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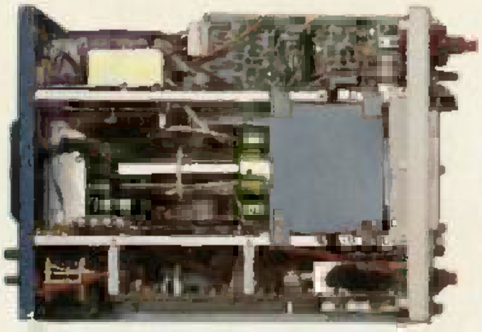

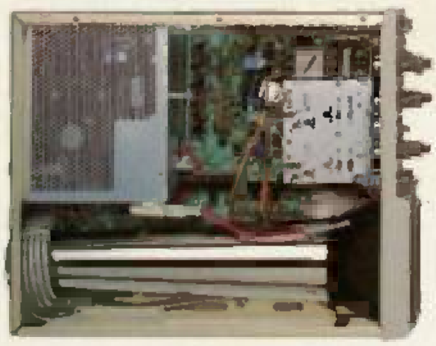

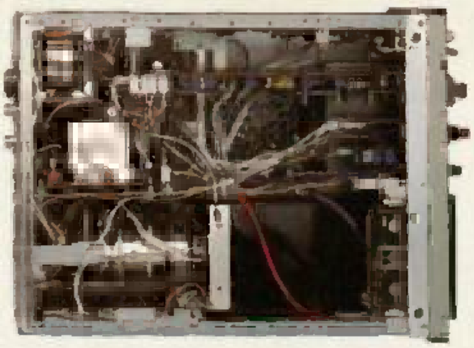

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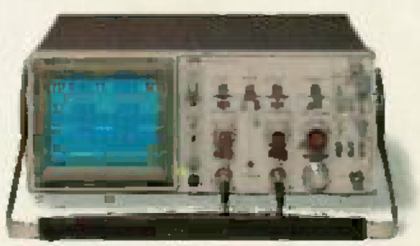

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Vol. 56 No. 9

Radio-Electronics, (ISSN 0033-7862) Published monthly by Gernsback Publications, Inc., 200 Park Avenue South, New York, NY 10003. Second-Class Postage paid at New York, NY and additional mailing offices. Second-Class mail authorized at Ottawa, Canada. One-year subscription rate U.S.A. and possessions $15.97, Canada $20.97, all other countries $23.47, subscription orders payable in US funds only, international postal money order or check drawn on a U.S.A. bank. Single copies $1.95.
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COVER 1

If you think that the automobile won't change much as the years pass, think again! Our special section will show you that electronics will change the way you drive. Navigation systems will display your progress on maps as you go, and multicolored liquid-crystal dash displays will become commonplace. Multiplexed wiring schemes will allow more sophisticated functions to be included in your car, but will actually make problems easier to find because your car will be able to diagnose itself!

Although the electronics under the hood aren't as visible, they are at least as important. Cars will run cleaner and more efficiently under microprocessor control. Monitor systems can keep track of performance and keep the driver well informed of any problems. Our special section on Automotive Electronics begins on page 49.

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WHAT'S NEWS

Equipment protection system removes motive for theft

A US patent has been issued for a new electronic-equipment system that the inventor believes will drastically reduce theft of computers, TV's, electrically tuned radios, or any other equipment that incorporates microprocessors. Called the K-circuit Lockout after its inventor, Norman Kaish, it prevents equipment that has been stolen from operating. Thus it removes the very motive for theft—nobody wants or can sell a piece of electronic equipment that doesn't work.

THIEVES ARE DISCOURAGED from even making an attempt to steal this radio. "Nobody will buy a radio or TV that doesn't work."

The K-circuit Lockout is built into the equipment, and provides an entry code without which, the equipment will not work. (Actually two codes are used, a complex one inserted by the factory and the owner's personal code, which the owner can change at will.) Any loss of power to the protected unit, whether by pulling the plug, cutting wires, or opening a circuit breaker or fuse in the line, disables the equipment. When power is again applied, the equipment will not work until the owner has keyed in his personal code.

The new system will be licensed to electronics manufacturers by International Electronic Technology Corporation of Far Rockaway, NY, owners of the patent. President Norman Kaish believes that it will add less than $5 to the price of any item to which it is added.

RCA signs up to service Commodore computer gear

Under a recently signed agreement, RCA Service Co. will provide nationwide warranty service on Commodore computers, disk drives, and color monitors. The company will also provide after-warranty service and will offer long-term service contracts on the above mentioned Commodore equipment.

The Third-Party Maintenance (TPM) agreement is part of a major reorganization and expansion of Commodore's customer service and support system. It is also part of RCA's national expansion of its current computer service expertise. Equipment covered by the agreement includes Commodore models *C16*, *C64*, *Plus 4* and *VIC 20* computers, *C1541* disk drive and *C1702* color monitor.

A walk-in facility for Commodore customers and non-servicing retailers will be located in each of RCA Service Co's 158 branches; those are located throughout the United States.

Violin bow may be replaced by computer?

In experiments believed to be the first of their kind, Professor Gabriel Weinreich of the University of Michigan and Rene Causse of the Institut de Recherche et Coordination Acoustique/Musique, in Paris, have used a computer to duplicate successfully the vibrations a violin string produces when bowed.

Weinreich points out that to make a metal string vibrate by electrical means is simple. But the action of a string being bowed is different from that of a string vibrating under the influence of an electric force. That is because of the special interaction of the horsehair bow and the string.

By mounting an electronic motion sensor near the string, feeding its output to a computer, and programming the computer to produce immediately the right current to send through the string, Weinreich and Causse were able to make the string vibrate correctly without a bow. They call the experiment the "digital bow."

"I can see a situation where a violinist's left hand might be in its ordinary position on the fingerboard, while his right hand would be operating the computer controls instead of holding the bow," says Weinreich. "Such sounds are especially interesting musically because they maintain a perpetual continuity with what we know as violin music. The more common synthesized sound loses that continuity as soon as any knob is turned."

The National Science Foundation recently awarded Weinreich a special travel grant to enable him to visit the Paris laboratory regularly. R-E

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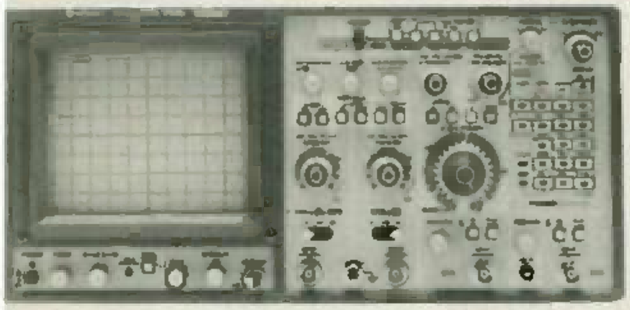

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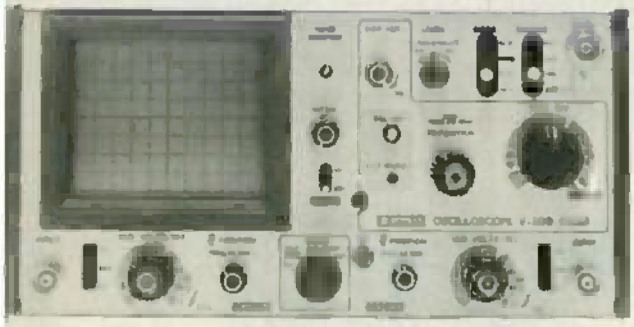

- A three-way power supply takes the V-209 anywhere, anytime for speedy field measurements.
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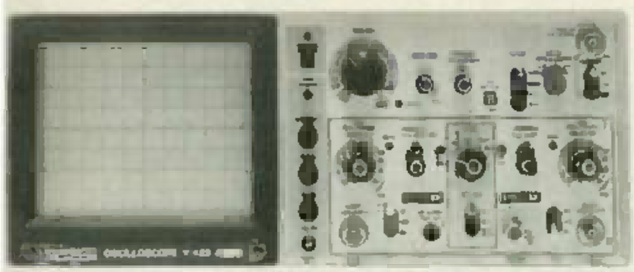

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VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Stereo TV for Everyone.** On the subject of stereo sound for TV, accessory company Recoton is introducing the first "universal" decoder to adapt any TV set—color or monochrome—to the new multichannel TV sound (MTS) transmissions. Recoton's decoder comes equipped with two sensitive RF probes, one for use with portable and table model TV's with plastic or wood cabinets, and the other for consoles and metal-cabinet sets. With a plastic or wood cabinet, the user moves the probe around the back and sides of the cabinet exterior until the stereo light appears on the adapter (if stereo is being transmitted) or until the sound is clearest through the adapter. The adapter is then affixed to that point with self-stick adhesive. With consoles or metal sets, a service technician installs an insulated probe inside the cabinet near the IF strip.

The adapter has an earphone jack and dual stereo outputs—one for a home stereo system, the other for a stereo VCR. It also creates synthesized stereo from monophonic TV sound, and is expected to retail for around $150.

• **Video with PCM Audio.** The proponents of the new 8mm video format have now uncorked what might be their biggest weapon in the battle to establish a new home VCR standard—digital sound. At the same time, they have doubled the recording and playing time of the 8mm system to four hours for a newly introduced "two-hour" cassette by installing a two-speed switch on their home decks.

At press time, Sony, Pioneer, and Eastman Kodak had introduced the new audio-video decks that not only can record and play back tapes with pulse code modulation (PCM) digital sound, but also make very creditable audio recorders—with up to 24 hours of digital audio on a single cassette not much bigger than a standard audio cassette. Although standard sound on an 8mm videocassette is the helical FM variety, the official 8mm standards permit PCM sound as an option.

When used for audio only, six tracks are recorded on the 8mm tape—one in the space normally reserved for a digital sound track, and five more in the space normally occupied by the video signal. At the four-hour speed, the tape passes the recording head six times, providing 24 hours of recording.

• **Pocket Camcorder.** Another 8mm byproduct is the first pocket-sized camera-recorder—well, pocket-*book* size, anyway. Sony's *Mini 8* is about the size of a large paperback book, weighs 2.2 pounds, contains a CCD pickup, and is designed for the aim-and-shoot Brownie camera trade, as opposed to Sony's more sophisticated

(and larger) *Video 8* camcorder, destined for home-movie hobbyists. Like the Sony PCM-sound video deck, the *Mini 8* is due here this fall, along with a companion record-and-play miniature video deck. A separate deck is required because the *Mini 8* is a record-only machine, unlike the *Video 8*, which will play back as well as record (**Radio-Electronics**, August 1985).

• **Stereo TV Spreads.** Although there is still a shortage of program material, a sharply increasing number of TV stations are now broadcasting in stereophonic sound. As of June 1, there were at least 60 stereo stations on the air, covering an area including more than 50 percent of the nation's population, and it seems almost certain that stereo broadcasting will be within range of just about everyone by the end of this year. **R-E**

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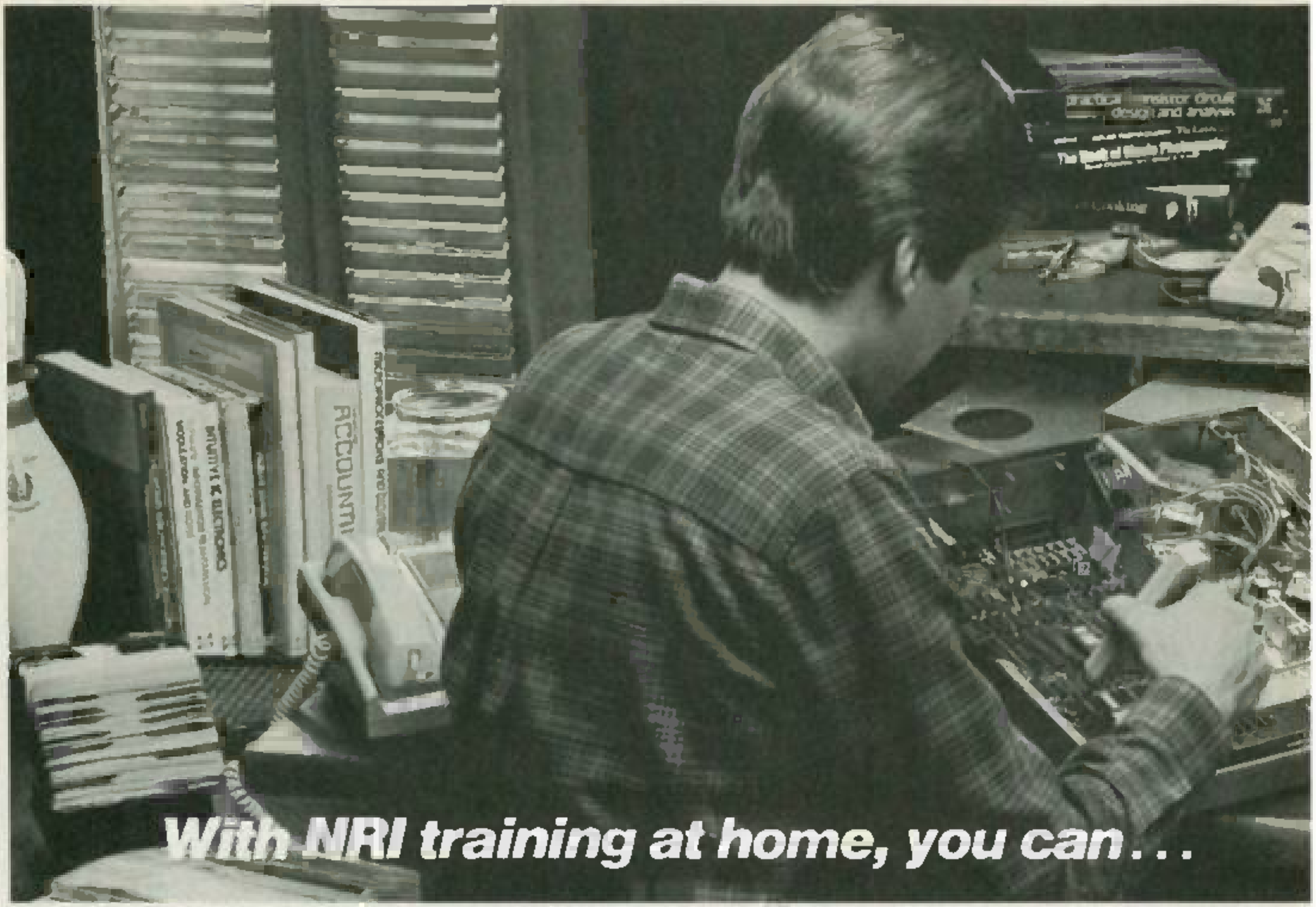

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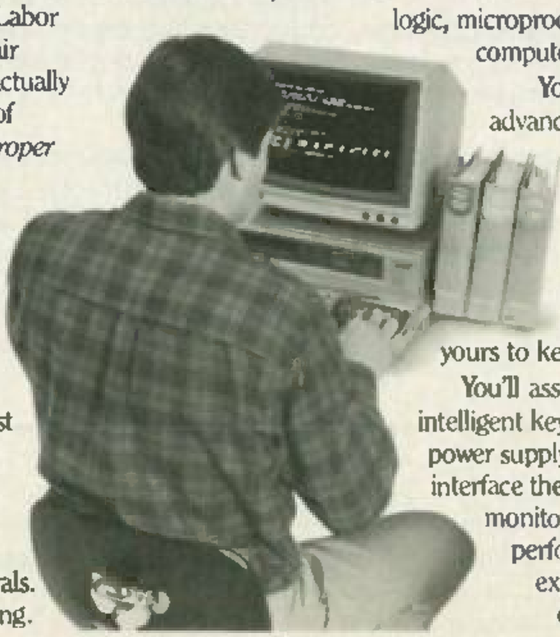

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BOB COOPER, JR*

More on scrambling

WE LEFT YOU LAST TIME WITH SOMEthing of a cliff hanger: HBO had decided to pull back their sales and marketing efforts for home TVRO customers; the TVRO receiver industry had "revolted" against the technical requirements set forth by HBO's scrambling-system supplier, Linkabit. And Showtime, an HBO competitor, was creeping into the scenario with hopes of creating a marketing plan of its own. Before we pick up our story, perhaps it is best if we backtrack a bit and see why HBO felt that scrambling was necessary.

Why scramble?

A satellite programmer scrambles to ensure that only those who are authorized (paying for or otherwise contracted) receive their signals. Home TVRO systems have, until now, been unauthorized. And with over 1,000,000 TVRO's in operation, there's surely a sizable amount of unauthorized viewing going on. Any good businessman would try to figure out some way to collect a fee from those "pirating" his service.

But it goes even deeper than that. HBO already has some 12,000,000-plus homes paying for their service through one of their cable affiliates, and those affiliates have their own theft-of-service problems. According to estimates released by the management of HBO and Showtime, there are probably upward of 8,000,000 U.S. homes now receiving HBO and/or Showtime programming directly from the cable-service systems without paying for it.

Yes, theft of service has reached

epidemic proportions, but how would scrambling help the situation? Directly, it would not help at all. For if HBO scrambles programming between their uplink and the satellite, upon returning to earth, each cable system "head end" must descramble the signal before it's placed on the cable for transmission to subscribers. So scrambling satellite feeds does not improve cable security. At least not yet, anyway. (There has long been a plan to place scrambled signals on the cable and have cable firms install special addressable descramblers at the customer end. That would, if it ever happened, allow the service to stay scrambled all the way to the customer's receiver. But that is down the road, perhaps a decade or so away.)

What scrambling offers

HBO knows that it is losing income because some cable operators either fail to report all of their paying customers, or simply sign up for one cable system, but use that feed for the several systems they own. Also, HBO has had significant problems in getting paid promptly by their affiliates. Years ago, HBO would have received payment by the 10th of every month. Not so anymore; significant 30, 60, and 90 day past-due accounts are common.

Since the scrambling system is addressable, each cable head-end descrambler, such as the one shown in Fig. 1, could have its own unique electronic address code. If the cable company is late with its payment, HBO could "pull-the-plug" on that firm's satellite feed. Thus, the scrambling system becomes a useful "collection tool." Firms that have become accustomed to making late payments would be in for a rude awakening.

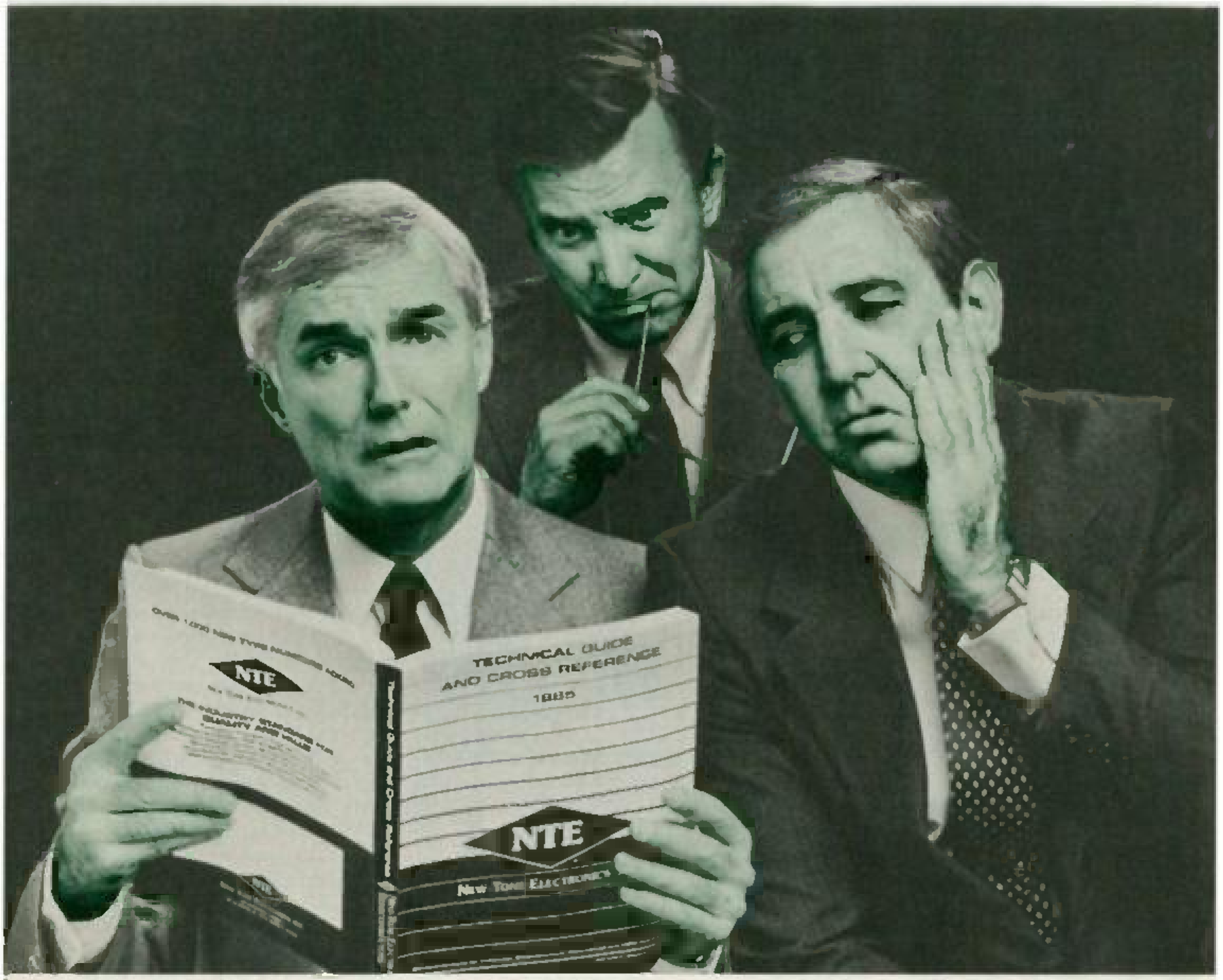
Some cable operators thought that they could beat the proposed system by ordering a spare descrambler or two. HBO has said that it would willingly sell its cable affiliates a spare descrambler and actually would encourage such purchases. That way, if the main unit quits, the cable affiliate could switch to the spare and maintain uninterrupted service. But local cable operators wanted the spare to be on-line and ready to "go" if the primary unit failed. To that HBO has said: "No way." If that

TVRO dealer "Starter Kit" available

If you own, operate, or are employed by an electronic sales or service center, 1985 may be the year for you to take a hard look at entering the TVRO sales and service business. Having passed the one-millionth terminal-installed mark and expecting to install upwards of 550,000 new home systems in 1985, this may just be "the growth industry" in home electronics for the rest of the 1980's.

Bob Cooper has assembled a collection of important materials for you to study to evaluate your own "chances for success" in the home TVRO business. You may obtain the "TVRO Dealer Starter Kit" free of charge or obligation by writing on company letterhead, or by enclosing a business card to: TVRO Starter Kit, P.O. Box 100858, Ft. Lauderdale, FL 33310.

* publisher of CSD magazine



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were allowed, HBO would have no way of knowing if the spare is actually located where the cable operator claims it to be. The cable operator could use the spare in an entirely different cable system, and thus receive HBO for the second system without paying for the privilege! So for those cable systems that have ordered spare descramblers, there's an elaborate system in effect when the primary fails.

When the primary unit goes down, the cable firm must call an HBO "hot line" to report the failure. HBO then deletes the electronic address code of the primary unit from the uplink data stream (after which it's no longer activated under any circumstances). Then the address code of the standby unit is added to the data stream and the standby turns on. In that way, each cable company has only one HBO (or Cinemax, etc.) descrambler operating at a time. Besides, if the primary unit really goes down, it wouldn't need to be addressed.

So, you can see that HBO and the other cable programmers have a much bigger reason for installing the scrambling system than merely shutting off private home viewers. They have some "accounting problems" in their primary market, their cable (and MDS) affiliates. And the scrambling system, while not the ultimate cure-all for their "security woes," is at least an effective tool for collection of payment and the control of their merchandise.

Continuing our discussion

We closed out last time by suggesting that Showtime came onto the scene as a me-too entrant into the possible packaging of a home TVRO service. We also noted that they were, unfortunately, saddled with the same scrambling technology and Linkabit package as HBO. Thus, any unresolved problems HBO faced with Linkabit were still facing Showtime.

That may not be the case. Up to this point, everything about the home TVRO business has centered almost exclusively on 4 GHz (C-band) technology. It is on C-band (3.7 to 4.2 GHz) that we have 100-plus TV transponders (channels) now operating, and it's C-band TVRO's that have reached the 1,000,000 plateau this year.

At the same time, we have seen the "rise and fall" of the first non-C-band home service entrant, USCI. You may recall that USCI spent upward of $70,000,000 to ultimately reach approximately 10,000 U.S. homes with a five-channel "quasi-DBS" service through some rented transponders on a Canadian satellite. We've also seen industry giant COMSAT pull back from their $250,000,000 plan to provide 12-GHz DBS service to America.

Seemingly, with the failure of USCI and the closing down of COMSAT before they even got started at 12 GHz, the prospects for a 12-GHz service would be marginal at best. However, Showtime is not so sure about that as we shall see next time. **R-E**

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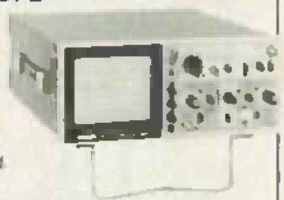

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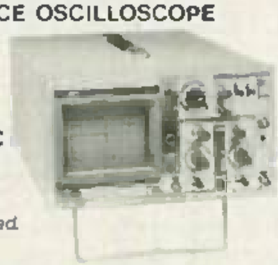
A.W. SPERRY 20 MHz DUAL TRACE OSCILLOSCOPE



Model 620C
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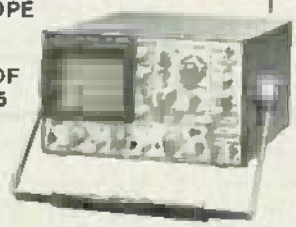
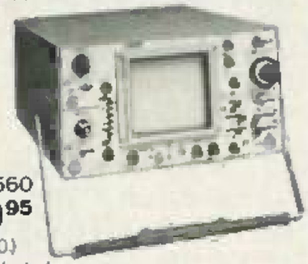
HITACHI 100 MHz QUAD TRACE DELAYED SWEEP OSCILLOSCOPE



Model V-1050F
$1249.95
(Reg. $1980)
Probes included

• Large 6" rectangular CRT w/internal graticule • Delayed alternate and single sweep functions • Autofocus

B&K 60 MHz TRIPLE TRACE OSCILLOSCOPE



Model 1560
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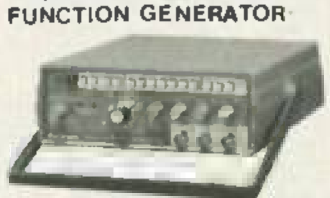

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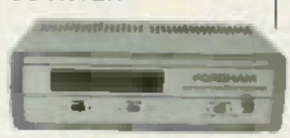

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Fordham

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LETTERS

WRITE TO:

LETTERS
Radio-Electronics
200 Park Ave South
New York, NY 10003

PRINTER BUFFER

In the article "Build This Buffer/Converter for your Printer," which appeared in last month's issue of **Radio-Electronics**, we regrettably left out the ordering information listed below:

The following are available from Alpha Electronics, PO Box 1005, Meritt Island, Florida 32952 (305-453-3534): Buffer board, $26 postpaid. Program ROM (91341) $26 postpaid. EPROM Programmer PC board, $15 postpaid. Complete BufferLink kit (includes all parts except computer connectors and cables) $139 plus $5 shipping and handling. Complete EPROM programmer kit, $49 postpaid. Florida residents must add 6% sales tax. Canadian orders add $2, and all other foreign orders must add $8. MasterCard and Visa orders are accepted.

BALL LIGHTNING

I found R. K. Golka's article on Ball Lightning (**Radio-Electronics**, March, 1985) quite interesting. An old friend of mine worked with Tesla back in Colorado Springs, and was involved in rebuilding the power companies' generators when the windings got blown. So I rather wonder how Golka avoided damage to the diesel's electric generator and motor assemblies with the near-simultaneous surges.

Actually, I've seen another form of ball lightning. I was standing near a 2200-volt power line, where I had a half-mile clear view of the system. Lightning struck at the far end, and a fireball-surge traveled

Electricity and water don't mix. At least not in our Heavy Duty Digital Multimeters. Because these Oops Proof™ instruments are protected by a system of seals to ensure contamination-free dependability in even the cruddiest conditions.

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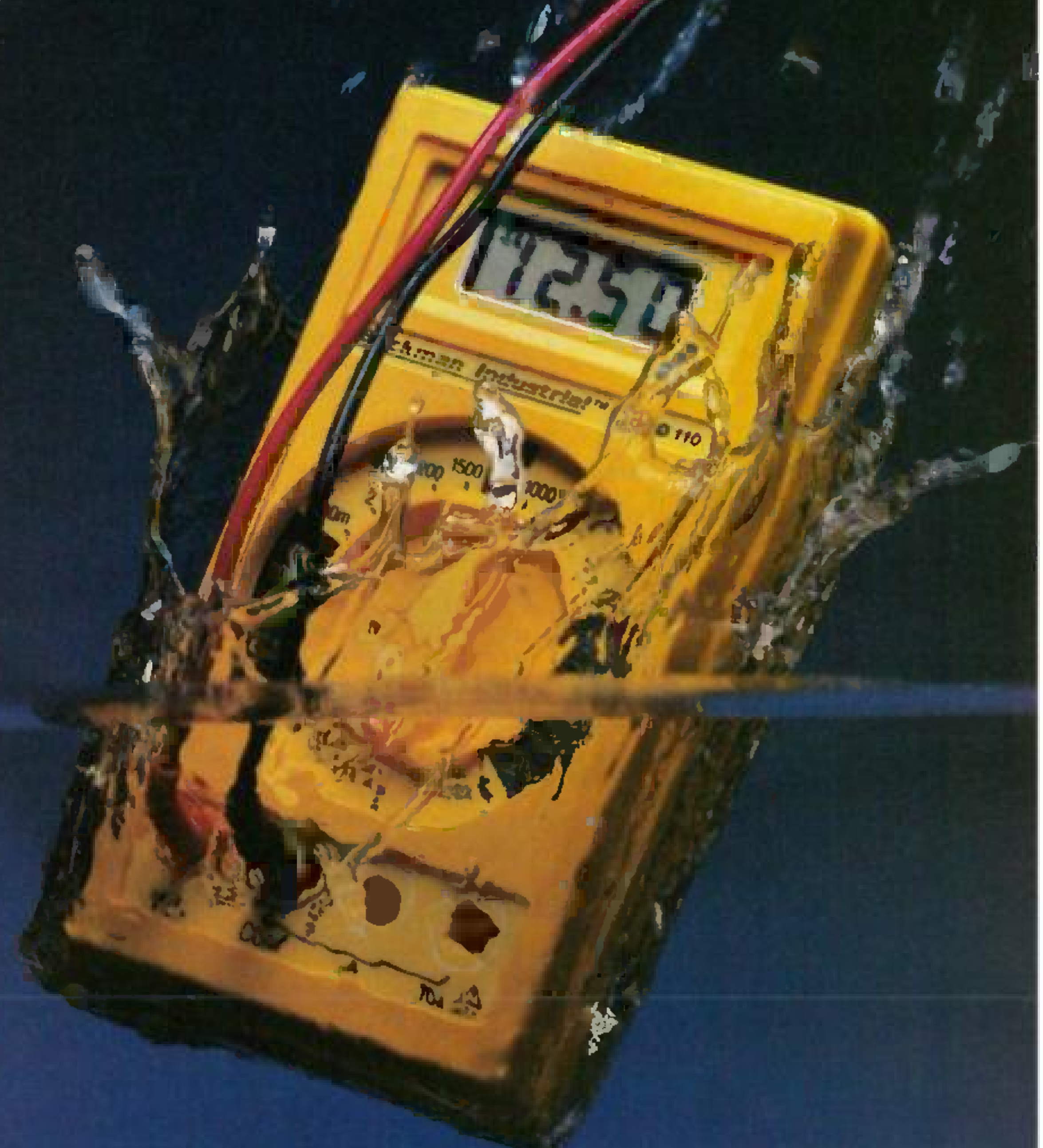
You'll want to try one out, of course, so drop into your nearest electronics distributor and drop one.

Our lips are sealed.



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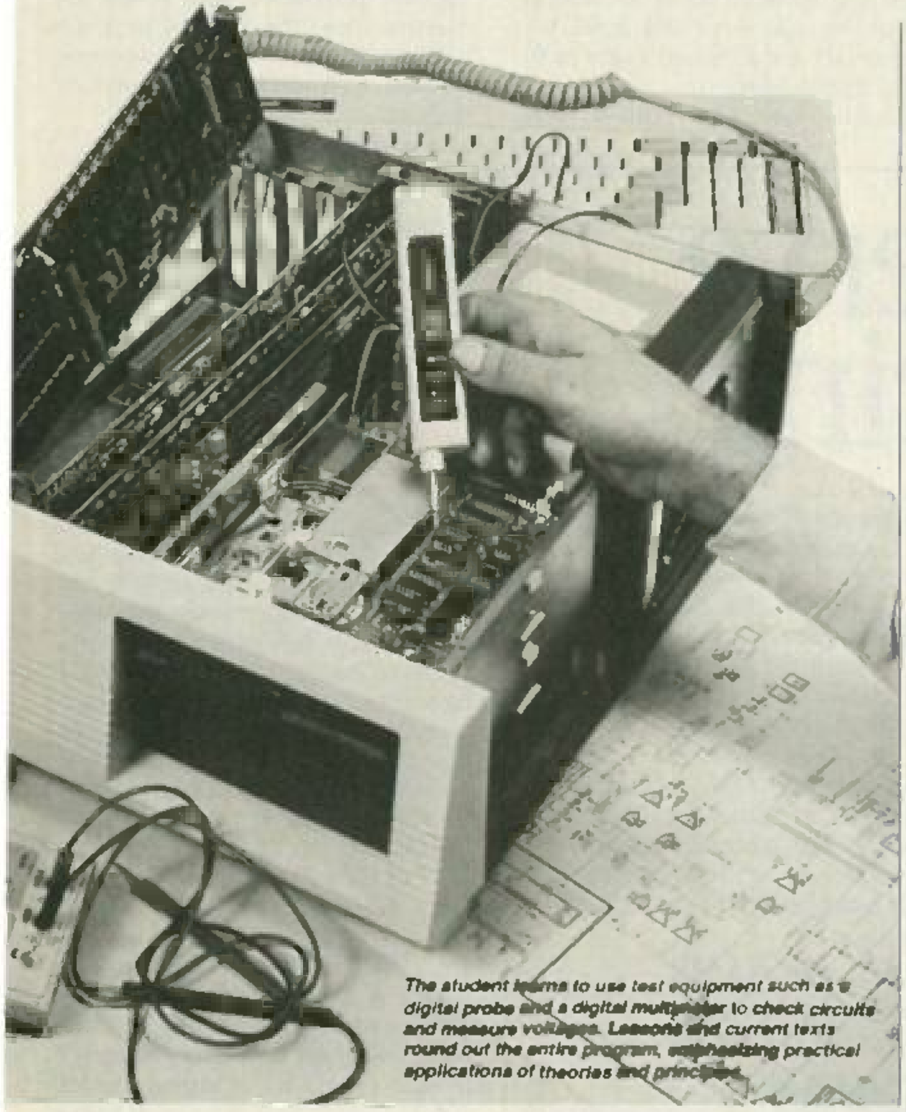
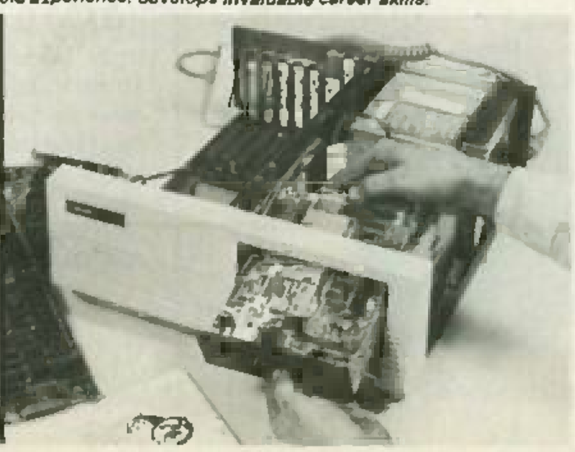


The student learns to use test equipment such as a digital probe and a digital multimeter to check circuits and measure voltages. Lessons and current texts round out the entire program, emphasizing practical applications of theories and principles.

Installing the disk-drive in the PC is one of the final stages in the assembly of the microcomputer. Learning the use of test equipment to check circuits is an integral part of the training which, with field experience, develops invaluable career skills.



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Industrial and Microprocessor Technology covers circuit analysis, microprocessors and automation applications, lasers, and basic industrial robotics.

TV & Radio Servicing is a specialized course offering an excellent foundation in the use and application of both analog and digital test equipment as applied to the TV servicing field. Learn circuits, adjustments, trouble-shooting, and servicing of Color and monochrome monitors.

Digital Electronics offers the student the opportunity to get involved with computer concepts, computer technology fundamentals, and digital equipment by training on the NTS Compu-Trainer.

Basic Electronics is a course designed for those wishing to have an over-view of electronics in many of its aspects including radio receivers, solid state devices, and electronic components.

NTS Intronic training programs include a variety of superb equipment, most of which is classified as field-type, making the training practical and career oriented. Texts and lessons have been tested in our Resident School in Los Angeles to assure home study students their courses of training are easy to understand. NTS, now in its 80th. year, continues to be at the leading edge in Electronics home training.

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If card is missing, simply write to the address shown below stating the course you are interested in. A FREE color catalog with all details will be sent to you by return mail.

NTS NATIONAL TECHNICAL SCHOOLS

TECHNICAL TRADE TRAINING SINCE 1905

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4000 So. Figueroa St., Los Angeles, CA 90037 up those wires at some 500 miles an hour. Arcs or flashes developed at every crossarm, and the local service transformer went *ker-chunk*, as did the house meter.

There has been quite a bit reported about electromagnetic pulses in case an nuclear bomb is set off at several hundred miles' elevation, with the resultant destruction of electrical systems, transistors, computers and their memory systems, etc. But has one ever considered what will happen to steel-frame buildings? The columns and steel floor-beams form many low-resistance closed-circuit inductive loops. Under the intense magnetic flux developed, a whale of a high amperage flow would develop—and I'm not so sure that some of those structural inductive loops would hold together. It's not a nice thought as to what might happen.

Finally, I have one request: Several AM stations in this area are operating in stereo, I've been told, on one frequency. I have seen nothing on the technique, or the AM circuitry in receivers to handle such signals. Having been involved in radio receivers ever since 1922, when regenerative, super-regenerative, and reflex receivers were the rage, I'm a bit baffled about how it is accomplished. Can you publish the information?

L. S. HANNIBAL,
Fair Oaks, CA 95628

Check the January 1984 issue of Radio-Electronics *for the description of a circuit to decode Motorola's C-QUAM stereo format. In the future, we hope to bring you decoding circuits for other formats as well.*—Editor

MANUAL NEEDED

I have a problem with a Ford Industries *CAP-222* telephone answering machine. Built in 1976, my unit will no longer seize the telephone line (all other functions seem to be operating properly). I have thus far been unable to locate a repair manual for that piece of equipment and was wondering if you or one of your readers might be able to help.

P. ROTH
2987 Cletus Pkwy
Lima, OH 45805

SCHEMATIC NEEDED

This is a request for help from your readers in obtaining a schematic diagram or *Sams Photofact* (if one exists) for a Sansui model *400* AM-FM stereo. The local Sams dealer here in San Diego informs me a folder was never issued for that model. The amplifier section (stereo) works, but the AM-FM front ends are both inoperative. There must be a stage that is common to both that is at fault (perhaps the power supply), but I don't know where to start.

MICKEY McDANIEL
940 Temple Street
San Diego, CA 92106

MISPRINT

I am a freshman, attending Fairmont State College, in hopes of

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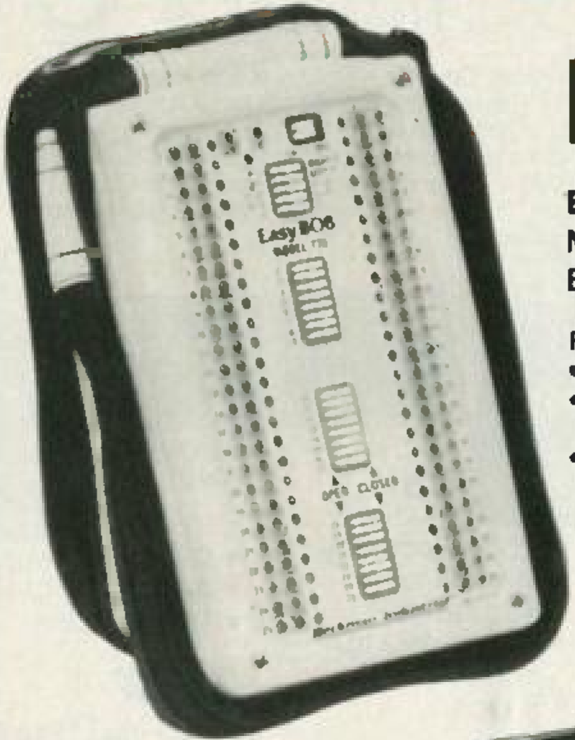

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Does not include probes
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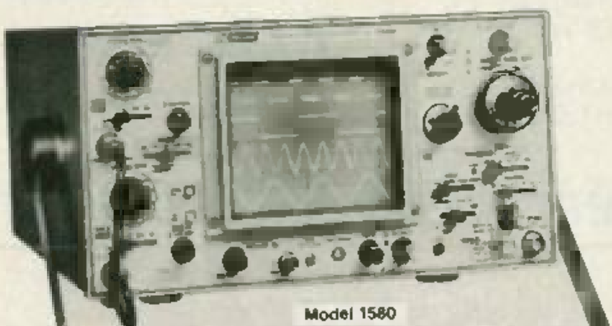

Model 1580

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INDUSTRIAL TRANSISTOR TESTER

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MODEL 520B

- Now with HI/LO Drive
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- Identifies all three transistor leads
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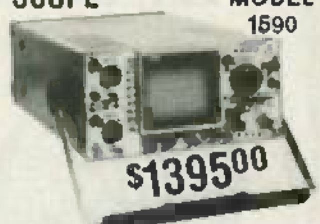

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PRICE DOES NOT INCLUDE PROBES

- 1mV/division sensitivity to 70 MHz
- 500 μ V/division cascade sensitivity
- Four-input operation provides trigger view on 4 separate inputs
- Alternate time base operation
- Switching power supply delivers best efficiency and regulation at lowest weight

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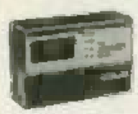

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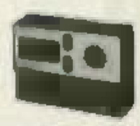
MODEL 830

- Automatically measures capacitance from 0.1pF to 200mF
- 0.1pF resolution
- 0.2% basic accuracy
- 3½ digit LCD display

$169.95



MODEL 820

- Resolves to 0.1pF
- 4 digit easy-to-read LED display
- Fuse protected against charged capacitors
- Overrange indication

becoming an electronics engineer. Your magazine, I have found, is very useful and helpful to the beginner. In reality, I've had no prior experience with electronics other than normal in-home uses.

In reading over the article, "3 High-Performance Scanner Antennas," in the April 1985 **Radio-Electronics,** I located a misprint on page 60, third paragraph down from the subhead "Antenna theory."

My teacher in "Circuit Analysis I" has set great store in knowing how to measure wavelengths both in miles and in meters. I have spent a great deal of time on this subject, and when I saw your expression of wavelengths in meters 3×10^5 I knew immediately that it should have read 3×10^8 meters/second. (I have made the change in my copy of this issue.)

It was recommended that each electronics student start a file, made up of useful technical literature to assist us now in our studies and later to be applied for use—and also to become aware of the advances taking place in electronics. My teacher recommended that we add your magazine to our file. In so doing, I have received detailed information that I might not have obtained otherwise.

I would like to thank you for the past issues I have read of **Radio-Electronics,** and I look forward to the exciting new electronics advancement features in future issues.

GLORIA J. JANNUZZI,
Morgantown, WV

HELP!

Recently I acquired a General Radio *1570-AL* AC regulator, which I intend to use with an emergency generator. Unfortunately, I have not been able to obtain a manual for the unit. None of the usual sources have been able to help, so I was wondering if either you or one of your readers could come to my rescue. As that manual is very much needed, any help would be most appreciated.

WARREN KERNAGHAN
901 E. 108th Street
Kansas City, MO 64131

CORRECTION

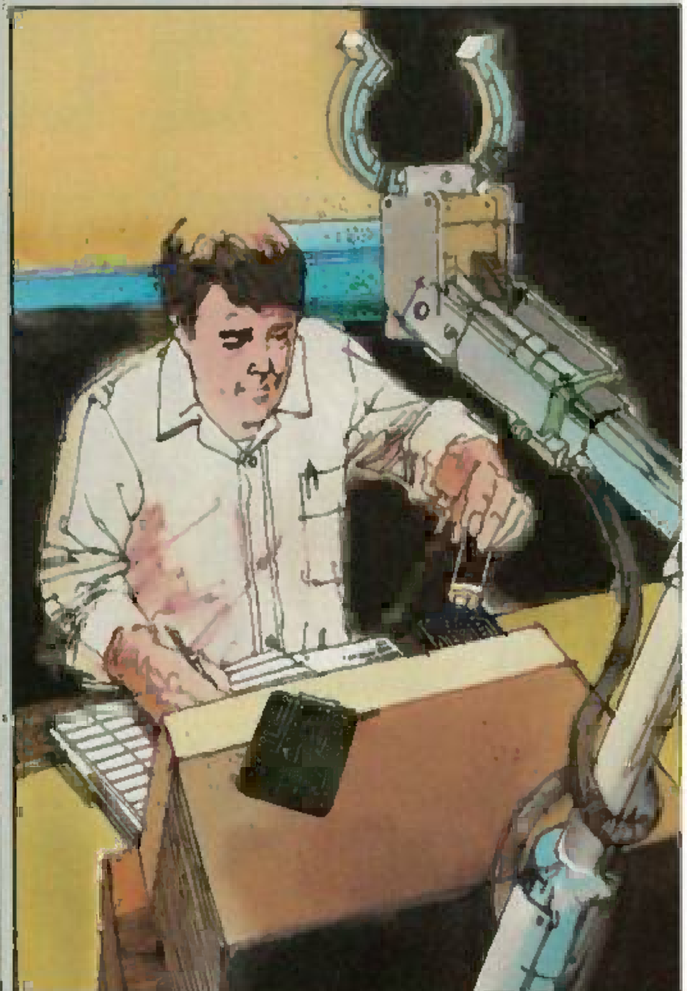
In our March 1985 issue, under the list of DMM Manufacturers (page 57) and Scope Manufacturers (page 62) we referred to Soar, 200 13th Ave., Ronkonkoma, NY 11779.

Both the name and the address of that manufacturer has changed. **Soar has become North American Soar Corporation,** and the address is 1126 Cornell Avenue, Cherry Hill, NJ 08002.

THANKS!

Just a note to thank you for the most useful articles I have ever seen. The "How To" section is always valuable. But the articles by Victor Meeldjik on selection of resistors and capacitors, in your February and March 1985 issues were outstanding. They were the most welcome articles that I have ever come across!

K. HANNING,
Salt Lake City, UT **R-E**



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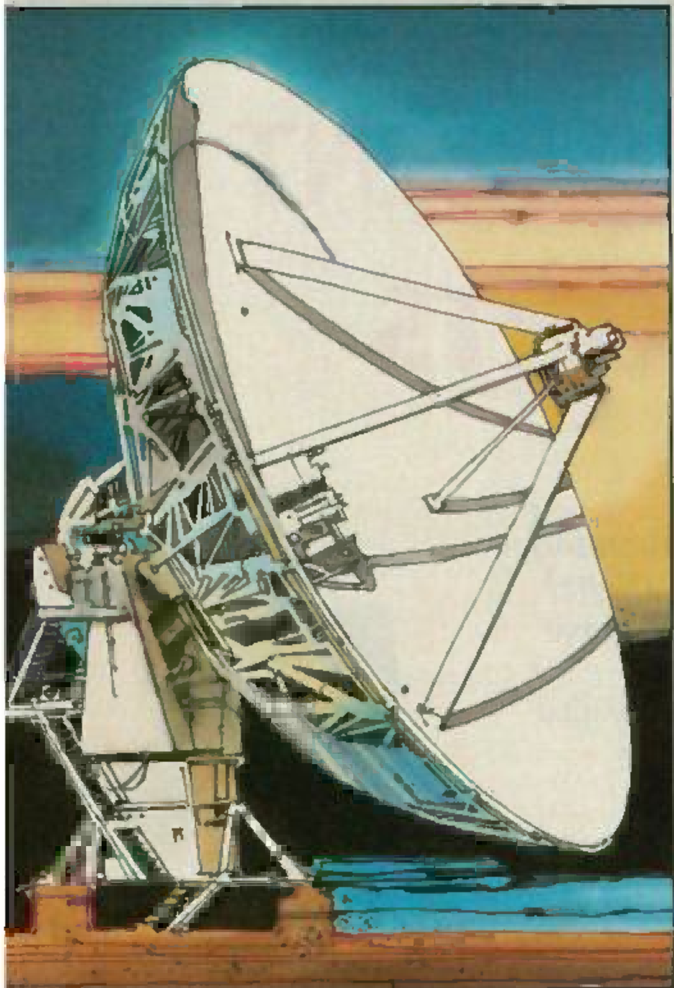


EQUIPMENT REPORTS

Mastertech Laboratories Microlab 1 Digital Laboratory Course

Learn all about digital electronics

CIRCLE 5 ON FREE INFORMATION CARD

ALTHOUGH WE OFTEN HEAR FROM readers wanting more information on a variety of topics, the one area that seems to attract the most interest is digital electronics. It's little wonder, of course, considering how important that field is, and how explosively it has grown over the past several years.

There is little doubt that it is important to know about digital electronics. But if your background in that area is lacking, where do you turn to to get the knowledge that you need? Perhaps the best way to go for many people is to invest in one of the digital electronics home-study courses currently available. One of the newest of those courses is the *Microlab 1* digital laboratory course from Mastertech Laboratories (6792 Kirkpatrick Crescent, Victoria, B.C., V8X 3X1, Canada).

The *Microlab 1*

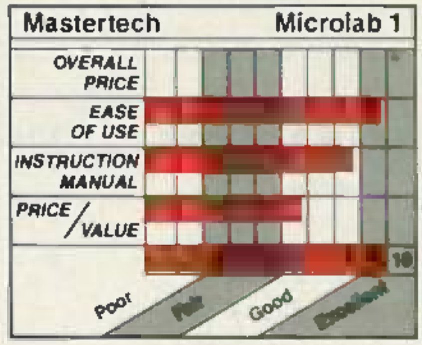
The *Microlab 1* digital-electronics course is designed for the student who has little or no knowledge of digital electronics. Indeed, it is possible for someone with no electronics knowledge whatsoever to use and benefit from the material. The student proceeds at his own pace through a series of lessons and labs so that when he is finished, he has a solid grasp of the fundamentals of each topic.

What makes or breaks a course of this type is the manner in which the material is presented. To be effective, the lessons must be interesting, and taught in such a way that the material will be remembered. One of the best ways to achieve both objectives is to have the student prove to himself each point he is shown.

That is the approach used in the product. Each lesson (there are 40 in all) follows the same basic format: first a theory or concept is presented, and then the student verifies the information for himself via an experiment. A conclusion that summarizes the important points of the lesson, and a short test that helps ensure that the material has been understood, wraps things up.

In order to simplify performing

the experiments, a training board is provided. In many ways, that board is the key to the course as it is designed to allow the student to get right to the heart of the experiment at hand. At the center of the board is a solderless breadboard that allows circuits to be easily assembled and disassembled. Arranged around the breadboard are 10 clearly labeled sections that contain most of the support circuitry needed for the experiments.



Section 1 is a regulated +5-volt supply. Section 2 is an array of 16 discrete LED's. Section 3 is a common-anode 7-segment display. Section 4 contains two squarewave generators. One outputs at a fixed rate of 1 kHz; the other is variable from 1 Hz to a few hundred Hz. Section 5 is a 10-LED bargraph voltmeter. Section 6 is a speaker. Sections 7 through 9 contain switches. And section 10 contains a 5-volt SPDT relay.

In addition to its value in the course, such a board is always handy to have around an electronics workshop. That's because it provides a handy way to design and debug your own circuits.

The course comes complete with everything needed. In addition to the manual and the training board, all components (logic IC's, switches, resistors, and even jumper wires) required for the various experiments are included.

The 40 lessons in the course cover topics such as simple logic gates, flip-flops, shift registers, counters, and more. Once the course is completed, add-on kits that cover such advanced topics as A/D and D/A conversion, speech synthesis, computer-bus interfacing, and microprocessor theory can be purchased. In fact, through the add-ons to the program, the student can eventually build a CP/M computer.

Unfortunately, the version of the course manual included with the trainer we received was only a preliminary one. That manual was missing several drawings (the manufacturer enclosed a note explaining that those were not ready as yet and would be included in the final version) and covered only the first six lessons. What we saw, however, was of generally good quality, though regular readers of Radio-Electronics might find some of the material a little simplistic. (But remember: One of the course's stated goals was that it could be used by someone who was not familiar with electronics.) If that quality is carried through in the balance of the manual, the *Microlab 1* grades out as a excellent educational product. At its selling price of under $250, it is also a good value. R-E

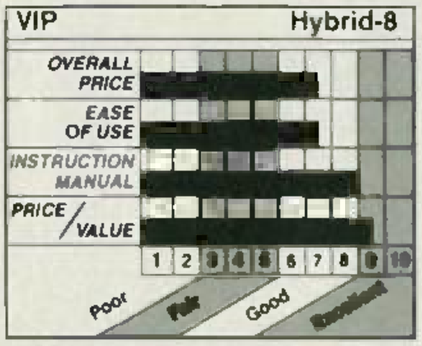
Video Interface Products Hybrid-8 Special Effects Generator

Add professional-looking special effects and editing to your videotapes.

CIRCLE 6 ON FREE INFORMATION CARD

IF YOU USE A CAMERA AND VCR TO make your own videotapes, you've probably learned that it's difficult to get professional-looking results. Even if you use a second VCR to edit out the parts you don't want, you still end up with scene-to-scene transitions that look and sound too harsh. We've recently seen a special-effects generator that could end all that: the *Hybrid-8* from Video Interface Products, or VIP (19310 Ecorse Road, Allen Park, MI 48101).

The *Hybrid-8* is a versatile switcher, fader, enhancer, mixer,



stabilizer, and video-effects generator. It's difficult in a short review to list all of the ways that the unit can be used, so we'll have to settle for bringing out only the more important features.

Switcher/fader

One of the features of the *Hybrid-8* is an A/B switcher that allows you to change quickly from one source to another. The switcher can be used along with the fader so that you can fade out one source and fade in another. The duration of the fade can be adjusted from only a fraction of a second to more than five seconds.

The *Hybrid-8* does not contain any circuitry to prevent picture-roll as you switch from one video source to the other. But we found that by adjusting the fade duration, we could often mask any partial picture roll that occurs.

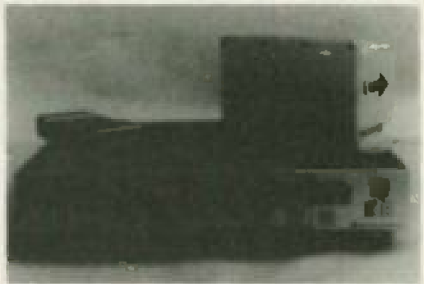
Special-effects generator

The *Hybrid-8* special-effects generator can be used along with the fader (and switcher, if desired) to produce different wipe patterns. The standard wipe patterns are: rightward, leftward, upward, downward, edge-to-center, and fade to black. All of those wipe patterns can be combined to give you a total of 31 possibilities. You could combine, for example, upward and downward wipes so that the picture would wipe from top and bottom to the center.

Audio switching

As you switch between video sources, you also have options on how you want to handle audio switching. If you are switching between two video signals and using the special-effects wipes, the audio normally fades out and switches along with the video. You do,

Radio-Electronics mini-ADS



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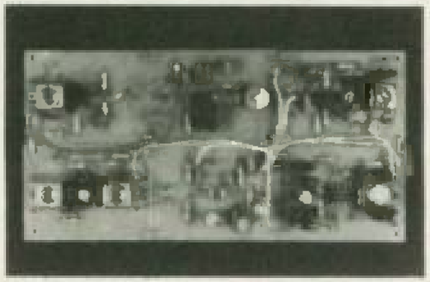

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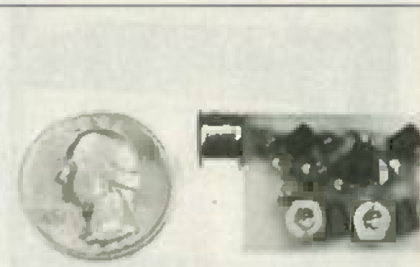

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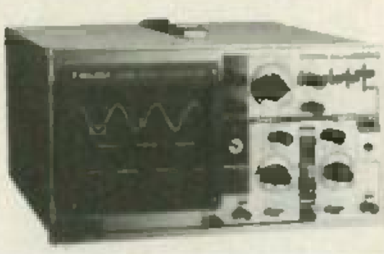

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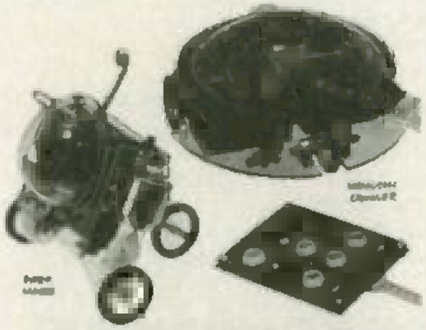

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however, have the option of mixing the audio as you switch video sources. If you do that, the new audio input fades in as the original audio fades out. Another option you can choose, called "video breakaway," lets you keep a single audio input regardless of how you switch the video. That's important if you want to string scenes together without a sense of choppiness. The unbroken audio has a unifying effect.

Stabilizer/enhancer

The *Hybrid-8* contains an enhancer and stabilizer. To help you properly adjust the stabilizer, you can select a comparison (split screen) mode in which you can view the normal and enhanced picture at the same time. The stabilizer, once selected, doesn't require any adjustment.

Other features included in the *Hybrid-8* are an elapsed-time meter (which is also a 24-hour clock) and an RF modulator. The manual that is supplied with the unit should serve most consumers well. Although it is lacking technical information, it does give a good description of the proper setup and operation. One thing we especially liked about the manual is that it listed the phone number of "Mr. Hookup." Customers who have trouble can call and receive assistance from him.

An optional accessory, called the *Zip Stick*, lets you take control of the *Hybrid-8*'s special-effects generator. Thus, for example, you can manually converge a wipe to "spotlight" a part of the scene, and you can use a joystick to move the spotlight around. By making that spotlight small enough, you can create a video pointer or "bouncing ball." The translucency of the wipe (which makes up the non-spotlighted area) can be continuously adjusted. The *Zip Stick* greatly increases what you can do with the *Hybrid-8*.

The suggested price of the *Hybrid-8* is $419 while the *Zip Stick* sells for about $200. If you own only one VCR, those prices might be too high to justify. But if you own two VCR's, the editing power of the *Hybrid-8* is something you don't want to be without, especially if you make a lot of home videotapes. R-E

THE NUMBER OF CARS STOLEN EACH year keeps going up and up, and that is a trend that is unlikely to be reversed in the near future. If you've ever been through the experience, you know that the

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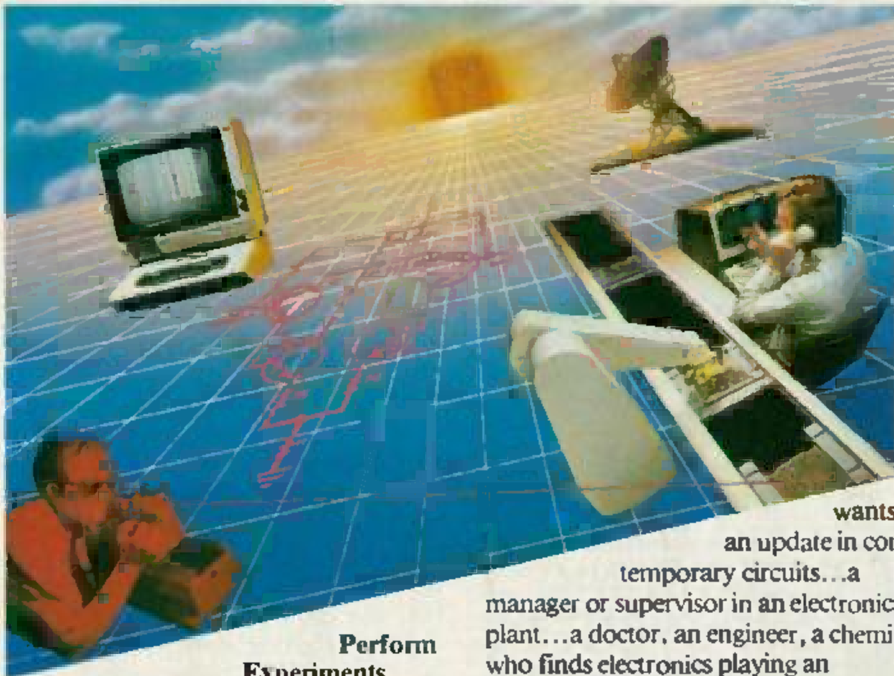

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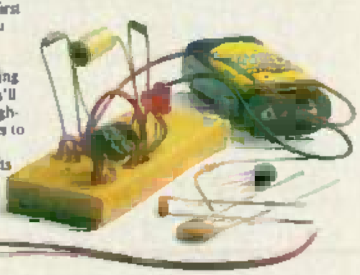

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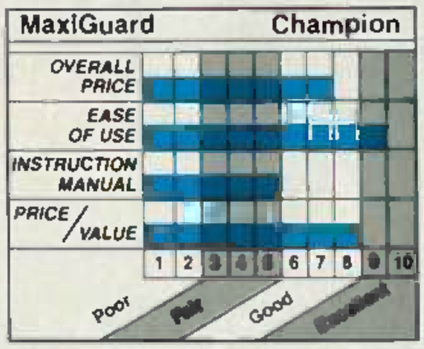
effects of a car theft can be devastating.

Because of that, millions of car owners have turned to one of the multitude of car-alarm systems on the market. Some do little other than give their owners a false sense of security. Others, such as the Black Max *Champion* auto-alarm system from MaxiGuard (2700 Touhy Ave., Grove Village, IL 60007), do an effective job of thwarting potential thieves.



The *Champion*

The *Champion* is a passive protection-system that arms automatically when the ignition key is turned off. It is disarmed from outside the car via a tiny transmitter. That transmitter, dubbed the "radio key" by the manufacturer, is small enough to act as a keychain fob.

The system incorporates four "subsystems" to protect your car In four different ways. First, there is a motion/shock detector. Since a parked car should not move at all, that module monitors for a sharp shock. Such a shock might be caused by a lock being forced, a window being broken, a door or trunk being opening, or the vehicle being moved. If such motion is detected, a piercing siren will sound immediately, and will continue to sound for a full three minutes. Once the three minutes have expired, the system will reset; the cycle is repeated if any further motion is detected.

Second, there is the alarm-control module. When clamped to a battery cable, the module senses current flow. Since opening any door, or the trunk, will cause an accessory light to come on, such an occurrence will cause the siren to sound. The module also can be activated by switches, so the hood, etc., can be protected in that manner.

Third, there is a passive starter-interrupt module. That module, as its name implies, disables the starter system whenever the alarm system is activated.

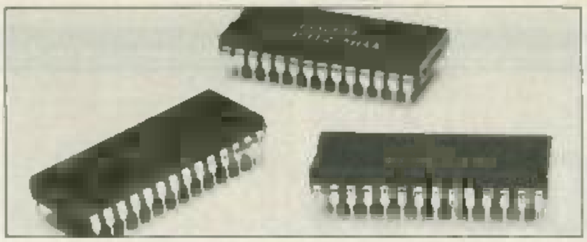
Finally, there is the "Maxi-lok" hood dead-bolt system. That securely locks the hood any time the ignition is off. The system can be manually deactivated for servicing, etc.

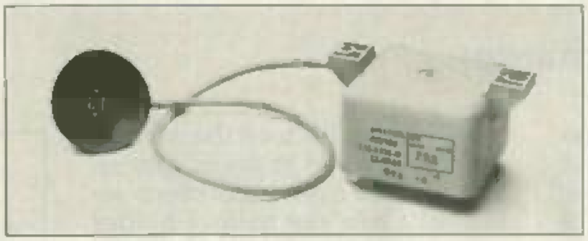
The system is exceptionally easy to use. All the driver needs do to enter the car is press a button on his keychain transmitter, unlock the car, and turn on the ignition within one minute. If for some reason the ignition is not turned on within that time period, the alarm will sound. The alarm can be reset by simply pressing the button on the keychain transmitter. To verify that the system has received the correct code to disarm, the parking lights turn on for about three seconds to let you know it is safe to enter the car.

Activating the system is even easier. Simply turn off the ignition, remove the key, and exit and lock the car. The alarm is automatically activated one minute after the ignition is turned off.

As this is a consumer product, the documentation provided is skimpy. In fact, aside from a card that provides basic user information, the only documentation provided is related to the installation of the unit. Though that information is intended for a professional installer, installing the alarm system is not particularly difficult, and requires no special tools. You could undertake it yourself if you are handy. However, most of the outlets that carry products of that nature, such as auto-stereo dealers, include installation as part of the purchase price, and that is how the suggested list price for the alarm system ($650) is quoted by the manufacturer.

On the whole, the unit provides a very high level of protection for your car. It carries a one-year guarantee on the electronics, and all mechanical components are guaranteed for as long as you own your car. R-E





ECG® IC's for Zenith "Z" Chassis

Philips ECG has replacement integrated circuits for the 221-175, -179 and -190 in the Zenith System 3 "Z" chassis. They are the ECG873, 874 and 875. Just three of the hundreds of integrated circuits available from Philips ECG to replace literally thousands of part numbers. All are manufactured to meet OEM specs so you know they fit and they work.

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ECG® High Voltage Triplers

You have a choice of 29 types of high voltage triplers from Philips ECG, and these 29 triplers replace hundreds of part numbers. Six step, five step, with damper, with resistor—you name it, Philips has it. For example, the ECG559 replaces the Zenith 212-148 and the ECG560 replaces the Zenith 212-147—and only Philips ECG has replacement parts for these Zenith types.

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ECG® Bipolar Transistors

Philips ECG replacement leadership is obvious again. The ECG 29, bipolar transistor, used as a replacement in the fan motor control system of Cadillacs, has been added to the Philips ECG line. (The ECG29 replaces Delco part numbers 139DDF and 7391-BT). There are 322 other bipolar transistors in the Philips ECG line that replace thousands of other domestic and foreign transistor types.

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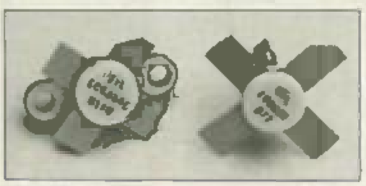

ECG® RF Power Transistors

Philips ECG power transistors are the ideal replacement RF power output devices for fire, police and taxi radios. They are suitable for transmitters and drivers up to 100 Watts RF power. They cover frequencies from the 13 to 30 MHz band to the UHF 806 to 870 MHz band. Most dealers will be happy to learn that Philips ECG replacement RF power transistors are designed to replace units in Asian and European equipment as well as domestic types. So, if it's ECG, it fits and it works... worldwide. Philips offers a selection of over 65 RF transistors that replace literally hundreds of domestic and foreign transistors in a broad range of frequencies.

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NEW IDEAS

A versatile battery charger

IT'S EASY TO FIND BATTERY CHARGERS that are capable of handling one, two, or four cells at once. But when you have some device that requires some odd-ball number of batteries, or perhaps uses more cells than a single charging unit can handle at one time, what do you do? If you own one of the commercially available units, you must charge the maximum number of batteries. And then, after what seems like years, do the same for the remaining cells.

Because of that, I decided to build my own charger; one that would handle any number of AA cells, from one to six and charge at a rate of 50 mA as recommended by the cell's manufacturer. The result is shown in Fig. 1.

A look at the circuit

The operation of the circuit is pretty simple. The supply for the circuit is a conventional full-wave rectifier. An LM317 voltage regulator is configured as a constant-current source. It is used to supply the 50 mA charging current to SO1–SO6, an array of AA-cell battery holders Each of the battery holders is wired in series with an LED and its associated shunt resistor. When the battery holder contains a battery, the LED glows during charging.

Note that each of the battery holder/LED combinations is paralleled by a 5.1-volt Zener diode. If the battery holder is empty, the Zener conducts the current around the holder. An exception to that is SO1. A microswitch, S1, is inserted in that battery holder so that the switch is closed when a battery is in place. That switch is the power switch for the circuit.

The balance of the unit is a timing circuit that prevents overcharging. When power is applied to the circuit, timing is initiated by IC2, a CD4541 oscillator/programmable timer. The output of IC2 is fed to Q1, a VN67AF VMOS transistor. When that output is high, the transistor is on, and the charging circuit is completed. When the output is low, the transistor is off, and the path to ground is interrupted.

Note that resistors R1, R2 and R5 through R11 are half-watt units. That's because of the power that each may have to dissipate. Also, the VN67AF may be replaced with a VN10KM. The circuit may be built using the construction method of your choice.

There is, however, one precaution to keep in mind; since IC2 is a VMOS device, it is static sensitive and we all know what that means. So be careful when handling the device. The LM317 regulator should be heat sinked to avoid thermal damage to the unit during operation.—*Joseph A. Scannell*

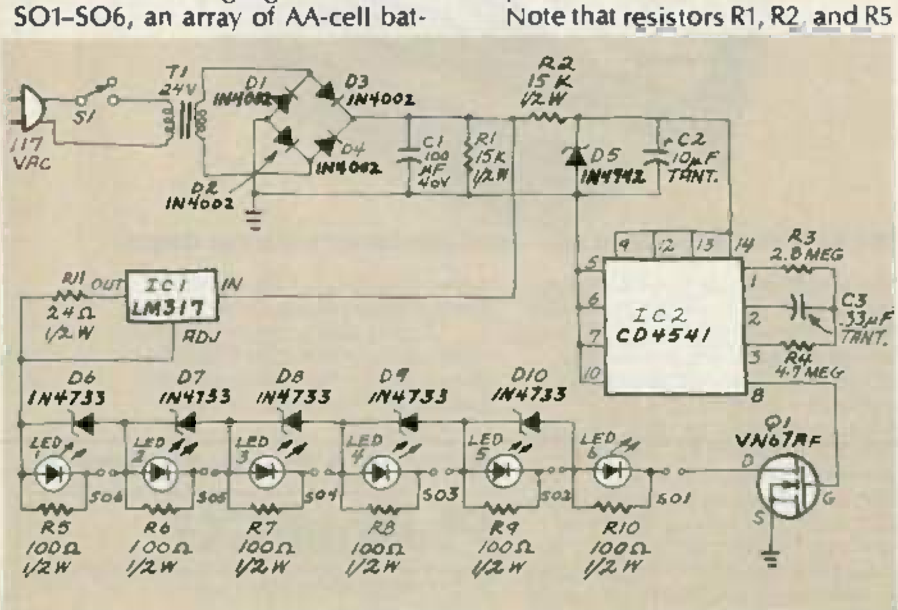

FIG. 1

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There's even built-in auto-tuning to let you scan the shortwave band automatically, as well as manually. All this means you can tune in Berlin, pick up Paris, or locate London in an instant. Without dialing all over the band.

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The Panasonic Command Series offers something for everyone. With equipment sophisticated enough to impress the most avid enthusiast, and automatic features that get you where you want to be. Fast.

There's a whole world out there that's waiting to be heard. Tune in to it with the Panasonic Command Series.

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NEW PRODUCTS

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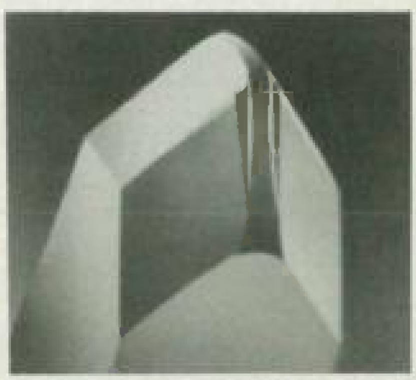
UNIVERSAL COUNTER, the Circuitmate model *UC10*, features an 8-digit display and has applications ranging from simple event counting, to audio and computer servicing, to FM-receiver and cordless-telephone repair.

The key functions of the model *UC10* are pushbutton-selectable; they include gate time, attenuator, frequency range, and reset and self-check functions. Four gate times range from 0.1 second to 10.0 seconds. The 14 LED indicators provide visual feedback, and there is also an audible signal indicating that positive contact was made. Because there are two inputs, the counter can also be used to measure frequency ratios and time intervals.

The Circuitmate model *UC10* is priced at $319.95.—**The Instrumentation Products Division,** Beckman Industrial Corporation, 630 Puente Street, Brea, CA 91621.

REPLACEMENT STYLI, are available for Shure's *V15 Type IV* and *V15 Type III* phonograph cartridges. The new models are *VN45MR* (for the *V15 Type IV*) and *VN35MR* (for the *V15 Type III*).

Both new models have micro-ridge stylus tips that make use of an extremely small tracing radius to greatly reduce tip-related distortion, while maintaining low indentation for long record life. The model *VN45MR* features a telescoped, aluminum stylus-shank for low effective mass and superior trackability; it also incorporates Shure's dynamic stabilizer, which removes static electricity and dust



CIRCLE 12 ON FREE INFORMATION CARD

from record surfaces, and allows accurate tracking of warped records.

The model *VN45MR* is priced at $80.00; the model *VN35MR* costs $58.00.—**Shure Brothers Incorporated,** 222 Hartrey Avenue, Evanston, IL 60204.

PHONE LINE LOOP TESTER, model *8455,* checks line shorts, opens, and multiple ringers. The compact 5½ × 3⅝ × 2⅞ instrument also measures 0 to 100 volts DC and has two resistance scales: R×1 (100K center scale) and R÷10.

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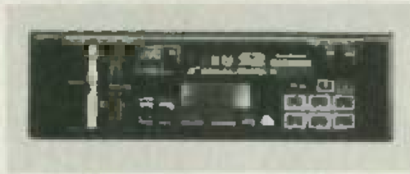
A reverse switch is provided for line checks, and the 0 to 100 points scale calibration conforms with telecom industry standards. A pair of 6' leads with clips is provided, as are an Eveready No. 455 (45 volt) battery and instruction manual.

The model *8455*, Catalog No. 12382, is priced at $110.00. Optional accessories include an extra test lead set and carrying case.—**Simpson Electric Company,** 853 Dundee Ave., Elgin, IL 60120.

CASSETTE RECEIVERS, model *KS-RX450,* model *KS-RX250,* model *KS-RX115,* and model *KS-RX105,* are in-dash stereo cassette car receivers offering high power output and high fidelity.

The model *KS-RX450* is designed for European, Japanese, and American cars. It features a digital PLL frequency-synthesized tuner



CIRCLE 14 ON FREE INFORMATION CARD

and clock, and offers up to 20 station presets. Compu-tuning, a new feature, automatically tunes to stations broadcasting a good signal, in preset order, when the station being received becomes too weak for clear reception. For improved FM tuning, the unit also features TNCC (*T*uner *N*oise *C*ontrol *C*ircuit), which reduces unpleasant interstation noise as well as the noise that occurs during signal fading. Other features include Dolby B noise reduction, line-level input and output terminals, preamp fader control, separate BASS and TREBLE tone controls, metal tape compatibility, DX/LOCAL button, key-off release/key-on play mechanism, and power antenna lead. The *KS-RX450* is priced at $399.95.

The model *KS-RX250* is an in-dash auto-reverse cassette car receiver featuring digital PLL frequency-synthesized tuning with LCD digital display. Security alarm-ready, there is also a new tape transport mechanism for improved reliability, and TNCC for improved FM tuning. There is also Dolby B noise reduction, independent bass and treble tone controls, and high power output—22 watts per channel. The *KS-RX250* is priced at $399.95.

The model *KS-RX115* features auto-reverse control and alarm-readiness, as well as Dolby B noise reduction, preamp fader control, independent bass and treble controls, and a 22-watt-per-channel maximum power output. It is priced at $259.95.

The model *KS-RX105* features a maximum output of 22 watts per channel, Dolby B noise-reduction system, separate bass and treble controls, metal tape compatability, rewind/auto-play, built-in AFNS, DX/Local button, line-level input and output terminals, and AM/FM stereo tuner. It is priced at $229.95.— **JVC Company of America,** 41 Slater Drive, Elmwood Park, NJ 07407. **R-E**

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Electronics in the Passenger Compartment

Henry Ford would not have believed how electronics has changed his automobile. In this article, we show you the latest in passenger-compartment electronics.

MARC STERN

IT IS SAFE TO SAY THAT THE AUTOMOBILE IS AMONG the most important innovations of the past hundred years. Although there have been improvements in manufacturing techniques, materials used, etc., the automobile has changed little over time, at least as far as the typical driver is concerned.

That all is changing, thanks to an across-the-board electronics revolution that is occurring in the auto industry. Automakers are currently experimenting with and implementing a variety of microprocessor-controlled systems.

One area where the fruits of the automakers' efforts will become obvious is the passenger compartment of your family's car. Already, automobile instrument clusters and displays are beginning to resemble those found in the cockpits of sophisticated jet aircraft. In addition, electronics is making it possible to offer automotive features and options that Henry Ford never even dreamed of.

Here and now

Just what features and options are we talking about? Well, for example, for the last three years Chrysler and Ford have had cars equipped with digital voice synthesizers. Other exciting developments have occurred in the area of display tech-

FIG. 1—A CRT WITH TOUCH-SENSITIVE SCREEN is used to replace traditional mechanical climate controls in this Mark VII Comtech, a limited-production vehicle from Ford.

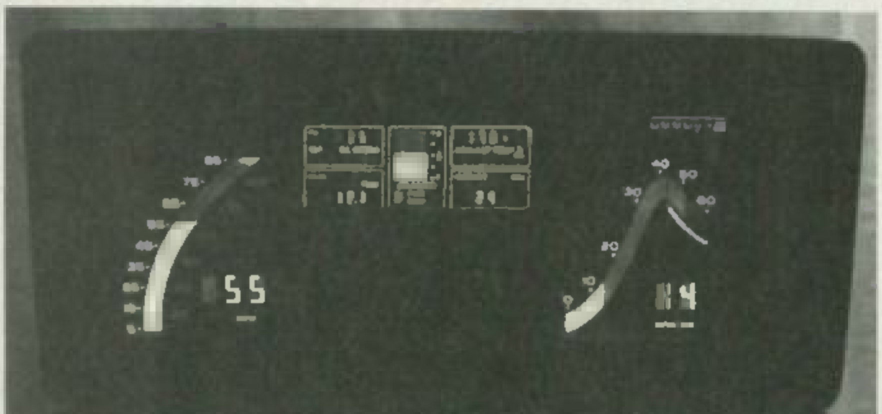


FIG. 2—MULTICOLOR LIQUID-CRYSTAL AND VACUUM-FLUORESCENT displays are being used to present driver information in several current production automobiles.

nology. First developed by Zenith in 1981, vehicular cathode ray terminals with touch-sensitive screens are actively being used in the Buick Riviera and Ford Comtech Mark VII, a limited production model (see Fig. 1). The CRT's are being used to replace traditional mechanical climate and entertainment controls, and multicolor, liquid-crystal and flat vacuum-fluorescent displays are being used for driver information. (See Fig. 2). Soon, expect to see cars equipped with navigational systems, using maps stored on compact discs, to help make sure that you never get "lost" again.

In fact the first such system is already available. It is the Etak *Navigator*. Manufactured by Etak, Inc. (1287 Lawrence Station Road, Sunnyvale, CA 94089), the system consists of a 1,024 × 770 pixel, high-resolution vehicular CRT; a cassette tape drive; compass, and the electronics package.

The heart of the system is the map database, designed by Etak, called EtakMaps. Those maps, stored on cassettes rather than CD's in this first commercially available system, are custom-designed to provide information down to individual addresses, the company says. Once the unit is installed, the owner can customize operation by selection of the appropriate map database.

The system uses a moving-map display to help you navigate. As you drive, your position on the viewing screen, marked by a small triangle, remains constant. Instead, it is the maps that move. The scale of the maps can be changed easily, allowing you to see your position in a neighborhood, a community, a city, or the country. The position of the vehicle relative to the maps is determined by the unit's special compass and sensor system, and is accurate to within 50 feet, on the average. Due to the nature of the system, correct positioning is automatically displayed as soon as the unit is turned on, no matter where the vehicle is located.

According to the company, the system is easily installed in two or three hours. The display and the tape player are mounted at the driver's position, along with the tape player. The sensors are mounted at the wheels, and the electronics package located in the trunk. The cost of the system averages between $1,350 and $1,595, depending on the size of the CRT used. (There are two, one seven inches and the other 4.5 inches.) The tape player is designed for trouble-free use because it contains no capstan or pinch roller. The only moving parts are the motor driveshafts.

Microprocessors and the car

The key to all of those hi-tech automotive features is, of course, the microprocessor. For instance, the Buick Riviera uses two eight-bit microprocessors—custom-masked Motorola 6801's—to control that car's CRT display system.

At the moment, each microprocessor in a car is assigned one and only one task (controlling a car's display system, for instance). But automotive experts predict that the day is coming when all of the microprocessors in a car will communicate with each other and with a master control microprocessor designed to oversee the entire vehicle's condition and operation. The advantages of that become quite apparent if you look at the car as a complete system. Let's look at a hypothetical example.

Let's say we are driving a car of the

FIG. 3—THE QUESTOR is a concept car from the Buick division of General Motors. It is being used as a test bed for systems that Buick hopes to incorporate in its products over the next decade.

FIG. 4—THE NAVIGATION SYSTEM in the Questor can display area, region, or state maps on one of the vehicle's center-console CRT's.

future. That car uses a barometric sensor in the manifold air-pressure-sensing system. But that same sensor could also be used to detect changes in air pressure that aren't related to engine variables: such changes would be signaled by a change in air pressure that differs from the normal system parameters. A microprocessor receiving such information could even be programmed to interpret the reading to forecast changing weather conditions!

That information could be relayed to the driver via the car's display system, and passed on to other systems in the car. One microprocessor-controlled system could be in charge of altering the car's handling characteristics to accommodate the impending change in road conditions. Another might tune the car radio to the National Oceanographic and Atmospheric Administration's frequencies so the driver could have a weather update.

The future

The current move to electronics in the automobile is but a preview of things to come. Already, many of the major automakers, both here and abroad, have developed what are called "concept" cars. Those are automobiles that showcase the features that automakers hope to be incorporating in their products within the next 5 to 10 years. Among those concept cars are Buick's Questor, Ford's Continental Concept 100, Chrysler's Stealth, Nissan's NRV-II, and Mazda's MX-02. Also, Saab recently unveiled its 900 Turbo EV-1.

The Buick Questor (see Fig. 3) is an idea car from GM. It is being used as a test bed for planned future systems. For example, the Questor features 14 microcomputers and has such features as a "laser key" entry system (an infrared transmit-receive system for vehicle entry); an automatic level, attitude, and spoiler control system; a "systems sentinel" (which monitors the status of the various systems within the car); a line-of-sight display for the speedometer and gauges (located at the top of the instrument pod); a map and navigation system; automatically aimed headlights; a theft deterrent system; a voice-actuated radiotelephone; a road surface traction monitoring system; a television rear-view mirror system, and a touch command center for entertainment, comfort and convenience functions.

The "heads-up," line-of-sight display is an interesting concept. It works much like the prompters used by public speakers. A specially angled screen, that is always in view of the driver, even while he is looking straight ahead at the road, is used to display information. Even though the screen is directly in the driver's line of sight, it doesn't block his view of the road because, like the displays used in jet fighters, it is transparent and appears as an overlay to the scene ahead. It is the first application of this type of technology to automobiles.

Also, Questor is one of the concept cars that features a navigation system. The Questor's navigation system can display area, region, or state maps on one of two display screens mounted in the center control console. (See Fig. 4.) In the navigation mode, a dot on the screen shows the location of the vehicle and moves when the vehicle moves. An electronic compass display gives the directional heading at all times.

The Chrysler Stealth concept car features the Chrysler Laser Atlas Satellite System (CLASS). This system, shown in Fig. 5, makes use of data from orbiting navigational satellites. Currently, there are five such NAVSTAR satellites in orbit; ultimately there will be a network of 18. Maps are stored on optical discs, touted for their high-density data storage capabilities. It is claimed that the system will be able to display your vehicle's position to within 300 feet.

Mounted in the trunk of the Stealth is a NAVSTAR receiver. As the NAVSTAR satellites circle the globe, they continuously transmit positional information. The CLASS receiver uses positional information from four of those satellites to continuously update the system microprocessor. From that information, and information stored in the system's ROM, the microprocessor is able to determine the car's position at all times. That information is displayed in map form on a nine-inch CRT.

The optical-disc storage system uses eight-inch discs that are capable of storing up to 25,000 images on a single side. That

FIG. 5—CHRYSLER'S CLASS system uses a satellite receiver to obtain navigational information from a system of orbiting satellites.

FIG. 6—IN THE CHRYSLER STEALTH concept car, many controls have been relocated to the steering wheel. In that vehicle, the traditional wiring harness has been replaced with a multiplexed wiring scheme.

is more than sufficient for the maps needed to adequately cover the U.S.; a demonstration version of the system contained 13,300 such maps. The leftover capacity could be used for a variety of applications, such as storing hotel, restaurant, and sightseeing information.

Like the system used in Buick's Questor, CLASS uses a moving icon to indicate the car's position on the map. The scale of the maps can be similarly varied, zooming in on a small area, or zooming out to accommodate an area as large as 1,600 square miles. Chrysler will be offering the CLASS system as an option when the NAVSTAR satellite system is fully operational.

Another interesting feature in the Chrysler Stealth concept car is the use of multiplexing for system controls. All controls have been removed from the instrument panel and placed at the hub of the steering wheel. (See Fig. 6.) However, instead of using separate parallel pairs of wires for each control, all the signals are multiplexed on a single bus.

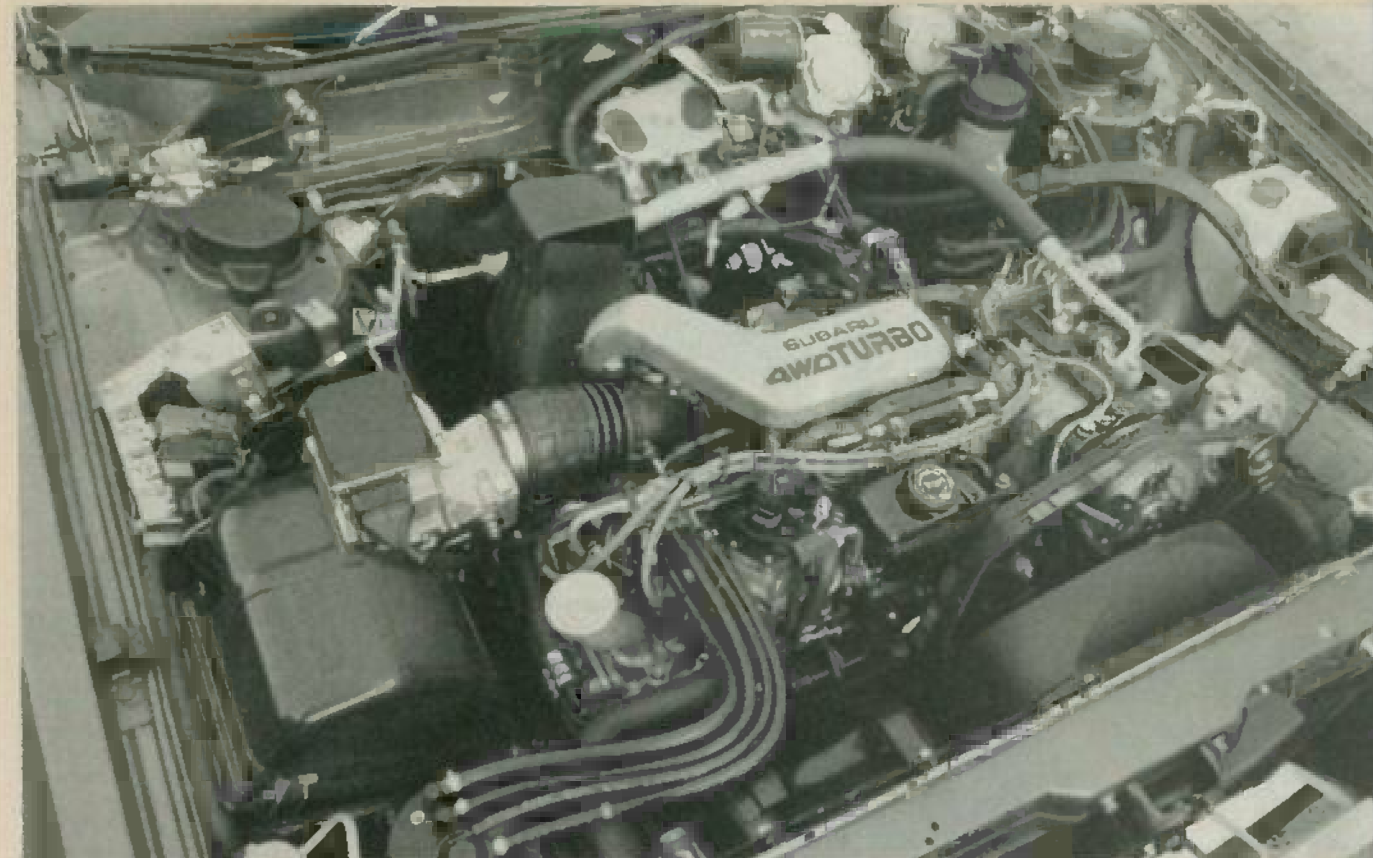
There are many advantages to multiplexing. One is the elimination of heavy and unwieldy wiring harnesses. Also, a multiplexed system offers some unique advantages in the area of diagnostics. Information exchange between the bus-control microprocessor, and the microprocessors controlling the systems that the bus feeds is constant, and two-way. If a system should fail, that data is received by the bus-control microprocessor and either the driver can be informed, or, if possible, a back-up system activated.

Another automobile that makes use of multiplexing is the Nissan NRV-II. In that system, however, fiber optics rather than wires are used for data transmission.

The NRV-II is noteworthy for a few additional reasons. For one, it is equipped with both voice-synthesis and voice-recognition systems. Voice-operated functions include the route-data input for the driver information system, speed warning settings, and control of exterior mirrors, interior lights and hazard flashers.

Another interesting innovation in the Nissan car is a "drowsiness" alert. For that, a microprocessor is used to monitor various functions, such as how the steering wheel is used, to look for signs that the driver might be getting drowsy. If any of those functions vary from the norm, the system sounds an alarm.

As you can see, the electronics revolution has finally reached the passenger compartment of your family's car. But it won't be limited to just that part of the car. Indeed, the role that electronics is, and will be, playing in the engine compartment is at least as important, if not more so. To find out more about the electronics revolution that is occurring "under the hood," turn to the next article in this section. R-E



Electronics under the Hood

MARC STERN

Though they may not be as glamorous as those found in the passenger compartment, the new electronics systems found under the hood of your family's car are just as important.

THE NEW ELECTRONICS SYSTEMS FOUND in the passenger compartment may have more "razzle-dazzle," but the new and future systems found under the hood of your family's car have done as much, if not more, to change that vehicle, and the way it operates, forever.

A little history

Up until the 1960's automakers used mechanical, not electronic systems for engine control. Until then, cars tended to run with over-rich air/fuel mixtures because that was what their engines and mechanical control systems were designed for. But, as we now know, that design was not at all beneficial to our environment.

As the various "clean-air" regulations were enacted in the 1960's and 1970's, that situation began to change. At first, the auto industry assumed that it could comply with those regulations without resorting to new designs. It soon realized, however, that that would be impossible. Continued use of the older mechanical and electro-mechanical engine-control systems resulted in serious tradeoffs in several areas, including reliability and fuel economy. The public began to complain and the industry began to search for alternatives.

The alternative that "worked" was electronic engine control. The first totally electronic engine-control system was introduced by Chrysler in the mid 1970's. Dubbed an engine "computer," it was an analog comparator circuit. The circuit accepted inputs from a limited number of devices and then advanced or retarded the timing, according to those inputs. Unfortunately, the circuit was comparatively slow and could only control two or three variables—air mixture, timing advance, and timing retardation. Further, though the circuit was designed to control air mixture, it proved to be unable to maintain the tight 14.6:1 air-to-fuel ratio required for optimum car performance.

An additional problem with early electronic systems was a lack of reliable sensor devices. There were few air-sampling devices available that could operate reliably over a long period of time in the hostile under-hood environment. (Such sensors have to survive a temperature range as wide as −40°C to +120°C.)

Eventually the electronics problems were solved, however, and today almost all automobiles rely on microprocessor controlled electronic engine-control systems.

Microprocessors and the car

Of this country's "Big Three" automakers (GM, Chrysler, and Ford), two are using the Motorola 6800 series of eight-bit microprocessors in their vehicles. According to Charles L. Duesenberry and Arden G. Gillund, two staff engineers at General Motor's Delco Division, the microprocessors that that automotive giant uses are custom-masked 6800's.

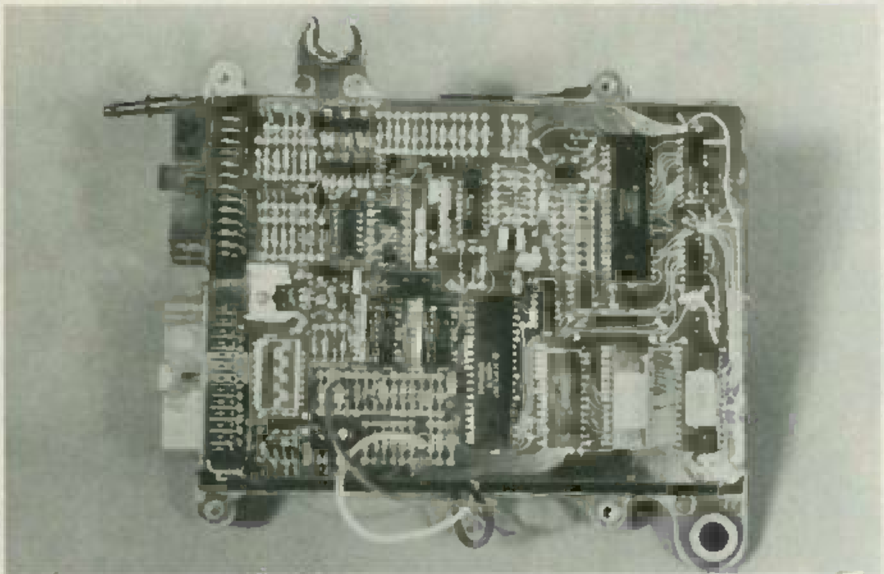


FIG. 1—THE HEART OF CHRYSLER'S engine control system is this 6801-based logic control module.

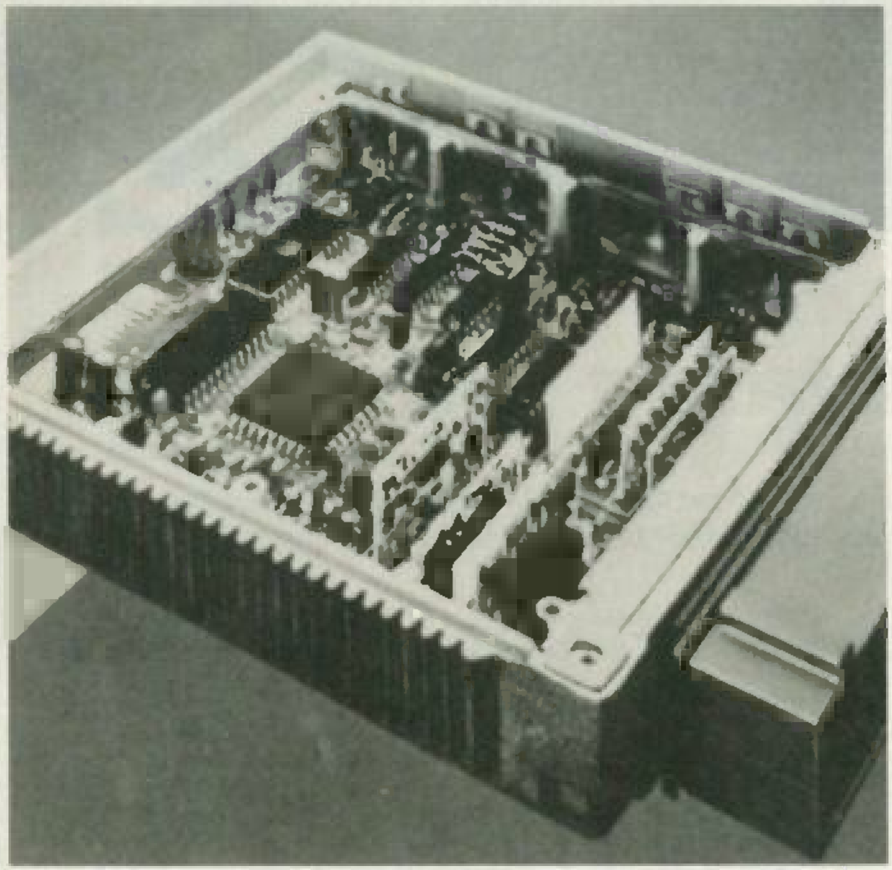


FIG. 2—FORD USES the 16-bit Intel 8061 microprocessor in its EEC-IV engine control system.

Chrysler, too, uses 6800-series microprocessors for its engine control system. The heart of the the Chrysler system is a 6801-controlled logic module. The module is also used in diagnostic operations (see Fig. 1).

In operation, the microprocessor takes inputs from various sensors—manifold air pressure, coolant temperature, exhaust-gas recirculation, etc.—and compares those inputs to parameters stored in ROM. If any of the inputs differs from the norm, the microprocessor takes steps to correct the cause.

There will be cases, however, where the condition causing the abnormal reading can not be corrected, or where the reading is wildly out of bounds with the norm. Such cases will be recognized by the microprocessor as a system failure, and the unit's self-diagnostics will take over. One function of those self-diagnostics would be to alert the driver to the presence of trouble. Another would be to maintain operation as well as possible until the fault is repaired.

For example, let's say that the manifold-air pressure sensor fails. That is one of the key sensors in the timing system chain because it constantly monitors air pressure within the manifold, and that information is used by the microprocessor to keep track of acceleration, deceleration, or cruising conditions. If that information is not made available, engine timing will likely be off, which will result in poor performance (stumbling and stalling) and poor fuel economy.

In the event of a manifold-air pressure sensor failure, the microprocessor will be programmed to revert to a set of timing and fuel-flow parameters. Those parameters, which are stored permanently in ROM, allow the car to continue to operate, although not at peak efficiency.

The third of the Big Three, Ford, does not use a 6800-series device. Instead, it has turned to the more powerful 16-bit Intel 8061 for its *E*lectronic *E*ngine *C*ontrol-IV (EEC-IV) system (see Fig. 2).

Electronic fuel system

For a more detailed look at just how an under-hood electronics system works, let's take a look at the Buick 3.8-liter multiport fuel-injected engine, General Motors' most advanced power plant. Just about every function of that engine is microprocessor-controlled. (See Fig. 3.)

The multiport fuel-injection system used by that engine is controlled by a microprocessor module Buick calls the *E*lectronic *C*ontrol *M*odule (ECM). It monitors engine operation and environmental conditions, and uses that information to determine the correct air/fuel mixture, ignition timing, and engine idle speed.

Inputs to the ECM come from an oxygen sensor, coolant-temperature sensor, detonation sensor, mass-air-flow sensor, and throttle-position sensor. The ECM also receives inputs on engine speed, vehicle speed, transmission gear selected, and loads placed on the engine by such accessories as power steering and air conditioning.

The multiport fuel-injection system uses six Bosch injectors, one located at each intake port, rather than a single injector found on throttle-body fuel-injection systems. The six injectors are mounted on a fuel rail and are activated simultaneously, once each engine revolution, on signal from the ECM. As a result, for each combustion cycle, two injections of fuel at the cylinder are mixed with incoming air.

According to Buick, the purpose of the fuel injectors is to inject a predetermined amount of fuel, which is mixed with the mass of air at each cylinder. The injector is a solenoid-operated valve; the solenoid winding is energized upon a pulse signal

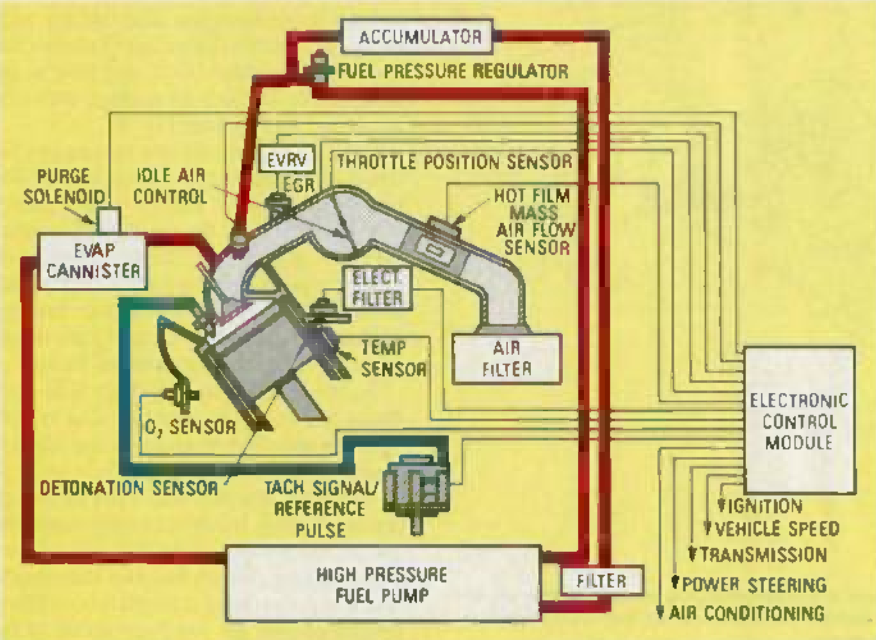


FIG. 3—BUICK'S 3.8-LITER multiport fuel-injected engine. Just about every function of that engine is microprocessor controlled.

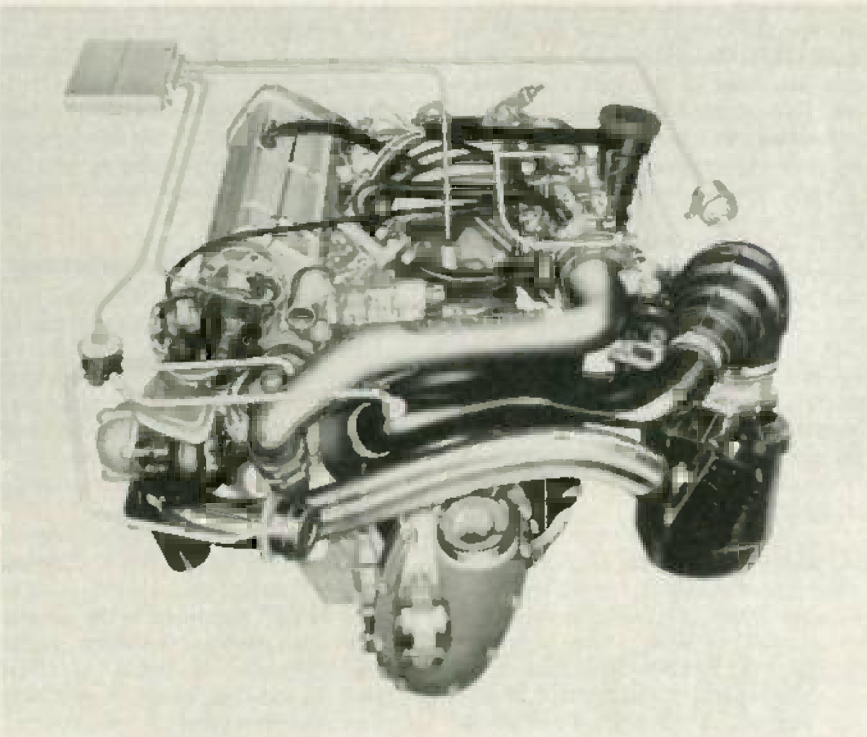


FIG. 4—SAAB's DIRECT IGNITION SYSTEM. This microprocessor controlled system overcomes many of the problems inherent in standard ignition systems.

from the ECM. As a result, the armature is drawn back, lifting a pin from its seat, which results in a nozzle opening for the pressurized fuel. The length of time the nozzle remains open depends on the width of the pulses from the ECM. The throttle-position sensor provides the ECM with throttle position information and that information helps the microprocessor determine the duration of the pulses.

That system relies on a high-pressure in-tank fuel pump that operates at 4500 rpm. The pump's impeller serves as a vapor separator and precharges the high pressure assembly. System pressure is maintained at 28 to 36 psi by a regulator, and an accumulator is used to dampen hydraulic line hammer (which occurs when all six injectors open simultaneously) in the system. The fuel tank itself is vented through an activated charcoal canister that stores fuel vapors until it receives a purge signal from the ECM. Those vapors are then sent to the fuel system where they are burned during combustion.

One of the most important parts of that system is the mass-air-flow sensor. Developed by Buick and AC-Delco, it is used to measure the mass of air that is drawn into the cylinders. It is located just ahead of the air throttle in the intake system and consists of a unique heated film that measures the mass of air, rather than just the volume. A thermistor is used to measure the temperature of the incoming air, and that information is sent to an electronics package that is located at the top of the assembly.

That electronics package is designed to maintain the temperature of the film at 75°C over the ambient temperature of the incoming air. If the temperature of the incoming air changes, the package changes the temperature of the film to match. Also, the package informs the engine-control module of the temperature change so that various engine parameters can be adjusted to maintain peak operation.

In the throttle body, there is an idle air-control that provides a bypass channel through which air can flow. It consists of an opening and a valve that is controlled by the ECM through a stepper motor. That bypass provides additional air flow for idling, and during cold-starting conditions until the engine has reached operating temperature. As the temperature rises, the air flow through that bypass is reduced.

The Buick engine uses a new electronic vacuum-regulator valve to control exhaust-gas recirculation and hence automobile emissions. The regulator valve contains a constant-current compensation circuit that ensures a given output vacuum for a given pulse width input, regardless of voltage or resistance variations. It also responds to signals from the ECM. In turn, the exhaust-gas recirculation valve is actuated by a vacuum motor. The exhaust-gas recirculation system operates in response to a signal from the regulator valve. In action, it allows the exhaust to gradually bleed through the system and into the intake manifold, where it heads to the cylinder for combustion.

FIG. 5—THIS PLUG/COIL COMBINATION develops the spark voltage right at each cylinder.

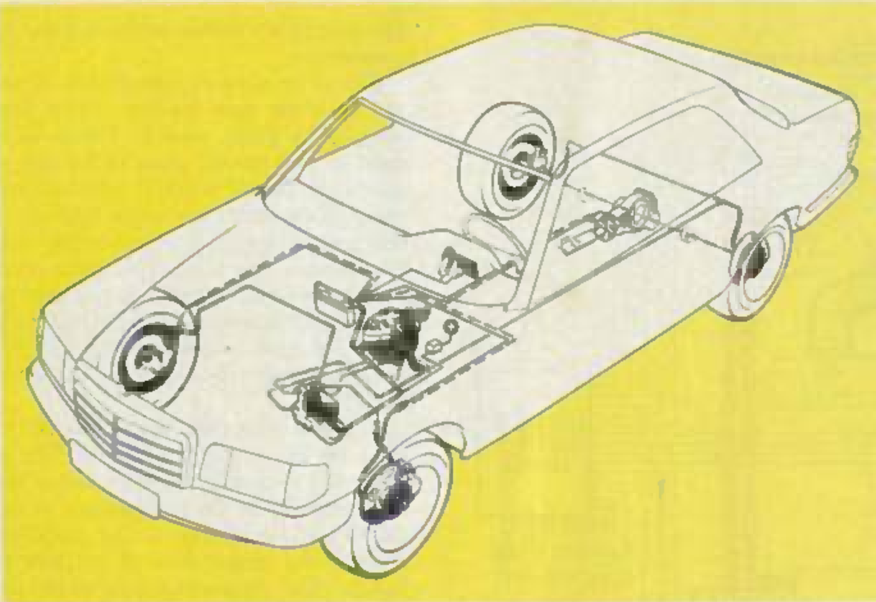


FIG. 6—THE MERCEDES BENZ anti-skid braking system. A microprocessor teams up with four wheel-mounted sensors and one pedal-mounted sensor to combat the brake lock-up that is common in a panic stop. Brake lock-up is what causes skidding to occur.

Solid-state ignition

The 3.8-liter Buick engine uses a solid-state ignition system with a distributor providing a high voltage spark to each plug at the proper time for ignition. The ignition system also sends a timing reference pulse to the ECM.

If detonation—knocking or pinging—occurs, an electronic spark control module is used to adjust the timing. It does that via a piezoelectric sensor that transforms engine detonation vibrations into electrical signals that are fed to the ECM. The ECM then adjusts the spark.

The ECM is also linked to the transmission and monitors the current gear and whether the cruise control is engaged. By monitoring the cruise control, the system avoids frequent disengagement of the clutch during cruising. The ECM also takes inputs from the speedometer drive at the transmission. That information is used for fuel cutoff during coasting above 45 mph.

Finally, the ECM monitors the loads placed upon the engine by accessories, and acts to compensate for them to maintain optimum operation. For instance, the ECM monitors the air conditioner and uses the information it receives to control idle speed when the air conditioner is on. The microprocessor anticipates air conditioner clutch engagement by about a half second, Buick says, and increases the engine idle rate to prevent stalling. It operates in a similar manner when it is adjusting for power steering load changes. That information is sent to the ECM by a pressure sensor in the power-steering system.

More reliable ignition

One of the problems associated with ignitions is related to the design of the system itself. It relies on a central coil to provide the correct voltage for all the spark plugs. The coil provides the voltage to a distributor so the spark can be sent out. That system has inherent losses and sometimes can't provide the critical timing requirements needed.

Saab, however, has found an answer to that in its direct ignition system (see Fig. 4). It varies from the standard ignition system in that it has no coil in the traditional sense. Spark information is sent to a coil-plug combination at each cylinder (see Fig. 5) and the spark voltage is developed directly at the cylinder. Microprocessor-controlled, the coil-plug combination uses information derived from the engine control microprocessor to fire at the exact moment for top mileage and cleanest emissions.

Another area where microprocessors are finding use is in the area of vehicle-maintenance warnings. For instance, consider the BMW oil-change warning system. Instead of being a simple mileage reminder, the BMW system uses its microprocessor to evaluate the type of driving you do. After evaluating several parameters, such as typical speed, oil and coolant temperatures, and miles driven, the microprocessor sets the oil change warning interval. Nine LED's (five green, one yellow, three red) are used to indicate the service interval. Immediately following an oil change, only the green LED's glow; as you accumulate mileage, they turn off one-by-one. When all of the green LED's are off, it indicates that it's time for an oil change. After a while, the yellow LED lights, issuing a reminder that you're past due for a change. If no service is performed, the red LED's turn on, one at a time, at about 1,000-mile intervals.

Anti-skid braking

Microprocessors are also finding uses in a wide variety of other applications. For instance, Mercedes Benz, and others, are using those devices to control anti-skid breaking systems (see Fig. 6).

Such a system consists of sensors located at the pedal, and at each wheel. The microprocessor is alerted to a "panic-stop" situation by the force used to press the pedal down. Once the microprocessor detects a panic-stop, it issues instructions to an electronic module in the braking system. That module then begins to engage the brakes to the point of lockup.

As the brakes near lockup, that condition is detected by a sensor. The system then releases and re-engages the breaks. That process is repeated as many as 12 to 15 times per second. The constant pumping action that results not only stops the car in shorter distances, but also allows you to retain control because the wheels don't stop turning completely. (When wheels do lock up, you lose control of the vehicle.)

As we have seen, there is a great deal of work which has been done and which is still continuing in automotive microprocessor-systems. At the moment, some automakers are experimenting with microprocessor-controlled collision-avoidance systems. Others are experimenting with tire-pressure warning systems that rely on pressure-sensor inputs to head off impending flats.

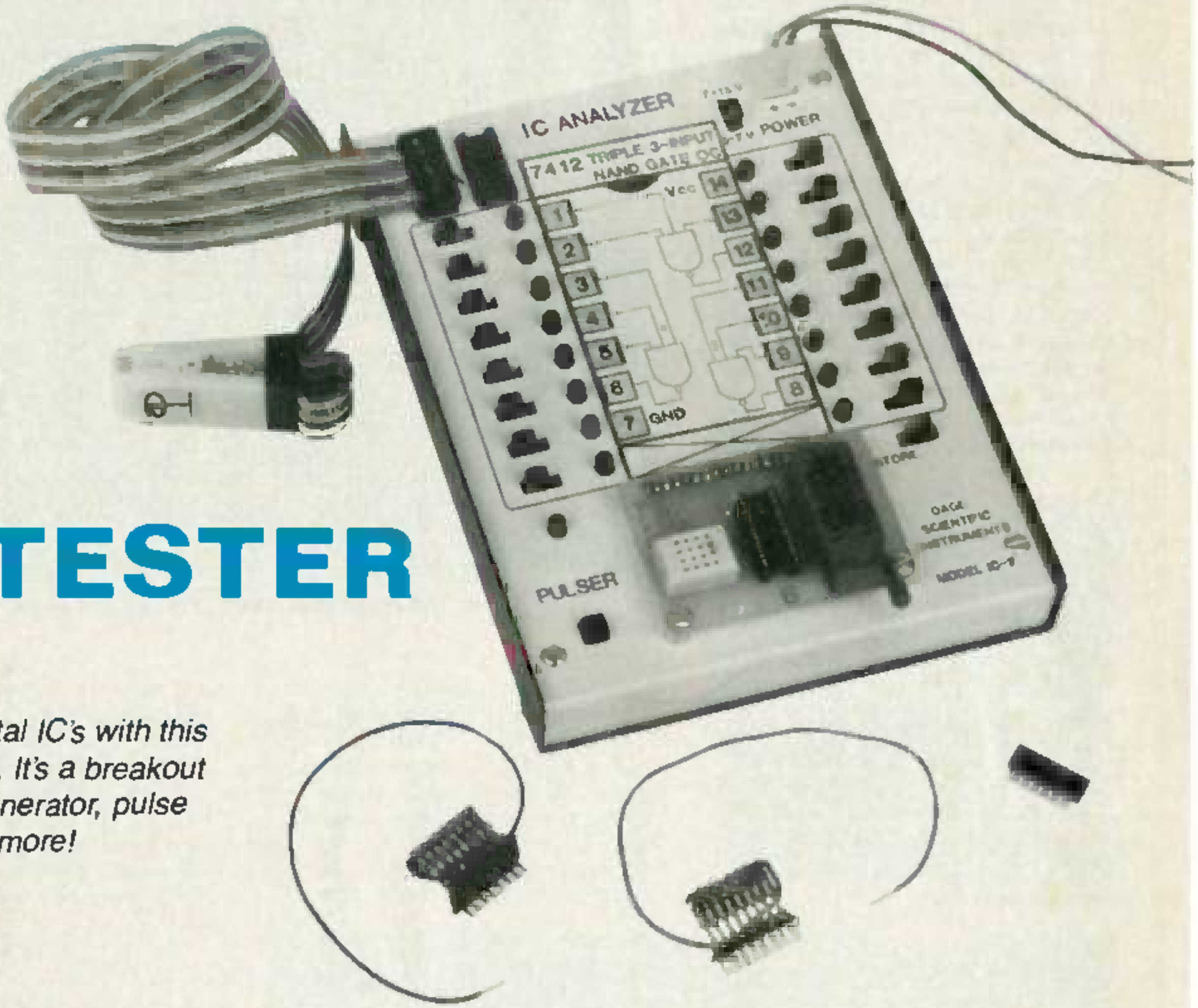
Servicing and the microprocessor

We discussed multiplexing and its ramifications in the first story in this special section, "Electronics in the Passenger Compartment." With multiplexing, all of the various microprocessors will be linked to each other via a common bus, and all vehicle operations will be monitored by a bus-controller microprocessor.

That will allow several thing to occur in the event of a failure. First, diagnostic routines built into such a multiplexed system will alert the driver to the condition earlier than previously possible, perhaps even before the subsystem has actually failed. In addition, it may be possible for other microprocessors in the system to "fill-in" for a failed device, allowing vehicle operation to continue until service can be obtained. Further, the system has the potential to make vehicle servicing simpler and more accurate.

That's because the diagnostic routines that will be built into the multiplexed systems of the future will be able to pinpoint the exact cause of a failure. Those same routines could also be used to give a driver, or service technician, a complete service history of the vehicle. All that information would be taken from the same sensors used for engine control. It's an exciting prospect. **R-E**

BUILD THIS



IC TESTER

DAVID H. DAGE

Test your digital IC's with this handy device. It's a breakout box, pulse generator, pulse detector and more!

TESTING DIGITAL CIRCUITS SHOULD BE easy. After all, there are only two voltage levels involved. If the signal isn't high, then it's low. So your voltmeter or oscilloscope should be all that you need, right? How wrong that is! Working with digital circuits requires a whole new generation of test instruments ranging from the indispensable logic probe up to the sophisticated logic analyzers and emulators.

We'll show you how to build a device that's several digital test instruments rolled into one. It's a monitor, breakout box, comparator, pulse generator, and pulse detector. It can be used to troubleshoot digital circuits that contain 14- and 16-pin TTL or CMOS IC's. And it makes a great IC tester and trainer.

To use the analyzer for troubleshooting your digital circuits, you connect the analyzer to the in-circuit IC using ribbon cable and an IC test clip. If the analyzer is being used as a monitor, the logic level of each pin is displayed by an LED right next to a pictorial pinout of the IC. Each pin of the IC is accessible at the analyzer for signal injection or simply for observation. That combination is hard to beat—it's certainly better than tilting your head, holding a databook open with your elbow, and jabbing spasmodically with a logic probe on what may very well be pin 10.

The analyzer gives you a remarkably simple way to troubleshoot an in-circuit IC. You can compare the outputs of the IC operating in-circuit to an IC of the same type that you know to be good. The good IC is inserted in the analyzer, and the power and input pins are connected together using slide switches, while the outputs are compared using EXCLUSIVE OR (XOR) gates. If the LED's remain off, the in-circuit IC is good. It's as simple as that.

The analyzer can also be used to check IC's before installation. Slide switches are used to set logic levels on appropriate pins, while the built-in pulse generator is used to inject single or multiple pulses.

A look at the circuit

The IC analyzer is made up of four main parts: the power feed, a pulse generator, a pulse stretcher, and a set of 16 pin-monitor circuits. To explain the circuit operation as clearly as possible, we will discuss those sections separately.

The schematic of the power feed is shown in Fig. 1. When testing in-circuit IC's, the analyzer gets it power from the circuit under test, through socket SO6. If that input voltage is higher than seven volts, S18 must be switched to supply 5

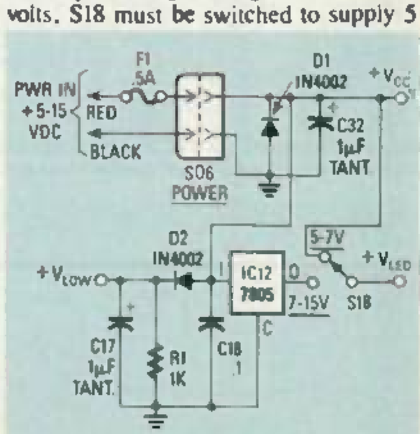


FIG. 1—A POWER-DISTRIBUTION CIRCUIT is used so that the LED's can have their own supply voltage if necessary.

volts to the LED's. Otherwise, the current through them will be too high.

Supply voltage V_{LOW} is 0.8 volt less than V_{CC} and powers the XOR gates and the flip-flops used for the individual pin-monitor circuits. The voltage is derived through D2 and is filtered by C17. This provides a high threshold voltage of 2.1 volts during 5-volt operation (which is necessary for TTL). The rest of the circuits operate between 5 and 15 volts DC.

A block diagram of the pin-monitor logic is shown in Fig. 2, while the schematic is shown in Fig. 3. Since the analyzer can be used to examine 16-pin IC's, it must contain 16 pin-monitor circuits. Instead of showing the circuit 16 times, we have shown it once and have used lettered subscripts. Although that is different from what we normally do in **Radio-Electronics**, it should serve to make

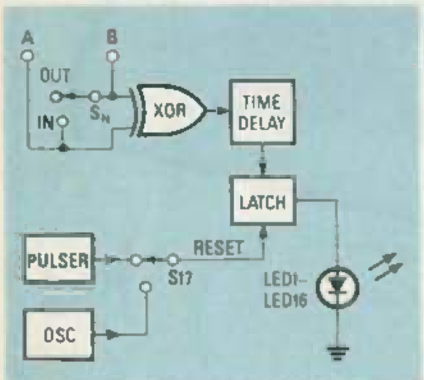


FIG. 2—THE PIN-MONITOR CIRCUIT is shown here in a block diagram.

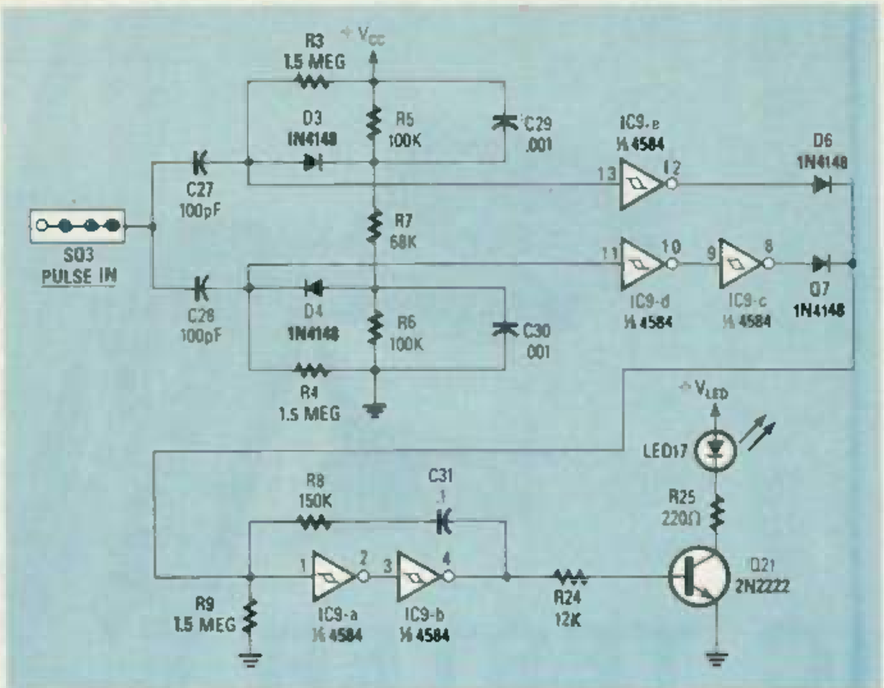


FIG. 5—SCHEMATIC OF THE PULSE STRETCHER. LED17 will light on both positive and negative transitions.

the circuit clearer. When referring to those parts, we'll use an "N" subscript. In Fig. 3, of course, N = 1. (Since the XOR gate and S-R flip-flop are *sections* of IC's, we couldn't do that. So we'll mention here that the XOR gates in the pin-monitor circuits are contained in IC1, IC2, IC5, and IC6, while the S-R flip-flops are contained in IC3, IC4, IC7, and IC8.) Just

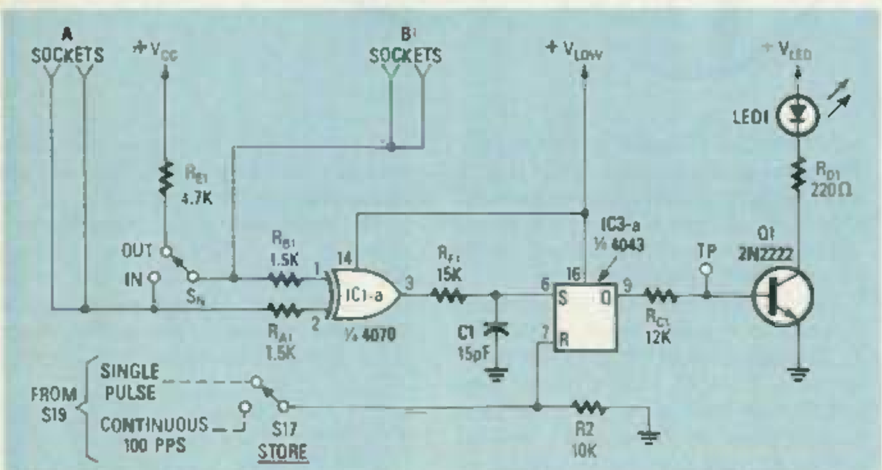


FIG. 3—SCHEMATIC OF THE PIN MONITOR CIRCUIT. Note that because this circuit is repeated 16 times in the analyzer, the part numbers use lettered subscripts.

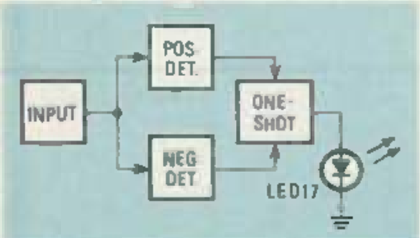


FIG. 4—THE PULSE STRETCHER block diagram.

keep it in mind when you go through the Parts List.

When switch S_N is in the OUT position, the logic level on pin A_N is compared with logic level on pin B_N by the EXCLUSIVE OR gate. If the two levels are different, the high output will set a 4043 flip-flop. Pulses less than 800 ns are considered glitches and are filtered out by R_{FN} and C_N.

A high output from the 4043 flip-flop will turn on transistor Q_N, and thus the LED. Resistors R_{AN} and R_{BN} isolate and protect the analyzer circuits while R_{CN} and R_{DN} limit current flow.

When switch S17 is in the STORE position, the flip-flop can be reset manually using the PULSER switch, S19. When S17 is not in the STORE position, the flip-flop is continually reset by a 100-pps pulse train.

Placing S_N to the IN position, connects pin A_N to pin B_N, so that an in-circuit IC can be compared to an out-of-circuit test IC.

The analyzer has a built in *pulse stretcher* and *pulse generator*. Both of those functions can be connected independently to any pin on the IC under test. The pulse stretcher will allow a single pulse or a fast pulse train can be caught and displayed on a separate LED. It is highly sensitive to true logic changes but is immune to low-level noise.

A block diagram of the pulse stretcher is shown in Fig. 4, and its schematic is shown in Fig. 5. As you can see, it uses five of the Schmitt-trigger inverters of IC9. The DC level on the input pins 13 and 11 of that IC is held midway between the switching point by R3 through R7, and diodes D3 and D4.

A negative transition discharges C27 and pulls pin 13 low. The capacitor is then charged through R3 until D3 conducts. The time constant of R3 and C27 coupled to the Schmitt trigger, produces a positive pulse of sufficient duration to then trigger the monostable flip-flop made up of R8, R9, C31 and two inverters, IC9-a and IC9-b. When triggered, output from pin 4 of IC9 will go and remain high for approx-

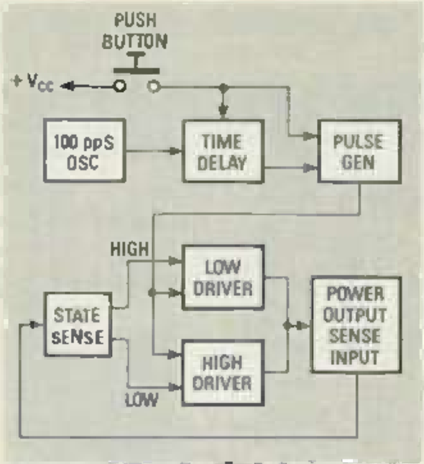


FIG. 6—THE PULSE GENERATOR block diagram.

imately 50 ms. This output drives the LED17.

Positive transitions charge C28 and pulls pin 11 of IC9 high. An output blink of LED17 is produced in a similar fashion. Capacitors C29 and C30 hold the midway reference voltage constant, while diodes D6 and D7 isolate the two outputs from pin 8 and pin 12 of IC9.

The pulse generator can be used to change the logic level voltage to the opposite state for a short time, overriding any logic output that is in control. Injecting pulse(s) to stimulate digital circuitry is indispensable for troubleshooting. The duration of the pulse is so short that no damage is done to the output device. The pulse output can be either a single pulse or a 100 pps (*Pulse-Per-Second*) pulse train.

A block diagram of the pulse generator is shown in Fig. 6, while its schematic is shown in Fig. 7. The logic level of the external circuit is sensed through R16, and is fed to the DATA input of flip-flop IC10-b. When switch S19 is pushed, a single positive pulse is generated by C19 and R13, setting flip-flop IC10-a.

A multivibrator that generates a 100-pps squarewave is made up of R10, C21, and IC9-f, a Schmitt-trigger inverter. The squarewave is fed to AND gate IC11-c. If S19 is held closed, C20 charges thru R12 and, after about 2 seconds, turns on IC11-c. That allows flip-flop IC10-a to be clocked as long as S19 is pushed. When S19 is released, C20 rapidly discharges thru D5 and R11. Flip-flop IC10-a resets

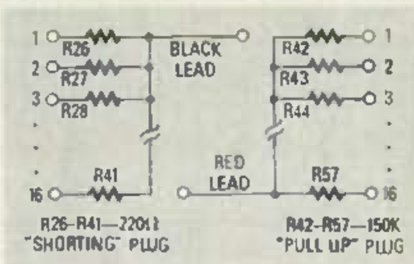


FIG. 8—THE PULL-UP AND SHORTING PLUGS are shown here schematically.

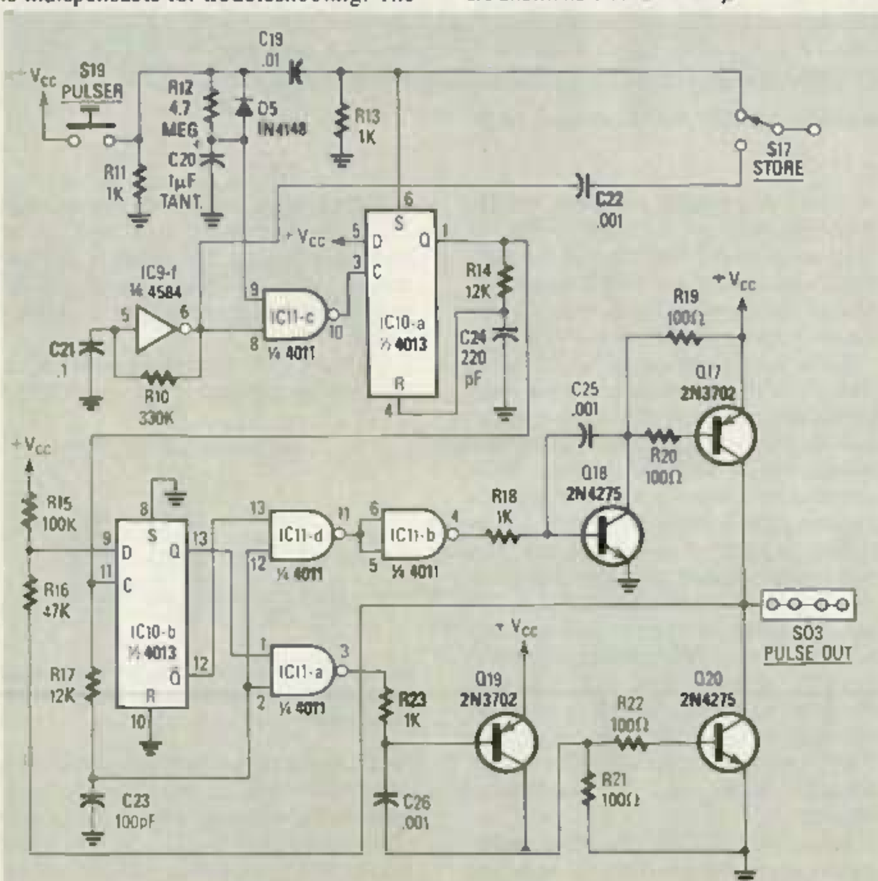


FIG. 7—SCHEMATIC OF THE PULSE GENERATOR. The generator's output is sent to the solderless breadboard socket.

PARTS LIST

All resistors ¼-watt, 5%

R_{A1}–R_{A16}, R_{B1}–R_{B16}—1500 ohms
R_{C1}–R_{C16}—12,000 ohms
R_{D1}–R_{D16}—220 ohms
R_{E1}–R_{E16}—4700 ohms
R_{F1}–R_{F16}—15,000 ohms
R1, R11, R13, R18, R23—1000 ohms
R2—10,000 ohms
R3, R4, R9—1.5 megohms
R5, R6, R15—100,000 ohms
R7—68,000 ohms
R8, R42–R57—150,000 ohms
R10—330,000 ohms
R12—4.7 megohms
R14, R17, R24—12,000 ohms
R16—47,000 ohms
R17—12,000 ohms
R19–R22—100 ohms
R25, R26–R41—220 ohms

Capacitors

C_{A1}–C_{A16}—15 pF, ceramic disc
C17, C20, C32—1.0 μF, 25 volts, tantalum
C18, C21, C31—0.1 ceramic disc
C19—0.01 ceramic disc
C22, C25-C26, C29, C30—0.001 μF, ceramic disc
C23, C27, C28—100 pF ceramic disc
C24—220 pF polystyrene

Semiconductors

IC1, IC2, IC5, IC6—4070 quad EXCLUSIVE OR gate
IC3-IC4, IC7, IC8—4043 quad 3-state latches
IC9—4584 Hex Schmitt trigger inverters
IC10—4013 dual D-type flip-flop
IC11—4011 quad NAND gate
IC12—7805 5-volt regulator (TO-220 case)
Q1–Q16, Q21—2N2222
Q17, Q19—2N3702
Q18, Q20—2N4275
D1, D2—1N4002
D3–D7—1N4148
LED1–LED17—standard red LED

Other components

S1-S18—SPDT slide switches
S19—Pushbutton switch, normally open
SO1, SO2, SO4—wirewrap type, 16-pin DIP sockets
SO3—Solderless breadboard strip (4 × 4)
SO5—ZIF socket
SO6—2-pin power connector
SO7—20-pin single-row female header

Miscellaneous: Main PC board; 8-socket PC board; IC sockets, cabinet, DIP headers for plugs, etc.

The following are available from Dage Scientific Instruments, P.O. Box 144, Valley Springs, CA 95252: Plated-thru PC boards, IC pin-out cards and detailed instructions (order number IC-18), $30.00 plus $2.00 shipping. Complete kit of parts less chassis, DIP-clip cable, and sockets (order number IC-20), $79.95 plus $3.00 shipping. Complete kit, includes assembled dip-clip cable, zero insertion force socket, even solder (order number IC-22), $119.00 plus $4.00 shipping. California residents please add sales tax. Countries other than U.S.A. and Canada, please add $8.00.

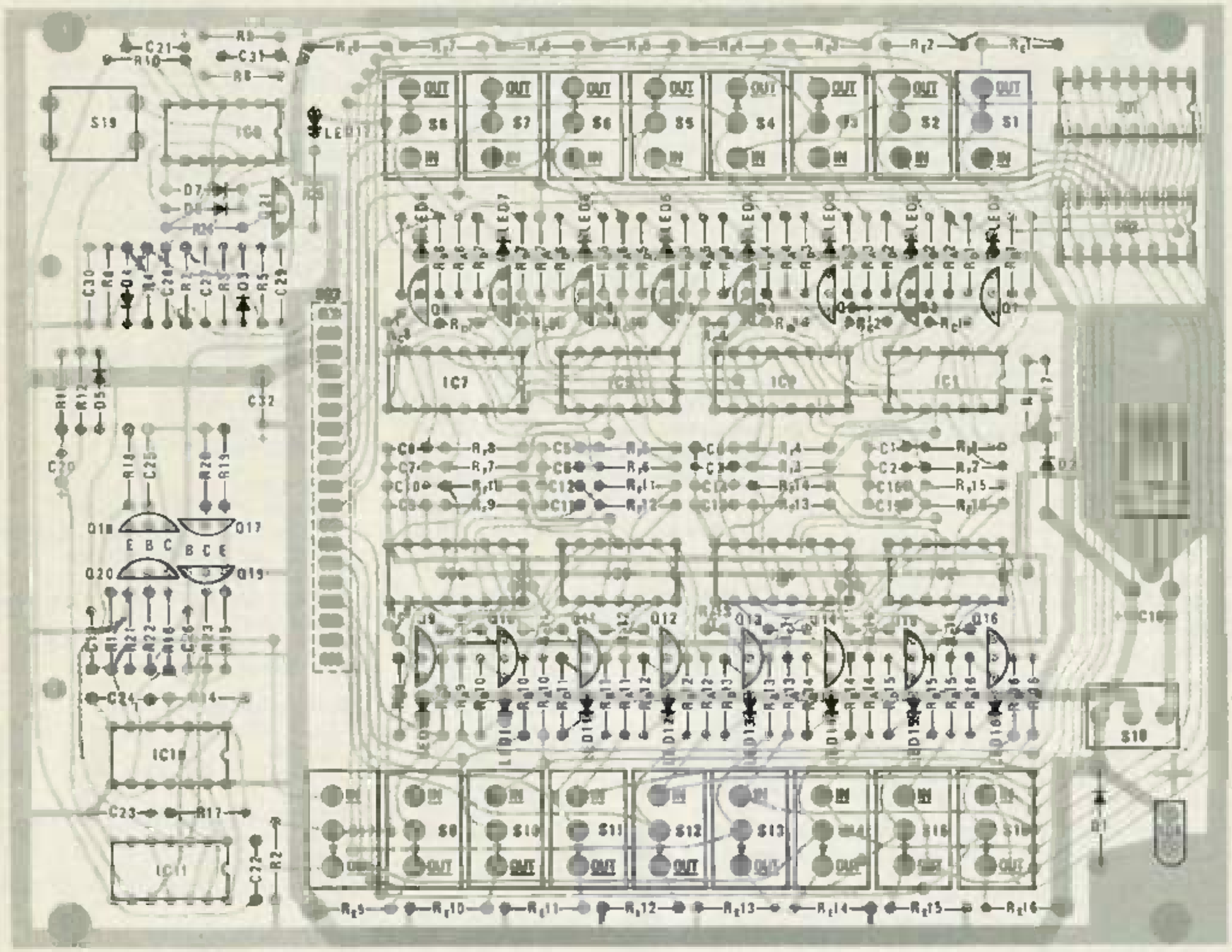


FIG. 9—PARTS PLACEMENT DIAGRAM FOR THE MAIN BOARD. Note SO7, the connection to the B-socket board.

itself by R14 and C24 producing a positive pulse of a few microseconds. That positive pulse latches the external circuit level sensed by IC10-b and, after a slight delay produced by R17 and C23, drives NAND gates IC11-a and IC11-d.

If the external circuit is high, the Q output of IC10-b will be high allowing IC11-a to turn on the negative-drive circuit containing Q19 and Q20. Conversely, if the external circuit is low, $\bar{Q}$ will be high which will turn on gates IC11-d and IC11-b, and then the positive drive circuits containing Q17 and Q18.

The final part of the analyzer's circuit are two plugs, each of which contains 16 identical resistors mounted on a header with all resistors connected to a common lead. The "shorting" plug uses 220 ohm resistors while the "pull-up" plug uses 150K resistors. The schematics of the plugs are shown in Fig. 8.

Building the IC analyzer

The easiest way to build the analyzer is to use printed-circuit boards. See our new "PC Service" section starting on page 81 for foil patterns for a double sided board. A parts-placement diagram for the 5×6½-inch board is shown in Fig. 9. That main board contains all the analyzer's active circuitry. (We'll also need a second board, called the B-socket board, but we're getting ahead of ourselves.)

In the author's prototype, the 18 IN/OUT slide switches determined the front panel height above this board. Mount a switch and measure this distance. For the unit shown, the distance is 0.35 inch. Make sure that all components that are not suppose to extend above the panel, are installed no higher than the switches. This will require careful assembly and selection of parts. Keep in mind, however, that you can mount switches to the front panel and use point-to-point wiring to connect them to the board. That will make your component sizes less critical. A cover for the analyzer is not absolutely necessary, but you must find some way to protect the circuitry from shorts or mechanical damage.

Install the 17 LED's first. They should extend above the panel by ⅛ inch, and their height should be as even as possible. That can be accomplished by making a mounting jig. A simple strip of aluminum 3¼ inches long and ¼ inch high can be placed between the LED leads before soldering. After soldering, the strip is removed, leaving the LED's at a uniform height.

The two "A" sockets, SO1 and SO2, must also be installed about ¼ inch above

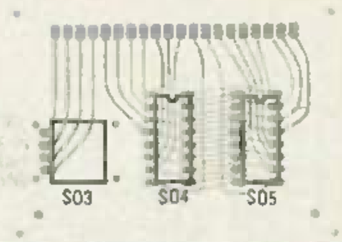
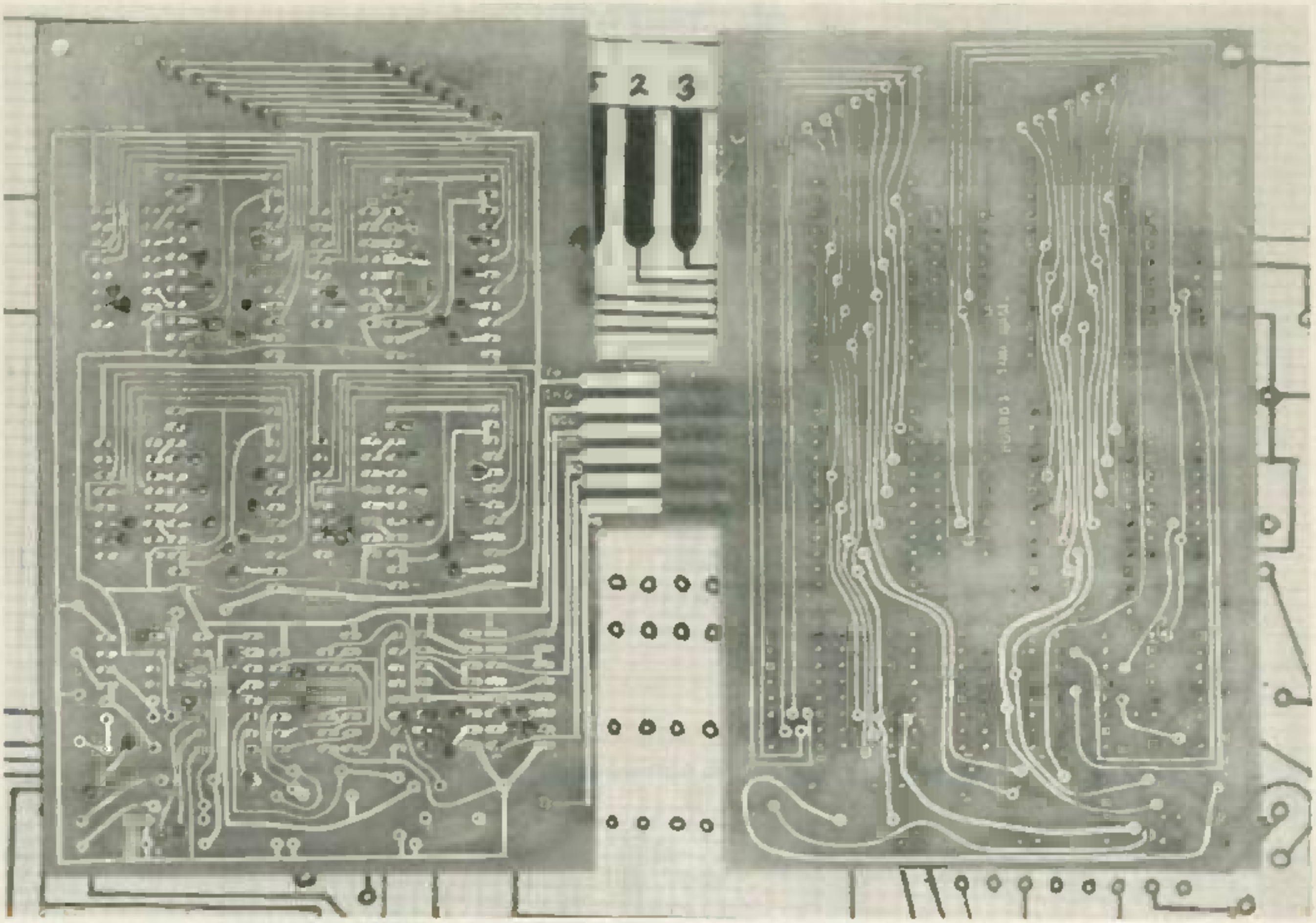


FIG. 10—THE B-SOCKET BOARD parts placement. Note that SO3 is a small solderless breadboard socket.

the PC board so that they protrude about ⅛ inch above the panel. Wire wrap IC sockets have the necessary pin length for such above-board mounting. Excess pin length should be trimmed even with the bottom side of the board.

continued on page 101



Designing Double-sided PC Boards

Making a double-sided PC board can be child's play when compared to designing the board's layout. Here are a few hints to make your design easier.

ROBERT GROSSBLATT

ALL ELECTRONIC DESIGNS, FROM THE SIMplest light dimmer to the most sophisticated satellite, go through the same three basic stages of development. First, the idea must be thought up, the circuit must be wired up, and then everything must be finished up.

All the electronics technology in the world can't help you much with the first of those. Coming up with an idea is always the most difficult step.

Wiring up the circuit on a breadboard is pretty much standard fare. If your design is sound, any problems that crop up in the breadboard stage can usually be corrected without too much difficulty.

Finishing up a design, however, can be almost as difficult as thinking up the idea. In this article, we're going to concentrate on the most difficult part of finishing up a design: laying out the PC board.

The same advancements in IC technology that simplified the circuit design have made printed-circuit design more difficult. Reducing the component count of a circuit to ten IC's and two resistors is great in electronic terms. But any notion you might have of getting it all on a single-sided board should be thrown out the window. Modern electronic design means double-sided (or even multilayered) PC boards. That unalterable fact has led to a resurgence of point-to-point wiring—an ancient construction technique that PC boards were supposed to replace! You can't whip out a PC layout for a double-sided board with quite the same mad abandon as a single-sided one. There's no getting around the fact that the job is more complex and will take a lot more time, attention, and planning to do properly.

To illustrate the process of making a PC board, we need a sample circuit. The circuit we'll use is one that generates a timebase and calculates the rate of an input signal. The circuit's function isn't really important to us here; we just need some example to start with.

The schematic of the circuit we'll use as an example is shown in Fig. 1. (*Editor's Note:* You may recognize the circuit as a subsystem of the heart-rate monitor presented in the September 1982 issue of **Radio-Electronics**.) Again, don't bother yourself with the details of how the circuit works. All that's important to us is how to design a PC board.

You can't design a PC board just from the schematic. You have to make a block diagram first—you'll use it as a starting point for your board design. Even if you made a block diagram before you started your schematic (which you *should* do),

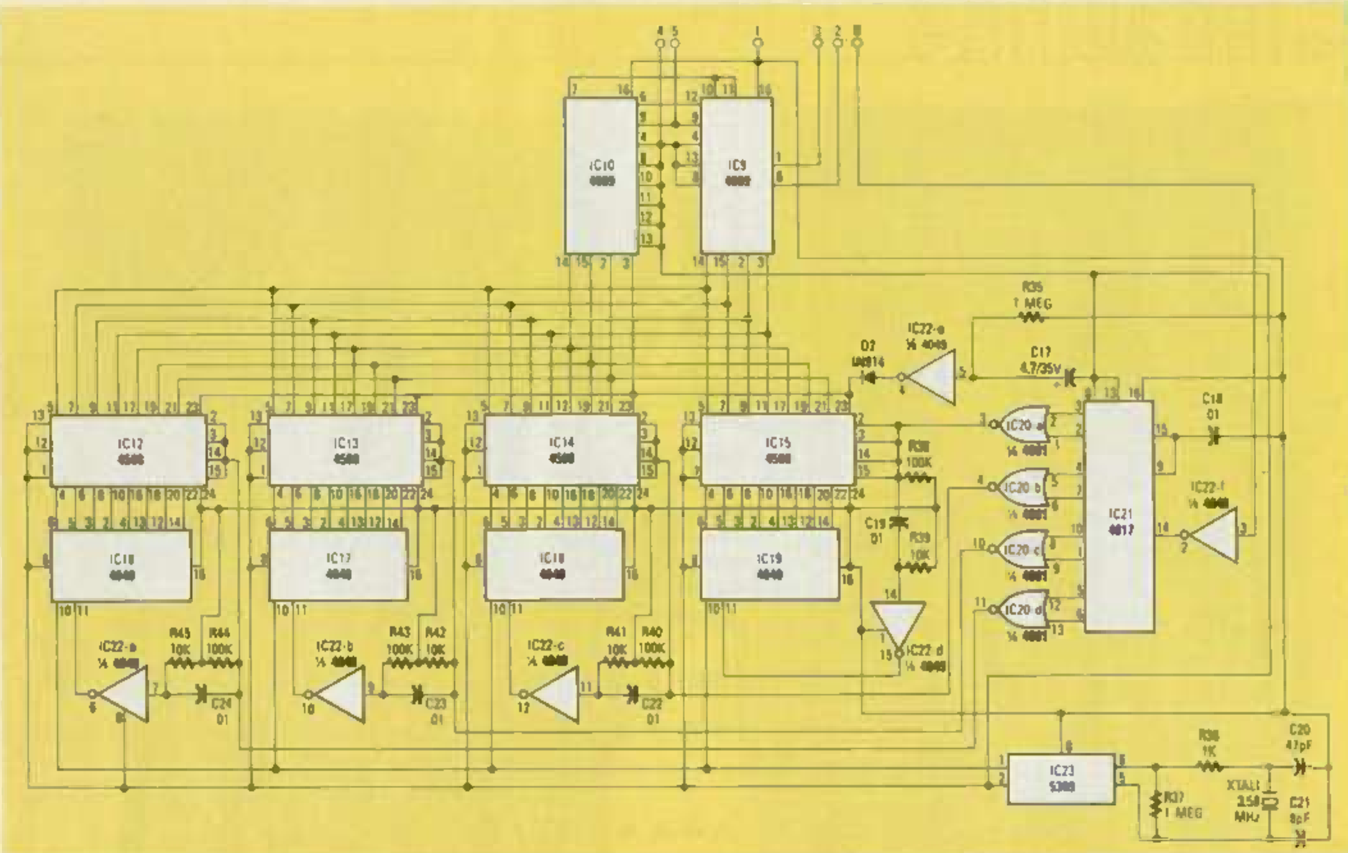


FIG. 1—THE SCHEMATIC OF THE CIRCUIT we'll be using as an example. Don't worry about what the circuit does or how it works.

you'll want to do another one so that you can include IC numbers, etc., as shown in Fig. 2.

Getting started

There are lots of ways to generate double-sided layouts, but all methods have one common goal: to make sure that registration is maintained between the two sides of the boards. The method we're going to describe will give you the high precision that you need while still taking into account the realities of dealing on a home workbench. The supplies you'll need are listed in Table 1. You can find them at any good drafting supply store—except, possibly, the last item.

TABLE 1—SUPPLIES FOR PC BOARD LAYOUT

1. Non-Repro Blue pencils for drawing in the layout. 2. A pad of ten-to-the-inch graph paper. 3. Several erasers of various sizes and shapes. 4. A good pair of drafting dividers. 5. Large, clear plastic triangles. 6. A ruler with ⅒-inch markings. 7. The actual components you plan to put on the final board. 8. Printed circuit board graphic aids (doughnuts, tape, etc.) 9. Transfer type lettering to label components on the board. 10. A roll of stick-on registration marks. 11. A bottle of correction fluid. 12. A lot of patience.

Your success with a double-sided layout—or a single-sided one, for that matter—depends on how well you understand the particular requirements of your circuit. Current draw, spiking, generation of heat and RF, etc. will determine how you go about routing the traces on the board. Before you start, you should ask yourself:

1. Do some sections require high current?
2. Is RF handled on the board?
3. Will some components get unusually hot?
4. Is there current spiking?
5. Does the final board have to be a particular shape?
6. How is the board I/O going to be handled?
7. Et cetera.

Of all those considerations, the seventh is the most important because each circuit has its own set of operating peculiarities. A workable layout depends on knowing what your circuit wants and doesn't want. The chances are that if your breadboard version is working, most of those questions have already been answered. But be careful. We've seen PC boards that were total clones of the breadboard—but the circuits built on them did nothing but drain the battery. Problems due to such things as inductance, heat transfer, and crosstalk won't show up in continuity checks. There are few things in life more frustrating than a PC layout that connects the right traces to the right pins of good components...but doesn't work.

What to do first

Once you've decided on the size and shape limitations of the board, you're ready to start planning the actual layout. Draw an actual-size outline of the planned shape on a piece of graph paper. You should use graph paper with 0.1-inch spacing. It's a perfect guide because all the components you'll be using—except for some oddball parts and edge connectors—are based on 0.1-inch spacing.

If your I/O has to appear at a particular place on the board, now is the time to draw it in. The same is true with LED's, and any other indicators that you might be using. At this point, don't worry about which of the connectors go where; you can take care of that later. All you want to do now is decide on the general topography of the layout.

After you decide on the position of all the components that *have* to be at particular places on the board, it's time to decide how all the rest of the components should be laid out. You can not simply place the parts anywhere on the board you like; there are two types of considerations to help you decide how to lay things out. The first is electronic, and the second is aesthetic.

Components that are part of a subsystem should be physically close to each

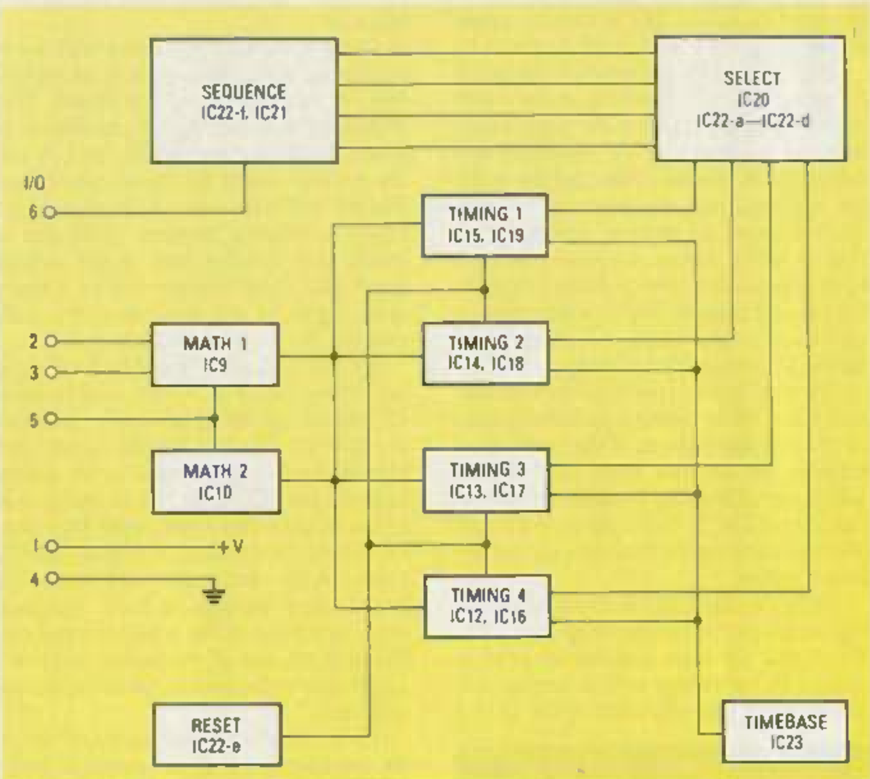


FIG. 2—A BLOCK DIAGRAM OF YOUR CIRCUIT is essential if you want to make an orderly layout. Even if you drew one before drawing your schematic, do it again, including IC numbers, etc.

other. There are probably quite a few of interconnections between the parts of a subsystem, so the PC pattern is going to be much easier to generate if those parts are grouped together. Some sections of your circuit may draw excessive amounts of current, require physical RF shielding, or something else that would dictate their position on the board. We can't give you a full list of considerations but we can give you a general guideline: When in doubt, do! In other words, if you're not sure whether components have to be near each other and it won't hurt anything to do it, go ahead and do it!

The second type of consideration is just good practice: The components should either face in the same direction or be exactly perpendicular to each other. It's much easier to connect common pins along even rows of IC's. You'll also find it easier to keep track of component groups, and, in general, the board will look a lot better.

The best way to group the components is by function, and the best guide for that is the block diagram you've made (or should have made) of your circuit. Using a block diagram makes it a lot easier to delegate board space and to lay out the traces a section at a time. Doing it section by section is going to make it much easier when a part of the design has to be revised.

As you draw each component on the board, keep the IC's *at least* three tenths of an inch apart. You should really start with a much greater distance; it can always be reduced later. Remember that nothing you've done at this stage of the game is carved in stone. The drawing you've made does three things: It shows whether all the components fit on the board, it serves as a guide for the final layout, and it tells us how to route the traces for each section.

Knowing how to route the traces is particularly important because of the approach we have to use in doing the final layout. You can't assume that your final layout will look anything like your first layout. The only sensible approach is treat each section as a separate circuit, with connections for power, ground, input, and output. Your first layout, however, gives you a general map of the final board, so you at least know in which direction to route the traces. Designing the power-supply section of the board with all the traces coming off to the left is useless if the rest of the circuitry is to the right!

The actual layout

The first step in doing the actual layout is to get a piece of graph paper at least four times larger than the board. That's because we're going to draw both sides of the board on the same piece of paper and we're going to work double-size. When you're doing a single-sided layout, there's

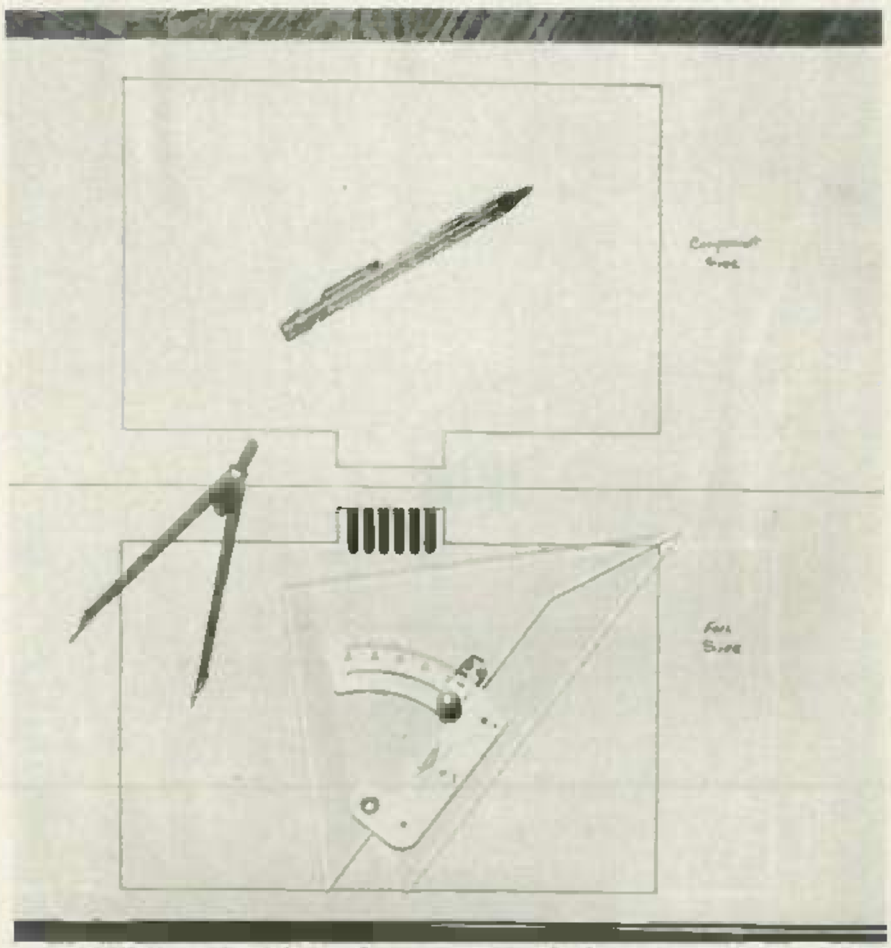


FIG. 3—ONLY THE CIRCUIT I/O is drawn in to start. Any other circuitry that has be near the edge of the board should be drawn in also.

usually enough room for a bit of slop and actual-sized layouts are possible. But double-sided layouts require a degree of precision that's impossible unless you work at least double size. And even that may not be enough for a really tight layout. Some boards need a pattern so complex that everything will have to be redone three or four times the actual size. It's not necessary to make that decision immediately because it soon becomes evident if you have to go up in magnification.

Take the graph paper and draw a horizontal line across the middle using as fine a black pen as you have. That line will serve as the baseline for the layout. Find the line on the graph paper that's a half an inch (five divisions) below the baseline. That's where you will draw the top edge of your board's bottom (solder) side. Now go up a half an inch from the baseline and draw a line to represent the top edge of your board's top (component) side. Once you have those lines located, you can draw a double-sized outline of both sides of your board with the same black pen you used to draw in the baseline.

You can use the divisions on the graph paper as a guide for locating the other edges of the board, but be careful: Some graph paper isn't as accurate as it looks!

The secret to a successful double-sided PC layout can be summed up in one word: registration. By dividing the graph paper into two sections, we've effectively unfolded the PC board so we can look at the top and bottom of the board on the same sheet of paper. In order to keep registration on the PC layout, we have to be able to exactly locate corresponding points on the top and bottom. Registration errors at this stage of the game are going to be harder to correct further along.

The only way to guarantee the registration when we're locating the same points on the top and bottom of the board is to transfer the distance from the baseline with a pair of drafting dividers, which you can see in Fig. 3. Let's get to work and start the layout of the board so we can see how it's done.

There's no hard-and-fast rule for deciding which part of the circuit to start with. We found the least amount of grief is caused by beginning with a section that has to directly handle some of the I/O on the board—display drivers, power supplies, etc.

One good choice is to start with some components that have to look at signals that are fed in from off the board. That includes things like switch circuitry, keyboard decoders, bus signals, and so on. As you start doing the layout, you'll find that the real estate around the edge of the board is valuable property. With that in mind, take another look at the actual-sized placement diagram you've already done. Now is the time to move stuff around. It's a lot harder later on.

By this time you should be looking at something like Fig. 4, the double-sized PC outline on the graph paper. You can see that the I/O and IC placement have already been drawn. Draw in the solder pads for the I/O on the foil (bottom) side of the board using a non-repro blue pencil. Using the dividers, locate the SAME points on the component (top) side of the board, draw the pads in there, and then draw an outline of the actual component. Measure the size of the device and don't forget that we're working at twice the actual size

We're drawing in the components so we can keep track of the available space on the top side of the board. When we start routing traces there, we're going to be doing some fancy navigating to keep the traces from running into IC's, resistors, and so on. As we keep adding components to the layout, we'll be doing that as a matter of course. Every time we put a pad on one side, we're going to draw it on the other side as well. And we'll be doing all the drawing in non-repro blue until the final design is done. The last step will be to go over everything in black—either with a pen or any of the stick-on graphic aids.

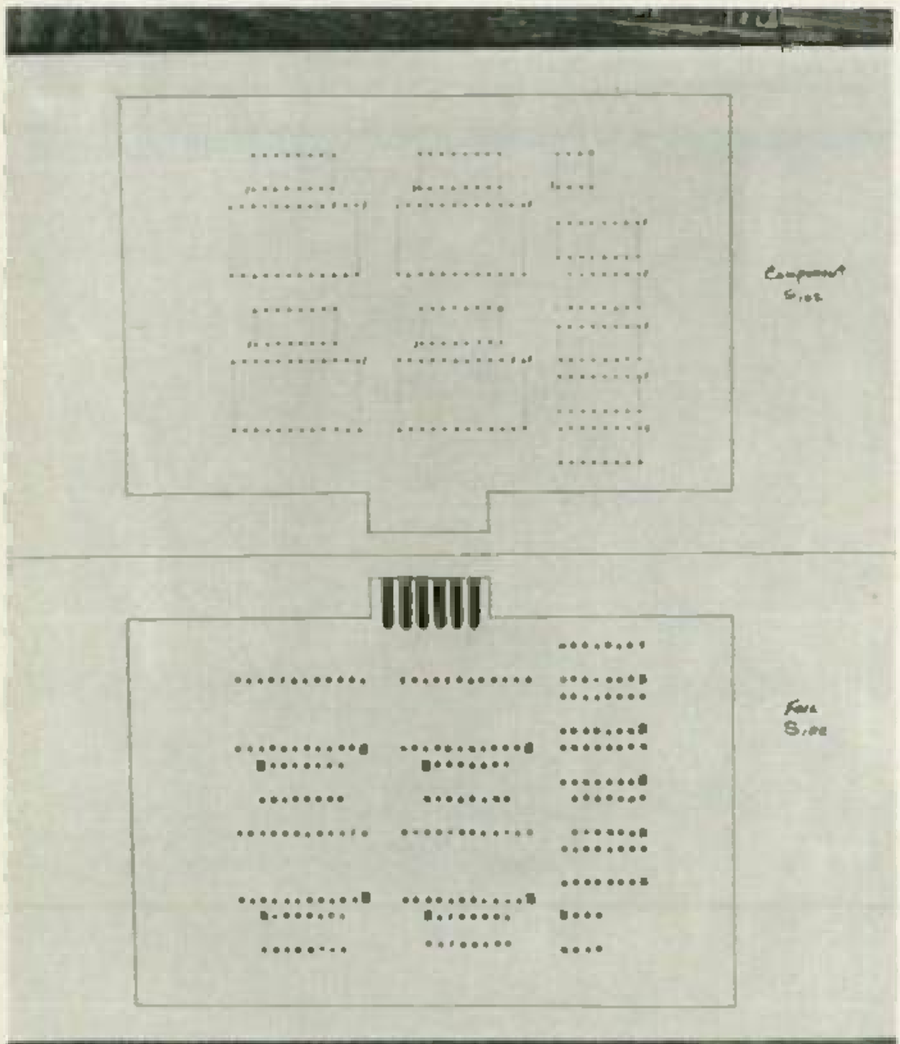


FIG. 4—A DOUBLE-SIZED LAYOUT showing the component placement. You can normally expect to change this layout as you go on.

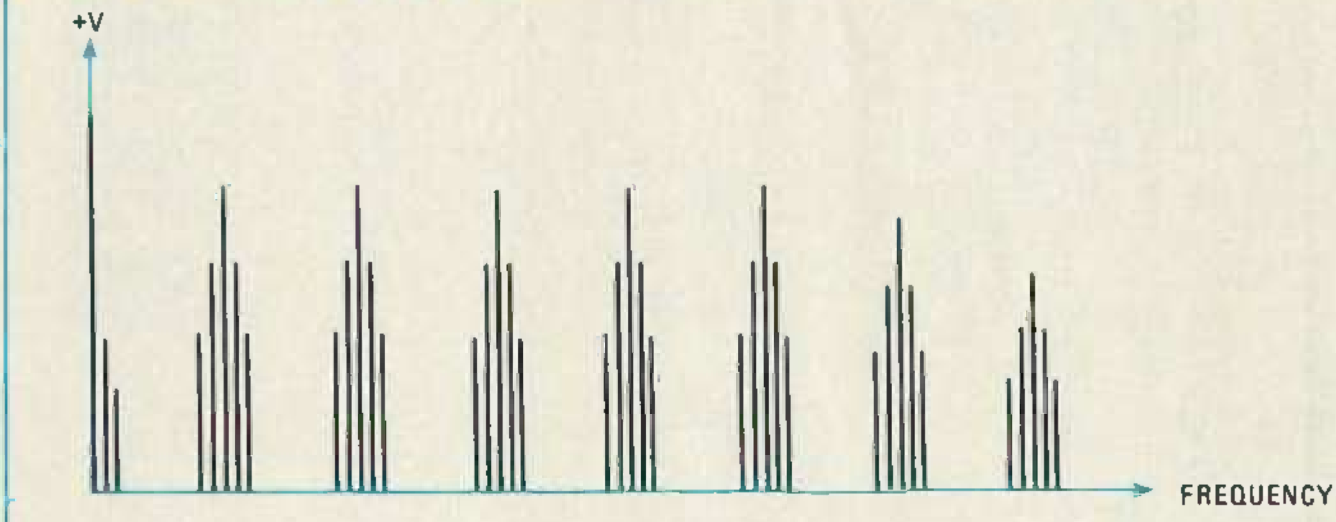
Routing the traces

As you can see in Fig. 4, there are six I/O connections on our board. Those edge-connector fingers are placed in the middle of one side because of size and space requirements on the motherboard to which this board connects. Three of the card-edge fingers go directly to two IC's on the board, so those two IC's are a good place to start.

As you start drawing traces, try to keep them as straight as possible. If you have to change direction, use drafting tools and make the angles definite rather than freehand curves since this is going to make it much easier when you actually tape up the final layout.

That's all we have room for this month. In the concluding part of this article, we will give you some more guidelines that can help make designing a double-sided board much easier. We'll also show you some of the pitfalls that can crop up in doing the design, and how to best avoid them. R-E

ALL ABOUT



COMB FILTERS for your TV

Learn all about comb filters, how they work, and how they can be used to improve the performance of your video system.

NEIL W. HECKT

Part 2 LAST TIME, WE COVered some of the basic principals behind the comb filter. We also looked at two devices, the PW600 and the TDA3301, that could be used to implement such a device. This month we'll take things one step further and show you an experimental NTSC decoder you can build that uses comb filter techniques.

An experimental decoder

The schematic diagram for our experimental decoder is shown in Fig. 11. The NTSC input of 1-volt P-P, negative sync, is AC coupled by a 10 µF capacitor (C1) to a voltage divider (R1, R2) which supplies a DC bias of 3.4-volts to the PW600 input, pin 3.

A 3.58 MHz color-burst reference, taken from the TDA3301 crystal oscillator, is applied to pin 7 of the PW600. The amplitude of that signal is 0.8-volt P-P, which was found to be just the right amount to run the PW600. It was necessary to place a 27-pF capacitor (C5) directly across pins 7 and 8 of the PW600 to ensure system lock-up. For the color-burst reference, the PW600 and TDA3301 are connected in a loop. The PW600 requires a locked 3.58-MHz burst to correctly separate the chroma signal, and the TDA3301 requires a correctly separated chroma signal to lock on the 3.58-MHz burst reference. The two essentially get together by bootstrapping the burst reference. Adjustment of the 3.58-MHz crystal tuning capacitor was initially critical, and the inclusion of C5 greatly accelerated the loop capture and made tuning of the crystal capacitor far less critical.

The luminance output, which is taken from pin 15 of the PW600, has a DC bias of 7.5-volts. An emitter follower (Q1) was included as an impedance match to the TDA3301. The 1000-ohm potentiometer (R6) in the emitter circuit serves as a luminance level preset and should be adjusted to produce a 1-volt P-P input at pin 37 of the TDA3301.

The chrominance output, which is taken from pin 1 of the PW600, has a DC bias of 4.7-volts. A PNP emitter follower was used to buffer the chroma output of the TDA3301. It is AC coupled to a 1000-ohm potentiometer, which serves as a chroma level preset and should be adjusted to provide 100-mV P-P at pin 1 of the TDA3301.

That is all there is to connecting the PW600. Just that much of the circuit could be added to any color-TV set to gain the improvements of the comb filter. A tap off the video detector, after the sound trap (which provides ½-to 1-volt P-P negative sync video), can be connected to the NTSC input. The luminance and chrominance outputs could then be connected to the normal luminance and chrominance inputs of whatever color-processing circuits are contained within the set. The TV set must also supply the needed voltages (−10 and +24 volts DC).

The PW600 comes factory-adjusted; however, if adjustments are needed, there are three that can be made. Those are shown in Fig. 12. To couple the circuit to an oscilloscope, loop one turn of wire around C23 on the module, and connect the free end to the scope. The three adjustments involve L6, L10, and C_{ADJ} (once again, those are part of the module itself); the positions of those components are shown in Fig. 12. Adjust L6 and L10 for the maximum signal at 10.74 MHz; adjust C_{ADJ} for minimum P-P horizontal sync as shown. For best results, any adjustments should be made in small increments, no more than a quarter turn at a time.

The TDA3301 provides a 3-volt P-P inverted luminance output at pin 35. One half of that is coupled to pin 36, which sets the value of luminance in the RGB outputs. The three-volt signal is also ideal to run a sync separator.

The three-volt output is AC-coupled to the base of a common-emitter transistor switch (Q8) that acts to clamp the positive-sync tips to slightly above ground. The transistor then acts as a switching amplifier, conducting for the sync tips only. The output is a squarewave representing the sync portion of the incoming luminance.

An MM74C221, dual one-shot (IC3), produces the sandcastle pulse. (Sandcastle pulses are used in color sets for black-level clamping of the luminance signals, burst keying, blanking, and chrominance

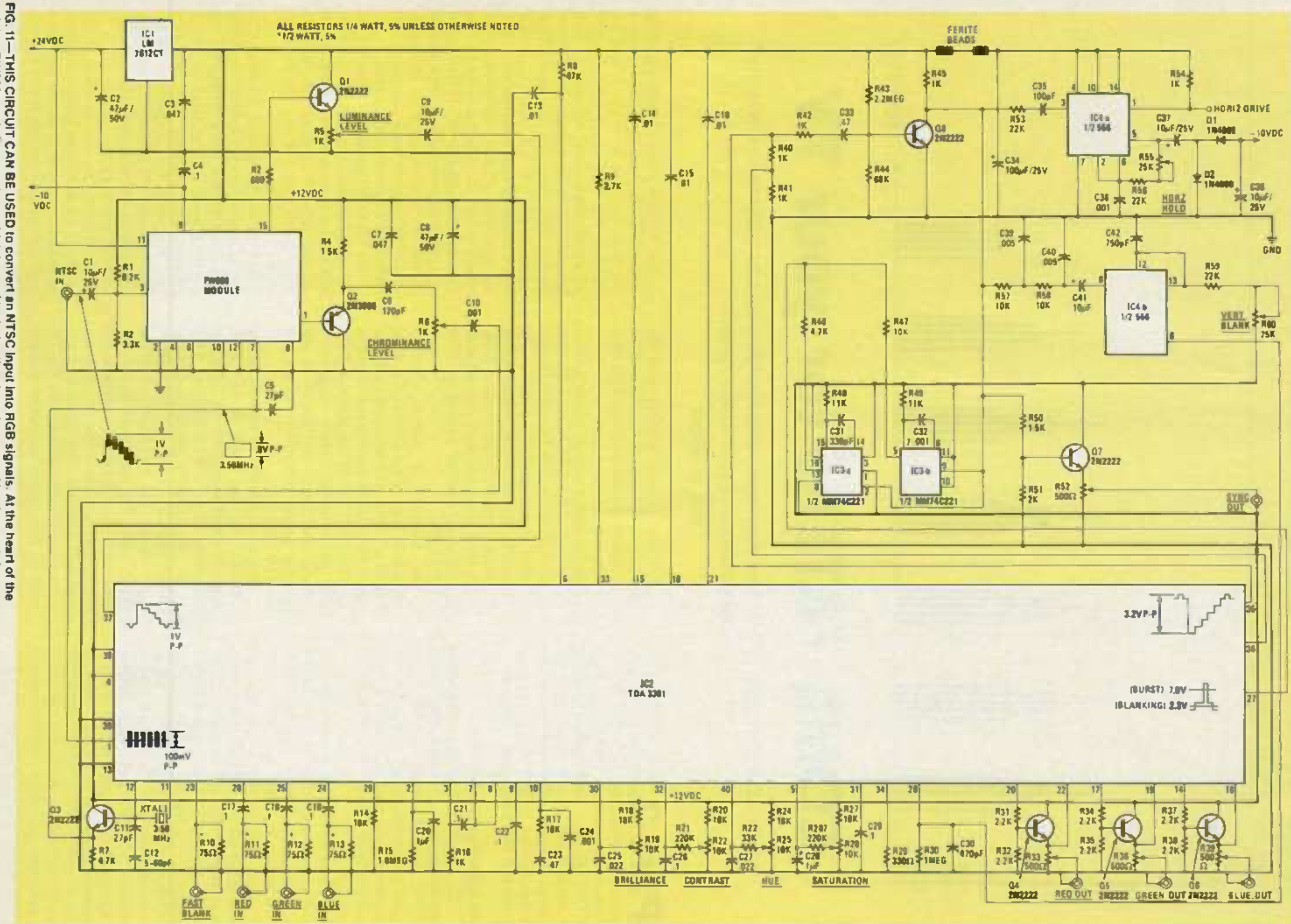


FIG. 11—THIS CIRCUIT CAN BE USED to convert an NTSC input into RGB signals. At the heart of the unit is a PW600 comb-filter module, which is used to derive the chrominance and luminance information from the input signal.

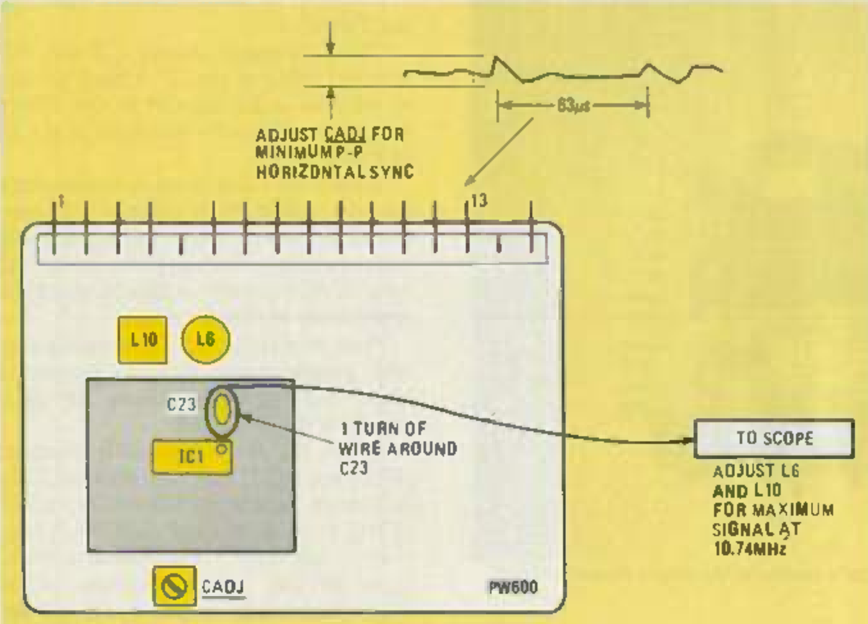


FIG. 12—IF THE PW600 requires adjustments, they can be made as shown here.

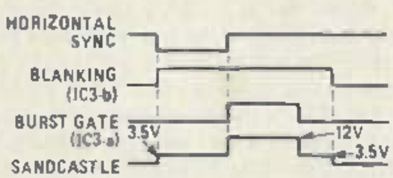


FIG. 13—THE HORIZONTAL SYNC, blanking, and burst gate pulses are used to derive the sandcastle pulse.

channel gating.) On the leading edge of a horizontal-sync pulse, IC3-b triggers, producing a 10-µs horizontal-blanking pulse. On the trailing edge of the horizontal-sync pulse, IC3-a triggers, producing a 3- to 4-µs burst-gate flag. The two one-shot outputs are added by R46 and R47 to produce the sandcastle (see Fig. 13). When neither one-shot is running (during active display time), the voltage at pin 27 of TDA 3301 is zero. When the blanking one-shot fires, the 12-volt output is divided by the resistors to produce a 3.5-volt blanking level at pin 27. When the burst one-shot fires, the blanking one-shot is still running. The voltage at pin 27 is then 12 volts. The specified blanking and burst thresholds of the TDA3301 are 2.3 volts and 7.5 volts.

An NE556 dual timer (IC4) is used as a horizontal-oscillator/ −10-volt power supply (IC4-a) and vertical-blanking one-shot (IC4-b).

Looking first at IC4-a, it is a free-running relaxation oscillator with a frequency of about 15,734 Hz. That frequency is set by R55, R56, and C36. The output from pin 5 has substantial current drive capability, and runs a "charge-pump" circuit composed of C37 and C38 and two 1N4000 diodes (D1 and D2). The output of that circuit is approximately −10-volts DC, which is used to satisfy the PW600's −10-volt DC power requirements. The oscillator is designed to be free-running so that that voltage will be generated with or without an input signal. The oscillator output is synchronized with the horizontal-sync signal via a 100-pF differentiating capacitor (C35) that instantaneously reduces the threshold voltage of the 556 timer at the leading edge of the horizontal-sync pulse. That is done so that any noise generated would tend to appear during horizontal blanking.

The other half of the 556, IC4-b, is connected as a one-shot. It is triggered by a conventional vertical-sync integrator (R57, R58, C39, and C40).

Since vertical sync is not required by the television monitor, why bother to detect it at all? The TDA3301 has a beam-current limiting circuit built in that samples only during vertical blanking. Without a vertical-drive input, the IC's output amplifiers assume an over-current condition and refuse to output anything. The TDA3301 can have the vertical blanking applied either to pin 27 as a super sandcastle pulse or directly to pin 28. For this circuit, we chose to apply it directly to pin 28 as that was the simplest method.

Two ferrite beads were required on the +12-volt DC supply line to the 556 in order to eliminate noise from the video output.

The sync output-amplifier is an emitter follower (Q7). Divider resistors R50 and R51 limit the output to about 5 volts P-P, which is suitable for most computer RGB monitors.

Oscillator and chroma section

Normally, the crystal oscillator consists of a crystal between pins 11 and 12, and a 12-pF capacitor from pin 12 to ground. The TDA3301 will operate without adjustment to the oscillator even when using low-grade crystals; however, it is necessary to "tap" the 3.58-MHz sinewave from the oscillator in order to drive the PW600. Emitter-follower Q3 is connected to pin 12. Since the resulting shunt capacitance of the emitter follower is unknown, a 5–60-pF trimmer capacitor (C12) is placed in series with a 27-pF capacitor (C11) to limit its range to a value of about 4- to 18-pF.

Normally the delay-line driver outputs (pins 3 and 4) are used to drive a PAL delay line to generate the U and V (color demodulator) inputs (pins 7 and 8). In this application, the collector of the delay line driver (pin 4) was connected to +12-volts DC, and an emitter load of 1000 ohms was placed in the driver emitter-circuit (pin 3), converting it to an emitter follower. The chroma information at pin 3 was then AC coupled to the U and V inputs by C21. That operates the color demodulators in the R−Y, B−Y mode.

On-screen display inputs

The on-screen display inputs are terminated in 75-ohm resistors. The high-speed blanking input is DC coupled and has a threshold of 0.7 volt. The RED, GREEN, and BLUE inputs are AC coupled and accept inputs of 0.7 to 1.0 volt P-P. Each of those inputs has a 9-MHz bandwidth.

Control section

The brightness, contrast, hue, and saturation inputs are all derived from similar circuits composed of 18K dropping resistors and 10K potentiometers. Those provide approximately zero to five volts-DC to each of the inputs.

The effective range of the brightness input is 1- to 4-volts DC, the contrast input 1- to 4.5-volts DC, the hue input 2- to 4-volts DC, and the saturation input 0.2- to 4.5-volts DC.

Output section

The output stages consist of emitter followers (Q4, Q5, and Q6). The TDA3301 expects to see a feedback voltage of about one half its output. Resistor networks such as R31/R32 divide the outputs by 2. The feedback is taken from the output of the emitter followers. Those provide about two-volts P-P maximum when adjusted to full level. Note that there is about a two-volt DC bias on the outputs. If the monitor to be driven has direct-coupled inputs, it may be necessary to add 10µF/10-volt electrolytic capacitors in series with the outputs. The vast majority of monitors are AC-coupled, however.

Normally a delay line would be connected between pins 35 and 36; however, the PW600 unit does not require a delay line. The normal function of the luminance delay line is to compensate for the delay introduced by the chroma bandpass filter. There is no equivalent filter in a comb-filter system.

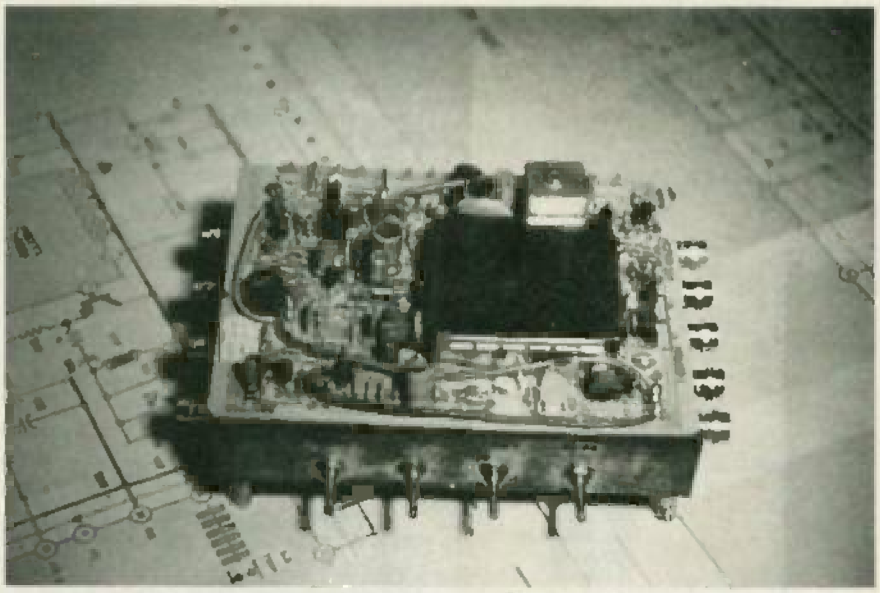


FIG. 14—THE AUTHOR'S PROTOTYPE. Here is the author's version of the circuit shown in Fig. 11.

Building the decoder

Figures 14 and 15 show the completed decoder. The TDA3301 and its associated circuitry were mounted on a piece of perforated construction board. The layout of the board is not critical. As usual, we recommend using IC sockets. The board and the PW600 were mounted on a homemade chassis made from scrap copper-clad solid stock. Once again, that is not critical, so the board and the module can be mounted in any enclosure that is convenient.

Completely wire the TDA3301 and supporting circuits before connecting the PW600. The TDA3301 and supporting circuits can be fully tested without the PW600 installed.

Checkout

Before installing any of the socketed IC's, run a preliminary power-supply check. With 24-volts DC applied, check the output of IC1 for +12-volts DC. Next, install IC4. Check for −10-volts DC across C38.

Next install IC2 and IC4. Connect a jumper from the junction of R1 and R2 (which will connect to pin 3 of the PW600) to the open end of R3 (which will connect to pin 15 of the PW600). That uses the network of R1/R2 to bias the emitter follower Q1 and couples video to the TDA3301 for luminance and sync tests.

Apply 1 volt P-P video from a color-bar generator or videotape player to the NTSC input. For a videotape player use the frame-freeze mode to provide constant waveforms for the oscilloscope.

Adjust the luminance preset (R5) for 1 volt P-P at pin 37 of the TDA3301. (That will have to be readjusted after installing the PW600.)

Check for approximately 3.5 volts P-P inverted video at pin 35. Check for detected sync at the collector of Q8. Check for proper sandcastle waveform at pin 27 of the TDA3301.

Assuming everything is satisfactory thus far, adjust the horizontal hold control, R55, until the horizontal-drive signal at pin 1 of IC4 is locked to the horizontal sync. If there are any problems, check the appropriate wiring for errors.

Next, adjust the vertical-blanking control, potentiometer R60, to produce a pulse width of approximately 200 µs at pin 28 of the TDA3301.

Adjust the brilliance (R19), contrast (R22), hue (R25), and saturation (R28) to half range. Adjust the RED (R33), GREEN (R36), BLUE (R39), and sync (R52) controls to full range. You should now observe positive video waveforms at the RED, GREEN, and BLUE outputs and approximately 5 volts P-P sync at the sync output.

Adjust the RED (R33), GREEN (R36), and BLUE (R39) levels to 1 volt P-P output each. That will set the RED, GREEN, BLUE drive levels equal so that white should result. If a TV monitor is connected to the RED, GREEN, BLUE, and sync outputs, a Black-and-White picture should be visible.

Finally, check for an approximately 0.8-volt P-P, 3.58-MHz signal at the emitter of Q3.

If all is fine, it is now time to connect the PW600. Once that is done, apply power and check for +24-volts DC at pin 11 and −10-volts DC at pin 9. Check for a luminance signal at pin 15 and a chrominance signal at pin 1. If the signal source is a colorbar generator, the waveforms are predictable and should be similar to those shown in the schematic (Fig. 11).

Adjust R5 for 1 volt P-P at pin 37 of the TDA3301, and adjust R6 for 100 mV P-P chrominance at pin 1 of the TDA3301 color demodulator.

Connect a color-TV monitor to the RED, GREEN, BLUE, and sync outputs and adjust C12 for color lock. Adjust the brilliance, contrast, hue, and saturation controls as you would on any color-TV set. You should now have an excellent picture and alignment is complete.

If the TDA3301 is not phase-locked to the color burst, the outputs at pins 1 and 15 of the PW600 will not be distinct on an oscilloscope. Adjust C12 until they appear as clean luminance and chrominance signals.

That completes the construction and adjustment of the unit. For the best possible picture, use the circuit with an RGB color monitor—such as those used in computer applications—that has very wide bandwidth video amplifiers with no sound or chroma notch filters. R-E

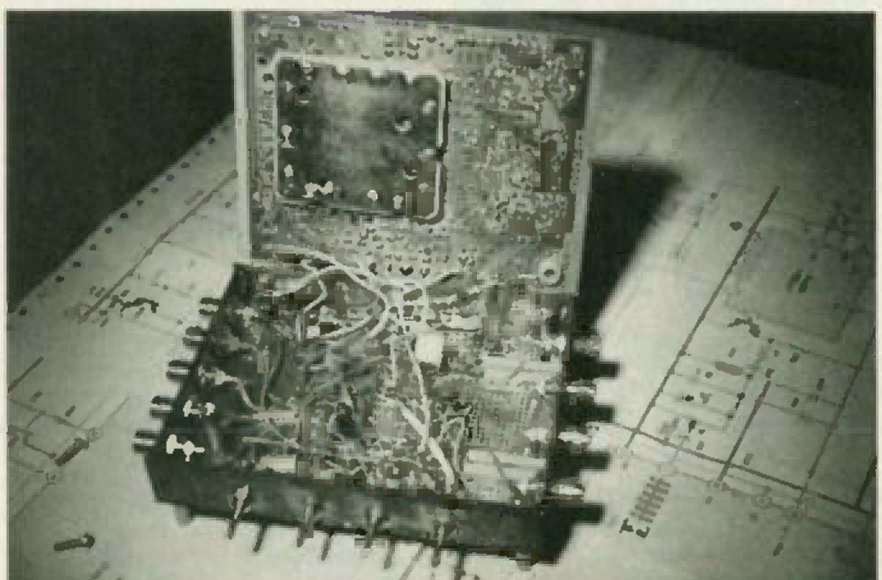


FIG. 15—INTERIOR VIEW of the NTSC decoder. The author mounted the PW600 and the board on a chassis made from scrap stock.

DESIGNING WITH DIGITAL IC'S

This month we learn more about flip-flops, and how they can be combined to form shift registers.

JOSEPH J. CARR

Part 6

LAST TIME WE LEARNED about some basic flip-flops. As we saw then, a flip-flop is a bistable device, meaning it can remain in either of two output states (set or reset). In the set state, the Q output is high, and $\bar{Q}$ is low.

There are four kinds of S-R flip-flops: NAND-logic S-R flip-flop, NOR-logic S-R flip-flop, clocked S-R flip-flop, and master-slave S-R flip-flop (also called a load/transfer flip-flop). The NAND and NOR S-R flip-flops are similar to each other, except for the "polarity" of the inputs (NAND-logic uses active-low inputs, while NOR-logic uses active-high inputs). In both types, a brief active signal to the S input forces the set condition, while a brief active signal to the R input forces the reset condition.

The clocked S-R flip-flop is an S-R flip-flop that uses a third input called clock. (Since the clocked S-R flip-flop is fashioned from NAND gates, its inputs are always active-high.) The clock input must be high before the circuit will respond to signals at the R and S inputs.

The master-slave (or load/transfer) flip-flop is another special case of S-R flip-flop. In that type of flip-flop, the R and S signal commands are stored in the flip-flop when the clock is low, but do not affect the output state until the clock input goes high. The clock input on that type of flip-flop is sometimes called the LOAD/TRANSFER or L/T input.

The T flip-flop

The T flop-flop, shown in Fig 1, is a cross-coupled master-slave flip-flop. In that circuit, the clock input is renamed the T input (for toggle). The T flip-flop is used primarily for binary division (divide-by-2). That is, the frequency of the output is exactly half the frequency of the T-input signal. That action occurs because the output of a T flip-flop changes only on the negative-going transition of the input signal (i.e. when the T-input makes a high-to-low transition).

J-K flip-flop

The equivalent circuit of a J-K flip-flop is shown in Fig. 2; the schematic symbol for that device is shown in Fig. 3. Note that that device is essentially a T flip-flop that uses cross-coupling though NAND gates. The "free" inputs of the two gates become the J and K inputs of the flip-flop, while the T-input is once again designated as a clock input (or CLK).

The J-K flip-flop has two different modes of operation: clocked and unclocked. In the clocked mode output state changes are synchronized with the clock signal. All action occurs on the negative-going (high-to-low) transition of the clock signal. If both J and K are low (i.e. logic 0), then no change occurs on clock line transitions. If J is low, and K is high, then a negative-going transition of the clock line forces the Q output low and $\bar{Q}$ high (that is a "reset" condition). If J is high, and K is low, then a negative-going transition of the clock line forces Q low and $\bar{Q}$ high (this is a "reset" condition). Finally, if both J and K are simultaneously high, then the J-K flip-flop will perform binary division in a manner similar to the T flip-flop (in other words, the output frequency will be one half of the clock frequency).

In most cases, the levels applied to the J and K inputs are quasi-fixed (for instance, in a binary divider J and K are always high). But don't be afraid to use the preceding rules in a dynamic manner. By doing that, you can perform circuit functions that are not immediately apparent from a quick reading of the preceding.

The unclocked mode makes use of the preset and preclear inputs shown in Fig. 3. In the unclocked mode, the J, K, and CLK inputs are ignored. Instead, the preset and preclear inputs are used to set the output of the device. Assuming that the inputs are active low, as is indicated in the diagram, applying an active low to the preset input forces Q high and $\bar{Q}$ low, while applying an active low to the preclear input forces Q low and $\bar{Q}$ high. Note that in most (but not all) cases, the preset and preclear inputs are active-low.

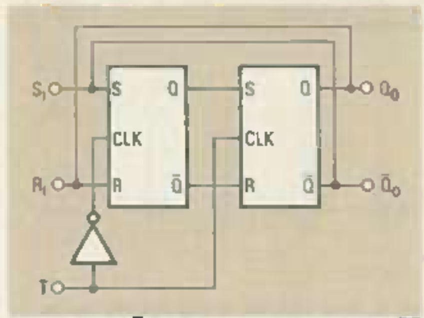


FIG. 1—TWO MASTER-SLAVE S-R flip-flops can be connected to form a T flip-flop.

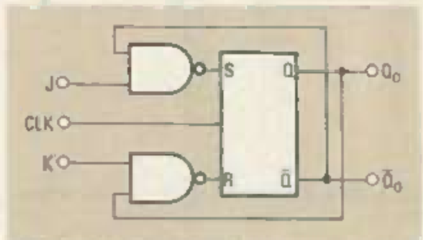


FIG. 2—SCHEMATIC DIAGRAM of a J-K flip-flop. Note that the heart of the circuit is an S-R flip-flop.

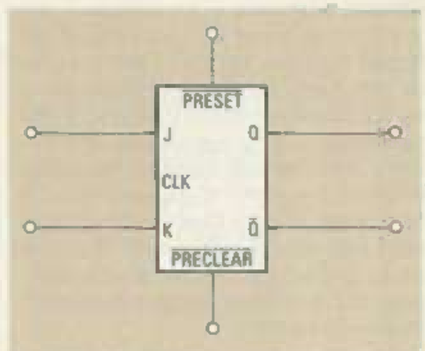


FIG. 3—SCHEMATIC SYMBOL for the J-K flip-flop.

It is good practice to tie unused inputs to the inactive state. For example, active-low preset and preclear inputs should be tied high when not used. That practice is used to prevent noise from triggering the input and thereby producing incorrect responses.

Note that signals applied to preset and preclear are momentary unless the design intent is to preclude response to other signals for awhile. The output changes, however, remain even after the preset/preclear input signals are removed.

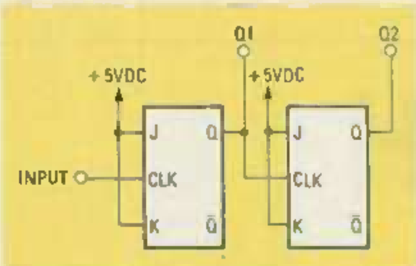


FIG. 4—J-K FLIP-FLOPS can be connected in series to obtain division by a factor greater than two. This two-flip-flop circuit, for example, provides division by four.

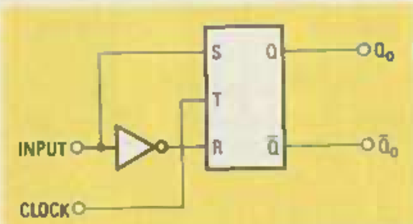


FIG. 5—THE ACTION of a D flip-flop makes it useful as a data latch, or one-bit memory.

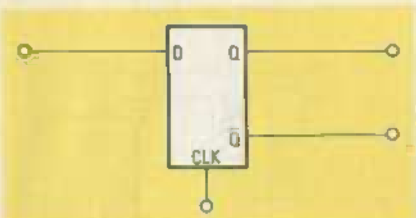


FIG. 6—THE SCHEMATIC SYMBOL for a D flip-flop.

We can cascade J-K flip-flops to obtain division by something other than two. Figure 4 shows two J-K flip-flops connected in series; that is, the Q output of the first flip-flop drives the CLK input of the second flip-flop. Since all J and K inputs are tied high, the flip-flops both act as binary dividers. The frequency of the squarewave at the Q output of the first flip-flop will be one-half the input frequency, while the frequency of the squarewave at the Q output of the second flip-flop will be one-fourth the input frequency. The chain can be extended further, with each additional flip-flop stage producing a further divide-by-two factor.

The D flip-flop

The basic D flip-flop is shown in Fig. 5; the schematic symbol for that device is shown in Fig. 6. As is shown in Fig. 5, the D flip-flop is basically a clocked S-R flip-flop where R and S inputs are fed from a common line, but, through the use of an inverter, are out of phase with each other. This common input line is designated the Data or D input.

Operation of the D flip-flop is simple: The signal present at the D input is transferred to the Q-output when the clock signal is active. In most D flip-flops, including the one shown in Fig. 5, the clock is active-high. In such a flip-flop the data transfer takes place when the clock signal goes high.

The characteristics of a D flip-flop makes it useful as a data latch (i.e. a one-bit digital memory). That's because signals input to the device during the interval when the clock is active remain at the Q output even after the clock signal has become inactive. Also, input signals during the interval when the clock signal is inactive do not affect the Q output. As a result, the data is said to be "latched".

Shift registers

Figure 7 shows an application of the D flip-flop: a shift register. The particular circuit shown in Fig. 7 is a five-stage serial input shift register. That circuit can output at Q1, Q2, Q3, Q4, or Q5 (parallel), or can provide a serial output.

Note in Fig. 7 that the D inputs and Q outputs of each flip-flop are connected in series, while the clock lines are all connected together. Thus, data presented to each register's input is shifted one stage to the right each time the clock line goes active.

An example of shift register operation is shown in Fig. 8. When the first clock pulse occurs (Fig. 8-*b*), the input to the first flip-flop in the register is high (Fig. 8-*a*), so output Q1 goes high (Fig. 8-*c*). At the second clock pulse, the input is low (and remains low) so a low is entered into the system. Output Q1 goes low, and the high that had been at Q1 is transferred to output Q2 (Fig. 8-*c*). At the third clock pulse the high on Q2 is transferred to Q3 (Fig. 8-*d*), the low on Q1 is transferred to Q2, and the low on the input is transferred to Q1. That process continues such that on each subsequent clock pulse, the original high is shifted one stage to the right until it has passed through the entire register.

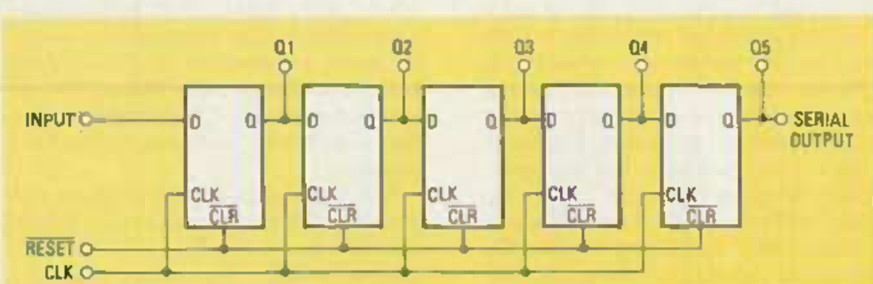


FIG. 7—A SERIAL-IN PARALLEL-OUT shift register can be fashioned by connecting D flip-flops in series as shown.

Shift register types

Shift registers are catagorized according to their input/output scheme. Typical types include *S*erial-*I*n/*S*erial-*O*ut (SISO), *S*erial-*I*n/*P*arallel-*O*ut (SIPO), *P*arallel-*I*n/*S*erial-*O*ut (PISO), and *P*arallel-*I*n/*P*arallel-*O*ut (PIPO).

In SISO registers, data is applied to the input in a "single-file" manner, and is output in the same manner. Data applied to the input is shifted one stage to the right on each clock pulse. One application of the SISO register is as a digital delay line. That's because the SISO register can be used to create a time delay between input and output of n + 1 clock pulses, where n is the number of stages in the register.

The circuit shown in Fig. 7 is an example of an SIPO register. Like the SISO, data is input to the circuit in single file fashion and is shifted one stage to the right on each clock pulse. Unlike the SISO, however, each stage has its own output. There may also be a serial output line, though if there is not, the last output of the the device may be used as a de facto serial output.

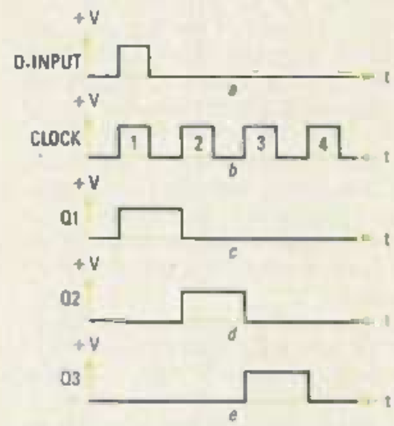


FIG. 8—TIMING DIAGRAMS for the shift register shown in Fig. 7. Note that the outputs of the first three stages only are shown.

In the PIPO register, inputs are fed simultaneously to each stage. Note that the first input of the register can be used as a de facto serial input, while the last output can be used as a de facto serial output.

Finally, the PISO register has parallel inputs, but only a serial output.

Figure 9 shows a SISO/SIPO register that is based on the J-K flip-flop. That circuit has four stages, although it could be shorter or longer if needed for a particular application. Note that all of the clock lines are connected together to form a master clock line, while all of the clear (or reset) lines are connected together to form a master reset line.

Except for the input stage, all J inputs are fed by the Q outputs of the preceding stage; likewise, all K inputs are fed by the Q̄ outputs of the preceding stage. The first stage is connected such that data is fed to the J input; that data is also passed through

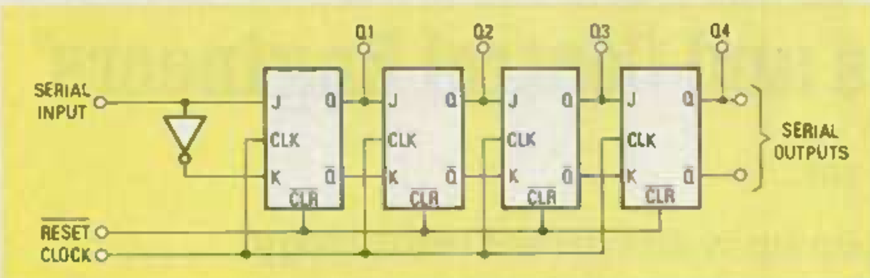


FIG. 9—THIS SISO/SIPO shift register is based upon the J-K flip-flop.

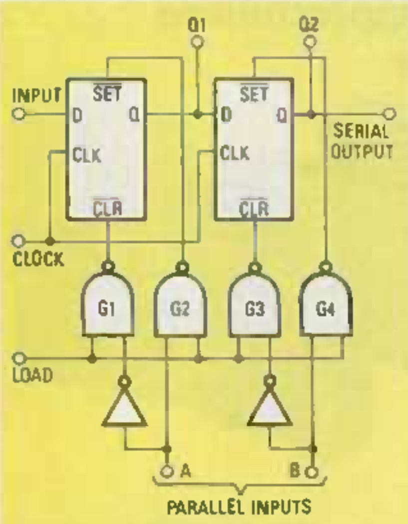


FIG. 10—DATA PRESENTED to the parallel inputs of this PIPO shift register is transferred to the outputs when the load line goes high.

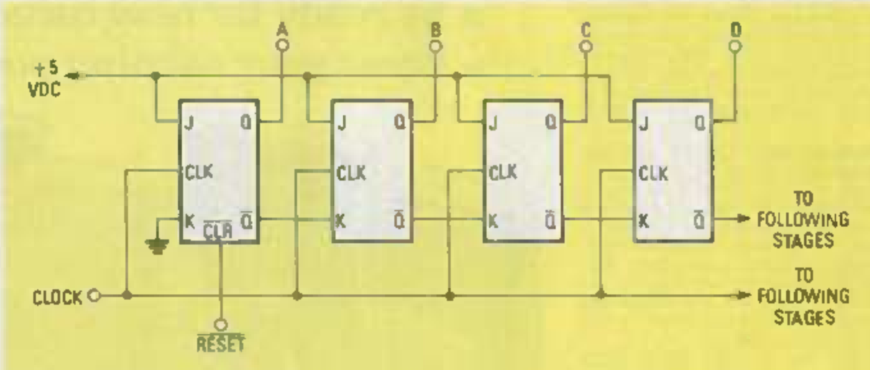


FIG. 13—THIS BUCKET BRIGADE device is analogous to an electromechanical stepper.

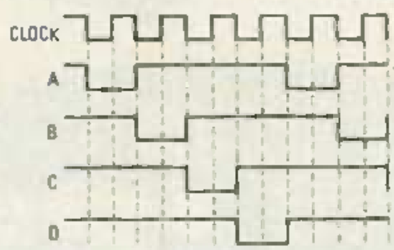


FIG. 14—TIMING DIAGRAM for the bucket brigade device shown in Fig. 13.

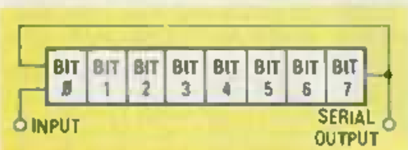


FIG. 11—BLOCK DIAGRAM of a recirculating shift register.

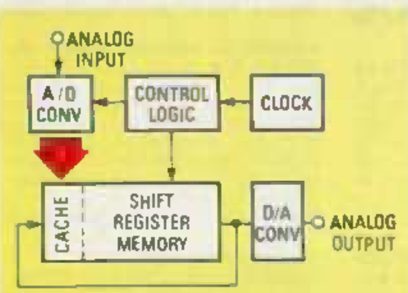


FIG. 12—A RECIRCULATING SHIFT REGISTER can be used as a memory in a digital storage oscilloscope.

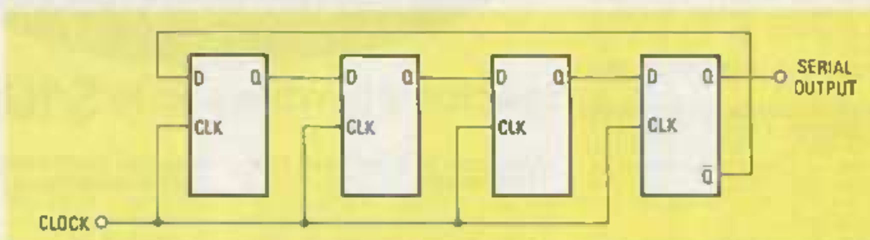


FIG. 15—A PSEUDO-RANDOM NOISE generator. The output of this circuit only appears random; instead it repeats after a long interval.

an inverter and fed to the first stage's K input. Thus, when a high is presented to the J input, a low is presented to the K input, and vice versa.

Let's see how that register works. First, let's assume that the input to the circuit is a high. That means that a high is presented to the J input of the first stage, while a low is presented to the K input. Due to the nature of the J-K flip-flop, the Q1 output will be forced high on the next negative going transition of the clock signal. Note that the J and K inputs of the second stage will now be presented with the first stage outputs of the previous cycle (that is, J will be high, while K will be low). On the next negative-going transition of the clock signal, the Q2 output will be forced high. And so on. The high will be passed one stage to the right on each subsequent negative-going transition of the clock signal until it is clocked out of the register.

Figure 10 shows a PIPO shift register; for the sake of simplicity, that particular register has only two stages. The circuit shown is built from D flip-flops. As in Fig. 7, a SIPO register built around D flip-flops, all of the clock lines have been connected together, and the input of each stage is driven by the Q output of the preceding stage. The D input to the first stage, together with the clock inputs, allow the PIPO to be used as either a SISO or SIPO shift register.

Now let's look at how the PIPO works. We'll discuss the circuitry attached to the A input; the B circuit works in just the same way. The LOAD line synchronizes loading of data at all stages (two, in our case).

Now A may be either high or low. When the load line is low, nothing happens, but when it is high, the input—high or low—will be latched at the Q output. That works as follows.

Assume that the load line is low. When it goes high, the data at A will force the flip-flop to be either set or cleared. If A is high when the load line goes high, the output of G2 will go low, setting the flip-flop. The input to G1 will be low, so its output will remain high, and the $\overline{\text{CLR}}$ input to the flip-flop will not be affected.

Conversely, if A is low, the input to G1 will be high, and its output low, thus clearing the flip-flop. The input to G2 will be low, so its output will remain high, and the $\overline{\text{SET}}$ input to the flip-flop will not be affected.

So you can see it is the inverter attached to the input that insures that the gates G1 and G2 will always have comlementary outputs, thus avoiding the situation wherein both the $\overline{\text{SET}}$ and the $\overline{\text{CLR}}$ inputs to the flip-flop would be low.

continued on page 101

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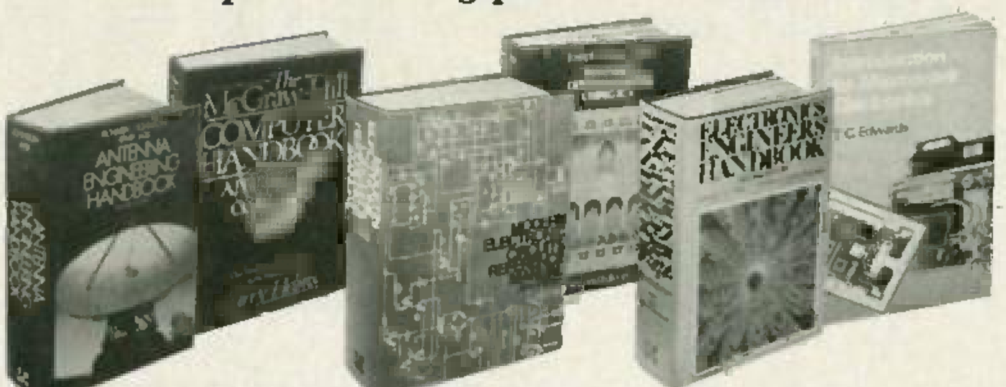

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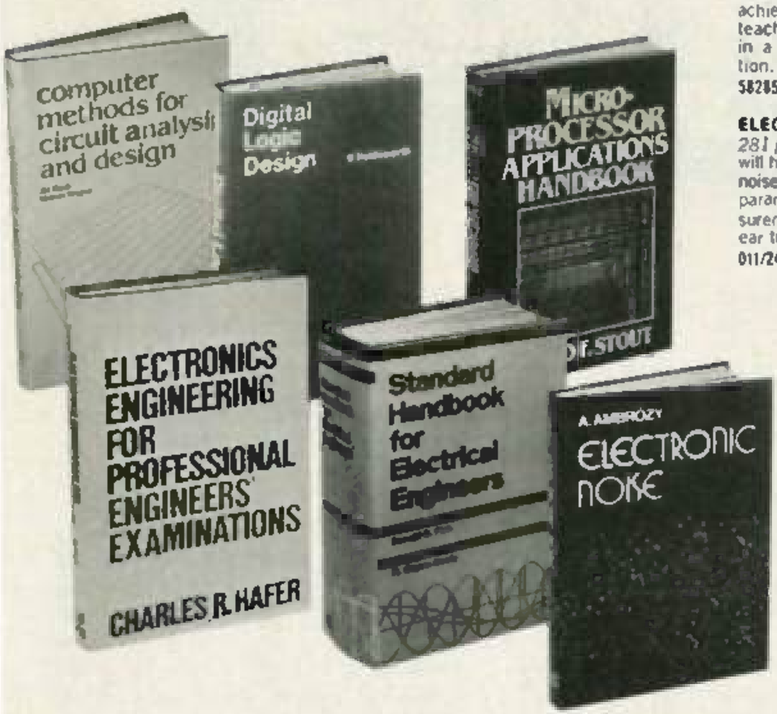

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BY BILL GREEN

Part 2

THIS MONTH WE SHOW you how to use the buffer. But first, lets finish the construction; have the August issue handy.

Now that the on-board components are mounted, mount the five switches on the front panel. See Fig. 5 and the parts-placement diagram of Fig. 4 (shown last month) to see how that's done. The power switch (S5) is a two-position toggle. The COPY switch (S4) is a pushbutton type, and the three FUNCTION SELECT switches (S1, S2, and S3) are SP3T, three-position toggle switches.

Connect a short piece of bare wire to the top terminal of S1, S2, and S3 and to one terminal of S4. Connect an insulated wire between that terminal of S4 and the pad above IC20 (a source of +5 volts). Connect another piece of bare wire to the bottom terminals of S1, S2 and S3. Connect an insulated wire between the bottom terminal of S1 and the pad indicated. Then connect the remaining insulated wires between the remaining switch terminals and pads shown. You might want to use a length of 6-conductor ribbon cable to make the connections between the switches and the board.

Use 6 inches of 20-gauge "zip cord" to wire the power switch, S5. Assuming that you'll use a SPDT switch for S5, the unused terminal should be the top one.

Connect 4 feet of 20-gauge "zip cord" to the AC input on the board. Run the cord through the hole in the back panel and connect the other end to the wall-mount power transformer (T1). Examine the board for solder shorts and correct installation of the components. If all looks good, plug the transformer in and turn the power on. Measure the voltage at pin 14 of IC18. If it is between 4.8 and 5.2 volts, turn off the power and install IC2, a 7404 hex inverter. Turn on the power and, using a scope, logic probe, etc., check for oscillation at pin 8 of IC26 (8 MHz). If all is well so far, turn off the power and install the remaining IC's. Remember that IC1 through IC10 are MOS devices. Handle them accordingly! Be sure that all IC's are in the correct locations and that pin 1 of each is oriented correctly.

TABLE 1—WIRING FOR THE COMMODORE 64

PLS3 pin	User I/O pin
SIN (7)	M
SINBUSY (8)	K
GND (5,6)	N
*SOUT (1)	C
*SOUTBUSY (2)	O

*Used only for output to C64

Turn on the power and check for a 2-MHz clock signal at pin 6 of IC1. Then check for activity on the data and address buses. If all seems well the unit is probably working properly. If not go back and check for the obvious or even the extremely obvious.

We can't be too specific about how to prepare your cables and connectors. Your printer and computer manuals will be of help. Ten- and fourteen-pin female IDC header connectors may be used with flat cable, or the appropriate chassis mount connectors may be installed on the back panel. The pinout of the header connectors are shown in the schematic.

The PARALLEL INPUT (PL1) and PARALLEL OUTPUT (PL2) ports operate with active-low STROBE and ACKNOWLEDGE and active-high BUSY signals. On the PARALLEL IN connector, an extra ground pin is provided for a PAPER EMPTY signal if needed.

The serial I/O channels operate with high start bits and low stop bits and busy signals. The handshake is hardware—XON/XOFF is not supported.

Using the *Commodore 64*

Those of you with *Commodore 64* computers know that the user I/O port is not RS-232 compatible, and that some of the code from it is not standard ASCII. This

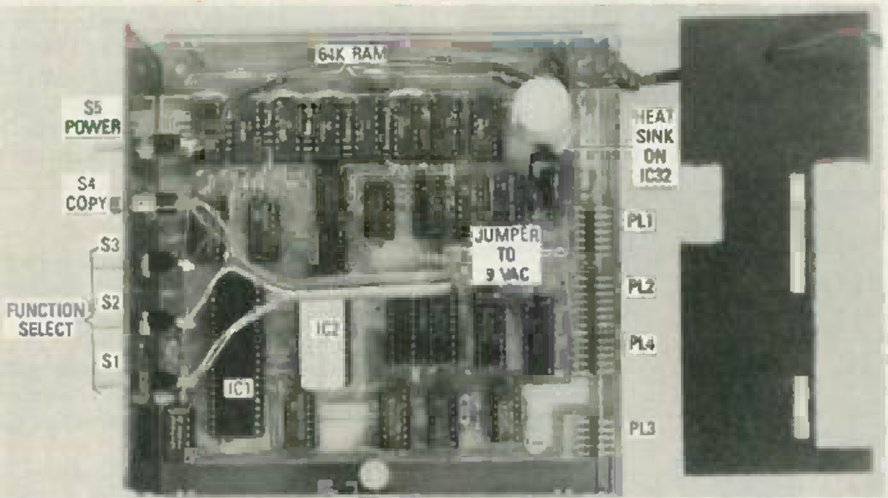

FIG. 5—THIS PHOTOGRAPH SHOWS THE PRINTER BUFFER with its cover removed. Note the heat sink on the regulator and note the jumper that brings 9 volts AC to header plug PL4. See the text for information on how to mount that header.

FIG. 6—EPROM PROGRAMMER PARTS PLACEMENT. Note that SO2 is a ZIF type socket. Note the jumper that runs from the board to the 5- to 25-volt converter.

buffer is designed to compensate for those differences but, of course, only when the function-selection switches are set for operation with the Commodore 64. The wiring for the 64's user I/O port is shown in Table 1. Keep in mind that the buffer will let a standard printer be used with a Commodore computer, but not the other way around: You cannot convert the output from a standard computer so that it can use a printer designed for the Commodore.

With a few changes to the hardware of the buffer, you can use the *C-64* like any serial I/O computer with the switches set as you would for other computers. The code from the *64* will not be converted in this case. To make the change for serial input from the *64*, connect a jumper from pin 3 of IC27 to pin 9 of PL3. To make the change for serial output to the *Commodore 64*, connect a jumper from pin 6 of IC27 to pin 3 of PL3. When you make up the cable for the *Commodore 64*, wire it for the new connections to PL3.

Install the finished board in a suitable case using three screws. Be sure to use a plastic insulating washer under the screw near IC27. If you're using the case indicated in the Parts List, install the front and rear panels and the top cover. Secure the cover with the screws provided and attach the 4 rubber feet to the bottom of the case.

EPROM programmer assembly

Assembling the EPROM programmer option is not difficult—especially if you use a printed-circuit board. The foil patterns can be obtained from the source indicated in the Parts List, or you can etch your own. The patterns for the double sided board are printed in the special "PC Service" section.

A parts-placement diagram for the EPROM programmer board is shown in Fig. 6 to help you during assembly. Start by installing SO1—a 26-pin female dou-

PARTS LIST—EPROM PROGRAMMER

All resistors 1/4 watt, 5%
R19—10,000 ohms
R20, R21—1000 ohms
R22—470 ohms
Capacitors
C11—1000 µF, 25 volts, electrolytic
C12, C13—0.1 µF, ceramic disc
Semiconductors
IC28–IC30—74LS373 octal D-type latch
IC31—7404 hex inverter
IC33—LM340 5-volt regulator
D2—1N4001
D3—3.9 volt Zener
D4—22 volt Zener
LED1—TIL220 standard red LED
Q1–Q3—MPS5172
Other components
S6,S7—SPST Toggle
S8—8-position DIP switch (only 7 positions are used)
SO1—26-pin female right angle header
SO2—28-pin ZIF socket
5- to 25-volt converter (TDK)

The following are available from: Alpha Electronics, PO Box 1005, Merritt Island, Florida 32952, 305-453-3534: buffer board, $26.00 postpaid; program ROM (91341) $26.00 postpaid, EPROM programmer PC board, $15.00 postpaid. A complete BufferLink kit (includes all parts except computer connectors and cables) $139.00 plus $5.00 shipping and handling; complete EPROM programmer kit $49.00 postpaid.
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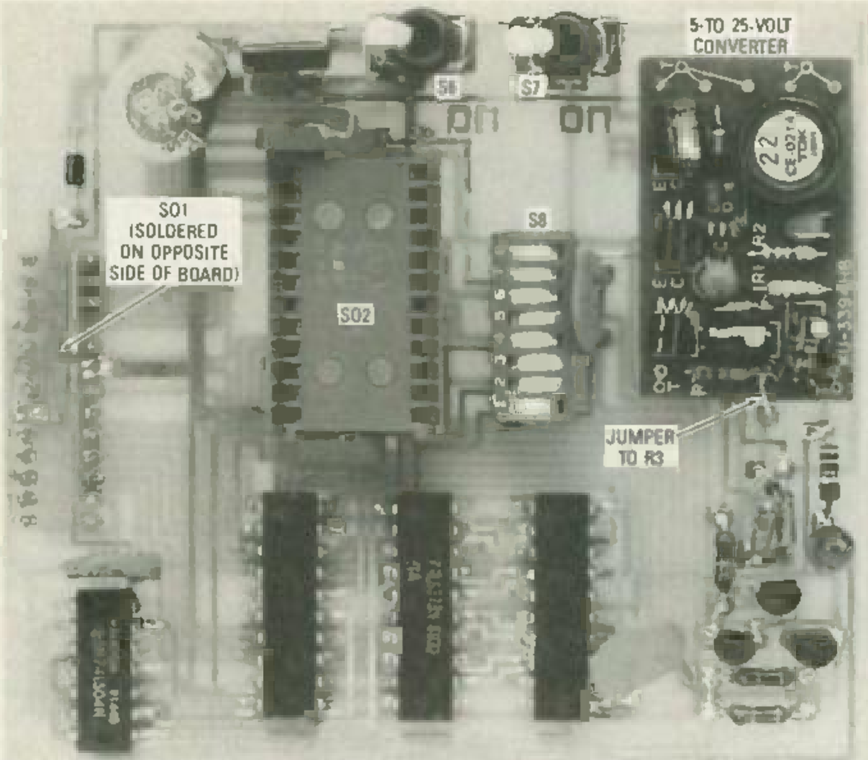


FIG. 7—THE EPROM PROGRAMMER BOARD. Note that the ZIF socket shown is a 24-pin type, although a 28-pin socket should be mounted. Note also that the DIP switch is an 8-position type, even though only 7 positions are shown. (Just try to find a 7-position DIP switch!)

TABLE 2—SETTING THE FUNCTION SELECT SWITCHES

IN	OUT	S3	S2	S1
Parallel	Parallel	0	0	0
Parallel	S300	0	0	1
Parallel	S600	0	0	2
Parallel	S1200	0	1	0
S300	Parallel	0	1	1
S600	Parallel	0	1	2
S1200	Parallel	0	2	0
S300	S300	0	2	1
S300	S600	0	2	2
S300	S1200	1	0	0
S600	S300	1	0	1
S600	S600	1	0	2
S600	S1200	1	1	0
S1200	S300	1	1	1
S1200	S600	1	1	2
S1200	S1200	1	2	0
C64 S1200	Parallel	1	2	1
C64 S1200	S300	1	2	2
C64 S1200	S600	2	0	0
C64 S1200	S1200	2	0	1
Read 2716	EPROM	2	0	2
Read 2732	EPROM	2	1	0
Read 2764	EPROM	2	1	1
Program 2716	EPROM	2	1	2
Program 2732	EPROM	2	2	0
Program 2764	EPROM	2	2	1
Download	—	2	2	2

TABLE 3—SETTING S8

	S8-a	S8-b	S8-c	S8-d	S8-e	S8-f	S8-g
2758	OFF	ON	ON	OFF	ON	OFF	OFF
2716	OFF	ON	ON	OFF	ON	OFF	OFF
2732	ON	OFF	ON	OFF	OFF	ON	OFF
2732A	ON	OFF	ON	OFF	OFF	ON	ON
2764	OFF	ON	OFF	ON	OFF	ON	ON

ble-row header—on the *solder side* of the board. Leave as much clearance as possible between the board and S01. If you don't, you'll have trouble plugging your other connectors into the buffer. Next install sockets for the all IC's except, of course, for the regulator. The EPROM socket, SO2, should be a 28-pin ZIF (Zero *I*nsertion *F*orce) type. Then install D2, LED1, the Zener diodes D3 and D4, and the transistors. Make sure that you orient those parts correctly! Then install the resistors and capacitors. Install the voltage regulator IC33 noting that the metal tab should be on the outside of the board.

Next install the 5-volt to 25-volt converter. You'll have to add one jumper from the converter to the board. It runs from the pad on the board above the Zener diodes to the end of R3 (that's R3 *on the converter board*) nearest the 5-volt input pin. Figure 7 shows just what that jumper looks like.

Install all of the switches. Note that they are all board-mounted on the author's prototype. Orient S8 in the same way as it is shown in Fig. 7. The first switch section should be toward the IC's.

Now it's time to plug the IC's in their sockets and to plug the finished programmer assembly, with the components up, onto PL2 and PL4 of the buffer. Turn S6 off, and power up the buffer. Check for 5 volts at the output of IC33. The EPROM socket, SO2, should be empty. Switch S7 to the READ position, and turn S6 on. With S8-g off, there should be about 25 volts at the cathode end of Z1. With S8-g on, there should be about 21 volts.

Using the buffer

Connect the buffer to your computer and printer(s). Before you turn anything on, remember these cautions.

- Apply power to the buffer *last*.
- Before first turning on the buffer each time, set the FUNCTION SELECT switches for the input and output operation that you want.
- Only now should you apply power.

Table 2 shows the 27 settings of the FUNCTION SELECT switches, S1, S2, and S3. Remember, those switches should be set for the function that you want before you turn on the power. Note that in Table 1, the settings for serial operation are indicated by Sxxx, where xxx is the baud rate.

After the power has been applied, or any time after completion of printing (or other function), you may change the switch settings. But you must hold the COPY switch (S4) closed until you have changed the switches to the new function.

A reset switch was not added to the buffer because resetting the Z80 will waste the contents of the dynamic RAM. If you need that capability, you can install a reset switch by connecting a normally open pushbutton switch across capacitor C7. (For safety's sake, mount the new switch on the back panel.) Remember that you can always reset the Z80 simply by turning the power off and back on. The contents of the memory will be lost in either case.

Printing with the buffer

To use the buffer with your printer, set the switches for the desired input and output combinations. After printing is completed, you can print another copy of the buffer contents. Simply press and hold the COPY switch (change the switches if you wish a different output), release the switch, and press it again after a short delay. There is a timing loop involved here that you must get fairly close. It isn't difficult and with a little practice you will master it. If you didn't get it the first time, just try again.

How to download a custom program

You can easily download a custom operating program to the buffer. Set the function switches according to Table 2. (Only parallel and serial at 1200 baud may

(Continued on page 103)

PC SERVICE

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!

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.

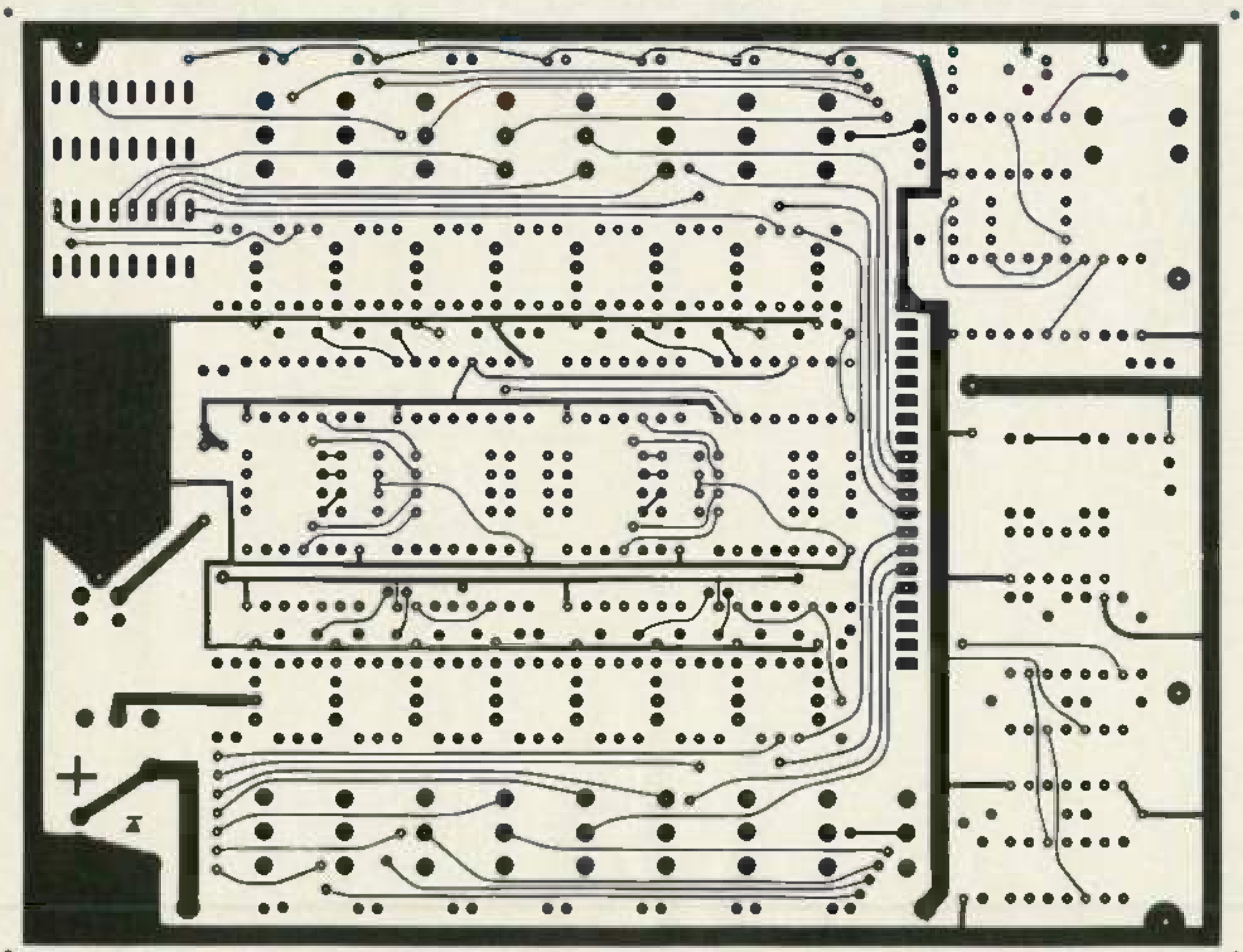
An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any oil on the front side of the paper (the side with the pattern) because you'll contaminate 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 because we don't know what kind of light source you use. As a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method to use with the chemicals you're familiar with. And once you find it, stick with it. Don't forget the "three C's" of making PC boards—care, cleanliness, and consistency.

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
200 Park Avenue South
New York, NY 10003

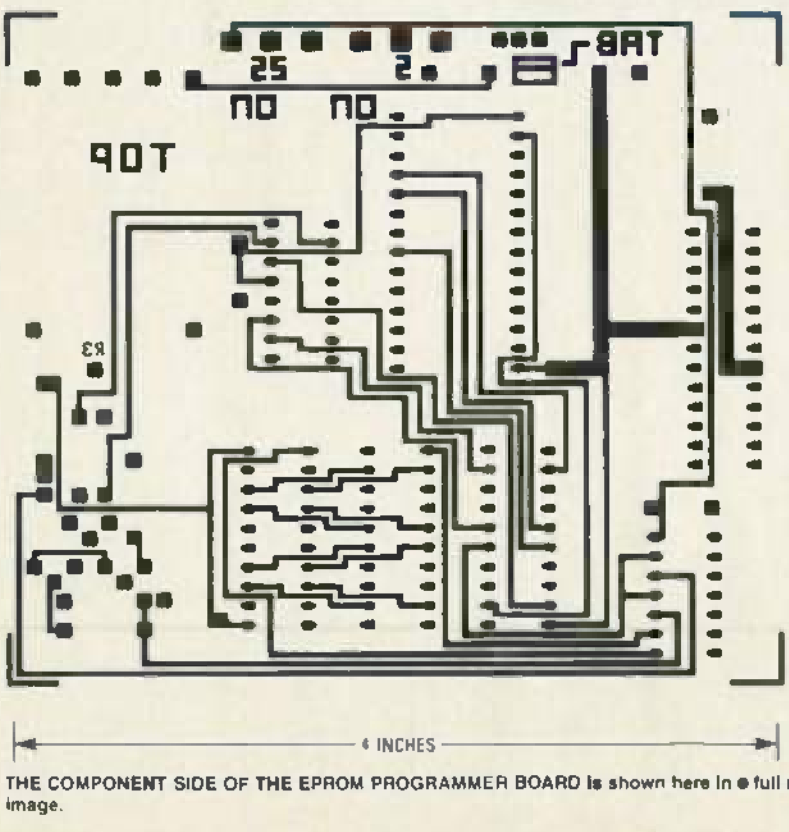
PC SERVICE



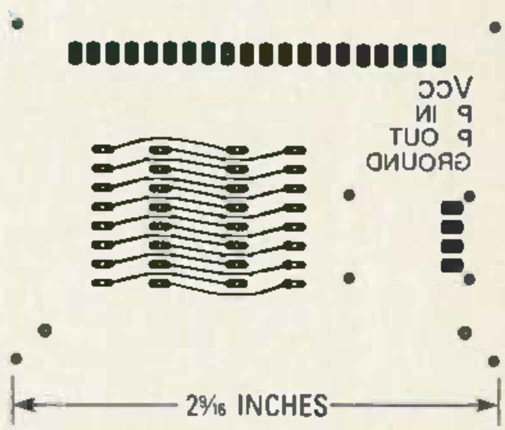
6½ INCHES

THE COMPONENT SIDE OF THE IC-TESTER BOARD is shown here as a full-sized mirror image. The solder side will appear here next month.

PC SERVICE

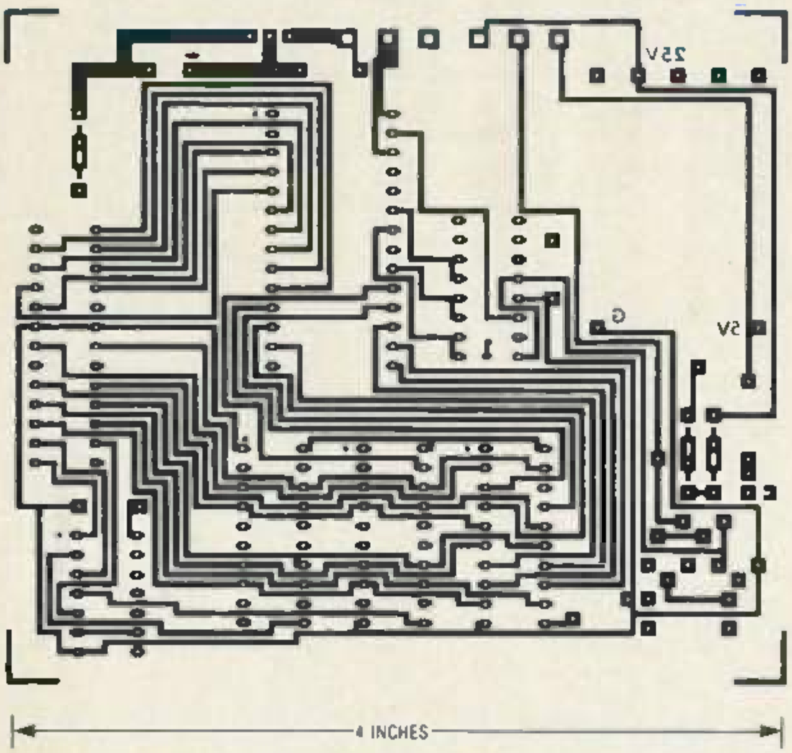


THE COMPONENT SIDE OF THE EPROM PROGRAMMER BOARD is shown here in a full size mirror image.

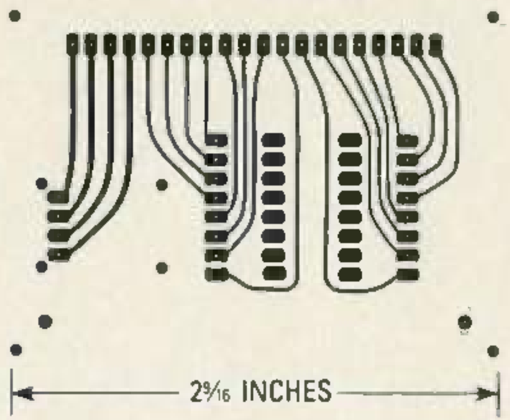


THE COMPONENT SIDE OF THE "B-SOCKET" board for the IC tester is shown here in a full-size mirror image.

PC SERVICE



THE SOLDER SIDE OF THE EPROM PROGRAMMER BOARD. See page 78 for more information.



THE SOLDER SIDE OF THE "B-SOCKET" BOARD for the IC tester. See page 59 for more information.

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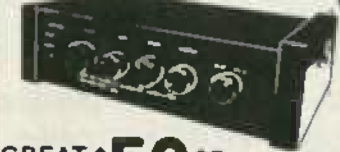

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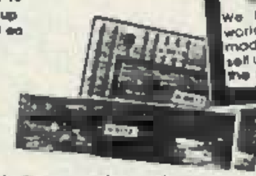

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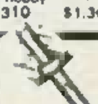

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Risetime	[illegible] nsec
Overshoot	[illegible]
Modes	CH1, CH2, DUAL, ADD, X-Y
Input Impedance	1 M / 28pF ±3 pF
Max Input	600V p-p or 300 VDC + peak AC
Chop Frequency	200 kHz
Channel Separation	[illegible] dB at 1 kHz
Time Base	Auto or triggered. In Auto Mode trace is on without input signal
Sweep Time	0.2 sec to 0.5 sec/div on 20 ranges in 1-2-5 step, x5 Mag
Linearity	[illegible]
Triggering	Sensitivity int 1 div or more, [illegible] Source Int, CH2, Line, [illegible] Auto range 20 Hz to 20 MHz, Sync AC, HF Rej, TV
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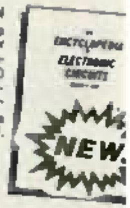

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ROBOTICS EDITOR

Building a robot from the bottom up.

IN THE FIRST FEW ISSUES, WE COVERED building a robotics laboratory and talked a little bit about robotic basics. This month, we'll go a little farther and build a simple programmable motion platform. The platform is essentially two wheels mounted on a plywood structure on which your control electronics will be secured.

What can you do with a programmable motion platform? Well, a path-navigation system and various control circuits can be built and studied using such a platform. We've all seen movie and TV robots that roll around on two or more wheels, or those that walk on legs. Although walking robots do exist, they are extremely hard to build; especially for the amateur experimenter. Given that fact, we'll stick with rolling robots, at least for the time being.

Motion platform

Figure 1 shows how the movement of the robot depends on the direction in which each wheel is spinning. When both wheels are turning in the same direction (say forward, as indicated by the arrows in Fig. 1-*a*), the robot moves forward in a straight line. When the rotation of both wheels is reversed, so is its direction, as Fig. 1-*b* shows.

But when, as Fig. 1-c shows, the right wheel is turning forward and the left wheel is rotating in the reverse direction, the robot turns or pivots left. The robot will turn right when the directions of those wheels are reversed (see Fig. 1-*d*). Thus, depending on the rotation of the two wheels, you can make your robot move in any of four different directions. There is, of course, another essential part of the platform—casters, which are used to stabilize the back-and-forth rocking of the robot during motion.

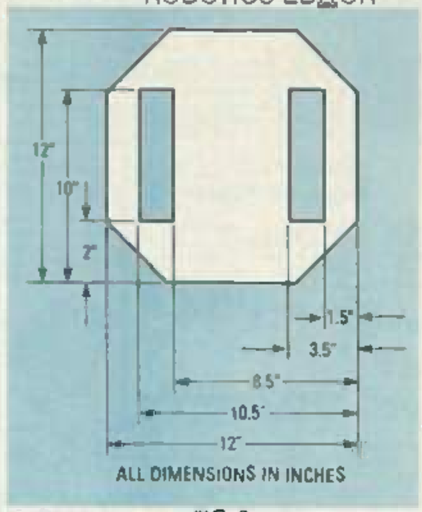


FIG. 2

The control electronics, including motor drivers, a complete computer-controlled system with various sensors, and even an arm, can be easily mounted on a plywood base. We'll discuss those and other options in the coming months; but for now, let's stick to our two-wheeled device.

The construction of the platform is fairly simple. The first thing you'll need is a base. Plywood was chosen because it's easy to work with, readily available, and relatively inexpensive. And if you make some horrendous mistake, you can easily toss out that piece of wood and start all over again. (That's a sharp contrast to machined aluminum, which tends to be rather expensive and adds a considerable amount of weight.)

Figure 2 shows a simple octagon-shaped base, but you could just as easily use a cylindrical or a square shape for the platform.

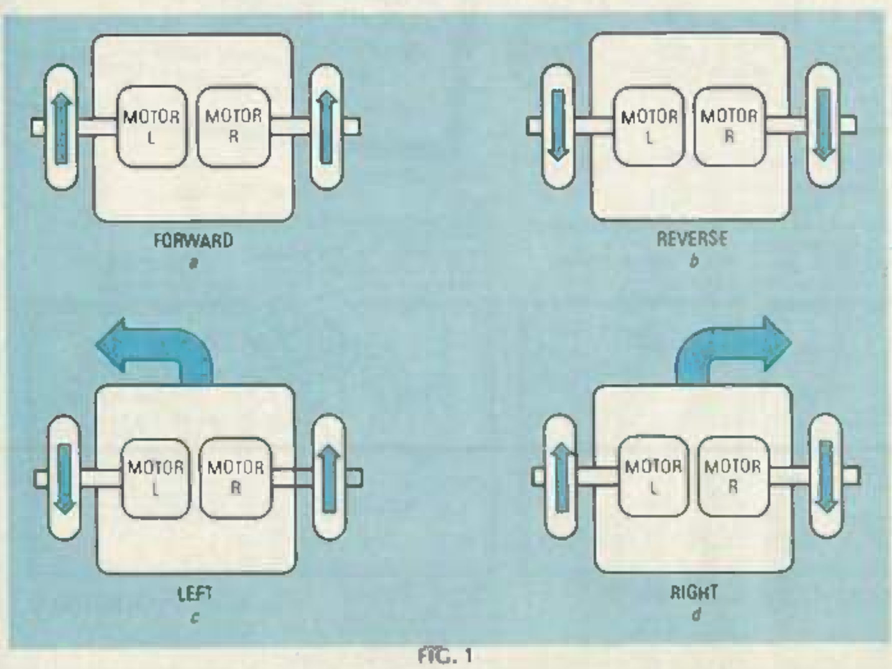


FIG. 1

Making an octagonal base requires only that you cut the corners off a square piece of wood; that is certainly easier than trying to make a perfect circle. The plywood should be ¼- or 5/16-inch thick, whichever is easier for you to find. The wood need not be any thicker than that. Cut the wood according to the dimensions shown in Fig. 2.

When building such a base, a double-axle wheel assembly makes the job a snap. A double-axle assembly is simply two motors connected to independent axles and housed in a plastic case with the proper gearing to provide enough torque to move the robot. (Don't worry about the terminology used, we'll devote some time to it in the future.)

The final assembly of the robot platform includes mounting the wheels, which should fit perfectly on the shafts of the double-axle motor assembly. Mount the motor onto the wooden base using metal or plastic stand-offs. The wheels should protrude through the bottom of the wooden platform. The finished platform with all components in place is shown in Fig. 3. Once done, it's time to think about building the motion-control circuits.

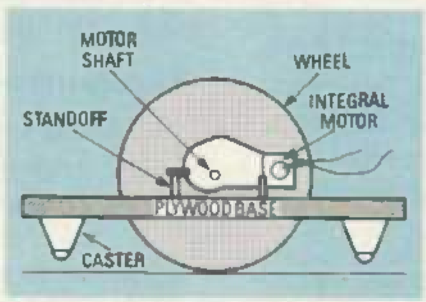


FIG. 3

Controlling the platform

Two simple hookups to control the platform's motion are shown in Fig. 4. Assume that there are two such circuits in each example, one to control the left wheel and the other to control the right.

Figure 4-*a* shows a manual switch setup that, along with a length of wire from the motors to the switches, can be used to control the robot's movement. When S1 is pressed, the motor rotates in one direction; when S2 is pressed, the motor rotates in the opposite direction.

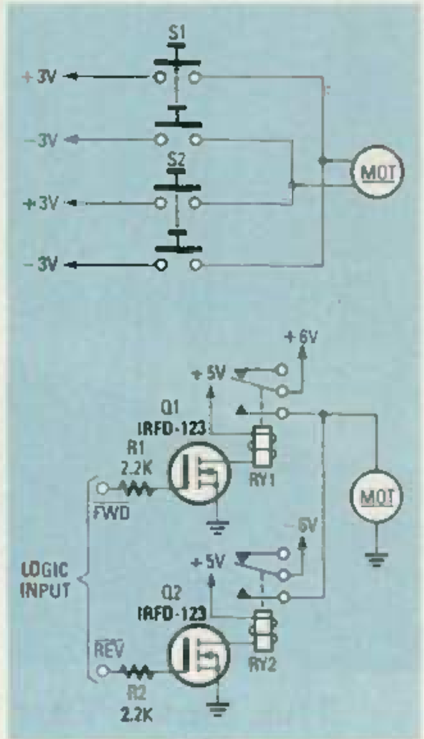


FIG. 4

That simple setup is great for demonstration purposes. But it's more likely that you'll want to interface your robot to a personal computer. To do so, you'll need a circuit like that shown in Fig. 4-*b*. In that scheme, a logic signal turns on a MOSFET transistor, Q1 or Q2, which then energizes its associated relay. Depending on which transistor is turned on, the motor rotates in either a forward or reverse direction.

The driver circuit, a FET transistor, requires little power. If the specified unit (rated 60 volts at 400 mA) is unavailable, feel free to make substitutions. The relays can be any type that suits the motor's power requirements.

It's a simple matter to write a short program that lets your personal computer control the platform. Figure 5 shows a simple flow chart for designing a control program to activate the motors. Let's assume that this program is looking at a four-button keyboard, one for each direction. When the forward button is pressed, both motors are turned on in the forward motion. Pressing the right-turn button, however, causes the

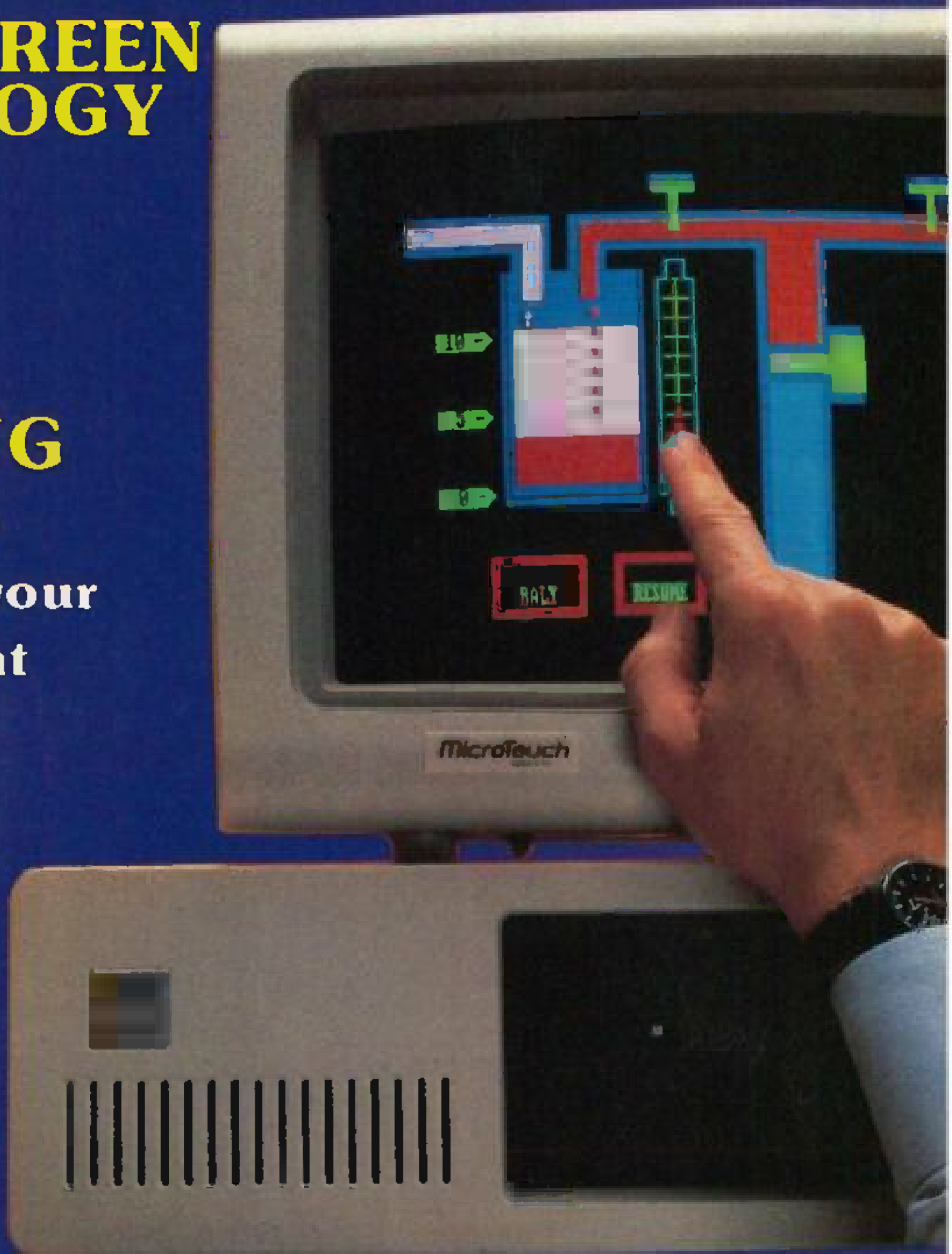
VOL. 2 NO. 9 September 1985

COMPUTER DIGEST

NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

TOUCHSCREEN TECHNOLOGY

Inputting the easy way.



EMULATING PRINTERS

How to make your printer do what you want.

A GERNSBACK PUBLICATION

VOICE REPRODUCTION FOR YOUR TIMEX

More than 5 seconds of speech with 16K.

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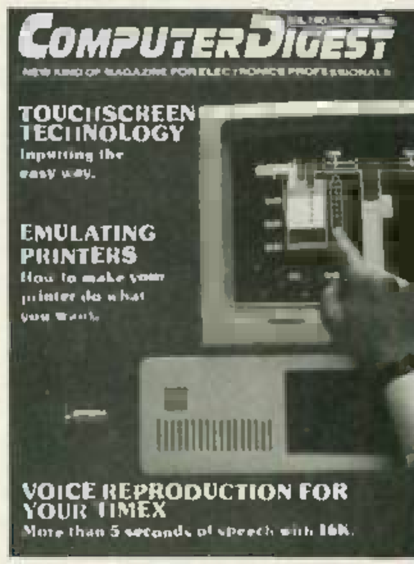
ON THE COVER

The new, lower-cost MicroTouch Screen™ employs technology to offer a combination of durability, optical clarity and high resolution not previously attainable to touch screen users. The screen, just announced by MicroTouch Systems, Inc., features a solid glass overlay sensor with a resistive coating bonded to its surface. See page 8.



COMING NEXT MONTH

Build A Firmware Card
It allows you to place a 2K or 4K EPROM anyplace in the USR memory of your Timex/Sinclair 1000.

Protecting Your Electronic Equipment
How to use MOV's (*Metal Oxide Varistors*) to protect against surges.

Computer Aided Design
Using your computer to help prepare schematics or other diagrams and flow charts.

EDITORIAL

Incompatibility.

■"My wife and I were incompatible," the old joke goes—"I didn't have enough income and she wasn't patable."

Be that as it may, the computer manufacturers *know* that certain words are necessary if you're going to sell a computer in today's marketplace. "User friendly" is one of the phrases that people look for.

Well, of course. You wouldn't buy an unfriendly computer, would you? And if the manufacturer didn't specifically say it WAS friendly, chances are that there was sufficient reason for that.

"Free" has always been a good sales tool, too. Offer something for nothing, and you may well be on the road to making a sale. "Free" can be anything from a truckload of software that the user may never have any use for, to an accessory or peripheral that he wouldn't know *how* to use. It doesn't really matter, as long as it's "free."

But what we're *really* going to jump on here, is the recent plethora of advertisements that boast "IBM Compatible." In fact, just about the *only* company that does not use this phrase in their advertising, is IBM itself!

What does "IBM Compatible" mean?

If you try to run a piece of IBM software in a foreign computer and the computer doesn't explode in protest, I suppose that's sufficient reason to call it compatible. Maybe so. But compatibility can come in varying degrees. And *how* compatible the computer you plan to purchase may be is more important than the mere fact that it is at all compatible. Compatibility, by my own measure, is the ability of my computer to run—with no modification—IBM software, and, in turn, allow me to run my own programs on the office IBM machine. Now *that's* compatibility.

Anything else is advertising.

It's the old story. *Caveat emptor* means "let the buyer beware." So the next time the salesman says "IBM Compatible," ask him exactly what he means. You just might get some very funny answers.

Byron G. Wels

Byron G. Wels
Editor

ComputerDigest is published monthly as an insert in Radio-Electronics magazine by Gernsback Publications, Inc., 200 Park Avenue South, New York, NY 10003. Second-Class Postage Paid at New York, N.Y. and additional mailing offices.

COMPUTER DIGEST

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LETTERS

18-Wheel Data Base

I work as a truck driver, and recently pulled into a computerized warehouse. The dispatcher pushed a card into a slot and the next thing I knew, my load was ready, the bill of lading was typed out, and I was almost on my way before I had time for a cup of coffee! On the way I got thinking about it. What would happen if the computer made a mistake? And is it going to be putting warehousemen out of their jobs? Where will it all stop?—Billy Horst, Clifton, NJ.

Don't panic. We're a long way from a computerized truck driver.

Warran-Tease

How can I take advantage of some of the tempting construction projects if my computer is still under warranty? Is there a way the manufacturer can tell if I opened the cabinet?—Jack Wilton, Cambridge, MA.

Yes Jack, there is. Check carefully and you might find a special paper patch cemented over one of the mounting screws, or even a drop of paint. Try to remove that screw and you break the "seal" revealing that you tampered with the unit. The best and safest bet is to wait until the warranty expires.

Wants To Learn

I recently purchased a computer, primarily for use in word processing. I agree with you completely that there is no need to learn to program, as you can buy better software than you could possibly write. But I can see several areas where I would have modified—the commercially-available programs I'm now using. I've tried several books, but they seem too advanced for me.—Fred Sandors, Omaha, Neb.

Fred, try a local Adult Education class in BASIC Programming. There's nothing like having a "live" instructor to answer questions.

COMPUTER PRODUCTS

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

TAPE BACKUP, the *Mountain 6300 combo* is completely compatible with the AT&T *PC 6300* running under the MS™-DOS 2.11 operating system. The hard disk is cable-connected to the AT&T *PC 6300*'s hard disk controller. Cabling is provided that allows the combo's disk to be connected either alone, or in addition to, the AT&T *PC 6300*'s internal disk.

CIRCLE 21 ON FREE INFORMATION CARD

The *Mountain 6300 combo* backs up 3.4MB per minute, with full error correction, and without using deferred writes, which could mean a loss of data during a power glitch. The tape-backup menu requires that you need only enter a "B" for backup, and walk away with the assurance that all your files will be quickly and accurately backed up. There's no need for the user to get involved in management of the files being transferred, no rewinding, no track addressing, etc.

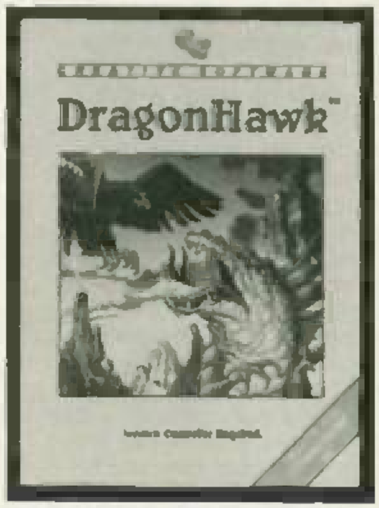
Restoring tape backup data to disk is also easy. The user can restore the entire disk at the same speed used to back up, or can choose to restore only a single file, or group of files by date of creation, or all files in a subdirectory, or any combination of the above.

The *Mountain 6300 combo* is priced at $5,595.00.—*Mountain Computer, Inc.*, 300 El Pueblo Road, Scotts Valley, CA.

EDUCATIONAL GAME, *DragonHawk*, is a disk-based adventure-strategy game.

The player controls *DragonHawk*. The mission is to kill a flying serpent that has put a full mountain range of creatures under its spell. Flying iguanas, phoenix birds, dragon puppies, bats, and mosquitos try to keep *DragonHawk* from gaining access to the flying serpent's airspace. *DragonHawk* destroys them by pouncing on them from above. However, if he stays at one level too long, he will also have to battle a violent lightning storm.

DragonHawk has as many lives as he has feathers, which are indicated by a feather-counter at the top of the screen. When all the creatures have been eliminated, *DragonHawk* faces the flying serpent itself. The fire-breathing serpent chases *DragonHawk*



CIRCLE 22 ON FREE INFORMATION CARD

all over mountains and skies until the serpent's weak spot is discovered and it is destroyed. The player must discover that weak spot.

DragonHawk is priced at $29.95.—*Creative Software*, 230 East Caribbean Drive, Sunnyvale, CA 94089.

EXPANSION BOARDS, the *Memory Companion/PC*, are designed for use with the Lotus/Intel Expanded Memory Specification; they are add-ons that provide the additional memory necessary for using the specification.

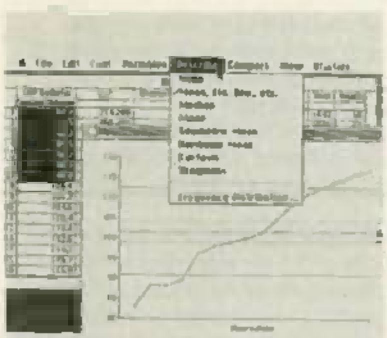
The new expanded memory specification (up to 8M) allows software to address RAM in excess of the standard 640K. The *Memory Companion/PC*

CIRCLE 23 ON FREE INFORMATION CARD

provides IBM PC/XTs™ (and compatibles) with up to 2M of additional memory. The board is compatible with Symphony ™ 1.1, and up to four *Memory Companion/PC's* may be installed in a system, increasing the memory to 8M. The 64K *Memory Companion/PC* is priced at $349.00; the 256K version sells for $395.00.—*STB Systems, Inc.*, 601 N. Glenville, Suite 125, Richardson, TX 75081.

STATISTICS PACKAGE, *StatView*, is an interactive statistics program for the Macintosh computer. It is designed for data analysis by people who work with numbers: economists, scientists, students, accountants, actuaries, sociologists, researchers, marketing executives, securities analysts, legislators, political campaign managers, and all other professionals who analyze data. It is a visual data-analysis package that takes advantage of the Macintosh computer's windows, pull-down menus, and mouse.

StatView is designed for use on all Macintosh formats, including 128K and 512K Macintoshes and the 1-Megabyte LISA equipped with Mac Works, the Macintosh emulation disk. *StatView* permits window-scrolling, changes in column width, and choice of font and font-size for data in a window -- small for viewing many columns and rows, or for ease of reading. Cut, copy, or



CIRCLE 24 ON FREE INFORMATION CARD

paste operations can be done between applications.

StatView is priced at $199.95.—*Brainpower, Inc.*, 24009 Ventura Blvd., Calabasas, CA 91302.

MEDIA SAFE, the Sentry Supreme, model *5750* keeps its contents cooler than conventional fire-rated safes that are used for storing paper documents. At 1700°F, the interior of the Sentry Supreme remains below 97°F, and the relative humidity below 80%, levels well below U.L. standards for safe media storage. The safe is also large enough to protect not only diskettes and tapes, but a variety of non-electronics valuables, such as microfiche, photographs, stamp collections, and documents. The safe is tested and classified by Underwriters Laboratories to protect the contents of both storage compartments at temperatures up to 1700°F for one hour.

CIRCLE 25 ON FREE INFORMATION CARD

The Sentry Supreme model *5750* has a retail price of approximately $600.00. The larger model *5760* is priced at approximately $750.00.—*John D. Brush & Co., Inc.*, 900 Linden Avenue, Rochester, NY 14625.

FAST POLL MODEM, the model *9600 FP*, is a fast-training 9600 bps modem designed for use on multipoint networks. The design combines LSI and microprocessor technologies that result in high reliability and low power consumption. Fully automatic adaptive line equalization allows 4-wire full duplex private line operation over 3002 unconditioned leased lines without manual strapping. The digital adaptive equalizer compensates for the effects of delay and amplitude distortion that would otherwise cause intersymbol interference in the received signal. The model *9600 FP* features an 8 ms RTS-CTS delay for fast turnaround time.

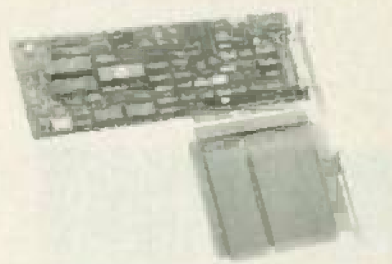
Also featured is a fallback mode,

CIRCLE 26 ON FREE INFORMATION CARD

which allows the user to change the data rate to 4800 or 7200 bps. Mixed-rate network operation allows independent or tributary modems to transmit to the Host modem at 9600, 7200, or 4800 bps. The model *9600 FP* comes equipped with diagnostics for isolating problems in the data-communications path. Built-in test features include local digital loopback, remote activated digital loopback, local analog loopback, remote activated analog loopback, and 511 test pattern generation/checking.

The model *9600FP* is priced at $1995.00.—*Universal Data Systems*, 5000 Bradford Drive, Huntsville, AL 35805-1953.

EXTENDER BOARD, the model *3690-26*, is designed for personal computers, and not only allows in-circuit probing of functional boards but also provides convenient marked test-points for all 98 bus lines on both card connectors. The extender includes a heavy-duty bracket to support cards while troubleshooting.



CIRCLE 27 ON FREE INFORMATION CARD

Card-edge-connector contacts are gold-over-nickel plated for low resistance and minimum wear. Receptacle contacts have gold inlays in copper-nickel alloy bifurcated fingers. Bus-line current-ratings are 5 amps with 200-volts RMS or 300-volts DC ratings. The bus lines are protected by a solder mask to prevent inadvertent short circuits while probing, making it ideal for experimenters.

In 1-4 piece quantities, the model *3690-26* extender cards are priced at $45.13 each.—*Vector Electronic Company*, 12460 Gladstone Avenue, Sylmar, CA 91342

SOFTWARE REVIEW

TYPITALL for word processing

■At last count there were more than 1000 word processor software packages. Unfortunately, some are so difficult to use that just digesting the instruction manual takes several evenings. A really good high-performance word processor should require no longer than an hour or so to learn, be easy to use, and almost never require reference to the documentation. While this kind of word processing software is rare, it does exist, as TYPITALL for the Radio Shack Model 4.

TYPITALL is generally unknown because it is the "Plain Jane" of word processing, having no cute screen displays, menus or individualized function help commands to get in their own way. The program is document oriented, meaning it prepares and saves complete documents, not pages or sections which are later assembled into a document during printing. TYPITALL is specifically designed to simplify *boilerplate* by saving and tagging as files or blocks bits and pieces of text that will eventually be incorporated into a larger document. In addition to unusual editing functions, TYPITALL has most of the conventional word processing features except for a conventional mail-merge. Instead, it substitutes instantaneous keyboard entry while printing.

Response to all functions except for saving and reading disk "inserts" is instantaneous because no disk overlays are used. Unlike most modern word processors which use disk overlays for routine functions, all of TYPITALL's features including printer commands reside in memory along with the document, and all functions are *command driven*, providing instantaneous response to any command. For example, to completely reformat a document or to skip from the beginning to the end of a 6000 character file takes about a half-second. To reformat or skip to the end of a 25,000 character (4000 word) file takes less than 2 seconds.

Disk overlays are used only for (1) The help screens; (2) Hyphenation—which is done when the entire document is complete and ready for printing; (3) An optional integrated spelling checker; (4) customizing of the program. Somewhat unusual, either temporary or permanent customizing can be done on-the-fly by leaving the program, making the changes, and then returning to exactly where you left off.)

TYPITALL requires a TRS-80 Model 4 computer with one or more disk drives and any commonly-used operating system such as Radio Shack's own TRSDOS 6 or the aftermarket DOSPLUS IV. (A somewhat similar version of Typitall 2 for the Model I and III computers will run under any DOS, including NEWDOS.) The program requires about 15K of RAM, leaving 33K for the document. There is no computer lockup if the full RAM is used since a full or partial dump to disk can be made because the program does not require additional memory to call in a disk overlay. Similarly, if a disk is full the user can install a disk in any drive and instantly save to the disk. If something causes the computer to hang (which is unlikely), a full reset of the computer and reenter of TYPITALL will come up with the document in the condition it was in just prior to whatever caused the problem. Short of turning the computer off, it is essentially impossible to accidentally lose an active document.

Because the program is document oriented the editing commands process complete sentence elements. In addition to conventional overwrite and insert, with a single command the user can delete or exchange words, sentences, or paragraphs with the previous sentence element, or randomly exchange blocks or pages throughout the document, or delete pages or any marked portion of the document. An on-the-fly *line insert* mode splits the screen so an insert can be viewed independently of what was written earlier, and the line can be independently edited. Touching a key instantly closes up the line and reformats the entire paragraph if the line insertion is more or less than a full line length. Any change to anything anywhere in the document automatically reformats text until the next end-of-paragraph marker or carriage return. Although TYPITALL is superfast in handling text, its speed requires extra care when deleting anything because the program has neither a paste nor a holding buffer: a deletion is gone forever—there is no recovery.

Boilerplate is under complete control of the user, not the program. Unlimited blocks with conventional filenames or labels A through Z can be marked and saved as either marked blocks or text blocks. Saved text blocks are handled by the program as conventional text or document files, and can be called back and inserted at the cursor position, chained in serial order, or chained to the end of the file. A labeled block is inserted into the text along with its label, leaving it premarked for easy relocation.

Although the screen can show the text as it will be printed on a line-by-line basis, the display isn't "what you see is what you get." If the screen width is the same as the printing width the display will show the proper words per line, but only left justified, like a standard typewritten page.

Except for an *undelete*, TYPITALL can do almost anything, and do it better than most word processors. If it was available for computers other than than the Radio Shack Model 4 there's a good chance that, like WordStar, it would be a legend in its own time.

TYPITALL, Howe Software, 14 Lexington Rd., New City, NY 10956. For Radio Shack Model 4 with one or two disk drives.

TOUCHSCREEN TECHNOLOGY

Touchscreen technology can vastly simplify computing.

MARC STERN

■How many times have you heard it said that computers will make your life easier, only to turn around, fire up a microcomputer and have your day go anything but smoothly? If you're like any computer user, you're probably thinking about all the contortions you have to go through to do a simple task.

Just look at telecommunications. You want to dial a number and transfer data or communicate with a second party. You turn on the computer; find your telecommunications program; start the disk operating system; load the program into memory, just to get set. You've just achieved step one. Step two requires you to have the program originate the call; dial the number and connect to the remote system. Somewhere in there—at some time—you also had to set the program up so it would work correctly with the person you are trying to contact.

The same is true of any function in the microcomputer world. Microcomputers are powerful beasties, waiting to do your bidding. Getting that bidding done can take some doing on your part.

Let's say you are using a program which requires you to continually input information from the keyboard. You answer a series of questions which appear on the screen. These may be leading to a relatively simple conclusion, such as setting your microcomputer's printer port; communications port, or clock. Along the way, you must continually hit various keys to answer the questions and then wait until the program updates the microcomputer. As you work with the system, you think there must be a better way of doing things.

Well, many in the microcomputer world agree with you and that's why there's a burgeoning number of input devices on the market, all aimed at making life easier. There's the mouse; the digitizing tablet; the bar code reader, and light pen. All of these give you an alternative input method. The keyboard, considered by many to be THE input device for a microcomputer isn't the only one, nor is it the best.

Many times, one of the alternative devices will work equally well and, more efficiently. In an environment which requires vast amounts of information input, an optical character reader may be the best device, followed by a bar code reader or light pen. Or, let's take a manufacturing environment. In this type of atmosphere, a keyboard would prove more of a hindrance than a help. Or, in a situation where a system merely wants to know your choices, so the work, a simple mousepointing device may be the answer.

In all of this, there is still another device, which, while it is complex, makes the use of a microcomputer simple, the touchscreen.

There's much more to touchscreen technology than this, but, in its simplest terms, this is all there is to it. To the user, everything appears very simple. All he has to do is press an area on the screen to access a function and the computer does the rest.

Underlying this, of course, is a program and complicated input and output routines which take the simple pointing action and turn it into the action you have chosen with your pointing finger. It's all completely natural, the sort of thing that instinct tells you to do—you point.

Typical applications of touchscreen technology include microcomputer-based directories; automotive electronics—Buick Electra, for example; simple manufacturing inventory; computer-aided manufacturing environments, and the like, or any environment which doesn't require keyboard input or a keyboard would be inappropriate. (See Fig. 1)

FIG. 1—CRT IN FORD 1985 Mark VII Comtech displays driver information and permits manipulation of such items as climate control simply by touching the screen.

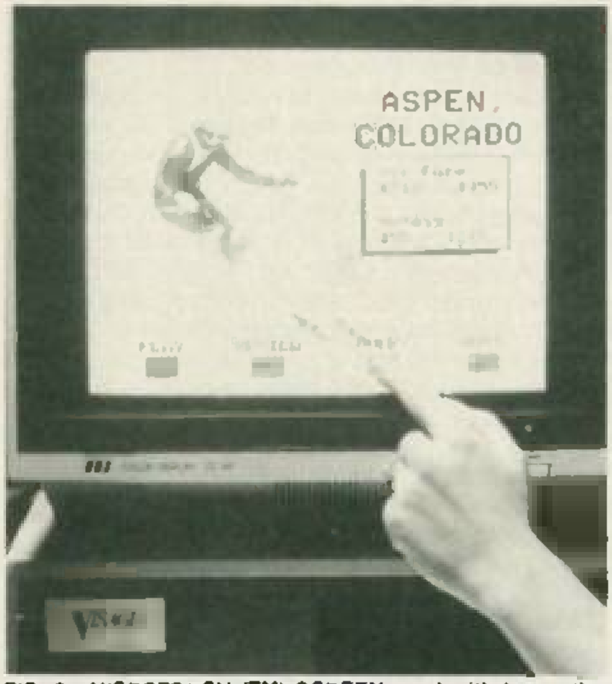


FIG. 2—MICROTOUCH (TM) SCREEN used with interactive videodisc system from Visage, Inc. for point-of-application where users can select vacation travel arrangements.

Three technologies

At the moment, there are three types of touchscreen technology.

The first is the traditional resistive, plastic-type; the second and newest is the resistive-capacitive glass-type, and the third, based on a different technology, is the light emitting diode-type.

The newest expression of touchscreen technology is offered by MicroTouch Systems Inc. of Wobum, MA. (See Fig. 2.) This company has come out with a touchscreen which eliminates many of the problems associated with plastic touch-sensitive screens.

For example, traditional plastic touchscreens are prone to damage from sharp objects, such as pens or pointing stylii and they cut down on the optical quality of a computer's video display. Further, the sandwich of plastic overlays and mechanical dots used in traditional touchscreens also degrades a display image.

The MicroTouch screen employs a solid glass sensor and bonded overlay to handle its functions. This type, since it is more impervious to damage, offers greater long-term reliability than traditional technology.

A plastic-based touchscreen system is actually a sandwich system.

Usually employing two or more sheets of plastic and a center electromechanical sheet covered with dots, the plastic-based system uses those dots to represent information to a touchscreen controller. Changes in the resistance of the middle layer indicate positional information. That controller, in turn, takes the information which has been generated by a user's touch and turns it into digital information for use with a driver program in the microcomputer's memory. In turn, the driver program interprets the touch to mean an action and the microcomputer supplies the solution.

If you look at a traditional touchscreen system, you will see the plastic overlay is linked with the microcomputer either through a parallel or serial port. In those cases where the system is built into a microcomputer, the touchscreen occupies the spot of a logical device in the microcomputer's memory. This means that although the device may not actually be present physically, the microcomputer thinks it is there and accepts its input.

The linkage between the touchscreen and its controller is handled via a bus which is connected to the dot screen that is sandwiched between the two plastic layers. Those layers are coated with an electrically conductive material and make contact with the center dot layer. The changes in electrical resistance that are generated when contact is made determine the input for the controller in the system.

The touchscreen's bus operates on the X-Y axis of the screen and positional inputs are determined in this manner. The contacts at the vertical sides of the screen act as the X-axis, while the contacts along the horizontal act as the Y-axis.

One drawback of this type of touchscreen system is that it is rather coarse in its positional inputs. Since the plastic is very flexible, when a user touches a certain area of the screen many X-Y positional inputs are generated at once. This mass of information is sent along the signal bus to the controller, which determines the action to be taken. Since so many dots are accessed during a touch, you can see it is impossible to have the system act in any more than a broad manner. Unless the driver program changes to a new, more finely tuned function, the touchscreen is incapable of rendering finely tuned input.

Another solution

A more durable solution to the plastic membrane is an LED touchscreen. Again, this system depends on an X-Y axis arrangement, but, instead of using a plastic membrane and electromechanical dots, it uses a rim of LEDs and detectors on the perimeter of the video display tube.

This has the advantage of not detracting from the optical clarity of a display device, but, like the plastic-based touchscreen, it is incapable of high resolution, due to size constraints. No matter how small the LED is, it and its array is still large in comparison to the video display screen and its positional inputs are very broad.

For example, let's say you break three LEDs vertically and four horizontally with your finger. That is a fairly broad area, using even mini-LEDs. So, you can see that resolution is low and, unless the driver program is ready with multiple screens and new choices, then the functionality of this type of technology is limited.

It is an interesting technology itself, though.

To picture an LED-driven touchscreen system, think of the screen of a microcomputer itself. Surrounding the screen, and raised slightly above it, is a bezel containing the ring of LEDs and detectors. Connected to the back of the bezel is the LED system's signal bus, which interacts with the touchscreen controller. That controller can either be in the CRT housing or within the system box. It takes the rough digital positional inputs and sends them on to the microprocessor for processing. Usually, the controller is an intelligent signal processor, which, like the processor in a plastic-membrane system, may either be recognized as a logical parallel or serial port.

In action, the LEDs emit a crisscross grid of infrared beams over the surface of the display tube and merely breaking the beams causes the positional input to register in the controller.

The problem with the LED touchscreen is not only its basic coarseness, but also the fact that the IR beams are suspended a distance above the highest point on the surface of the curving CRT screen. This can translate to parallax problems for the system. The signal processor must have error correcting capability and this increases its complexity. One advantage to this system is that its digitization is almost instantaneous. Since the IR beam is either continuous or broken (on or off), its inputs are digital and this can eliminate a layer of conversion (analog to digital) since the voltage is on or off.

A new technology

Representing the newest resistive touchscreen technology is that developed by MicroTouch. This technology has certain inherent features that make it more reliable that older forms. For example, since it doesn't rely on plastic membranes, its durability factor is higher, which is important in a heavy use environment. It provides the microcomputer user with greater display clarity. And, since it is part of the touchscreen, no parallax problem.

The key to this system—and systems like it—is a solid glass sensor. It features a solid glass overlay with a resistive coating bonded to its surface. The key to this system is capacitive coupling between the object used for pointing and the surface. This coupling changes the resistive qualities of the glass and information is generated. (See Fig. 2.)

Almost immediately, you can see the advantages of this system. However, it has some advantages which aren't that apparent, such as high-resolution capability. With this type of system, a CRT now has 256 by 256 or 65,536 touch points. With this type of resolution, it should be possible to increase the information content of a program screen and also make the driver program far more efficient for the user. Instead of having to page

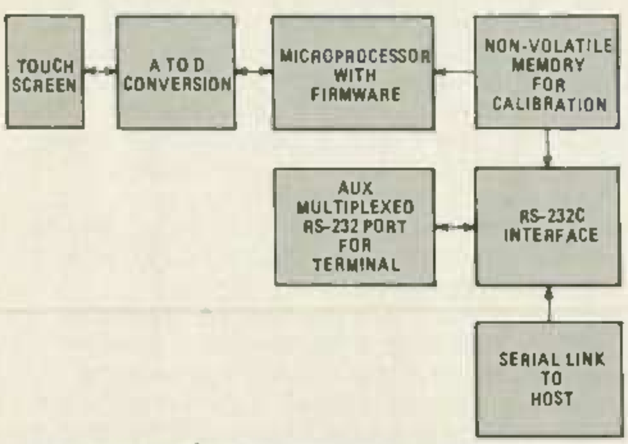


FIG. 3—BLOCK DIAGRAM illustrates simple touchscreen system.

through screen after screen of material, most of the choices are presented on one screen.

This system is also capable of nearly instant reaction to multiple touches. With a sampling rate of 50 points per second, a user can make choices far more quickly than with other systems. It can transmit touch data in either a stream mode or in a one point per touch, point mode. This means you can have some detailed screens of information available for the user. Typically, plastic membrane and LED systems have lower sampling rates and are more limited in their functionality. The sampling rate does rely on the type of controller used, but, you will find most touchscreen systems have a 10 to 30 point per second sampling rate.

Driven by a microprocessor, this type of system also is system-independent. It uses an RS-232 serial link to communicate with the microprocessor in a system unit and is capable of operating over a range of 110 to 9,600 baud. It provides a multiplexed, auxiliary RS-232 port for a terminal. (See Fig. 3)

The microprocessor handles several functions. Since the signals generated by a touch on the screen are actually changes in electrical voltage, they are analog in nature and must be converted to digital form before they can be used by the touchscreen's controller. The touchscreen's intelligent controller performs the analog-to-digital conversion and then sends those signals to the controller. The controller, typically an 8-bit microprocessor, has four Read-Only Memory (ROM) based commands, including mode, which permits the user to select the point, stream or inactive mode (no touch data transmitted so a CRT can be used normally); calibration, which aligns the touchscreen with the CRT; data format, which allows the selection of decimal, hexadecimal or binary data representations; resent, which returns the controller to the stream mode and decimal format, clears the output buffer, and runs a diagnostic, and command-point, which is available for the creation and management of special touch zones on the screen.

Since this type of touchscreen is system independent, it also includes programming capability to handle the needs of various microcomputer systems. Different data formats and calibrations can be programmed and stored in an electrically erasable programmable read-only memory.

A breakthrough

Until now, touchscreens have generally lacked the definition and durability to make them effective in many environments. Since their resolution was low, they needed copious software to handle their tasks and this constant need to refer to new screens of information slowed down efficiency. With a system such as the new high-resolution ones now appearing on the market, this has changed and the user can have one screen handle many functions, which speeds efficiency. And, since the coating is bonded to the glass in new systems, it means durability should be very high. It represents a breakthrough which will make touchscreens a very real alternative input technology.

VOICE REPRODUCTION

More than 5 seconds of speech with 16K.

JASON M. KINSER

FIG. 1—AUTHOR POINTS TO SCREEN as computer runs in the "speaking" mode. TV lines flicker according to outputted sound.

■Timex-Sinclair users may have experienced the same feeling. My brother and I were discussing our computers. He owns a Commodore 64 and I have the Sinclair. He laughed because his computer could do "real" things. He had hi-res, and sound, and color.

Interfacing

The Sinclair has no speaker but it does have the two cassette interfaces.

An operational amplifier with a speaker connected to the mic-jack interface of the computer will serve as the speaker. Likewise, a microphone with an amplifier can be connected to the ear-jack interface to act as a microphone. The connecting cables are provided.

The cassette interfaces are tied directly with the TV and somewhat directly to the data bus. Being connected to the TV elimininates the need for one of the amplifiers. (See Fig. 1.)

Since the data bus, cassette interfaces, and the TV are all tied together all of the following programs must be run in the FAST mode. The SLOW mode will keep the display running and this will drown out anything.

Noise from nowhere

The first task of voice synthesis is to have the computer produce simple frequencies. These frequencies are single-amplitude square waves. Voice reproduction will be just differing frequencies.

Access to the mic-jack (output) or the TV speaker is handled by the machine language command OUT (n),A. This command takes the contents of the Accumulator and dumps them onto the data bus. The contents are then sent to device number "n."

There are 256 device numbers. The ear-jack is FE and the mic-jack is FF. Therefore, OUT (FF), A is used.

This will output one pulse. The signal coming out of the machine will oscillate according to the bit pattern of the Accumulator. These oscillations are too fast to produce an audible tone. They are, however, used to change the flavor of the produced tones.

The frequencies are determined by the amount of time between the output of the Accumulator. This can be set by the programmer. The following program will produce simple frequencies depending on what is in register B. This holds the length of the wait before the Accumulator is sent on to the bus.

The Accumulator will be accessed until BREAK is pressed. CALL 0F46 is the subroutine which will recognize BREAK. If it is pressed it will return from the subroutine with the Carry low.

The Accumulator can hold any number. Also the screen will display the noise being produced along with the bit pattern of the Accumulator.

```
LD A, FF        3E FF
OUT (FF), A     D3 FF
LD B, 66        06 66
CALL 0F46       CD 46 0F
RET NC          D0
DJNZ FA         10 FA
JR              18 F2
```

The voice reproduction will consist of inputting a voice and having the computer reproduce it.

The input into the machine must be done through the cassette interface (see Fig. 2). If a microphone with an amplifier is not available, then record the voice and play the recording into the computer. It is more work, but better than nothing. (See Fig. 3.)

Inputting is similar to outputting. Instead of OUT (n), A the comparable IN A, (n) is used. When using the ear-jack IN A, (FE) is used.

Unfortunately, the input does not record all of the information. It only sees a threshold. So, the incoming signal is recorded as high if the signal is above the threshold, and low if it is not. The machine will not see

FIG. 2—THE COMPUTER with audio amplifier and mike connected to cassette interfaces. The program seen on the screen is a representation of the machine code program.

All photos by Bruce Wittenmyer

FIG. 3—MICROPHONE IS CONNECTED TO AMPLIFIER which enters the ear-jack of the computer. Mic-jack is unconnected but will connect to another amplifier and speaker.

how far above or below the signal is.

The accumulator will have either 39 or B9. The only bit that makes any difference is bit number 7. (Sometimes the lowest bit alters, but this is independent of the incoming signal.) The highest bit is rolled off and saved in succession.

The bad news is that the wave cannot be stored completely. Only the frequency is stored. The amplitude is lost. Voice reproduction is still possible though. Some clearness will be foregone.

The good news is that now each byte can hold eight different samplings of the signal. This increases the amount of speech time by a factor of eight. This allows for almost six seconds of speech. Generally, a 64 K machine would allow only 2.5 seconds of speech.

The only remaining problem is to find someplace to store the data. The data can be stored in a RAM statement, but you first have to make a REM statement 13,000 characters long. The data could be stored in a string, but these are easy to erase and move around in the memory. The data could be put above the RAMTOP, but this cannot be saved on tape. For this demonstration, the data will be put above the RAMTOP.

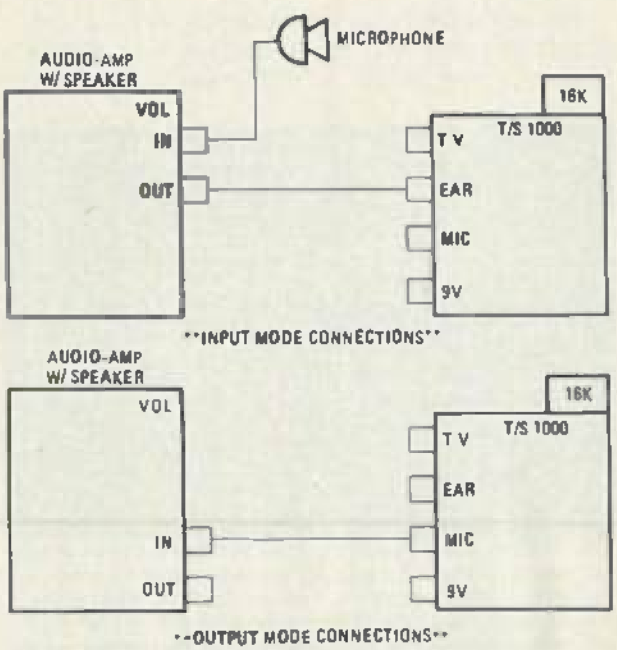


FIG. 4—BLOCK DIAGRAMS reveal input and output mode connections.

First move the RAMTOP down.

```
POKE 16389, 77
POKE 16388, 56
```

The first location for data storing is 19768. There are 13,000 bytes afterwards set aside for storage.

The following program will load the data. It is best to put the program in a REM statement. Enter the first basic command as a REM statement with at least 71 spaces following. That will make the first available position for the start of this program 16514.

```
LD HL, 4D38     21 38 4D
LD C, 32        OE 32
LD B, FF        O6 FF
LD D, 08        16 O8
IN A, (FE)      DB FE
RL A            CB 17
RL E            CB 13
CALL OF46       CD 46 OF
RET NC          DO
DEC D           15
JR NZ, F3       20 F3
LD (HL), E      73
INC HL          23
DEC B           05
JR NZ, EC       20 EC
DEC C           OD
JR NZ, E9       20 E9
RET             C9
```

Reproducing the signal is as simple as putting it into the machine. The data will be accessed one bit at a time. If the bit is high then the contents of the Accumulator are put onto the data bus. If it is low, then that part of the program is bypassed.

The following program is the output. It will take the same data that the computer received and kick it back out. The program should also be put in the REM statement. It will start at 16545.

One section of the program may seem a bit useless.

```
LD B, 01
DJNZ FE
```

This is a wait of 1. It can be used to slow down the voice by loading B with another number. Inserting this into the first program can speed up the voice when it is replayed. There are still other uses of this routine that are still being explored. It does slightly slow down the reproduction, but it is not noticeable unless a pure tone is being compared by its reproduction.

Now it is ready. Run the first program and immediately input a voice. Next turn up the TV speaker or turn on the external speaker and run the second program. (See Fig. 4)

What will be heard are the frequencies of the original voice. It will be slightly rough. Remember, the TV will add some fuzziness to the voice. The best response is outputted through the mic-jack.

Now my brother is down to only one laugh. He can no longer laugh about hi-res or his sound any longer. Of course, he still laughs about the the color that his computer produces, but he who laughs last...

EMULATING PRINTERS

Resolving some incompatibility problems

HERB FRIEDMAN

■The difficulty with anything as dynamic as personal computing is that perfectly suitable and costly equipment can become obsolete and unusable. This is particularly true of printers, whose functions, features and characteristics are rapidly outstripped by the level of technical competence expected of the user, and by new hardware and software. For example, although the conventional 80-column printer is more than adequate for most of the typical office routines, commercially prepared spreadsheets intended for business use have become so large and complex that an 80 character line barely conveys the desired information. Many of the latest spreadsheets require a 130 column line, or sidewise printing for an endless number of columns per line of printing.

While most matrix printers can be programmed to print "mice type"—meaning 16 to 18 characters per inch, which produces at least 132 characters per line on 8-1/2 inch wide paper—virtually all printer manuals assume the user has some level of competence as a BASIC programmer and can write a short program routine to configure the printer for "mice type." The BASIC program is necessary because few application programs have a direct way to send the printer control codes used to configure the printer. Configuration via the printer's control codes must be done through a BASIC program.

In the early days of personal computing most users had a working knowledge of BASIC, today, more often than not a personal computer is a business tool, and few users have any idea what programming or BASIC is about: Telling a user to write a short BASIC program for a printer is confusing and unproductive.

None of the older printers and almost none of the new non-IBM printers are 100% compatible with the characters produced in IBM computers by ASCII codes higher than 127, yet the IBM PCs and their clones are the standard of reference computer for the small businessman. Although a few of the latest non-IBM printers can reproduce from some to most of the IBM PC's graphic and foreign symbols, at the time this article was prepared none reproduced all characters provided by IBM compatible computers. It gets sort of sticky when you run a commercial applications program that is supposed to print a musical symbol, or even the omega symbol for resistance, and all your printer turns out is a blank space or characters bearing no relationship to what is seen on the screen.

The printer's computer.

The major reasons for the character incompatibility of specific matrix printers and computers are: (1) Manufacturers attempt to marry the consumer to a particular line of hardware; (2) matrix characters are generated by a computer built into the printer itself, and it is this computer which responds differently to ASCII input signals: The very same ASCII codes that cause one kind of printer to generate graphic lines will cause another printer to generate itallic or conventional characters. Actually, reasons 1 and 2 are interlocked because a manufacturer of a complete line of computer equipment can easily modify his software to work properly only with his particular line of printers and vice versa.

Software for hardware

The way to resolve printer incompatibility is to use applications software either as a substitute for a BASIC program or as an emulator for hardware. Depending on

FIG. 1—PRINTER CONFIGURATION SOFTWARE lets the user program a printer's function(s) through menu selection instead of a BASIC program. This menu, from Adapta-Print, allows direct selection of forms control and printer ports. However, while the user can select a serial port for the printer, the port had to be previously configured for serial parameters through the DOS MODE command.

your particular printer there are three ways this can accomplished.

First, we have the substitute for a BASIC program. Virtually all printer manuals show a few samples of BASIC programs that might be used to send the control codes which configure a matrix printer for some unusual font, such as double width characters, "mice type," itallics, or enhanced characters (correspondence quality). Aside from needing a working knowledge of both printer control codes and BASIC programming, using BASIC for configuration becomes unwieldy if it handles all possible printer functions, and there often isn't enough space on a disk to hold BASIC, the printer configuration program, and the applications software.

The best way to handle control code programming is to avoid the whole thing with printer configuration software, a special program that is generally booted through a batch file so the first thing the user does is configure the printer.

A particular advantage of independent configuration software (compared to a simple BASIC program) is that the software can automatically translate control codes so the correct one is sent to the printer when the user makes a menu selection. For example, the Epson, Okidata and Hewlett Packard printers employ different control codes for emphasized printing. If you were doing your own configuration through a BASIC program you would have to keep track of the correct codes for the various printers. This isn't true if you use a printer package such as Adapta-Print (Computational Systems, Inc., One Energy Center, Pellissippi Parkway, Knoxville, TN 37922), which provides printer configuration from the menu shown in Figure 1.

Adapta-Print is initially configured through an installation program for the printer control codes of a particular kind of printer. The installation provides automatic translation of a menu-selected feature into the proper printer codes for a specific printer. If the user selects *emphasized* printing, the program generates the correct control code for the installed printer. Typical of most printer configuration software, Adapta-Print permits stacking of control codes. As instructed by the menu, a user might enter a 20 for Double Width printing, then a 14 which would provide emphasized double width printing, and fnally a 15, which would produce "near letter quality" double-width characters. (Actually, the menu selections can be entered in any order).

Creating characters

The second level of printer configuration software creates characters which are beyond the normal capability of the printer. While virtually all printer manufacturers provide some graphic symbols in response to ASCII codes above 127, there is no standard set of graphic characters: Printer A doesn't produce the same characters as printer B in response to ASCII codes higher than 127. Although many printer manufacturers go their own way because there is no *official* standard for the graphic codes, IBM has set a defacto standard for graphic characters, and much commercial software utilizes the IBM graphics set.

Unless your printer is 100% compatible with the IBM graphics characters—and few are even partially compatible—what you get from a printer is not what you see on the screen. Many of the most popular printers print the horizontal and vertical lines, and the math and foreign characters of an IBM-compatible screen display as itallic characters.

Short of replacing the printer, the way around this problem is printer software such as The DigiCon Print Package (Digital Concepts, Inc, Inc., P.O. Box 8345, Pittsburgh, PA 15218), which is intended for Epson and Epson-compatible printers. In addition to other printer control functions, the DigiCon package uses the printer's addressable dot printing feature to generate its own fonts (type styles) such as script, block, and conventional characters, all of which duplicate all 56 characters in IBM's Set 1 and Set 2 character sets.

As shown in Figure 2, a dump of each DigiCon character set is mapped so the user can instantly determine the decimal ASCII value for every IBM character; information that is necessary to easily incorporate the IBM graphics into programs and documents. The ASCII values are determined by locating the vertical (left side) and horizontal (top)

FIG. 2a—THE DIGICON PRINT PACKAGE generates complete IBM graphics printer character sets. This one is for the default character set. The numbers along the left and top edge provide the ASCII code for each character. The omega symbol (used to indicate resistance) is ASCII 23 + 4, or ASCII 234.

values for a character. For example, the upper case A is ASCII 065 (or 65); the omega symbol used to represent "ohms" is 234, while the international symbols for male and female are respectively 011 (11) and 012 (12).

The characters are attained by printing through the DigiCon program, which means that the original file must be saved in ASCII. If you have a WordStar file it must be converted to ASCII (yes, it can be easily done), while a PFS:Write file can be saved directly in ASCII. The same is true for data files or anything else: they must be in ASCII in order to be processed properly by the DigiCon system. Screen dumps are unaffected by the conversion—they do not print what is seen in the screen—because the dump goes directly to the printer, bypassing the conversion software.

FIG. 2b—SINCE DIGICON GENERATES the characters independently through dot-addressable graphics, it can generate various type faces, such as this "script" font.

FIG. 2c—DIGICON'S CONVENTIONAL printer control functions are determined through menu selection.

Load your own

The most convenient way to accommodate the IBM graphic characters—which is arranged in two *Sets*—is by programming the printer to recognize and generate the characters directly from conventional software. Low cost programmable printers like the Epson FX+ series are a recent concept for personal computing. The FX+ has its own character set in ROM as well as RAM, which can be user configured with a user-designed font. A program such as the Printer BOSS (Connecticut Software Systems Corp., 30 Wilson Ave., Rowayton, CT 06853), which offers conventional control code configuration for Epson printers, can also program an FX+ printer to recognize and print IBM's graphic character sets. The printer can respond directly to the orginal applications software without the need for an intermediate ASCII-only print mode. Figure 3 shows the large menu selection screen of the Printer BOSS, which permits the user to program both the printer control codes and the character font at the same time.

FIG. 3—THE PRINTER BOSS can actually configure a printer so the printer itself "thinks" it's IBM compatible. It does this by downloading a character set(s) into the printer's memory. The only limitation to this method is that it is presently available only for the Epson FX printer series.

A programmed font is the ultimate emulation because the printer itself functions as conventional hardware, meaning that it does not require intermediate translation software. Even screen dumps will produce the accurate hardcopy of the screen display.

Because of the pervasive influence of IBM most printers will reproduce the complete IBM character and graphics set(s). Until then, or until you're ready to purchase a new printer, the best way to generate unconventional type styles and characters is to use software that emulates hardware.

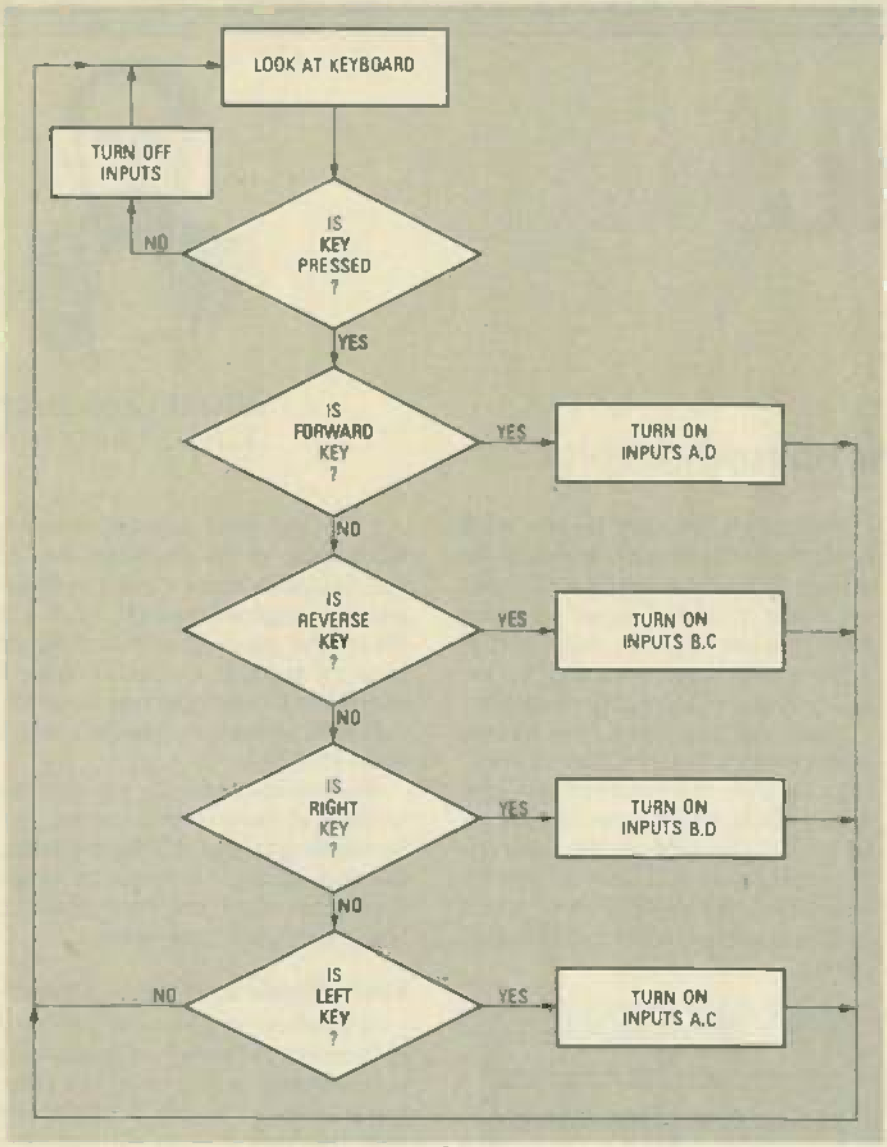


FIG. 5

right motor to rotate backward while the left motor rotates forward, causing the unit to turn right. And so on.

You may be wondering where to get the motors for the two-wheeled device we've described. We've found that for motors, and the many other parts that we'll be needing in the coming months, there's no better place than a surplus store. But some of you may live in areas where suitable surplus outlets simply do not exist. So for you, the following firms can supply suitable motors by mail: Edmund Scientific, 101 E. Gloucester Pike, Barrington, NJ 08007, Phone—609-547-3488 (motor assembly part No. B31-827, $4.95), and H & R Corporation, 401 E. Erie Avenue, Philadelphia, PA 19134, Phone 215-426-1708 (motor assembly, part No. TM22K638, $4.95). Those firms list in their catalogs many different motors, motors with wheels, and even complete robot kits.

Next time, we'll take a look at a commercially available robot. In the meantime, why not get started on your mobility base? **R-E**

"About that new natural English syntax translator package, Mossman...!"

DRAWING BOARD

ROBERT GROSSBLATT
CIRCUITS EDITOR

Designing microprocessor-based circuits

IN THE PAST, WE'VE SPENT PLENTY OF time talking about gates, latches, flip-flops and counters. After all, anyone interested in circuit design needs a clear understanding of what those elements are, how they work, and how they can be used. Although logic families have changed—DTL having given way to RTL, and RTL to TTL and CMOS technologies—the basic design approach has not. Flow charts, block diagrams, and other paper work are all still necessary to obtain a final product.

Some time ago I stated that circuit design should begin with basic building blocks. But as technology advances, what once was an exotic part becomes so common that we begin to think of it as a basic element. And that's certainly true of the microprocessor.

Many people think that microprocessors are computers. Well, they're not. Computers are one application of microprocessors, but not the only one. Microprocessors are IC's that accept instructions, move data from place to place, and perform logical operations.

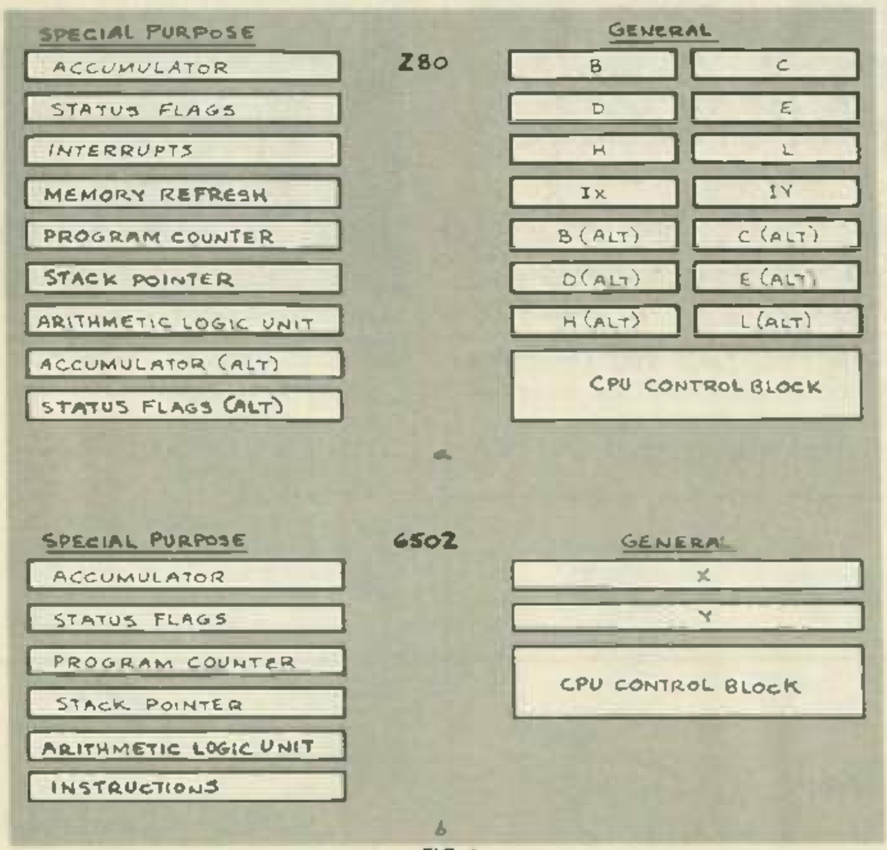


FIG. 1

Over the next several months, we'll look at microprocessors to see how they can be used to lower power requirements, and cut down the parts count and board size of typical circuits. What's more, you'll see how one basic circuit can be made to handle a multitude of jobs.

Microprocessors can control various elements of a circuit, but something has to tell them what to do and when. That means you'll finally have to come to terms with the great "god," software.

Understanding microprocessors

If you had to pinpoint the basic difference between a gates-only circuit and a microprocessor-based one, it would probably be that the former can do only the specific job it's designed to do, while the latter can do a number of different things, as long as it's properly told what to do. Everything depends on the set of instructions (software) fed to the microprocessor. But for now, let's examine the internal structure of the microprocessor to see what's inside and how it works. Once we have a clear understanding of that, we can start telling it what to do.

Basically, there are two types of microprocessors: top-down and bottom-up. The difference has as much to do with how they handle memory as with their internal organization.

Microprocessors spend a lot of time moving and manipulating data, and they need a place to store the interim and resulting data. The way they handle that task marks another basic difference be-

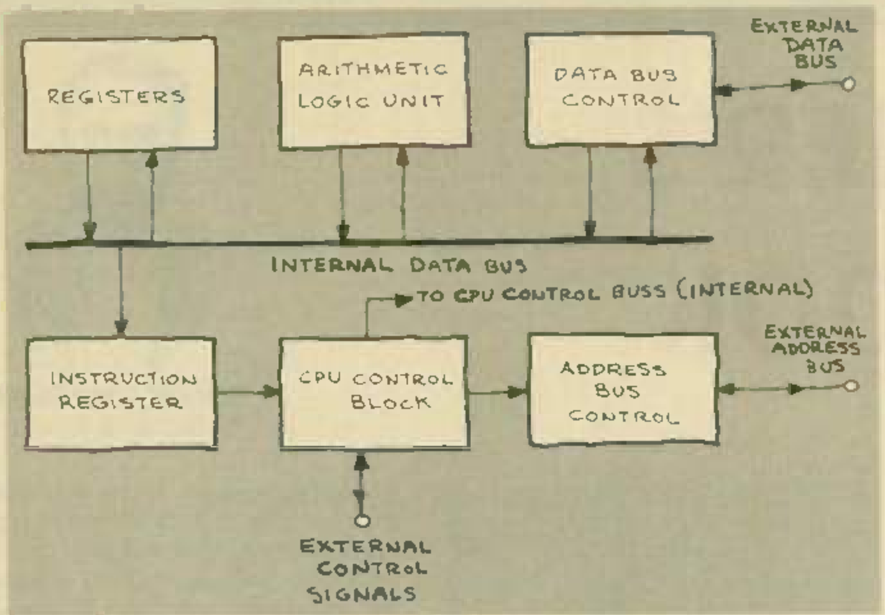


FIG. 2

tween the two types of microprocessor. The bottom-up type has internal registers that can be used for data storage, "housekeeping," counters, and so on. The top-down type uses external memory for the same purpose.

Figure 1 should give you a better idea of what I mean. The Z80 (Fig. 1-*a*) and 6502 (Fig. 1-*b*) are perfect examples, respectively, of a bottom-up and a top-down microprocessor or CPU (*C*entral *P*rocessing *U*nit). The Z80 has a total of 14 general-purpose internal registers, while the 6502 has only two. Both have the other registers that all microprocessors need: the accumulator, the stack pointer, the flag register, and so on. We'll cover all of those eventually.

The number of registers doesn't necessarily make one microprocessor better than another, only different. However, that difference can make one better suited for a particular application than another. A CPU with many internal registers (bottom-up) can manipulate data between the registers very quickly. But they slow down when they have to access external memory.

On the other hand, a top-down microprocessor like the 6502 uses external memory for almost everything it does, but it has a speedy way of accessing the bottom range of external memory. By contrast, all external memory appears the same way to bottom-up microprocessors (another topic for future discussion).

Microprocessors with many internal registers (like the Z80) can move and manipulate data from register to register very quickly, making number-crunching faster—a definite asset in applications doing a lot of arithmetic. But the 6502 is capable of doing BCD (*B*inary *C*oded *D*ecimal) math. If BCD is used, the round-off errors that crop up in binary math (the normal way arithmetic computations are handled in that and other microprocessors) are avoided.

Finally, if you're doing a lot of I/O operations, the simpler bus interface requirements of the 6502 are worthy of serious consideration. In any case, when dealing with microprocessors, remember that anything you can do with one, you can also do with another, although maybe not as easily.

Since learning to use a CPU means putting in plenty of time, you should pick your microprocessor carefully. I've chosen to use the Z80 for the balance of our discussions; it's cheap, available, powerful, and there's a wide range of support IC's available for it. To design microprocessor-based circuits you must first understand exactly what the microprocessor can do, and how it does it.

Figure 2 shows a block diagram of the internal structure of the Z80. As you study it, notice that it isn't really much different from the circuits we've designed in the past. In fact, it would be possible—although not really practical—to build a CPU from discrete logic IC's.

The Z80, like most other microprocessors, is made up of five different parts: the instruction decoder, the CPU control block, the address and data bus controllers, the ALU (*A*rithmetic *L*ogic *U*nit), and the storage registers. What separates a CPU from just a collection of discrete elements is the inclusion of the ALU and the instruction decoder.

The ALU is the workhorse of the CPU. That is where addition, subtraction, logical operations (AND, OR, XOR, NOT) and other operations occur. Precisely what goes on in the ALU depends upon another part of the CPU—the instruction decoder.

The instruction decoder is the part of the CPU that contains the instruction set (a preprogrammed series of routines that are performed when the CPU receives the appropriate command). The instruction decoder mediates between the ALU and external memory. It is the job of the instruction decoder to recognize a command, decode it, and issue the appropriate instructions to the ALU. The ALU acts accordingly and then waits for the next set of instructions. The series of commands that the instruction decoder receives, of course, is the program being run.

Translating low-level data manipulation into useful work requires plenty of additional hardware and the right software. As with everything else we've done together, you're going to be doing a lot of work on paper before you ever look at a soldering iron. The first—and probably the most important—thing you have to do before we continue our discussion is to get a good book on the Z80 and start reading. There's just no way to fit all the necessary information into this column.

Our next step will be to put together a bare-bones Z80 system and see what can be done with it. If you're new to microprocessors, I think you'll be amazed by its versatility. R-E

DESIGNER'S NOTEBOOK

ROBERT GROSSBLATT
CIRCUITS EDITOR

Custom-tailored audio

EVERY AREA TO WHICH ELECTRONICS IS applied has its own peculiar requirements; sometimes those requirements get really peculiar. Talk to someone doing amplifier design, and you'll hear about purity of sound, minimum distortion, and bandwidth from DC to daylight. Talk to someone else and you'll hear about wah-wah, fuzz, and flanging.

It seems as if there's all the difference in the world between producing and reproducing sound. In any event, it's a safe bet to say that things aren't as straightforward in making electronic music as they might be. Anyone who gets interested in designing circuitry with an eye toward music, learns rapidly that lots of coloring has to be added to the audio for it to sound "good."

Probably the most basic addition you can add is tremolo. But, before we go any farther, let's make sure we know what tremolo means. Tremolo is produced by modulating (varying) the amplitude of the input signal, making it louder and softer.

A violinist produces tremolo by varying the strength of his bowing. Most other musicians and singers also use tremolo to color the sounds they produce. This month, we'll look at a circuit that lets you easily add tremolo to any audio circuit that you're building.

Audio circuit add-on

Before we get into any of the nitty-gritty of the design, there are a few ground rules that should be laid out. Tremolo sounds best when it's subtle—too little and it won't be heard; too much and you'll wish that it couldn't be heard at all.

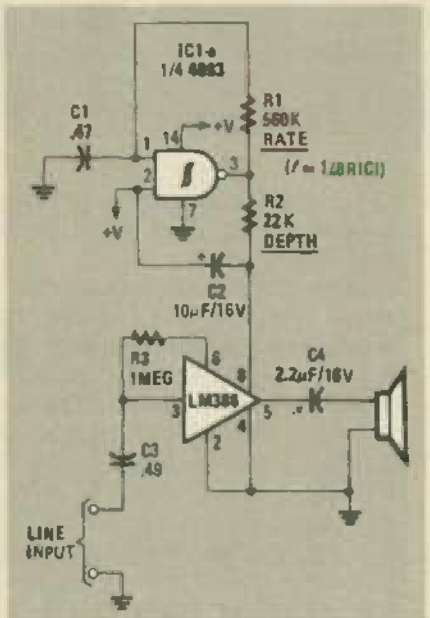


FIG. 1

The simple circuit that's shown in Fig. 1 can be used to color the sound coming from your audio system. Clocking for the circuit is provided by an oscillator built from one quarter of a 4093 quad NAND Schmitt trigger. With the component values shown, it will run at about 5 Hz. The clock frequency is fed to the gain control, pin 8, of an LM386 amplifier. Tremolo is produced by varying the gain of the amplifier.

There are design parameters of that circuit that allow you to tailor it to work any way that you want. However, one thing deserves your particular attention—CMOS oscillators swing almost the full range of the supply voltage (from ground to the supply rail).

If you use a CMOS oscillator to produce tremolo in an arrangement similar to that shown in Fig. 1, it's going to vary the gain of the amplifier from just about zero to the maximum, and it will sound really weird. Now that we know that much, let's look at the circuit in more detail.

The mathematics used to determine the frequency of the clock is pretty hairy, but you can get a close approximation from:

$$f \cong 1/.8R1C1.$$

If you want to change the tremolo rate, simply plug your own numbers into the formula to get the needed component values. A trimmer potentiometer can be put in series with R1, so that you can easily experiment with different rates. If you decide to do that, however, make R1 about 100,000 ohms and use a 1-megohm trimmer. That should let you dial up frequencies from about 2 to 20 Hz.

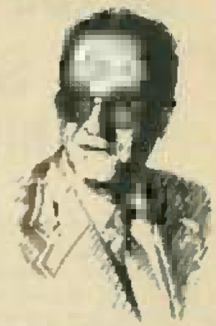
Resistor R2 is the depth control. By that we mean that it controls the degree of tremolo that you'll get from the circuit. It's a straight application of an R-C time constant. You can experiment with different values for R2 and C2. And just as we did with the clock rate, you can put a trimmer in series with R2. But if you do, make R2 a 5000-ohm unit and use a 50,000-ohm trimmer. If you're curious, leave it out altogether and see what it sounds like. (After all, music is a subjective art.)

Although I've used a 4093 to build the tremolo clock, you can use just about any oscillator at all. The only requirements are that it will reliably oscillate at below 10 Hz, and that it can produce an out-

(Continued on page 122)

HOBBY CORNER

More control circuits



EARL "DOC" SAVAGE, K4SDS,
HOBBY EDITOR

LAST TIME, WE STARTED LOOKING AT control circuits and talked about various types of manual switches. Such switches are not always best for direct control of a circuit. In addition, the controlling force is not always pressure on a switch. Sound, light, or RF can be made to "reach" out and "flip" a switch!

There are a variety of reasons for using something other than a manual switch for circuit control. One alternative to the manual switch is a relay. A relay is nothing more than an electromagnet that, when energized, pulls on a piece of metal causing the relay contacts to open and/or close. (We'll ignore the source of the voltages being applied to the relay, for now.)

The size and shape of the magnet, and the number and arrangement of the contacts vary greatly, but the operation of all standard relays is the same! Figure 1 shows the schematic representation of several relay types. Figure 1-a is an example of a SPDT relay. Current passing through the coil, which is wound to activate at a given voltage and/or current, causes the armature (the center contact) to be pulled toward it. The source should match the coil requirement, and the relay's electrical specifications (AC or DC) must be adhered to.

Let's suppose that a controlling voltage is applied to the armature, which is in the upper contact position. When the coil is energized, the armature is pulled downward. Now the armature connects with the relay's lower contact and whatever is connected to that terminal is energized. Because the armature is connected to a spring, it jumps back to its original position as soon as current ceases to flow through the coil—the lower circuit is disconnected and the upper is reconnected.

Another type, a stepping relay, is shown in Fig. 1-*b*. That type steps forward (to the next contact) each time the coil is momentarily energized, going from one to four and then repeating. Stepping relays are useful in some applications, but are expensive.

A latching relay is shown in Fig. 1-*c*. When the upper coil is energized, the armature "latches" (locks) in the upper position. It stays there until current flows through the lower coil, causing the armature to move to the lower position. When you want a short signal to hold a relay "in," you need a latching relay. The latching relay can cost three, or more times as much as one of the common type shown in Fig. 1-a. But when you need one, you need one—or do you?

Fortunately, you can make a latching relay from two of the common variety and save a few bucks, as Fig. 1–*d* shows. (Assume that there are two electromagnets acting as one.) Note that the contacts are in the double pole configuration; i.e., there are two armatures.

When the momentary switch is pressed, the coil is energized and both armatures are pulled downward. The lower armature contacts make or break the circuit being controlled. When the upper armature makes contact, a voltage is applied to the coil, so that releasing the switch has no effect—the relay is latched in the "on" position.

Of course, the relay will remain latched indefinitely, defeating its purpose in most applications. Therefore, some method of deactivating the relay is needed. A switch (toggle or normally closed momentary) may be inserted between the coil and +V, so that

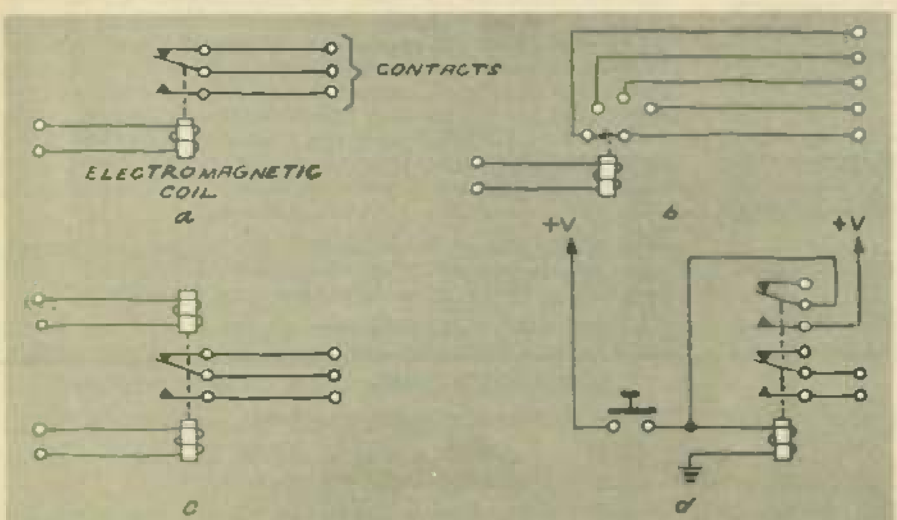
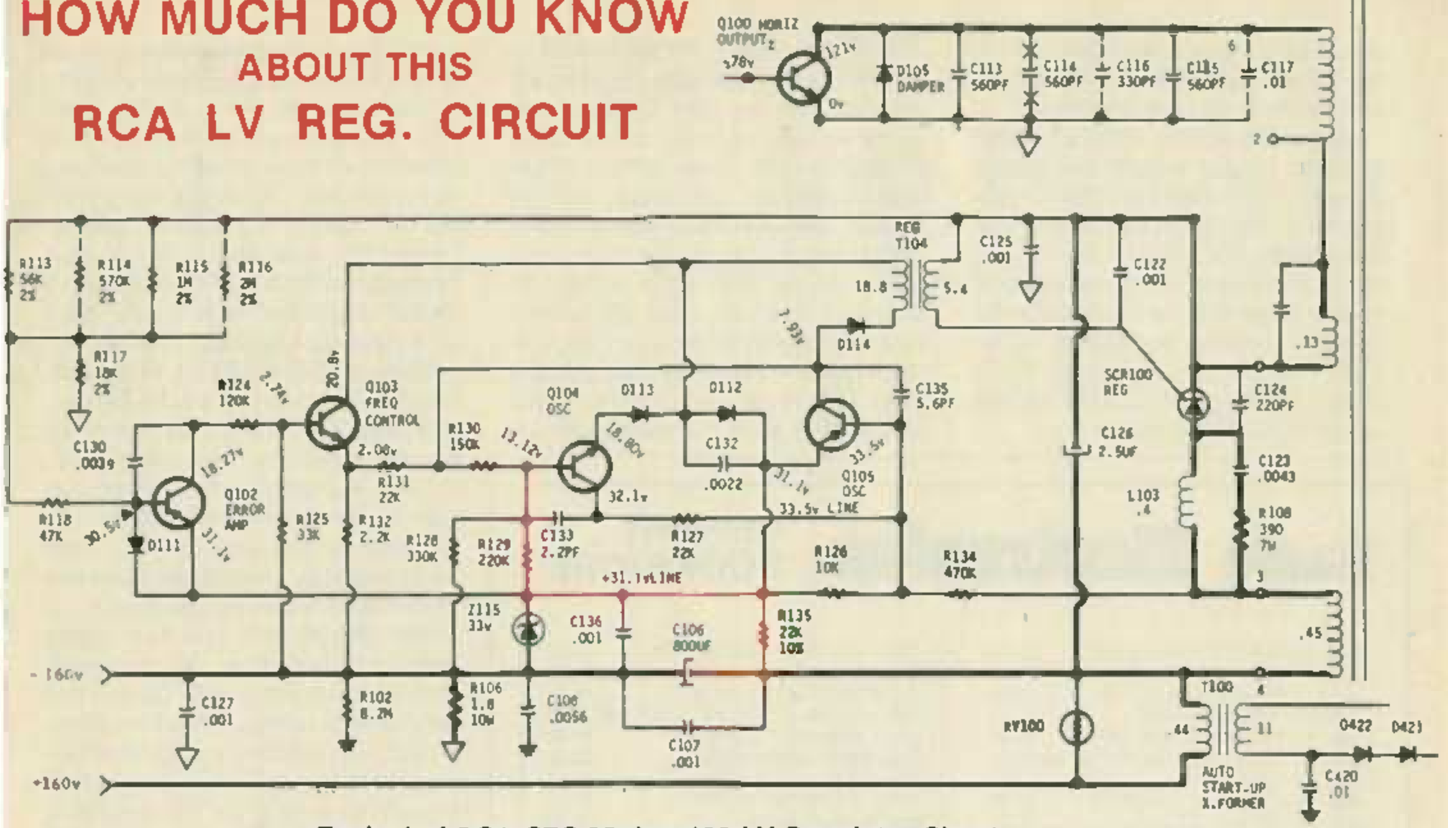


FIG. 1

ADVERTISEMENT

HOW MUCH DO YOU KNOW
ABOUT THIS
RCA LV REG. CIRCUIT



Typical of RCA CTC 85 thru 108 LV Regulator Circuits

Schematic by Diehl Engineering

How many of these questions can you answer?

(1) Every circuit has a beginning and an ending. Where does this circuit begin?
(2) Specifically, what is the purpose of this circuit?
(3) What turns it on? What turns it off, or does it ever really turn off?
(4) Does this circuit have a shut down feature? If so, which components are involved?
(5) What would happen if Q103 were to become shorted E to C?
(6) What purpose does Z115 serve?
(7) What would happen if D114 became shorted?
(8) What purpose does C126 serve? What will happen if C126 becomes open?
(9) Is the winding between terminals 3 and 4 of the flyback a primary or a secondary winding?
(10) What purpose does C117 serve? Exactly what does it do, and exactly how does it do it?
(11) Exactly what do resistors R113, 114, 115, 116, and 117 do? What happens if they change value?
(12) What occurs that causes this circuit to produce an initial start up pulse?
(13) Why does this entire circuit become shorted and begin to destroy horiz output transistors if the regulator SCR becomes shorted?
(14) There is exactly one safe and practical method of circumventing this LV regulator circuit for test purposes. This technique does not involve a variac. Instead, you must disconnect one wire then connect a jumper wire from terminal #4 directly to .... Which wire do you disconnect and where do you connect the other end of your jumper wire?
(15) If SCR100 is shorted, this circuit will still "eat" horiz output transistors even if you are using a variac. Why?
(16) Why does this circuit use a floating ground?

We publish a monthly magazine called the Technician / Shop Owners Newsletter. Each month we take a popular circuit and absolutely disect it.

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After reading our newsletter on this circuit, you could answer all of the above questions as fast as anyone could ask them. In fact, you will then know everything there is to know about this circuit. Including how to troubleshoot it !!

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CIRCLE 274 ON FREE INFORMATION CARD

when pushed, current flow is interrupted and both armatures revert to their original positions.

Since the upper armature contacts no longer supply voltage to the coil, the entire unit "sits" waiting for a trigger. In examining the possibilities of the circuit (Fig. 1-*d*), don't forget that the second switch need not be a manual one. Another relay, a transistor, or an SCR can handle the job. We'll cover transistor and SCR switch substitutes in the future.

Telephone ringer modification

There are many aspects of modern life that we take for granted, but that can present considerable difficulties for those with a physical handicap. Consider, for instance, the difficulty the hearing impaired have using the telephone system. There are, of course, devices that allow the hearing impaired to use that system (such as handset amplifiers and teletype terminals), and others that alert the user to an incoming call using something other than a standard telephone ringer.

Such devices are available from the telephone company and others, but their cost may be high. In some cases, however, it is possible to modify a privately owned phone (i.e. one that is not leased from the telephone company) so that it might be more easily used by a hearing impaired person.

Henry Milowski of Ontario, Canada has devised a scheme that requires no change to the telephone circuitry. He simply removed the telephone's cover and taped a magnetic reed switch to the side of the transformer. Then he brought out two wires from the switch and replaced the cover.

The telephone still functions normally; but now, the magnetic field of the transformer causes the reed switch contacts to close. That switch can control any kind of device. In his application, the switch is used to turn on a 555 oscillator that has adjustable tone and volume controls, but, of course, the "ringer" can be any kind of sound or light source.

Repairing old receivers

Obviously there are many "Hobby Corner" readers who are interested in restoring old radios and televisions. My recent mention of Ken McIntosh's newsletter brought forth a flood of inquiries. Some of you need a source of schematics, while others are looking for parts sources.

Well, from Mick McDaniel (CA), W6FGE, I received the information you asked for! Here are a few suggestions from Mick. For schematics, write to: McMahon Vintage Radio, PO Box 1331, North Highlands, CA 95660; Scaramelia, PO Box 1, Woonsocket, RI 02895, or Panaxis Productions, PO Box 130, Paradise, CA 95969.

For parts, write to: JWF Pruett, PO Box 28572, Dallas, TX 75228; The Old Radio Place, 616 St., Rockville, MD 20850, or Antique Electronic Supply, 1725 W. University, Temple, AR 85281. When writing to those (and other) places, remember that you are more likely to get a prompt reply if you send an SASE (Self-Addressed Stamped Envelope)! Our thanks to Mick for sharing that information with us. R-E

IC TESTER

continued from page 62

All of the resistors are mounted horizontally on 0.4-inch centers except for R_{C1} to R_{C16}. Mount those resistors vertically with the resistor body down and the bare lead toward the top of the board. (The bare lead will be used as a test point for checking the LED circuitry.) Be sure that the resistors do not extend high enough to touch the top panel when installed. The finished PC board should look something like that shown in Fig. 9.

A second PC board, the B-socket board, contains a small solderless breadboard socket (SO3), a standard 16 pin DIP socket (SO4), and a zero-insertion-force or ZIF socket (SO5). It sits above the main board and the cabinet top and mates to the main board with a 20-pin connector. The foil patterns for that double-sided board are shown in our special "PC Service" section, and the parts-placement diagram is shown in Fig. 10.

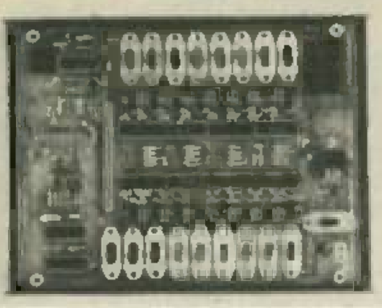

FIG. 11—YOUR FINISHED MAIN BOARD should look like this before you install a top cover.

The 16-pin resistor plugs can be assembled by using a standard 16 pin header as shown in Fig. 11. The common connection can be made with a tiny PC board or simply by tying the leads together. The shorting plug uses 220-ohm resistors while the pull-up plug uses 150K resistors.

Power is supplied from the circuit under test using a 2-pin connector with leads, mini clips and an in-line fuse. Connection to the IC under test is via an IC test clip, which we'll call a DIP clip. The plugs, DIP clip, and power connector are shown in Fig. 11.

Circuit checkout

Before applying power, check over the entire assembly for solder bridging, poor solder connections or missing solder points. Verify that all 11 DIP IC's are oriented with pin 1 up toward the top of the board. Check all LED's and transistors for polarity, and correct any mistakes now.

Mount the main PC board on the bottom chassis, but don't install the top cover until we're done testing. Plug the small PC board into the main board (through SO6) and place all of the IN/OUT slide switches to the OUT position (toward the outside). Put the power switch in the 5–7-volt position and apply 5 volts from a regulated external DC source.

To check the pulse detector, connect a 1K resistor between the pulse input (PULSE IN) and V_{CC} on the solderless connector, SO3. Short PULSE IN to ground with a wire lead. The pulser LED must blink each time the short is made or broken. That verifies that either a rising or falling edge will trigger the pulse detector. Remove the resistor and lead.

Immediately to the left of the solderless connector is IC9. Connect pin 6, a square wave output, to PULSE IN using a short piece of wire. The pulser LED should pulse on and off rapidly. Remove the wire. If you have a pulse generator, feed a 25-ns pulse to PULSE IN. The pulser LED should blink for each pulse. Do that with both positive- and negative-going pulses.

To check the output pulser, use a short length of wire to connect PULSE OUT to PULSE IN on the solderless connector. Then connect a 22-ohm resistor from PULSE OUT to V_{CC}. When you momentarily press the pulser button, the pulser LED (LED17) should blink. Next, connect the 22-ohm resistor from PULSE OUT to ground. Once that is done, when you momentarily press the pulser button, the LED17 should blink. Depress and hold the pulser button again. In about 2 seconds the pulser LED should start and keep pulsing on as long as the button is depressed. Remove jumper and resistor.

To check the individual pin logic, insert the 220-ohm shorting plug into one of the A sockets (SO1 or SO2) and connect its common lead to ground. Place the STORE switch to the not-stored position, and cycle each of the individual pin slide switches to verify that the corresponding LED is on when the switch is in the OUT position and off when in the IN position. If an LED does not perform properly, a simple check can determine if the LED and drive transistor are working.

The test is done as follows. To turn off the LED, connect one end of a 1K resistor to ground. With a clip lead or jumper wire, connect the free end of the resistor to the top of R_{CN}. (R_{CN} is the vertically mounted resistor; there's one for each pin). To turn on an LED, connect one end of a 1K resistor to V_{CC} and repeat the above.

To check the STORE function, place the STORE switch to the STORE position. Turn each LED on by placing its switch to the OUT position, then place all IC switches to the IN position. The LED's should remain on until either the store switch is moved "out" or the pulser is pulsed.

Do not continue if the analyzer is not operating as described. Correct any problems before you go on. Next time, we'll see how to use the analyzer. R-E

DIGITAL IC's

continued from page 80

Other shift registers

A recirculating shift register is a special type of shift register whose output is fed back to its input. A block diagram of such a circuit is shown in Fig. 11.

In that circuit, as data is clocked out of the serial output, it is re-entered into the register via the serial input. The result is that after every n + 1 clock pulses, where n is the number of stages, or "bits", in the register, the contents of the register is reset to its original state.

One application for that type of shift register is in a digital storage oscilloscope; a block diagram of such a device is shown in Fig. 12. In such a scope, the analog input is converted to digital form by the A/D converter and then stored in the shift register. The section of that register denoted as the "cache" is four to eight bytes of parallel data that are used to update the stored waveform. The serial output of the register is re-converted to analog form by the D/A converter for display on the scope's CRT, and also fed back to the register's input for reinsertion.

Figure 13 shows a bucket brigade device, or stepper; the timing diagram for that circuit is shown in Fig. 14. That circuit is an electronic version of the electromechanical stepper, where a voltage is applied sequentially to a series of contacts.

In that type of shift register, J-K flip-flops are connected so that the J inputs are always high and the K inputs are always low. In that state, the Q outputs of each flip-flop are usually high. However, if a reset pulse is applied, it will force the Q output of the first stage low. As shown in Fig. 14, that low will be passed, in "bucket-brigade" fashion, to each succeeding stage of the register on negative-going transitions of the clock signal.

Figure 15 shows a pseudo-random sequencer. The output of that circuit is a pseudo-random signal (i.e., noise). Such a signal can be used to test a variety of equipment, such as audio amplifiers and radio receivers.

The pseudo-random sequencer can output $2^n - 1$ (where n is the number of stages in the device) different states. The particular state output on a given clock pulse appears to be random. We say "appears" because the outputs do repeat in a sequential manner; however, that sequence is not apparent over a "short" period of time. (Short is a relative term; a 64 stage pseudo-random sequencer will repeat only after $2^{64} - 1$, or 1.84467×10^{19}, clock pulses.)

Next time, we will look at another circuit in which flip-flops are used—the counter. R-E

ANTIQUE RADIOS

RICHARD D. FITCH

Antennas and grounds

SO FAR, WE'VE DISCUSSED LOCATING A suitable radio, restoring the cabinet, and repairing some chassis problems. But what of the antennas used with those sets? These days, you can get good reception by simply using a short length of wire, but that was not always the case. This month, let's step back in time and see what it took to get good reception with those old sets.

Early radio reception

Radio listeners back in the 1920's faced quite a few reception problems. For one thing, RF shielding was not a prime concern in those days. Thus, though there were far fewer sources of man-made interference around, the sources that did exist were troublesome. To make matters worse, transmitters in the mid-twenties used much lower power levels, making it tough sometimes to pull a signal out of the "hash."

One way that early radio listeners fought interference was to locate the antenna as high above ground as possible. Unfortunately, efforts to elevate the antenna were often in vain, as the lead-in still had to pass by and through most of the interference sources.

Often, lead-ins were just dropped down the back of the building and tacked to the window sill or a metal strap, which allowed the window to close. And it was not unusual to see window glass replaced by wood so that a hole could be drilled for the wire. A porcelain tube insulator inserted into a hole drilled through the wall or window frame (extremely unpopular with landlords) was another method used to bring the lead-in into the house. In any event, by the time the lead-in reached the set, it had usually picked up more signals than the antenna itself. Putting up with those unwanted signals was considered a part of owning a radio in the early thirties.

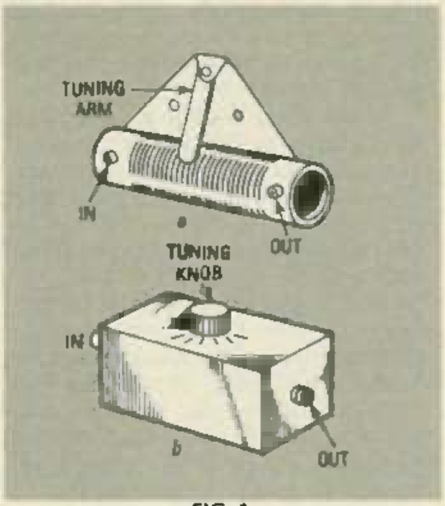

FIG. 1

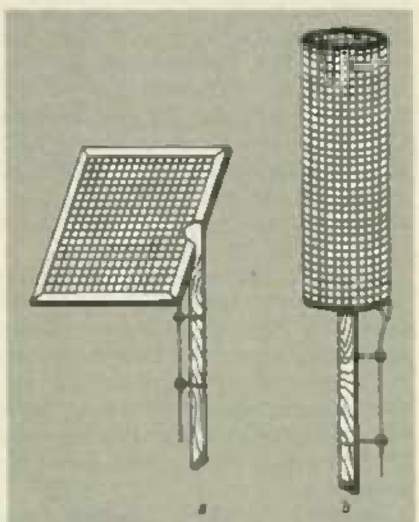

FIG. 2

Of course, shielded wire would have solved the lead-in problem. But the length of the runs—often down three stories, then through three rooms—made the cost prohibitive. At six to ten cents a foot, three dollars or more could be invested in just the lead-in wire. (That was quite a sum back in those days.) And the high ceilings of old houses added many feet to the distance between the antenna and set.

In any event, the real fun began once the the antenna was in place. Even though interference was a fact of life, it was not easily tolerated. That's because it would severly curtail the possiblitles of DX. And DX was one of the passions of many an early radio owner.

For those unfamiliar with it, DX is the reception of distant radio signals. A "DX hound" would often spend considerable time and money pursuing any scheme that would bring in that one extra signal.

As a result, many innovations were offered by manufacturers eager to cash in on the DX craze. Some worked wonders, while others only worsened interference problems.

Improving reception

One early device used to improve reception was an *aerial tuner*. The tuner in Fig. 1-*a* uses a coil with a slide lever (tuning arm) to tune the antenna for best performance. That device sold for about one dollar and could be home-made. Fig. 1-*b* shows another antenna tuner common to that period.

One problem with erecting a roof-top antenna was that it were considered unsightly by landlords and neighbors. Further, for a time local fire departments sought to have those antennas banned because they considered them a hazard to fire fighting. One solution to that problem was an antenna called the *Gold Test Aerial*. It was small—only 5 inches wide, and 2½ inches high—and was said to perform as well as 50 feet of wire strung 50 feet high. That antenna was usually screwed inside the radio cabinet; it cost about $2.50.

In the late 1920's, the *screen aerial*, a round or sometimes flat screen device mounted on a pole (as shown in Fig. 2), came along. Since that antenna eliminated the need to string wire across a roof, it was advertised as having the approval of the Fire Department.

By the 1930's, many of the problems faced by radio listeners began to disappear. Improved transmitters, with increased power, coupled with improved receiver design, all but eliminated the need for long, high-mounted antennas for broadcast reception. R-E

PRINTER BUFFER

continued from page 71

be used to download a program.) The code must be assembled to operate at start address 0900H. The RAM from 0800 to 08FFH is reserved for stack and scratchpad memory if you wish to use it. After your program is downloaded, press and release the COPY switch. The processor will jump to 0900H and execute your program. Top of RAM is FFFFH.

There are few subroutines used in the IC2 program EPROM that would be of any value, and because they do wreck nearly all of the registers in the main and alternate bank, we have not supplied their entrance addresses. IC25 decodes 8 port strobes and all may be used as input or output strobes.

Using the EPROM programmer

With the power switches (S5 and S6) off, set the FUNCTION SELECT switches for the proper type of EPROM and for either READ or PROGRAM. Also set S8-a–S8-f according to the EPROM chart of Table 3. Install an EPROM in SO2. If the EPROM is a 2758, 2716, 2732 or 2732A, it must be installed so that its pin 12 is in pin 14 of the socket. In other words, pins 1, 2, 27, and 28 should be left empty. (Note that the ZIF socket shown in the photos is a 24-pin type. If you haven't already done so, plug the Programmer board onto plugs PL4 and PL2.

Reading an EPROM

Now you're ready to read an EPROM. Switch S7 should be off. Turn on the buffer (S5) and then turn on the programmer. Press and release COPY. You should see LED1 flash when reading 2758's, 2716's and 2764's. When reading 2732 type EPROM's, the LED will not flash. In either case, the READ operation will be completed within one second.

The data from the EPROM will be stored in the buffer's memory. You may read the data from the memory through the serial output port or the parallel output port. (Of course, if you want to use the parallel port, you'll have to remove the programmer board and set the FUNCTION SELECT accordingly.) When your computer is ready to receive the data, press and release COPY. If you wish to copy the data onto another EPROM, remove the copied EPROM and replace it with a blank EPROM. Change the FUNCTION SELECT switches and S8 for the type of EPROM you wish to program. Follow the instructions for programming an EPROM. (But remember that you already have, in the buffer, the data that you want programmed.

Programming an EPROM

Set up the programmer as described in the section "Using the EPROM programmer" before installing the EPROM to be programmed. With S7 off, turn on the buffer and then the programmer. Dump the data to be programmed through either the parallel or serial (1200 baud only) input port of the buffer. Turn S7 on. (That applies the high programming voltage.) Press and release COPY, pause for a second and repeat. LED1 will light. As data is programmed, it is verified byte for byte. If the data to be programmed matches the data which is now programmed into the EPROM, the programming will proceed until the last byte sent from the computer has been programmed, at which point the LED will go off. Turn off S7 and S6, and remove the EPROM. If an error is found during the verify operation, the LED will flash. If that occurs, switch off S7, S6 and S5 and repeat the above procedures with another EPROM. R-E

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FINEST proven names in satellite TVRO systems available at discount prices. Send $1.00 for our prices. **C.V.P.**, Box 2414, Danbury, CT 06810.

SATELLITE television components, huge savings. Contact **FORCE ONE SYSTEMS**, 120 16th N.W., Canton, OH 44703. (216) 456-0259.

SATELLITE equipment at discount prices. All major brands available. Send for free price list. **GALAXY SATELLITE SYSTEMS**, P.O. Box 970499, Miami, FL 33197.

THE LNA specialists! Brand name, lowest noise, lowest prices! We will not be undersold! Send for prices: **LNA**, 201 E. Southern, Suite 100, Tempe, AZ 85282.

CATALOG: TV descramblers, microwave converters, satellite systems, many types, kits or built. $1.00. **MINUTE KITS**, Box 531, Westchester Sq. Sta., Bronx, NY 10461.

SATELLITE-TV systems . Lowest prices! Name brand dishes, receivers, LNA's, etc. Factory guaranteed. Send $2.00 for latest catalog and information: **TITANSAT**, Box 101, Lemont, PA 16851.

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Electronic Know-how not required
Easy to build from our plans or kits
Lowest prices on satellite electronics
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Mail today to: GFI-D14, Box 9108 Missoula, MT 59807
P-411

E-Z Satellite kit, computer print-out of your location, 2" liquid compass, inclinometer. MasterCard/Visa. **IN-X-SALES**, Box 45, Tilton, NH 03276. (603) 286-3082.

SATELLITE-TV—Home—RV's. Complete fully operational systems from $6.95. Send $2.00 for catalog. **MIDWEST SATELLITE SYSTEMS**, P.O. Box 43008, Mt. Clemens, MI 48043

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We accept MasterCard and Visa for payment of orders. If you wish to use your credit card to pay for your ad fill in the following additional information (Sorry, no telephone orders can be accepted.):

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PROJECTION TV..Make $$$'s assembling projectors...Easy... Results comparable to $2,500.00 projectors...Your total cost less than $20.00...**Plans, 8" lens & dealers' information** $17.50...Illustrated information free...**MACROCOMA-GAX**, Washington Crossing, PA 18977. Creditcard orders 24 hours (215)736-2880.

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CABLE-TV Converters: Jerrold products include "new Jerrold Tri-Mode", SB-3, Hamlin, Oak VN-12, M-35-B, Zenith, and more. UHF Deluxe II kits. (Quantity discounts) 60 day warranty. Repairs of cable converters. For fast service C.O.D. orders accepted. Send S.A.S.E. (60 cents postage), or call for info., (312) 637-4408. HIGGINS ELECTRONICS, 5143 W. Diversey, Chicago, IL 60639. No Illinois orders accepted.

TV stereo adapter plans **PCB** also **UHF gated-pulse** descrambler with simulated stereo output. For additional information—send S.A.S.E. to **SOKOLOWSKI**, Box 150, Elmont, NY 11003.

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SCHEMATICS made from your PC board, $7.00 per component. **CONNELLY**, 717 E. Bauer, Naperville, IL 60540.

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PROJECTION TV...Convert your **TV** to project 7 foot picture...Results comparable to $2,500.00 projectors...Total cost less than $30.00...Plans and 8" lens $19.95...Illustrated information free. **MACROCOMA-GA**, Washington Crossing, PA 18977. Creditcard orders 24 hours (215) 736-3979.

PC/XT computer mother board July issue compatible. Wave-soldered w/all components less IC $110.00 and more. **NRPC**, (713) 484-9575, 104G S. Friendswood, Friendswood, TX 77546.

TESLA coil construction plans, Kirlian Electrophotography plans. Free information/photo. **SCIENTIFIC**, Box 962RE9, Norco, CA 91760.

VCR amplifier kit: transmits to any TV in your house. FM transmitter, function generator. Kits are $24.95 each and include PC board and all board mounted parts. (CA residents add 6.5%). **CAS ELECTRONICS**, 1559-J Amar Rd., Suite 457, West Covina, CA 91792.

CABLE-TV

BONANZA!

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RCA 36 CHANNEL CONVERTER (CH. 3 OUTPUT ONLY)	29.95	18.00 ea.
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LCC-58 WIRELESS CONVERTER	92.95	76.00 ea.
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BRAND NEW — TRIMODE UNIT FOR JERROLDS	*Call for specifics*	
MINICODE (N-12)	109.95	58.00 ea.
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MINICODE VARISYNC W/AUTO ON-OFF	179.95	115.00 ea.
M-35 B (CH. 3 OUTPUT ONLY)	139.95	70.00 ea.
M-35 B W/AUTO ON-OFF (CALL FOR AVAILABILITY)	199.95	125.00 ea.
MLD-1200-3 (CALL IF CH. 2 OUTPUT)	109.95	58.00 ea.
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SPECIFY CHANNEL 2 or 3 OUTPUT

Quantity	Item	Output Channel	Price Each	TOTAL PRICE
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			TOTAL	

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DECLARATION OF AUTHORIZED USE — I, the undersigned, do hereby declare under penalty of perjury that the products purchased will only be used on cable TV systems with proper authorization from local officials or cable company officials in accordance with all applicable federal and state laws.

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Pacific Cable Company, Inc.

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IMPORTANT: WHEN CALLING FOR INFORMATION —
Please have the make and model # of the equipment used in your area. *Thank You*

FOR SALE

CABLE-TV Secrets—the outlaw publication the cable companies tried to ban. HBO, Movie Channel, Showtime, descramblers, converters, etc. Suppliers list included. $8.95. **CABLE FACTS**, Box 711-R, Pataskala, OH 43062.

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WHOLESALE MATV/CATV equipments, antenna, accessories, cartridges, radios, speakers, cables. (718) 897-0509, **D&WR**, 68-12 110 Street, Flushing, NY 11375.

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Ribbon Header	IDMxx	—	5.25	6.00	6.70	7.20	8.55
Ribbon Edgecard	IDExx	1.70	2.15	2.60	2.80	3.70	3.90
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CONVERTERS all types for all systems. Lowest prices anywhere, quantity discounts, dealer inquiries accepted. Free catalog. **PG VIDEO CORP.**, 61 Gatchell St., Dept. RE, Buffalo, NY 14212.

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NOISE eliminators, expanders, power meters, others. Twelve-24 bands/channel equalizers from $89.00. Kit see R-E 5-6/78, 2/80, 3-4/81. Catalog: SSS, 856R Lynnrose, Santa Rosa, CA 95404. (707) 546-3895.

CABLE-TV

DEALERS wanted: Channel 2, 3, and 4 notch filters. Money back guarantee. Send $15.00 for sample and quantity price list. Specify channel(s). **GARY KURTZ,** P.O. Box 291394, Davie, FL 33329.

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Z80A CPU	2.80	8155-2	7.80
Z80B CPU	6.00	8202	13.95
Z80A CTC	3.70	8212	1.80
Z80A DART	7.00	8214	4.80
Z80A PIO	3.70	8216	1.75
Z80A SIO	10.00	8224	3.00
8Z C43	4.75	8226	3.00
AMD2901	6.95	8237	8.00
6502	4.75	8238	3.95
6800	3.50	8250	10.00
6802	4.80	8251	4.40
6803L	6.00	8253	6.00
6808	8.00	8256A-5	5.00
6810	4.00	8257	6.00
6821	2.70	8259	6.00
6845	8.00	8272A	14.00
6850	3.70	8279	14.90
6875	4.60	8279-5	3.50
D7220-1	12.00	8755	8.00
8035	4.80	8350	13.95
8080A	3.75	8748	20.00
8085A	4.75	TMS9927NL	9.95
8088	8.00	8800OL3	25.00

INTER FACE & DRIVERS

AY5-1013A	3.75
AY3-1015D	6.75
1488	.80
1489	.65
TR1602B	3.00
ER1941L	3.95
AY5-3600PRO	9.95
CRT5037	16.95
MM5307	7.65
UM5369	2.80
6130	7.50
8830	3.50
8833	2.50
8834	2.00
8837	3.00

SHIFT REGISTERS

MM1402	1.75
MM1403	1.75
MM1404	1.75
MM5013	2.50
MM5056	2.50
MM5058	2.50
MM5057	2.50
MM5058	2.50
MM5060	2.50

DISC Controllers

D765C	10.00	1793	17.00
1771	5.95	1795	17.00
1791	14.00	1797	17.00

RAM's

2016	2.00
21L02-3	.80
2101A-4	1.50
2111A	1.75
2112-1	1.85
2114-2	1.00
2116-4	2.00
2147-3	2.50
3242	6.00
TMS2409	1.75
MK4027-3	1.75
TMS4050NL	2.95
MK4096-11	1.20
4108-3	6.50
4116-3	1.00
4118-4	4.00
MK4802	6.95
Z6104-4	3.80
6116-3	3.75
6116-12	4.95
6167P-3	7.00

ROM's

TP818S42	3.80
825126	1.85
825130	1.85
825131	1.80
TP828S166	6.50
823181	6.95
745474	3.95
2708	3.75
2716 + 5V	2.75
2732A	4.00
2764	4.80
3341A	2.95
3628A-3	3.00
6331	1.95
6388-5	1.20
AM9214C	2.95
27128	7.50

NO. 30 WIRE WRAP WIRE SINGLE STRAND 100' . . . $1.40

CRYSTALS

1.843	6.000
2.000	6.144
3.000	8.000
3.579	10.000
4.000	18.000
5.000	18.432
	20.000

2.75 ea.

EPOXY GLASS VECTOR BOARD

1/16" thick with 1/10" spacing
4½" x 6½" $2.40

SCR's / TRIAC's

SCR's PRV	1.5A	6A	35A	110A	TRIAC's PRV	1A	10A	25A
100	.35	.40	1.40		100	.35	.60	1.40
200	.40	.60	1.80		200	.50	.80	1.80
400	.60	.70	2.40	12.00	400	.70	1.00	2.60
600	.80	1.00	3.60	15.00	600	1.00	1.20	3.60

C/MOS

74C00	.35	74C915	1.10	4017	.45	4076	.60
74C02	.35	74C921	3.50	4018	.80	4077	.60
74C04	.35	4001	.35	4020	.70	4081	.70
74C10	.35	4002	.35	4023	.40	4082	.30
74C14	.55	4006	.95	4024	1.75	4093	.45
74C20	.35	4007	.35	4035	.85	4098	1.75
74C32	.35	4008	.95	4040	.75	4001	.80
74C42	1.20	4009	.40	4043	.75	4503	.80
74C74	.80	4010	.45	4042	.65	4506	.75
74C76	.80	4011	.30	4043	.80	4510	1.20
74C83	1.20	4012	.30	4044	.80	4511	.85
74C85	1.25	4013	.35	4046	.80	4513	.85
74C86	.40	4014	.75	4047	.95	4514	1.20
74C93	1.00	4015	.35	4049	.35	4516	1.60
74C154	3.00	4016	.35	4050	.35	4518	1.80
74C157	1.70	4017	.50	4051	.75	4518	.80
74C161	1.10	4018	.75	4052	1.60	4520	.80
74C174	1.10	4018	.40	4053	.75	4526	1.10
74C175	1.10	4020	.75	4060	.75	4528	1.40
74C192	1.40	4021	.75	4066	.40	4538	1.80
74C193	1.40	4022	.75	4068	.40	4539	1.80
74C245	1.75	4023	.25	4069	.35	4541	1.75
74C901	.40	4024	.80	4070	.35	4553	1.75
74C903	.50	4025	.30	4071	.70	4583	.80
74C907	.80	4026	1.25	4073	.30	4585	.75

74S SERIES

74S00	.30	74S74	.50	74S163	1.75
74S02	.35	74S85	1.75	74S168	1.50
74S03	.35	74S86	.50	74S174	.90
74S04	.35	74S88	3.00	74S175	.90
74S05	.35	74S112	.60	74S181	2.00
74S08	.35	74S113	.60	74S182	2.00
74S09	.45	74S124	2.70	74S188	1.60
74S10	.35	74S133	.45	74S194	1.30
74S11	.35	74S138	.85	74S195	1.30
74S15	.35	74S139	.80	74S241	2.00
74S20	.35	74S140	.80	74S244	1.75
74S30	.35	74S151	.80	74S251	1.30
74S32	.40	74S153	.85	74S251	.90
74S40	.40	74S157	.80	74S260	.75
74S42	.85	74S158	.80	74S373	3.00
74S51	.35	74S161	1.75	74S374	2.00

2114-4	$ .70
4116-25	$ .75
4164-15	$1.50
6264-15	$9.00
41256-15	$5.00

T IS 73 N FET . . . . $ .45
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2N3820 P FET . . . . $ .45
2N 6028 PROG. UJT . . . . $ .65

DISC CAPACITORS

1UF 16V	10 $1.00	100 $8.00
.01UF 35V	16 $1.00	100 $5.00

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4" x 6" DOUBLE SIDED EPOXY BOARDED 1/16" THICK $.60 ea. . . . . . 5/$2.60

FULL WAVE BRIDGE

PRV	2A	6A	25A
100			1.60
200	.80	1.20	2.20
400	1.00	1.65	3.30
600	1.30	1.90	4.40

12V DC RELAYS TTL SIZE
S.P. 400 ohm coil .75
D.P. 400 ohm coil .95

SILICON POWER RECTIFIERS

PRV	1A	3A	12A	50A	125A	240A
100	.06	.14	.35	.90		
200	.06	.17	.80	1.30	7.00	9.00
400	.08	.25	.65	1.50	10.00	12.00
600	.11	.30	.80	2.00	13.00	15.00
800	.13	.35	1.00	2.50	16.00	19.00
1000	.20	.45	1.25	3.00	20.00	28.00

REGULATORS

78L05 or 15	$ .30	LM338K	$6.75
LM309G	$ .75	340T-5,6,8,12, 15,18 or 24V	$ .75
LM317T	$1.10	723	$ .50
320T-5,12,15 or 24	$ .85	LAS1412 +12V3A	$3.80
79M5, 12 or 15	$ .40		
323K (LA1405)	$1.75		

40 PIN EDGEBOARD CONN and others

40 PIN EDGEBOARD CONN	3.00
28 PIN EDGEBOARD CONN	2.50
50 PIN RIBBON CABLE CONN	2.50
40 PIN RIBBON CABLE CONN	3.00
34 PIN RIBBON CABLE CONN	2.75
26 PIN RIBBON CABLE CONN	2.60
20 PIN RIBBON CABLE CONN	2.00

TRANSISTOR SPECIALS

TIP 31B NPN Si TO-220	$ .45
TIP 32B PNP Si TO-220	$ .40
TIP 34 PNP Si	$ .85
TIP 111	$ .50
TIP 121 PNP Si U64	$ .60
TIP 141 NPN Si U87	$1.00
TIP 145	$1.35
BU208	$1.75
2N6056 PNP GE TO-5	3/$1.00
2N1307 PNP GE TO-5	$ .40
DP92000 . . DUAL POWER DARL	$3.50
2N2222 NPN Si TO-18	1/$1.00
2N2907 PNP Si TO-18	7/$1.00
TIP 2955 PNP Si	$ .70
2N3055 NPN Si TO-3	$ .60
MJE3055T	$ .60
2N3904 NPN Si TO-92	7/$1.00
2N3906 PNP Si TO-92	7/$1.00
2N4908 PNP Si TO-3	$1.00
2N6109 PNP Si TO 220	$ .55
MJE13008A 400V NPN	$1.00
MRF 8004 CM RF TRANSISTOR NPN	$ .75
HEP G6014 – PNP GE TO-3	$ .85

TTL IC SERIES

7400	.20	7480	.45	74166	1.00
7401	.20	7483	.50	74170	1.30
7402	.20	7485	.55	74173	.75
7403	.20	7486	.35	74174	.85
7404	.20	7489	1.80	74175	.85
7405	.25	7490	.50	74176	.75
7406	.27	7491	.50	74177	.65
7407	.27	7492	.50	74180	1.20
7408	.25	7493	.35	74181	2.00
7409	.20	7494	.60	74182	.80
7410	.20	7495	.55	74184	1.30
7411	.25	7496	.60	74185	.40
7412	.25	74107	.30	74191	.80
7413	.25	74116	1.20	74192	.75
7414	.45	74121	.30	74193	.75
7416	.25	74122	.45	74194	.80
7417	.25	74123	.45	74195	.80
7420	.20	74125	.45	74196	.75
7425	.27	74126	.45	74197	.80
7426	.30	74145	.60	74198	1.30
7427	.27	74147	1.20	74221	1.20
7430	.20	74148	1.20	74273	1.00
7432	.27	74150	1.30	74276	.70
7437	.27	74151	.55	74298	.60
7438	.75	74153	.55	74365	.65
7440	.20	74154	1.20	74367	.65
7442	.40	74155	.75	74390	.90
7445	.65	74157	.55	75325	1.60
7447	.70	74158	.60	75492	1.00
7448	.70	74160	.65	8091	1.00
7450	.20	74161	.65	9602	.80
7472	.30	74162	.65	8T28	1.10
7473	.35	74163	.65	8T26	1.10
7474	.32	74164	.85	8T97	1.10
7475	.45	74165	.85	8T98	1.10
7476	.35				

74LS SERIES

74LS00	.22	74LS107	.35	74LS241	.80
74LS01	.25	74LS109	.35	74LS242	.80
74LS02	.25	74LS112	.35	74LS243	.80
74LS03	.25	74LS113	.35	74LS244	1.30
74LS04	.25	74LS114	.35	74LS245	1.40
74LS05	.25	74LS122	.75	74LS246	1.40
74LS08	.25	74LS125	.45	74LS247	.75
74LS09	.25	74LS126	.45	74LS248	1.00
74LS10	.25	74LS132	.55	74LS251	.55
74LS11	.30	74LS136	.35	74LS253	.55
74LS12	.30	74LS137	.80	74LS257	.45
74LS13	.40	74LS138	.50	74LS258	.55
74LS14	.50	74LS139	.50	74LS259	1.75
74LS15	.25	74LS147	2.20	74LS260	.55
74LS20	.25	74LS151	.55	74LS266	.55
74LS21	.25	74LS153	.55	74LS273	1.30
74LS22	.25	74LS155	.55	74LS279	.45
74LS26	.25	74LS156	.55	74LS280	1.70
74LS27	.25	74LS157	.65	74LS283	.65
74LS28	.30	74LS160	.65	74LS290	.80
74LS30	.25	74LS161	.65	74LS293	.80
74LS32	.25	74LS162	.75	74LS298	.80
74LS37	.35	74LS163	.65	74LS320	2.00
74LS38	.35	74LS164	.65	74LS322	3.50
74LS40	.30	74LS165	.85	74LS365	.45
74LS42	.50	74LS166	1.75	74LS366	.45
74LS47	.75	74LS169	1.50	74LS367	.45
74LS48	.75	74LS170	1.80	74LS368	.45
74LS51	.25	74LS173	.65	74LS373	1.30
74LS54	.30	74LS174	.50	74LS374	1.30
74LS73	.35	74LS175	.50	74LS377	1.30
74LS74	.35	74LS181	2.00	74LS385	.45
74LS75	.35	74LS190	.80	74LS390	1.10
74LS76	.35	74LS191	.80	74LS393	1.00
74LS83	.60	74LS192	.75	74LS395	2.50
74LS85	.60	74LS193	.75	74LS445	2.00
74LS86	.35	74LS194	.65	74LS641	2.20
74LS90	.55	74LS195	.65	74LS625	1.75
74LS92	.55	74LS196	.65	74LS668	1.60
74LS93	.55	74LS197	.65	74LS670	1.75
74LS95	.75	74LS221	.80	81LS95	1.40
74LS96	.85	74LS240	.95		

LINEAR CIRCUITS

DAC08EQ	2.75	LM380	1.20	LM1310	1.40
TL082CP	.80	LM384	1.80	LM1391	1.00
TL084CN	1.80	LM386	1.00	1458	.60
TL072	1.25	LM387	1.25	1488	.50
TL082	.80	LM393	.75	LM1800	2.75
TL084	1.80	LF398A	3.00	ADC0800LD	4.85
LM301	.75	LM555	.35	LM7801	.95
LM301/748	.35	LM556	.65	CA3018	1.95
LM307	.45	558	1.75	CA3078AT	1.00
LM308	.85	564	2.50	CA3080	1.00
LM310	1.10	565	.90	CA3080A	1.75
LM311	.85	566	1.20	CA3084	1.30
LM318	1.25	567	.95	CA3130	1.00
LM319	1.85	NE592	.85	CA3140	1.00
LM324	.80	709CH	.80	CA3622	.75
LM339	.80	LM710	.85	LM3900	.30
LM348	.85	733	.85	LM3909	.80
LF351	.60	741CV	.30	4136	.85
LF353	.80	747	.85	NE5558A	1.50
LF356	.85	CA758	1.75	8038CC	1.00
LF364	1.00	LM7880CT	.80	8700CJ	5.95
LM358	.85	DAC0800	2.95	LM13080	.95
LM370	1.80				

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IN4148 (IN914) 15/1.00

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FP 100 PHOTO TRANS . . . . $ .50
RED LED's 2" . . . . 8/$1.00
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RED-GREEN BIPOLAR LED . . . . $ .90
RED-YELLOW BIPOLAR LED . . . . $ .90
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CTS 206- 8	8 POSITION	.95
CTS 206-10	10 POSITION	1.25

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8 PIN	.10	22 PIN	.25
14 PIN	.15	24 PIN	.25
16 PIN	.16	28 PIN	.35
18 PIN	.20	40 PIN	.40
20 PIN	.25		

WIRE WRAP SOCKETS

14 PIN	.45
16 PIN	.60
18 PIN	.65
20 PIN	.90
24 PIN	1.10
28 PIN	1.25
40 PIN	1.90

20KV DIODES 250 ma. $1.95

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DB9P	$3.00	DB25P	$2.00
DB9S	$3.00	DB25S	$3.00
HOODS	$1.10	HOODS	$1.10

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22UF 35V	5/$1.00	15UF 16V	3/$1.00
47UF 35V	5/$1.00	30UF 6V	5/$1.00
68UF 35V	5/$1.00	33UF 16V	$ .50
1UF 20V	5/$1.00	47UF 20V	$ .85
2.2UF 20V	5/$1.00	68UF 16V	$1.00
3.3UF 20V	4/$1.00	200UF 20V	$1.75
4.7UF 35V	4/$1.00	150UF 16V	$1.30
6.8UF 20V	4/$1.00	330UF 10V	$1.75
10UF 20V	$ .40		
22UF 10V	$ .30		

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3/$2.00
50 OHM, 100 OHM, 1000 OHM, 5K, 10K, 20K, 50K, 100K

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(14 volts DC @ 285MA)

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3 isolated sockets; quality spike suppression; basic protection. . $81.95

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3 dual isolated sockets; suppressor; commercial protection. $122.95

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4 quad isolated sockets; suppressor; laboratory grade protection. . $213.95

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2114-300ns	.50
FDC1793	5.00
74LS322	.50
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Z80ASIO/0	3.75

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2901	3.00	8039	2.00
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68000-8	18.00	8085	2.00
68008-8	18.00	8086	4.00
Z8001	7.50	8086-2	5.00
80186-3	15.00	8088	7.50
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8035	2.00	8741A	10.00

ADC/DAC

ADC08XX	3.50
DAC08XX	1.50
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1691	5.25	2661	4.00
1771	6.50	5027	3.00
1791	10.00	5037	5.00
1793	5.00	7201	4.50
1795	10.00	765	4.00
1797	10.00	COM8116	5.00
2651	4.00	3250	4.00

SOUND CHIPS

76477	2.00
AY3-8910	2.00
AY3-8912	2.00

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8202	14.00	8259	2.00
8212	1.00	8272	4.00
8216	1.00	8273	10.00
8224	3.00	8274	9.00
8228	3.00	8275	9.00
8237	3.00	8276	15.00
8238	2.50	8279	3.50
8243	1.50	8282	7.50
8251	2.00	8283	5.50
8253	2.00	8284	2.00
8254	4.00	8288	4.00
8255	2.00	8291	20.00
8257	2.00	8292	21.00

TMS 9900 SERIES

9901	1.50
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74LS01	.25	74LS158	.59
74LS02	.25	74LS160	.69
74LS03	.25	74LS161	.65
74LS04	.24	74LS163	.65
74LS05	.25	74LS164	.69
74LS08	.28	74LS165	.95
74LS09	.29	74LS166	1.95
74LS10	.25	74LS169	1.75
74LS11	.35	74LS173	.69
74LS12	.35	74LS174	.55
74LS13	.45	74LS191	.89
74LS14	.59	74LS192	.79
74LS20	.25	74LS193	.79
74LS21	.29	74LS194	.69
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74LS27	.29	74LS197	.79
74LS32	.29	74LS221	.89
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74LS73	.39	74LS253	.59
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74LS75	.39	74LS258	.59
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74LS126	.49	74LS373	1.39
74LS132	.59	74LS374	1.39
74LS136	.39	74LS377	1.39
74LS138	.55	74LS390	1.19
74LS139	.55	74LS393	1.19
74LS145	1.20	74LS640	2.20
74LS148	1.35	74LS645	2.20
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74LS154	1.90	74LS688	2.40
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7400

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7402	.19	74100	1.75
7403	.19	74107	.30
7404	.19	74116	1.55
7405	.25	74121	.29
7406	.29	74122	.45
7407	.29	74123	.49
7408	.24	74125	.45
7409	.19	74126	.45
7410	.19	74132	.45
7411	.25	74143	.60
7413	.35	74148	1.20
7414	.49	74150	1.35
7416	.25	74151	.55
7417	.25	74153	.55
7420	.19	74154	1.25
7421	.35	74155	.75
7425	.29	74157	.55
7427	.29	74159	1.65
7430	.19	74161	.69
7432	.29	74163	.69
7437	.29	74164	.85
7438	.29	74165	.85
7442	.49	74166	1.00
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7489	2.15	74368	.65
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74S00

74S00	.32
74S02	.35
74S04	.35
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.35
74S32	.40
74S37	.88
74S74	.50
74S86	.50
74S112	.50
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DESIGNER'S NOTEBOOK

continued from page 96

put with something near a 50% duty cycle. That last restriction is based solely on my own experience and, consequently, it's also subjective.

The LM386 is used because it can directly drive a speaker, but the whole idea can easily be applied to any amplifier. Once again, the idea here is to experiment and adapt the basic principles to suit your own needs.

On a final note: Since the tremolo clock uses the gain-control pin of the amplifier, you'll have to change the value of capacitor C4 in order to change the gain of the amplifier.

You can make C4 larger to increase the gain or smaller to decrease it. The range of values for C4 can go from about .1 to 500 microfarads. But, don't go any lower than .1 µF because you'll be cutting into the bottom-end frequency response. R-E

CIRCLE 82 ON FREE INFORMATION CARD

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