did find the reward—a portable receiver that works from a single supply of 4.7-6 Volts—to be worth the effort of using Exar's model.

GIL ROBERTS
Duarte, CA

NEW PRODUCTS

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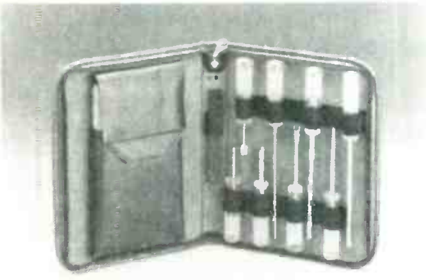
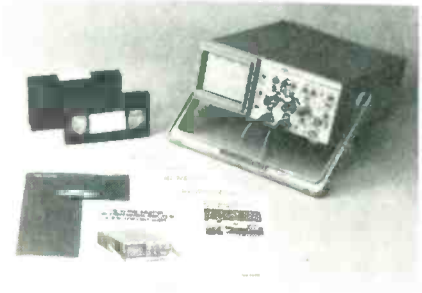


CIRCLE 15 ON FREE INFORMATION CARD

tape transport, pinch wheel audio, synchronization, and erase heads), and an eight-piece driver/wrench set with precisely configured bits for adjusting the tape-feed guide, tape-tension heads, tape transport, audio, and control heads.

The tools are furnished in a padded, vinyl zipper case having elastic straps to hold the drivers and the height gauge. A velcro-closure pouch holds the base-plate reference jig. Case size is 10 × 8 × 1½". The kit is priced at $169.00—**Jensen Tools, Inc.**, 7815 S. 46th St., Phoenix, AZ 85044.

PORTABLE OSCILLOSCOPE. The Tektronix *2225* is a 50-MHz scope, and comes with a library of support material that includes a demonstration video tape, a full-color



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brochure, a 36-page primer (*The XYZ's of Using a Scope*) and five technical briefs on oscilloscope measurements.

Viewers of the video tape will see demonstrations of the model *2225's* dual-channel operation, alternate horizontal magnification, 500-microvolt sensitivity, and extensive triggering features. The primer provides a study guide that expands on all aspects of the scope's operation and use. The technical briefs provide further details on specific measurement methods—period, frequency, phase, risetime, amplitude, etc.

The model *2225* is priced at $995.00.—**Tektronix,** P.O. Box 500, Beaverton, OR 97077.

RATCHET TOOL SET. Electronic Technology Today's Cuecraft *716* consists of a reversing and locking ratchet handle having an integral ¼-inch socket wrench/driver-holder and a fingertip shaft-spinner, number 1 and 2 Phillips-head drivers, 3/16" and ¼" flat-blade drivers,

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and two *Torx* drivers in sizes that are commonly used in automobiles and appliances. A 2⅜-inch handle extension is also provided for the times when you need a little extra reach or torque.

The set also includes 1/16" and 3/32" flat-blade screwdrivers for miniature screws, and a fingertip slide-knife. All parts fit inside a form-fitted, foam-lined 4⅝" × 3 7/16" × 1 7/16" hard-plastic travel case.

Price is $12 postpaid. New York residents must add appropriate sales tax.—**Electronic Technology Today, Inc.,** P.O. Box 240, Massapequa Park, NY 11762-0240

AUDIO UPDATE

Can you believe your ears?

LARRY KLEIN,
AUDIO EDITOR

THE TERM "PSYCHOACOUSTICS" HAS recently become a prominent part of the audio vocabulary. But despite the fact that its use seems mostly reserved for those devices that are designed, electrically or acoustically, to enhance stereo imaging, as we've discussed in previous columns, the term covers much more than that. The study of psychoacoustics specifically involves the relationship of the *subjective* sensations of the human ear/brain mechanism to *objective* acoustical events.

The significant differences between the subjective and objective worlds of sound are illustrated nicely by the inconsistent ways in which the ear responds to frequency and intensity—or in psychoacoustic terms, *pitch* and *loudness*. Three examples: (1) More than fifty years ago Harvey Fletcher demonstrated that the subjective judgment of the pitch of a pure tone can be shifted as much as 10% by simply varying the intensity of the sound. (2) Aside from the pitch shift, as shown in Fig. 1, the human ear's sensitivity to low- and high-frequency ranges diminishes disproportionately as the volume (intensity) of the sound is reduced. The loudness controls found on most amplifiers and receivers are meant to compensate for that fact. (3) Most of us are aware that the ear does not respond linearly to increases in the intensity of the stimulus. For example, the measured acoustic power of a sound has to be raised about *ten times* before the average person hears it as merely *twice* as loud.

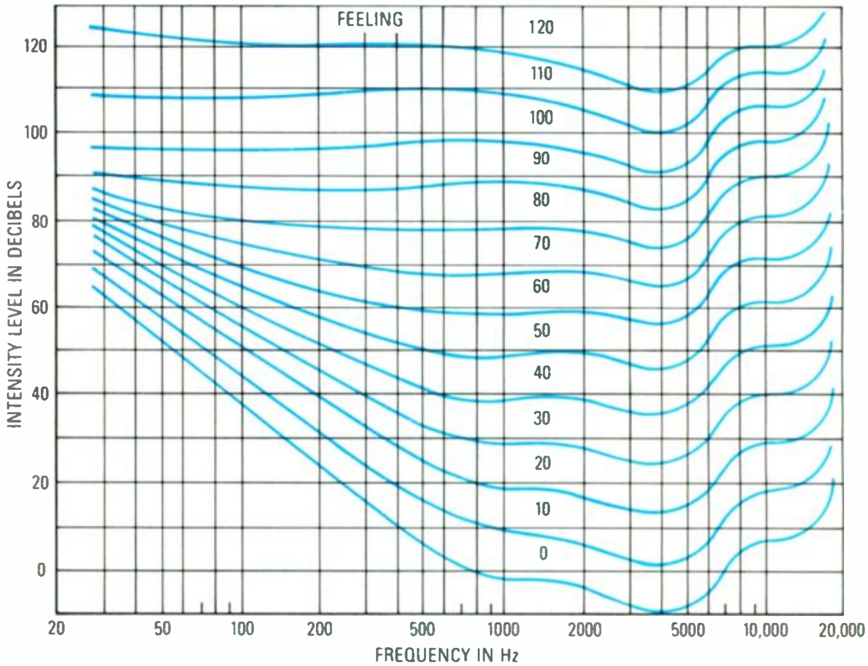

FIG. 1

Those are only three of the psychoacoustic peculiarities of human hearing, and I'm sure that most of you have read discussions of such matters before. But what is not generally appreciated is that the stereo-reproduction process itself is a totally artificial phenomena dedicated to deceiving the ear's psychoacoustic sound-localization process. Think about it—where in nature do you encounter two widely spaced, discrete sound sources each producing a portion of the sound that is heard as coming from *between* them?

Localization

Two main differences between the sounds reaching each ear are used for localization: time-of-arrival differences, and sound-pressure-level (SPL) differences. In general, differences in arrival times are used to localize the lower-frequency sound sources, SPL differences are used for the higher frequencies; the crossover point between the two is about 1,200 Hz.

There's a good reason why the ear/brain uses (actually, needs) at least two different sound cues for localization. For high- to mid-frequency audio wavelengths, your head is an acoustic barrier that partially blocks the sound reaching the ear most distant from the sound source. The measured difference at the ears is something like 16 dB at 5,000 Hz, falling to about 7 dB at 1,000 Hz. When the frequency is low enough (the wavelengths long enough), the head is no longer an adequate baffle and approximately the same signal level is heard by both ears. However, your brain is still sensitive to the relative *timing* of the signals reaching each ear, even though there's only about a 0.6-millisecond difference when the source is located fully on one side of your head. That fraction of a millisecond difference provides the brain with the data needed for localization. When the audio wavelengths get very long—below 200 Hz or so—arrival time differences also disappear and localization is completely lost. That, by the way, explains why subwoofers operating below 200 Hz can be installed almost anywhere in the room without confusing the directional information.

Sonic masking

Most noise-reduction techniques rely on psychoacoustic *masking* to help achieve their ends. Masking describes the ear's loss in sensitivity to sounds in one frequency area when there are louder sounds within the same, or adjacent octaves. Hiss is not heard when there is a lot of music going on in the octaves at or adjacent to the hiss frequencies. Only when the musical frequencies are low (a drum or cello solo), intermittent (a solo piano or guitar), or absent, does hiss become obtrusive. Obviously, the task of a noise-reduction circuit is eased if it has to cope with hiss only in the absence of masking musical sounds.

Masking can be a severe problem in a car because the music gets obscured by wideband wind and tire noises, rather than vice versa. The soft passages in a wide-dynamic-range compact disc will inevitably be masked unless player volume is turned up high enough to override the road noise. But with the volume turned up that high, the louder passages are likely to be unbearably loud! I've not seen any indication that the manufacturers of CD car units recognize the problem and are about to install switchable dynamic-range attenuator (compression) circuits

continued on page 45

STATE OF SOLID STATE

An electronic potentiometer

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

UPON HEARING OR READING THE words potentiometer or *pot*, we immediately think of a variable resistor having a rotary control shaft. But this is the age of electronics, and a potentiometer need no longer be a mechanical device adjusted by turning a shaft; it can be an electronic device that uses small voltages to emulate a potentiometer. One kind of device that can do that is Xicor's *E²POT* Digitally Controlled Potentiometer, which is available in several different versions as the X9MME 8-pin miniDIP series of solid-state non-volatile potentiometers. Basically, the device functions as a digitally-controlled trimmer resistor.

A digitally-controlled potentiometer can be adapted to many applications where mechanical potentiometers or digital-to-analog circuits cannot be used, or would be inconvenient to use. For example:

- It provides for automatic potentiometer calibration or adjustment on an assembly line.
- It eliminates the need for manual adjustments of mechanical potentiometers.
- It makes possible remote control via a keyboard of variable adjustments, such as volume and brightness.
- It simplifies adjustment or control of a remote device via a radio, LAN, or modem link.

99 resistors

The device is essentially an array composed of 99 resistive elements with 100 tap points that are accessible to the "wiper" element. (100 points because the taps are located between adjacent resistor elements and at each end of the resistor string.) The X9MME's functional diagram and pinout are shown in Fig. 1. The wiper's position is digitally controlled by TTL-Level voltages on the $\overline{CS}$, U/$\overline{D}$, and $\overline{INC}$ inputs. Table 1 shows the mode selection. The position data is stored in a non-volatile memory and is automatically recalled on power-up. The memory is capable of retaining the wiper position data for 100 years.

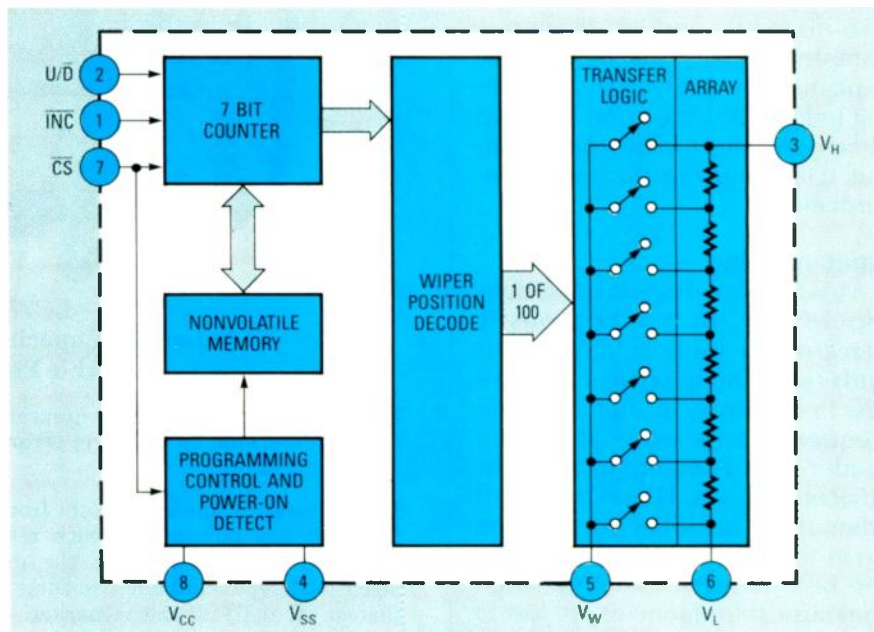

FIG. 1

TABLE 1

Mode Selection			Mode	Power
CS	INC	U/D		
L	↓	H	Wiper Up	Active
L	↓	L	Wiper Down	Active
↑	H	*	Store Wiper Position	Active

* equals high or low

The X9MME *E²POT* is available in three versions, each having different value ranges. The *X9103P* is 10K, the *X9503P* is 50K, and the *X9104P* is 100K. The resolution—the value between tap points—equals the maximum end-to-end resistance divided by 99, or 101, 505, and 1010 ohms for the *X9103P*, *X9503P*, and *X9104P*, respectively.

Other *E²POT's* features include:

- Single-chip MOS implementation
- Three-wire TTL control

- Operation from a 5-volt supply
- Analog voltage range of ±5 volts
- Temperature compensation for ±20% of end-to-end resistance range
- Wiper current of 1-mA maximum
- Typical wiper resistance 40 ohms at 1 mA
- Resolution 1% of resistance

For information on pricing and availability of the E²POTS's, write to *XICOR INC.*, 851 Buckeye Court, Milpitas, CA 95035.

New 8-bit D/A converter

The ZN438 is a new low-cost monolithic D/A converter that requires only two external passive components for full 8-bit conversion. Features include a trimmable 2.5-volt bandgap reference, which is also available externally for use as a system reference. A trim pin can be left floating to provide the nominal 2.5 volts, or it can be connected to a 10K potentiometer to provide a ±5% trim range. The ZN438 has a settling time to ±0.5 LSB of 1.25 μsec.

The ZN348E device is available for commercial applications in a 16-lead plastic DIP package, and is priced at $5.44, in 1000-piece lots. The ZN348J is ceramic packaged and operates in the military temperature range. Price is $10.37 each, in 1000-piece lots. For additional information, contact *Ferranti Semiconductors*, 87 Modular Avenue, Commack, NY 11725.

CMOS megabit memory

In the Mega-Project, in conjunction with Philips, Siemens is producing the first laboratory samples of a CMOS memory chip with more than 4-million bits of storage capacity. The project's 1-Megabit DRAM will be mass-produced at Siemens' Regensburg facility this year; followed by the 4-Megabit DRAM in 1989. The 4-Megabit chip stores 4,194,304 bits on a surface of 91 mm² (6.5 mm × 14 mm). It feature the novel "trench cell"—a trench not wider than 1 μm (1/1000 mm) etched 4 μm deep into the silicon.

1987 data book

The 320-page *1987 Data Converters and Voltage References* data book features information on 27 A/

D converters (including 16 new devices), 20 new D/A converters, and 11 voltage references from Maxim Integrated Products. A complete product listing, converter selector guides, and package information selector guides, and package information sections are also included.

For a free copy of the *1987 Data Converters and Voltage References* data book, contact a Maxim sales representative or distributor, or call Customer Service direct at 408/737-7600. *Maxim Integrated Products* 510 N. Pastoria Avenue, Sunnydale, CA 94086.

New Hall-effect switches

Sprague has developed a new sensor chip that makes possible the new UGN/UGS-3119, UGN/UGS-3120, and UGN/UGS-3140 monolithic Hall-effect switches that are less susceptible to mechanical stress and have better stability over their operating temperature ranges than earlier Hall-effect devices.

The 3119 is recommended for applications that provide steep magnetic slopes and low residual levels of magnetic flux density. The 3120 is for applications that require precise switch points. The 3140 is for use with small inexpensive magnets or for applications where there are relatively large distances between the magnet and the Hall cell.

The UGN types are rated for operation over the −20°C to +85°C temperature range. The UGS series has an operating range of −40°C to +125°C. All types are offered in two 3-pin plastic SIPS—a 60-mil thick (1.54 mm) "U" package and a 80-mil-thick (2.03 mm) "T" package. They also come in SOT 89 (TO-24AA) packages and in hermetically sealed 3-pin ceramic packages.

The UGN-3119, -3120, and -3140 are priced at $0.47, $0.50, and $0.81, respectively in lots of 100. The UGS-3119; -3120, and -3140 are priced at $0.79, $0.90, $1.20 each, respectively.

For detailed technical information,. request Data Sheets 26621, 27622, and 27627 from Technical Literature Service, *Sprague Electric Co.*, P.O. Box 9120, Mansfield, MA 02048-9120. **R-E**

AUDIO UPDATE

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in their players; but it seems to me that they are a necessity. The compression circuit could even be controlled by the brake system and arranged so that compression would be *off* when the car is stopped and *on* when it is moving. Or better yet, let's stay with cassettes—which to my mind are far more sensible for car use. At least one manufacturer (NAD) is producing a cassette deck with a novel car-tape recording feature. When the circuit is switched in, cassettes are recorded with both compression and equalization to compensate for both the noise and the special acoustics of the automotive environment.

As might be surmised, I'm all for psychoacoustic manipulation of the stereo signal if greater realism can be achieved. I've long since given up any hope of being able to provide facsimile reproduction in my home of an original acoustical event. I would be content with a reproduced musical performance that sounded *plausible* In other words, it might have been heard that way live in some other acoustic space and time. Plausible reproduction, in my use of the term, is not easy to achieve. Perhaps half a dozen times in my 30 years of audio involvement have I experienced the acoustic illusion "I am there" or "they are here." And in almost every case, for it to succeed, the illusion required multiple channels or binaural headphone reproduction.

I hope this brief guided tour through some of the mysteries of psychoacoustics has been interesting, instructive, and has provoked some appreciation of what it takes to delude your ears into believing that they are hearing music freshly producec without artificial preservatives. Psychoacousticians are well aware that they do not as yet have all the answers as to how to hear. However, I'm convinced that there's an R&D *Twilight Zone* inhabited by a few special psychoacoustically-oriented equipment designers from whose joint efforts the audio millennium will one day emerge. **R-E**

Information radio is on the air.

Before you hear *about* it on your old radio, hear it *live* on your new Informant Information Radio. Whether its an all-points-bulletin from the State Police, the dispatcher for the city's Fire Department, an ambulance racing to the hospital or a National Weather Service report, the new Informant from Regency makes you a part of all the action... instantly.

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Informant Information Radio uses a revolutionary new technology that allows you to constantly monitor your police, fire and emergency frequencies, as well as NOAA weather information channels in all 50 states. All pre-programmed. This new Information Radio utilizes a principle similar to the seek and scan feature found on expensive AM/FM radios. Your information radio scans the public service channels in the area, locates the active signals, locks in and broadcasts all the information right to you. With revolutionary TURBO-SCAN speed!

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ELECTRONIC XMAS TREE

THOMAS L. JOZWIAK

This pocket-size electronic Christmas tree will give your holiday lighting a new and festive look.

FOR ABOUT $10 YOU CAN BUILD A UNIQUE high-tech Christmas tree that will add a new and festive look to both your home and office holiday decorations. And because it's powered by two AA batteries, if you can't be home for the holidays you can pack one along in a suitcase to remind you of your loved ones.

The electronic Christmas tree is really a 6½-inch high tree-shaped printed-circuit board that's outlined by what appears to be randomly-blinking red, green, and yellow LED's. The tree's trimming is the components for the electronic circuit that makes the LED's wink and blink. The Christmas tree's base consists of two AA-size battery holders cemented together with the tree's PC board sandwiched between the two. A little imaginative spray painting before the components are installed puts a realistic finishing touch to the Christmas-tree project.

Because the LED's are continuously cycled *on* and *off*, two alkaline batteries provide more than 300 hours of continuous operation: that's enough to provide almost two full weeks of window display or entertainment before the batteries need to be replaced.

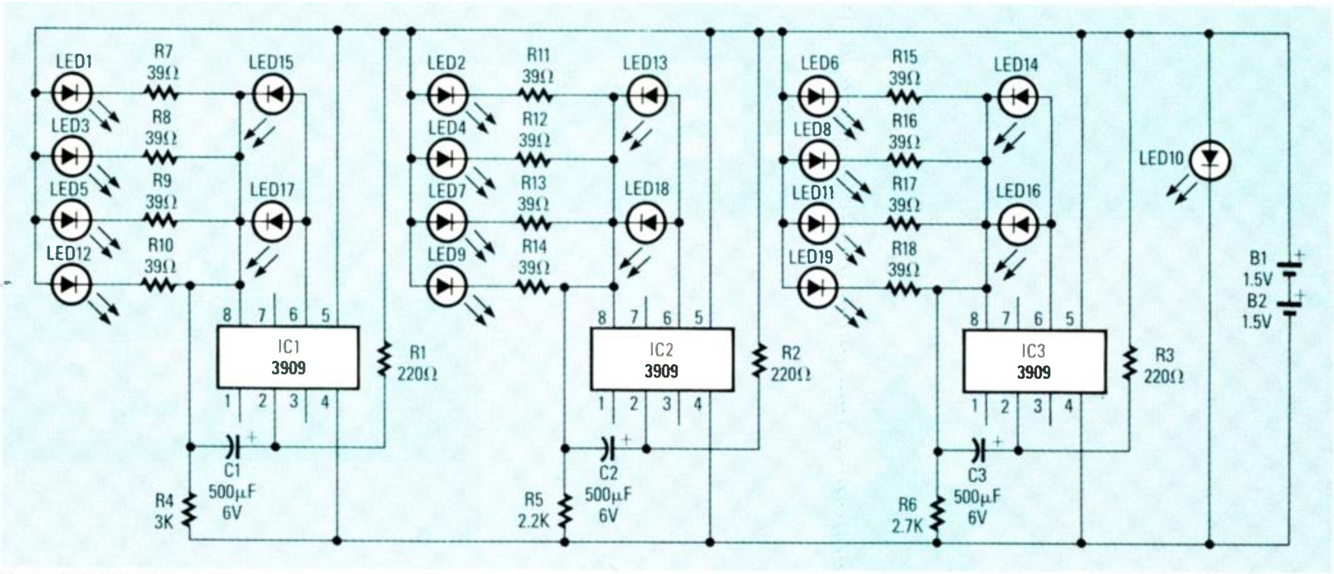

FIG. 1—THREE INDIVIDUAL FLASHER CIRCUITS having unrelated flash rates create a pseudo-randown blinking of the LED's because the LED's from each individual circuit are intermixed around the edges of the tree.

How it works

As shown in Fig. 1, three individual flashing circuits that use an LM3909 LED flasher/oscillator IC create the appearance of a pseudo-random firing order. The combination of C1/R4, C2/R5, and C3/R6 control the blink rate, which is between .3 and .8 second, while the inherent wide tolerance range (−20% to +80%) of standard electrolytic capacitors add to the irregularity of the blink cycles. The continuous current drain is about 10 mA; however, if you decrease the values of R4–6 or C1–3 in order to to increase the blink rate, the current will then increase proportionately.

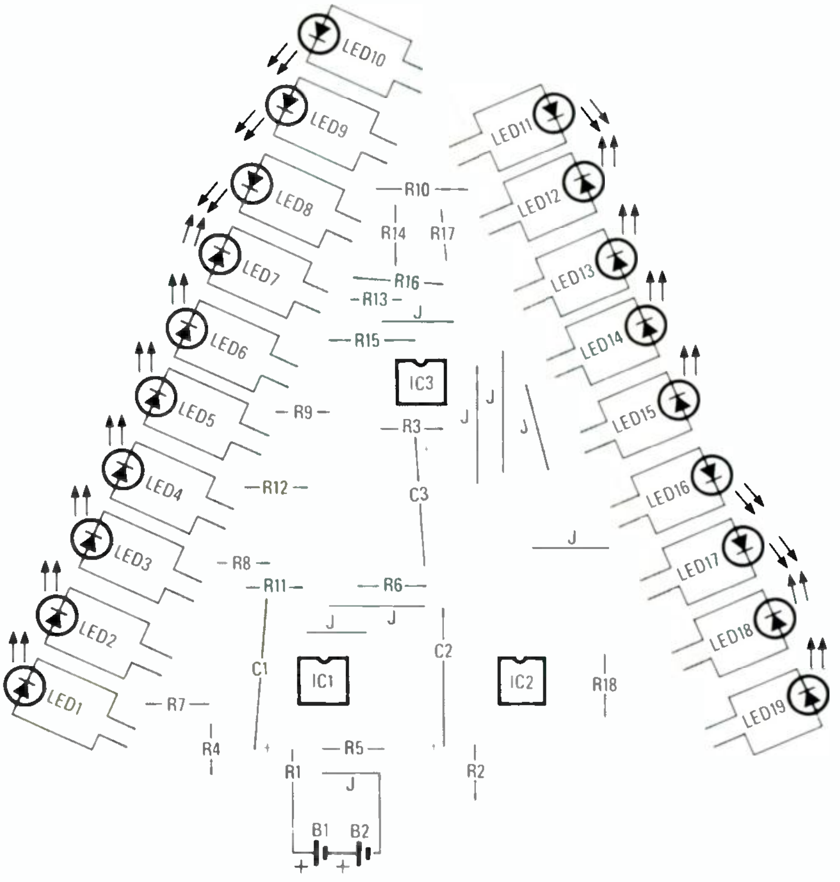

FIG. 2-TAKE EXTRA CARE THAT THE LED'S are installed with the correct polarities. If you want to decorate the "tree", do it before drilling the mounting holes for the components.

PARTS LIST

All resistors are ¼-watt, 5%.
R1–R3—200 ohms
R4—3000 ohms
R5—2200 ohms
R6—2700 ohms
R7–R18—39 ohms

Capacitors
1–C3—500 µF, 6 volts, electrolytic

Semiconductors
IC1–IC3—LM3909, LED flasher
LED1, LED4, LED7, LED13, LED 16, LED 19—Red, diffused 5-mm LED
LED2, LED5, LED6, LED11, LED14, LED17—Yellow, diffused 5-mm LED
LED3, LED6, LED9, LED12, LED15, LED18—Green, diffused 5-mm LED
LED10—Red flasher LED (Radio Shack 270-401 or equivalent)

Other Components
B1, B2—1.5-volt AA alkaline battery

Miscellaneous: battery holders, PC board, wire, solder, etc.

Note: An etched and drilled PC board is available for $10 postpaid from Fen-Tek P.O. Box 5012, Babylon, NY 11707-0012. NY residents must add appropriate sales tax.

Note in particular that external current-limiting resistors aren't needed for LED13 through LED18; the resistors are built into the IC's. LED10, which serves as the tree's "star," is a special kind of flashing LED that blinks continuously at a fixed rate.

Power can be turned off by simply removing either battery, or by slipping a small piece of paper between any battery and either of its battery-holder terminals. Of course, a switch can also be added.

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MACROVISION STABILIZER

Are copy-protected video tapes also mucking-up normal viewing on your TV? Then use a Macro-Scrubber to make the picture squeaky-clean.

D. DUPRE

YOU ARE PROBABLY ALREADY AWARE that the movie industry has launched a new front against video tape copying with a new "encoding" scheme called *Macrovision*. Although many new releases from Embassy, CBS/Fox, MGM/UA, HBO/Cannon, MCA, and Disney have been protected with it, its use is generally not advertised on the label. However, you can easily identify a *Macrovision*-processed tape by turning the vertical hold control on your TV (if your set has one) so that the black bar across the top of the picture becomes visible. If the signal contains *Macrovision* encoding, you will see five or six gray or white pulsating "boxes" on the left side of the black bar. According to a top *Macrovision* executive, plans are already in the works to transmit *Macrovision*-encoded signals through cable systems.

The basic idea behind the *Macrovision* process is to render the program material uncopyable to a VCR while allowing the unimpaired viewing of the original tape (a goal not achieved by the original *CopyGuard* system, which has since passed away). Although some proponents of the *Macrovision* process claim that the system meets those goals, numerous consumers who have either purchased or rented a number of *Macrovision*-encoded tapes can attest to the contrary. That is evidenced by the large influx of letters to magazines predominant in the video field, and by continuous complaints to video rental and retail stores.

Both the users and developers of the *Macrovision* process admit that some TV's and VCR's are adversely affected in the PLAY mode, but that that percentage is very small. So, if you are one of the "small percentage" you probably have a significant sum of money invested in the best features that state-of-the-art video has to offer; yet with it you wind up watching a dark murky picture that may be flashing, rolling or streaking as well.

If you're among the users who have discovered that your VCR or TV equipment simply can't handle the so-called

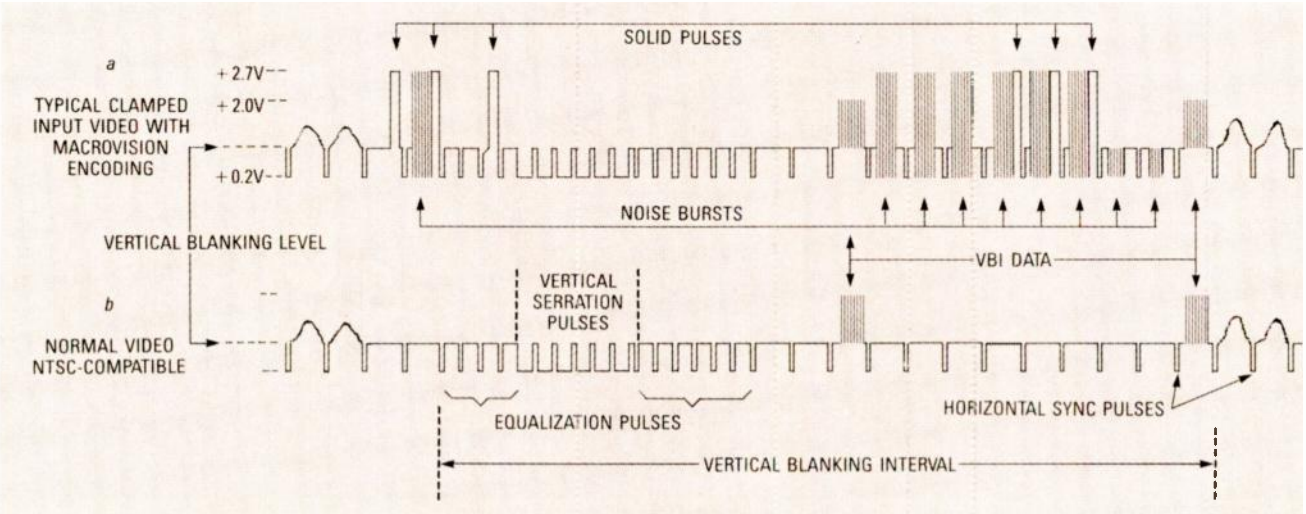


FIG. 1—MACROVISION DELIBERATELY injects interference during the vertical-blanking interval (*a*). The Macro-Scrubber restores the signal to standard NTSC (*b*).

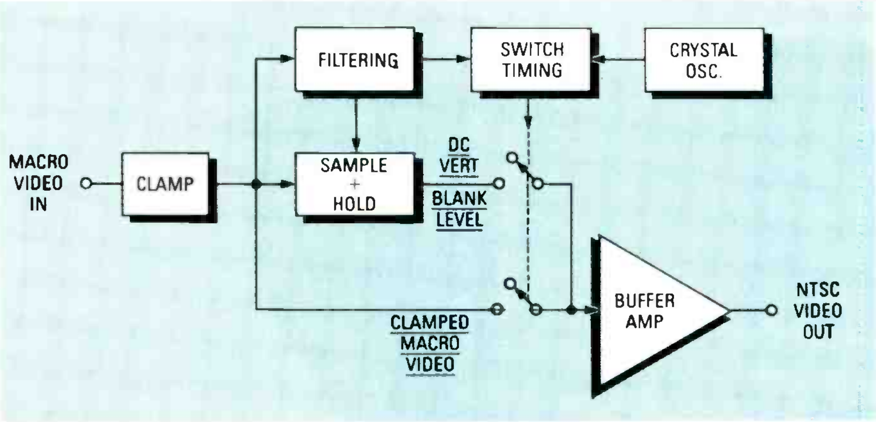


FIG. 2—AN ELECTRONIC DPDT SWITCH is used to restore the video signal to the conventional NTSC format.

"invisible" *Macrovision* encoding, then you need the Macro-Scrubber, a device that simply eliminates the encoding. Plug the device between your VCR and its TV or monitor and you won't know that *Macrovision* even exists.

Macrovision encoding

Macrovision is not an encoding process at all. If it were, then an appropriate decoder would have to be made available to the consumer just so he could view a *Macrovision*-encoded tape. In fact, the video information remains intact and unmodified in the signal, as does the audio. The encoding is really a disturbance in the TV signal's vertical-blanking interval that is supposed to affect only a VCR attempting to copy the tape. Unfortunately, the encoding also affects some TV's. By simply eliminating the disturbance and returning the offending signal to normal NTSC standards you can view a completely normal picture while playing a *Macrovision*-processed tape.

As shown in Fig. 1, the *Macrovision* process merely injects noise bursts and solid pulses into the signal during selected line times within the vertical blanking interval. One possible form of *Macrovision* encoding is shown in Fig. 1-*a*; the same signal in conventional NTSC form is shown in Fig. 1-*b*. The peak level of the bursts is randomly varied from black to white. Sometimes the bursts are pumped between two or three different levels; at other times the burst level is ramped slowly up and down. The location of the injected noise is also randomly alternated between the available line times; however, the location and level of solid pulses usually remains constant for the duration of a particular title—thus all copies of a particular title have the same encoding.

The *Macrovision* irregularities created during the vertical retrace time are intended to upset a VCR's RECORD-mode AGC circuit so that it records an unviewable picture. Since a VCR is designed to record only the NTSC video signal—which contains no noise transitions during the vertical blanking interval—any fast irregularities in the vertical blanking interval cannot be tracked by the AGC.

The effectiveness of the *Macrovision* anti-copying system varies with the type of VCR used, but in general, synchronization is lost, leaving an unviewable picture on the attempted copy. At best, the resulting dubbed copy will exhibit erratic brightness changes. Sometimes the picture will roll vertically due to a noise burst injected just before vertical sync.

WARNING

Duplication of copyright material is prohibited by law. The Macro-Scrubber is recommended for use only between a VCR and its TV or monitor as a solution to viewing problems that are generated within the TV or the monitor by *Macrovision* encoding.

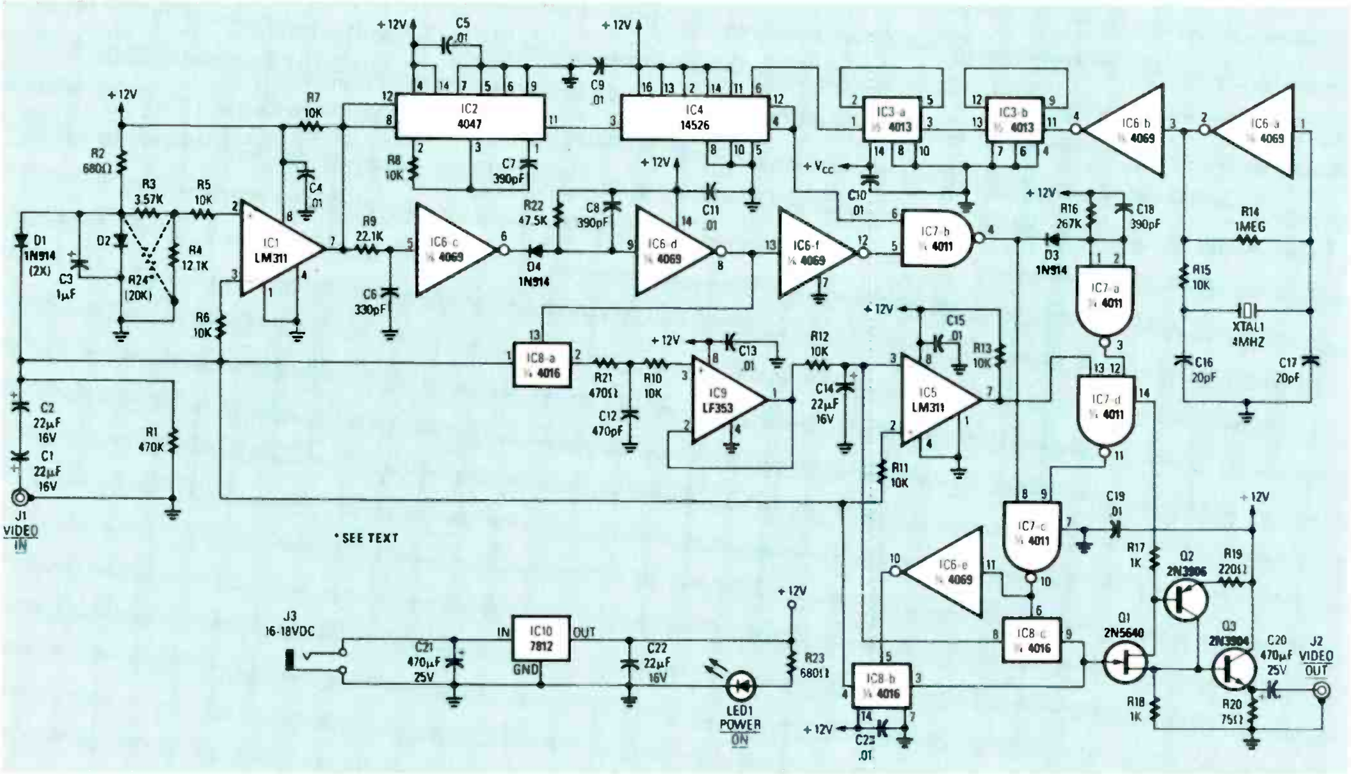


FIG. 3—THE INPUT-SIGNAL LEVEL must be within a specified range for the Macro-Scrubber to work properly. If there is some problem with the input-signal level it is suggested that R24—shown with dashed lines—be substituted for R3 and R4.

COMPLEX IS REALLY BETTER

The majority of devices sold with a purpose similar to that of the Macro-Scrubber either blank or clip the entire vertical-blanking interval, which also removes any other VBI data (color correction signals, closed captions, teletext, etc.). They then attempt to economically reconstruct the entire vertical-blanking interval, including horizontal sync, equalization, and serration pulses. From a technical viewpoint, that is often not very successful because the characteristics of the reconstructed pulses are usually set to some form of "standard" value, and as such do not really match the actual input signal. Since those units do not actually detect and selectively remove the *Macrovision* noise, they also strip the vertical-blanking interval of a normal TV signal if not bypassed or removed from the system.

Many models also require factory-type calibrations of numerous timing potentiometers. Their new blanking level is either preset to some kind of standard value or an external adjustment is provided to compensate for signals from different video tapes or sources.

What makes the Macro-Scrubber unique, when compared to the restoration devices, is that there are there are no precision adjustments; digital filters remove only the *Macrovision* pulses and pass the original vertical-blanking interval data and sync pulses, while sample-and-hold circuits reproduce the correct vertical-blanking level, which is switched into the output signal in place of *Macrovision* pulses. Also, the use of a crystal oscillator eliminates the need for timing adjustments. And since the Macro-Scrubber has no effect on normal video signals, there is no need to switch the Macro-Scrubber out of the system for normal viewing.

Unfortunately, similar symptoms sometimes are experienced when merely playing the original tapes on some VCR/TV combinations.

A logical solution

In comparing Figs. 1-*a* and 1-*b*, you can see that a normal NTSC video waveform is held at the vertical blanking level during times when injected noise exists in the *Macrovision*-encoded waveform. By locating the individual noise bursts and solid pulses, and by connecting the output to a DC voltage that is equivalent to the vertical blanking level at those times, we can essentially recreate the NTSC version of the waveform. When no encoding signals are present, we connect the output to the clamped video input.

Figure 2 shows a block-diagram of how the encoding can be removed. First, the incoming video signal is clamped to hold the negative sync tips at the same level, thereby removing any AC hum or other time-varying offset from the signal; that step is critical for detecting signal transitions against a fixed reference level. The clamped video is then sent to a filtering circuit to accurately locate the noise bursts and the solid pulses from which the switch-timing and the control signal are created. (A crystal oscillator is used so that timing adjustments aren't necessary.)

The sample-and-hold circuit continuously samples the video waveform to generate a DC voltage equivalent to the vertical blanking level of the incoming signal. That assures that the switched-in blanking level is always correct for the actual input signal applied and eliminates the need for any manual adjustment. Finally, an electronic double-pole, single-throw switch that is controlled by the noise-locating signal connects either the clamped input video or the reproduced blanking level to the output buffer amplifier. In so doing, *Macrovision* noise is eliminated and the signal is restored to normal NTSC video.

Circuit description

Figure 3 shows Macro-Scrubber's circuit. The *Macrovision*-encoded video signal is applied to jack J1 and is fed through back-to-back capacitors C1 and C2 to a resistor/diode network that clamps the negative sync tips close to ground potential (approximately 0.2 volt). The clamped video input applied to IC1's inverting input (pin 3) resembles the waveform shown in Fig. 1-*a*. A DC reference voltage derived from diode D2 is fed to IC1's non-inverting input (pin 2). Since the DC reference is slightly higher than the clamped voltage, IC1's output goes positive whenever the input signal is lower than the reference signal. As shown in Fig. 4-*a*, IC1 outputs a waveform that is normally low (0 volts) with high-going pulses con-

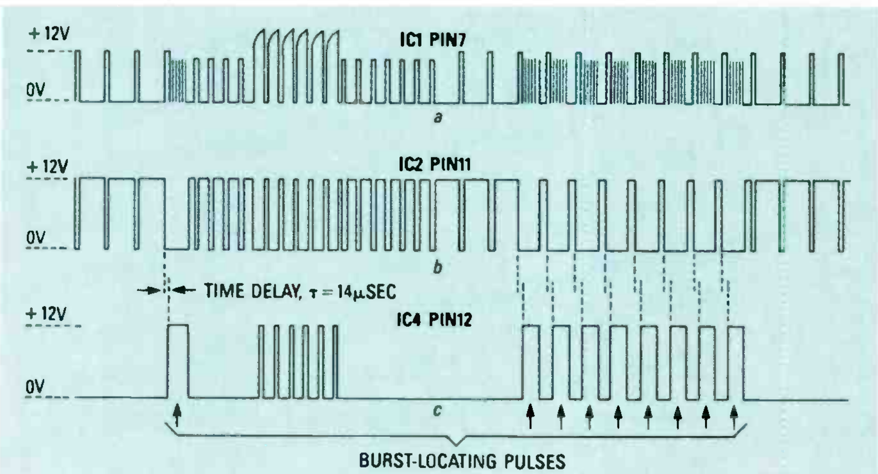


FIG. 4—THE MACRO-SCRUBBER GENERATES noise pulses which are used to locate and suppress the *Macrovision* noise-burst interference.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.
R1—470,000 ohms
R2, R23—680 ohms
R3—3,570 ohms, 1%
R4—12,100 ohms, 1%
R5–R7, R10–R13, R15—10,000 ohms
R8—10,000 ohms, 1%
R9—22,100 ohms, 1%
R14—1 Megohm
R16—267,000 ohms, 1%
R17, R18—1,000 ohms
R19—220 ohms
R20—75 ohms
R21—470 ohms
R22—47,500 ohms, 1%
R24—20,000 ohms, trimmer potentiometer

Capacitors
C1, C2, C14, C22—22 µF, 16 volts, electrolytic
C3—1 µF, 35 volts, electrolytic
C4, C5, C9–C11, C13, C15, C19, C23—0.01 µF, ceramic disk
C6—330 pF, NPO
C7, C8, C18—390 pF, silver mica
C12—470 pF, polypropylene
C16, C17—20 pF, NPO
C20, C21—470 uF, 25 volts, electrolytic

Semiconductors
IC1, IC5—LM311 comparator
IC2—4047B multivibrator
IC3—4013B dual D flip-flop
IC4—4526B binary counter
IC6—4069B hex inverter
IC7—4011B quad NAND gate
IC8—4016B quad analog switch
IC9—LF353 dual JFET op-amp
IC10—7812, 12-volt regulator
Q1—2N5640, JFET transistor
Q2—2N3906, PNP transistor
Q3—2N3904, NPN transistor
D1–D4—1N914, switching diode
LED1—Light-emitting diode

Other components
XTAL1—4-MHz crystal, AT cut (parallel), HC-18 package
J1, J2—RCA-type phono jacks

Miscellaneous: PC board materials, 16–18-volt, 200-mA AC adapter, etc.

Note: A complete Macro-Scrubber kit, model *MAK-1*, which includes the PC board, cabinet, all components, and an AC adapter, is available for $52.95 plus $3.00 shipping and handling from: The Hobby Helper, P.O. Box 308, Bridgewater, MA. 02324. (617) 339-1026. Massachusetts residents must add appropriate sales tax.

current with negative-going pulses below the vertical-blanking level (i.e. horizontal-sync pulses, equalization pulses, vertical-serration pulses, and *Macrovision* noise bursts).

The clamped video signal is also delivered to the input of a sample-and-hold circuit, which consists primarily of analog switch IC8-a, hold capacitor C12, and op-amp IC9. The switch is driven in such a way that it samples the level of the video signal only during vertical-sync time at the peaks of the vertical-serration pulses. The output of IC9 is a DC voltage equal to the vertical-blanking level, which will be switched into the output waveform in place of the *Macrovision* noise bursts and solid pulses.

Clamped input video is fed to the input of analog switch IC8-b, and the DC output voltage from IC9 is fed to the input of analog switch IC8-c. Notice that the outputs of analog switches IC8-b and IC8-c are connected together, and that because of inverter IC6-e, their control inputs at pins 5 and 6 respectively are driven 180° out of phase. That arrangement creates the electric equivalent of a single-pole, double-throw switch, with either the clamped input video or a DC voltage that is equal to the vertical-blanking level being fed to buffer amplifier Q1 at any one time.

It is through control of the electronic DPDT switch shown in Fig. 2 that the encoded video is restored to a normal NTSC signal. All that is needed is a proper signal to pin 6 of IC8.

The signal from IC1 pin 7 (Fig. 4-*a*), which contains pulses that correspond to the sync and the *Macrovision* noise pulses, is fed to IC2 pins 8 and 12. IC2 is a multivibrator that is configured as a digital low-pass filter. The time constant determined by R8 and C7 causes frequencies greater than twice the horizontal frequency to be filtered out. IC2's output at pin 11 looks like a squared-up and inverted version of its input, except that the high-frequency pulses corresponding to the *Macrovision* noise bursts have been filtered out, leaving a low level for each burst duration. (See Fig. 4-*b*).

The filtered signal is fed to pin 3 (ENABLE) of binary counter IC4. A 4-MHz crystal-oscillator circuit feeds dual flip-flop IC3, which divides the crystal frequency by four, yielding a 1-MHz clock input to IC4 pin 6. When the input at IC4 pin 3 goes high, that counter is asynchronously preset to the binary value determined by preset lines P3, P2, P1, and P0 (pins 2, 14, 11, and 5 respectitvely). With the connections shown in Fig. 3, the preset count is 14 decimal (1110 binary). Whenever the count is not zero, the counter output at pin 12 is low. The counter decrements once for each clock pulse it sees on pin 6 while pin 3 remains low. Thus, 14 µs after the leading, negative-going edge of the input signal on pin 3 goes low, the count reaches 0 and the counter's output switches high. The high output is fed back to pin 4, the INHIBIT line, which prevents any further counting. When the input signal at pin 3 returns high, the counter is again preset to a 14 count and the output returns to its low preset state. low input pulses having a duration less than 14 µsec are ignored because the counter is preset before the count ever reaches zero.

The resulting output signal at IC4 pin 12 is normally low, with high-going pulses that start 14 µs after the beginning of each horizontal-sync pulse that precedes a *Macrovision* noise burst. The 14 µsec delay forces the horizontal sync pulses (and color-bursts) to be switched into the output waveform. Each of the noise-burst locating pulses returns to a low at the end of the corresponding *Macrovision* burst. Those pulses, as shown in Fig. 4-*c*, define the points in time when the bursts occur, with one exception. Concurrent with the vertical-serration pulses, there are a string of pulses that must be removed in order to create a signal that will totally isolate the *Macrovision* noise. In order to remove those pulses we must create a gating signal with a single pulse that lasts only for the duration of the vertical sync pulse in each frame. To do that, sync and noise pulses from IC1 pin 7 (Fig. 4-*a*) are fed to a low-pass filter consisting of R9 and C6.

Narrow, positive-going pulses are attenuated because C6 never gets a chance to charge to a logic-high level unless the pulses are long compared to the time constant determined by R9 and C6. The only pulses wide enough to allow C6 to charge

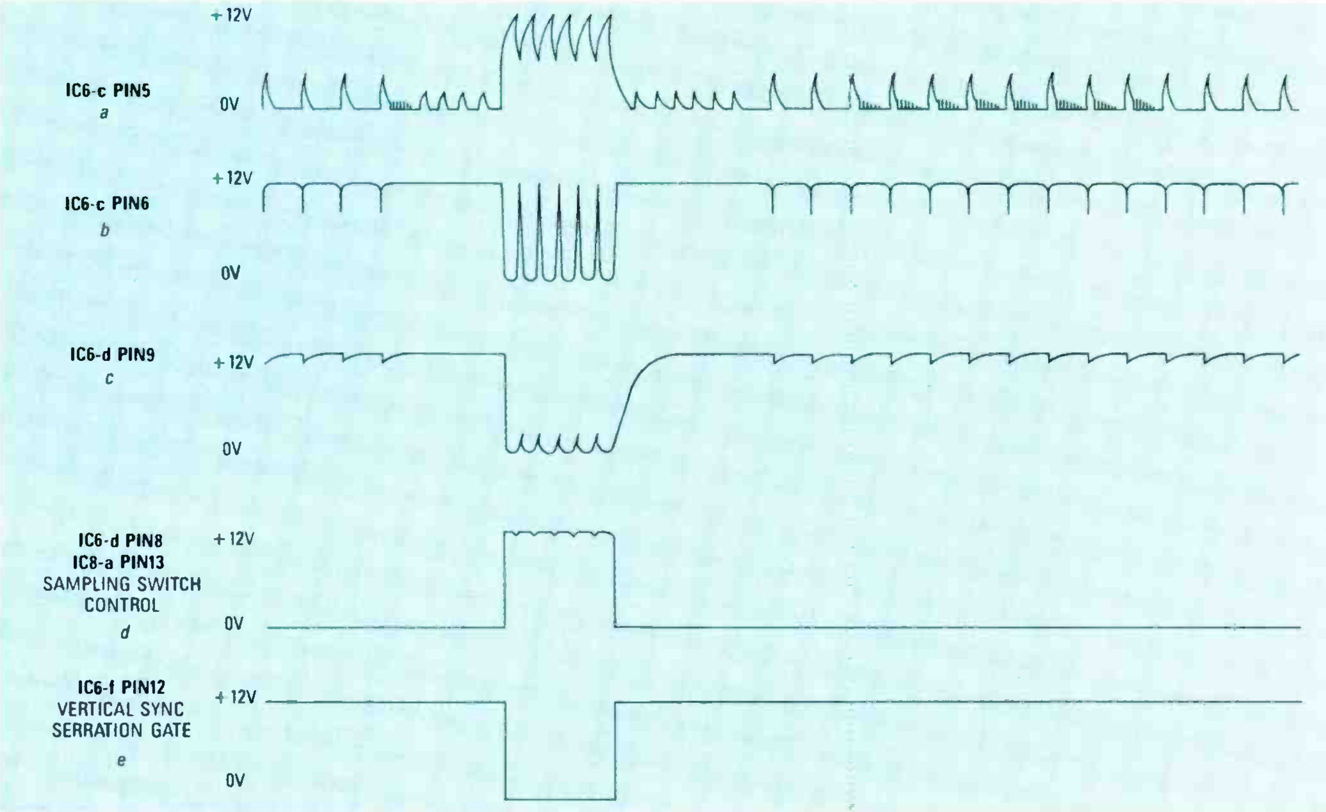


FIG. 5—VERTICAL SYNC AND BLANKING level sampling pulses are derived from the *Macrovision*-induced noise bursts.

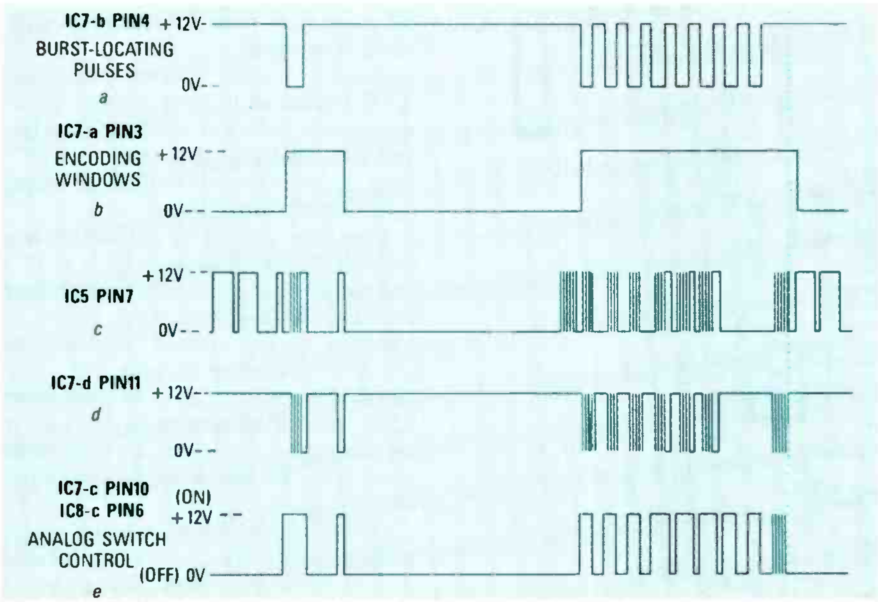


FIG. 6—WINDOWS DERIVED FROM the burst-location pulses provide the switch control signals that eliminate the *Macrovision* interference from the output signal.

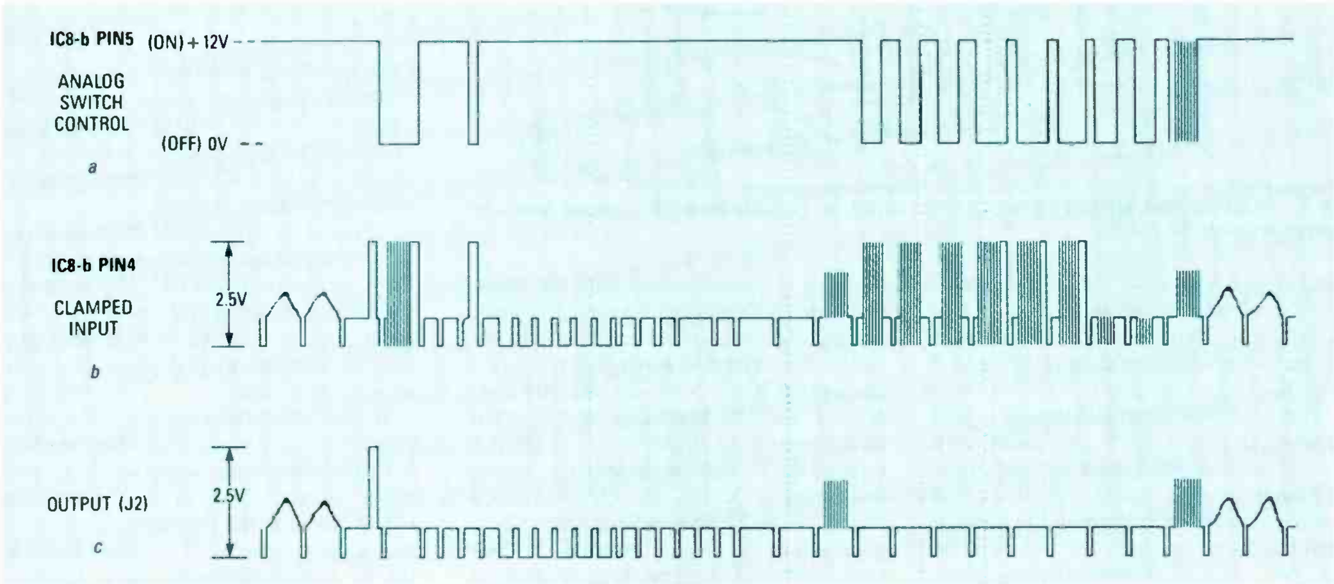


FIG. 7—THE NTSC SIGNAL IS CREATED by selectively switching the encoded input and the sampled vertical-blanking level into the output.

to a logic-high value are those corresponding to the vertical serration pulses.

Therefore, as shown in Fig. 5-*a*, at IC6-c pin 5 we have a signal that has +5-volt pulses corresponding to the horizontal sync pulses, and +12-volt pulses concurrent with the serration pulses during vertical-sync time.

Inverter IC6-e discriminates farther, since input pulses lower than a logic high (approximately +7V for a +12V supply) will not trigger output pulses. Therefore, as shown in Fig. 5-*b*, at inverter IC6-e pin 6 we have a normally high signal with low-going pulses occurring only during the vertical sync period. When that signal goes low, diode D4 becomes forward-biased and inverter IC6-d pin 9 is immediately pulled low as well. When IC6-e pin 6 goes high, D4 is reverse-biased, so that pin 9 charges to a logic-high level at a rate determined by R22 and C8. (See Fig. 5-*c*.) Again, narrow pulses are ignored and, as shown in Fig. 5-*d*, the inverter's output (IC6-d pin 8) is normally low with logic-high sync pulses.

The inverter's output signal turns on sampling-switch IC8-a during the vertical-serration time, and C12 charges to the vertical blanking level. The high input impedance of op-amp IC9, and IC8-a in its OFF state, prevent the charged voltage on C12 from leaking off between samples. Unity-gain amplifier IC9 feeds C12's DC-voltage level to analog switch IC8-c, where it will be switched into the output waveform in place of the *Macrovision* noise.

As shown in Fig. 5-*e*, the vertical-sync signal at IC6-d pin 8 is inverted by IC6-f, and is then fed to NAND gate IC7-b to gate the burst-locating signal from IC4 pin 12 (Fig. 4-*c*). The output signal at IC7-b pin 4 (Fig. 6-*a*), is normally high, with logic-low pulses that last for the duration of the corresponding *Macrovision* noise burst.

Notice, from Fig. 1-*a*, that some *Macrovision* bursts are followed by a solid pulse that doesn't have a negative transition. Since the *Macrovision* noise-locating pulses shown in Fig. 6-*a* were created by detecting high-frequency bursts below the blanking level, they do not locate the solid pulses. In order to remove the solid pulses without affecting any non-*Macrovision* pulses we must: 1) detect positive transitions above the vertical blanking level that occur during the *Macrovision*-encoded areas of vertical blanking, and 2) combine the new signal that locates the *Macrovision* solid pulses with the signal that locates the *Macrovision* noise bursts at IC7-b pin 4.

Macrovision-encoded areas of the signal are defined by feeding the signal at IC7-b pin 4 (Fig. 6-*a*) to a low-pass filter consisting of D3, R16, C18, and IC7-a. The resulting waveform at IC7-a pin 3 contains wide pulses, or *windows*, that define the time periods in which the *Macrovision* encoding is present. That signal is shown in Fig. 6-*b*.

The DC output voltage from the sample-and-hold circuit is fed to the inverting input of comparator IC5, while the clamped video input signal is fed to IC5's non-inverting input. A train of high-going pulses appears at IC5 pin 7 that corresponds to all transitions above the blanking level; including video, vertical-blanking interval data and *Macrovision* pulses. See Fig. 6-*c*.

The signal from IC5 pin 7 (Fig. 6-*c*) is gated by the window pulses from IC7-a

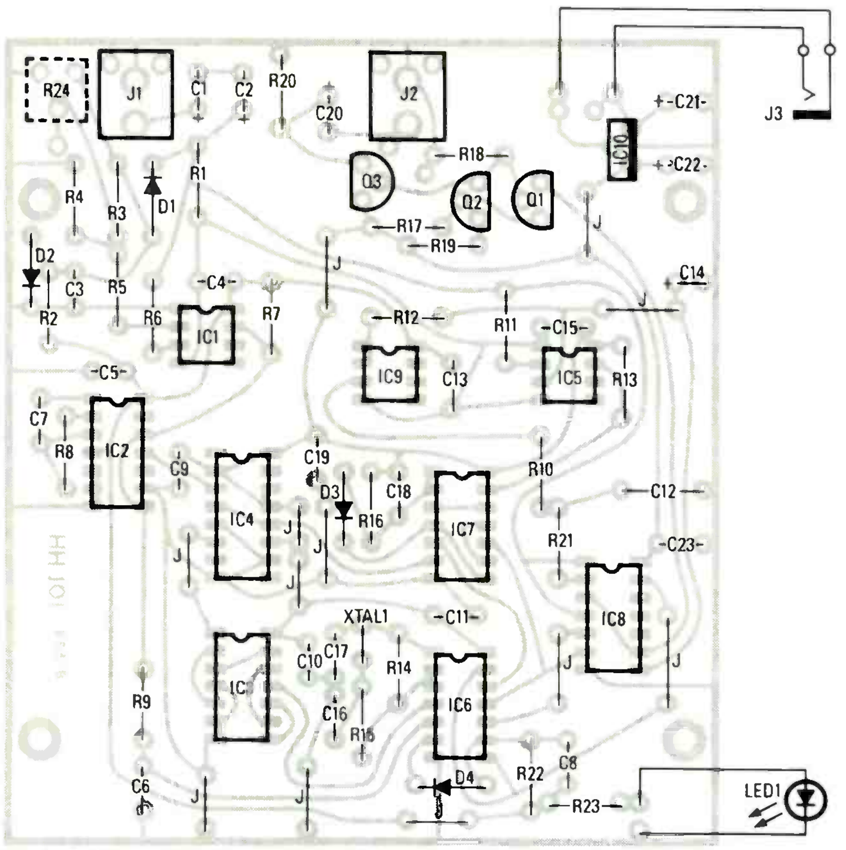


FIG. 8—RESISTOR R24, SHOWN BY THE DOTTED LINES, isn't usually used. If it is needed, you must remove resistors R3 and R4.

pin 3 (Fig. 6-*b*) at NAND gate IC7-d, yielding the waveform shown in Fig. 6-*d* at IC7-d pin 11. That signal is combined with the burst-locating signal from IC7 pin 4 (Fig. 6-*a*) by NAND gate IC7-c.

The final *Macrovision*-locating signal appears at IC8-c pin 6 and looks very similar to an inverted version of the original burst-locating signal (Fig. 6-*a*), but the pulses have been stretched to include both the bursts and the solid pulses. (See Fig. 6-*e*.) Notice that no locating pulse exists to remove the single solid pulse occurring at the start of the vertical blanking shown in the sample input waveform (Fig. 1-*a*). That is because there is no preceding negative noise burst that can be used to locate the solid pulse. As a result, that pulse will remain in the output waveform (Fig. 7-*c*), but it doesn't cause a problem because it is narrow and is not pumped.

The signal shown in Fig. 6-*e* directly feeds the control input, IC8-c pin 6, and an inverted form of the signal (Fig. 7-*a*) feeds analog switch IC8-b via inverter IC6-e.

The removal of the *Macrovision* encoding signal works as follows: During video time, horizontal-sync time, vertical-serration time, and all non-*Macrovision*-encoded vertical-line times, the control input of analog switch IC8-c is low—the switch is open. At the same time, the control input of analog switch IC8-b is high—it is closed, connecting the clamped-video video (Fig. 7-*b*) to Q1's gate. During *Macrovision* noise times, the situation is reversed. Switch IC8-b is open and switch IC8-c is closed, thereby connecting the DC blanking voltage from sample-and-hold amplifier IC9 to Q1. An impedance-matching amplifier stage, consisting of Q1, Q2, and Q3, provides a match for the 75-ohm video output. Thus, as shown in Fig. 7-*c*, a "normal" NTSC-compatible video signal is reconstructed at the output, eliminating only the *Macrovision* noise.

Construction

The circuit is assembled on a printed-circuit board. The foil pattern for that board is provided in PC Service. The parts-placement diagram for that PC board is shown in Fig. 8.

Begin stuffing the printed-circuit board by first installing all resisitors, diodes, and capacitors. Make sure that all of the electrolytic capacitors and the diodes are installed with the proper polarity. Save the clipped component leads for use as jumpers.

Capacitor C12 must be a "polypropylene" type because the extremely low-leakage characteristic of the material prevents the vertical-blanking hold voltage from sagging between samples. As correct R-C time constants are critical to the proper operation of the circuit, use of the component values shown in the schematic is essential.

The PC board's spacing for crystal XTAL1 is for an HC-18 package. Values specified in the Parts List for resistors R14 and R15, and capacitors C16 and C17, must be used in order to insure proper operation of the oscillator.

Mount the transistors and voltage regulator IC10 next. Transistor Q1 is an FET and should be handled with proper regard for static charges. A heatsink should be mounted on the voltage regulator, especially if the circuit is housed in a case that has limited ventilation. Potentiometer R24, which is indicated by dashed lines in the schematic, is not normally used, so its holes in the PC board will remain empty. (We'll explain R24 later.)

Finally, mount the IC's, using proper precautions for static electricity because most of them are CMOS. Sockets aren't necessary, but using them would make any troubleshooting or repair easier. The project will fit nicely into a PAC-TEC *CM5-125* case.

Checkout and hookup

Apply power and check that the AC adapter's output voltage is between 14–24-volts DC when it is powering the circuit, and that IC10's output voltage is +12-volts DC, ±0.6 volt.

Connect an input signal and monitor or a TV to the Macro-scrubber. Connect the VCR's video output to J1. If you have a video monitor or a TV having a video input, connect the Macro-scrubber's output, J2, directly to that piece of equipment's video input.

If your equipment lacks a video input, you'll need an RF modulator for the channel you normally use when watching your VCR (channel 2, 3, or 4). Connect the video output to the modulator's video input. Connect the VCR's audio output to the RF modulator's audio input. Connect the modulator's RF output to the TV's antenna-input jack or terminals.

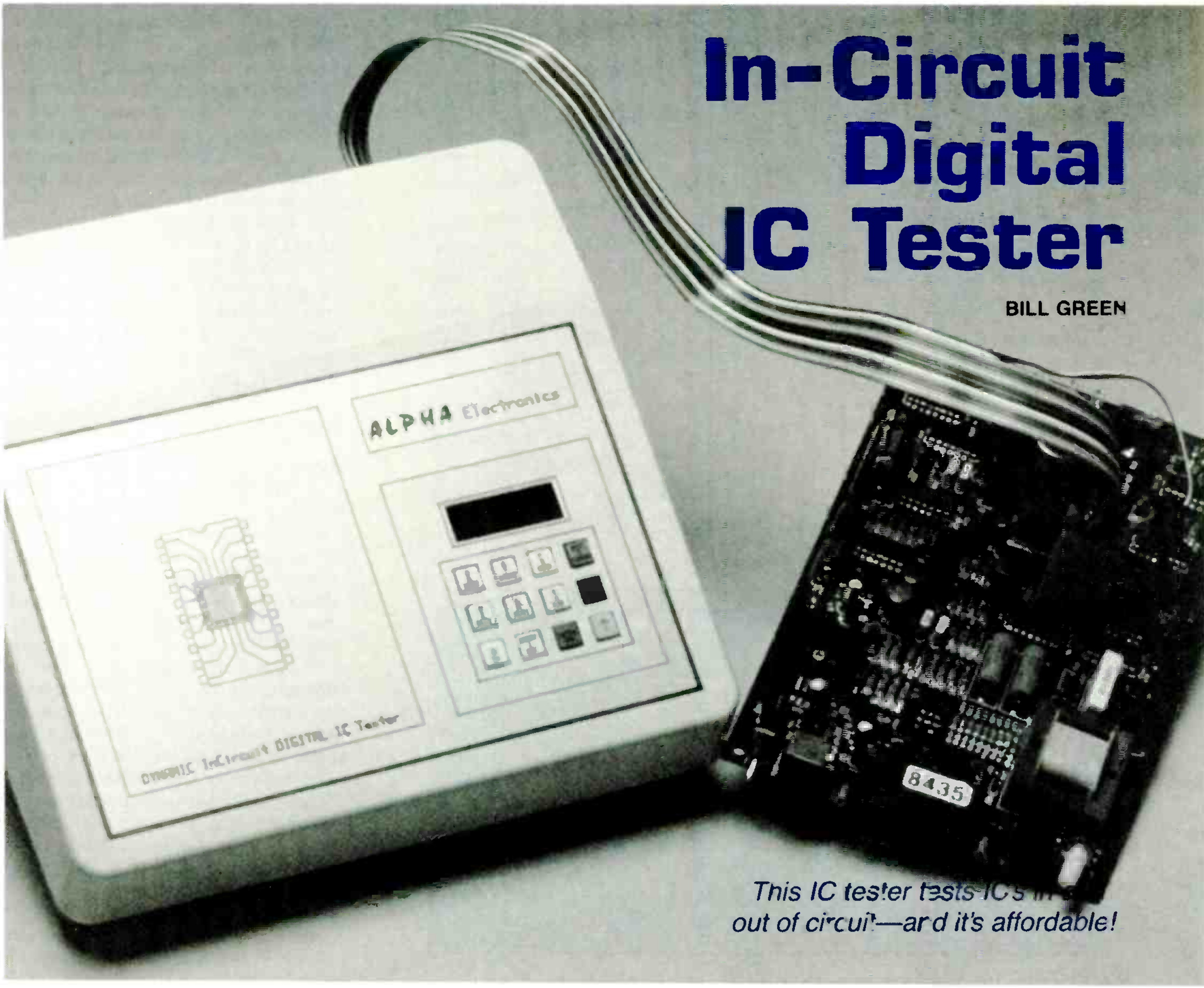
Play a video tape that you have already identified as containing *Macrovision* pulses. The picture you see should now be free of interference.

If the *Macrovision*-related viewing problems still exist, or if part of the picture is blanked out, the input-signal level from your VCR may be excessively high or low. In that case, a pattern of holes has been provided in the PC pattern so that fixed resistors R3 and R4 can be replaced with a 20,000-ohm potentiometer. The potentiometer is shown in the schematic by dashed lines, and is identified in the schematic and on the PC placement diagram as R24. (Remember, if you install R24 you must remove R3 and R4.)

To adjust R24, play a *Macrovision* tape, and while observing the TV picture, adjust R24 until the picture appears to be normal—interference-free. **R-E**

In-Circuit Digital IC Tester

BILL GREEN



This IC tester tests IC's in or out of circuit—and it's affordable!

Part 2

LAST MONTH WE BUILT the tester and discussed basic test methodology. Now we'll go on and provide specific examples showing how to set up your own test routines on paper and by computer, and how to send those files to and from your desktop computer.

Before we get started, lets correct a few errors from last month. The schematic of the driver board incorrectly identified P2 and P4. Also, the ordering information should have noted that IC16 and IC17 are not included in the partial kit.

7404 test data

Here is how to generate test data. This procedure applies whether data is entered via external computer using the data-entry routine discussed later, or is entered via the tester's keyboard.

Our first example illustrates the process for a 7404 hex inverter. First, obtain the pin numbers for inputs, outputs, V_{CC}, and ground, and the functional description (or truth table) from the device's data sheet.

To ease the process of generating the test data, make a copy of the template shown in Fig. 7; then fill in the blanks for the part number, number of pins, and group number. You must make a template for each test group if you need more than one. You may also sketch the part's logic diagram in the box on the template.

Next fill in the data blanks, leaving room to write eight binary digits at each pin that must be tested. If we put a 1 into an inverter, we should get a 0 out of it. So put a 1 in the blank for pin 1, and a 0 by pin 2. Repeat the procedure with the remaining five inverters. Then put an X at pins 7 and 14 to indicate that they will be ignored. Now we have all data for the first test cycle.

There is a total of eight test cycles, so now place a 0 at each input and a 1 at each output. (The X's should remain by pins 7 and 14.) That accounts for two of the eight bits in this test group's byte, so duplicate the bit pairs four times. Then convert the eight-bit data, four bits at a time, to two hexadecimal digits using the binary/hexadecimal chart at the bottom of the template. The completed test form is shown in Fig. 8.

The test information, along with the part number and the number of pins, is then stored in the tester's memory using the procedure outlined last time. There is no need for more than one test group to test a 7404 completely.

In-circuit example

The data for an in-circuit IC depends on how the IC is connected. For example, input pins may be tied to V_{CC} or to ground, so we tell the tester to ignore those pins. Or, if the IC's input is connected to one of its outputs, ignore the input, because its data will be supplied by the output it's connected to. A sample chart is shown in Fig. 9.

TEST ROUTINE TEMPLATE

PART NUMBER (8 Alphanumeric Digits Maximum: ____________
NUMBER OF PINS (2 Digits Maximum, Even Numbers 4 to 24): ____________
GROUP NUMBER (1 to 5): ________
REMARKS: ____________

Binary Data	Hex	Funct	Pin#		Pin#	Binary Data	Hex	Funct
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____
____ =	____	____	____		____	____ =	____	____

BINARY TO HEXADECIMAL CONVERSION TABLE

BINARY	HEX	BINARY	HEX
0000	0	1000	8
0001	1	1001	9
0010	2	1010	A
0011	3	1011	B
0100	4	1100	C
0101	5	1101	D
0110	6	1110	E
0111	7	1111	F

FIG. 7—COPY THIS TEMPLATE to simplify generating your own test routines.

Multiple test groups

IC's with pins that can function as both inputs and outputs can be tested as follows. We'll use a 74LS245 octal bus transceiver for illustration. That IC is commonly used to buffer data into and out of a microprocessor; direction of data flow is controlled by a single DIR input (pin 1).

The data for testing the IC in send mode is shown in Fig 10; the data for testing it in receive mode is shown in Fig. 11. Notice that the data in both cases is identical except for the setting of the direction line.

The enable line of a registered (latched) IC must be toggled to ensure that the IC responds when it is enabled, and does not respond when it is not enabled. Fig. 12 shows the test pattern for a 74LS373 octal data latch. The outputs should follow the inputs when the enable line (pin 11) is high, and shouldn't change otherwise.

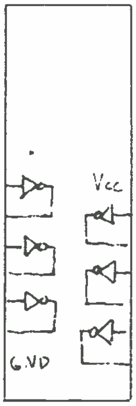
Clocked logic

A clocked IC that has no means of setting or clearing its outputs will have an indeterminate state before it is clocked. Therefore, all outputs must be listed as indeterminate (D). The first state of a pin defined as indeterminate will be cleared to zero. (Only outputs can be indeterminate.) The remaining 7 states of the group will be processed normally. If more than one test group is needed, the first state of each additional group will not be indeterminate and should be defined as Output. Note in the test data that the clock line goes high in the odd-number cycles (1, 3, 5, and 7). The outputs will only change on those cycles, because the 74LS374 changes state during the leading clock edge. Test data is shown in Fig. 13.

Multiple-output-state devices

An IC with many inputs or outputs may require more than one test group. (Remember that there is a maximum of five test groups per part number). For exam-

PART NUMBER (8 Alphanumeric Digits Maximum 7404
NUMBER OF PINS (2 Digits Maximum, Even Numbers 4 to 24) 14
GROUP NUMBER (1 to 5). 1
REMARKS HEX INVERTER



Binary Data	Hex	Funct	Pin#	Pin#	Binary Data	Hex	Funct
0101 0101	55	I	1	14			X
1010 1010	AA	O	2	13	0101 0101	55	I
0101 0101	55	I	3	12	1010 1010	AA	O
1010 0101	AA	O	4	11	0101 0101	55	I
0101 0101	55	I	5	10	1010 1010	AA	O
1010 1010	AA	O	6	9	0101 0101	55	I
		X	7	8	1010 1010	AA	O

FIG. 8—TEST DATA FOR A 7404 hex inverter. All states are redundantly checked four times.

PART NUMBER (8 Alphanumeric Digits Maximum 7404
NUMBER OF PINS (2 Digits Maximum, Even Numbers 4 to 24) 14
GROUP NUMBER (1 to 5). 1
REMARKS IN-CIRCUIT

Binary Data	Hex	Funct	Pin#	Pin#	Binary Data	Hex	Funct
0101 0101	55	I	1	14			X
1010 1010	AA	O	2	13			X
		X	3	12	0000 0000	00	O
0101 0101	55	O	4	11	0101 0101	55	I
		X	5	10	1010 1010	AA	O
1010 1010	AA	O	6	9	0101 0101	55	I
		X	7	8	1010 1010	AA	O

FIG. 9—TEST DATA FOR AN IN-CIRCUIT 7404. Input pins 3, 5, and 13 are marked X, for "ignore." Those pins might be hard-wired to ground, V_{CC}, or elsewhere in an actual circuit.

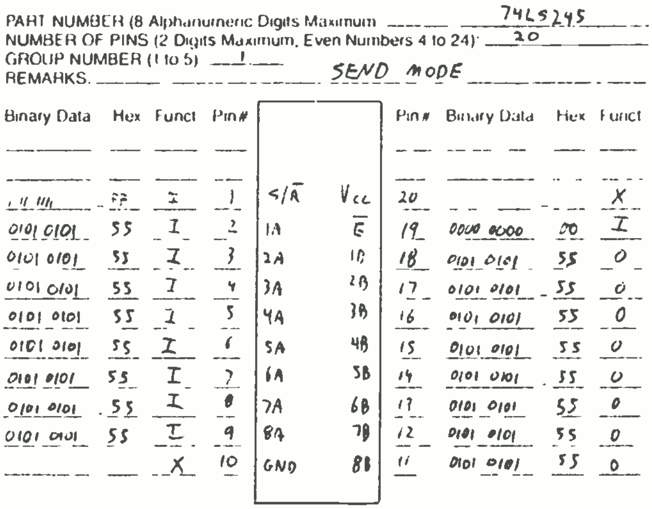


FIG. 10—TEST SETUP FOR A 74LS245 octal bus transceiver in send mode.

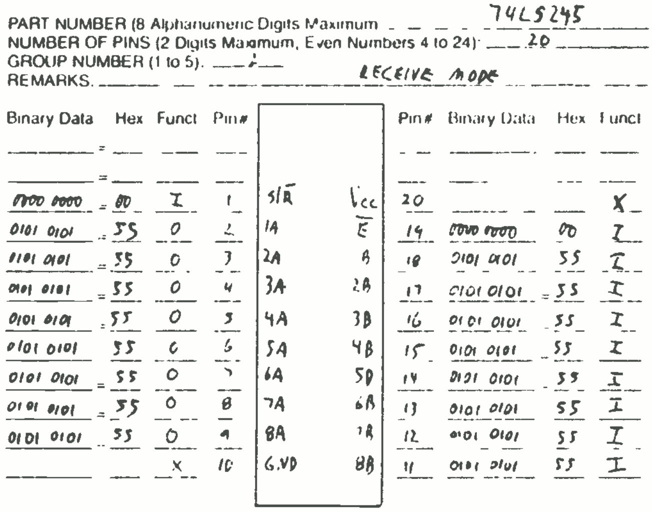


FIG. 11—TEST SETUP FOR A 74LS245 octal bus transceiver in receive mode.

ple, the 74154 4-to-16 line decoder has four address inputs (pins 20–23), two active-low gate inputs (pins 18 and 19), and 16 outputs, one of which goes low when both gate inputs are low, depending on the state of the four address inputs. Figures 14, 15, and 16 show the data required to test the IC completely.

Advanced commands

After generating test data you'll probably want to store it in your desktop computer. The tester provides storage for as many as 105 test routines, which you may upload to and download from the tester's internal memory.

After entering test data, if you wish to store it, press the Store key, and the data will be stored in memory for future use under the part number that is entered with the data.

To load a test routine from the tester's local memory, press Load and then enter the part number. If a corresponding routine is in memory, *CLEAR OR ENTER?* will appear on the display. Press Clr to erase the entry from memory, or press Enter to leave the data in the test buffer for testing or transfer to the external computer. To upload the data, press Send. To download it, press Recv. If you wish to retain a received file, press Store. Use the BASIC programs shown in Listings 1 and 2 to send and receive programs.

Remote data generation

The BASIC program shown in listing 3 can be used to create test patterns somewhat more conveniently than on the tester itself. It is important to note that when using the program to generate test files, only hex characters (0–9, A–F) may be used in the part number (TF$) if the file is to be stored in the Tester's memory. The reason for this is that the Tester's keyboard has no other characters to access the test routine in its memory. Therefore you would not be able to load or delete the test routine. For example, a part entered as 74LS138 would be inaccessible because there is no L or S on the Tester's keyboard.

Usage hints

First a few words of caution. Never connect the test clip to an IC that has power on it unless the tester is on and *COMMAND?* is scrolling in the display. Conversely, never shut the tester off when the clip is connected to a powered IC. And always make sure when testing in-circuit IC's that the tester and the DUT (*D*evice *U*nder *T*est) share a common ground. Connect the black test hook clip to a ground on the board near the IC's to be tested.

The test drivers (IC7–IC15) are rated at 7 volts maximum, so be careful what you connect the test clip to. A powered RS-232 driver might have ±12 volts, or even more, and voltages at those levels

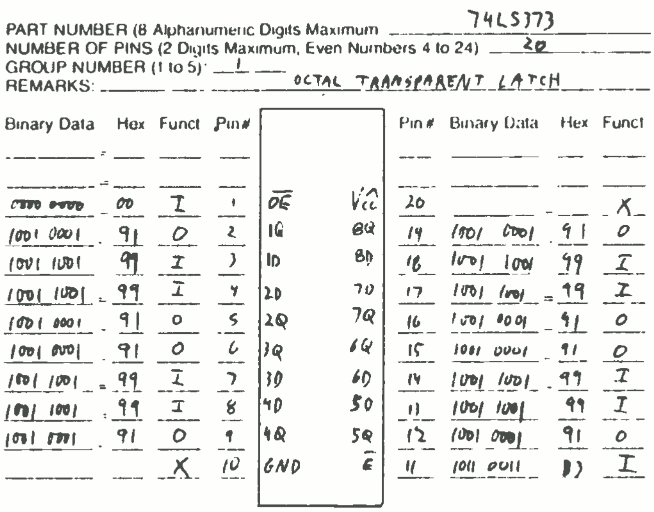


FIG. 12—TEST SETUP FOR A 74LS373 octal transparent data latch. Whenever the enable line (pin 11) is high, each output follows the corresponding input.

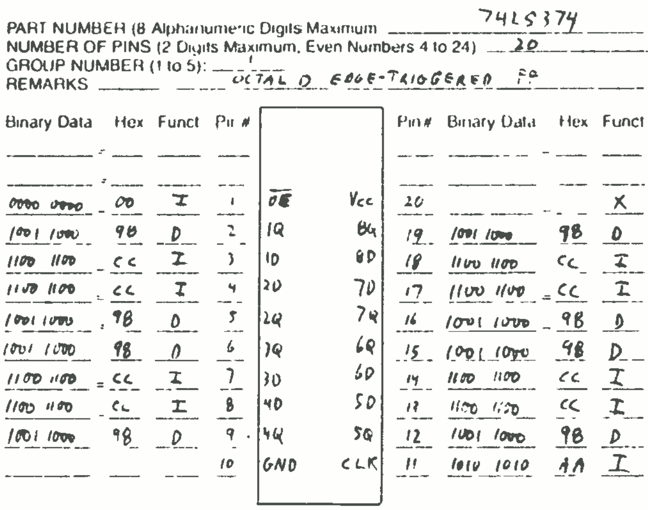


FIG. 13—TEST SETUP FOR A 74LS374 octal D flip-flop. Data on each input is clocked into the corresponding output on the leading edge of each clock pulse. Clock pulses are applied to pin 11.

PART NUMBER (8 Alphanumeric Digits Maximum: 74154
NUMBER OF PINS (2 Digits Maximum, Even Numbers 4 to 24): 24
GROUP NUMBER (1 to 5): 1
REMARKS: 4-TO-16 LINE DECODER

Binary Data	Hex	Funct	Pin#			Pin#	Binary Data	Hex	Funct
1111 0111	F7	0	1	Q0	Vcc	24			X
1110 1111	EF	0	2	Q1	A	23	0101 0111	57	I
1101 1111	DF	0	3	Q2	B	22	0110 0111	67	I
1011 1111	BF	0	4	Q3	C	21	1000 0111	87	I
0111 1111	7F	0	5	Q4	D	20	0000 0111	07	I
1111 1111	FF	0	6	Q5	$\overline{G2}$	19	0000 0011	03	I
1111 1111	FF	0	7	Q6	$\overline{G1}$	18	0000 1001	05	I
1111 1111	FF	0	8	Q7	Q15	17	1111 1111	FF	O
1111 1111	FF	0	9	Q8	Q14	16	1111 1111	FF	O
1111 1111	FF	0	10	Q9	Q13	15	1111 1111	FF	O
1111 1111	FF	0	11	Q10	Q12	14	1111 1111	FF	O
		X	12	GND	Q11	13	1111 1111	FF	O

FIG. 14—A 74154 demultiplexer has six inputs and 16 outputs, so it requires three test groups to test all combinations. Group 1 is shown here.

PART NUMBER (8 Alphanumeric Digits Maximum: 74154
NUMBER OF PINS (2 Digits Maximum, Even Numbers 4 to 24): 24
GROUP NUMBER (1 to 5): 2
REMARKS: 4-TO-16 LINE DECODER

Binary Data	Hex	Funct	Pin#			Pin#	Binary Data	Hex	Funct
1111 1111	FF	0	1	Q0	Vcc	24			X
1111 1111	FF	0	2	Q1	A	23	0101 0101	55	I
1111 1111	FF	0	3	Q2	B	22	0110 0110	66	I
1111 1111	FF	0	4	Q3	C	21	1000 0111	87	I
1111 1111	FF	0	5	Q4	D	20	1111 1000	F8	I
1111 1110	FE	0	6	Q5	$\overline{G2}$	19	0000 0000	00	I
1111 1101	FD	0	7	Q6	$\overline{G1}$	18	0000 0000	00	I
1111 1011	FB	0	8	Q7	Q15	17	1111 1111	FF	O
1111 0111	F7	0	9	Q8	Q14	16	1111 1111	FF	O
1110 1111	EF	0	10	Q9	Q13	15	1111 1111	FF	O
1101 1111	DF	0	11	Q10	Q12	14	0111 1111	7F	O
		X	12	GND	Q11	13	1011 1111	BF	O

FIG. 15—GROUP TWO OF THE 74154 TEST set is shown here.

PART NUMBER (8 Alphanumeric Digits Maximum: 74154
NUMBER OF PINS (2 Digits Maximum, Even Numbers 4 to 24): 24
GROUP NUMBER (1 to 5): 3
REMARKS: 4-TO-16 LINE DECODER

Binary Data	Hex	Funct	Pin#			Pin#	Binary Data	Hex	Funct
1111 1111	FF	0	1	Q0	Vcc	24			
1111 1111	FF	0	2	Q1	A	23	1111 1101	FD	I
1111 1111	FF	0	3	Q2	B	22	1111 1110	FE	I
1111 1111	FF	0	4	Q3	C	21	1111 1111	FF	I
1111 1111	FF	0	5	Q4	D	20	1111 1111	FF	I
1111 1111	FF	0	6	Q5	$\overline{G2}$	19	1111 1000	F8	I
1111 1111	FF	0	7	Q6	$\overline{G1}$	18	1111 1000	F8	I
1111 1111	FF	0	8	Q7	Q15	17	1111 1011	FB	O
1111 1111	FF	0	9	Q8	Q14	16	1111 1101	FD	O
1111 1111	FF	0	10	Q9	Q13	15	1111 1110	FE	O
1111 1111	FF	0	11	Q10	Q12	14	1111 1101	FE	O
1111 1111	FF	X	12	GND	Q11	13	1111 1111	FE	O

FIG. 16—GROUP THREE OF THE 74154 TEST set is shown here.

could damage the drivers easily. The display will probably dim if you inadvertently connect the test clip to an IC incorrectly, or if you have entered test data incorrectly. If the display does become dim, disconnect the test clip and remove power immediately.

In addition to testing IC's both in and out of circuit, the tester can also be used as a simple logic analyzer to test as many as twenty four points in a digital circuit. Simply replace the DIP clip with individual test-hook clips. Some lines would be used as outputs to stimulate the circuit, and others would be used as inputs to read the results. **R-E**

PARTS LIST

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

R1—22,000 ohms
R2—330 ohms
R3–R6—1000 ohms

Capacitors

C1, C8—1000 µF, 16 volts, electrolytic
C2, C4–C7, C9–C17—0.1 µF, 10 volts, ceramic disc
C3—10 µF, 16 volts, electrolytic

Semiconductors

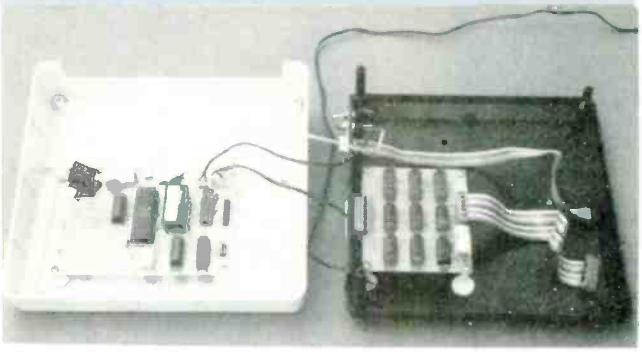
IC1—Z80 microprocessor
IC2—DS1230-104 32K nonvolatile RAM
IC3—MAX233 RS-232 interface
IC4—75499 custom decoder
IC5—75498 custom decoder
IC6—75500 custom decoder
IC7, IC10, IC13—NE591 open-emitter octal driver
IC8, IC11, IC14—NE590 open-collector octal driver
IC9, IC12, IC15—74LS373 octal latch
IC16—7805 5-volt regulator
IC17—2-Mhz crystal oscillator
D1—1N4001 rectifier
DISP1—DL1414 16-segment decoder/driver/display

Other components

F1—1-amp pigtail fuse
J1—9-pin D connector
P1, P2—right-angle double-row 20-pin male header strips
P3—right-angle double-row 26-pin male header strips
S1—minature SPDT toggle switch
S2—momentary SPST pushbutton
S3–S14—momentary SPST keyboard switches
T1—Transformer, 9.5–12-volts, 1-amp, wall-mount

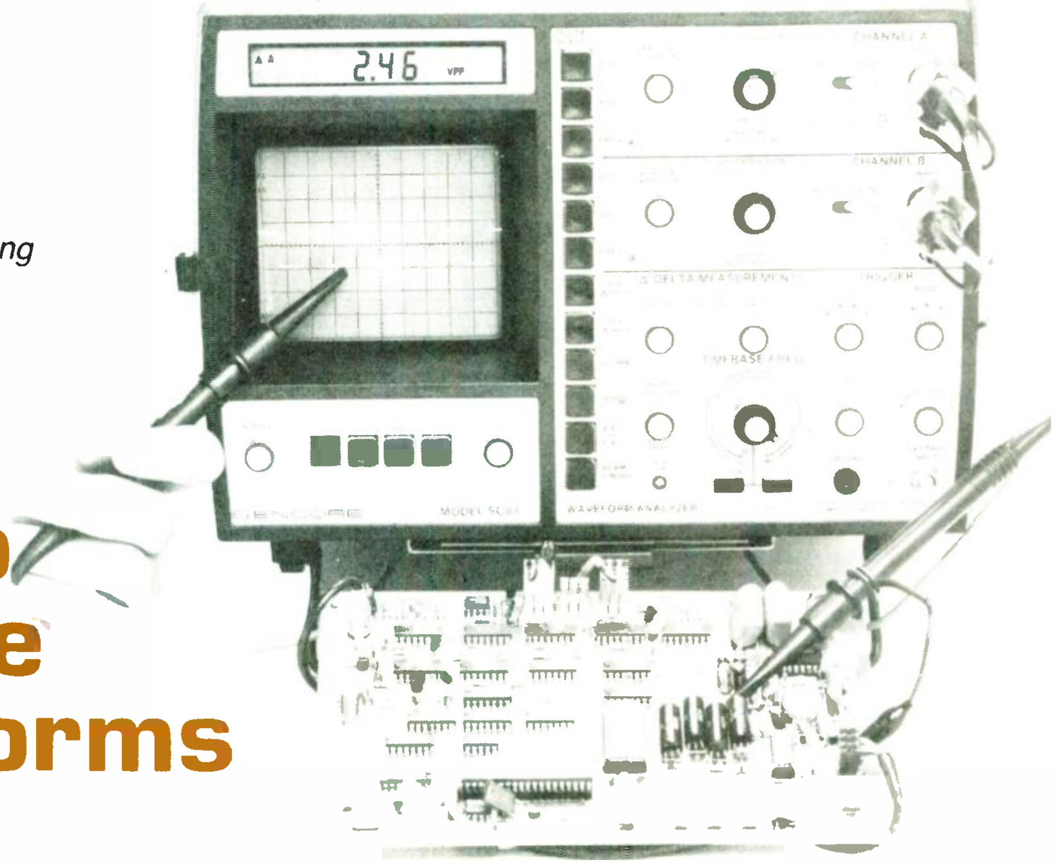
Miscellaneous: One 10-pin, two 20-pin and one 26-pin double-row female IDC header connectors. Two 12-pin single-row female IDC header connectors. Flat ribbon cable and test clips.

Note: The following are available from: ALPHA Electronics Corporation, P.O. Box 1005, Merritt Island, Florida 32952-1005, (305) 453-3534: Kit of parts for $299.00 + $6.00 P&H. Includes all parts, punched and screened panel, case, and labeled keys. Test cable and clips not included. Completely assembled tester for $399.00 + $6.00 P&H. Includes test cable with 16-, 20-, and 24-pin IC test clips. Partial kit, including all IC's (except IC16 and IC17), display, and PC boards for $199.00 + $5.00 P&H. Three custom IC's (75498, 75499 and 75500) for $60.00 + $4.00 P&H. Florida customers please add 5% State sales tax. Canadian customers please add $3.00 additional postage to all orders. All foreign orders add appropriate postage for Air shipping and insurance.



INSIDE THE IC TESTER. Last time we showed you how to build the project; this month we show you how to use it.

An oscilloscope is an indispensable troubleshooting tool. Adding a digital readout makes it ideal.



How to Analyze Waveforms

GREGORY D. CAREY, CET

AN OSCILLOSCOPE IS LIKE AN ELECTRONIC stethoscope—it allows you to confirm a circuit's "health" by examining the signals flowing through it. Whether you are designing a circuit, building a project from a magazine, or repairing circuits for a living, the ability to analyze waveforms quickly, accurately, and without mistakes can let you make the most of your technical skills. Unfortunately, many technicians only use their scopes when absolutely necessary. Because of that, they often are unfamiliar with the unit's operation, making waveform interpretation seem difficult. Combining a digital readout with the scope's graphic display, eliminates most of the problems of waveform interpretation.

What is a waveform?

Before we go on, let's be certain that you understand what the waveform on an oscilloscope's CRT screen represents. The CRT graphically displays the relationship between the voltage and time at the test point you're measuring. The vertical movement (deflection) indicates the signal's voltage, with more deflection representing larger voltages. Simultaneously, the beam is moving horizontally at a constant rate, so that each horizontal division on the CRT represents a constant time interval.

Analyzing the signal helps identify which components are responsible for circuit problems. Let's look at how each part of the waveform helps find different component problems.

The seven waveform parameters

The seven parameters shown in Fig. 1 fully define any signal. Four of those parameters apply to any signal, and the other three apply to complex signals. We will explain how to interpret each parameter and which components are most likely to affect each one.

(1) Waveshape: The signal's waveshape confirms the general operation of a circuit. Waveform distortion is often caused by a problem in a reactive component, such as a coil or a capacitor. Waveform clipping ("flat-topping") may be caused by saturation of a stage or a power supply with low output. After discovering a waveshape problem, other parameters can be used to provide additional clues about the circuit's operation.

(2) DC level: The DC bias at a test point is such an important troubleshooting parameter that many people use their voltmeters as their main piece of test equipment. DC problems may be responsible for problems with any of the other parameters, including distorted waveshape, or incorrect amplitude or frequency. DC problems may be caused by power-supply problems or an open or shorted

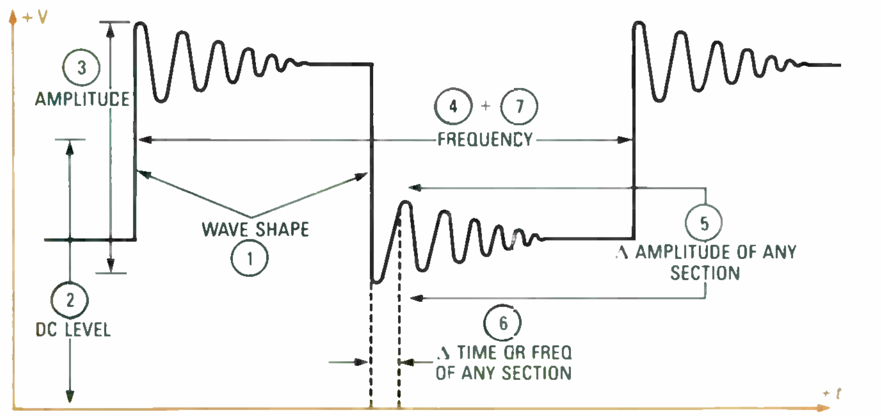


FIG. 1—TO FULLY ANALYZE A WAVEFORM, these seven parameters must be measured or observed.

component somewhere in the circuit. A DC-coupled scope, especially one with a digital readout, allows you to measure DC bias directly, while simultaneously observing the signal's waveshape. The DC and waveform readings also work together when a power supply has excessive ripple, even though its DC output is correct.

(3) Amplitude: The next test is to confirm that the signal has the correct peak-to-peak voltage. Low signal amplitude may be caused by low stage gain or by excessive loading. Poor gain often results from a defective transistor or IC, low power-supply voltage, or a defective emitter-bypass capacitor. Excessive loading may be the result of a component that has shorted or has changed value.

(4) Frequency: Some circuits, such as oscillators, generate signals for use by later stages. Other stages may be referenced to an external source, such as in VCR servo circuits, phase-locked loops, digital counter stages, or television sweep circuits. Testing the frequency of those circuits confirms whether they are working correctly.

Delta measurements

The previous four tests will fully analyze a signal if you are testing a simple waveshape, such as a sinewave or squarewave. If, on the other hand, you are testing a complex signal, you may need to know the details of the secondary parts of the signal to complete the analysis. Those added tests are called *delta* measurements. There are three types of delta measurements as follows:

(5) Delta amplitude: The peak-to-peak voltage test covered earlier measured the total amplitude from the signal's lowest to its highest points. But many signals have additional signals buried within them. For example, an incorrect color-burst level on a composite video waveform (see Fig. 2) may cause color problems. An incorrect sync-pulse level on the same composite signal may cause sync instability. Ripples or glitches, riding along the top of digital squarewaves may cause later circuits to operate incorrectly. Those conditions can be detected by using delta peak-to-peak voltage measurements, which allow the level of secondary signals to be measured independently of the main signal level.

(6) Delta time: Time measurements fall into two categories: those that are part of one signal, and those involving the time difference between two signals. An example of time within one signal would be the duty cycle of a switching power supply, where the "on-time" compared to the "off-time" determines the power delivered to the load. The time delay between two signals is important in many VCR servo adjustments. See Fig. 3. Either of those applications uses a point on the waveform as a reference for a delta-time measurement.

(7) Reciprocal time measurements: You can determine the approximate frequency of a signal by measuring the time for a single cycle and then inverting the time measurement mathematically. You can use that method to determine the time constant of circuits responsible for ringing, or the frequency of an interfering signal to determine its source.

Digital measurements

You make all seven of those measurements every time you fully analyze a signal with an oscilloscope. Conventional scopes require you to make every parameter reading by measuring beam displacement on the CRT, and multiplying that by the settings of the vertical or horizontal circuit controls. Some scopes with microprocessor-controlled measuring circuits, such as the Sencore *SC61* shown in the opening of this article, allow every parameter to be converted to a direct digital reading. The CRT is then only used to display the overall shape of the signal.

A digital readout offers three advantages over using the CRT for measurements: Speed, accuracy, and freedom from errors. Let's look at each of those advantages in a little more detail.

Speed: You may begin to appreciate the time that direct digital readings save when you look at the number of steps needed to make a single measurement on a conventional CRT. Those steps are outlined in Table 1. If you use an oscilloscope often, you perform those steps without even

continued on page 82

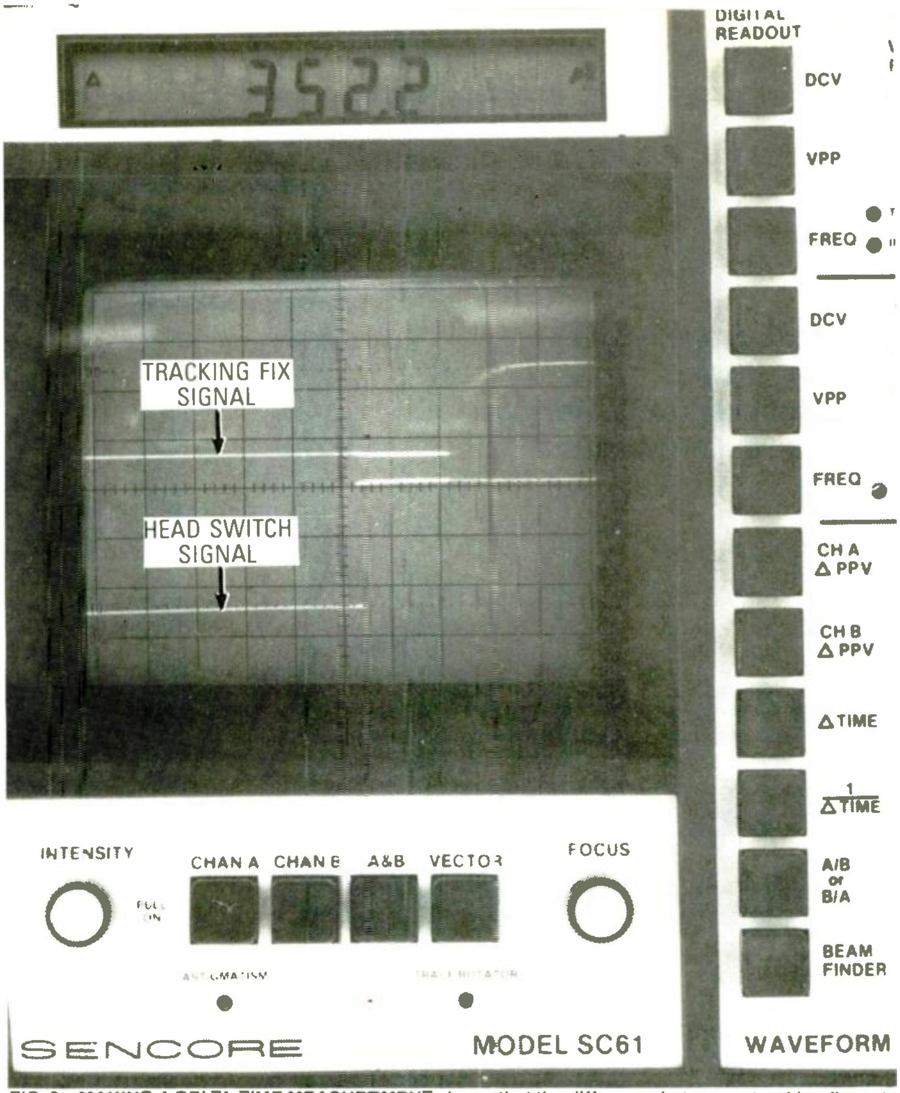


FIG. 3—MAKING A DELTA-TIME MEASUREMENT shows that the difference between a tracking fix and a head-switch signal to be 352 μs; factory specifications call for a 400 μs delay.

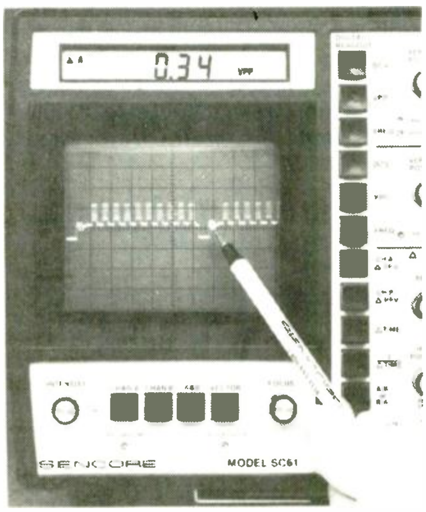
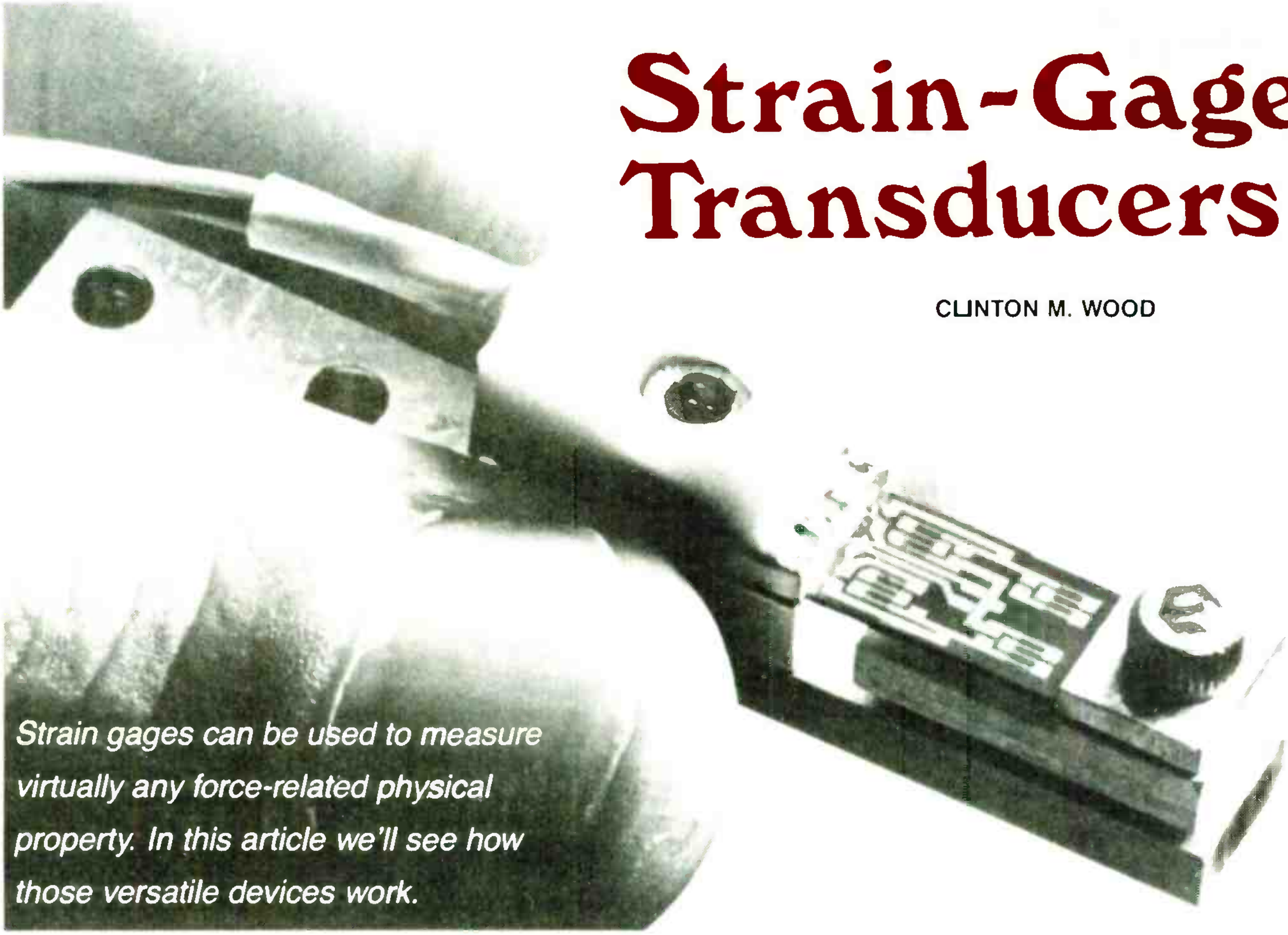


FIG. 2—PERFORMING A DELTA PEAK-TO-PEAK measurement confirms that the color burst of a composite video signal has the correct amplitude.

ALL ABOUT

Strain-Gage Transducers

CLINTON M. WOOD



Strain gages can be used to measure virtually any force-related physical property. In this article we'll see how those versatile devices work.

STRAIN-GAGE TRANSDUCERS, USED IN EVerything from automobiles to zinc plants, have found their way into our homes, our supermarkets, our factories, and our hospitals. They're commonly used in nearly every branch of science and technology, including research, space flight, product development, robotics, automation, energy production, agriculture, and consumer products. They can be used to measure a wide range of force-related physical properties like weight, acceleration, pressure, volume, liquid level, flow rate, and velocity. Further, they are accurate, durable, inexpensive, linear, and inherently simple to use.

Since strain-gage transducers are linear, it's easy to determine the value of a force-related input. All that's required is to divide the output voltage by the transducer sensitivity as shown in Fig. 1. That's because the input and output are related by a simple linear equation. In this article we'll see where that equation comes from, and, in the process, learn something about the underlying principles that are common to all strain-gage transducers. Toward that end, we have divided the strain-gage transducer into three components: 1) the spring element, 2) the strain gage, and 3) the bridge circuit. We'll take a look at each of those components to see what they contribute to the operation of the transducer. Then we'll put them back together to see how the complete transducer works.

The spring element

The principle of elasticity, that is the tendency of solids to deform or change dimensions when subjected to an external force, is central to the operation of the strain-gage transducer. It makes no difference whether the force is from a weight, a fluid pressure, or even mechanical inertia; the result is the same.

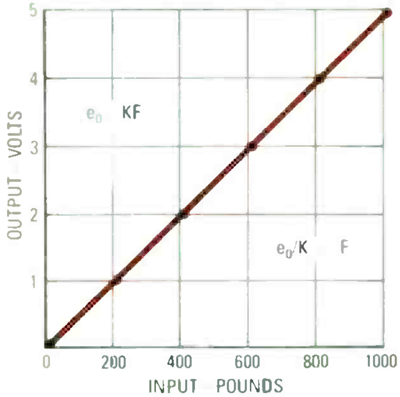


FIG. 1—IN A STRAIN-GAGE TRANSDUCER the relationship between the applied force and the output voltage is linear.

As an example, Fig. 2 shows a steel bar subjected to a force in the form of a weight. In Fig. 2-*a* the bar is unloaded and has a length of L. In Fig. 2-*b*, the bar is anchored at the top, and the weight is attached to the bottom. In that case, the resulting deformation will appear as an increase in length. In Fig. 2-*c*, the weight is placed on top of the bar. That will result in a decrease in length. Note that no matter how the bar is loaded, it will return to its original length when the weight is removed, provided that the applied force was not so large as to cause the bar to permanently stretch or break. The change in length resulting from an applied force is known as strain. For metallic solids like steel or aluminum, the maximum allowable strain before deformation is in the range of a few thousandths of an inch.

The property of elasticity is widely used in the manufacture of instruments because there is a linear relationship between strain and the applied force. This relationship can be expressed as

$$S = kF \quad (1)$$

where F is the applied force, S is the resulting strain, and k is the spring-element constant; the value of k depends on a number of things like the geometry and type of material, and the direction of the

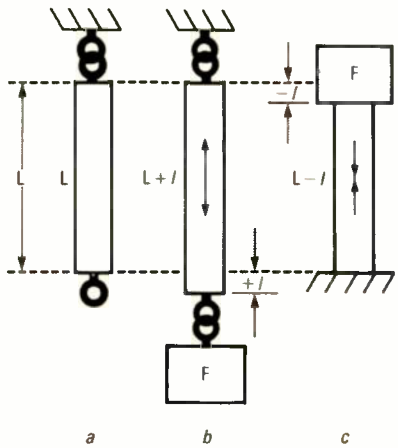


FIG. 2—IF A STEEL BAR (*a*) is loaded, its length will change. Depending on the placement of the load, the bar will either expand (*b*) or contract (*c*).

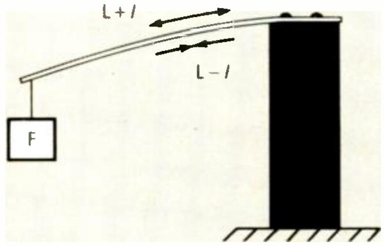


FIG. 3—WHEN FORCE IS APPLIED to the free end of the arm, the upper surface will expand and the bottom surface will contract.

applied force. That relationship, known as Hooke's Law, was originally applied to coil springs for use as a measure of weight. But we have since recognized that, within limits, it is essentially true for all solids.

The spring element is the foundation of the strain-gage transducer. It is an elastic solid (usually metallic) designed to linearly translate an applied force into an equivalent strain. Its size and shape depend on the magnitude and type of force that the transducer is to sense. A spring element could be as simple as the steel bar in Fig. 2, but a design of that type provides only one direction of strain in response to an applied force. If the applied force can produce two equal strains that are opposite in direction, the resulting transducer will be more accurate. That is often done by applying a force to the spring element in a way that will make it bend.

Figure 3 shows one way that can be done. A rectangular steel bar is anchored at one end in a cantilever configuration. The force is applied to the free end of the bar, perpendicular to the axis, rather than along the axis as in Fig. 2. As a result, the upper surface of the bar will stretch, and the bottom surface will compress. The surface strain will vary along the bar, from a maximum near the end that is anchored, to zero at the other end. But at any given position along the bar, the strain of the upper and lower surfaces will be equal in magnitude and opposite in direction. Later we will see that those opposing strains can help stabilize the transducer against varying environmental conditions that may occur.

Some commercial transducers use spring elements that are similar to the cantilever configuration, but there are a great many other designs that are used as well—in fact, too many to discuss here realistically. Fortunately, a study of the design variations is unnecessary as long as you remember that a spring element is a structural component designed to provide a linear deformation in response to an applied force.

The strain gage

The purpose of the strain gage is to convert the strain of the spring element into an equivalent change in resistance. A strain gage is just a metallic conductor that is bonded to the spring element, stretching and compressing in the same way as the spring element. We know from basic electricity that the resistance of a conductor depends on its length. And, we know that if we place it in tension its length will increase as the steel bar did in Fig. 2. Since resistance is proportional to length, that stretching will result in an increase in resistance. If we turn that around and put the conductor into compression, its resistance will decrease.

Figure 4 shows a typical commercial strain gage. It consists of a thin foil conductor bonded to a plastic backing material. The backing, which serves as a carrier for the metal foil and provides insulation from the spring element, must be flexible enough to follow the spring element, yet tough enough to transfer the strain to the metal foil. The foil conductor is usually made of an alloy having a low temperature coefficient, like constantan. To keep the strain gage reasonably short, the foil has been laid out in a criss-cross pattern over the surface of the backing material. At one end, the foil expands to form two solder tabs which are used to attach lead wires to the strain gage. Although the design shown in Fig. 4 is typical, a number of other designs are available, including multiple gages on a single backing and circular gages for use with diaphragm-type pressure transducers. A number of designs from one supplier, Transducers Inc. (14030 Bolsa

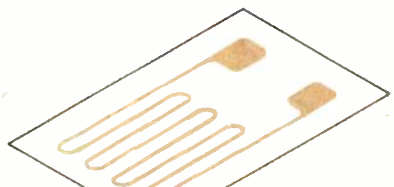


FIG. 4—A TYPICAL strain-gage design.

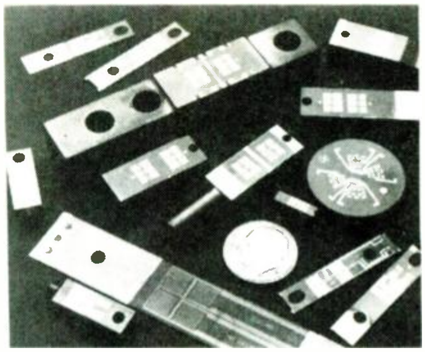


FIG. 5—STRAIN GAGES are made in a number of configurations and designs for different applications.

Ln., Cerritos, CA 90701), are shown in Fig. 5.

The strain gage is usually bonded to the spring element with an adhesive like epoxy. The quality of the bond is critical since the adhesive must accurately transfer any spring-element deformation to the strain gage. A poor bond will result in "creep"—a slippage between the strain gage and the spring element. That will make it look as if the input is slowly changing when, in fact, it is not.

The change in strain-gage resistance is related to strain by the gage factor, that is defined as the ratio of the unit change in resistance to the strain, or:

$$G = (r/R)/S \qquad (2)$$

where G is the gage factor, R is the initial (unstrained) resistance of the gage, S is the strain, and r is the change in resistance resulting from a change in length. Most strain gages have an initial resistance of 120 or 350 ohms. For most metal-foil strain gages, the gage factor is usually between 2 and 3; the precise value depends on the composition of the alloy used for the foil conductor.

The last equation can be rewritten in terms of r, or:

$$r = GRS \qquad (3)$$

That shows that, since both R and G are constants of the strain gage, the change in resistance is proportional to the strain.

Most strain-gage transducers use metal-foil strain gages. However, transducers using semiconductor strain gages are gaining popularity. Instead of a metal alloy, they are built using a semiconductor material. Functionally, they are similar to metal-foil gages, but they have a higher initial resistance and a larger gage factor. Since they can be made very small, they are often used in miniature transducers.

The bridge circuit

So far, we've seen that the change in strain-gage resistance is proportional to the change in the length of the spring element. And we've seen that the change in the length of the spring element is proportional to the applied force. Since both of those relationships are linear, we can say that the change in resistance is proportional to the applied force. But a resistance change itself is not always a convenient parameter to measure because data loggers, computers, and process controllers usually require a voltage or current signal.

We could convert the resistance change into a voltage change by connecting a resistor in series with the strain gage and applying a DC voltage across the pair. If we used a series resistor of the same value as the strain gage and applied 5-volts DC, the voltage at the junction of the strain gage and the resistor would be 2.5 volts. A change made in the strain-gage resistance would then produce a change in that voltage.

Notice that it is the change in voltage that we want, because it is the change in voltage that is proportional to the change in resistance. But the change will be very small compared to the initial value of 2.5 volts. It's as if the desired signal voltage has been summed with a large, unwanted DC bias voltage. We can't amplify the small change until we eliminate the initial 2.5 volts. In transistor amplifiers, DC bias is often removed with a coupling capacitor, but we can't use that technique here because we want the steady-state voltage change as well as the dynamic change. What we need is some way to null out the initial voltage level.

One approach would be to configure the strain gage in a resistance bridge, as shown in Fig. 6. If the three resistors and the strain gage were all of the same resistance, the voltage at the junction of each pair would be the same. As a consequence, the voltage difference from one junction to the other would be zero. If we consider that voltage difference to be the output, (e_o) then we have effectively nulled out the initial voltage but preserved the DC response of the strain gage. We have also re-invented the Wheatstone bridge.

Unlike the Wheatstone bridge, though, balancing serves only to null out the initial voltage level. To make a measurement with that type of circuit, the bridge must

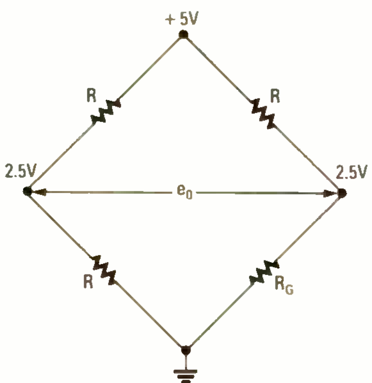


FIG. 6—USING A BRIDGE CIRCUIT allows us to null out the bridge supply voltage and only see the DC response of the strain gage.

be unbalanced by a change in the strain-gage resistance. That will cause a change in voltage difference across the bridge. We can use that change as an indication of the change in strain-gage resistance.

In the circuit of Fig. 6, you will find that for very small resistance changes, the output voltage appears to be a linear function of the change in resistance. But, as the change becomes larger it is no longer linear. We could limit the non-linearity to an acceptable level by limiting the change in resistance. But there is a better way.

Non-linearity can be eliminated entirely by building the bridge from four identical strain gages, instead of just one. The resulting circuit, which is known as a *four-arm, fully-active bridge*, is shown in Fig. 7.

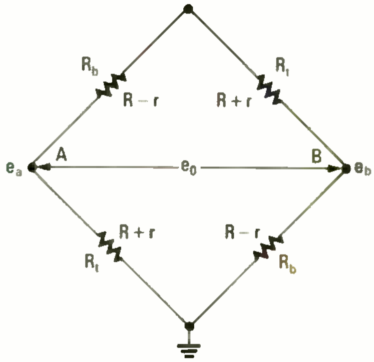


FIG. 7—A FOUR-ARM, FULLY-ACTIVE BRIDGE is made up of four identical strain gages.

The output of that bridge is a linear function of the change in strain-gage resistance, provided that the change in each strain gage is identical and that the change in two of the gages will result in an increase in resistance while the change in the other two will result in an identical decrease. In addition to being linear, the output of the circuit is higher and less sensitive to environmental changes than that of the single-gage bridge configuration. That type of circuit is used almost exclusively in strain-gage transducers.

To see how it works, let's use the spring element again as shown in Fig. 8. At some point near the fixed end of the bar, we will bond two of the strain gages to the upper surface, and the other two directly below them on the lower surface. In Fig. 8, R_t refers to the gages on top of the spring element and R_b refers to those on the bottom. When no force is applied to the bar, the top and bottom surfaces will be the same length. Since all four of the strain gages have the same initial resistance, the bridge will be balanced and the potential difference across the bridge will be zero. If we now apply a force to the end of the bar, the upper strain gages will increase in length and the lower gages will decrease. That is shown in Fig. 8 as R + r

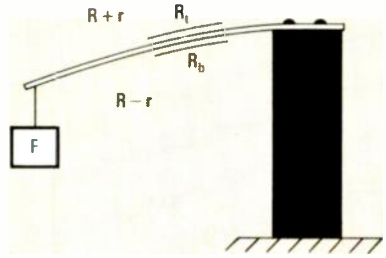


FIG. 8—WHEN FORCE IS APPLIED to the end of the spring arm, the resistance of the strain gages on its upper and lower surfaces change by equal but opposite amounts.

and R − r. Note that since the upper and lower strains are equal, r is the same for all four gages. But, since they are opposite in direction, r is then added to the gages on top and subtracted from the gages on the bottom.

We can show that the relationship between the voltage difference across the bridge and the change in resistance is linear. The first step is to find an expression for the voltage at point A (e_a) of the bridge (as shown in Fig. 7) as a function of the change in resistance. If we look at the bridge circuit as the parallel combination of two series resistances, we can see that the voltage at point A is given by:

$$e_a = I(R + r) \qquad (4)$$

where I is the current in the left leg of the bridge. But I can be expressed as:

$$E/[(R - r) + (R + r)] = E/(2R) \qquad (5)$$

where E is the bridge supply voltage. Combining those equations yields:

$$e_a = E(R + r)/(2R) \qquad (6)$$

We can find an expression for the voltage at point B of the bridge in the same way, which yields:

$$e_b = E(R - r)/(2R) \qquad (7)$$

Since e_a and e_b are both referred to ground, the difference in potential (e_o) between point A and point B is just the difference between e_a and e_b, or:

$$e_o = e_a - e_b = E[(R + r)/(2R)] - E[(R - r)/(2R)] \qquad (8)$$

That can be further reduced to:

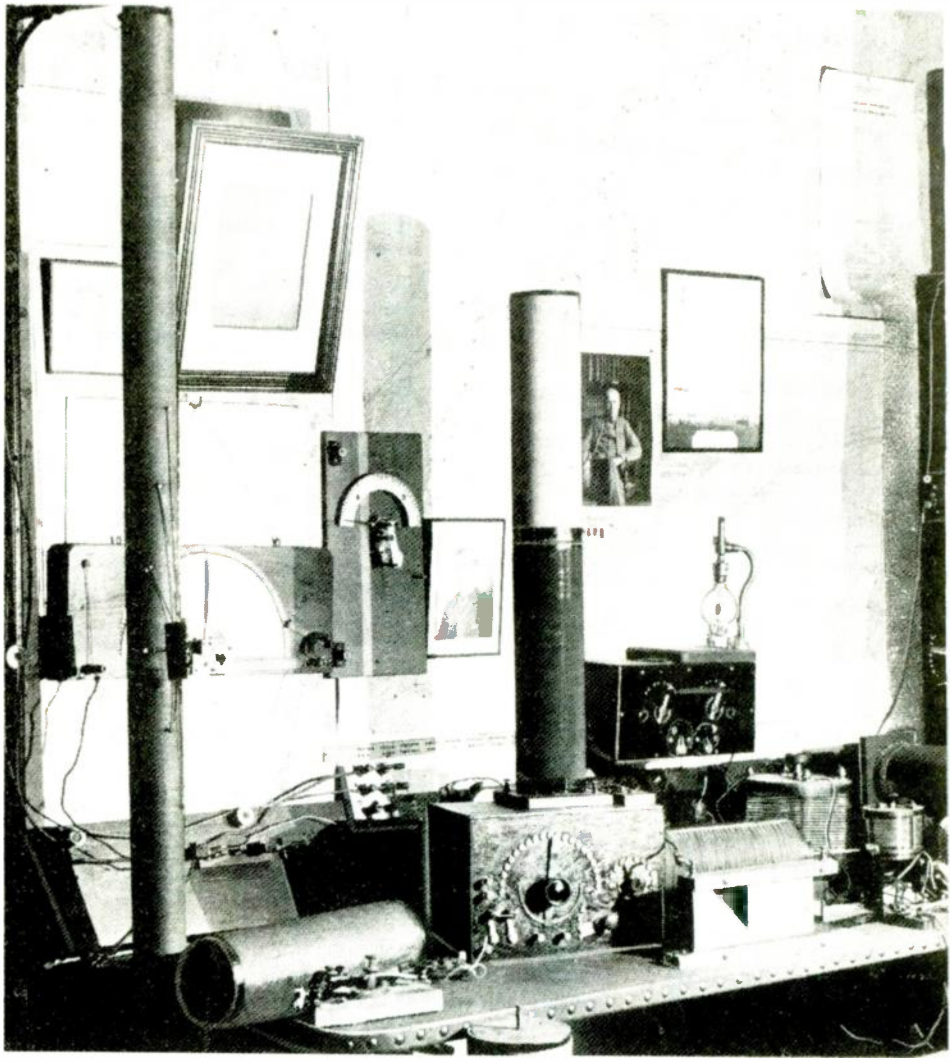
$$e_o = Er/R \qquad (9)$$

The last equation shows that the bridge output voltage is directly proportional to the change in strain-gage resistance.

The four-arm fully-active bridge has another advantage over the single strain-gage bridge. While the single strain gage is mounted on the spring element, the other three resistors must be mounted in a strain-free location. That means that the strain gage could be subjected to temperature changes that are different from those seen by the other three resistors. Since a temperature change will cause a

continued on page 83

The Early Days of RADIO



More nostalgia from radio's pioneer days.

Part 5

AS IMPORTANT AS AMplification was during radio's early days, an even more important receiver criterion was selectivity. Selectivity is a measure of the ability to receive closely spaced signals without interference from each other. Improved selectivity was usually attained by using taps on the antenna coil to increase its Q through better impedance matching on both sides of the antenna coil. Figure 1 shows two "selective" circuits used by the early radio experimenters. In Fig. 1-*a* the taps on both the primary and the secondary of antenna coil L1 are adjusted for best reception or minimum interference. In Fig. 1-*b* a separate tapped antenna loading coil (L2) is used to peak the antenna itself for a particular range of frequencies, and a tapped inductor (L3) increases the impedance that L1 "sees" when looking into the rectifier.

But better selectivity created an unforseen problem: insufficient receiver sensitivity. Being able to tune between the local powerhouse signals allowed the listener to partially hear much weaker signals from far-away places, and so was born "DX'ing"—DX'ing meaning the reception of distant signals. Unfortunately, crystal detectors could not provide sufficient volume from the weak DX stations. The need for more volume, coupled with a sharp decrease in the price of vacuum tubes, sounded the death knell for the crystal receiver. At first, only one tube was used for amplification; then, two; and finally three or more as designers learned how to build multi-stage amplifiers that didn't break into self-oscillation if the canary chirped.

Audio coupling

As shown in Fig. 2, early audio amplifiers used transformer coupling between stages, starting at the crystal detector. The transformers provided an amplifier's plate load, DC blocking, and AC coupling into the following stage. Though the transformer simplified interstage connections, the DC current flowing in the primary winding of the amplifier-output transformers caused core saturation, which reduced the effective inductance of the transformer—thereby producing a distorted sound. Known as *hysteresis* distortion, it marked the beginning of awareness of the need for better sound quality.

Various attempts were made to get around core saturation. The most effective, of course, was to use a transformer with "more iron," but this led to transformers that weighed more than a small boat anchor. The next attempts at reducing core saturation were the circuits shown in Fig. 3, where the transformer was isolated from the DC circuit. The tube got its plate voltage either through an adjustable power resistor (R in Fig. 3-*a*) or through

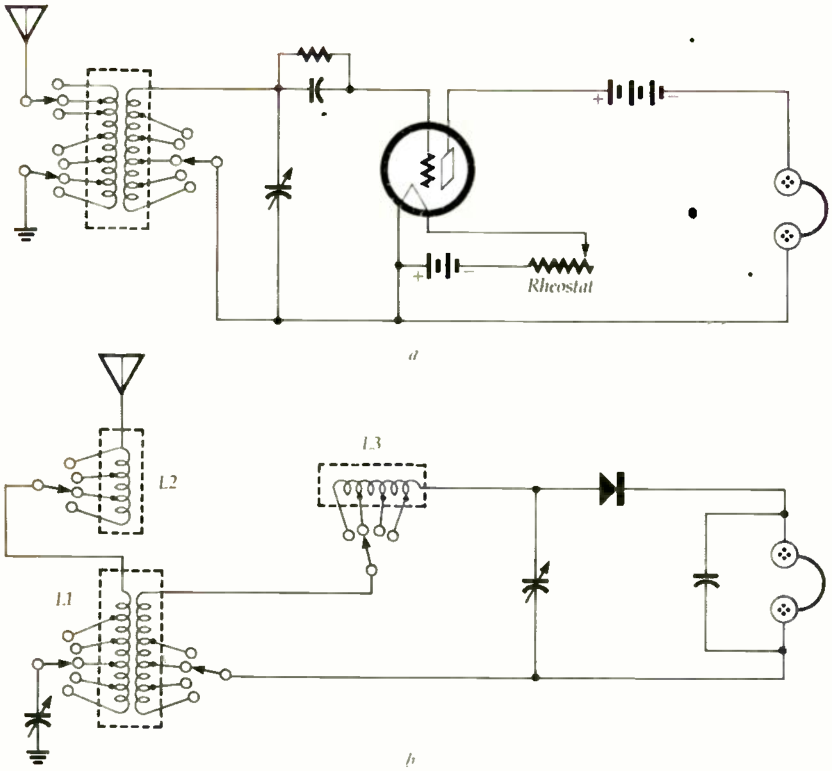


FIG. 1—SIMILAR TUNING METHODS were used for both single-tube and crystal receivers.

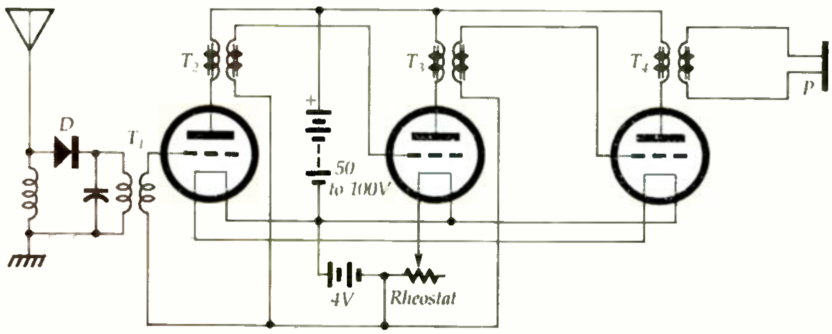


FIG. 2—INITIALLY, A CRYSTAL receiver's multistage audio amplifier was transformer coupled.

an inductor (L in Fig. 3-*b*). In both instances, capacitor C effectively isolates interstage transformer T from the DC plate voltage/current.

Neither circuit became popular because resistor R required a larger-than-usual battery voltage, while inductor L was frequency-selective.

One of the first attempts to eliminate the interstage transformer completely was the impedance-coupling circuit you'll find shown in Fig. 4. Unlike the interstage transformer, it did not supply voltage step-up. Also, as with other attempts to use an inductor as the plate feed, coil L was frequency-selective.

Resistance coupling

The really big breakthrough in both performance and production cost was the resistance-coupled circuit shown in Fig. 5. It was inexpensive to build, had no inductors or transformers to saturate, and was not frequency-selective. Hence, it resulted in better sound quality. The disadvantage of resistance coupling was that the voltage drop across plate load-resistor R necessitated a higher battery voltage to make up for the voltage drop.

The disadvantages of resistance, transformer, and impedance coupling were overcome in 1931 by the invention of the first practical direct-coupling system by E.H. Loftin and S.Y. White. As shown in Fig. 6, in the direct-coupled amplifier the plate of one stage was directly connected to the grid of the following stage. Its advantages were its low manufacturing cost, and the possibility of greater fidelity, because it contained no frequency-discriminating components. Early units had a flat frequency-response capability of 30 Hz to 7,000 Hz, with the possibility of extending the upper limit to 10,000 Hz, which was an upper limit for those days.

Electron flow

Prior to the invention of the diode and

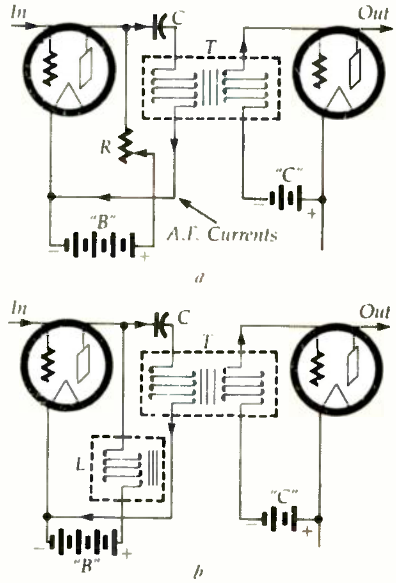


FIG. 3—THESE ARE TWO WAYS by which DC was kept out of the interstage transformer.

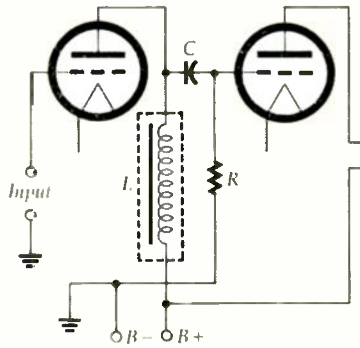


FIG. 4—IMPEDANCE COUPLING eliminated the interstage transformer, but still used an inductor (L) for the plate load.

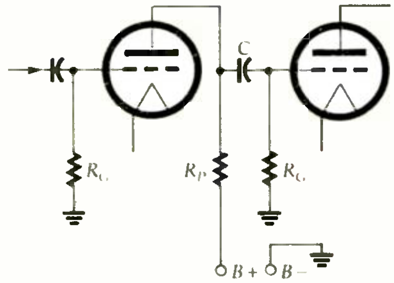


FIG. 5—IN RESISTANCE COUPLING there is neither a transformer nor an inductor. Resistors R_p and R_c and capacitor C3 provide the interstage coupling.

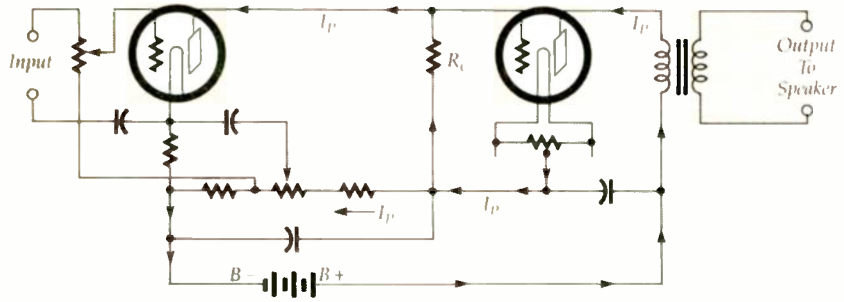


FIG. 6—DIRECT INTERSTAGE COUPLING provided the best fidelity. Note that the direction of the arrows indicates what is called "conventional current flow"; something that never really existed.

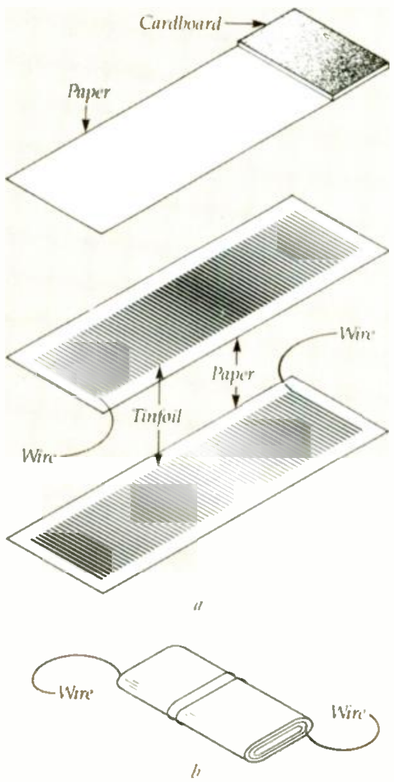


FIG. 7—EXPERIMENTERS MADE CAPACITORS from interleaved strips of tinfoil and paper held together by a rubber band or string.

triode tubes, the movement of an electron current was thought to be from positive to negative, a concept based on the ideas of Benjamin Franklin, who, having a 50-50 chance of guessing right, guessed wrong. Current flow in a vacuum tube clearly showed that current moved from a negative filament (cathode) to a plate (anode) that carried a positive charge. Although correct, the electron concept confused many experimenters, technicians, and engineers who had adopted the positive-to-negative concept and were most unwilling to give it up. Consequently, the electric and electronic industries compromised, and positive-to-negative current flow was called *conventional current flow*, while negative-to-positive current flow was called *electron flow*. For example, the arrows shown in Fig. 6, an original drawing of the Loftin-White direct-coupled amplifier, indicates conventional current flow.

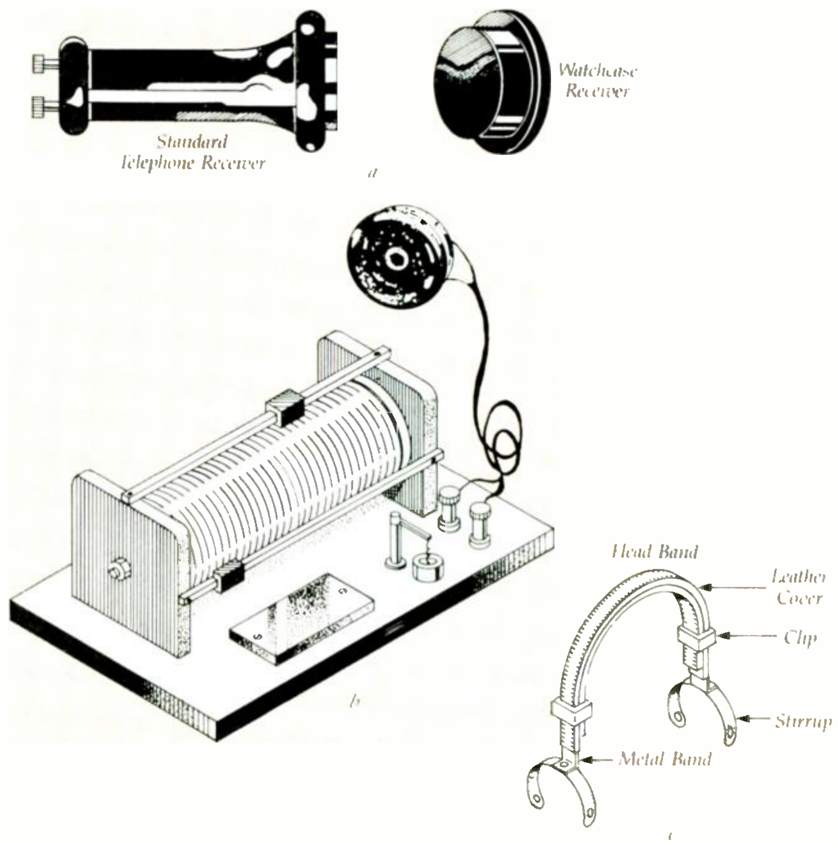


FIG. 8—THE DEVELOPMENT OF HEADPHONES: It started with a conventional telephone receiver, and ended in a headband.

Capacitors

In the early days of radio, to avoid the relatively high cost of capacitors, many experimenters and hobbyists "rolled their own" using the tinfoil from a pack of cigarettes and small sheets of paper. As shown in Fig. 7-*a*, alternate layers of foil formed the plates of the capacitor, whereas the paper was used for the dielectric. The interleaved sheets of tinfoil and paper were held together with string or a rubber band (Fig. 7-*b*). The value of the capacitance thus achieved was unknown, but it didn't matter because it was usually used for a non-critical receiver circuit.

Headphones and speakers

As shown in Fig. 8, headphones evolved from the telephone industry; in fact, the first earphone was the "roaring twenties" standard telephone receiver, and it's spin-off *watchcase* receiver (Fig. 8-*a*)—which was specifically designed for use with a radio. Although both types worked with radio receivers, they had two problems: (A) they were fatiguing because they had to be supported by hand, as shown by the complete radio in Fig. 8-*b*; (B) they had a very low impedance of approximately 75 ohms. Eventually, their impedance was increased to about 100 ohms, and finally to about 1000–3000 ohms. Fatigue was mitigated when the headband shown in Fig. 8-*c* was invented. It allowed the user to literally "wear" the receiver. When one or two receivers were mounted in a headband the entire assembly was called a "headphone," "headphones," or "headset."

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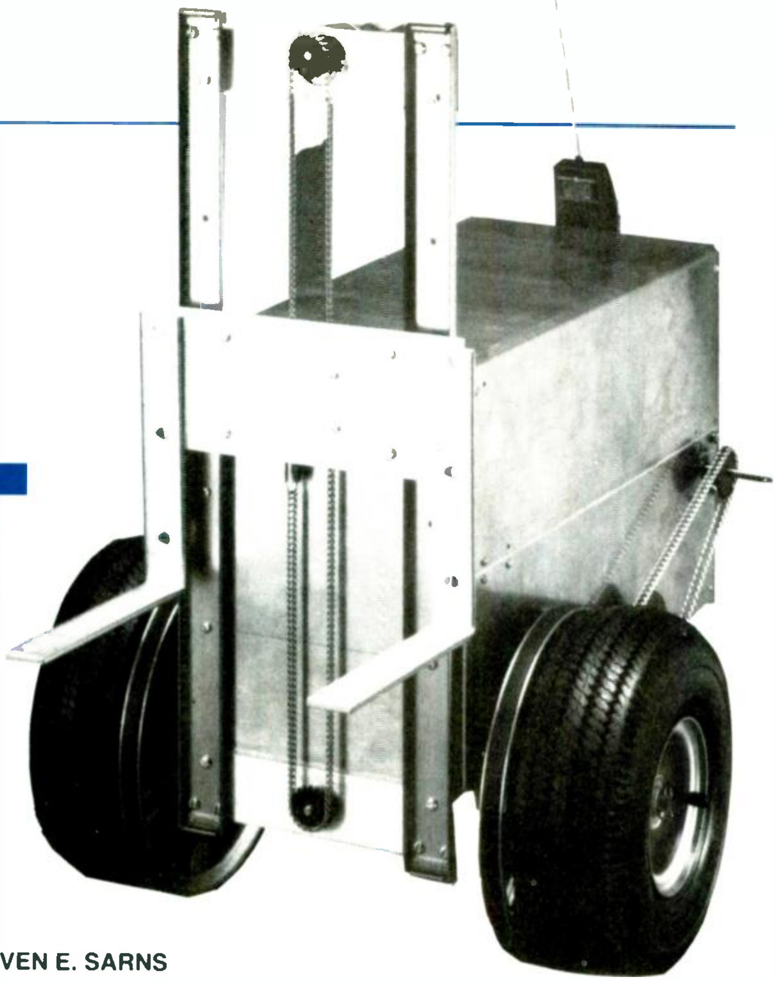
R-E ROBOT



This month, we add the first of the R-E Robot's sensors—an electronic eye.

Part 12

STEVEN E. SARNS

AT THIS POINT, OUR robot is an efficient tractor unit, moderately intelligent, with plenty of pulling power. He can carry items from place to place, and can understand complex instructions. However, he is also as blind as a bat. To make the unit as useful as possible, we must give it a way to see.

You can fully appreciate the severity of the problem by imagining the following example: You are at the end of a hallway. Several doors can be chosen. Look carefully, close your eyes and, without touching or peeking, walk forward and turn into a doorway.

That is what we were asking the robot to do when we programmed the MAILBOT example in Part 9 of this series (**Radio-Electronics**, August 1987). Instructions like "Go forward 10 steps, turn right, and then go forward again 10 steps" seem clear enough on paper, but what if you did not turn exactly 90 degrees? What if your steps were short for some reason? Worst of all, what if you lost your bearing and had to start over, all without peeking?

To make it easier for the robot to get around, we will give it the ability to detect and track light sources. That capability will allow the robot to follow a light beam or an optical stripe on the floor.

Ideally, we also would like to provide the robot with the capacity to determine the distance to a light source and to triangulate its position using several light sources. Unfortunately, the software required to perform those last two tasks is quite formidable, and at this time is far from being fully developed. For now, we will discuss the problems involved in giving the robot those capabilities, and the hardware needed to input the data that future software will require.

The robot eye will eventually be mounted on a rotating platform, or "head." The head will contain the electronics for a number of the robot's sensors and will be discussed in more detail in the next installment of this series. The head will move the eye through a few degrees, mapping light intensities at several points. The data collected in that way will be used by all of our navigation schemes.

Navigation schemes

The navigation scheme that we will implement now permits the robot to track a light beam. The robot will rotate the eye until a light-intensity maxima is determined. The robot will then angle toward that maxima.

For the future, position-finding is merely an extension of that navigation technique. By mapping the maxima of several known light sources, the robot can determine its position fairly accurately using triangulation.

For range-finding, we will need to add a second eye to the head. Then, the robot can use parallax to determine the distance between it and an unknown light source. The parallax principal, in which the difference in viewing angle at two points that are equidistant from the third are used to determine the distance to that point, is what provides humans with depth perception; the two equidistant viewing points are our two eyes. See Fig. 1. Note that the technique is only good at relatively close ranges. But remember that even humans lose their depth perception at distances beyond 30 feet.

The human eye

In terms of design, the human eye is difficult to match. The spectral response is not too wide, ranging from 360 to 780 nanometers, but color is of secondary importance to other factors. The eye is capable of resolving details as small as one minute of arc (1/60 of a degree). And most importantly, the eye can operate in a very wide range of light intensities, ranging from star-lit night to bright sunlight. If those light levels are quantized, you will find that the range is on the order of 180 dB, or a billion to one.

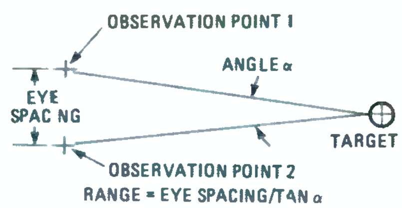


FIG. 1—USING PARALLAX to determine the distance to an object.

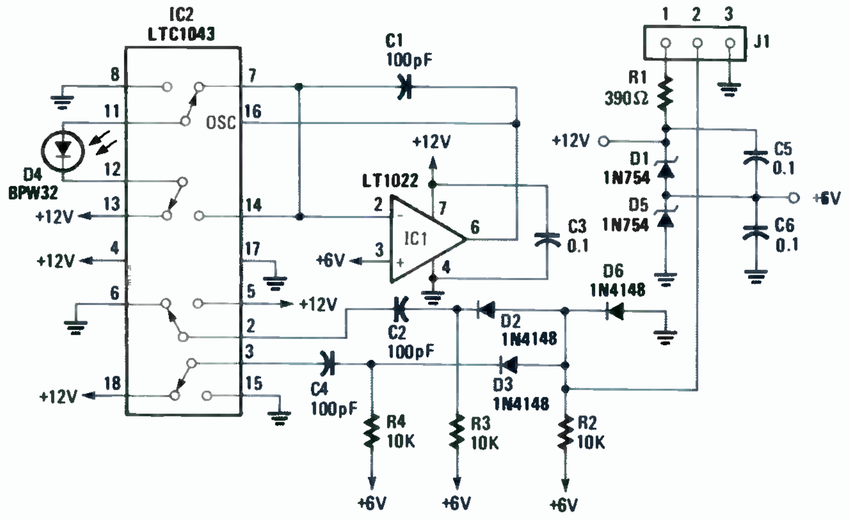


FIG.2—THE ROBOT'S EYE. The photodiode, D4, can be configured to source or sink current by IC2.

PARTS LIST

All resistors are ¼-watt, 5%
R1—390 ohms
R2–R4—10,000 ohms
Capacitors
C1, C2, C4—100 pF, ceramic disc
C3, C5, C6—0.1 µF, ceramic disc
Semiconductors
IC1—LT1022 op amp (Linear Technology)
IC2—LTC1043 IC switch (Linear Technology)
D1, D6—1N754 Zener diode
D2, D3, D5—1N4148 diode
D4—BPW32 photodiode (Siemens)
Other components
J1—male header
Miscellaneous: Fresnel lens, PC board, wire, solder, etc.

The 2.3-inch Fresnel lens can be ordered for $10.00 each, plus $6 postage and handling, from Edmund Scientific Company, 101 East Gloucester Pike, Barrington, N.J. 08007, (609) 573-6250. The part number is E32,589. NJ residents must add appropriate sales tax.

A bare printed-circuit board for the eye can be obtained from Vesta Technology Inc., 7100 W. 44th St., Wheatridge, CO 80033, (303) 422-8088, for $19 each. An assembled and tested eye PC board, Fresnel lens not included, is available for $59. CO residents must add appropriate sales tax.

The robot eye

Our design goal was to make the robot's eye useful over as wide a range of light conditions as possible. While it is unlikely that you will need to have the robot navigate by starlight, giving the robot low-light capabilities will increase its distance range. Since light follows the inverse square law, that is, the illumination is inversely proportional to the square of the distance, light levels fall rapidly as you move away from the source. At the same time, operation at conventional ambient light-levels must be possible, and the robot should be able to deal with most common light sources.

Therefore, we feel that the minimum acceptable range should span at least 4 orders of magnitude (10,000:1 or 80 dB); that corresponds (using the inverse square law) to tracking an ideal light source over a 100:1 distance range. The maximum possible dynamic range using readily available components is about 120 dB. That corresponds to a light range of 1,000,000:1, or a distance range of 1000:1.

We choose .01 lux as the lowest light level that we wish the sensor to respond to. A lux is the amount of light falling on one square meter from a candle located one meter away. That is at the extreme low-end of most detectors so to improve performance we will enhance the unit's light-gathering power with a Fresnel lens. Focusing a 4-square-inch Fresnel lens will amplify the light level by a factor of 100. If we were to focus such a lens on the sensor, a light level of .01 lux at the lens will result in a light level of 1 lux at the sensor. Most detectors can work with such a light level.

As we mentioned earlier, future range-finding requires that the robot be equipped with two eyes. Those will be mounted 10-inches apart on the head. If the robot can locate a light source to within 5 degrees of arc, that spacing will allow range finding at distances of up to 30 feet.

TABLE 1

Light Level	Photodiode Current
10,000 lux	100 µA
1,000 lux	10 µA
100 lux	1 µA
10 lux	100 nA
1 lux	10 nA
0.1 lux	1 nA
0.01 lux	100 pA
0.001 lux	10 pA
0.0001 lux	1 pA

Selecting a sensor

Many different sensors for measuring illumination are available. Phototransistors, photodiodes, and PIN photodiodes are all common and well understood.

If our prime design criteria is dynamic range, then we must choose the device with the largest sensitivity range. The key parameter in determining a unit's sensitivity is its *dark current*; that is the leakage current that flows when no light reaches the device. In general, photodiodes have the greatest ratio between dark current and high-illumination output. One, the Siemens BPW32 has a rated dark current of less than 10 pA and a high-level output at 10,000 lux of 100 µA. Those figures represent a dynamic range of 140 dB. Typical output currents of that photodiode for various light levels are shown in Table 1.

Note that the photodiode's output current becomes non-linear above 1,000 lux and below .001 lux. Also, remember that linearity can also be affected by the supporting circuitry. If you can not locate the Siemens component, a suitable substitute is NEC's PH201A photodiode.

The circuit

A schematic diagram of the eye circuit is shown in Fig. 2. The BPW32 photodiode, D4, provides an output current that is proportional to the illumination level. That small current will span a range of 10 million to one. If we were to convert the current into a voltage and the voltage into a binary number with an analog-to-digital converter, we would need a 23-bit unit! For example, if the full-scale voltage was 5, then the least significant bit would be 5 microvolts. Such a unit, if you could find one, would cost thousands of dollars.

Instead, we will convert our current into a frequency and use the RPC (*R*obotic *P*ersonal *C*omputer) to determine the period of the frequency. That will give us the dynamic range that we need, since a 140-dB range can be accommodated using a frequency band of 0.1 Hz to 1 MHz. The circuit will output approximately 200 kHz when held 3 inches away from a 60-watt light bulb in a reflective lamp. The circuit will output 0.5 Hz when illuminated by the trace of an oscilloscope 2 feet away.

The frequency range used is critical. The eye must rotate a small amount, take a reading and repeat the process continu-

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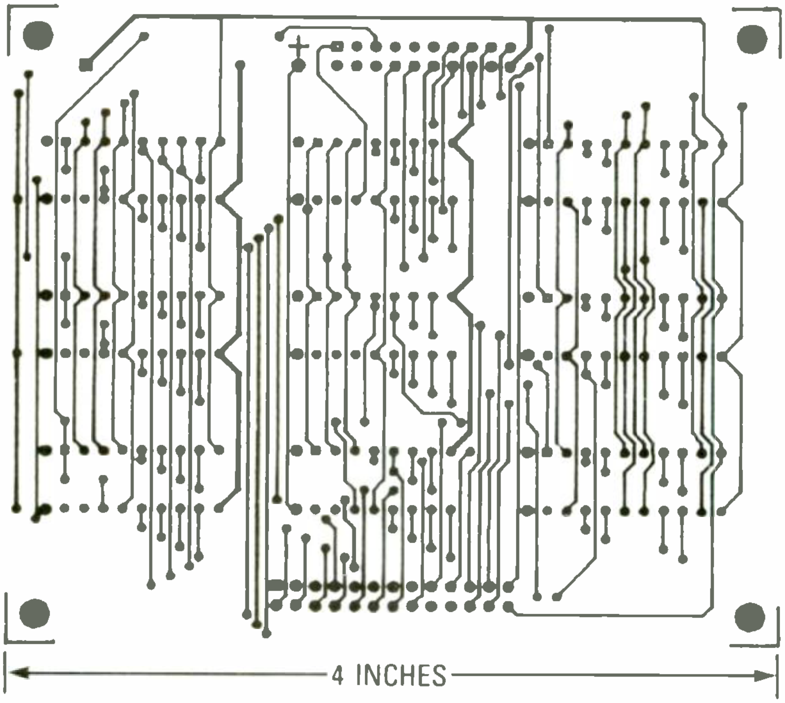
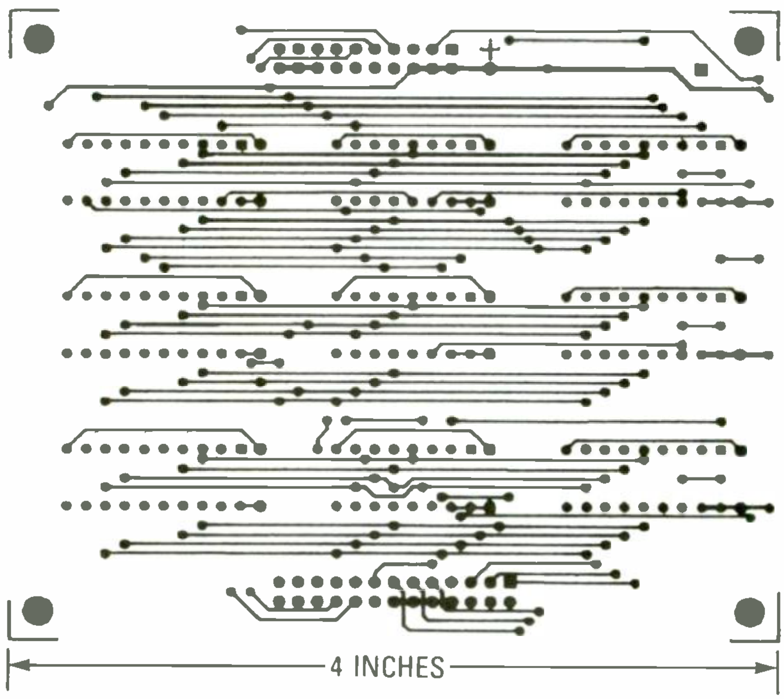
PC SERVICE



THE IC TESTER'S DRIVER BOARD. The foil side is shown here.



MOUNT THE COMPONENTS ON THIS SIDE of the IC Tester's driver board. The PC pattern for the main board will be shown next time.

One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

Note: The patterns provided can be used directly only for *direct positive photoresist methods.*

In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up you own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

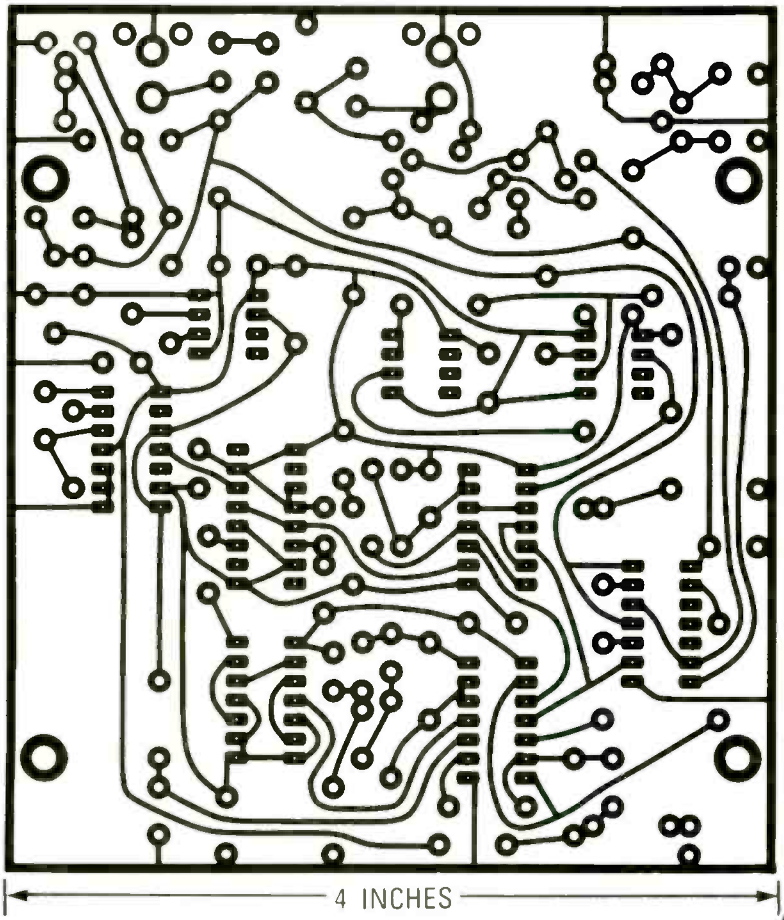
An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are used to.

We can't tell you exactly how long an exposure time you will need as it depends on many factors but, as a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'l have to experiment to find the best method for you. And once you find it, stick with it.

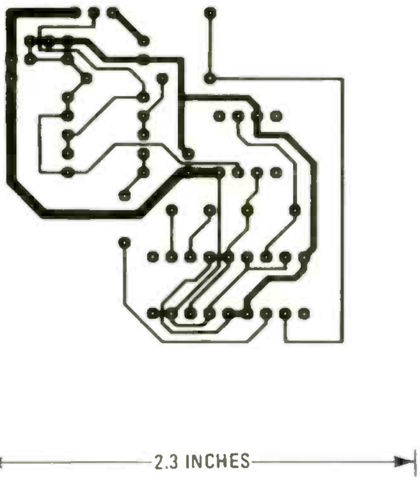
Finally, we would like to hear how you make out using our method. Write and tell us of your successes, and failures, and what techniques work best for you. Address your letters to:

Radio-Electronics
Department PCB
500-B Bi-County Blvd.
Farmingdale, NY 11735

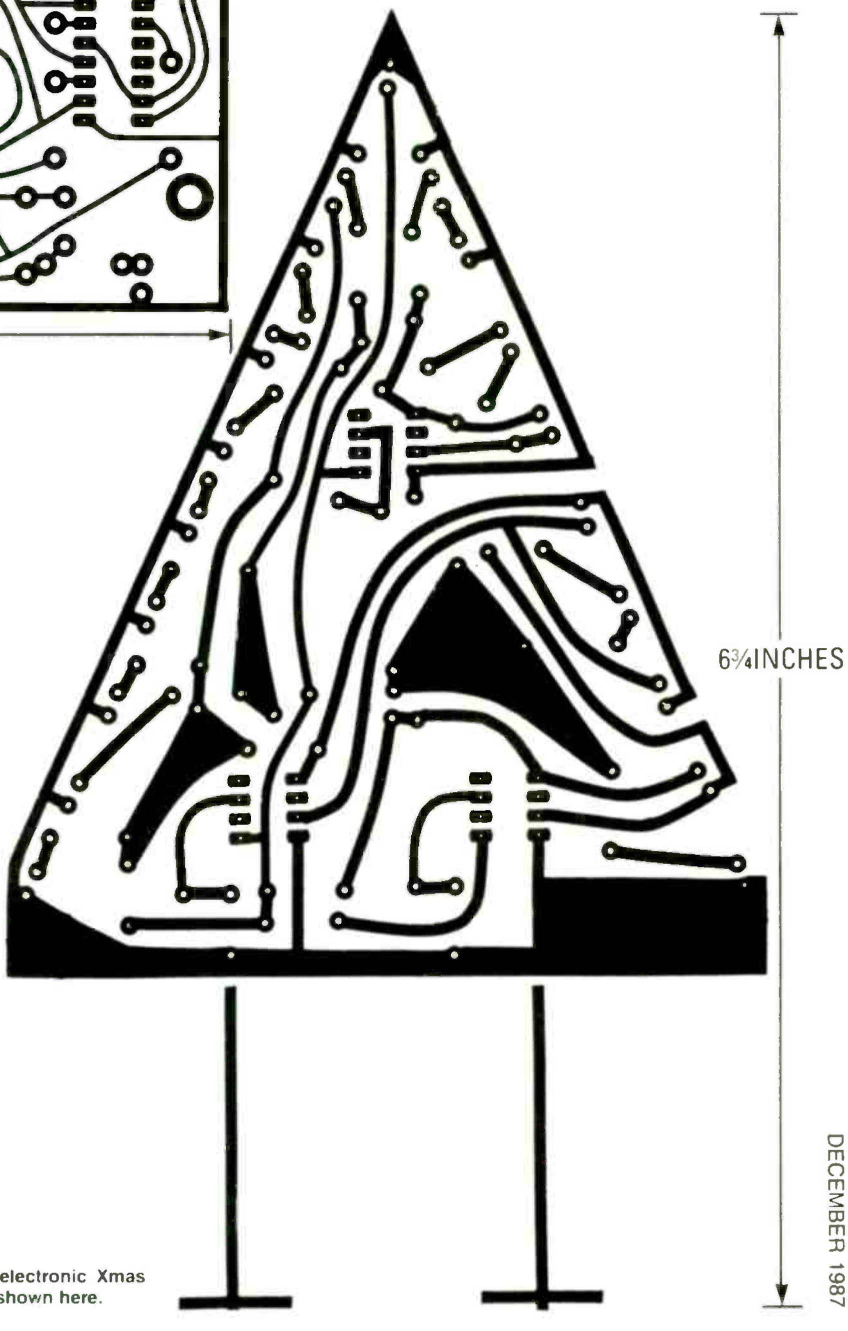
PC SERVICE



BUILD THE MACROSCRUBBER using this board.



THE ROBOT EYE'S PC board is shown here. Remember that the components mount on the foil side.



LIGHT UP THE HOLIDAYS with the electronic Xmas tree. The PC board for that project is shown here.

PC SERVICE

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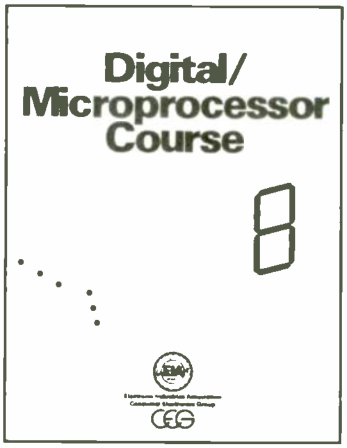

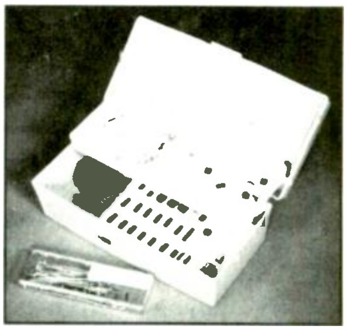

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SATELLITE TV

What's next?

BOB COOPER, Jr.
SATELLITE-TV EDITOR

BY THE MOST ACCURATE COUNT, THE home-dish industry was producing, selling, and installing as many as 70,000 home-dish systems per month in the fall of 1985. Now, the most accurate figures suggest that fewer than 12,000 home-dish systems are being sold per month at the present time.

Those numbers mean different things to different groups. The cable-television industry sees a "thriving low-power satellite broadcasting business". The home-satellite industry, the people who manufacture, distribute, and install such systems "sees a business on the verge of collapse". Both of the preceding quotes appeared in the July 20, 1987 issue of *Broadcasting Magazine*, which contained a full report on the status of the home-dish industry.

Death of an industry

Which view is correct? One only has to peruse the few remaining trade publications serving the TVRO market, or to attend an electronics flea market to witness the depth of the industry's doldrums. Complete home systems with 10-foot dishes are wholesaling for under $400; individual parts, such as 70° Kelvin LNB's are selling for as little as $40. Much of the merchandise warehoused in the spring of 1986 for the anticipated 1986 is still there.

Several pieces of legislation have been introduced to provide some form of assistance to an ailing industry and a stunted communications medium. Hearings in support of that legislation were held, but the legislation was never enacted. And even if it were, at best it would have made it *slightly* more difficult for satellite programmers and cable-television-system operators to maintain their present monopolistic control over programming access.

Control over programming—how it is distributed to home-dish owners and what it costs per service per month—is the central issue. Some say it is the *only* issue. Cable programmers and cable operators have married one another at the corporate level. TCI, the largest cable-system owner in the world, has bought substantial stock in services such as WTBS/CNN and others. Virtually every programmer making a profit has some or all of its stock owned by its customers, the cable system owners.

Home-dish proponents believe that such cross ownership has worked against the development of a "competitive delivery system". As David Wolford, a publisher in the home-dish industry told Congress: "Programmers such as HBO and Showtime/Viacom derive the vast majority of their revenue from cable operators. Are they really going to undercut the prices of their primary customers? The market is moving into a dangerous situation. If present conditions are allowed to continue, satellite TV will (end up being) controlled by its one and only natural competitor, cable TV."

Programmers such as HBO and Showtime have refused to date to allow anyone but themselves or their cable affiliates to market programming to home-dish owners. Cable operators are further controlled by specified geographical territories outside of which they cannot sell to home-dish owners. That has resulted in a form of price control because there are no competitive forces at work. If you live within a cable franchise area and want HBO, you *must* buy from the local-cable HBO affiliate. If you live outside a cable franchise area, you *must* buy from HBO directly.

Cable trade-association head James Mooney told Congress: "Cable programming is readily available to home-dish owners at prices less than those paid by the average cable subscriber for the same service."

Others, such as Bob Phillips of the National Rural Telecommunications Corporation testified that his firm has not been able to buy cable programming for resale to home-dish owners at all, or in the best case they are paying 500% to 700% more per home than cable systems are paying for the identical programming service.

Stephen Shulte of Viacom/Showtime has his own pet theory as to why the home dish industry suddenly dried up and quit functioning. He told Congress: "The infrastructure of the (TVRO) industry grew up during a time when the basic selling argument (to would-be consumers) was erroneous...that cable programming was available at no charge (with a dish). When services started to scramble (their programming), the sales were simply no longer great enough to support the industry that had been created."

Charles Rule, acting assistant attorney general for the antitrust division of the Department of Justice seemed to agree with that assessment when he told Congress "(our) investigation has not uncovered the existence of any illegal concerted activity among cable operators (or programmers)."

The next generation

Is this to be the end of direct broadcasting satellites for North America, an industry that did too well, too fast, and then was ill-equipped to face its adversaries? Probably not, but a significant period of readjustment is certainly ahead. Even the most optimistic cable-system operators admit that when the cable-television industry has completed the "wiring of America" between ten million and twenty million homes will still be without the magical cable interface. Would those homes be sufficient to support a direct-to-home satellite industry?

The answer of course is yes. But not using the present C-band satellites or frequencies. All planning for the future centers on the use of the 11–12 GHz band, generally called the K or Ku band. Several large firms, such as Comsat, have planned satellites to operate in those frequency bands. Most of those firms have suspended work on the project. Hubbard Broadcasting, a Minnesota-based television and radio station owner has plans to make use of that band. Hughes, the same people who pushed C-band satellite technology to new limits, plans a 1991 launch of a pair of satellites for Ku band as well; those satellites are intended specifically for direct-to-home broadcasting. RCA(GE)-Americom, in conjunction with HBO/Time-Life, also plans to launch Ku-band satellites sometime between 1989 and 1990.

But none of those would-be satellite operators has yet been successful in attracting programming to their satellites. Americom might have a slight advantage here; they have an investment in programming through their association with HBO and could at least fill up some channels from their own stock. But Hubbard and Hughes are offering some attractive financial deals to cable programmers such as Showtime, Turner, or ESPN.

For now, the route to the next generation of home-satellite broadcasting is not clearly marked. Nor is there any certainty that it will happen unless programmers such as Showtime feel comfortable that an offering on the Ku band will not in any way anger their existing cable-TV clients. HBO is even now trying to head off future problems by offering their present cable customers exclusive rights to the sale of Ku-band programming within their cable-franchise territories. That of course translates to monopolistic control of programming rates and terms; the very thing that has has stifled C-band sales and growth. **R-E**


EARLY RADIO

continued from page 66

There were two types of headphones used in the early 20's. One type had an iron armature that was mechanically connected to a mica or composition diaphragm. In the other, an electromagnet was used to attract an iron diaphragm that was supported around its circumference. An unusual design, called a "Baldwin receiver," used a fiber diaphragm; a later model had a diaphragm made of aluminum. Compared to speakers that were used during the early 1920's, a Baldwin-type headphone rendered superior sound.

The earliest speaker was a headphone put into a resonant chamber such as a glass bowl or a wood box. Subsequently, an enterprising experimenter developed a horn with tubular extension arms to accommodate a headset (Fig. 9).

FIG. 9—ONE OF THE EARLIEST ATTEMPTS to get more volume was a small horn that fitted over an earphone.

Commercial horn speakers were soon manufactured. Some were little more than oversized headphone units attached to curved metal or paper-mache funnels (or even to brass automobile horns). Others, like the Magnavox (first to introduce the voice coil) with a 6-volt, 1-ampere field coil, and the Western Electric, produced very good sound.

Later in the 20's cones came into use. Most of the early ones were "balanced-armature" types like a Baldwin headphone. A stylus from the armature connected to the center of the cone.

These were superseded by the "dynamic speaker," still in use. A voice coil in a strong magnetic field is connected across a low-impedance winding on the receiver's output transformer. The coil and the cone moves in and out of the field in accordance with the signal. R-E

DRAWING BOARD

Designer RAM

ROBERT GROSSBLATT,
CIRCUITS EDITOR

EVER SINCE CP/M BEGAN TO DECLINE, people have been saying that the days of the Z80 were numbered—don't you believe it. It's true that you won't see many new computer designs done around a Z80, but it's also true that the Z80 has too much muscle to wind up on the silicon scrap heap. It's still one of the microprocessors of choice to use as a dedicated controller.

Building our dynamic-RAM system around a Z80 makes sense because the chip's built-in features relieve us of the burden of implementing much of the design in external hardware. We'll still need glue to put all the pieces together, but not anywhere as much if we were building the whole circuit from gates alone.

There are four Z80 control signals that are critically important in the construction of our circuit. Understanding what they are, how they work, and what their timing relationships are, is the first step in the design. The four signals, all of which are active low, are:

- Memory Request ($\overline{\text{MREQ}}$), pin 19
- Read ($\overline{\text{RD}}$), pin 21
- Write ($\overline{\text{WR}}$), pin 22
- Refresh ($\overline{\text{RFSH}}$), pin 28

Let's discuss them one at a time.

$\overline{\text{MREQ}}$ is a control signal that is active whenever the Z80 has been instructed to perform an operation that involves external memory. As soon as the Z80 has an address ready to put out on the bus it brings this line low. That happens for *all* memory operations: read, write, and refresh.

$\overline{\text{RD}}$ goes low when the Z80 wants data from the outside world, which can be from either a memory location or an I/O port. Therefore a request for a read from memory must be sensed by watching $\overline{\text{MREQ}}$ as well as $\overline{\text{RD}}$.

$\overline{\text{WR}}$ is the opposite of $\overline{\text{RD}}$. When it goes low, the Z80 has data that it wants to send to either memory or an I/O device. Just as with $\overline{\text{RD}}$, the destination is determined by watching the $\overline{\text{MREQ}}$ line.

$\overline{\text{RFSH}}$ is the signal that keeps the Z80 popular. When it goes low it signals that the microprocessor has incremented its internal refresh counter and has put the new refresh address on the lower seven bits of the address bus (A0–A6). By combining $\overline{\text{RFSH}}$ signal with $\overline{\text{MREQ}}$, you can determine exactly when a refresh operation must take place in your system.

All memory operations require two Z80 control signals, so it's important that we have a good understanding of the timing relationships between them. And any discussion of timing must start with a look at the basic heartbeat of the Z80: the instruction cycle.

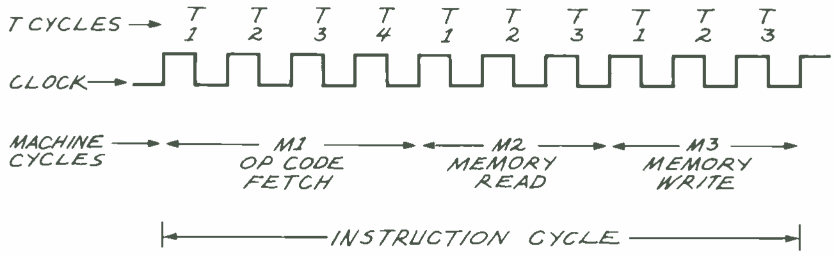

FIG. 1

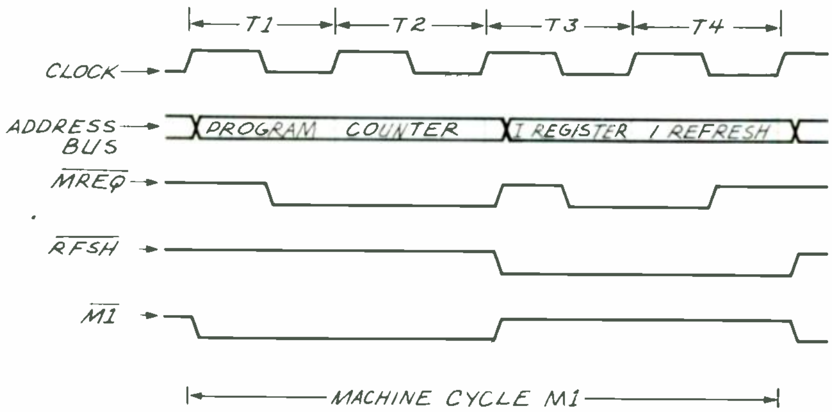

FIG. 2

M and T cycles

Figure 1 is a representation of the two fundamental parts of all Z80 instruction cycles: the M (machine) cycle, and the T (time, or clock) cycle. Every instruction that the Z80 executes requires from one to six machine cycles, M1–M6. During M1 the Z80 fetches the op-code of the next instruction. If the op-code is more than one byte long there will be more than one M1 cycle. In addition, it's during M1 that the Z80 handles refresh addressing. By the way, as shown in the figure, M2 and M3 are used for reads and writes.

Figure 2 is an expanded look at the M1 cycle. During T1 and T2, the Z80 places the contents of the program counter on the the address bus to get the next op-code. The microprocessor uses the next two T cycles, T3 and T4, to decode the op-code; it doesn't need the bus during that time. So, during T3 and T4, the address bus is divided in half to provide two kinds of data. The upper eight bits, A7–A15, have the contents of the I (index) register, and the lower seven bits, A0–A6, have the contents of the R, or refresh, register.

When the refresh address stabilizes, both $\overline{MREQ}$ and $\overline{RFSH}$ go low. That combination of signals is therefore a guaranteed-stable refresh address that can be used to systematically refresh dynamic memory.

In case you missed it, what the Z80 is doing for us is to eliminate the need for the external counters and logical glue that used to be necessary to ensure that dynamic memory would be refreshed at the right time and in the right order.

Now that you understand how much work the Z80 is ready to do for us, let's see what we have to do to take advantage of it.

Putting it to work

In using dynamic RAM with a Z80, the most important design task is to ensure that the memory is fast enough to work in the amount of time available for refresh. In our circuit we'll use a Z80B and run it at a maximum speed of 2.5 MHz, which translates into 400 nanoseconds ($1/(2.5 \times 10^6)$) per T cycle, or 800 ns to complete one refresh. In fact, however, we can't count on having the full 800 nanoseconds. Some time is eaten by delays internal to the Z80; more is needed to allow for propagation delays in our support circuitry; and all dynamic RAM needs a refresh "precharge" time. Keeping that in mind, let's see how much of the 800 nanoseconds we actually have for refresh.

Even though Fig. 2 is only a representation of actual timing, it's clear that there are delays associated with the memory-control signals generated by the Z80. It takes about three quarters of a T cycle for the Z80 to put the program counter on the address bus and then guarantee that the memory control signals ($\overline{MREQ}$ and $\overline{RD}$) are stable. And after the op-code appears on the data bus, we also must allow for settling time on the data bus.

Assuming the maximum clock speed of 2.5 MHz, we can expect to see the following timing for the whole op-code fetch cycle, (T1–T2):

$$\begin{aligned} T(\text{OP-CODE}) &= (T1 + T2) - T(\text{ADDRESS/SIGNAL}) - T(\text{DATA}) \\ &= 800 - 300 - 50 \\ &= 450 \text{ nanoseconds} \end{aligned}$$

The amount of time needed for a memory read is also an important consideration, but it is usually longer than the time needed for an op-code fetch. For our 2.5 MHz system, a memory read requires about 650 nanoseconds. Not only is that longer than an op-code fetch, but both numbers are well within the bounds of the modern 150-nanosecond (and faster) RAM.

The logic that we'll need to make our system work also has built-in delays. Each of the buffers and gates that comprise the circuit contributes to the total amount of time the circuit needs to operate. TTL and fast CMOS parts have very small propagation delays, but if you add enough of them together you can wind up with a circuit that is too slow. A worst-case analysis might look like this:

- 40 ns for memory buffer delays
- 40 ns for data buffer delays
- 30 ns for gating delays
- 40 ns for Z80 buffer delays

That's a total circuit-propagation delay of 150 ns.

Those figures are not exact, but if you look through a TTL or CMOS data book, you'll see that I've overestimated the maximum possible times by a large margin.

Now that we have all the numbers worked out, we also have the maximum access time for the RAM

we'll need. You don't need a lot of equipment to see that even if we used some slow 250-nanosecond RAM, the total circuit delay time would only be 400 (150 plus 250) ns. Most mail-order houses don't even stock 250-ns parts. The bottom line is that by using 150-ns RAM we can eliminate all the potential problems that would be caused by timing restrictions.

System design

There are a couple of things to keep in mind when using a Z80 to control a RAM system. All of them come from one general principle: *If the Z80 stops running, all our memory data will be history.*

That principle is of critical importance and it's also really easy to forget. As long as the Z80 is executing instructions it will continue putting out new refresh addresses during each M1 cycle. However, anything that puts the Z80 to sleep will also trash the memory. Fortunately, there are only a few circumstances in which that can happen:

- A reset pulse longer than 1 millisecond.
- A wait state longer than 1 millisecond.
- A DMA operation longer than 1 millisecond.

In our system, all memory access will be done through the Z80, we don't have to worry about the last two on the list. DMA simply won't be used in our system; any external request to store or retrieve data will be done by loading latches and then asking the Z80 to perform a read or a write. Similarly, we simply don't have any wait states.

Any slow I/O device using our memory system will talk to buffers and latches, not directly to memory. Some memory systems (like that of the IBM PC) must place wait states into every memory request because there isn't enough time for the "precharge time" required by the dynamic RAM. As we've seen from the mathematical analysis above, we surely don't have that problem.

Next month we'll start building the circuit. If you haven't done so already, you should get good data sheets on the Z80 and dynamic RAM. R-E

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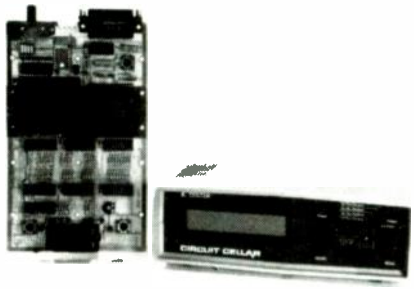

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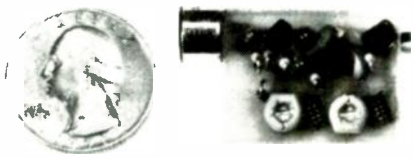

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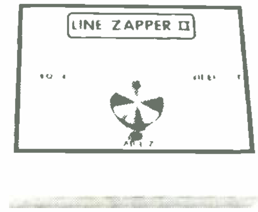

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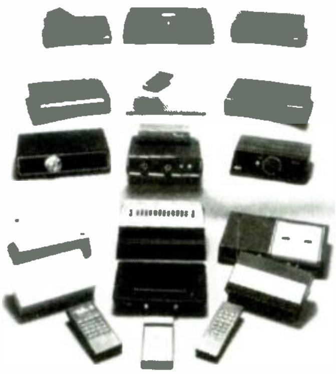

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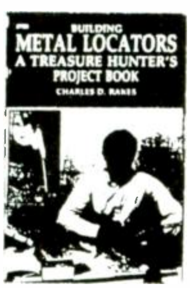

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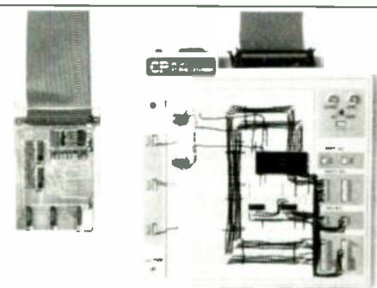

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XMAS TREE

continued from page 48

Construction

The PC board can be made photographically using the foil pattern shown in PC Service, or the pattern can be used as a guide for applying liquid and tape resist by hand. Although the foil pattern itself is only 5-inches high, the PC board material must be 6¼ inches high because the tree's 1¼-inch trunk is part of the PC board. Since etching large copper areas not only takes excessive time but also shortens the life of the etchant, we suggest you trim away the unwanted PC board material before you etch the board. Or, if you prefer to cut the tree to size after the pattern is etched, protect the foil of the large unused trunk area with resist and simply let the copper remain. As long as the trunk's foil doesn't come in contact with any of the circuit traces it makes no difference whether it's there or not.

If you want to decorate the front of the tree, do it before the holes for the components are drilled. For example, the author sprayed the component side with a bright automotive metallic-green paint. To prevent a defined line, a cardboard mask was held about ½ inch above the board. Then, the edge of the PC board was "dusted" with a fine mist of white paint to simulate snow. After allowing for adequate drying, again using a cardboard mask, the trunk portion of the board was painted with a metallic-brown paint.

Allow the decorative paint to dry overnight before drilling the component mounting holes. Then install and solder the eight jumpers, the resistors, the IC's, and the capacitors. Then insert all the LED's, observing the polarities shown in Fig. 2. Position the LED's so that they are raised approximately ½ inch off the board. To do that, turn the board over and lay it down on a flat surface, being careful not to allow any LED's to fall out; that can be done easily by holding a piece of stiff cardboard against the LED's while turning the board over. Keeping the board parallel to your work surface, solder one lead of each LED. Turn the board over and carefully look across the surface to see whether the LED's are straight and at the same height. If not, correct as needed. When you're satisfied with their alignment, solder the other lead of each LED.

Adding the base

Prepare the surfaces of the battery holders and the PC board for gluing by sanding the back of each holder and a ⅜-inch strip on both sides of the circuit board at the bottom of the trunk. Mix a small amount of a 5-minute epoxy and apply some to the ⅜-inch strip on both sides of the circuit board. With the battery polarities opposite each other, sandwich the PC board between the holders. Hold the assembly firmly on a flat surface that's covered with a piece of wax paper. You will have a few minutes working time before the epoxy sets to ensure proper alignment. Make certain that the holders are even and that the circuit board is centered and upright between the holders. In about 5 minutes the glue will have set up sufficiently, and the tree can be lifted from the wax paper. Use acetone or flux remover to clean excess glue from the bottom of the battery holders. As with most other cleaners, be careful not to touch the painted surface.

After allowing at least one hour for the epoxy to cure, solder a jumper wire at one end of the battery holders, across the adjacenet positive and negative terminal lugs. From the battery source ends, solder the positive and negative leads directly to the foil traces—as shown in Fig. 2. The LED's will start to flash as soon as the batteries are installed. Any LED that fails is most likely defective, or installed with reversed polarity.

When you're certain the project is working, you can add a final "dress up" by gluing a colorful felt material over foil traces on the back of the board. **R-E**

ANALYZE WAVEFORM

continued from page 60

thinking about them, but you do go through them.

A properly designed digital readout reduces each measurement to simply pushing a button and reading a number, including the correct decimal placement and the range multiplier. Since the tests are so much easier to do, you will probably analyze waveforms more often, instead of using less effective troubleshooting methods.

Accuracy: Digital readings provide much higher accuracy than a CRT. Most people don't think much about the accuracy of a reading, but errors can add up quickly when using a standard oscilloscope. First, no scope reading can be more accurate than the calibration of the vertical and horizontal circuits. Published accuracies range from 2% to 5%, but only if the scope has been recalibrated within the past few months. If not, the circuit errors may be higher.

Next, consider the errors in determining the displacement of the trace on the CRT. A typical CRT trace has 8 major vertical divisions, each divided into 5 minor divisions. If a waveform is 4 major divisions tall (one-half the screen height), it covers a total of 20 minor divisions. Since the width of the trace is about 1 minor division, the trace thickness adds an extra 5% error to the calibration uncertainly. When we add interpolation and parallax errors, a scope reading will only be accurate to within 10% to 20%.

Digital scope readouts offer a much higher degree of accuracy. For instance, the peak-to-peak voltage function of the Sencore *SC61* is accurate to 2%. The accuracy improvements are even greater for frequency measurements; that is because

continued on page 84

TABLE 1

Peak-to-peak volts

1. Turn vertical vernier to CAL.
2. Lock waveform and adjust horizontal circuits until desired number of waveforms appear.
3. Adjust VOLTS/DIVISION control until waveform is 2 to 4 divisions tall.
4. Adjust VERT POSITION control until the bottom of waveform sits on a horizontal graticule line.
5. Adjust HORIZ POSITION control until tallest portion of waveform is on center CRT graticule.
6. Count divisions between bottom and top of waveform.
7. Multiply number of divisions times VOLTS/DIVISION setting.
8. Multiply times 10 if a ×10 probe is used and input is calibrated for direct readings.

DC volts

1. Set vertical vernier to CAL.
2. Lock waveform and adjust horizontal circuits until desired number of waveforms appear.
3. Adjust VOLTS/DIVISION setting until waveform is 2 to 4 divisions tall.
4. Set INPUT COUPLING switch to ground.
5. Adjust VERT POSITION control until line is on a horizontal graticule line.
6. Move INPUT COUPLING switch to the DC position.
7. Readjust VOLTS/DIVISION switch if has trace moved off screen.
8. Estimate vertical midpoint of waveform.
9. Count number of divisions from reference in step 5 to midpoint of step 8.
10. Multiply number of divisions by the VOLTS/DIVISION setting.
11. Multiply by 10 if a ×10 probe is used and input is calibrated for direct readings.

Time or frequency

1. Turn horizontal vernier to CAL.
2. Lock waveform and adjust horizontal circuits until desired number of waveforms appear.
3. Adjust the HORIZ POSITION control until left edge of signal touches a vertical graticule line.
4. Adjust VERT POSITION control until right edge of signal crosses center CRT graticule.
5. Count number of divisions between left and right edge of waveform.
6. Multiply number of divisions by the setting of the TIMEBASE-FREQ switch.
7. Divide by 10 if the horizontal ×10 expander is on.
8. For frequency, invert results.

STRAIN GAGE

continued from page 63

resistance change, any difference in temperature between the strain gage and the other resistors could look like a legitimate output. But when four strain gages are used, and all are mounted on the spring element, they all see the same temperature variations. Then they will all increase or decrease by the same amount, thereby preserving the bridge balance and producing no output.

Putting it together

We are now in a position to say that the bridge output voltage is directly proportional to the force applied to the spring element. To find out what that relationship looks like all we have to do is combine equations 1, 3, and 9. Reviewing what we've learned so far:

$$e_o = E(r/R),\ r = (GS)R, \text{ and } S = kF$$

By substituting kF for S in the gage-factor equation and then substituting (GkF)R for r in the bridge equation we find that:

$$e_o = (EGk)F \qquad (10)$$

You may recognize that as the equation of a straight line that passes through the origin. The applied force, F, is the independent variable and the bridge output voltage, e_o, is the dependent variable. The slope of the line is represented by the three constants, E, G, and k. They are shown in parentheses because once the transducer has been assembled and supplied with a suitable operating voltage, they can be treated as a single constant. The slope of the line is also known as the sensitivity of the transducer. We must know the sensitivity of the transducer in order to determine the applied force. We can make that conversion simply by dividing the output voltage by the sensitivity.

Strain-gage transducers can be purchased with or without built in amplification. The transducer's sensitivity is specified a little differently in each case. First of all, a transducer with built in electronics is usually provided a fixed bridge-supply voltage and enough gain to bring the maximum output up to some standard level. Adding that additional gain to equation 10 will result in:

$$e_o = (AEGk)F \qquad (11)$$

where A is the gain of the built-in amplifier. Since the gain and the bridge supply voltage, as well as the gage factor and spring constant, are all fixed at the time of assembly, they can all be combined into one constant as the transducer sensitivity.

But, rather than specifying transducer sensitivity outright, transducer manufacturers often list the maximum value of the input force and the corresponding maximum output-voltage level. Both of those specifications are important in themselves, and the sensitivity is implied in the two numbers. Since equation 10 defines a line that passes through the origin, all we have to do is divide the full-scale output voltage by the full-scale input force to determine the sensitivity. A typical value for the maximum output might be 5 volts. If the maximum input force is 500 pounds, then the sensitivity of the transducer would be 5-volts/500 psi = 0.01-volts/psi.

If the transducer does not have built-in electronics, it is up to the user to provide the bridge supply voltage and whatever gain may be required. Since the output voltage is a linear function of both the applied force and the bridge supply voltage, sensitivity is then specified as output volts per bridge supply volts per input force. The maximum output voltage corresponding to a maximum input is listed for a bridge supply of one volt. That way we can determine what the maximum output voltage will be when some other value of supply voltage is used by simply multiplying the listed maximum by the supply voltage actually used. R-E

R-E ROBOT

continued from page 68

ously throughout a full 360° rotation of the head. Under low-light conditions the output of the eye will be a low frequency. If the eye is operating at 1 Hz and light readings are taken every 5°, it will take over a minute to rotate the head. Obviously, then, the higher the frequency output of the eye, the better. We can always divide the frequency down to get it in a range that the RPC will be able to process effectively; however, we cannot multiply a low-frequency input to obtain information faster.

The active integrator used in the circuit is based on a simple, classic design. The photodiode's output current is used to charge a capacitor; the charging time, of course, is the integral of the input voltage. A novel twist, however, is that we will use the photodiode to both charge and discharge the capacitor. A newly developed IC from Linear Technology Corporation, the LTC1043, will be used to switch the photodiode from a current-sourcing to a current-sinking configuration. That IC is also used to convert the output of the integrator to a frequency signal for input to the robot's RPC.

The integrator is built around op-amp IC1, a Linear Technology LT1022. That op-amp is chosen for its high-speed operation, modest input-bias current, and low cost. Other operational amplifiers can be substituted, but be aware that any increased input-bias current will degrade the low-light performance, and decreased output slew-rate will degrade high-light-level performance.

Construction

The PC-board's design is somewhat different in that all of the components except J1 are mounted on the *foil side* of the board; the PC pattern can be found in PC Service, and the parts-placement diagram is shown in Fig. 3. The components are mounted in that way so that the PC board can be used as one side of a light-tight structure supporting the Fresnel lens as shown in Fig. 4. Placing the traces on the inside of the box protects them somewhat from contamination; over time, that contamination can build up on the circuitry and affect performance. The completed board can also be covered with a conformal coating (that's a coating that closely conforms to the surface that it is applied to) or potted to minimize any contamination problems.

The printed circuit board is 2.3 inches by 2.3 inches. Those are the same dimensions as the Fresnel lens available from the supplier mentioned in the Parts List. Use screws or standoffs to mount the lens 1.3 inches from the photodiode. That is the

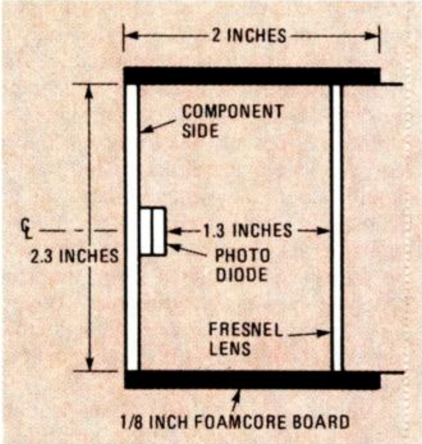

FIG. 3—ALL OF THE COMPONENTS, except J1, mount on the foil side of the PC board.

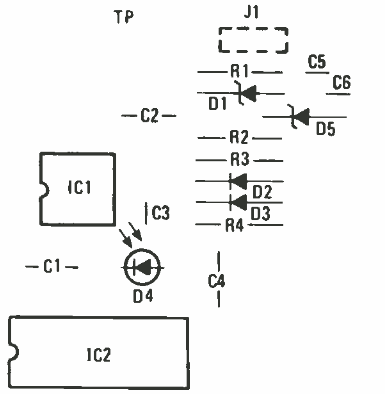

FIG. 4—A FRESNEL LENS is used to concentrate the light on the photodiode.

focal distance of the lens and will result in maximum light gathering power. To fine-focus the lens, attach an oscilloscope to the photodiode and, with the eye pointed towards a light source located several feet away, adjust the lens supports for maximum frequency output. If you find that your eye saturates too quickly, you can simply defocus the lens slightly to reduce the light level that reaches the photodiode.

After the lens has been focused, cut and mount the remaining sides of the box. Cardboard or a similar material is suitable for that; the author used Foamcore board, which is available at art supply stores. Hot-melt glue is a handy means of attaching the sides.

Paint the cardboard sides black to reduce the amount of light entering the eye except through the lens. That won't do much to stop infrared light, however. If interference due to infrared noise becomes a problem, laminate a layer of aluminum foil to the sides.

Next time

That completes the eye's construction. Now it's time to hook it up and test it. Unfortunately, at the moment there's nothing to hook it up to. That shortcoming will be taken care of next time when we show you the robot's rotating head. **R-E**

ANALYZE WAVEFORM

continued from page 82

a 0.001%-accurate frequency counter replaces the 10 to 20% errors associated with CRT-based frequency measurements.

Freedom from errors: The third difference may have even more impact than the first two. That's because an error in counting or multiplication—or forgetting to set the horizontal or vertical vernier to the CAL position—may lead you down a completely wrong path.

What is worse is that you won't realize that you've made the error until some time later when you re-test a signal. A direct-reading digital readout prevents that because it gives accurate results independently of display settings.

Other problems can happen, too. The verniers can be out of their calibrated position; the signal can be off of the CRT; or the triggering circuits can even be out of sync. But none of those problems will affect the digital readings.

Digital readings make it easier to use waveform analysis for more and more of your troubleshooting. You can lock the waveform onto the CRT when you want to fully analyze all seven parameters of complex waveforms. When making general tests, however, you don't even need to adjust the CRT circuits, if DC voltage, peak-to-peak voltage, or frequency readings are enough to tell you whether the circuits are operating correctly. Such general testing can speed your circuit analysis even more. And, what service technician or engineer could possibly argue with that? **R-E**

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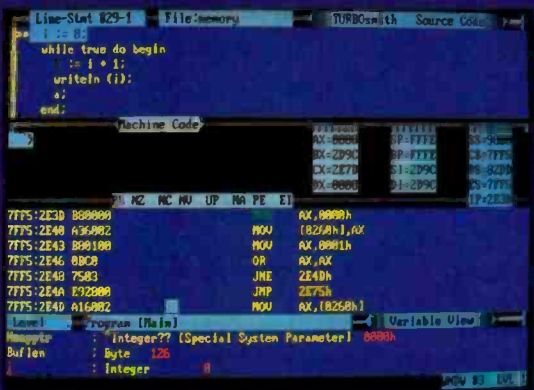

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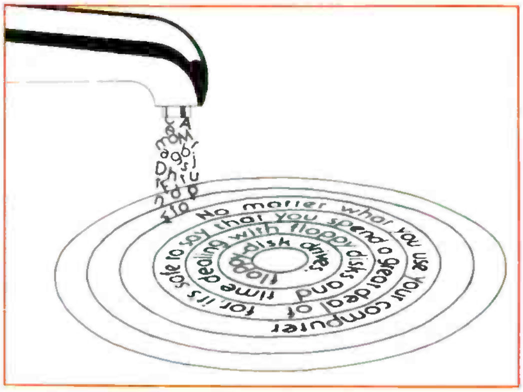

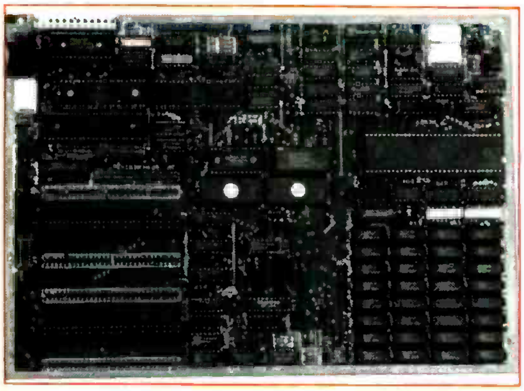

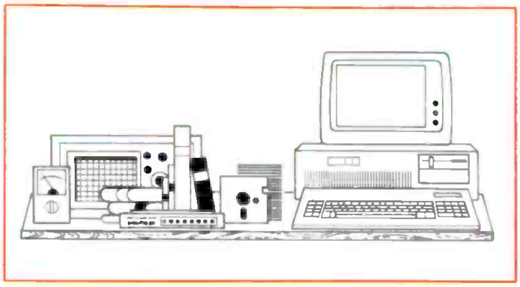

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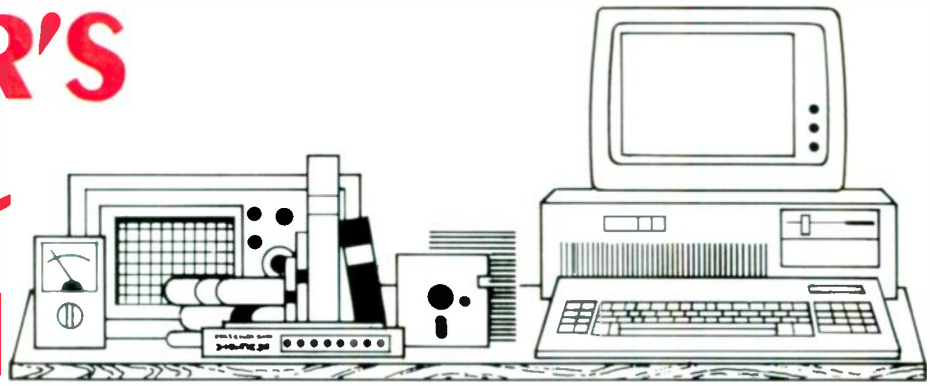


Periscope

Debug is the standard MS DOS machine-language debugger It is included with every copy of DOS, so every programmer, hacker, and hobbyist is familiar with it. Debug is useful for tracing and analyzing both software you write yourself, and software written by others. And with care you can even use it to create short programs without the aid of an external assembler.

However, you don't have to use the program for very long to realize that it has limitations, the most severe of which are limited breakpoint facilities, lack of windowing, and lack of support for the symbols generated by the assembler or compiler you use to generate object code

Attempting to remedy those deficiencies, the Periscope Company sells a line of high-quality debugging tools with varying capabilities. The latest incarnation includes an expansion card that allows you to trap bus events in real time, thereby providing many of the capabilities of a development system for about 10% of the cost.

Actually, there are four models of Periscope, which differ mainly in the hardware included.

- Periscope I ($345) includes a memory board with 56K of write-protected memory and a break-out switch. The memory is installed outside of the 640K DOS limit (usually in segment D000 or E000), the Periscope software runs from that memory. Pressing the break-out switch at any time—even when the system is apparently locked-up—generates a hardware interrupt that activates the Periscope software
- Periscope II ($175) includes just the break-out switch; the software runs from normal DOS memory, so it may be overwritten by a run-away program. In that case you may not be able to regain control of a hung system. The break-out switch does not require an expansion slot; a small finger slips in an in-use slot between the expansion card and the connector's own finger
- Periscope II-X ($145) includes just the software and no hardware. You may use your own break-out switch or a keyboard hot-key to activate the software.
- Periscope III ($995) is a full-length expansion card (shown in Fig. 1) that includes 64K of write-protected memory, a break-out switch, and additional circuitry that continuously monitors the expansion bus and allows you to create breakpoints that are activated when memory locations, I/O ports, or microprocessor registers attain certain values. A small module must be inserted into your motherboard's 8087 (or 80287) socket.

FIG. 1—The Periscope board.

The software functions pretty much the same for all versions, given the hardware differences. In fact, the same software is included with all versions; during the installation you must specify your hardware configuration

How to use it

The Periscope software comes in two parts: PS.EXE, the 50K debugger, and RUN COM, a 7K program that loads and runs your software. First you run PS, which lies dormant in memory until you Run a program. When you do, the Periscope screen comes up, a register dump is displayed, and the first instruction is disassembled You can then execute your program in various ways

To ease the learning process, Periscope duplicates many Debug commands, so you can Trace a single instruction or a group thereof, or Go, starting at an address you specify, with breakpoints at addresses you specify In addition, you can Dump memory in the standard Debug format, Read and Write files and disk sectors, Unassemble, Examine, Search, and Fill memory, etc.

Normally, all output scrolls up the screen in standard fashion. However, you can open windows (see this month's cover for an example) that maintain information in fixed places on the screen, thereby making that information much easier to find and assimilate. Window size and color is easily specified, windows may contain registers, memory dumps (in several formats), disassembled instructions, stack dump, and a text file dump. Pressing Ctrl-F9 or Ctrl-F10 brings up default windows for mono and color windows, respectively.

The disassembly will contain the symbols and high-level instructions of your program, if an appropriate .MAP file is available (Most assemblers and linkers can generate such a file.) For example, the program shown in Fig. 2 is written in Turbo Pascal; a utility sold by Turbo Power created the required .MAP file. Note that both Turbo source lines and the generated object code are shown See this month's software reviews for more information

You can add your own labels to programs and save them separately That capability is useful when disassembling third-party software.

Breakpoints and program tracing

You can set an almost bewildering variety of breakpoints with Periscope BC sets a Code Breakpoint, activated when your program tries to execute code at the specified address That address may be specified using hex notation or symbolically. BI sets an Interrupt Breakpoint, activated when a software interrupt is executed. For example, to stop execution any time a DOS function (interrupt 21h) was to be executed, you'd type

BI 21

You can also set breakpoints on source-

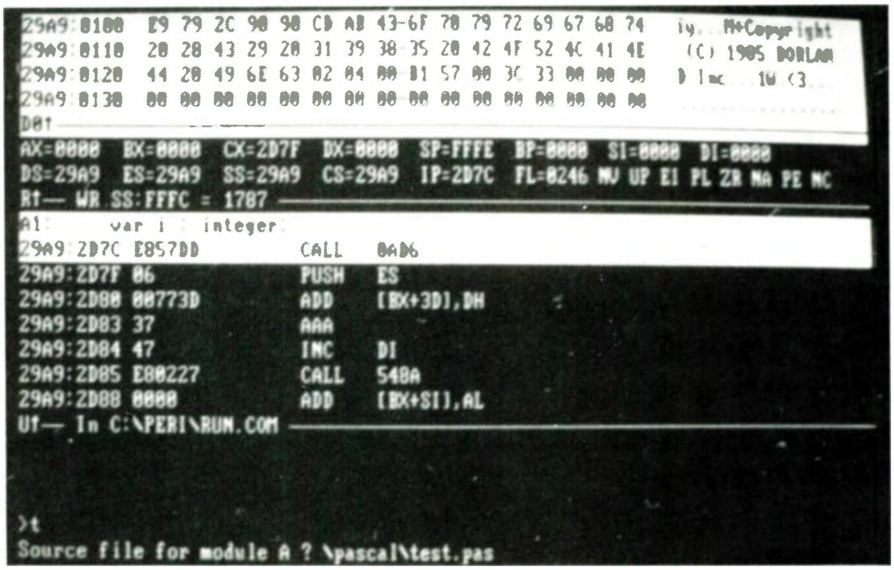


FIG. 2—The Periscope debugging screen.

code line numbers (BL), memory addresses (BM), I/O port addresses (BP), registers (BR), user-specified conditions (BU), memory contents (BW), and subroutine exit (BX). Note that those are not hardware-activated breakpoints, so execution must be started via the GT command, in which machine instructions are executed one at a time, breakpoint settings are examined, and then control reverts either to Periscope or to the user program, depending on whether the breakpoint conditions were met.

Each of the breakpoint commands may be cleared by entering the command with an asterisk. In addition, breakpoints of a particular type may be enabled (by typing +), disabled (by typing −), or displayed (by typing ?).

Hardware control

All of the commands discussed thus far may be used on any version of Periscope. Periscope III enables an additional set of breakpoint, trace, and display commands that let you execute your program in real time until a specified condition is met. The HB command, for example, sets a breakpoint when a specific bit pattern appears on the data bus. Values of 0, 1, and X (don't care) are legal. You can also trap memory and port reads or writes (or either) using the HM and HP commands, respectively. Further, using the JD command you can qualify the breakpoint so that execution will continue until data within a specified range, and at the specified address is accessed.

Periscope III's hardware buffer has sufficient memory to trap 8192 bus events. When defining a breakpoint, you can instruct the hardware to save the 8K events preceding the breakpoint, the 8K following it, or 4K on either side. You can also set up a pass count, so that, for example, the breakpoint will not be executed until the fifth time an 0Dh is output to port 61h. The HC (Hardware Control) command sets those modes

Operation on an AT is somewhat more complicated. For example, when setting a bit breakpoint, you must specify the upper or lower half of the bus (or both). In addition, you can force a hardware breakpoint to be executed when memory beyond the one-megabyte area is accessed, again using the HC command.

Hardware buffer display

There are four commands for displaying the contents of the hardware buffer; a fifth (DW) saves the buffer to disk (or memory) for future examination. The display commands are as follows.

The HR command provides a full-screen display of the raw contents of the hardware buffer. Each line contains an address, data, operation type (input, output, read, write, DMA, instruction pre-fetch), plus an address symbol, if available. A sequence number that corresponds to the 8K of stored data is also displayed. You can scroll through the buffer and search for address, data, and operation types.

HS displays a single line in the same format as the HR command.

HT and HU provide a full-screen display of the hardware buffer, but in a more digestible format. HT provides a disassembly (with labels) plus the operation types (in, out, etc.), and HU provides just the disassembly.

Other goodies

Naturally, Periscope includes a built-in assembler. The surprise is that you can use symbols for address references—those from your program's MAP file, or those that you've defined within Periscope (using ES).

There is also (optional) on-line help. Pressing ? brings up a list of commands; pressing ? plus a command brings up a brief summary of that command.

Periscope can use two monitors—one for your program's output, and one for the Periscope debug display. When used with an EGA and enhanced color display, the Periscope display can optionally run in the 43-line mode.

The Periscope command line is fully editable, and the program maintains a stack of recently issued commands, which you can scroll through and then edit and execute the new line. Limited macro-type facility is available, and you can repeat the last command executed by pressing F4.

A word about the break-out switch: If you run the following piece of code under Debug, the only way to regain control of your machine would be by resetting:

```
XXXX:0100 JMP 0100
```

A break-out switch will, however, allow you to escape from the loop.

Conclusions

With or without a break-out switch, Periscope impresses us as one of the finest pieces of development software we've ever seen. It will be part of our tool kit for years to come. The hardware models aren't cheap, but if you need one, you need it bad, so cost should be no object. If you're on a tight budget, you can buy the software-only version and add your own break-out switch.

Turbo Pascal Debuggers

Turbo Pascal, when it was introduced some four years ago, laid to rest forever the notion that serious software development could only be done by means of the traditional and time-consuming edit-compile-link-test-repeat loop. Comprising less than 40K of code, and widely available at well under $100, Turbo Pascal also dispelled the notion that a professional compiler had to be big or expensive. In addition, it's available for a number of operating systems (CP/M, CP/M-86, and MS-DOS)

The only thing missing from Turbo Pascal was a symbolic source-level debugger of the type that companies like Periscope (see this month's hardware review) have been selling for some time.

That lack was addressed a few years ago when a program called TDebug appeared on BBSes across the nation. Since then, the product has gone commercial; the commercial implementation, called T-DebugPlus, adds a host of new features and several extremely useful utility programs.

TurboSmith, a latecomer, provides many of the features of T-DebugPlus, as well as several unique ones, including an integrated machine-language debugger.

TurboSmith

The program is contained in a single 120K file (TSM.EXE). In keeping with the Turbo philosophy, TurboSmith costs $69 It's written entirely in assembly language, and requires 512K of free RAM to run. In fact, TurboSmith really needs most of 640K to function properly; it wouldn't work at all on a 3Com network station, which gobbles about 200K of memory for device drivers.

You run TSM to get into Turbo; TSM loads Turbo and adds a new item, Trace, to Turbo's main menu. (See Fig. 3.) The editor and compiler functions work just as they do without TSM; the new Trace option compiles the current program and then brings up the debugging screen. (See Fig. 4.)

That screen can display as many as three windows simultaneously. One is the source-code window, which is always displayed. The other two may contain program variables, a hex/ASCII memory dump, or a machine-language control window.

You switch among windows cyclically by pressing the F10 key; pressing F2 inside any window brings you to a command line where you can initiate various operations. For example, by typing Q you return to the Turbo menu. A full range of line-editing functions is available at each command line.

Other non-command-line operations are initiated by Ctrl-key and Alt-key combinations, and the commands work as much alike as possible inside different windows. For example, pressing Alt-B inside either the source or the machine-code window sets a breakpoint where the program will stop when it tries to execute that Pascal statement or that machine-language instruction, respectively.

In either program-control window you can execute a single statement or instruction by pressing the + key by the numeric keypad. Or press Alt-X (eXecute) to execute full-speed until a breakpoint is reached or Alt-S (Stop) is pressed. Another way of starting executing is to press Alt-A (Auto single-step). In that mode, a statement or instruction is executed, the screen is updated, and then the next program element is executed. Terminate Auto mode by pressing any key. Auto mode is not as useful as it might be because you can't control the speed at which statements are executed. You might want to slow execution in order to get the feel of how a loop was executing, for example.

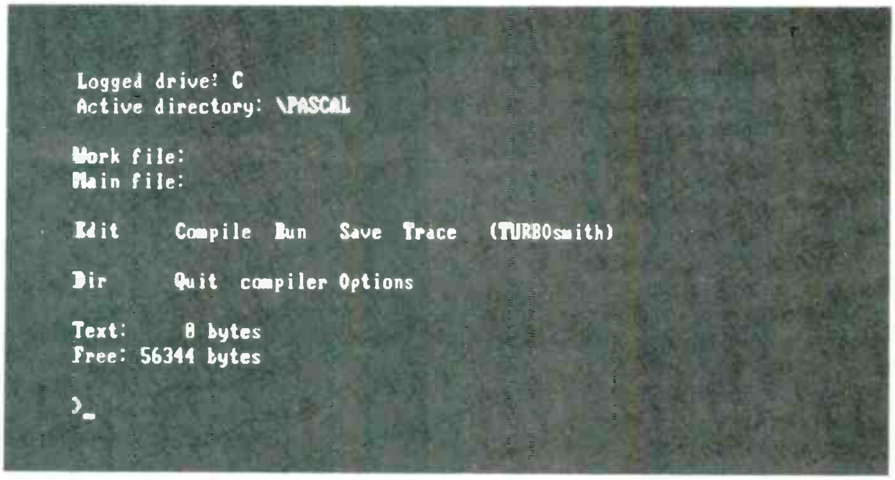


FIG. 3—TurboSmith adds a new item to the Turbo menu.

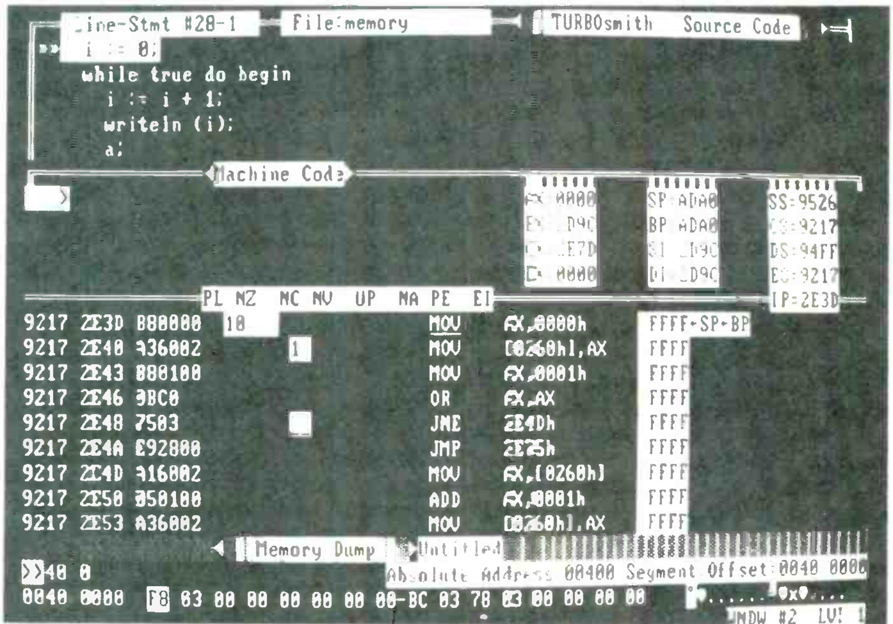


FIG. 4—The TurboSmith debugging screen.

The Variables window displays the values of all global variables, Turbo's internal variables as well as your own. You can only view variables inside a nested procedure or function when the program is executing that procedure or function. Further, you can open as many as eight window *levels*, each of which overlays one of the three on-screen windows. You cycle among displayed windows by pressing F10, and among levels by pressing F9. You are free to change the values of variables within any window.

Version 2.1 (which was not available in time for this review) should automatically open variable windows in nested procedures and functions.

Screen swapping

Most programs produce some sort of screen output; TSM can deal with screen output in two ways. First, and best, you can use two monitors, one mono (IBM or Hercules) and one color (CGA or EGA). In that case, program output must go to the mono screen; the debugging windows come up on the color screen. Otherwise, on a single-monitor system, you can use screen swapping, wherein TSM maintains memory images of both the debugging data and the program's output data, swapping them at the press of a key.

One useful feature is that TSM will respond to a break-out switch. If your program gets locked in a loop and the keyboard won't respond, chances are the break-out switch will allow you to regain control and continue debugging. See this month's hardware review for more information on break-out switches.

TSM's machine-language debugger provides powerful breakpoint facilities. You

Products Evaluated

- TurboSmith ($69), Visual Age, 642 N. Larchmont Blvd., Los Angeles, CA 90004, 800-732-2345, 213-534-4202 (CA).
CIRCLE 31 ON FREE INFORMATION CARD

- T-DebugPlus ($60), Turbo Power, 2109 Scotts Valley Drive, Scotts Valley, CA 95066, 408-438-8608.
CIRCLE 32 ON FREE INFORMATION CARD

- Turbo Pascal ($99.95), Borland International, 4585 Scotts Valley Drive, Scotts Valley, CA, 800-255-8008, 408-438-8400 (CA).
CIRCLE 33 ON FREE INFORMATION CARD

- Periscope (price varies according to model), The Periscope Company, 14 Bonnie Lane, Atlanta, GA 30328, 404-256-3860.
CIRCLE 34 ON FREE INFORMATION CARD

can set *passpoints*, breakpoints that will occur only when an instruction has been executed a number of times (ranging from 1 to 65535). In addition, you can *tag* an instruction or a group of instructions with a number ranging from 1 to 99; you can then set, clear, or disable breakpoints by tag number. The ML debugger also provides DEGUG-like facilities for searching, filling, moving, and disassembling memory, computing hex values, inputting and outputting values to I/O ports, etc. You can also append comments to disassembled instructions, but the comments may not be saved. A macro facility allows you to record sequences of keystrokes and assign them to any key. Macros may not be saved. TSM will also accept keystrokes from a file.

In the machine-code window, you can use a non-symbolic assembler to enter assembly-language instructions into your program in one of two ways. First, by pressing Ctrl-A, you enter an overwrite mode in which your instructions overwrite whatever instructions currently reside in memory. Second, by pressing Ctrl-P, you enter a patch mode in which your instructions are inserted *between* current instructions—even if there is no space for them!

You can also patch memory in the memory-dump window, in either hex or ASCII notation. You can also force the memory-dump window to track the machine-code window, so that any time you execute a machine instruction that accesses memory, that area of memory will be displayed.

One deficiency is that you can't use TSM to debug graphics programs. Future versions of the program may correct that deficiency, but for now, you'll have to stick to text-mode debugging. Our only other complaint is that window position is hard to control; by contrast, some machine-language debuggers allow window placement by screen line number.

T-DebugPlus

Turbo Power has been selling Turbo enhancements for a long time, and the company has a number of products, including T-DebugPlus; Turbo Extender, which allows you to create very large (greater than 64K) Turbo programs; Turbo Optimizer, which allows you to compact the size of run-time files and to create and link libraries of often-used routines; and Programmer's Utilities, which contains a program structure analyzer, an execution timer and profiler, pretty printer, and several file-management utilities. Source code is available for all programs, all of which are written in Turbo Pascal.

T-DebugPlus is contained in one .COM file and one overlay file, which together occupy about 100K of disk space. To run T-DebugPlus you need about 256K of free memory. The main features that distinguish T-DebugPlus from TSM are that (a) the program is written in Turbo Pascal, anc the source is included; (b) the program has no

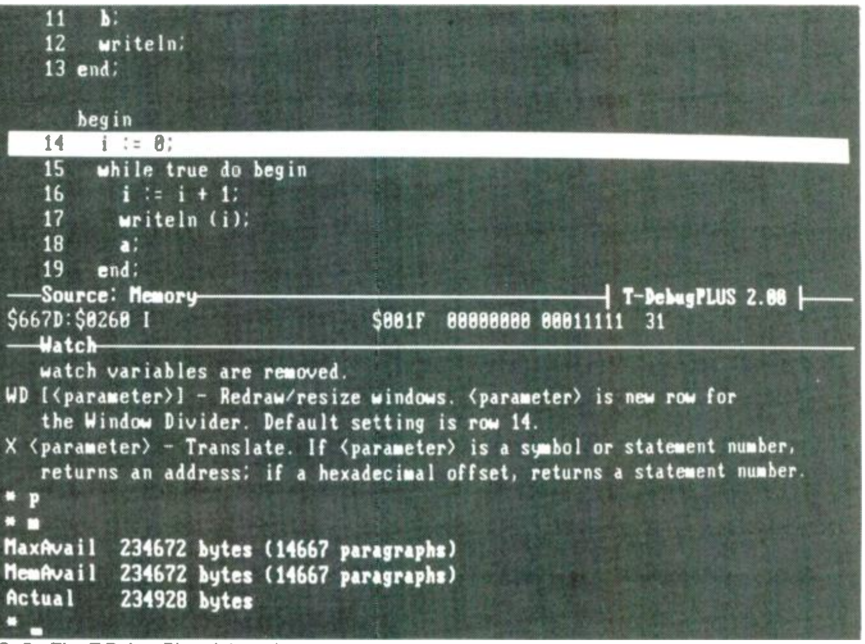


FIG. 5—The T-DebugPlus debugging screen.

built-in machine-language debugger; (c) the program does support graphics modes; (d) program and debug screens can appear on either mono or color monitors in a dual-monitor system. T-DebugPlus also has a screen-swapping mode.

In addition, T-DebugPlus includes several useful utilities, including TMAP, which generates a .MAP file for use with an external symbolic machine-language debugger; TMERGE, which allows T-DebugPlus to debug large Turbo programs (when used in conjunction with Turbo Extender), and two program-listing programs, one of which generates a symbolic disassembly. In addition, several files contain information about various routines in Turbo's run-time library; that information is extremely useful for learning about now Turbo works. All source files are contained in a single .ARC file on the distribution disk.

To use T-DebugPlus, you run the program, which, like TurboSmith, loads and runs Turbo for you. When you Run your program from Turbo's menu, T-DebugPlus's debugging screen comes up. (See Fig. 5). There you can single-step individual statements and entire functions and procedures. You can set breakpoints that become active when a variable changes or becomes equal to a specified value, or when a particular memory location is altered. You can also set breakpoints by line number and by routine name. A breakpoint may also include passpoint count values, so that the breakpoint would be executed after a routine was executed the specified number of times. In addition, you can open a memory-dump window in one of several formats, display "watch" variables, whose values are updated on the screen each time a breakpoint is reached, and examine and change the values of variables.

All commands are executed from a command line, which can be edited No macros are allowed, but the function keys provide shortcuts to the most common commands, and F4 repeats the last command.

Although T-DebugPlus has no built-in machine-language interface, it can be used in conjunction with an external debugger—even Debug. The DG command will drop you into your debugger. Source-level debugging is not possible in that manner. However, you can use TMAP, one of the utilities included with the package, to generate a .MAP file, which most source-level debuggers can use to link source code and machine instructions.

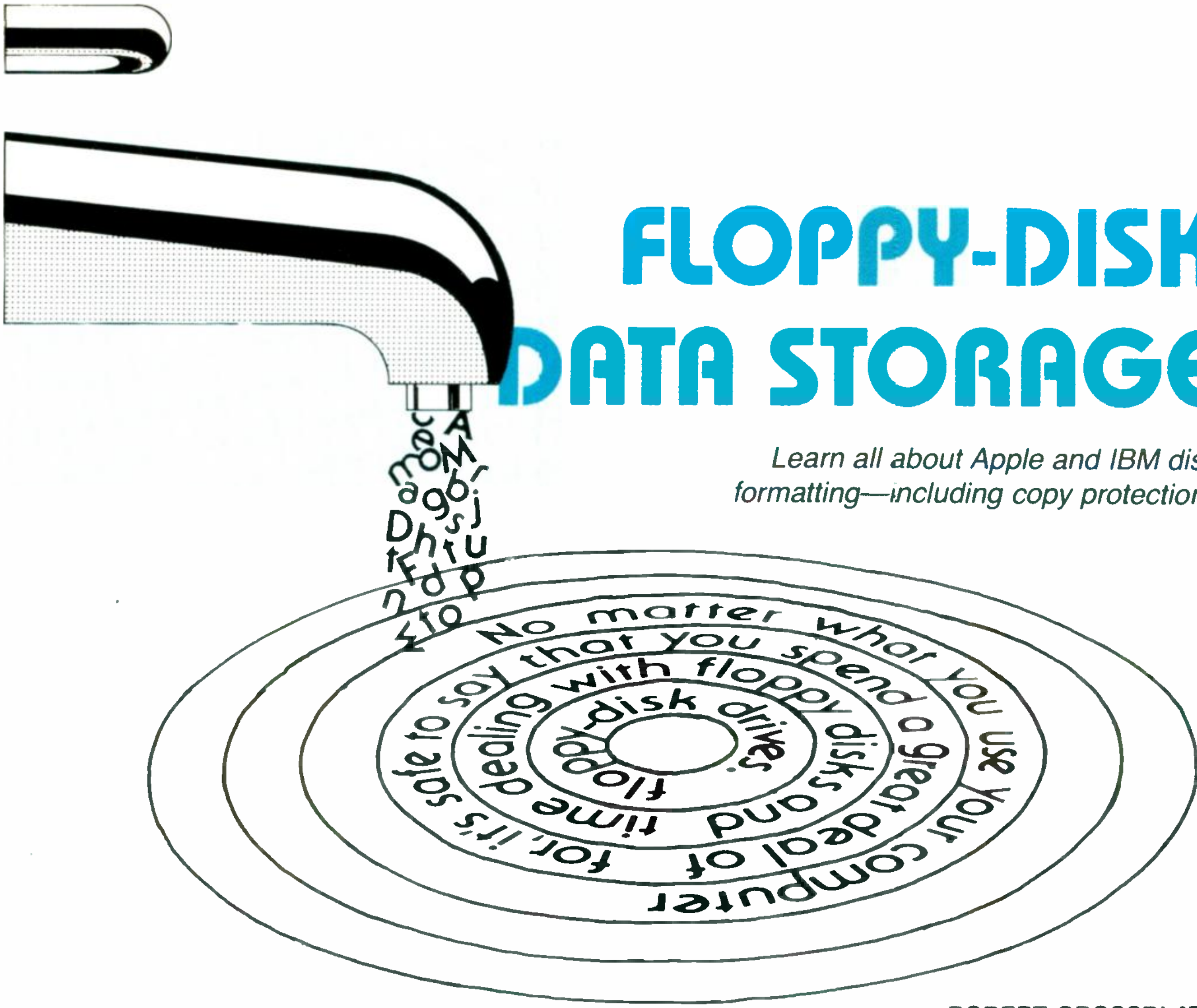
Several miscellaneous commands provide useful functions. For example, a brief command summary is available by pressing F1. In addition, the X command allows you to find the machine addresses of variables, source-code line numbers, procedures, and functions. Conversely, you can find the nearest statement to a specified address.

Conclusions

T-DebugPlus and TurboSmith are both extremely useful accessories to anyone programming in Turbo Pascal.

Points to keep in mind, however, are that T-DebugPlus does graphics, has full dual-monitor support, and slightly more convenient breakpoint facilities (at the source level). In addition, it requires less memory, and its documentation is more concise and better produced. For beginners and those not needing full machine-language support, it may be the better choice. TurboSmith's strength are its windows, its built-in machine-language interface, and its ability to work with a break-out switch. But considering the reasonable prices of these packages, you may want to get copies of each.

FLOPPY-DISK DATA STORAGE



Learn all about Apple and IBM disk formatting—including copy protection!

ROBERT GROSSBLATT

No matter what you use your computer for, it's safe to say that you spend a great deal of time dealing with floppy disks and floppy-disk drives. Loading programs and saving data are such common operations that we tend to forget how fragile the whole system is. But all it takes is one disk disaster to remind us of that fragility.

Of course, there are ways of protecting against those types of disasters, and other ways of dealing with them when they do occur. Performing regular backups is the best protection, but even that is not fail-safe. What happens if a disk crashes during a backup procedure?

In order to have any chance at all of recovering that data, as well as to back up copy-protected software, you need to know how data is stored on your disks. The more of the process you understand, the better your chances of successfully recovering a crashed disk. So in this article we'll examine how data is stored on both IBM and Apple floppy disks. The information provided will put you far on the road toward being a real "disk jockey."

Tracks and sectors

The standard 5¼-inch floppy disk consists of a disk of magnetically coated plastic that is contained in a jacket, as shown in Fig. 1-a. In order for your computer to use the disk, it must have a way of finding its way around the magnetic coating on the surface. It does so by treating the disk as a group of tracks that are divided into sectors. As shown in Fig. 1-b, the tracks are a series of concentric circles, each of which is divided into a number of segments, the sectors. In addition to tracks and sectors, disks also have two sides, as shown in Fig. 2. Not all disk control hardware and software can use both sides, however.

The number of tracks and sectors determines how much data will fit on the disk. That amount is dependent on your computer's hardware and disk operating system (DOS). The numbers vary among computers and disk sizes, but the basic principles of operation are the same.

When you tell your computer to format a disk, the hardware moves the read/write head to track zero, the outermost track, and then forces it to deposit information on the surface of the disk that indicates the sector locations. The process is repeated for each track until the last track has been formatted.

Standard 5¼-inch Apple disks have 35 tracks on one side of the disk only, and the most common IBM format has 40 tracks on each side of the disk. Double-sided 3½-inch and 8-inch disks have 77 tracks per side, and the AT's quad-density 5¼-inch disks have 80 tracks on each side.

DOS (IBM or Apple) uses tracks and sectors to organize the disk's surface. At the DOS level, to find a particular piece of information, all you need are two pieces of information: track and sector numbers. With double-sided disks, you must also specify the head number.

The number of tracks per disk is usually a function of the hardware. The DOS talks to the disk controller, which, in turn, talks to the stepper motor in the drive and tells it to move the head in or out the desired number of tracks.

The number of sectors, however, is controlled by the DOS. IBM's DOS, for example, can format for eight or nine sectors per track, but standard Apple disks have sixteen sectors per track. So you can have more small sectors or fewer large sectors

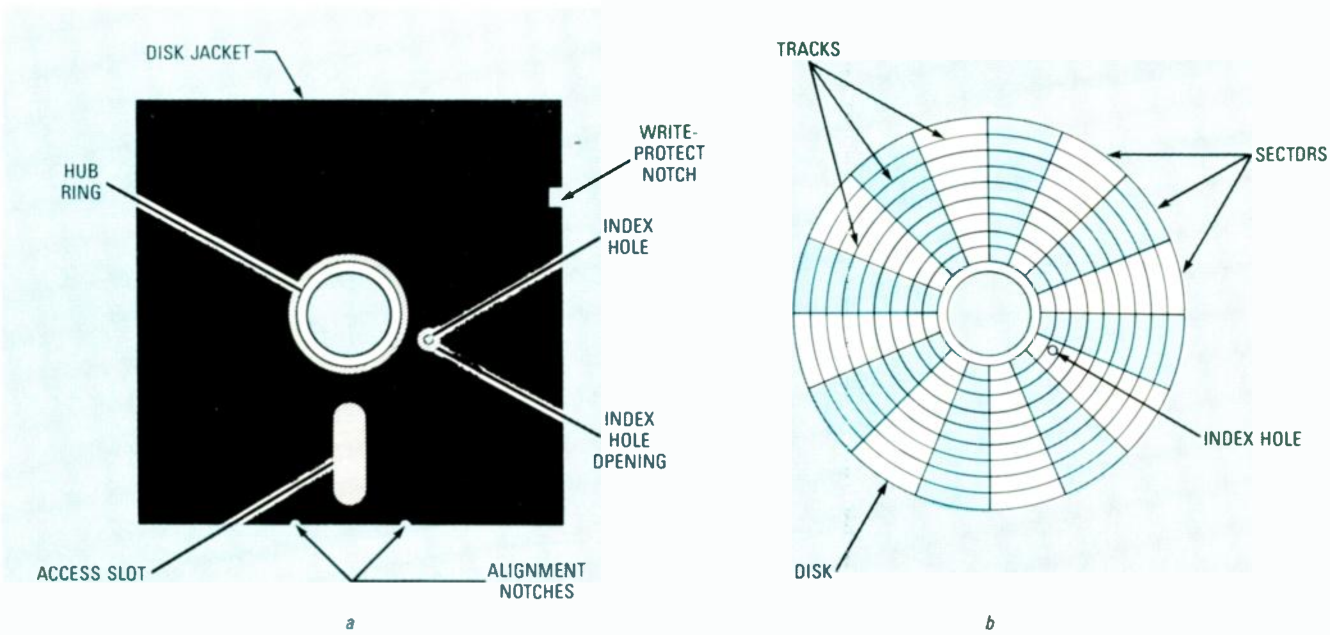


FIG. 1—DISK CONSTRUCTION: The magnetically coated disk is contained in a jacket (a), and is formatted to contain tracks and sectors (b).

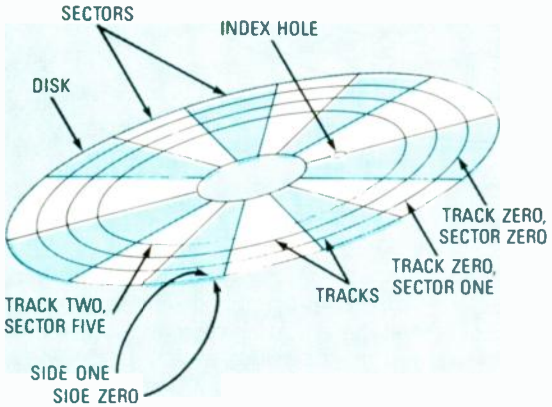


FIG. 2—BOTH SIDES of a disk are used by some disk control hardware and software.

Disk formatting

When a track is formatted, DOS writes three kinds of information in each sector: ID bytes, sync bytes, and gap bytes. The exact format of those bytes differs from computer to computer, but the same sort of scheme is used by every DOS. The reason is that DOS must have a way of determining exactly which sector it's looking at. Not only that, but there must be a way of ensuring that the special formatting bytes are never overwritten by data. If that does happen, DOS has no way to identify the sector and the result is what you might expect—a crashed disk.

There are actually two kinds of ID bytes on a sector—one is the signpost that marks the sector's location on the disk, and the other lets DOS know that it's looking at the beginning of the data stored in the sector.

Figure 3-a shows a dump of an Apple DOS 3.3 sector, and Fig 3-b shows a dump from an IBM DOS 3.1 sector. At first glance, they both look meaningless—clearly different but equally meaningless. Those disk formats are the two most popular, and both the hardware and the software used to create them are totally incompatible. It's even more interesting, therefore, to see that they use similar schemes to write disk data.

The ID marks on the IBM sector are written in hex on the disk; you'll find them in Fig. 3-b at offset 00A1h. The first three bytes (00, 00, and 01) show that you're looking at track 0, side 0, sector 1. The next byte (02) shows that the sector can hold 512 bytes.

Other sector sizes can be accommodated, as shown in Table 1. Normally, a maximum of about 6000 bytes can be written per track, so the final entry in the table may seem questionable. On the other hand, perhaps IBM has something up its sleeve.

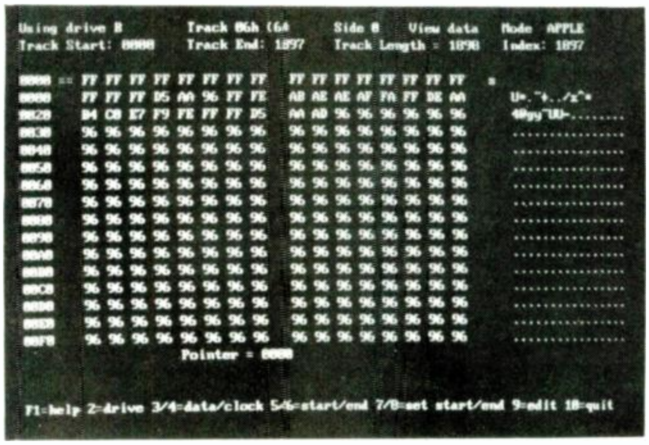
The two bytes following the ID bytes contain a special error-detecting code called a CRC (cyclic redundancy check). The CRC is used by DOS to make sure that data read from the disk is correct. If the CRC calculated from the data that is read from the disk doesn't match the four CRC bytes in the header, DOS considers the data corrupt. Every time you change the data in a sector, DOS recalculates the CRC and writes it to the disk.

In order to keep those bytes from being overwritten accidentally, DOS uses sync bytes to mark the location of the ID bytes. When the floppy-disk controller writes a data byte on the disk, it sends out a steady clocked stream of ones and zeros. The Apple, for example, writes bytes to the disk at intervals of 32 microseconds. Sync bytes, however, are written at a different interval so they're easy to spot on the disk. Apple sync bytes are written in 40-microsecond intervals, and each sync "byte" is 10 bits long.

IBM sync bytes differ. The IBM sector in Fig. 3-b shows that there are three bytes containing a value of A1 beginning at offset 9D. Those are the specially written sync bytes that the floppy-disk controller uses to mark the location of the ID bytes. The twelve 00 bytes preceding the A1 bytes are also sync bytes. You can understand how they're used by tracing through the mechanics of a normal disk read.

When an IBM controller must read data, the first thing it does is make sure that it's looking at the right sector. It starts reading data, watching for a stream of 00 sync bytes, which lets it know that there's a chance that A1 sync bytes will follow. If they do, DOS knows that the following bytes are ID bytes.

Although ID bytes are used to mark both the signposts and your data, DOS can tell the difference by looking at the byte immediately following the A1 bytes. If it's an FE, the ID bytes are signposts, but if it's an FB then it's data. The amount of data is



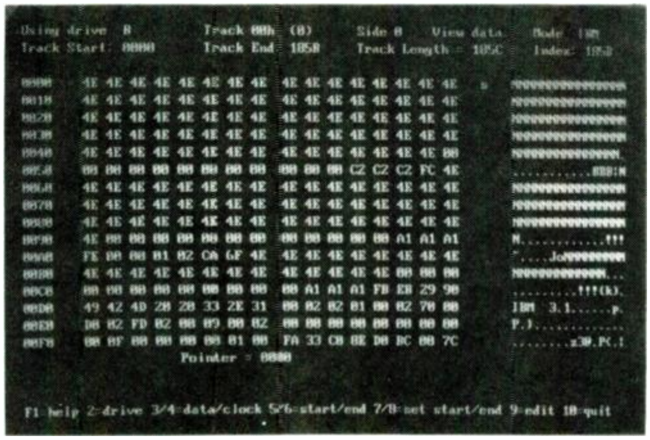


FIG. 3—SECTOR DUMP of an Apple disk (a) and an IBM disk (b).

known because the sector size is specified in the signpost

The last non-data byte on the disk is called a gap byte. Gap bytes are insurance against worst-case operation. They're needed because not all disk drives turn at the same speed, so there's no way to guarantee that writing a new block of data to a sector won't overwrite existing ID and sync bytes. A disk drive only has one head per surface, so there's no way to read and write simultaneously. As long as drive speed is within tolerance, the DOS standards have been set so that there's no possibility of destroying any of the critical bytes needed to read the sector. On an IBM disk, the gap bytes usually have a value of 4E. Apple, on the other hand, uses 10-bit FF "bytes."

As for data bytes, if the sector hasn't been used, it will be filled with the DOS formatting bytes. IBM uses F6, Apple uses 96, and CP/M uses E5.

TABLE 1—IBM SECTOR SIZE ENCODING

ID Byte	Bytes/Sector
$00	128
$01	256
$02	512
$03	1024
$04	2048
$05	4096
$06	8192

TABLE 2—APPLE DISK ENCODING

One Byte Volume Number	=	B7 B6 B5 B4 B3 B2 B1 B0
Two Byte Disk Encoding	=	$FF FE
	=	11 11 11 11 11 11 11 10
Apple's Encoded Format	=	1B7 1B5 1B3 1B1 1B6 1B4 1B2 1B0
Decoded Binary Number	=	1 1 1 1 1 1 1 0
Volume Number	=	$FE
	=	254
One Byte Track Number	=	B7 B6 B5 B4 B3 B2 B1 B0
Two Byte Disk Encoding	=	$AB AE
	=	10 10 10 11 10 10 11 10
Apple's Encoded Format	=	1B7 1B5 1B3 1B1 1B6 1B4 1B2 1B0
Decoded Binary Number	=	0 0 0 0 0 1 1 0
Track Number	=	$06
	=	6
One Byte Sector Number	=	B7 B6 B5 B4 B3 B2 B1 B0
Two Byte Disk Encoding	=	$AE AF
	=	10 10 11 10 10 10 11 11
Apple's Encoded Format	=	1B7 1B5 1B3 1B1 1B6 1B4 1B2 1B0
Decoded Binary Number	=	0 0 0 0 1 1 0 1
Sector Number	=	$0D
	=	13

Although Apple's disk format is structurally similar to IBM's, the details are different because Apple's disk control hardware and software are unique. Most disk controllers store data in unencoded format, so that a dump of an ASCII text file, for example, will be comprehensible.

The Apple hardware, however, limits the values that can be stored on disk. The high bit of each byte must be set, there can't be more than two adjacent zero bits, and at least two adjacent bits must be set in each byte. Some values are reserved for use as ID bytes, and hardware restrictions eliminate many others, so there are only 64 possible values that can be written to the disk to represent your data.

So, in order to be able to write all 256 combinations of eight bits, it's clear that the data must be encoded. In fact, Apple has gone through three major revisions of their encoding scheme. However, that's not a subject that can be covered here; see the books in the References sidebar for more information.

Apple format

Apple's sector format is somewhat different. Referring back to Fig. 3-a, the signpost ID bytes are located at offset 0013h after the series of FF sync bytes. The signpost bytes always begin with a prologue (D5 AA 96), which serves the same purpose as the FE marking the IBM signpost. The next eight bytes are encoded versions of the disk volume number, track, sector, and checksum. As shown in Table 2, by decoding them we see we're looking at volume 254, track 6, sector 13. The checksum is calculated by sequentially XORing all data bytes in that sector together.

Following that information is an epilogue, which can be seen beginning at offset 0C1Eh. It marks the end of the signpost area and has no counterpart on an IBM disk. The epilogue is there so that DOS can make sure it's been reading the correct signpost marks and that it is still in sync with the disk. They're not really necessary, but remember that the Apple system was devised in the late seventies when disk drives were not as reliable as they are today.

Following another group of sync bytes comes the data bytes. At offset 0028h is the prologue (D5 AA AD); then follow 342 bytes of data. Apple stores 256 bytes of data in each sector, but, because the data is encoded, 342 bytes are needed to do it. A checksum is calculated for the data and stored at the end of the data space along with the epilogue (DE AA EB).

Sector numbering

Although sectors are numbered sequentially, often they're not stored sequentially. When DOS looks for a particular sector, it must locate the signpost markers, read them, verify the read, and then see if they're the ones it was looking for. All that takes time, but meanwhile the disk keeps spinning, so there's a good chance the next sector will have passed beneath the read/write head while the previous sector was being analyzed.

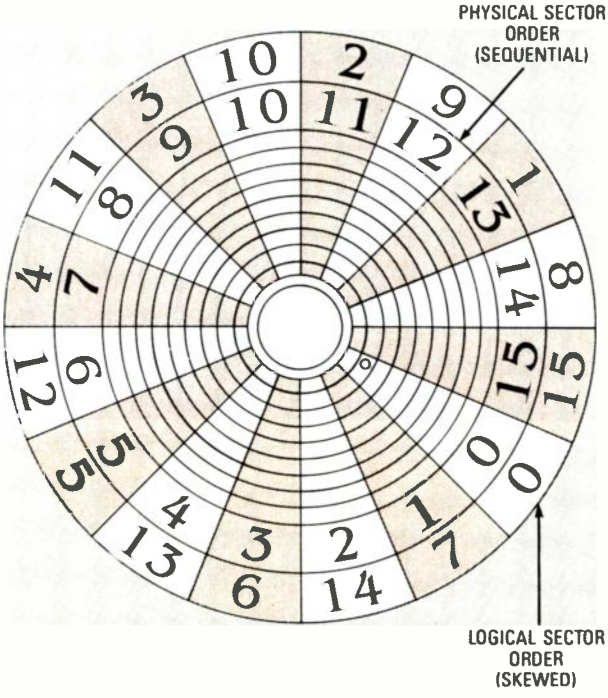


FIG. 4—LOGICAL AND PHYSICAL sector orders are not necessarily the same.

So, to make things more efficient, the sectors are interleaved, or skewed, as shown in Fig. 4. The inner circle indicates physical sector numbering; the outer circle indicates logical sector numbering.

Disk organization

Now that we know how data is stored on the disk, the next step is to see how it's organized. Once again, although the details vary from computer to computer, the basic method is the same. Let's look at the general principles and then see how they're actually applied in both Apple and IBM systems.

DOS divides the disk into four areas: System, Directory, Table of Contents, and Data. Any disk operation makes use of the information stored in all four areas.

DOS itself is stored in the System area of the disk—the first few tracks on the disk. The number of tracks depends on the size of DOS and the type of computer. The very first sector on the first track is called the *boot sector* and it's used whenever you boot a disk. It has a short machine-language program that tells the computer how to go about loading DOS from the disk. In addition, in some systems it contains data related to the directory structure, disk format, and so on.

When you boot your computer, the disk controller reads the boot sector into memory. Then the computer turns control over to the program, called the bootstrap loader, that is contained in that sector. Things are done that way because the controller can read in only a sector at a time. You can read in more than one sector at a time—but that's DOS's job. So it's a chicken-and-egg problem: you need DOS to read multiple sectors and you can only read in multiple sectors by using DOS. But because DOS is located in a specific place on the disk, the bootstrap loader knows how to transfer it to the computer's memory.

The Directory and the Table of Contents go hand in hand. The former is a list of the files stored on the disk, and the latter is a list of sectors telling DOS where to find them. Every time you tell DOS to access a particular file, it first goes to the Directory to see if the file exists and, if it does, DOS then turns to the Table of Contents to get the file's location on the disk.

As you might have guessed, the Data space is where DOS stores your data.

IBM stores DOS in three disk files: IBMBIO.COM, IBMDOS.COM, and COMMAND.COM. (Clones running MS-DOS store the first two of those programs under different names.) In order for the computer to load DOS from the disk, IBMBIO.COM and IBMDOS.COM must be the first two files on the disk. If they're not, the bootstrap loader won't be able to find them, and you'll get the infamous "NON-SYSTEM DISK OR DISK ERROR" message. Those two files contain the routines the computer uses to control the disk hardware. The third file, COMMAND.COM, is loaded after the first two and it's the part of DOS that executes internal DOS commands (DIR, REN, DEL, etc.), external programs, and batch files.

IBM's Table of Contents is called the FAT (file allocation table). It's used to keep track of where each chunk of each file is stored on the disk, which sectors are available for use, which sectors are bad, and so on. The basic unit of the FAT is called the cluster, and it represents a variable number of disk sectors, depending on the operating system and on the format of the disk. For example, single-sided IBM disk clusters are one sector long, double-sided IBM disk clusters are two sectors long, and higher density disks have even larger clusters.

The Directory is also located on track 0, right after the FAT. It stores the names of your files, their attributes, the date and time they were created, their size, and the location of the file's first entry in the FAT. The rest of the disk is set aside for your data. When you change anything on the disk by writing new data, DOS must update the Directory and the FAT, because they work together to keep your files organized.

The Apple also has a boot sector to start the process of loading DOS into the computer. The actual contents of the boot sector (as well as the organization of the disk) depends on which Apple DOS you're using. Both systems, however, differ from the IBM version in that the only job of Apple's boot sector is to start the process of loading in DOS.

There are major differences in the two current Apple operating systems, DOS 3.3 and ProDOS. Although the basic sector formatting is the same, the organization of the disk is quite different. The older system, DOS 3.3, stores the System on the first three tracks, and the directory on track 11h (in the middle of the disk). That was done, the reasoning went, because, on average, the head would have less distance to travel to get to the directory than if the directory had been located in track 0, as on the IBM. Less distance means less time, so that wasn't bad reasoning.

ProDOS, on the other hand, has a closer resemblance to the IBM system in that the directory is stored in the lower tracks. Disk space is allocated a sector at a time under DOS 3.3, and a block at a time under ProDOS. (A block equals two consecutive sectors.) The Table of Contents is called the Volume Table of Contents in DOS 3.3 and the Volume Bit Map in ProDOS.

Both are similar to the IBM's FAT in that each contains a table that DOS uses to keep track of which sectors are free, which are reserved, and which are otherwise used. Each file on the disk reserves a track-and-sector list sector (or block) that contains a list of the sectors where each file's data is stored. Overall, the Apple has to do about the same amount of housekeeping as the IBM. It must update the directory, the table of contents, and the track/sector list for each file you use.

Copy protection

With those facts in mind, let's examine various copy-protection schemes. But before we get into the details, let's talk about the philosophy behind copy protection. Both software publishers and software owners make strong arguments about protecting their investment—and they're both right. Nobody wants to get ripped off, so publishers should be able to make money, and owners should be able to make legitimate backup copies of software they have purchased. Of course, there is much

continued on page 100

BUILD THE PT-68K

The big moment: add the microprocessor.

PETER STARK, STARK SOFTWARE SYSTEMS CORPORATION

Part 3 In the first installment of the **Computer Digest** Classroom, we presented an overview of the PT-68K. In part two, we built clock, reset, and test circuits. Now let's install the 68000 and start learning how it works.

Step 7: hardware basics

The pinout of the 68000 microprocessor is shown in Fig. 1. Though it's a 64-pin IC and looks complex, it really is straightforward. Let's go over it pin by pin.

In the figure, notice first the data bus, with its 16 lines labeled D0–D15, and the address bus, with its 23 lines labeled A1–A23. In case you're wondering, there is no A0—see below.

The remaining signals are known collectively as the control lines; let's look at them in more detail. Each control line is labeled with an arrow to indicate whether it is an input, an output, or, in some cases, both.

The three active-high output lines FC0, FC1, and FC2 output a function code that can be decoded to indicate what the 68000 is doing internally; the function code can also be used to increase the 68000's addressable memory to 64 megabytes.

The enable line (E), the valid memory address line (VMA), and the valid peripheral address (VPA) line are all useful when the 68000 is used with older input-output IC's, particularly those originally intended for use with Motorola's 6800 processor. Also, VPA provides some interrupt information.

IPL0, IPL1, and IPL2 are interrupt-level inputs. We will discuss interrupts later; for now let us just say that an event such as a keypress can interrupt the 68000, cause it to stop whatever it's doing, and then respond to the interrupt. The three interrupt inputs tell the 68000 whether an interrupt is being asked for, and what kind of an interrupt it is.

The RESET and HALT inputs come from the 555 circuit shown in Part 2, Fig. 6. Note, however, that those two pins are also outputs. That explains why an open-collector 7406 inverter was used to drive them; occasionally the 68000 may output a low on one of those lines, and that would conflict with the normally high output of a standard inverter (such as a 7404).

BR, BG, and BGACK are used with DMA circuitry, which is used to transfer blocks of data without help from the microprocessor. If DMA were used, the DMA controller would send a bus request (BR) signal to the 68000, which would release the data and

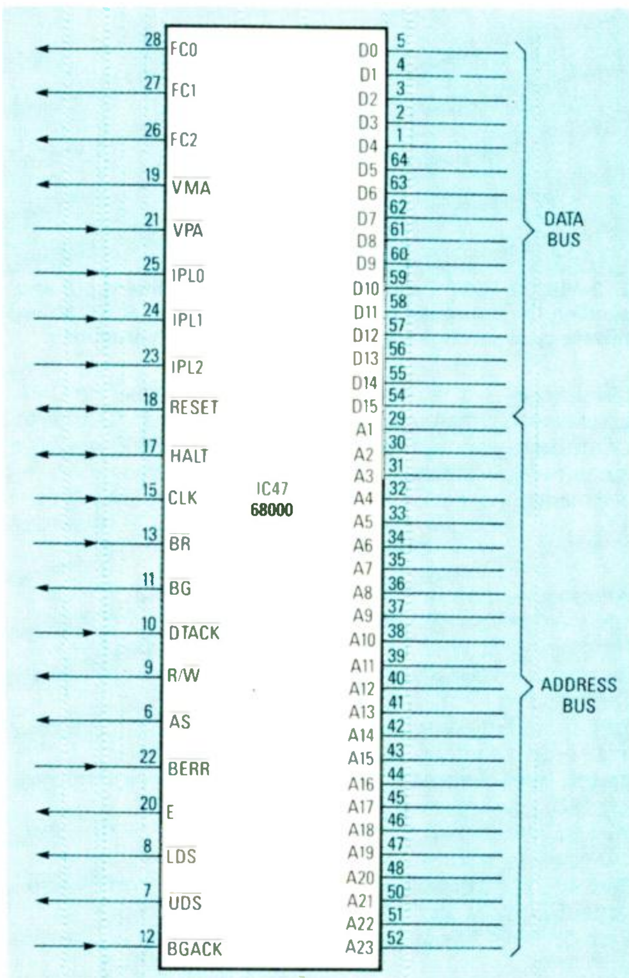


FIG. 1—THE 68000 MICROPROCESSOR has sixteen data lines, 23 address lines, and 21 control lines.

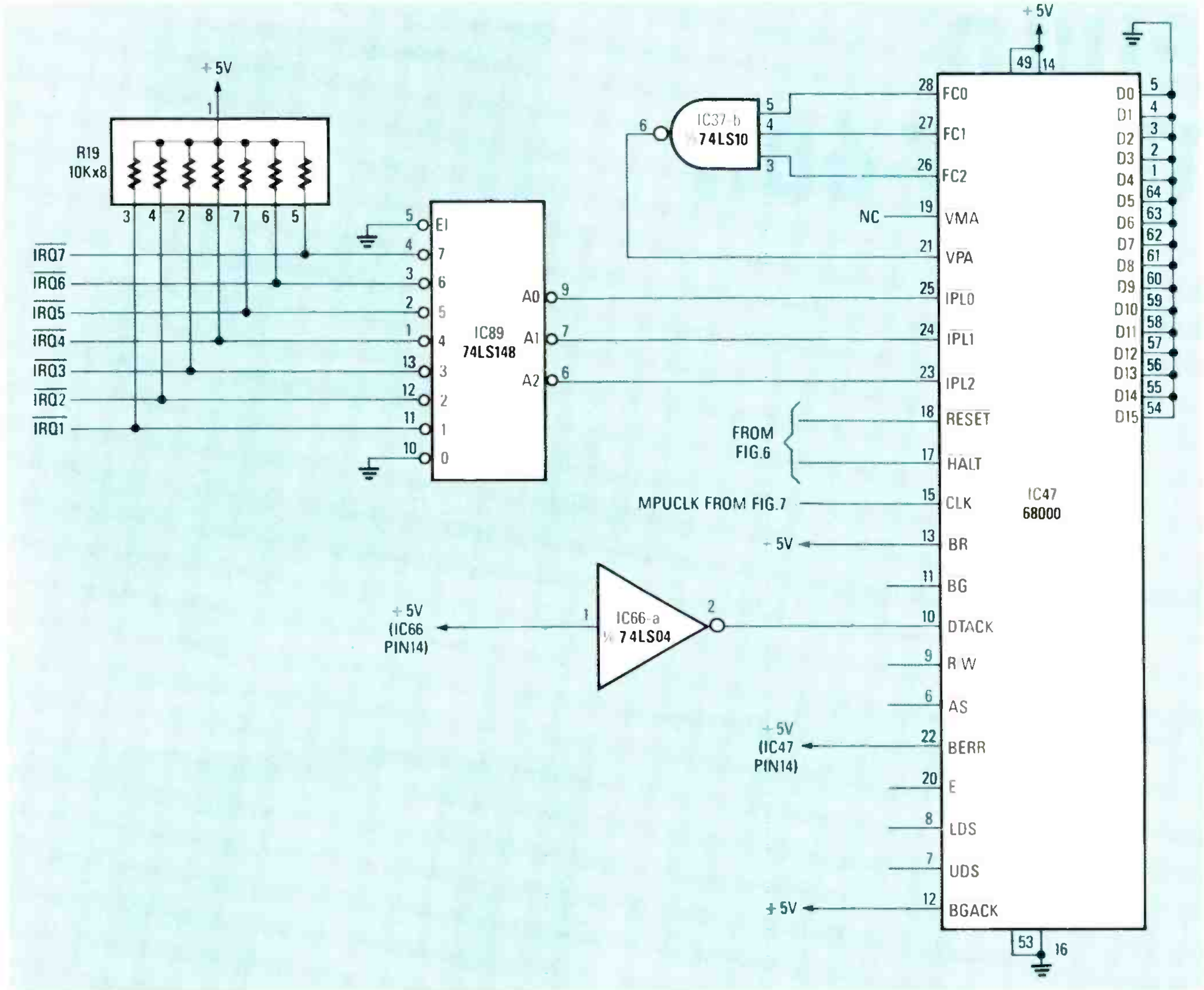


FIG. 2—68000 TEST CIRCUIT. By disabling all interrupts and grounding the entire data bus, you can force the 68000 to repetitively cycle through four million "phantom" instructions.

address buses and return a bus granted (BG) signal. The DMA controller would then send a bus grant acknowledge (BGACK) to confirm that it has control of the buses. Then the 68000 would sit back and wait while the DMA controller did its thing.

We mentioned that LDS and UDS replace address line A0; they do so in an interesting way. The 68000 has a 16-bit data bus, but memory is organized as eight-bit bytes. Even so, the data bus can access two bytes at a time. The memory is wired so that half of memory—the odd-numbered locations—connects to the lower part of the data bus (bits D0–D7), and the other half of memory—the even-numbered locations—connects to the upper part of the data bus (bits D8–D15). The 68000 asserts LDS when it wants to use the lower half of the data bus, UDS if it wants to use the upper half of the data bus, or both if it wants to transfer 16 bits on the entire data bus. Thus an odd address turns on LDS, and an even address turns on UDS. The overall effect is similar to that provided by address line A0 in other microprocessors, where A0 is low for an even address and high for an odd address.

AS is an address strobe which is generally asserted by the 68000 at the same time as either LDS or UDS; it simply tells external circuitry (address decoders, for example) that there is a valid address on the address bus. That's an important point, because the address bus often carries data that is meaningless; AS provides a way of preventing decoders from responding to invalid addresses.

Next comes the read/write line (R/W), which is used by the 68000 to tell other circuitry whether it wants to read data in (when R/W is high) or write data out (when R/W is low). In other words, R/W is high when data goes from RAM or ROM to the

Past, present, future

What follows is a listing of the contents of past and projected future articles in the **Computer Digest** 68000 Classroom. The precise number of articles—and their contents—will depend on your response, so *let us know what you're interested in!*

Part 1: System overview, block diagram, parts list, memory map, ordering information.
Part 2: Parts-placement diagram, power connector mounting, LED, speaker, reset, and clock circuits.
Part 3: Introduction to the 68000, test circuit, EPROM and RAM circuits, address-bus waveforms.
Part 4: Logic symbols, MAP circuit, address decoding, BERR and DTACK, RAM and ROM, HUMBUG.
Part 5: Serial interfacing and IBM-compatible expansion slots.
Part 6: Dynamic RAM.
Part 7: Disk control hardware and software. SK*DOS.

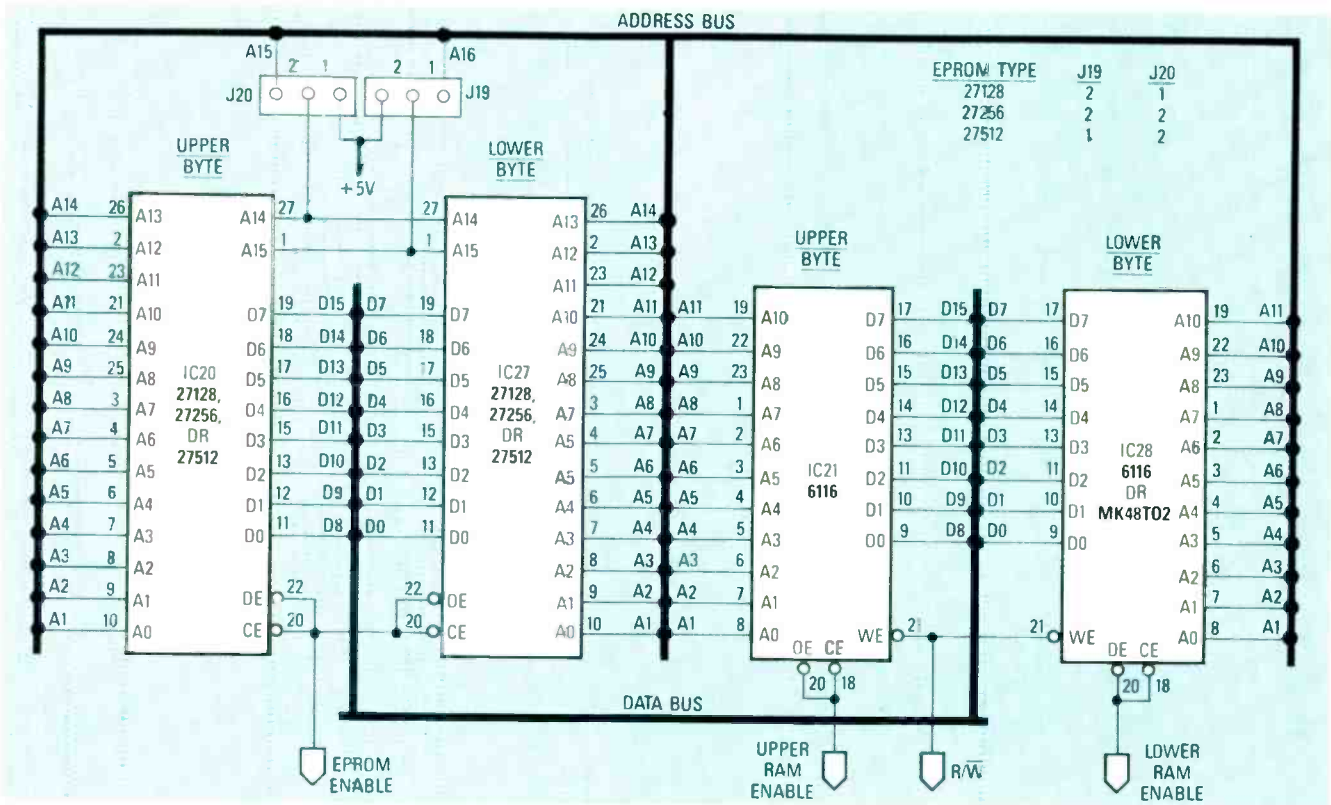


FIG. 3—EPROM AND STATIC-RAM WIRING is shown here.

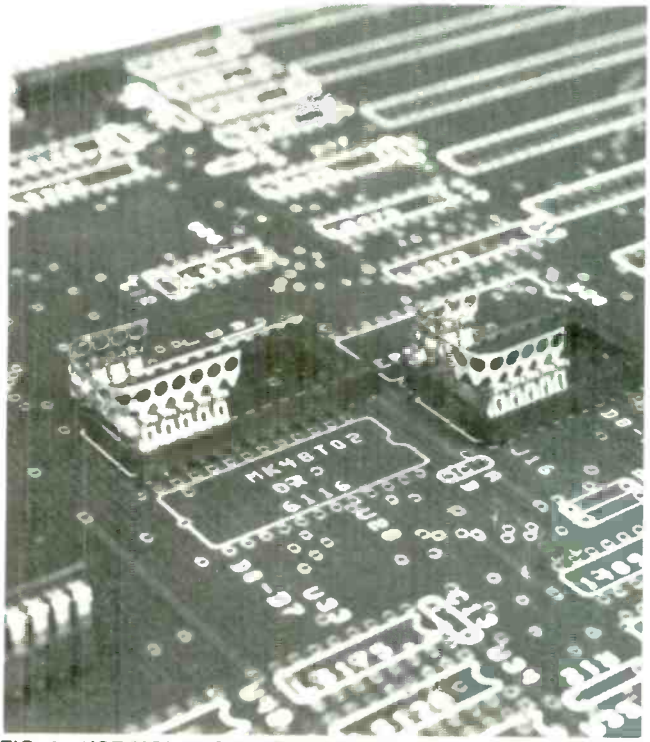


FIG. 4—USE MOLEX SOLDERCON PINS to ground all data lines without soldering.

Thanks

I'd like to thank Fred Brown of Peripheral Technology, Inc., kit supplier for this CD Classroom series. Fred is the wizard who designed the hardware of the PT-68K; without his assistance, the project would never have gotten off the ground.

68000, and low when data goes from the 68000 to RAM. Normally we don't write to a ROM.

BERR is an input to the 68000 that external circuitry uses to tell the 68000 when something has gone wrong on one of the buses. We will see how that is done later.

Last, DTACK stands for data transfer acknowledge. Whenever the 68000 wants to read or write to memory (or an I/O device), it (a) puts the address on the address bus, (b) puts a high or low on R/W, (c) asserts AS, (d) asserts LDS, UDS, or both, and (e) waits until either DTACK is asserted, indicating that the transfer has completed successfully, or BERR is asserted, indicating that something went wrong. When DTACK is received, the 68000 goes on to the next instruction. We'll discuss what happens if BERR is asserted later.

If DTACK were permanently grounded, the 68000 would assume that all transfers finished quickly, so it would zip along at maximum speed. In most cases, though, DTACK is generated by an external timer that gives memory and I/O just enough time to finish their jobs. And if a memory or I/O device is particularly slow, DTACK can then be delayed so that the 68000 will wait for it to finish.

In practice, each 68000 memory or I/O access takes a specific amount of time, which is measured in clock cycles. If DTACK is delayed, for even an instant, the 68000 lets an extra clock cycle slip by and checks again. If DTACK is still off, the 68000 waits another clock cycle, and so on. Each of those clock cycles is called a *wait state*. Ideally, everything would be fast enough so that the 68000 could continue processing without wait states. However, some computers have slow memory or I/O devices, and therefore run with one or even more wait states, which obviously slows everything down. You'll be happy to know that the PT-68K runs with no wait states!

68000 test circuit

Last time we built the clock and reset circuits, and now that we have some basic familiarity with the 68000, it's time to get the system running. Normally, you need quite a bit of external hardware to get a 68000-based computer running, but there is a

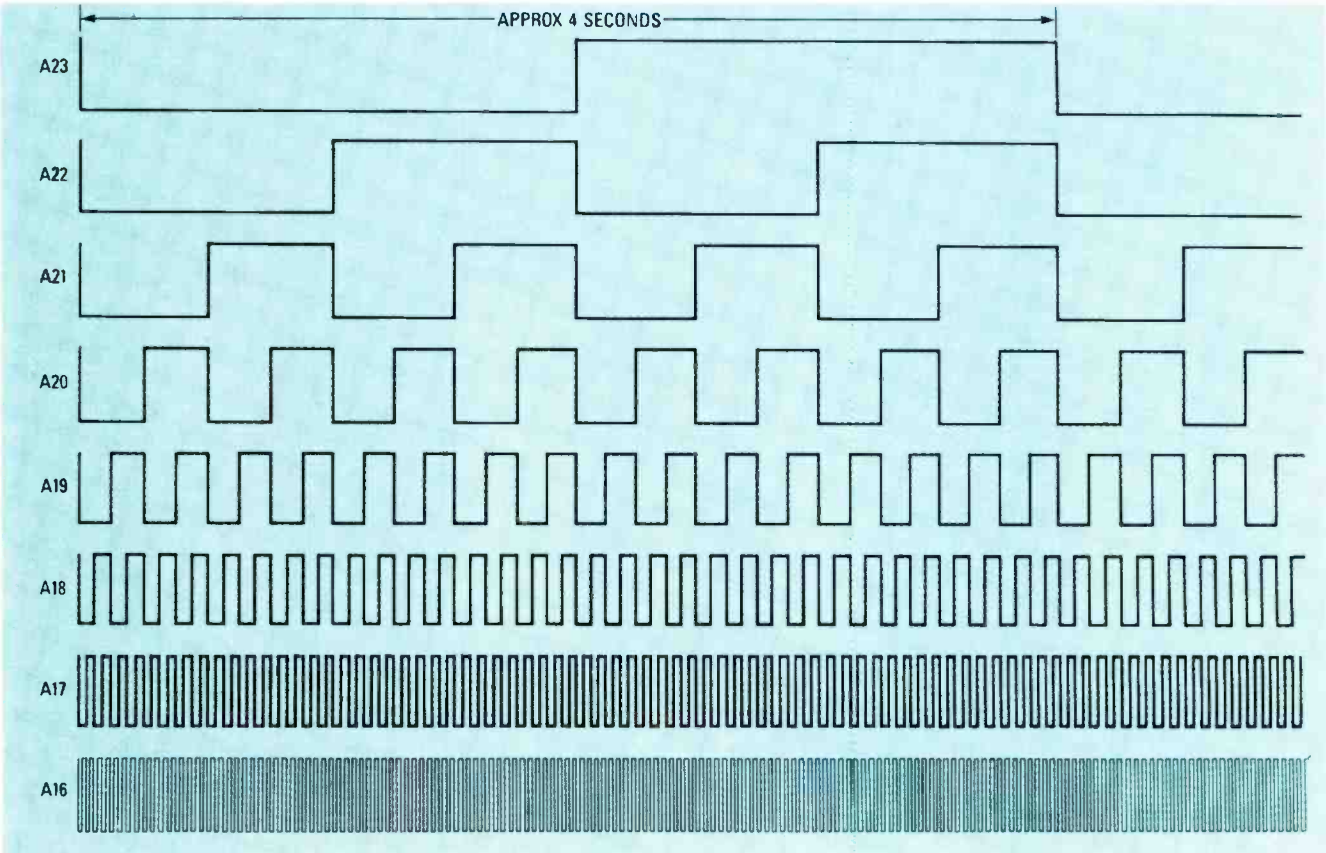


FIG. 5—EACH SUCCESSIVE ADDRESS LINE runs at half the frequency of its predecessor.

way of fooling the microprocessor into thinking the necessary support circuitry is connected, even though it isn't. Figure 2 shows how. Basically, the circuit ensures that interrupts are disabled and jams the data bus with "phantom" instructions that the 68000 will execute over and over.

In order to minimize the amount of extra wiring we have to do, we will take advantage of circuitry already on the printed-circuit board (which will be needed later anyway). For example, we can use RESET, HALT, and CLK as-is.

The circuit works like this: IC37-b is a NAND gate that asserts VPA when FC0, FC1, and FC2 are all high, and negates VPA at all other times. That is done because VPA is used only during interrupt processing; for now, we need to force it high.

Also dealing with interrupts is IC89, a priority-encoder IC. In normal operation, when an interrupt request appears on one of the IRQ lines (IRQ1–IRQ7), IC89 functions as a traffic cop that determines which line has the highest priority. IRQ7 has a higher priority than IRQ6, which is in turn higher than IRQ5, and so on. Depending on which interrupt lines are active, IC89's three outputs send a binary number corresponding to the highest priority interrupt to the IPL0, IPL1, and IPL2 lines of the 68000. For example, if the highest priority interrupt request is IRQ4, U89 sends the binary number 100 (4) to the 68000 by forcing IPL2 high and the others low.

In our test circuit, however, the seven resistors in R19 are pulling all of the IRQ lines high. Therefore, IC89 sees no interrupt request, so it sends the binary number 000 to the 68000, telling it that there are no interrupt requests.

By the way, we could have achieved the same result by grounding the three IPL pins of the 68000 and by tying VPA high. However, we can save ourselves extra labor by installing R19, IC89, and IC37, which we'll have to do eventually anyway.

Two of the inputs, labeled BR and BGACK, are already tied high, and a number of other pins are unconnected.

That leaves the data bus, BERR, and DTACK to contend with. First, BERR must be tied high so that the 68000 won't think a bus error has occurred. That is easily done by installing a short jumper between pins 14 and 22 of the 68000, on the foil side of the board.

Normally DTACK will carry a meaningful signal, but for now we want to ground it to make the 68000 think that all is well on the outside. The inverter (IC66-a) that drives DTACK was installed previously, so force the input high by installing a jumper from pin 1 to pin 14 of that IC on the foil side of the board.

Last, as shown in Fig. 2, we want to ground all sixteen data lines. The reason is that, when the 68000 is running normally, it fetches instructions and addresses from memory, so we have to provide it with some apparently meaningful data. By grounding the entire data bus, every time the 68000 tries to read anything from memory, it will read the number 0000. As it turns out, that is a valid 68000 machine-language instruction, which is written:

OR.B #0,D0

That instruction tells the microprocessor to *or* a 0 to register D0; the instruction consists of four 00 bytes.

Though that OR instruction seemingly does nothing, the 68000 thinks that all 16 megabytes of memory are filled with 4 million OR instructions, and so it starts executing them one after another. When it gets to the top of memory at $FFFFFF, it simply "wraps around" and starts over at $000000.

Fire it up

Now let's wire up the circuit and see what happens. Install the following components: sockets for IC37, IC47, and IC89; R19, a 10K single-in-line package. Pin 1 of R19, identified by a white line or dot, should point toward J25. Then install C14, C48, and C66 (0.1 µF disc capacitors), and last jumpers from pin 14 to pin 22 of IC47 and from pin 1 to pin 14 of IC66. Both jumpers will be removed later, so install them neatly and in a way such that they can be removed easily.

Grounding all sixteen lines of the data bus at the micro-

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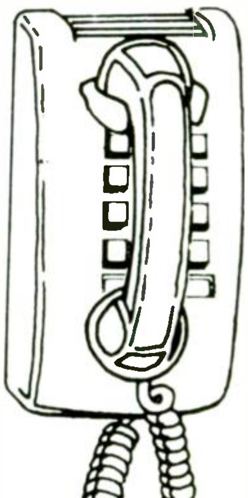

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processor's socket could lead to problems later, so we'll do it another way. The data bus is more accessible at the two EPROM sockets (IC20 and IC27) and at the two static RAM sockets (IC21 and IC28). The wiring diagram of the EPROM and static-RAM circuitry is shown in Fig. 3. Install a 28-pin socket at IC27 and a 24-pin socket at IC21.

The D0–D7 lines of the data bus are connected to IC27 via pins 11–13 and pins 15-19, and pin 14 is conveniently grounded. So we need to short pins 11–19 together. In the same way, the D8–D15 lines of the data bus are connected to IC21 via pins 9–11 and 13–17, and pin 12 is conveniently grounded. So we need to together pins 9–17 together.

On both IC21 and IC27, those are the bottom four pins on the left and the bottom five pins on the right. Instead of soldering any wires, take a strip of Molex Soldercon pins and insert them into the sockets as shown in Fig. 4, with four pins on the left, five pins on the right, and a section of six or so pins bent in a U shape below. Molex pins are normally sold as an inexpensive substitute for sockets; they consist of individual clips joined by a perforated carrier strip that is normally broken off after soldering the pins to the PC board. In our case, we insert the thin pins into the socket, and use the entire strip as one big short circuit.

Now plug in the IC's, being careful not to bend pins, and turn on the power. Connect your LED probe to pin 52 of the 68000, which is address line A23. If all is well, the LED will light for about 2 seconds, go off for about 2 seconds, and so on. (That flashing rate will be faster if your PT-68K's clock is faster than 16 MHz.)

If the LED does not flash at the expected rate, recheck the signal at every pin of the 68000. Look especially for a low on DTACK, lows on all data lines, highs on BERR, HALT, and RESET. When looking at the clock signal, the LED should be slightly dim.

If the LED flashes as expected, all is probably well. What's happening is that the 68000 is racing through memory (or what it thinks is memory, all 16 megabytes worth), executing or instructions at maximum speed, one instruction per microsecond. One complete run through four million instructions (4,194,304 instructions, to be exact) therefore will take slightly more than four seconds.

During that time, the address bus is counting off the addresses where the 68000 thinks those instructions are coming from. If you look at the address bus you see that A1 alternates 0, 1, 0, 1, 0, 1, ... A2 also alternates, but slower: 0, 0, 1, 1, 0, 0, ...; and so on.

Figure 5 shows the waveforms present on the upper eight bits of the address bus. When the LED probe is connected to A23, it flashes on and off once every four seconds. If it is connected to A22, it repeats once every two seconds; on A21 it repeats once per second. As we go down to A20, A19, and so on, it flashes faster and faster, until at A16 (pin 44) it flashes so fast (about 32 times per second) that we can barely see it flicker; A15, flashing about 64 times per second, looks absolutely steady.

Last, if you have access to an oscilloscope or frequency counter, examine each address line to make sure that its frequency is half that of its next higher neighbor. This ensures that there are no shorts between adjacent address lines. If you use a frequency counter, keep in mind that real-world waveforms are not as well defined as the idealized ones shown in Fig. 12, so some counters may have difficulty properly counting the frequency of such a square wave.)

Next time we'll add address decoders, ROM and RAM. See you then.

Ordering Information

Complete details were given in part one (in the October issue). To summarize: The basic kit (PT1, $200) contains all parts except power supply, case, and video terminal or personal computer to get a small system (ROM monitor, 2K RAM) up and running. The full basic system (PT68K, $460) includes 512K of dynamic RAM, floppy-disk controller, parallel port, battery-backed clock/calendar, and three PC-compatible expansion slots. To order, or for more information, contact Peripheral Technology, 1480 Terrell Mill Road #870, Marietta, GA 30067, (404) 984-0742.

FLOPPY-DISK DATA STORAGE

continued from page 94

illegitimate software floating around, so it seems that something has to be done about basic human nature before copy protection will cease to be an issue.

Even though there are obvious (and subtle) differences between the hardware and software comprising various types of computers, the basic approach to copy protection is the same: Make the disk unreadable by the standard DOS. It's easy to do because any DOS must make a number of assumptions about disk format before it tries to read or write information. It must assume, for example, that it's going to find tracks formatted in a particular way, that each one will contain a specific number of sectors, and that those sectors will contain data written in a predefined fashion. If any of those conditions aren't met, DOS will throw in the towel, and, instead of data, all you'll get is an error message. The point is that any disk that has data organized in a non-standard way must also have a non-standard way to read that data.

When Apple introduced its disk system in the late seventies, the company emphasized software rather than hardware. That was a departure from the norm, because most disk systems were and are built around a single-IC LSI controller. As a result, Apple disks were (and still are) unreadable by most other machines. However, Central Point Software's Option Board allows an IBM to read Apple disks, and many others as well.

Doing most of the disk control in software makes it simple to upgrade DOS. It also makes it easy for creative programmers to write copy-protection schemes that do strange things with the disk. That dependence on software, as we'll see, has produced methods of copy protection that are unique to the Apple.

Non-standard data formats

There are many methods of storing data in a non-standard format; we'll examine several in what follows. The most popular methods are these:

- Oddball track formatting
- Nibble counting
- Modified DOS
- Non-standard sectoring
- Unique data encryption
- Synchronized tracks
- Quarter tracks
- Spiral tracking

Of course, there are variations on those methods, and they're often used in combination. But attaining a good understanding of them will help you unravel any copy-protection scheme likely to come your way.

Those methods of copy protection are used on the Apple; due to differences in the IBM's disk-control hardware, it has fewer means of copy-protecting a disk. For example, the IBM cannot do quarter tracking. The most popular methods are:

- Oddball formatting
- Weak bits
- Laser burning

We'll examine those and other means of copy-protecting software next time.

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Radio-Electronics Volume 58

and

ComputerDigest Volume 4

Abbreviations: (AR)Antique Radio; (ARE) Ask Radio-Electronics; (AUD)Audio Update; (C)Construction; (COMC)Communications Corner; (D)Department; (DB)Drawing Board; (DN)Designers Notebook; (ED)Editorial; (ER)Equipment Report; (LTR)Letter; (NI)New Ideas; (PCS)PC Service; (SC)Service Clinic; (SQ)Service Questions; (SOSS)State Of Solid State; (STV)Satellite TV

A

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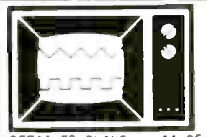

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74C193	1.25	4020	.55	4053	.65	4528	.75		
74C245	1.75	4021	.65	4060	.65	4529	1.40		
74C901	.35	4022	.65	4066	.28	4538	.95		
74C902	.40	4023	.25	4068	.35	4539	1.50		
74C903	.80	4024	.48	4069	.19	4541	1.20		
74C907	.75	4025	.25	4070	.28	4553	1.75		
		4026	1.25	4071	.20	4583	.90		
						4585	.75		

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74HC00	.35	74HC125	.50	74HC257	.55
74HC02	.35	74HC126	.50	74HC259	.60
74HC04	.35	74HC133	.60	74HC273	.80
74HC08	.35	74HC137	.75	74HC354	.95
74HC10	.35	74HC139	.45	74HC373	.80
74HC11	.40	74HC153	.55	74HC374	.80
74HC20	.35	74HC154	1.75	74HC533	1.35
74HC30	.35	74HC157	.50	74HC534	1.35
74HC32	.35	74HC162	.55	74HC573	2.50
74HC50	.40	74HC163	.55	74HC595	2.50
74HC51	.45	74HC164	.80	74HC640	2.00
74HC74	.40	74HC174	.60	74HC4002	.50
74HC75	.40	74HC175	.60	74HC4020	1.10
74HC85	.70	74HC194	.70	74HC4066	.60
74HC107	.35	74HC240	.75	74HC4514	3.20
74HC109	.40	74HC242	.75	74HC4538	1.40
74HC112	.40	74HC244	.80	74HC4543	1.40

74LS SERIES

74LS00	.17	74LS112	.29	74LS240	.65
74LS01	.17	74LS113	.33	74LS241	.65
74LS02	.17	74LS114	.33	74LS242	.65
74LS03	.17	74LS123	.45	74LS243	.65
74LS04	.17	74LS125	.35	74LS244	.65
74LS05	.17	74LS126	.35	74LS245	.75
74LS08	.17	74LS132	.39	74LS246	1.40
74LS09	.17	74LS136	.35	74LS247	.75
74LS10	.17	74LS137	.90	74LS243	.65
74LS11	.20	74LS138	.39	74LS251	.45
74LS12	.27	74LS139	.39	74LS253	.45
74LS13	.25	74LS145	.70	74LS257	.39
74LS14	.36	74LS147	1.00	74LS258	.45
74LS15	.25	74LS148	.90	74LS259	1.20
74LS20	.17	74LS151	.39	74LS260	.45
74LS21	.22	74LS153	.39	74LS266	.55
74LS22	.22	74LS154	1.50	74LS273	.75
74LS26	.23	74LS155	.55	74LS279	.39
74LS27	.23	74LS156	.45	74LS280	1.70
74LS28	.26	74LS157	.35	74LS283	.55
74LS30	.17	74LS158	.20	74LS290	.80
74LS32	.17	74LS160	.29	74LS293	.80
74LS37	.26	74LS161	.49	74LS298	.65
74LS38	.26	74LS162	.49	74LS320	2.00
74LS40	.17	74LS163	.49	74LS322	3.00
74LS42	.35	74LS164	.45	74LS323	2.40
74LS48	.65	74LS165	.65	74LS365	.39
74LS51	.17	74LS166	.95	74LS366	.39
74LS54	.22	74LS169	.90	74LS367	.39
74LS73	.25	74LS170	.80	74LS368	.39
74LS74	.24	74LS173	.49	74LS373	.75
74LS75	.29	74LS174	.39	74LS374	.75
74LS76	.29	74LS175	.39	74LS377	.75
74LS83	.45	74LS181	1.40	74LS386	.45
74LS85	.45	74LS190	.49	74LS390	1.10
74LS86	.22	74LS191	.49	74LS393	.75
74LS90	.39	74LS192	.65	74LS398	2.50
74LS92	.45	74LS193	.65	74LS446	2.00
74LS93	.45	74LS194	.65	74LS541	1.40
74LS95	.48	74LS195	.65	74LS625	1.75
74LS96	.49	74LS196	.55	74LS645	.95
81LS98	1.40	74LS197	.55	74LS668	1.45
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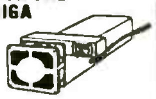

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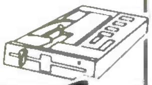

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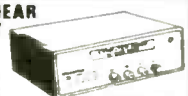

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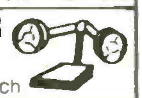

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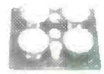

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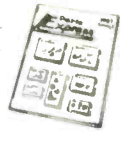

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7403	25
7404	25
7406	30
7407	25
7408	30
7409	30
7410	25
7411	25
7416	25
7420	25
7425	25
7426	30
7427	25
7429	25
7430	25
7432	25
7437	25
7438	25
7439	25
7440	30
7442	[illegible]
7445	[illegible]
7447	75
7450	60
7451	25
7454	30
7474	30
7475	45
7476	45
7482	85
7483	50
7485	55
7486	40
7490	45
7491	85
7492	45
7493	35
7495	45
7496	55
74107	35
74109	40
74116	1.00
74121	35
74123	40
74125	45
74126	40
74128	55
74145	45
74148	1.00
74151	50
74153	50
74156	70
74157	50
74161	60
74163	60
74164	80
[illegible]	70
74174	50
74175	50
74177	60
74180	[illegible]
74181	1.80
74192	70
74193	65
74194	70
[illegible]	75
74298	55
74365	60
74367	60
74390	85
74393	1.00
75324	20
75452	55
75454	55
N8T22	25
N8T24	50
N8T26	75

74LS SERIES

74LS00	20
74LS01	20
74LS02	20
74LS03	20
74LS04	25
74LS05	20
74LS08	25
74LS09	20
74LS10	20
74LS11	25
74LS12	25
74LS13	25
74LS14	35
74LS15	25
74LS20	20
74LS21	20
74LS22	20
74LS26	20
74LS27	20
74LS28	25
74LS29	40
74LS30	20
74LS32	20
74LS33	25
74LS37	25
74LS38	25
74LS40	30
74LS42	30
74LS47	80
74LS51	20
74LS54	25
74LS55	30
74LS73	25
74LS74	25
74LS75	30
74LS76	35
74LS78	40
74LS83	40
74LS85	40
74LS86	25
74LS90	40
74LS93	35
74LS107	30
74LS112	25
74LS113	30
74LS114	30
74LS123	45
74LS125	35
74LS126	30
74LS1[illegible]	35
74LS1[illegible]	30
74LS1[illegible]	40
74LS139	40
74LS151	40
74LS15[illegible]	45
74LS15[illegible]	30
74LS158	30
74LS160	25
74LS161	45
74LS162	45
74LS163	45
74LS164	45
74LS165	60
74LS173	45
74LS174	30
74LS191	45
74LS192	60
74LS194	60
74LS195	60
74LS221	55
74LS240	65
74LS241	60
74LS242	60
74LS244	65
74LS245	70
74LS247	1.90
74LS251	40
74LS253	40
74LS257	35
74LS258	40
74LS259	85
74LS260	40
74LS262	40
74LS266	40
74LS273	45
74LS290	75
74LS293	75
74LS295	75
74LS298	60
74LS299	1.35
74LS3[illegible]	75
74LS365	35
74LS366	35
74LS367	40
74LS368	35
74LS373	65
74LS374	75
74LS375	85
74LS377	70
74LS378	1.10
74LS393	70
74LS620	1.50
74LS670	85

74SC SERIES

74SC137	50
74SC138	35
74SC139	35
74SC237	60
74SC239	60
74SC240	50
74SC241	50
74SC244	65
74SC245	50
74SC[illegible]	50
74SC[illegible]	60
74SC533	50
74SC534	50
74SC540	50
74SC[illegible]	[illegible]
74SC564	60
74SC573	[illegible]
74SC574	[illegible]

DATA BOOK FOR ABOVE [illegible] 2.50

CMOS SERIES

74C00	25
4000	20
4001	20
[illegible]	20
4006	60
4011	20
4012	25
4013	25
4015	30
4016	25
4019	30
4022	60
4023	20
4024	45
4025	20
4035	60
4040	60
4041	70
4042	50
4046	60
4047	65
4049	25
4050	25
4051	35
4052	60
4060	60
4066	30
4068	60
4069	20
4070	25
4071	20
4072	20
4073	35
4076	50
4077	25
4078	35
4081	20
4082	20
4085	35
4086	45
4093	45
4160	45
4163	45
4416	45
4428	45
4449	45
4497	45
4502	65
4511	70
4516	[illegible]
4517	[illegible]
4518	85
4519	60
4528	[illegible]
4532	[illegible]
4538	[illegible]
4555	[illegible]
4556	35
4573	45
4574	45
4581	70
4585	[illegible]
40098	45
401[illegible]7	45
45[illegible]	45

EPROM/MISC

2716	[illegible]
2732 [illegible]	[illegible]
2764 [illegible]	[illegible]
27128 [illegible]	4.50
27256 [illegible]	[illegible]
8035	[illegible]
8085	[illegible]
Z80A CTC	[illegible]
[illegible]	50
[illegible]	55
[illegible]	[illegible]
[illegible]	[illegible]

LINEAR

[illegible]	[illegible]
LM325N	[illegible]
LM339N	[illegible]
NE555	25
NE556	50
UA741	25
UA796	50
MC1330	50
MC1350	1.40
MC1496	50
UA1458	25
MC7805	[illegible]
MC7806	[illegible]
MC7812	[illegible]
MC7824	45
MC7905	45
MC7912	45

TRANSISTORS & DIODES

[illegible]	[illegible]
PN2222A	[illegible]
2N2222A	[illegible]
PN2907A	[illegible]
2N2904A	[illegible]
2N3055	[illegible]
PN3904	10/1
PN3906	10/1
2SD898	[illegible]
1N914A	[illegible]
1N4148	[illegible]
1N4001	[illegible]
1N4004	[illegible]
1N4007	[illegible]

DIP IC SOCKETS

8 PIN/.09, 14 PIN/.13, 16 PIN/.15, 18 PIN/.17, 20 PIN/.19, 22 PIN/.21, 24 PIN/.23, 28 PIN/.26, 40 PIN/.28
Zero Insertion Test Socket 28 PIN 5.00

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1,000uF 75V Axial .75
3,200uF 50V Twist Lock .65
3,300uF 50V Axial Lytic .85
5,000uF 40V Computer Grade (Mallory) 1.50
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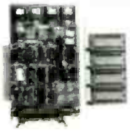

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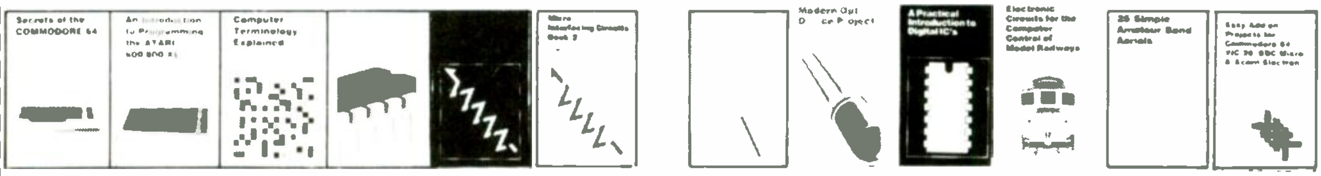

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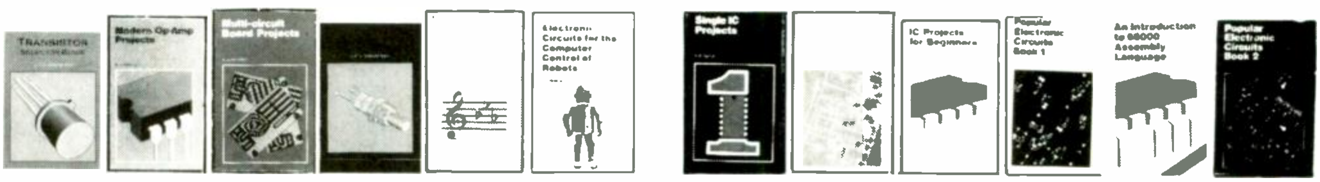

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7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	.29	.19	7485	.65	.55
7402	.29	.19	7486	.45	.35
7404	.29	.19	7489	2.05	1.95
7405	.35	.25	7490	.49	.39
7406	.39	.29	7493	.45	.35
7407	.39	.29	74121	.45	.35
7408	.35	.25	74123	.55	.45
7410	.29	.19	74125	.55	.45
7414	.49	.39	74126	.69	.59
7416	.39	.29	74143	3.95	3.85
7417	.39	.29	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	.59	.49
7442	.55	.45	74175	.59	.49
7445	.79	.69	74176	.99	.89
7446	.89	.79	74181	1.95	1.85
7447	.89	.79	74189	1.95	1.85
7448	2.05	1.95	74193	.79	.69
7472	.89	.79	74198	1.85	1.75
7473	.39	.29	74221	.99	.89
7474	.39	.29	74273	1.95	1.85
7475	.49	.39	74365	.65	.55
7476	.45	.35	74367	.65	.55

74LS

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	.69	.59
74LS30	.29	.19	74LS243	.69	.59
74LS32	.35	.25	74LS244	.69	.59
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	2.95	2.85
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74LS164	.59	.49	74LS688	2.39	2.29

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74S04	.29	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	.49	74S288*	1.49
74S124	2.75	74S373	1.49
74S174	.79	74S374	1.49
74S175	.79	74S472*	2.95

74F

74F00	.29	74F139	.69
74F04	.29	74F157	.69
74F08	.29	74F193	2.95
74F10	.29	74F240	.99
74F32	.29	74F244	.99
74F74	.39	74F253	.69
74F86	.39	74F373	.99
74F138	.69	74F374	.99

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CD4008	.69	CD4081	.25
CD4011	.19	CD4082	.25
CD4013	.29	CD4093	.35
CD4016	.29	CD4094	.89
CD4017	.49	CD40103	2.49
CD4018	.59	CD40107	.49
CD4020	.59	CD40109	.79
CD4024	.49	CD4510	.69
CD4027	.35	CD4511	.69
CD4030	.29	CD4520	.75
CD4040	.65	CD4522	.79
CD4049	.29	CD4538	.79
CD4050	.29	CD4541	.89
CD4051	.59	CD4543	.79
CD4052	.59	CD4553	4.95
CD4053	.59	CD4555	.79
CD4063	1.49	CD4559	7.95
CD4066	.29	CD4566	2.49
CD4067	1.29	CD4583	.89
CD4069	.25	CD4584	.39
CD4070	.25	CD4585	.89
CD4071	.25	MC14411P	8.95
CD4072	.25	MC14490P	4.49

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Z80-PIO	1.79
Z80A	1.69
Z80A-CTC	1.79
Z80A-DART	4.95
Z80A-PIO	1.69
Z80A-SIO/0	5.75
Z80B	3.49
Z80B-CTC	3.95
Z80B-PIO	4.29
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6502	2.65
65C02 (CMOS)	8.95
6520	1.95
6522	3.95
6532	6.49
6551	4.49
65C802 (CMOS)	19.95
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6802	3.95
6810	1.25
6821	1.75
6840	3.95

6500/6800/68000 Cont.

Part No.	Price
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MC68000L10	13.95
MC68010L10	49.95
MC68020RC12B	169.95
MC68881RC12A	149.95
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80C31	9.95
8035	1.95
8073	9.95
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8085A	2.49
8086	5.95
8086-2	6.95
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8087-1(10MHz)	229.95
8087-2(8MHz)	169.95
8088	6.49
8088-2	8.95
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8156	3.95
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8259-5	2.25
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MC68705P3S	8-Bit EPROM Microcomputer	$ 14.95
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80286-10	16-Bit Hi Performance MPU	$ 99.95
80287-8	Math Co-processor (8MHz)	$299.95
80287-10	Math Co-processor (10MHz)	$329.95
80387-16	Math Co-processor (16MHz) GRID ARRAY	$494.95

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Part No.		Price
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4128-20	131,072 x 1 (200ns) (Piggyback)	3.25
4164-120	65,536 x 1 (120ns)	1.75
4164-150	65,536 x 1 (150ns)	1.25
4164-200	65,536 x 1 (200ns)	.99
TMS4416-12	16,384 x 4 (120ns)	3.49
8118	16,384 x 1 (120ns)	.49
41256-100	262,144 x 1 (100ns)	4.95
41256-120	262,144 x 1 (120ns)	3.95
41256-150	262,144 x 1 (150ns)	3.25
50464-15	65,536 x 4 (150ns) (4464)	4.95
511000P-10	1,048,576 x 1 (100ns) 1 Meg	34.95
514256P-10	262,144 x 4 (100ns) 1 Meg	29.95
STATIC RAMS		
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2018-45	2048 x 8 (45ns)	6.95
2102-2L	1024 x 1 (250ns) Low Power	1.95
2114N	1024 x 4 (450ns)	.99
2114N-2L	1024 x 4 (200ns) Low Power	1.49
21C14	1024 x 4 (200ns) (CMOS)	.49
2149	1024 x 4 (45ns)	2.49
5101	256 x 4 (450ns) CMOS	1.95
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6116LP-3	2048 x 8 (150ns) LP CMOS	1.95
6264LP-12	8192 x 8 (120ns) LP CMOS	4.25
6264P-15	8192 x 8 (150ns) CMOS	3.49
6264LP-15	8192 x 8 (150ns) LP CMOS	3.75
6514	1024 x 4 (350ns) CMOS	3.49
43256-15L	32,768 x 8 (150ns) Low Power	11.95
EPROMS		
TMS2516	2048 x 8 (450ns) 25V	6.95
TMS2532	4096 x 8 (450ns) 25V	6.95
TMS2532A	4096 x 8 (450ns) 21V	5.95
TMS2564	8192 x 8 (450ns) 25V	9.95
TMS2716	2048 x 8 (450ns) 3 Voltage	9.95
1702A	256 x 8 (1µs)	6.95
2708	1024 x 8 (450ns)	4.95
2716	2048 x 8 (450ns) 25V	3.75
2716-1	2048 x 8 (350ns) 25V	4.25
27C16	2048 x 8 (450ns) 25V (CMOS)	5.49
2732	4096 x 8 (450ns) 25V	3.95
2732A-20	4096 x 8 (200ns) 21V	4.25
2732A-25	4096 x 8 (250ns) 21V	3.95
27C32	4096 x 8 (450ns) 25V (CMOS)	5.95
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	3.95
2764-45	8192 x 8 (450ns) 21V	2.95
27C64-15	8192 x 8 (150ns) 21V (CMOS)	6.49
27128-20	16,384 x 8 (200ns) 21V	6.95
27128-25	16,384 x 8 (250ns) 21V	5.95
27128A-25	16,384 x 8 (250ns) 12.5V	5.25
27C128-25	16,384 x 8 (250ns) 21V (CMOS)	6.95
27256-20	32,768 x 8 (200ns) 12.5V	6.95
27256-25	32,768 x 8 (250ns) 12.5V	5.95
27C256-25	32,768 x 8 (250ns) 12.5V (CMOS)	7.95
27512-20	65,536 x 8 (200ns) 12.5V	13.49
27512-25	65,536 x 8 (250ns) 12.5V	11.95
68764	8192 x 8 (450ns) 25V	13.95
EEPROMS		
2816A	2048 x 8 (350ns) 5V Read/Write	5.95
2817A	2048 x 8 (350ns) 5V Read/Write	7.95
2865A	8192 x 8 (250ns) 5V Read/Write	9.95
52B13 (21V)	2048 x 8 (350ns) 5V Read Only	1.49

COMMODORE CHIPS

Part No.	Price
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SI3052P	2.49
6502	2.65
6504A	1.95
6507	4.39
6510	9.95
6520	1.95
6522	3.95
6525	4.95
6526	14.95
6529	2.95
6532	6.49
6545-1	4.95
6551	4.49
6560	10.95
6567	14.95
6569	24.95
6572	8.95
6581 (12V)	14.95
6582 (9V)	14.95
8360	14.95
8501	10.95
8502	7.95
8563	15.95
8564	9.95
8566	24.95
8701	9.95
*8721	14.95
8722	9.95
*251104-04	10.95
318018-03	10.95
318019-03	10.95
318020-04	10.95
325302-01	10.95
*325572-01	14.95
*82S100PLA**	15.95
901225-01	11.95
901226-01	11.95
901227-03	11.95
901229-05	11.95

*No specs available
**Note: 82S100PLA U17 (C-64)

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 interlaced 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	1.19
74HC04	.29	74HC240	.99
74HC08	.29	74HC244	.99
74HC10	.29	74HC245	.99
74HC14	.49	74HC253	.59
74HC30	.29	74HC259	.89
74HC32	.29	74HC273	.99
74HC74	.39	74HC373	.99
74HC75	.39	74HC374	.99
74HC76	.45	74HC595	1.29
74HC85	.79	74HC688	.99
74HC86	.39	74HC943	8.95
74HC123	.89	74HC4040	.99
74HC125	.49	74HC4049	.59
74HC132	.69	74HC4050	.59
74HC138	.49	74HC4060	.99
74HC139	.49	74HC4511	1.29
74HC154	1.49	74HC4514	1.79
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	1.79
74C08	.35	74C240	1.79
74C10	.35	74C244	1.79
74C14	.59	74C373	1.95
74C32	.35	74C374	1.95
74C74	.59	74C912	8.95
74C85	1.49	74C915	1.39
74C86	.35	74C920	6.95
74C89	5.49	74C921	6.95
74C90	.99	74C922	3.95
74C154	2.95	74C923	3.95
74C173	1.05	74C925	5.95

LINEAR

DS0026CN	1.95	LM1458N	.39
TL074CN	1.19	LM1488N	.49
TL084CN	.99	DS14C88N (CMOS)	1.19
AF100-1CN	8.95	LM1489N	.49
LM307N	.45	DS14C89N (CMOS)	1.19
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LM311N	.45	MC1648P	3.49
LM317T	.79	LM1871N	1.95
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LM323K	3.95	ULN2003A	.79
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LM338K	4.95	XR2211	2.95
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LM348N	.69	26LS31	1.19
LM350T	2.95	26LS32	1.19
LF351N	.39	26LS33	1.49
LF353N	.49	LM2901N	.39
LF355N	.79	LM2907N	1.29
LF356N	.89	LM2917N (8 pin)	1.95
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LM358N	.49	MC3446N	1.69
LM360N	2.19	MC3450P	1.95
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LM386N-3	.89	MC3479P	4.79
LM387N	.99	MC3486P	1.69
LM393N	.39	MC3487P	1.69
LM399H	2.95	LM3900N	.49
LF411CN	.79	LM3905N	1.19
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NE540H (C540H)	2.95	LM3914N	1.95
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XRL555	.59	NE5532	.69
LM556N	.49	NE5534	.69
NE558N	.89	7805K (LM340K-5)	1.29
LM565N	.99	7812K (LM340K-12)	1.29
LM567V	.79	7815K (LM340K-15)	1.29
NE592N	.89	7805T (LM340T-5)	.49
LM741CN	.29	7812T (LM340T-12)	.49
LM747CN	.59	7815T (LM340T-15)	.49
MC1350P	1.09	7905K (LM320K-5)	1.35
MC1372P	1.95	7905T (LM320T-5)	.59
MC1377P	2.29	75472	.59
MC1398P	8.95	75477	.89
LM1414N	1.29	MC145106P	3.25
		MC145406P	2.95

IC SOCKETS

Low Profile		Wire Wrap (Gold) Level #3	
8LP	.11	8WW	.59
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.25	24WW	1.19
28LP	.27	28WW	1.39
40LP	.29	40WW	1.89

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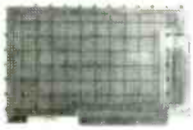
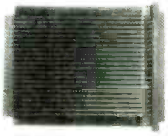


- Wire Wrap
- Component Testing
- Point-to-Point Wiring
- 31/62 Connection

JE417 (Pictured)

JE411	(6½", No Pads, Gen. Purp.)	$12.95
JE415	(6½", No Pads, PC/XT)	$14.95
JE417	(6½", Plated w/Pads, PC/XT)	$19.95



Extender Boards Designed for Troubleshooting and Testing

JE419 (Pictured)

JE419	(5¼" Extender, 22/44 Connector)	$19.95
JE421	(4¾" Extender, 31/62 Connector)	$19.95

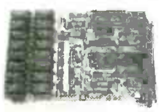
Accessories for Commodore VIC-20, C-64 & C-128

JE232CM (Pictured)

*CM1	(300B Modem VIC-20, C-64)	$19.95
*JE232CM	(RS232 Inter. VIC-20, C-64)	$39.95
CPS10	(C-64 Power Supply)	$39.95
CPS128	(C-128 Power Supply)	$59.95

*Also compatible with C-128 in 64 mode only.

ZUCKERBOARD



TANDY 1000 Expansion Memory Half Card

Expand the memory of your Tandy 1000 (128K Version) to as much as 640K. Also includes DMA controller chip.

TE512	Includes 512K RAM	$119.95
TANC	Plug-in Clock option chip (only)	$39.95

20Meg Hard Disk

T20MB	20MB Hard Disk Drive Board for Tandy 1000	$494.95
SX20MB	20MB Hard Disk Drive Board for Tandy 1000SX	$499.95

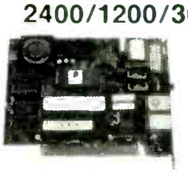
TANDY 1000 Multifunction Board with Clock Calendar

Expand the memory on your Tandy 1000 (128K Version) to as much as 640K. Complete with an RS232 port, clock/calendar, RAM Disk, Printer Spooler and on-board DMA controller chip.

MT512 Includes 512K RAM $199.95

DATATRONICS

2400/1200/300 Modems



· Hayes command compatible · Bell 103/212A compatible · Auto-dial/auto-answer · FCC approved · 1-year warranty · The 1200H & 2400S include MaxiMite Communication Software · The 1200C & 2400E do not include software

1200H	1200/300 Baud Internal Modem	$ 79.95
2400S	2400/1200/300 Internal Modem	$174.95
1200C	1200/300 Baud External Modem	$119.95
2400E	2400/1200/300 External Modem	$219.95

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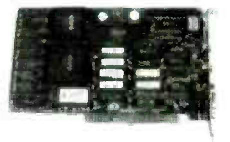

· Graphics: 720 x 348 · 16 out of 64 colors · Manual included

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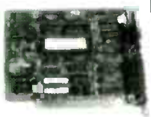
I/O Cards for PC/XT/AT



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- RS232 Port
- Game Port
- Manual included

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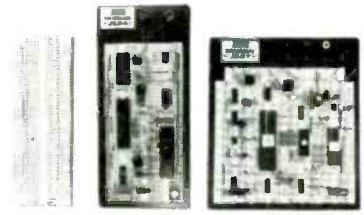

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Part No.	Dim. L" x W"	Contact Points	Binding Posts	Price
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HM6116LP-4	2048x8	(200ns)(CMOS)(LP)	1.85
HM6116LP-3	2048x8	(150ns)(CMOS)(LP)	1.90
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4116-200	16384x1	(200ns)	.89
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4116-120	16384x1	(120ns)	1.49
MK4332	32768x1	(200ns)	6.95
4164-150	65536x1	(150ns)	1.29
4164-120	65536x1	(120ns)	1.55
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4011	.19	4050	.29
4012	.25	4051	.69
4013	.35	4052	.69
4015	.29	4053	.69
4016	.29	4060	.69
4017	.49	4066	.29
4018	.69	4069	.19
4020	.59	4070	.29
4021	.69	4081	.22
4023	.25	4093	.49
4024	.49	14411	9.95
4025	.25	14433	14.95
4027	.39	14497	6.95
4028	.65	4503	.49
4040	.69	4511	.69
4042	.59	4518	.85
4044	.69	4528	.79
4046	.69	4538	.95
4047	.69	4702	12.95

HIGH SPEED CMOS

74HC00		74HCT00	
74HC00	.21	74HCT00	.25
74HC02	.21	74HCT02	.25
74HC04	.25	74HCT04	.27
74HC08	.25	74HCT08	.25
74HC14	.35	74HCT32	.27
74HC32	.35	74HCT74	.45
74HC74	.35	74HCT138	.55
74HC86	.45	74HCT161	.79
74HC138	.45	74HCT240	.89
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74HC244	.85	74HCT374	.99
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74HC273	.69	74HCT4017	1.19
74HC373	.69	74HCT4040	.99
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74LS00

74LS00	.16	74LS112	.29	74LS241	.69
74LS01	.18	74LS122	.45	74LS242	.69
74LS02	.17	74LS123	.49	74LS243	.69
74LS03	.18	74LS124	2.75	74LS244	.69
74LS04	.16	74LS125	.39	74LS245	.79
74LS05	.18	74LS126	.39	74LS251	.49
74LS08	.18	74LS132	.39	74LS253	.49
74LS09	.18	74LS133	.49	74LS257	.39
74LS10	.16	74LS136	.39	74LS258	.49
74LS11	.22	74LS138	.39	74LS259	1.29
74LS12	.22	74LS139	.39	74LS260	.49
74LS13	.26	74LS145	.99	74LS266	.39
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74LS20	.17	74LS151	.39	74LS280	1.98
74LS21	.22	74LS153	.39	74LS283	.59
74LS22	.22	74LS154	1.49	74LS290	.89
74LS27	.23	74LS155	.59	74LS293	.89
74LS28	.26	74LS156	.49	74LS299	1.49
74LS30	.17	74LS157	.35	74LS322	3.95
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74LS33	.28	74LS160	.29	74LS365	.39
74LS37	.26	74LS161	.39	74LS367	.39
74LS38	.26	74LS162	.49	74LS368	.39
74LS42	.39	74LS163	.39	74LS373	.79
74LS47	.75	74LS164	.49	74LS374	.79
74LS48	.85	74LS165	.65	74LS375	.95
74LS51	.17	74LS166	.95	74LS377	.79
74LS73	.29	74LS169	.95	74LS390	1.19
74LS74	.24	74LS173	.49	74LS393	.79
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7475	.45
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7483	.50
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7486	.35
7489	2.15
7490	.39
7493	.35
74121	.29
74123	.49
74125	.45
74150	1.35
74151	.55
74153	.55
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3.0 MHz

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2.5 MHz

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4.0 MHz

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1.0 MHz

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2.0 MHz

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74S00

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74S10	.29	74S241	1.49
74S32	.35	74S244	1.49
74S74	.49	74S280	1.95
74S86	.35	74S287	1.69
74S112	.50	74S288	1.69
74S124	2.75	74S299	2.95
74S138	.79	74S373	1.69
74S153	.79	74S374	1.69
74S157	.79	74S471	4.95
74S158	.95	74S571	2.95

PALS

16L8	$2.95	16R6	$2.95
16R8	$2.95	16R4	$2.95

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TERMS: Minimum order $10.00. For shipping and handling include $2.50 for UPS Ground and $3.50 for UPS Air. Orders over 1 lb. and foreign orders may require additional shipping charges—please contact our sales department for the amount. CA. residents must include applicable sales tax. All merchandise is warranted for 90 days unless otherwise stated. Prices are subject to change without notice. We are not responsible for typographical errors. We reserve the right to limit quantities and to substitute manufacturer. All merchandise subject to prior sale. A full copy of our terms is available upon request. Items pictured may only be representative.

CIRCLE 113 ON FREE INFORMATION CARD

20 MEG HARD DISK DRIVE ON A CARD $349!

CAPACITORS

TANTALUM

1.0µf	15V	.12	.47µf	35V	.39
6.8	15V	.42	1.0	35V	.45
10	15V	.45	2.2	35V	.19
22	15V	.99	4.7	35V	.39
.22	35V	.15	10	35V	.69

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	.11	10	50V	.16
4.7	50V	.11	22	16V	.14
10	50V	.11	47	50V	.19
47	35V	.13	100	35V	.19
100	16V	.15	220	25V	.25
220	35V	.20	470	50V	.29
470	25V	.30	1000	16V	.29
2200	16V	.70	2200	16V	.70
4700	25V	1.45	4700	16V	1.25

VOLTAGE REGULATORS

TO-220 CASE		TO-3 CASE			
7805T	.49	7805K	1.59	7905K	1.69
7808T	.49	7812K	1.39	7912K	1.49
7812T	.49				
7815T	.49				
7905T	.59				
7908T	.59	TO-92 CASE			
7912T	.59	78L05	.49	79L05	.69
7915T	.59	78L12	.49	79L12	1.49

LM323K 5 VOLTS, 3 AMPS, TO-3 4.79
LM338K ADJUSTABLE, 5 AMPS, TO-3 6.95

WISH SOLDERLESS BREADBOARDS

PART NUMBER	DIMENSIONS	DISTRIBUTION STRIP(S)	TIE POINTS	TERMINAL STRIP(S)	TIE POINTS	BINDING POSTS	PRICE
WBU-D	.38 x 6.50"	1	100	---	---	---	2.95
WBU-T	1.38 x 6.50"	---	---	1	630	---	6.95
WBU-204-3	3.94 x 8.45"	1	100	2	1260	2	17.95
WBU-204	5.13 x 8.45"	4	400	2	1260	3	24.95
WBU-206	6.88 x 9.06"	5	500	3	1890	4	29.95
WBU-208	8.25 x 9.45"	7	700	4	2520	4	39.95

RESISTOR NETWORKS

SIP	10 PIN	9 RESISTOR	.69
SIP	8 PIN	7 RESISTOR	.59
DIP	16 PIN	8 RESISTOR	1.09
DIP	16 PIN	15 RESISTOR	1.09
DIP	14 PIN	7 RESISTOR	.99
DIP	14 PIN	13 RESISTOR	.99

EXTENDER CARDS FOR IBM

EXT-8088 $29.95
EXT-80286 $39.95

WIREWRAP PROTOTYPE CARDS

FR-4 EPOXY GLASS LAMINATE
WITH GOLD-PLATED EDGE-CARD FINGERS

XT

BOTH CARDS HAVE SILK SCREENED LEGENDS AND INCLUDES MOUNTING BRACKET

IBM-PR1 WITH +5V AND GROUND PLANE . . . $27.95
IBM-PR2 AS ABOVE W/ DECODING LAYOUT . . $29.95

AT

IBM-PRAT LARGE +5V & GROUND PLANES $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

BYPASS CAPACITORS

.01 µf	CERAMIC DISC	100/$5.00
.01 µf	MONOLITHIC	100/$10.00
.1 µf	CERAMIC DISC	100/$6.50
.1 µf	MONOLITHIC	100/$12.50

SHORTING BLOCKS

.1" CENTERS
GOLD CONTACTS
5/$1.00

FRAME STYLE TRANSFORMERS

12.6 Volts AC	2 Amps	(CT)	5.95
12.6 Volts AC	4 Amps	(CT)	7.95
12.6 Volts AC	8 Amps	(CT)	10.95
25.2 Volts AC	2 Amps	(CT)	7.95

DISCRETE

1N751	.15
1N759	.15
1N4148 25	1.00
1N4004 10	1.00
1N5402	.25
KBP02	.55
KBU8A	.95
MDA990-2	.35
N2222	.25
PN2222	.10
2N2905	.50
2N2907	.25
2N3055	.79
2N3904	.10
4N26	.69
4N27	.69
4N28	.69
4N33	.89
4N37	1.19
MCT-2	.59
MCT-6	1.29
TIL-111	2.25
2N3906	.10
2N4401	.25
2N4402	.25
2N4403	.25
2N6045	1.75
TIP31	.49

IC SOCKETS

SOLDERTAIL	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
WIREWRAP		
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
ZERO INSERTION FORCE		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

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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

36 PIN CENTRONICS

MALE

IDCEN36 RIBBON CABLE 3.95
CEN36 SOLDER CUP 1.85

FEMALE

IDCEN36-F RIBBON CABLE 4.95
CEN36PC RT. Angle PC Mount 1.85

EDGECARD CONNECTORS

100 Pin Soldertail	S-100	.125	3.95
100 Pin Wirewrap	S-100	.125	4.95
62 Pin Soldertail	IBM PC	.100	1.95
50 Pin Soldertail	APPLE	.100	2.95
44 Pin Soldertail	STD	.156	1.95
44 Pin Wirewrap	STD	.156	4.95

SOCKET-WRAP I.D.™

- SLIPS OVER WIRE WRAP PINS
- IDENTIFIES PIN NUMBERS ON WRAP SIDE OF BOARD
- CAN WRITE ON THE PLASTIC, SUCH AS AN 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
20	IDWRAP 20	5	1.95
22	IDWRAP 22	5	1.95
24	IDWRAP 24	5	1.95
28	IDWRAP 28	5	1.95
40	IDWRAP 40	5	1.95

PLEASE ORDER BY NUMBER OF PACKAGES (PCK. OF)

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
WIREWRAP HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WIREWRAP HEADER	IDHxxWR	2.05	3.28	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.63	.89	.95	1.29	1.49	1.69
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	.85	1.25	1.35	1.75	2.05	2.45

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS BELOW

EPROM ERASERS

SPECTRONICS CORPORATION

Model	Timer	Chip Capacity	Intensity (uW/Cm²)	Unit Cost
PE-140	NO	9	8,000	$89
PE-140T	YES	9	8,000	$139
PE-240T	YES	12	9,600	$189

DATARASE $34.95

- ERASES 2 EPROMS IN 10 MINUTES TIME
- VERY COMPACT - NO DRAWER
- THIN METAL SHUTTER PREVENTS UV LIGHT FROM ESCAPING

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 POS. 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

D-SUBMINIATURE CONNECTORS

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.45	.59	.69	.69	1.35	1.85
	FEMALE	DBxxS	.49	.69	.75	.75	1.39	2.29
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	.49	.69	---	.79	2.27	---
	FEMALE	DBxxSR	.55	.75	---	.85	2.49	---
WIREWRAP	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	1.39	1.99	---	2.25	4.25	---
	FEMALE	IDBxxS	1.45	2.05	---	2.35	4.49	---
HOODS	METAL	MHOODxx	1.05	1.15	1.25	1.25	---	---
	GREY	HOODxx	.39	.39	---	.39	.69	.75

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 59¢

LIGHT EMITTING DIODES

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
TIL-313	COM CATHODE	.3"	.45
TIL-311	4x7 HEX W/ LOGIC	.270"	10.95

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

"SNAPABLE" HEADERS

CAN BE SNAPPED APART TO MAKE ANY SIZE HEADER. ALL WITH .1" CENTERS

1x40	STRAIGHT LEAD	.99
1x40	RIGHT ANGLE LEAD	1.49
2x40	2 STRAIGHT LEADS	2.49
2x40	2 RIGHT ANGLE LEADS	2.99

25 PIN D-SUB GENDER CHANGERS $7.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
TOOLED SOLDERTAIL IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
TOOLED WIREWRAP 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	.49	.59	1.29	1.49	---	.85	1.49	1.59

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE CONNECTORS ABOVE

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	10'	COLOR CODED 1'	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	.55	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

MUFFIN FANS

3.15" Sq. $14.95 3.63" Sq. $14.95
3.18" Square $16.95

LINE CORDS

2 conductor 39¢ 3 conductor 99¢
3 conductor w/ female socket $1.49

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8087 5MHz $99^{00} 80287 6 MHz $179^{95}

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MCT-MF MULTIFUNCTION $79^{95}
ALL THE FEATURES OF 6 PACK - AT HALF THE PRICE
- 0-384K DYNAMIC RAM USING 4164s
- SERIAL, PARALLEL, GAME PORTS, CLOCK/CALENDAR

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TOTAL SYSTEM CONTROL FROM A SINGLE SLOT
- 2 FLOPPY CONT, SERIAL, PARALLEL, GAME PORT, CLOCK/CAL
- RUN COLOR GRAPHICS SOFTWARE ON A MONOCHROME MONITOR

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A PERFECT COMPANION FOR OUR MOTHERBOARDS
- SERIAL, PARALLEL, GAME PORT, CLOCK/CALENDAR
- SUPPORTS UP TO 2 360K FLOPPIES, 720K WITH DOS 3.2

MIO-SERIAL 2nd SERIAL PORT $15^{95}

MCT-IO MULTI I/O CARD $59^{95}
USE WITH MCT-FH FOR A MINIMUM OF SLOTS USED
- SERIAL PORT, CLOCK/CALENDAR WITH A BATTERY BACK-UP
- PARALLEL PRINTER PORT ADDRESSABLE AS LPT1 OR LPT2

IO-SERIAL 2nd SERIAL PORT $15^{95}

MCT-ATMF AT MULTIFUNCTION $139^{95}
ADDS UP TO 3 MEGABYTES OF RAM TO THE AT
- USER EXPANDABLE TO 1.5 MB OF MEMORY (ZERO K INSTALLED)
- INCLUDES SERIAL PORT AND PARALLEL PORT

ATMF-SERIAL 2nd SERIAL PORT $24^{95}
MCT-ATMF-MC PIGGYBACK BOARD (NO MEMORY) $29^{95}

MCT-ATIO AT MULTI I/O $59^{95}
USE WITH MCT-ATFH FOR A MINIMUM OF SLOTS USED
- SERIAL, PARALLEL AND GAME PORTS
- USES 16450 SERIAL SUPPORT CHIPS FOR HIGH SPEED OPERATION

ATIO-SERIAL 2nd SERIAL PORT $24^{95}

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MCT-RAM 576K RAM CARD $59^{95}
A CONTIGUOUS MEMORY SOLUTION IN A SHORT SLOT
- USER SELECTABLE CONFIGURATION AMOUNTS UP TO 576K USING 64K & 256K RAM CHIPS (ZERO K INSTALLED)

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2 MB OF LOTUS/INTEL/MICROSOFT COMPATIBLE MEMORY FOR XT
- CONFORMS TO LOTUS/INTEL EMS
- USER EXPANDABLE TO 2 MB
- EXPANDED/CONVENTIONAL MEMORY, RAMDISK AND SPOOLER

MCT-ATRAM AT 4 MB RAM CARD $149^{95}
A POWER USER'S DREAM: 4 MB OF MEMORY FOR AT
- BACKFILL TO 640K, FLEXIBLE STARTING ADDRESS
- UP TO 2 MB ON CARD, 4 MB WITH OPTIONAL PIGGYBACK BOARD

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MCT-ATEMS AT COMPATIBLE EMS $139^{95}
CAN BE USED FOR EXPANDED, EXTENDED OR CONVENTIONAL MEMORY
- CONFORMS TO LOTUS/INTEL EMS
- USER EXPANDABLE TO 2 MB
- RAMDISK, PRINT SPOOLER AND LIM/EMS SOFTWARE INCLUDED

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QUALITY DESIGN OFFERS 4 FLOPPY CONTROL IN A SINGLE SLOT
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- SUPPORTS BOTH DS/DD AND DS/QD WITH DOS 3.2

MCT-HDC HARD DISK CONTROLLER $79^{95}
HD CONTROL FOR WHAT OTHERS CHARGE FOR FLOPPY CONTROL
- SUPPORTS 16 DRIVE SIZES INCLUDING 5, 10, 20, 30 & 40 MB
- DIVIDE 1 LARGE DRIVE INTO 2 SMALLER, LOGICAL DRIVES

MCT-FDC-1.2 1.2MB FLOPPY CONTROLLER $69^{95}
ADD VERSATILITY & CAPACITY TO YOUR XT
- SUPPORTS 2 DRIVES, BOTH MAY BE 360K OR 1.2 MEG
- ALLOWS DATA TO FLOW FREELY FROM XTs TO ATs

MCT-FH FLOPPY/HARD CONTROLLER $139^{95}
SYSTEM STARVED FOR SLOTS? SATISFY IT WITH THIS TIMELY DESIGN
- INTERFACES UP TO 2 FDDs & 2 HDDs, CABLING FOR 2 FDDs & 1 HDD
- SUPPORTS BOTH DS/DD & DS/QD WITH DOS 3.2

MCT-ATFH AT FLOPPY/HARD CONTROLLER $149^{95}
FLOPPY HARD DISK CONTROL IN A TRUE AT DESIGN
- SUPPORTS UP TO 2 360K/720K/1.2MB FDDs AS WELL AS 2 HDDs USING STANDARD CONTROL TABLES

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MCT-EGA ENHANCED GRAPHICS ADAPTOR $149^{95}
100% IBM COMPATIBLE, PASSES IBM EGA DIAGNOSTICS
- 256K OF VIDEO RAM ALLOWS 640 x 350 IN 16 OF 64 COLORS
- COMPATIBLE WITH COLOR AND MONOCHROME ADAPTORS

MCT-CG COLOR GRAPHICS ADAPTOR $49^{95}
COMPATIBLE WITH IBM COLOR GRAPHICS STANDARDS
- SHORT SLOT SUPPORTS RGB, COLOR & COMPOSITE MONOCHROME
- 640/320 x 200 RESOLUTION, LIGHT PEN INTERFACE

MCT-MGP MONOCHROME GRAPHICS $59^{95}
TRUE HERCULES COMPATIBILITY, SUPPORTS LOTUS 123
- SOFTWARE DRIVER ALLOWS COLOR GRAPHICS PROGRAMS TO RUN ON A MONOCHROME MONITOR
- PARALLEL PRINTER PORT

HALF HEIGHT HARD DISK DRIVES

40 MB $469
Seagate model ST-251 5¼" half height
FAST 40ms access time

60 MB $649
Seagate model ST-277 5¼" half height
FAST 40ms access time (RLL)

HALF HEIGHT HARD DISK SYSTEMS

20 MB $289 **30 MB $329**

Systems include Seagate ½ height hard drive, hard drive controller, cables and instructions.
All drives are pre-tested and warranted for one year.

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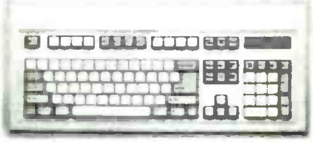
MCT-TURBO TURBO 4.77/8 MHz $109^{95}
- 4.77 OR 8 MHz OPERATION WITH 8088-2 & OPTIONAL 8087-2 CO-PROCESSOR
- DYNAMICALLY ADJUSTS SPEED FOR MAXIMUM THROUGHPUT & RELIABILITY DURING DISK I/O
- CHOICE OF NORMAL/TURBO MODE OR SOFTWARE SELECT PROCESSOR SPEED

MCT-XTMB STANDARD MOTHERBOARD $97^{95}

MCT-ATMB 80286 6/8 MHz $379^{95}
- 8 SLOT (2 EIGHT BIT, 6 SIXTEEN BIT) AT MOTHERBOARD
- HARDWARE SELECTION OF 6 OR 8 MHz
- 1 WAIT STATE
- KEYLOCK SUPPORTED, RESET SWITCH, FRONT PANEL LED INDICATOR
- SOCKETS FOR 1 MB OF RAM AND 80287
- BATTERY BACKED CLOCK

MCT-BATMB MINI 80286 $429^{95}
- REPLACEMENT BOARD FOR XT STYLE CHASSIS
- OPERATE AT 6/10 MHz WITH UP TO 1MB ON-BOARD MEMORY (ZERO K INSTALLED)
- SOCKET FOR 80287 MATH CO-PORCESSOR
- BATTERY BACKED CLOCK
- 8 SLOTS: 2 EIGHT BIT, 6 SIXTEEN BIT
- USES CHIPS & TECHNOLOGY CHIP SET FOR RELIABILITY AND SMALL SIZE

IBM COMPATIBLE KEYBOARDS



MCT-5339 $79^{95}
- IBM ENHANCED STYLE LAYOUT
- SOFTWARE AUTOSENSE FOR XT OR AT COMPATIBLES
- LED INDICATORS
- AUTO REPEAT FEATURE
- SEPARATE CURSOR PAD

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- MORE THAN 10,000 SOLD!

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Daryl Hammond

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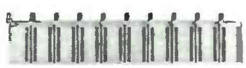
- MOTHERBOARD
- 256K OF MEMORY
- 135 WATT POWER SUPPLY
- FLIP-TOP CASE
- 5060 STYLE KEYBOARD
- 360K FLOPPY DRIVE
- DRIVE CONTROLLER
- MONOCHROME MONITOR
- GRAPHICS ADAPTOR

FOR ONLY $499^{15}

ANYONE CAN BUILD A SYSTEM IN ABOUT 2 HOURS USING A SCREWDRIVER AND OUR EASY-TO-FOLLOW INSTRUCTIONS!

DEVELOPMENT TOOLS
FROM MODULAR CIRCUIT TECHNOLOGY



MCT-EPROM PROGRAMMER $129^{95}
PROGRAMS 27xx & 27xxx EPROMS UP TO 27512
- SUPPORTS VARIOUS PROGRAMMING FORMATS AND VOLTAGES
- SPLIT OR COMBINE CONTENTS OF SEVERAL EPROMS OF DIFFERENT SIZES
- READ, WRITE, COPY, ERASE CHECK AND VERIFY
- SOFTWARE FOR HEX AND INTEL HEX FORMATS

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SOLDER TAIL DIP SOCKETS
- Single beam
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- YOUR CHOICE: TIN OR GOLD*

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- YOUR CHOICE: TIN OR GOLD*
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Part No.	Description	Pkg.	1	10	100	1,000
1N5400	3 Amp 50PIV	Plastic	28	2.56	22.80	199.50
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5¼", 10Mb HARD DISK DRIVE

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Fits standard 5¼" spacing. Shock mtd. High speed, low power. Mfr – Seagate/Tandon
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Controller Card for above
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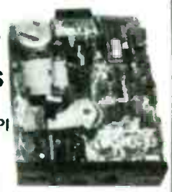
5¼" FULL HT. DISK DRIVES

48 TPI (IBM® Compat.)
Double sided/double density, full height drive. 48 T.P.I., 80 tracks. Mfr – Tandon TM100-2
Item #7928 **$79.00**
2 for **$150.00**
96 TPI, DS/Quad Density
Mfr – CDC #9409T
Item #1893 **$99.00**

5¼" 1/2 HT. DISK DRIVES

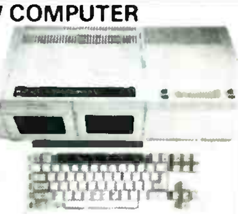


48/96 TPI 1.2 Mb. (AT Compat.)
DS/single-double density; 80 track. Mfr – Panasonic #JU-475
Item #10005 **$119.00** New
96 TPI, DS/Quad Density (DOS 3.2 Compatible)
Tandon TM55-4; DS/Quad
Item #1904 **$79.00**
2 for **$150.00**

5" COMPOSITE VIDEO MONITOR

Power regulated, 12VDC. Mtd. in plastic cabinet, w/brightness control knob. Mfr – Sperry
OA Dim.: 8"W x 8"H x 8¾"deep
Item #14536 **$24.95**

ADAM COMPUTER



(Less printer)
No wiring necessary (just plugs together). Hook-up diagram included. Includes: Keyboard, 1 cassette digital data drive, 2 game controllers, power supply, & one cassette. Capable of running CP/M, has built-in word processor.
Item #7410 Complete – **$99.00**

5¼" FLOPPY DISKETTES

Single side/single density; 16 hard sectors. Mfr – Xerox #11R61630
Item #14537
Pack of 10 **$9.95** New

115 CFM MUFFIN® FAN With Adjustable Speed Control

115 VAC/60 Hz., 21W., 28A., 3100 RPM; 5-blade model, aluminum housing. Can be mounted for blowing or exhaust.
Dim.: 4¹¹⁄₁₆"sq. x 1½"deep.
Item #5345S **$8.95**

27 CFM MINI FANS

115VAC; 50/60Hz.; 12W. Low noise level fans, can be mtd. for blowing or exhaust.
1½" STANDARD
7 metal blades
Dim.: 3⅛" sq. x 1½" deep
NEW – Rotron #SU2A1
Item #5970 **$7.95**
USED – Rotron
Item #1873 **$5.95**

12/24 VDC MUFFIN-TYPE FANS

55/100 CFM
8 W. Can be mounted for blowing or exhaust. Aluminum housing, brushless, ball-bearing type.
1" Thin: 5 plastic blades with feathered edges.
Mfr – Centaur #CUDC24K4-601
Item #8541 **$19.95** New
1½" Standard: 5 plastic blades
Mfr – Centaur #CNDC24K4-601
Item #12109 **$14.95** RFE

ADAM 5¼" DISK DRIVE

Gives your Adam fast, reliable data storage & retrieval. Can hold up to 160K bytes of information. Uses industry-standard SS/DD disks. Connects directly to your Adam memory console. Comes w/disk drive power supply, Disk Manager disk and owner's manual.
Mfr – Coleco, model 7817
Item #12830 *Like New* – **$199.00**

American's IBM PC/XT-COMPATIBLE COMPUTER . . .

Contains:
- 256K RAM;
- XT/AT Style Keyboard;
- 5¼" Full-Height Floppy Disk Drive
- 10Mb Full-Height Hard Disk Drive
- Hard Disk & Floppy Disk Controller Cards
- Color/Monochrome Monitor Card (monitor not included).

Item #14331
$549.95 New

MAGNIFYING LAMP

Multi position, 30", completely adjustable swing arm w/3-way metal C-clamp. Has 4" diopter magnifying lens, w/ruler. Porcelain lamp socket, & on/off switch; uses up to a 60W bulb. Color: Beige. UL listed.
Item #13136 **$24.95** New

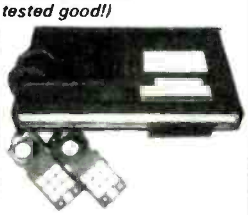
— BATTERIES — FANS — BLOWERS

ADAM PRINTER

Complete, less top cover plate. Friction feed. Takes standard paper 8½" x 11". (Customer returns; tested – operational.)
Item #8839 **$69.50**

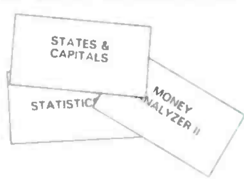
COLECOVISION GAME

(Factory returns – tested good!)



Also includes power supply, instruction manual, modulator, and one Donkey Kong cartridge.
Item #7411 **$29.95**

TIMEX-SINCLAIR 1000 & ZX-81 CASSETTES



Consists of 13 assorted cassettes. May include: *Money Analyzer II, States & Capitals, Casino Craps, Statistics, The Carpooler, and others.*
Item #14651
Set of 13 **$19.95** New

NEON TRANSFORMER (Hi-Voltage)

7300 VAC @ 5 Ma.
May be used for powering neon lights, replacing oil burner ignition transformer, building Jacob's ladder (spark gap). A high-volt. output: ¼ quick connect terminal & case ground input fully enclosed metal case. Weight: 12 lbs.
Base mount: 4½"H x 5⅛"W x 6⅞"
Item #151 **$9.95** RFE

GELL CELL/LEAD ACID BATTERIES . . .

RECHARGEABLE – Used for solar energy storage, alarm systems, remote control boats, robots, etc.

6V @ 7.5AH
Dim.: 5⅞"L x 3⅝"H x 2"D
Mfr – EPC #0031
Item #13324 **$5.95**

6V @ 2.6AH
Dim.: 5¼"L x 2¼"H x 1¼"D
Mfr – EPC #0030
Item #13326 **$3.95**

12V @ 4.5AH
Dim.: 6"L x 3⅝"H x 2½"D
Mfr – EPC #0027
Item #13325 **$7.95**

12V @ 2.6AH
Dim.: 5¼"L x 3¼"H x 2¹⁄₁₆"D
Mfr – EPC #0026
Item #13323 **$5.95**

12V @ 1.2AH
Dim.: 3⅞"L x 2"H x 1¾"D
Mfr – EPC #0025
Item #13327 **$3.95**

ADAM Accessories . . .

Data Drive –	Item #6641	$19.95
Printer Power Supply –	Item #6642	$14.95
ASCII Keyboard –	Item #6643	$19.95
Controllers – (Set of 4)	Item #7013	$9.95
Adam Cassettes – (Consisting of Smart Basic, Buck Rogers & blank cassette.)	Item #7786 *BAKER'S DOZEN* –	$19.95
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COLECOVISION . . . Accessories . . .

***ColecoVision* to *Adam* Expansion Kit**
Just plugs into your *ColecoVision*.
Item #9918 **$59.50**

Expansion Module #2
Incl. *Turbo* cart.
Item #13146 **$39.95** New

Roller Controller
Incl. *Slither* cart.
Item #13147 **$39.95** New

Super Action Controller Set
Incl. *Baseball* cart.
Item #13148 **$39.95** New

PLUG-IN POWER SUPPLIES

COMPUTER/ GAME ADAPTOR
Output: +5 VDC, .9A
−5 VDC, .1A
+12 VDC, .3A
Input: 120 VAC/60 Hz., .25A
Mfr – Coleco #55416
Item #1882 **$4.95** New

9VDC ADAPTOR
Input: 115 VAC, 50/60 Hz.
Output: 9.5V @ 1A.
Dim.: 2⅜"W x 3⅛"H x 2" deep
Mfr: Commodore #251539-01/02
Item #9393 **$5.95** New

NICAD BATTERIES (Rechargeable)

12V @ 450 ma
Contains 10 AA cells. Recharge rate: 45 ma. 16–18 hours.
Dim.: 2¹¹⁄₁₆"H x 1¼"W x 2¹⁵⁄₁₆"L
Mfr – GE 123233 or equiv.
Item #5443 **$5.95** New

"D" CELLS

Dual Pack 2.4V @ 1.2Ah
2 D cells, stacked & series connected (easily ganged for carrying). Recharge in 12-14 hrs. OA Dim.: 1½" dia. x 4½"L
Item #12142 (pack of 2) **$5.95**
(Major mfrs.) 5 packs/**$25.00**

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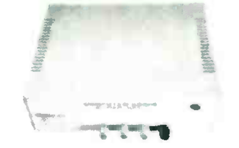
"The First Source"— for electromechanical & electronic equipment and components — AMERICAN DESIGN COMPONENTS!

EXTERNAL DISK DRIVE CHASSIS

With 60W power supply (fan cooled). Can accommodate:
2 full ht. drives — our item #7928
2 floppy drives — #1904
1 hard drive & 1 floppy — #13250
Input: 115/230V, 50/60 Hz.
Originally for Burroughs computer.
Dim.: 11"W x 8"H x 12" deep

Item #14541 **$59.50**

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/60Hz. Dim.: 9¼"W x 3¾"H. (Rubber ft. incl.)

Item #9501 **$24.95** New

PC 8300 HOME COMPUTER

(Advanced version of the Timex 1000)

42-key mechanical keyboard (not membrane). Incl. 2K RAM. Reverse video, Z80A, 6.5MHz processor. ROM 8K BASIC. Graphics capabil./sound–music, TV or monitor. Joystick input operates on 115 VAC. Includes: AC adapter, TV cable, & pair of cassette cables. Will run all prerecorded tapes for Sinclair/Timex 1000-ZX85. Mfr - Power 3000. (In orig. boxes.)

Item #10336 **$29.95** New

Accessories . . .

★ **16K RAMPACK upgrade**
Item #10337 **$9.95** New

★ **32K RAMPACK upgrade**
Item #12148 **$19.95** New

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LH0002CN	$5.35	LM1456V	1.75
LM10CLH	2.65	LM1458N	.44
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TL071CP	.53	LM1496N	.90
TL072CP	.71	LM1899N	1.43
LM301N	.32	ULN2003A	.90
LM307N	.41	DS26LS31CN	1.34
LM310N	1.16	DS26LS32CN	1.34
LM311N	.41	LM2901N	.53
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LM317LZ	.62	LM2907N	1.75
LM317MP	.80	LM2917N	1.39
LM317T	.90	LM2917-14N	1.34
LM318N	1.07	LM2931CT	1.07
LM319N	1.07	MC3346P	.90
LM324N	.35	MC3486	1.34
LM334Z	1.07	MC3487	1.34
LM336Z	.98	SG3524	1.75
LM337MP	1.03	LM3900N	.53
LM337T	1.34	LM3914N	1.75
LM338K	3.55	RC4136N	.80
LM339N	.44	RC4151N8	.90
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LM350K	3.55	7812K	1.21
LF353N	.53	7815K	1.21
LF356N	.80	7818K	1.21
LM358N	.44	7824K	1.21
LM380N	.80	7805T	.44
LM380N-8	.98	7812T	.44
LM381N	1.16	7815T	.44
LM383T	1.34	7818T	.44
LM385Z	1.70	7824T	.44
LM386N-4	.80	78S40	1.75
LM389N	.90	7905K	1.21
LM393N	.41	7906K	1.21
LF398N	2.15	7912K	1.21
LF411CN	.71	7915K	1.21
TL494CN	1.75	7918K	1.21
TL496CP	1.34	7924K	1.21
TL497ACN	1.97	7905T	.53
NE555V	.26	7912T	.53
XR-L555	.62	7915T	.53
LM556N	.53	7918T	.53
NE558N	1.07	7924T	.53
NE564N	1.75	79L12AC	.53
LM565N	.90	79L15AC	.53
LM566CN	1.25	LF13201N	2.33
LM567V	.80	LM13600N	1.07
NE570N	2.24	LM1889	1.85
NE571N	1.75	75107N	.90
NE592N	.80	75108N	.90
LM748CN	.53	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

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Z80-CTC	1.61
Z80-DART	4.45
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Z80A	1.66
Z80A-DART	4.72
Z80A-DMA	5.35
Z80A-PIO	1.75
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Z80B-CTC	4.45
Z80B-PIO	4.45

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TMS2564	8.05
2708	3.55
TMS2716	5.99
2716	2.24
27C16	8.95
2732	2.50
2732A-25	2.95
27C32	9.85
2764-25	2.95
2764A-25	2.95
27C64	6.25
27128-25	2.65
27128A-25	4.45
27256-25	7.15
27C256-25	12.55
68701	9.95
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6800	$2.12
6821	2.72
68A09EP	5.95

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Commodore VIC 20 CPU board & mechanical keyboard. Guaranteed not to work. (For parts only.)

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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

MICROCOMPUTERS with EPROM

MC68701 — an 8-bit single chip microcomputer unit, enhances the capabilities of the M6800 family. TTL compat. Req. one +5V power supply for nonprog. operation. Incl. 2K eprom, 128 bytes RAM, serial comm. interface (SCI), parallel I/O & 3-function programmable timer.

Item #9496 (house #) **$9.95**

MC68705 — HMOS, 8-bit med. perform. microcomputer. On-chip resources: 3776 bytes eprom, 112 bytes RAM, 8 inputs & 24 programmable bidirectional outputs. Self-programming boot strap.

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COMMODORE CARTRIDGES

C-64

Consists of 12 asstd. cartridges. Includes: *Number Nabber, Star Post, Financial Advisor, Radar Rat, Jupiter Land, Magic Compos, Viduzzles, Golf, Easy Calc, Simon Basic, Dragon's Den, & ABC Voice.* Item #13573

Set of 12 — **$49.95** New

C16 & +4

Consists of 9 asstd. cartridges. Includes: *Script + 2, Calc Plus, Script +, Jack Attack, Pirate Adventures, Atomic Miss, Strange Odyssey, Financial Advisor, & Logo.* Item #13572

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COMMODORE/AMIGA POWER SUPPLY

DC Output: +5V @ 8 amps.
+12V @ 1 amp.
−5V @ 250 ma.
Input: 110VAC/60 Hz., ± 20%
Dim.: 12"L x 3¾"H x 5¾"D
Encl. in alum. housing. Fan cooled.
Mfr — Shindenger Electric #130569SXD

Item #14707 **$19.95** New

COMPUTER & GAME — EQUIPMENT —

HIGH-RESOLUTION TTL MONITORS

12VDC. Mtd. in metal housing. Schematic supplied.

12", Green Phosphor
Item #6811 **$19.95** New

9", Amber
Item #14332 **$14.95** New

STEPPING MOTORS for ROBOTICS . . .

Precision steppers with increments from 1 to 7.5 degrees. Speeds up to 5,000 steps.

Fig. 1

Fig. 2

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
5275	1.8	1.8	72	PM	Superior Electric MO61-FF-6201B	2	$19.95 ea. 2/$37.50
7630	1.8	3.0	200	PM	Superior Electric MO92-FT-402	2	$34.50 ea. 2/$59.50

— MOTORS — TIMERS — PUMPS — POWER SUPPLIES — VOLTAGE REGULATORS

AT-STYLE COMPUTER CABINET

Contains 10 full-length expansion slots (w/guides). With room for an internal 5¼" hard disk drive. Has 3 half-height disk drive slots. Rear on/off switch, notched to hold in power supply (not incl.), and security switch w/key.

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140 VA MINI MICRO-COMPUTER REGULATOR

Provides voltage regulation & 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, & 6 ft. line cord.
Input: 95 — 130V, 60Hz.
Output: 120V @ 1.17A
Dimen.: 11⅝"L x 4⅜"H x 5⅝"W
Mtd on metal base w/rubber ft.
Mfr — Sola #63-13-114

Item #9999 **$99.00** New

COMPUTER/COPIER — SUPPLIES CART/STAND

Metal cabinet w/wood finish formica top. On 2" swivel casters. Has 2 sliding doors & 2 inside shelves. Easily assembled.
OA Dim.: 32"H x 30"W x 18" deep
Cabinet Dim.: 20½"H x 30"W x 18" deep
Weight: 63 lb.

Item #14538 **$49.95** New

AMERICAN DESIGN COMPONENTS, 62 JOSEPH STREET, MOONACHIE, N.J. 07074

MINIMUM ORDER $15.

RE-127

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)

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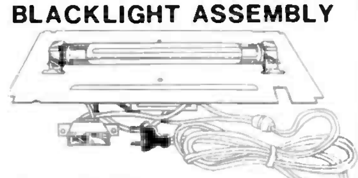
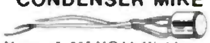
BLACKLIGHT ASSEMBLY



Complete, functioning assembly includes ballast, on-off switch, power cord, sockets and F4T5-BL blacklight. Mounted on a 7 1/8" X 3 1/8" metal plate. Use for special effects lighting or erasing EPROMS.

CAT# BLTA $10.00 EACH

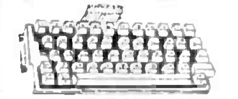
ELECTRET CONDENSER MIKE



Mouser# 25LMO44 Highly sensitive mini microphone. 6" wire leads. 0.39" dai. X 0.27" high. Omni directional. Operates on 2-10 Vdc @ less than 1 mA. 1K impedance. 50 to 8 K Hz range.

CAT# MKE-1 $1.00 EACH

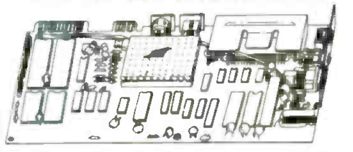
48 KEY ASSEMBLY



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

VIC 20 MOTHERBOARD



26 IC's including 6502A and 6560. 2 ea. 6522, 2 ea. 8128, 2 ea. 901486, 3 ea. 2114. Not guaranteed but great for replacement parts or experimentation.

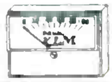
CAT # VIC-20 $15.00 each

SLIM LINE FAN

TOYO# TF92115A New 115 Vac cooling fan. 3 5/8" square X 1" deep. Metal housing. 5 blade impeller.

CAT# SCFE-115 $8.50 each
10 for $75.00

1mA METER



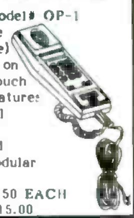
Modutec 0-1 mA signal strength meter with KLM logo. 1/4" X 1 3/4" X 7/8" deep.

CAT# MET-2 $2.00 each

2K 10 TURN

Multi-turn pot
Spectrol# MOD 534-7161
CAT# MTP-10-2
$5.00 each

PUSHBUTTON PHONE



Spectra-phone Model# OP-1
1 piece telephone with rotary (pulse) output. Operates on most rotary or touch tone systems. Features last minute redial and mute button. Includes coil cord with standard modular plug. IVORY.

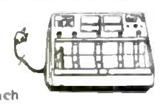
CAT# PHN-1 $8.50 EACH
2 FOR $15.00

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: 4 3/4" square.
Includes 18 Vac @ 1 amp wall transformer designed to power this supply.

CAT# PS-TX $5.00 / set
10 for $45.00

NI-CAD CHARGER/TESTER



DELUXE universal charger and tester for almost every size Ni-cad battery available.

CAT# UNCC-N $15.00 each

RECHARGEABLE NI-CAD BATTERIES

AAA SIZE 1.25V 180mAH	$2.25
AA SIZE 1.25V 500mAH	$2.00
AA with solder tabs	$2.20
C SIZE 1.2V 1200mAH	$4.25
SUB-C SIZE solder tab	$4.25
D SIZE 1.2V 1200mAH	$4.25

VENTED PROJECT CASE

Bopla #BO 718L Vented top and bottom. Black plastic with removable end panels. 9" X 8 1/2" X 4"

CAT# MB-718 $12.50 each

6-12 VDC MOTOR

Mabuchi # RS-550S
Permanent magnet motor.
1 7/16" dia X 2 1/4" long
2,600 RPM @ 6 Vdc-200 mA
5,300 RPM @ 12 Vdc

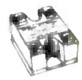
CAT# DCM-7 $3.00 each

RELAYS

12 VDC-4PDT

P.C. mount
5 amp contacts
150 ohm coil
Size: 1 1/4" X 1 3/4" X 7/8"
CAT# 4PRLY-12PC $3.50
10 for $30.00

10AMP SOLID STATE

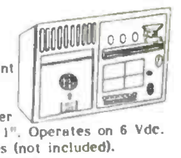


Control: 3-32 Vdc
Load: 10 AMPS, 120 Vac
Size: 2 1/2" X 3/4" X 7/8"
CAT# SSRLY-10A $9.50
10 for $85.00

25 AMP SOLID STATE

OPTO 22# 240D25
TTL compatable.
INPUT: 3-32 VDC
OUTPUT: 25 AMPS @ 240 VAC
SIZE: 2 1/2" X 3/4" X 7/8"
CAT# SSRLY-2524 $15.00 each

LIGHT ACTIVATED MOTION SENSOR



This device contains a photocell which senses sudden change in ambient light. Could be used as a door anunciator or modified to trigger other devices. 5 1/2" X 4" X 1". Operates on 6 Vdc. Requires 4 AA batteries (not included).

CAT# LSMD $5.75 per unit

COMPUTER GRADE CAPACITORS

1,400 MFD 200 VDC
2" dia. X 3" high
CAT# CG-1420 $2.00

7,500 MFD 200 VDC
3" dia. X 4 3/4" h.
CAT# CG-75 $4.00

22,000 MFD 25 VDC
2" dia. X 4 3/4" h.
CAT# CG-22 $2.50

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2" dia. X 4 3/8" h.
CAT# CG-130 $3.50

TRANSISTORS

2N2222A
3 for $1.00

PN2222A
4 for $1.00

2N2904
3 for $1.00

2N2905
3 for $1.00

2N3055
$1.00 each

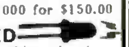
PN3569
10 for $1.00

LED'S

Standard Jumbo Diffused
T 1-3/4 Size

RED	CAT# LED-1	10 for $1.50 100 for $13.00 1000 for $110.00
GREEN	CAT# LED-2	10 for $2.00 100 for $17.00 1000 for $150.00
YELLOW	CAT# LED-3	10 for $2.00 100 for $17.00 1000 for $150.00

FLASHING LED



w/ built in flashing circuit operates on 5 Volts...

RED $1.00 each
CAT# LED-4 10 for $9.50
GREEN $1.00 each
CAT# LED-4G 10 for $9.50

BI-POLAR LED

Lights RED one direction, GREEN the other. two leads.
CAT# LED-6 2 for $1.70

LED HOLDERS

Two piece holder.
CAT# HLED 10 for 65c

CLIPLITE LED HOLDER

Makes L.E.D. look like a fancy indicator

CLEAR	CAT# HLDCL-C
RED	CAT# HLDCL-R
GREEN	CAT# HLDCL-G
YELLOW	CAT# HLDCL-Y

4 of one color $1.00

THIRD TAIL LIGHT

Sleek high-tech lamp assembly. Red lens is 2 3/4" X 5 1/2" mounted on a 4" high pedestal with up-down swivel adjustment. Has 12V replaceable bulb.

CAT# TLB $3.95 each

TRANSFORMERS

5.6 VOLT- 750ma
CAT# TX-56 $3.00

12 V.c.t.-1amp
CAT# TX-121 $4.00

12 V.c.t.-2amp
CAT# TX-122 $4.85

12 V.c.t.-4amp
CAT# TX-124 $7.00

18 VOLT-650ma
CAT# TX-186 $2.00
10 for $18.00

24 V.c.t.-1amp
CAT# TX-241 $4.85

24 V.c.t.-2amp
CAT# TX-242 $6.75

24 V.c.t.-3amp
CAT# TX-243 $9.50

24 V.c.t.-4amp
CAT# TX-244 $11.00

SWITCHES

MINIATURE TOGGLE SWITCHES rated 5 Amps

S.P.D.T. (ON-ON)

Non threaded brushing
P.C. mount.
CAT# MTS-40PC
75c each
10 for $7.00

S.P.D.T. (ON-ON)

Solder lug terminals.
CAT# MTS-4
$1.00 each
10 for $9.00

D.P.D.T. (ON-ON)

Solder lug terminals.
CAT# MTS-8
$2.00 each
10 for $19.00

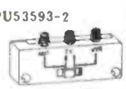
MINI PUSH BUTTON

S.P.S.T. momentary. Push to make 1/4" brushing. Red button.
CAT# MPB-1 35c each
10 for $3.00

WALL TRANSFORMER

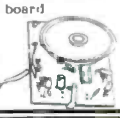
11.5 Vdc
1.95 AMP.
Input: 120 Vac
SIZE: 3 3/4" X 2 7/8" X 2 5/8"
CAT# DCTX-11519
$6.50 each

A/B SWITCH



JVC# PU53593-2 High quality A/B switch. Measures: 3 3/4" X 1 7/16" X 1". 75 OHMS IN/OUT
CAT# ABS-2 $3.50 each

SOUND EFFECTS BOARD



P.C board with 2 1/4" speaker, 2 LEDs, IC, battery snap, other components 2 3/8" X 3". When switch is pushed board beeps and leds light. Operates on a 9V battery (not included)
CAT# ST-3
$1.25 each

13.8 VDC REGULATED POWER SUPPLY

Solid state, fully regulated 13.8 Vdc power supplies. Both feature 100% solid state construction, fuse protection and LED power indicator. UL listed.

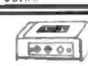
2 AMP CONSTANT, 4 AMP SURGE
CAT# DVP-412 $22.50 each

3 AMP CONSTANT, 5 AMP SURGE
CAT# DVP-512 $30.00 each

XENON FLASH TUBE

3/4" long X 1/8" dia.
CAT# FLT-1 2 for $1.00

POLARITY SWITCH



Designed to control an external coaxial relay on a satellite t.v. system. Ideal for parts. Contains a 5 Vdc relay and many other parts on a P.C. board.
CAT# RPDS $1.75 each 10 for $15.00

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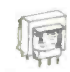
CAT# AVMOD $5.00 each

TELEPHONE COUPLING TRANSFORMER



STANCOR # TTCP-8

600 ohms c.t. to 600 ohms c.t. P.C. board mount. 3/4" X 5/8" X 3/4"

CAT# TCTXS
$2.50 each

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